الإتحاد العربي للأسمدة

Arab Fertilizer Association

In co- operation with

thyssenkrupp

# AFA WORKSHOP

## Operation and Maintenance Optimization

Jordan - Aqaba: 11-14 April, 2016

# Papers

Sponsors:

Arab Potash

Jordan Phosphate Mines Co.

Indo Jordan Chemicals Co.

Nippon Jordan Fertilizer Co.

KEMAPCO Arab Fertilizers & Chemicals Industries Ltd.

afa

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## Operation and Maintenance Optimization

Jordan - Aqaba: 11-14 April, 2016

# DAY 1: Monday 11 April, 2016

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NJFC

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KEMAPCO

KEMAPCO Arab Fertilizers & Chemicals Industries Ltd.

Business Area
# Industrial Solutions

Dr Malcolm Cook
April 2016

engineering. tomorrow. together.

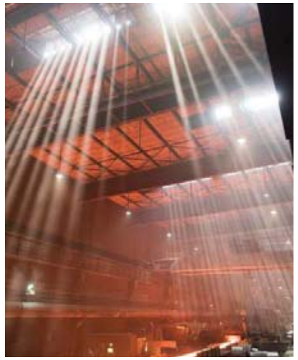
thyssenkrupp

# thyssenkrupp – Business Areas

## Key indicators – fiscal year 2014/2015[1]








| | Components Technology | Elevator Technology | Industrial Solutions | Materials Services | Steel Americas | Steel Europe |
|---|---|---|---|---|---|---|
| Sales [million €] | 6,753 | 7,208 | 6,256 | 14,254 | 1,773 | 8,697 |
| EBIT[2] [million €] | 313 | 794 | 424 | 206 | (138) | 492 |
| Employees | 29,627 | 51,335 | 19,388 | 20,226 | 3,725 | 27,601 |

**thyssenkrupp AG** Sales: 42,778 [million €] | EBIT adj.[2]: 1,676 [million €] | Employees: 154,906

1. Continuing operations (after reclassification of Steel Americas) | 2. Adjusted before consolidation

# Industrial Solutions

## The new dimension in Plant Engineering

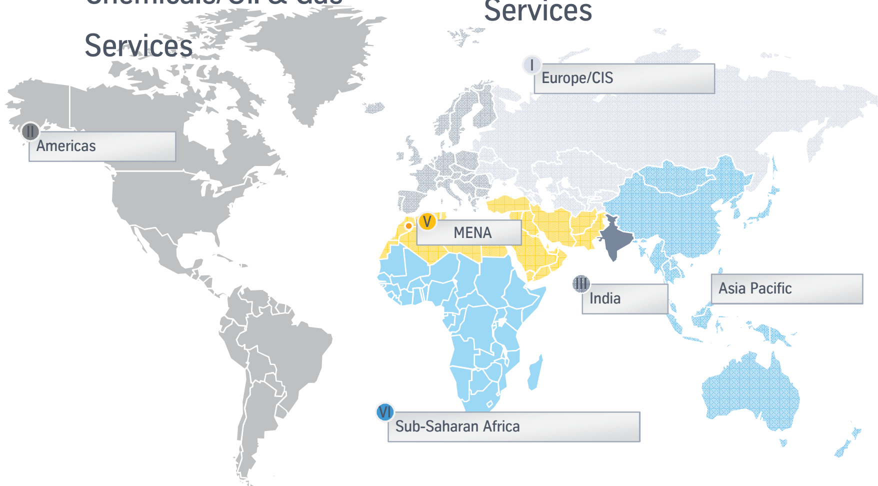
**Business Area**

### Industrial Solutions

**Business Unit**

| Marine Systems | Process Technologies | Resource Technologies | System Engineering |
|---|---|---|---|
|  |  |  |  |
| Submarines<br>Surface Vessels<br>Services | Fertilizer/<br>Coke Plant Technologies<br>Chemicals/Oil & Gas<br>Services | Mining<br>Cement<br>Services | Assembly Systems<br>Car Body Technology<br>Lightweight Solutions<br>Forming Dies<br>Testing Solutions<br>Services |

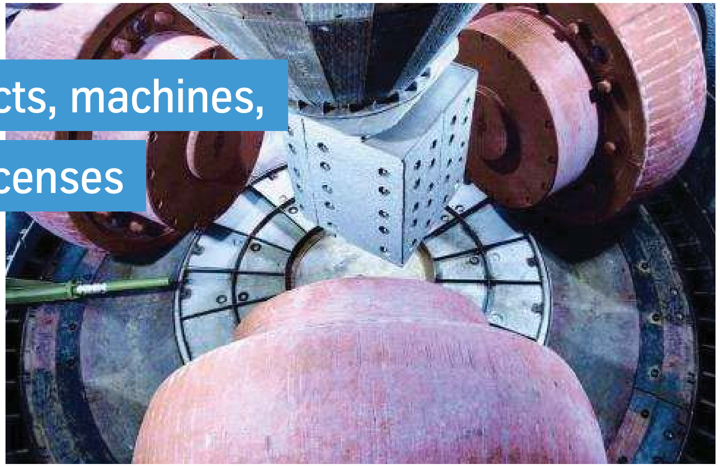
**Regional Organi-sations**



# Industrial Solutions

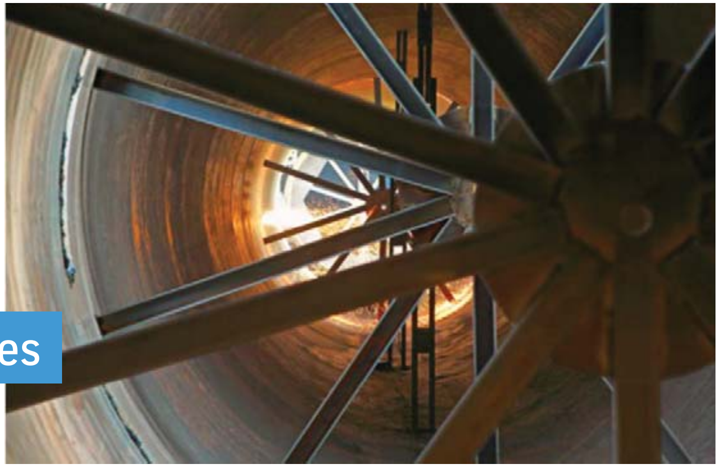
## Four business types to create a strong business

Products, machines,
IP & licenses



System integration

Services

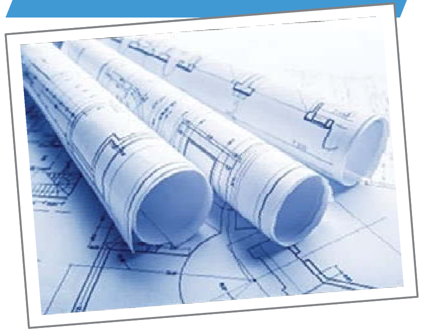


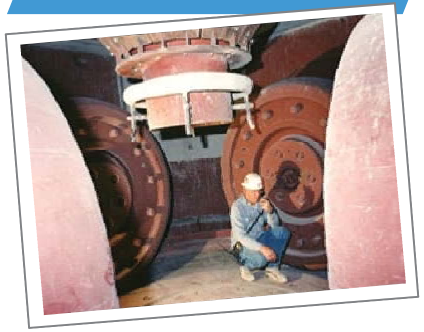
Engineering,
Procurement
& Construction

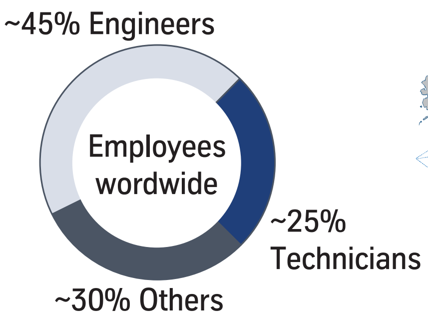
# Industrial Solutions

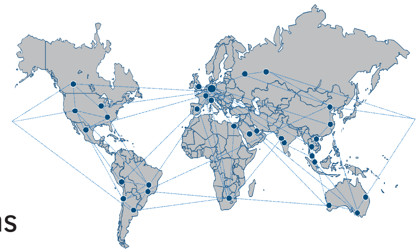
## Joint EPC-S business model with aspiration to grow

| Engineering (E) | Procurement (P) | Construction (C) | Services (S) |
|---|---|---|---|



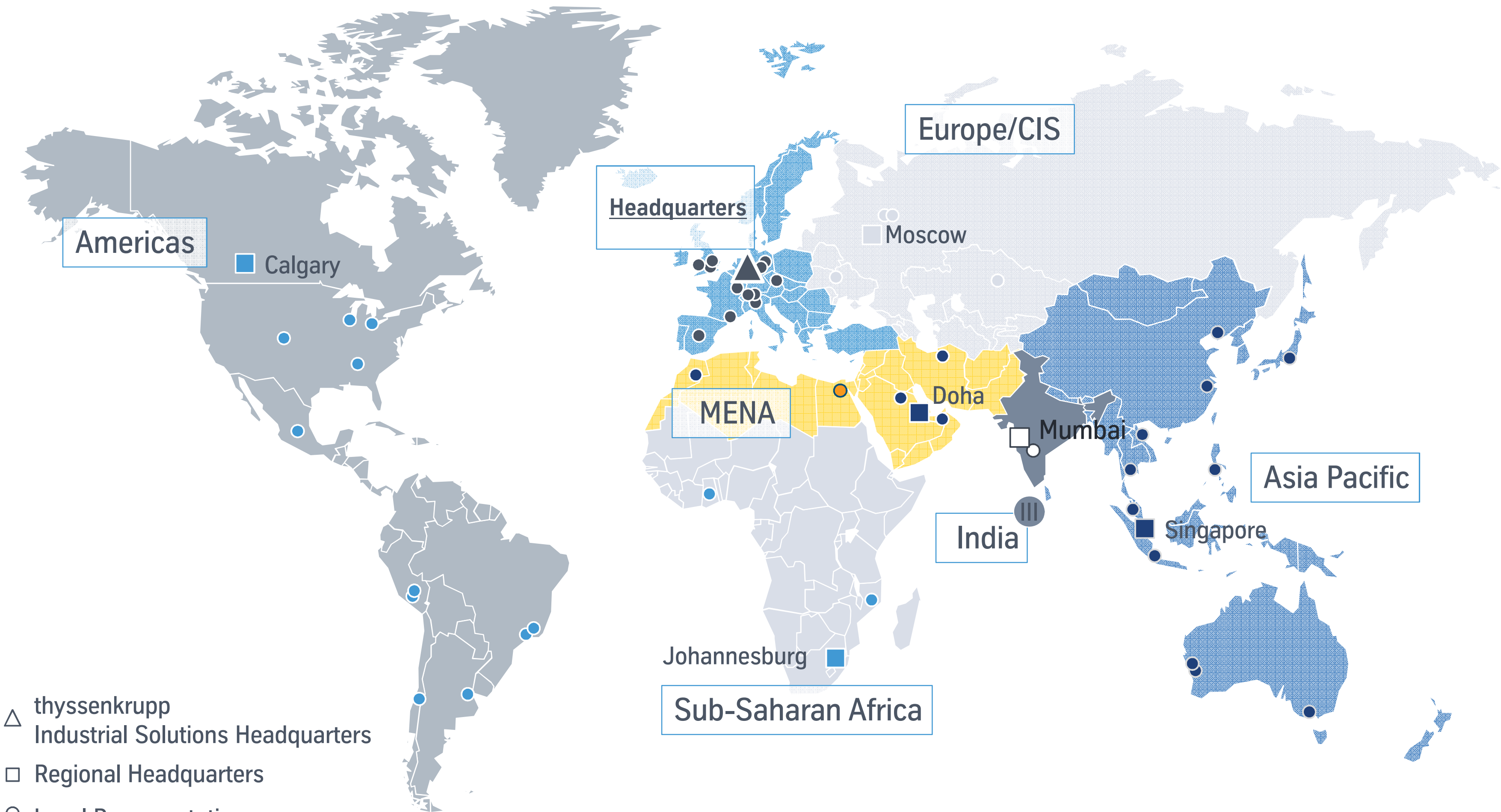



| Leading technologies & engineering skills | Global network & efficiency | Local know-how & presence | Reliability & customer proximity |
|---|---|---|---|

# Regional cluster organization and locations

## We are present wherever our customers need us




△ thyssenkrupp Industrial Solutions Headquarters

□ Regional Headquarters

○ Local Representations

# Engineering Excellence

## Global business, local implementation

### Fertilizer plant, USA

One of the largest single-train UAN plants

Capacity: 4,500 tpd of UAN

### Hydrogen plant, Finland

One of the largest hydrogen plants

Capacity: 153,000 Nm³/h of hydrogen

### Fully-mobile crusher, China

Open pit coal mining at 40°C below zero in winter

Capacity: 6,000 tph for removal of overburden

### Mining service center, Peru

Replacement and repair of wear parts

10 locations worldwide

### Fertilizer plant, Algeria

Nitrogen fertilizer plant

Capacity: 2 x 2,200 tpd of ammonia

1 x 3,450 tpd of urea

### Cement factory, Indonesia

Turnkey construction of 2 fully equipped cement production lines

Capacity: 4,000 tpd of clinker each

# Industrial Solutions

## Process Technologies at a glance

### Fertilizer/Coke Plant Technologies

Ammonia/Urea

Hydrogen/Nitrates

Phosphate Fertilizers

Coke plant technologies

Technical services

### Chemicals/ Oil & Gas

Electrolysis

Gas technologies

Oil & Gas

Polymers

Technical services

### Services

**360° Lifecycle Services**

Asset management

Spare parts supply & management

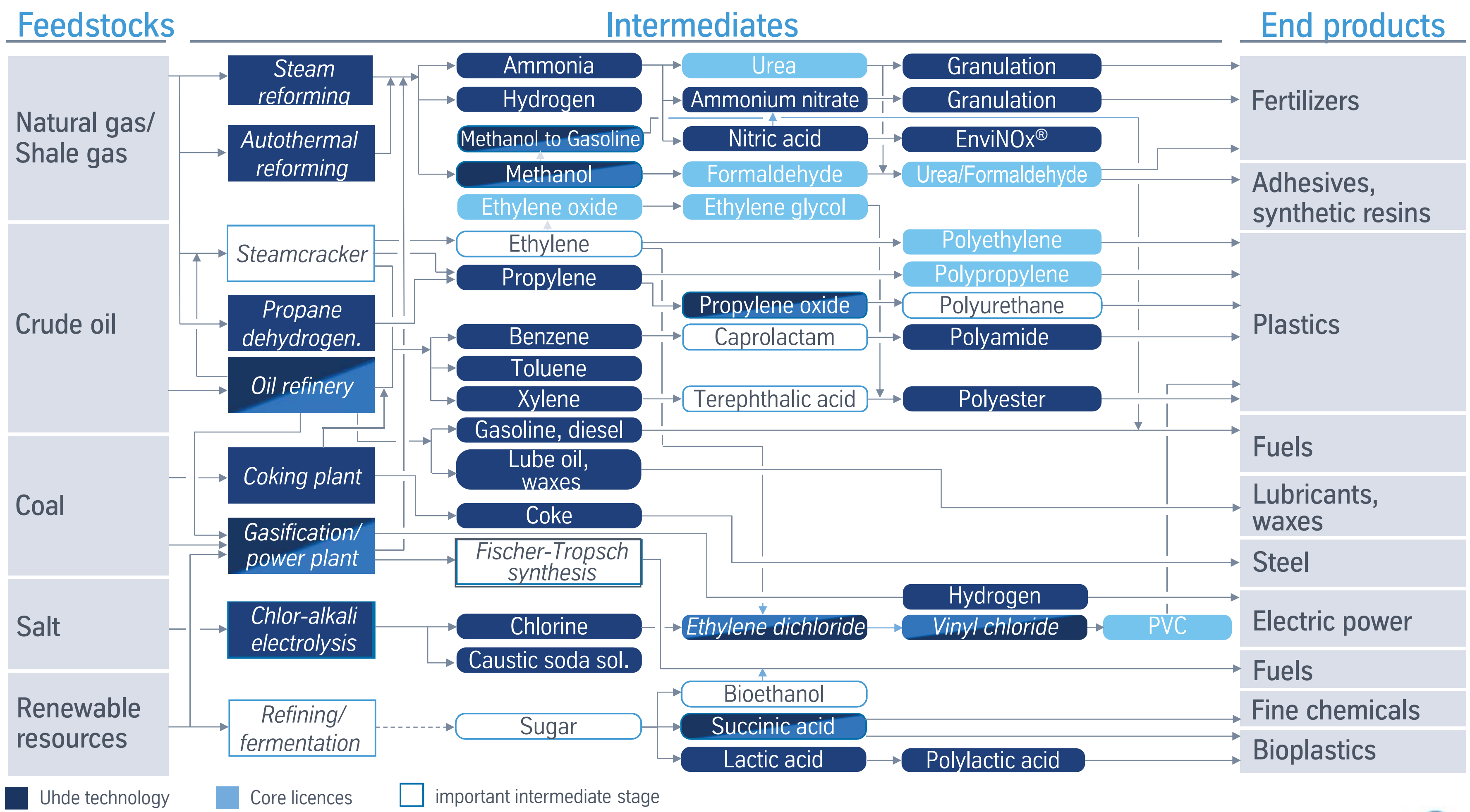
Engineering, Training & Consulting

Service center & Field Services

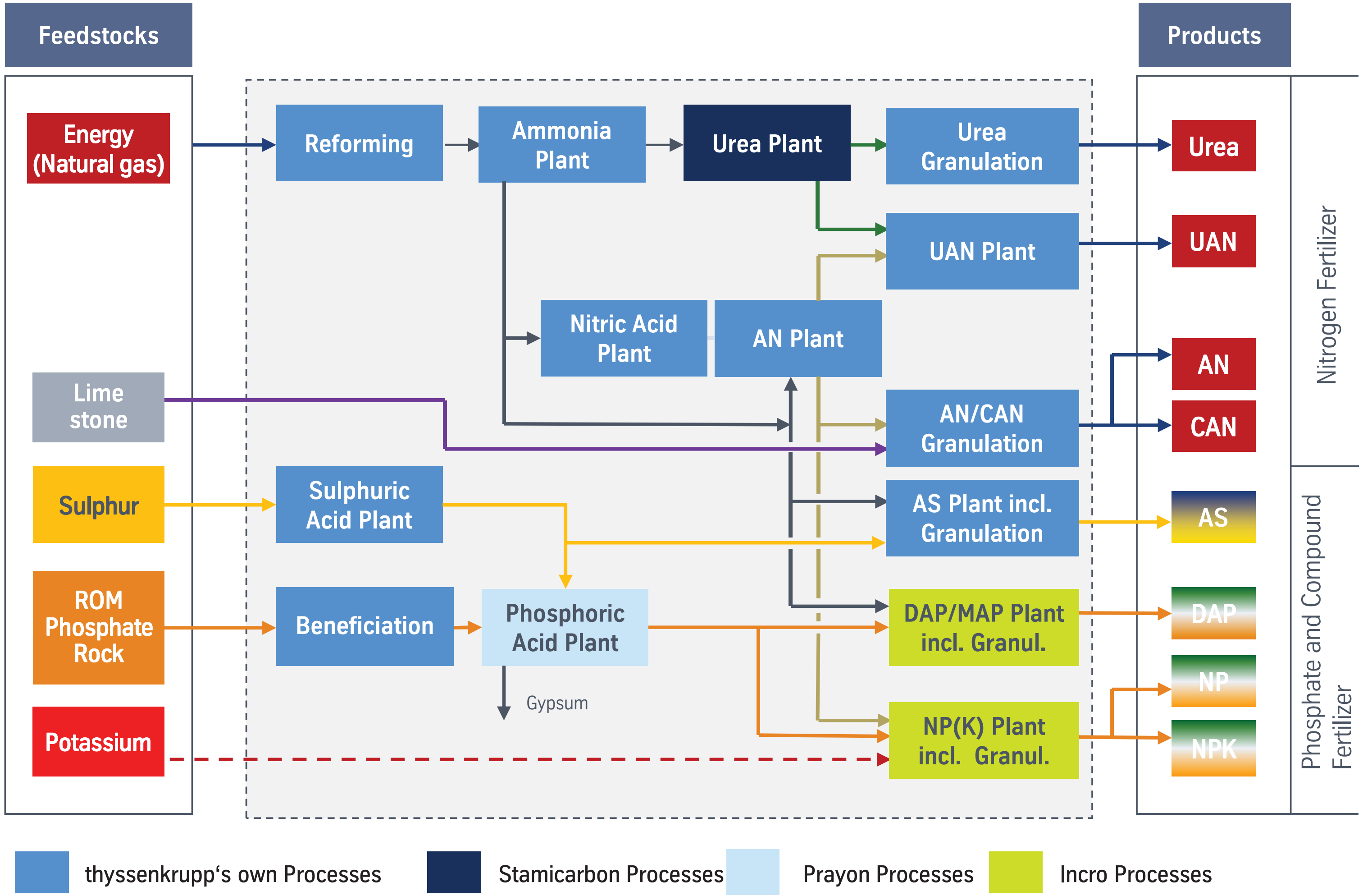
Revamps & Relocations

# Industrial Solutions

## Process Technologies – Outstanding technology portfolio



# TKIS is able to offer the whole process chain for N and P Fertilizers as an integrated solution with own and licensed technologies



