Assessment Report

Development of national action plans and assessment of the priority locations for BAT/BEP implementation

Prepared for the project:

Promotion of Strategies to Reduce Unintentional Production of Pops in the Red Sea and Gulf of Aden (PERSGA) Coastal Zone

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- All environment directorate stuff in ASEZA.
### Glossary/Abbreviations

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
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<tbody>
<tr>
<td>°C</td>
<td>Degree Celsius</td>
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<tr>
<td>µg</td>
<td>microgram (10⁻⁶ grams)</td>
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<tr>
<td>ADC</td>
<td>Aqaba Development Corporation</td>
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<tr>
<td>AFESD</td>
<td>Arab Fund for Economic and Social Development</td>
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<tr>
<td>AFP</td>
<td>Aluminum Florid Plant</td>
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<tr>
<td>AIC</td>
<td>Aqaba Industrial Complex</td>
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<tr>
<td>APC</td>
<td>Arab Ports Company</td>
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<tr>
<td>ASEZ</td>
<td>Aqaba Special Economic Zone</td>
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<tr>
<td>ASEZA</td>
<td>Aqaba Special Economic Zone Authority</td>
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<tr>
<td>ATPP</td>
<td>Aqaba Thermal Power Plant</td>
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<tr>
<td>AWWS</td>
<td>Aqaba Waste Water Station</td>
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<tr>
<td>AZEM</td>
<td>Aqaba Zone Economic Mobilization</td>
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<tr>
<td>BAT</td>
<td>Best Available Techniques</td>
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<tr>
<td>BEP</td>
<td>Best Environmental Practices</td>
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<tr>
<td>BTU</td>
<td>British Thermal Unit</td>
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<tr>
<td>CIDA</td>
<td>Canadian International Cooperation Agency</td>
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<tr>
<td>DAP</td>
<td>Di Ammonium phosphate</td>
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<tr>
<td>DCP</td>
<td>Di Calcium Phosphate</td>
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<tr>
<td>DOS</td>
<td>Department of Statistics</td>
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<tr>
<td>DWT</td>
<td>Dead Weight Tonnage</td>
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<tr>
<td>ECD</td>
<td>Ethylene Chlorine or 1,2-dichloroethane</td>
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<tr>
<td>EIA</td>
<td>Environmental Impact Assessment</td>
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<td>EMS</td>
<td>Environmental Management System</td>
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<tr>
<td>FSA</td>
<td>fluosilicic acid</td>
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<tr>
<td>FBC</td>
<td>Fluidised Bed Combustor</td>
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<tr>
<td>GEF</td>
<td>Global Environmental Facility</td>
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<tr>
<td>g</td>
<td>Gram</td>
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<tr>
<td>GDP</td>
<td>gross domestic product</td>
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<tr>
<td>GJ</td>
<td>Gigajoule (10⁹ Joules)</td>
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<tr>
<td>gmol</td>
<td>Gram mole</td>
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<tr>
<td>GRP</td>
<td>gross regional product</td>
</tr>
<tr>
<td>GTZ</td>
<td>German Technical Corporation</td>
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<tr>
<td>GWh</td>
<td>Giga Watt hour</td>
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<tr>
<td>HDI</td>
<td>Human Development Index</td>
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<tr>
<td>HFO</td>
<td>Heavy Fuel Oil</td>
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<td>HP</td>
<td>High Pressure</td>
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<tr>
<td>I-TEQ</td>
<td>International Toxic Equivalents</td>
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<td>IMO</td>
<td>International Maritime Organisation</td>
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<tr>
<td>JES</td>
<td>Jordan Environment Society</td>
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</table>
JISM  Jordanian Institution for Standards and Meteorology
JOD  Jordanian Dinar
JPMC  Jordan Phosphate Mines Company
JREDS  The Royal Marine Conservation Society of Jordan
JSSD  The Jordan Society for Sustainable Development
JUST  Jordan University of Science & Technology
Kcal  Kilo Calorie
KEMAPCO  Kemira Arab Potash Company
kg  kilogram (10^3 grams)
L  Litre
Lb  Pound
LP  Low Pressure
MSS  Marin Science Station
MSW  Municipal Solid Waste
Mt  Megaton (106 tonnes)
MW  Medical Waste
NA  Not Applicable
Ng  Nanogram (10^-9)
NGOs  Non Governmental Organizations
Nm^3  Normal cubic meter (Temp. = 0 °C, Pressure = 1 atmosphere)
OHS  Occupational Health and Safety
OHSAS  Occupational Health and Safety Advisory Services
PAP  Phosphoric Acid Plant
PCB  Polychlorinated Biphenyls
PCDD  Polychlorinated dibenzo-p-dioxins
PCDD/F  PCDD/F dibenzo-p-furans
PCDF  Polychlorinated dibenzo-p-furans
PCP  Pentachlorophenol
PERSGA  The Regional Organization for the Conservation of the
         Environment of the Red Sea and Gulf of Aden
POPs  Persistent Organic Pollutants
PPE  Personnel Protective Equipment
Ppm  Part Per Million
PPP  Purchasing Power Parity
PRA  Participation Rapid Appraisal
PVC  Polyvinyl Chloride
Rpm  Rotation per minute
RSCN  The Royal Society for the Conservation of Nature
RSS  Royal Scientific Society
RSTI  Red Sea Timber Industries
SAP  Sulfuric Acid Plant
Scf  standard cubic foot
SEA  Socio Economic Assessment
SG  Specific Gravity
SGP  Small Grants Program
TCDD  Tetrachlorodibenzo-p-dioxin
Toxicity Equivalency Factor (TEF)
Toxic Equivalent (TEQ)
Training of Trainers (ToT)
Total Suspended Particles (TSP)
Unintentional Production of Persistent Organic Pollutants (UP-POPs)
United Nations Development Programme (UNDP)
United Nations Environment Programme (UNEP)
United States Agency for International Development (USAID)
Vinyl Chloride Monomer (VCM)
Volatile Organic Compounds (VOCs)
Water Efficiency and Public Information for Action (WEPIA)
Wight

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**Background**
Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), commonly known as dioxins and furans are of non-natural origin and extremely persistent in the environment. Among 2,3,7,8-substituted toxic congeners, the 2,3,7,8-TCDD is the congener of highest toxicological significance.

They have been detected in sediment, air, water, animals and plants. These pollutants are primarily emitted to the atmosphere from combustion processes. The presence of a chlorine donor in combustion seems to be the major source of their release. High levels are emitted from incineration of municipal, clinical and industrial wastes as well as in chlorine production, metal smelters, paper and pulp industries, petroleum refining processes, vehicle emissions, accidental fires, and combustion of biomass and biogenic fuels (De Assuncao and Pesquero, 1999; Kouimtzis et al., 2002).

Based on the Annex C POPs inventory developed specifically for the coastal zone of Jordan; priority locations for BAT/BEP implementation have been identified. The main objective of BAT/BEP implementation would be to achieve meaningful release reductions of the Annex C POPs releases. A specific source has been selected; which is Jordan Phosphate mines Company (JPMC).

Collection and analysis of different technical information on selected enterprise for the study; JPMC is carried out in this report. The technologies of production at this enterprise, raw materials, data on contaminants releases, and products are considered also.

The project will assist the selected industry to implement BAT/BEP measures. Detailed assessments were undertaken at each location in order to scientifically prove the effectiveness of the BAT/BEP measures. The assessments considered the technologies and releases of Annex C POPs
from the source locations, the environment and human health impacts of the releases as well as the socio-economic implications prior to and after the BAT/BEP implementation were conducted.

**Overview**

Aqaba is a coastal city overlooking the Red Sea located in the south of Jordan. It is strategically important to Jordan as it is the country's only seaport and access to the sea. Aqaba was first announced as a district belonging to Ma'an governorate according to the administrative system organized in 1957, and then upgraded in 1994 to be a separate Governorate. Aqaba Governorate includes the Aqaba district (encompassing the Aqaba sub district and Wadi Araba sub district) and the Quairah district.

In 2001 Aqaba city was announced as a Special Economic Zone (ASEZ) with its own Authority (ASEZA). The ASEZ encompasses an area of 375 km². Its purpose was to incorporate the entire Jordanian coastline, Jordanian sea-ports, and the historical city of Aqaba as a duty-free, low tax- multi-sectored development zone. The ASEZ provides global investment opportunities within tourism, recreational services, professional services, multi-modal logistics, value-added industries, and light manufacturing sectors. The establishment of the ASEZ with its characteristics of low tax and regulations is regarded as a model of government-provided framework for private sector-led economic growth to be emulated throughout the Kingdom.

**Site Selection**
The selected location is located about 22 km south of the City of Aqaba in the Industrial Zone (Figure I). It is surrounded from three sides by other industrial facilities including chemical storage tank farms, fertilizer industries, LPG Companies, and others; the fourth side is the sea (Gulf of Aqaba). The nearest residential areas are the Tala bay tourists area (resorts and hotels), and the city of Aqaba respectively, Figure (II).
Figure (I): The Industrial Zone
Industrial zone is surrounded by mountains from the eastern side and by Gulf of Aqaba from the western side (Figure (III) and Figure (IV)).
Figure (III): Coastal Zone Topography
Figure (IV): The Contour Lines of the Coastal Zone
The emissions of dioxins and furans from major sources in Aqaba region were estimated within the framework of Phase I (Development of the Annex C Pop's Inventories of the Coastal Zone of Aqaba), forming the base for implementation of Phase II. The emissions from the sources were estimated from data on production and raw materials consumption multiplied with so-called emission factors for dioxins/furans formed per unit of end product produced or unit raw materials consumed.

The largest industrial sources of dioxins/furans identified in the region during Phase I were:
- JPMC
- RSTI
- Aqaba Thermal Power Plant (ATPP).
- Arab company for fertilizers and chemicals - Kemapco

The above enterprises are considered in this report as the objects where it is necessary to implement the activities that provide elimination or reduction of their adverse impact of the environment of the region.

In particular, ATPP and JPMC are the biggest air polluters in Aqaba region. JPMC was selected to be assessed and discussed during this phase since the ATPP consumption of fossil fuel cannot be reduced or altered.

**Scope of Work**

According to the GEF supported project entitled “Promotion of strategies to reduce unintentional production of POPs in the Red Sea and Gulf of Aden (PERSGA) coastal zone”, and base on the annex C POPs inventory developed specifically for the coastal zone of Aqaba, priority locations for BAT/BEP implementation had been identified.
A TOR was established to conduct full assessments of Technology, Environment and Health Related Research and Monitoring Assessment, and Socio-economic and Public Participation Assessment on the industrial sector represented by JPMC to promote implementation of BAT/BEP concept.

A team of experts was formed to conduct these assessments. The team consists of:

2. Eng. Issam Ahmad Al Falayleh – Senior Chemical Safety Officer.

The assessment was performed as follows:

1. Develop a process map of the assessments.
2. Design an appropriate action plan.
3. Identify and partner with JPMC.
4. Obtain appropriate permits from JPMC to make the assessments (signing an agreement with each facility)
5. Trained personal were interviewed during the field visits
6. Screening the data collected, documentation, and forming the draft report.

Then analysis and assessment of controlled parameters of processes that can initiate generation of dioxins was carried out. For JPMC the dioxins generation depends on such main factors, as the combustion conditions (i.e. fuel type, temperature, and oxygen), and pollution control system.

Data on assessment of technologies applied at the enterprise, selection of the most efficient technologies and development of recommendations to reduce the dioxin and furan releases at the JPMC are provided in the report. Also
the present report provides the technical and economic assessment of arrangements related to the reduction/elimination of dioxin/furan releases at the JPMC complex plant.
CHAPTER 1

APPLIED TECHNOLOGY

ASSESSMENT
1.1 Summary

It is clear that current dioxin and furan contamination poses a serious threat to public health and the environment, with future generations at the greatest risk if dioxin pollution continues. Because these compounds are so persistent in the environment and the human body, dioxins that have already accumulated will not disappear quickly.

Local authorities should initiate a comprehensive national up-pops elimination program, with the goal of reducing human exposure and preventing the formation and discharge of up-pops into the environment from all sources.

According to that, this assessment made to put the baseline in which we can determine the up-pops concentration, so any application of BAT/BEP concept on the industrial facilities that responsible for the formation of up-pops can be noticed.

For this purpose JPMC was selected to be assessed including its units and surroundings. It's found that JPMC can adopt good BEP program on the short term and BAT concept on the long term.

The capital costs of power generation are about 5,000-8,000 US$/kW. A 1,000 MW power plant would therefore cost about 5-8 billion US$. Such very high costs would make very unlikely that any modification of the plant would be made after it has been put into operation. A modification would be difficult to implement as the manufacturers rely on standardized models, the size and geometry of the boiler would determine the residence time, turbulence etc. BEP has to be implemented at users’ level that consists of boiler purchase (technical specifications), operation and maintenance
(efficiency). BAT/BEP implementation takes place at fuel supply and equipment design level. The fuel supply strategy is very important as a large power plant consumes millions of tons of fuel per year. The power plant design would be affected by state or local environmental regulations, air quality standards, emission limitations, etc. The air abatement system has DeNO₃ system, electrostatic precipitator and DeSO₅ system.

Once up-pops is produced, it is too late to prevent its discharge into the environment; pollution control devices, filters, treatment systems, and disposal methods such as burning and burying simply shift captured chemicals from one environmental medium to another or delay their release until a later date. Up-pops discharges can be eliminated only through primary prevention: industrial processes and feedstocks that result in dioxin formation must be changed so that no dioxin is formed. Because dioxin occurs throughout the field of chlorine chemistry, this goal appears to require the planned phase-out of chlorine and chlorinated organic feedstock's from industrial processes. So at this time JPMC can focus on BEP to reduce up-pops formation on boilers.

All dioxin sources are addressed at all known and suspected sources of dioxin in order to bring future releases of dioxin to zero. All identified dioxin sources must be subject to action. All of these sources were addressed along the costal zone during phase 1 of this project. During this assessment the following were addressed:

**Name of Company:** Jordan Phosphate Mines Co. LTD (JPMC- Aqaba Industrial complex).

**Address:** P.O.Box: 409 –Aqaba 77110 Jordan

**Telephone:** +962-3-2014151/59 Fax +962-3-2017008
Contact Details: Eng. Mohammad Alhajoj, Manager of safety and environmental department.


Production and Capacity:

a) Utilities: supply the factories with electricity, water, steam and pressured air.

b) Sulfuric acid plant: consist of two symmetric unit to produce 98.5% concentrated sulfuric acid with capacity of 2225 t/day/unit, steam resulting from sulfur burning used in electricity generation in the service unit by using 2 steam turbines with total capacity of 44 MW.

c) Phosphoric acid plant: from the reaction between phosphate and sulfuric acid, with a capacity of 1250 t/day.

d) Fertilizers plant: consist of 2 symmetric units to produce (DAP) with a capacity of 1200 t/unit /day by the reaction of phosphoric acid with imported ammonia

e) Aluminum fluoride plant: this plant was constructed to make use of floucelesic acid (incidental produced in the phosphoric plant) and that by reacting it with imported Aluminum hydroxide. The capacity of the plant is 15000 t/a

Waste production:

Sludge: 6 m$^3$/a
Dust from ($V_2O_5$): 12 t/a
Gypsum: 1.5 million t/a
Silica: 5000 – 6000 t/a
Metallic Oil: 10-12 t/a
Snag: 10 barrels/a
Waste Disposal & Collection:
Snag: this material is collected from service boilers in closed barrels and stored in special place.
Sludge: all waste water is used in phosphoric plant
V₂O₅: this material is used as catalyst in sulfuric acid plant, they sieves it every 2 year and quantity resulting from sieving is about 12 t/a, they collect it in closed barrels and saved in special place for this reason
Gypsum: the resulting quantity of gypsum in phosphoric acid plant is 5 t/a for each ton of producing acid (about 2 million t/a), this material is transferred by scraper and collected about 3 km away from the plant.
Silica (SiO₂): this material is incidental resultant from Aluminum Fluoride Plant, some of it used in phosphoric plant and the remaining quantity send to gypsum scraper.
Used metallic oil: collected in closed metal barrels and sold to petroleum refinery throw contractors.
Maintenance waste: (metallic material /wood/rubber/.....etc) collected in special place and sold as scrap.
Industrial water: all quantity of industrial water and resulting from all production units is reused in phosphoric acid plant in closed system

1.2 Background
The Complex is located at WADI 2, 15 km south of the port of Aqaba WADI 2 is further located as the second WADI North of the coastal border of Saudi Arabia.
Production started in 1982 to produce Sulfuric Acid (SA), Phosphoric Acid (PA), Diamonium Phosphate (DAP) and Aluminum Fluoride (AlF₃). The AIC – Figure 1.1 – is designed to be self-sufficient for electrical power and all other utilities with the exception of raw water and seawater for cooling and fuel oil.

![Figure (1.1): A top view of AIC](image)

It employs approximately 1000 persons. The plant runs 24 hours with three shifts (fourth shift is off). The main raw materials consumed are phosphate rock from AL-SHEDIA, ALHASA, and AL-ABIAD phosphate mines, sulfur, anhydrous ammonia, Aluminum hydroxide and small amount of sodium hydroxide.

AIC has been approved by Lloyd’s Register Quality Assurance OHSAS: 1999. The Occupational Health and Safety Management System is applicable to the activities including and associated with the production of Sulfuric Acid, Phosphoric Acid, Di-Ammonium Phosphate, and Aluminum Fluoride. Also AIC awarded ISO 9001 and the Export Department was awarded ISO 9002.

AIC obtained the ISO 14001:2004 that was approved by Lloyd’s Register
Quality Assurance. The Environmental Management System is applicable to the activities including and associated with the production of Sulfuric Acid, Phosphoric Acid, Di-Ammonium Phosphate, and Aluminum Fluoride. The main emissions associated with this type of complexes include mainly SO\textsubscript{x}, NO\textsubscript{x}, CO, CO\textsubscript{2} dust, F\textsuperscript{-}…ect. All these emissions are subjected to good monitoring program conducted by JPMC. No up-pops sampling or monitoring program adopted by the complex.

JPMC has the ability to apply BAT/BEP concept in a strong and good manner.

1.3 General Information on the Location

The Jordan Phosphate Mining Company was established in 1949 for the purpose of mining and exporting of phosphate rock via Aqaba main port. In 1982 the fertilizers complex was established and started operation. JPMC facilities in Aqaba contain three major components: Jordan chemical complex, industrial port and Phosphate company branch at the main port.

The complex includes five main units i.e. phosphoric acid unit, sulfuric acid unit, Aluminum fluoride unit, DAP unit and the utilities unit, with a man power of about 989 workers. Human figure of JPMC Industrial Complex according to their departments is shown in Table 1.1.

Table (1.1): Human Figure of JPMC Industrial Complex

<table>
<thead>
<tr>
<th>NO.</th>
<th>Department</th>
<th>NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Plant Manager Dept.</td>
<td>64</td>
</tr>
<tr>
<td>2.</td>
<td>Financial Dept.</td>
<td>26</td>
</tr>
<tr>
<td>3.</td>
<td>EHS Dept.</td>
<td>30</td>
</tr>
<tr>
<td>4.</td>
<td>Production Dept.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Production Manager Office</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>- Utilities</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>- SAP</td>
<td>28</td>
</tr>
</tbody>
</table>
The complex was designed to produce fertilizers and chemicals according to the following capacities:-

1. DAP  740,000 t/a  
2. Phosphoric Acid  415,000 t/a  
3. Aluminum Fluoride  20,000 t/a  
4. Sulfuric Acid  1,200,000 t/a  
5. Fluorosilisic Acid  25,000 t/a  

The main and side products production can be summarized as follows:

**Phosphoric Acid Production**

Phosphate rock is transported by trucks from the phosphate mining site at Al-Shidiya. It is stored in a main warehouse and transported to the process by a conveyer belt system. The phosphate rock is grounded and weighed. By acidulation with Sulfuric Acid, Phosphate rock is converted to Phosphoric Acid and Gypsum is a by product.

**Sulfuric Acid Production**

Elemental Sulfur is imported from different countries to Aqaba port and then transported from the port to the storage warehouse using a conveyer belt...
system.
Sulfur is melted by hot steam then filtered to remove the impurities. Melted Sulfur is then burned to Sulfur dioxide (SO₂). SO₂ is cooled down and transferred to SO₃ using Vanadium Pentoxide as a catalyst. SO₃ is then hydrolyzed to Sulfuric Acid.

**Aluminum Fluoride Production**
Aluminum Hydroxide is brought to the warehouse by trucks then transported to the process unit using bucker elevator and skew conveyers. Fluorosilisic acid is transported by pipes where Aluminum Hydroxide is dried using hot air produced by a diesel burner. Aluminum Hydroxide and Fluorosilisic acid are mixed and Silica is produced and later on being separated.

**Di-Ammonium Phosphate Production**
Ammonia is transported through the industrial port into the storage tanks via pipes. The process starts by mixing Phosphoric acid with anhydrous Ammonia to produce slurry. The slurry is then spread onto a bed of recycled solids in a rotating granulator and Ammonia is sparrred into the bed from underneath. Granules pass to a rotary dryer followed by a rotary cooler. It is solidified using a special heavy oil burner.

Wastewater treatment Unit: Domestic wastewater at the plant is treated biologically using an activated sludge treatment system. It consists mainly of an aeration tank and a sedimentation tank. The treated effluent is pumped to an evaporation lagoon.
All complex power needs are produced by the utility unit. Full description of this unit will discussed later in section (1.5.1)
1.4 Description of Applied Technology

1.4.1 General chemistry and technology used

Phosphate fertilizers are produced by adding acid to ground/pulverized phosphate rock. If sulfuric acid is used, then single or normal, phosphate (SSP) is produced having a phosphorous content of 16-21 percent as phosphorous pentoxide (P_2O_5). If phosphoric acid is used to acidulate the phosphate rock, then triple super phosphate (TSP) is the result. TSP has a phosphorous content of 43-48 percent as P_2O_5.

SSP production involves mixing the sulfuric acid and the rock in a reactor followed by discharging the reaction mixture onto a slow moving conveyor in a den. It is cured for 4 to 6 weeks before bagging and shipping.

Two processes are used to produce TSP fertilizers: run-of-pile and granular. The run-of-pile process is similar to the SSP process. Granular TSP uses lower strength phosphoric acid (40 percent compared to 50 percent for run-of-pile). The reaction mixture as slurry is sprayed on to recycled fertilizer fines in a granulator. Granules grow and are then discharged to a dryer, screened and sent to storage.

Phosphate fertilizer complexes often have sulfuric and phosphoric acid production facilities. Sulfuric acid is produced by burning molten sulfur in air to produce sulfur dioxide which is then catalytically converted to sulfur trioxide for absorption in oleum. Sulfur dioxide can also be produced by roasting pyrites ore. Phosphoric acid is manufactured by adding sulfuric acid to phosphate rock. The reaction mixture is filtered to remove phosphogypsum, which is discharged to settling ponds or waste heaps.

1.4.2 Manufacturing Processes
This section summarized the manufacturing processes for all units and its facilities. Detailed description is shown in section (1.5).

### 1.4.2.1 Sulfuric Acid Plant

The raw sulfur is imported from abroad according to market prices and to specification (chloride and acidity content). Since the last three years only refined sulfur is used.

The sulfur is melted, filtered and stored in the liquid sulfur tank at around 140ºC. It is burned with dried combustion air, which is dried through absorption with concentrated sulfuric acid in the drying tower. The SO$_2$ generated is into SO$_3$ in the four stage double absorption process.

Since 1996 ring shaped V$_2$O$_5$ catalyst is used. The process is exothermic and the released energy is used to produce high pressure steam, which is sent to the power generators in the utility section.

Sea water is used to cool the intermediate and the final absorption circuits as well as the final sulfuric acid (98.5%) before sending it to the two acid storage tanks.

### 1.4.2.2 Sulfur Storage Area in Mekresh

Solid sulfur, which cannot be stored in the plant storage area, is brought by trucks to Mekresh site about 10 km from the plant. It is weighed unloaded and stored on an open paved area surrounded by concrete walls from where it can be reclaimed by bulldozers and returned to the plant if needed.

**Consumption of Raw Materials in SAP:**

<table>
<thead>
<tr>
<th>Material</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfur</td>
<td>6500 t/day</td>
</tr>
</tbody>
</table>
1.4.2.3 Phosphoric Acid plant

After weighing, the trucks are unloaded by hydraulic back-loaders in a semi closed area. The rock is freed from big particles on a screen and let into the underground pit from where it is transported to the big storage silos by means of a conveyor system. A de-dusting unit is installed to remove generated dust locally at the screens.

Phosphate rock delivered from the silos by a conveyor belt system is grinded in a ball mill. Dust and product from the ball mill is led through the hydrocyclones and de-dusting unit. The milled phosphate of the desired size is stored in silos.

The phosphate rock reacts in the two reactors with sulfuric acid to produce phosphoric acid, gypsum and fluorine gases. The slurry passes the filtration system, where gypsum is separated and conveyed to the disposal site. The filtrate is concentrated in the concentration lines to produce the desired 54% H₃PO₃, which is sent to the DAP plant or sold after clarification if necessary. Fluorine gases released during the reaction and digestion are absorbed by water in the primary and secondary scrubbing towers. Absorbing water is returned to the reactor.

The HF gases escaping from the concentration lines are also absorbed by water to produce fluosilicic acid, which is used as raw material in the aluminum fluoride plant.

The three storage tanks for diluted phosphoric acid are bounded with concrete walls and acid resistant floors with channels directing any acid to
an underground pump sump, from where it can be pumped to any of the three tanks. Seven tanks are installed for the concentrated phosphoric acid.

Consumption of Raw Materials in PAP:

<table>
<thead>
<tr>
<th>Material</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphate rock</td>
<td>185 t/hr</td>
</tr>
<tr>
<td>Sulfuric acid (98.5%)</td>
<td>92 m³/hr</td>
</tr>
<tr>
<td>Water</td>
<td>200-350 m³/hr</td>
</tr>
</tbody>
</table>

1.4.2.4 Gypsum Disposal, Industrial Waste and Hazardous Waste Storage Site

The produced gypsum from the phosphoric acid plant is transported to the site by means of a conveyor belt system (approximately 2 km). It is then handled and distributed by moveable conveyor belt and by bulldozers. On the same site industrial waste (like empty barrels, filter cake from sulfur melting unit, sludge from the evaporation ponds and silica from the aluminum fluoride plant) is dumped. A special area is designated to store the metal barrels containing the hazardous wastes from the plant (spent V₂O₅ catalyst dust and soot).

1.4.2.5 Di-Ammonium Phosphate (DAP) plant

DAP is produced by neutralizing phosphoric acid with ammonia in the reactor and by subsequent granulation of the addition of the slurry and the addition of filler (sand). The granules are dried by combustion air then cooled, screened and polished before sending the storage. Over-sized
material from the screen are milled and sent together with the undersized material as well as with the dust recovered back to the granulator as seeding material.

The gaseous emissions from the reactor and granulator are absorbed in the venturi and then in the cyclonic scrubbers before they are sent to the tail gas scrubber. The dust from the drier, the screens and the product cooler is recovered by cyclones. The remaining air of the cyclones is then also treated in the scrubbing system. The overflow of the scrubbing liquid is sent to the reactor.

The company has two identical units for producing DAP; each has a capacity of 1200 t/day.

Ammonia is imported from abroad by ships and stored as liquid in two insulated single wall tanks (30000 m³ and 10000 m³). Two ammonia compressors liquefy evaporated gases to maintain the ammonia temperature at 33°C and pressure at a maximum of 125 mbar.

Consumption of Raw Materials DAP:

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphoric acid (49%)</td>
<td>2200 t/day</td>
</tr>
<tr>
<td>Anhydrous Ammonia (99.5%)</td>
<td>1000 t/day</td>
</tr>
</tbody>
</table>

### 1.4.2.6 Aluminum Fluoride Plant

Aluminum fluoride is produced from fluosilicic acid coming as waste product from the phosphoric acid plant and Aluminum hydroxide, which is imported from abroad. The unit includes the follow steps: Al(OH)₃ handling and drying, fluosilicic acid (H₂SiF₆) heating, reaction, silica filtration, AlF₃ crystallization, filtration, drying, calcination, and bagging.
Environmental features were installed in most important areas to minimize dust emissions and recycle product (like cyclone and bag filters, and scrubbers).

Heat recovery is partially applied to re-use part of the flue gases from the calciners for flash-driers of wet Al(OH)₃ and AlF₃.

Consumption of Raw Materials Aluminum Fluoride plant:

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum Hydroxide</td>
<td>24000 t/a</td>
</tr>
<tr>
<td>Fluorosilisic Acid</td>
<td>22 t/a</td>
</tr>
</tbody>
</table>

1.4.2.7 Utilities

The overall water consumption consists of about 60% from Disi and 40% from reclaimed treated water from the Aqaba wastewater treatment plant. Significant savings in water resources are achieved.

The water treatment section aims at treating the fresh water from Disi aquifer to produce boiler feed water, industrial water, fire fighting, cooling water and domestic water. The fresh water is clarified, then filtered through sand filters and sent to the water storage tank. From where, it is pumped throughout the plant to the different areas.

The boiler feed water is further treated in the demineralization unit mixed with the condensate returns from the different plants then cooled, polished, preheated and sent to the boilers.

The water is filtered through activated carbon before using for domestic purposes. The reclaimed water is only used for industrial purposes in the phosphoric acid, DAP and AFP.

Domestic wastewater is treated and collected with all other wastewater into
the evaporation pond from where it is reused in the phosphoric acid plant. The company, therefore, does not discharge wastewater outside its boundary. In addition to the sulfuric acid boilers, two auxiliary fuel oil boilers produce high pressure steam of about 45 bars 405°C, which is expanded over two steam turbo generators to produce electric energy of about 22 MW each. The resulting low pressure steam is used all over the plant for different purposes. The company was switched from fuel oil and diesel to natural gas by the end of 2008. The fuel oil is delivered by tank cars from Jordan Petroleum Refinery Company. It is pumped to a 17450 m³ storage tank. A foam fire fighting system and a non sealed retention basin are installed for emergency reasons.

Compressed air of 6.5 to 7 bars is produced by 5 compressors (2 of them are stand-by). About 70% of the air is dried and used as instrument air; the rest is distributed as service air. According to utility plant engineer, an emergency air grid (or buffer volume) is necessary, since the plant is connected to the public electricity net, which would guarantee the operation of the compressed air in case of locally generated power failures. In addition to that, the instruments would fall into "fail-safe position", if air pressure would become too low.

Sea water is sucked through the intake channel, chlorinated and pumped to the utility condensers (steam turbines) and to the sulfuric acid coolers. It is returned through two break pits for reducing the temperature and temperature difference between sea water inlet and outlet of maximum 3°C. A respective monthly record conducted by Marine Science was reviewed during the assessment.

Water and fuel Consumption Rate:
Phosphoric acid unit 200-350 m³/hr
Sulfuric acid unit 15-20 m³/hr
Aluminum fluoride unit 20-30 m³/hr
DAP unit 15-20 m³/hr
Steam generation unit 50 m³/hr
Household uses 20-25 m³/hr
Make-up water 15 m³/hr
Fuel Oil 2040 t/month
Diesel 10 t/day

Safety warning and instruction signs are posted all over the plant. Also the company assures to train all staff (annually in-house training) and distribute the necessary occupational health and safety (OHS) equipments. Eye wash showers and showers are distributed throughout the company areas where needed.

The fire fighting water system is inspected and tested weekly according to a checklist. This is to guarantee the overall availability of the system during emergency cases.

1.5 Detailed Technology Description
1.5.1 Utility Plant

The utilities plant is designed to provide the production unites with their requirements of power, steam, and sea cooling water, fresh cooling water, instrument air and industrial water.

A total of 3.5 millions cubic meters (annual consumption) of water is brought from Al–Disi reservoir 120 km far from the complex.
1.5.1.1 Raw Water Treatment
The raw water treatment system receives QA DISI pipeline water. Water is filtered through three sand filters (one spare). The filter backwash water is returned to the decanter.
The above treatment produces industrial water. This water is sent to a storage tank by three electric driven pumps (one spare). From the storage tank, industrial water is distributed by two electric driven pumps (one spare) to the individual plants battery limit and to the drinking water and demineralization treatment facilities.

1.5.1.2 Dematerialized Water
Dematerialized Water is produced by passing water through ion exchange beds.
The Dematerialization plant consists of four parallel ion exchange trains; each is composed of a cation exchanger to be regenerated by sulfuric acid, and of an anion exchanger to be regenerated by caustic soda solution. After treatment, dematerialized water is sent to the two condensate storage tanks as make up feed to the sulfuric waste heat boilers and utilities auxiliary boiler systems.

1.5.1.3 Drinking Water
Drinking Water is produced from industrial water by hypochlorite injection and filtration over active carbon.
After treatment, drinking water is stored in a tank and distributed by three electric motor driven pumps (one spare) to the different consumers in the complex.
1.5.1.4 Fresh Cooling Water

The Fresh Cooling Water system is designed to remove heat from the following equipment:

- Turbo alternator air coolers.
- Turbo alternator oil coolers.
- Air compressor air coolers.
- Sulfuric acid plant lowers.
- Ammonia refrigeration condensers.

The system includes a three section cooling tower cells; each cell is provided with a fan, and an electric motor driven pump (two cells are running in parallel, one spare).

Industrial water is used for cooling tower feed water make up and the circulating systems injected with corrosion /scale inhibitors and algae side treatment.

1.5.1.5 Sea Water Cooling

Sea water is pumped and chlorinated in the pumped station and to be used for cooling in the following equipment:

- Turbo generator condensers.
- Auxiliary steam condenser.
- Sulfuric acid coolers.

These items of equipment are designed so that the temperature between the seawater intake and outfall does not exceed 10°C.

The sea water system is a once through system with outfall back to the ocean.
1.5.1.6 Fire Fighting System

The fire protection system includes the following:

- Two pumps, electric driven and one diesel driven, taking suction from the industrial water storage tank and supply water to looped fire water system.
- One "jockey" pump to maintain the fire piping network under pressure. The jockey pump is electric driven.

An automatic starting device for the electric drive pump that operates on pressure loss in the fire fighting system network and an automatic starting system for the diesel pump will be remote started from the control room.

A buried firewater distribution network, including indoor fire fighting equipment (cocks and fittings, hoses, hydrants etc…..)

1.5.1.7 Instrument and Plant Air

Air is compressed in four electric driven compressors (one spare) Compressors are utilized provide instrument and plant air requirements. One is normally running. One compressor will be connected to the emergency electrical power system. Compressors discharge to a common unit air receiver.

A portion of the wet air is dried to a dew point of 40°C (calculated at atmospheric pressure) in dual automatic air dryers. The dried air is then distributed through the plant.

