

**HASHEMITE KINGDOM OF JORDAN  
AQABA SPECIAL ECONOMIC ZONE AUTHORITY**

**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**

UNIDO PERSGA Project Number: GH / RAB / 08 /

**Regional Organization for the Conservation of Environment of the Red Sea and Gulf of Aden (PERSGA)**

April 2011

### *Acknowledgements*

The assessment team would like to acknowledge the following individuals that contributed to the information studies and assessments under the Regional Project (EGYPT, JORDAN, SUDAN, and YEMEN) for Promotion of strategies to reduce unintentional production of POPs in the Red Sea and Gulf of Aden coastal zone:

- H.E. Dr. Salim M. Al-Moghrabi, Environment Commissioner, ASEZA
- Dr. Aiman Soleiman Oklat, Aqaba International Laboratories Director, Aseza.
- Szabolcs Fejes, Consultant , Hungary
- Raid A. Damra, Pops project manager, ASEZA.
- Dr. Mohammad Badran, PERSGA.
- Eng. Mohammad Alhojooj, JPMC.
- Eng. Omar Alkhwaldah, JPMC.
- Eng. Refad Rfaeh, JPMC.
- Eng. Ayman Alzorayky, JPMC.
- Eng. Jehad Alswaeear, Aqaba International Laboratories, ASEZA
- Eng. Mohammad Alkabaretee, ASEZA
- All environment directorate stuff in ASEZA.

## ***Glossary/Abbreviations***

°C Degree	Celsius
µg	microgram (10 <sup>-6</sup> grams)
ADC	Aqaba Development Corporation
AFESD	Arab Fund for Economic and Social Development
AFP	Aluminum Florid Plant
AIC	Aqaba Industrial Complex
APC	Arab Ports Company
ASEZ	Aqaba Special Economic Zone
ASEZA	Aqaba Special Economic Zone Authority
ATPP	Aqaba Thermal Power Plant
AWWS	Aqaba Waste Water Station
AZEM	Aqaba Zone Economic Mobilization
BAT	Best Available Techniques
BEP	Best Environmental Practices
BTU	British Thermal Unit
CIDA	Canadian International Cooperation Agency
DAP	Di Ammonium phosphate
DCP	Di Calcium Phosphate
DOS	Department of Statistics
DWT	Dead Weight Tonnage
ECD	Ethylene Chlorine or 1,2-dichloroethane
EIA	Environmental Impact Assessment
EMS	Environmental Management System
FSA	flosilicic acid
FBC	Fluidised Bed Combustor
GEF	Global Environmental Facility
g	Gram
GDP	gross domestic product
GJ	Gigajoule (10 <sup>9</sup> Joules)
gmol	Gram mole
GRP	gross regional product
GTZ	German Technical Corporation
GWh	Giga Watt hour
HDI	Human Development Index
HFO	Heavy Fuel Oil
HP	High Pressure
I-TEQ	International Toxic Equivalents
IMO	International Maritime Organisation
JES	Jordan Environment Society

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 <sup>3</sup> grams)
L	Litre
Lb	Pound
LP	Low Pressure
MSS	Marin Scce Station
MSW	Municipal Solid Waste
Mt	Megaton (10 <sup>6</sup> tonnes)
MW	Medical Waste
NA	Not Applicable
Ng	Nanogram (10 <sup>-9</sup> )
NGOs	Non Governmental Organizations
Nm <sup>3</sup>	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

TEF	Toxicity Equivalency Factor
TEQ	Toxic Equivalent
ToT	Training of Trainers
TSP	Total Suspended Particles
UP-POPs	Unintentional Production of Persistent Organic Pollutants
UNDP	United Nation Development Programme
UNEP	United Nations Environment Programme
USAID	United State Agency for International Development
VCM	Vinyl Chloride Monomer
VOCs	Volatile Organic Compounds
WEPIA	Water Efficiency and Public Information for Action
wt	Wight

## ***Table of contents***

<b>Glossary/Abbreviations</b>	<b>i</b>
<b>List of Tables</b>	<b>x</b>
<b>List of Figures</b>	<b>xi</b>
<b>Background</b>	<b>xii</b>
<b>Overview</b>	<b>xiii</b>
<b>Site Selection</b>	<b>xiii</b>
<b>Scope of Work</b>	<b>xviii</b>
<b>Chapter 1: Applied Technology Assessment</b>	<b>1</b>
<b>1.1 Summary</b>	<b>2</b>
<b>1.2 Background</b>	<b>5</b>
<b>1.3 general Information on the Location:</b>	<b>7</b>
<b>1.4 Description of Applied Technology</b>	<b>9</b>
<b>1.4.1 General chemistry and technology used</b>	<b>9</b>
<b>1.4.2 Manufacturing Processes</b>	<b>10</b>
<b>1.4.2.1 Sulfuric Acid Plant</b>	<b>10</b>
<b>1.4.2.2 Sulfur Storage Area in Mekresh</b>	<b>11</b>
<b>1.4.2.3 Phosphoric Acid plant</b>	<b>11</b>
<b>1.4.2.4 Gypsum Disposal, Industrial Waste and Hazardous Waste Storage Site</b>	<b>12</b>
<b>1.4.2.5 Di-Ammonium Phosphate (DAP) plant</b>	<b>12</b>
<b>1.4.2.6 Aluminum Fluoride Plant</b>	<b>13</b>
<b>1.4.2.7 Utilities</b>	<b>14</b>
<b>1.5 Detailed Technology Description</b>	<b>16</b>
<b>1.5.1 Utility Plant</b>	<b>16</b>
<b>1.5.1.1 Raw Water Treatment</b>	<b>16</b>
<b>1.5.1.2 Dematerialized Water</b>	<b>16</b>

<b>1.5.1.3 Drinking Water</b>	<b>17</b>
<b>1.5.1.4 Fresh Cooling Water</b>	<b>17</b>
<b>1.5.1.5 Sea Water Cooling</b>	<b>18</b>
<b>1.5.1.6 Fire Fighting System</b>	<b>18</b>
<b>1.5.1.7 Instrument and Plant Air</b>	<b>18</b>
<b>1.5.1.8 Fuel Oil Storage</b>	<b>19</b>
<b>1.5.1.9 Diesel Oil Storage</b>	<b>19</b>
<b>1.5.1.10 Storage Capacities</b>	<b>20</b>
<b>1.5.1.11 Power Plant</b>	<b>20</b>
<b>1.5.1.11.1 HP Steam</b>	<b>20</b>
<b>1.5.1.11.2 LP Steam</b>	<b>20</b>
<b>1.5.1.11.3 Normal Electrical Power</b>	<b>21</b>
<b>1.5.1.11.4 Emergency Electrical Power</b>	<b>21</b>
<b>1.5.1.11.5 Boiler Feed Water and Desuperheating Water</b>	<b>21</b>
<b>1.6 Sulfuric Acid Plant</b>	<b>22</b>
<b>1.6.1 Sulfur Storage</b>	<b>23</b>
<b>1.6.2 Solid Sulfur Melting and Filtration</b>	<b>24</b>
<b>1.6.3 Sulfuric Acid Section</b>	<b>24</b>
<b>1.6.3.1 Air Driving</b>	<b>25</b>
<b>1.6.3.2 Sulfur Combustion</b>	<b>25</b>
<b>1.6.3.3 Conversion</b>	<b>25</b>
<b>1.6.3.4 Acid Production</b>	<b>26</b>
<b>1.6.3.5 Acid Storage</b>	<b>27</b>
<b>1.7 Phosphoric Acid Plant</b>	<b>29</b>
<b>1.7.1 Phosphate Rock Grinding</b>	<b>31</b>
<b>1.7.2 Attack and Filtration</b>	<b>33</b>
<b>1.7.3 Reaction System</b>	<b>35</b>
<b>1.7.4 Digestion Tanks</b>	<b>39</b>
<b>1.7.5 Filtration</b>	<b>40</b>
<b>1.7.5.1 Filtration Description</b>	<b>41</b>
<b>1.7.5.1.1 Slurry Attack</b>	<b>41</b>
<b>1.7.5.1.2 First Washing</b>	<b>42</b>
<b>1.7.5.1.3 Second Washing</b>	<b>42</b>
<b>1.7.5.1.4 Cake Discharge</b>	<b>42</b>
<b>1.7.5.1.5 Cloth Washing</b>	<b>43</b>
<b>1.7.6 ( 28% )acid storage</b>	<b>43</b>
<b>1.8 Concentration Lines</b>	<b>44</b>

1.8.1	54% P <sub>2</sub> O <sub>5</sub> Acid storage	45
1.8.2	Floussilicic Acid Storage	46
1.9	Fertilizer Granulation Plant	46
1.9.1	Ammonia Storage	47
1.9.2	Granulation Units Section (75&76)	48
1.9.2.1	Acid and Water System	48
1.9.2.2	Ammonia Feed System	48
1.9.2.3	Reaction System	48
1.9.2.4	Granulation System	49
1.9.2.5	Driving System	49
1.9.2.6	Conveying, Screening and Milling System	50
1.9.2.7	Product Cooling and Conveying System	50
1.9.2.8	Recycle System	51
1.9.2.9	Ventilation and Scrubbing System	52
1.9.2.10	Fertilizer Storage	52
1.10	Aluminum Florid Plant	53
1.10.1	Al (OH) <sub>3</sub> Handling and Drying	54
1.10.2	Production of Hot Acid	54
1.10.3	AlF <sub>3</sub> – Reaction	55
1.10.4	Silica Filtration	56
1.10.5	AlF <sub>3</sub> .3H <sub>2</sub> O Filtration	57
1.10.6	Crystallizers	58
1.10.7	Drying	59
1.10.8	Calcining	59
1.10.9	AlF <sub>3</sub> Handling and Bagging	60
1.11	Material Handling Section	60
1.11.1	Sulfur Handling	60
1.11.1.1	Ship Unloading	60
1.11.1.2	Conveying Section	60
1.11.2	Fertilizer and Potash Handing	61
1.11.2.1	The Fertilizer Reclaims	61
1.11.2.2	Handing Section	61
1.11.3	Phosphate Rock Handing	62
1.11.3 .1	Conveyor system includes:	62
1.11.4	Ammonia Unloading	63
1.12	Boilers	63
1.12.1	Summary	63

1.12.2 Overview of boilers	64
1.12.3 Generation of PCDD/PCDF:	68
1.12.4 Estimation of emissions of persistent organic pollutants from boilers	72
1.13 Pollution Control System	73
1.13.1 Gas Emissions:	73
1.13.1.1 PAP Gaseous Emissions	73
1.13.1.2 SAP Gaseous Emissions	73
1.13.1.3 AFP Gaseous Emissions	73
1.13.1.4 DAP Gaseous Emissions:	74
1.13.1.5 Utility Gaseous Emissions	75
1.13.2 Industrial Liquid Wastes:	76
1.13.2.1 PAP Industrial liquid wastes:	76
1.13.2.2 SAP Industrial Liquid Waste	77
1.13.2.3 AFP Industrial Liquid Waste:	77
1.13.2.4 DAP Industrial Liquid Waste:	77
1.13.3 Solid Wastes	77
1.13.3.1 PAP Industrial solid waste:	77
1.13.3.2 SAP industrial solid Waste	77
1.13.3.3 AFP Industrial Solid Waste	78
1.13.3.4 UTILITIES industrial Solid Waste	78
1.13.4 Results of Monitoring Programs	78
1.13.4.1 Internal Monitoring Program	79
1.13.4.1.1 Air quality results	79
1.13.4.2 External Monitoring Program	82
1.13.4.2.1 Air quality results	82
1.14 Proposal for BAT/BEP Implementation Plan:	82
1.14.1 What is BAT/BEP?	82
1.14.2 Best Available Techniques BAT:	83
1.14.2.1 BOILER ENCLOSURE	83
1.14.2.2 Natural gas use as a fuel in boilers instead of fuel oil	84
1.14.2.3 Scrubbing system	85
1.14.3 Best environmental practices- BEP:	85
1.14.4 What to do for Pollution Prevention and Control in industrial complex:	86
1.14.4.1 Target Pollution Loads	88
1.14.4.2 Treatment Technologies	88
1.14.4.3 Emission Guidelines	89
1.14.4.4 Air Emissions	89

1.14.4.5 Monitoring and Reporting	89
1.14.4.6 Key Issues	90
<b>Chapter 2: Environmental &amp; Health Assessment</b>	<b>91</b>
2.1 Summary	92
2.2 Background	93
2.3 On-site sampling points	94
2.4 Off –site sampling points	97
2.4.1 Topography	97
2.4.2 Climatology	97
2.4.3 Methodology	98
2.4.4 Sites Selected	100
2.4.4.1 Aqaba Marine Park:	101
2.4.4.2 Tala Bay:	101
2.4.4.3 Civil Defence Department	102
2.4.4.4 Area south of the industrial zone	103
2.5 Occupational safety measures	104
2.5.1 OHS Policy in AIC	104
2.5.2 Dioxin and Furan in Environment	105
2.5.2.1 Sources of Dioxin and Furan in Environment	105
2.5.2.2 Toxicity of Dioxin and Furan	105
2.5.2.3 Pathways of Human Exposure	105
2.5.2.4 Effect on Human Health	106
2.5.3 Indoor noise	107
2.5.4 Environmental situation monitoring in JPMC	110
<b>Chapter 3: Socio-Economic and Public Participation Assessment</b>	<b>114</b>
3.1 Summary	115
3.1.1 What is Socio-Economic Assessment?	115
3.1.2 Why should national implementation plans include Socio-Economic Assessment?	116
3.2 Background	119
3.2.1 Introduction	119
3.2.2 Demographics	120
3.2.2.1 Population and Population Growth:	120
3.2.2.2 Age-Gender Breakdown:	122
3.2.2.3 Poverty :	123
3.2.2.4 Human Development Index	123
3.2.2.5 Employment:	125
3.2.3 Economic Context & Indicators	127

<b>3.2.3.1 The ASEZ and Growth Projections:</b>	<b>127</b>
<b>3.2.3.2 Economic activities in Aqaba:</b>	<b>129</b>
<b>3.2.3.2.1 Ports Sector:</b>	<b>130</b>
<b>3.2.3.2.1.1 Main Port Site :</b>	<b>130</b>
<b>3.2.3.2.1.2 South Port Site</b>	<b>132</b>
<b>3.2.3.2.2 The Industrial Sector:</b>	<b>135</b>
<b>3.2.3.2.2.1 The Northern Industrial Zone:</b>	<b>136</b>
<b>3.2.3.2.2.2 The Southern Industrial Zone :</b>	<b>136</b>
<b>3.2.3.2.3 The Tourism Sector:</b>	<b>137</b>
<b>3.3 Detailed description of target groups” STAKEHOLDERS”</b>	<b>139</b>
<b>3.3.1 Who are Stakeholders?</b>	<b>140</b>
<b>3.3.2 Stakeholder Analysis:</b>	<b>140</b>
<b>3.3.2.1 Why to do a Stakeholder Analysis:</b>	<b>141</b>
<b>3.3.2.2 How to do a Stakeholder Analysis</b>	<b>141</b>
<b>3.3.2.2.1 Stakeholder Identification – the stakeholder table</b>	<b>141</b>
<b>3.3.2.2.2 Impact Assessments</b>	<b>141</b>
<b>3.3.3 Assessment of the Influence and Importance of Stakeholders</b>	<b>143</b>
<b>3.3.3.1 Influence/Importance Matrix:</b>	<b>144</b>
<b>3.3.3.2 The stakeholder participation</b>	<b>144</b>
<b>3.3.4 Detail description of the target groups:</b>	<b>145</b>
<b>3.3.4.1 Aqaba Special Economic Zone Authority:</b>	<b>145</b>
<b>3.3.4.2 Environmental Non Governmental Organizations “NGOs”.</b>	<b>146</b>
<b>3.3.4.2.1 Jordan Environment Society (JES):</b>	<b>146</b>
<b>3.3.4.2.2 The Royal Marine Conservation Society of Jordan (JREDS)</b>	<b>148</b>
<b>3.3.4.2.3 The Royal Society for the Conservation of Nature “RSCN”</b>	<b>150</b>
<b>3.3.4.2.4 The Jordan Society for Sustainable Development (JSSD)</b>	<b>151</b>
<b>3.3.4.3 Industries near the source</b>	<b>152</b>
<b>3.3.4.3.1 Jordan phosphate mines company / industrial complex.</b>	<b>153</b>
<b>3.3.4.3.2 Aqaba Thermal Power Plant</b>	<b>154</b>
<b>3.3.4.3.3 Red Sea Timber Industries Company</b>	<b>154</b>
<b>3.3.4.3.4 Nippon Jordan Fertilizer Company:</b>	<b>155</b>
<b>3.3.4.3.5 Arab Potash Company:</b>	<b>155</b>
<b>3.3.4.3.6 Arab Fertilizers and Chemicals Industries LTD,(Kemapco):</b>	<b>156</b>
<b>3.3.4.4 Tourism Sector and Local Hotel “nearby the source”.</b>	<b>156</b>
<b>3.3.4.4.1 Tala bay:</b>	<b>157</b>
<b>3.3.4.4.2 Tala bay hotels:</b>	<b>157</b>
<b>3.3.4.4.2.1 Radisson Blu Tala Bay Resort:</b>	<b>157</b>

3.3.4.4.2.2 Moevenpick Resort Tala Bay	157
3.3.4.4.2.3 Marina Plaza	158
3.4 Detailed description of adequate and effective tools for awareness rising	159
3.4.1 Communications and awareness tools	159
3.4.1.1 The "Interpersonal communication tools"	160
3.4.1.2 The "Group media tools"	161
3.4.1.3 The "Information and communication technologies tools"	162
3.5 Detailed description of information content dissemination approach	162
3.5.1 Questionnaire	163
3.5.2 Questionnaire Analysis	164
3.5.3 Description of Information Content	166
3.6 Cost Benefit Analysis of BAT/BEP implementation	168
3.6.1 Introduction	168
3.6.2 Project Benefits	168
3.6.2.1 Health benefits	168
3.6.2.1.1 Health Benefit Estimation	169
3.6.2.2 Environmental benefit	171
3.6.3 Project Cost	171
3.6.3.1 Direct costs	172
3.6.3.2 Indirect Costs	174
3.6.4 Conclusion	174

### ***List of Tables***

Table (1.1): Human Figure of JPMC Industrial Complex	7
Table (1.2): FM (HC) 140/97 STEAM BOILER SUPERHEATER DATA SHEET	65
Table (1.3): FM (HC) 140/97 STEAM BOILER ECONOMIZER DATA SHEET	65
Table (1.4): FM (HC) 140/97 STEAM BOILER DATA SHEET	67
Table (1.5): AIC gas emissions and pollution control devices	76
Table (2.1): Emissions from main industries in Aqaba southern industrial area	94
Table (2.2): Coordinates and Altitudes of Sites Selected for Off-site sampling points in Aqaba Special Economic Zone (ASEZ)	100

Table (2.3): Noise measurements in ACI at 2010	109
Table (3.1) Population Distribution According to Residential Complexes in Qasabet Al Aqaba	120
Table (3.2) Changes in Number of Population over a 10 Year Period.	121
Table (3.3) Aqaba Population Projections, 2006-2020	122
Table (3.4) Change in Head Count Ratio between 1997 and 2002 (World Bank Poverty Assessment Report, 2004)	123
Table (3.5) Human Development Indices	125
Table (3.6) Average Monthly Wages for Labour in Aqaba Area	126
Table (3.7) Aqaba Governorate Regional Product Baseline Projections, 1995-2020 - (JD 2005 millions)	129
Table (3.8) Summary of Dry Bulk Forecasts Related to the Fertilizer Industry Complex	133
Table (3.9) Summary of Liquid Bulk Forecasts	133
Table (3.10) Summary of General Cargo Forecast	134
Table (3.11) Employment Sector Distribution and Salaries Allocation	135
Table (3.12) Tourism Targets to 2010 (annual hotel bed nights)	138
Table (3.13) Stakeholder table	142
Table (3.14) Summary Participation Matrix	145
Table (3.15) Questionnaire Content	163
Table (3.16) Questionnaire Analysis	164

### ***List of Figures***

Figure (I): The Industrial Zone	<b>xiv</b>
Figure (II): 1- City of Aqaba, 2-Toutist Area, 3-The Industrial Zone	xv
Figure (III): Coastal Zone Topography	xvi
Figure (IV): The Contour Lines of the Coastal Zone	xvii