# Industrial Solutions

## More than 2,000 plants built around the globe

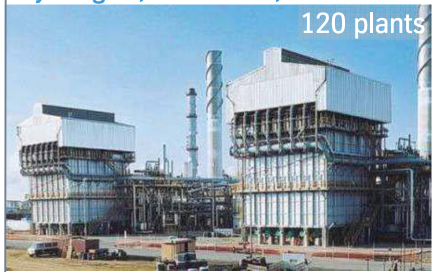
Fertilizers


Nitric acid


Refineries


Aromatics


Hydrogen, Ammonia, Methanol




Organic chemicals, Petrochemicals


Plastics, Synthetic fibers


Polyester, Polyamides


Electrolysis


Coke plants


Gasification


Industrial plants

# Industrial Solutions

## Resource Technologies at a glance

### Mining

**Mining Systems**

Continuous mining systems

In-pit crushing systems

Belt conveyor systems

**Mineral Processing**

Crushing & grinding plants

Crushers, mills, screens, feeders, separators

Pyroprocessing & metallurgical injections systems

**Materials Handling**

Stockyard & port handling systems for bulk materials

Cable cranes

Drive units and gearboxes

### Cement

Raw material preparation

Clinker production

Cement manufacturing

Factory automation

### Services

**360° Lifecycle Services**

Asset management

Spare parts supply & management

Engineering, Training & Consulting

Service center & Field services

Revamps & Relocations

# thyssenkrupp Industrial Solutions

## Your Partner in the Phosphate Fertilizer Industry

From the mine pit to the port




via sulphuric acid, phosphoric acid to fertilizer



With our services supporting you from project development to complete EPC implementation of the full process chain

# Industrial Solutions

## Resource Technologies – Selected track record around the globe

Bucket wheel excavators


Spreaders/Belt wagons/
Tripper cars


Mobile and
semi-mobile crushing plants


Customer training
lessons


Stockyard handling systems

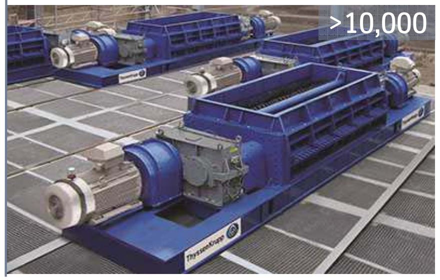

Asset management contracts


Port Handling systems


Cement kiln lines

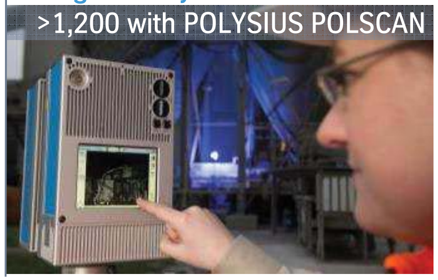

Available OEM spare parts


Crushers




Screens


Kiln geometry measurement




Thank You for Your Attention!
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# AFA workshop

General Presentation of tkIS' Asset Management (O&M) capabilities

Stefan Dähn & Olaf Kraska

Aqaba, 11th April 2016

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# Asset Management (AM)

## Focus for AM Services of thyssenkrupp Industrial Solutions

Asset Management

<u>Operation</u>
Improve Asset Utilization

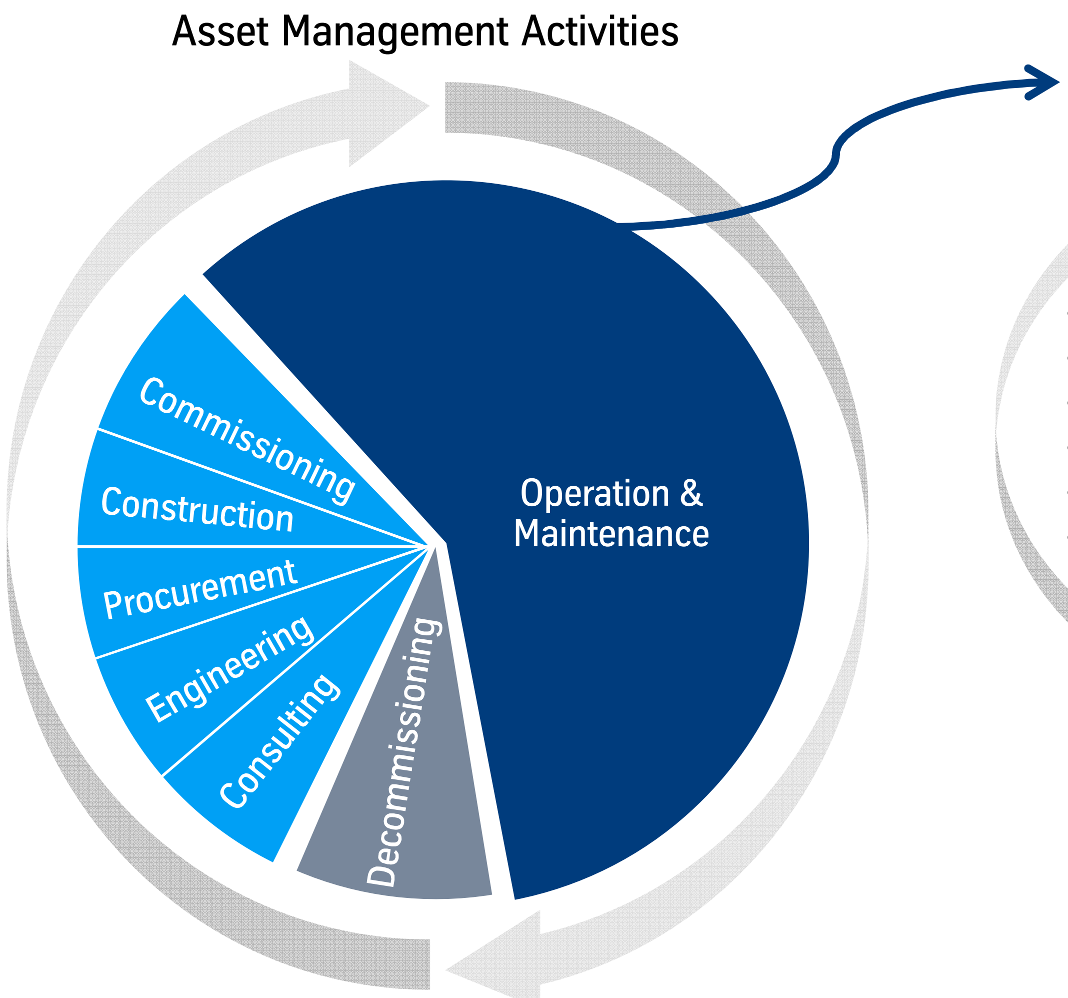
<u>Maintenance</u>
Improve Asset Availability & Condition


Processes

Software (CMMS)

Experience

# Asset Management – Plant Lifecycle



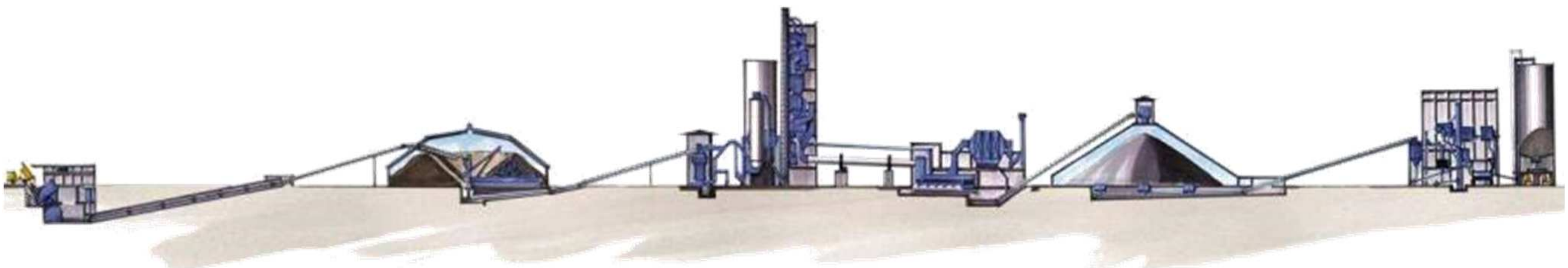


tkIS activities covers the whole plant lifecycle (EPC + Services)

# Asset Management

## tkIS' AM services cover the whole production process from raw materials to final product

- thyssenkrupp offers joint AM services as one-stop-shopping solution for customers:
  - tkIS Process Technologies, e.g. fertilizer & (petro)chemical plants
  - tkIS Resource Technologies, e.g. raw material handling, cement plants, mining equipment



**Raw material preparation**

- Crushing
- Bulk material storage and blending
- Metered feeding
- Grinding
- Homogenizing

**Production process**

- Ammonia
- Steam reformer
- Nitric acid
- Urea (pool condenser / pool reactor)
- Catalyst
- Granulation