Alarm and safety control is provided as follows:

- Low air pressure alarm.
- Automatic shut – off value on plant air when air pressure is low.
- Low instrument air pressure alarm.
1.5.1.8 Fuel Oil Storage

The plant is provided with one heated storage tank for fuel oil. Storage capacity is 15000 t. Storage tank is equipped with heated coils supplied with LP steam. One retaining pit (about 16000 m³ capacity), is provided for the storage tank. Fuel oil is received via ships and transfer facilities from the dock. Fuel oil is also received by truck and unloaded by pumps. Fuel oil is pumped, filtered, preheated with steam and then distributed through a common header to different day storage tanks (i.e. power plant and granulation plant). All fuel oil transfer lines are steam traced and insulated. Fuel oil is pumped by an electric driven pump (with one 100% preheated stand by) from the unit day tanks to the point of use with provisions for constant circulation back to the day tank.

1.5.1.9 Diesel Oil Storage

Diesel oil received by truck and unloaded by pump. Diesel oil in two storage tanks, respectively located in the power plant, sulfuric acid plant. Power plant and storage are provided with two electric driven distribution pumps (one 100% stand by). Sulfuric acid plant storage is provided with one electric driven distribution pump.

1.5.1.10 Storage Capacities

- Power plant 100 m³
- Sulfuric acid plant 400 m³
1.5.1.11 Power Plant

The power plant is designed to produce and supply:
- High pressure steam (HP).
- Low pressure steam (LP).
- Normal electric power.
- Emergency electric power.
- Boiler feed water and desuperheating water.

1.5.1.11.1 HP Steam

Supplemental HP steam is produced by two auxiliary boilers working in parallel with the two waste heat boilers of the sulfuric acid plant. Both auxiliary boilers are of the superheating, water tube, package type with natural circulation and forced draft pressurized fireboxes. Start up is by the use of fuel and auxiliary burners. Flame control type by U.V. scanners is provided. In duplicate, economizers preheat the feed water.

1.5.1.11.2 LP Steam

LP steam necessary to operate the complex is normally obtained by extraction from the turbines of the turbo generator sets and the sulfuric acid plant air turbo blowers. LP steam is also expanded and desuperheated from HP steam if required.

1.5.1.11.3 Normal Electrical Power
Total electrical power is needed by the complex is generated by two extraction and condensation type turbo generator sets. Extraction allows a normal LP steam feed to the complex while the condensing load is adjusted to meet the electrical power demand. Each turbo generator set is designed for a normal capacity of 22 MW at a voltage of 6600V and 50Hz. The turbine drives are designed to receive steam at 44 bars, to extract a portion at 4.5 bars and to exhaust the remainder to surface condensers at 90 mbar at normal operating conditions. Parallel shaft type gear reducers connect the turbines to the generators. The extracted steam is distributed to the complex along with LP steam produced by the sulfuric acid plant. In addition to the exhaust condensers, valuable condensate is sent to the condensate storage tanks by two electric motor driven pumps.

1.5.1.11.4 Emergency Electrical Power
Emergency and start-up electrical power is generated by one diesel driven generator set. The emergency generator unit is designed for 2.5 MVA at 6600V and 50Hz with a 15 second starting time and a 50 second minimum to full load cycle time. This diesel drive is air started (gasoline engine driven compressor) with sufficient capacity for several successive starts.

1.5.1.11.5 Boiler Feed Water and Desuperheating Water
Boiler Feed Water is obtained from a mixture of condensate and demineralized water which is treated, deaerated, and distributed at high pressure to the two sulfuric unit boilers and to the auxiliary boilers.
Condensate from the various plants plus the required amount of deminerlizer water make-up is stored in two tanks. Water is pumped from the tanks by two electric motor driven pumps (one stand-by) through a four-train, mixed bed, polishing type dematerializer system using sulfuric acid and caustic soda for regeneration. Sulfuric acid and caustic soda for regeneration are obtained from a common utility storage and preparation system. The deaerator is sized for the full capacity of all boilers feed water streams.

Five boiler feed water pumps are arranged to take suction from the deaerator tank. One electric driven pump normally feeds both sulfuric acid plant waste heat boilers. A turbine driven pump fully spares this service. Separate electric driven pumps (three) are arranged to normally feed the auxiliary boilers and desuperheating water system.

### 1.6 Sulfuric Acid Plant

The sulfuric acid plant is designed to produce 1800 t/day of the sulfuric acid from each of two units (total 3600 t/day) from solid/or molten sulfur, air and industrial water.

Sulfuric acid plant is involved in a revamping project to increase production capacities to 2250 t/day of the sulfuric acid from each of two units. It produces sulfuric acid (H$_2$SO$_4$) from sulfur and water. Sulfur is imported from abroad.

The sulfur is first melted in a special melter, and then filtered. The filtered sulfur is then burned at 1010°C to produce sulfur dioxide (SO$_2$).

\[(S + O_2 \rightarrow SO_2)\]
(SO₂) is then converted in a special converter to sulfur trioxide (SO₃), in the presence of vanadium pentoxide (V₂O₅).

\[
(\text{SO}_2 + \frac{1}{2} \text{O}_2 \xrightarrow{\text{V}_2\text{O}_5} \text{SO}_3)
\]

(SO₃) is then allowed to come in contact with water to produce (H₂SO₄):

\[
(\text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4)
\]

Main Product: Sulfuric Acid (98.5%).
Product Capacity: 4500 metric t/day.

Sulfuric acid plant includes the following sections:

1.6.1 Sulfur Storage

Dry solid sulfur is received from marine bulk carriers and unloaded at the dock.

A conveyor transports the dry sulfur to a 35000 ton storage building. A manually operated belt tripper system distributes the incoming sulfur in the building. Sulfur is reclaimed from the stockpile by front and loaders (supplied by JFI). The front end loaders charge the sulfur into a reclaiming hopper. Two hoppers are provided to reduce the travel of the front end loaders. The sulfur is extracted from the hoppers by constant speed extractor.
belt conveyors. The extraction rate can be manually adjusted by a gate located at the outlet of the hoppers.
The belt extractors conveyor discharge to a belt conveyor which conveys the product to a sulfur melting system.
A dosing feeder is provided to meter calcium carbonate onto the melter feeder belt for neutralization of the sulfur.

1.6.2 Solid Sulfur Melting and Filtration
The melting and filtration section is designed to the filtered sulfur necessary to the production of sulfuric acid.
Sulfur may be received either in the solid or molten state. If infiltrated molten sulfur is received, it is transferred directly from dock by pipes to the tow molten sulfur storage tanks through boosting pumps. These tanks feed by gravity the filtration pit. The molten sulfur system and tanks are steam heated and insulated.
Solid sulfur is reclaimed from storage by a solid sulfur belt conveyor equipped with a lime injection for acidity neutralization. Sulfur is liquefied in a melter equipped with an agitator and steam heated. The molten sulfur overflows in filtration pit. Agitated and steam heated.
Vertical pumps feed the two sulfur filters. The filters are steam heated and insulated.
Filtered sulfur is sent and stored in a small sump (the molten sulfur pit) which feeds directly the sulfuric acid section. The filtered sulfur can be sent from filters to the molten sulfur storage tanks.
The pre-coat system, including a pre-coat pit with agitator and steam heated pumps applies diatomaceous earth filter to aid the sulfur filtration. The filtration cake is sent to the gypsum disposal by trucks.

**1.6.3 Sulfuric Acid Section**

The sulfuric acid unit includes two sulfuric acid production trains. The plants are of the contact type with step (double absorption) towers. Each train is described as follows:

**1.6.3.1 Air Driving**

Combustion air is drawn through a filter by a steam turbine driven blower. The blower then feeds the air to the drying tower, where it is then dried by contact with a circulated steam of 98.5% sulfuric acid in a packed, brick lined tower. The acid is pumped from the drying and inter-absorbing acid tank and cooled in the drying and inter absorbing coolers, before entering the tower. In the drying tower the acid absorbs virtually all moisture from the air along with some eat of dilution before returning to the circulation tank. A mist eliminator in installed at the top of the drying tower to reduce the carryover of acid droplets into the combustion chamber.

**1.6.3.2 Sulfur Combustion**

Filtered, molten sulfur is pumped from the molten sulfur pit to the combustion chamber to join the dry combustion air. In the combustion
chamber, high-pressure spray nozzles to facilitate rapid and complete burning with the dried air atomize sulfur. The combustion is carried out with approximately 100% excess air, to form a hot mixture or SO₂ and N₂ with heat of formation.

The hot gas steam leaving the combustion chamber is cooled in a caste heat boiler. In order to obtain accurate temperature controlled portion of the hot gas bypasses the waste heat boiler. The boiler is a fire tube type and generates steam at approximately 45 Kg/cm².g.

1.6.3.3 Conversion

The cooled gases from the waste heat boiler flow to the converter. The converter uses vanadium oxide catalyst in four separate beds to affect the conversion of SO₂ to SO₃. The conversion is an exothermic equilibrium reaction. SO₃ is absorbed from the gas twice by sulfuric acid; once after the third catalyst bed, and finally after the fourth bed (two stage absorption).

Partly converted gas leaving the first catalyst bed is cooled by exchange if heat to steam in a steam superheated.

The degree of exchange is controlled by a bypass. The cooled gas enters the second catalyst bed for additional SO₂ conversion.

Gas leaving the second catalyst is again cooled in the hot gas heat exchanger before passing to the third bed. After the third bed, the gas is cooled substantially by exchange in the intermediate gas heat exchanger, in the cold gas heat exchanger and finally in the inter-passing economizer before passing to the inter absorption tower where the first absorption of SO₃ takes place.

The acid system of this tower is the same that the drying tower acid system. Gas exiting the inter absorption tower through a B.M.E. is virtually free of
SO$_3$ bur still contains some SO$_2$ and is ready for final conversion in the fourth catalyst bed. The gas is first re-heated in the cold, intermediate and hot gas heat exchangers mentioned above before entering in the fourth bed. Gas exiting the fourth bed is cooled by the final economizer before entering the final absorption tower, for a complete absorption of the remaining SO$_3$. After the final absorption, the gas is discharged to atmosphere through a mist eliminator and a stock: with a double absorption process, the SO$_2$ and SO$_3$ content are very low.

The acid is pumped from the final absorption tank and is cooled in the final absorbing acid cooler before entering in the tower.

### 1.6.3.4 Acid Production

The absorption towers are quite similar, in that, that are acid-brick lined carbon steel packed with Intalox ceramic saddles. In the top of each tower is a mist eliminator which reduces carry-over of acid particles to acceptable levels.

Acid at a concentration of 98.5% is pumped from ground level circulation tanks, through coolers, to the absorption towers. The acid, after absorbing SO$_3$ returns to the circulation tanks. A single common tank serves both the drying and inter absorption tower. A separate tank serves the final absorption tower. The acid strength are controlled and adjusted by process water injection into the two acid tanks and/or by interconnection between the two tanks. All the acid coolers are sea water cooler: the acid temperature is only adjusted by passing the acid flow. The sea water flow remains even the same.

### 1.6.3.5 Acid Storage
Produced acid is obtained from the drying and inter absorbing system. It is sent through a product cooler and cooled to final temperature suitable for storage. The 98.5% sulfuric acid is stored in carbon steel tanks. Figure 1.2 shows the flow diagram of SAP. The remaining flow diagrams of the other plants are in Annex 1.
1.7 Phosphoric Acid Plant

The phosphoric acid plant is designed to produce P$_2$O$_5$ (phosphoric anhydride) as unconcentrated phosphoric acid:

- 54% (P$_2$O$_5$) unclarified phosphoric acid for captive fertilizer production.
- 54% (P$_2$O$_5$) clarified phosphoric acid for export (200 t/day P$_2$O$_5$).

The plant is designed to produce 1350 t/day P$_2$O$_5$ according to the phosphate rock quality.

The phosphoric acid plant produces the following by-products:

- 25% hexa fluosilicic acid (H$_2$SiF$_6$).
- Gypsum, 25-30% free water.

It produces phosphoric acid (H$_3$PO$_4$) from phosphate rock and sulfuric acid. The rock is brought from JPMC mines 200Km far.

The process starts by treating the phosphate rock with sulfuric acid in a reactor. As a result of this reaction gypsum slurry (gypsum acid 30% phosphoric acid mixture) is produced and hydrofluoric acid is liberated:

$$3Ca_3(PO_4)_2CaF_2+10H_2SO_4+20H_2O \rightarrow 6H_3PO_4+10CaSO_4.2H_2O+2HF$$

The mixture passes into a filter where gypsum (CaSO$_4$.2H$_2$O) is separated and conveyed to a belt for disposal, and the 30% phosphoric acid (H$_2$PO$_4$) flows into storage tanks. The 30% acid is concentrated to 54% in concentration units by evaporation using steam heaters.

During this concentration process HF reacts with silica (which is present in the rock in sufficient amounts) producing fluosilicic acid (H$_2$SiF$_6$) in 22% concentration and water vapor:
$6HF + SiO_2 \rightarrow H_2SiF_6 + 2H_2O$

Water vapor is condensed and then cooled in cooling towers. Both the phosphoric acid 54% and fluosilicic acid are stored in rubber lined tanks.

Main Product: Phosphoric Acid

Product Capacity: 1310 metric tons P$_2$O$_5$/day

Product Capacity: 2400 metric tons/day

The plant is divided into four main sections:

1- Grinding section
2- Attack and filtration section
3- Concentration section
4- Cooling and storage section.

The grinding section is where the phosphate rock is ground and prepared to be suitable for attack in the reaction section, after grinding phosphate.

It should have fineness:

- $98\% < 315$ um
- $75\% < 80$ um
- $H_2O\%$ by wt $\leq 1\%$

The grinding of phosphate is important to ensure having a good, complete reaction, and wilding phosphate losses due to incomplete reaction which will directly effect on the product specification.

In attack and filtration section the reaction produces 28% P$_2$O$_5$ acid, the gypsum crystals are formed here, so filtration should be done to separate the 28% acid from the solids, in order to get good crystals that will not cause bad filtration, digesting tanks are used to increase the retention time of
crystals formation. The gypsum is conveyed after filtration to be disposed out of the plant.

After 28% $P_2O_5$ acid production and storage, it is sent to the concentration liner to be concentrated up to 50-54% $P_2O_5$. Fluoslisc acid (H$_2$SiF$_6$) 20% fluorine content is produced here as a by-product, it is consumed by the AIF$_3$ plant, while the 54% acid is stored and consumed by the granulation plant.

1.7.1 Phosphate Rock Grinding

A rock grinding system is provided in order to reduce the merchant grade rock or low grade rock to a partial size suitable for acidulation in the manufacture of phosphoric acid.

The phosphate rock is fed from rock storage into a hopper by an automatic conveying system: low or high level controller starts or stops the rock reclaiming system.

The phosphate rock is brought from four mines mentioned later by truck unloading section on a shuttle conveyor belt passing through a grid to avoid passing any foreign materials (woods, metals, stones,..),the shuttle belt could move in two directions allowing discharging the rock, at the bottom of each silo, five gates are located on the line allowing discharging the phosphate over a conveyor belt Q6110,each gate feeds a belt feeder and a slide gate valve is used to open and close the gate, the conveyor belt Q6110 is 400 t/hr capacity and a counter weight is installed on this belt. The silos are supplied with a switch to know that he supplied silo is full. The Q6110 feeds another conveyor belt 6108 which is 400 t/hr capacity and 173 m length.

A balance W1.6101 is used to counter the amount of phosphate passing over the belt and fed to the mill hopper, magenta element is located at the inlet of mill hopper to catch any iron pieces which will cause choking of hopper
outlet or damage of the chain feeder Q16201. The mill hopper is 200 m³ capacity and supplied with switches LASH & LAL to increase or decrease the speed of phosphate passing. Two slide gates are located at the bottom of the hopper to pass phosphate to the mill chain feeder which is driven by a variable speed motor, the operating speed (40-65 rpm) gives us the amount of phosphate fed to the mill in t/hr, that is by multiplying chain feeder speed by 3, then the mill load is dependent on the chain feeder speed.

The mill chain feeder feeds the ball mill, the mill is a cylindrical horizontal shape, and it is used for grinding the phosphate depending on the 225 ton balls (forget steel) which are 30 mm and 40 mm sizes and on the rotation speed of the mill cylinder length is 8.84 m. The mill shell is made of carbon steel lined with a liners made of manganese steel, molded (12-14% Mn, 1% Cr), the liners weight is 57.6 tons while the body and liners weight is 96.6 tons.

The mill is driven by a high voltage motor of 4100 KW power and a rotation speed of 995 rpm. A speed reducer used to reduce the speed of the motor to be 94.64 rpm, the reduction ratio is 10.514, the clutch is connected to the low speed side and rotates at 94.64 rpm speed, the clutch consists of four disks, two of them are fixed with the low speed shaft of reducer while the other two disks are connected with the pinion shaft, air of 5-6 bar pressure is used for clutching by pushing the motor side disks then by friction the translation of motion from the rotating disks to the stationary disks occurs, pinion stars rotating which will rotate the mill by the gear wheal, the mill rotation speed will be 12.94 rpm with the reduction ratio from pinion to gear wheal of 7.31.

The mill rotating speed is the best for grinding where the balls are carried over with the rotating body of mill and fall down causing grinding of the
phosphate. The mill has a critical rotating speed which is about 14.8rpm where the balls rotate with the mill without causing no phosphate grinding. Two doors are located on the mill shell to e used for inspection purposes, a gate located at the phosphate inlet duct to mill is used for balls addition, a screen is located at the mill outlet is used to avoid ball escaping, some of balls which have small sizes due to erosion will pass out and fall down to the discharge duct of exhaust fan, a gate there is used to discharge duct of these balls when plant stops.

The ground phosphate is sucked by two reasons, the first one is the sweeping air exists due to vacuum, then the second reason is the pressure difference, to mill outlet, occurs due to dust and air circulation done by the exhaust fan which is 320000 m³/hr capacity and driven by a motor of 850 KW power and rotates at a speed of 1000 rpm, the circulated media passed to the classifier to classify and separate the phosphate big size particles from the fine phosphate, the big size particles are sent back to the mill inlet, but the classifier is out of operation at the time.

The media (dust and air) will continue to the cyclones, there are light cyclones of 40000 m³/hr capacity which is equal to 23.75 t/hr of rock phosphate, they are 2m diameter and 9m height, the big size particles fall down to the ground phosphate silo which is 1320 m³ capacity passing through a rubber flap valve. The fines continues from the cyclones to the exhaust fan to be sent again a part to the bags filter the excess to the ball mill outlet, the part sent to the bags filter is sucked by the vent fan which is 65000 m³/hr driven by 75 KW motor, the filter consists of 270 bags, each bag is 0.16m diameter and 3.375 m length, the filtrate area is 459 m², electrical heater is used to heat the internal ambient inside the filter to avoid accumulation of phosphate over the bags, air pulsing system is used to
drop the collected phosphate over a screw to be pushed to the ground phosphate silo through a rubber flap valve.

The silo is supplied with air slides and two fans for 5 sliding the phosphate; also the bottom of the silo is sloped to the discharge side to make discharging of phosphate easier.

1.7.2 Attack and Filtration

The reaction and filtration system mainly consists of an old reactor R6301 which is 17.1 m diameter and 6.7 m height, new reactor R2.6301 which is 18.7×7.2×9.3 m dimensions, three digesters of 6.4m diameter and 9.67m height each and the UCEGO filter which is 250 m².

The old reactor R6301 is 17.1 m diameter and 6.7 m height, it's supplied with agitator M6301 driven by a motor of 900 KW power to keep the slurry homogeneous. The reactor shell is made of concrete with rubber and anti acid brick lining, five sulfuric acid mixers M6306 A,C,D,E&F are installed at the top of the reactor, also nine surface coolers M6302 A to I and used for decreasing the slurry temperature. The top cover of the reactor is provided with opening for external air admission to sweep the air over the slurry surface for cooling purposes.

The new reactor R2.6301 is made of concrete with rubber and anti acid brick lining, it consists of two compartments A and B, each compartment is supplied with a mixer M2.6301 A/B to keep the slurry homogeneous and to ensure getting good mixing of reactants. An adjustable air duct X2.6309 is provided for external air admission. The old and new reactor are connected together via two channels X2.6305 A/B, the slurry over flows from new reactor to old reactor through these two channels which also allows passing of acid vapors and gases from the new reactor to the old one. The pump
P2.6302 ensures the gypsum slurry circulation between new and old reactor through the flash cooler E2.6301 which cools the sucked slurry by 2.5°C. The slurry is sucked from the old reactor to the flash cooler system. The two compartments A and B of new reactor are connected by rectangular lateral opening, one below liquid level for liquid flow while the other is above liquid level for gas flow. The slurry over flow through a funnel to the self regulating pump P6301 which then send it to the digesting tank A. Digestion tanks R6302A/B/C are three equal volume agitated, vertical and cylindrical shape tanks of 6.4 m diameter and 9.67 m height for each, they are made of carbon steel with carbon bricks lining, they are connected with each other by an over flow line, above the third digester R6302c, a vertical immersed pump P2.6301 sends the slurry to the filter.

1.7.3 Reaction System
The ground phosphate is being fed to the old and new reactors by means of reactors chain feeder Q6302 and Q2.6302 consequently, the sulfuric acid is fed to the reaction system directly by the 98.5% acid pumps P5501 A/B, it is fed to the old reactor through sulfuric acid splitters and to the compartment A and B of the new reactor to be mixed before entering to the reactor with the recycle acid, the wet process phosphoric acid may be represented by the following equation:

\[
\text{Ca}_{10}\text{F}_2(\text{PO}_4)_6 + 10\text{H}_2\text{SO}_4 + 10.n\text{H}_2\text{O} \rightarrow 40\text{CaSO}_4.n\text{H}_2\text{O} + 6\text{H}_3\text{PO}_4 + 2\text{HF}
\]
Where \( n = 0, 0.5 \text{ or } 2 \)

The above equation is the net of the following two reactions:

\[
\text{Ca}_{10}\text{F}_2\text{(PO}_4\text{)}_6 + 12\text{H}_3\text{PO}_4 \rightarrow \longrightarrow 9\text{Ca(H}_2\text{PO}_4\text{)}_2 + \text{CaF}_2
\]

\[
9\text{Ca(H}_2\text{PO}_4\text{)} + \text{CaF}_2 + 10\text{H}_2\text{SO}_4 + 20\text{H}_2\text{O} \rightarrow \longrightarrow 10\text{CaSO}_4.2\text{H}_2\text{O} + 18\text{H}_3\text{PO}_4 + 2\text{HF}
\]

The main purpose of phosphoric acid production is to change the \( \text{P}_2\text{O}_5 \) exists in the rock phosphate from water insoluble to water soluble. The HF formed by the reaction reacts with silica and other impurities (Na, Mg, K, and Al) to form fluosilicates and other more complex compounds. A variable amount of the fluorine is volatized as SiF\(_4\); HF of both, the heat of reaction is 230 Kcal/gmol of appetite which equals 2287Kcal/Kg of appetite or 505Kcal/Kg of \( \text{P}_2\text{O}_5 \).

The process of production of phosphoric acid is different according to the gypsum crystal produced, in the above reaction, if \( n = 0 \) then it is anhydrate process, if \( n = 1/2 \) then it is semi hydrate process and if \( n = 2 \) then its dehydrate one which the plant is operating at the conditions of operation of An, hemi, or dehydrate process are not the same.

The reaction between phosphate and sulfuric acid needs few minutes only, but it is important to give the slurry produced enough time in order to get good crystallization of gypsum which will affect later on the filtration and the recovery of \( \text{P}_2\text{O}_5 \) from the gypsum solid, the solids content of the formed slurry should be ranged between 35 - 40 % and the slurry temperature should be 76-79.5°C in order to be always within the range of dehydrate process, for this reason (temperature controlling) a cooling system is needed in order to keep temperature within range about 50% of the heat is removed by water.
evaporation in the low level flash cooler E2.6301, the process is as the follow:

- Vacuum generated by ejectors j2.6301, j2.6302, a level is maintained in the flash cooler and pump p2.6302 circulates the slurry from R6301 to R2.6301 compartment through the flash cooler.
- Due to vacuum, water vapor flashing takes place in the flash cooler, this water vaporization cools down reaction slurry.
- Due to high flow rate of slurry through the flash cooler, ΔT of inlet and outlet slurry of flash cooler is less than 2.5°C, thus scaling is limited.
- Vapors leaving flash cooler are separated in the cyclonic separator S2.6301, collected liquid is returned back to R2.6301A, the vapor out of separator S2.6301 are condensed in two condensers cooling in series:
  - E2.6302 the precedence where a part of cake washing water is heated by direct contact with the vapor, this returns to tank D6309 which feeds the cake washing system.
  - E2.6303 where the vapor from E2.6302 are condensed by direct contact with cooling water. The hot cooling water resulting from the condensation flows down to the seal tank D2.6309 through a barometric leg. From this tank, cooling water is pumped by means of P2.6305 to the hot cooling water channel.
  - The non condensable gases (inert saturated with water vapors) are sucked out and compressed to atmospheric pressure by a vacuum unit consisting of two steam ejectors j2.6301mj3.6302 and one interstate condensers and a vacuum pump. The outlet to atmosphere is water sealed in D2.6309 in view
to maintain the vacuum in case of shut down. The vacuum in flash cooler is automatically controlled by air admission valve PV2.6301 actuated by PRC2.6301.

Air sweeping also helps in cooling down the slurry, the air is sucked from outside into the reactor R6301 by means of fans K6301A/B and contacts the surface of slurry which is also cooled by coolers M6302 A to I which improve the contact and increase the heat transfer between air and slurry.

The water vapors and fluorinated gases are washed in towers C6301A/B (primary washing towers) to abate or decrease the fluorine content in the gases rejected to atmosphere. High scrubbing water flows rate is ensured by circulation pump P6314A/B and cold cooling water make up is controlled by means of FRC6316A/B, the blow down goes to the vessel D6309 where it is mixed with water coming from E2.6302 to produce cake washing water. The excess of water is evacuated from D6309 by a level controller LIC2.6301 and goes to the cooling water channel via D2.6309.

The fans K6301A/B discharge the scrubber air into a second stage washing tower C6302A/B where it is possible to wash it with NaOH if needed make up flow is done via FRC69305A/B with fresh process water, the blow down goes to the affluent sump via the level controller LIC6302A/B.

There are some parameters affecting the reaction system could be explained here after:

⇒ Solids concentration in acid slurry
  • A high solids concentration increases viscosity and impairs the chemical reaction, pumping of slurry and filtration.
A low solid concentration increases the volumes circulating between the reaction and filtration section and thus limits the capacity. The target value is ranged between 35-40 % wt.

⇒ Free SO₃ percentage

- The phosphoric acid slurry must contain a slight excess of free SO₄²⁻ to allow an easy combination with Ca⁺² ions which exist also in solution, solubility of gypsum decreases as SO₄²⁻ content increase.
- The HPO₄⁻² has more or less the same lectrophysical configuration as SO₄²⁻, if there is not enough SO₄²⁻ in solution, HPO₄⁻² can react with Ca⁺² to form CaHPO₄ crystals which will be a loss of P₂O₅ (co crystallization P₂O₅ loss),so that 2% excess SO₄²⁻ is being added to reaction system.
- The SO₄²⁻ concentration also affects directly the size of the gypsum crystals, when SO₄²⁻ content ration increases, the size increases up to a certain limit and finally break into small crystals, but a too large excess SO₄²⁻ has a several drawn backs. The reaction between rock phosphate and sulfuric acid is then too fast and one obtains large concentrations of Ca⁺² and SO₄²⁻ around the rock particles. This precipitation of gypsum occurs on the surface of the rock particles, and this coating does not allow further attack. It is the unrelated P₂O₅ loss.
- A high SO₄²⁻ concentration also dilutes the phosphoric acid for the same reading of acid density and increase the sulfuric acid consumption. The target value is ranged between 20-28 g/L
SO₃, SO₄⁻² analyzer has been installed at the discharge line of variable slurry pump P6301 feeding the digester A, also Slurry sample is taken and analyzed to check on the SO₄⁻² content.

⇒ Silica
Silica is being added to the slurry in order to help in the crystallization of gypsum crystals which will affect by getting good filtration. The silica is mixed with water to form slurry of 20-25 % wt solid content, the pump P2.3101 sends the slurry to the new reactor; it is added at a range at 1.5-2.3 t/hr.

⇒ De-foam
Since the phosphate rock contains an organic compounds, foams will be formed, so to avoid that de-foam is injected where it is added and prepared in a tank and injected at digester A, funnel and flash cooler.

⇒ P₂O₅ concentration
Too high P₂O₅ concentration can result in formation of undesirable hemihydrates crystals and increase the crystallized P₂O₅ losses. The viscosity of acid increases with P₂O₅ concentration increase and impairs filtration because the gypsum crystals size decrease when % P₂O₅ increase, while low P₂O₅ concentration will produce diluted phosphoric acid, then the concentration section have to remove more water or produce a less concentration acid. The target value of P₂O₅ % in the produced slurry is 28-28.5 %.
1.7.4 Digestion Tanks

The digesters are three equal volume, agitated tanks R2.6302A/B/C where reaction slurry matures before filtration. It provides condition for the formation of good gypsum crystals and for the de-saturation of the solution. An amount of reaction slurry pumped by pump P6301 at a rate of 250-550 m³/hr enters into the first tank R2.6302A through a deep pipe X2.6302. From this tank, the slurry overflows to the second digestion tank R2.6302B and then it flows from B to the third digester R2.6302C. A vertical immersed pump P2.6301 is installed over the third digester, it sends the matured slurry to the filter at a rate automatically controlled by FRC2.6305 acting on P2.6301.

At the line from the slurry pump P6301 to the first digester, a sulfate analyzer is provided. This analyzer allows recording the SO₄ content in the liquid phase of the slurry and therefore helps the operator to adjust the sulfuric and flowing.

At the top of this digester line a venting line with a manual valve for adjustment is connected to the suction fan K2.6301 which rejects the sucked air to the gas phase of the reactor R6301. For inspection purpose an in section door is located at the tank which could be used also to connect a movable pump to discharge the tanks when needed.

1.7.5 Filtration

UCEGO filter S6301 is used to separate the solids (gypsum crystals) from the phosphoric acid (28% P₂O₅), the UCEGO filter is a rotating table made of stainless steel 317 L, it carries a polyethylene cloth and has an area of 250 m² with an active area (under vacuum) of 205 m², the gypsum extraction is done by a screw made of stainless steel 316L driven by a motor of 37 kW.
power, the slurry is feed to the filter through a slurry feed box made of UB6 and distributes the slurry to ensure a uniform distribution onto the table, the filter is driven by a DC Motor to have a variable speed according to operation parameters, the nominal speed is about 23-25 rpm, while the cake thickness should be 60-80 mm. A vacuum box of five compartments A to E is located under the filter table and connected to the table by tubes. The vacuum box is connected to the multi stage separator D6301 which is made of FRP; it is a horizontal cylindrical drum with 1.91m diameter and 7.6 m length and separated from inside the three compartments A, B and C. One of these compartments (A) is used to collect the produced phosphoric acid 28% P₂O₅ and connected to pump P6302 which sends the product to the storage tanks.

Various filtrates are collected in the separator drum D6301, the gases and vapors are sucked by the vacuum pump to pass through the cyclonic separator D2.6307 which removes more effectively the carried over liquid droplets, liquid returns from D2.6307 to the recycled acid and the gases continue to the condenser E6302 fed with process water through the flow indicator F16311, after condensation the gases are sucked by the liquid ring vacuum pump P6317, fed also with process water, the condenser E63.2 is sealed in tank D6304 from which, by over flow, the water goes to the sump D6308 where the water coming from the vacuum pump P6317 returns. The vertical pump P2.6308, installed in the sump, sends this water to:

- The pre-condenser E2.6302 by FIC2.6358.
- The hot water channel by LIC6304.

### 1.7.5.1 Filtration Description

The steps at which filtration takes place could be explained as below:
1.7.5.1.1 Slurry Attack
The rate of slurry fed to the VCEGO filter table is controlled by variation at pump speed according to a signal from flow controller FRC2.6350. The first portion of the filtrate is slightly diluted by the water remaining in the clothes and also contains some small gypsum particles; it is discarded to the recycle acid compartment A of the vacuum box.
Then after formation at a first layer at gypsum, when the filtrate quality I correct, the product acid (28%P₂O₅) is drawn off through the compartment B of vacuum box into the first compartment of multistage separator where it is pumped to storage tanks T6602 and T6603A/B by the variable speed pump P6302 which is controlled by the recycled acid pump P6302 which is controlled by the recycled acid flow rate recorder FRC6309, while the amount of produced phosphoric acid is measured by the flow indicator FQI6308.
A hood located over the slurry attack zone to suck the vapors and gases, that hood is connected to the old reactor R6301 to be washed with gases and vapors in the washing system.

1.7.5.1.2 First Washing
The gypsum cake still contains P₂O₅ which is needed to be recovered by washing the cake by a washing liquid fed by pump P6304 and distributes the liquid over the cake, this area of filter table is connected with compartment C of vacuum box, then the liquid is sucked to the second compartment at the separator D6301 where the pump P6303 pumps the washing liquid to the spilt box D2.6301 which is located over the new reactor to be then distributed into two lines, each line feeds one compartment of new reactor,
this recycled acid density is measured by density recorder DRC6301 while is its amount is measured by the recorder FRC6309.

1.7.5.1.3 Second Washing
The gypsum is washed here again by the washing liquid that is supplied by pump P6306 which receives its liquid from the cloth washing section, the pump P7306 is also fitted with a speed variation which allows to keep constant level in its suction, the liquid that gypsum has been washed by is sucked to the compartment D and E of vacuum box which is connected to the pumps P6306 is controlled by FRC6310.

1.7.5.1.4 Cake Discharge
The rotating screw S6301.2 will remove the cake formed over the cloth and discharge it to the gypsum conveyor Q6301 which will conveys it to a series at belt conveyors to be disposed out at plants site. Screw should be 80-120 mm over the cloth to ensure good removal at cake.

1.7.5.1.5 Cloth Washing
After removing gypsum, a thin layer will remain over the cloth, pump 6318 will supply the hydro cyclonic separator S6302 which will distribute the washing liquid over the cloth through ≈ 84 stainless steel nozzles fixed along the distributor, the washing liquid will drop to the compartment F of vacuum box to be fed to the pump P6307 Which Also receives the makeup water coming from P6318, the washing water is circulated through P6307 to the hydro cyclone separator S6302, the makeup water is heated by steam and
controlled by means of TIC6314 then the filter cloth is ready for a new filtration cycle.

