28th
AFA Int’l. Fertilizer Technology
Conference & Exhibition
07 - 09 June 2015 Amman - Jordan

Program

ARAB FERTILIZER IMPRESSING
FUTURE SUSTAINABILITY
DAY 1: Sunday 7th June, 2015

08:00 -10:00   Registration
10:00 -11:00   Conference Inauguration
                Ishtar ballroom

Welcome addresses:
• Dr. Shafik ASHKAR
  CEO, JPMC
  AFA Jordan Fertilizer Industry Representative.
• Lord Bill Jordan
  CBE, President of the Royal Society for the
  Prevention of Accident (RoSPA), UK
• Eng. Mohamed Abdallah Zain
  AFA Secretary General.

11:00 -12:00   Exhibition Opening Jarasia hall
                Networking Coffee / Tea
                Jarasia hall

12:00 – 14:00   Session I

Chairperson: Yasser Abdulrahim
Plants Operation Manager
GPIC, Bahrain

1. How Rigorously Plant Modeling Can Advance your
Urea Business
   Luc Dieltjens
   Senior Urea Process Engineer
   Stamicarbon, The Netherlands
2. AFA Working Groups
   2.1. Energy Saving Working Group
       Yasser Abdulrahim
       AFA (ESWG) Chairman
       Energy Saving in Fertilizer Industries
       DNV
   
   2.2 Health, Safety and Environment Working Group
       Mohamed Masrori
       AFA (HSEWG) Chairman
   
   2.3 Communication and Public Affairs Working Group
       Mohamed Benzekri
       AFA (C&PAWG) Chairman

14:00   Networking Lunch   La Vista Restaurant

DAY 2: Monday 8th June, 2015

10:00 – 12:00   Session II

Chairperson: Ahmad AL MULLA
              Technical Services Manager
              PIC, Kuwait

1. Successful Ammonia Plant Revamping: A Model For Future Plants Modernization

Iacopo Cerea
Senior Process Engineer
CASALE SA, Switzerland
2. Enhancement of Urea Production Efficiency Via the Improvement of Existing Automatic Control Systems

**Kostikov Evgeniy**
Senior Software Engineer of Advanced Process Control Department
NIIK (R&D Institute of Urea, Russia)

3. Removal of Black Powder and Other Contaminants in Fertilizer Plants Gas Feeds

**Emmanuelle Biadi**
Fuels & Chemicals Business Development Manager
Pall, France

4. Successful Turnaround Planning and Execution by New TA Procedures, Standardization of TA Packages and Best Practices

**Mohammed Zia**
Turnaround and Central Maintenance department, SAFCO, Saudi Arabia

**12:00 - 12:30 Networking Coffee / Tea**
*Jarasia Hall*
12:30 - 14:00  Session III

Chairperson: Jamal AMIRA
Technical Director, APC, Jordan

1. GPIC’s Experience in Managing Turnarounds
   Bader Al Mansoori
   Planning Superintendent, GPIC, Bahrain

2. Case Studies on APC Energy Management
   Hussein Shorman
   Power Plant Superintendent, APC, Jordan

3. Oil Degradation in Rotating Equipment
   Alain Henrad
   Sales Manager, EFC NV, Belgium

4. Failure of Primary Shift Effluent W/H Exchanger (103-C) –
   A case study of High Temperature Hydrogen Attack
   Muhammad Nasir Abbas
   Inspection Engineer, Reliability & Inspection Department, AlBayroni, SABIC, Saudi Arabia

14:00  Networking Lunch  La Vista Restaurant

20:00  Gala Dinner  Ishtar ballroom
DAY 3: Tuesday 9th June, 2015

10:00 – 12:00  Session IV

Chairperson: Abdelhak Kababi
HSE Manager, OCP.SA, Morocco

1. Phosphogypsum Utilization in China & Economic Analysis
   Liu Bo
   Senior Project Manager, ECEC, China

2. CASALE: A New Force in The Nitrate And Phosphate Technology Business
   Jean François Granger
   CASALE SA, Switzerland

3. Safety Taskforce as a Tool to Improve Adhesion and Positive Behavior in the Gantour Mining Site.
   Salaheddine Knouzi
   Washing plant Manager, OCP.SA, Morocco

4. “HSE Best Practices: Case Studies» Ammonia Release to Atmosphere Due to Ammonia Pre-Heater Tube Rupture
   Yacoub Abdulla Al-Rayyis
   Head of Urea-6, QAFCO, Qatar

12:00 - 12:30  Networking Coffee / Tea
   Jarasia hall
12:30 - 14:00  Session V

Chairperson: Mohamed Masrori
HSE Manager, OMIFCO, Oman

1. Premium Catalyst and Technology Solutions Leading the Way Forward for the Fertilizer Industry
   Kristina Svennerberg
   Catalyst Marketing Manager
   Haldor Topsoe A/S, Denmark

2. Carbon Formation in Steam Reforming and Effect of K-promotion
   Mohammed Bendjana
   Malika Oukhedou
   Johnson Matthey, Bahrain

3. HSE Best Practices in APC
   Yousef Al Ma’aytah
   Safety Superintendent
   APC - Jordan

14:00  Networking Lunch
       La Vista Restaurant
28th
AFA Int’l. Fertilizer Technology
Conference & Exhibition
07 - 09 June 2015
Amman - Jordan

Session 1

ARAB FERTILIZER IMPRESSING
FUTURE SUSTAINABILITY
How rigorously plant modeling can advance your urea business
How Rigorously Plant Modeling Can Advance Your Urea Business

Luc Dieltjens
Stamicarbon
The Netherlands
How rigorously plant modeling can advance your urea business

Nitrogen + Syngas
Istanbul, February, 2015

Luc Dieltjens

What makes urea plant modeling challenging?

- Presence of an azeotropic ratio
- Feedstock in supercritical conditions
- Inflection points in mathematical functions
- Lots of publications available, but little data for validation
What is the Stamicarbon plant model?

- Rigorous thermodynamic static modeling of urea plant
- This includes the kinetics in the reactor
- Know-how is based on more than 60 years fundamental research + validation
- About 6000 variables are calculated, about 350 process streams
- Model calculation time, typically 2-5 seconds

Stamicarbon: a Full Life Cycle Philosophy

Create a new plant for sustainable and profitable urea production.
Optimize your plant for increased performance and product quality.
Upgrade your plant to increase capacity and to lower energy and emissions.
**A new service offered by Stamicarbon:**

- Process historical plant data (e.g. 1-2 months) through a plant model
- Evaluate performance by means of **KEY VARIABLES**
  - E.g. the urea yield in the reactor is set by:
    - N/C
    - H/C
    - System pressure (Total pressure – Inert pressure)
    - Retention time
  - Only N/C can be measured real time
- Operator uses **DERIVATIVE VARIABLES** to control the process, like temperature and pressure.
- **DERIVATIVE VARIABLES** are subject of interpretation; a high temperature in the reactor might mean high conversion, but could also mean high water content or low inert pressure

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**ADVANCE™ CONSULT**

Critical DCS plant data
Often derivatives

![Diagram](image)

- Compare critical model outputs with critical plant data
- Look to the essentials:
  - Overall mass balance
  - Overall energy balance
  - Urea production
- Difference comparison = f(errors measurements, errors models, simplifications, unknown plant streams, non ideal behavior)

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How rigorously plant modeling can advance your urea business

Validation reactor outlet temperature:

- Sensor deviations
- Dynamic stability (plant oscillations)
- Operation towards KEY VARIABLES
- Constraints
- Proposed actions for improvements

And finally…

Your operation can be benchmarked with other urea producers
Carbamate recycle flow to synthesis

Flow = (speed x K – recycle) x density
Recycle = f (valve position, pressure drop)

• The error in carbamate flow is caused by the recycle valve
• High correlation coefficient R² = 0.93
• Cavitation in valve, erosive, trim damaged
Root cause:
Wrong density compensation for office

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Feed stream to the waste water section

Operator forgot to close flush

28th AFA Int’l. Fertilizer Technology Conference: Amman, Jordan
How rigorously plant modeling can advance your urea business

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Conclusions

- In operation at OCI urea plant Geleen since 2012
- Advance Consult™ indicated an expected 1 to 2% production increase
- Project delivered an energy reduction and capacity increase in the range of 4-5%
- EVOLVE™ OPTIMIZER is:
  - A revamp tool
  - Predictive maintenance tool (reliability improvement)
  - In dept analysis tool for troubleshooting
  - A sensor duplicator

an Auto-Pilot for your plant
that maximizes efficiency and increases production
"Мجموعة عمل
ترشيد الطاقة في مصانع الأسمدة"
Energy Saving Working Group
2015/6/6

Yasser A.Rahim
AFA (ESWG) Chairman
<table>
<thead>
<tr>
<th>ترشيد الطاقة في مصانع الاسمنت</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Saving Working Group</td>
</tr>
<tr>
<td>2015/6/6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>خطط عمل المجموعة</th>
<th>الرقم</th>
</tr>
</thead>
<tbody>
<tr>
<td>تتيح معايير خاصة بالرصد والاستهداف</td>
<td>1</td>
</tr>
<tr>
<td>وضعت نظام معلومات لإدارة الطاقة</td>
<td>2</td>
</tr>
<tr>
<td>تخص تدابير ترشيد الطاقة فيما بين أعضاء الاتحاد العربي للاسمنت</td>
<td>3</td>
</tr>
<tr>
<td>وضع مصفوفة بالتدريبات والكفاءات الخاصة بترشيد إدارة الطاقة</td>
<td>4</td>
</tr>
<tr>
<td>إجراء عمليات مراجعة وتفاقيف للطاقة. كيفية إعادة عملية المراجعة والتفاقيف الخاصة بأعضاء الاتحاد</td>
<td>5</td>
</tr>
</tbody>
</table>
Energy Saving KPIs

Energy Indicators

<table>
<thead>
<tr>
<th>Energy Indicators</th>
<th>Type of data</th>
<th>UCM 2013</th>
<th>UCM 2014</th>
<th>UCM 2015</th>
<th>UCM 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENO Direct energy consumption by energy source</td>
<td>quantitative</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENM Indirect energy consumption by primary source</td>
<td>quantitative</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENT Energy level due to conservation and efficiency improvements</td>
<td>quantitative</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENI Initiatives to reduce energy consumption and emissions (primary)</td>
<td>qualitative</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENP Initiatives to reduce energy consumption and emissions (secondary)</td>
<td>qualitative</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENS Initiatives to reduce energy consumption and emissions (total)</td>
<td>qualitative</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Emissions, effluents and waste**

| EN15 Total direct and indirect greenhouse gas emissions by weight | qualitative |          |           |           |           |
| EN17 Other relevant greenhouse gas emissions and reductions achieved | qualitative |          |           |           |           |
| EN18 Initiatives to reduce greenhouse gas emissions | qualitative |          |           |           |           |
| EN19 Emissions of ozone-depleting substances | quantitative |          |           |           |           |
| EN20 NOx, SOx, and other significant air emissions by type and weight | quantitative |          |           |           |           |
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Data Base for Listing Energy Saving Project of AFA Members

<table>
<thead>
<tr>
<th>Name of Company</th>
<th>Country</th>
<th>Location</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-</td>
<td>Capacity (MT/Year)</td>
<td>1-</td>
<td>Licenses (process type)</td>
</tr>
<tr>
<td>2-</td>
<td>Capacity (MT/Year)</td>
<td>2-</td>
<td>Licenses (process type)</td>
</tr>
</tbody>
</table>

Energy Saving Working Group
## Data Base for Listing Energy Saving Project of AFA Members

**Blank Template for company profile:**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Year of Implementation</th>
<th>Production Unit</th>
<th>Energy Saving Scheme/Project Short Description</th>
<th>Area of Improvement</th>
<th>Obtained Benefit</th>
<th>Full Description of the Project/Presentation if available</th>
<th>Cost estimate and/or actual</th>
<th>Pay Back time</th>
<th>ROI</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
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<td></td>
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</tr>
</tbody>
</table>
Guidelines for Establishing Energy Saving Culture

<table>
<thead>
<tr>
<th>No.</th>
<th>Task Description</th>
<th>Task Lead</th>
<th>Start Date</th>
<th>End Date</th>
<th>Percentage Complete</th>
<th>Energy Usage</th>
<th>Working Days</th>
<th>Days to Complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Energy Team Appointment</td>
<td>[Name]</td>
<td>1 Mar '15</td>
<td>19 Mar '15</td>
<td>0%</td>
<td>15</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>1.1</td>
<td>Appoint a member of the management to champion the energy saving campaign</td>
<td>[Name]</td>
<td>1 Mar '15</td>
<td>20 Mar '15</td>
<td>0%</td>
<td>15</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>1.2</td>
<td>Set up an energy team</td>
<td>[Name]</td>
<td>21 Mar '15</td>
<td>19 Apr '15</td>
<td>0%</td>
<td>20</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>Become familiar with products and materials</td>
<td>[Name]</td>
<td>20 Apr '15</td>
<td>19 May '15</td>
<td>0%</td>
<td>32</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>2.1</td>
<td>Assess the current situation</td>
<td>[Name]</td>
<td>20 Mar '15</td>
<td>17 Sep '15</td>
<td>0%</td>
<td>87</td>
<td>0</td>
<td>121</td>
</tr>
<tr>
<td>2.2</td>
<td>Identifying the needed Messages and slogans, preparing promotional materials</td>
<td>[Name]</td>
<td>20 May '15</td>
<td>18 Jul '15</td>
<td>0%</td>
<td>43</td>
<td>0</td>
<td>60</td>
</tr>
<tr>
<td>2.3</td>
<td>Collecting and reporting data on the current energy management</td>
<td>[Name]</td>
<td>20 May '15</td>
<td>18 Jul '15</td>
<td>0%</td>
<td>43</td>
<td>0</td>
<td>60</td>
</tr>
<tr>
<td>2.4</td>
<td>Identifying the needed Messages and slogans, preparing promotional materials</td>
<td>[Name]</td>
<td>20 Jul '15</td>
<td>17 Sep '15</td>
<td>0%</td>
<td>44</td>
<td>0</td>
<td>60</td>
</tr>
<tr>
<td>3</td>
<td>Setting and reviewing the organisation’s mission</td>
<td>[Name]</td>
<td>16 Sept '15</td>
<td>25 Dec '15</td>
<td>100%</td>
<td>71</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>3.1</td>
<td>Setting and reviewing the organisation’s mission</td>
<td>[Name]</td>
<td>16 Sept '15</td>
<td>15 Nov '15</td>
<td>0%</td>
<td>42</td>
<td>0</td>
<td>60</td>
</tr>
<tr>
<td>3.2</td>
<td>Launching the Energy Management System</td>
<td>[Name]</td>
<td>17 Nov '15</td>
<td>25 Dec '15</td>
<td>0%</td>
<td>29</td>
<td>0</td>
<td>40</td>
</tr>
</tbody>
</table>
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Guidelines for Establishing an Energy Saving Culture

✓ INTRODUCTION
✓ MILESTONE 1 PLANNING
✓ MILESTONE 2 IMPLEMENTATION
✓ MILESTONE 3 REVIEWING AND COMMUNICATING
✓ MILESTONE 4 MAINTAINING AWARENESS
✓ Next steps

Energy Saving Working Group
### Energy Management Competency Matrix Development Plan

<table>
<thead>
<tr>
<th>Task</th>
<th>Time Based Execution Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepare role/job description</td>
<td></td>
</tr>
<tr>
<td>Conduct discussions</td>
<td></td>
</tr>
<tr>
<td>Generate a list of generic competencies</td>
<td></td>
</tr>
<tr>
<td>Identify functional competencies</td>
<td></td>
</tr>
<tr>
<td>Create competency matrices profiling for Workers</td>
<td></td>
</tr>
<tr>
<td>Have the competency analysis in interviews with departmental heads a</td>
<td></td>
</tr>
<tr>
<td>nd a HR specialist</td>
<td></td>
</tr>
<tr>
<td>Identification of the matrix in final form</td>
<td></td>
</tr>
<tr>
<td>Perform Gap Analysis</td>
<td></td>
</tr>
<tr>
<td>Prepare Development plans</td>
<td></td>
</tr>
<tr>
<td>Prepare Gap Closure</td>
<td></td>
</tr>
</tbody>
</table>

*This is where we are till now*

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### Energy Saving Auditing Protocol

**Arabic: إجراء عمليات مراجعة وتفتيش للطاقة**

**English: Energy Saving Auditing Protocol**
Our Deliverables to AFA (1st Phase)

- DNV GL Business Assurance Middle East & Africa shall provide AFA and its members a customized rating protocol that provides a quantitative insight into and understanding of an energy management system's performance as a whole and in detail within each of its six elements. With its structured, comprehensive and proven approach, the customized Energy Management System Rating Protocol (EnMS Rating Protocol) provides you with insight into and understanding of the performance and the improvement potential of the energy management system of the organization. The tool will be excel based and DNV GL shall provide it to AFA free of cost.
- It is a requirement that the assessors that will use the EnMS Rating tool have a sound knowledge on ISO 50001.
- Training on the use of the tool (Free of cost)
- ISO 50001 Internal / Lead auditor training for the AFA members in collaboration with AFA for the assessors that do not possess the required knowledge of ISO 50001. (Special AFA rates shall apply)
Mohamed Masrori,
AFA (HSEWG) Chairman

HSE Working Group
2015/6/6
28th AFA International Technology Conference & Exhibition

• HSEWG Vision:

To promote the (HSE) Health, Safety and Environment performance levels for all AFA members and disseminate related culture in order to protect the human being and achieve the sustainable development of fertilizer sector.

HSE Working Group

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• AFA HSEWG Mission:

• Improving the HSE awareness and culture within AFA.

• Establishing AFA HSE KPIs & reporting matrix & updating the database.