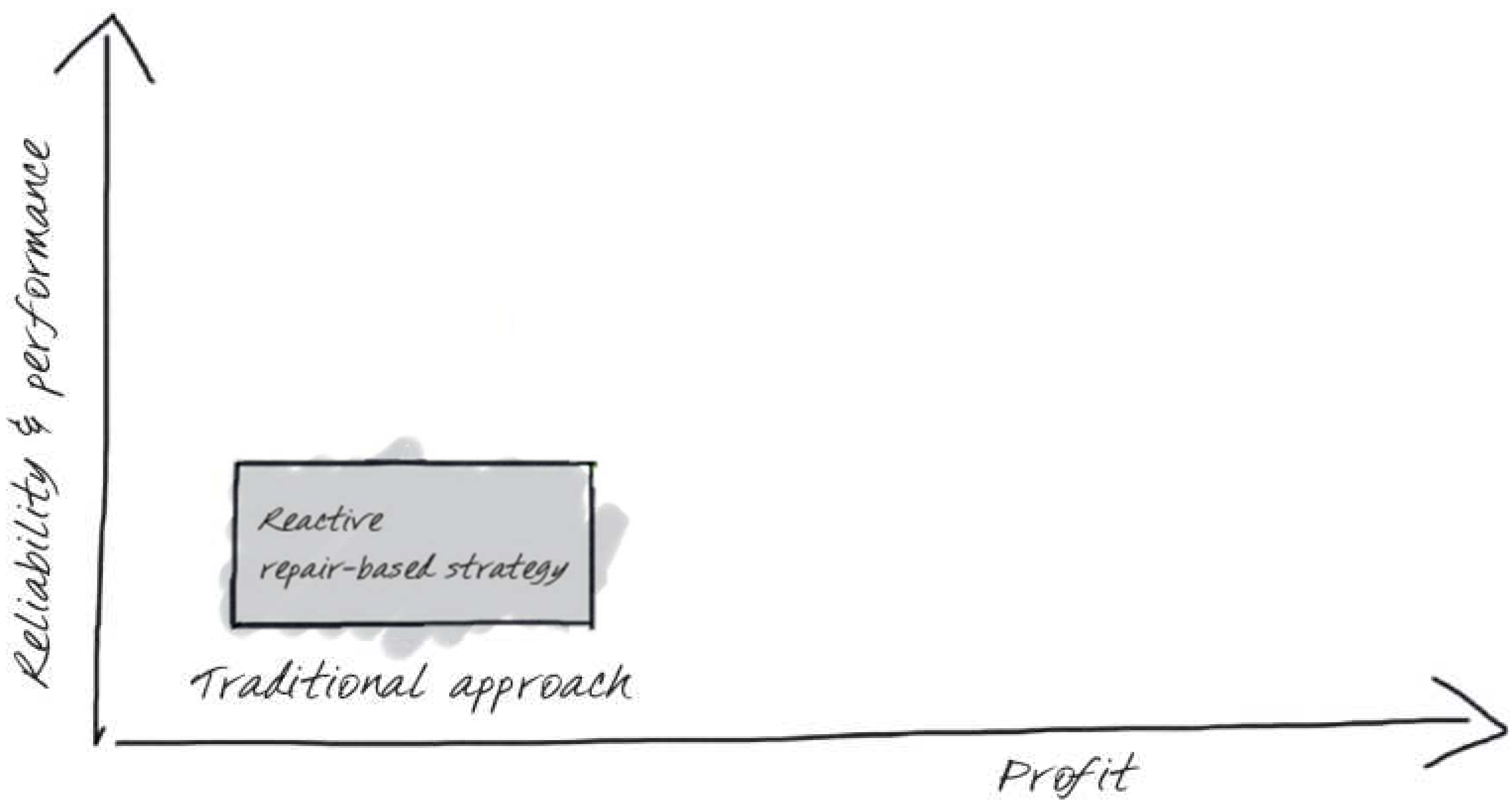
**Material handling & logistics**

- Storage
- Conveying/metered feeding
- Grinding
- Storage, packing and shipping

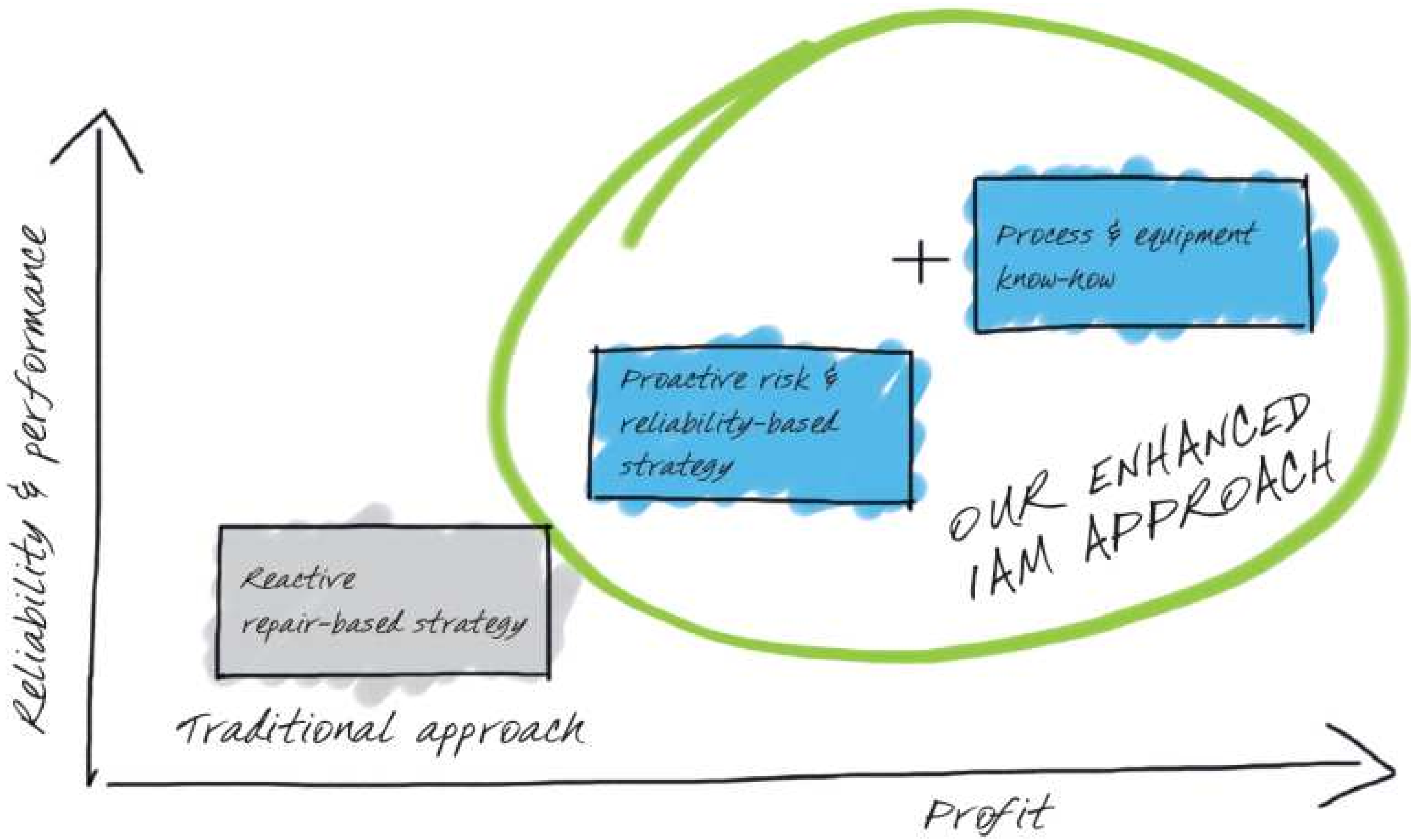
# Asset Management

## Iceberg Model – But what about the hidden costs that can really hurt your business?

# Adding value to the traditional, reactive strategy by…



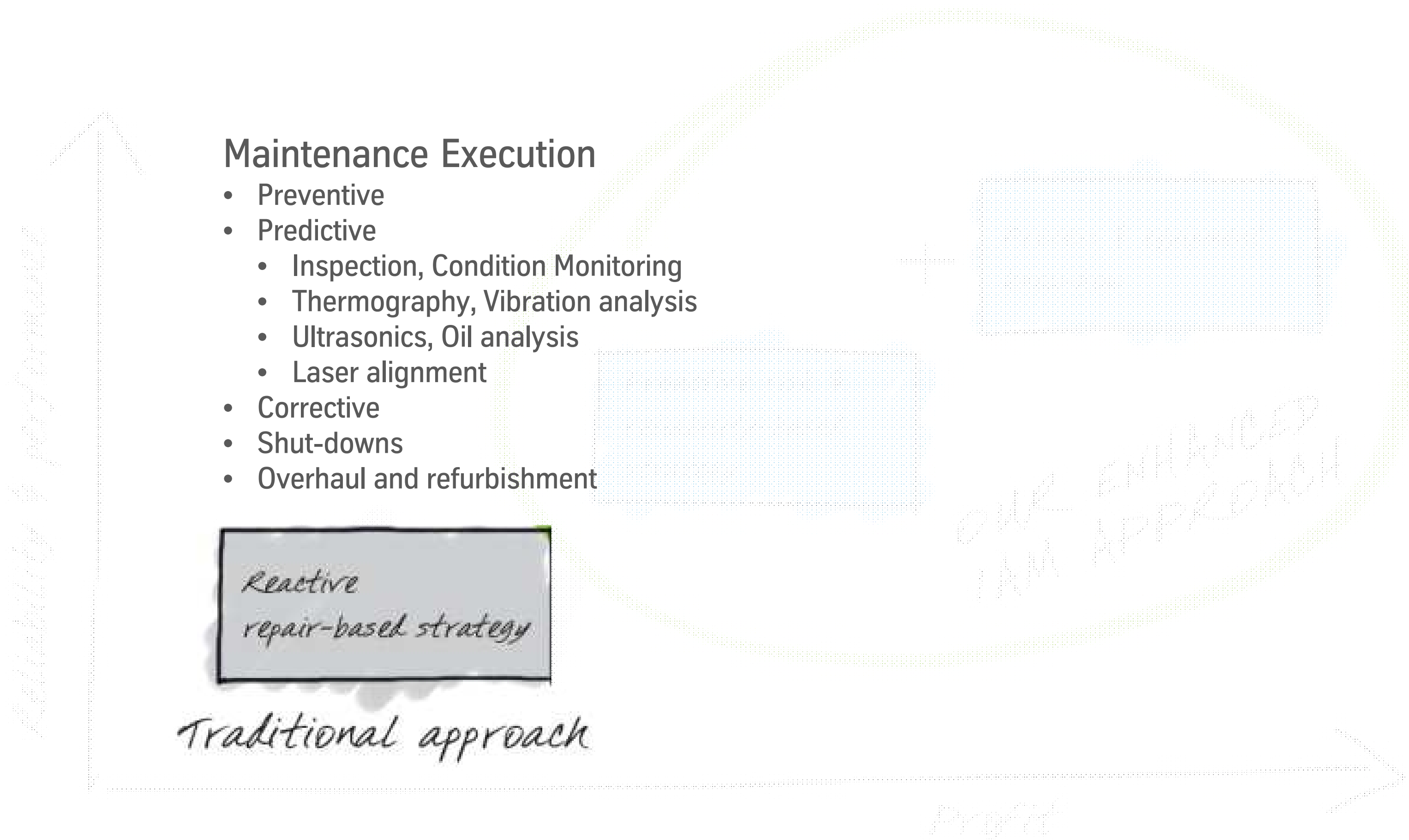
# Adding value to the traditional, reactive strategy by…
# improving reliability and performance through our enhanced AM approach



# Adding value to the traditional, reactive strategy by…
# improving reliability and performance through our enhanced AM approach

## Maintenance Execution

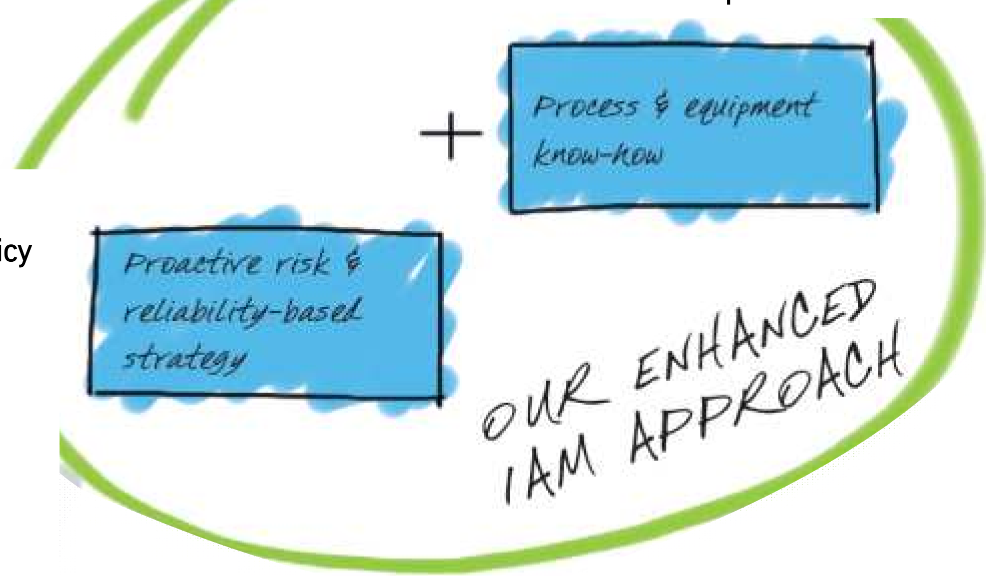
- Preventive
- Predictive
  - Inspection, Condition Monitoring
  - Thermography, Vibration analysis
  - Ultrasonics, Oil analysis
  - Laser alignment
- Corrective
- Shut-downs
- Overhaul and refurbishment



# Adding value to the traditional, reactive strategy by… improving reliability and performance through our enhanced AM approach

### tkIS Plant Engineering

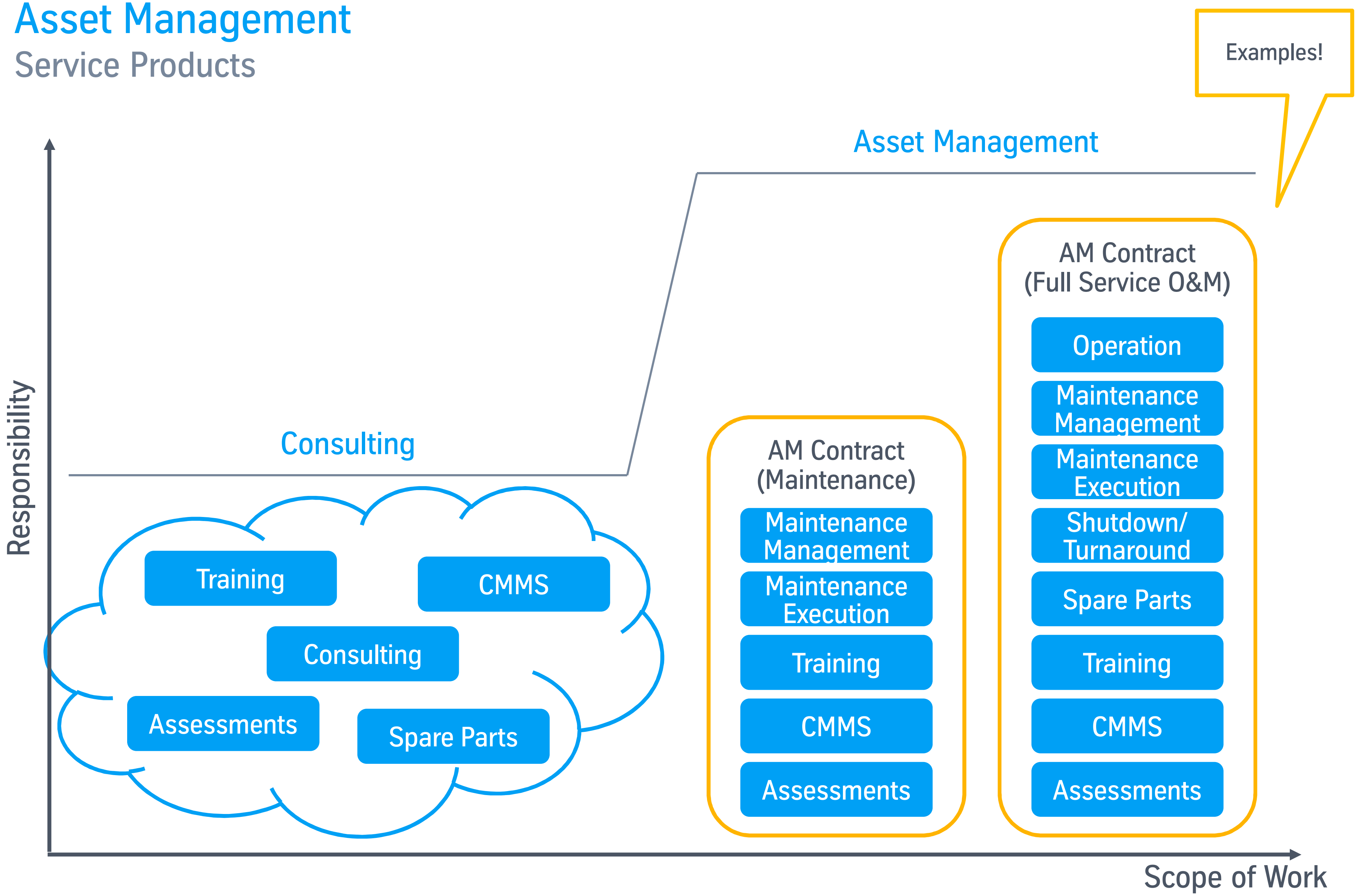
- Optimization of Equipment Design
- Optimization of Process
- Optimization of Spare and Wear parts




### tkIS Maintenance Engineering

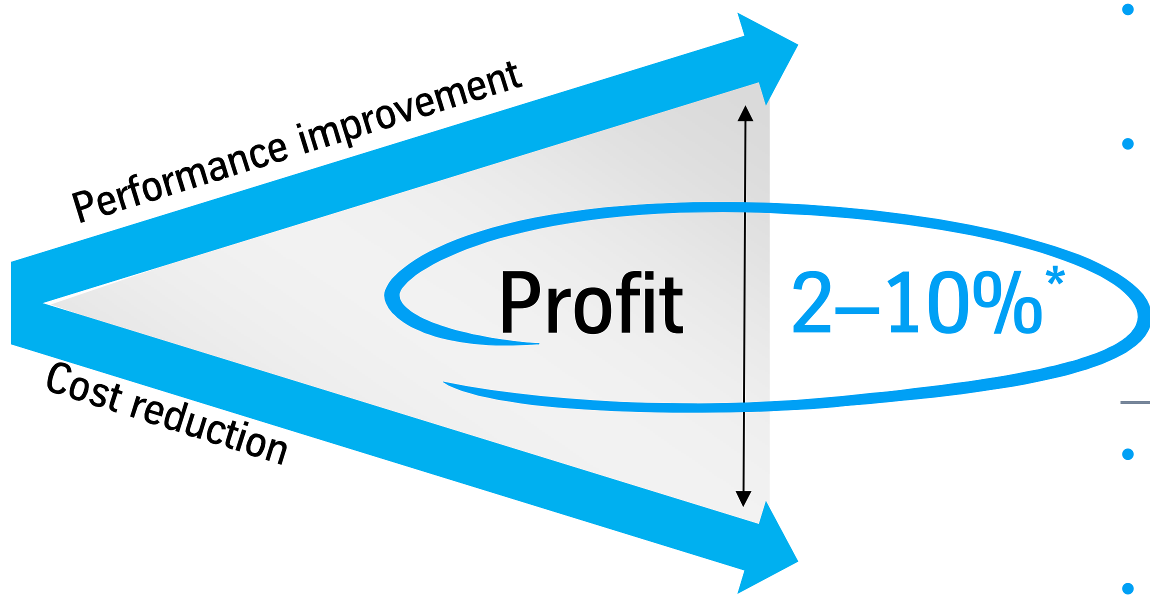
- Developing maintenance strategy / policy
- Developing maintenance plans and procedures
- Planning and scheduling maintenance work
- Training of personnel
- Root Cause Analysis Procedure
- Provision and / or use of CMMS
- Condition Monitoring
- Materials Management

# Asset Management
## Service Products




* CMMS – Computerized Maintenance Management System

# tkIS Asset Management (AM)




## Performance Improvement

- Proactive Approach
- Strong and proven Systems & Processes
- Focus on Maintenance Management, Maintenance Engineering and modern Condition Monitoring

## Cost Reduction

- Focus on hidden / indirect costs (iceberg)
- High efficiency and productivity of work force due to high amount of Planning & Preparation
- Medium to long-term effect as a result of the above

*for each percent of improvement, depending on industry and country

# Asset Management

## Contact Us!

Industrial Solutions
Resource Technologies

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Head of Maintenance
Global Service

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Industrial Solutions
Process Technologies

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E-mail: stefan.daehn@thyssenkrupp.com

# Backup

# AFA workshop

Maintenance Strategies & Contracting Options

Stefan Dähn

Aqaba, 11th April 2016

engineering. tomorrow. together.

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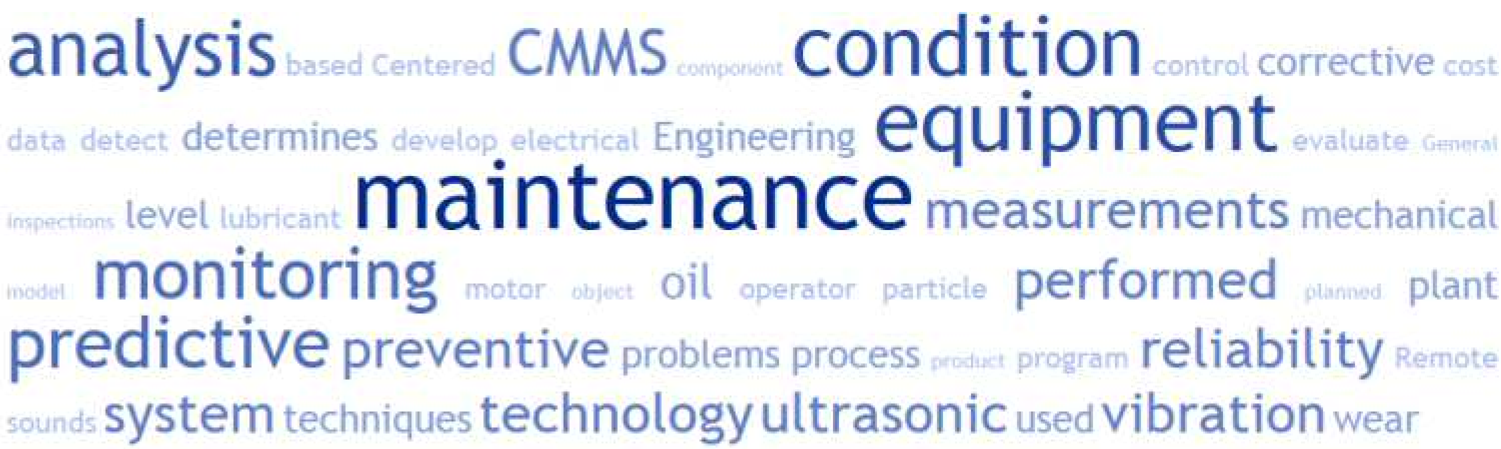
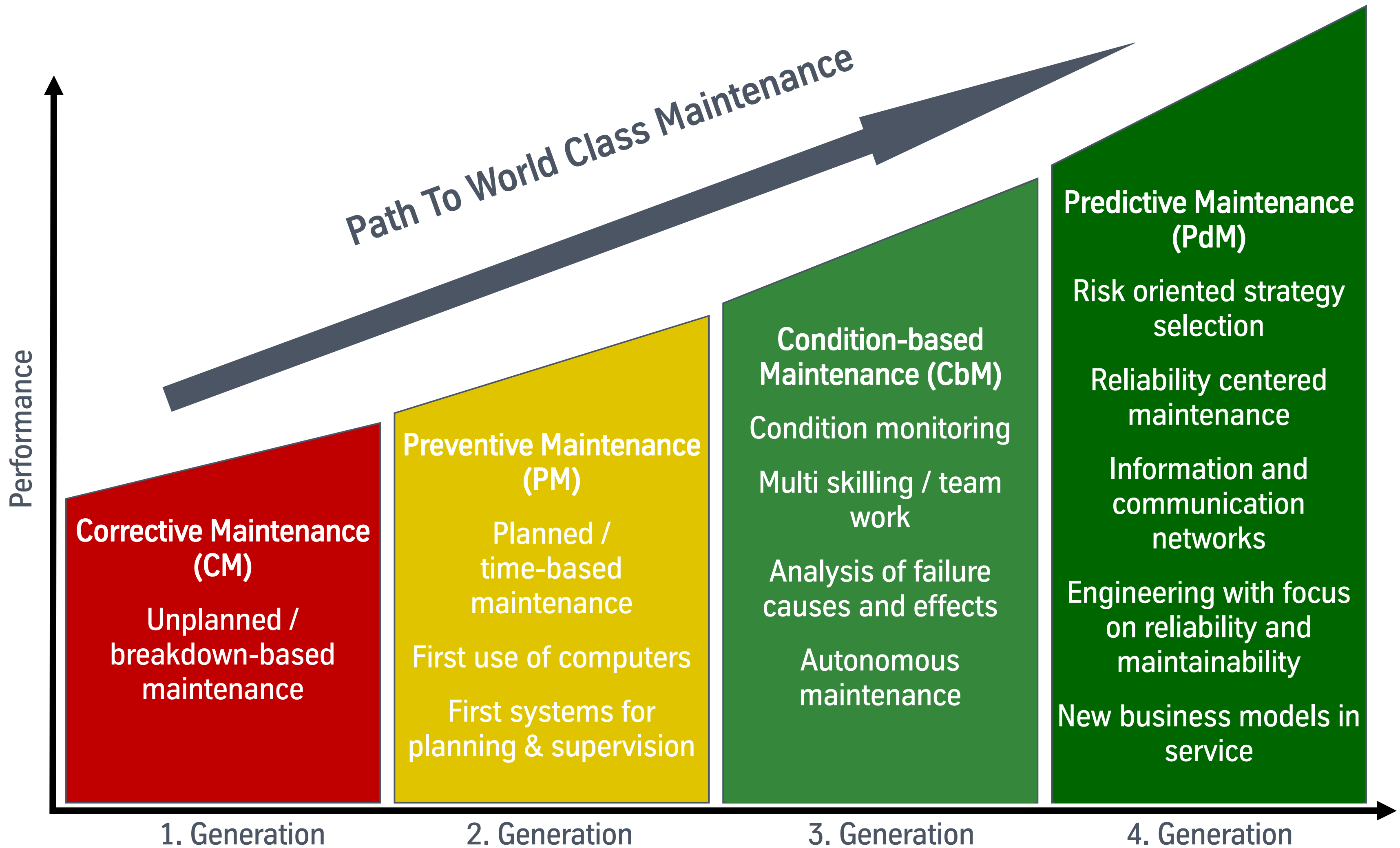
# Maintenance Strategies

Lots of buzz words at the moment – How to make sense of it all?