1.7.6 28% acid storage
The produced 28% acid is stored in four tanks made of carbon steel with rubber lining and four baffles, pump P6302, is also 160 m$^3$/hr capacity, supplies the tank T6601 (120 m diameter, 12.5 m height) which is called the de-saturation tank, its capacity is 3750 m$^3$ of acid, also the pump P6302 supplies the tank T6602 (20 m diameter, 9 m height) which is the setting tank, its capacity is 2610 m$^3$, also the tanks T 6603A/B could be fed by the pump P6302, they are named as settled acid tanks, they are 18 m diameter and 10m height for each and each one has a capacity of 2420 m$^3$ of acid.

The tanks T6601 and T6603A/B are supplied with agitators of $\approx$ 20 rpm rotating speed to keep the solution homogeneous. The tank T6602 is supplied with a racker to get rid of solids exists in the solution, the racker supplies a sludge pumps P6603A/B C/D (concentration feed pumps) which are 50 m$^3$/hr flow rate capacity for each, three of these pumps are feeding the three concentration lines, while the fourth one is stand by. The tank T6601 is supplied with a pump P6601 (30% acid redaim pump) that could supply the other tanks with acid.

1.8 Concentration Lines
The concentration section of three symmetric lines which are operating under vacuum, each concentration line consist of an evaporator D6401, acid heater, condenser, seal tank and finally the circulation and product pumps 28 % phosphoric acid concentration up to 56 % by evaporation of a part of
water exists in the acid, a vacuum is being done in the evaporator in order to evaporate the water at low temperature, the absolute pressure must remain steady, if it raises, the acid temperature ill raise and when the pressure comes back to normal, sever flashing of the acid may occur with deposits in evaporate and loss of P₂O₅. The vacuum in the evaporator and other equipments is done in fact by two ways by steam ejectors that such gases from the condenser, condensate line out of acid heater and condensate drum and by the huge amount of water (2500 m³/hr) galling from top of condenser to be drained to the seal tank then to the hot water channel.

The steam consumption show the capacity of the concentration lines, when tubes of the heat exchanger are clean, a low pressure steam (i.e. steam temperature) is required for a given capacity. As the scale builds up, the steam pressure increases. The target value of steam floe and pressure is 35.5 ton/hr and 1.3 bar (109°C) consequently, and it is measured by FR2.6450A,B,C and PR2.6451A,B,C the steam is desuperheated by desuperheating water of ≈ 18-20 bar supplied from utility plant to decrease the steam temperature from 180°C-190°C to ≈ 109°C while the pressure is reduced from 5-6 bar to 1.2 bar by enlargement of steam pipe diameter. The 54% acid circulated by an axial circulating pump P2.6401 is heated in the heat exchanger E2.6401 to raise the acid temperature by 3.7°C maximum. The acid temperature after heating should not be more than 91°C to avoid damage of heater.

The 30% acid (1.28 g/cm³ density) fed at rate of 50% m³/hr through FIC2.6456 to each line out of heat exchanger. The evaporator is filled at initial startup with 54% phosphoric acid, then evaporation occurs in evaporator then the acid concentration will become 54% (after 30% acid dosage). A riser tube located in the evaporator tanks the 54% acid by over
flow and fed to the 54% acid pump P6402 which pumps the produced acid to storage tanks T6604A/B, T6605A/B, T6606A/B which are 17 m diameter and 10m height and to the storage tank T6607 which is 20.5 m diameter and 10m height at a rate of 20-22 m³/hr with acid density of 1.59-1.60 g/cm³. The condensate out of heat exchanger flows to the condensate drum to be sent by pump P6405 to utility plan if conductivity is through the conductivity value CV6401.0 or to be drained when conductivity is high through the conductivity value CV6401.2. The evaporated water and the vapors and gases exists in the demister S6402 to catch any droplets of 54% acid to be sent back from demister bottom line to meet with the 54% acid line out of evaporator while vapors and gases continue flowing to the primary fluorine absorber D6402 to be washed by diluted flousilicic acid (H₂SiF₆) circulated and spranged by nozzles, an industrial water is fed to acid circulation line. Here a chemical reaction occurs between the SiF₄ and the water forming flousilicic acid and silica according to the reaction:

\[ 3\text{SiF}_4 + 2\text{H}_2\text{O} \rightarrow 2\text{H}_2\text{SiF}_6 + \text{SiO}_2 \]

The produced flousilicic acid (F.S.A) is 18-20% concentration and 1.195-1.2 g/cm³ density, it is sent by pump P6404 at a rate of 7-8 m³/hr to be stored in four F.S.A tanks.

1.8.1 54% P₂O₅ Acid storage

The concentrated phosphoric acid from the evaporation system is sent to the 54% P₂O₅ acid storage tank. These tanks are equipped with agitators to maintain the insoluble salts formed by de-saturation and cooling in suspension.
These tanks supply concentrated acid feed to the fertilizer plant or to filtration system to produce 54% P₂O₅ clarified acid. The clarified acid coming from the filter is transferred into 54% P₂O₅ clarified acid storage tanks which are also equipped with agitators.

1.8.2 Flousilicic Acid Storage

The flousilicic acid solution produced in the concentration system fluorine absorbers is stored in four storage tanks T6701A/B/C/D for disposal. T6701A/B/C/D which are 15 m diameter and 10 m height for each, they are rubber lining, located inside the primary scrubber. If P₂O₅ content in the produced acid (F.S.A) is more than 150ppm the F.S.A is stored in the tank T6701D which is called (off specification tank) to be used in the granulation plant on to be disposed out of plants area.

1.9 Fertilizer Granulation Plant

The fertilizer plant consists of two granulation units (trains) each sized for production of MAP or DAP. It produces diammonium phosphate (DAP) from phosphoric acid and ammonia. Ammonia is imported from abroad. The process starts by reacting phosphoric acid with ammonia in a special reactor. The reaction mixture (slurry) is pumped to the granulator where the reaction is completed by adding further ammonia. The granulated product (diammonium phosphate) then dried and passed to the storage area after cooling.

\[ \text{H}_3\text{PO}_4 + \text{NH}_3 \rightarrow (\text{NH}_4)_2\text{HPO}_4 \]
Main Product: Diammonium Phosphate
Raw materials are imported liquid ammonia and phosphoric acid.

Fertilizer plant includes:

1.9.1 Ammonia Storage

The ammonia storage facility consists of two tanks of 30000 ton and 10000 ton capacity, single wall, and atmospheric pressure storage tanks with a package electric refrigeration system to maintain the tank contents at the required temperature condition.

Liquid ammonia is held at 33°C by a refrigeration unit which compensates for heat gained from ambient. Ammonia vapor is drowning from the top of the tank by the refrigeration system, the vapor is compressed and condensed by fresh cooling water and then recovered in a receiver. The liquid is returned to the storage tank after expansion.

The refrigeration unit includes 100% spare capacity for the tank holding load. Compressors are electrically driven.

The storage tank is provided with a retention pit equal to 110% of the tank capacity i.e. about 48000 m³.

The liquid ammonia is pump at 33°C to the granulation plant. The transfer system includes two 100% electric driven pumps (one spare). Transfer rate is 30 t/h of liquid ammonia at 33°C and at a discharge pressure of 7.5 bars and 6 t/h is required for start up of the granulation unit. A bypass from the granulation plant back to the ammonia storage tank is included to permit safe operation of the ammonia transfer pumps at low rates.
The refrigeration system is fully automatic. The ammonia storage facility includes control valves and control recording and indicating instruments as required for normal and safe operation.

1.9.2 **Granulation Units Section (75&76)**

Two identical units are provided. The operation of each is described as follows:

1.9.2.1 **Acid and Water System**

54% P₂O₅ phosphoric acid is received at battery limits and metered into the reactor and into the recycle acid tank. The blow down of the tail gas scrubber is introduced into the recycle tank to adjust the acid concentration. The diluted acid is pumped to the acid scrubber for recovery of ammonia vapors from the off-gases of the plant. A production of this diluted acid is also metered to the reactor to produce an equivalent P₂O₅ feed of about 38% P₂O₅, when mixed with the 54% P₂O₅ acid fed directly to the reactor.

1.9.2.2 **Ammonia Feed System**

Liquid anhydrous ammonia is received at battery limits. A portion is vaporized by steam and sent to the reactor for the partial neutralization of the phosphoric acid. The remaining flow is warmed and then metered to the drum granulator for final neutralization.

1.9.2.3 **Reaction System**

Re-circulated scrubber acid (≈30% and partially neutralized) is pumped and metered to the reactor.
Gaseous ammonia is sparged into the reactor below the slurry level through four spargers spaced 90° apart.
The reaction of the acid and ammonia is very violent and mechanical agitation is not normally required, however, the reactor is equipped with an agitator and baffles for start-up.
The heat produced by the reaction of ammonia and phosphoric acid drives a large portion of water off as steam. The high partial pressure of ammonia over the slurry results in ammonia loss from the reactor. This loss may be as high as 15% of the flow to the plant.
This ammonia is captured in the reactor-granulator scrubber. The slurry is then pumped (one operating and one spare) and metered to the drum granulator at a rate consistent with production requirements. The slurry piping is steam traced and fitted with necessary 'clean-outs' and wash water connections.

1.9.2.4 Granulation System
The granulation of reaction slurry is accomplished in a drum granulator. The tumbling action caused by the rotating drum presents an ever-changing product surface to the slurry which is introduced by a distributor above the moving bed. Liquid ammonia is sparged into the tumbling bed to complete the desired reaction and to finish heat to drive-off more water from the system. For DAP, the mole Ratio of the material discharging from the granulator is about 2:1 (N: P). Excess ammonia is fed to the granulator intentionally to assure driving the reaction to completion. The excess is captured in the acid scrubbers as previously mentioned.
The granular fertilizer is formed in the granulator by repeated coatings and drying of the slurry feed on the surface of previously formed particles (recycle).
All vapors are air swept from the granulator to the reactor-granulator scrubber system for recovery of ammonia and dust and to remove fluoride from the gases before release to atmosphere.

1.9.2.5 Driving System
The material discharging from the granulator is dried in a rotary dryer by a flow of heated air. The dryer is a parallel flow, rotary with specially designed lifting flights to distribute the material through the hot air. External knockers are provided at the feed end to dislodge material which adheres to the shell.
The grizzly section at the discharge end of the dryer passes the minus 100 mm granular material is discharged to a lump crusher and then back to the boot of the elevator.
The dryer discharge breeching has an air seal that ensures dust tight operation and minimum air leakage. Inspection openings and access doors are provided in the breeching for clean-out and maintenance operations.
The dryer operation requires regulation of the fuel oil feed to the burner. A temperature recorder-controller in the dryer exit gases controls the fuel rate to the burner to maintain the desired temperature. The dryer inlet gas temperature is also recorded on the same recorded and will actuate an alarm if the temperature approaches the decomposition point of the granular product.
The dryer off-gases are sent to the dryer cyclone for removal of the large dust particles. Collected dust is returned to the recycle feed system.
The gases discharging from the dryer cyclone are laden with fine particulate dust. This dust is recovered from the gases in the dryer acid scrubber. Any ammonia resulting from decomposition or free ammonia in the dryer feed will also be captured in the dryer acid scrubber.

1.9.2.6 Conveying, Screening and Milling System

The 100 mm dryer product is elevated by continues type bucket elevator and is then split into four equal streams to each of the four double deck screens. The top screens are six-mesh (Tyler). The lower screen will retain product size material, + 9 mesh, which will be discharged directly from each screener to the product bin. The under-size material from the bottom screen (-14 mesh) flows directly to the recycle drag conveyer. The oversize material is crushed and fed to the recycle drag conveyor.

1.9.2.7 Product Cooling and Conveying System

The product size material has a screen analysis of about 90% (-6, +9) mesh and a moisture content of about 1%. The flow from the bottom of the product size surge bin is controlled by a variable speed belt conveyor. The extractor is set to maintain constant recycle as indicated by the amperage load of the recycle elevator motor. Excess product size material not removed by the extractor overflows to the recycle conveyor to maintain the constant recycle rate. The extractor discharges to the cooler. Product cooling is desirable to minimize the evolution of ammonia from the DAP product and to reduce caking in storage. The product is cooled in a
counter-current, rotary drum type cooler using chilled, atmospheric air as the cooling medium.

The product discharges from the cooler at approximate 55°C to the product elevator and then to a belt conveyor for transfer to the storage building.

In route to storage, the material is screened once more in polishing screen to insure quality. The screened product is weighed by continuous scales and sent to storage.

1.9.2.8 Recycle System

The recycle system consists primarily of two pieces of equipment, the recycle drag conveyor and the recycle elevator. The recycle conveyor is a continuous heavy-duty, drag flight type conveyor. It is completely enclosed and vented to the dust collection system.

The excess product size material that overflows from the surge bin is fed directly to the recycle conveyor as it is the undersize material from the screens and the crushed oversize material.

The recycle drag conveyor discharges to the recycle elevator which returns the material directly to the drum granulator.

A spills reclaim system allows recovery of any material from the ground floor. This material is put into a hopper feeding a spillage elevator which conveys the recovered material to the recycle conveyor for reprocessing in the plant.

1.9.2.9 Ventilation and Scrubbing System

Three collecting systems are supplied for the plant:
- The reactor-granulator scrubbing system.
- The dryer scrubbing system.
- The cooler dust-vent collecting and scrubbing system.

A large part of the dust entrained in the gases entering the dryer cyclone and the cooler dust vent cyclone is recovered by the cyclones and discharged from each cyclone hopper through an air lock to the recycle conveyor. The fine dust particles remaining in the gases are then vented to the scrubbing system for removal. The dust, fumes, and water vapor from the recycle feed tank, reactor, and granulator scrubbing system. Each vent system consists of a venturi-cyclonic scrubber the gases are scrubbed with phosphoric acid to assure capture of the free ammonia and dust. The weak scrubbing acid is below-down to process. All other contaminated water steams in the plant are connected in an accumulation system and returned to the process.

1.9.2.10 Fertilizer Storage

Separate product conveying system removes fertilizer from each of the granulation units to the fertilizer storage building. The production from each train is continuously weighed and recorded. The design capacity of each conveying system is selected to allow for peak loads expected from this type of service. A transfer tower is located at the top of the fertilizer storage building. A diverter system is installed to allow transfer of material from either two of the conveying belts to either two of the stock piling belts in the storage building. The storage building is divided into four equal volume bins and one smaller "off-grade" bin.
Manually operated trippers are located on the stock piling belts so that discharge from the belts can go to any of the five storage compartments. The total storage capacity of the buildings is 60000 ton. Product is reclaimed from any of the four large storage bins by an automatic declaimer system at a rate of 1500 t/h. The reclaimed fertilizer is weighed and conveyed to the dock on an enclosed belt conveyor.

1.10 Aluminum Florid Plant

It produces aluminum fluoride (AlF₃) from fluosilicic acid (H₂SiF₆) and aluminum hydroxide.

The process starts by reacting fluosilicic acid solution with Aluminum hydroxide Al(OH)₃ (alumina trihydrate AL₂O₃.3H₂O) in special reactors to produce the soluble form of aluminum fluoride:

\[
2\text{Al(OH)}_3 + \text{H}_2\text{SiF}_6 \rightarrow 2\text{AlF}_3 + \text{SiO}_2 + 4\text{H}_2\text{O}
\]

The reaction product (slurry) is passed onto a belt filter to separate the formed silica from the aluminum fluoride solution, and then silica is conveyed to a belt for final disposal. The aluminum fluoride emanating from the belt filter flows into a crystallizer in which aluminum fluoride trihydrate crystals (AlF₃.3H₂O) precipitates. These crystals pass into calciners (driers) where anhydrous aluminum fluoride AlF₃ is produced. The calcined product is cooled and conveyed to the storage silo for bagging.
- Main Product  Aluminum Fluoride  
- Product Capacity  60 metric t/day  

Aluminum fluoride includes:

1.10.1 Al(OH)₃ Handling and Drying

Wet Al(OH)₃ (about 13 % moistures) is delivered by trucks to the hydrate storage building the hydrate is transported via hopper 1'101 chain conveyor 1'102 bucket elevator 1'103 and screw conveyor 1'103-1 to Al(OH)₃ wet silo 1'104 from of the bottom of the wet silo hydrate is fed via silo discharge device 1'105 screw conveyor 1'105-1 and screw feeder 1'106 into a flash 1'111 where the free moisture is removed. Hot gases as drying agent in the flash dryer are coming from the clarinet hot gas circulation system.

The dried hydrate is separated from the gases in cyclone 1'112 and fed to dry Al(OH)₃ storage silo 1'113. From this storage silo dry Al(OH)₃ is pneumatically conveyed (1'116) to day bin 1'118 at the top of the process building.

1.10.2 Production of Hot Acid

Fresh acid is stored outside battery limit in four fresh acid tanks (1'001A,1'001B,1'001C,1'001D).The acid to be heated to appropriate reaction temperature of 70-80°C centigrade therefore cold acid is pump 1'002A or B through graphite block heat exchanger 1'003 to hot acid tank 1'004A or B only one acid tank is in operation. The other one is installed for safety reason to avoid plant shut down. Steam is used heating medium in the heat exchanger.
From the hot acid tank the hot acid is pumped to the reactors by a hot acid pump 11'005A or B. The cold acid is pumped by cold acid pumps 11'002A/B through heat exchanger 111'003 to the hot acid tanks. The heat exchanger consists of 7 graphite blocks. Stream is used as heating system.

**1.10.3 AlF$_3$ – Reaction**

Four reactors 11'500A/B/C/D operate batch wise each batch gives about 675Kg aluminum fluoride to reach expected average production around 100 batches/day are required. The 18-25% H$_2$SiF$_6$- solution with a temperature of 70-80°C is charged into the reactor by one of the hot acid pumps 11'005A/B the quantity (volume) is measured by a magnetic flow meter FQ-2032 if the acid is strong -25% the temperature shall be about 75°C and if the acid is weak -18% the temperature shall be about 80°C. Al(OH)$_3$ is weighed into the reactor by one of the two batch scale 11'124A/B. The quality must correspond to the acid volume and the acid concentration. The reaction of H$_2$SiF$_6$ and Al(OH)$_3$ yield a metastable solution of AlF$_3$ and precipitated SiO$_2$:

$$\text{H}_2\text{SiF}_6(\text{l}) + 2 \text{Al(OH)}_3(\text{s}) \rightarrow 2 \text{AlF}_3(\text{l}) + \text{SiO}_2(\text{s}) + 4\text{H}_2\text{O}(\text{l})$$

The reaction is exothermic and has to be carried out so that the boiling point, about 102°C, is reached during the reaction time. If the hot acid temperature is too high, the reaction will be vigorous and the reaction mixture will over foam. If this happens cold water can be fed into the reactor to cool down the reaction mixture if the hot acid temperature is too low. The reaction mixture
will not reach the boiling temperature in this case; the precipitated can be
difficult to filtrate.

1.10.4 Silica Filtration
The mixture of silica and metastable aluminum fluoride is separated on a
PANNEVIS vacuum belt filter. The filter is automatically operated by a
filter program.
From silica filter seed tank 11'503 reaction mixture is continuously fed to
one of the silica belt filters 11'502A/B. One belt filter is always in a standby
position. The amount of slurry fed to the filter is controlled by the liquid
level on the filter.
The belt filter consists essentially of an endless filter cloth on an endless
rubber belt where the filtration is achieved by means of a vacuum when the
filter cloth passes the vacuum box.
The vacuum (about 0.5 bar) is attained by vacuum pump 11'508A/B in the
machine room.
The vacuum box is divided in four sections. From the first section
preliterate, which always contains some solid material, is recovered and
recalculated via filtrate receiver 11'506A or B and preliterate pump 11'507A
or B. In the filtrate receiver the filtrate is separated from the vacuum.
The filter cake is washed three times with water in a counter-current way in
order to minimize the wash water quantity. Fresh wash water is continuously
fed from wash water tank 11'511 by pump 11'513A or B to the last part of the filter and collected in the fourth section of the vacuum box. This wash water is via filtrate receiver 11'506G or H and pump 11'507G or H recalculated as wash water to the belt filter. Again this wash water is collected in the third section of the vacuum box and via filtrate receiver 11'506E or F and pump 11'507E or F recalculated together with metastable AIF3-solution as main stream in the second section of the vacuum box. Via filtrate receiver 11'506C or D and pump 11'507C or D this filtrate is pumped to one of eight crystallizers.

Filtrate pumps 11'506 A/B/C/D are connected to the emergency power net. The vacuum gases escaping from the filtrate receivers are washed in spray condenser 11'510A or B. In the vacuum to the vacuum pumps there is also a drop separator (11'510-1A/B).

The silica filter cake is discharged from the filter cloth onto belt conveyor 11'505 which takes it to the gypsum belt conveyor for disposal.

1.10.5 AlF₃.3H₂O Filtration

The AlF₃.3H₂O – slurry is separated on a vacuum belt filter. The filter is automatically operated by program. From The ALF₃- filter tank 11'606 slurry is continuously fed to one of the AlF₃- belt filters 11'612A/B. One belt filter is always in a standby position. The amount of slurry fed to the filter is controlled by the liquid level on the filter. If there is too much liquid the feed valve will close.

The belt filter consists essentially of an endless filter cloth on an endless rubber belt where the filtration is achieved by means of vacuum when the filter cloth passes the vacuum box.
The vacuum (about 0.3-0.5 bar) is achieved by vacuum pump 11'618A or B in the machine room.

The vacuums box in two sections. From the first section prefiltrate is recovered and recalculated via filtrate receiver 11'615A or B and preliterate pump 11'619A or B back to the belt filter. From the second vacuum box section mother liquor and wash water is collected and led via filtrate receiver 11'615C or D to the barometric sealing vessel 11'617. Wash water is continuously fed to the filter cake from wash water tank 11'621 by pump 11'622A or B. Wash water is collected in the wash water tank from filter cloth washing nozzles.

The vacuum gases escaping from the filtrate receivers are washed in spray condenser 11'620A or B. In the vacuum line to the vacuum pumps there is also a drop separator (11'620-1A/B).

The AlF₃.3H₂O filter cake is discharged from the filter cloth onto belt conveyor 11'613 which transports it into intermediate bin 11'614.

1.10.6 Crystallizers

The metastable aluminum fluoride solution from silica belt filter 11'502 A or B is pumped to one of the eight crystallizers. The volume of each crystallizer is 20 m³. Each crystallizer can be changed with 4 reaction batches, one crystallizes will be filled in about 40 minutes. In order to initiate the crystallization seed crystals have to be added as a seed crystals aluminum fluoride dust from bag filter 11'703 and 11'717A/B are used the dust is collected in silo 11'611shall be returned to the crystallizer via the seeding system. The total crystallization time will be 4-5 hours with a strong fluosilicic acid the crystallization time can be reduced compared to the time necessary for the weak acid. Each crystallizer has agitator which is connected to the emergency power net if the agitator should not be in
operation during the crystallization the aluminum fluoride crystallize will settle down to the bottom of the crystallize and give rise to a solid block which will be very difficult to remove. During feeding the crystallizer and during the crystallization, the temperature is kept constant (about 95°C) in the crystallizer.

When the crystallization is finished the slurry is emptied through the bottom discharged valve into slurry collecting tank 11'602 from slurry connecting tank 11'602 the slurry is pumped by slurry pump 11'605A/B to filter feed tank 11'606.

Crystallizer 11'600A/B/C/D/E/F/G/H. Each crystallizer is equipped with four Side and bottom baffles and an impeller type agitator (11'601A/B/C/D/E/F/G/H). If an agitator stops an alarm will be given a panel: M-11'601 A (B/C/D/E/F/G/H) agitator failure. The crystallizer is regularly washed with mother liquor from barometric sealing vessel 11'617 with this washing the scaling in the crystallizer will be kept under the control. The liquid is pumped to the crystallizer by filter pump 11'619C or D.

1.10.7 Drying

AlF₃·3H₂O fed into intermediate bin 11'614 contains in addition to chemically bound crystal water also about 10% free moisture. This free moisture is removed in flash dryer 11'700.

Via try feeder 11'614-1, screw conveyor 11'614-2 and screw conveyor 11'701 wet aluminum fluoride is charged into flash dryer 11'700. Screw conveyor 11'614-2 is a vortex screw mixer in order to disintegrate any lumps
or cakes entering it. The flue gas is sucked from calciner flue gas stack 11-981 by exhaust gas fan 11'734A or B. The dried AlF₃·3H₂O is separated from the gas in cyclone 11'702 and discharged via a rotary vane feeder into calciner feed bin 11'705. The gas still containing some solids is sucked to bag filter 11'703 and exhaust gas scrubbers 11'732A/B before it is discharged to atmosphere via exhaust gas stack 11'980.

1.10.8 Calcining

Dried AlF₃·3H₂O with a temperature of about 100°C is fed from calciner feed bin 11'705 into two rotating calciners 11'709A/B by screw conveyors 11'707A/B and 11'708A/B. Both calciners are normally in operation. The calciners are rotating drums indirectly heated from the outside by hot gases from six diesel oil burners per calciner. At the calciner drum outlet the product has a temperature of about 550°C and conforms now to chemical formula AlF₃. The product is cooled down in water coolers 11'725A/B before it is pneumatically conveyed to the storage silo. The hot gases from the burners are recalculated by hot gas circulating fans 11'712A/B. A portion of the hot gases is continuously bled to the flue gas stack 11'981. This flue gas is sucked from the stack to flash drier 11'700 by fan 11'943A or B from drying wet and flash dryer 11'111 by fan 11'115 to dry wet Al(OH)₃. The suction outlets in stack 11'981 are positioned so that flash dryer 11'700 has first priority. This utilization of the flue gases from the calciners for drying makes the over-all plant heat balance favorable.
1.10.9  

**ALF$_3$ Handling and Bagging**

From product cooler 11'725A/B calcined aluminum fluoride is fed into surge bin 11'801 by screw conveyors 11'726A/B. Surge bin 11'801 feeds product into pneumatic conveyor 11'800, which conveys the product batch wise to AlF$_3$ storage silo 11'803 or to special product silo 11'807. AlF$_3$ is conveyed from silo 11'803 or silo 11'807 by air slide 11'817 into a vessel which is located above the bagging unit in the storage building. From this vessel AlF$_3$ is conveyed by a screw to the bag filling machine. The filled bags are palletized and afterwards stored in the storage building.

1.11  

**Material Handling Section**

1.11.1  

**Sulfur Handling**

1.11.1.1  

**Ship Unloading**

This section includes the ship unloader X8401 which operate all along the dock and sea side (out of service).

The selected ship unloader is the continuous discharge type by means of a scraper conveyor working inside the ship hold and of a conveyor system to carry the sulfur from the scraper to the dock conveyor, item Q4101.

1.11.1.2  

**Conveying Section**

The transfer dry sulfur from the dock up to the storage building is by mean of belt conveyor system. This includes:

One belt conveyor Q4101 located above the dock and inside a gallery and fed by the ship-unloader. The head section of this conveyor and the tail section of the conveyor which is the following are located inside the junction tower T1.
One belt conveyor item Q4102 for liaison between the dock (tower 1) and the plant (tower 1), the junction tower T.2 encloses the head section of conveyor Q4102 and the tail section of conveyor Q4103.

One belt conveyor Q4104 for liaison between the junction tower T.2 and T.4. This conveyor is equipped with a belt scale W4103 for weighing sulfur incoming into the plant. The tower T.4 encloses the head section of conveyor Q4203 and the tail section of conveyor Q4104.

One belt conveyor Q4104 for liaison between junction tower T.4 and storage building. This conveyor is equipped with one traveling tripper item Q4105 for dispatching sulfur all along the pile length and according storage possibilities.

1.11.2 Fertilizer and Potash Handing

1.11.2.1 The Fertilizer Reclaims

This section mainly includes:

One scraper reclaimer of portal type (item no.X4107) located inside the storage building. One reclaim belt conveyor (item no.Q4106) fed by here above scraper reclaimer. This conveyor partially located inside the storage building handles the fertilizer from the reclaimer discharge chute to the transfer tower T.2.

1.11.2.2 Handing Section

This section mainly includes:

- The transfer tower T.2 where are installed:
  - The conveyor Q4106 head section.
  - The conveyor Q4107 tail section.
  - One maintenance electrical hoist.
-One liaison belt conveyor (X4107) to handle the fertilizer from T.2 to T.3.
-The transfer tower T.3 where are installed:
  -The conveyor Q4107.
  -The dedusting unit for each conveyer (out of service).
  -Two belt conveyors Q4111 fed by the conveyor Q4107.
  -One belt conveyor Q4114.
  -The tail sections of two conveyors Q4109 and Q4112.
  -All the required diverter flaps Q4115 and Q4120.
-Two liaison belt conveyors (Q4109 and Q4112) to handle the fertilizer from T.3 to T.1.
-The transfer tower T.1 where are installed:
  -The conveyor Q4109 and Q4112 head section.
  -The conveyor Q4110 and Q4113 tail section.
  -Two maintenance electrical hoist.
  -All the required diverter flaps Q4118 and Q4119.

1.11.3 Phosphate Rock Handling
To avoid dust pollution, unloading equipment is located inside a building made of steel structure and roofed and sided with corrugated asbestos cement sheets.

The building is designed to be dust tight with inlet doors (opening by trucks and automatic shutting).

Inside the building, two parallel and identical unloading stations include:
-One tipper, item X6101, operated by means of hydraulic cylinders.
-One concrete receiving hopper, item V6101, fitted with a grid at the top opening and with flow adjusting gates at the discharge outlet.
The transfer of phosphate rock from receiving hopper up to the storage building is made by mean conveyor system.

1.11.3.1 Conveyor system includes:
Two identical belt conveyors Q6101A/B, located under the receiving hoppers and fed by the hopper discharge gates.
Two belt conveyors Q6102 and Q6103 fed by Q6101A/B and conveying the phosphate up to the top of the storage building.
One built conveyor, of the shuttle type, allowing distributing phosphate in the storage building and according storage possibilities.

1.11.4 Ammonia Unloading
The ammonia necessary for the granulation units imported from abroad by tanker of about 15000 tons of liquid ammonia at minus 32°C.
The ammonia is received at the jetty through unloading flow boom rig able to connect the ammonia ship to 14" pipeline installed between the jetty and storage facilities.

1.12 Boilers
Since auxiliary boilers are the main expected source of dioxins emissions in AIC, they will be discussed in details to evaluate their performance and efficiency. UNEP guidelines will be followed during this assessment.

1.12.1 Summary
Utility and industrial boilers are facilities designed to burn fuel to heat water or to produce steam for use in electricity generation or in industrial
processes. The volumetric concentrations of chemicals listed in Annex C of the Stockholm Convention in the emissions from fossil fuel-fired boilers are generally very low. However, the total mass emissions from the boiler sector may be significant because of the scale of fossil fuel combustion - in terms of both tonnage and distribution - for electricity generation and heat or steam production.

Measures that can be taken to decrease the formation and release of chemicals listed in Annex C include: maintenance of efficient combustion conditions within the boiler and ensuring sufficient time is available to allow complete combustion to occur; undertaking measures to ensure fuel is not contaminated with PCB, HCB or chlorine, and is low in other components known to act as catalysts in the formation of PCDD and PCDF; use of appropriate gas-cleaning methods to lower emissions that may contain entrained pollutants; and appropriate strategies for disposal, storage or ongoing use of collected ash.

PCDD/PCDF air emission levels associated with best available techniques can be significantly lower than 0.1 ng I-TEQ/Nm³ (oxygen content: 6% for solid fuels; 3% for liquid fuels). (UNEP-POPS-BAT/BEP GUIDELINES).

1.12.2 Overview of boilers

Boilers are facilities designed to burn fuel to heat water or to produce steam. The majority of boilers use fossil fuels to provide the energy source, although boilers can also be designed to burn biomass and wastes. The steam produced from the boiler can be used for electricity production or used in industrial processes; likewise hot water can be used in industrial processing, or for domestic and industrial heating.

AIC utility boilers built by BABCOCK & WILCOX GAMA KAZAN
Technologies – Twinkie in 1999 in order to burn the fuel and generate heat. The heat is initially transferred to water to make steam; this produces saturated steam at ebullition temperature, saturated steam which can vary according to the pressure above the boiling water. The higher the furnace temperature; the faster the steam production. The saturated steam thus produced can then either be used immediately to produce power via a turbine, or else may be further superheated to a higher temperature throw a superheater (see Table 1.2); this notably reduces suspended water content making a given volume of steam produce more work and creates a greater temperature gradient in order to counter tendency to condensation due to pressure and heat drop resulting from work plus contact with the cooler walls of the steam passages and cylinders and wire-drawing effect from strangulation at the regulator. Any remaining heat in the combustion gases can then either be evacuated or made to pass through an economizer (see Table 1.3), the role of which is to warm the feed water before it reaches the boiler.

**Table (1.2): FM (HC) 140/97 STEAM BOILER SUPERHEATER DATA SHEET**

<table>
<thead>
<tr>
<th>CODE</th>
<th>ASME SEC. 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>DESIGN PRESSURE</td>
<td>850 psig</td>
</tr>
<tr>
<td>HYDROSTATIC TEST PRESSURE</td>
<td>1275 psig</td>
</tr>
<tr>
<td>STEAM OUTLET PRESSURE</td>
<td>682 psig</td>
</tr>
<tr>
<td>STEAM OUTLET TEMPERATURE</td>
<td>761 F</td>
</tr>
<tr>
<td>STEAM FLOW AT 100% LOAD</td>
<td>22500 lb/h</td>
</tr>
<tr>
<td>S.H TOTAL HEATING SURFACE</td>
<td>1775 sq. ft</td>
</tr>
<tr>
<td>NUMBER OF LOOP</td>
<td>7</td>
</tr>
<tr>
<td>NUMBER OF ELEMENT</td>
<td>25</td>
</tr>
<tr>
<td>NUMBER OF PASS</td>
<td>5</td>
</tr>
<tr>
<td>HEADER O.D &amp; THK.</td>
<td>14&quot; SCH 140</td>
</tr>
<tr>
<td>HEADER MATERIAL</td>
<td>SA 335p11</td>
</tr>
<tr>
<td>TUBE O.D &amp; THK</td>
<td>50.8 * 4.6 mm M.W.T</td>
</tr>
<tr>
<td>TUBE MATERIAL</td>
<td>SA 192 / SA 209T1a / SA 213T22</td>
</tr>
<tr>
<td>PAINTING</td>
<td>N/A</td>
</tr>
<tr>
<td>INSULATION</td>
<td>N/A</td>
</tr>
</tbody>
</table>
There are significant differences between utility and industrial boilers, the major differences occurring in three principal areas:

- Size of the boilers;
- Applications for the steam and hot water produced by the boilers;
- Design of the boilers.