• Listing and reporting the HSE Best Practices applied in AFA Companies.

HSE Working Group
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- **AFA HSEWG Mission:**

  - Establishing HSE benchmarking criteria with similar industries.
  - To promote AFA programs and initiatives in international events.
  - Share and present AFA-HSE journey in similar HSE International events
  - To develop competitiveness criteria by providing AFA HSE Award, developing questionnaires and other forms together with setting incentives

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- **2015 Working Plan:**

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Listing and reporting the HSE Best Practices applied in AFA Companies</td>
</tr>
<tr>
<td>2</td>
<td>Adopting HSE Key Performance Metrics Reporting system for AFA</td>
</tr>
<tr>
<td>3</td>
<td>Developing guidelines for effective HSE management system for ( ATR )</td>
</tr>
<tr>
<td>4</td>
<td>Initiating effective awareness program streamlining &amp; helping AFA members to be more involvement in the field of Corporate Social Responsibility certificates.</td>
</tr>
<tr>
<td>5</td>
<td>AFA HSE award for 2015 round</td>
</tr>
</tbody>
</table>

**خطة العمل العام 2015**

- تحسين واعداد معايير اollar الامكانيات في مجال الصحة والسلامة والبيئة التي تم تنفيذها في أعمال الشركات الإقامة بالالحاب بهدف توثيقها ونشرها للقراءان منها
- وضع وتصميم معايير متطلبات للقيام في مجالات الصحة والسلامة والبيئة خاصة بالالحاب وإصدار تقرير أداء مستوى الشركات المحتوى
- وضع نظام استردادي شامل لادارة النشاطات البيئية المحددة من الجهات المتعاطفة بالصحة والسلامة والبيئة
- تعميق مفهوم المسؤولية الاجتماعية وإيجابيات الانتاج الإجتماعي لهذا المعهد عن طريق اعداد خطة تأهيل الشركات المتمورة الإجتماعي في المسؤولية الاجتماعية للتفاوض مع رؤية الإحجاب المستقلة
- متابعة حصول معايير الإجراءات الإنسانية لاجهزة الإحجاب في مجال الصحة والسلامة والبيئة لعام 2015.
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Best HSE practices

- Initiating communicating the form to all AFA members.
- Review & segregate the applications.
- Select & short list the recommended schemes for printing & publications.

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Best HSE practices

- Updating AFA database with the received information for wider sharing.
- Print out and publishing some selected schemes.

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**Best HSE practices**

- Main contents of the form:
  - Administrative information
  - Area of practice
  - Description of the adopted practice.
- The added value of the best practice:
  - Procedural enhancement
  - Risk control
  - Minimizing HSE impact
  - Improving the HSE control.
  - Positively improving the economical & social impact
- 32 practices received

HSE Working Group

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**Key Performance Metrics Reporting**

- Establish a standard HSE reporting metrics for AFA members.
- Create a sustainable platform on HSE metrics for monitoring and benchmarking.
- Issue an annual performance metrics report for AFA member companies.

HSE Working Group
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<table>
<thead>
<tr>
<th>S.No</th>
<th>Metric Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Occupational Safety</td>
</tr>
<tr>
<td>1</td>
<td>Employee Fatalities</td>
</tr>
<tr>
<td>2</td>
<td>Lost Time Injury Incident rate for Employees</td>
</tr>
<tr>
<td>3</td>
<td>OSHA Recordable Cases Incidence Rate for Employees</td>
</tr>
<tr>
<td>4</td>
<td>Contractor Employee Fatalities</td>
</tr>
<tr>
<td>5</td>
<td>Lost Time Injury Incidence Rate for Contract Employees</td>
</tr>
<tr>
<td>6</td>
<td>OSHA Recordable Cases Incidence Rate for Contract Employees</td>
</tr>
<tr>
<td>B.</td>
<td>Process Safety</td>
</tr>
<tr>
<td>1</td>
<td>Process Safety Incidents</td>
</tr>
<tr>
<td>2</td>
<td>Process Safety Total Incident Rate (PSTIR)</td>
</tr>
<tr>
<td>3</td>
<td>Process Safety Total Incident Severity Rate (PSTIR)</td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>S.No</th>
<th>Metric Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.</td>
<td>Emissions / Discharges to Environment</td>
</tr>
<tr>
<td>1</td>
<td>Hazardous Waste for Disposal</td>
</tr>
<tr>
<td>2</td>
<td>Non-Hazardous Waste for Disposal</td>
</tr>
<tr>
<td>3</td>
<td>Quantity of Waster Water discharged to Environment</td>
</tr>
<tr>
<td>4</td>
<td>Discharges to Water - Chemical Oxygen Demand</td>
</tr>
<tr>
<td>5</td>
<td>Sulfur Dioxide</td>
</tr>
<tr>
<td>6</td>
<td>Nitrogen Oxides (NOX)</td>
</tr>
<tr>
<td>7</td>
<td>Total Green House Gas Emissions (GHG)</td>
</tr>
<tr>
<td>8</td>
<td>Carbon Dioxide (CO2) Intensity</td>
</tr>
<tr>
<td>D.</td>
<td>Resource Utilization</td>
</tr>
<tr>
<td>1</td>
<td>Use of Energy (Tons of Fuel oil Equivalent; TOE)</td>
</tr>
<tr>
<td>2</td>
<td>Specific Energy Consumption</td>
</tr>
<tr>
<td>3</td>
<td>Process Water Consumption</td>
</tr>
<tr>
<td>E.</td>
<td>Product Distribution</td>
</tr>
<tr>
<td>1</td>
<td>No of Distribution Incidents</td>
</tr>
</tbody>
</table>
28th AFA International Technology Conference & Exhibition

Developing guidelines for effective HSE management system for (ATR)

- To establish the guideline principles upon which ATR are managed whilst maintaining utmost degree of control & commitment toward HSE controls.
- Describing the approaches to establish and maintain a strong ATR HSE culture.
- To achieve ATR Goals by monitoring the activities through following metrics

---

28th AFA International Technology Conference & Exhibition

**EFFECTIVE HSE MANAGEMENT SYSTEM for ATR**

<table>
<thead>
<tr>
<th>PHASE</th>
<th>AREA</th>
<th>METRICS &amp; FORMULAE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre TA</td>
<td>TA EHSS Goals</td>
<td>No. of employees attended Awareness</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No. of employees &amp; contractor involved in TA</td>
</tr>
<tr>
<td></td>
<td>Lesson Learning</td>
<td>No. of Lesson learning session conducted</td>
</tr>
<tr>
<td></td>
<td>Formation of EHSS</td>
<td>No. of Lesson learning session planned (TA Incidents)</td>
</tr>
<tr>
<td></td>
<td>Coordinators</td>
<td>No. of EHSS Coordinator selected</td>
</tr>
<tr>
<td></td>
<td>Completion of Pre TA</td>
<td>No. of Coordinator’s required</td>
</tr>
<tr>
<td></td>
<td>activities</td>
<td>Announcement of TA EHSS Theme</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Layout finalization including traffic plan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pre TA awareness programs &amp; its Materials</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inspection of plant safety &amp; Fire equipment’s readiness</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Blind list (Color Coding) &amp; PSV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Availability of all EHSS devices and documents</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rigging plan</td>
</tr>
<tr>
<td>EHSS Training</td>
<td>No. of EHSS Training</td>
<td>No. of EHSS Training conducted</td>
</tr>
<tr>
<td></td>
<td>scheduled</td>
<td>No. of EHSS Training scheduled</td>
</tr>
<tr>
<td>Critical high risk jobs</td>
<td>No. of JSA prepared</td>
<td>No. of Critical High Risk Jobs identified</td>
</tr>
<tr>
<td>Rigging Plan</td>
<td>No. of Rigging plan</td>
<td>No. of Rigging plan required for the lifting</td>
</tr>
</tbody>
</table>

---

HSE Working Group
### EFFECTIVE HSE MANAGEMENT SYSTEM for ATR

<table>
<thead>
<tr>
<th>PHASE</th>
<th>AREA</th>
<th>METRICS &amp; FORMULAE</th>
</tr>
</thead>
<tbody>
<tr>
<td>During TA</td>
<td>Management Commitment</td>
<td>No. of management audit conducted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No. of management audit scheduled</td>
</tr>
<tr>
<td></td>
<td>Tool Box Meeting</td>
<td>No. of Tool Box meetings conducted</td>
</tr>
<tr>
<td></td>
<td>Daily EHSS Rep Meeting</td>
<td>No. of EHSS Representatives meetings conducted</td>
</tr>
<tr>
<td></td>
<td>Compliance Audit Rate</td>
<td>Overall average compliance audit rate per day</td>
</tr>
<tr>
<td></td>
<td>(WP, PPE &amp; HK)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EHSS Observation Reporting Rate</td>
<td>Number of EHSS Observation reported</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total manpower engaged in TA</td>
</tr>
<tr>
<td></td>
<td>Waste Recycling</td>
<td>Waste recycled</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Waste generated</td>
</tr>
</tbody>
</table>

HSE Working Group
Mohamed Benzakri
AFA (C&PAWG) Chairman
Content

1. Communication and PA working Group
2. Public Affairs
3. Vision
4. Mission
5. Strategy
6. Scope of work
7. KPIs

Communication and PA working Group

Communication

The exchange of thoughts, messages, or information, as by speech, signals, writing, or behavior.

Business communication

Is the sharing of information between people within an organization to achieve commercial benefit.
Public Affairs

- Public affairs is a term used to describe an organization's relationship with stakeholders. These are individuals or groups with an interest in the organization's affairs, namely civil servants, customers, local communities, clients, shareholders, trade associations, business groups, charities, unions and the media means.

- Public affairs practitioners can be tasked with a wide range of activities. Some may be specialized in media sources relations and others in campaign management.

- Public affairs work combines government relations, media sources communications, issue management, corporate and social responsibility.

Vision

The main vision of Communication and Public Affairs working group is to improve the image of fertilizers industry through different kinds of media means and strengthen its important role in the economic, agriculture and social development.
Mission

1. Present AFA role and activities to move forward to a new horizon that meets AFA member companies expectations and reflects AFA position.
2. Exchange knowledge and experiences between Arab industry companies.
3. Encounter the challenges facing association member companies in fields of education/ awareness responsibility.
4. Communicate with international associations and organizations aiming to eliminate poverty and achieve food security.

Our Strategy

1. Share strategic news & information relevant to fertilizers.
2. Communicate member companies activities to entrench sense of credibility and highlight differences.
3. Raise awareness of member companies efforts in CSR.
4. Establish a unified database of member companies on AFA website including media sources connections.
5. Exchange knowledge and experiences between members companies.
6. Contribute with research organizations to develop the activities relevant to fertilizers.
7. Extending the scope of audience distribution.
8. Make C&PAWG a source of information to raise awareness of HSE principles and solutions.
9. Educate industry workers on relevant issues by adopting media sources and coordinating between trainers and owners.
10. Communicate AFA efforts on poverty elimination and food security achievement.

---

Some of our scope of work:

1. Build an Arabic media sources database to facilitate publishing all news and information relevant to fertilizers. *(Join social media: Twitter / YouTube / Facebook / Google +)*
2. Build database for agriculture research centers and Ministries to have access to agricultural statistical of Arabic Countries.
3. Publish AFA Magazine regularly (hard copies and soft copies through emails, social media and AFA website)
4. Develop AFA Website

<table>
<thead>
<tr>
<th></th>
<th>January</th>
<th>February</th>
<th>March</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>8530</td>
<td>2228</td>
<td>1952</td>
</tr>
<tr>
<td>2015</td>
<td>10691</td>
<td>4990</td>
<td>3336</td>
</tr>
</tbody>
</table>

5. Share all collaterals / reports/newsletters / workshops / events and activities of AFA with targeted audiences.
6. Exchange best practices of AFA member companies in regular meetings.
7. Promote all AFA events.

Share our Best Practice: KPIs
28th AFA Int’l. Fertilizer Technology Conference & Exhibition
07 - 09 June 2015
Amman - Jordan

Session 2

ARAB FERTILIZER IMPRESSING FUTURE SUSTAINABILITY
How rigorously plant modeling can advance your urea business
Successful ammonia plant revamping; a model for future plants modernization

Sergio Panza
CASALE SA
Switzerland
Successful ammonia plant revamping; a model for future plants modernization
Successful ammonia plant revamping; a model for future plants modernization

F. Sassi – Casale SA
Amman - June 2015

IN HARMONY WITH YOUR NEEDS

---

CASALE revamping of Nevinnomyssk TEC plant

- Capacity increase: up to 2000 MTD
- Energy saving: > 0.7 Gcal/MT;
- Reliability improvement.
## Background

The Ammonia Plant is an original TEC 1973 design

The nameplate capacity was 1360 mtpd

Modified in 1989-1991 to 1700 mtpd (usual load 1640-1680MTD)

2014 revamped to 2,000 mtpd

---

## Revamp Major Milestones

- **April 2013** – CASALE selected to perform detail engineering
- **March 2014** – Detailed engineering completed
- **April 2014** – Material start to be gathered in field
- **October 2014** – Plant shut-down to execute revamp
Activities sharing

Casale was responsible for:

- Detail engineering;
- Procurement of most of the critical equipment;
- Advisor during construction.

Activities sharing

Nevinnomyssky Azot was responsible for:

- Construction;
- Modification of existing equipment;
- Procurement of the foundation/steel structure bulk material.
Successful ammonia plant revamping; a model for future plants modernization

Pages 60 - 61

PROJECT SCHEDULE

PROJECT ENGINEERING & REVAMPED CAPACITY REACHED IN

21 MONTHS

Main modifications

1) Steam reforming capacity;
2) Air compressor section;
3) CO2 removal section;
4) Synthesis compressor;
5) Refrigerant section;
6) Synthesis loop;
7) BFW pumps;
1. Steam reforming capability

Capacity increased with bigger ID tubes;
Steam to carbon ratio reduced

NEW ID: >92mm
OLD ID: 85mm
NEW ID: >92mm

2. Air compressor section

Air compressor train revamping (Entechmach and Alstom).

The compressor internals were replaced with new ones with revamping of interstage coolers and steam condensers replacement. The steam turbine is brand new.
2. Air compressor section

New Casale secondary reformer burner. Upper catalyst layer was sieved.

<table>
<thead>
<tr>
<th></th>
<th>Plant capacity [MTD]</th>
<th>Pressure drop [kg/cm²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base case</td>
<td>1680</td>
<td>1.14</td>
</tr>
<tr>
<td>Revamped case</td>
<td>2000</td>
<td>1.0</td>
</tr>
</tbody>
</table>

3. CO₂ removal section revamping

Two regenerators from parallel to series operation (GV low energy scheme).
3. CO₂ removal section revamping

3B. CO₂ removal section revamping

Foaming phenomena was encountered during start-up, but the addition of antifoam agent and the use of the carbon filter solved the problem.
4A. Synthesis gas compressor

Syn-compressor: New upgraded internals (Dresser Rand and Mitsubishi)

And HTS converter: new low DP Casale axial-radial internals instead of old axial and Clariant catalyst.

4B. HTS performances

<table>
<thead>
<tr>
<th></th>
<th>Plant capacity [MTD]</th>
<th>Pressure drop [kg/cm²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base case</td>
<td>1680</td>
<td>0.8</td>
</tr>
<tr>
<td>Revamped case</td>
<td>2000</td>
<td>0.47</td>
</tr>
</tbody>
</table>
5. Refrigerant compressor

Chillers duty reduction with two new exchangers using chilled water (generated by Li/Br packages).

6. Synthesis Loop

The synthesis loop has two ammonia converters, Main and "Baby" converter.

The main converter was already revamped by Casale.

Also the "baby" converter was revamped by Casale.
7. BFW pumps

An additional pump electrically motor driven was added. This pump has same head of the existing pumps.

**PERFORMANCES**

<table>
<thead>
<tr>
<th></th>
<th>Pre-revamp</th>
<th>Guarantees</th>
<th>Test run 13-3-2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production, MTPD</td>
<td>1650</td>
<td>1950</td>
<td>1982</td>
</tr>
<tr>
<td>Energy saving, Gcal/MT</td>
<td>0.62</td>
<td>0.86</td>
<td></td>
</tr>
<tr>
<td>Specific energy consumption, Gcal/MT</td>
<td>8.80</td>
<td>8.18</td>
<td>7.94</td>
</tr>
</tbody>
</table>
CONCLUSION

Most of the ammonia plant sections were involved in the hardware modifications.

The sections modified have additional spare capacity for a further capacity increase.

Presently the plant is the biggest in operation in Russia and former CSI countries.

CONCLUSION

This plant represent a benchmark for the revamping of old ammonia plant.

Revamping: a viable solution to improve profitability and reliability.
Enhancement of Urea Production Efficiency Via the Improvement of Existing Automatic Control Systems

Kostikov Evgeniy, Senior software engineer of Advanced Process Control department
NIIK
Russia
NIK, R&D INSTITUTE OF UREA (Russia): vast experience in fertilizer and chemical industry in Russia and overseas

NIK’s services:
1. Engineering and design
2. Technology and revamping concept development
3. Diagnostics and repairs
4. DCS and process simulators development
5. Equipment and material procurement

28th AFA Int’l. Fertilizer Technology Conference: Amman, Jordan

**Basic process functions of DCS**

- Data collection, parameter analysis and process visualization
- Control function generation
- Process start-up
- Commissioning
- Maintaining optimum operation mode under the existing processing limits
- Normal and emergency shutdown of the production process
- Technical & Economic Report generation

Enhancement of Urea Production Efficiency via the Improvement of Existing Distributed Control System
Disadvantages of existing DCS

- Lack of control and real-time monitoring of the process quality parameters.
- Lack of control loop parameter optimization.
- Modern DCS are normally used to perform only basic tasks related to the automatic production control, while the other powerful advantages of the automation equipment stay out of use.
- The algorithmic structures of modern DCS are not designed to solve the economic issues.