# Maintenance Strategies

## Evolution of maintenance




Source: K. Matyas (2013), p. 23

# Maintenance Strategies

## Analysis of failure risk and failure impact

High

Criticality / impact of failure

Low

### Time-based Maintenance (PM)

- Maintenance based on fixed time or operating hours
- Appropriate for components with low failure risk, but high failure impact

### Predictive Maintenance (PdM)

- Maintenance based on steady, intense condition monitoring and anticipated failure impact
- Recommended for the most vulnerable and critical components

### Corrective Maintenance (CM)

- No inspection or maintenance until breakdown (only for components where failure does not affect safety)
- For components with low failure risk and impact, or where preventive maintenance is not feasible

### Condition-based Maintenance (CbM)

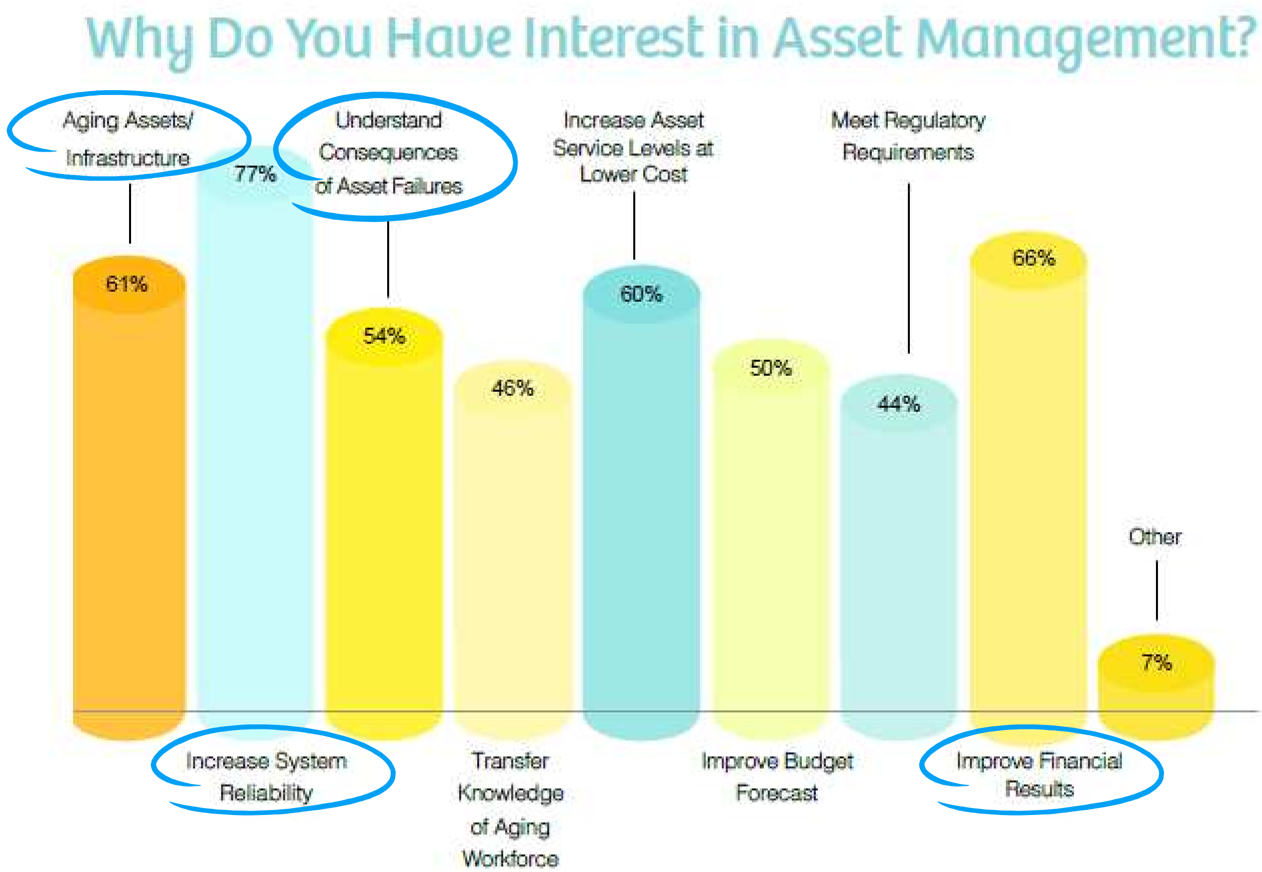
- Maintenance when required based on continuous or occasional monitoring
- Recommended for components with high failure risk
- Condition monitoring for components must be feasible

Low

Vulnerability / risk of failure

High

# Maintenance Strategies
## Motivation




Source: Asset Management Report (2014), http://www.reliabilityweb.com.

# Contracting Options

## Motivation & common contracting options

- **Motivation for engaging with third-party contractors:**
  - Optimization of (overall) costs → Iceberg Model / Asset Management Report
  - Mitigation of risk
  - External know-how / know-how transfer

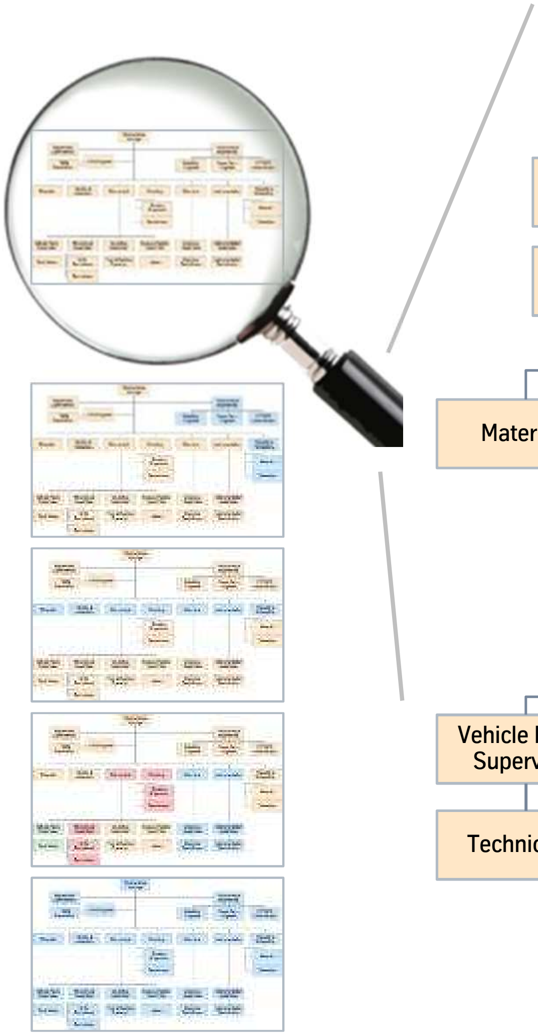
- **Different contracting options:**
  - No contracting (maintenance solely performed by customer)
  - Integrated team of customer and contractor (various combinations)
  - Maintenance contracted to one general contractor (Full Service contract)

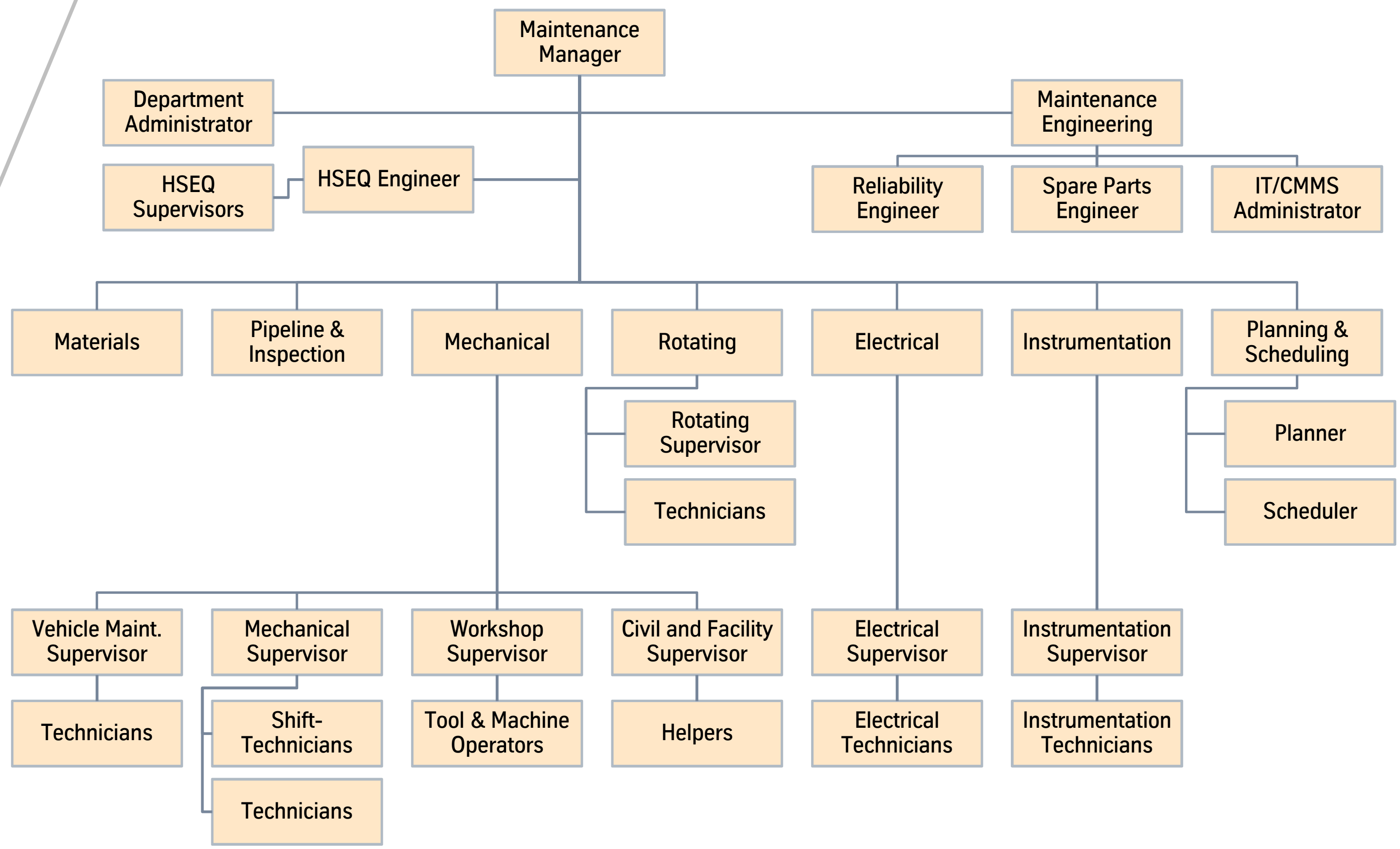
**Best contracting solution depends on O&M strategy, location, personnel, process technology**

# Contracting Options

## No third-party contractor

Example!



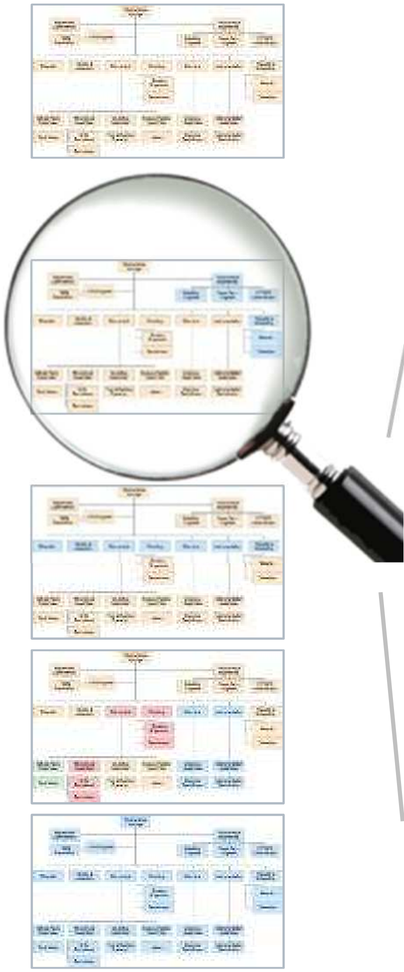


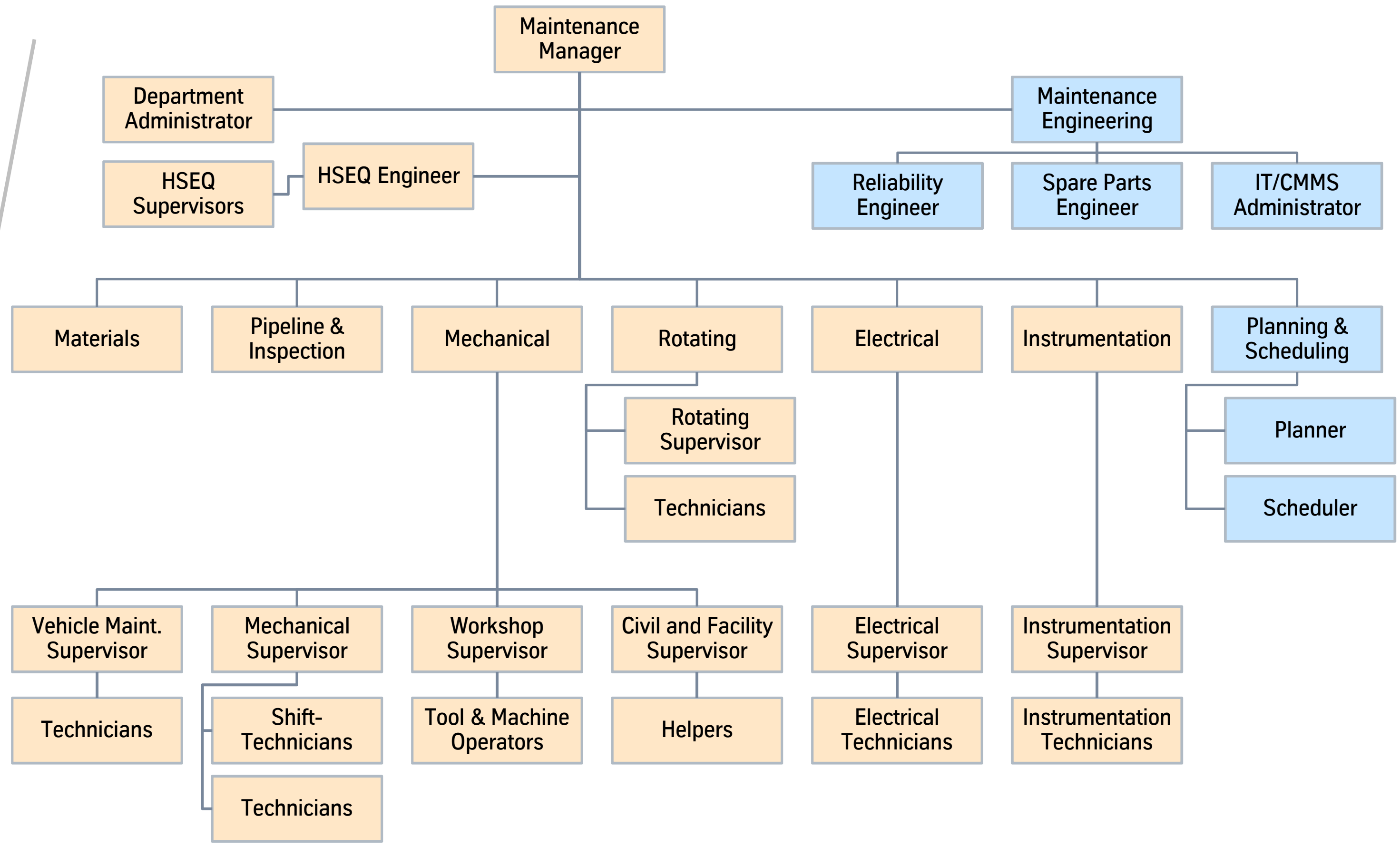

Notice: CUSTOMER | CONTRACTOR 1 | CONTRACTOR 2 | CONTRACTOR 3

# Contracting Options

## Integrated Maintenance (one discipline)

Example!



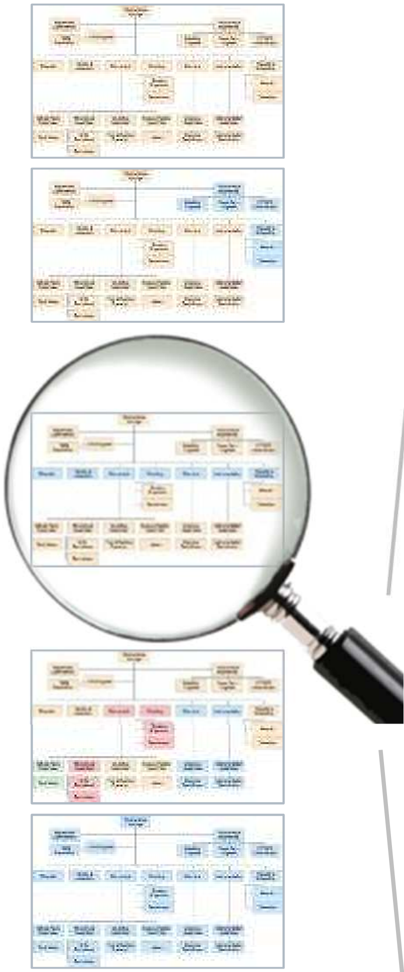


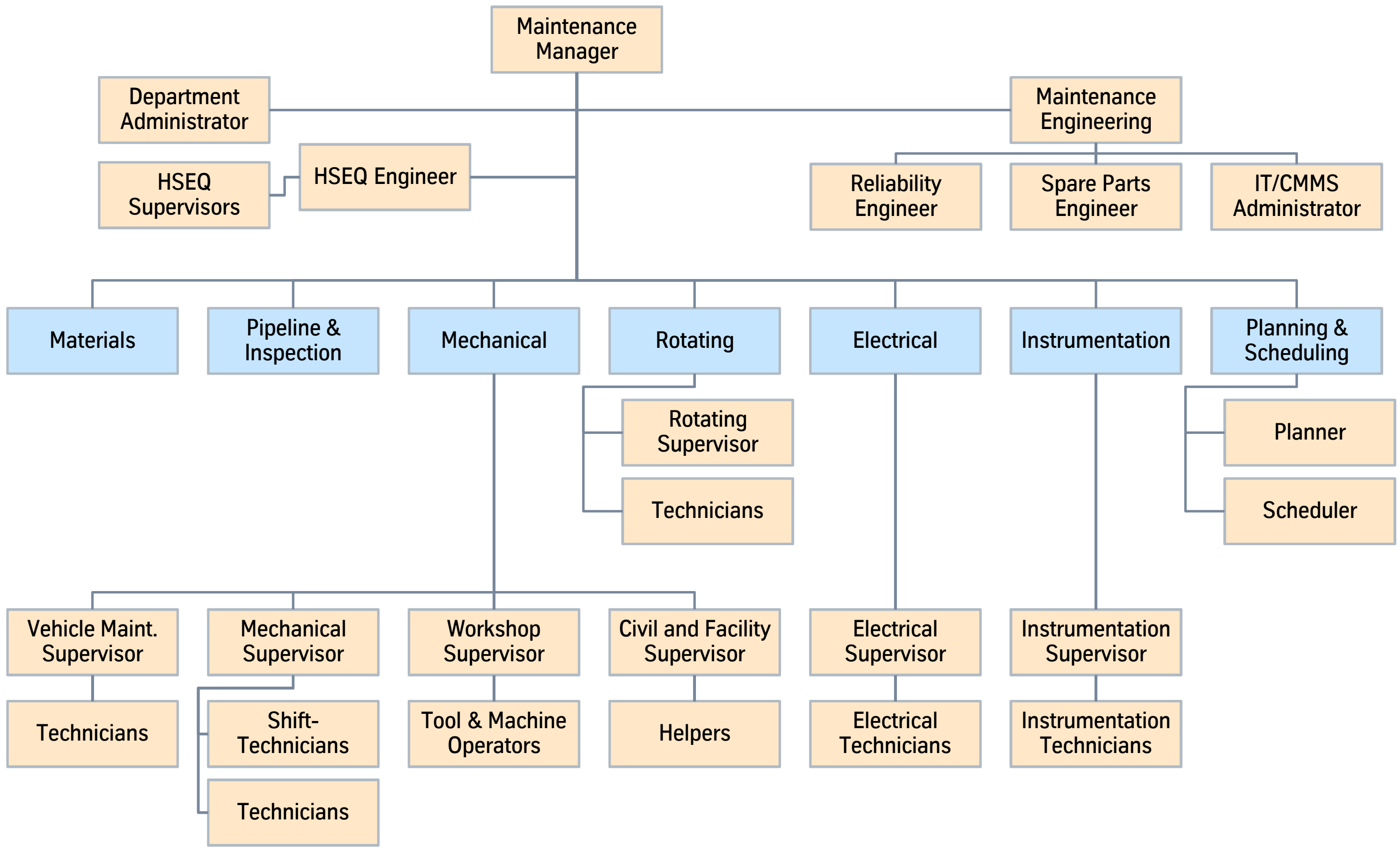

Notice: CUSTOMER | CONTRACTOR 1 | CONTRACTOR 2 | CONTRACTOR 3

# Contracting Options

## Integrated Maintenance (supervisory level)

Example!