According to above principal areas, AIC boilers are of the utility ones. AIC has two auxiliary boilers of 100 t/h steam generation for each one in utilities plant units, (see Figure 1.3).
Also, due to the high heat generated from sulfur burning in SAP, AIC has two main boilers (shell and tube heat exchangers) of 105 t/h steam generation for each, (see Figure 1.4).
In AIC, utility boilers are large units combusting primarily fuel oil or natural gas at high pressure and temperature. Individual utility boiler types tend to have relatively similar design and fuel combustion technologies. Utility plant facilities are built around the boilers and turbine(s) and their size allows for significant economies of scale in the control of emissions. According to combustion furnace configuration; AIC utilities boilers are of the type (D-shape, wall tube) with temperature of 700-1200°C, and according to the heat transfer systems; AIC utilities boilers are of the type (water tube boilers) in which heat transfer tubes containing water are directly contacted with hot combustion gases. Commonly used in coal-fired installations but can accommodate almost any combustible fuel including oil, gas, biomass, municipal solid waste and tyre-derived fuel. According to UNEP, there are mainly two types of combustion systems: Stokers and Burners, and in case of AIC each boiler has tow burners of the gun type. Burners are devices manage the delivery of air-fuel mixtures into the furnace under conditions of velocity, turbulence and concentration appropriate to maintain ignition and combustion (UNEP), (see Table 1.4).

Table (1.4): FM (HC) 140/97 STEAM BOILER DATA SHEET

<table>
<thead>
<tr>
<th>CODE</th>
<th>ASME SEC. 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>DESIGN PRESSURE</td>
<td>850 psig</td>
</tr>
<tr>
<td>HYDROSTATIC TEST PRESSURE</td>
<td>1275 psig</td>
</tr>
<tr>
<td>DESIGN TEMPERATURE (FOR DRUMS)</td>
<td>527 F</td>
</tr>
<tr>
<td>STEAM OUTLET PRESSURE</td>
<td>682 psig</td>
</tr>
<tr>
<td>STEAM OUTLET TEMPERATURE</td>
<td>761 F</td>
</tr>
<tr>
<td>STEAM FLOW AT 100% LOAD</td>
<td>2205000 lb/h</td>
</tr>
<tr>
<td>TOTAL HEATING SURFACE OF BOILER (BLR.+FURN)</td>
<td>9617 sq. ft</td>
</tr>
<tr>
<td>TOTAL WEIGHT OF BOILER (EMPTY)</td>
<td>3330000 lb</td>
</tr>
<tr>
<td>PAINTING</td>
<td>YES</td>
</tr>
<tr>
<td>INSULATION</td>
<td>YES</td>
</tr>
</tbody>
</table>
1.12.3 Generation of PCDD/PCDF:
In a properly operated combustion system, volatiles should be subjected to sufficient time at high temperature, with adequate oxygen and mixing, to enable uniform and complete combustion. When those conditions are not present the potentially toxic airborne emissions polychlorinated dibenzo-p-dioxins (PCDD), polychlorinated dibenzofurans (PCDF), polychlorinated biphenyls (PCB) and hexachlorobenzene (HCB) can be produced in or survive the combustion process (Van Remmen 1998; UNEP 2005).
Effect of fuel types on generation of emissions

Fuel oil properties:

Fuel oil is used in AIC boilers. Fuel oil is one of the six groups extracted from crude oil. The fuel oil used in AIC is of the type known BUNKER or N6, diesel oil or N2 used also.

Generally petroleum consists of C, H, O, N, and S. So according to C : H ratio we have different types of fuel.

Main properties affected fuel oil used in boilers can be summarized as follows:

-specific gravity:
  SG for all fuel types ranges between 0.8-0.98. It is known as SG decreases, the heating value of the fuel increases.
  Fuel oil heating value = 17645*DEG API.
  DEG API is specific gravity of petroleum.
  DEG API= (141.5/SG at 60 F)-131.5

-Pour point:
  Pour point is important to know conditions of fuel feeding and flow.

-Viscosity:
  It is known that as fuel oil viscosity decreases, it becomes easier to flow and as fuel oil temperature increases viscosity decreases.

-Flash point:
  Flash point is the temperature at which fuel oil evaporates enough to fire in presence of ignition source.

-Fire Point:
  Fire point is the temperature at which fuel oil firing . This point affected
by air pressure mixed with fuel, air velocity, furnace properties, turbulence, and fuel oil type.

**Combustion process:**

Combustion is a chemical process in which C and H in fuel oil react with O₂ to release heat.

\[
\begin{align*}
C + O_2 & \rightarrow CO_2 + \text{heat (complete reaction)} \\
C + \frac{1}{2}O_2 & \rightarrow CO + \text{heat (incomplete reaction)}
\end{align*}
\]

Firing 1 lb of carbon releases 4380 BTU.

\[
\begin{align*}
H_2 + O_2 & \rightarrow H_2O + \text{heat}
\end{align*}
\]

Firing 1 lb of hydrogen releases 61100 BTU.

Combustion process can be summarized as follows:

<table>
<thead>
<tr>
<th>Dry Air</th>
<th>Fuel Oil</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>O₂</td>
<td>C</td>
<td>CO₂</td>
</tr>
<tr>
<td></td>
<td>H</td>
<td>CO</td>
</tr>
<tr>
<td>N₂</td>
<td>S</td>
<td>SO₂</td>
</tr>
<tr>
<td>H₂O</td>
<td>N</td>
<td>N₂</td>
</tr>
<tr>
<td></td>
<td></td>
<td>H₂O vapor</td>
</tr>
</tbody>
</table>

To reach complete combustion; it is very important to keep sufficient amount of O₂ during the process. Also excess air used to reach complete combustion which usually ranges between 5% - 20% in case fuel oil is used.
in boilers. Amount of excess air can be calculated by analyzing the gas stream emissions to reach minimum percentage of CO₂ in gas stream. Combustion process can be controlled through three Ts Rules: (Turbulance, Temperature, and Time).

Reviewing the operating conditions of the boilers, special attention should be paid to the following regions in the furnace (see Figure 1.6):

1- Inlet fuel with atomizing steam which is entering the furnace at 200°C.
2- Economizer in which temperature about 420°C.
3- Superheater where outlet steam reaches 405°C and 45 bar.

![Figure (1.6): ACI Control Startup Boiler](image)

At AIC the following was calculated:

Each ton of fuel oil gives 13 tons of steam at 405°C and 45 bar. Also each ton of steam gives 1 MW.

The fossil fuels – coal, oil and gas – are used, either individually or in combination with energy - containing fuels from other processes, for steam
generation in boilers. The type of fuel used depends on fuel availability and process economics.

AIC uses heavy fuel oil, diesel, and ready to use natural gas as fuels in boilers, and these types of fuels are generally result in low levels of organic emissions.

1.12.4 Estimation of emissions of persistent organic pollutants from boilers:
AIC uses both heavy fuel oil and diesel in its boilers to generate power.

Heavy Oil consumption = 32000 ton/year * 1000 kg/ton
= 32000000 kg/year

From Table 96 (Heating values for oil, page 231, PCDD/PCDF Toolkit 2005):
Heavy fuel oil heating value: 40 – 43 MJ/kg
Taking average value: 41.5 MJ/kg
Activity Rate = 41.5 MJ/kg * 32000000 kg/year
= 1328000000 MJ/year

Source Strength (for air) = Emission Factor * Activity Rate
= 2.5 µg TEQ/TJ * 10^-6 TJ/MJ * 1328000000 MJ/year
= 3320 µg TEQ/year

Diesel consumption = 3640 ton/year * 1000 kg/ton
= 3640000 kg/year

From Table 96 (Heating values for oil, page 231, PCDD/PCDF Toolkit
Light fuel oil/ Diesel fuel heating value: 43 – 46 MJ/kg
Taking average value: 44.5 MJ/kg
Activity Rate = 44.5 MJ/kg * 3640000 kg/year
= 161980000 MJ/year
Source Strength (for air) = Emission Factor * Activity Rate
= 0.5 µg TEQ/TJ * 10^{-6} TJ/MJ * 161980000 MJ/year
= 80.99 µg TEQ/year

The above calculations were made for the year 2008.

1.13 Pollution Control System
JPMC gas emissions and liquid and solid wastes from each unit in the industrial complex can be summarized as follows:

1.13.1 Gas Emissions:
1.13.1.1 PAP Gaseous Emissions:
The most important emission source in the typical wet process is the ventilating air from the digester. The vent gases contain water vapour, particulate dust, and fluorides. Fluoride emissions include HF and SiF4 which is favoured at temperatures below 1000°C [Nyers 1979]. It must be noticed that operating temperatures are 76-78°C. Therefore, increasing
levels of SiF4 are expected. Furthermore, hydrolysis of SiF4 in the scrubbers will lead to the formation of a gelatinous deposit of polymeric silica, which tends to plug the scrubber pickings (USEPA, 1973), installed at the stacks. Two stacks of 47 m are used to dispose the effluent emissions to the outside environment.

1.13.1.2 SAP Gaseous Emissions:
The sulfuric acid plant has two principal air emissions: SO₂, SO₃, and acid mist, produced in the packed column absorbers. Added to that, there will be particulates in air emissions which may contain heavy metals that existed in elemental sulfur as impurities. Also, minor amounts of H₂S may be expected. The gases are transported to the ambient air through a 55 m stack. A double contact process and a brink mist eliminator are used to control the emissions.

1.13.1.3 AFP Gaseous Emissions:
SOₓ, NOₓ, CO, and CO₂ gases are expected due to diesel burning. HF and dust are expected produced in the drying and crystallization units. All emissions are passed through bag filters, cyclones, and wet scrubbers leading to a 60 m stack.

1.13.1.4 DAP Gaseous Emissions:
The emissions from this unit arise mainly from the reactor and granulator. These emissions include gaseous NH₃ and HF. It is caused by the volatilization due to incomplete chemical reactions and excess free ammonia. Also, fluoride and V₂O₅ emissions due to the dissociation of the fertilizer product, and particulate emissions due to the DAP dust entrainment
in the ventilation air streams; are expected. Added to that; $\text{SO}_x$, $\text{NO}_x$, $\text{CO}$, and $\text{CO}_2$ gases are expected due to heavy fuel oil combustion in the burner. All emissions are passed through a combination of dry and wet scrubbers connected to a 43 m high stack.

Three collecting systems are supplied for ventilation and scrubbing in DAP:
- The reactor-granulator scrubbing system.
- The dryer scrubbing system.
- The cooler dust-vent collecting and scrubbing system.

A large part of the dust entrained in the gases entering the dryer cyclone and the cooler dust vent cyclone is recovered by the cyclones and discharged from each cyclone hopper through an air lock to the recycle conveyor. The fine dust particles remaining in the gases are then vented to the scrubbing system for removal. The dust, fumes, and water vapor from the recycle feed tank, reactor, and granulator scrubbing system.

Each vent system consists of a venturi-cyclonic scrubber the gases are scrubbed with phosphoric acid to assure capture of the free ammonia and dust.

The weak scrubbing acid is below-down to process.

All other contaminated water steams in the plant are connected in an accumulation system and returned to the process. Typical wet scrubber system used shown in Figure (1.7).
1.13.1.5 Utility Gaseous Emissions:

SO\textsubscript{x}, NO\textsubscript{x}, CO, and CO\textsubscript{2} gases are expected due to heavy fuel oil burning in the steam generation unit.

The term wet scrubber describes a variety of devices that remove pollutants from a furnace flue gas or from other gas streams. In a wet scrubber, the polluted gas stream is brought into contact with the scrubbing liquid, by spraying it with the liquid, by forcing it through a pool of liquid, or by some other contact method, so as to remove the pollutants.

The design of wet scrubbers or any air pollution control device depends on the industrial process conditions and the nature of the air pollutants involved.

Inlet gas characteristics and dust properties (if particles are present) are of primary importance. Scrubbers can be designed to collect particulate matter
and/or gaseous pollutants. Wet scrubbers remove dust particles by capturing them in liquid droplets. Wet scrubbers remove pollutant gases by dissolving or absorbing them into the liquid.

Any droplets that are in the scrubber inlet gas must be separated from the outlet gas stream by means of another device referred to as a mist eliminator or entrainment separator (these terms are interchangeable). Also, the resultant scrubbing liquid must be treated prior to any ultimate discharge or being reused in the plant.

Table (1.5) summarizes AIC gas emissions and pollution control devices.

<table>
<thead>
<tr>
<th>Industrial process</th>
<th>Raw materials</th>
<th>Gas Emissions</th>
<th>Treatment Devices</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTILITIES</td>
<td>water(fresh, sea, reclaimed), heavy fuel oil, diesel oil</td>
<td>SOx, NOx, CO, CO2</td>
<td>No treatment device</td>
</tr>
<tr>
<td>PAP</td>
<td>Phosphate rock</td>
<td>H2O vapour</td>
<td>De-dusting unit</td>
</tr>
<tr>
<td></td>
<td>sulfuric acid (98.5%)</td>
<td>particulate dust</td>
<td></td>
</tr>
<tr>
<td></td>
<td>water</td>
<td>Florides (HF, SiF4)</td>
<td>Scrubbing system</td>
</tr>
<tr>
<td>SAP</td>
<td>sulfur</td>
<td>SO2, SO3, H2S</td>
<td>double contact double absorption unit</td>
</tr>
<tr>
<td></td>
<td>Steam</td>
<td>Acid mist, particulate</td>
<td>Acid mist eliminator</td>
</tr>
<tr>
<td>AFP</td>
<td>aluminum hydroxide</td>
<td>SOx, NOx, CO, CO2</td>
<td>Cyclone</td>
</tr>
<tr>
<td></td>
<td>fluorsilisic acid</td>
<td>HF</td>
<td>Scrubber</td>
</tr>
<tr>
<td></td>
<td>diesel</td>
<td>Dust</td>
<td>Bag filter</td>
</tr>
<tr>
<td>DAP</td>
<td>phosphoric acid (49%)</td>
<td>Gaseous ammonia</td>
<td>Ventury, cyclonic scrubber, gas scrubber</td>
</tr>
<tr>
<td></td>
<td>anhydrous ammonia (99.5%)</td>
<td>Florides</td>
<td>Cyclone</td>
</tr>
<tr>
<td></td>
<td>heavy fuel oil</td>
<td>SOx, NOx, CO, CO2</td>
<td></td>
</tr>
</tbody>
</table>

1.13.2 Industrial Liquid Wastes:

1.13.2.1 PAP Industrial liquid wastes:

The main source of industrial wastewater is due to the wash water of gaseous emission treatment scrubbers. The scrubbing water is treated using caustic soda. It is either recycled to other units or disposed in the main effluent line to the evaporation lagoons within the same complex. Recycled
scrubbing water is used as fluorosilisic acid (22 %) in the aluminum fluoride unit within the same complex.

1.13.2.2 SAP Industrial Liquid Waste:
Hot sea water from the heat exchanger is dumped back to the sea. Added to that, steam condensate containing dissolved H₂S and SO₂ gases is recycled back to the utilities unit to be cooled and reused.

1.13.2.3 AFP Industrial Liquid Waste:
Excess water from the crystallization unit is either disposed to the main effluent channel to the evaporation pond or recycled to the phosphoric acid unit for reuse. Added to that, scrubbing water from the main stack is disposed to the main effluent channel.

1.13.2.4 DAP Industrial Liquid Waste:
The only source is the washing water from the scrubbers installed at the stack. It is usually mixed with diluted phosphoric acid and make-up water and recycled to the scrubbers.

1.13.3 Solid Wastes
1.13.3.1 PAP Industrial solid waste:
The main source of solid waste produced by this process is gypsum which is collected manually and transported by conveyer belts to an assigned dump land behind the complex. Gypsum is produced at a rate of 2 million t/a. Added to that, dust production is apparent at the loading and
unloading as well as the transportation of phosphate rock through the complex from the warehouse to the process.

1.13.3.2 SAP industrial solid Waste:
Elemental sulfur dust is the main waste through the transporting belts as well as at the unloading and loading stations. Another type of solid waste is the impurities produced at the filter unit (filter cake) of melted sulfur. It is disposed at the gypsum dump behind the complex.

1.13.3.3 AFP Industrial Solid Waste:
Silica constitutes the main source of solid waste produced and disposed in the gypsum dump.

1.13.3.4 UTILITIES industrial Solid Waste:
One main source of solid waste is the domestic sludge resulting from the wastewater treatment plant. It is usually dumped in the mentioned gypsum dump. Added to that, slag and asbestos are produced due to boiler maintenance. Amounts are unknown.

1.13.4 Results of Monitoring Programs
AIC has external and internal monitoring programs including environmental, occupational health, and safety aspects. Monitoring programs and major environmental projects will be discussed in chapter 2. Internal program concerns of: air quality from stationary sources, indoor noise and well water. While the external program concerns of air quality from stationary sources, air quality at working environment areas, and coastal marine environment.
During the assessment, the results of external and internal monitoring program were reviewed for the last two years ((2009 and 2010). All of these results are shown in Annex (1).
Following are the main conclusions of this review:

1.13.4.1 Internal Monitoring Program
1.13.4.1.1 Air quality results
Company conducts quarterly measurements of NH₃ emissions from DAP plants, F⁻ emissions from phosphoric acid plant and aluminum fluoride plant and SO₃ and acid mist emissions from sulfuric acid plants. The results are summarized in the following figures. All the results comply with the Jordanian Standards (JS: 1189/2006) except of ammonia which much more above the standard limits.
Figure (1.8): Results of NH3 emissions measurements conducted by JPMC environmental division at DAP plant U75 (2009 -2010)
Figure (1.9): Results of F- emissions measurements conducted by JPMC environmental division at DAP plant U75 (2009 -2010)
Figure (1.10): Results of F- emissions measurements conducted by JPMC environmental division at DAP plant U76 (2009 -2010)
Figure (1.11): Results of SOx emissions measurements conducted by JPMC environmental division at SAP plant U53 (2009 -2010)

Figure (1.12): Results of SOx emissions measurements conducted by JPMC environmental division
**1.13.4.2 External Monitoring Program**

**1.13.4.2.1 Air quality results**

Company hired external consultant – JUST and RSS – to conduct some measurements three times a year. The results shown in Annex 1 revealed that stacks emissions from the boilers A and B comply with IS: 1189/1999. In addition, the dust emitted from phosphate unloading station and phosphate mill stacks are within Jordanian standards due to the new dust control system built in 2008. High levels of F- at the area of cooling tower of the phosphoric acid plant are observed most of the monitoring times. High level of NH₃ emissions in DAP during the assessment was observed. These exceedances will be reduced to less than 50 ppm when the new scrubbing system finished this year with estimated coast of 28 million dollars.

**1.14 Proposal for BAT/BEP Implementation Plan**

**1.14.1 What is BAT/BEP?**

The “best available technologies” BAT are technologies, treatment techniques, or other means that found to be the most effective in preventing and/or reducing pollution and impact to the environment, after verification or evaluation for efficacy, and are available taking into account cost considerations. ‘Technologies’ include both the technology used and the way in which the installation is designed, built, maintained, operated, and decommissioned. ‘Available’ technologies means those developed on a scale which allows implementation in the relevant industrial sector, under economically and technically applicable conditions, taking into
consideration the costs and advantages, whether or not the technologies are used or produced inside the country as long as they are reasonably accessible to the adopter. ‘Best’ means most effective in achieving a high general level of protection of the environment as a whole.

“Best environmental practices” BEP are proven methods and techniques that enable effective technology applications and materials end uses under certain conditions to reduce wastes and control pollution. ‘Practices’ refer to ways of performing operational activities – either materials sourcing, processing, product manufacturing, or direct end-use applications – and to methods that help create products that meet customer needs. The BAT/BEP presented in this assessment demonstrates technology, detailed procedures (EMS), and to general practices applicable to the boilers.

### 1.14.2 Best Available Technologies BAT

#### 1.14.2.1 Boiler Enclosure

Principle of the Technology:

Boilers in AIC are used to generate steam and power that are used in all complex units. They consist of a number of tubes for either water or fire, which carry the water-steam mixture through the furnace for maximum heat transfer. These tubes run between steam-distribution drums at the top of the boiler and water-collecting drums at the bottom of the boiler. Steam flows from the steam drums to the super-heater before entering the steam-distribution system. Conventionally, the boilers do not have insulation or enclosures. This leads to heat losses, and hence, lower steam generation, and this leads to more fuel consumption.

Boiler enclosures or jackets are installed externally on the boiler for heat
conservation, maintenance of operating temperatures, and protection of personnel. Suitable insulation materials such as mineral wool, calcium silicate, or urethane foam, are used for boiler enclosures. The use of boiler enclosures improves the efficiency of steam generation by up to 5 percent. It also reduces external noise pollution and maintenance costs. This is already applicable to AIC boilers, but should be subjected to maintenance program.

1.14.2.2 Natural gas use as a fuel in boilers instead of fuel oil

Natural gas is one of the major combustion fuels used throughout the world. It is mainly used to generate industrial and utility electric power, produce industrial process steam and heat, and heat residential and commercial space. Natural gas consists of a high percentage of methane (generally above 85 percent) and varying amounts of ethane, propane, butane, and inerts (typically nitrogen, carbon dioxide, and helium). The average gross heating value of natural gas is approximately 1020 British thermal units per standard cubic foot (Btu/scf), usually varying from 950 to 1050 Btu/scf.

There are three major types of boilers used for natural gas combustion in commercial, industrial, and utility applications: water-tube, fire-tube, and cast iron. Water-tube boilers are designed to pass water through the inside of heat transfer tubes while the outside of the tubes is heated by direct contact with the hot combustion gases and through radiant heat transfer. The water-tube design is the type uses in JPMC in utility and large industrial boilers (SAP). Water-tube boilers are used for a variety of applications, ranging from
providing large amounts of process steam, to providing hot water or steam for space heating, to generating high-temperature, high-pressure steam for producing electricity. Furthermore, the emissions from natural gas-fired boilers and furnaces include nitrogen oxides (NO\textsubscript{x}), carbon monoxide (CO), and carbon dioxide (CO\textsubscript{2}), methane (CH\textsubscript{4}), nitrous oxide (N\textsubscript{2}O), volatile organic compounds (VOCs), trace amounts of sulfur dioxide (SO\textsubscript{2}), and particulate matter (PM) are less than those produced from fuel oil.

1.14.2.3 Scrubbing system

According to this assessment, techniques, and as far as possible emission and fuel consumption levels associated with the use of BAT, are presented here that are considered to be appropriate to the boilers as a whole and in many cases reflect current performance of some installations within this sector of industry. Where emission or fuel consumption levels ‘associated with best available techniques’ are presented, this is to be understood as meaning that these levels represent the environmental performance that could be anticipated as a result of the application, in this sector, of this technique, bearing in mind the balance of costs and advantages inherent within the definition of BAT.

1.14.3 Best environmental practices- BEP:

High amounts of steam and condensate from different places are expelled because of leaks, corrosion, venting or improper maintained steam traps, so a steam and water saving plan should be implemented. This will lead to good savings in raw materials (i.e. fuel) by adopting good maintenance program.
Boilers efficiency (excess air) should be routinely checked and the online gas analyzer should be maintained for stack gas monitoring.

The best environmental practices described below could be applicable to AIC boilers, with efficient way and lead to great savings in energy:
- Identify key process parameters, either from site-specific investigations or research undertaken on similar facilities elsewhere. These can be summarized in terms of:
  1- Combustion quality as indicated by: Carbon monoxide (CO), total hydrocarbons, soots formation, Particle entrainment and burnout.
  2- Air pollution control temperatures.
  3- Fuel/waste parameters: Sulfur; Metals; Chlorine.
- Introduce measures that enable control of key process parameters;
- Introduce monitoring and reporting protocols for key process parameters;
- Introduce and follow planning cycles, implement appropriate inspection and maintenance cycles;
- Introduce an environmental management system that clearly defines responsibilities at all levels. this is already found by ISO14001;
- Ensure adequate resources are available to implement and continue best environmental practices;
- Introduce process improvements to reduce technical bottlenecks and delays;
- Ensure all staff is appropriately trained in the application of the best environmental practices relevant to their duties;
- Define a fuel specification for key fuel parameters and introduce a monitoring and reporting protocol;
- Ensure the environmentally sound management of fly ash, coarse ash and
flue gas treatment residues.
The assessment at JPMC showed high potentials for reducing environmental problems in different process plants, especially regarding huge losses of raw materials and energy. Also inappropriate housekeeping in the different plants was observed.
However assessment showed that the company does not lack technical knowledge and expertise. The production and process staff at JPMC are experienced and understand the complex processes perfectly.

1.14.4 What to do for Pollution Prevention and Control in industrial complex:

In AIC the major source of potential pollution is solids—from spills, operating upsets, and dust emissions. It is essential that tight operating procedures be in place, and that close attention be paid to constant cleanup of spills and other housecleaning measures. Product will be retained, the need for disposal of waste product will be controlled, and potential contamination of storm water runoff from the property will be minimized.
Minimize the discharge of sulfur dioxide from sulfuric acid plants by using the double contact double absorption process with high efficiency mist eliminators which is used in AIC boilers. Prevent spills and accidental discharges through well bund storage tanks, installing spill catchments and containment facilities, good housekeeping and maintenance practices.
In the phosphoric acid plant, minimize emissions of fluorine compounds from the digester/reactor by scrubbers that are well-designed, well-operated, and well-maintained. Again, design for spill containment is essential to avoid inadvertent liquid discharges. Maintain an operating water balance to
avoid an effluent discharge.
The management of phosphogypsum tailings is a major problem because of the large volumes and large area required, and the potential for release of dust and radon gases, and fluorides and cadmium in seepage. The following will help to minimize the impacts:
- Maintain a water cover to reduce radon gas release and dust emissions.
- Where water cover cannot be maintained, keep the tailings wet or revegetate to reduce dust. (The revegetation process, however, may increase the rate of radon emissions.)
- Line the tailings storage area to prevent contamination of groundwater by fluoride.
- Where contamination of groundwater is a concern, a management and monitoring plan should be implemented.
- Phosphogypsum may find a use in the production of gypsum board for the construction industry.

1.14.4.1 Target Pollution Loads

Implementation of cleaner production processes and pollution prevention measures can provide both economic and environmental benefits. The following production-related targets can be achieved by measures. The numbers relate to the production processes before the addition of pollution control measures.

In the sulfuric acid plant using the double contact, double absorption process, emission levels of 2-4 kilograms of sulfur dioxide per metric ton (kg/t) of sulfuric acid can be achieved, and sulfur trioxide levels in the order
of 0.15-0.2 kg/t H₂SO₄ are attainable.
The following primary measures are considered to be the most critical in avoiding the formation and emission of PCDD/F from boilers stacks:
- Quick cooling of boilers exhaust gases to lower than 200°C.
- Monitoring and stabilization of critical combustion parameters, i.e. homogenous raw mix and fuel feed, regular dosage and excess oxygen.
A smooth and stable combustion process, operating close to the process parameter set points, is beneficial for all boilers emissions as well as for the energy use. This can be obtained by applying:
- Process control optimization, including computer-based automatic Control systems, which are already implemented in AIC;
- The use of modern fuel feed systems.
- Minimizing fuel energy use.
- Careful selection and control of fuel type with low contents of sulfur, nitrogen, chlorine, metals and volatile organic compounds entering the boiler can reduce emissions.

1.14.4.2 Treatment Technologies

Scrubbers are used to remove fluorides and acid from air emissions. The effluent from the scrubbers is normally recycled to the process. If it is not possible to maintain an operating water balance in the phosphoric acid plant, then treatment to precipitate fluorine, phosphorous, and heavy metals may be necessary. Lime can be used for treatment. Spent vanadium catalyst is returned to the supplier for recovery or, if unavailable, then locked in to a solidification matrix and disposed in a secure landfill.
There may be opportunities to use gypsum wastes as soil conditioner (for
alkali soil and soils that are deficient in sulfur) and this should be explored so that the volume of the gypsum stack can be minimized.

1.14.4.3 Emission Guidelines

All of the maximum levels should be achieved for at least 95% of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours.

1.14.4.4 Air Emissions

The emission requirements and standards (JS 1140/2006 and JS 1189/2009) can be consistently achieved by well-designed, well-operated and well-maintained pollution control systems.

1.14.4.5 Monitoring and Reporting

Fluoride and particulate emissions to the atmosphere from the fertilizer plant should be monitored continuously. In the sulfuric acid plant, sulfur dioxide and acid mist in the stack gas should be monitored continuously. Liquid effluents should be monitored continuously for pH. All other parameters may be monitored on a monthly basis. Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken. Records of monitoring results should be kept in an acceptable format. These should be reported to the responsible authorities (ASEZA and relevant parties), as required.
For land storage of phosphogypsum, the following monitoring parameters and frequency are recommended for the stack drainage and runoff: continuously for pH; daily for fluorides; and monthly for phosphorous, sulfates, and gross alpha particle activity.

1.14.4.6 Key Issues

The following summarizes the key production and control practices that will lead to compliance with emission requirements:
- Achieve the highest possible sulfur conversion rate and use the double contact double absorption process for sulfuric acid production.
- Consider the use of phosphogypsum to produce gypsum boards for the construction industry
- Design and operate phosphogypsum disposal facilities to minimize impacts.
- Maximize product recovery and minimize air emissions by appropriate maintenance and operation of scrubbers and baghouses.
- Eliminate effluent discharges by operating a balanced process water system.
- Prepare and implement an Emergency Preparedness and Response Plan.
An effective Emergency Preparedness and Response Plan is required for the plant because of the large quantities of sulfuric and phosphoric acids and other hazardous materials stored and handled on site.
The implementation of BAT/BEP could be more difficult, but if properly applied it could lead to significant reductions on PCDD/PCDF releases.
CHAPTER 2

ENVIRONMENTAL & HEALTH ASSESSMENT
2.1 Summary

Air quality assessment is frequently driven by the need to determine whether a standard or guideline has been exceeded. This overshadows another objective of air quality assessment: providing the information needed to estimate population exposure to air pollution and the effects on the health of the population. Consequently, most existing air quality monitoring systems do not fully address population exposure to toxic air pollution. Given the importance of these data for air quality management,

Human exposure to air pollution may result in a variety of health effects, depending on the types of pollutants, the magnitude, duration and frequency of exposure and the associated toxicity of the pollutants of concern. People are exposed to air pollutants both indoors and outdoors depending on the activities of individuals. It is important to assess the exposure levels of different population groups, especially sensitive or susceptible individuals such as children, elderly people and chronically ill people. Health impact assessment combines estimates of population exposure with information on toxicity or the relationship between exposure and response.

Information on the relationship between exposure and response is necessary to estimate the potential health risks.

The estimates of health effects for a population base are typically calculated in terms of predicted excess negative health effects (such as increases in hospital admissions or mortality) caused by exposure to a certain level of air pollution. This involves combining the information on the response to certain concentrations derived from epidemiological or toxicological studies with the number of people exposed to each concentration of air pollution in the community being assessed.
2.2 Background

Persistent organic pollutants (POPs) are those chemicals that are not materially broken down over a reasonable period of time, usually measured in decades or more. The POPs of most concern are those that build up in the environment or are bioaccumulated and/or biomagnified in the food chain. The chemical characteristics of POPs are relatively similar. Many are polyhalogenated aromatic hydrocarbons (PHAHs), or other polycyclic aromatic hydrocarbons (PAHs) that are very slowly metabolized or otherwise degraded. The chemicals are lipid soluble; hence they are stored in the fatty tissue of all animals, and they build up in the food chain. Some classic examples of POPs are the pesticides DDT, Dieldrin, Aldrin, Heptachlor, Mirex, and Kepone. Another group of POPs are the chlorodibenzodioxins, dibenzofurans, and some PCBs.

The health effects of these chemicals, as neat compounds, have been very well studied. However, low-dose, lifetime exposure studies are lacking. The dioxins and benzo furans are highly toxic and are extremely persistent in the human body as well as the environment.

International efforts to minimize exposure to these compounds include the banning of their use except in emergency situations where it has been determined that no other chemical is efficacious. With the exception of DDT, few, if any, of these compounds have been authorized for use. PCBs, which were widely used in capacitors, transformers, and lubricating oils, have not been manufactured for several decades but linger in the environment. Chlorinated dibenzodioxins and dibenzofurans were never products per se, but are byproducts of products made from chlorophenols. The processes by
which these final products are manufactured have been altered to minimize the unwanted dioxins. The other source of dioxins is the chlorine bleaching of paper pulp. This bleaching process has been altered to eliminate chlorine, and thereby to eliminate the possibility of dioxins. Several combustion processes also result in the formation of dioxins and benzofurans. Municipal and chemical waste incinerators can be sources of these unwanted by-products. Engineering controls have been put in place in modern facilities to minimize production. However, older and less controlled processes may continue to contaminate the environment.

AIC steam generation boilers had been examined during this assessment including the environmental situation, occupational health, and emergency response plan. Four on-site and sex off-site sampling points were determined to take and analyze samples to be the baseline of BAT/BEP implementation plan.

2.3 On-site sampling points

Based on the Annex C POPs inventory developed specifically for the coastal zone of Aqaba in the first stage of this project, boilers of industrial sector were selected to be assessed as the main source of UP-POPs and the locations of high priority for BAT/BEP implementation plan, in where meaningful release reduction should be achieved.

Table (2.1) shows the main sources of pollutants in the industrial zone.

<table>
<thead>
<tr>
<th>The company</th>
<th>No. of Stacks</th>
<th>Stack Location Coordinates</th>
<th>Stack Height (m)</th>
<th>Stack Diameter (m)</th>
<th>Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utility</td>
<td>2</td>
<td>X 303233.879, Y 251919.450</td>
<td>86</td>
<td>1.75 - 2.1</td>
<td>SO\textsubscript{X}, NO\textsubscript{X}, CO</td>
</tr>
</tbody>
</table>
In this study, JPMC is selected to be assessed and implement BAT/BEP strategic plans for reduction of UP-POPs, since it is the main polluter in the southern industrial zone. JPMC has many pollution sources (i.e. emissions, liquids, and solids) and since the formation of UP-POPs is a function of temperature, boilers are the only source of UP-POPs formation, so boilers stacks emissions will be monitored and sampled. It should be noted that the probability of UP-POPs formation in the other processes in JPMC is negligible since the appropriate formation temperature of UP-POPs is not
reached (250 °C – 450 °C).

Sampling points will be at the exit gas stream of boilers stacks (four sampling points) since UP-POPs are emitted to the atmosphere through a gas stream of several pollutants (eg. SO₃, NO₅, CO₂, etc.).

Figure (2.1) shows two utilities boilers stacks. Figure (2.2) shows two SAP boilers stacks.

![Figure (2.1): Utilities Boiler Stacks](image-url)
2.4 Off-site sampling points

2.4.1 Topography

The Gulf of Aqaba is 180 kilometers long and 14-26 kilometers wide with an average depth of around 800 meters. The Gulf represents the southern extension of the Syrian-African Rift, which reaches the Gulf region after passing through the Jordan River Valley, the Dead Sea and Wadi Araba Desert. Mountain ridges with varying elevations, some above 1600 meters surround the Gulf region. These mountain ridges are interrupted by a series of intermittent valleys of various widths. This topography is thought to be responsible for creating wind channels that are responsible for the behavior of wind speed and wind direction especially in the vicinity of the shorelines.