Required functional capabilities to improve the performance of existing DCS

- Computer-assisted search of the optimal settings for the DCS controllers
- Automatic real-time monitoring of the advanced system parameters for the process quality supervision
- Automatic real-time control of the advanced system parameters
- Automatic criterion analysis of the process quality at various production stages and units of equipment
- Automatic real-time monitoring of the control loops’ settings
- Automatic Advanced Process Control
- Case analysis
Main stages of the Advance Process Control Implementation

- Optimal Process Control
- Efficient Process Control
- Adjustment of PID controllers

Enhancement of Urea Production Efficiency via the Improvement of Existing Distributed Control System

Tuning station by NIJK
for adjustment of control loops and PID controllers

Enhancement of Urea Production Efficiency via the Improvement of Existing Distributed Control System
Example of the parameter optimization efficiency

- Process simulation with the basic system settings
- Process simulation with the optimized system settings

Due to the implementation of the Tuning station by NIIG, the bandwidth of dynamic deviations was substantially reduced.

Decreasing by 50%!
**The implementation of the Tuning station by NIiK at JSC NAK AZOT (EuroChem)**

- The implementation of the Tuning station by NIiK allowed the parameter optimization of 48 existing control loops at the JSC NAK AZOT Urea plant.

- Following the parameter optimization the independent experts confirmed the performance quality improvement for each control loop.

- Upon the parameter optimization of existing control loops the bandwidth of dynamic deviations is reduced at the average of 30-35% (confidence coefficient is 0.98).

**The result achieved is the substantial improvement of the process performance and stability.**

---

**Efficient Process Control**

- Equipping of the process with the required additional instruments.
- The algorithmic structures are designed with respect to the special characteristics of the object controlled (instability, hysteresis effect, long response time etc.).
- Algorithm design considering the transportation lag and disturbance effects at the input of the object controlled.
- The use of analytical expressions to predict the behavior of the object controlled.
- The performance criteria formulation and analysis of algorithms efficiency of the production process.
- The use of parameter optimization algorithms and mathematical models for the process improvement (active experiment, passive observation etc.)
- System analysis and process trouble signaling.
Optimal Process Control

- Optimal Process Control is based on the Efficient Process Control solutions
- Advanced Process Control system is designed to achieve the following goals:
  - maximum capacity
  - maximum optimization (max optimality criterion)
  - minimum energy requirement

Enhancement of Urea Production Efficiency via the Improvement of Existing Distributed Control System
28th AFA Int’l. Fertilizer Technology Conference: Amman, Jordan

Cost advantages

- Implementation time — 4 months min.
- Payback period — 1 year max.
- Cost savings — 1-2% (on a case-by-case basis)

Thank you!

Enhancement of Urea Production Efficiency via the Improvement of Existing Distributed Control System
Enhancement of Urea Production Efficiency Via the Improvement of Existing Automatic Control Systems
Removal of Black Powder & other Contaminants from Feed Gas to Fertilizer Plants

Emmanuelle BIADI
EMEA Fuels and chemicals downstream business development manager
Pall Corporation
Gas Feed – Black Powder

- Generic term for **corrosion products** (iron sulphide, iron oxide, iron hydroxide, etc.)
- Formation mainly due to **internal corrosion** with pipe steel
- Most chemical related: internal corrosion in the presence of water, acidic components (\(\text{H}_2\text{S} / \text{CO}_2\)), oxygen
- Very fine...1-10 \(\mu\)m in size

**Typical Impacts of Black Powder in Ammonia plants**

- **Fouling** & Delta P increase in catalyst reactors

- **coke formation acceleration** in catalyst pellets & reformer furnaces tubes, leading to:
  - *Pressure drop* increase and *hot spots* in parts of the tubes.
  - *unscheduled shutdown* for Catalyst steaming
  - *Partial replacement* of furnace tubes damaged by hot spots

- Valves blockage
- Failure of critical instrumentation
Filtration/Separation Technologies for gas feed purification

There are 3 identified product platforms

- **Depth** or pleated “absolute” cartridge filters to remove solid contaminants
- Systems of **cyclonic devices** in combination with cartridge filters
- **Liquid/gas coalescers** to remove liquid contaminants, such as water and condensed hydrocarbons

And different filters & separators designs

- Pipes internal filter - Simple Coalescer or filter - Complete Cyclonic separation skid

---

**Nominal Versus Absolute Rated Filters**

- **Nominal rating**: An arbitrary μm value, usually based on weight % removal
- **Absolute rating**: tested efficiency, according to industry standards
Profile ® Coreless Depth Filter Element

Continuous graded pore depth filter media captures fine Black Powder particles

Used cartridges Showing Black Powder retention

Black Powder removal on a Pall Absolute rated filter cartridge

- Online measurement recorded during Field Testing of newly installed filters:

<table>
<thead>
<tr>
<th></th>
<th>Total Suspended Solids</th>
<th>Upstream Filter in ppmw</th>
<th>Downstream Filter in ppmw</th>
<th>Total Solids Removal Efficiency Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter</td>
<td>0.61</td>
<td>&lt;0.01</td>
<td></td>
<td>97.5%</td>
</tr>
</tbody>
</table>

Upstream Profile ® Coreless filter
Downstream Profile ® Coreless filter
Profile ® Coreless filter media examination
Solids collected in the upstream depth zone.
Cyclo-Filter for High Solids Content

1. Cyclone Section
   Separates the coarsest particles & slugs

2. Cartridge Filter Section,
   featuring Coreless depth filters

Coalescence

- **Coalescence** = Removal of a fine dispersed liquid phase from bulk
  Phase (either liquid or gas)
  - Liquid/Gas coalescers = Removal of liquid **AEROSOLS** from a gas
  - Liquid/Liquid coalescers = Removal of liquid **DROPLETS** from a liquid

- **Coalescence principle**: MECHANICAL separation based on the ability
  of the coalescer media to combine the droplets and to separate them

  - No chemicals required
  - No electricity
  - No centrifugal motion
### High-Efficiency Liquid/gas Coalescers

- Conventional separation devices are not fine enough

<table>
<thead>
<tr>
<th>Separation Equipment</th>
<th>Drop Size Removal</th>
<th>Separation Mechanism</th>
<th>Sensitivity to Flow Rate Variations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knock Out Drum</td>
<td>&gt; 300 μm</td>
<td>Gravity</td>
<td>Medium</td>
</tr>
<tr>
<td>Cyclonic Separator</td>
<td>&gt; 10 μm</td>
<td>Centrifugal</td>
<td>Medium</td>
</tr>
<tr>
<td>Yoke Pack</td>
<td>&gt; 10 μm</td>
<td>Inertial impaction</td>
<td>Sensitive</td>
</tr>
<tr>
<td>Demister Pad</td>
<td>&gt; 5-10 μm</td>
<td>Inertial impaction</td>
<td>Sensitive</td>
</tr>
<tr>
<td><strong>High-Efficiency Coalescer</strong></td>
<td>&gt; 0.1 μm</td>
<td>Diffusion &amp; direct interception</td>
<td>Low</td>
</tr>
</tbody>
</table>

### Typical Layout of Pall Liquid/Gas Coalescers

![Diagram of a coalescer with labels for inlet, outlet, Sepranol™ Plus cartridges, Stand pipes (adaptors), DP control, Tubesheet (filter plate), Pre-separator: optional, Liquid level control]
Case Study 1: Natural gas Feed to Middle East Ammonia plant solids & liquids removal

Plant data
- 500 Ktpa ammonia plant
- Flow Rate of Natural Gas: 4,744 AM³/h @ 40 Kg/cm² & 50°C

Issues
- Delta P increase in the HDS reactor & reformer
- Failures on compressors

Presence in the feed gas of:
- High level of Black Powder,
- Glycol

Consequences
- Unscheduled 3 to 5 days shutdown per event
- Production losses estimated to 2.6 to 4.4 M$ per shutdown
- Reformer tubes partial replacement estimation: 150 K$ /shutdown (5%)

Solution
- Installation in 2007 of:
  - 2 * 30 Profile ® Coreless cartridges 1µm in gas absolute rated depth cartridge filters
  - 2 * 12 Seprasol ™ Plus liquid/gas Coalescer cartridges

Recently, feedstock quality has been further improved by treating the feed gas at the inlet of the whole chemical complex with Pall Cyclo-Filters.
Case Study 1 - Qualitative & quantitative results

- 1µm absolute in gas, protection of the reformer against solids

Used cartridge cut with solids upstream retention

- Excellent protection as well against liquids with some limitations when the volume of liquid slugs exceeds the liquid handling design capacity of the coalescer
- Full installation of filters & coalescers was paid back by eliminating shutdowns due to feed contamination.
- Cartridges change out frequency 6 - 9 months

Case Study 2 - Natural gas Feed to a Middle east Ammonia plant.

Solids removal

Plant data
- 540 000 T/y plant
- 3 672 Am³/h of Natural Gas feed

Issues
- Blockage of the main plant natural gas (NG) valve.
- NG control valve of the metering skid was blocked by black powder.

Consequences
- Unscheduled 2 days shutdown per event
- Estimated production Losses of 2 400 T or +/- 1.6 M$ per shutdown
Case Study 2 — Natural gas Feed to a Middle east Ammonia plant. Solids removal

**Solution**
- Installation of a 2*9 Profile ® Coreless cartridges filter skid.
- Efficiency of 0.3μm absolute in gas

**Results**
- No more Unscheduled shutdowns
due to black powder and main plant natural gas valve blockage.
- Cartridges change out frequency 6 - 9 months
- Total expenditure, including installation cost, was approx. 0.5 M$ and resulted in more than 1.5 M$ of savings.

---

**Major Conclusions**

- In these 2 case studies, main challenges were:
  - Limitation of delta P increase and coke formation in HDS and reformer due to gas feed contaminants.
  - Protection of critical equipments such as valves & compressors
- In the 2 cases studies the key contaminant in the feed gas was black powder
- Installation of high efficiency filters and coalescers resulted in:
  - Elimination of shutdown time due to gas feed contamination.
  - Excellent return of investment due to increased Ammonia production
- More than 30 references in Black Powder removal installations in Middle east in overall Fuels and Chemical markets.
Thank you for your attention

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Removal of Black Powder & other Contaminants from Feed Gas to Fertilizer Plants
Successful Turnaround Planning and Execution by New TA Procedures, Standardization of TA Packages and Best Practices

V. Mohammed Zia
Saudi Arabian Fertilizer Company
Successful Turnaround Planning and Execution by New TA Procedures, Standardization of TA Packages and Best Practices
Introduction

Turnarounds are scheduled cyclic events wherein an entire process unit is taken off stream for an extended period for revamp and/or renewal including Inspection & Testing, debottlenecking projects, revamps and catalyst regeneration projects.

They are expensive - both in terms of lost production and in terms of direct costs for labor, tools, heavy equipment and materials used to execute the project.

The main objective of the Turnarounds is to safely complete all the turnaround jobs within the approved duration and approved budget.

In order to achieve all of this, effective Turnaround planning, better TA procedures, progress monitoring software's, audits, etc. are needed and to be complied.

Challenges

- Delays in review and finalizing the TA scope of work
- Preparation of TA Job Packages
- Delays in getting the approved packages for MOC's
- Scheduling of Turnaround activities
- Procurement of spares
- Overrun of TA budget due to Add-on jobs after the cut-off date
- Securing of lump sum contractors
- Selection of manpower and global contractors
- Overrun of the budget due to additional jobs during the turnaround execution
- Extension of turnaround duration
- Turnaround rolling plan
- Turnaround execution and quality control
Turnaround Objective

- Achieve EHSS KPI’s
- Achieve Turnaround KPI’s & Milestones
- Ensure quality work for all phases of turnaround
- Safe & Flawless start-up, zero leaks and reliable run
- Continue safe and sustained operation until the next TA

Approach

- Turnaround management process was modified by adding 2 more phases
- Standardization of Turnaround packages
- New MOC cycle introduced to match TA frequency
- Primavera software introduced
- Introduced follow up mechanism to expedite material delivery and services
- Developed new procedure to control Add on jobs after scope freezing and during execution
- Developed 10 year rolling plan
- Specific Quality control plan developed for the turnaround
Change on Timeline

Previous working process time line

1. Business Planning
   - 18 Months
2. Planning
   - 12 Months
3. Pre-TA
   - 2 Months
4. Execution
   - Zero Hours
5. Post TA
   - + 2 Months

Scope cut-off is – 6 months

PRESENT WORKING PROCESS TIME LINE

1. Initiation & Strategy
   - -20 Months
2. Scoping
   - -10 Months
3. Planning & Scheduling
   - 12 Months
4. Pre-TA
   - 2 Months
5. Execution
   - Zero Hours
6. Post TA
   - + 2 Months
7. Close out

Scope cut-offs – 12 months

SUCCESSFUL TURNAROUND PLANNING WITH NEW PROCEDURES AND STANDARDIZATION

Process map

SUCCESSFUL TURNAROUND PLANNING WITH NEW PROCEDURES AND STANDARDIZATION
Successful Turnaround Planning and Execution by New Procedures, Standardization of Turnaround Packages and Best Practices

Turnaround packages standardization

- Maximize the reliability, safety and quality of the job being planned
- Eliminate the repetitive work by the Planning Engineers up to extent
- Reduce in time for planning
- Have a common, centralized database for Turnaround jobs

<table>
<thead>
<tr>
<th>JOB PACKAGE CONTENT</th>
<th>STANDARDIZED FORMATS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Job List</td>
<td>Job Scope</td>
</tr>
<tr>
<td>Job Scope</td>
<td>Job List</td>
</tr>
<tr>
<td>Material Plan</td>
<td>Material Plan</td>
</tr>
<tr>
<td>Blind diagram</td>
<td>Service FR Master List</td>
</tr>
<tr>
<td>Bar Charts</td>
<td>Master Plan</td>
</tr>
<tr>
<td>JSA</td>
<td>Process Circuit Availability</td>
</tr>
<tr>
<td>Technical Documents (drawings, data sheets)</td>
<td>Bid Document – Master</td>
</tr>
<tr>
<td>Inspection Requirements</td>
<td>Bid Document – Hardware supply</td>
</tr>
<tr>
<td>Process Requirements</td>
<td>Bid Document – OEM Specialist</td>
</tr>
<tr>
<td>Special Tools List</td>
<td>PROMEGA Schedule Package</td>
</tr>
<tr>
<td>Inter-changeability List for Rotatory</td>
<td>Spare parts Inter-changeability List</td>
</tr>
</tbody>
</table>

SUCCESSFUL TURNAROUND PLANNING WITH NEW PROCEDURES AND STANDARDIZATION

New MOC cycle introduced

- MOC Study
- CAPEX Proposal
- CAPEX Approval
- Funds Approval
- Procurement / Execution
- T/A

30 Months

10 Months

6 Months

14 Months

SUCCESSFUL TURNAROUND PLANNING WITH NEW PROCEDURES AND STANDARDIZATION
Introducing new software

Primavera latest version introduced for scheduling and TA execution progress monitoring

Primavera software was introduced in order to efficiently schedule, track, monitor the progress and generate the tailor made progress reports as needed.

Expediting Material delivery and services

Procurement and logistic are a vital factor and a major challenge for planning and execution of large turnarounds due to delay in delivery, customs clearance, shipping etc.

Securing the best contractors to execute the turnaround was very challenging

Both above issues were overcome by Enhancing personnel follow up mechanism (Working & Management Level) with GPS.

PO’s issued well before the Turnaround execution and at optimum prices.
Revised TA Procedures

<table>
<thead>
<tr>
<th>Sl. #</th>
<th>Procedure</th>
<th>Changes in revised procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>LEFT OUT JOBS &amp; FOLLOW-UP ACTION PLAN</td>
<td>Existing Procedure revised to assign the responsibility to Operation for following up. Next TA long gestation jobs during the period -33 Months to -24 Months of TA cycle.</td>
</tr>
<tr>
<td>2</td>
<td>DEVELOPING JOB LIST PROCESS</td>
<td>Inspection and test plans to be provided by Inspection department in the TA initiation period.</td>
</tr>
<tr>
<td>3</td>
<td>HANDLING ADD-ON JOBS</td>
<td>TA Execution ADDON form revised to take SWMT approval if the requirement can not be accommodated within approved TA window.</td>
</tr>
<tr>
<td>4</td>
<td>TA MAINTENANCE ACTIVITY SCHEDULING</td>
<td>Inclusion of SMP procedures and check list in TA Handover package.</td>
</tr>
<tr>
<td>5</td>
<td>TRACKING OF TA EXECUTION ACTIVITIES</td>
<td>Quality audit check for the compliance of SMP &amp; approved ITP’s.</td>
</tr>
</tbody>
</table>
| 6     | TA FINDINGS REPORTING & TRACKING | Finding Cell team is included in TA organization chart.  
                                                 | Roles and responsibilities of finding cell team has been defined.                                    |
| 7     | TA PROGRESS REPORT              | Close out report to be published with Cell team inputs within 1 Month after TA.                      |
|       |                                 | Final close out report with OEM reports to be published within 3 Months after TA.                    |
|       |                                 | Audit as per revised milestone plan shall be conducted by MICE/Affiliates.                          |

### Turnaround 10 Year Rolling Plan

- Plan developed considering recommendations from Inspection, Process, Rotary and Operations.
- It is aimed to maximize the reliability, safety and quality of the job.
- To optimize turnaround activities and help in streamlining various turnaround functions.
- Improve Asset Availability by executing the recommendations made by RBI, Latest up gradation, technology improvements.
- Optimize Turnaround process, Turnaround Cost, workload, plant outage duration and time for each turnaround.
- Manage the equipment replacement schedules for each plant turnaround.
- Increase the reliability of the plants.
- Apply periodic overhauling for rotary and other equipment’s covered under preventive maintenance and overhauling frequency.