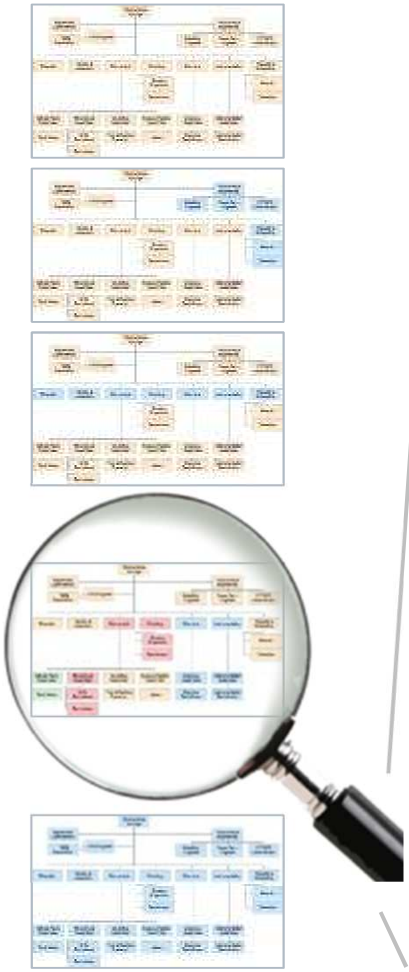


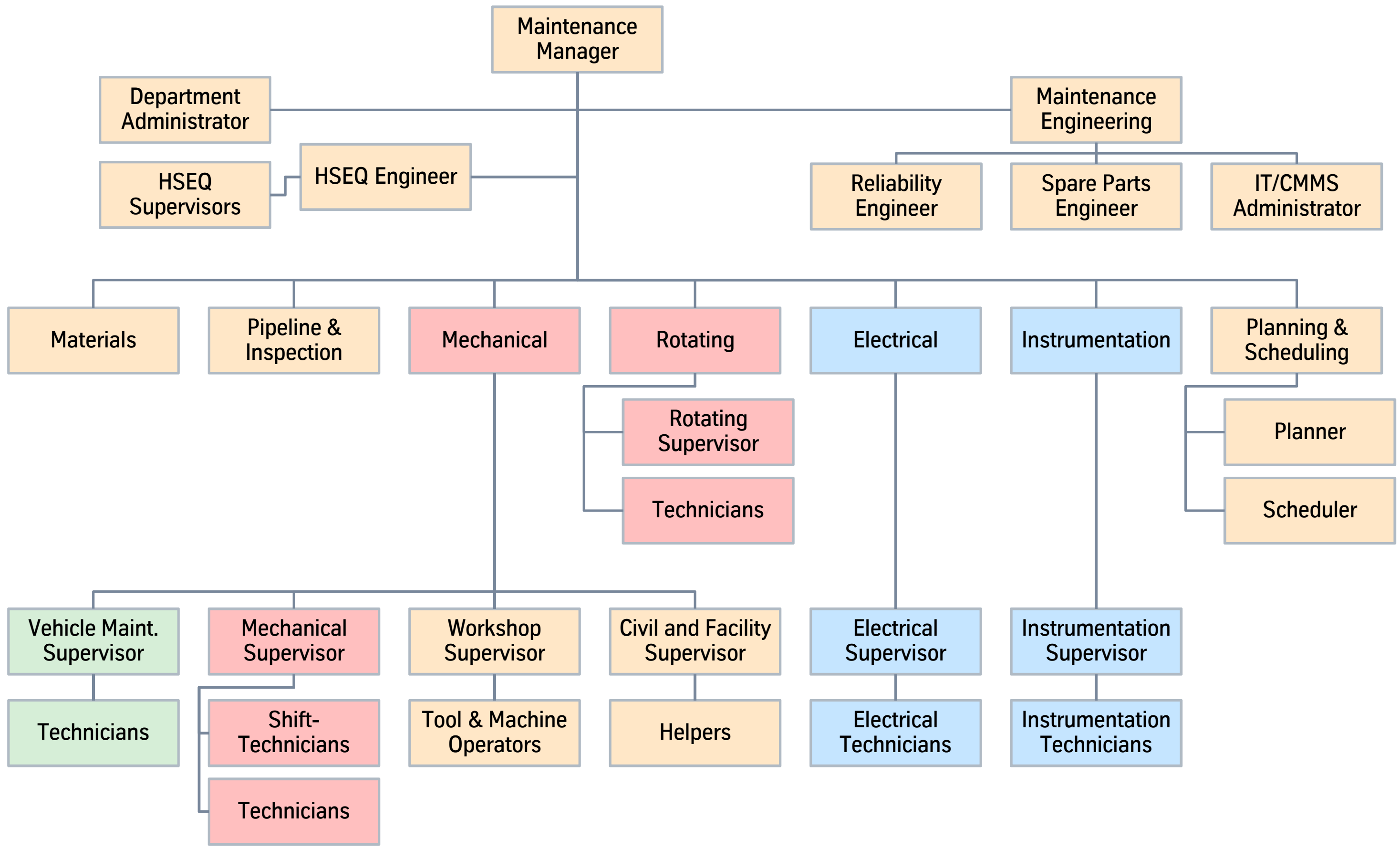

Notice: CUSTOMER | CONTRACTOR 1 | CONTRACTOR 2 | CONTRACTOR 3

# Contracting Options

## Integrated Maintenance (multi contractor concept)

Example!



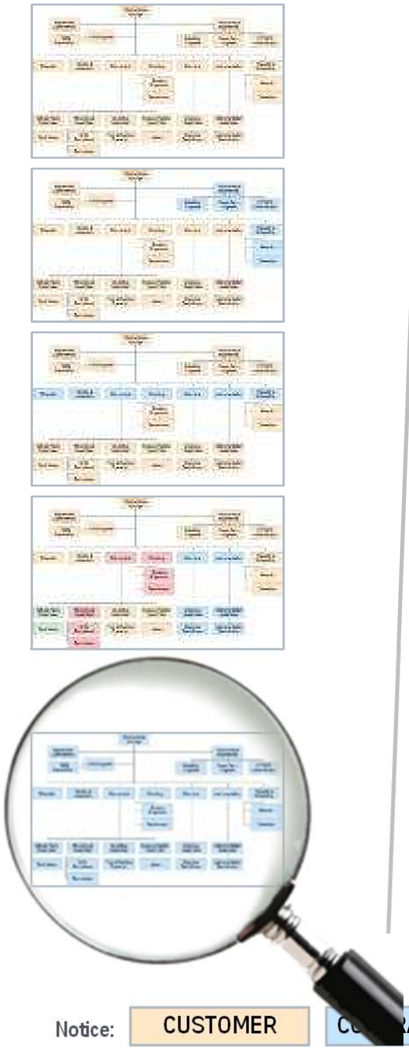


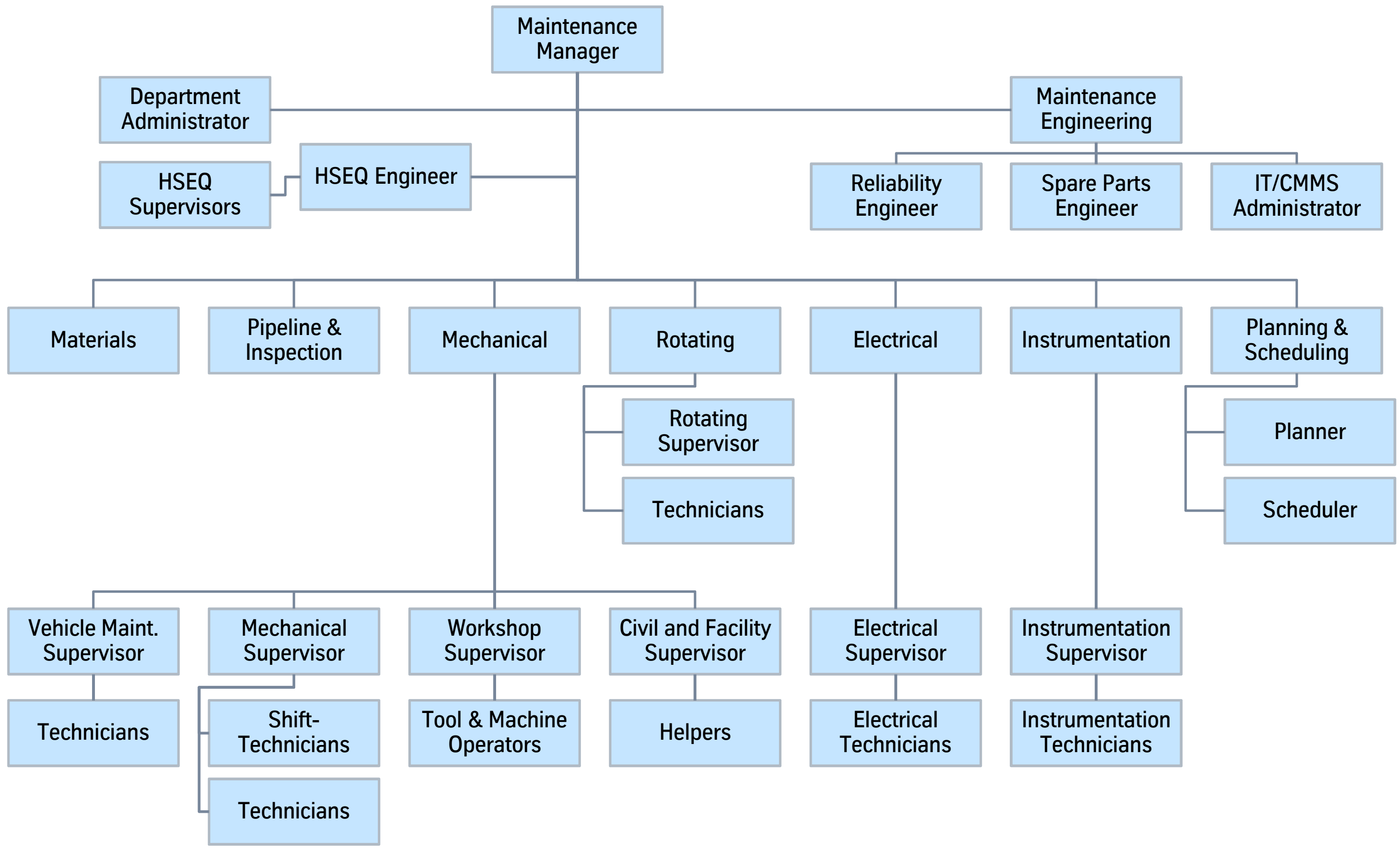

Notice: CUSTOMER | CONTRACTOR 1 | CONTRACTOR 2 | CONTRACTOR 3

# Contracting Options

## Full Service Maintenance (one general contractor)

Example!



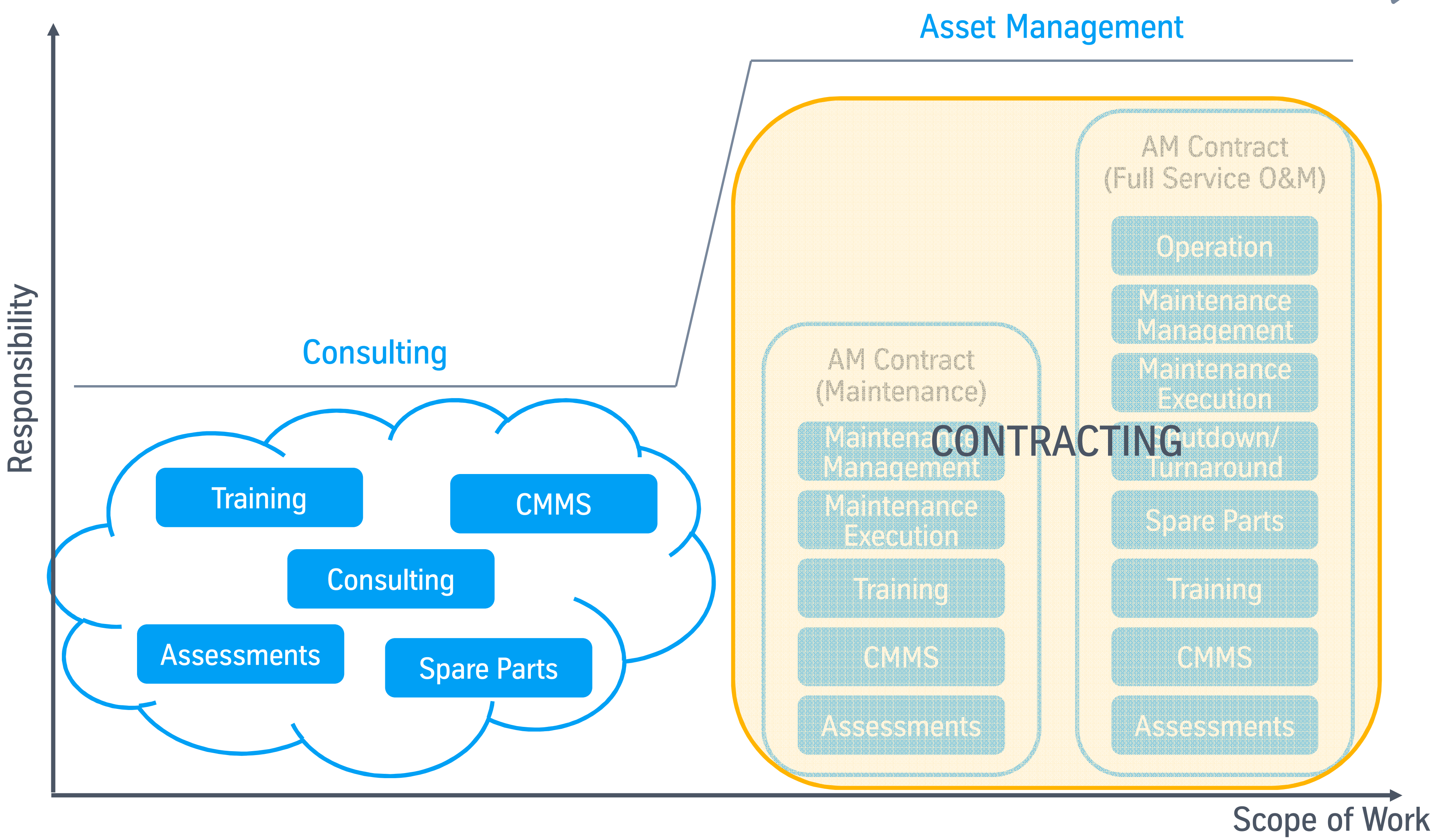



Notice: CUSTOMER | CO ACTOR 1 | CONTRACTOR 2 | CONTRACTOR 3

# Contracting Options

## Scope of work

Examples!




CMMS – Computerized Maintenance Management System

# Contracting Options
## Commercial considerations

- Typically long-term contracts (≥3 years)

- Reimbursable
  - Negotiated unit rates
- Lump sum
  - Fixed installments (e.g. milestones, months)
- Lump sum + performance based incentive scheme
  - Fixed installments + KPI based bonus/malus (e.g. quarterly, annually)
- Open book
  - Actual price + handling/management fee
- Open book + performance based incentive scheme
  - Actual price + handling/management fee + KPI based bonus/malus (e.g. quarterly, annually)
- Output based
  - Unit rate per output

**Model to be developed jointly by tkIS and customer (combinations possible)**

# Maintenance Strategies & Contracting Options

## Questions for the audience

END of Presentation – Thank you for your attention!

&

BEGINNING of Discussions:

- In which of the generations of maintenance do you see your organization?
- Do you apply CM+PM+CbM+PdM?
- What is your motivation to work with contractors and how happy are you with the performance?
- What contracting model and commercial model do you apply?