2.4.2 Climatology
The weather in Aqaba is generally hot and dry. The information below concerning ambient temperature, relative humidity, wind speed and wind direction were extracted from a long-term study that was conducted by RSS during the period (Dec. 2000-Jan. 2002) at Ad Derra Area, near the Jordanian-Saudi borderline. The study showed that the maximum monthly average of temperature was 36°C during the months of July and August, while the minimum was 17°C. Daily average temperature ranged between 14°C and 37°C, while the maximum hourly temperature reached a value of 46°C.

Regarding the relative humidity, the maximum monthly average was 49% in October, while the minimum was 33% in June. Daily average of relative humidity ranged between 16% and 72%, while the maximum hourly average reached a value of 90%.

The prevailing wind direction was northwest with a percentage of 29%, followed by north wind with a percentage of 21%. Thus wind originating from the north accounts for more than 50% of wind originating from all different directions. Wind speed with values of 5-10 knots prevailed with a percentage of 37%, followed by wind speed of 2-5 knots with a percentage of 32%, Figure (2.3).

Selection of the appropriate locations for ambient air quality monitoring is of utmost importance to assure that the data generated is representative of the region or area to be investigated.
2.4.3 Methodology

The off-site selection process for sampling points in Aqaba took into account the following different areas of Aqaba:

- Populated areas; especially the heavily populated ones so as to account for the maximum population exposure sites, regardless of the air pollution source type or size.

- Areas affected by air pollution resulting from the industrial activities that take place in Aqaba Southern Industrial Zone. These areas will
include areas located south of the industrial zone to account for air pollution concentrations transported by the prevailing north wind. In addition, they will include areas located to the north/northwest of the industrial zone to account for air pollution transported by south/southeast wind to the nearby touristic/populated areas.

The off-site sampling points selection process depends primarily on the purpose of the air quality-monitoring program, since the UP-POPs are carried by gaseous pollutants stream (i.e. CO₂, SOₓ, NOₓ, etc.). For example, if the purpose of the samples is to assess the public exposure to air pollution levels, then the siting of the monitoring station should be in a populated area influenced by air pollution source(s) in addition to a station outside that area for monitoring background levels. In general, the number and location of monitoring sites depend on type of pollutant, size of area, and population density, and is affected by the complexity and topography of that area.

The European Union Directive (96/62/EC) on ambient air quality assessment and management states the need for establishing long-term air quality objectives that include protection of human health and the environment, in addition to assessment of air quality against limit values. It also states the need for specifying the location and number of sampling points for air quality monitoring. The EU Daughter directives (99/30/EC, 2000/69/EC, 2002/3/EC) specify criteria for site selection for different pollutants taking into account macro-scale siting considerations. These directives were followed during the work of site selection as much as possible through applying the following macro-scale siting considerations:
• Sampling points directed to the protection of human health should be sited to provide data on the areas within zones where the highest concentrations occur to which the population is likely to be directly or indirectly exposed for a period which is significant in relation to the averaging period of the limit value(s).
• Sampling points should be sited to provide data on levels in other areas within zones, which are representative of the general population.
• Sampling points should in general be sited to avoid measuring very small microenvironments in their immediate vicinity.

2.4.4 Sites Selected
The following table and map show the selected sites for air quality monitoring in Aqaba Special Economic Zone (ASEZ) for both fixed station and mobile laboratory. Below is a description of these selected sites.

<table>
<thead>
<tr>
<th>No.</th>
<th>Site</th>
<th>Coordinates (UTM)</th>
<th>Altitude (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Aqaba Marine Park / Northern Parking Area</td>
<td>0691702 3257477</td>
<td>17</td>
</tr>
<tr>
<td>2</td>
<td>Tala Bay/Southern Border</td>
<td>0691988 3254695</td>
<td>26</td>
</tr>
<tr>
<td>3</td>
<td>Civil Defense Dept./ Ad Derra</td>
<td>0691011 3249506</td>
<td>28</td>
</tr>
<tr>
<td>4</td>
<td>Site South of Industrial Zone</td>
<td>0691467 3249491</td>
<td>28</td>
</tr>
</tbody>
</table>

Table (2.2): Coordinates and Altitudes of Sites Selected for Off-site sampling points in Aqaba Special Economic Zone (ASEZ)
2.4.4.1 Aqaba Marine Park:
This site is located along the highway connecting Aqaba city to southern industrial zone, around 300 meters east of coastline and around 300 meters west of the highway. It is a representative touristic site that will enable assessment of air pollution levels that might be caused by pollutants plume that may reach the area from the industrial zone (see Figure 2.4 below).

![Figure (2.4): Aqaba Marine Park](image)

2.4.4.2 Tala Bay:
This site was proposed as it represents a touristic village. The village is situated around 3 km to the north of the southern industrial zone, and it will be the first touristic/populated area to be exposed to air pollution that may reach the area from the industrial zone in case of south wind. The site chosen for monitoring will be in the southern part of the Bay (see Figure 2.5).
2.4.4.3 Civil Defense Department

This site is located at Ad Derra Area southwest of the industrial zone. The site was selected to assess ground level concentrations of air pollutants emitted from the industrial zone when wind is northeast or in case of calm wind, taking into account that this site is around 1 km from the industrial zone (see Figure 2.6 below).
2.4.4.4 Area south of the industrial zone

The site selected is around 1 km south/southeast of the industrial zone and will be used for assessing maximum ground level concentration that may arrive from the industrial zone, when north wind prevails. Taking into account, according to RSS study, that north and northwest wind prevailed during 50% of the monitoring time, which lasted for around one year (see Figure 2.7 below).
According to the metrological statistics for the Gulf of Aqaba for the last five years, and the above discussion the following have been noted:

- Wind direction in Gulf of Aqaba is usually north (N) to north-west (NW) during the most days of the year.
- The average wind speed during the year is about 10 knots, with a temperature range from 17°C to 36°C.

Depending on the above two points, and because the city is faraway, there is no need to allocate sampling points in the city at this stage.

2.5 Occupational safety measures

2.5.1 OHS Policy in AIC

JPMC - AIC stated that it will comply with all current applicable OHS legislations in Jordan and with all international codes, standards and specifications related to its operations and equipments. As a further
commitment the complex is implementing an OHS Management System that is compliant with OHSAS 18001.

The OHS management system and the objectives set below will be periodically reviewed and audited to monitor the company’s achievements in its commitment to continual improvement and of improvement in OHS performance.

JPMC- AIC has established the following OHS objectives:

1) Minimizing human injuries and property damage. For this the management will ensure safe working conditions including work permit system, safe guarding rotating equipments and personal protective equipments.

2) Preventing occupational diseases. Here the management will observe the following principles: recognition, evaluation and control of OHS hazards. In controlling OHS hazards, the following measures will be considered: engineering, administrative, medical and as a last choice, personal protective equipments. Medical control measures will include health surveillance, biological and biological effect monitoring.

3) In protecting their health, workers will be educated about OHS hazards and their control.

4) Workers will be trained on the use of safety devices and fire fighting procedures.

5) Comprehensive systems and procedures for various operational and maintenance activities will be implemented by all concerned. Periodic checks will be carried out by OHS personnel to identify deviations and appropriate corrective measures will be taken.

This Policy and objectives statement is available to the interested parties. JPMC- Industrial Complex will distribute this document locally to the site to

2.5.2 Dioxin and Furan in Environment

2.5.2.1 Sources of Dioxin and Furan in Environment
Dioxin (PCDDs) and Furan (PCDFs) are not produced commercially, as there are no known technical uses of these compounds. These are undesirable by-products of chemical manufacturing processes such as - chlorinated phenols and their derivatives, chlorinated di-phenyl ethers, poly-chlorinated bi-phenyls (PCBs) and other industrial processes involving chlorine such as pulp and paper industries. Waste incineration and other combustion processes are also known to generate dioxin and furan.

2.5.2.2 Toxicity of Dioxin and Furan
All the isomers of dioxin and dioxin like compounds are toxic but their toxicity potential varies widely among their different congeners and positional isomers. Only 7 out of 75 isomers of dioxin and 10 out of 135 isomers of furan exhibit critical toxic effects because of their chemical nature and property.
2,3,7,8 TCDD, the most toxic compound has been utilized as a prototype for investigating the toxicity, carcinogenicity and reaction mechanism. It is a microcrystalline solid, insoluble in water, sparingly soluble in other solvents and thermally very stable. Thermal decomposition can only occur at above 750°C. It undergoes substitution reactions and de-chlorination as well.

2.5.2.3 Pathways of Human Exposure
Dioxins are released into the ambient environment either directly along with
emissions or indirectly through volatilization from land, water and
resuspension of particulates. The atmospheric temperature and vapor
pressure of each compound in ambient condition will govern the congener's
speciation of Dioxin (PCDDs) and Furan (PCDFs).

The food has been identified as the major route of human exposure to Dioxin
(PCDDs) and Furan (PCDFs) in European countries. Some segment of
population such as nursing babies and people, who takes high animal fat or
contaminated food because of their proximity to dioxin releasing sites, are
exposed to high levels of dioxin / furan than average. Food having animal
origin contributes about 90% of daily intake of dioxin among European
population. Dietary intake may contribute to the extent of 90 – 98% of the
total daily intake of dioxin by population in advanced countries.

Average daily intake of dioxin in European population was estimated as 0.9
– 3.0 pg/Kg of body weight assuming 70 Kg as average body weight. Due to
lipophilic properties of dioxin, these accumulate mostly in fat tissues of fish,
meat and dairy products. Consequently, may enter in human system, when
people consume these contaminated foods and undergoes bio-magnification
during repeated exposure.

The degree of bio-magnification was estimated as 10,000 times higher than
the concentration of dioxin in surrounding environment. Traces of Dioxin
(PCDDs) and Furan (PCDFs) have also been reported in human adipose
tissues, blood and milk among the population from various advanced
countries.

2.5.2.4 Effect on Human Health

Short-term exposure to high levels of dioxin may result in skin lesions, such
as chlorance, patchy darkening of the skin, altered liver functions etc. in
human beings. Chronic exposure may result in various types of cancer, porphyria – a disorder in enzyme synthesis (Kociba et al. 1976,1978) and Sweeny et al. (1984). A specific type of human porphyria known as ‘Porphyria Cutanea Tarda (PCT)’, which is marked by discoloration and increased fragility of the skin may occur on chronic exposure.

Dioxin (PCDDs) generally causes immune system toxicity as well as gastrointestinal ulcers in human beings. Industrial exposure to dioxin may lead to neuro-toxic effects involving polyneuropathy of lower extremities. Inhalation of high levels of dioxin not only chokes the lungs but also enter into the blood stream. The liver is affected to such an extent that it leads to increased susceptibility to cancer.

Dioxin exposure may result in increase in serum cholesterol and triglycerides concentrations, which ultimately changes blood lipids and liver function indicators.

Many scientists believe that dioxin exposure is responsible for developing breast cancer in women and reduced sperm count in men. Organic chemicals like PCBs, PCDDs, PCDFs, OCPs are known as "Gender bender". Long-term exposure is linked to impairment of immune system, nervous system, endocrine system and reproductive functions. Long-term exposure even to low concentration of dioxin alters the reproductive functions including infertility, miscarriage, spontaneous abortion, congenital anomalies, and neonatal developmental abnormalities. Dioxin released during spraying of phenoxy herbicide results in soft tissue sarcomas, malignant lymphoma and tumors of all organs.

In AIC case, and referring to the above, the main route for workers' exposure will be mainly through the respiratory system since the formation of Dioxin (PCDDs) and Furan (PCDFs) results from the combustion processes in
boilers, which emitted to air through stacks emissions.

2.5.3 Indoor noise

AIC conducts monthly measurements of indoor noise levels at different distances (1m, 2m, 3m, and 4m) from the noise generation sources at all company plants and facilities. The minimum and maximum records of all measurements conducted in the year 2010 are summarized and shown in Table (2.3). It is clear that most of indoor measurements exceeded the Jordanian Standard Limit of 85 dB even at relatively far distance (4m).

JPMC policy focuses on the environment and occupational health with sustainable bases. They adopt a strong occupational health program, with focusing on workers health.

As discussed previously, it is found that utilities and SAP boilers are the sources of UP-POPs emissions. Referring to JPMC human figures, the number of workers in utilities and SAP is 41 and 28 respectively, so a good attention should be paid for these two groups.
### Table (2.3): Noise measurements in ACI at 2010

<table>
<thead>
<tr>
<th>Plant</th>
<th>Region</th>
<th>At distance [dB Noise]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1m</td>
</tr>
<tr>
<td>Utilities</td>
<td>1. Turbine Generators</td>
<td>95</td>
</tr>
<tr>
<td></td>
<td>Turbine A-A T1301</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AT1301- Turbine B</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. BOILERS FEED PUMP</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>3. Air blowers K 1101</td>
<td>102</td>
</tr>
<tr>
<td></td>
<td>4. Main Condensers</td>
<td>92</td>
</tr>
<tr>
<td>SAP</td>
<td>1. Phosphate mill</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>2. Phosphate Silo /Blower 2601</td>
<td>98</td>
</tr>
<tr>
<td></td>
<td>Concentration</td>
<td>101</td>
</tr>
<tr>
<td></td>
<td>Line A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Concentration line B</td>
<td>103</td>
</tr>
<tr>
<td></td>
<td>Concentration line C</td>
<td>102</td>
</tr>
<tr>
<td>DAP</td>
<td>1. DAP Mills</td>
<td>Unit 75</td>
</tr>
<tr>
<td></td>
<td>Unit 76</td>
<td>95</td>
</tr>
<tr>
<td></td>
<td>2. GEAR BOX DAP Dryer</td>
<td>Unit 75</td>
</tr>
<tr>
<td></td>
<td>Unit 76</td>
<td>97</td>
</tr>
<tr>
<td></td>
<td>3. DAP Dryer Fans</td>
<td>Unit 75</td>
</tr>
<tr>
<td></td>
<td>Unit 76</td>
<td>95</td>
</tr>
<tr>
<td>AFP</td>
<td>1. Dryers Region</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>2. Burners Blower</td>
<td>Blower 11710 A</td>
</tr>
<tr>
<td></td>
<td>Blower 11710 B</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>3. Exhaust Gas Blower</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>4. Machines and Equipment Room</td>
<td>93</td>
</tr>
</tbody>
</table>
2.5.4 Environmental situation monitoring in JPMC

Environmental aspects in JPMC are being monitored by following methods:

1. Daily inspection tours: where environmental supervisor writes a daily report about the inspection tours. The report includes gas emissions, dust, solid waste, and spills (water, acids, oils, etc.); the report then is adopted by the division head and the directorate manager and forwarded to JPMC general manager. A copy of the report is sent to all concerned departments to avoid negative environmental remarks.

2. Inner and Outer Measurements

- Stack gas emissions measurements
  - Measuring gas and dust emissions from the Complex stacks. The samples are taken and analyzed in the main laboratory from the following stacks:
    - Sulfuric Acid Plant Stacks (53,54): once per week for (SO₃, Acid mist)
    - Phosphoric Acid Plant Stack: once per week for (F-containing gases)
    - DAP Plant Stacks (75,76): once per week for (F, P₂O₅, NH₃)
- A third party (e.g. JUST) – according to a signed agreement and in coordination with the environment team in JPMC – is implementing environmental measurements for gaseous emissions and TSP in working environment and surrounding air every three months in several locations. These measurements include:
  - CO₂, CO, and SO₂ in sulfuric acid plant and utilities.
  - HF in three different locations in phosphoric acid plant and three different locations in Aluminum fluoride plant.
• NH₃ in three different locations in DAP plant.
• Total suspended particulate (TSP) in the following location:-
  • Loading + unloading phosphate unit.
  • Grinding + mill in PAP.
  • DAP plant.
  • Warehouse # 9.
  • AlF₃ Packaging area.

All above measurements are compared with Jordanian national standard no. 1189/2006.

3. Monitoring and measurements

JPMC environmental stuff collects a monthly water sample from Hassad well and analyzes it for the following parameters: (F⁻, SO₄²⁻, PH, P₂O₅, NH₃, Fe, CaCO₃, Conductivity), to know the effects of liquid wastes especially phosphogypsum on ground water.

4. Sea water (used for cooling purposes)

Monitoring program contains the following tests: ΔT, PH, Residual chlorine.

5. Marine science station (MSS)

It monitors - through an agreement - the coastal line physical and chemical properties, within six locations in front of JPMC monthly on (10m, 20m, 30m) depth respectively.

6. Noise Monitoring:-

Noise level inside and outside the industrial complex measured through JPMC safety stuff in of locations outside of and in each plant of JPMC. All of these measurements sent to local authorities.
7. **Radiation Level:**
Radiation Level tested monthly around phosphoric acid tanks and phosphogypsum mountain.

8. **Environmental assessments:**
All JPMC activities are assessed regularly (e.g. monitoring programs, inspections, measurements) including gas emissions, dust, noise and take proper actions toward violations.

9. **Monthly and Annual Environmental Reports.**

10. **Environmental Project:**
Replacement project of heavy fuel oil by natural gas in utilities boilers to reduce harm effects of emissions. The project is ready now to link with Egyptians gas line.
Project of using reclaimed water from Aqaba waste water station (AWWS) for cooling purposes instead of potable water from Dissi. This project reduced Dissi water consumption by (45%).
New loading and unloading dedusting unit reduced TSP below 10mg/m³.
Project of reducing NH₃ emissions from DAP stacks from 727 mg/m³ to less than 50 mg/m³. The project is under construction and will be ended soon with estimated coast of about $25 million. New technology used by replacing old tank reactor with a pipe reactor type which is more efficient in scrubbing NH₃ emissions.

11. **Internal Auditing:**
By JPMC stuff all environmental aspects and producers are audited every six months.

12. **External Auditing:**
Every six months, teams of “Loyids” review procedures to check complying with ISO 14001.

As mentioned above JPMC has external and internal monitoring programs including environmental, occupational health, and safety aspects. Internal program concerns of: air quality from stationary sources, indoor noise and well water. While the external program concerns of air quality from stationary sources, air quality at working environment areas, and coastal marine environment. During the assessment, the results of external and internal monitoring program were reviewed for the last two years. All of these results are shown in Annex (1).
3.1 Summary

Social, economic, political and legal considerations significantly influence the global generation, marketing, use and release of the listed POPs, human and environmental exposure to them, their effective management and the development and access to viable (cost effective, practical and less risky) alternatives. These considerations can be analyzed by examining institutional arrangements, national infrastructures, information availability and transfer, technology development and co-operation, POPs pricing structures, efforts to reduce the risk of exposure to POPs, and domestic and international legal arrangements for managing POPs. These considerations are all interrelated and interdependent, are complex and difficult to qualify
and quantify, and perhaps most importantly, differ markedly in different parts of the world.

3.1.1 What is Socio-Economic Assessment?

Socio-Economic Assessment (SEA): is a systematic appraisal of the potential social impacts of economic or other activities such as the management of persistent organic pollutants on all sectors of society (including local communities and groups, civil society, private sector and government).

It is a means of analyzing and managing the intended and unintended social impacts, both positive and negative, of planned interventions (policies, programs, plans and projects) and any social change processes invoked by those interventions.

Social impacts are the changes to individuals and communities that come about due to actions that alter the day-to-day way in which people live, work, play, relate to one another, organize to meet their needs and generally cope as members of society.

The context of managing persistent organic pollutants, social and economic impacts include:

- Vulnerability arising from exposure to persistent organic pollutants
- Deterioration or improvement in health,
- Loss or improvement in livelihoods,
- Changes in cost of living
- Changes in employment, income and workplace protection
Opportunities for enterprise development (including Small and Medium Enterprises)

3.1.2 Why should national implementation plans include Socio-Economic Assessment?

There are three compelling reasons:

i) To ensure a positive impact on people as well as the environment

ii) Obligations under the Stockholm Convention

iii) Contribution to Parties’ Commitments to Other Socially-Focused International Agreements

i) To ensure a positive impact on people as well as the environment:

Much of the data informing decision-making in national implementation plans have been related to technical and scientific information about chemicals and the environment. Socio-Economic Assessment ensures that people are brought into the equation and that the management of persistent organic pollutants takes into account the impact of proposed management strategies on the well-being of all sectors of a community, especially the most vulnerable. The data generated by Socio-Economic Assessment will inform the national implementation plan and implementation teams, enabling them to analyze, monitor and manage the social consequences of action on persistent organic pollutants.

ii) Obligations under the Stockholm Convention:

References to socio economic assessment can be found throughout the text of the Stockholm Convention.

Annex F of the Stockholm Convention on information on socio-economic
considerations, provides an indicative list of items to be taken into consideration by Parties when undertaking an evaluation regarding possible control measures for chemicals being considered for inclusion under the Convention.

The preamble to Annex F states that: “An evaluation should be undertaken regarding possible control measures for chemicals under consideration for inclusion in [the Stockholm Convention], encompassing the full range of options, including management and elimination.

For this purpose, relevant information should be provided relating to socio-economic considerations associated with possible control measures to enable a decision to be taken by the Conference of the Parties”.

**iii) Contribution to Parties’ Commitments to Other Socially-Focused International Agreements:**

Almost all Parties completing a national implementation plan will have made other socially-focused international commitments to human rights, the rights of children, the rights of women, poverty reduction etc. Many of these will have been embedded in national constitutions and legal systems. Socio–Economic Assessment will help to identify synergies between these commitments and the Stockholm Convention which have important implications for activating national implementation plans:

- It is easier to attract funding when it can be shown that the same funds can be maximized to serve more than one purpose.
- Such synergies raise the possibility of making community consultation processes less demanding both on the communities themselves as well as on the implementation teams.
Socio-Economic Assessment assists in deciding on and choosing actions that are appropriate and correctly focused as well as monitoring their effectiveness. It also provides a basis for minimizing the negative impact on populations and also in improving equitable outcomes for the most vulnerable groups.

The Assessment is set out in five parts:
1. Background
2. Detailed description of target groups
3. Detailed description of adequate and effective tools for awareness raising
4. Detailed description of information content dissemination approach
5. Cost Benefit Analysis of BAT/BEP implementation
3.2 Background

3.2.1 Introduction

Aqaba is a coastal city overlooking the Red Sea located in the south of Jordan. It is strategically important to Jordan as it is the country's only seaport and access to the sea. Aqaba was first announced as a district belonging to Ma'an governorate according to the administrative system organized in 1957, and then upgraded in 1994 to be a separate Governorate. Aqaba Governorate includes the Aqaba district (encompassing the Aqaba sub district and Wadi Araba sub district) and the Quairah district.

In 2001 Aqaba city was announced as a Special Economic Zone (ASEZ) with its own Authority (ASEZA). The ASEZ encompasses an area of 375 km2. Its purpose was to incorporate the entire Jordanian coastline, Jordanian sea-ports, and the historical city of Aqaba as a duty-free, low tax- multi-sectoral development zone. The ASEZ provides global investment opportunities within tourism, recreational services, professional services, multi-modal logistics, value-added industries, and light manufacturing sectors.

The establishment of the ASEZ with its characteristics of low tax and regulations is regarded as a model of government-provided framework for private sector-led economic growth to be emulated throughout the Kingdom.
3.2.2 Demographics

3.2.2.1 Population and Population Growth:
According to the Department of Statistics, by the end of the year of 2008, the estimated population of the Governorate of Aqaba was 127,500, comprising 2.2% of the population of Jordan. The gender breakdown was 56,500 females and 71,000 males. Based on the World Gazetteer, the population of the ASEZ for the year of 2008 was 95,408.
Within the district of Aqaba (Qasabet al Aqaba), there are 6 sub-divisions (Localities) with populations as follows:

Table (3.1) Population Distribution According to Residential Complexes in Qasabet Al Aqaba
The population growth of the Aqaba Governorate for the period between 1995 and 2008 is illustrated below:

**Table (3.2) Changes in Number of Population over a 10 Year Period.**

<table>
<thead>
<tr>
<th>Locality</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mezfer</td>
<td>150</td>
</tr>
<tr>
<td>Teten</td>
<td>17</td>
</tr>
<tr>
<td>Track Area</td>
<td>560</td>
</tr>
<tr>
<td>Re’a Sa’adeh</td>
<td>17</td>
</tr>
<tr>
<td>Kaldi</td>
<td>171</td>
</tr>
<tr>
<td>Aqaba</td>
<td>99,985</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100,900</strong></td>
</tr>
</tbody>
</table>

*Source: Department of Statistics*
<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
<th>Population Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>82,300</td>
<td>1.93%</td>
</tr>
<tr>
<td>2005</td>
<td>115,100</td>
<td>2.1%</td>
</tr>
<tr>
<td>2008</td>
<td>127,500</td>
<td>2.2%</td>
</tr>
</tbody>
</table>

Source; Department of Statistics

It is evident that the population of Aqaba has been increasing at an exceptional rate; the table above shows a growth equivalent to approximately 40% between a 10 year period (1995 to 2005) and one of 10% for a 3 year period (2005 to 2008). This increase is expected to continue into the future.

According to some population growth study projections, the total population of Aqaba City and Aqaba Governorate are anticipated to increase by 50,000 and 70,000 by the year 2020. The table that follows illustrates the significant contribution migrants (both Jordanian and non-Jordanian) will have on the increase of population size.
### Table (3.3) Aqaba Population Projections, 2006-2020

<table>
<thead>
<tr>
<th>Year</th>
<th>Aqaba City Total Population</th>
<th>Aqaba Governorate Total Population</th>
<th>Migrants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Subtotal</td>
<td>Jordanians</td>
</tr>
<tr>
<td>2006</td>
<td>100,325</td>
<td>118,030</td>
<td>26,492</td>
</tr>
<tr>
<td>2010</td>
<td>122,536</td>
<td>144,160</td>
<td>43,801</td>
</tr>
<tr>
<td>2015</td>
<td>153,450</td>
<td>180,530</td>
<td>68,501</td>
</tr>
<tr>
<td>2020</td>
<td>161,218</td>
<td>201,522</td>
<td>77,090</td>
</tr>
</tbody>
</table>

Source: AZEM Internal Migration and Demographic Projections, prepared by Kamal Saleh (May 2007)

#### 3.2.2.2 Age-Gender Breakdown:

Age structure is a basic demographic feature of a population which refers to the relative proportion of each age group within a population. The present age structure of the population is a result of past demographic processes and thus future results can be predicted based on present demographic processes. Trends observed in Aqaba have illustrated a decrease in the younger age population and an increase in the productive-age population (from 15-64 years). A graphical representation of the age-gender structure of the Aqaba Governorate in 2005 is given in the population pyramid displayed below, using data from the Department of Statistics. The graphic indicates a high proportion of children, a rapid rate of population growth, and a lower
proportion of older people. There is a bias towards males, probably illustrating the importance of male workers who have come to the city without families for work.

![Population Pyramid for Aqaba Governorate 2005](image)

#### Figure (3.1) Population Pyramid for Aqaba Governorate 2005

#### 3.2.2.3 Poverty:

The most recent report on Poverty Assessment in Jordan was done by the World Bank in 2004. The report cited a reduction in Headcount Ratio in the Aqaba Governorate (the % age of people living below the poverty line) from 37.3% to 24.1% between 1997 and 2002, and a reduction in the Poverty Gap (a measure of the depth of poverty – the average gap expenditure of the poor from the poverty line) from 11.5% to 6.2% over the same period.

<table>
<thead>
<tr>
<th>Governorate</th>
<th>1997</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Headcount</td>
<td>Gap</td>
</tr>
<tr>
<td>Aqaba</td>
<td>37.3</td>
<td>11.7</td>
</tr>
</tbody>
</table>

3.2.2.4 Human Development Index

The Human Development Index is used to determine the overall human well-being in a country, which is then used for its classifications as developed, developing or underdeveloped. There are three indicators used in the measurement:

1. A long and healthy life, measured by life expectancy at birth
2. Standard of living, measured by GDP per capita at purchasing power parity (PPP) in USD
3. Educational attainment, measured by adult literacy and the combined gross primary, secondary and tertiary enrolment criteria

According to the Jordan Human Development Report 2004, the overall HDI for Jordan is 0.743 ranking 90th in the world and classifying the kingdom as a developing country in the year 2003.

Within the Kingdom, Aqaba Governorate HDI value for the year 2002 was 0.763 and was second to Amman. Between 1997 and 2002 time period, Aqaba experienced an overall increase in all three indicators used in the HDI measurement. The life expectancy index increased by 3.2 percent, educational attainment index increased by 6.0 percent and GDP index increased by percent.
Table (3.5) Human Development Indices
<table>
<thead>
<tr>
<th>Governorate</th>
<th>Life expectancy index</th>
<th>Education index</th>
<th>GDP index</th>
<th>Human Development index (HDI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jordan</td>
<td>0.751</td>
<td>0.775</td>
<td>3.2</td>
<td>0.802</td>
</tr>
<tr>
<td>Amman</td>
<td>0.758</td>
<td>0.785</td>
<td>3.6</td>
<td>0.833</td>
</tr>
<tr>
<td>Aqaba</td>
<td>0.802</td>
<td>0.828</td>
<td>3.2</td>
<td>0.796</td>
</tr>
<tr>
<td>Irbid</td>
<td>0.773</td>
<td>0.798</td>
<td>3.0</td>
<td>0.798</td>
</tr>
<tr>
<td>Madaba</td>
<td>0.776</td>
<td>0.817</td>
<td>5.3</td>
<td>0.783</td>
</tr>
<tr>
<td>Ajloun</td>
<td>0.770</td>
<td>0.793</td>
<td>3.0</td>
<td>0.781</td>
</tr>
<tr>
<td>Zarqa</td>
<td>0.743</td>
<td>0.773</td>
<td>4.0</td>
<td>0.821</td>
</tr>
<tr>
<td>Balqa</td>
<td>0.738</td>
<td>0.733</td>
<td>0.7</td>
<td>0.761</td>
</tr>
<tr>
<td>Jarash</td>
<td>0.725</td>
<td>0.747</td>
<td>3.0</td>
<td>0.789</td>
</tr>
<tr>
<td>Karak</td>
<td>0.720</td>
<td>0.752</td>
<td>4.4</td>
<td>0.742</td>
</tr>
<tr>
<td>Tafila</td>
<td>0.692</td>
<td>0.712</td>
<td>2.9</td>
<td>0.757</td>
</tr>
<tr>
<td>Mafraq</td>
<td>0.738</td>
<td>0.768</td>
<td>4.1</td>
<td>0.708</td>
</tr>
<tr>
<td>Ma’an</td>
<td>0.709</td>
<td>0.730</td>
<td>3.0</td>
<td>0.703</td>
</tr>
</tbody>
</table>

Source: 1997 data from NHDRI; 2002 from DoS

### 3.2.2.5 Employment:
Despite being one of Jordan's smaller Governorates, Aqaba has the most economically active population. An estimated 36% of Aqabawis are employed - approximately 6.1% more than the average for other regions. Furthermore, Aqabawis work on average more hours per week (2.4%) than the rest of Jordanians.

Jordanian workers make up 73% of the total workforce. 22% of the Jordanian workforce is female, compared with only 4% of the non-Jordanian workers. In terms of the types of work, the following breakdown was listed in the AZEM Study (ref) - skilled agricultural and fishery workers (1.4%), legislators, senior officials and managers (0.9%), professional workers (9.3%), and service workers (8.9%). Gender plays a crucial role in determining employment distribution per occupation. Women are employed mainly either in elementary occupations or as professionals and managers; while men are distributed among all categories concentrating slightly in technical and skilled work.

The illiteracy rate is estimated at 9.7% with male illiteracy estimated at around 5.85% and female illiteracy around 14.45%. In 2003, there were 65 schools in Aqaba as 20 were designated for male students, 15 for female students and 30 co-educational.

Businesses are permitted to hire up to 70% foreign labour in the ASEZ, and labour costs in Aqaba are among the lowest in the region. A minimum wage was recently set by law at JOD 150 per month. Table 3.6 represents the average monthly wages for labour in Aqaba.

Table (3.6) Average Monthly Wages for Labour in Aqaba Area

<table>
<thead>
<tr>
<th>Type of Employee</th>
<th>JOD</th>
<th>USD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unskilled</td>
<td>99-128</td>
<td>140-180</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>Semi-skilled</td>
<td>178-199</td>
<td>250-280</td>
</tr>
<tr>
<td>Skilled and Technical</td>
<td>284-426</td>
<td>400-600</td>
</tr>
<tr>
<td>Administrative</td>
<td>320-355</td>
<td>450-500</td>
</tr>
<tr>
<td>Middle Manager</td>
<td>426-568</td>
<td>600-800</td>
</tr>
</tbody>
</table>

Overtime is as follows:
- Regular working day 25% premium
- Holidays and weekends 50% premium

Religion plays a pivotal role in the society of Aqaba and its culture. There are 39 mosques in Aqaba City and four mussalas (worshiping places). There are also at least four churches. Religion strongly influences every day life issues such as family planning in Aqaba. For example, as the general trend is to have many children and with much of the population being young adults, this suggests that there will be a large increase in birth rate in Aqaba in the future.

3.2.3 Economic Context & Indicators
3.2.3.1 The ASEZ and Growth Projections:
The gross regional product (GRP) for the Aqaba Zone in 2004, with a value of $540 million, represented 4.5% of the national gross domestic product (GDP) for the Kingdom, with a value of $11,890 million. Aqaba's economic importance far exceeds that of its population size in relevance to the national scale.

It is estimated that 66,000 new jobs will be created as ASEZ predicts an annual 15% increase in economic activity between 2005 and 2010. There are
critical implications for municipal housing, infrastructure, public services, recreational and cultural facilities associated with this prediction.

There are many factors contributing to Aqaba’s economy. The strategic location Aqaba occupies between the Arabian Gulf and the Mediterranean, favorable climate, access to recreational and cultural activities and operations of newly established hotels are such factors. The streamlined administrative, customs and fiscal regulations of the Zone further enhance the appeal of investment in the region. In addition, funding is being funneled to Aqaba from international financing to Jordan as a result of its emergence as a regional investment center. It is anticipated that an estimated $6 billion will be invested in Aqaba between now and the year 2015, shifting the economy from transportation, port activities and manufacturing towards various service industries. There is also a large interest in the region from real estate investors.