![BAPCO 10 Year Forecast Model](image)
Quality Management Plan

- Responsibilities – ensuring quality work for all phases of execution
- Quality target – safe & flawless start-up, zero leaks and reliable run length
- Control procedures – external and internal activities
- Material traceability – records
- Marking and labeling – items dismantled and sent to workshop
- Control of critical activities – e.g. flanged joints, pressure tests etc.
- Test – pressure and radiography including hold points
- Audits – non conformance reports and rectification

SUCCESSFUL TURNAROUND PLANNING WITH NEW PROCEDURES AND STANDARDIZATION

TA QUALITY ASSURANCE PLAN

Purpose
Turn Around Quality Assurance Plan is to control and practice the standard check list formats from Standard maintenance procedures* to ensure that for each maintenance activity required quality checks are maintained, recorded and accepted by all team members.

Covering
- Stationary Equipment's
- Rotary Equipment's
- Electrical Equipment's
- Instrument Equipment's
- Conveyors
- Pipeline and flanges
- Valves etc.

SUCCESSFUL TURNAROUND PLANNING WITH NEW PROCEDURES AND STANDARDIZATION
Turnaround Readiness assessment

The purpose of this Readiness Assessment is to assess the Turnaround preliminary planning activities and work-list basis.

It focuses on the various Turnaround activities that is to be progressed further for detailed planning and scheduling.

Furthermore, the Readiness Assessment confirms the early planning activities and deliverables were timely met, in readiness for detailed planning and scheduling phase.

Results

✓ Safe and successful completion of Turnarounds.
✓ Primavera effectively used
✓ Effective and continuous monitoring of Turnaround budget.
✓ Proper tracking of materials and service contracts.
✓ TA TARA#3 audit conducted by SABIC AMS
✓ All Turnaround KPI’s like duration and budget were achieved.
✓ Leak free start up
✓ Increase in the plant production capacities
✓ Effective planning and scheduling
Conclusion

With effective planning, best turnaround management procedures and practices, proper scheduling and continuous progress monitoring during all the phases turnarounds, can be successfully completed within the scheduled target dates and within the approved budget at highest quality norms.
Successful Turnaround Planning and Execution by New TA Procedures, Standardization of TA Packages and Best Practices
28th
AFA Int’l. Fertilizer Technology
Conference & Exhibition
07 - 09 June 2015 Amman - Jordan

Session 3

ARAB FERTILIZER IMPRESSING
FUTURE SUSTAINABILITY
How rigorously plant modeling can advance your urea business
Turnaround – Planning and Controls

Jasim Haji
Gulf Petrochemical Industries
Bahrain
Introduction

- Established in December 1979.
- Joint-Venture between NOGA, SABIC & PIC.
- Utilizes Natural Gas as raw material.
- Produce: Ammonia, Methanol and Urea.
- Production Capacity: 1.5 million T/A
- Manpower: 572 Employees.
- 95% are Bahrainis.

Introduction

"Your Family Is Expecting you Back... Work Safely"

- Turnaround at GPIC is mainly carried out with an interval of 24 to 30 months.

- Tentatively the next planned Turnaround is to be carried out after 28 months

- Turnaround Objectives:

  "Safely, With High Quality, on Time and Within Approved Budget".
Turnaround 2015

- **3,000+** Jobs were planned & executed during the Turnaround.
- There were **3,100** Contractor personnel available at site during the peak daytime shift of the Turnaround.
- There were **530** Contractor personnel available on site during the peak night shift of the Turnaround.
- The 2015 GPIC turnaround was planned for **24 Days**.

Turnaround 2015

**Number of Contractor Personnel in the Complex**

![Bar chart showing the number of contractor personnel over the course of the turnaround.](chart.png)
Turnaround Planning Roadmap – Initiation

- The Turnaround Roadmap is developed; three (3) months after the completion of previous Turnaround.

- Turnaround Implementation Plan: shows overall Turnaround preparation & Planning programs; in detail, with identified Targets.

- Both the programmes are being updated, periodically against the actual progress status.

- Turnaround Internal Audits, as per Roadmap.
Turnaround Workload (Job List) – Initiation

Basis for defining the Workload are:

- Rolling 10 Years Turnaround Plan
- Major Rotary Equipment overhauling Schedules.
- Statutory as well as GPIC Inspection Schedules.
- Preventive/corrective Maintenance requirements.
- Approved Modifications/Capital Projects.
- Backlog from previous turnarounds

Equivalent to Approximately 90-95% of Our Workload

Turnaround Rolling Plan

<table>
<thead>
<tr>
<th>Year</th>
<th>2015</th>
<th>2017</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example</td>
<td>Description</td>
<td>Example</td>
<td>Description</td>
</tr>
<tr>
<td>1</td>
<td>Example 1</td>
<td>2</td>
<td>Example 2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>2021</th>
<th>2023</th>
<th>2025</th>
</tr>
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<tbody>
<tr>
<td>Example</td>
<td>Description</td>
<td>Example</td>
<td>Description</td>
</tr>
<tr>
<td>1</td>
<td>Example 1</td>
<td>2</td>
<td>Example 2</td>
</tr>
</tbody>
</table>
### Turnaround Master Schedule – Initiation

The turnaround master schedule indicates the maintenance Span as well as Shutdown & Start-up Schedule for each process unit.

![Image](image_url)

### Turnaround Material Strategy – Initiation

<table>
<thead>
<tr>
<th>Item</th>
<th>Class ‘A’</th>
<th>Class ‘B’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria</td>
<td>Items most likely to be used during Turnaround</td>
<td>Contingency requirement, unanticipated need during the Turnaround</td>
</tr>
<tr>
<td>Action</td>
<td>Item is reserved and procurement action taken based on the levels</td>
<td>Items are blocked procurement action only in case required quantities are not available for blocking</td>
</tr>
</tbody>
</table>

![Image](image_url)
**TA Preparation**

![Diagram of TA Preparation process]

**Turnaround Detailed Schedule - Preparation**

- Turnaround Master Schedule
- Critical Path for each Plant
- Activity breakdown schedule for Critical & Major Maintenance Jobs.
- Bar Charts for each job/Equipment
- Schedules submitted by the contractors against Package Contractors or Lump sum Jobs
- Pre-shutdown activities
Turnaround Services Procurement - Preparation

- Identify the services requirements (GPIC Vs. Contractor).
- Develop various types of standard contract documents for:
  - Manpower - *Trade test*.
  - Rental Equipment - *physical verification*
  - Package Contracts - *Site Visits & Meetings*
  - Vendor Services - *CV reviews*
- Prepare, get verified (by all concerned) and issue the contract documents with purchase requisitions (SOW/SRS>PRs).
- Float Enquiries [RFQ] to the potential contractors; as listed in each PR attachment.

Turnaround Services Procurement - Preparation

- Technical Evaluation of quotations received; as a result of floating enquiries.
- Final Recommendations for the award of the contracts.
- Issuance of Purchase Orders.
- Kick-off Meetings.
- Trade Testing / Equipment Physical Verification.
- Resources Mobilization at site.
Turnaround Material Reservation – Preparation

Keeping our materials ready

- Material Reservations for the Long delivery items are done early so that these items are available in Time for Turnaround.
- For Critical Machinery Spares the minimum and the maximum levels are revised in consultation with concerned section. This ensures that one more spare set is available for any contingencies.
- Material Status list is issued, periodically and is updated based on the feedback received from the Stock control section.
- Turnaround Meeting are conducted, issues & concerns are discussed.
- Pre-inspection of critical spares by OEM.

Turnaround Organization - Preparation

- List of Turnaround Area Leaders
- Turnaround Organization Charts:
  - Department Level
  - Area Leader Level
  - Each Package Contract
  - Technician Level; including GPIC Seconded Manpower, Contractor Manpower, Equipment & Vendors.
- Temporary Assignment & Role for each Planning Personnel
- Seconded Manpower List
Turnaround Budget and Cost – Preparation

Budget Estimates - Basis:

- Estimated Cost for the proposed Packages, Vendor services, Foreseen Manpower & Equipment.
- Initial cost estimation for Major & Critical jobs.
- Historical cost for previous Turnaround tasks taking into account a conservative escalation factor.
- PR/PO Routine values for Manpower, Equipment and Vendors.
- PR/PO values for Package Contracts.
- PR/PO values for Direct Use Material Procurement.
- Material (Stock Items & Consumables) reserved against various Orders.

Turnaround Management

TA Strategy  Monitoring & Control  Procedures

Audits  TA Meetings  TA Reports

Initiation  Preparation  Execution  Finalization

Communication & coordination
QC and QA
Progress monitoring and control
Turnaround Variation Control
Turnaround Communication and coordination – Execution

- Turnaround Briefing to GPIC Management as well as to Contractors.
- Turnaround related Memos issuance to various Internal as well as External parties SI-GEN-00-05.
- Assigning extra Supervisors to enhance coordination with contractors and maintenance.
- Detailed Bar Charts (Schedules) distribution to concerned Area Leaders and Operations.
- Turnaround Rules and Guidelines.
- 72 Hours look-ahead schedule.
- SHE, Audit Reports and others (total 23 daily report).
- Daily Meetings (Management, Technical and SHE).

Turnaround Quality Assurance and Control – Execution

- Third (3rd) party Quality Controllers (specialized services) in various disciplines for Critical Equipment.
- Third (3rd) Party Inspectors for Scaffolding activities.
- Special Task Force for Repacking of Critical Valve Glands.
- Included all Critical Joints [Control Valves, PSVs, Flanges and Pumps] in the Critical Joints List.
- Various checklists for Quality control
**Turnaround Progress Monitoring and Control – Execution**

The following are the main techniques utilized for performance analysis:

- Effective use of 72 Hours look-ahead schedule.
- Accurate updating of Actual Progress on daily basis (feedback by Area Leaders, Operations as well as by Planning Field coordinators).
- Daily Monitoring of available Budgets.
- Daily Monitoring of Resources Deployment.
- Control of Variation Orders.
- Highlighting anticipated deviations or slippage from the plan and taking corrective actions to rectify the situation.

The Forms being used for Turnaround Progress Monitoring are:

- Daily Progress Report
- The 72 Hours Look-ahead schedule.
- Management of variation Orders.
- Management of Additional jobs and activities (inspection findings).

---

**Turnaround Variation Control – Execution**

- Predefined Scope of Work; as agreed and specified in POs.
- Deviation from original scope of work/supply.
- Unforeseen activities/Jobs raised as a result of Inspection Findings

Prior GPIC must be obtained (ref: FR-PLN-70-06) for any deviation to the scope defined in the Purchase Order. (SOP-GEN-00-04)
**Turnaround Management**

- **TA Strategy**
- **Monitoring & Control**
- **Procedures**
  - Audits
  - TA Meetings
  - TA Reports
  - Payment to contractors
  - Reports & Actions
  - Lessons Learned & Recom.
  - Technical Closeout

**Turnaround Payments to Contractors – Finalization**

- Invoices verification through 3 levels.
- Creation of Service Entry Sheets (SEs) against job done, verified, accepted.
- POs amendment against approved variation Orders.
- Invoice Status Report regarding Payments made and Balance amount.
- Official Standard letters sent to contractors to confirm receipt of full payment against the job carried out.
Turnaround Reports – Finalization

- Executive Summary Report
- Detailed Turnaround Report:
  - Operation
  - Maintenance
  - Inspection
  - Engineering
  - Safety, Health and Environment
- Technical Reports by:
  - Vendors
  - Package Contractors

Turnaround Recommendations and Lessons Learned – Finalization

Suggestion to improve the current business practices as well as Technical Recommendations

- Feedback by Contractors & Vendors {Ref: FR-PLN-40-07}
- Suggestions made by GPIC staff
- Evaluation Process:
  - Database
  - Department wise segregation
  - Meeting & Discussions
  - Recommendations changes to Suggestion
  - Follow-up for Implementation
  - Progress status updates
Turnaround Technical Closeout – Finalization

Finishing Off

- Return of unused Material to Warehouse.
- Technical Completion [TECO] of all completed Maintenance Orders.
- Technical completion [TECO] of all completed WBS and NETWORKS of Capital Projects.
- Disposal of various types of wastes generated during the Turnaround.
- Preserving removed equipment for at least next cycle.

Thank You,
Case Studies on APC Energy Management

Jasim Haji
Gulf Petrochemical Industries
Bahrain
28th AFA Int’l. Fertilizer Technology Conference: Amman, Jordan

Contents

- Brief on APC
- APC Energy Management Committee
- Electricity and Fuel Prices
- Cost Reduction Through Lean Six Sigma
- Opportunity Log
- Quick Wins

Case Studies on APC Energy Management

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28th AFA Int’l. Fertilizer Technology Conference: Amman, Jordan

Brief on APC

- One of the world producers of potash (KCl).
- Plants are located in Jordan, about 120 km south-west of Amman, south of the Dead Sea.
- The brine (or the water of the Dead Sea) forms the raw material for producing potash in APC.
- APC produces competitive potash (KCl) with different particle sizes (fine, standard, & granular), and industrial potash via 4 production lines.

Case Studies on APC Energy Management
APC Energy Management Committee

- Formed in April, 2012.
- Opportunities, technical studies, recommendations for improvement.
- Team members were selected from different work areas and different specialties in APC.
- Training:
  - All team members attended Energy Auditing training course.
  - Team Leader attended the following training courses:
    - Energy Auditing
    - Certified Energy Manager
    - Lean Six Sigma
APC Energy Management Committee

- Partnership between APC Energy Management Committee and AFA Energy Saving Committee:
  - Establishing Energy Saving Culture
  - Establishing Energy Management Information System
  - Establishing Energy Saving Training and Competencies Matrix
  - Establishing Monitoring & Targeting Criteria
  - Establishing own audit and AFA consolidated audit

Electricity and Fuel Prices
Average Electricity Price for APC:

<table>
<thead>
<tr>
<th>Year</th>
<th>Price (JD/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>58</td>
</tr>
<tr>
<td>2007</td>
<td>72</td>
</tr>
<tr>
<td>2008</td>
<td>210</td>
</tr>
<tr>
<td>2009</td>
<td>225</td>
</tr>
<tr>
<td>2010</td>
<td>225</td>
</tr>
<tr>
<td>2011</td>
<td>254</td>
</tr>
<tr>
<td>2012</td>
<td>246</td>
</tr>
</tbody>
</table>

Electricity Price for APC:

<table>
<thead>
<tr>
<th>Period</th>
<th>Price (JD/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Night</td>
<td>11:00 PM – 07:00 AM</td>
</tr>
<tr>
<td>Day</td>
<td>07:00 AM – 11:00 PM</td>
</tr>
<tr>
<td>Average Price</td>
<td>246</td>
</tr>
</tbody>
</table>

Peak Period Penalty = 2.98 JD/kW/month for the maximum monthly load. The maximum monthly load is the maximum value of the average load per half an hour measured in kW during the peak period.
Cost Reduction Through Lean Approach:

**Lean** is defined as a set of principles, concepts, and techniques aimed at continuously eliminating waste in any process.

**Lean Principles:**
- Identify and focus on value (customer view)
- Identify value stream & eliminate waste
- Get value to flow without interruptions
- Let the customer pull value
- Do it continuously

---

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Cost Reduction Through Lean Approach:

**Types of Waste:**

1. Transportation
2. Inventory
3. Motion
4. Waiting
5. Over production
6. Over processing
7. Defects
Cost Reduction Through Lean Six Sigma:

**Six Sigma**: is a methodology that uses statistical analysis to measure and improve operational performance by identifying and eliminating "defects" in any process.
Cost Reduction Through Lean Six Sigma:

- Process Flow Diagram.
- SIPOC Analysis & Critiques.
- Availability and accuracy of the daily energy & water consumptions.
- Baselines and planned values for the energy & water consumptions.

SIPOC Analysis and Critiques:
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Cost Reduction Through Lean Six Sigma:

- Process Flow Diagram.
- SIPOC Analysis & Critiques.
- Availability and accuracy of the daily energy & water consumptions.
- Baselines and planned values for the energy & water consumptions.

SIPROC Analysis and Critiques:
Energy & Water Meters:

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1</td>
<td>0101</td>
<td>123</td>
<td>456</td>
<td>789</td>
<td>123</td>
<td>456</td>
<td>789</td>
</tr>
<tr>
<td>Site 2</td>
<td>0202</td>
<td>123</td>
<td>456</td>
<td>789</td>
<td>123</td>
<td>456</td>
<td>789</td>
</tr>
<tr>
<td>Site 3</td>
<td>0303</td>
<td>123</td>
<td>456</td>
<td>789</td>
<td>123</td>
<td>456</td>
<td>789</td>
</tr>
</tbody>
</table>

Case Studies on APC Energy Management

Opportunity Log:

Case Studies on APC Energy Management
## Opportunity Log:

<table>
<thead>
<tr>
<th>No.</th>
<th>Quick Win</th>
<th>Action Requested</th>
<th>Opportunity Searcher</th>
<th>Impact JOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>All Plants</td>
<td>Nutrient recovery</td>
<td>Reduce by 10%</td>
<td>100,000</td>
</tr>
<tr>
<td>2</td>
<td>HRD</td>
<td>Reduce by 10%</td>
<td>Reduce by 10%</td>
<td>20,000</td>
</tr>
<tr>
<td>3</td>
<td>Power Plant</td>
<td>Implement measures to reduce</td>
<td>Reduce by 10%</td>
<td>100,000</td>
</tr>
</tbody>
</table>

**Total Annual Saving = 65 million JOD**
Next Step: Energy Management System (EnMS ISO 50001:2011)

This International Standard (ISO 50001: 2011) specifies requirements for establishing, implementing, maintaining and improving an energy management system, whose purpose is to enable an organization to follow a systematic approach in achieving continual improvement of energy performance, including energy efficiency, energy use and consumption.