# Maintenance Strategies & Contracting Options

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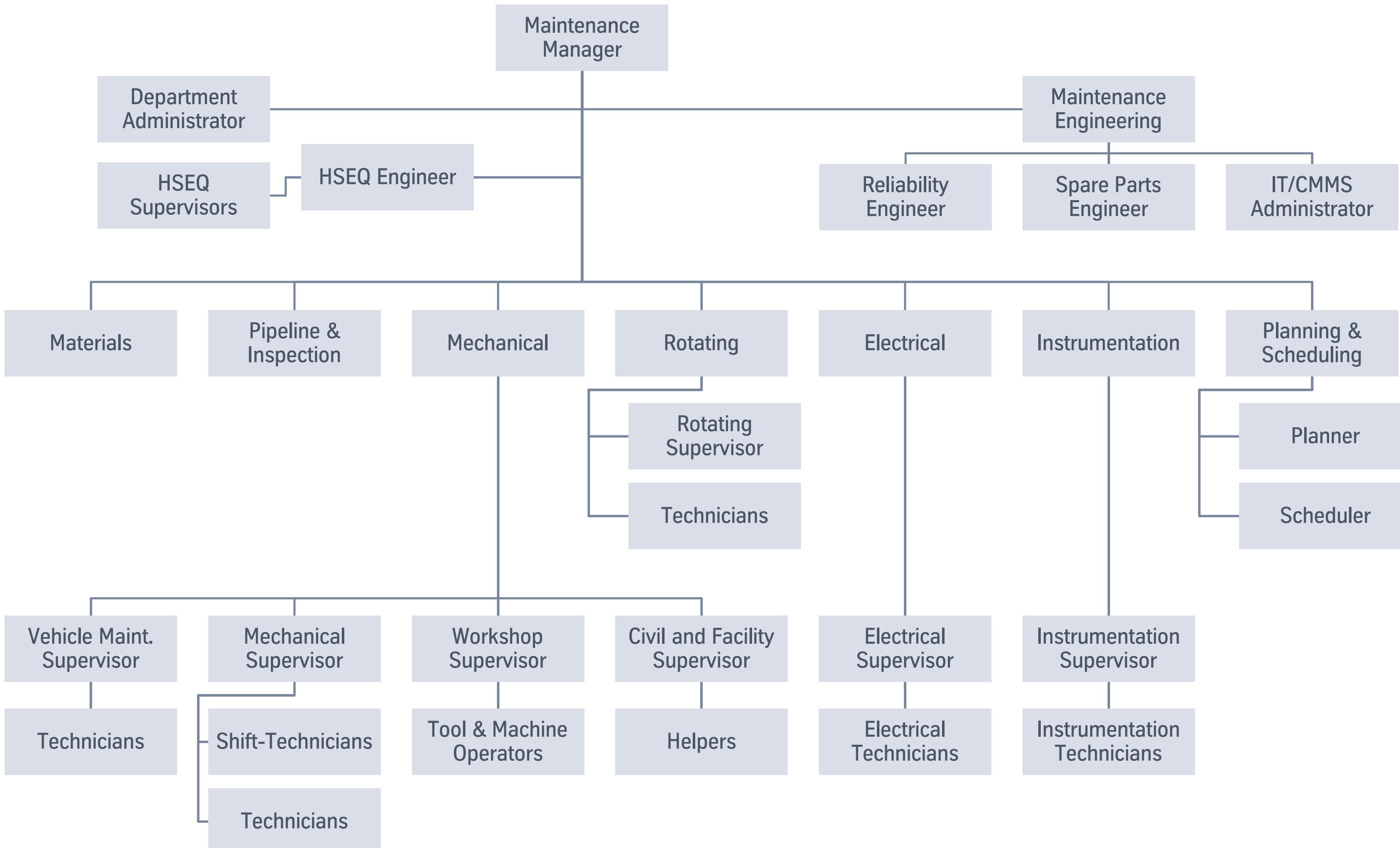
# Backup


Maintenance Manager
Department Administrator
Maintenance Engineering
HSEQ Supervisors
HSEQ Engineer
Reliability Engineer
Spare Parts Engineer
IT/CMMS Administrator
Materials
Pipeline & Inspection
Mechanical
Rotating
Electrical
Instrumentation
Planning & Scheduling
Rotating Supervisor
Technicians
Planner
Scheduler
Vehicle Maint. Supervisor
Mechanical Supervisor
Workshop Supervisor
Civil and Facility Supervisor
Electrical Supervisor
Instrumentation Supervisor
Technicians
Shift-Technicians
Technicians
Tool & Machine Operators
Helpers
Electrical Technicians
Instrumentation Technicians

# AFA workshop

Maintenance Engineering – From equipment to maintenance plans

Olaf Kraska

Aqaba, 11th April 2016

engineering. tomorrow. together.

thyssenkrupp

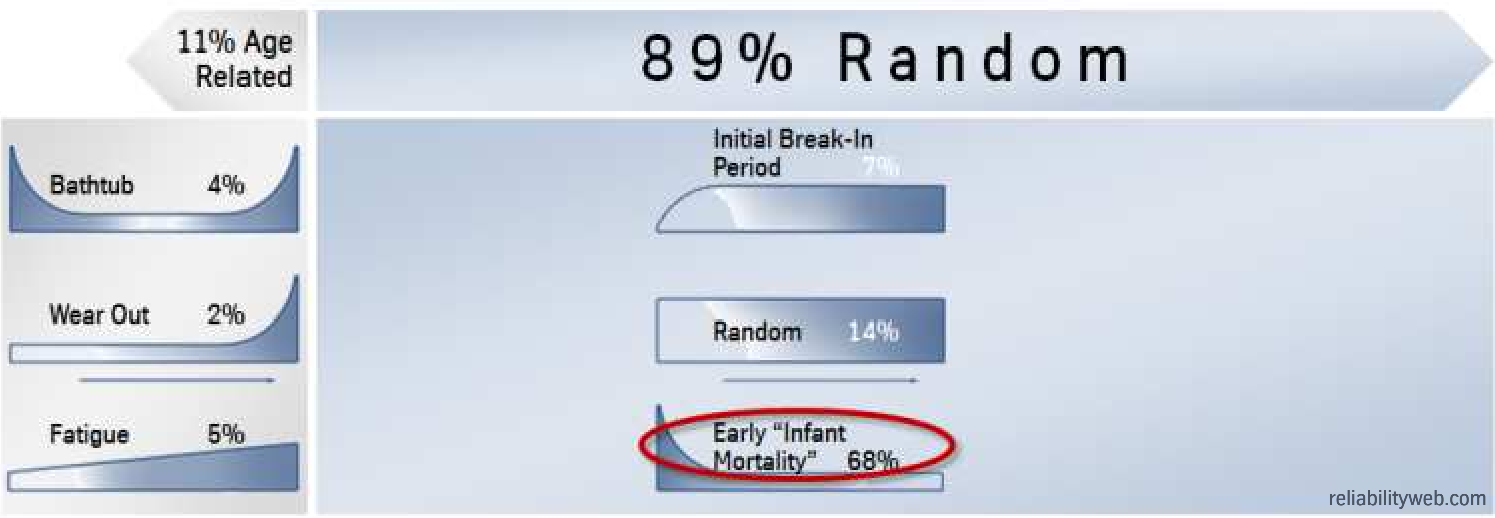
# Agenda

1. Introduction to Maintenance Engineering
2. Maintenance Engineering - Process details
3. Some figures from references
4. Next steps: What is needed in addition?

# Introduction to Maintenance Engineering

## General information

- Why Maintenance Engineering?
  - To have individual & customized maintenance plans with the right strategy for each equipment!
- Why customized maintenance plans?
  - Because each plant and equipment is different! No “one fits all” solution!

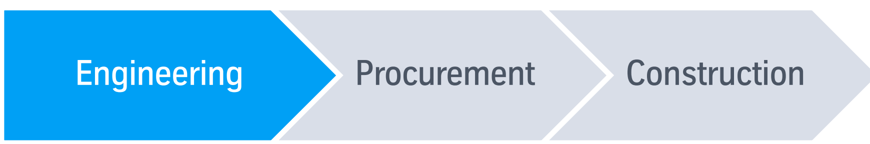


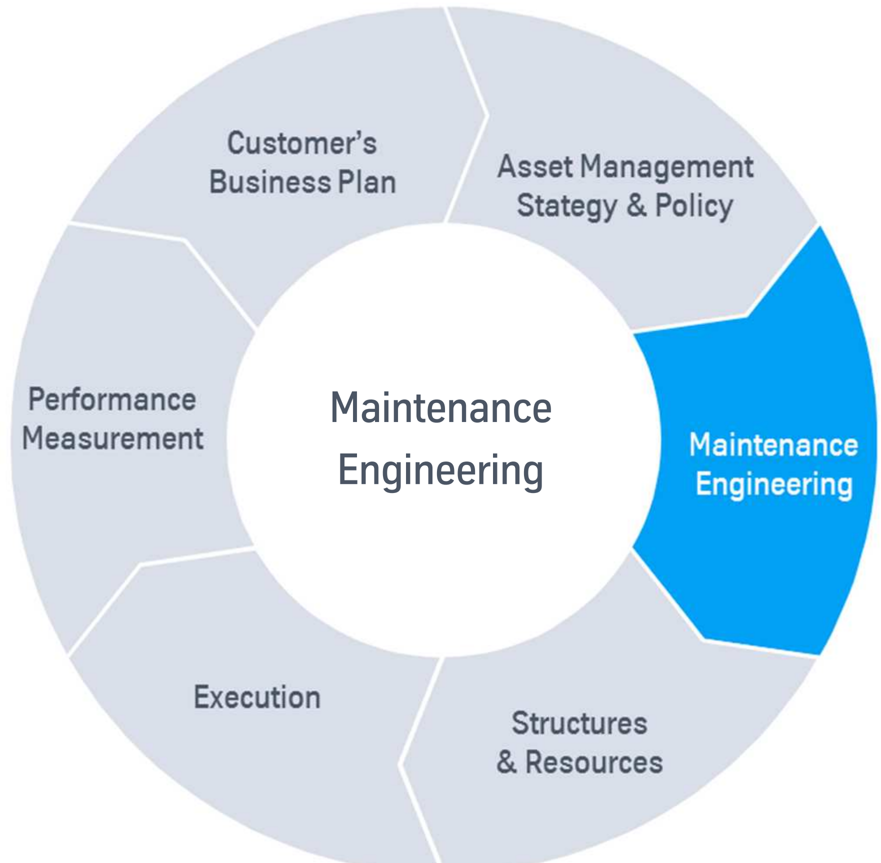

**Maintenance Engineering: To achieve highest uptime at lowest production costs!**

# Introduction to Maintenance Engineering

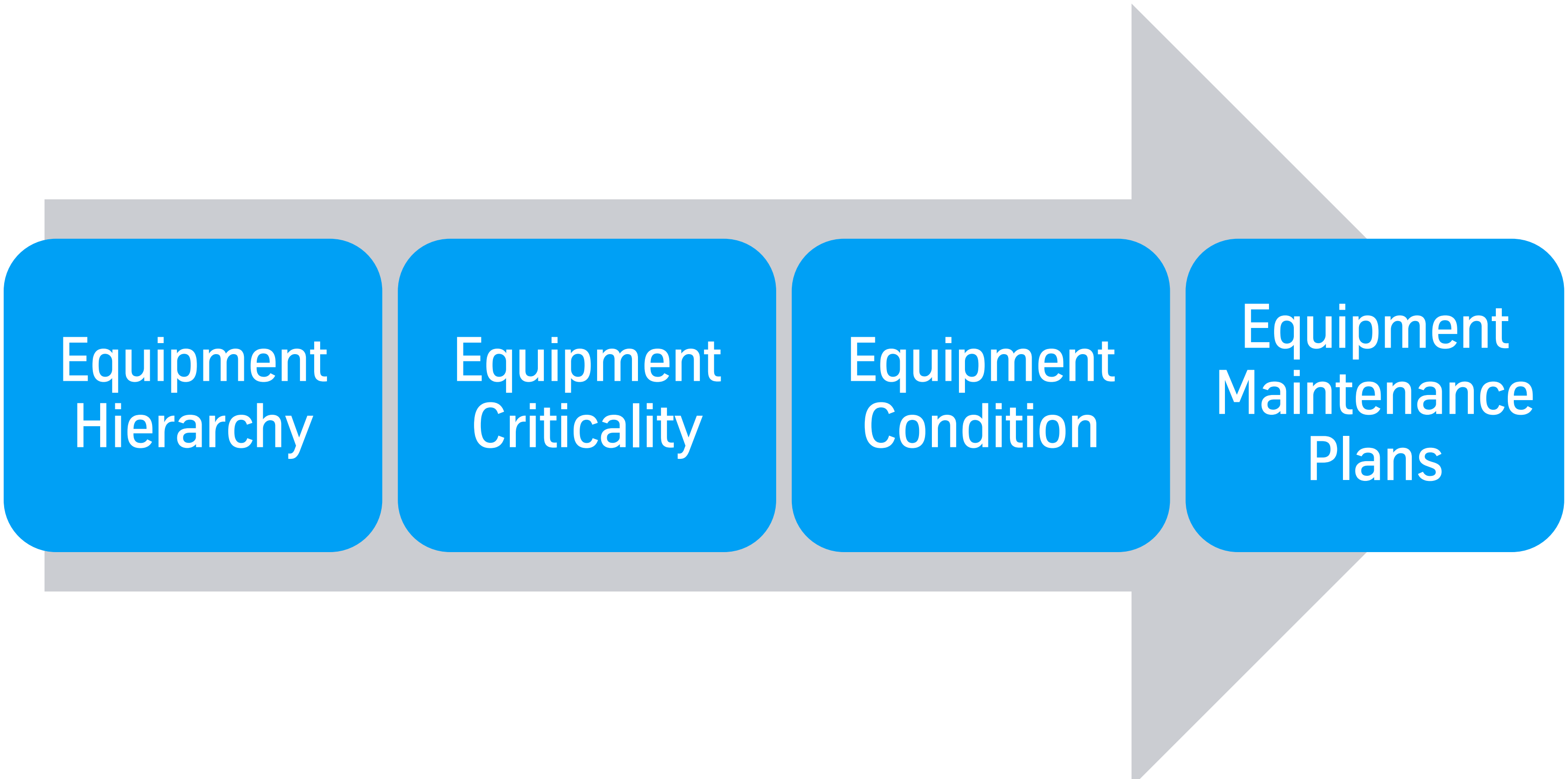
## Project Engineering vs Maintenance Engineering

Project Engineering



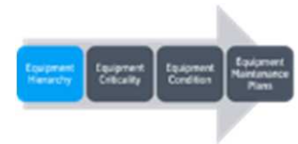
# Maintenance Engineering – Process details
## General




**Mandatory steps to success!**

# Maintenance Engineering – Process details

## Equipment Hierarchy



The aim is to structure and codify the equipment in order to achieve a unique identification.

- Positive influence on Health and Safety (lock-out, tag-out)
- Basis for all future maintenance activities and analysis (amount, details)

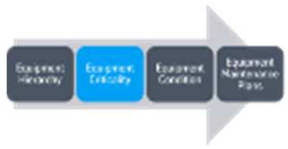
Target:

- Create an Asset Code Book from Plant level to Maintainable Unit level

| Level | Example 1 | | Example 2 | |
|---|---|---|---|---|
| 1. Location | PS1 | Production Site 1 | PS2 | Production Site 2 |
| 2. Process | FP | Fertilizer Production | FS | Fertilizer Storage |
| 3. Sub - Process | U02 | Unit 02 | SH1 | Storage Hall 1 |
| 4. Equipment | BE1 | Bucket Elevator 1 | BC2 | Belt Conveyor 2 |
| 5. Maintainable Unit | HC | Hydraulic Coupling | M1 | Motor 1 |
| Asset Code | PS1-FP-U2-BE1-HC | | PS2-FS-SH1-BC2-M1 | |

# Maintenance Engineering – Process details

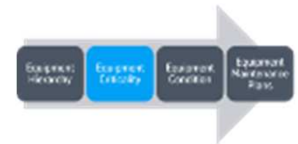
## Equipment Criticality Definition



| Criticality | Maintenance Strategy | Description | Tasks |
|---|---|---|---|
| A | High level of Predictive & Preventive Maintenance | Failure will cause a serious safety, environmental or quality problem or will cause a serious production impact on an important plant section with no redundant plant available. | Complementary Condition Monitoring Tasks (Vibration, Ultrasonic, Oil Analysis, Thermography), as well as online systems if required. Ensure strategic spares in stock. |
| B | High level of Preventive Maintenance & using Predictive Maintenance if cost effective | Medium impact on production or high impact but with redundancy and no serious safety, environmental or quality impact. | Regular visual inspections or easy Condition Monitoring techniques in Key Maintainable Units. Ensure routine spares in stock. |
| C | Basic Inspections & maintenance tasks | Low impact on production or medium impact but with redundancy and no serious safety, environmental or quality impact. | Lubrication, Alignment, Housekeeping Program, etc. |

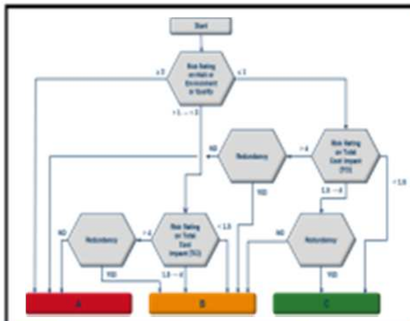
# Maintenance Engineering – Process details

## Equipment Criticality



Target: Classify all Maintainable Units (or Equipment) by their Criticality

- Criticality has high influence on mandatory maintenance activities and intervals (maintenance strategy)
- Target: Cluster into Criticality **A**, **B** and **C**
- Using the following criteria to be impacted:
  - Health & Safety
  - Environment
  - Quality
  - Cost (customized)
- Cross check in matrix with:
  - Probability in time
  - Existing redundancies

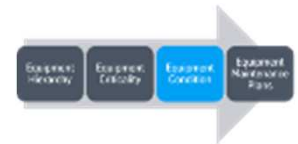



| Equipment Consequence Failure | | | | | |
|---|---|---|---|---|---|
| Health & Safety | Injury not requiring medical treatment | First aid treatment but no lost time | Medical treatment and Lost Time > 1 day | Multiple injuries with >1 day LT or 1 injury with 1 week LT | Multiple injuries > 1 week LT Or 1 LT > 1 month |
| Environment | Discharge contained in 1 Block | Discharge outside of the Block but contained within the Jorf site | Discharge outside the site but with no report | Discharge outside the site with a report | Discharge in violation of the regulations |
| Quality | Unofficial report contained within Fertilizer | Unofficial report from Infrastructure | Official report & reclaim required in Infrastructure | Product must be replaced in Infrastructure | Reclamation outside of Jorf |
| Cost Impact | 10 | 100 | 1.000 | 100.000 | 1.000.000 |
| Cost Impact in MAD | 4.100 | 41.000 | 401.000 | 4.100.000 | 40.100.000 |

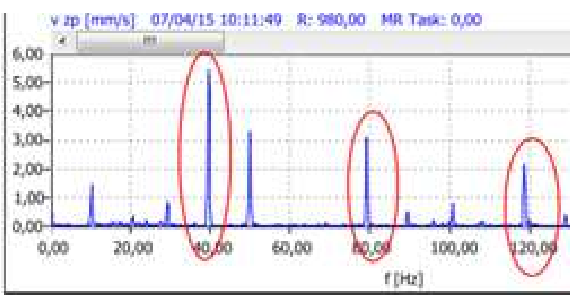
| Probability | Frequency | Description | Per Year | Log10 | 1 | 2 | 3 | 4 | 5 | Risk Rating |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1x per Month | Certain | 10 | 1 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | |
| | 1x per 3 month | Almost certain | 3 | 0.5 | 1.5 | 2.5 | 3.5 | 4.5 | 5.5 | |
| | 1x per Year | Almost certain | 1 | 0 | 1.0 | 2.0 | 3.0 | 4.0 | 5.0 | |
| | 1x per 3 years | Probable | 0.3 | -0.5 | 0.5 | 1.5 | 2.5 | 3.5 | 4.5 | |
| | 1x per 10 years | Possible | 0.1 | -1 | 0.0 | 1.0 | 2.0 | 3.0 | 4.0 | |
| | 1 per 30 years | Unlikely | 0.03 | -1.5 | -0.5 | 0.5 | 1.5 | 2.5 | 3.5 | |

# Maintenance Engineering – Process details

## Equipment Condition

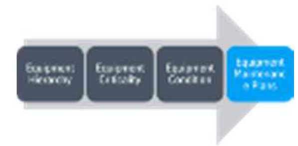


- In “Brownfield” plants, the equipment condition is very important to determine the right maintenance strategy, capex plans and budgets.
- The following parameters / conditions shall be checked:
  - Physical (housekeeping, leakages, tagging, corrosion,...)
  - Functional (different condition monitoring techniques)
  - Maintainability (accessibility, spare parts availability,…)
  - Reliability (historical records, people’s know-how,…)
- The aim is to come up with individual scores.