The anticipated $6 billion is expected to be invested in hotels, housing, and construction which in turn will contribute to a 15% ($1.5 billion) growth rate increase in the GRP. This increase is considered rapid and assumes no shortage of productive factors, such as water or labor. Based on the 2005 gross product, all of the region’s leading sectors are expected to have a higher growth rate than those of the national sectors. The majority of the sectors are expected to grow at a rate equal to or greater than 10% per year while those related to agriculture, health and education are expected to growth at one in the range of 5-6% per year.
Table (3.7) Aqaba Governorate Regional Product Baseline Projections, 1995-2020 - (JD 2005 millions)
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, forestry and hunting</td>
<td>1.8</td>
<td>2.4</td>
<td>3.1</td>
<td>4.2</td>
<td>5.6</td>
<td>5.6</td>
</tr>
<tr>
<td>Mining and quarrying</td>
<td>0.3</td>
<td>0.3</td>
<td>1.6</td>
<td>7.1</td>
<td>7.8</td>
<td>18.2</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>26.0</td>
<td>32.3</td>
<td>54.3</td>
<td>113</td>
<td>135.5</td>
<td>7.6</td>
</tr>
<tr>
<td>Electricity and water</td>
<td>2.3</td>
<td>6.2</td>
<td>8.3</td>
<td>14.4</td>
<td>25.0</td>
<td>13.7</td>
</tr>
<tr>
<td>Construction</td>
<td>6.7</td>
<td>32.0</td>
<td>82.2</td>
<td>207.5</td>
<td>394.1</td>
<td>28.5</td>
</tr>
<tr>
<td>Wholesale/retail trade</td>
<td>12.7</td>
<td>29.2</td>
<td>59.7</td>
<td>123.8</td>
<td>256.7</td>
<td>16.7</td>
</tr>
<tr>
<td>Hotels and restaurants</td>
<td>10.0</td>
<td>12.9</td>
<td>19.2</td>
<td>46.5</td>
<td>69.7</td>
<td>6.7</td>
</tr>
<tr>
<td>Transport, storage, communications</td>
<td>42.7</td>
<td>72.7</td>
<td>127.4</td>
<td>202.1</td>
<td>320.8</td>
<td>11.6</td>
</tr>
<tr>
<td>Finance and insurance</td>
<td>3.0</td>
<td>5.4</td>
<td>11.7</td>
<td>20.9</td>
<td>37.6</td>
<td>14.6</td>
</tr>
<tr>
<td>Real estate, renting, business activities</td>
<td>13.1</td>
<td>30.0</td>
<td>54.1</td>
<td>120.2</td>
<td>266.7</td>
<td>15.2</td>
</tr>
<tr>
<td>Public administration, defense, social security</td>
<td>16.5</td>
<td>21.4</td>
<td>24.0</td>
<td>46.3</td>
<td>79.7</td>
<td>3.8</td>
</tr>
<tr>
<td>Education (private)</td>
<td>0.7</td>
<td>1.0</td>
<td>1.3</td>
<td>1.7</td>
<td>2.2</td>
<td>6.4</td>
</tr>
<tr>
<td>Health and social services</td>
<td>0.8</td>
<td>1.2</td>
<td>2.0</td>
<td>2.8</td>
<td>3.8</td>
<td>9.6</td>
</tr>
<tr>
<td>Other community, social, and personal services</td>
<td>2.3</td>
<td>2.7</td>
<td>3.1</td>
<td>4.6</td>
<td>7.3</td>
<td>3.0</td>
</tr>
<tr>
<td>Private households with employees</td>
<td>0</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.2</td>
<td>--</td>
</tr>
<tr>
<td>Imputed bank charges</td>
<td>-1.2</td>
<td>-2.9</td>
<td>-6.3</td>
<td>-12.8</td>
<td>-22.5</td>
<td>18.0</td>
</tr>
<tr>
<td>Gross Regional Product (at basic prices)</td>
<td>137.8</td>
<td>246.6</td>
<td>445.7</td>
<td>902.6</td>
<td>1590.4</td>
<td>12.5</td>
</tr>
<tr>
<td>Net taxes on products</td>
<td>0</td>
<td>0</td>
<td>3.7</td>
<td>7.5</td>
<td>13.2</td>
<td>5.6</td>
</tr>
<tr>
<td>Gross Regional Product (at market prices)</td>
<td>137.8</td>
<td>246.6</td>
<td>449.4</td>
<td>910.1</td>
<td>1603.5</td>
<td>12.5</td>
</tr>
</tbody>
</table>

Source: Computed from AZEM, (July 2006)

3.2.3.2 Economic activities in Aqaba:

The main economic activities in Aqaba revolve around the ports, shipping
and the associated land transportation, power generation, manufacturing, fertilizer production, tourism, and commercial fishing.

The largest percentage of labour is employed in the transportation and communication sector. The Ports Corporation, which operates the Port of Aqaba, is considered the largest single employer in Aqaba. In the past 25 years, the Port has developed into the third largest Port on the Red Sea after Suez and Jeddah. Almost thirty percent of the coastline is allocated to port related facilities.

The fishing industry is very limited in Aqaba, consisting of around 85 fishermen and 40 boats in 1995. The total saleable catch reached a low of 15 tons (valued at 45,000 JD) in 1995. Fish must be sold immediately at docksides, usually to restaurants and hotels, as there are no holding facilities found.

Aqaba serves as a major tourist attraction site due to its proximity to Petra and Wadi Rum and due to the availability of crossings that lead to Egypt, and Eilat. Furthermore, rich coral reef colonies, a spectacular mountain backdrop, sandy beaches calm waters, and warm weather throughout the year promote Aqaba as a recreational tourist destination. Around 66% of the tourists entering Jordan visit Aqaba. Tourism in Aqaba generates an estimated revenue of around JD 40 Million (US $58 Million) and directly employs a workforce of over 800.

The number of tourists is expected to increase due to regional tourism plans related to the National Tourism Strategy, published in 2004, and ASEZA’s drive to further develop tourism in Aqaba.

3.2.3.2.1 Ports Sector:
3.2.3.2.1.1 Main Port Site:
The Main Port encompasses 12 berths that handle general cargo, grain cargo, phosphate and light traffic. The general cargo area consists of 9 berths, each 35 m in length. One berth is used for imported grain handling. A mid-basin area contains a 300 tons maintenance slipway, with a workshop and is used for lighter crafts.

![Aerial Photograph Showing the Main Port Site.](image)

Other facilities include 245,000 m² of open yard, 103,000 m² of transit sheds and covered warehouses, and cold storage space for 2,000 tons of cargo. An established yacht basin is also present within the Main Port vicinity. A truck area is located above the port in Wadi Jeishieh. Access to the Main Port is provided by 5 gates from the Coast Road.
The visual setting of the Main Port is primarily characterized by the presence of the phosphate facilities, grain silos and the JoPetrol facility, in addition to several hangers and storage sheds. Another characteristic structure is the control tower present in the north western portion of the Main Port.

3.2.3.2.1.2 **South Port Site**

The South Port site has already been classified as an "Industrial Zone" by ASEZA and existing fertilizer and port works are well-established in the western coastal area of the Zone.

![Aerial Photograph Showing the South Port Site.](image)
Approximately 13% of the Zone is occupied by fertilizer industries, bulk liquid import and storage companies and the Aqaba Thermal Power Plant. About 30% of the available coastline is occupied by the existing port including three jetties, and various seawater outfalls, intakes and gas pipelines.

Imports and exports through the ports, and the associated industrial activity are a major contribution to the economic activity in Aqaba, and in Jordan. A number of studies project significant increase in imports and exports as regional stability improves.

The tables below illustrate some of the projected growth in port traffic, expected in the next 3 decades, for dry bulk, liquid bulk, and general cargo. Data is taken from the Update of Trade and Traffic Forecasts, ADC, July 2007.

The following table shows the dry Bulk expected in the next 3 decades:

Table (3.8) Summary of Dry Bulk Forecasts Related to the Fertilizer Industry Complex
The following table shows the liquid Bulk expected in the next 3 decades:

**Table (3.9) Summary of Liquid Bulk Forecasts**

<table>
<thead>
<tr>
<th>Year</th>
<th>2006</th>
<th>2007*</th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphate rock export (1000 tonnes)</td>
<td>3212</td>
<td>3673</td>
<td>3974</td>
<td>3772</td>
<td>5205</td>
<td>5205</td>
<td>5205</td>
<td>5205</td>
</tr>
<tr>
<td>MOP export (1000 tonnes)</td>
<td>1372</td>
<td>1653</td>
<td>1978</td>
<td>2423</td>
<td>2423</td>
<td>2423</td>
<td>2423</td>
<td>2423</td>
</tr>
<tr>
<td>Sulphur import (1000 tonnes)</td>
<td>608</td>
<td>567</td>
<td>719</td>
<td>1175</td>
<td>1175</td>
<td>1175</td>
<td>1175</td>
<td>1175</td>
</tr>
<tr>
<td>DAP export (1000 tonnes)</td>
<td>608</td>
<td>596</td>
<td>625</td>
<td>674</td>
<td>684</td>
<td>684</td>
<td>684</td>
<td>684</td>
</tr>
<tr>
<td>NPK export (1000 tonnes)</td>
<td>236</td>
<td>210</td>
<td>210</td>
<td>210</td>
<td>210</td>
<td>210</td>
<td>210</td>
<td>210</td>
</tr>
<tr>
<td>Aluminium hydrate import (1000 tonnes)</td>
<td>14</td>
<td>21</td>
<td>23</td>
<td>24</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>

*based on figures up to 20 June 2007

The following table shows the general cargo expected in the next 3 decades:

**Table (3.10) Summary of General Cargo Forecast**

<table>
<thead>
<tr>
<th>Year</th>
<th>2006</th>
<th>2007*</th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA export (JPMC and IJCC) (1000 tonnes)</td>
<td>363</td>
<td>379</td>
<td>580</td>
<td>1362</td>
<td>1353</td>
<td>1353</td>
<td>1353</td>
<td>1353</td>
</tr>
<tr>
<td>Ammonia import (1000 tonnes)</td>
<td>225</td>
<td>217</td>
<td>231</td>
<td>244</td>
<td>246</td>
<td>246</td>
<td>246</td>
<td>246</td>
</tr>
<tr>
<td>Vegetable oil (1000 tonnes)</td>
<td>203</td>
<td>45</td>
<td>47</td>
<td>49</td>
<td>51</td>
<td>54</td>
<td>56</td>
<td>58</td>
</tr>
<tr>
<td>Mineral oil (1000 tonnes)</td>
<td>28</td>
<td>29</td>
<td>35</td>
<td>45</td>
<td>57</td>
<td>70</td>
<td>85</td>
<td>104</td>
</tr>
<tr>
<td>Chemicals (1000 tonnes)</td>
<td>61</td>
<td>56</td>
<td>67</td>
<td>86</td>
<td>110</td>
<td>135</td>
<td>164</td>
<td>200</td>
</tr>
</tbody>
</table>

*based on figures up to 20 June 2007
Employment at APC is distributed between General and Administration, and Operational. The table below provides a useful summary of employment and salary costs. According to the figures obtained, a total of 3,892 staff are employed.
### Table (3.11) Employment Sector Distribution and Salaries Allocation

<table>
<thead>
<tr>
<th>Sector</th>
<th>Number of Employees</th>
<th>Average Monthly Salary per Sector</th>
<th>Average Annual Salary</th>
<th>Salaries Allocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>General &amp; Admin.</td>
<td>1,758</td>
<td>644,749</td>
<td>7,736,952</td>
<td>45%</td>
</tr>
<tr>
<td>DG Office</td>
<td>112</td>
<td>38,934</td>
<td>467,208</td>
<td></td>
</tr>
<tr>
<td>Admin &amp; HR</td>
<td>32</td>
<td>12,409</td>
<td>148,908</td>
<td></td>
</tr>
<tr>
<td>Head Office</td>
<td>6</td>
<td>11,384</td>
<td>136,608</td>
<td></td>
</tr>
<tr>
<td>Legal Depart</td>
<td>14</td>
<td>5,911</td>
<td>70,932</td>
<td></td>
</tr>
<tr>
<td>Training and Development</td>
<td>34</td>
<td>15,632</td>
<td>187,584</td>
<td></td>
</tr>
<tr>
<td>Control and Assurance</td>
<td>308</td>
<td>101,077</td>
<td>1,212,924</td>
<td></td>
</tr>
<tr>
<td>Purchases and Procurement</td>
<td>130</td>
<td>52,797</td>
<td>633,564</td>
<td></td>
</tr>
<tr>
<td>Projects and Development</td>
<td>182</td>
<td>70,261</td>
<td>843,132</td>
<td></td>
</tr>
<tr>
<td>Service</td>
<td>445</td>
<td>146,349</td>
<td>1,756,188</td>
<td></td>
</tr>
<tr>
<td>Technical Dept</td>
<td>407</td>
<td>154,137</td>
<td>1,849,644</td>
<td></td>
</tr>
<tr>
<td>Finance Dept</td>
<td>88</td>
<td>35,855</td>
<td>430,260</td>
<td></td>
</tr>
<tr>
<td>Operational Dept</td>
<td>2,177</td>
<td>755,361</td>
<td>9,064,332</td>
<td>54%</td>
</tr>
<tr>
<td>Main Port (Main Operations)</td>
<td>1,657</td>
<td>546,244</td>
<td>6,544,928</td>
<td></td>
</tr>
<tr>
<td>Specialized Berths</td>
<td>417</td>
<td>158,627</td>
<td>1,903,524</td>
<td></td>
</tr>
<tr>
<td>Marine Dept</td>
<td>103</td>
<td>50,490</td>
<td>605,880</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>47</td>
<td>12,228</td>
<td>146,736</td>
<td></td>
</tr>
<tr>
<td><strong>Total APC</strong></td>
<td><strong>3,982</strong></td>
<td><strong>1,412,335</strong></td>
<td><strong>16,948,020</strong></td>
<td></td>
</tr>
</tbody>
</table>

#### 3.2.3.2.2 The Industrial Sector:
According to the master plan of Aqaba, The industrial sector is located mainly in two areas:

3.2.3.2.1 **The Northern Industrial Zone:**
The light and medium industries located at the Aqaba Industrial city at the north of the city.
The site is located north of the town of Aqaba, east of Aqaba International Airport and is boarded by the Aqaba Dead Sea highway from the east and Safi road to the west.
The site is approximately 4 km north east of the Aqaba municipal wastewater treatment plant.

3.2.3.2.2 **The Southern Industrial Zone:**
It consists of two adjacent areas – Wadi 1 and Wadi 2 which are located 22 km south of the Main Port and outside the Municipal boundary (Figure 3.4). These zones are both linked by the Back Road to the Amman Route and have been designated for heavy industrial use.

The main industries are:

- Jordan phosphate mines company / industrial complex.
- Red Sea Timber Industries Company.
- Aqaba Thermal Power Plant.
- Al-Fajr Egyptian Jordanian Company.
- Nippon Jordan Fertilizer Company.
- KEMAPCO.
3.2.3.2.3 The Tourism Sector:

Despite regional instability, Aqaba still remains a strong touristic destination due to its location, physical amenities and potential cultural attraction. It is clear that the region itself would gain from further developing tourism in Aqaba as it is a high quality international holiday destination and a gateway to Jordan and the region as a whole.

The rapid growth of the tourism sector in Aqaba is estimated to add 7,300 new 4 & 5 star rooms to Aqaba's hospitality facilities within the next 5 years. 11,000 new jobs are expected to be created in Aqaba as a result in the increase in tourism activities. It is also projected that over the period 2007 -
In 2011, the restaurant sector will require an additional 2,300 new employees annually, with at least 1,000 of these new employees absorbed by the fast food sector each year.

Over the next 5 years, Aqaba will need in excess of 10,000 new hotel & restaurant workers.

The tourism projections for Aqaba are predicted to rise substantially in the medium term future. The above table illustrates the projections, taken from the Aqaba Tourism Marketing Strategy 2005 – 2010 (IS-ASEZA, 2004). The figures illustrate a projected increase of 200% between 2006 and 2010. This will give rise to an additional load on local services and utilities, as well a corresponding increase on the load on the dive sites and beaches along the south coast.

**Table (3.12) Tourism Targets to 2010 (annual hotel bed nights)**

<table>
<thead>
<tr>
<th>Year</th>
<th>2003*</th>
<th>2006</th>
<th>2008</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit</td>
<td>‘000 bed nights per year</td>
<td>‘000 bed nights per year</td>
<td>‘000 bed nights per year</td>
<td>‘000 bed nights per year</td>
</tr>
<tr>
<td>Corporate</td>
<td>88</td>
<td>100</td>
<td>168</td>
<td>260</td>
</tr>
<tr>
<td>Wholesale (groups)</td>
<td>244</td>
<td>320</td>
<td>490</td>
<td>720</td>
</tr>
<tr>
<td>Individual Leisure</td>
<td>44</td>
<td>60</td>
<td>182</td>
<td>420</td>
</tr>
<tr>
<td>Domestic</td>
<td>506</td>
<td>520</td>
<td>560</td>
<td>600</td>
</tr>
<tr>
<td>Total</td>
<td>882</td>
<td>1,000</td>
<td>1,400</td>
<td>2,000</td>
</tr>
</tbody>
</table>

Source (ADC)

A number of tourism mega projects are underway in Aqaba which have major impacts on the overall economic rate of growth due to their size, some
of these are:

- Tala Bay investing $65 million per year through 2011
- Ayla Oasis investing $75 million per year through 2017
- Saraya investing $300 million per year
- ADC Capital Investment Plan investing JD 2,600 million through 2015

3.3 Detailed description of target groups” STAKEHOLDERS”

Article 10 of the Stockholm Convention identifies those groups, which are either particularly sensitive for POPs or their role is important for the successful implementation of the Convention.

“Article 10 of the Stockholm Convention”:
Public information, awareness and education
1. Each Party shall, within its capabilities, promote and facilitate:
   (a) Awareness among its policy and decision makers with regard to persistent organic pollutants;
   (b) Provision to the public of all available information on persistent organic pollutants, taking into account paragraph 5 of Article 9;
   (c) Development and implementation, especially for women, children and the least educated, of educational and public awareness programmes on persistent organic pollutants, as well as on their health and environmental effects and on their alternatives;
   (d) Public participation in addressing persistent organic pollutants and their
health and environmental effects and in developing adequate responses, including opportunities for providing input at the national level regarding implementation of this Convention;

(e) Training of workers, scientists, educators and technical and managerial personnel;

(f) Development and exchange of educational and public awareness materials at the national and international levels; and

(g) Development and implementation of education and training programmes at the national and international levels.

2. Each Party shall, within its capabilities, ensure that the public has access to the public information referred to in paragraph 1 and that the information is kept up-to-date.

3. Each Party shall, within its capabilities, encourage industry and professional users to promote and facilitate the provision of the information referred to in paragraph 1 at the national level and, as appropriate, sub regional, regional and global levels.

4. In providing information on persistent organic pollutants and their alternatives, Parties may use safety data sheets, reports, mass media and other means of communication, and may establish information centers at national and regional levels.

5. Each Party shall give sympathetic consideration to developing mechanisms, such as pollutant release and transfer registers, for the collection and dissemination of information on estimates of the annual quantities of the chemicals listed in Annex A, B or C that are released or disposed of.
3.3.1 *Who are Stakeholders?*

**Stakeholder:**

It is any person, group or institution that has an interest in a development activity, project or programme. This definition includes intended beneficiaries and intermediaries, winners and losers, and those involved or excluded from decision-making processes. The role Stakeholders play in any participatory process may differ for any number of reasons but all may bring legitimate perspectives to the table.

3.3.2 *Stakeholder Analysis:*

Stakeholder analysis is a collection of useful tools or processes for identifying stakeholder groups and describing the nature of their stake, roles and interests.

3.3.2.1 *Why to do a Stakeholder Analysis:*

Doing a stakeholder analysis helps to:

- Identify who we believe should be consulted and engaged with as part of the proposed persistent organic pollutants-reducing initiatives.
- Identify winners and losers, those with rights, interests, resources, skills and abilities to take part or influence the course of the process.
- Reduce or hopefully remove negative social and economic impacts on vulnerable and disadvantaged groups
- Enable useful alliances which can be built upon thereafter
- Enable understandable and timely information disclosure
3.3.2.2 How to do a Stakeholder Analysis

There are many different tools to help people to think about stakeholders. The following is a simple and commonly used process used to identify the individuals and groups that need to be consulted and their real/potential interests in the process.

3.3.2.2.1 Stakeholder Identification – the stakeholder table

The possible stakeholders are:
1. Aqaba Special Economic Zone Authority (ASEZA)
2. Jordan Phosphate Mining Company/Industrial Complex
3. Environmental Non Governmental Organizations “NGOs”.
4. Industries near the source
5. Tourism Sector and Local Hotel “nearby the source”.

3.3.2.2.2 Impact Assessments

Following is a preliminary assessment of the likely impact may have on each stakeholder’s interests. The used symbols are as follows
+ Potential positive impact on interest
- Potential negative impact on interest
+/- Possible positive and negative impacts in different circumstances

A stakeholder group may be impacted in both positive and negative ways by the proposed activities.

Table (3.13) Stakeholder table
<table>
<thead>
<tr>
<th>Stakeholders</th>
<th>Interests</th>
<th>Likely impact of the BAT/BEP implementation</th>
<th>Priority of interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASEZA</td>
<td>Safe environment, less PCB in the country, greater public awareness of BAT/BEP</td>
<td>+</td>
<td>4</td>
</tr>
<tr>
<td>Jordan Phosphate Mining Company/Industrial Complex</td>
<td>Safe working environment, Improved product Cost</td>
<td>+</td>
<td>2</td>
</tr>
<tr>
<td>Environmental Non Governmental Organizations</td>
<td>Safe environment, less PCB in</td>
<td>+</td>
<td>3</td>
</tr>
</tbody>
</table>
3.3.3 Assessment of the Influence and Importance of Stakeholders

How ‘key’ stakeholders can influence or are important to the success of the BAT/BEP Implementation.

- **Influence** is the power which stakeholders have over the ‘project’. How much can stakeholders (whether individual, group or organization) persuade or coerce others into making decisions or doing things?
- **Importance** is the priority given by the ‘project’ to satisfying the needs and interest of each stakeholder.

<table>
<thead>
<tr>
<th>Quadrant A</th>
<th>Quadrant B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quadrant C</td>
<td>Quadrant D</td>
</tr>
</tbody>
</table>

Quadrants A, B and C are the key stakeholders of the project - those who can significantly influence the project or are most important if project...
objectives are to be met.

**Quadrant A:** Stakeholders of high importance to the project, but with low influence. They require special initiatives if their interests are to be protected.

**Quadrant B:** Stakeholders of high importance to the project, but who are also of high importance for its success.

**Quadrant C:** Stakeholders with high influence, who can therefore affect the project outcomes, but whose interests are not the target of the project.

**Quadrant D:** Stakeholders in this box are of low priority but may need limited monitoring and evaluation. They are unlikely to be the subject of project activities and management.

### 3.3.3.1 Influence/Importance Matrix:

<table>
<thead>
<tr>
<th>HIGH IMPORTANCE/LOW INFLUENCE</th>
<th>HIGH IMPORTANCE/INFLUENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tourism sector and local hotels</td>
<td>ASEZA, JPMC</td>
</tr>
<tr>
<td>Industries near the source</td>
<td>NGOs</td>
</tr>
</tbody>
</table>

| LOW IMPORTANCE/INFLUENCE | LOW IMPORTANCE/HIGH INFLUENCE |

### 3.3.3.2 The stakeholder participation

Based on the Stakeholder Table, below is the **Summary Participation Matrix** which is used to clarify the role that all key stakeholders should play at different stages of the project cycle.
### Table (3.14) Summary Participation Matrix

<table>
<thead>
<tr>
<th>Type of participation</th>
<th>Stage</th>
<th>Inform</th>
<th>Consult</th>
<th>Partnership</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification</td>
<td>ALL</td>
<td>ASEZA</td>
<td>JPMC</td>
<td>+</td>
<td>ASEZA</td>
</tr>
<tr>
<td>Planning</td>
<td>ALL</td>
<td>ASEZA</td>
<td>JPMC</td>
<td>+</td>
<td>JPMC</td>
</tr>
<tr>
<td>Implementation &amp; Monitoring</td>
<td>ALL</td>
<td>ASEZA</td>
<td>JPMC</td>
<td>+</td>
<td>JPMC</td>
</tr>
<tr>
<td>Evaluation</td>
<td>ASEZA</td>
<td>ASEZA</td>
<td>JPMC</td>
<td>+</td>
<td>JPMC</td>
</tr>
</tbody>
</table>

#### 3.3.4 Detail description of the target groups:

**3.3.4.1 Aqaba Special Economic Zone Authority:**

The Aqaba Special Economic Zone (ASEZ) was inaugurated in 2001 as a bold economic initiative by the government of Jordan. A liberalized, low tax duty-free and multi-sector development zone, the ASEZ offers multiple investment opportunities in a strategic location on the Red Sea covering an
area of 375 km² and encompassing the total Jordanian coastline (27 km), the sea-ports of Jordan and an international airport.

The Aqaba Special Economic Zone (ASEZ) was inaugurated in 2001 as a bold economic initiative by the government of Jordan. A liberalized, low tax duty-free and multi-sector development zone, the ASEZ offers multiple investment opportunities in a strategic location on the Red Sea covering an area of 375 km² and encompassing the total Jordanian coastline (27 km), the sea-ports of Jordan and an international airport.

The Aqaba Special Economic Zone Authority (ASEZA) is the financially and administratively autonomous institution responsible for the management, regulation and development of the zone. Striving to turn Aqaba into a world class Red Sea business hub and leisure destination. ASEZA sustains a globally competitive investor-friendly environment and optimizes the efficient utilization of entrusted resources in harmony with the Zone's Master Plan to internationally recognized standards.

3.3.4.2 Environmental Non Governmental Organizations “NGOs”.

The main NGOs that may help in this assessment are:

- Jordan Environment Society (JES)
- The Royal Marine Conservation Society of Jordan (JREDS)
The Royal Society for the Conservation of Nature (RSCN)
The Jordan Society for Sustainable Development (JSSD)

3.3.4.2.1 Jordan Environment Society (JES):
JES was established in 1988 as a non-profit non-governmental organization. It is the largest NGO in Jordan in its field. The objective of JES includes, but is not limited to, protecting the environment and its basic elements of water, air, soil and wildlife. Following the belief that the environment is the both the endowment and responsibility of all people, JES encourages interaction of various entities in environmental solutions. Through its 15 branches around the country, JES raises public awareness and promotes community action at the local level.

By accessing professionals in both the private and public sector, JES enables the adoption of policies and the application of international environmental standards. JES also aims to create a sound equilibrium between economic growth and the environment by promoting practices of sustainable development. Understanding that the current environmental situation determines the future, JES aspires to cultivate a culture where the environment is a high priority. It initiates innovative projects that will conserve and protect our natural resources for generations to come.

Since its establishment, JES has hosted various unique environmental projects. Some of these projects include: awareness in water and environment, eco-media, integrated pest control, biogas, recycling, medical waste management, hazardous domestic waste management, solid waste management in Arab countries, comedian environmental theatre and an eco-student network. To accomplish its goals, JES has worked in partnership
with many national, regional and international institutions. Some of the supporting agencies are: The Jordanian government and private sectors, USAID, WEPIA, UNDP, GTZ, Arab Fund for Economic and Social Development (AFESD), Fridrich Naumann Foundation, Canadian International Cooperation Agency (CIDA), WHO, and the French and Swedish governments.

In early 2003, a memorandum of understanding was signed with the Ministry of Environment for cooperation in all environmental issues. Many environmental challenges have been dealt with at the national level and proper solutions were set forth. JES worked hand in hand with the legislative authority, especially the Health and Environment Committee at the House of Representatives, with the aim to develop the current environment laws and regulations.

JES also issues a number of publications, such as the quarterly magazine "The Environment", which educates the reader about current environmental issues around the world. JES also publishes a periodical, called "The message of Environment Journal", that documents the activities that JES and its branches are carrying out. JES has specialized committees to cater to all environmental issues.

It hosts a legal committee, scientific, cultural, media, and agricultural committee, as well as the environment volunteers committee.

In cooperation with the Ministry of Environment, and through the former Program of King Hussein Environmental Management Training Program, JES has been holding Training of Trainers (ToT) courses in the environmental management field since 2003. JES offers courses on environmental audit, state of environmental reporting, environmental law, environmental awareness, and participatory appraisal. JES also offer a
specialized course in Environmental Impact Assessment (EIA), which is necessary for achieving sustainable development and meeting legal requirements for investment projects. At the completion of each course, the participant is granted a comprehensive certificate signed by the Ministry of Environment and JES.

3.3.4.2.2 The Royal Marine Conservation Society of Jordan (JREDS)
JREDS was founded in 1993 by a group of concerned Jordanian ecological divers, headed by Princess Basma bint Ali, one of the first female divers in Jordan. The initiative officially became a non-governmental organization in 1995. It first gained technical and financial momentum with the help of the Global Environment Fund’s Small Grants Program (SGP). Capacity development was a main element of the “Coral Reef Rehabilitation, Research & Conservation Project” implemented with a grant of US $50,000. The project activities included the initiation of a continuous coral reef monitoring program, in close association with the top Marine Ecology scientists in the country, followed by an intensive public information and awareness campaign that was the first of its kind in Aqaba.

During the implementation of this pilot project, JREDS staff was exposed to training, capacity building initiatives and skill-building opportunities, greatly augmenting the staff’s project management, public advocacy, and information dissemination skills. JREDS also benefited from its close cooperation with the Marine Science Station, the leading marine research institution in Jordan, in building a comprehensive information database within JREDS, which has served all its subsequent awareness and capacity development initiatives and programs. JREDS has also managed to develop,
update and maintain this database and use it to lobby for the environment and the sustainable management of economic development of Aqaba.

JREDS capitalized on its technical, advocacy, and project management capacity, to attract further support from donor agencies. Working with stakeholders in the marine environment, such as the Aqaba Special Economic Zone Authority, and local communities, JREDS has greatly expanded its programs over the years. JREDS current scope of activities ranges from community development and income generating programs, to public awareness and clean-up campaigns, to rehabilitation of water networks in poor urban areas and Environmental Impact Assessments. Since inception, JREDS has grown in size and influence, currently managing 19 projects under 3 program areas, with local, regional and global partners. JREDS has also gained influence at the regional level, working with other national environmental groups under a regional initiative to regional protect the Red Sea. Under The Regional Organization for the Conservation of the Environment of the Red Sea and the Gulf of Aden (PERSGA), JREDS has coordinated public awareness programs in the Red Sea region

3.3.4.2.3 The Royal Society for the Conservation of Nature “RSCN”
The Royal Society for the Conservation of Nature is an independent non-profit non-government organization devoted to the conservation of Jordan's natural resources. Established in 1966 under the patronage of His Majesty the late King Hussein, RSCN has been given the responsibility by the Government of Jordan to protect the Kingdom’s natural heritage. As such, it is one of the few voluntary organizations in the Middle East to be granted
this kind of public service mandate. As a result of its pioneering conservation work, RSCN has achieved international recognition.

RSCN accomplishes its role in managing Jordan’s natural resources by:

- Setting up and managing protected areas to safeguard Jordan’s natural environment and biodiversity;
- Running captive breeding programs to save endangered species from extinction;
- Conducting research to provide a scientific base to aid conservation efforts;
- Enforcing governmental laws to protect wildlife and control illegal hunting;
- Raising awareness on environmental issues, with a focus on school students through establishing nature conservation clubs, providing educational programs in the reserves, and integrating biodiversity concepts in school curricula;
- Ensuring the socio-economic development of rural communities by creating job opportunities through eco-tourism, craft production, and other nature-based businesses;
- Providing training and capacity building for environmental practitioners and other institutions throughout Jordan and the Middle East;
- Encouraging public participation in RSCN nature activities through membership packages;
- Promoting public action for environmental protection through campaigns and activities run by an advocacy committee comprised of volunteers from different sectors.
The policies and practices of RSCN are shaped and guided by an elected Board of Directors, made up of eleven members. Responsibility for day-to-day work is delegated to a team of over 320 staff, headed by the Director General. This work falls under four main functional divisions: Conservation, Outreach, Administration and Finance and Wild Jordan.

3.3.4.2.4 The Jordan Society for Sustainable Development (JSSD)
The Jordan Society for Sustainable Development (JSSD) is an environmental non-governmental organization established in Amman, Jordan, in 1997. Under the guidance of HRH Prince Firas ben Raad, founder and president of JSSD, the organization is dedicated to promoting the principles and policies of sustainable development in Jordan. JSSD has adopted the U.N. definition of sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

Through ongoing research, public awareness campaigns, international, and public policy recommendations, JSSD hopes to foster a thoughtful approach to ensuring Jordan’s socioeconomic development within a framework of protecting its rich natural, cultural, and economic resources for future generations.

Objectives of JSSD:

1) Conduct research to further refine the principles of sustainable development and their specific application to Jordan and the surrounding
region.

2) Establish and maintain a database to assist local efforts for sustainable development.

3) Coordinate with international organizations to keep informed about developing sustainability techniques, increase the visibility of the challenges Jordan faces and ensure comprehensive solutions, and participate within the global community to share information, resources, and benefits.

4) Conduct awareness campaigns to educate the public schools, communities, businesses regarding the principles and benefits of sustainable development.

5) Establish a dialog with local governments to elicit their participation, support and implementation of policies that respect both the need for socioeconomic growth and the principles of sustainable development.

3.3.4.3 Industries near the source:

The main industries that may help in this assessment are:

- Jordan phosphate mines company / industrial complex.
- Red Sea Timber Industries Company.
- Aqaba Thermal Power Plant.
- Nippon Jordan Fertilizer Company
- Arab potash company
- Arab Fertilizers and Chemicals Industries LTD
3.3.4.3.1 Jordan phosphate mines company / industrial complex.

The Jordan Phosphate Mining Company was established in 1949 for the purpose of mining and exporting of phosphate rock via Aqaba main port. In 1982 the fertilizers complex was established and started operation. The Complex is located at WADI 2 which is 15 km south of the port of Aqaba, WADI 2 is further located as the second WADI North of the coastal border of Saudi Arabia.

JPMC facilities in Aqaba contain three major components: Jordan chemical complex, industrial port and Phosphate company branch at the main port. The complex includes four main units i.e. phosphoric acid unit, Aluminum fluoride unit, DAP unit and the utilities unit. The complex was designed to produce fertilizers and chemicals according to the following capacities:-

<p>| | | |</p>
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<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>6</td>
<td>DAP</td>
<td>740,000 t/a</td>
</tr>
<tr>
<td>7</td>
<td>Phosphoric Acid</td>
<td>415,000 t/a</td>
</tr>
<tr>
<td>8</td>
<td>Aluminum Fluoride</td>
<td>20,000 t/a</td>
</tr>
</tbody>
</table>
3.3.4.3.2 Aqaba Thermal Power Plant

The Aqaba Thermal Power Station is the largest power station in Jordan. It is located in the south-western border of Jordan, approximately 22 km south of the town of Aqaba and 1 km from the Red Sea. The plant site is some 35 meters above sea level and located in the middle of the industrial area adjacent to the fertilizer complex.

The Aqaba Thermal Power Station was established in 1986 as an oil-fueled power station. After construction of the Arab Gas Pipeline, the power station was switched to use natural gas.