- Continual improvement
- Energy policy
- Energy planning
- Implementation and operation
- Monitoring, measurement and analysis
- Internal audit of the EnMS
- Nonconformities correction, corrective and preventive action

Figure 1 — Energy management system model for this International Standard.

<table>
<thead>
<tr>
<th>#</th>
<th>Phase 1</th>
<th>Phase 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Survey &amp; Assessment</td>
<td>Energy Audits &amp; Assessments</td>
</tr>
<tr>
<td>2</td>
<td>Energy Efficiency Action Plan</td>
<td>Energy Management Plan</td>
</tr>
<tr>
<td>3</td>
<td>Energy Management System Implementation</td>
<td>Energy Management System Review</td>
</tr>
<tr>
<td>4</td>
<td>Continuous Improvement</td>
<td>Energy Management System Implementation</td>
</tr>
<tr>
<td>5</td>
<td>Reporting &amp; Communication</td>
<td>Energy Management System Review</td>
</tr>
<tr>
<td>6</td>
<td>Monitoring &amp; Evaluation</td>
<td>Communication &amp; Training</td>
</tr>
<tr>
<td>7</td>
<td>Compliance &amp; Audit</td>
<td>Energy Management System Review</td>
</tr>
</tbody>
</table>

Case Studies on APC Energy Management

Thank You
Oil Degradation in Rotating Equipment

Alain Henrad
EFC
Belgium
Content

- Introduction EFC nv
- Factors causing oil degradation
  - Particles
  - Water
  - Temperature
- Solutions for Better Reliability

Introduction EFC NV

- Single Source partner for:
  - Air filtration (Air Intake Turbines,...)
  - Liquid filtration (Water, chemicals,...)
  - Gas filtration
  - Mist Eliminators (Atephos Fiber bed)
  - Oil / Hydraulic Filtration (Turbine Lube Oil Systems,...)
Importance Oil Management

High capital investment / Turbines,...
Critical applications / Production

Sources oil degradation
3 main sources

- 1: PARTICLES (silica, metals,...) : PRESENCE / QUANTITY (friction rotating equipment,...)
- 2: WATER / MOISTURE (leaks, condensation,...)
- 3: HIGH TEMPERATURES (process hot spots)
OIL OXIDATION

OIL DEGRADATION

COMPONENT FAILURES

PRODUCTION LOSS...

1: PARTICLES
New Oil could look like this ...)
(scale : 10μm)

www.efc-belgium.be
About Particle Growth

- MPW : Particle Weight, 0,8μm patch < 20mg/kg(ltr)
- ISO : General Cleanliness Codification
- Specifications Cleanliness :
  - Hydraulics servo control : < ISO 14/12/10
  - Lubrication Turbines, Compressors : < ISO 17/15/12
  - => ISO class reduction = Component life increase!
### Fluid contamination under control...

with Innovative filtration products, support, and solutions

#### Particle Size

<table>
<thead>
<tr>
<th>Size</th>
<th>Particles per milliliter</th>
<th>ISO 4406 Code range</th>
<th>ISO Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>4μm</td>
<td>151773</td>
<td>80000~150000</td>
<td>24</td>
</tr>
<tr>
<td>6μm</td>
<td>38363</td>
<td>20000~40000</td>
<td>22</td>
</tr>
<tr>
<td>10μm</td>
<td>8229</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14μm</td>
<td>3339</td>
<td>2500~5000</td>
<td>19</td>
</tr>
<tr>
<td>21μm</td>
<td>1048</td>
<td></td>
<td></td>
</tr>
<tr>
<td>38μm</td>
<td>112</td>
<td></td>
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</tr>
</tbody>
</table>

#### Particle Size

<table>
<thead>
<tr>
<th>Size</th>
<th>Particles per milliliter</th>
<th>ISO 4406 Code range</th>
<th>ISO Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>4μm</td>
<td>492</td>
<td>320~640</td>
<td>16</td>
</tr>
<tr>
<td>6μm</td>
<td>149</td>
<td>80~180</td>
<td>14</td>
</tr>
<tr>
<td>10μm</td>
<td>41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14μm</td>
<td>15</td>
<td>10~20</td>
<td>11</td>
</tr>
<tr>
<td>21μm</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>38μm</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

### 2: Water / Moisture

- Dissolved => Emulsified => Free

- Water level max for system < 200ppm
- Saturation < 30%
## Water influence on bearing life

(0.05% = 500ppm)

Effect of water in oil on bearing life (based on 100% life at .01% water in oil.)

<table>
<thead>
<tr>
<th>% Water in Oil</th>
<th>Appearance Normal (Dissolved Water)</th>
<th>Appearance Cloudy (Free Water)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0025</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>0.01</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>0.05</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>0.1</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>0.15</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>0.25</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>0.50</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>


---

## 3: High Temperature

- Dependent on installations
- Hot Spots: Turbo compressors > 100°C
- Oil Reservoirs < 60°C
Oil Degradation Effects

- Contamination + T° = Oil Additive Depletion
- Creation of by-products (soluble – insoluble)
- Varnish deposits
- Productions issues
SOLUTIONS...

- **Oil Analysis** => Define actions
- **Particle Control** => Stress Resistant Elements,…
- **Water Control** => Vacuum Dehydrators,…
- **Varnish Control** => Specific Turbine Media + Ion Exchange Bounding = Soluble & Insoluble fractions control.

---

Oil analysis report should contain:

- ISO particle count (APC or visual)
- Comments on particle types : silica, type metals,…
- Water concentration (ppm or %)
- MPC (varnish potential) < 10
- TAN (acid level) < 0,4
- Viscosity

- Technical recommendations, actions to be taken
SOLUTIONS...

- **Oil Analysis** => Define actions
- **Particle Control** => Stress Resistant Elements,…
- **Water Control** => Vacuum Dehydrators,…
- **Varnish Control** => Specific Turbine Media + Ion Exchange Bonding = Soluble & Insoluble fractions control.

Oil analysis report should contain:

- ISO particle count (APC or visual)
- Comments on particle types: silica, type metals,…
- Water concentration (ppm or %)
- MPC (varnish potential) < 10
- TAN (acid level) < 0,4
- Viscosity

- Technical recommendations, actions to be taken
Particle Control

- Designed and tested to outperform original
- Cleaner Oil (better performance)
- DFE rated (high stress resistance)
Mobile or Fixed Skid
Removes Free AND Dissolved water
System Range 6 LPM - 230 LPM
Oil Volume Tank : > 50,000 L
Reduce Water content :
5000 ppm => 100 ppm less 20 hr
ATEX Equipment possible

Varnish Control

VTM  Removing Insoluble fractions > 0,8 micron

ICB Removing Soluble Oxidation Bi-Products
**BENEFITS…**

- Avoid oil replacement ($10,000 => $100,000…)
- Avoid component replacement ($5,000 => $50,000…)
- Decrease maintenance costs
- Avoid Production lost

**Varnish control = $50,000 Benefit**

*Gas Turbine (20,000L)*

![Graph showing varnish control over time](www.efc-belgium.be)
Thank You!
Failure of Primary Shift Effluent W/H Exchanger (103-C) – Case study of HTHA

Muhammad Nasir Abbas
Al-Jubail Fertilizer Company (Al-Bayroni)
Saudi Arabia
Failure of Primary Shift Effluent W/H Exchanger (103-C) – Case study of HTHA
28th AFA Int’l. Fertilizer Technology Conference: Amman, Jordan

**Contents**

- Facility Introduction
- Process Description
- Failure Event
- Inspection Findings with Pictures
- Repairs with Pictures
- Root Cause Analysis (RCA)
  - Timeline
  - Possible Causes
  - Outcome
  - Recommendations
- Discussion on High Temperature Hydrogen Attack (HTHA)
- Follow-up Actions
- Lesson Learned
- References

---

**Facility Introduction**

Al-Jubail Fertilizer Company (Al-Bayroni) is SABIC affiliate formed in 1979 by a 50/50 joint venture with Taiwan Fertilizer Company (TFC).

It is situated in the Al-Jubail Industrial City in Eastern Province of Saudi Arabia with coordinates 27°3′54″N 49°33′30″E and comprises of Fertilizer & Petrochemical complexes. Main products are Ammonia, Urea, 2-Ethyl Hexanol (2-EH) & Di-Oxyle Phthalate (DOP).

Fertilizer Complex comprises of Ammonia Plant, Urea Plant and associated utilities. This case study relates to Ammonia Plant, which is Pullman Kellogg design Plant having current rated capacity of 1300 Metric Ton per Day.
28th AFA Int’l. Fertilizer Technology Conference: Amman, Jordan

Process Description

To convert unwanted CO to CO₂ in Process Gas coming from Reforming Section, Shift Conversion Reactors (High Temperature Shift Converter 104-DA & Low Temperature Shift Converter 104-DB) are installed in series.

As both Shift Reactors operate at different temperatures, Primary Shift Effluent/BFW Heat Exchanger 103-C is installed at outlet of 104-DA to reduce temperature of process gas from 431°C to 333°C at 27.8 bar(g). Methanator Feed Heater 104-C receives this process gas & further reduces the temperature to 237°C before inlet to 104-DA.

This heat is exchanged by Boiler Feed Water coming from 101-F at 288°C and exiting at 314°C at 110 bar(g).
Failure Event

Location: Ammonia Plant, Shift Conversion Section
Primary Shift Effluent Waste Heat Exchanger (103-C)

Date: 18th April, 2012

Description: On 18-April-2012 Night shift; Ammonia Plant Field Operator reported “Fumes/Smoke” from inlet channel of Primary Shift Effluent/BFW Heat Exchanger (103-C).

In Morning shift of 19th April-2012, insulation of the inlet channel was removed & it was confirmed that the leakage was from weld joint of inlet channel (Nozzle T1) reinforcement pad.

Ammonia Plant was shut down at 1400 Hours, due to this leakage.

Failure of Primary Shift Effluent W/H Exchanger (103-C) – Case study of HTFA
Location of the visible Crack

Visible crack found along reinforcing pad-to-channel weld
More than 85% of Nozzle-to-Channel weld found cracked

Failure of Primary Shift Effluent W/H Exchanger (103-C) – Case study of HTHA

Repairs

Inlet channel was removed and shifted to ASME approved workshop for repairs.

After removal of RF pad, during PT nozzle to channel weld joint was found cracked for more than 85% circumference. Complete removal & redoing was carried out as per ASME Al & Al-Bayroni Inspector recommendation.

After carrying out repairs & NDT on the inlet channel of 103-C as per ASME code, exchanger was boxed-up and tube side hydrostatic pressure test was conducted at 33 bar(g) and approved by authorized ASME inspector for R-stamp.

The exchanger was then taken in service at Ammonia plant startup.

Failure of Primary Shift Effluent W/H Exchanger (103-C) – Case study of HTHA
UT inspection after repair of Reinforcing Pad welding joint

Inlet Channel Head after repairs & Inspections
103-C with repaired Inlet Channel, taken in Service

Failure of Primary Shift Effluent W/H Exchanger (103-C) – Case study of HTHA
RCA - Possible Failure Causes

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Possible Causes</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operations / Process</td>
<td>Higher velocities / Vibrations at inlet channel</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Higher inlet temperatures than design of 446 ºC</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Natural gas flow interruption</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Under design w.r.t 2002 debottlenecking</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Material / Mechanical Design</td>
<td>Unsuitable material of construction, as per API 941 – 1990 &amp; Later Editions</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Design deficiency of TV-10 affecting 103-C</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Piping stresses &amp; piping supports</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Mechanical / Inspection</td>
<td>Mishandling during maintenance activities</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Welding failure</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Defective fabrication</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prolonged operation in high temperature hydrogen service</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Instrument</td>
<td>Malfunction of FC-1</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

RCA Outcome

Following were identified the Root & contributing causes, after extensive data review, evaluation and consultations with subject matter experts.

Root Cause:
Non-suitable material for high temperature hydrogen service

Contributing Cause:
Prolonged exposure to hydrogen service >350 ºC
RCA Recommendations

<table>
<thead>
<tr>
<th>Sr.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Replacing the exchanger with upgraded materials and current design details and standards as already in service since 30 year.</td>
</tr>
<tr>
<td>2</td>
<td>Ammonia Plant survey need to be done for the equipment/piping in operation for Hydrogen service with material of construction 0.5 Mo Steel and assess for acceptance or replacement and develop plan accordingly.</td>
</tr>
<tr>
<td>3</td>
<td>Conduct piping stress analysis for 103-C inlet line from 104-DA and implement the outcome recommendation. Implement all the recommendations of piping stress analysis.</td>
</tr>
</tbody>
</table>

Discussion on High Temperature Hydrogen Attack (HTHA)

**Description:** High temperature hydrogen attack results from exposure to hydrogen at elevated temperatures and pressures. Hydrogen reacts with carbides in steel to form Methane (CH₄) which cannot diffuse through the steel. The loss of carbide causes an overall loss in strength. Methane pressure builds up, forming bubbles or cavities, micro-fissures and fissures that may combine to form cracks.

**Material Selection:** Temperature & Hydrogen Partial Pressure

**Affected Material:** In order of increasing resistance: Carbon Steel, C-0.5Mo, Mn-0.5Mo, 1Cr-0.5Mo, 1.25Cr-0.5Mo, 2.25Cr-1Mo, 2.25Cr-1Mo-V, 3Cr-1Mo, 5Cr-0.5Mo and similar steels with variations in chemistry.

**Forms:** Surface Decarburization, Internal Decarburization and Fissuring.
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Discussion on High Temperature Hydrogen Attack (HTHA)

Factors Influencing HTHT: Incubation Time, Primary Stresses, Secondary Stresses, Heat Treatment & Stainless Steel Cladding or Weld Overlay

Guidance for C-0.5Mo:

“As a result of the problems with the 0.5 Mo alloy steels, its curve has been removed from the main set of curves and the material is not recommended for new construction in hot hydrogen services.

For existing equipment, this concern has prompted an economic review of inspection cost versus replacement with a more suitable alloy.

Inspection is very difficult because problems have occurred in weld heat affected zones as well as base metal away from welds.”

API-571 (2nd Ed.), para 5.1.3.1.6 (d)

Follow-up Actions:

Replacement of 103-C with improved metallurgy, as per API-941.

Improved Action plan with more focus on vulnerable equipment.

Evaluation of all Ammonia Plant Equipment & Piping of CS-0.5%Mo MOC

- No piping found with MOC of CS-0.5%Mo
- Following equipment found with MOC of CS-0.5%Mo and were evaluated based on API-941 latest standard and the results are as follows:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>H₂ Service</th>
<th>Safe?</th>
<th>Planned?</th>
</tr>
</thead>
<tbody>
<tr>
<td>104-DA, HTS Converter</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>105-D, Methanator</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>108-D, Zinc Oxide Guard Chamber</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>160-D, Hydrotreater</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
Lesson Learned

To keep-up with technology development in the field of Design Changes, Maintenance and Operability.

References:

3. 103-C Root Cause Analysis (RCA) Report by Al-Bayroni
4. 103-C Inspection Reports by Al-Bayroni
Session 4

ARAB FERTILIZER IMPRESSING FUTURE SUSTAINABILITY
How rigorously plant modeling can advance your urea business
Phosphogypsum Utilization In China and Economic Analysis

Liu Bo
ECEC
China
Phosphogypsum Utilization In China and Economic Analysis
Contents

1. PG Stacking in China
2. PG Applications
3. Block Process Flow Sheet
4. Operation Cost Estimated
5. Reference Plants

<table>
<thead>
<tr>
<th>Year</th>
<th>Production Capacities of Phosphate Fertilizer (P₂O₅, 100%, Mt)</th>
<th>PG Produced (Mt)</th>
<th>Utilization Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>8.2</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>9.92</td>
<td>48</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>9.48</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>10.62</td>
<td>52</td>
<td>20.87</td>
</tr>
<tr>
<td>2010</td>
<td>13.02</td>
<td>62</td>
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<td>2011</td>
<td>14.13</td>
<td>68</td>
<td>23.53</td>
</tr>
<tr>
<td>2012</td>
<td>14.89</td>
<td>70</td>
<td>24.58</td>
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<td>2013</td>
<td>15.0</td>
<td>70</td>
<td>27.40</td>
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<tr>
<td>2014</td>
<td>19.02</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td></td>
<td>115.3</td>
<td>545</td>
<td></td>
</tr>
</tbody>
</table>
3. Block Process Flow Sheet

**Fig. 2 Block Process Flow Sheet for Cement Retarder**

- Lime
- Washing water to Air
- PG (Dihydrate)
- Fuel Coal
- Drying
- Mixing
- Granulation
- Storage
- Retarder Product
- Ash

---

**Fig. 3 Ammonium Sulfate Block Process Flow Sheet**

- Carbonation
- Scrubbing
- To Air
- Reactions
- Filtration
- Curdulation
- Evaporation & Crystalization
- Separation
- Drying
- Final Product
- Recycled Liquor
- Washing water
- Mother Liquid
- PG
- Calcium Carbonate

---

Phosphogypsum Utilization In China and Economic Analysis
4. Operation Cost Estimated

Sulfuric Acid Cost

- Sulfuric Acid Manufacture
- Price Variation
- Market Trends

Cement Retarder Cost

- Raw Materials: 1st (fuel and power), 2nd (labor of workers), 3rd (manufacturing cost), 4th (production cost), 5th (additional charges)
- Total Cost: 100,000
4. Operation Cost Estimated

Ammonium Sulfate Production

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>64.13</td>
<td>25.24</td>
<td>0.16</td>
<td>6.54</td>
<td>0.48</td>
<td>84.76</td>
<td>15.24</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Ammonium sulfate Cost

Phosphogypsum Utilization in China and Economic Analysis

Page 10

5. Reference Plants

SA and Cement Plant
Lubel Group

Phosphogypsum Utilization in China and Economic Analysis

Page 11
5. Reference Plants

SA and Cement Plant
Calcination
Lubei Group

SA and Cement Plant
Drying & Absorption
Lubei Group
5. Reference Plants

SA and Cement Plant
Silos in Prehomogenization
Lubei Group

Cement Retarder Plant
Guixi, 200 kta/a
5. Reference Plants

Cement Retarder Plant
Granulation Unit
600 kt/a

Ammonium Sulfate Plant
PG Purification & AS Filtration
Wenfu Group
THANKS
More value out of your plant
Know-how
Integrated technologies
Advances services

Jean François Granger
CASALE SA
Switzerland
More value out of your plant
Know-how
Integrated technologies
Advances services

IN HARMONY
WITH YOUR NEEDS

CORE COMPETENCIES

Casale is a global supplier of technologies & engineering solutions
CASALE ENHANCES ITS TECHNOLOGICAL PORTFOLIO

2013: Casale acquires Borealis’ HP Melamine technology

2014: Casale acquires Borealis’ (GPN) Nitrate, Phosphates and Complex fertilizer technologies

NITRATES, PHOSPHATES AND COMPLEX FERTILIZERS

Nitric acid
Ammonium nitrate: Solution, UAN, solid, CAN
Phosphate: SSP, TSP
Complex fertilizers: DAP, NP/NPK
CASALE ENHANCES ITS TECHNOLOGICAL PORTFOLIO

Acquisition includes:

- Collaboration with Borealis for further technology development
- Full support, incl. personnel, during technology transfer

TECHNOLOGICAL PORTFOLIO

AMMONIA  NITRATES & PHOSPHATES  UREA  MELAMINE  METHANOL  SYNGAS
CASALE NITRIC ACID PROCESS

In 2014 Casale acquired the technology of Nitric Acid production by mono & dual pressure process developed in the 1950’s by Grande Paroisse

Continuous improvements have concerned

- efficiency (both Ammonia consumption and energy)
- environment,
- safety.