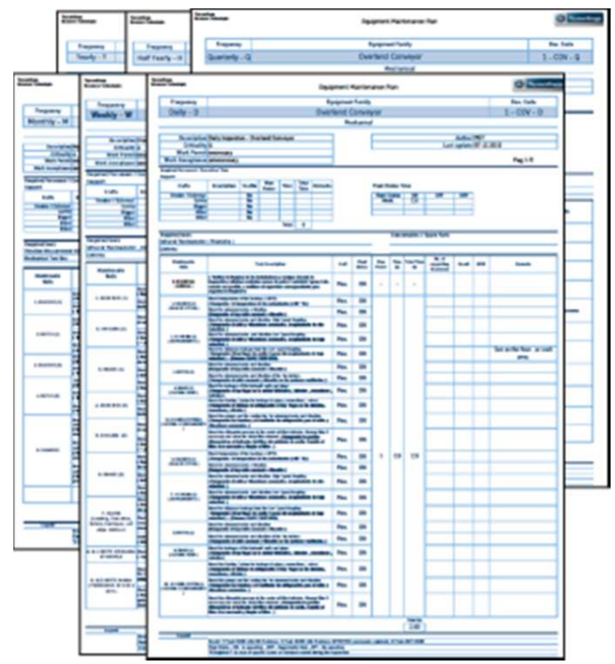



# Maintenance Engineering – Process details

## Equipment Maintenance Plans



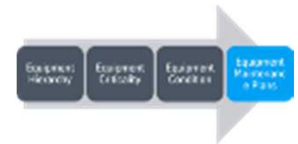
- Equipment Maintenance Plans are developed, based on the results of Equipment
  - Hierarchy,
  - Criticality,
  - Condition.
- Minimum information in Equipment Maintenance Plans:
  - Asset Code
  - HSE precautions
  - Task description, duration, interval
  - Trade details, including planned man-hours
  - Tools, consumables, **Spare Parts**



**The maintenance plans have to be uploaded to a CMMS (see separate session)**

# Maintenance Engineering – Process details

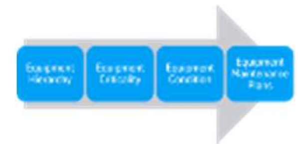
## Equipment Maintenance Plans (cross check)



- Calculate necessary man-hours
- Check against available time for work coming from Equipment Maintenance Plans
- Typical spilt:
  - Urgent repairs: 40%
  - Equipment Maintenance Plans: 20%
  - Planned corrective jobs and shutdown activities: 40%
- If necessary to reduce man-hours:
  - Combine activities on higher level in hierarchy
  - Combine activities by “Routing”
  - Check and correct estimated intervals and task duration

# Some figures from references

## Our experience



Figures for one average fertilizer production line (granulation)

- Number of Maintainable Units: 800
- Number of Bills of Material: 180
- Number of failure modes to be checked: 1000
- Number of spare parts to be assigned: 2400

- Min. number of man-years to execute the above: 3.4
  - A team of 10 engineers can do the job in: 4 months
  - Time is “net”, pure engineering time without meetings, discussions, familiarization, etc.
  - Total average time for 10 engineers: 7-8 months
  - Not including manpower to setup / upload / implement CMMS

# Next steps: What is needed in addition?

Processes and experience

Mandatory processes for high level asset management:

- Work Flow Process
- Failure Analysis / Root Cause Analysis
- Work Priority System
- Shut Down Process
- Continuous Improvement Process
- Purchasing Procedure
- Training System


In addition, people with Maintenance Engineering and Asset Management Process experience are needed to implement all the results on site.

**Target: To achieve highest uptime at lowest production costs!**

# Maintenance Engineering
## Contact Us!

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# AFA workshop

Recent Asset Management projects and their particular challenges

Stefan Dähn & Olaf Kraska

Aqaba, 11th April 2016

engineering. tomorrow. together.

thyssenkrupp

# Process Technologies

## Asset Management Services for ALL kinds of technology

tkIS PT Portfolio

**Fertilizers**


**Nitric acid**


**Refineries**

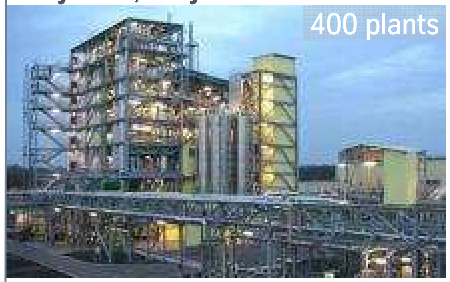

**Aromatics**


**Hydrogen, Ammonia, Methanol**


**Organic chemicals, Petrochemicals**


**Plastics, Synthetic fibers**


**Polyester, Polyamides**




**Electrolysis**


**Coke plants**


**Gasification**


**Industrial plants**

# Asset Management Projects & Challenges

## Selected Reference – MICCO-TB, Thai Binh, Vietnam

**Project:**

Operation Assistance (Low Density Ammonium Nitrate plant)

**Customer:**

MICCO-Thai Binh Mining Chemical Company

**Completion:**

Ongoing since 2015

**Scope of supply and services:**

- Advise on operational tasks e.g. panel operation, inspections, adjustments, troubleshooting
- Support in tasks related to operation e.g. review documentation, safety instructions, training
- Support with maintenance works
- Support for start-ups and shutdowns

# Asset Management Projects & Challenges

## Selected Reference – MICCO-TB, Thai Binh, Vietnam

**Project:**

Operation Assistance (Low Density Ammonium Nitrate plant)

**Achievements:**

- Safe production
- Development/update of emergency procedures
- On-the-job training for operations team (control room & field)
- Fine tuning of production parameters
- Support for troubleshooting
- Documentation

**Challenges:**

- First of its kind plant in Vietnam
- Customer hired mostly university/college graduates and unskilled personnel
- Limited English language skills among customer's personnel
- Budget/market conditions (final product used for coal mining)

# Asset Management Projects & Challenges

## Selected Reference – EPPC, Port Said, Egypt

**Project:**

Integrated Maintenance Management Assistance (PDH/PP Plant)

**Customer:**

Egyptian Polypropylene Company

**Completion:**

2012 & 2014

**Scope of supply and services:**

- Integrated Maintenance Management Assistance contract right after end of commissioning
- Up to eight engineers integrated in EPPC's maintenance organization
- Maintenance assistance for engineering, planning and spare parts optimization
- Development of maintenance procedures, spare parts criticality analysis
- Development of preventive and predictive maintenance plans as well as reliability-centered maintenance

# Asset Management Projects & Challenges

## Selected Reference – EPPC, Port Said, Egypt

**Project:**

Integrated Maintenance Management Assistance (PDH/PP Plant)

**Achievements:**

- Update of master equipment list (asset register, asset groups, MWI)
- Sync between equipment criticality and maintenance strategy
- Risk assessment matrix for all units
- Development of inspection plans
- Development of annual maintenance plan (resource & financial planning)
- Development of spare parts inventory stock levels & warehouse procedures

**Challenges:**

- Force Majeure (political reasons), strikes (unions)
- Work permits
- Technical issues between customer and EPC contractor
- “Cooperation” of customer’s personnel on different hierarchy levels
- “Visibility” of small team in a very big organization

# Asset Management Projects & Challenges

## Selected Reference – Mellitah Gas, Wafa Oil & Gas Field, Libya

**Project:**

Full Service Maintenance (Gas Processing Plant)

**Customer:**

Melittah Oil & Gas

**Completion:**

2011 (5 years contract)

**Scope of supply and services:**

- Logistic for camp, workshop, tooling and equipment
- Establishment of maintenance organization and processes
- Plant personnel training „on the job“ within an integrated team
- Supply of 25 engineers for various disciplines
- 80 supervisor and technicians for the execution of the services
- Coordination, supervision and execution of all maintenance tasks:
  - Predictive, preventive & corrective maintenance
  - Mechanical, electrical, instrumental and civil maintenance
  - Maintenance engineering, planning & scheduling and execution
  - Spare parts management

# Asset Management Projects & Challenges

## Selected Reference – Mellitah Gas, Wafa Oil & Gas Field, Libya

**Project:**

Full Service Maintenance (Gas Processing Plant)

**Achievements:**

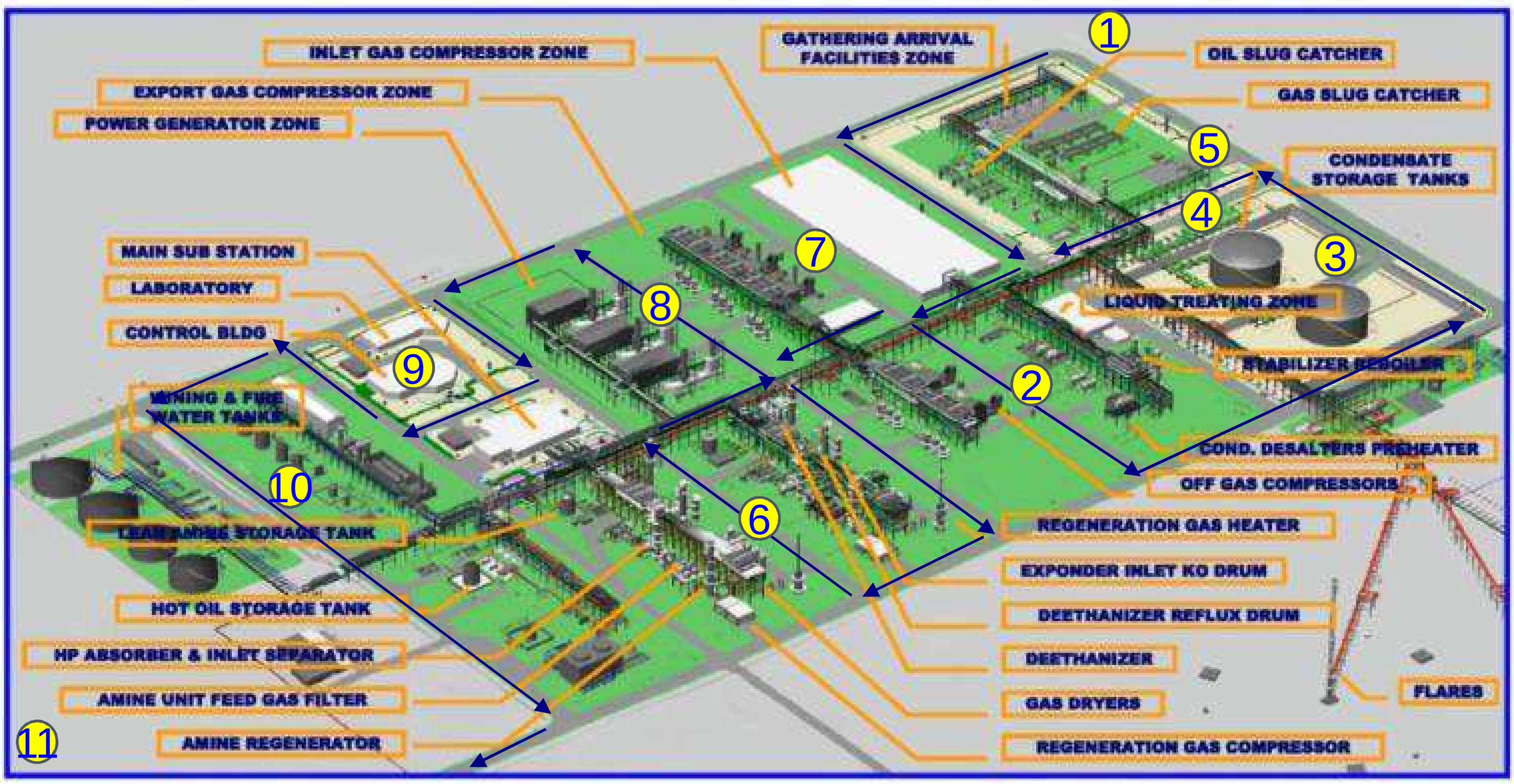
- Execution of very comprehensive scope of work
- Performance exceeding contractual levels (e.g. availability, HSE)
- Setup of camp, workshops, etc. in remote (desert) location
- Establishment of organization / team building
- Successful (on-time) execution of TAR's
- Technical & commercial success (first of its kind contract at tkIS PT)

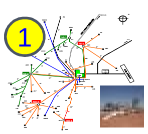
**Challenges:**

- Remote location (spare parts, personnel, logistics, etc.)
- Third-party technology plant
- Localization of work force
- Force Majeure (evacuation)
- Dealing with ministries in Tripoli

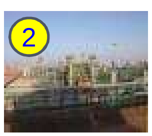
# Asset Management Projects & Challenges

## Selected Reference – Mellitah Gas, Wafa Oil & Gas Field, Libya



Wells & satellites



Oil treatment

Oil storage

Oil export system

Pipelines

Gas treatment

Gas export system

Power generation

Control room

Utilities

Logistics

# Resource Technologies

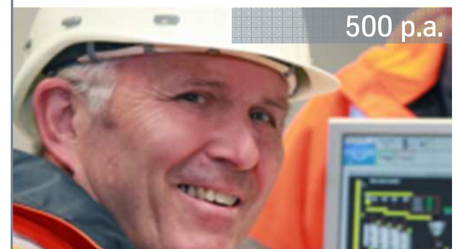
## Asset Management Services for ALL kinds of technology

Bucket wheel excavators


Spreaders/Belt wagons/ Tripper cars


Mobile and semi-mobile crushing plants


Customer training lessons



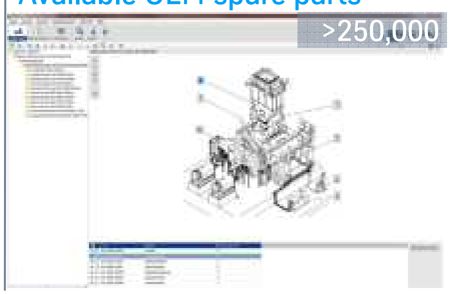

Stockyard handling systems


Asset management contracts


Port Handling systems


Cement kiln lines


Available OEM spare parts




Crushers


Screens


Kiln geometry measurement

# Asset Management Projects & Challenges

## Selected Reference – Vale, Carajás Mine, Brazil

**Project:**

Operation & Maintenance (Iron Ore Mine, overburden)

**Customer / Location:**

Vale / Carajás

| **Start:** | **Duration:** |
|---|---|
| 2014 | 16 months |

**Scope of supply and services:**

- Commissioning support
- Operation & Maintenance Management
- Maintenance Engineering, Planning, Execution (tk + customer)

**Achievements:**

- Ramped up and stabilized production after commissioning and short phase of client's own O&M approach
- Developed and implemented customized maintenance plans
- Trained local personnel

# Asset Management Projects & Challenges

## Selected Reference – Vale, Carajás Mine, Brazil

**Project:**

Operation & Maintenance

**Core equipment:**

- 2 fully mobile crushers
- 2 belt wagons
- 10 conveyors (5 km total)
- 1 spreader
- 1 tripper car
- electrical power distribution system

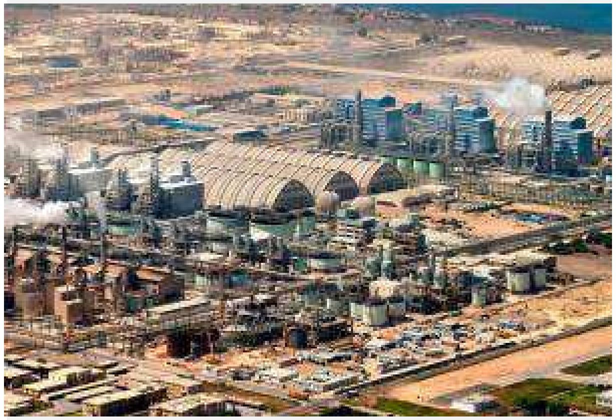
**Challenges:**

- Remote location (spare parts, personnel, logistics, etc.)
- Extreme weather conditions (humidity, rain, mud)
- Big amount of repair work after client's initial approach
- First time equipment operated by thyssenkrupp Industrial Solutions RT

⇨Always achieved targets according to client's mining planning!

# Asset Management Projects & Challenges

## Selected Reference – OCP S.A., Jorf Lasfar, Morocco



**Project:**

Strategic Partnership for Integrated Asset Management (Chemical Complex)

**Customer / Location:**

OCP S.A. / Jorf Lasfar

| **Start:** | **Duration:** |
|---|---|
| 2014 | 6 years<br>Including 1 year pure Maintenance Engineering phase |

**Scope of supply and services:**

- o Integrated Asset Management
- o Performance based contract
- o Taking over maintenance of
  - o Fertilizer Production Units
  - o Port transshipment area (partly)
  - o Sulphur melting plant

# Asset Management Projects & Challenges

## Selected Reference – OCP S.A., Jorf Lasfar, Morocco

**Project:**

Strategic Partnership for Integrated Asset Management

**Core Equipment:**

- Granulators, dryers, coaters
- Belt conveyors, bucket elevators, portal reclaimers
- Crushers, screens, ship-loaders
- Pre-neutralizers (agitators, pumps, valves, pipes)
- Scrubbers, de-dusting systems

**Targets:**

- Highest focus on health, safety and environment
- Implement proactive approach
- Increase availability significantly
- Increase capacity and efficiency
- Training & know-how transfer

**Challenges:**

- Establish new local tk Business Unit (tk IS Maroc SARL)

# Asset Management
## Contact Us!


Industrial Solutions
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# Backup

# WAFA Oil & Gas Field (Libya) Reference

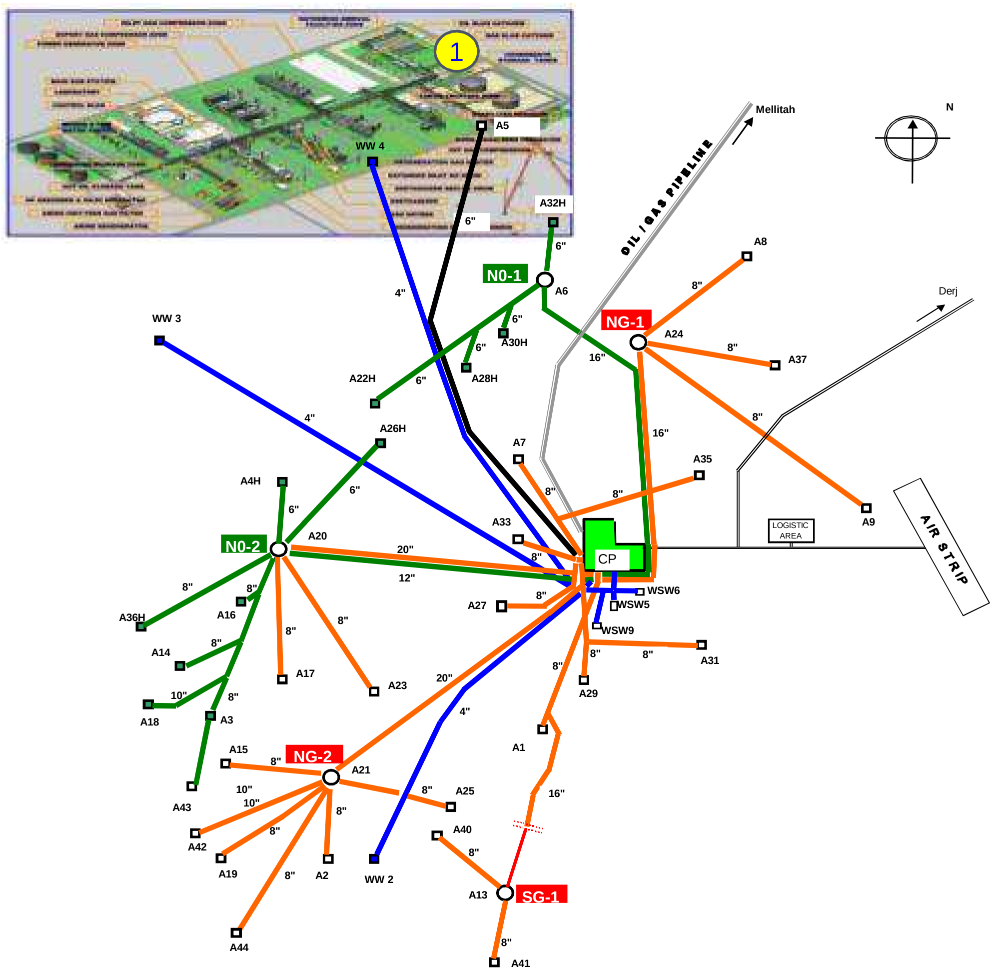
## Maintenance Workshop




- GMS contract included the responsibility for the maintenance workshop
- Workshop was used for modifications, repair and training
- Pictures have been taken during the establishment of the workshop

# WAFA Oil & Gas Field (Libya) Reference

## Wells and Satellites




Total number of wells: 44

- 15 oil wells
- 22 gas wells
- 6 water wells
- 1 water injection well (for future use).