It has a total generation capacity of 656 MW, which consists of five steam turbines units (5 x 130 MW), and two hydraulic turbines (2 x 3 MW). The power station is operated by the Central Electricity Generating Company of Jordan.

3.3.4.3.3 Red Sea Timber Industries Company

Red Sea Timber Industries (RSTI) is a timber processing plant that has a workforce of over 250 employees, located in the middle of the industrial area adjacent to the fertilizer complex. And 1 km from the Red Sea which makes importing the timber and exporting product extremely efficient and fast.

Its mission is the manufacturing of high quality Sawn Timber, Block Board, Particle Board, Plywood, Lamination Board, Pallets and Furniture, from carefully selected timber obtained mostly from the forests of Russia, Canada and the Far East.

First rate and highly specialized equipment coupled with precise quality
control checks made it possible for RSTI to become one of the most reputable timber plants in the world.

Being the only timber plant in the region and among a limited, 40 plants worldwide of this size, it export sizeable quantities of processed timber to the Middle East constantly opening new markets beyond the region.

3.3.4.3.4 *Nippon Jordan Fertilizer Company:*
NJFC is the first joint venture company between Japan and Jordan to produce high quality fertilizers with the participation of two Jordanian companies (JPMC, APC) as well as four Japanese companies. It is situated about 26 km from Aqaba city at southern coast. The plant was mechanically completed at the end of December 1996 as scheduled, followed by commissioning activities startup, then the commercial production at the beginning of May 1997.

The production design capacity of the plant is 300,000 MT/a for producing compound fertilizers consisting of 4 grades in addition to DAP.

3.3.4.3.5 *Arab Potash Company:*
The site is located 110 kilometers south of Amman and 200 kilometers north of Aqaba. The site is a Solar Evaporation Pond System of an area of 150 square kilometers and processing plants for the ore.

The investment in the original project, including substantial infrastructure was nearly 480 Million USD. Financing was obtained through loans from international finance institutions and aid agencies as well as Arab development funds. The project began in 1976 with tests and experiments to determine the parameters of various technologies and ideas in a very hostile environment. Construction began in 1979 and was completed in 1982. At the
end of construction, about (117) kilometers of seepage proof dykes were built (other dykes built later on). These were more than 8 meters wide at the top and were an engineering challenge to be built on top of a non-stable sea bed. The excavation carried out during the construction period was of a colossal magnitude, 16 million cubic meters of earth material was displaced.

Potash production began in 1983 and has since progressed with various schemes aimed at optimizing and expanding this production. The initial plant was built to a capacity of 1.2 million tonnes of product. This was expanded in the late eighties to handle 1.4 million tonnes and key modifications were undertaken with the Solar System to enhance the production of the ore accordingly. A second plant based on different technology and of a capacity of 0.4 million tonnes was built in 1994 and this brought the total production capacity to 1.8 million tonnes. The cost of the new plant was around 120 million USD. There are plans to expand through further optimization of the existing plants. Projects are underway to expand the Solar Evaporation System and construct another plant and thus raise the capacity to 2.4 million tons of product after the year 2008.

The capital of the Arab Potash Company is JD 83318000. It has a concession from the Jordanian Government to exploit, manufacture, and market the mineral resources of the Dead Sea, until 2058

3.3.4.3.6 Arab Fertilizers and Chemicals Industries LTD, (Kemapco):

Kemapco has a plant production capacity of 150000 t/a of potassium nitrate (NOP) and 75000 t/a of dicalcium phosphate (DCP). Since Feb. 1st 2007 The Company has been 100% owned by Arab Potash Company.
The company was originally established under the name Kemira Arab Potash Company Ltd. (Kemapco) as a 50:50 joint venture set up in Jordan in 1999 between Kemira GrowHow (Finland) and Arab Potash Company (Jordan) with a 110 million USD investment.

3.3.4.4 Tourism Sector and Local Hotel “nearby the source”.
Near the Jordan phosphate mines company “industrial complex” there are several tourism activities which may help in this assessment as target groups they are:

- Tala bay:
- Tala bay hotels:

3.3.4.4.1 Tala bay:
The project site is located about 14 km of the Aqaba city in the southeastern corner of Jordan, on the big bay shoreline which overlooks the Gulf of Aqaba of the red sea, with an approximate area of 2,700,000m².

The project consists of the following major elements:

- Recreation and entertainment facilities and include Town center, Marina,
- Beach hotels, Golf courses, Shopping centers.
- The visitors residential facilities and include beach hotels, villas, semi-villas and apartments.
- Supporting facilities and include staff housing, light industries and utility area.
- Open space, roadway and vehicular circulation.

3.3.4.4.2 Tala bay hotels:

3.3.4.4.2.1 Radisson Blu Tala Bay Resort:
Bordering the Marina Town from the north and surrounded by the Majestic Sharah Mountains, the 5-star Radisson Blu Tala Bay Resort sits on the shores of the beautiful Red Sea and offers guests exciting aquatic activities, gourmet, international cuisines and sumptuous hotel rooms and suites. Aqaba is home to world-famous coral reefs, and the hotel staff plan expert diving expeditions to explore the area's natural beauty. From parasailing to jet skiing and five beach side pools, this beach hotel ensures guests have an exciting and active holiday.

- 336 luxury hotel rooms and suites.
- Private beach access.
- Snorkeling and diving expeditions led by trained professionals.
- Five pristine pools.

3.3.4.4.2.2 Moevenpick Resort Tala Bay
Adjacent to the Lake Residences, the 5-star 306-room Moevenpick Resort Tala Bay has 161-meter spectacular beach front. Guests can enjoy a workout at the state-of-the-art gym or choose from the wide range of water activities that include the hotel’s own diving centre, or shopping spree at the hotel’s shopping arcade, a visit to the open air amphitheatre, or may simply lounge by the sea or the 3,000 square meters of magnificent swimming pools.

3.3.4.4.2.3 Marina Plaza
At the entrance of Tala Bay, the Marina Plaza Hotel offers you a stunning view of the Marina and central swimming pool, as well as an open sea view that stretches all the way to the mountains of Egypt on the other side of the Gulf of Aqaba. This stunning perspective can be enjoyed from any of the
hotel’s 260 rooms, which include 8 suites that can be booked as a junior or senior suite.

Guests at the hotel can enjoy a wide range of recreational activities for all ages, from a delightful children’s playground, to a gym & fitness centre, aqua aerobics, stretching, or yoga.

3.4 Detailed description of adequate and effective tools for awareness rising

The reduction of POPs emissions in Aqaba may be done by increasing the public awareness in both sectors, the local community and the workers in the companies’ responsible for emitting these emissions.

This assessment will analyze the tools available for conveying information to the identified target groups. The objective is to identify the most
appropriate public awareness tools that will be used during the implementation of BAT/BEP for awareness rising at the selected locations.

3.4.1 Communications and awareness tools

World wide there are many types of communications and awareness tools that can be grouped under five categories:

1. The "Interpersonal communication tools": are considered as one of the basic steps to be considered in stimulating awareness and preparing for future activities. It can be implemented through discussions and debates sessions, visioning and focus group sessions, Participatory Rapid Appraisal (PRA) techniques, role playing in addition to visits, tours, workshops and exhibitions.

2. The "Group media tools": include mainly posters, banners, photography, flip charts and drawings, in addition to video and audio recordings.

3. The "Traditional media tools": include the theatre, songs, stories, sayings and music as tools for communicating with the community.

4. The "Mass media tools": include the press, radio and television.

5. The "Information and communication technologies tools": include mainly the use of computer slide show and presentations and the internet.

It is very important to point out here that the use of the above mentioned tools should be planned in a cost-effective manner taking into consideration the ability of the community to absorb or afford the used communication tools.

In this assessment the following awareness tools will be used:
3.4.1.1 The "Interpersonal communication tools"

This tool will be implemented through the following:

1. Community Organization/Neighbourhood workshops

**Objective:** To bring together neighbourhood industries and organizations to plan and convene neighbourhood-based viewing dialogues that engage communities disproportionately impacted by pollution and that will connect organizations to opportunities that advance good environment with a relevant neighbourhood-based agenda.

**Target groups:**
- Jordan phosphate mines company / industrial complex.
- Red Sea Timber Industries Company.
- Aqaba Thermal Power Plant.
- Nippon Jordan Fertilizer Company
- Tala bay Resort
- Tala bay hotels

2. Internal company workshops:

**Objective:** To spark a broader dialogue and reflection of institutional work and to identify common areas of intersection and opportunities for action.

**Target Audience:**
All internal staff of industrial complex / Jordan phosphate Mines Company.
Process and Timeline: Estimate from 1-3 months. As there are multiple sites, identify an on-site point person who can liaison with staff and who can also effectively publicize and coordinate a workshop. Efforts to bring in staff or outside guests whose work is relevant to content of the workshop subject thus tie the workshop’s content with on the ground work.

3. **Local community workshops:**

**Objective:** To bring together and educate environmental leaders, policy makers, zone and city department heads and officials, in a common dialogue around the subject.

**Target Audience:**
- ASEZA Environment Department
- Environmental non governmental organizations :
  - Jordan Environment Society (JES)
  - The Royal Marine Conservation Society of Jordan (JREDS)
  - The Royal Society for the Conservation of Nature “RSCN”
  - The Jordan Society for Sustainable Development (JSSD)

Process and Timeline: One to three months. Convene a planning committee to work on planning the event including developing the agenda, coordinating logistics and inviting speakers.

**3.4.1.2 The "Group media tools"**

This tool will be implemented through the following:
- Brochure
- Briefs
• Graphics
• Newspaper essays

3.4.1.3 The "Information and communication technologies tools"
This tool will be implemented through the following:
1. POPs BAT/BEP Day Presentations:
The objective of this tool is to assign a day for raising the public awareness during the implementation of BAT/BEP at the selected location. It may be divided to several days according to other awareness tools for example:
The BAT/BEP day may be held at the same time of the Community organization/Neighborhood workshops or local community workshops mentioned earlier.
The Jordan phosphate mines company /Industrial complex may assign a working day as the BAT/BEP day, and it may be the same day for the internal company workshop mentioned above.
2. Presentation for educational sector (schools, colleges and universities)
3. Advertising using social media such as face book and twitter is simply a new type of public awareness campaign.

3.5 Detailed description of information content dissemination approach
This assessment will identify the information that the target groups are lacking and is crucial for them concerning the implementation of the BAT/BEP.
The objective is to identify the information that will be included in the public awareness tools.
The assessment was carried out according to pre-developed tools of socio-economic assessment that is using questionnaires. A 15 socio-economic questionnaires were distributed to the target groups see Annex 3.

3.5.1 Questionnaire

The questionnaire contains the following questions:

<table>
<thead>
<tr>
<th>Questionnaire Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you Know anything about Stockholm Convention?</td>
</tr>
<tr>
<td>Do you know What POPs are?</td>
</tr>
<tr>
<td>Do you know what UP-POPs are?</td>
</tr>
<tr>
<td>Do you have any information about Annex C POPs?</td>
</tr>
<tr>
<td>Do you know what the facilities in Aqaba that release POPs are?</td>
</tr>
<tr>
<td>Do POPs have any health or environmental impacts at the workers at site?</td>
</tr>
<tr>
<td>Do you know what are the safety measures to protect the workers at site that release POPs?</td>
</tr>
<tr>
<td>Do we have any existing national regulations and rules concerning the POPs?</td>
</tr>
<tr>
<td>Is there a need to have more regulation for POPs?</td>
</tr>
</tbody>
</table>
Are there any standards for the releases of pops in the Jordanian standards?

Do you think that your organization has a role in reducing the release of POPs?

Do you have any idea about What are the ways and possible measures to reduce the release of POPs?

Do you know What the meaning of BAT/BEP is?

How do you think that BAT/BEP will reduce the releases of POPs?

### 3.5.2 Questionnaire Analysis

Following is analysis of the questionnaire answers that was obtained from concerned parties:

**Table (3.16) Questionnaire Analysis:**

<table>
<thead>
<tr>
<th>Question</th>
<th>No of the “Yes answers“</th>
<th>No of the “No answers“</th>
<th>No of the “don’t know answers“</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you Know anything about Stockholm Convention?</td>
<td>10</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>Do you know What are POPs?</td>
<td>8</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<td>------------------------------------------------------------------------</td>
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<td>---</td>
</tr>
<tr>
<td>Do you know what are UP-POPs?</td>
<td>4</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Do you have any information about Annex C POPs?</td>
<td>6</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Do you know what are the facilities in Aqaba that release POPs?</td>
<td>6</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Do POPs have any health or environmental impacts at the workers at site?</td>
<td>7</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Do you know what are the safety measures to protect the workers at site that release POPs?</td>
<td>5</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Do we have any existing national regulations and rules concerning the POPs?</td>
<td>4</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>Question</td>
<td>4</td>
<td>8</td>
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</tr>
<tr>
<td>Is there a need to have more regulation for POPs?</td>
<td>4</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Are there any standards for the releases of pops in the Jordanian standards?</td>
<td>3</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>Do you think that your organization has a role in reducing the release of POPs?</td>
<td>4</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Do you have any idea about What are the ways and possible measures to reduce the release of POPs?</td>
<td>6</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Do you know What is the meaning of BAT/BEP?</td>
<td>4</td>
<td>8</td>
<td>3</td>
</tr>
</tbody>
</table>
reduce the releases of POPs?

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### 3.5.3 Description of Information Content

According to the above analysis, it seems that the target groups in general don’t have proper information concerning the Stockholm Convention, POPs, and other related issues. Consequently, the awareness program should focus on the following:

- **Definition of Stockholm Convention on Persistent Organic Pollutants**: Focuses on countries' commitment towards the reduction of the releases of unintentionally produced persistent organic pollutants (UP-POPs).
- **Definition, risks, toxicity of POPs, UP-POPs, and Annex C POPs**.
- **Identifications of the facilities in Aqaba that release POPs**.
- **Environmental and human health impacts of the UP-POPs**.
- **Occupational safety measures at the UP-POPs source locations**.
- **Assessment of the existing national regulations and rules concerning the POPs if any and the need to have more regulation for POPs**.
- **International standards for the releases of POPs and the Jordanian standards**.
- **The organizations' role in reducing the release of POPs**.
- **The ways and possible measures to reduce the release of POPs**.
- **The definition of BAT/BEP**.
- **Methods of BAT/BEP implementation**.
3.6 Cost Benefit Analysis of BAT/BEP implementation

3.6.1 Introduction

A cost-benefit analysis is defined as:

A technique that compares the monetary value of benefits with the monetary value of costs in order to evaluate and prioritize issues. In its simple form, cost-benefit analysis uses only financial costs and financial benefits. A more sophisticated cost-benefit analysis approach attempts to put a financial value on intangible costs and benefits (e.g., the cost of environmental damage or the benefit of quicker and easier travel to work) (World Bank, 2009).

The cost-benefit analysis is a widely used and recognized technique for assessing public policies and projects from an economic perspective (Arrow
et al., 1996). The cost-benefit analysis allows decision-makers to determine whether financial resources should be allocated to these policies or projects.

3.6.2 Project Benefits

3.6.2.1 Health benefits

Scientific evidence indicates that exposure to POPs - even at low concentrations - may cause a wide range of adverse effects to human health (Strawson 1997; Strober 1998).

Fish, birds and animals with high concentrations of POPs were found to develop cancers and have serious developmental mutations and high death rates.

The kids.health.org Web site reports that exposure to POPs has been linked in humans to:

- Birth defects (low birth weight, impaired intelligence).
- Immune system disorders.
- Developmental disorders in children.
- Reproductive health disorders.
- Endocrine and nervous system abnormalities.
- Cancers.

In JPMC case, the main route for workers' exposure will be mainly through the respiratory system since the formation of Dioxin (PCDDs) and Furan (PCDFs) results from the combustion processes in boilers, which emitted to air through stacks emissions.
The reduction of negative health impacts due to POPs on the hotspot population represents a primary benefit (a "saved cost") of the proposed risk management scenario.

3.6.2.1.1 Health Benefit Estimation:

To estimate health benefits in monetary terms, a standard technique, used by the World Health Organization (WHO), is the valuation of disability-adjusted life-years (DALY).

The DALY is an economic parameter which extends the concept of potential years of life lost due to premature death to also include equivalent years of “healthy” life lost due to poor health or disability (WHO, 2008).

The DALY combines in one measure the time lived with a disability, and the time lost due to premature mortality, both of which are plausible outcomes of contaminant exposure.

From WHO website the DALY rates for Jordan in the year 2002 was 15819 (Annex 3).

The DALY rate determined by WHO is applicable to the entire population of the countries considered; it can be used to estimate the number of DALYs (total or potentially related to chemical exposure) at specific sites through the following formula, where Population_{site} is the potentially exposed population at the site who may benefit from the proposed remediation efforts.

$$\text{DALYS}_{\text{site}} = \text{DALYrate}_{\text{country}} \times \text{Population}_{\text{site}}$$
Where:

- $DALYS_{site}$ are the number of site specific DALYs calculated
- $DALY_{rate_{country}}$ is the total number of DALYs per 100000 population for a country, obtained from the WHO website

Population$_{site}$ is the potentially exposed population at the site who may benefit from the proposed remediation efforts

Taking the following figures:

$DALY_{rate_{Jordan}} = 15819$

Population$_{site} = 1000$

Then $DALYS_{AIC} = \frac{15819 \times 1000}{100000}$

$DALYS_{AIC} = 158.19$

To obtain the value of a DALY, the Value of a Statistical Life must be divided by the number of DALY corresponding to a premature death. This number varies in function of the age at which death occurs, which itself depends on the nature of the risk considered (here, POPs-related health impacts). However, no information is available about age-specific mortality caused by exposure to POPs; and, there is no basis to assume that POP-related diseases would impact a given age class more than another.

**3.6.2.2 Environmental benefits**
Contamination has various environmental impacts, reduction in contamination will translate into better quality of environmental resources and services (i.e., in environmental benefits).

Greenhouse gases and POPs are often emitted by the same sources, and, therefore, a single set of technologies or policy measures has co-benefits for emission reduction.

3.6.3 Project Cost

Project costs include:

- Direct costs (including investment costs and operating costs) associated with design and implementation and monitoring and evaluation.
- Indirect costs, including:
  - economic costs (e.g. loss of productivity due to more stringent safety procedures);
  - social costs (e.g., adverse health impacts); or
  - environmental costs (e.g., greenhouse gas emissions).

3.6.3.1 Direct costs

Referring to chapter 1 section 1.14.2, PCDD/PCDF air emission levels associated with best available techniques can be significantly lower than 0.1 ng I-TEQ/Nm$^3$ (oxygen content: 6% for solid fuels; 3% for liquid
fuels). (UNEP-POPS-BAT/BEP GUIDELINES).
The BAT can be used through the following:
1-Boiler Enclosure:
Boiler enclosures or jackets are installed externally on the boiler for heat conservation, maintenance of operating temperatures, and protection of personnel. Suitable insulation materials such as mineral wool, calcium silicate, or urethane foam, are used for boiler enclosures. The use of boiler enclosures improves the efficiency of steam generation by up to 5 percent. It also reduces external noise pollution and maintenance costs.

The price of the insulation materials according to internet websites selling these materials are:
US $0.3 - 5 / Square Meter

2- Natural gas use as a fuel in boilers instead of fuel oil:
To detect the advantages of such a step the following comparison is done:

❖ **Total Fuel Cost**: the cost of fuel is not just the price per unit of fuel, but also the cost of running the auxiliary equipment required to burn that fuel. Natural gas requires only combustion air fan(s). Fuel oil requires pumps, combustion air fans, atomizers, soot blowers, and perhaps tank and line heaters depending on the oil grade and season.

❖ **Emissions**: burning fuel oil results in a substantial increase of carbon (CO₂), particulates and sulfur (SO₂) as compared to natural gas combustion.
Operation and Maintenance: in addition to emissions increases, the by-products that foul the inside of the boiler (soot) are also much higher with fuel oil than with natural gas. Because there are more moving parts, pumps, and other components with burning oil, the associated equipment maintenance is also higher.

Boiler Capacity: fuel oil as a liquid has a higher energy density than natural gas; it also burns with more luminosity - which can be a major factor in water tube boiler capacity. Therefore, depending on boiler and burner design, one fuel may have a capacity advantage over the other in a specific boiler.

Other Advantages of using Natural Gas:
- No on-site storage of fuel required; no inventory issues
- Pay for fuel after/as it's used, not before
- Potentially less labor costs with reduced boiler operator requirements in some application

Basic Fuel Cost Comparison Factors
The BTU content of 1 gallon of fuel oil varies with grade and quality; the heavier the grade (higher number) the higher the BTU content. Heavier grade fuel oil is also less expensive. For this example, let's assume that the comparison is with #2 Fuel Oil at about 140,000 BTUs per Gallon and Natural Gas at about 1,000,000 BTUs per MCF

(1 MCF is about equal to 1 DekaTherm)
1,000,000 BTUs (gas) / 140,000 BTUs (oil) = 7.14 Gallons per Million BTUs.
The simple formula is $7.14 \times \text{$/Gallon} = \text{$/million BTUs}$

Therefore, if Fuel Oil is $3.00 per gallon, 1 million BTUs cost $7.14 \times 3.00 = 21.42$ per million BTUs

1 MCF of Natural Gas is about 1 million BTUs; if gas is about $10.00 per MCF, then fuel oil would be twice the cost of natural gas, in this example - before considering the other losses and issues explained above.

NOTE: #6 Fuel Oil has more BTUs per gallon and costs less than #2 Fuel Oil.

If #6 Fuel Oil has 155,000 BTUs/Gallon and costs $2.00 per gallon:

\[
\frac{1,000,000}{155,000} = 6.4 \text{ gallons} \times 2.00 = 12.90 \text{ per million BTUs}
\]

3.6.3.2 Indirect Costs

Referring to chapter 1 section 1.14.3, the best environmental practices if applied to JPMC boilers, with efficient way will lead to great savings in energy combined with great reduction in UP-POPs emissions.

The assessment at JPMC showed high potentials for reducing environmental problems in different process plants, especially regarding huge losses of raw materials and energy.

However assessment showed that the company does not lack technical knowledge and expertise. The production and process staff at JPMC are experienced and understand the complex processes perfectly.

3.6.4 Conclusion

According to the above Cost Benefit Analysis for BAT/BEP Implementation; it can be seen that several limitations prevent the implementation of the Cost
Benefit Analysis process where data is limited for the following reasons:

- Difficulty of establishing a dose-response or exposure-response function for health impacts due to POPs: despite the recognized link between POPs exposure and health impacts, establishing an unequivocal relationship between POPs-exposure and adverse health impacts has yet evaded scientists (Herkovits, 1998). There is no available exposure-response or dose-response equation that would allow us to derive a quantitative estimate of a disease incidence (and severity) in the population from its level of exposure to, or contamination by, POPs.

- Difficulty of estimating the reduction in exposure achieved due to the multiple exposure pathways between the environment and human population. In addition there is no samples analysis program for the up-pops emitted from AIC boilers.

- Limited data and knowledge gathering: in most developing countries, data are not available and the cost of data collection is economically prohibitive.

However the implementation of BAT/BEP will lead to:

- The reduction of negative health impacts due to POPs on the hotspot population.
- Reduction in contamination will translate into better quality of environmental resources and services.
Greenhouse gases and POPs are often emitted by the same sources, and, therefore, a single set of technologies or policy measures has co-benefits for emission reduction.

The use of boiler enclosures improves the efficiency of steam generation by up to 5 percent. It also reduces external noise pollution and maintenance costs.

Switching to natural gas instead of fuel oil will lead to attractive savings in both fuel consumption and emitted pollutants.

The best environmental practices if applied to JPMC boilers with efficient way; will lead to great savings in energy combined with great reduction in UP-POPs emissions.
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ANNEX 1

1- 2009 stack measurements conducted by JPMC environment division.
| Unit   | Pollutant | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | JS |
|--------|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|        | NH₃       | -   | 710 | 705 | 686 | 718 | 698 | 713 | 578 | 425 | 682 | 666 | 470 | 50 |
|        | F         | -   | 0.7 | 0.4 | 0.7 | 0.8 | 0.8 | 1.1 | 0.7 | 0.5 | 1   | 0.6 | 0.6 |
|        | P₂O₅     | -   | 1.4 | 2.1 | 1.2 | 1.6 | 1.8 | 2.3 | 1.6 | 1.6 | 1.6 | 1.6 |
|        | NH₃       | -   | 725 | 715 | 696 | 713 | 711 | 715 | 618 | 632 | 550 | 712 | 530 | 50 |
|        | F         | -   | 0.8 | 0.6 | 0.6 | 1.2 | 0.9 | 1.3 | 0.8 | 0.4 | 0.8 | 0.6 | 0.6 |
|        | P₂O₅     | -   | 1.2 | 1.9 | 1.9 | 2.4 | 1.3 | 3.8 | 1.6 | 1.7 | 4   | 1.8 | 1.1 |
|        | NH₃       | -   | 739 | 647 | 713 | 614 | -   | 715 | 712 | 718 | 440 | -   | 720 | 50 |
|        | F         | -   | 1.9 | 0.7 | 0.8 | 1.1 | -   | 0.3 | 1   | 0.9 | 0.4 | -   | 0.7 |
|        | P₂O₅     | -   | 3.9 | 1.4 | 2.1 | 3.3 | -   | 2.5 | 2.4 | 1.6 | 1.8 | -   | 1.6 |
|        | NH₃       | -   | 668 | 2445| 719 | -   | 714 | 716 | 710 | 629 | -   | 624 | 50 |
|        | F         | -   | 2.1 | 0.9 | 0.5 | -   | 0.4 | 0.6 | 0.9 | 0.9 | -   | 0.8 |
|        | P₂O₅     | -   | 1   | 1.8 | 2.2 | -   | 1.6 | 1.6 | 1.8 | 1.8 | -   | 1.4 |
|        | NH₃       | -   | -   | 2360| 663 | -   | 724 | 718 | -   | 707 | -   | -   | 50 |
|        | F         | -   | -   | 1.1 | 0.3 | -   | 0.8 | 0.9 | -   | 0.7 | -   | -   |
|        | P₂O₅     | -   | -   | 2.3 | 1.9 | -   | 2.9 | 1.8 | -   | 1.4 | -   | -   |

|        | NH₃       | -   | 844 | 549 | 715 | 718 | 667 | 705 | 718 | 706 | 638 | 690 | 50 |
|        | F         | -   | 0.8 | 0.9 | 0.6 | 0.4 | 0.9 | 1.4 | 0.8 | 0.7 | 0.9 | 0.9 |
|        | P₂O₅     | -   | 1.9 | 1.6 | 0.8 | 2.4 | 2.6 | 3   | 1.8 | 2.4 | 1.7 | 2.1 |
|        | NH₃       | -   | 825 | 826 | 718 | 702 | 720 | 717 | 717 | 716 | 657 | 680 | 50 |
|        | F         | -   | 0.8 | 1.2 | 0.8 | 0.8 | 0.4 | 0.7 | 0.7 | 1.3 | 0.7 | 0.8 |
|        | P₂O₅     | -   | 1.7 | 3.1 | 2.5 | 2.1 | 1.8 | 1.4 | 1.4 | 1.2 | 1.4 | 1.8 |
|        | NH₃       | -   | 818 | 818 | 638 | 714 | 712 | 712 | 724 | 703 | 697 | 690 | 50 |
|        | F         | -   | 0.6 | 0.9 | 1.6 | 0.4 | 0.5 | 0.5 | 0.4 | 0.3 | 0.9 | 0.9 |
|        | P₂O₅     | -   | 2.2 | 2.7 | 4.8 | 1.8 | 2.6 | 2.6 | 1.8 | 1.6 | 1   | 2   |
|        | NH₃       | -   | 739 | 630 | 713 | 719 | 721 | -   | -   | 715 | 640 | 50 |
|        | F         | -   | -   | 0.6 | 1.4 | 0.9 | 0.9 | -   | 0.9 | -   | 0.4 | 1   |
|        | P₂O₅     | -   | -   | 1.4 | 3.7 | 2.3 | 1.3 | 1.8 | -   | -   | 1.8 | 1.8 |
|        | NH₃       | -   | -   | 1222| 704 | -   | -   | -   | -   | -   | -   | 50 |
|        | F         | -   | -   | 1.5 | 0.8 | -   | -   | -   | -   | -   | -   | -   |
|        | P₂O₅     | -   | -   | 3.4 | 2.4 | -   | -   | -   | -   | -   | -   | -   |
|        | NH₃       | -   | -   | 698 | -   | -   | -   | -   | -   | -   | -   | -   |
|        | F         | -   | -   | 0.8 | -   | -   | -   | -   | -   | -   | -   | -   |
|        | P₂O₅     | -   | -   | 1.6 | -   | -   | -   | -   | -   | -   | -   | -   |

| AIF₃   | F         | -   | -   | 4.1 | 3.6 | 3.5 | 3.1 | 3.2 | 3.1 | 3.2 | 2.5 | 2.4 | 15 |
| PA     | -         | -   | -   | -   | 2.4 | 3.9 | 4.1 | 2.8 | 2.8 | 2.6 | 1.4 | 1.4 |
|        | -         | -   | -   | -   | 2.9 | 3.2 | 3.8 | 2.8 | -   | -   | 2.6 | 2.1 |
|        | -         | -   | -   | -   | -   | -   | -   | 1.9 | -   | -   | -   | -   |
|        | -         | -   | -   | -   | -   | -   | -   | 2.9 | 2.3 | 2.9 | 3.1 | 3.1 |
|        | -         | -   | -   | -   | -   | -   | -   | 3   | 2.1 | 2.6 | 2.9 | 2.5 |
|        | -         | -   | -   | -   | -   | -   | 1.6 | 1.80| -   | -   | -   | 2.9 |
|        | -         | -   | -   | -   | -   | -   | 2.1 | -   | -   | -   | -   | -   |

| SO₂ + acid mist | -   | -   | -   | 29  | 21  | 18  | 28  | 15  | 30  | 55  | 65  |
|                | -   | -   | -   | 27  | 26  | 28  | 19  | 49  | 32  | 51  | -   |
|                | -   | -   | -   | 23  | 19  | 38  | 21  | 21  | 28  | -   | -   |
|                | -   | -   | -   | 32  | 32  | 30  | -   | -   | -   | -   | -   |

| SO₄ | acid mist | -   | -   | 41  | 25  | 21  | -   | 25  | 102 | 80  | 60  |
|      |           | -   | -   | 27  | 22  | 17  | 31  | 22  | -   | 65  | 90  |
|      |           | -   | -   | 31  | 29  | 21  | 24  | 29  | -   | 58  | -   |
|      |           | -   | -   | 28  | 21  | 26  | -   | 21  | -   | -   | -   |
2- 2010 stack measurements conducted by JPMC environment division.
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**AIiF₃**

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<th>July</th>
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11/09/0206
Fig. 2 Sulfuric Acid Production

- Hot Steam 175°C to Burner
- Air to Burner
- Cool Seawater to Hot Seawater
- Vanadium Pentoxide Catalyst to Ceramic Packed Column
- H₂SO₄ to Ceramic Packed Column
- H₂SO₄ 98.5% to Phosphoric Acid Unit

- Elemental Sulfur to Burner
- Burner to Hot Steam, H₂S, SO₂ to Utilities Unit
- Burner to Filter
- Filter to Solid Impurities to Gypsum Landfill
- Filter to Heat Exchanger
- Heat Exchanger to Ceramic Packed Column
- Ceramic Packed Column to SO₂, SO₃ Acid Mist
Al(OH)₃

Dryer (Diesel Burner) → SO₂, NOₓ, CO₂, CO, Dust

Reactor

Vacuum Filter → SiO₂ to Gypsum Landfill

Heater

Filter

Dryer (Heat Exchanger) → Package & Storage

H₂SiF₆

Wet Scrubber → Scrubb Water to Ponds

Hot Steam

Excess Water to Phosphoric acid Unit or Ponds

HF

Fig 4. Aluminum Fluoride Production
Fig. 3 Di-Ammonium Phosphate Production

- Phosphoric Acid 49%
- Anhydrous Ammonia 99.5%
- NH₃, HF, Dust, P₂O₅
- CO₂, CO, SOₓ, NOₓ
- Burner
- Wet Scrubber
- Phosphoric Acid + H₂O
- Scrub Water
- Storage & Packaging
- Stack
1. **Introduction**

BEN HAYYAN - Aqaba International Laboratories were approached by the Environment Directorate to measure gaseous emissions and dust from stationary sources at Jordan Phosphate Mines Company - Industrial Complex. These sources were:

- Utilities - boiler B
- Sulfuric Acid unit 53 & 54
- Phosphoric Acid
- Aluminum Fluoride
- DAP unit 75 & 76
- Phosphate Grinder

<table>
<thead>
<tr>
<th>Source</th>
<th>Measured Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utilities boiler B</td>
<td>SO\textsubscript{2}, NO\textsubscript{x}, CO, CO\textsubscript{2} and O\textsubscript{2}</td>
</tr>
<tr>
<td>Sulfuric Acid unit 53 &amp; 54</td>
<td>SO\textsubscript{2}, CO, CO\textsubscript{2} and O\textsubscript{2}</td>
</tr>
<tr>
<td>Phosphoric Acid</td>
<td>HF, NO\textsubscript{x}, CO, CO\textsubscript{2} and O\textsubscript{2}</td>
</tr>
<tr>
<td>Aluminum Fluoride</td>
<td>HF, NO\textsubscript{x}, CO and O\textsubscript{2}</td>
</tr>
<tr>
<td>DAP unit 75 &amp; 76</td>
<td>NH\textsubscript{3}</td>
</tr>
<tr>
<td>Phosphate Grinder</td>
<td>Dust</td>
</tr>
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</table>

2. **Methodology**

Measuring was conducted for Ten minutes for each source utilizing state-of-the-art equipment, whose principles of operation are shown in table (2) below.
Table (2): Measured parameters and their measurement principles

<table>
<thead>
<tr>
<th>Measured Parameter</th>
<th>Principle of measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO$_2$, CO, CO$_2$</td>
<td>Non-dispersive infrared (NDIR)</td>
</tr>
<tr>
<td>Nitrogen oxides (NO$_x$)</td>
<td>Chemiluminescence</td>
</tr>
<tr>
<td>Oxygen (O$_2$)</td>
<td>Paramagnetic</td>
</tr>
<tr>
<td>Ammonia (NH$_3$)</td>
<td>UV Spectroscopy</td>
</tr>
<tr>
<td>Dust</td>
<td>Gravimetric Analysis based on Iso-kinetic Sampling</td>
</tr>
</tbody>
</table>

3. Results

Results expressed as 1-minute average concentrations and values of all measured parameters are shown in tables 3, 4a, 4b, 5, 6, 7a, 7b and 8 below:

*Note: Concentrations of SO$_2$, NO$_x$, CO and HF are corrected based on Oxygen content of 8% as required by Jordanian Standards (JS 1189\2006).*

Table (3): Gaseous emissions from Boiler B\ Utilities at JPMC conducted by Ben Hayyan- Aqaba International Laboratories on 26/5/2010

<table>
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<tr>
<th>Date</th>
<th>Time</th>
<th>NO$_x$ (mg/Nm$^3$)</th>
<th>SO$_2$ (mg/Nm$^3$)</th>
<th>CO (mg/Nm$^3$)</th>
<th>CO$_2$ (%)</th>
<th>O$_2$ (%)</th>
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</thead>
<tbody>
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<td>3270</td>
<td>32</td>
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</tr>
<tr>
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<td>34</td>
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<tr>
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<td>457</td>
<td>3275</td>
<td>31</td>
<td>12.05</td>
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<td>3270</td>
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</table>
Jordanian Standards (JS 1189/2006)
SO₂: 6500 mg/Nm³ (Fuel Derivatives combustion)
NOₓ: 200 mg/Nm³ (Combustion temperature <1200 °C);
    : 1500 mg/Nm³ (Combustion temperature >1200 °C)

<table>
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<th>Date</th>
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<th>SO₂ (mg/Nm³)</th>
<th>CO (mg/Nm³)</th>
<th>O₂ (%)</th>
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</thead>
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<tr>
<td>5/26/2010</td>
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<td>453</td>
<td>3277</td>
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Table (4a): Gaseous emissions from sulfuric acid unit 53 at JPMC conducted by Ben Hayyan-Aqaba International Laboratories on 27/5/2010

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Table (4b): Gaseous emissions from sulfuric acid unit 54 at JPMC conducted by Ben Hayyan-Aqaba International Laboratories on 27/5/2010

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Jordanian Standards (JS 1189\2006)
SO2: 1500 mg/Nm³ (Sulfuric acid industries)

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</table>

Jordanian Standards (JS 1189\2006)
HF: 15 mg/Nm³
Table (6): Gaseous emissions from Aluminum fluoride at JPMC conducted By Ben Hayyan-Aqaba International Laboratories on 31/5/2010

<table>
<thead>
<tr>
<th>Date</th>
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<th>CO (mg/Nm³)</th>
<th>HF (mg/Nm³)</th>
<th>O₂ (%)</th>
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</table>

Jordanian Standards (JS 1189/2006)
HF: 15 mg/Nm³

Table (7a): Ammonia emissions from DAP unit 75 at JPMC conducted by Ben Hayyan-Aqaba International Laboratories on 6/6/2010

<table>
<thead>
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<th>Date</th>
<th>Time</th>
<th>NH₃ (mg/Nm³)</th>
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</thead>
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<td>6/6/2010</td>
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<td>13:05</td>
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<tr>
<td>6/6/2010</td>
<td>13:06</td>
<td>143</td>
</tr>
<tr>
<td>6/6/2010</td>
<td>13:07</td>
<td>142</td>
</tr>
<tr>
<td>6/6/2010</td>
<td>13:08</td>
<td>144</td>
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</tbody>
</table>
Table (7b): Ammonia emissions from DAP unit 76 at JPMC conducted by Ben Hayyan-Aqaba International Laboratories on 6/6/2010

<table>
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<th>Date</th>
<th>Time</th>
<th>NH$_3$ (mg/Nm$^3$)</th>
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<td>6/6/2010</td>
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<td>6/6/2010</td>
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<td>75</td>
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Jordanian Standards (JS 1189\2006)
NH$_3$: 50 mg/Nm$^3$

Table (8): Dust emissions concentration from phosphate grinder stack at JPMC measured on 9/6/2010 by Ben Hayyan-Aqaba International Laboratories

<table>
<thead>
<tr>
<th>Stack ID</th>
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<th>Dust Concentration (mg/Nm$^3$)</th>
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<td>12:40 - 13:00</td>
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Jordanian Standards (JS 1189\2006)
Dust: 50 mg/Nm$^3$ (Phosphate industries)
ANNEX 2
شركة مناجم الفوسفات الأردنية المساهمة المحدودة
المجمع الصناعي
Prepared by : Eng. Mohammad Al-Hjouj
Environment & Safety Manager

Date    JUN 2009

Authorised by :Eng. Najib AL-Sheikh
Industrial Complex Executive Manager
MR for Occupational Health & Safety Management

Date : JUN 2009

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Special Note:

- The First revision will be “Revision 0”.
- It is the responsibility of the recipient to ensure that amendments are included and that the superseded document or pages are destroyed.