CASALE
CASALE NITRIC ACID PROCESS

Capacity range

✓ First Nitric Acid plant  Frais Marais (France) designed by Grande Paroisse (1958). Capacity 160 MTPD.
✓ Largest one (1986)  Yara Sluiskil site (The Netherlands) capacity over 2000 MTPD.
✓ Largest single burner (2007)  NZR1 Varpalotta site (Hungary) name plate capacity over 1500 MTPD, debottlenecked to 1800 MTPD
✓ Borealis Operation  6 plants  3 dual pressure  3 mono pressure including duplication of NZR1 plant
✓ Design  78 plants 25% mono pressure from 35 to 900 MTPD in 8 countries 75% dual pressure from 80 to 2000 MTPD in 30 countries
CASALE NITRIC ACID PROCESS  

- Improvements = loss reductions  
  = pressure drop reductions  
- Achieved through collaboration  
  ➢ Licensor  
  ➢ Engineering  
  ➢ Clients  

Export > 700 kg/MT HNO3

CASALE NITRIC ACID PROCESS

- Successfully commissioned in May-June 2007  
- Performances exceeded  
- Plant operates smoothly  
- Duplicated in France with commissioning in 2010  
- Debottlenecked
CASALE Ammonium Nitrate Solution Processes

Conventional Process

- P~ 4 bars g 78%
- P~ ?? 90-95 %
- P~ Atmos 80-85 %

CASALE PIPE REACTOR PROCESS

Main features

- Atmospheric
- Proper mixing is ensured through the Pipe Reactor itself
- Nitric acid is added along with the ammonia without any recycling
CASALE PIPE REACTOR PROCESS ADVANTAGES

<table>
<thead>
<tr>
<th>Category</th>
<th>Advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw materials</td>
<td>Pipe Reactor</td>
</tr>
<tr>
<td>Downstream uses</td>
<td>Pipe Reactor</td>
</tr>
<tr>
<td>Safety</td>
<td>Pipe Reactor</td>
</tr>
<tr>
<td>Environmental issues</td>
<td>Pipe Reactor</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Pipe Reactor</td>
</tr>
<tr>
<td>Ease to operate</td>
<td>Pipe Reactor</td>
</tr>
<tr>
<td>Investment cost</td>
<td>Pipe Reactor</td>
</tr>
<tr>
<td>Energy consumption</td>
<td>Pipe Reactor</td>
</tr>
</tbody>
</table>

Except in case of re-use of off-gases, Casale considers the Pipe Reactor Process as the best according to all criteria.

CASALE UAN PROCESS

- AMMONIUM NITRATE SOLUTION PLANT
- NITRIC ACID PLANT
- UAN PLANT
- UREA PLANT
The first GPR was designed in 1970
The first DPR was designed in 1974

In 1976 GP AZF
designed two of its own NPK plants
without preneutralizer
for the first time.

<table>
<thead>
<tr>
<th>RECYCLE RATIOS &amp; FUEL CONSUMPTIONS (kg/MT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPR</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>DAP : 5+1</td>
</tr>
<tr>
<td>10-26-26 : 3+1</td>
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<tr>
<td>12-32-16 : 3.5+1</td>
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CASALE NPK PIPE REACTOR PROCESS

FLEXIBILITY IN PIPE REACTOR TECHNOLOGY

- DUAL PIPE REACTOR SYSTEM (DPR & GPR)
- DRYER PIPE REACTOR SYSTEM (DPR)
- GRANULATOR PIPE REACTOR SYSTEM (GPR)

---

CASALE NPK PIPE REACTOR PROCESS

EXAMPLE OF GRADES PRODUCED IN GRANDE PAROISSE PLANT

<table>
<thead>
<tr>
<th></th>
<th>Time</th>
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<td>15:09:24</td>
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<td>06:15:30</td>
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<td>15:10:25</td>
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**CASALE NPK PIPE REACTOR PROCESS**

**EXAMPLE OF GRADES PRODUCED IN GRANDE PAROISSE PLANT**

<table>
<thead>
<tr>
<th></th>
<th>16:08:24</th>
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<td>52</td>
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<td>20:11:18</td>
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<tr>
<td>66</td>
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<td>20:12:00 S</td>
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<td>67</td>
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<tr>
<td>68</td>
<td>18:46:00</td>
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</table>

S: WITH AMMONIUM SULPHATE  MG: WITH MAGNESIUM SK: WITH POTASSIUM SULPHATE  B: BORON

---

**COMPLETE RANGE OF SERVICES**

Casale Service Process

- Pre-project
- Project
- Customer Care

AMMONIA  NITRATES AND PHOSPHATES  UREA
MELAMINE  METHANOL  SYNGAS
MAKING A DIFFERENCE IS WHAT MAKES US DIFFERENT

THANK YOU IN HARMONY WITH YOUR NEEDS
Safety Task Force as tool to improve adhesion and positive behavior in the Gantour Mining Site.

Salaheddine KNOUZI
OCP SA
Morocco
Safety Task Force as tool to improve adhesion and positive behavior in the Gantour Mining Site.
1-1 OCP OVERVIEW:

[Map of OCP Group in Morocco]

- Main sites of OCP Group in Morocco
- Atlantic Ocean
- Spain
- Algeria
- Morocco
- Mauritania
- Offshore

[Map of OCP offices around the world]
Safety Task Force as tool to improve adhesion and positive behavior in the Gantour Mining Site.
1-2 GANTOUR SITE:

Historical View

- 1931: Starting up the underground extraction of white phosphates at Youssoufia with Solar drying;
- 1935: Drying in 4 rotary ovens dryers (Drying phosphates by using 4 rotary ovens that working with coal thermal power);
- 1965: Introduction of the mechanization in the underground mining and starting up drying by FUEL (8 ovens);
- 1968: Use of natural gas in stead of fuel to the drying plant;
- 1974: Starting up underground mining of black phosphates;
- 1978: 1st calcination unit (UC1) for black phosphates treatment;
- 1980: Starting up open pit mining at Benguerir;
- 1985: Three additional calcination (UC2, UC3 and UC4);
- 1988: Starting up open pit mining at Bouchane;
- 1999: Realization of unloading trains station at calcination units
- 2000: ISO 9001 for processing plant in Youssoufia
- 2002: Benguerir mine was TPM awarded by JIPM
- 2004: Starting up open pit mining at Youssoufia
- 2004: Bouchane mine TPM awarded by JIPM
- 2005: Stopping the underground mining of black phosphates at Youssoufia
- 2005: Starting up of two washing units
- 2007: Benguerir and Bouchane mines awarded by JIPM
- 2008: Starting up of the 3rd washing unit
- 2010: Starting up mining in MZINDA
Safety Task Force as tool to improve adhesion and positive behavior in the Gantour Mining Site.
3-SAFETY TASKFORCE PROJECT

Objective

- Washing plant: an exemplary unit with SHE excellence
- Visible/visual change on field
- Taskforce team to be SHE experts

Main actions

Opérationnel/governance standards
- Accelerating Deployment of Operational & governance standards

Structure
- Creation of VOSM at EXOMS
- Review of manager’s SPAC (schedule)
- Solving structural and organizational issues after the deployment of SHE standard
- Establishing taskforce team schedules

Behavior and Competencies/skills
- Training standard operation: how to learn to be SHE experts ...
- Safety rules enforcement
- Culture change workshops
- Communication
- Field coaching and communication by managers

3-SAFETY TASKFORCE PROJECT

Project coordination

- Steering meetings: daily Check-in/out, weekly review, steering committee;
- Construction of weekly schedule of TFS members and washing plant managers;
- Following up and reporting daily and weekly schedules progress
- Saving up project data: updating dashboards, verification of standards output, reporting deployment problems and difficulties
- Following up and sharing TFS members performances
- Coordination and consultants’ evaluation

Safety Task Force as tool to improve adhesion and positive behavior in the Gantour Mining Site.
3-SAFETY TASKFORCE PROJECT

CULTURE CHANGE: EXEMPLARITY, COMMITMENT AND WORKERS IMPLICATION

- Workshops about Safety culture
  - Communication sessions
  - Definition of Washing plant Safety rules
  - Deployment steering

- Coaching and training on field by managers and consultants

- Training on safety and operational standards

- Reinforcing safety dialogue on site: VOSES, steering committee...

Commitment and implication of managers:
- Prioritization HSE back log execution
- Solving irritating problems
- Actions plans execution: ADRPT, PPE, Confined spaces...
- Reviewing scheduled shutdown preparations procedures...

3-SAFETY TASKFORCE PROJECT

GIASE/ VOSE/... 

- Coaching on safety dialogue rules and SHE leadership
- Training TFS members on VOSE & GIASE
- Workshops on safety culture and behavior change

VOSES: Unsatisfactory realization rate
GIASE: Investigation and analysis of incidents and accidents by managers and collaborators.

- VOSE: Improvement of realizations rates and dialogue quality
- GIASE: Improvement of Analysis quality

Setting up safety rituals: Safety point, weekly HSE performances meetings, prioritizing HSE back log execution...
3-SAFETY TASKFORCE PROJECT

2. RISK/Hazard analysis standard
- Reviewing scheduled shutdowns preparation procedures:
- Developing procedures for approbation and execution of operating manuals and actions plans
- Training workers on operating manuals and displaying them on work stations
- Execution action plan
- Reviewing activities’ splitting
- Training workers on standard
- Hazard analysis and elaboration of operating manuals and actions plans
- Training TFS members
- Splitting activities into work stations and operations
- Coaching

3. Lock out and Tag out : History of change
- Audits
- Communication and safety culture workshops and meetings
- Rule
- lock = life
- Full application of Lock and tag standard:
- Establishing energy flow sheet including the stored energy, application of stablished separation plans, tag out, verification...
- Elaboration isolation plans
- Provision lockout equipment and devices
- Training collaborators and subcontractors
- Establishing energy flow sheets
- Training TFS members, establishing master plan
- Lockout electrical energy only

Safety Task Force as tool to improve adhesion and positive behavior in the Gantour Mining Site.
3-SAFETY TASKFORCE PROJECT

PPE & SAFETY Display

- Starting display project
- Setting a temporary SHE display according to hazards analysis
- Setting a standardized HSE display according to the chart and Risk/hazard analysis
- Initial Diagnostic of safety display on washing plant
- Definition of display content: circulation plan, separation panel...

Inadequate safety messages on the panel with their position

Display chart

Training TaskForce team on display standards
Display chart development

3-SAFETY TASKFORCE PROJECT

Personal protective equipment

- Selection, for each operation, the appropriate PPEs according to the hazard analysis: Construction of PPEs matrix
- Provision of identified PPEs

Selection of PPEs for each task/workstations

- Displaying and communication of PPEs matrix
- Training the stuff on how to use specific and category III PPEs

Training workers on PPE
- Establishing PPE data base: For every PPE, its contained types, specification, standard

Training TFS members

PPEs data base

Awareness on basic and specific PPEs
3-SAFETY TASKFORCE PROJECT

Confined spaces standard

- Holding Preparation meeting a day before between process engineer, operations responsible and S&H animator to set penetration permit’s requirements: rescue procedures, lock out plan, operating manuals...
- Coordination with occupational rescue team

- Sharing the penetration permit with all operators
- Verification and validation of confined spaces penetration permit before the beginning of operations

- Establishing confined space penetration’s permit slightly before the maintenance task

3-SAFETY TASKFORCE PROJECT

Subcontractors management and traffic

- Establishing access’s permit for subcontractors
- Training subcontractors on OCP HSE’ standards and procedures
- Regular audit and on site safety’ awareness
- Realizing a subcontractors audit
- Implementation of Subcontractors management standard

- Elaboration of traffic plans
- Building parking
- Updating traffic signs

- Updating visitors and subcontractors safety debriefing/awareness
4- ILLUSTRATIONS/ACHIEVEMENTS

CULTURE CHANGE: EXEMPLARITY, COMMITMENT AND COLLABORATORS IMPLICATION

Visible Commitment of management:
- Prioritization the treatment of Safety anomalies
- Solving irritating problems
- Action plan execution: ADAPT, PPE, Confined spaces
- Reviewing scheduled shutdowns procedures

Workshops about safety culture change
- Communication sessions
- Definition of washing plant safety rules
- Steering

Team building/workshop
Learning by doing

Training on safety and operational standards

Coaching and training on field by managers and consultants

Strengthening safety dialogue on field: VSDES, EVPS...

4- ILLUSTRATIONS/ACHIEVEMENTS

SECURITY RULES IN THE BENEFICIATION PLANT

- Reverse parking is mandatory
- Use zebra crossing while crossing roads
- Seat belts must be buckled up at all times
- Hold on to the handrail
- No hand held cell phone use while driving
- No personal vehicle use on site
- Basic Personal protection equipment must be worn at all times
- Specific personal protective equipment related to a specific task or zone are required
- No maintenance or repair on a machine without lockout of all energies
- Every worker must put his personal lock
- Every intervention (maintenance/repair) = operating manual + work permit
- NO intervention inside any confined space without a penetration permit
4- ILLUSTRATIONS/ACHIEVEMENTS

REVIEWING SCHEDULED SHUTDOWN PREPARATIONS PROCEDURES

- Shutdown Master plan
- Updating & Communication of operating manuals
- Confined spaces: permit to work

Auditing:
100% of scheduled tasks are executed according to operating manuals

4- ILLUSTRATIONS/ACHIEVEMENTS

RISK ANALYSIS STANDARD: WORKPLACE TRANSFORMED IN ORDER TO MASTER THE RISK

- Flocculation workplace
- Parameter monitoring
- Inadequate workplace: electric sub-station, noises

Workplace transformed
4- ILLUSTRATIONS/ACHIEVEMENTS

PERSONAL PROTECTIVE EQUIPMENT: REDEFINED ACCORDING TO RISK ANALYSIS

4- ILLUSTRATIONS/ACHIEVEMENTS

LOCK OUT TAG OUT STANDARD

1. Tagging out by the electrician
2. Locksheet
3. Electrician Padlock
4. Locking out and tagging out only the electrical energy
5. Pre-established "LOTO" plan
6. Locking out and tagging out all source of energy
7. Plant owner is in charge of "LOTO" procedure
8. Verification and lock for every collaborator

Lock = Life
Safety Task Force as tool to improve adhesion and positive behavior in the Gantour Mining Site.

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<th>Taskforce Action Plan</th>
<th>State of play - August</th>
<th>Assessment - January</th>
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<td>Safety signs and labels</td>
<td>Performing a safety audit</td>
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<td>Safety drills</td>
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Ammonia Release to atmosphere due to Ammonia pre-heater tube rupture IN UREA -5 PLANT
Ammonia Release to atmosphere due to Ammonia pre-heater tube rupture IN UREA -5 PLANT
INTRODUCTION

- At QAFCO Urea-5 plant, Ammonia Pre-heater (152.E2307) tube failed causing a sudden LP section loop pressure increase.
- As an immediate consequence the LP Decomposer Relief valve lifted, resulting in an ammonia release to atmosphere through the blow down separator stack and consequently the Urea-5 plant was stopped.
- Ammonia smell was reported from neighboring plants, while there was no smell observed inside Q5 plant area as the release occurred at a higher elevation (61 m) and having a repellent wind direction.