Figure (1.1): A top view of AIC	6
Figure (1.2): SAP Flow Diagram	28
Figure (1.3): Auxiliary AIC Utilities Boiler	66
Figure (1.4): SAP Main Boiler	66
Figure (1.5): Cross Section of Auxiliary AIC Utilities Boiler	68
Figure (1.6): ACI Control Startup Boiler	71
Figure (1.7): Wet scrubber used in AIC.	75
Figure (1.8): Results of NH <sub>3</sub> emissions measurements conducted by JPMC environmental division at DAP plant U75 (2009 -2010)	79
Figure (1.9): Results of F- emissions measurements conducted by JPMC environmental division at DAP plant U75 (2009 -2010)	80
Figure (1.10): Results of F- emissions measurements conducted by JPMC environmental division at DAP plant U76 (2009 -2010)	80
Figure (1.11): Results of SO <sub>x</sub> emissions measurements conducted by JPMC environmental division at SAP plant U53 (2009 -2010)	81
Figure (1.12): Results of SO <sub>x</sub> emissions measurements conducted by JPMC environmental division at SAP plant U54 (2009 -2010)	81
Figure (2.1): Utilities Boiler Stacks	96
Figure (2.2): SAP Boiler Stacks	96
Figure (2.3): Aqaba Weather Statistics	98
Figure (2.4): Aqaba Marine Park	101
Figure (2.5): Tala Bay	102
Figure (2.6): Ad Derra Area	102
Figure (2.7): Area south of the industrial zone	103
Figure (3.1) Population Pyramid for Aqaba Governorate 2005	123
Figure (3.2) Aerial Photograph Showing the Main Port Site.	131
Figure (3.3) Aerial Photograph Showing the South Port Site	132
Figure (3.4) Southern Industrial Zone	137
<b>Figure ( 3.5 ) Industrial Complex</b>	<b>153</b>

## ***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.

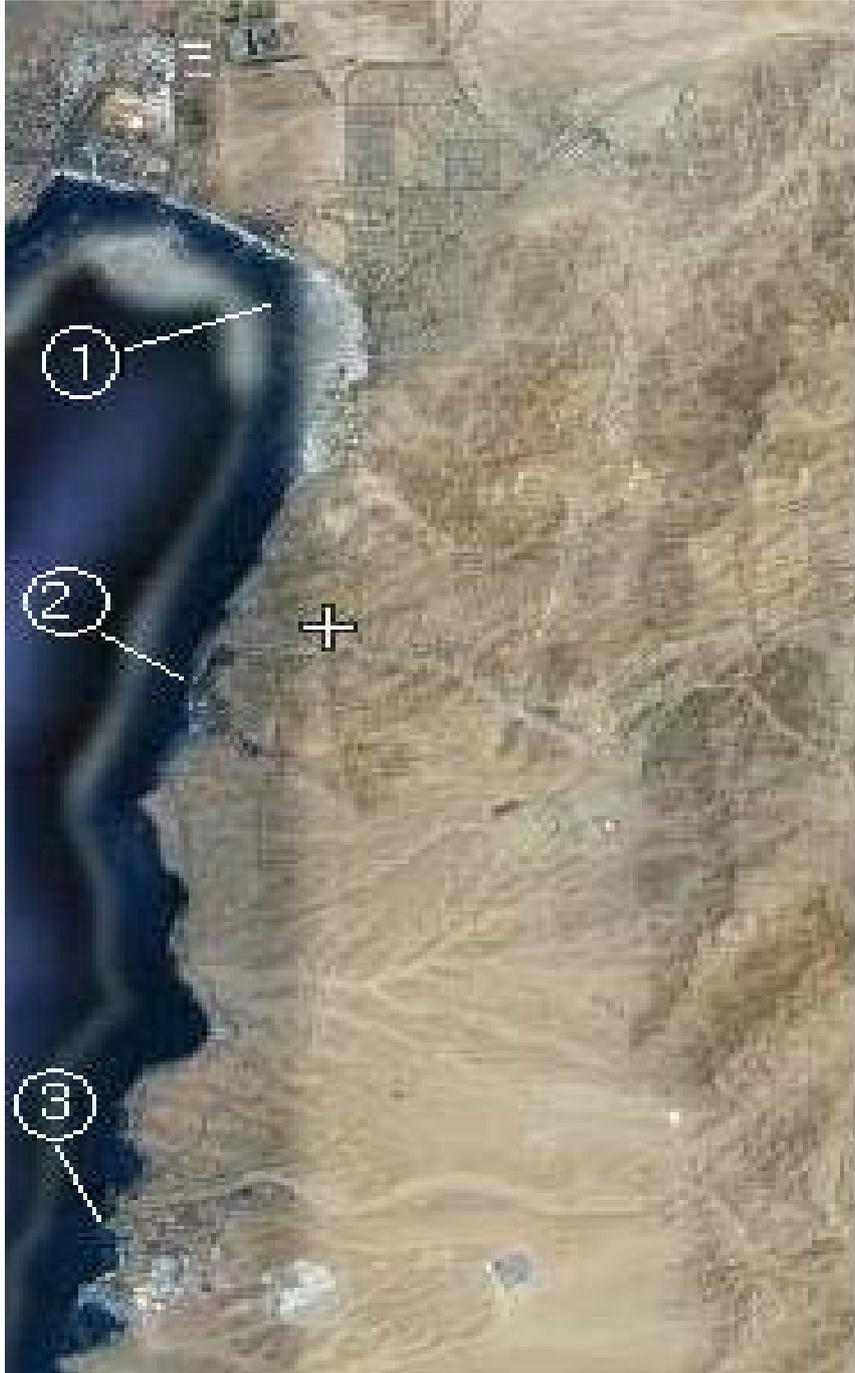
In 2001 Aqaba city was announced as a Special Economic Zone (ASEZ) with its own Authority (ASEZA). The ASEZ encompasses an area of 375 km<sup>2</sup>. Its purpose was to incorporate the entire Jordanian coastline, Jordanian sea-ports, and the historical city of Aqaba as a duty-free, low tax- multi-sectored 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**

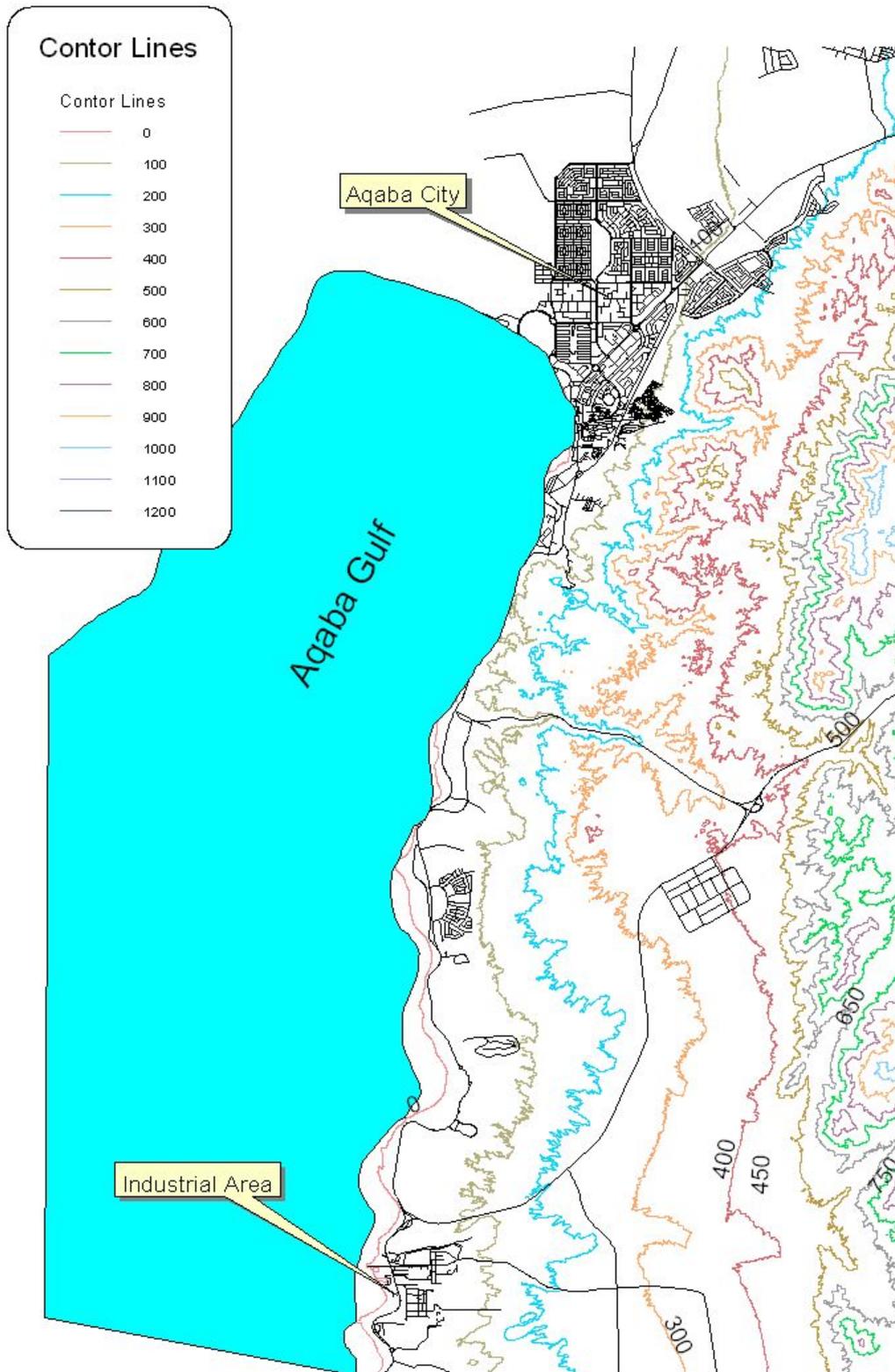


**Figure (II): 1- City of Aqaba, 2-Toutist Area, 3-The Industrial Zone**

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:

1. Eng. Bassam H. Al Saleem – Environmental Inspection and Auditing Division Head (Team Leader).
2. Eng. Issam Ahmad Al Falayleh – Senior Chemical Safety Officer.
3. Eng. Eman Suleiman Al-Kouz – Acting Head of Permitting and EIA Division.

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 DeNO<sub>x</sub> system, electrostatic precipitator and DeSO<sub>x</sub> 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.

**Age of Production Line:** Start of Production: 1982 where built by BABCOCK & WILCOX GAMA KAZAN Technologies –Twinkie. It was renewed at 1999.

**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 fluocelsic 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<sup>3</sup>/a

Dust from (V<sub>2</sub>O<sub>5</sub>): 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

V<sub>2</sub>O<sub>5</sub>: 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 (SiO<sub>2</sub>): 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 ( $AlF_3$ ).

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**

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<sub>x</sub>, NO<sub>x</sub>, CO, CO<sub>2</sub> dust, F<sup>-</sup> .....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**

	<b>Department</b>	<b>NO.</b>
<b>1.</b>	<b>Plant Manager Dept.</b>	<b>64</b>
<b>2.</b>	<b>Financial Dept.</b>	<b>26</b>
<b>3.</b>	<b>EHS Dept.</b>	<b>30</b>
<b>4.</b>	<b>Production Dept.</b>	
	- <b>Production Manager Office</b>	<b>4</b>
	- <b>Utilities</b>	<b>41</b>
	- <b>SAP</b>	<b>28</b>

	- PAP	69
	- DAP	43
	- AFP	30
	- Loading/ Unloading	76
	<b>Total Production Dept. Stuff</b>	<b>291</b>
5.	<b>Maintenance Dept.</b>	<b>308</b>
6.	<b>Managerial Dept.</b>	<b>209</b>
7.	<b>Technical Dept.</b>	<b>61</b>
	<b>Total Sum of Workers</b>	<b>989</b>

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	Fluorosilicic 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 ( $\text{SO}_2$ ).  $\text{SO}_2$  is cooled down and transferred to  $\text{SO}_3$  using Vanadium Pentoxide as a catalyst.  $\text{SO}_3$  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 bucket elevator and skew conveyers. Fluorosilicic acid is transported by pipes where Aluminum Hydroxide is dried using hot air produced by a diesel burner. Aluminum Hydroxide and Fluorosilicic 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 sparged 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 be 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 on to 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 140°C. It is burned with dried combustion air, which is dried through absorption with concentrated sulfuric acid in the drying tower. The SO<sub>2</sub> generated is into SO<sub>3</sub> in the four stage double absorption process.

Since 1996 ring shaped V<sub>2</sub>O<sub>5</sub> 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:

Sulfur

6500 t/day

Steam

15-20 m<sup>3</sup>/hr

### ***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% H<sub>3</sub>PO<sub>3</sub>, 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:

Phosphate rock	185 t/hr
Sulfuric acid (98.5%)	92 m <sup>3</sup> /hr
Water	200-350 m <sup>3</sup> /hr

#### ***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 V<sub>2</sub>O<sub>5</sub> 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 m<sup>3</sup> and 10000 m<sup>3</sup>). 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:

Phosphoric acid (49%)	2200 t/day
Anhydrous Ammonia (99.5%)	1000 t/day

#### ***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)<sub>3</sub> handling and drying, fluosilicic acid (H<sub>2</sub>SiF<sub>6</sub>) heating, reaction, silica filtration, AlF<sub>3</sub> 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  $\text{Al}(\text{OH})_3$  and  $\text{AlF}_3$ .

Consumption of Raw Materials Aluminum Fluoride plant:

Aluminum Hydroxide	24000 t/a
Fluorosilicic Acid	22 t/a

#### ***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 m<sup>3</sup> 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 m <sup>3</sup> /hr
Sulfuric acid unit	15-20 m <sup>3</sup> /hr
Aluminum fluoride unit	20-30 m <sup>3</sup> /hr
DAP unit	15-20 m <sup>3</sup> /hr
Steam generation unit	50 m <sup>3</sup> /hr
Household uses	20-25 m <sup>3</sup> /hr
Make-up water	15 m <sup>3</sup> /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 valve 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 m<sup>3</sup> 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 m<sup>3</sup>
- Sulfuric acid plant            400 m<sup>3</sup>

### ***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 demineralizer 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.

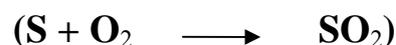
### ***1.6 Sulfuric Acid Plant***

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.

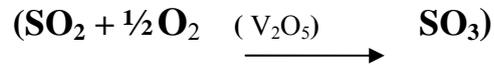
Sulfuric acid plant is involved in a revamping project to increase production capacities to 2250 t/day of the sulfuric acid from each of two units.

It produces sulfuric acid (H<sub>2</sub>SO<sub>4</sub>) 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<sub>2</sub>).

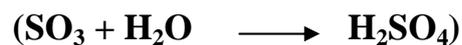


(SO<sub>2</sub>) is then converted in a special converter to sulfur trioxide (SO<sub>3</sub>), in the presence of vanadium pentoxide (V<sub>2</sub>O<sub>5</sub>).



(SO<sub>3</sub>) is then allowed to come in contact with water to produce (H<sub>2</sub>SO<sub>4</sub>):

It passes first in an absorption tower where it allowed to come in contact with (H<sub>2</sub>SO<sub>4</sub>) 98.5%, thus increasing its concentration. This concentrated acid is passed into a circulation tank where water is added to decrease its concentration to 98.5%. This 98.5% acid again is passed to the absorption tower to absorb SO<sub>2</sub>, and this cycle is repeated continuously.



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 end 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 facilitated 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 of  $\text{SO}_2$  and  $\text{N}_2$  with heat of formation.

The hot gas steam leaving the combustion chamber is cooled in a waste 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/cm<sup>2</sup>.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  $\text{SO}_2$  to  $\text{SO}_3$ . The conversion is an exothermic equilibrium reaction.  $\text{SO}_3$  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 of heat to steam in a steam superheater.

The degree of exchange is controlled by a bypass. The cooled gas enters the second catalyst bed for additional  $\text{SO}_2$  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  $\text{SO}_3$  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<sub>3</sub> but still contains some SO<sub>2</sub> 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<sub>3</sub>. After the final absorption, the gas is discharged to atmosphere through a mist eliminator and a stack: with a double absorption process, the SO<sub>2</sub> and SO<sub>3</sub> 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<sub>3</sub> 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.

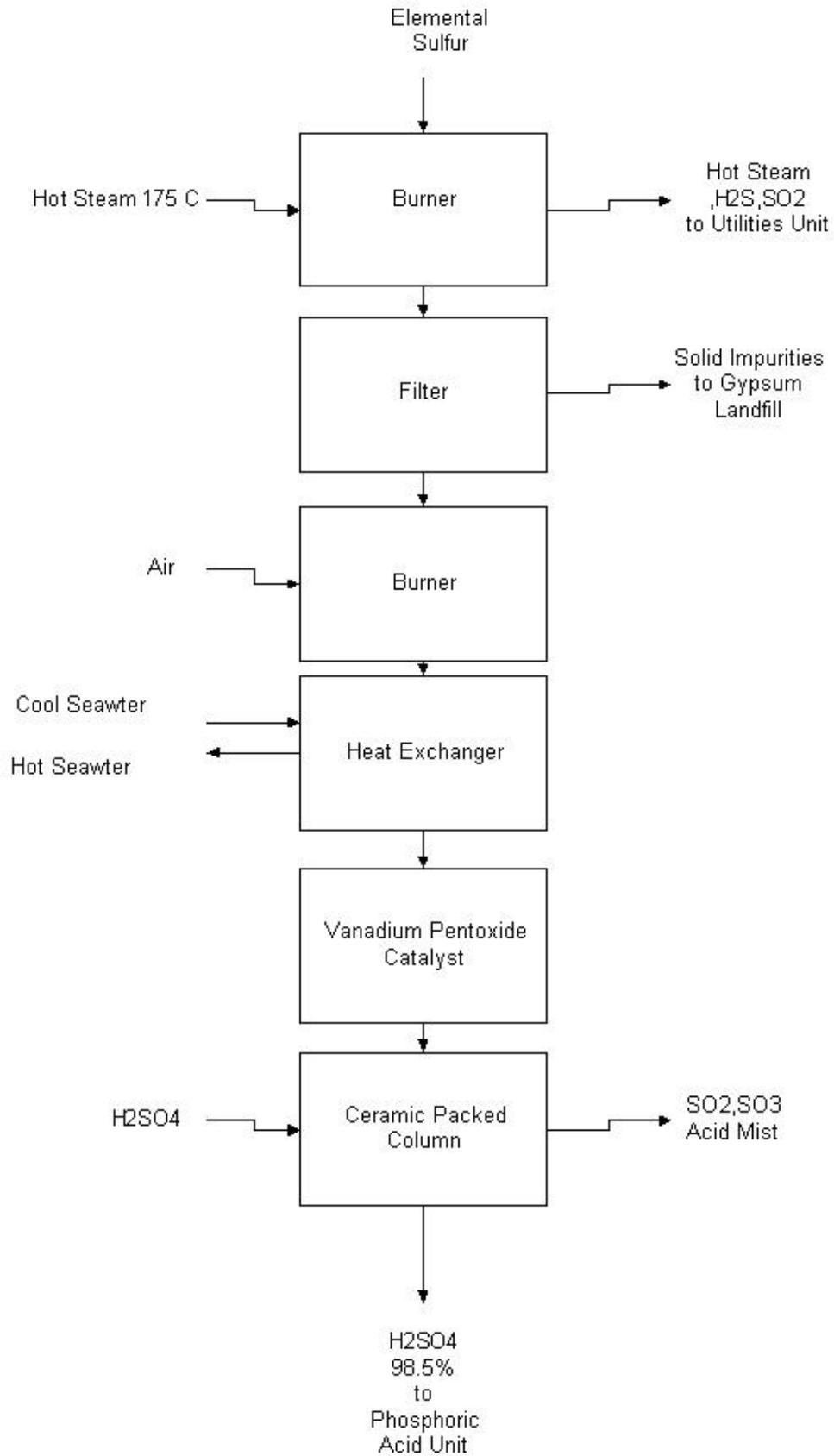


Figure (1.2): SAP Flow Diagram

### ***1.7 Phosphoric Acid Plant***

The phosphoric acid plant is designed to produce P<sub>2</sub>O<sub>5</sub> (phosphoric anhydride) as unconcentrated phosphoric acid:

- 54% (P<sub>2</sub>O<sub>5</sub>) unclarified phosphoric acid for captive fertilizer production.
- 54% (P<sub>2</sub>O<sub>5</sub>) clarified phosphoric acid for export (200 t/day P<sub>2</sub>O<sub>5</sub>).

The plant is designed to produce 1350 t/day P<sub>2</sub>O<sub>5</sub> according to the phosphate rock quality.

The phosphoric acid plant produces the following by – products:

- 25% hexa fluosilicic acid (H<sub>2</sub>SiF<sub>6</sub>).
- Gypsum, 25-30% free water.

It produces phosphoric acid (H<sub>3</sub>PO<sub>4</sub>) 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:



The mixture passes into a filter where gypsum (CaSO<sub>4</sub>·2H<sub>2</sub>O) is separated and conveyed to a belt for disposal, and the 30% phosphoric acid (H<sub>2</sub>PO<sub>4</sub>) 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<sub>2</sub>SiF<sub>6</sub>) in 22% concentration and water vapor:



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 <sub>2</sub> O <sub>5</sub> /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 grinded 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<sub>2</sub>O% by wt ≤ 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<sub>2</sub>O<sub>5</sub> 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%  $P_2O_5$ . Fluosilic acid ( $H_2SiF_6$ ) 20% fluorine content is produced here as a by-product, it is consumed by the  $AlF_3$  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 the 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, magnet element is located at the inlet of mill hopper to catch any iron pieces which will cause chocking of hopper

outlet or damage of the chain feeder Q16201. The mill hopper is 200 m<sup>3</sup> 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 starts rotating which will rotate the mill by the gear wheel, the mill rotation speed will be 12.94 rpm with the reduction ratio from pinion to gear wheel 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 be 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 m<sup>3</sup>/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 m<sup>3</sup>/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 m<sup>3</sup> 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 m<sup>3</sup>/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 m<sup>2</sup>, 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 m<sup>2</sup>.