Distribution and Control

Copy Distribution
Copy No.

1. Industrial Complex Executive Manager/ MR for Occupational Health & Safety Management
2. Environment & Safety Manager
3. Production Manager
4. Maintenance Manager
5. Technical Manager
6. Administrative Manager

Copy Control

Originals are with the MR for OHS.

Controlled copies will be identified by a copy number in ink on page 1 of the document. Records of each issue will be maintained. Each copy will be dated and endorsed "CONTROLLED COPY on the front page.

Uncontrolled copies of this manual may be issued to interested parties or customers at the discretion of the Industrial Complex Executive Manager. Each copy will be dated and endorsed "UNCONTROLLED COPY - DESTROY AFTER USE" on the front page.

Any queries regarding this document should be addressed to the Industrial Complex Executive Manager.
Section 4.0  Introduction to JPMC- industrial Complex

Jordan has enormous phosphate ore reserve that covers about 60% of its total area. Nowadays, a total of 6 million tons of different grades is produced annually by Jordan Phosphate Mines Company (JPMC). The bulk is exported as raw material, making Jordan probably the fourth largest exporter of phosphate rock in the world after USA, Russia and Morocco. About one million tons are utilized locally for the production of phosphoric acid and phosphate fertilizer (diammonium phosphate) by its JPMC- Industrial complex.

Historical perspective

1935  Jordan Phosphate Mines Company was established as a private company in 1935, to exploit phosphate deposits in Rusaifa.

1953  It became a public share holding company.

1962  The company started production in 1962 from Al-Hassa mine.

1988  The production started from Eshidiya mine which is located about 125 km north-east of Aqaba.

1982  Its Industrial Complex was constructed and started production of Diammonium phosphate (DAP) and aluminum fluoride.
JPMC- Industrial Complex

This complex is located 17 Km south of Aqaba town, produces DAP as a final phosphate fertilizer product, which contains two elements N and P. Another end product produced in this complex is Aluminum Fluoride, by using aluminum hydroxide and fluosilicic acid. The later is a byproduct of the reaction between phosphate rock and sulfuric acid.

Production process

The production process can be summarized in the following diagram.

This complex consists of 4 production and one utilities plants. It uses 5 main raw materials to produce 2 final products (see the next box):
1) Sulfuric Acid Plant

It produces sulfuric acid (H₂SO₄) from sulfur and water. Sulfur is imported from abroad.
The sulfur is first melted in a special melter, then filtered. The filtered sulfur is then burned at 1010 °C to produce sulfur dioxide (SO₂).

\[
S + O_2 \rightarrow SO_2
\]

SO₂ is then converted in a special converter to sulfur trioxide (SO₃), in the presence of vanadium pentoxide (V₂O₅).

\[
SO_2 + \frac{1}{2} O_2 \rightarrow SO_3
\]

SO₃ is then allowed to come in contact with water to produce H₂SO₄:

\[
SO_3 + H_2O \rightarrow H_2SO_4
\]

- Main Product                        Sulfuric Acid (98.5%)
- Product Capacity                  4500 metric tons/day

2) Phosphoric Acid Plant

It produces phosphoric acid (H₃PO₄) from phosphate rock and sulfuric acid. The rock is brought from JPMC mines 200 Km far.
The process starts by treating the phosphate rock with sulfuric acid in a reactor. As a result of this reaction gypsum slurry (gypsum and 30% phosphoric acid mixture) is produced and hydrofluoric acid is liberated:

\[
3\text{Ca}_3(\text{PO}_4)_2\text{CaF}_2 + 10\text{H}_2\text{SO}_4 + 20\text{H}_2\text{O} \rightarrow 6\text{H}_3\text{PO}_4 + 10\text{CaSO}_4 \cdot 2\text{H}_2\text{O} + 2\text{HF}
\]

The mixture passes into a filter where gypsum (\(\text{CaSO}_4 \cdot 2\text{H}_2\text{O}\)) is separated and conveyed to a belt for disposal, and the 30% phosphoric acid (\(\text{H}_3\text{PO}_4\)) flows into storage tanks. The 30% acid is concentrated to 54% in concentration units by evaporation using steam heaters.

During this concentration process HF reacts with the silica (which is present in the rock in sufficient amounts) producing fluosilicic acid (\(\text{H}_2\text{SiF}_6\)) in 22% concentration and water vapor:

\[
6\text{HF} + \text{SiO}_2 \rightarrow \text{H}_2\text{SiF}_6 + 2\text{H}_2\text{O}
\]

Water vapor is condensed and then cooled in cooling towers. Both the phosphoric acid 54% and fluosilicic acid are stored in rubber lined tanks.

- **Main Product**: Phosphoric Acid
- **Product Capacity**: 1310 metric tons \(\text{P}_2\text{O}_5\)/day

### 3) Granulation (Fertilizer) Plant

It produces diammonium phosphate (DAP) from phosphoric acid and ammonia. Ammonia is also imported from abroad.

The process starts by reacting phosphoric acid with ammonia in a special reactor. The reaction mixture (slurry) is pumped to the granulator where the reaction is completed by adding further ammonia.

The granulated product (diammonium phosphate) then dried and passed to the storage area after cooling.

\[
\text{H}_3\text{PO}_4 + \text{NH}_3 \rightarrow (\text{NH}_4)_2\text{HPO}_4
\]

- **Main Product**: Diammonium Phosphate
- **Product Capacity**: 2400 metric tons/day

### 4) Aluminum Fluoride Plant

It produces aluminum fluoride (\(\text{AlF}_3\)) from fluosilicic acid (\(\text{H}_2\text{SiF}_6\)) and aluminum hydroxide.

The process starts by reacting fluosilicic acid solution with Aluminum hydroxide \(\text{Al(OH)}_3\) (alumina trihydrate \(\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}\)) in special reactors to
produce the soluble form of aluminium fluoride:

\[ 2Al\,(OH)_3 + H_2SiF_6 \rightarrow 2AlF_3 + SiO_2 + 4H_2O \]

The reaction product (slurry) is passed onto a belt filter to separate the formed silica from the aluminum fluoride solution. Silica is conveyed to a belt for final disposal.

The aluminum fluoride emanating from the belt filter flows into a crystallizer in which aluminum fluoride trihydrate crystals (\(AlF_3 \cdot 3H_2O\)) precipitates. These crystals pass into calciners (driers) where anhydrous aluminum fluoride \(AlF_3\) is produced. The calcined product is cooled and conveyed to the storage silo for bagging.

\[ AlF_3 \text{ solution} \rightarrow \text{Crystallizers} \rightarrow AlF_3 \cdot 3H_2O \rightarrow \text{Calciners} \rightarrow AlF_3 \]

- Main Product: Aluminum Fluoride
- Product Capacity: 60 metric tons/day

5) Utilities Plant

The utilities plant is designed to provide the production units with their requirements of power, steam, sea cooling water, fresh cooling water, instrument air and industrial water.

A total of 3.5 millions cubic meters (annual consumption) of water is brought from Al-Disi reservoir 120 km far from the complex.

This plant contains:

1- Two steam Turbo-Generators:
These produce 44 Mw to provide the production units with the required power. These Generators are steam driven by the high pressure steam produce in the sulfuric acid plant from the waste heat boilers, and from two auxiliary boilers in the utilities plant.

2- Boilers and Water Treatment Unit:
The boilers feed water is treated in a water treatment plant which has both deminerallized and polishing units, where the contents of salts and solids are reduced to less than 1 ppm.

3- Sea Cooling Water Station:
The Utility Plant provides the sulfuric acid coolers with sufficient quantities of sea cooling water after being filtered and chlorinated in this station which is capable to pump more than 16000 m3/hr.
**Industrial Jetty**

Two berths and mooring dolphins are provided for 40000 and 30000 ton vessels. The main dock is long enough to provide sufficient cranes to operate over the full length of hatchways. The dock includes a roadway, fertilizer conveyors, electric power cables and pipelines.

The port facilities area is fenced off from all public areas and access is gained through one gate.

The Industrial Jetty contains loading and unloading facilities for more than 4.5 millions tons/year of solid and liquid products.

---

**Section 4.1 General Requirements**

OHS Management System Documentation
JPMC-Industrial Complex has developed and implemented an OHS System compliant with OHSAS 18001 Requirements. For practical reasons, this system is produced in a four-level structure.

Level 1: OHS Manual

The OHS Manual is the first level document. It is a "policy manual" that describes and includes general management policy with regard to OHS organization structure and responsibilities. It summarizes what is being done, or will be done, in the various departments and functions of the organization, to achieve the objectives.

Level 2: System Procedures

The System Procedures Manual is the second level document. System procedures are the tools through which the policies of each activity are implemented. These describe in detail the purpose and scope of the activity; what shall be done and by whom; documentation that shall be used; and how they are controlled.

Level 3: Operational Control Systems

These are the third level documents. These describe in details, the activities to control the OHS hazards. These include safety procedures, safety rules and work instructions.

Level 4: All Other Documents, Forms, and References

Documents such as forms, plans, logs and references are classified as fourth level documents. They may amplify a procedure or work instruction.
Section 4.2 : OH&S Policy

JPMC- Industrial Complex manufactures Diammonium Phosphate fertilizer (DAP) using sulfuric and phosphoric acids produced by its plants, and Aluminum Fluoride using fluorsilicic acid produced as a byproduct from the phosphoric acid production.

JPMC- Industrial Complex will comply with all current applicable OH&S legislations in Jordan and with all international codes, standards and specifications related to our operations and equipments. As a further commitment the complex is implementing an OH&S Management System that is compliant with OHSAS 18001.

The OH&S management system and the objectives set below will be periodically reviewed and audited to monitor the company's achievements in its commitment to continual improvement and of improvement in OH&S performance.

JPMC- Industrial Complex has established the following OH&S objectives:

1) Minimizing human injuries and property damage. For this the management will ensure safe working conditions including work permit system, safe guarding rotating equipments and personal protective equipments.

2) Preventing occupational diseases. Here the management will observe the following principles: recognition, evaluation and control of OHS hazards.

In controlling OH&S hazards we will consider the following measures: engineering, administrative, medical and as a last choice, personal protective equipments.

Medical control measures will include health surveillance, biological and biological effect monitoring.

3) In protecting their health, workers will be educated about OH&S hazards and their control.

4) Workers will be trained on the use of safety devices and fire fighting procedures.

5) Comprehensive systems and procedures for various operational and maintenance activities will be implemented by all concerned. Periodic checks will be carried out by OHS personnel to identify deviations and appropriate corrective measures will be taken.

This Policy and objectives statement is available to the interested parties. JPMC-Industrial Complex will distribute this document locally to the site to all employees.
سياسة السلامة والصحة المهنية

تنجز شركة مناجم الفوسفات الأردنية/المجمع الصناعي سماد فوسفات ثنائي الأمونيا باستخدام حامض الكبريتنيك وحامض الفوسفوريك المنتج في مصانعها. وتقوم أيضاً بإنتاج فلوريد الأمونيوم باستخدام حامض الفلوسيليك وهو عبارة عن منتج ثانوي خلال إنتاج حامض الفوسفوريك.

تلتزم شركة مناجم الفوسفات الأردنية - المجمع الصناعي بكافة القوانين والتشريعات الأردنية ذات العلاقة بالسلامة والصحة المهنية، وكافة المعايير والمواصفات العالمية المتعلقة بالأجهزة والمعدات والعمليات التشغيلية، وبناءً على ذلك يقوم المجمع الصناعي بتطبيق نظام إدارة السلامة والصحة المهنية بما يتوافق مع نظام "OHSAS 18001/2007".

ستقوم شركة مناجم الفوسفات الأردنية بمراجعة نظام إدارة السلامة والصحة المهنية والأهداف المبينة أعلاه والتفتيق عليها بشكل دوري لمراقبة أداء الشركة والتزامها بالتطوير والتحسين المستمر في مجال السلامة والصحة المهنية:

* منع ووقوع الإصابات بين العاملين وذلك بالتأكد على وجود ظروف عمل آمنة من خلال التدقيق بنظام تصاريح العمل وتوقيع وسائل السلامة والحماية اللازمة.
* منع التعرض للإصابة بالأمراض المهنية بين العاملين من خلال تحديد وتقسيم المخاطر التي تؤدي إلى حصول الأمراض المهنية واتخاذ التدابير اللازمة لتفاديها من التخلص من الأخطار وإنتهاء باستخدام معدات السلامة كملاءم أخير. كما ستقوم الشركة بإجراء الفحوصات الطبية الدورية للعاملين.
* توعية العاملين بالمخاطر المتعلقة بالسلامة والصحة المهنية وتدريبهم على وسائل السيطرة على هذه المخاطر.
* توعية وتدريب العاملين على استعمال وسائل الحماية الشخصية وطرق مكافحة الحرائق.
* تطبيق إجراءات العمل المعتمدة في مجال التشغيل والصيانة وكافة النشاطات الأخرى حسب الأنظمة الموقعة في الشركة.
Section 4.3 Planning

4.3.1 Hazard Identification & Risk Assessment Procedure

Reference Procedure: RA-OHS /0100

JPMC has based its policy, objectives and targets on the knowledge about the OHS hazards and their effects and on risk assessment. Risk assessment is an ongoing process that determines the potential and likelihood of harm/damage of all activities. This process includes the identification of all activities (routine, nonroutine & emergencies), persons at risk, severity of harm and the necessary control measures.

AT JPMC - Industrial Complex

An OHS review of the site has been carried out to identify its OHS hazards. Risks of all the hazards have been quantified, where practicable.

The results of assessments of hazards have been used to set objectives & targets for improvement and to prioritize action plans.

A system is set in place for reviewing and updating the register of Hazards.
4.3.2 Legal and other Requirements

Reference Procedure: LR-OHS /0200

To maintain regulatory compliance, applicable regulatory requirements have been identified and communicated to employees.

At JPMC- Industrial Complex

All relevant legal requirements have been identified. All international codes, standards and specifications related to our operations and equipments have been identified aslo. TLVs and health surveillance programs have been identified. System has been set to keep track of legal requirements, any changes, and their communication to employees. A list of laws and regulations pertaining to its activities and products has been established, and will be maintained.

4.3.3 Objectives and Targets

Reference Procedure: OT-OHS /0300

Objectives have been established to meet the OHS policy. These objectives are the overall goals for OHS performance identified in the policy.

OHS targets are set to achieve these objectives within a specified time-frame. The targets are specific and measurable.

Objectives and targets are defined by appropriate levels of management. They are reviewed periodically and revised.

At JPMC- Industrial Complex
OHS objectives and targets reflect both the OHS policy and nontolerable risks. Employees responsible for achieving these objectives and targets were involved in their development. Specific measurable indicators have been established for objectives and targets. Systems are set in place to regularly review objectives and targets. Objectives and targets are revised as necessary in the light of changing circumstances.

4.3.4 OHS Management Programmes

Reference Procedure : OT-OHS /0300

OHS management programmes help to improve OHS performance. They address schedules, resources and responsibilities for achieving the environmental objectives and targets. They identify specific actions in order of their priority.

At JPMC- Industrial Complex

There is a clear process for the identification of OHS management programmes (action plans) to achieve the objectives and targets. All responsible parties are involved in the management planning process. There are periodic reviews of the programmes. OHS management programmes are monitored and revised, as necessary.

4.4 Implementation and Operation

Section 4.4 Implementation and Operation
4.4.1 Structure and Responsibility

Reference Procedures:
SR-OHS\1400 Structure and Responsibility

4.4.1a Industrial Complex Management Structure

A chart of the industrial complex management structure is shown below.
4.4.1b OHS Management System Structure

A Chart of OHS management structure is shown below.

Top Management

1) Deciding an OH&S policy
2) Gives the MR the full authority to establish the system.
3) Authorizes all documents related to the system.
4) Chairs the Management Review meeting.
5) Supporting MR in implementing the system.
6) Approving OH&S management programs.

Management Review Committee

It is responsible for the evaluation and review the performance of OHS MS.
4.4.1c Management Representative

JPMC has nominated the Industrial Complex Executive Manager as the management representative for Occupational Health & Safety Management System who shall be responsible for all matters in connection with the company OHS management system and liaison with Certification Body representatives.

The MR for OHS has been given the following roles, responsibilities and authority for:
1- Ensuring that the OHS management systems are established, implemented and maintained in accordance with the international standard OHSAS.
2- Reporting on the performance of the OHS management systems to top management for review and as a basis for improvement of the system.

4.4.1d Occupational Health Section

Responsibilities of the head of this section:

Performing the following activities:

1) Clinical activities

   Pre-employment assessments.
   Periodic medical examinations.
   Medical surveillance for groups at risk.
   Biological and biological effect monitoring.
   Health education and counseling.
   Surveillance of sanitary and catering amenities.
   Supervision of nursing and first aid services.
   First aid treatment of injuries and illnesses at work.
   Diagnosis and management of diseases due to or exacerbated by workplace factors.

2) Advisory functions

   Advise on environmental issues.
   Advise on sickness absence.
   Medical aspects of legislations about employment.
4.4.1e Occupational Hygiene & Environment Section

Responsibilities of the head of this section:

1- Ensure Compliance with OHS & Environmental policies.
   2- Perform regular patrols to inspect the environmental & O. Hygiene performance of the different activities.
3- Develop and implement different environmental & O. Hygiene monitoring programs for the different environmental aspects & OH hazards.
4- Perform monthly & annual environmental & O. Hygiene performance reports to MR for OHS and his department Manager.
   5- Conduct internal training programs on the different environmental issues.
   6- Reporting to his department manager

4.4.1f Safety and Fire Fighting Section

Responsibilities of the head of this section:

1- Review emergency procedures on regular basis.
2- Conduct emergency drills to ensure readiness to deal with the emergencies within the complex.
3- Conduct internal training programs on fire fighting, safety equipments and different safety issues.
4- Manage all types of fires and spills that may occur on site.
5- Ensure the availability of the appropriate safety equipments.
6- Reporting to his department manager

4.4.1g Department Heads

With regard to quality all department heads shall be responsible within their own departments for :-

1- The quality of work carried out by personnel within their groups.

2- Verifying that approved procedures are adopted within their departments and any necessary complementary procedures are raised, updated and implemented.

3- Ensuring that all personnel are adequately qualified and experienced in their relevant technical discipline to perform the duties of their position in a satisfactory manner.
4- Ensuring that all staff are familiar with all procedures.

**With regard to environment** all department heads shall be responsible within their own departments for :-

1- Carry out day-to-day activities in compliance with the environmental policy and the legal requirements.
2- Perform self-evaluation and carry out corrective actions for non-compliances.
3- Carry out activities needed to meet the environmental targets and objectives.
4- Supply information for the environmental management system.
5- Setting the action plans to achieve the targets and objectives.
6- Perform the corrective actions required by the Environment & Safety Department.

**With regard to OHS**

A section head is responsible for all safety matters in his section and must ensure the safety of his employees as well as the safety of machinery and equipment. He must control safety according to a policy decided by MGR and execute duties for the following:

1. Planning and executing safety activities in his section.
2. Compiling necessary standard operation program (SOP) and checklists as well as educating and training.
3. Promoting safety activities.
4. Grasping the actual situation in the section as well as improving environment and installations.
5. Issuing necessary matters concerning safety in the section.
6. Cooperating with the safety section and make sure from time to time that all safety instructions given to his subordinates are understood and respected.
7. On introducing and/or using new chemicals, clear information on the chemical specification and potential hazards to be obtained prior to the use of such chemicals, safety section shall be informed how and when safety measures are to be taken.
8. Ensure that his subordinates are trained and educated in safety matters.

**4.4.1h Job Descriptions**

Reference Procedures:
Job Descriptions & Responsibilities XX-QPR/YY10
Everyone JPMC- Industrial Complex employee has a job description which details his or her responsibilities and organisational relationships. This is given to all new employees at the time of employment.

Copies of job descriptions are held by the Aqaba Administrative Manager Departmental section heads for the respective job holders who have the right of access to their own job description at any time. The generation of job descriptions is the responsibility of the Industrial Complex Manager.

4.4.2 Training, Awareness and Competence

Reference Procedure: TR-OHS/0400

To maintain and have an effective implementation of the OHS Management System, training and awareness of personnel play a key role.

At JPMC- Industrial Complex

Training needs are identified and implemented and then kept under review to take into account changing circumstances. All relevant personnel have the necessary training in OHS issues. Personnel are aware of their OHS responsibilities. Personnel are trained for emergencies. Competent employees are to be given refreshment courses on OHS issues.

4.4.3 Consultation & Communication

Reference Procedure : CC- OHS /0500

Consultation & Communication include establishing processes to report both internally and externally on the OHS activities in order to demonstrate management commitment to the OHS, and deal with complaints, concerns and questions.

At JPMC- Industrial Complex

There is an established process for receiving and responding to internal and external complaints and concerns.
There is an established process for the communication of the environmental policy, OHS MS audits and reviews.
Employees are involved in the investigation of accidents & incidents. Employees are represented in the safety committee.

4.4.4 OHS Documentation

Same as general requirements 4.1

4.4.5 Document & Data Control

Reference Procedures: DC-OHS/0600

All documents and data necessary to the effective functioning of the company quality, environmental & OHS systems will be subject to formal approval, issue and control. All documents of OHS MS will be reviewed and by the OHSAS team loader and authorized by the Industrial Complex Manager. The signitures will be on the first page of each document. Pertinent issues of appropriate documentation shall be available where necessary. It is the responsibility of the authorised recipient to ensure the removal and disposal of all obsolete documentation.

Authorised changes can only be made via a uniquely numbered Document Change Request. A master record card system is maintained to identify current issue status of documents and data. Documents shall be totally reissued to accommodate major changes or as directed by the Industrial Complex Executive Manager.

4.4.6 Operational Control Systems

Reference Procedure: OC-OHS/0700

Different operations and activities contributing to OHS hazards were considered in the development or modification of operational procedures and controls.

At JPMC- Industrial Complex

Operational control activities include:
1) Safety procedures
2) Safety rules
3) Work instructions.
These were put to control the different OHS hazards which were identified from the different operations and activities.

Of the different activities which were considered, are the following:

- Handling and storage of raw materials
- Production
- Maintenance
- Laboratory
- Storage of products
- Medical department
- Canteen.
- Transportation
4-4-7 Emergency Preparedness and Response


Emergency plans and procedures are established to identify the potential for and responses to incidents and emergency situations, and for preventing and mitigating the likely illness and injury that may be associated with them.

At JPMC- Industrial Complex

There are defined procedures for identifying the emergency situations and the potential for them.
There is a defined procedure for dealing with environmental & OHS accidents and potential emergency situations.
Drill are performed to evaluate the effectiveness of the procedures.
One major plan for disasters and 8 other plans for the different areas.

Section 4.5 Checking and Corrective Action

4.5.1 Monitoring and Measurements

Reference Procedure: MM- OHS/0900

A system is set in place for measuring and monitoring actual performance against the OHS objectives and targets. This includes evaluation compliance with relevant OHS legislation and regulations. The results are analyzed and used in determining areas of success and in identifying activities requiring corrective action and improvement.

At JPMC- Industrial Complex

Monitoring systems are in place for activities which potentially affect the OHS. Applicable OHS legislations are recorded & Maintained.
Monitoring system include: Periodic inspections of workplaces, regular measurements of hazards, health surveillance, biological & biological effect monitoring.
Records of compliance with environmental regulations and of incidents of non-compliance are maintained and readily available.
4.5.2 Accidents, Incidents, Nonconformance and corrective and preventive action

Reference Procedure: AP-OHS/1000

The company operates a system to record, analyse and put in place corrective and preventive action to eliminate the causes of non-conformity.

Each non-conformity report identified within the company is investigated and the root cause established. Then the appropriate corrective action is undertaken to clear up the identified problem. Measures are also put to prevent reoccurrences.

All non conformances identified will be dealt with in the above manner.

The company shall undertake a regular review of the instances of non conformity and associated corrective actions. This will demonstrate that the corrective action loop remains effective.

All internal and external complaints are formally registered and only closed out when it has been established corrective action is complete.

4.5.3 Control of Records

Reference Procedure: RC-OHS/1100

The company has developed formal procedures to ensure production, environmental & OHS documents are generated correctly. Once work is completed, these and other supporting data become our quality, environmental & OHS records, which are then identified, collected, indexed, filed, stored and maintained in accordance with the defined record control procedures. These procedures also identify the right of access and final disposition.

Documents and records shall be retained for a minimum of 5 years, except health records for a minimum of 10 years. Prime consideration is given to legislation.

They shall be stored in safe and secure conditions, and protected from deterioration.

OHS records are routinely audited as part of internal audit activities to determine continued compliance for completeness, identification, and legibility.

Records are moved into long term archive storage within a year of completion, protected to the extent necessary to ensure they can be referenced with comparative ease and will remain intact.
Evaluation of the storage of records forms part of the audit program. Records reaching the end of retention periods are disposed to the municipal Sanitary Landfill while health records are to be incinerated, or given renewed retention periods.

4.5.4 OHS Management System Audits

Reference Procedure: IA-OHS/1200

4.5.4a Programme (Plan)

Planned internal audits are used to confirm that the practices and procedures are being employed as planned and according to the requirements of OHSAS specifications. Audits are used to determine whether also OHS management system is effective in meeting the JPMC-Industrial Complex policy & objectives. Audits are carried out by trained personnel, independent of the activity being audited who report to the MR for OHS. An audit programme is available and covers all aspects of the Company's OHS management system.

The audit programme defines: areas, activities and procedures to be audited, frequency of audits and auditor identity.

Audit schedules are reviewed periodically and scheduling will take place whenever there is a change in circumstances e.g. when audits have found evidence of non-compliance.

4.5.4b Audit Methodology

- Audits are carried out in accordance with a written audit procedure.
- Audit non conformities are recorded on an action report. An agreed date for corrective action is established with the concerned personnel. The action report is then reviewed by the Department Head who will assign responsibilities for action.
- A summary internal audit report and action request is then communicated to the MR for OHS.
- Copies of action report are distributed to the concerned department head and any actioned personnel.

- All action taken to correct a non conformance shall be re audited to verify compliance and a close out of the action report is then issued.
- Internal audit reports and action report shall be used by management to review the continued effectiveness of the OHS management system.

- Any indication of poor response will be brought immediately to the attention of the management representative.

- Completed OHS audit action report shall be signed off by the MR.

### Section 4.6 Management review

Reference Procedure: MR-OHS /1300

A management review committee shall be established, comprising of all managers & production section heads and chaired by the Industrial Complex manager.

The Company's OHS system shall be reviewed a minimum of two times per year and whenever possible at equally spaced intervals which shall be attended by senior management. The management review process is fully detailed in the Management Review procedure MR-OHS/1300.

The records of such interviews are maintained.
Section 4.7 Documented EMS Reference

Ref : OHSAS 18001 clause 4.4.4

Level 1 Documentation

OHS Manual

Level 2 Documentation

Consists of the following procedures :

RA-OHS/0100 Hazard Identification and Risk Assessment
LR-OHS/0200 Legal and Other Requirements
OT-OHS/0300 OHS Objectives, Targets & Management Programs
TR-OHS/0400 Training
CC-OHS/0500 Consultation and Communication
DC-OHS/0600 Document and Data Control
EP-OHS/0800 Emergency Preparedness and Response
MM-OHS/0900 Monitoring and Measurement
AP-OHS/1000 Accidents, Incidents, Nonconformance and Corrective and Preventive Action
RC-OHS/1100 Control of Records
IA -OHS/1200 Internal Audit
MR-OHS/1300 Management Review
SR-OHS/1400 Structure and Responsibility
Level 3 Documentation

Consists of the following system working instruction:
OC-OHS/0700 Operational Control Systems

Level 4 Documentation

Consists of the following References and Formes.

A) References:

Annex 1 التشريعات والأنظمة والتعليمات الأردنية المتعلقة بالصحة والسلامة المهنية
Annex 2 Emergency plans
Annex (2-1) Main Emergency Plan for Industrial Complex
Annex (2-2) Emergency Plan for Utilities Plant
Annex (2-3) Emergency Plan for Sulfuric Acid Plant
Annex (2-4) Emergency Plan for Phosphoric Acid Plant
Annex (2-5) Emergency Plan for Granulation Plant
Annex (2-6) Emergency Plan for Aluminium Fluoride Plant
Annex (2-7) Emergency Plan for Material Handling
Annex (2-8) Emergency Plan for Maintenance Department
Annex (2-9) Emergency plan for Ware House
Annex 3 Risk Assessment Rating for OHS hazards.
Annex 4 Materials Safety Data Sheets
Annex 5 Flow diagrams and site map.

B) Forms :

1. نموذج تحديد وتقييم المخاطر
2. نموذج سجل المخاطر غير المحتملة
3. نموذج سجل التشريعات والقوانين المتعلقة بالصحة والسلامة المهنية
4. نموذج سجل أهداف نظام الصحة والسلامة
5. نموذج البرامج الإدارية لنظام الصحة والسلامة DCR
6. نموذج طلب تغير وثيقة
7. نموذج تصريح عمل حار
8. نموذج تصريح عمل بارد
9. تصريح حفر
10. شهادة غزل كهرباء
11. شهادة توصيل كهرباء
12. شهادة دخول الأماكن المحصورة
13. تقرير حادث عمل
14. نموذج التفتيش اليومي على مواقع العمل
15. نموذج قياس مستوى الإشعاع
16. نموذج قياس مستوى الضجيج
17. نموذج تقرير شهري لحوادث العمل
18. نموذج تقرير سنوي لحوادث العمل
19. تقرير حريق / انفجار
20. نموذج تصريح مناولة مواد كيمائية
21. نموذج سجل MSDS
22. نموذج التفتيش على طفايات الحريق
23. نموذج التفتيش على نقاط الإطفاء
24. نموذج التفتيش على مدافع الإطفاء
25. نموذج التفتيش على مضخات الإطفاء
26. نموذج التفتيش على صمامات الإطفاء
27. نموذج التفتيش على سيارات الإسعاف
28. نموذج التفتيش على اجهزة التنفس
29. نموذج التفتيش على دوشات الطوارئ
30. نموذج تدريب العاملين على المخاطر التي تواجههم في المواقع
31. نموذج التفتيش على خزانة معدات الطوارئ
32. نموذج التفتيش على سيارات قسم السلامة
33. نموذج إجراء تصحيحي
34. نموذج محضر اجتماع
35. نموذج سجل المراسلات الداخلية والخارجية
36. نموذج التفتيش على السقالات
37. الكشف الدوري على المطعم
ANNEX 3