SEQUENCE OF EVENTS

During E2307 Tube Failure

In April 2014, U-5 plant was running at 110% load.
At 18:15hrs plant upset observed as follows:
- Carbamate separator, U2201 level increased.
- Ejector pressure, PIC22021 pressure decreased from 23 Mpa to 19 Mpa
- Ammonia flow to Synthesis suddenly increased.
- Suspected ammonia Pump discharge RV23061A, passing. The RV isolated, & the stand-by RV put on line. Even though no improvement was noticed.
SEQUENCE OF EVENTS

During E2307 Tube Failure

- Ammonia Receiver, V2105 level observed coming down.
- V2105 RV checked, no passing observed.
- All parameters in MP loop found normal.
- LP Loop pressure increased & Ammonia Pre-heater (E2307) outlet temperature decreased. Which indicates E2307 tube leak, so immediately decided and stopped the Plant at 18.44 hrs.
- There was no Ammonia smell around Urea-5 plant as the emission taken place at higher elevation (61M) through Blow down Separator, U2211.
Q5/6 SITE OVERVIEW

AMMONIA RELEASE TO ATMOSPHERE DUE TO AMMONIA PRE HEATER TUBE RUPTURE IN UREA-5 PLANT
Ammonia Release to atmosphere due to Ammonia pre-heater tube rupture in UREA -5 PLANT

28th AFA Int’l. Fertilizer Technology Conference: Amman, Jordan

Ruptured Tube

Total of 67 tubes were plugged (tubes with wall loss >30%).
ROOT CAUSE ANALYSIS

A root cause analysis was carried out and the following causes were identified:

1. Initial condensation of inlet vapors to highly corrosive ammonium carbamate solution at the vapor inlet area between baffle no #1 & #2.

2. Accelerated corrosion of tubes having high skin temperatures depending on tube pass. This pattern is evident from the ECT report where in most tubes have thickness loss on tube pass #3 and #4.

3. No Supply of Carbonate Solution from P2303A/B to the vapor inlet mixer. The passivation, which is normally believed to take place via metal ion, is missing in this freshly condensed carbamate solution. Hence presence of oxygen does not completely assure passivation of stainless steel. Therefore to avoid severe corrosion of steel in such areas, liquid phase is added at the inlet via liquid-gas mixing devices to prevent dry spots on surfaces where condensation takes place.
28th AFA Int’l. Fertilizer Technology Conference: Amman, Jordan

RCA Recommendations

1. Line up the carbonate solution from P2303 A/B to the mixer at the inlet of Ammonia Pre-heater.

2. Replace the existing exchanger/tube bundle with new one.

3. Up-gradation of tube material of construction to Duplex SS or 25/22/2 could be considered for more corrosion resistance to condensation corrosion.

IMPROVEMENT STUDY

This matter was taken seriously by QAFCO management considering the surrounding area & to avoid such incidents in future, an improvement project team was established to study in detail & recommend possible solutions.
**UREA-5 BASIC DESIGN**

Every effort has been made in the design of Urea 5 plant to avoid any Emission release.

To minimize environmental effect during plant operation, startup & shutdowns, two types of flare and blow down separator system are provided in Urea 5 plant.

- **Continuous gaseous effluents:**
  
  Inert effluents are continuously discharged from MP Inert washing drum (C2103) and Vacuum vent scrubber (C2435).

  These vents are collected and flared via Continuous flare system (Y2112).

---

**UREA 5 BASIC DESIGN**

- **Discontinuous gaseous effluents:**

  During Plant startup /shutdown or during any upset, the gasses released from HP section, LP section & WWT section vents are flared via Discontinuous flare system (Y2213).

- **Blow down Separator/Stack:**

  When the system pressure goes out of control, to protect the equipment & Human, Relief Valves & Rupture discs are provided to release pressure in the system.
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  When the system pressure goes out of control, to protect the equipment & Human, Relief Valves & Rupture discs are provided to release pressure in the system.
UREA 5 BASIC DESIGN

➢ All RVs & RDs are connected to the Blow Down separator (U2212), to recover maximum discharges to the process & the remaining will be released at safe location to atmosphere through blow down separator stack at 61 Meters height.
➢ A number of the instruments in the plant are equipped with passive alarms to warn the operators in the control room against deviating operating conditions which may lead to dangerous situations or which may cause damage to the equipment.

Improvement Study Details

The team studied the system in detail for further improvements:
➢ All RVs/RDs & equipment details checked. Extra controls are discussed and evaluated to mitigate any ammonia release to the atmosphere.
➢ Based on equipment criticality & condition, RVs lifting chance & its control evaluated.
Improvement study
Conclusions/Recommendations

- Provide high pressure trip for MP/LP loops before RV setting.
- Provide temperature indication /Limit switch with alarm at the outlet of RD to get RD failure indication immediately.
- Provide on line NH₃ Analyzer at U2212 stack top with alarm to alert DCS operator in case of any Ammonia release.
THANK YOU

AMMONIA RELEASE TO ATMOSPHERE DUE TO AMMONIA PRE-HEATER TUBE RUPTURE IN UREA PLANT
Ammonia Release to atmosphere due to Ammonia pre-heater tube rupture IN UREA -5 PLANT
28th

AFA Int’l. Fertilizer Technology
Conference & Exhibition

07 - 09 June 2015
Amman - Jordan

Session 5

ARAB FERTILIZER IMPRESSING
FUTURE SUSTAINABILITY
How rigorously plant modeling can advance your urea business
Premium catalyst and technology solutions

Kristina Svennerberg,
Haldor Topsoe A/S
Denmark
“Support of food security and the fight against hunger. Best utilization of available natural resources, utmost achievement of added value, effective contribution in economic, social and agriculture development and efficiently promote safe and secure production, storage and transportation of agricultural nutrients.”

Mission statement for Arab Fertilizer Association
Premium catalyst and technology solutions
Best utilization of available natural resources, utmost achievement of added value

Purchasing strategy
Are you saying yes to added value?
Reformer optimization boosts production
“Successful plants can’t afford to underperform”

- **Challenge**
  - Verify actual conditions
  - Compare to design limits
  - Optimize performance

- **Solution**
  - Combustion air adjustment
  - Reinstallation of burners
  - Increase furnace draught
  - Insufficient sealing

- **Outcome**
  - Increase production by 2.6%
  - Saving on natural gas consumption

---

**Topsoe helps realize full potential**
“Topsoe’s plant optimization expertise enabled us to boost production by 3%”

- **Challenge**
  - Bottlenecks in reforming
  - Poor heat transfer from waste heat section
  - Too hot tubes

- **Solution**
  - Tuning of burner air intake
  - Higher flue gas flow

- **Outcome**
  - 3% higher production
  - 0.74 GJ energy saving per metric ton
Load twice as fast with SpiraLoad™
“SpiraLoad™ enabled catalyst loading twice as fast with better results”

- Challenge
  - Traditional sock loading has been used before
  - Find significantly faster loading method
- Solution
  - SpiraLoad™ technology
  - Less labor intensive method
  - Fast and uniform loading
- Outcome
  - SpiraLoad™ is twice as fast
  - More uniform pressure drop distribution
  - Reformer performance enhanced

**LK-853 FENCE™**
Optimized use of natural resources
KM111
Leading the way forward

Minimized energy consumption

- 3.5 Bar reduced operating pressure
- 1% lower energy consumption
- Premium payback 100 days

Maximized feed stock utilization

- Up to 1.9% increased production
- Premium payback 10 days

Are you saying yes to added value?
Premium products and services from Topsoe
Carbon formation in steam reforming and effect of K-promotion

Mohammed Bendjana & Malika Oukhedou
Johnson Matthey
Bahrain
Carbon formation in steam reforming and effect of K-promotion
Carbon formation in steam reforming and effect of K-promotion

Mikael Carlsson

1. Introduction

When choosing a reformer catalyst, there are a number of important things to consider. Steam reforming of methane is an endothermic reversible reaction, whilst steam reforming of higher hydrocarbons is not reversible. The activity of the catalyst installed is critical in determining the reaction rate within the reformer. However, the steam reforming reaction is diffusion limited, so the geometric surface area of the installed catalyst is directly related to the catalyst activity. This article will show the mechanisms by which carbon can form on a catalyst and how a potassium dopant can prevent carbon formation and aid catalyst recovery following a carbon formation event.¹

Because the reaction is endothermic, the transfer of heat from the burners to the catalyst is just as important as the activity. Whilst within the reformer itself the primary heat transfer mechanism is radiation, within the tube it is convection and conduction. Within the tube the hottest point is the internal tube wall. The size and shape of the catalyst will impact on the tube-side laminar film layer, and therefore on the overall heat transfer coefficient as represented in Figure 1.

![Figure 1: Heat transfer balance inside a steam reformer box from flames to reactant stream](image)

Due to the temperatures at which steam reformers operate, carbon is constantly being formed from the hydrocarbon feedstock, with the primary route being through cracking reactions. However, there are also carbon removal (or gasification) reactions that occur at the same time which remove the carbon laid down, meaning there is no net accumulation of carbon in a well-run plant. With a given catalyst loading in the reformer, the rate of gasification is fixed by the catalyst type and the process conditions. However, the rate of carbon laydown is a function of a number of conditions such as the catalyst activity, degree of sulphur poisoning and heat input to the tubes. The rate of laydown is therefore more likely to vary than the rate of gasification. The selected catalyst should have appropriate activity or alkali promoters to ensure that the carbon removal rate is faster than the carbon formation rate, which would result in no net carbon laydown.

Finally, the catalyst should allow for the lowest possible pressure drop, as this will enable the highest possible plant throughput before compressor limits are reached. However the catalyst breakage characteristics are also important as all pelleted steam reforming catalysts will break due to the forces exerted on them when reformer tubes expand in operation and then contract during plant shutdowns, which will lead to an increase in pressure drop.

2. Carbon-formation

The three main reactions for carbon formation are hydrocarbon cracking (Equation 1 and 2), carbon monoxide disproportionation (the Boudouard reaction) (Equation 3) and carbon monoxide reduction (Equation 4).

\[
\begin{align*}
\text{CH}_4 & \rightleftharpoons \text{C} + 2\text{H}_2 & \Delta H_{298}^\circ &= +75 \text{ kJ mol}^{-1} & \text{Equation 1} \\
\text{C}_n\text{H}_m & \rightarrow n\text{C} + (m/2)\text{H}_2 & \text{Equation 2} \\
2\text{CO} & \rightleftharpoons \text{C} + \text{CO}_2 & \Delta H_{298}^\circ &= -172 \text{ kJ mol}^{-1} & \text{Equation 3} \\
\text{CO} + \text{H}_2 & \rightleftharpoons \text{C} + \text{H}_2\text{O} & \Delta H_{298}^\circ &= -131 \text{ kJ mol}^{-1} & \text{Equation 4}
\end{align*}
\]

Cracking or decomposition of hydrocarbons is favoured at temperatures above approximately 620°C (1148°F) depending on the hydrocarbon species. As can be seen in the equations the reaction with methane is reversible but with the heavier hydrocarbons they are not.

Both the carbon monoxide reduction and disproportionation reactions are more prevalent at lower temperatures but at those temperatures the concentrations of carbon monoxide would normally be low, depending on recycle rates, so the cracking reactions are normally the most important to consider. However, any combination of these reactions can lead to detrimental effects on catalyst activity and, if left untreated, eventually lead to permanent damage and carbon build-up.

There are three catalyst parameters that can be altered to prevent carbon formation. These are the activity, the inherent heat transfer coefficient, and the catalyst alkali promoter content.
Increasing the catalytic activity can be achieved by the use of a higher surface area catalyst due to the diffusion limited nature of the reaction mentioned previously. This has a threefold effect; firstly, as there is more reforming reaction near the inlet of the tube, there is a lower process gas temperature due to the increased heat of reaction required. Secondly, the hydrocarbon content of the process gas is reduced. And finally as more hydrogen is produced the carbon formation reaction is suppressed.

By improving the heat transfer characteristics of the reforming catalyst, the rate of heat transfer within the tube can be increased. Intuitively this would appear to increase the process gas temperature thereby making the carbon forming potential worse. However since carbon is most likely formed on the inside tube wall which is the hottest part of the process where carbon can form, increasing the heat transfer characteristics of the catalyst reduces this temperature by transferring heat to the bulk of the catalyst. The additional heat transferred will in turn increase the reaction rate, which will also reduce the hydrocarbon content of the process gas making carbon formation less likely. It also reduces the process gas temperature as there is more reaction. Overall, this has a similar effect as that seen by installing a highly active catalyst. Another way of preventing the formation of carbon is to include a promoter in the catalyst to help increase the rate of carbon gasification; one such promoter is potassium.

3. Potassium promotion

It is well known that the carbon formation on a surface, either the support or catalyst, is affected by the acidity of that surface. Positively charged acidic sites on a surface will increase the rate of carbon formation, which is partly due to acidic sites catalysing the cracking reaction which enables carbon formation. Alpha alumina which is a common catalytic support contains acidic sites and adding group 2 metals such as magnesium or calcium neutralises these making the surface less acidic.

For a supported nickel catalyst the steam ratio at which a catalyst would run without forming carbon can be decreased by approximately 16% compared to an un-doped alumina through the addition of dopants such as calcium or magnesium. A way to further increase the surface basicity is to add a potassium-containing compound such as potash as a dopant, which will lead to an increased prevention of carbon formation. For alkalized calcium aluminate catalyst the steam ratio can be decreased by approximately 65% without forming carbon compared to an un-doped alumina. The reason for this is due to both the acceleration of carbon gasification reaction and the suppression of carbon formation reactions.

In addition to increasing the surface basicity, the potassium will form hydroxide species in the presence of steam and these will aid in any removal of carbon that is formed on the surface. As highlighted earlier, depending on the conditions, there are locations within the reformer where carbon will form on hot surfaces e.g. the inner tube wall. This is especially likely if heavier species slip further down the tube where the wall is hotter. That carbon will have to be removed at a faster rate that it is formed in order to prevent any build-up.

The history of potassium promoted catalysts goes back to 1975 where a trial was carried out on the No 1 Low Pressure Ammonia Plant in Billingham. During the trial it was shown that the promoted catalyst, where the potassium was incorporated in the support, was successful
in the suppression of hot bands that had been seen for the previous charge of un-promoted catalyst. These hot bands associated with carbon formation appeared after only a few months of operation, and it was thought at the time that they were due to a plant uprate. Alkali metals are known to inhibit the steam reforming reaction, but the findings of the plant trial were that the way the potassium was incorporated into the support did not inhibit activity and this was confirmed by laboratory experimental testing. After nine months of operation the reformer was inspected and the tubes containing the potassium promoted catalyst were running cooler with a more uniform temperature than adjacent tubes. The material was discharged and when examined only a very limited potassium loss of was detected.

The Johnson Matthey KATALCOJM catalyst range available today has been designed with different amounts of promoter for different operations. As can be seen in Table 1 the range spans from un-promoted KATALCOJM 23 and 57 series which are used for light feedstock's such as methane in combination with a low heat flux, up to KATALCOJM 48-3 which contains much higher levels of potassium for operations with heavy naphtha. The two catalysts series with intermediate levels of potassium promotion are for operations where the feed composition is heavier than methane but lighter than heavy naphtha e.g. LPG. In reality this summary is slightly over-simplified as both the steam to carbon ratio and the overall heat flux also affects the amount of carbon protection required.

<table>
<thead>
<tr>
<th>K₂O wt%</th>
<th>Series</th>
<th>Feedstock / carbon protection requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>KATALCOJM 23-4 or 57 series</td>
<td>Light feed/low C protection</td>
</tr>
<tr>
<td>1.5 - 2.5</td>
<td>KATALCOJM 25-4 series</td>
<td></td>
</tr>
<tr>
<td>4 - 5</td>
<td>KATALCOJM 47 series</td>
<td>Heavy feed/high C protection</td>
</tr>
<tr>
<td>6 - 7</td>
<td>KATALCOJM 46-3</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Range of Johnson Matthey KATALCOJM with different potassium promotion

The potassium is incorporated into the catalyst in ceramic phase reservoirs with a precise stability to regulate the rate of release onto the surface. This leads to the right level of potassium and hydroxide species on the surface to ensure gasification of carbon from all nickel sites throughout the catalyst’s lifetime.

The potassium-containing phases present in Johnson Matthey catalysts depends on the catalyst series but typically they are either a potassium-alumino-silicate or potassium-aluminate which is incorporated in the support. The use of a range of phases allows for the release of potassium at an appropriate rate under a range of process conditions and maintains high activity in terms of carbon removal. This also ensures that any adverse effect on the steam reforming activity is minimized.
Figure 2: EMPA images showing aluminium and potassium distribution in a catalyst support highlighting areas of K-Al reservoirs

Figure 2 shows an Electron Probe Micro Analysis (EPMA) of a potassium-promoted catalyst which clearly shows areas which are rich in Al (left image) and K (right image). What can be seen is that where there is a high abundance of potassium there is also high aluminium content. This clearly indicates that there are areas of potassium-aluminates which are there as potassium reservoirs for the catalyst.

Froment et al. examined different potassium loadings on a nickel catalyst and found that in conditions where methane cracking was taking place the presence of potassium seemed to have three effects on the carbon formation. Specifically, it reduced the final level of carbon formed, secondly it reduced the rate of carbon formation and finally it apparently delayed the onset of carbon formation, which is speculated to be as a result of decreasing the nucleation rate on the catalyst surface. Furthermore, the gasification rate of filamentous carbon that had been deposited is also affected by the presence of potassium as shown in Figure 3. The rate of gasification by steam as a function of the potassium content exhibits a maximum of around 1.6 - 2.0 wt% K₂O for this catalyst system.

---

Figure 3: Carbon gasification rate as a function of potassium loading. (Recreated from Ind. Eng. Chem. Res. 2002, 41, 3548-3556)

The presence of a potassium dopant will promote the adsorption of water which will in turn increase the carbon gasification. The potassium will also affect the gasification kinetics and increase the carbon monoxide production rate and, as steam adsorbs dissociatively, there could be an increase in oxygen on the surface as a result of the increase number of sites for water adsorption on an alkali metal catalyst, which leads to an increase of the rate of gasification.