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:



Where n = 0, 0.5 or 2

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



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 volatilized as  $\text{SiF}_4$ ; 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,  $\Delta T$  of inlet and outlet slurry of flash cooler is less than  $2.5^{\circ}\text{C}$ , 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 below 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  $\text{SO}_3$  percentage

- The phosphoric acid slurry must contain a slight excess of free  $\text{SO}_4^{-2}$  to allow an easy combination with  $\text{Ca}^{+2}$  ions which exist also in solution, solubility of gypsum decreases as  $\text{SO}_4^{-2}$  content increase.
- The  $\text{HPO}_4^{-2}$  has more or less the same lectrophysical configuration as  $\text{SO}_4^{-2}$ , if there is not enough  $\text{SO}_4^{-2}$  in solution,  $\text{HPO}_4^{-2}$  can react with  $\text{Ca}^{+2}$  to form  $\text{CaHPO}_4$  crystals which will be a loss of  $\text{P}_2\text{O}_5$  (co crystallization  $\text{P}_2\text{O}_5$  loss),so that 2% excess  $\text{SO}_4^{-2}$  is being added to reaction system.
- The  $\text{SO}_4^{-2}$  concentration also affects directly the size of the gypsum crystals, when  $\text{SO}_4^{-2}$  content ration increases, the size increases up to a certain limit and finally break into small crystals, but a too large excess  $\text{SO}_4^{-2}$  has a several drawn backs. The reaction between rock phosphate and sulfuric acid is then too fast and one obtains large concentrations of  $\text{Ca}^{+2}$  and  $\text{SO}_4^{-2}$  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  $\text{P}_2\text{O}_5$  loss.
- A high  $\text{SO}_4^{-2}$  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

SO<sub>3</sub>. SO<sub>4</sub><sup>-2</sup> 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 SO<sub>4</sub><sup>-2</sup> 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.

⇒ P<sub>2</sub>O<sub>5</sub> concentration

Too high P<sub>2</sub>O<sub>5</sub> concentration can result in formation of undesirable hemihydrates crystals and increase the crystallized P<sub>2</sub>O<sub>5</sub> losses. The viscosity of acid increases with P<sub>2</sub>O<sub>5</sub> concentration increase and impairs filtration because the gypsum crystals size decrease when % P<sub>2</sub>O<sub>5</sub> increase, while low P<sub>2</sub>O<sub>5</sub> 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 P<sub>2</sub>O<sub>5</sub> % 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 m<sup>3</sup>/hr enters into the first tank R2.6302A through a deep pipe X2.6302. From this tank, the slurry over flows 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 SO<sub>4</sub> 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 inspection 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% P<sub>2</sub>O<sub>5</sub>), the UCEGO filter is a rotating table made of stainless steel 317 L, it carries a polyethylene cloth and has an area of 250 m<sup>2</sup> with an active area (under vacuum) of 205 m<sup>2</sup>, 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%  $P_2O_5$  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 is correct, the product acid (28% $P_2O_5$ ) 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  $P_2O_5$  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 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 convey it to a series of belt conveyors to be disposed out at plants site. Screw should be 80-120 mm over the cloth to ensure good removal of 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  $\approx 84$  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<sup>3</sup>/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<sup>3</sup> 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<sup>3</sup>, 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<sup>3</sup> 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<sup>3</sup>/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 will raise and when the pressure comes back to normal, severe flashing of the acid may occur with deposits in evaporator and loss of  $P_2O_5$ . 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 ( $2500 \text{ m}^3/\text{hr}$ ) galling from top of condenser to be drained to the seal tank then to the hot water channel.

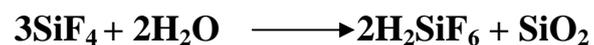
The steam consumption shows the capacity of the concentration lines, when tubes of the heat exchanger are clean, a low pressure steam (i.e. steam temperature) is required for a given capacity. As the scale builds up, the steam pressure increases. The target value of steam flow and pressure is  $35.5 \text{ ton/hr}$  and  $1.3 \text{ bar}$  ( $109^\circ\text{C}$ ) consequently, and it is measured by FR2.6450A,B,C and PR2.6451A,B,C the steam is desuperheated by desuperheating water of  $\approx 18\text{-}20 \text{ bar}$  supplied from utility plant to decrease the steam temperature from  $180^\circ\text{C}\text{-}190^\circ\text{C}$  to  $\approx 109^\circ\text{C}$  while the pressure is reduced from  $5\text{-}6 \text{ bar}$  to  $1.2 \text{ bar}$  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  $3.7^\circ\text{C}$  maximum. The acid temperature after heating should not be more than  $91^\circ\text{C}$  to avoid damage of heater.

The  $30\%$  acid ( $1.28 \text{ g/cm}^3$  density) fed at rate of  $50 \text{ m}^3/\text{hr}$  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 m<sup>3</sup>/hr with acid density of 1.59-1.60 g/cm<sup>3</sup>.

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 (H<sub>2</sub>SiF<sub>6</sub>) circulated and spranged by nozzles, an industrial water is fed to acid circulation line. Here a chemical reaction occurs between the SiF<sub>4</sub> and the water forming flousilicic acid and silica according to the reaction:



The produced flousilicic acid (F.S.A) is 18-20% concentration and 1.195-1.2 g/cm<sup>3</sup> density, it is sent by pump P6404 at a rate of 7-8 m<sup>3</sup>/hr to be stored in four F.S.A tanks.

### ***1.8.1 54% P<sub>2</sub>O<sub>5</sub> Acid storage***

The concentrated phosphoric acid from the evaporation system is sent to the 54% P<sub>2</sub>O<sub>5</sub> 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% P<sub>2</sub>O<sub>5</sub> clarified acid.

The clarified acid coming from the filter is transferred into 54% P<sub>2</sub>O<sub>5</sub> clarified acid storage tanks which are also equipped with agitators.

### ***1.8.2 Floussilicic Acid Storage***

The floussilicic 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 P<sub>2</sub>O<sub>5</sub> 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.

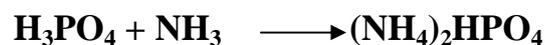
### ***1.9 Fertilizer Granulation Plant***

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.



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 drawn 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 m<sup>3</sup>.

The liquid ammonia is pumped 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% P<sub>2</sub>O<sub>5</sub> 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 P<sub>2</sub>O<sub>5</sub> feed of about 38% P<sub>2</sub>O<sub>5</sub>, when mixed with the 54% P<sub>2</sub>O<sub>5</sub> 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 recorder 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 continuous 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 conveyor. 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.

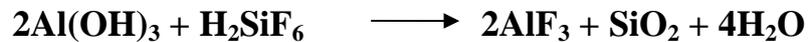
Manually operated trippers are located on the stock piling belts so that discharge from the belts can go to any of the five storage compartments. The total storage capacity of the buildings is 60000 ton.

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 (AlF<sub>3</sub>) from fluosilicic acid (H<sub>2</sub>SiF<sub>6</sub>) and aluminum hydroxide.

The process starts by reacting fluosilicic acid solution with Aluminum hydroxide Al(OH)<sub>3</sub> (alumina trihydrate AL<sub>2</sub>O<sub>3</sub>.3H<sub>2</sub>O) in special reactors to produce the soluble form of aluminum fluoride:



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 (AlF<sub>3</sub>.3H<sub>2</sub>O) precipitates. These crystals pass into calciners (driers) where anhydrous aluminum fluoride AlF<sub>3</sub> 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)<sub>3</sub> Handling and Drying***

Wet Al(OH)<sub>3</sub> (about 13 % moistures) is delivered by trucks to the hydrate storage building the hydrate is transported via hopper 11'101 chain conveyor 11'102 bucket elevator 11'103 and screw conveyor 11'103-1 to Al(OH)<sub>3</sub> wet silo 11'104 from of the bottom of the wet silo hydrate is fed via silo discharge device 11,105 screw conveyor 11'105-1 and screw feeder 11'106 into a flash 11'111 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 11'112 and fed to dry Al(OH)<sub>3</sub> storage silo 11'113. From this storage silo dry Al(OH)<sub>3</sub> is pneumatically conveyed (11'116) to day bin 11'118 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 (11'001A,11'001B,11'001C,11'001D).The acid to be heated to appropriate reaction temperature of 70-80°C centigrade therefore cold acid is pump 11'002A or B through graphite block heat exchanger 11'003 to hot acid tank 11'004A 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.

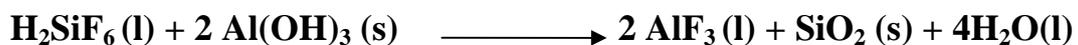
The cold acid is pumped by cold acid pumps 11'002A/B through heat exchanger 111'003 to the hot acid tanks. The heat exchanger consists of 7 graphite blocks. Steam is used as heating system.

### **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%  $H_2SiF_6$ - 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  $H_2SiF_6$  and  $Al(OH)_3$  yield a metastable solution of  $AlF_3$  and precipitated  $SiO_2$  :



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 prefiltrate, which always contains some solid material, is recovered and recalculation via filtrate receiver 11'506A or B and prefiltrate 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 recirculated 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 recirculated together with metastable  $AlF_3$ -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 $AlF_3 \cdot 3H_2O$ Filtration***

The  $AlF_3 \cdot 3H_2O$  – slurry is separated on a vacuum belt filter. The filter is automatically operated by program. From The  $AlF_3$ - filter tank 11'606 slurry is continuously fed to one of the  $AlF_3$ - 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 vacuum box in two sections. From the first section prefiltrate is recovered and recalculation via filtrate receiver 11'615A or B and prefiltrate 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  $\text{AlF}_3 \cdot 3\text{H}_2\text{O}$  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  $20 \text{ m}^3$ . Each crystallizer can be changed with 4 reaction batches, one crystallizer 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 11'611 shall 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 crystallizer 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***

$\text{AlF}_3 \cdot 3\text{H}_2\text{O}$  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  $\text{AlF}_3 \cdot 3\text{H}_2\text{O}$  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  $\text{AlF}_3 \cdot 3\text{H}_2\text{O}$  with a temperature of about  $100^\circ\text{C}$  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  $550^\circ\text{C}$  and conforms now to chemical formula  $\text{AlF}_3$ .

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 recirculated 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  $\text{Al}(\text{OH})_3$ . 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<sub>3</sub> 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<sub>3</sub> storage silo 11'803 or to special product silo 11'807.

AlF<sub>3</sub> 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<sub>3</sub> 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/Nm<sup>3</sup> (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 through 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**

CODE	ASME SEC. 1
DESIGN PRESSURE	850 psig
HYDROSTATIC TEST PRESSURE	1275 psig
STEAM OUTLET PRESSURE	682 psig
STEAM OUTLET TEMPERATURE	761 F
STEAM FLOW AT 100% LOAD	22500 lb/h
S.H TOTAL HEATING SURFACE	1775 sq. ft
NUMBER OF LOOP	7
NUMBER OF ELEMENT	25
NUMBER OF PASS	5
HEADER O.D & THK.	14" SCH 140
HEADER MATERIAL	SA 335p11
TUBE O.D & THK	50.8 * 4.6 mm M.W.T
TUBE MATERIAL	SA 192 / SA 209T1a / SA 213T22
PAINTING	N/A
INSULATION	N/A

**Table (1.3): FM (HC) 140/97 STEAM BOILER ECONOMIZER DATA SHEET**

CODE	ASME SEC. 1
DESIGN PRESSURE	1025 psig
HYDROSTATIC TEST PRESSURE	1538 psig
ECONOMIZER EFFECTIVE HEATING SURFACE	15300 sq. ft
RATED HEAT ABSORBTION	22806204 BTU/h
HEADER MATERIAL	6" SCH 80
TUBE O.D & THK	SA 106 b
TUBE MATERIAL	50.8 * 3.05 mm M.W.T
SHIPPING WEIGHT	SA 178-A
SHIPPING WEIGHT	54000 lb
PAINTING	YES
INSULATION	YES

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).



**Figure (1.3): Auxiliary AIC Utilities Boiler**

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).



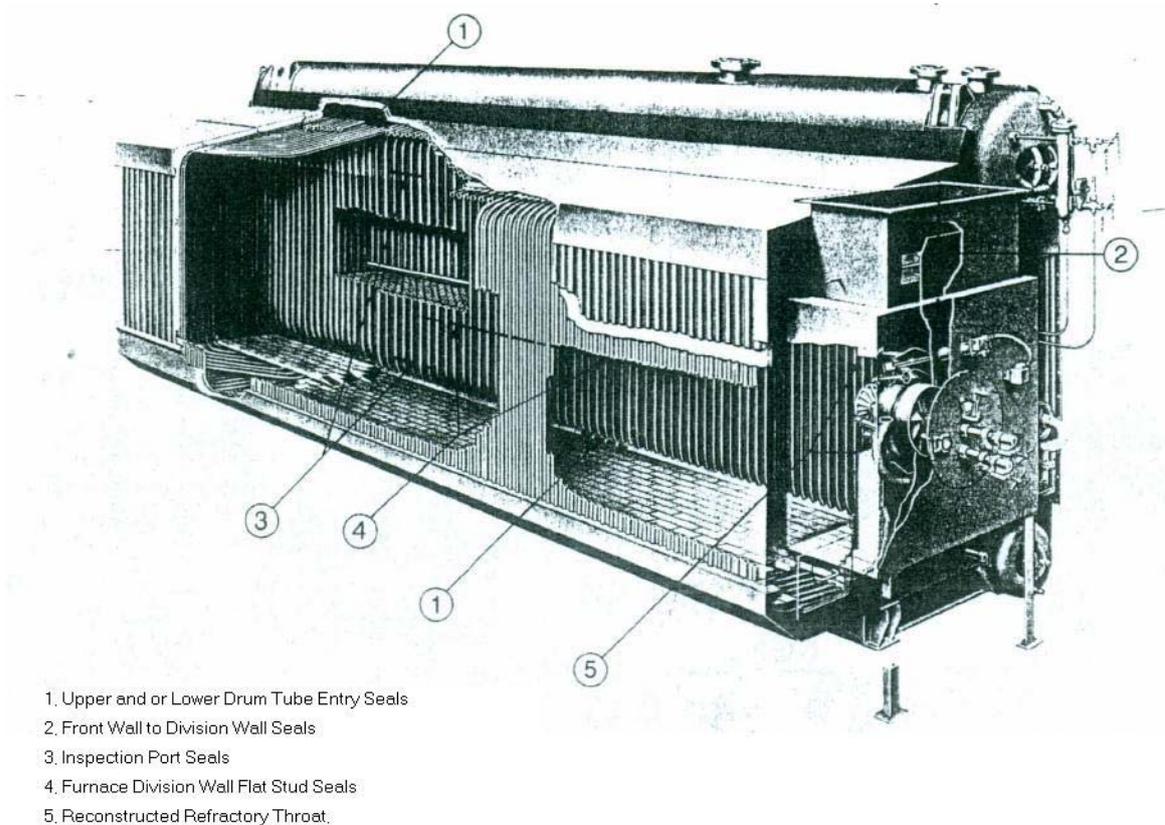
**Figure (1.4): SAP Main Boiler**

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**

CODE	ASME SEC. 1
DESIGN PRESSURE	850 psig
HYDROSTATIC TEST PRESSURE	1275 psig
DESIGN TEMPERATURE (FOR DRUMS)	527 F
STEAM OUTLET PRESSURE	682 psig
STEAM OUTLET TEMPERATURE	761 F
STEAM FLOW AT 100% LOAD	220500 lb/h
TOTAL HEATING SURFACE OF BOILER (BLR.+FURN)	9617 sq. ft
TOTAL WEIGHT OF BOILER (EMPTY)	333000 lb
PAINTING	YES
INSULATION	YES



**Figure (1.5): Cross Section of Auxiliary AIC Utilities Boiler**

### ***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.

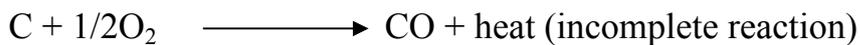
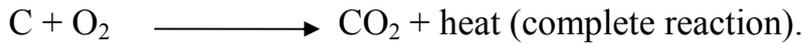
-Fire Point:

Fire point is the temperature at which fuel oil firing .This point affected

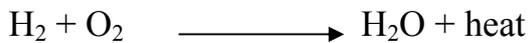
by air pressure mixed with fuel, air velocity, furnace properties, turbulence, and fuel oil type.

**Combustion process:**

Combustion is a chemical process in which C and H in fuel oil react with O<sub>2</sub> to release heat.

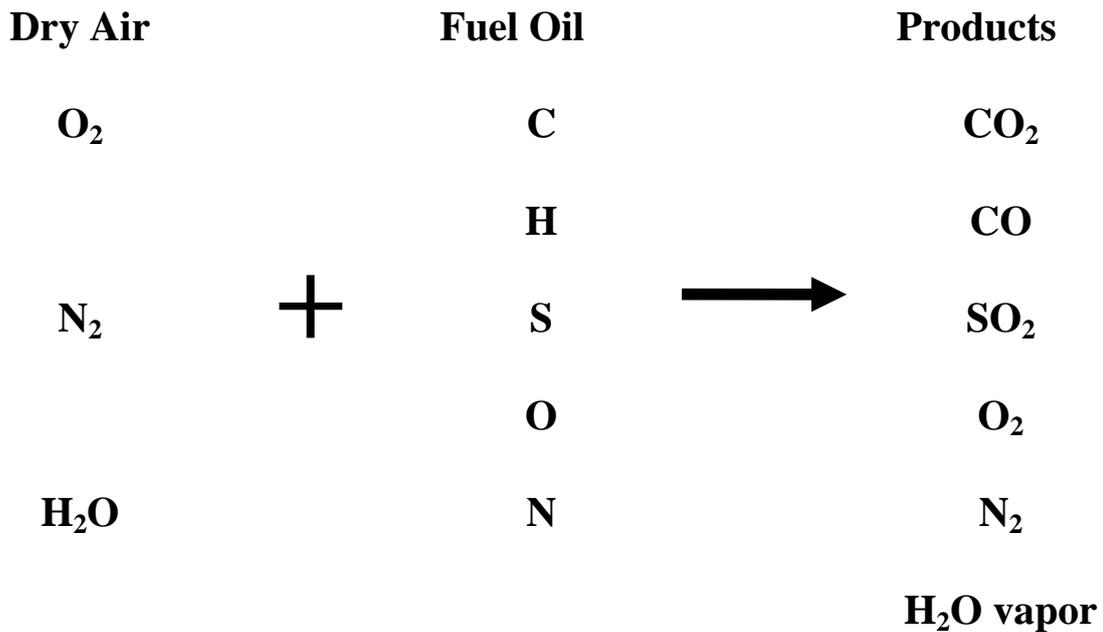


Firing 1 lb of carbon releases 4380 BTU.



Firing 1lb of hydrogen releases 61100 BTU.

Combustion process can be summarized as follows:



To reach complete combustion; it is very important to keep sufficient amount of O<sub>2</sub> 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 CO<sub>2</sub> in gas stream.

Combustion process can be controlled through three Ts Rules:

(Turbolance, 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.

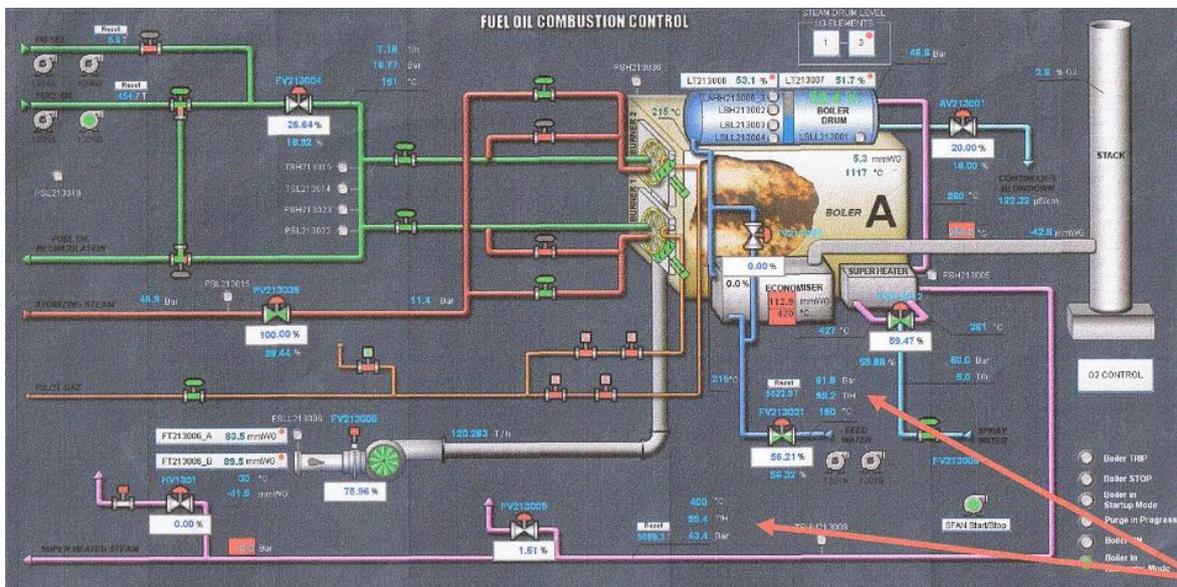


Figure (1.6): ACI Control Startup Boiler

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.

$$\begin{aligned}\text{Heavy Oil consumption} &= 32000 \text{ ton/year} * 1000 \text{ kg/ton} \\ &= 32000000 \text{ kg/year}\end{aligned}$$

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

$$\begin{aligned}\text{Activity Rate} &= 41.5 \text{ MJ/kg} * 32000000 \text{ kg/year} \\ &= 1328000000 \text{ MJ/year}\end{aligned}$$

$$\begin{aligned}\text{Source Strength (for air)} &= \text{Emission Factor} * \text{Activity Rate} \\ &= 2.5 \mu\text{g TEQ/TJ} * 10^{-6} \text{ TJ/MJ} * 1328000000 \text{ MJ/year} \\ &= 3320 \mu\text{g TEQ/year}\end{aligned}$$

$$\begin{aligned}\text{Diesel consumption} &= 3640 \text{ ton/year} * 1000 \text{ kg/ton} \\ &= 3640000 \text{ kg/year}\end{aligned}$$

From Table 96 (Heating values for oil, page 231, PCDD/PCDF Toolkit

2005):

Light fuel oil/ Diesel fuel heating value: 43 – 46 MJ/kg

Taking average value: 44.5 MJ/kg

$$\begin{aligned}\text{Activity Rate} &= 44.5 \text{ MJ/kg} * 3640000 \text{ kg/year} \\ &= 161980000 \text{ MJ/year}\end{aligned}$$

$$\begin{aligned}\text{Source Strength (for air)} &= \text{Emission Factor} * \text{Activity Rate} \\ &= 0.5 \text{ } \mu\text{g TEQ/TJ} * 10^{-6} \text{ TJ/MJ} * 161980000 \text{ MJ/year} \\ &= 80.99 \text{ } \mu\text{g TEQ/year}\end{aligned}$$

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 SiF<sub>4</sub> 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 SiF<sub>4</sub> are expected. Furthermore, hydrolysis of SiF<sub>4</sub> 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: SO<sub>2</sub>, SO<sub>3</sub>, 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 H<sub>2</sub>S 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:***

SO<sub>x</sub>, NO<sub>x</sub>, CO, and CO<sub>2</sub> 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 NH<sub>3</sub> and HF. It is caused by the volatilization due to incomplete chemical reactions and excess free ammonia. Also, fluoride and V<sub>2</sub>O<sub>5</sub> 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; SO<sub>x</sub>, NO<sub>x</sub>, CO, and CO<sub>2</sub> 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.

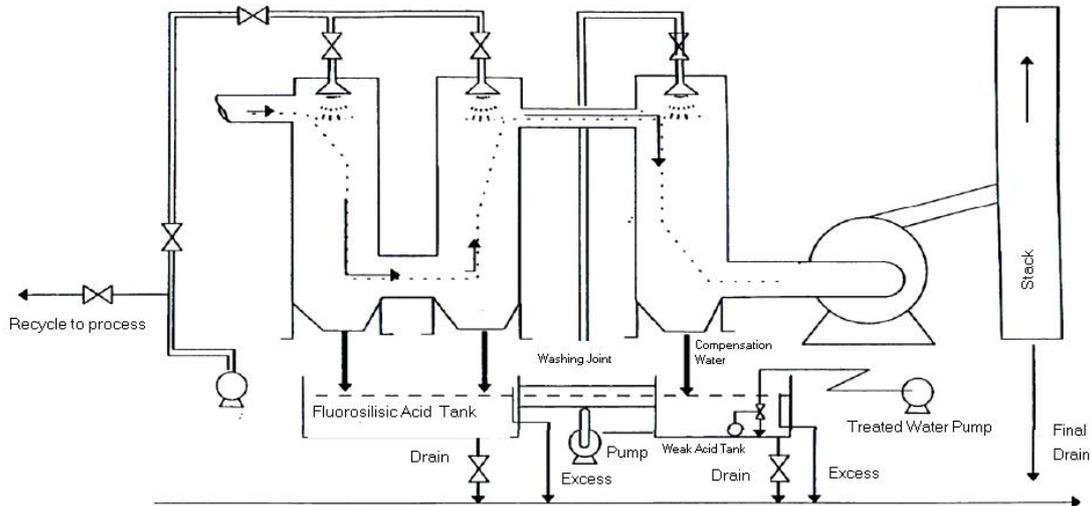
A large part of the dust entrained in the gases entering the dryer cyclone and the cooler dust vent cyclone is recovered by the cyclones and discharged from each cyclone hopper through an air lock to the recycle conveyor.

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).



**Figure (1.7): Wet scrubber used in AIC.**

#### ***1.13.1.5 Utility Gaseous Emissions:***

SO<sub>x</sub>, NO<sub>x</sub>, CO, and CO<sub>2</sub> 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 (1.5): AIC gas emissions and pollution control devices**

<b>Industrial process</b>	<b>Raw materials</b>	<b>Gas Emissions</b>	<b>Treatment Devices</b>
<b>UTILITIES</b>	water(fresh, sea, reclaimed),heavy fuel oil, diesel oil	SO <sub>x</sub> , NO <sub>x</sub> , CO, and CO <sub>2</sub>	No treatment device
<b>PAP</b>	Phosphate rock	H <sub>2</sub> O vapour	
	sulfuric acid (98.5%)	particulate dust	De-dusting unit
	water	Fluorides (HF,SiF <sub>4</sub> )	Scrubbing system
<b>SAP</b>	sulfur	SO <sub>2</sub> ,SO <sub>3</sub> ,H <sub>2</sub> S	double contact double absorption unit
	Steam	Acid mist, particulate	Acid mist eliminator
<b>AFP</b>	aluminum hydroxide	SO <sub>x</sub> , NO <sub>x</sub> , CO, and CO <sub>2</sub>	Cyclone
	fluorosilicic acid	HF	scrubber
	diesel	Dust	bag filter
<b>DAP</b>	phosphoric acid (49%)	Gaseous ammonia	Ventury, cyclonic scrubber, gas scrubber
	anhydrous ammonia (99.5%)	Fluorides	Cyclone
	heavy fuel oil	SO <sub>x</sub> , NO <sub>x</sub> , CO, and CO <sub>2</sub>	

### ***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 fluorosilicic 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 H<sub>2</sub>S and SO<sub>2</sub> 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).

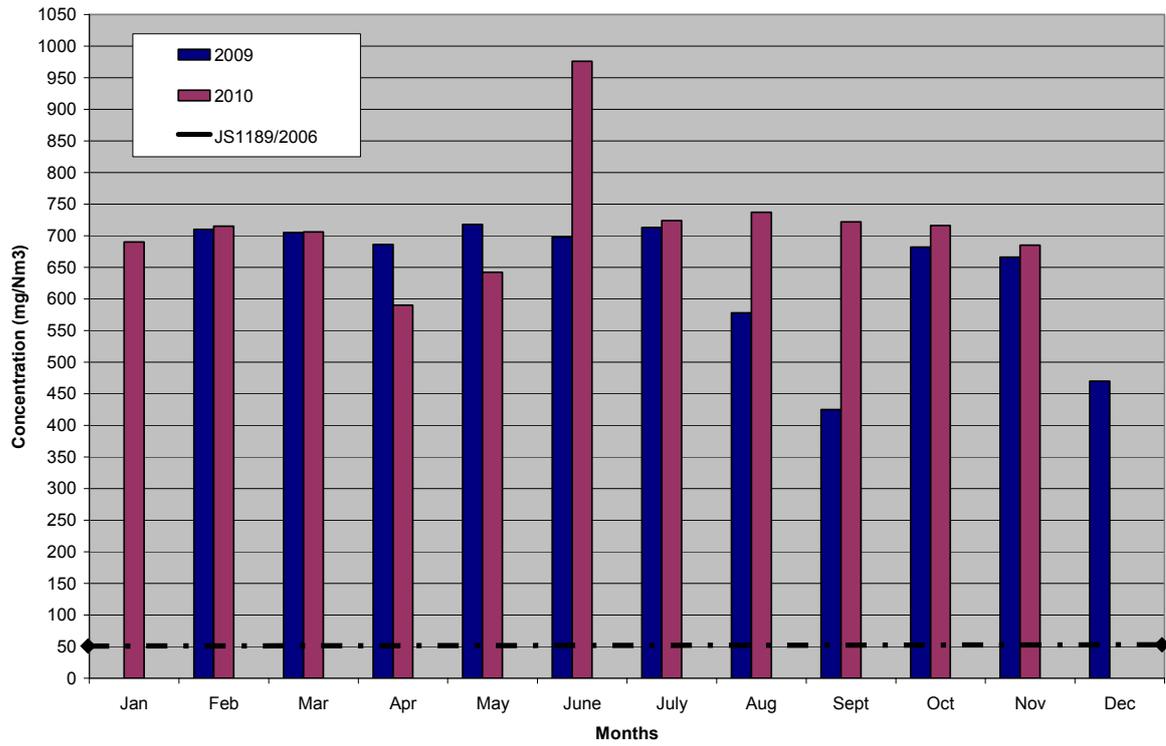
Following are the main conclusions of this review:

#### ***1.13.4.1 Internal Monitoring Program***

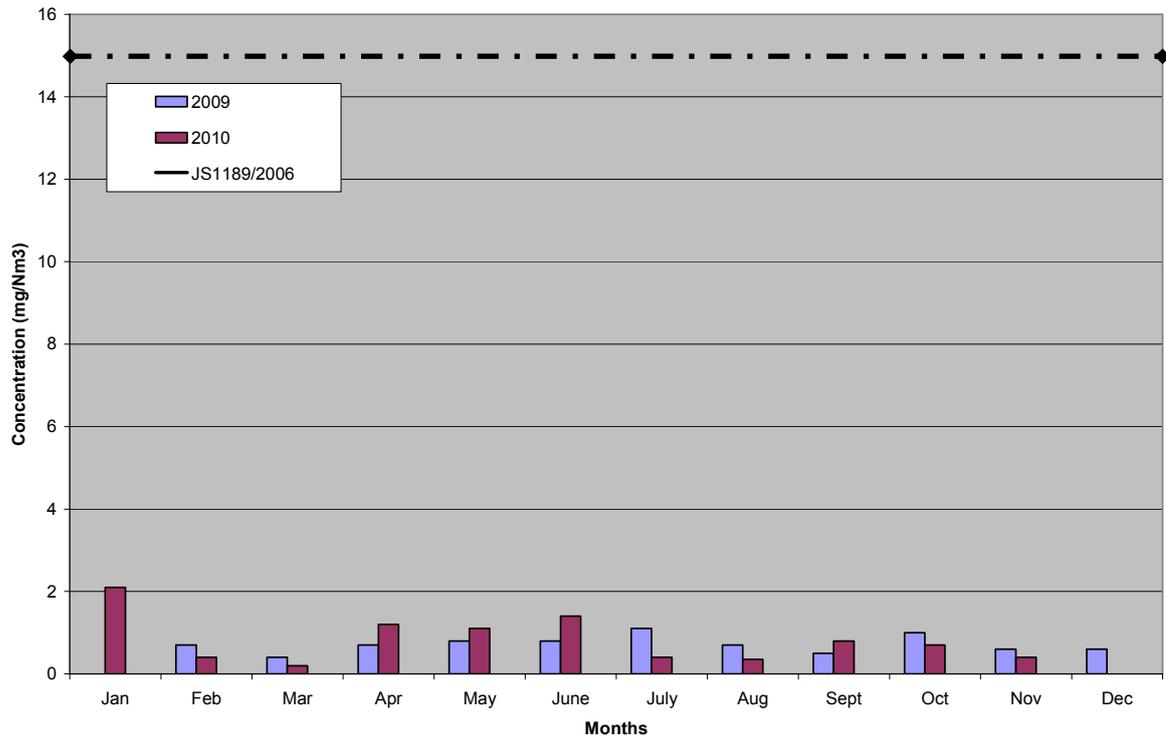
##### ***1.13.4.1.1 Air quality results***

Company conducts quarterly measurements of NH<sub>3</sub> emissions from DAP plants, F<sup>-</sup> emissions from phosphoric acid plant and aluminum fluoride plant and SO<sub>3</sub> and acid mist emissions from sulfuric acid plants.

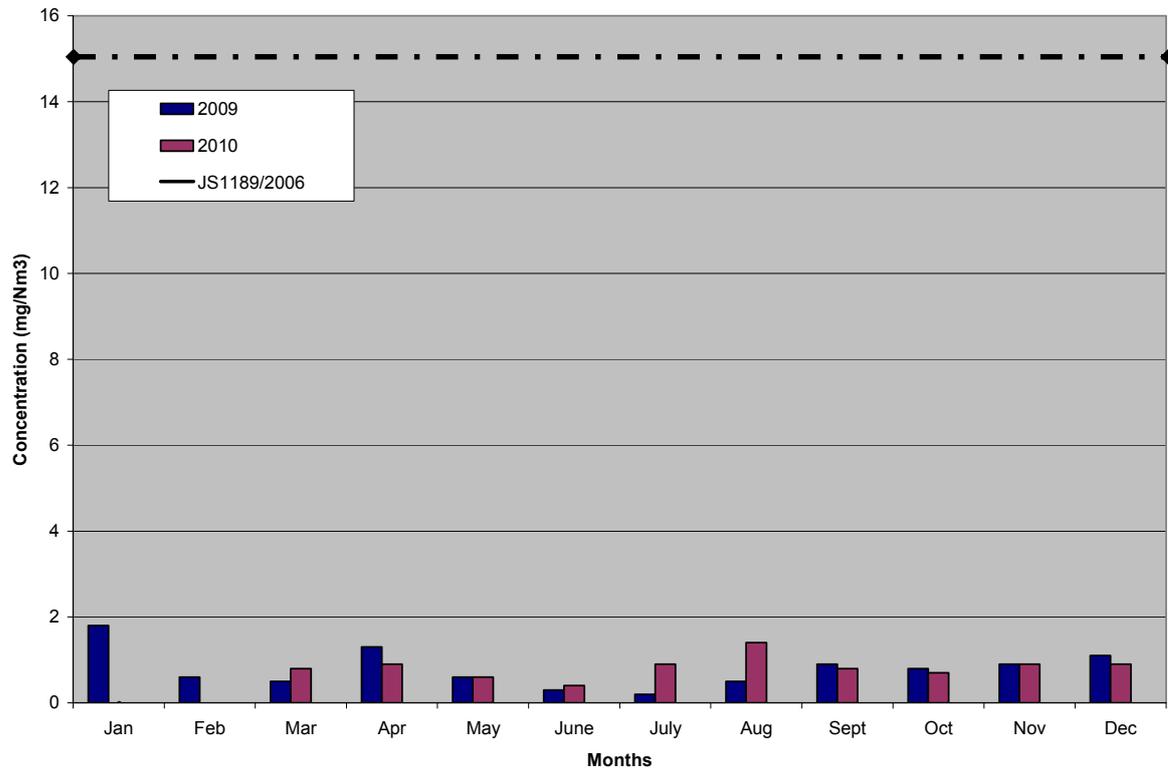
The results are summarized in the following figures. All the results comply with the Jordanian Standards (JS: 1189/2006) except of ammonia which much more above the standard limits.



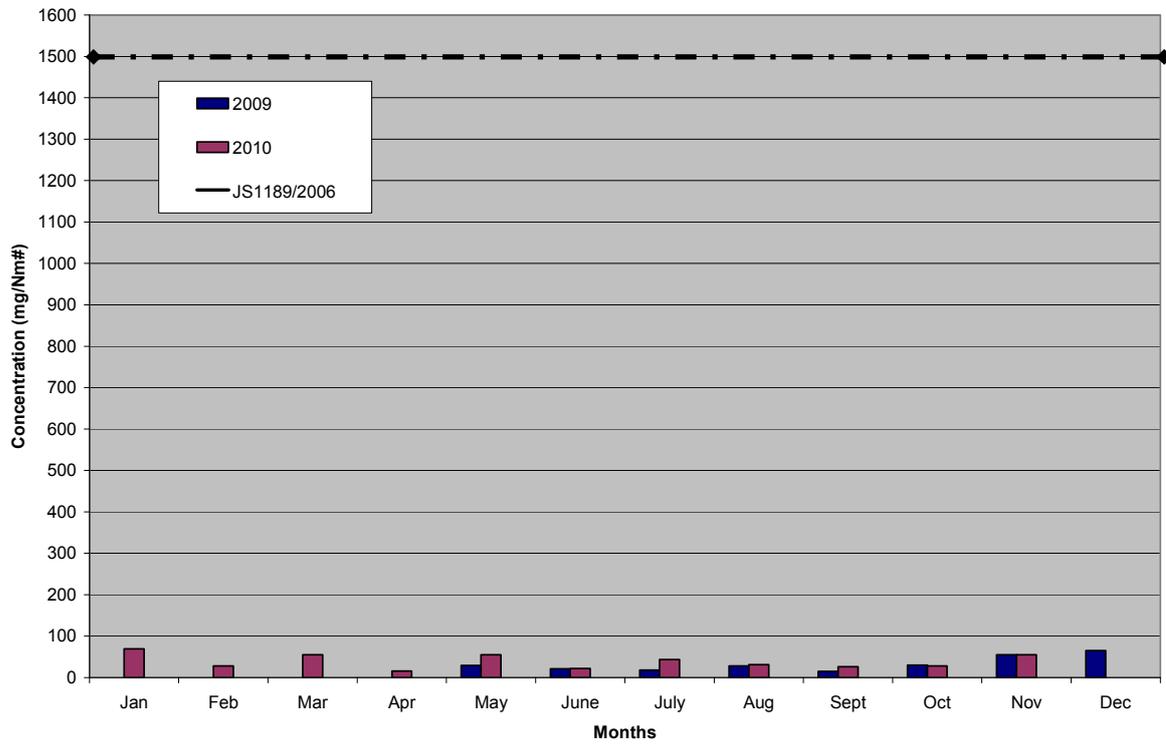
**Figure (1.8): Results of NH3 emissions measurements conducted by JPMC environmental division at DAP plant U75 (2009 -2010)**



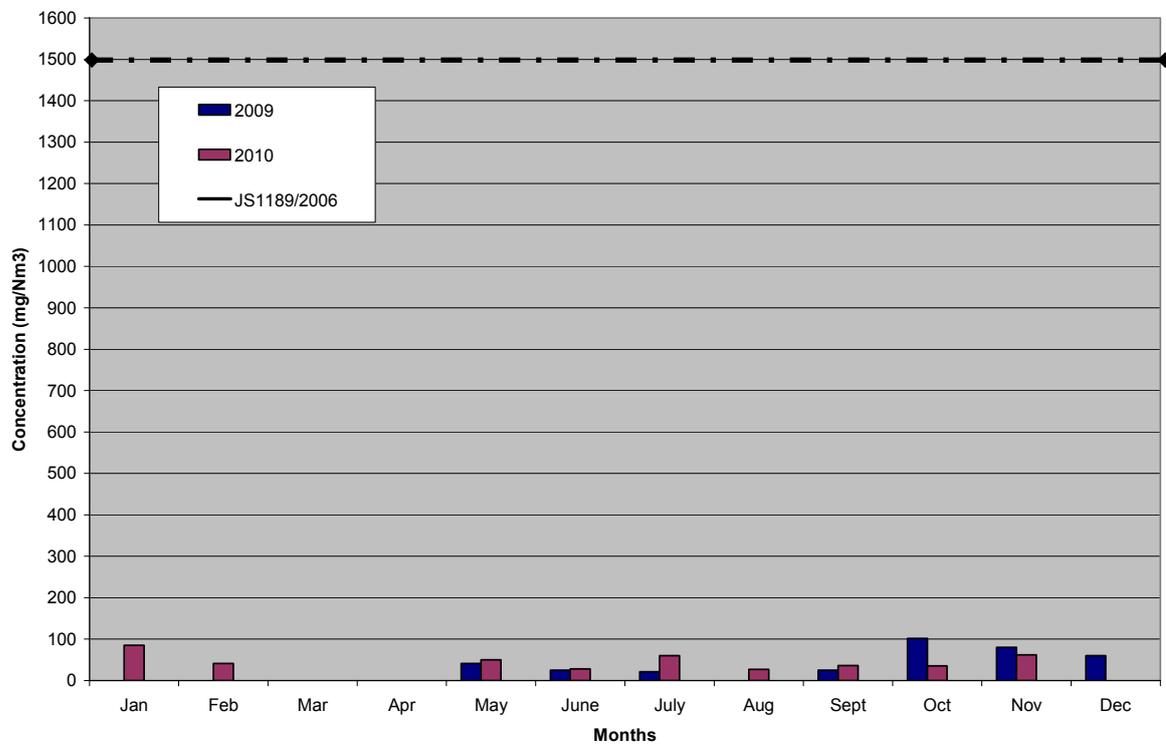
**Figure (1.9): Results of F- emissions measurements conducted by JPMC environmental division at DAP plant U75 (2009 -2010)**



**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 at SAP plant U54 (2009 -2010)

#### ***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 NH<sub>3</sub> 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 cost 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 used 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<sub>x</sub>), carbon monoxide (CO), and carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), volatile organic compounds (VOCs), trace amounts of sulfur dioxide (SO<sub>2</sub>), 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 improperly 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 H<sub>2</sub>SO<sub>4</sub> 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 benzofurans 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 six 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 (2.1): Emissions from main industries in Aqaba southern industrial area**

The company		No. of Stacks	Stack Location Coordinates		Stack Height (m)	Stack Diameter (m)	Emissions
			X	Y			
Industrial Co.	Utility	2	303233.879	251919.450	86	1.75 - 2.1	SO <sub>x</sub> ,NO <sub>x</sub> ,CO

			303208.567	251918.673			
	Phosphoric Acid	2	303234.325	251602.926	47	2	HF, Particulates
	Sulfuric Acid	2	303227.848	251771.461	55	2.6	SO <sub>x</sub>
			303227.574	251704.119			
	DAP	2	303187.252	251491.840	48.2	3	HF, NH <sub>3</sub>
			303187.530	251424.090			
	AlF <sub>3</sub>	1	303400.285	251486.628	60	1.4	HF
	Phosphate Unloading Station	1					Particulates
Aqaba Thermal Station	Unit 1 + 2	1	303561.558	252346.274	125	3	SO <sub>x</sub> , NO <sub>x</sub> , CO <sub>2</sub> , CO, O <sub>2</sub> , N <sub>2</sub>
	Unit 3 + 4	1	303687.347	252345.132	125	3	
	Unit 5	1	303775.130	252342.256	125	3	
Nippon Jordan Fertilizer Company		1	303538.868	251391.050	59	3	Dust, F, NH <sub>3</sub>
KEMAPCO	Burner of DCP	1	03458.117	2921.903	18		SO <sub>x</sub> , NO <sub>x</sub> , CO
	Aux. Boiler	1	03458.248	2921.929	70		SO <sub>x</sub> , NO <sub>x</sub> , CO
	Nitric Acid	1	03458.247	2921.904	36		NO <sub>x</sub> , NH <sub>3</sub>
	Ion Exchange	1	03458.198	2921.909	10		NO <sub>x</sub> , HF
	NOP	2					Particulates
Red Sea Timber Industries		2					SO <sub>x</sub> , NO <sub>x</sub> , CO

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. SO<sub>x</sub>, NO<sub>x</sub>, CO<sub>2</sub>, etc.).