4. Carbon formation case study

An example of the where the use of a potassium promoted catalyst was crucial in the recovery after a carbon incident in a reformer on an European ammonia plant is shown in Figure 4 to Figure 6 and discussed below.

Figure 4 shows hot bands on the reformer tubes that appeared following a carbon incident due to LPG condensate trapped in a line being inadvertently fed into the reformer. This carbon led to an increase in pressure drop from 3.6 to 5.0bar (52.2 to 72.5psi) across the reformer.

---

Although carbon had been formed, the presence of the potassium promoted catalyst will have limited the severity of this incident and a full shutdown was averted. As the plant needed to keep running the operators decided that it would be run at a higher steam to carbon ratio in an attempt to promote the carbon gasification reactions. Over the following months the pressure drop decreased to 4.7 bar (68.1 psi) and the extent of hot bands on the tubes decreased, which can be seen in Figure 5. The measurement of the tube wall temperature revealed a decrease of up to 30°C (54° F). This highlights the effect of carbon removal that is promoted by the potassium containing catalyst.
After two months of running at an increased steam to carbon ratio the plant tripped, providing an opportunity to steam the catalyst prior to restart. When the plant was restarted no hot bands were observed (as can be seen in Figure 6) and operation was back to normal with pressure drop at 3.8bar (52.2psi). This case study illustrates both how the KATALCO\textsubscript{M} catalyst can slowly recover during normal operation and also the dramatic return to normal operating conditions after steaming.
Figure 6: Tube appearance after plant shutdown and steaming showing conditions returning to normal

5. Conclusion

There are a number mechanisms by which carbon formation can occur on a nickel based steam reforming catalyst, with the cracking of hydrocarbons most prevalent. Carbon deposition happens when the formation rate is greater than the removal rate which is a function of surface chemistry and the addition of promoters to reduce the carbon formation rates. It is important that the potassium dopant is added to the catalyst in optimized phases with appropriate hydrothermal stability to give a controlled release rate. The release and mobility of the potassium is required to keep tube walls free from carbon and also assist in recovery from plant upset conditions resulting in carbon formation.
Carbon formation in steam reforming and effect of K-promotion
HSE Best Practices in APC

Yousef Al Ma’aytah,
APC
Jordan
Best Practices in Arab Fertilizers’ Association For Health, Safety and Environment

Arab Potash Company (APC) as a Case Study

28th AFA Int’l. Fertilizer Technology Conference: Amman, Jordan

Fields of Best Practices

1. Corporate Social responsibility
2. Safety
3. Environment
1. Corporate social responsibility:

1.1. Water
1.2. Solar energy
1.3. Education
1.4. HEALTH

- APC's CSR work is inspired by the vision of His Majesty King Abdullah II's vision that the first priority is to secure a better life for all Jordanians. Accordingly, APC actively cooperates with government organizations, local community leaders, charities and NGOs to drive social development across Jordan, particularly in the governorates of Karak, Tafileh and Ma'an where we operate.

- Our annual CSR contributions support and sustain initiatives focus primarily on the vital sectors of education, health, water, and the environment, with the overall aim of alleviating poverty, raising living standards, upgrading infrastructure and public services, and addressing community needs. In 2012 and 2013, APC's CSR programs amounted to JD 10 million each year and directly benefited more than 2,000 organizations and 100,000 citizens.
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#### Arab potash Company’s CSR program 2014 in Jordan Dinars

<table>
<thead>
<tr>
<th>Sector</th>
<th>Sub-Sector</th>
<th>Subsector total</th>
<th>Sector total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Universities</td>
<td></td>
<td>949,117</td>
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<tr>
<td>Schools</td>
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<td>1,254,140</td>
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<td><strong>Education</strong></td>
<td>Welfare associations</td>
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<td></td>
<td>Welfare packages</td>
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<tr>
<td></td>
<td>Orphans’ care</td>
<td>122,500</td>
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<tr>
<td><strong>Social development</strong></td>
<td>Municipalities</td>
<td>567,329</td>
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<td></td>
<td>Official organization</td>
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<td></td>
<td>Community halls</td>
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<td></td>
<td>Development associations</td>
<td>165,000</td>
<td></td>
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<tr>
<td><strong>Official bodies</strong></td>
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<td>1,550,948</td>
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<tr>
<td><strong>Water &amp; environment</strong></td>
<td>Health organization</td>
<td>586,500</td>
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<td></td>
<td>Health associations</td>
<td>174,800</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Special needs care</td>
<td>70,440</td>
<td></td>
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<tr>
<td><strong>Health</strong></td>
<td>Churches</td>
<td>18,000</td>
<td>831,740</td>
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<td><strong>Sports</strong></td>
<td>Mosques</td>
<td>168,899</td>
<td>604,550</td>
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<tr>
<td><strong>Houses of worship</strong></td>
<td></td>
<td>186,899</td>
<td></td>
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<tr>
<td><strong>Culture</strong></td>
<td></td>
<td>209,340</td>
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<tr>
<td><strong>Professional associations</strong></td>
<td></td>
<td>102,700</td>
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<tr>
<td><strong>Total</strong></td>
<td></td>
<td>7,500,000</td>
<td></td>
</tr>
</tbody>
</table>

### Summary of the Arab potash Company’s CSR program 2014 in Jordan Dinars

[Graph showing various sectors with bars for Education, Social development, Official bodies, Water & environment, Health, Sports, Houses of worship, Culture, and Professional associations.]
His Excellency Jamal Al Sarayrah, APC Chairman of the Board opens two wells in Southern Ghors in September 2014.

His Excellency Jamal Al Sarayrah, APC Chairman of the Board inspects Phase-01 of the “Environmental Villages” Project.
Patients at Salt Hospital receive treatment using dialysis machines provided by APC.

Her Princess Dina Mira'ed of King Hussein Cancer Foundation receives a grant from Chairman of the Board His excellency/ Jamal Al Sarayrah for the expansion of King Hussein Cancer Center Project.
2. safety

- 2.1. Safety Forums
- 2.2. Effective Safety Control on APC Service Providers
- 2.3. Effective Key Safety Procedures Audits
- 2.4. Effective Multi-Disciplinary and Specialized Safety Committees
- 2.5. Effective Emergency Response Planning and Application
- 2.6. Effective Incidents’ Investigation Methodology

2.1. safety forums

➢ A Total of 8 Safety forums are conducted every year
➢ The targeted attendees are: Superintendents, Supervisors and Trucking Drivers
➢ GM, DGMT, Directors and Managers attend these forums and they are profoundly engaged at these forums.
2.1. safety forums...(Cont.)

- At Trucking Drivers’ Forums; “Incident Recall Technique” is applied, where those drivers who encountered dangerous driving situations and DID prevented an accident from happening, explain WHAT happened and WHAT was that element they did which prevented the accident from happening.
- Effective Direction, Coaching, Awareness and Recognition Platform.
- Drivers’ Proposals for improving Trucking Safety are taken during the forum, timely acted upon and the corrective actions taken are announced at the next forum.

2.1. safety forums...(Cont.)

- Superintendents and Supervisors’ forums:
- As Superintendents and Supervisors are the most important link in the supervisory chain:
  - Effective Communication, Direction, Coaching, Awareness and Recognition platform.
  - Critical Near Misses are discussed at these forums and corrective actions are developed at these forums.
  - Actual performance on the set Sectional Safety Objectives is addressed.
  - The APC Service Providers attend these forums and asked to present their safety performance.
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2.2. Effective safety control on contractors

• 2.2.1. Effective Safety Procedure was developed for APC Service Providers-(Bi-lingual), of pocket size and a copy is timely distributed for every contractor worker.
APC Service Providers Safety Chart

Pre-awarding Phase
- Service Requester Department
  - Provide a list of existing and potential hazards
- Procurement Department
  - Develop previous safety performance forms
- Supervising Department
  - Daily Safety Inspections
  - Safety compliance tracking reports and score rating report
  - Inform QES dept. about any radiation activity
  - Attend APC Service Providers meetings
- Incubating Department
  - Communicate all hazards to SP
  - Intervene in risk behavior and unsafe conditions
  - Report all safety behaviors or unsafe conditions to the Supervising Department
- HR/Security Department
  - Only authorizes SP allowed to enter APC sites
  - Security Inspections at SP working sites
- QES Dept.
  - Orientation
  - Safety Meetings
  - Safety Inspections
  - Audits
  - Safety performance Assessment reports

Post-awarding Phase
- Service Requester Department
  - Attend APC Service Providers meetings
- Procurement Department
  - Communicate HSE requirements to the service provider
- Supervising Department
  - Receives safety performance tracking reports from supervising department

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Contractors’ Safety Performance Assessment Criteria for Full Compliance:

- Mandatory PPE “Full Compliance” = 15 scores
- As Applicable PPE “Full Compliance” = 3 Scores for each equipment/individual
- APC Procedures = 20 Scores
- Legal Requirements = 5 Scores
- Electrical Safety Requirements = 10 Scores
- Protective guards = 05 Scores
- Warning Signs = 05
- Effective Fire Protection Availability = 05
- Housekeeping = 10
- Others safety requirements as applicable = 10
  - Demerits = Minus Scores
  - For each “Serious at Risk Behavior” observed, 10 points from the total score will be deducted.
2.3. effective key safety procedures audits

- A special audit procedure has been developed and applied at APC for our Key Safety Procedures. Examples of these Key Safety Procedures are:
  1. Energy Isolation (LOTO)
  2. Confined Space Entry
  3. Fall Protection

2.3. effective key safety procedures audits...(Cont.)

- 4. Crane Use
- 5. Work Permit Procedure (HSP 4.4.6.4)
- 6. Hot Work Permit ( HSF 4.6.6.4.1)
- 7. Safety Instructions for Operators and Maintenance technicians for Avoiding injuries caused by Rubber Joints of Hot Lines ( HSWI 4.4.6.1.22)
Key Safety Procedures Audits for Departments

<table>
<thead>
<tr>
<th>Department</th>
<th>Safety Glasses</th>
<th>Safety Hardhats</th>
<th>RCDs</th>
<th>Multipurpose Permit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance</td>
<td>68.9%</td>
<td>82.6%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Production</td>
<td>62.3%</td>
<td>81.8%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Garages</td>
<td>63.3%</td>
<td>82.5%</td>
<td>99.4%</td>
<td>100%</td>
</tr>
<tr>
<td>Aqaba Site</td>
<td>59.0%</td>
<td>84.2%</td>
<td>98.0%</td>
<td>100%</td>
</tr>
<tr>
<td>Energy &amp; Water</td>
<td>53.5%</td>
<td>79.9%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Total Average for Key Safety Procedures Audits

- Safety Glasses: 61.1%
- Safety Hardhats: 94.8%
- RCDs: 95.7%
- Multipurpose Permit: 93.3%
2.4. Effective Multi-Disciplinary and Specialized Safety Committees

- The following are the functional safety and environmental committees:
  1. Labors’ Safety Committee - Mandatory by Jordan Labor Law
  2. Electrical Safety Committees - (2)
  3. Slings and Lifting Ropes Committees - (2)

2.4. Effective Multi-Disciplinary and Specialized Safety Committees...(Cont.)

1. Labors’ Safety Committee:
   - This committee is composed of 16 members representing management and non-management workers and meets on monthly basis
   - The head of this committee is the DGM/Technical
   - It is very effective platform to gather observations and proposals for improving safety performance and at the same time engages the members in needed safety tasks pertaining their departments’ works
2.4. Effective Multi-Disciplinary and Specialized Safety Committees...(Cont.)

- 1. Labors’ Safety Committee...(Cont.):
  - Members and guests are encouraged to freely talk and address safety issues across all organization and APC worksite
  - Actions on the addressed issues and concerns are reported at the following meeting

- 2. Electrical Safety Committees (2)
  - 2.1. Steering Electrical Safety Committee – Meets Monthly
  - 2.2. Executive Electrical Safety Committee – Meets Weekly
  - The DGM/Technical is the head of the steering while the Electricity and Instrumentation Manager is the head of the executive one
Executive Electrical Safety Committee:
Electrical Maintenance Hand Tools, extension cords & RCDs for APC & Contractors. Check lists were prepared and audits are being done.
2.4. Effective Multi-Disciplinary and Specialized Safety Committees...(Cont.)

• 3. Slings and Lifting Ropes Committees-(2)
• 3.1. Steering Committee
• 3.2. Executive committee
Sling & Lifting Ropes Committee:
Sorting, Tagging and periodical inspection internally & externally.

- Perform internal quarterly inspection for all lifting hand tools stored at all sections & submit findings to VP / Operations.
- Check the section slings & lifting hand tools checklists are filled in a proper way.
- Ensures all lifting hand tools have their tags, clear and observable.
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- Ensures that all lifting hand tools arranged in a proper way and clean.
- Ensures that all lifting hand tools are in good working condition.
- Ensure supervisors to focus on selecting the right tool depending on the nature of the work (actual load to match with selected capacity of lever hoist).

- Adopt new inventory stock items for all rigging materials and equipment to ensure purchasing upon standard specification for these equipment,
- New purchased and received lifting tools are inspected by committee members, before handing over to the requester.
- Execute annual external inspection for slings; lifting tools by third party certified inspector and document inspections.
### FIXING TAG NUMBERS

Tag numbers have been prepared & fixed on all lifting hand tools.

### LIFTING HAND TOOLS SURVEY

All lifting hand tools in all concerned sections / departments have been defined. Total lifting hand tools is 983, distributed on all concerned sections / departments as below:

<table>
<thead>
<tr>
<th>No</th>
<th>Section</th>
<th>Available Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wire</td>
<td>Nylon</td>
</tr>
<tr>
<td>1</td>
<td>Hot Leach Plant Mech.</td>
<td>66</td>
</tr>
<tr>
<td>2</td>
<td>Cold Cryst. Plant 1 Mech.</td>
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</tr>
<tr>
<td>3</td>
<td>Cold Cryst. Plant 2 Mech.</td>
<td>58</td>
</tr>
<tr>
<td>4</td>
<td>Mech. Workshop</td>
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<tr>
<td>5</td>
<td>Garages-TRK (Trucks)</td>
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<tr>
<td>6</td>
<td>Garages-GRG (General)</td>
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<tr>
<td>7</td>
<td>Garages-HVG (Heavy Vehicles)</td>
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<tr>
<td>8</td>
<td>Construction W/S</td>
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</tr>
<tr>
<td>9</td>
<td>Aqaba Site Mech.</td>
<td>13</td>
</tr>
<tr>
<td>10</td>
<td>Off Site Mech.</td>
<td>13</td>
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<tr>
<td>11</td>
<td>Utilities Mech.</td>
<td>15</td>
</tr>
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<td>12</td>
<td>Spare Parts Manuf. W/S</td>
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<tr>
<td></td>
<td>Total</td>
<td>385</td>
</tr>
</tbody>
</table>

**Total**: 983
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2.5. effective emergency response planning and application

- As a part of APC Management commitment to protect APC individuals and assets, APC established an Emergency Response Center operated by Civil Defense crew in 2009 through an agreement with Civil Defense to ensure high level performance in rescue, Paramedic and Fire Fighting operations.

- The location of the center was carefully selected vis-à-vis APC plants which enables very short response time to all APC work units.
Follow-up of Some Refreshing Training Exercises
APC supports & shares effectively to open the closed roads by snow accumulation & landslides also in rescue operations & emergency cases such as floods, as support to local community.
• Updating the Emergency Safety Plan for all APC sites and implementing scheduled emergency drills in conjunction with Civil Defense.

Rescue Operations: Logistic support to Potash Civil Defense for rescue operations from heights, sinking accidents and the related paramedic. Training Drills were implemented.
2.6. effective incidents’ investigation methodology

- Effective 2007 APC has applied TapRoot Incidents’ Investigation Methodology
- TapRoot methodology is applied through a software developed by Systems’ Improvements’ Company in Tennessee/U.S.A and proved to be the most effective incidents’ investigation methodology and it is widely applied in US.

---

2.6. effective incidents’ investigation methodology...(Cont.)

- TapRoot is a Non-Blame oriented investigation process that addresses the sequence of events that led to the incident in chronological order, defining the causal factor, then root cause/s and then the development of SMARTER corrective actions.
- A group of highly skilled TapRoot investigators from APC engineers were trained and they effectively perform the investigations to APC incidents.
3. Environment

• APC had been granted the certification of compliance for ISO-14001:2004 effective 2001 and had been continuously certified since then.
• Effective and periodic measurements and monitoring for APC Plants effluents and emissions
• Effective Waste management Projects had been implemented
Environment Best Practice
From August to October 2014 Housekeeping Sections Performance

4.0 is the standard score

Housekeeping Scoring program is adopted by APC according to SS Criteria

28th AFA Int’l. Fertilizer Technology Conference: Amman, Jordan

Two Ambient Air Quality Stations will be installed by June 2015 to measure Sox, NOx and PM10 at Two Locations:
1- At APC Township
2- Southern the Plants.
Water effluent from Softener is used to irrigate 50,000 m² of plants, these mainly are date palms and olive trees.
How rigorously plant modeling can advance your urea business
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Delegate List

20th AFA International Petroleum Technology Conference & Exhibition - 2013
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**Delegate Report**

28th AFA Intl Fertilizer Technology Conference & Exhibition - 2016
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Delegates List

28th AFA International Fertilizer Technology Conference & Exhibition - 2015

Delegate Report

AFA

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Delegate Report

28th AFA Oil & Gas Technology Conference & Exhibition - 2015
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<th>Telephone</th>
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<td>+212 661 893311</td>
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Delegate List

28th AFA International Fertilizer Technology Conference & Exhibition ~ 2015
<table>
<thead>
<tr>
<th>Name</th>
<th>Email</th>
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<th>Fax</th>
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<td>sabic</td>
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**Delegate Report**

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