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



**Figure (2.1): Utilities Boiler Stacks**



**Figure (2.2): SAP Boiler Stacks**

## ***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.

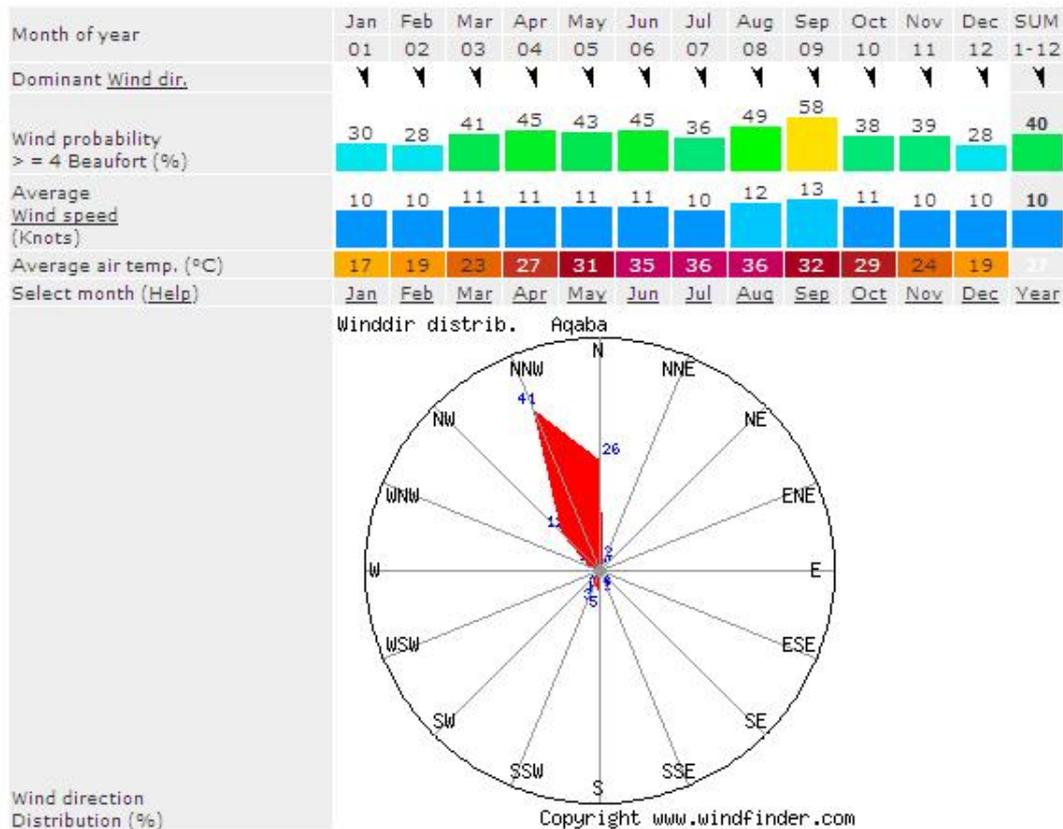
Regarding the relative humidity, the maximum monthly average was 49% in October, while the minimum was 33% in June. Daily average of relative humidity ranged between 16% and 72%, while the maximum hourly average reached a value of 90%.

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.

### Aqaba (AQABA)

Statistics based on observations taken between 7/2006 - 12/2010 daily from 7 am to 7 pm local time.



**Figure (2.3): Aqaba Weather Statistics**

### 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. CO<sub>2</sub>, SO<sub>x</sub>, NO<sub>x</sub>, 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 (2.2): Coordinates and Altitudes of Sites Selected for Off-site sampling points in Aqaba Special Economic Zone (ASEZ)**

No.	Site	Coordinates (UTM)		Altitude (m)
		X (east-west)	Y(north-south)	
1	Aqaba Marine Park / Northern Parking Area	0691702	3257477	17
2	Tala Bay/Southern Border	0691988	3254695	26
3	Civil Defense Dept./ Ad Derra	0691011	3249506	28
4	Site South of Industrial Zone	0691467	3249491	28

#### ***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**

#### ***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).



**Figure (2.5): Tala Bay**

#### ***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).



**Figure (2.6): Ad Derra Area**

#### ***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).



**Figure (2.7): Area south of the industrial zone**

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

all employees (JPMC OHSAS Manual. 2009 – Annex 2).

## ***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, polychlorinated 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 discolouration 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

Plant	Region		At distance [dB Noise]				
			1m	2m	3m	4m	
Utilities	1. Turbine Generators	Turbine A-A T1301	95	92	90	89	
		AT1301- Turbine B	-	-	-	-	
	2. BOILERS FEED PUMP		92	91	91	90	
	3. Air blowers K 1101		102	97	95	91	
4. Main Condensers		92	91	90	88		
SAP	Turbine Air Blower	Unit 53	114	105	102	100	
		Unit 54	104	102	101	100	
PAP	1. Phosphate mill		92	91	90	89	
	2. Phosphate Silo /Blower 2601		98	96	94	92	
	Steam ejector	Concentration		101	97	92	89
		Line A					
		Concentration line B		103	97	93	90
Concentration line C		102	97	92	89		
DAP	1. DAP Mills	Unit 75	-	-	-	-	
		Unit 76	95	92	90	88	
	2. GEAR BOX DAP Dryer	Unit 75	-	-	-	-	
		Unit 76	97	92	90	90	
	3. DAP Dryer Fans	Unit 75	-	-	-	-	
		Unit 76	95	92	90	87	
AFP	1. Dryers Region		92	91	90	87	
	2. Burners Blower	Blower 11710 A	102	97	92	89	
		Blower 11710 B	100	95	91	89	
	3. Exhaust Gas Blower		92	91	90	87	
4. Machines and Equipment Room		93	91	90	88		

#### ***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 (SO<sub>3</sub>, Acid mist)
    - Phosphoric Acid Plant Stack: once per week for (F-containing gases)
    - DAP Plant Stacks (75,76): once per week for (F, P<sub>2</sub>O<sub>5</sub>, NH<sub>3</sub>)
- ❖ 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:
  - CO<sub>2</sub>, CO, and SO<sub>2</sub> in sulfuric acid plant and utilities.
  - HF in three different locations in phosphoric acid plant and three different locations in Aluminum fluoride plant.

- NH<sub>3</sub> 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.
  - AlF<sub>3</sub> Packaging area.

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

### ***3. Monitoring and measurements***

JPMC environmental staff collects a monthly water sample from Hassad well and analyzes it for the following parameters: (F<sup>-</sup>, SO<sub>4</sub><sup>-</sup>, PH, P<sub>2</sub>O<sub>5</sub>, NH<sub>3</sub>, Fe, CaCO<sub>3</sub>, 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 staff 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  $10\text{mg}/\text{m}^3$ .

Project of reducing  $\text{NH}_3$  emissions from DAP stacks from  $727\text{ mg}/\text{m}^3$  to less than  $50\text{ mg}/\text{m}^3$ . 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  $\text{NH}_3$  emissions.

#### ***11. Internal Auditing:***

By JPMC staff 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).

# CHAPTER 3

# SOCIO-ECONOMIC AND PUBLIC PARTICIPATION ASSESSMENT

## *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 through out 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 km<sup>2</sup>. 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**

<b>Locality</b>	<b>Population</b>
<b>Mezfer</b>	<b>150</b>
<b>Teten</b>	<b>17</b>
<b>Track Area</b>	<b>560</b>
<b>Re'a Sa'adeh</b>	<b>17</b>
<b>Kaldi</b>	<b>171</b>
<b>Aqaba</b>	<b>99,985</b>
<b>Total</b>	<b>100,900</b>

Source; Department of Statistics

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.**

<b>Year</b>	<b>Population</b>	<b>Population Percentage</b>
<b>1995</b>	<b>82,300</b>	<b>1.93%</b>
<b>2005</b>	<b>115,100</b>	<b>2.1%</b>
<b>2008</b>	<b>127,500</b>	<b>2.2%</b>

**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**

Year	Aqaba City Total Population	Aqaba Governorate			
		Total Population	Migrants		
			Subtotal	Jordanians	Non- Jordanians
<b>2006</b>	<b>100,325</b>	<b>118,030</b>	<b>26,492</b>	<b>14,571</b>	<b>11,921</b>
<b>2010</b>	<b>122,536</b>	<b>144,160</b>	<b>43,801</b>	<b>13,140</b>	<b>30,661</b>
<b>2015</b>	<b>153,450</b>	<b>180,530</b>	<b>68,501</b>	<b>23,290</b>	<b>45,211</b>
<b>2020</b>	<b>161,218</b>	<b>201,522</b>	<b>77,090</b>	<b>30,836</b>	<b>46,254</b>

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.

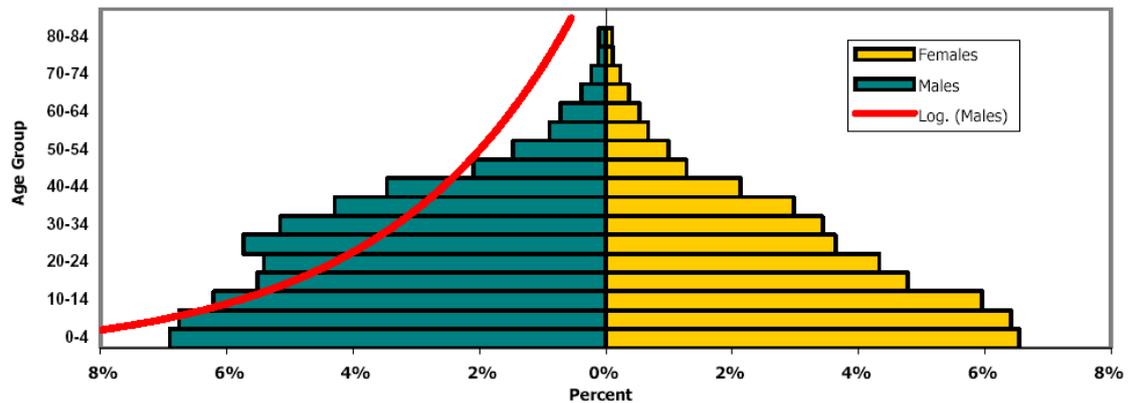


Figure (3.1) Population Pyramid for Aqaba Governorate 2005

### 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 (3.4) Change in Head Count Ratio between 1997 and 2002

Governorate	1997		2002	
	Headcount	Gap	Headcount	Gap
Aqaba	37.3	11.7	24.1	6.2

Source ( World Bank Poverty Assessment Report , 2004)

#### ***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**

human development index by governorate, 1997 and 2002														
Governorate	Life expectancy index			Education index			GDP index			Human Development index (HDI)				
										Value			Rank	
	1997	2002	% +/-	1997	2002	% +/-	1997	2002	% +/-	1997	2002	% +/-	1997	2002
Jordan	0.751	0.775	3.2	0.802	0.846	5.5	0.591	0.621	5.1	0.715	0.747	4.5	-	-
Amman	0.758	0.785	3.6	0.833	0.860	3.2	0.624	0.656	5.1	0.738	0.767	3.9	1	1
Aqaba	0.802	0.828	3.2	0.796	0.844	6.0	0.593	0.618	4.2	0.730	0.763	4.5	2	2
Irbid	0.773	0.798	3.2	0.798	0.849	6.4	0.562	0.606	7.8	0.711	0.751	5.6	5	9
Madaba	0.776	0.817	5.3	0.783	0.841	7.4	0.578	0.590	2.1	0.712	0.749	5.2	4	4
Ajloun	0.770	0.793	3.0	0.781	0.851	9.0	0.544	0.584	7.4	0.699	0.743	6.3	6	5
Zarqa	0.743	0.773	4.0	0.821	0.847	3.2	0.574	0.572	-0.3	0.713	0.731	2.5	3	6
Balqa	0.738	0.733	-0.7	0.761	0.831	9.2	0.578	0.609	5.4	0.692	0.724	4.6	7	7
Jarash	0.725	0.747	3.0	0.789	0.843	6.8	0.547	0.583	6.6	0.687	0.724	5.4	8	7
Karak	0.720	0.752	4.4	0.742	0.810	9.2	0.588	0.611	3.9	0.684	0.724	5.8	9	7
Tafiela	0.692	0.712	2.9	0.757	0.845	11.6	0.547	0.597	9.1	0.665	0.718	8.0	10	10
Mafraq	0.738	0.768	4.1	0.708	0.784	10.7	0.543	0.565	4.1	0.663	0.706	6.5	11	11
Ma'an	0.709	0.730	3.0	0.703	0.789	12.2	0.553	0.573	3.6	0.655	0.697	6.4	12	12

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**

<b>Type of Employee</b>	<b>JOD</b>	<b>USD</b>
Unskilled	99-128	140-180

Semi-skilled	178-199	250-280
Skilled and Technical	284-426	400-600
Administrative	320-355	450-500
Middle Manager	426-568	600-800

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)**

	1995	2000	2005	2010	2015	Avg. Annual Growth Rate (%)		
						1995-2005	2005-2010	1010-2015
Agriculture, forestry and hunting	1.8	2.4	3.1	4.2	5.6	5.6	6.3	5.9
Mining and quarrying	0.3	0.3	1.6	7.1	7.8	18.2	34.7	1.9
Manufacturing	26.0	32.3	54.3	113	135.5	7.6	15.8	3.7
Electricity and water	2.3	6.2	8.3	14.4	25.0	13.7	11.6	11.7
Construction	6.7	32.0	82.2	207.5	394.1	28.5	20.3	13.7
Wholesale/retail trade	12.7	29.2	59.7	123.8	256.7	16.7	15.7	15.7
Hotels and restaurants	10.0	12.9	19.2	46.5	69.7	6.7	19.4	8.4
Transport, storage, communications	42.7	72.7	127.4	202.1	320.8	11.6	9.7	9.7
Finance and insurance	3.0	5.4	11.7	20.9	37.6	14.6	12.3	12.5
Real estate, renting, business activities	13.1	30.0	54.1	120.2	266.7	15.2	17.3	17.3
Public administration, defense, social security	16.5	21.4	24.0	46.3	79.7	3.8	14.0	11.5
Education (private)	0.7	1.0	1.3	1.7	2.2	6.4	5.5	5.3
Health and social services	0.8	1.2	2.0	2.8	3.8	9.6	7.0	6.3
Other community, social, and personal services	2.3	2.7	3.1	4.6	7.3	3.0	8.2	9.7
Private households with employees	0	0.1	0.1	0.1	0.2	--	0.0	14.9
Imputed bank charges	-1.2	-2.9	-6.3	-12.8	-22.5	18.0	15.2	11.9
Gross Regional Product (at basic prices)	137.8	246.6	445.7	902.6	1590.4	12.5	15.3	12.0
Net taxes on products	0	0	3.7	7.5	13.2	5.6	15.2	12.0
Gross Regional Product (at market prices)	137.8	246.6	449.4	910.1	1603.5	12.5	15.2	12.0

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.



Figure (3.2) Aerial Photograph Showing the Main Port Site.

Other facilities include 245,000 m<sup>2</sup> of open yard, 103,000 m<sup>2</sup> 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.



Figure (3.3) Aerial Photograph Showing the South Port Site.

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**

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

\*based on figures up to 20 June 2007

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

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

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

\*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**

<b>Year</b>	<b>2006</b>	<b>2007*</b>	<b>2010</b>	<b>2015</b>	<b>2020</b>	<b>2025</b>	<b>2030</b>	<b>2035</b>
<i>Ro-ro vehicle imports (1000 vehicles)</i>	108	93	115	154	201	241	279	312
<i>Ro-ro vehicle re-exports (1000 vehicles)</i>	6	5	6	7	10	12	16	20
<i>Logs and wood products import (1000 tonnes)</i>	216	214	282	394	489	576	610	640
<i>Iron and steel products import (1000 tonnes)</i>	99	189	226	284	336	371	410	452
<i>Rice in bags (1000 tonnes)</i>	58	88	73	73	55	32	27	27
<i>Sugar in bags (1000 tonnes)</i>	68	59	62	62	43	20	15	15
<i>Bagged animal feed (1000 tonnes)</i>	117	141	101	82	67	52	36	36
<i>Miscellaneous general cargo imports (1000 tonnes)</i>	34	101	55	59	60	61	63	64
<i>Miscellaneous general cargo exports (1000 tnes)</i>	76	73	80	86	88	89	91	93

\* 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**

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

**3.2.3.2.2 The Industrial Sector:**

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

#### ***3.2.3.2.2.1 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.

#### ***3.2.3.2.2.2 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.

- Solvochem.
- Arab Potash company

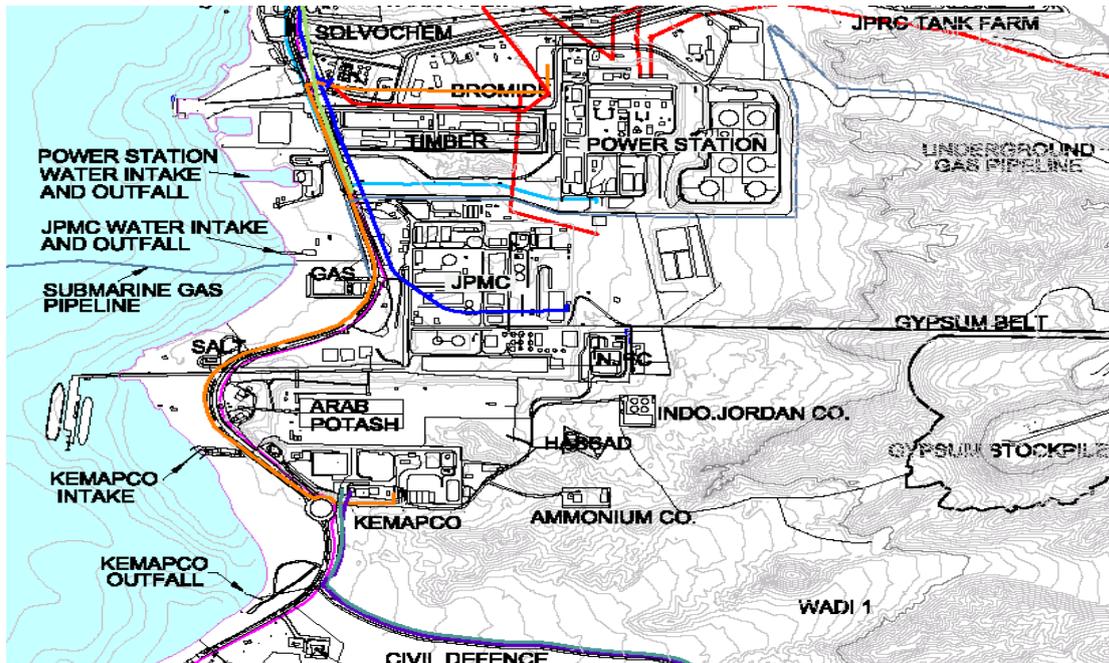


Figure (3.4) Southern Industrial Zone

### 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 -

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)**

Year	2003*	2006	2008	2010
Unit	'000 bed nights per year			
Corporate	88	100	168	260
Wholesale (groups)	244	320	490	720
Individual Leisure	44	60	182	420
Domestic	506	520	560	600
Total	882	1,000	1,400	2,000

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

- ❖ Improve chances of opportunities for accessing funding

### ***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**

<b>Stakeholders</b>	<b>Interests</b>	<b>Likely impact of the BAT/BEP implementation</b>	<b>Priority of interest</b>
ASEZA	-Safe environment	+	4
	- less PCB in the country	+	4
	-greater public awareness of BAT/BEP	+	3
Jordan Phosphate Mining Company/ Industrial Complex	Safe working environment,	+	2
	Improved product	+	2
	Cost	-	3
Environmental Non Governmental Organizations	-Safe environment - less PCB in	+	3

“NGOs”.	the country		
Industries near the source	-Safe environment - less PCB in the country	+	3
Tourism Sector and Local Hotel “nearby the source”.	-Safe environment - less PCB in the country	+	3

### 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.

Quadrant A	Quadrant B
Quadrant C	Quadrant D

**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:**

*HIGH IMPORTANCE/LOW INFLUENCE*

*HIGH IMPORTANCE/INFLUENCE*

Tourism sector and local hotels	ASEZA, JPMC
Industries near the source	NGOs

*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**

Type of participation Stage	Inform	Consult	Partnership	Control
Identification		ALL	ASEZA + JPMC	ASEZA
Planning	ALL		ASEZA + JPMC	
Implementation & Monitoring	ALL		ASEZA + JPMC	
Evaluation		ASEZA	ASEZA + JPMC	ASEZA + JPMC

**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 km<sup>2</sup> 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 km<sup>2</sup> 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 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.



Figure (3.5) 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:-

6	DAP	740,000 t/a
7	Phosphoric Acid	415,000 t/a
8	Aluminum Fluoride	20,000 t/a

9 Sulfuric Acid	1,200,000 t/a
10 Fluorosilicic Acid	25,000 t/a

#### ***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. 1<sup>st</sup> 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 2,700,000m<sup>2</sup>.

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 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.

#### ***3.3.4.4.3 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 (3.15) Questionnaire Content**

Do you Know anything about Stockholm Convention?
Do you know What POPs are?
Do you know what UP-POPs are?
Do you have any information about Annex C POPs?
Do you know what the facilities in Aqaba that release POPs are?
Do POPs have any health or environmental impacts at the workers at site?
Do you know what are the safety measures to protect the workers at site that release POPs?
Do we have any existing national regulations and rules concerning the POPs?
Is there a need to have more regulation for POPs?

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:**

<b>Question</b>	<b>No of the “Yes answers “</b>	<b>No of the “ No answers “</b>	<b>No of the “ don’t know answers”</b>
Do you Know anything about Stockholm Convention?	<b>10</b>	<b>5</b>	-
Do you know What are POPs?	<b>8</b>	<b>7</b>	

Do you know what are UP-POPs?	<b>4</b>	<b>11</b>	
Do you have any information about Annex C POPs?	<b>6</b>	<b>9</b>	
Do you know what are the facilities in Aqaba that release POPs?	<b>6</b>	<b>9</b>	
Do POPs have any health or environmental impacts at the workers at site?	<b>7</b>	<b>4</b>	<b>4</b>
Do you know what are the safety measures to protect the workers at site that release POPs?	<b>5</b>	<b>10</b>	
Do we have any existing national regulations and rules concerning the POPs?	<b>4</b>	<b>9</b>	<b>2</b>

Is there a need to have more regulation for POPs?	<b>4</b>	<b>8</b>	<b>3</b>
Are there any standards for the releases of pops in the Jordanian standards?	<b>4</b>	<b>6</b>	<b>5</b>
Do you think that your organization has a role in reducing the release of POPs?	<b>3</b>	<b>11</b>	<b>1</b>
Do you have any idea about What are the ways and possible measures to reduce the release of POPs?	<b>4</b>	<b>11</b>	
Do you know What is the meaning of BAT/BEP?	<b>6</b>	<b>9</b>	
How do you think that BAT/BEP will	<b>4</b>	<b>8</b>	<b>3</b>

reduce the releases of POPs?			
---------------------------------	--	--	--

### ***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 and accordingly 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.

$$DALYS_{site} = \frac{DALYrate_{country} \times Population_{site}}{\quad}$$

100000

Where:

- $DALYS_{site}$  are the number of site specific DALYs calculated
- $DALYrate_{country}$  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 :

$$DALY_{rate\ Jordan} = 15819$$

$$Population_{site} = 1000$$

$$\text{Then } DALYS_{AIC} = 15819 * 1000 / 100000$$

$$DALYS_{AIC} = 158.19$$

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<sup>3</sup> (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

[http://www.alibaba.com/product-gs/385604198/mineral\\_wool.html](http://www.alibaba.com/product-gs/385604198/mineral_wool.html)

[http://www.alibaba.com/product-gs/386232495/Calcium\\_silicate\\_board\\_low\\_price.html](http://www.alibaba.com/product-gs/386232495/Calcium_silicate_board_low_price.html)

#### 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 (CO<sub>2</sub>), particulates and sulfur (SO<sub>2</sub>) 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)

$1,000,000 \text{ BTUs (gas)} / 140,000 \text{ BTUs (oil)} = 7.14 \text{ Gallons per Million BTUs.}$

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:

$1,000,000 / 155,000 = 6.4$  gallons  $\times$  \$2.00 = \$12.90 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.

## ***References***

1. Methodical Manual on revealing and a quantitative estimation of dioxins and furans emissions. Subprogram of UNEP on chemicals. Edition 2 - February 2005.
2. <http://www.nsp.su/factories/66/>
3. [http://www.mbrk.ru/index/news3/2006/08/10/news3\\_1055.html](http://www.mbrk.ru/index/news3/2006/08/10/news3_1055.html)
4. Chemical encyclopedia. T. 5. M.: BRE. 1998. S. 339.
5. Chemical encyclopedia. T. 5. M.: BRE. 1998. S. 336-337.
6. Revised draft Guidelines on best available techniques and provisional guidance on best environmental practices relevant to Article 5 and Annex C of the Stockholm convention on persistent organic pollutants, December 2 2006
7. Methodical Guidelines on Identification and Quantity Assessment of Dioxin and Furan Releases. UNEP Chemicals, January, 2001 (English), December, 2001 (Russian). M. CIP. Page 204.
8. Environmental report 2005. Syktyvkar Wood Complex.
9. Technical report on the Activity 7 "Selection/Development of environmental technologies for disposal of PCB-containing liquids" CIP. M. 2002.
10. <http://www.mondibp.ru/news/release/2007/36060fcd-3ef0-4741-2c6b-6aa4e4daefce/>
11. The report «The calculated and experimental estimation of dioxins and furans emission from the basic sources in the Arkhangelsk, Murmansk regions and the Republic of Komi ". Moscow. 2004
12. The report by agreement № 7 from 27.10.2006 «Study of dioxin incomes from the picked industrial sources of the Arkhangelsk region and the Republic of Komi ". Institute of biological and chemical safety. Moscow. 2007.
13. Methodical Guidelines on identification and quantitative assessment of dioxins and furans. United Nations Environmental Programme. 2001.
14. Methodic of implementation of measurements of mass concentration of polychlorinated dibenzo-para-dioxins and dibenzofurans in samples of gas releases into atmosphere per method of chromatography-mass spectrometry of END F 13.3.10-91. Register of methods of MNR.
15. EN 1948-1, European standard on sampling of kiln gases for measurement of PCDD/PCDF content

16. Karstensen K.H. 2006a. Cement Production in Vertical Shaft Kilns in China: Status and Opportunities for Improvement. Report to the United Nations Industrial Development Organization, 31 January 2006.
17. Karstensen K.H. 2006b. Formation and Release of POPs in the Cement Industry. Second edition, January 2006. World Business Council for Sustainable Development/SINTEF
18. UNEP (United Nations Environment Programme) (1999), 'Dioxin and Furan Inventories, National and Regional Emissions of PCDD/F' UNEP Chemicals, Geneva, Switzerland.
19. UNEP (United Nations Environment Programme) (2003), 'Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases', UNEP Chemicals, Geneva, Switzerland.
20. UNEP (United Nations Environment Programme) (2005), 'Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases', UNEP Chemicals, Geneva, Switzerland
21. USEPA (United States Environment Protection Agency), (1995b), 'Locating and Estimating Air Emissions from Sources of Dioxins and Furans', Office of Air Quality Planning and Standards, Research Triangle Park, NC.
22. National Programme of Action for the Protection of the Marine Environment from Land-Based Activities (2008), Aqaba special Economic Zone Authority (ASEZA), Jordan.
23. National Implementation Plan (NIP) for Stockholm Convention on Persistent Organic Pollutants (POPs), First Edition, (2006), Ministry of Environment, Jordan.
24. Implementation of the Stockholm Convention National Implementation Plan Strategies to Reduce Unintentional Production of POPs in the Coastal Zone of the Red Sea in Egypt, (2006), Ministry of State for Environmental Affairs, Egypt.
25. An Inventory of Sources and Environmental Releases of Dioxin-Like Compounds in the United States for the Years 1987, 1995, and 2000, National Center for Environmental Assessment Office of Research and Development U.S. Environmental Protection Agency Washington, DC 20460
26. New Zealand inventory of dioxin emissions to air, land and water, and reservoir sources Organochlorines Programme, Ministry for the Environment, March 2000
27. INVENTORIES OF DIOXINS AND OTHER BY-PRODUCT POPs – THE MYTHS AND REALITIES, Persistent Organic Pollutants and Waste and Chemicals Policy Brandys nad labem, Czech Republic, May 2004
28. Environmental RTDI Programme 2000–2006, Inventory of Dioxin and Furan Emissions to Air, Land and Water in Ireland for 2000 and 2010, (2000–DS–2–M1), ENVIRONMENTAL PROTECTION AGENCY, An Ghníomhaireacht um Chaomhnú Comhshaoil
29. F. Kanbour. 'Design and Specification of Ambient Air Monitoring System'. Aqaba Assistance Support Project (ATASP), 2003.
30. ERC, RSS. 'Monitoring Ambient Air Quality in Jordan (Aqaba, Fuheis and Al-Qadisia)', 2002.
31. United States Government. Code of Federal Regulation (CFR), Title 40, Part 58, Appendix D. 'Network Design for SLAMS, NAMS, and PAMS, 1997.

32. The Council of the European Union. Council Directive 96/62/EC on Ambient Air Quality and Management, 1996 and EU Daughter Directives (1999/30/EC, 2000/69/EC, 2002/3/EC).
33. ERC, RSS. 'Environmental Impact Assessment Study for Natural Gas Pipeline Project', 2004.
34. Benefits and Trade-Offs Between Energy Conservation and Releases of Unintentionally Produced Persistent Organic Pollutants. A STAP advisory document, The Scientific and Technical Advisory Panel, administered by UNEP, advises the Global Environment Facility.
35. Draft guidance on socio-economic assessment for national implementation plan development and implementation under the Stockholm Convention 1997 data from NHDRI, 2002 from DoS.
36. Aqaba Thermal Power Plant Website, <http://www.cegco.com.jo>.
37. Aqaba Tourism Marketing Strategy 2005-2010 ( IS- ASEZA 2004).
38. Arab Fertilizers and Chemical Industries Website, [www.kemapco.com](http://www.kemapco.com)
39. Arab Potash Company Website, <http://www.arabpotash.com>, Arrow et al , 1996
40. ASEZA National Tourism Strategy ,2004.
41. AZEM International Migration and Demographic Projection, Prepared by Kamal Saleh ( May 2007).
42. Department of Statistic web site, <http://www.dos.gov.jo>, Herkovits, 1998
43. [http://www.alibaba.com/product-gs/386232495/Calcium\\_silicate\\_board\\_low\\_price.html](http://www.alibaba.com/product-gs/386232495/Calcium_silicate_board_low_price.html)
44. [http://www.alibaba.com/product-gs/385604198/mineral\\_wool.html](http://www.alibaba.com/product-gs/385604198/mineral_wool.html)
45. JES Website, <http://www.facebook.com/JordanEnvironmentSociety>, JPMC Website, [www.jordanphosphate.com](http://www.jordanphosphate.com)
46. JREDS Website, [www.jreds.org](http://www.jreds.org)
47. JSSD Website, [www.jssd-jo.org](http://www.jssd-jo.org)
48. Nippon Jordan Fertilizers Company Website, [www.njfcjo.com/](http://www.njfcjo.com/) POPs UNEP Socioeconomic Toolkit.
49. Public Awareness and Communication Tools for effective Involvement of Community , Shihab Najib Al-Beirut .
50. RSCN Website, [www.rscn.org.jo](http://www.rscn.org.jo)
51. RSTI Website, [www.redseatimber.com](http://www.redseatimber.com)
52. Stockholm Convention.
- 53;. Strawson 1997, Strober,1998
54. Tala Bay Website, [www.talabay.jo](http://www.talabay.jo)
55. Trade and Traffic Forecast , ADC, July 2007.
56. WHO, 2008, <http://www.who.int>
57. World bank Poverty assessment Report, 2004.
58. World bank, 2009



# ANNEX 1

**1- 2009 stack measurements conducted by JPMC environment division.**

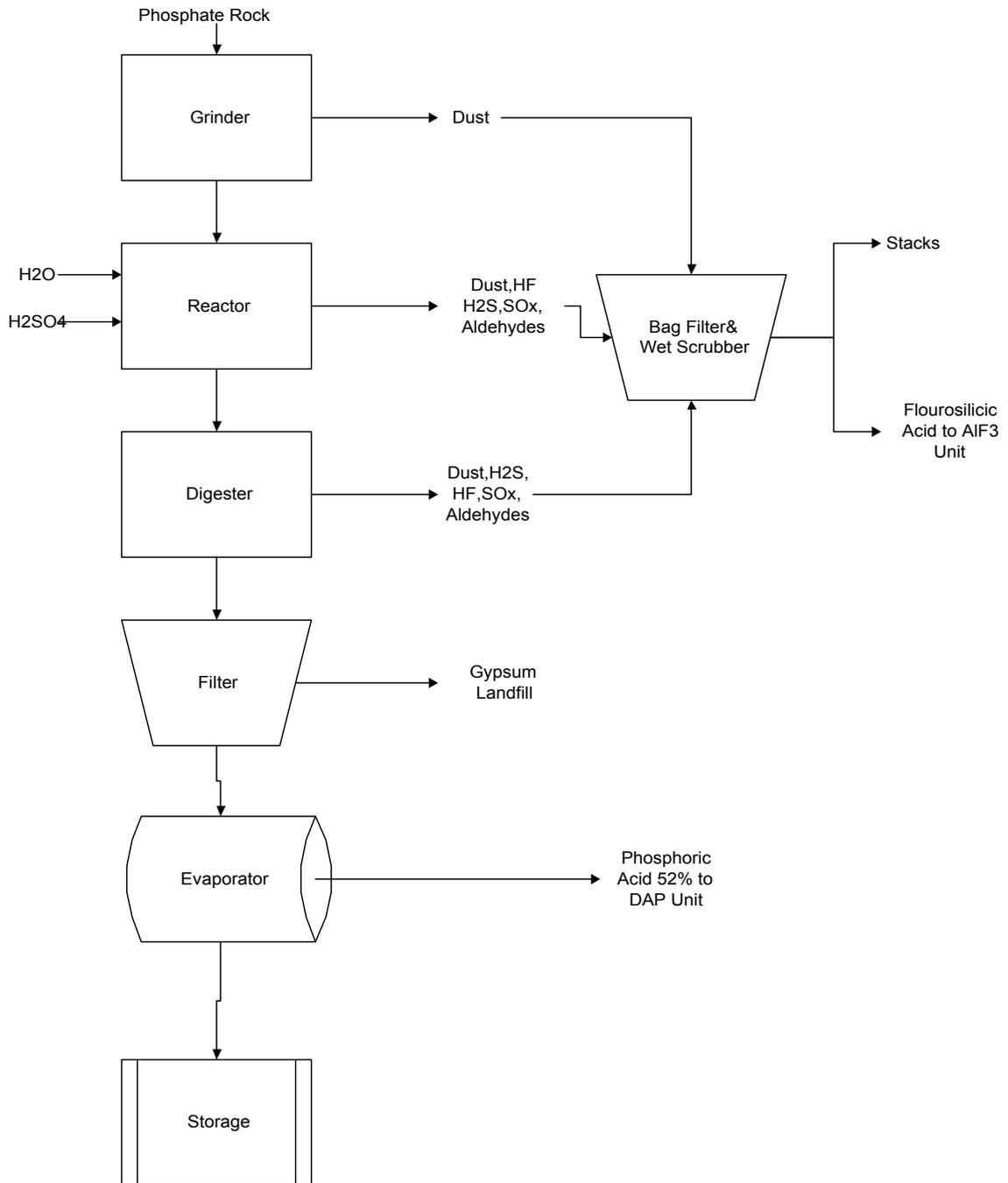
Unit	Pollutant	Jan	Feb	Mar	Apr	May	June	July	Aug.	Sept	Oct	Nov	Dec	JS
75	NH <sub>3</sub>	-	710	705	686	718	698	713	578	425	682	666	470	50
	F <sup>-</sup>	-	0.7	0.4	0.7	0.8	0.8	1.1	0.7	0.5	1	0.6	0.6	
	P <sub>2</sub> O <sub>5</sub>	-	1.4	2.1	1.2	1.6	1.8	2.3	1.6	1.6	1.1	1.6	1.4	
	NH <sub>3</sub>	-	725	715	696	713	711	715	618	632	550	712	530	50
	F <sup>-</sup>	-	0.8	0.6	0.6	1.2	0.9	1.3	0.8	0.4	0.8	0.6	0.6	
	P <sub>2</sub> O <sub>5</sub>	-	1.2	1.9	1.9	2.4	1.3	3.8	1.6	1.7	4	1.8	1.1	
	NH <sub>3</sub>	-	739	647	713	614	-	715	712	718	440	-	720	50
	F <sup>-</sup>	-	1.9	0.7	0.8	1.1	-	0.3	1	0.9	0.4	-	0.7	
	P <sub>2</sub> O <sub>5</sub>	-	3.9	1.4	2.1	3.3	-	2.5	2.4	1.6	1.8	-	1.6	
	NH <sub>3</sub>	-	-	668	2445	719	-	714	716	710	629	-	624	50
	F <sup>-</sup>	-	-	2.1	0.9	0.5	-	0.4	0.6	0.9	0.9	-	0.8	
	P <sub>2</sub> O <sub>5</sub>	-	-	1	1.8	2.2	-	1.6	1.6	1.8	1.8	-	1.4	
	NH <sub>3</sub>	-	-	-	2360	663	-	724	718	-	707	-	-	50
	F <sup>-</sup>	-	-	-	1.1	0.3	-	0.8	0.9	-	0.7	-	-	
	P <sub>2</sub> O <sub>5</sub>	-	-	-	2.3	1.9	-	2.9	1.8	-	1.4	-	-	
76	NH <sub>3</sub>	-	-	844	549	715	718	667	705	718	706	638	690	50
	F <sup>-</sup>	-	-	0.8	0.9	0.6	0.4	0.9	1.4	0.8	0.7	0.9	0.9	
	P <sub>2</sub> O <sub>5</sub>	-	-	1.9	1.6	0.8	2.4	2.6	3	1.8	2.4	1.7	2.1	
	NH <sub>3</sub>	-	-	825	826	718	702	720	717	717	716	657	680	50
	F <sup>-</sup>	-	-	0.8	1.2	0.8	0.8	0.4	0.7	0.7	1.3	0.7	0.8	
	P <sub>2</sub> O <sub>5</sub>	-	-	1.7	3.1	2.5	2.1	1.8	1.4	1.4	1.2	1.4	1.8	
	NH <sub>3</sub>	-	-	818	818	638	714	712	712	724	703	697	690	50
	F <sup>-</sup>	-	-	0.6	0.9	1.6	0.4	0.5	0.5	0.4	0.3	0.9	0.9	
	P <sub>2</sub> O <sub>5</sub>	-	-	2.2	2.7	4.8	1.8	2.6	2.6	1.8	1.6	1	2	
	NH <sub>3</sub>	-	-	-	739	630	713	719	721	-	-	715	640	50
	F <sup>-</sup>	-	-	-	0.6	1.4	0.9	0.9	0.9	-	-	0.4	1	
	P <sub>2</sub> O <sub>5</sub>	-	-	-	1.4	3.7	2.3	1.3	1.8	-	-	1.8	1.8	
	NH <sub>3</sub>	-	-	-	1222	704	-	-	-	-	-	-	-	50
	F <sup>-</sup>	-	-	-	1.5	0.8	-	-	-	-	-	-	-	
	P <sub>2</sub> O <sub>5</sub>	-	-	-	3.4	2.4	-	-	-	-	-	-	-	
NH <sub>3</sub>	-	-	-	698	-	-	-	-	-	-	-	-	50	
F <sup>-</sup>	-	-	-	0.8	-	-	-	-	-	-	-	-		
P <sub>2</sub> O <sub>5</sub>	-	-	-	1.6	-	-	-	-	-	-	-	-		
AlF <sub>3</sub>	F <sup>-</sup>	-	-	-	4.1	3.6	3.5	3.1	3.2	3.1	3.2	2.5	2.4	15
		-	-	-	-	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	-	-	-	-	
PA	F <sup>-</sup>	-	-	-	-	-	-	2.9	2.3	2.9	3.1	3.1	2.9	
		-	-	-	-	-	-	3	2.1	2.6	-	2.9	2.5	
		-	-	-	-	-	-	1.6	1.80	-	-	-	2.9	
		-	-	-	-	-	-	2.1	-	-	-	-	-	
53	SO <sub>3</sub> + acid mist	-	-	-	-	29	21	18	28	15	30	55	65	JS 1189/2006 150
		-	-	-	-	27	26	28	19	49	32	51	-	
		-	-	-	-	23	19	38	21	21	-	28	-	
		-	-	-	-	-	32	32	30	-	-	-	-	
54	SO <sub>3</sub> + 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.**

Unit	Pollutant	Jan	Feb	Mar	Apr	May	June	July	Aug.	Sept	Oct	Nov	Dec	JS	
75	NH <sub>3</sub>	690	715	706	590	642	976	724	737	722	716	685	-	50	
	F <sup>-</sup>	2.1	0.4	0.2	1.2	1.1	1.4	0.4	0.35	0.8	0.7	0.4	-		
	P <sub>2</sub> O <sub>5</sub>	2.5	0.9	0.8	1.9	0.8	1.7	1.8	1.8	0.9	0.9	0.8	-		
	NH <sub>3</sub>	658	698	688	787	718	718	748	678	716	733	702	-	50	
	F <sup>-</sup>	0.8	0.6	0.4	1.2	0.8	0.8	0.8	0.7	0.6	0.9	0.7	-		
	P <sub>2</sub> O <sub>5</sub>	1.9	1.8	1.4	1.1	1.6	1.2	1.1	1.3	1.2	1.2	1.1	-		
	NH <sub>3</sub>	718	662	-	-	728	659	-	719	738	767	-	-	50	
	F <sup>-</sup>	0.8	0.6	-	-	0.4	0.5	-	0.9	0.9	0.8	-	-		
	P <sub>2</sub> O <sub>5</sub>	1.3	1.2	-	-	1	0.9	-	0.6	1.3	1.1	-	-		
	NH <sub>3</sub>	721	-	-	-	-	-	-	806	719	657	-	-	50	
	F <sup>-</sup>	2.0	--	-	-	-	-	-	1.1	0.7	0.7	-	-		
	P <sub>2</sub> O <sub>5</sub>	3.1	-	-	-	-	-	-	0.9	1.1	1.4	-	-		
	NH <sub>3</sub>	-	-	-	-	-	-	-	748	-	-	-	-	50	
	F <sup>-</sup>	-	-	-	-	-	-	-	0.9	-	-	-	-		
P <sub>2</sub> O <sub>5</sub>	-	-	-	-	-	-	-	1.0	-	-	-	-			
76	NH <sub>3</sub>	719	718	704	715	1046	733	721	805	728	736	745	689	50	
	F <sup>-</sup>	1.8	0.6	0.5	1.3	0.6	0.3	0.2	0.5	0.9	0.8	0.9	1.1		
	P <sub>2</sub> O <sub>5</sub>	1.5	1.1	1.2	1.4	1.8	1.5	0.9	1.2	1.1	1.4	1.6	1.3		
	NH <sub>3</sub>	811	721	721	798	796	720	740	717	719	750	852	598	50	
	F <sup>-</sup>	1.8	1.2	1.2	0.8	1.3	0.2	0.4	0.8	0.9	0.9	0.7	0.7		
	P <sub>2</sub> O <sub>5</sub>	2.6	1.6	1.6	1.6	0.8	1	0.9	0.6	1.3	1.2	1.8	0.9		
	NH <sub>3</sub>	-	719	-	-	806	-	751	765	742	738	721	360	50	
	F <sup>-</sup>	-	1.8	-	-	1.1	-	0.8	0.5	0.2	1.6	0.8	0.6		
	P <sub>2</sub> O <sub>5</sub>	-	0.7	-	-	1	-	0.9	0.9	0.8	2.1	1.1	0.9		
	NH <sub>3</sub>	-	720	--	-	747	-	748	751	729	727	844	-	50	
	F <sup>-</sup>	-	0.6	-	-	1.6	-	0.8	0.8	0.9	0.6	1	-		
	P <sub>2</sub> O <sub>5</sub>	-	1.5	-	-	0.7	-	0.4	0.9	0.6	0.9	1.4	-		
	NH <sub>3</sub>	-	-	-	-	766	-	-	760	-	-	-	-	50	
	F <sup>-</sup>	-	-	-	-	3.7	-	-	0.6	-	-	-	-		
P <sub>2</sub> O <sub>5</sub>	-	-	-	-	2.8	-	-	1.1	-	-	-	-			
AlF <sub>3</sub>	F <sup>-</sup>	2.6	2.6	1.7	-	1	0.6	0.8	2.1	0.4	1.1	0.8	1	JS 1189/2006	
		3.2	2.8	-	-	-	0.9	0.9	0.8	0.2	1.6	1.1	0.8		
		3.1	2.4	-	-	-	0.8	0.5	0.7	-	-	-	-		
		-	-	-	-	-	-	-	0.8	0.7	-	-	-		-
		-	-	-	-	-	-	-	-	0.6	-	-	-		-
	3.2	2.9	1.8	-	0.8	0.9	0.9	0.3	0.5	0.9	0.7	0.9			



# Phosphoric Acid Unit





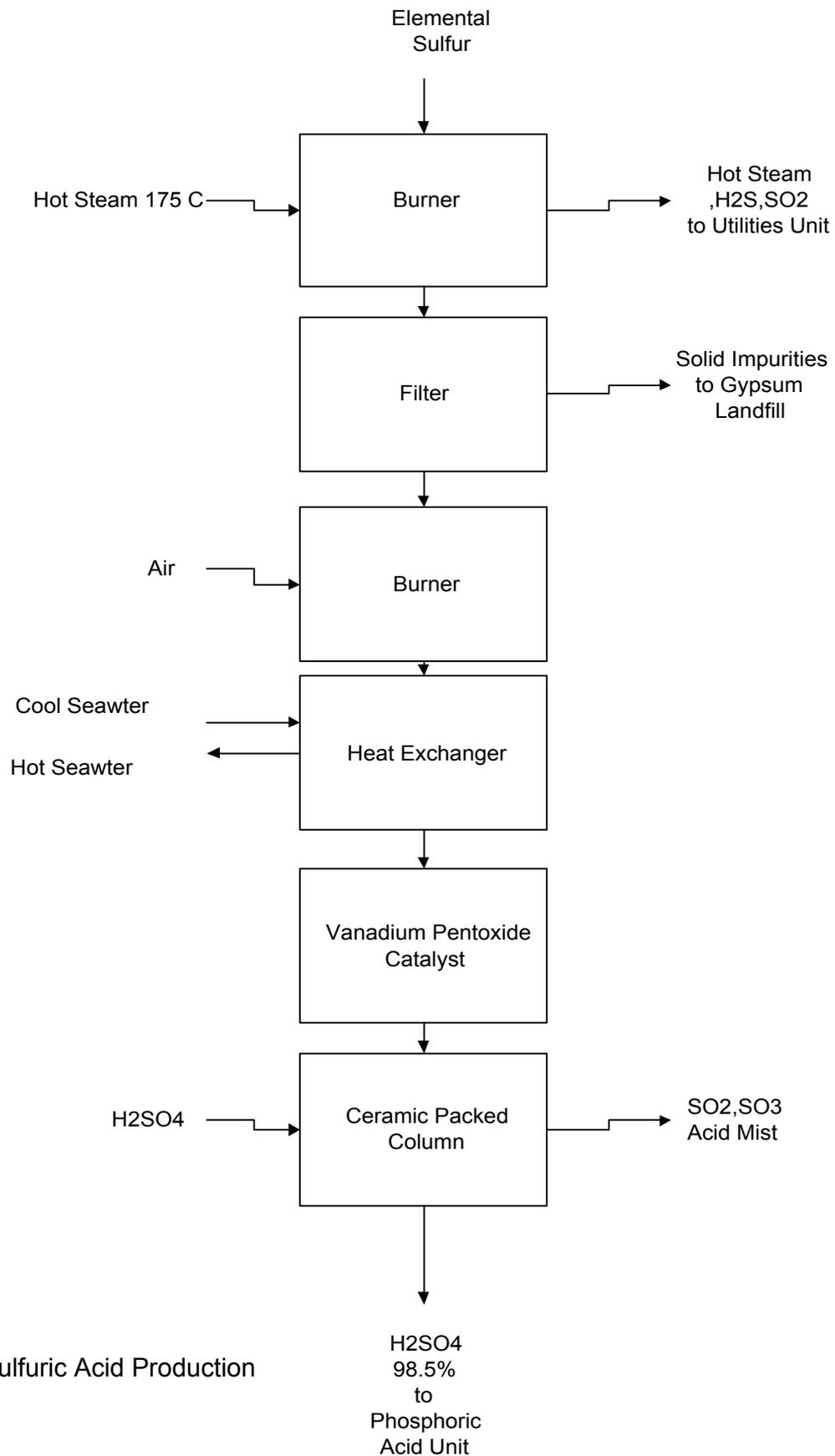


Fig.2 Sulfuric Acid Production

Fig 4. Aluminum Fluoride Production

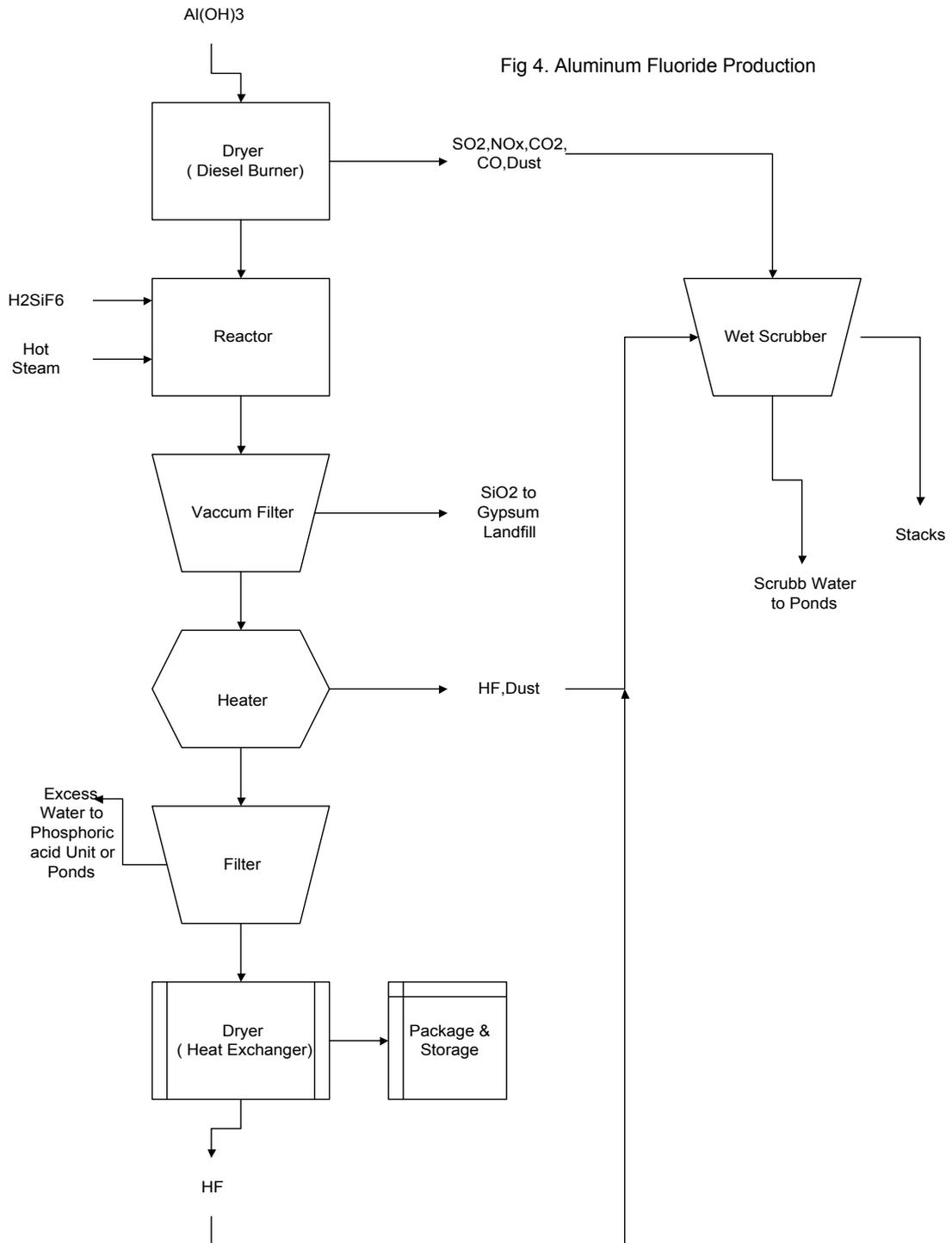
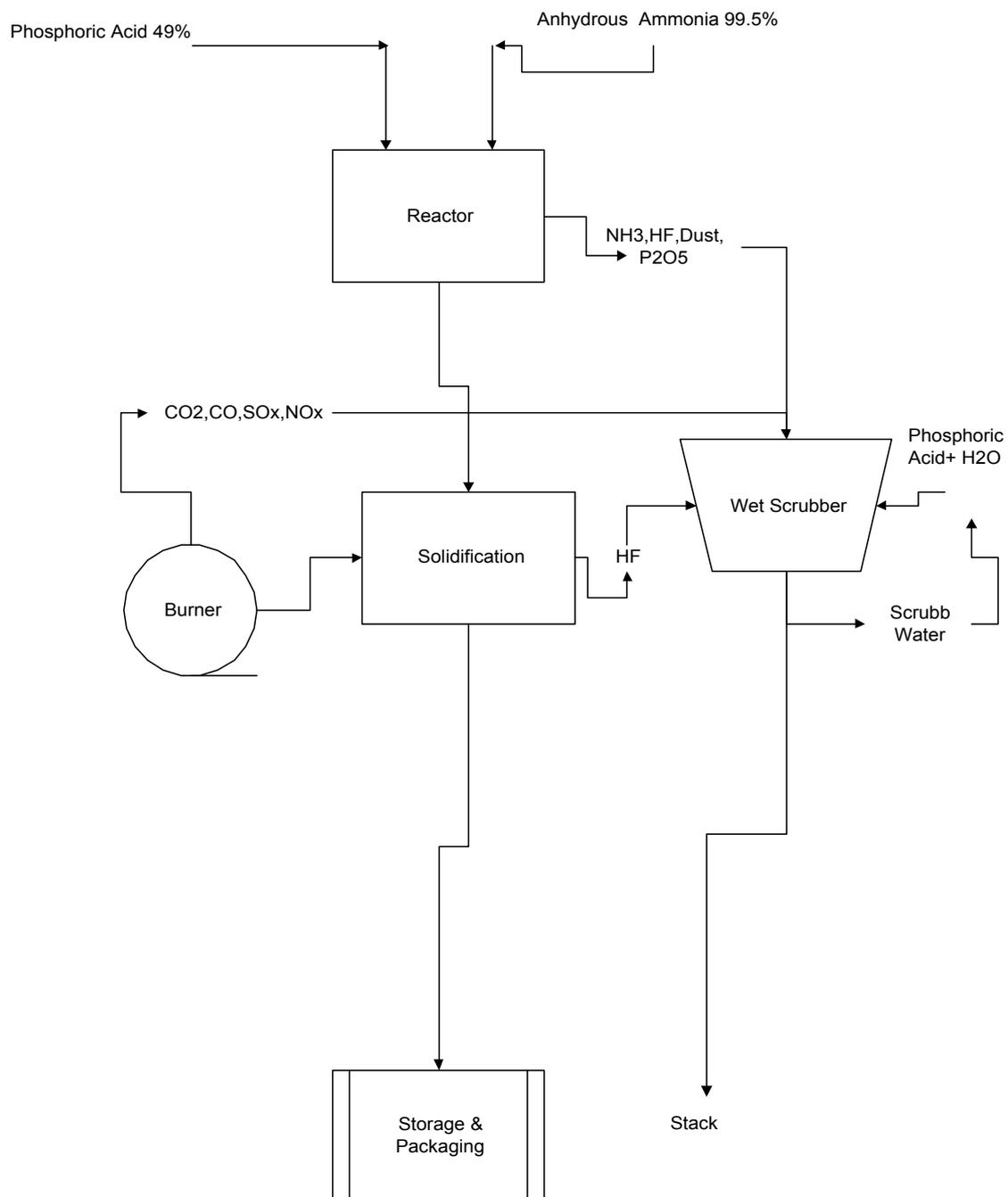


Fig.3 Di-Ammonium Phosphate Production



## 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 (1) Parameters Measured from JPMC stacks**

Source	Measured Parameter
Utilities boiler B	SO <sub>2</sub> , NO <sub>x</sub> , CO, CO <sub>2</sub> and O <sub>2</sub>
Sulfuric Acid unit 53 & 54	SO <sub>2</sub> , CO, CO <sub>2</sub> and O <sub>2</sub>
Phosphoric Acid	HF, NO <sub>x</sub> , CO, CO <sub>2</sub> and O <sub>2</sub>
Aluminum Fluoride	HF, NO <sub>x</sub> , CO and O <sub>2</sub>
DAP unit 75 & 76	NH <sub>3</sub>
Phosphate Grinder	Dust

## 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**

Measured Parameter	Principle of measurement
SO <sub>2</sub> , CO, CO <sub>2</sub>	<b>Non</b> -dispersive infrared (NDIR)
Nitrogen oxides (NO <sub>x</sub> )	Chemiluminescence
Oxygen (O <sub>2</sub> )	Paramagnetic
Ammonia (NH <sub>3</sub> )	UV Spectroscopy
Dust	Gravimetric Analysis based on Iso-kinetic Sampling

### 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<sub>2</sub>, NO<sub>x</sub>, 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

Date	Time	NO <sub>x</sub> (mg/Nm <sup>3</sup> )	SO <sub>2</sub> (mg/Nm <sup>3</sup> )	CO (mg/Nm <sup>3</sup> )	CO <sub>2</sub> (%)	O <sub>2</sub> (%)
5/26/2010	14:28	451	3280	31	12.02	4.40
5/26/2010	14:29	451	3270	32	12.05	4.34
5/26/2010	14:30	453	3265	34	12.06	4.32
5/26/2010	14:31	457	3275	31	12.05	4.37
5/26/2010	14:32	457	3275	29	12.04	4.37
5/26/2010	14:33	457	3275	31	12.02	4.32
5/26/2010	14:34	456	3275	32	12.05	4.37
5/26/2010	14:35	458	3270	34	12.06	4.37

5/26/2010	14:36	457	3275	31	12.05	4.40
5/26/2010	14:37	453	3277	29	12.04	4.34

Jordanian Standards (JS 1189\2006)

SO<sub>2</sub>: 6500 mg/Nm<sup>3</sup> (Fuel Derivatives combustion)

NO<sub>x</sub>: 200 mg/Nm<sup>3</sup> (Combustion temperature <1200 °c);

: 1500 mg/Nm<sup>3</sup> (Combustion temperature >1200 °c)

Table ( 4a ): Gaseous emissions from sulfuric acid unit 53 at JPMC conducted by Ben Hayyan-Aqaba International Laboratories on 27/5/2010

Date	Time	SO <sub>2</sub> (mg/Nm <sup>3</sup> )	CO (mg/Nm <sup>3</sup> )	O <sub>2</sub> (%)
5/27/2010	11:26	2391	2.00	6.03
5/27/2010	11:27	2346	1.90	4.63
5/27/2010	11:28	2340	1.94	4.55
5/27/2010	11:29	2329	1.94	4.58
5/27/2010	11:30	2305	1.92	4.62
5/27/2010	11:31	2277	1.93	4.64
5/27/2010	11:32	2104	1.94	4.60
5/27/2010	11:33	2062	1.93	4.59
5/27/2010	11:34	2745	1.95	4.58
5/27/2010	11:35	2285	1.94	4.58

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

Date	Time	SO <sub>2</sub> (mg/Nm <sup>3</sup> )	CO (mg/Nm <sup>3</sup> )	O <sub>2</sub> (%)
5/27/2010	13:24	2752	1.65	6.62
5/27/2010	13:25	2675	1.64	4.22
5/27/2010	13:26	5072	2.22	4.27

5/27/2010	13:27	6323	2.23	4.09
5/27/2010	13:28	6728	2.30	4.09
5/27/2010	13:29	6810	2.35	4.10
5/27/2010	13:30	5124	2.25	4.11
5/27/2010	13:31	5879	2.35	4.10
5/27/2010	13:32	6254	2.33	4.08
5/27/2010	13:33	5847	2.30	4.05

Jordanian Standards (JS 1189\2006)

SO<sub>2</sub>: 1500 mg/Nm<sup>3</sup> (Sulfuric acid industries)

Table ( 5 ): Gaseous emissions from Phosphoric Acid at JPMC conducted by Ben Hayyan-Aqaba International Laboratories on 31/5/2010

Date	Time	HF (mg/Nm <sup>3</sup> )	NO <sub>x</sub> (mg/Nm <sup>3</sup> )	CO (mg/Nm <sup>3</sup> )	CO <sub>2</sub> (%)	O <sub>2</sub> (%)
5/31/2010	11:10	0.39	0.39	6.87	0.02	19.08
5/31/2010	11:11	0.46	0.33	8.59	0.03	19.08
5/31/2010	11:12	0.60	0.30	10.34	0.03	19.08
5/31/2010	11:13	0.73	0.31	11.95	0.04	19.08
5/31/2010	11:14	0.89	0.42	13.93	0.04	19.07
5/31/2010	11:15	1.01	1.72	15.45	0.05	19.06
5/31/2010	11:16	1.11	4.67	16.53	0.05	19.05
5/31/2010	11:17	1.22	10.52	24.70	0.05	19.07
5/31/2010	11:18	1.54	8.68	27.30	0.04	19.07
5/31/2010	11:19	1.86	7.62	22.39	0.04	19.06

Jordanian Standards (JS 1189\2006)

HF: 15 mg/Nm<sup>3</sup>

Table ( 6 ): Gaseous emissions from Aluminum fluoride at JPMC conducted By Ben Hayyan-Aqaba International Laboratories on 31/5/2010

<b>Date</b>	<b>Time</b>	<b>SO<sub>2</sub> (mg/Nm<sup>3</sup>)</b>	<b>CO (mg/Nm<sup>3</sup>)</b>	<b>HF (mg/Nm<sup>3</sup>)</b>	<b>O<sub>2</sub> (%)</b>
5/31/2010	12:20	39	127	1.86	18.76
5/31/2010	12:21	135	228	2.56	18.36
5/31/2010	12:22	230	253	2.81	17.66
5/31/2010	12:23	272	257	3.64	17.6
5/31/2010	12:24	298	262	4.50	17.59
5/31/2010	12:25	322	257	5.36	17.62
5/31/2010	12:26	327	278	6.02	17.6
5/31/2010	12:27	346	288	6.75	17.51
5/31/2010	12:28	379	298	7.61	17.51
5/31/2010	12:29	398	304	8.31	17.5

Jordanian Standards (JS 1189\2006)

HF: 15 mg/Nm<sup>3</sup>

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

<b>Date</b>	<b>Time</b>	<b>NH<sub>3</sub> (mg/Nm<sup>3</sup>)</b>
6/6/2010	13:00	142
6/6/2010	13:01	145
6/6/2010	13:02	146
6/6/2010	13:03	144
6/6/2010	13:04	140
6/6/2010	13:05	138
6/6/2010	13:06	143
6/6/2010	13:07	142
6/6/2010	13:08	144

6/6/2010	13:09	142
----------	-------	-----

Table ( 7b ): Ammonia emissions from DAP unit 76 at JPMC conducted By Ben Hayyan-Aqaba International Laboratories on 6/6/2010

Date	Time	NH <sub>3</sub> (mg/Nm <sup>3</sup> )
6/6/2010	12:05	70
6/6/2010	12:06	75
6/6/2010	12:07	79
6/6/2010	12:08	66
6/6/2010	12:09	68
6/6/2010	12:10	62
6/6/2010	12:11	78
6/6/2010	12:12	80
6/6/2010	12:13	79
6/6/2010	12:14	75

Jordanian Standards (JS 1189\2006)

NH<sub>3</sub>: 50 mg/Nm<sup>3</sup>

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

Stack ID	Sampling Date	Sampling Period	Dust Concentration (mg/Nm <sup>3</sup> )
phosphate grinder	9/6/2010	12:40 - 13:00	7

Jordanian Standards (JS 1189\2006)

Dust: 50 mg/Nm<sup>3</sup> (Phosphate industries)



# ANNEX 2



شركة مناجم الفوسفات الأردنية المساهمة المحدودة  
المجمع الصناعي

# Occupational Health & Safety Manual

Reviewed by : .....	Approved by.....
Authorized by : .....	Date : / 06 /2009

Copy No .

AQABA - JORDAN  
P.O.Box 409  
Tel No : 00962 3 2090500  
Fax No : 00962 3 201 7008

**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

### **Copyright**

This manual is the exclusive property of **JPMC –Industrial Complex** and its contents must not be communicated to unauthorised persons, or persons outside the company without written consent from the **Industrial Complex Executive Manager**.

# Contents

	<u>Section</u>	<u>Title</u>	<u>Page</u>
		Contents	
1			
		Amendment record	3
		Distribution and Control	
4			
4.0		Introduction to <b>JPMC- Industrial Complex</b>	
	5		
4.1		General Requirements	
10			
4.2		OHS Policy	
	11		
4.3		Planning	
	13		
	4.3.1	Hazard Identification and Risk Assessment	13
	4.3.2	Legal and other Requirements	
14			
	4.3.3	Objectives and Targets	15
	4.3.4	OHS Management Program (s)	
15			
4.4		Implementation and Operation	
16			
	4.4.1	Structure and Responsibilities	
16			
	4.4.2	Training, Awareness and Competence	21
	4.4.3	Consultation and Communication	21
	4.4.4	OHS Documentation	
	21		

22	4.4.5	Document and Data Control	
22	4.4.6	Operational Control System	
	4.4.7	Emergency Preparedness and Response	
23			
4.5		Checking and Corrective Actions	
23			
	4.5.1	Monitoring and Measurements	
	4.5.2	Accidents, Incidents, Nonconformance and Corrective and Preventive Actions.	24
	4.5.3	Control of Records	
		24	
25	4.5.4	OHS Management Audit	
4.6		Management Review	
		26	
4.7		Documented OHS Reference	
27			

## **Amendment Record**

<b>2</b>	<b><u>Date</u></b>	<b><u>Page No.(s)</u></b>	<b><u>Doc.Change Request</u></b>
	20/3/2006	All	No.

**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.

### 3

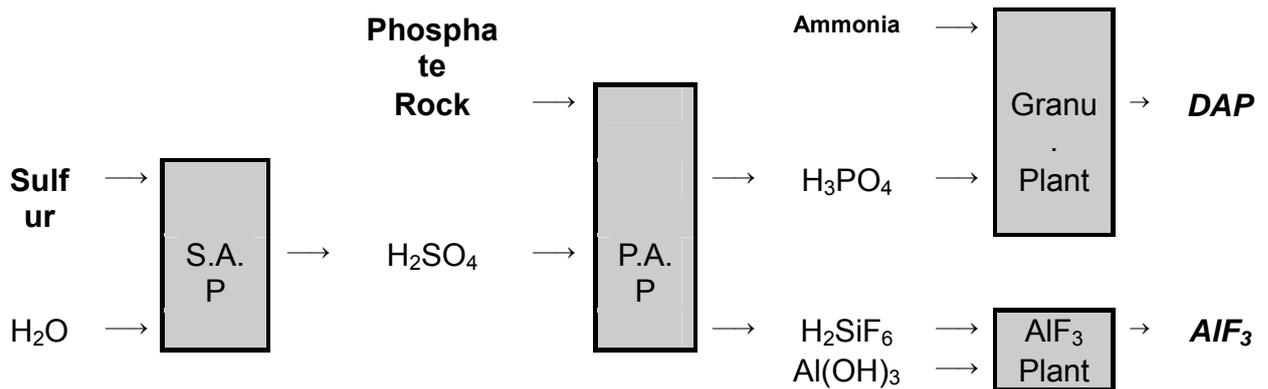
## JPMC- Industrial Complex

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.



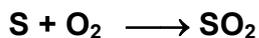
This complex consists of 4 production and one utilities plants. It uses 5 main raw materials to produce 2 final products ( see the next box):

JPMC- Industrial Complex	
4 Plants	Sulfuric Acid Plant Phosphoric Acid Plant Granulation Plant Aluminum Fluoride Plant
5 Raw Materials	Phosphate rock Sulfur Ammonia Aluminum Hydroxide Fluosilicic Acid
2 Final Products	Diammonium Phosphate Aluminum Fluoride

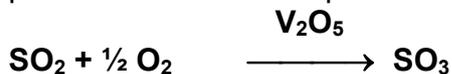
## 1) Sulfuric Acid Plant

It produces sulfuric acid (  $\text{H}_2\text{SO}_4$  ) 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 (  $\text{SO}_2$  ).

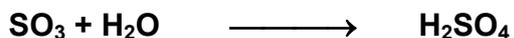


$\text{SO}_2$  is then converted in a special converter to sulfur trioxide (  $\text{SO}_3$  ), in the presence of vanadium pentoxide (  $\text{V}_2\text{O}_5$  ).



$\text{SO}_3$  is then allowed to come in contact with water to produce  $\text{H}_2\text{SO}_4$ :

It passes first in an absorption tower where it allowed to come in contact with  $\text{H}_2\text{SO}_4$  98.5%, thus increasing its concentration. This concentrated acid is passed into a circulation tank where water is added to decrease its concentration to 98.5%. This 98.5% acid again is passed to the absorption tower to absorb  $\text{SO}_2$ , and this cycle is repeated continuously.



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

## 2) Phosphoric Acid Plant

It produces phosphoric acid (  $\text{H}_3\text{PO}_4$  ) 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:



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 :



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

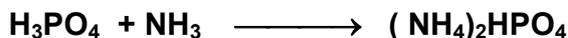
- Main Product                                      Phosphoric Acid
- Product Capacity                                1310 metric tons  $\text{P}_2\text{O}_5$ /day

### 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.



- 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  $\text{Al}(\text{OH})_3$  (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:



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 ( $\text{AlF}_3 \cdot 3\text{H}_2\text{O}$ ) precipitates. These crystals pass into calciners (driers) where anhydrous aluminum fluoride  $\text{AlF}_3$  is produced. The calcined product is cooled and conveyed to the storage silo for bagging.



- |                    |                    |
|--------------------|--------------------|
| - 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 demineralized 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 m<sup>3</sup>/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 fluosilicic 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.

Eng . Najib AL-Sheikh.

Industrial Complex Executive

Manager

### سياسة السلامة والصحة المهنية

تنتج شركة مناجم الفوسفات الأردنية/ المجمع الصناعي سماد فوسفات ثنائي الامونيا باستخدام حامض الكبريتيك وحامض الفوسفوريك المنتج في مصانعها . وتقوم أيضاً بإنتاج فلوريد الألمنيوم باستخدام حامض الفلوسيليسك 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 ، وبناء 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 أدناه والتدقيق عليها بشكل دوري لمراقبة أداء الشركة والتزامها بالتنوير والتحسين المستمر في مجال السلامة والصحة المهنية :-

- \* منع وقوع الإصابات بين العاملين وذلك بالتأكد على وجود ظروف عمل آمنة من خلال التقيد بنظام تصاريح العمل وتوفير وسائل السلامة والحماية اللازمة.
- \* منع التعرض للإصابة بالأمراض المهنية بين العاملين من خلال تحديد وتقييم المخاطر التي تؤدي إلى حصول الأمراض المهنية والتدرج في تطبيق إجراءات السيطرة اللازمة ابتداءً من التخلص من الأخطار وإنهاءً بإستخدام معدات السلامة كملاذ 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 إستعمال وسائل الحماية الشخصية وطرق مكافحة الحرائق.
- \* تطبيق إجراءات العمل المعتمدة في مجال التشغيل والصيانة وكافة النشاطات الأخرى حسب الأنظمة الموثقة في الشركة .

\* الالتزام بمتابعة المستجدات في موضوع السلامة والصحة المهنية بما يضمن تطوير النظام وتحسين الأداء

\* تلتزم الشركة بإطلاع المقاولين على سياسة السلامة والصحة المهنية المعتمدة في المجمع الصناعي بهدف التقيد بمضمونها.

ستقوم شركة مناجم الفوسفات الأردنية /المجمع الصناعي بتوزيع هذه السياسة والأهداف محلياً في الموقع بالإضافة إلى الجهات المعنية والمهتمة بها في حال طلب ذلك.

م. نجيب الشيخ  
المدير التنفيذي للمجمع الصناعي

## 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**

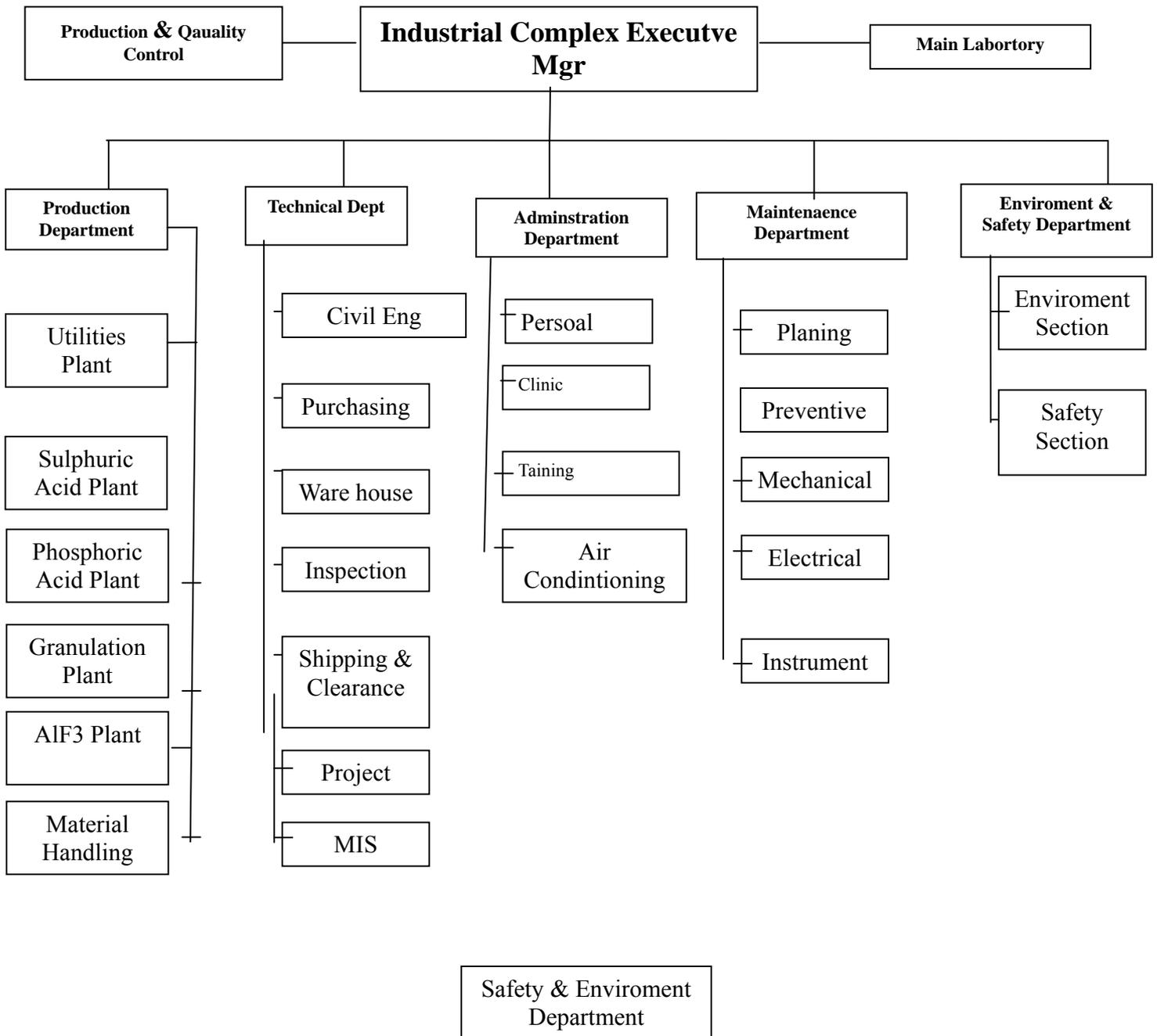
#### 4.4.1 Structure and Responsibility

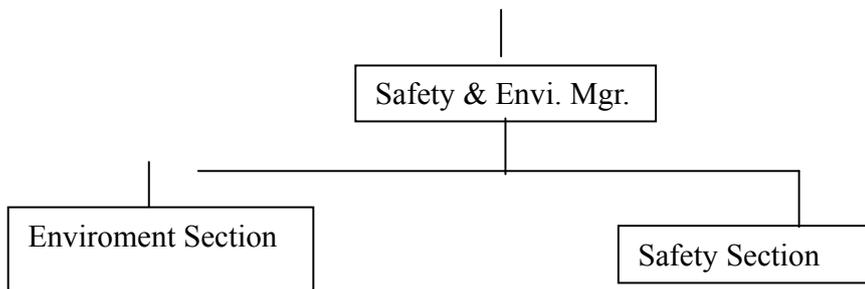
Reference Procedures :

SR-OHS\1400 Structure and Responsibility

#### 4.4.1a Industrial Complex Management Structure

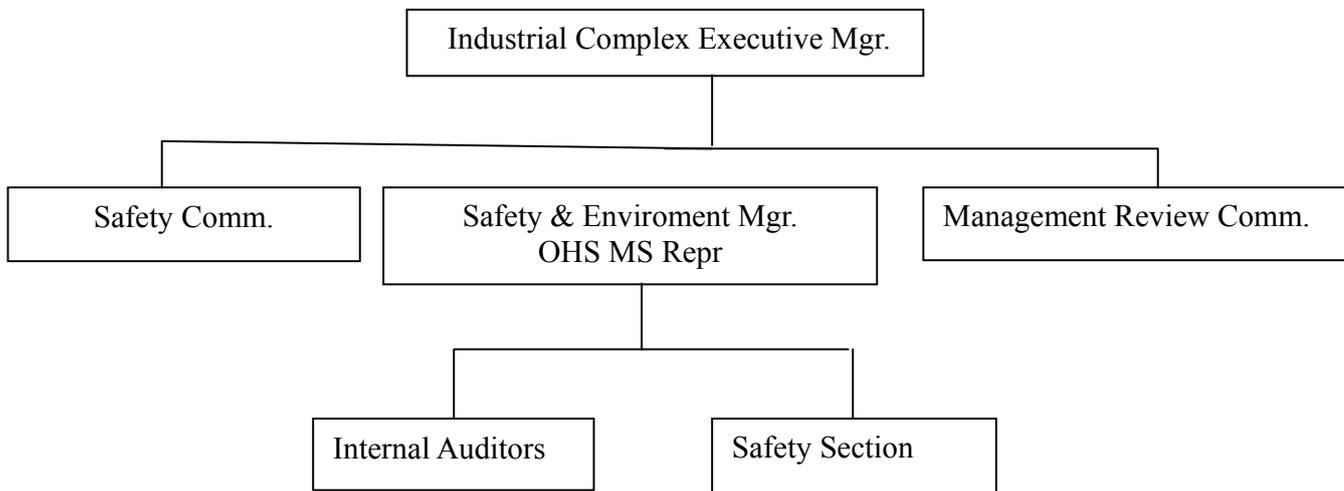
A chart of the industrial complex management structure is shown below.





#### 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 leader and authorized by the Industrial Complex Manager. The signatures 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**

### **Reference Procedure: EP-OHS & E /0800**

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.
- Drills 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. M
- 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 under take 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 committce 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 والانظمة والتعليمات الاردنية 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

<b>Annex (2-8)</b>	Emergency Plan for Maintenance Department
<b>Annex (2-9)</b>	Emergency plan for Ware House
<b>Annex 3</b>	Risk Assessment Rating for OHS hazards.
<b>Annex 4</b>	Materials Safety Data Sheets
<b>Annex 5</b>	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
6. نموذج طلب تغيير وثيقة DCR
7. نموذج تصريح عمل حار
8. نموذج تصريح عمل بارد
9. تصريح حفر
10. شهادة عزل 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 كيميائية
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 أجهزة التنفس
29. نموذج التفتيش على دوشات الطوارئ
30. نموذج تدريب العاملين على المخاطر التي تواجههم في المواقع
31. نموذج التفتيش على خزائن معدات الطوارئ
32. نموذج التفتيش على سيارات قسم السلامة
33. نموذج إجراء صحيحي
34. نموذج محضر اجتماع
35. نموذج سجل المراسلات الداخلية والخارجية
36. نموذج التفتيش على السقائل
37. الكشف الدوري على المطعم



# ANNEX 3