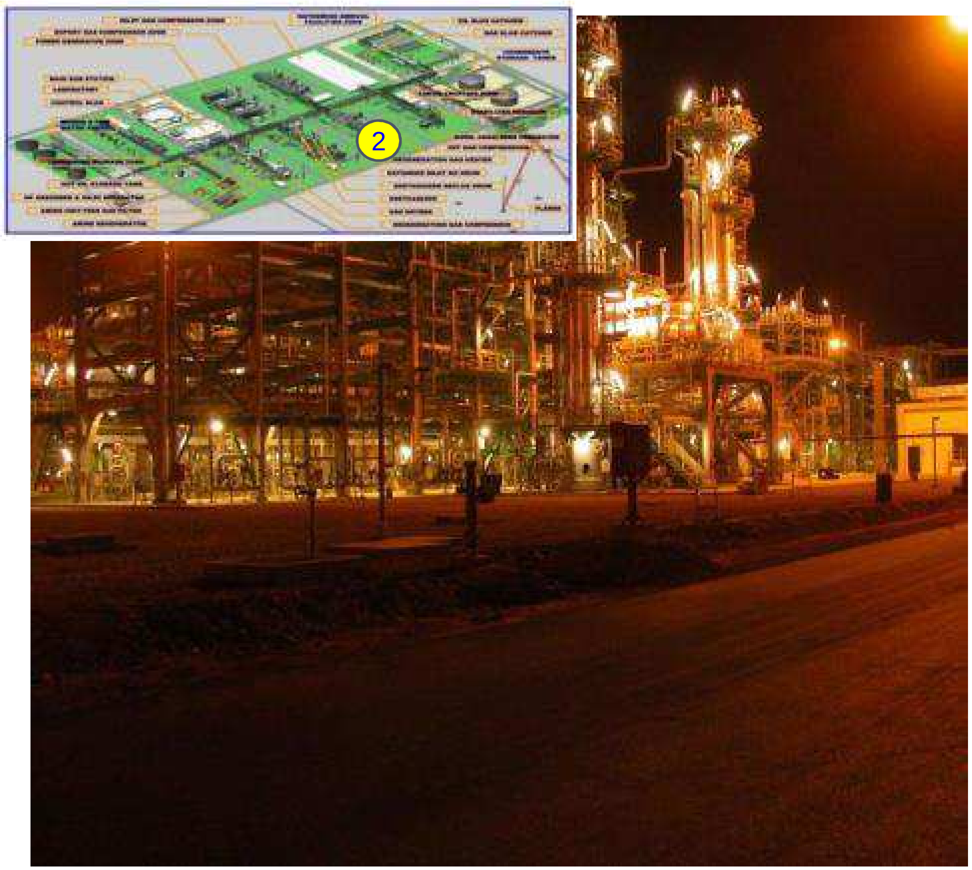
Six gas wells are connected directly to the central plant while the remaining are gathered through Satellites:

- 3 gas satellites (NG1, NG2, SG1)
- 1 Oil satellite (NO1)
- 1 Oil/Gas satellite (NO2).

Total length of trunk and flow lines: ~207 km.

# WAFA Oil & Gas Field (Libya) Reference

## Oil Treatment




The Oil Treatment train has a process capacity of 60.000 bopd.

It consists of inlet separators, heaters, desalters, stabilisers and pumps.

The train separates the liquids from the associated gas, treats and stabilises the liquids to specification before sending to the storage.

# WAFA Oil & Gas Field (Libya) Reference

## Oil Storage


Two tanks, each one with a capacity of 16,000 $m^3$ are installed.

The oil coming from the Oil Treatment train is stored and then sent to Wafa Coastal.

### Technical data

- Diameter 39 m
- Height 16.2 m
- Atmospheric pressure

# WAFA Oil & Gas Field (Libya) Reference

## Oil Export System


The oil is sent into the pipeline by means of 3 Booster pumps and 3 Oil Export pumps. The Booster raise the oil pressure before entering the Export.

**Booster pumps**

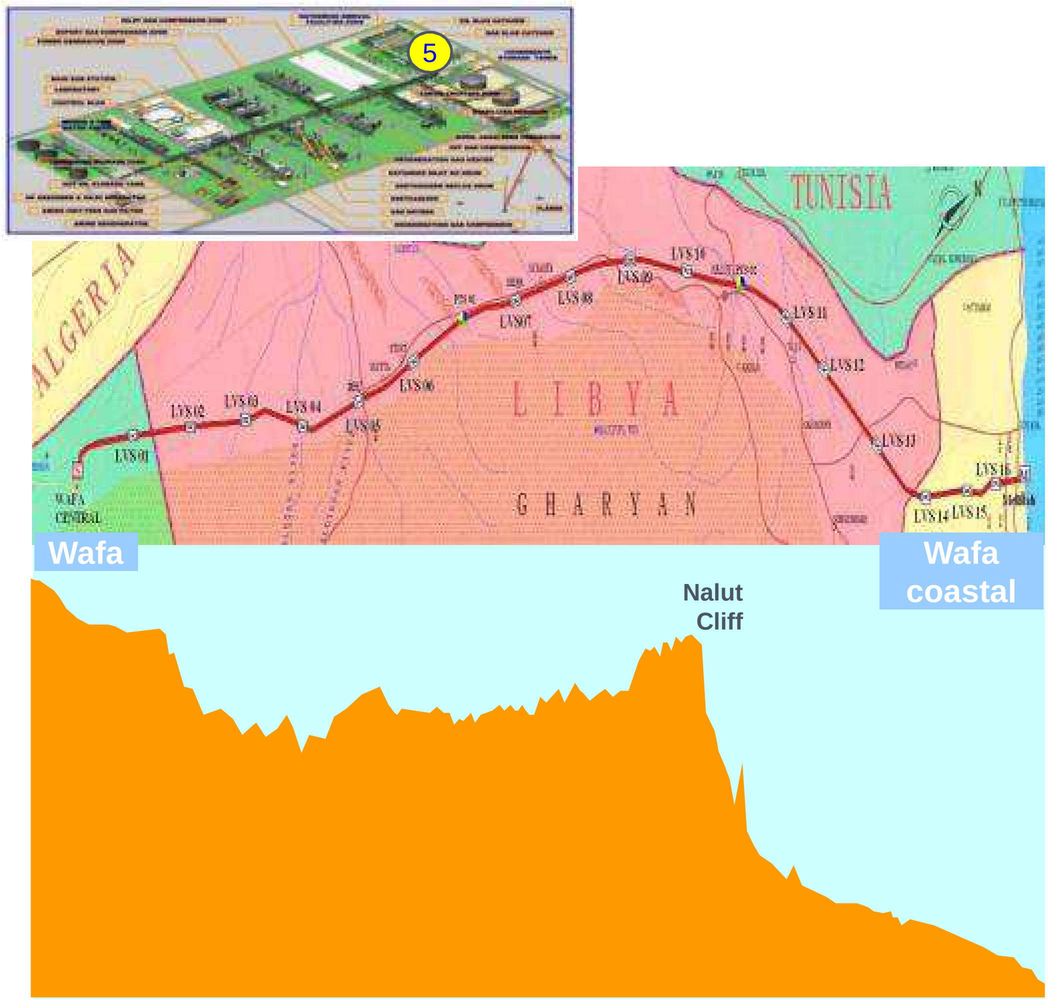
- Flowrate 193 $m^3/h$,
- Discharge pressure 6 barg
- Speed 2950 rpm.
- Installed power 115 kW

**Export pumps**

- Flowrate 193 $m^3/h$,
- Discharge pressure 87 barg
- Speed 2950 rpm.
- Installed power 780 kW

# WAFA Oil & Gas Field (Libya) Reference

## Pipelines




**Gas:**

- Length: 525 km
- Nominal diameter: 32”
- Capacity: 12.7 MMscm/d @ 75 barg

**Oil:**

- Length: 525 km
- Nominal diameter: 16”
- Capacity: 77,000 bbl/d @ 85 barg

# WAFA Oil & Gas Field (Libya) Reference

## Gas Treatment


Two gas treatment trains are installed.

Each one has a capacity to process 6.35 MMscm/day of raw gas.

The process consists of gas dehydration for water removal, gas sweetening and hydrocarbon dew point control with NGL extraction.

NGL is mixed with oil before entering the pipeline.

# WAFA Oil & Gas Field (Libya) Reference

## Gas Export System


Three Gas Turbine Compressors are installed to compress the gas into the pipeline. The compressors are 2 stage type. Normally two compressors are running while one is in stand by mode.

### Technical data (each unit)

- Flow 230 T/h
- Diff. Pressure 20/80 bar
- Installed power 18 MW
- SGT 600 (GT 10 B) &
- DR Compressor

# WAFA Oil & Gas Field (Libya) Reference

## Power Generation


Three Gas Turbine Generators are installed, each equipped with a Waste Heat Recovery at each GT gas exhaust duct to produce Hot Oil for process purpose. Normally two generators are running while one is in stand by mode.

### Technical data (each unit)

- Power Generation 18 MW
- Waste heat recovery 17 MW
- GE Frame 5

# WAFA Oil & Gas Field (Libya) Reference

## Control Building

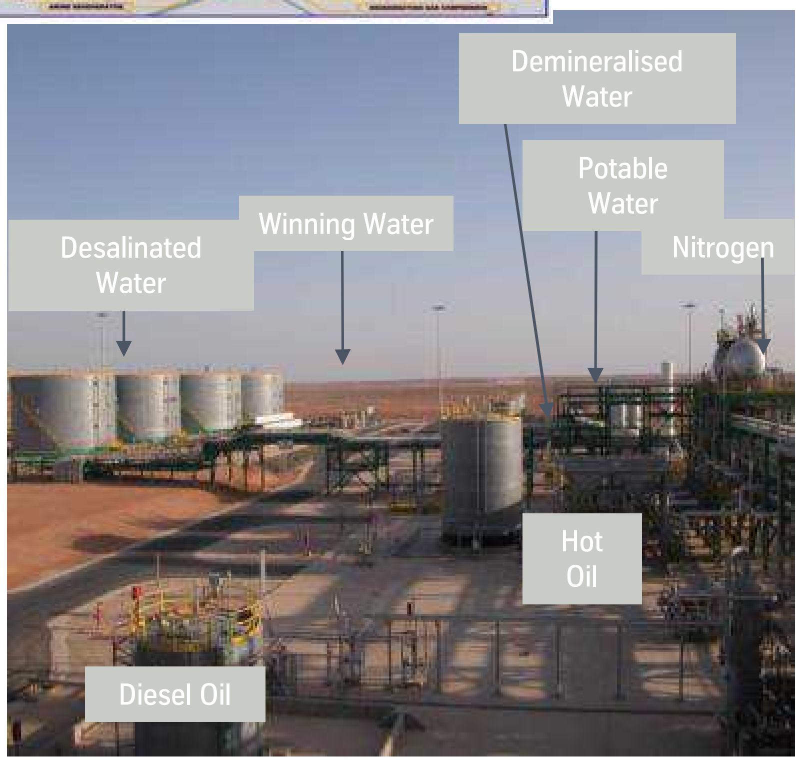

A Distributed Control System (**DCS**) provides the control and operation of the plant, monitoring of the process parameters and the operation of the Units.

An Emergency Shutdown System (**ESD**) separated from the DCS, provides the control and operation to the plant during emergency situations, allowing a safe operation of the plant.

A Fire & Gas (**F&G**) system monitors the plant for any gas leak and for fire detection.

# WAFA Oil & Gas Field (Libya) Reference

## Utilities


- Winning water is obtained by clarification, filtration of water from wells. Total capacity 95 $m^3/h$, storage 17,000 $m^3$
- Desalinated Water is produced by means of reverse osmosis membranes. Total capacity 80 $m^3/h$, storage 12,000 $m^3$
- Demineralised water is obtained by means of mixed beds filters. Total capacity 7 $m^3/h$, storage 450 $m^3$
- Potable water is obtained by mineralisation with CaCI2 and NaHCO3 and sterilisation with NaCIO. Storage 700 $m^{3.}$
- Compressed Air for Utility and Instrument air to users is obtained by means of 5 compressors. Total capacity 3,000 N $m^3/h$ @8 barg
- Nitrogen generation for plant users is obtained by air distillation. Capacity 1,350 $Nm^3/h$, 99.9% purity @ 7 barg
- Diesel oil for Emergency Diesel Gen. and Fire Water Pumps. Storage capacity 130 $m^3$

# WAFA Oil & Gas Field (Libya) Reference
## Logistics


In the logistics area are 130 persons accommodated:

10 in VIP accommodations and 120 in accommodations blocks. All rooms are furnished and have air condition.

The logistics includes:

- Recreation Building & Cinema
- Mess
- Mosque
- Clinic
- Laundry
- Swimming Pool

afa

الإتحاد العربي للأسمدة

Arab Fertilizer Association

Since 1975

In co- operation with

thyssenkrupp

# AFA WORKSHOP

## Operation and Maintenance Optimization

Jordan - Aqaba: 11-14 April, 2016

# Session 2

Sponsors:

Arab Potash

Jordan Phosphate Mines Co.

Indo Jordan Chemicals Co.

NJFC

Nippon Jordan Fertilizer Co.

KEMAPCO

KEMAPCO Arab Fertilizers & Chemicals Industries Ltd.

# Mining Systems & Materials Handling
# Service Portfolio

April 2016  David Bovenkerk

# Giant bucket wheel excavator system

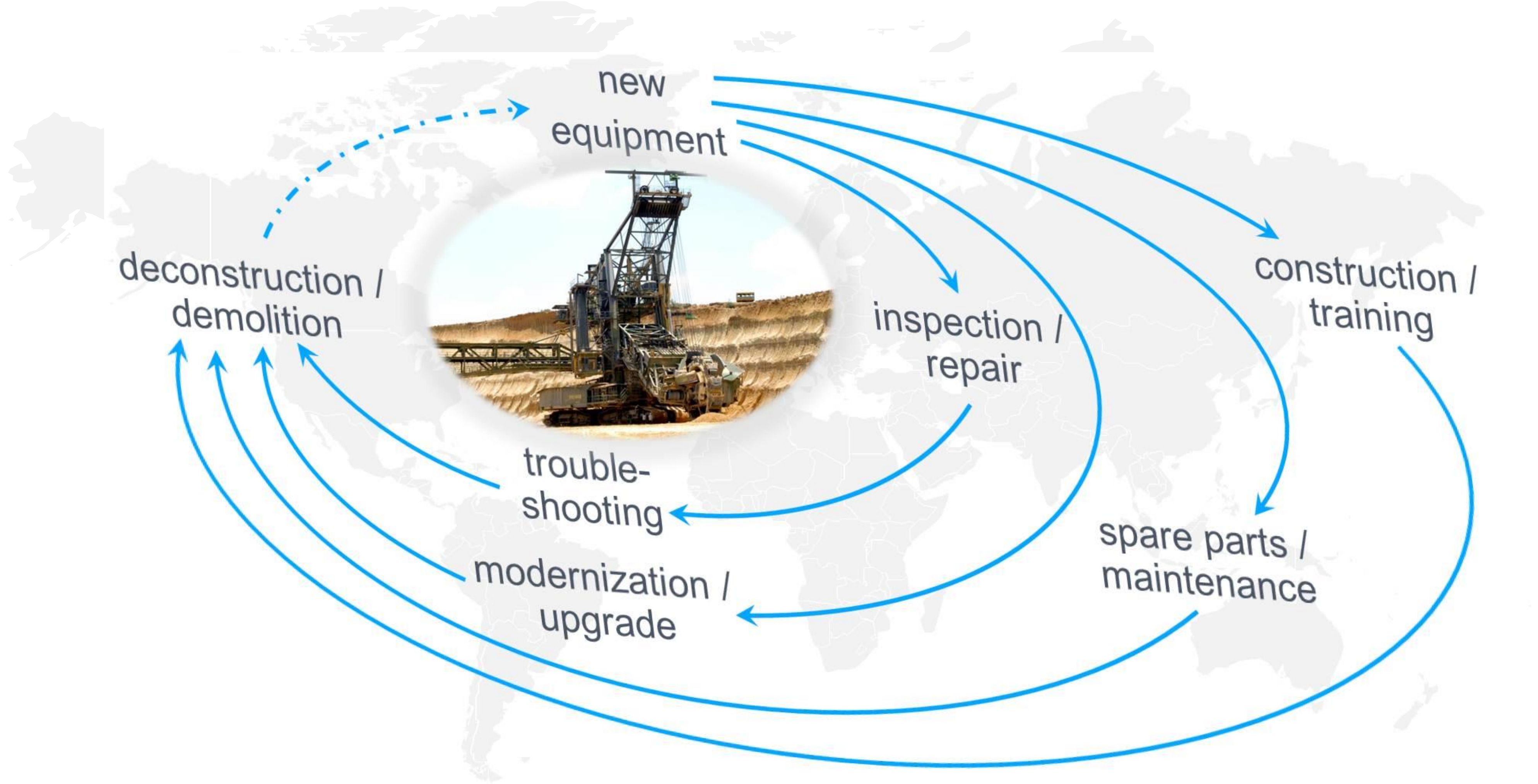
Giant spreader

Combined bucket wheel stacker/reclaimer

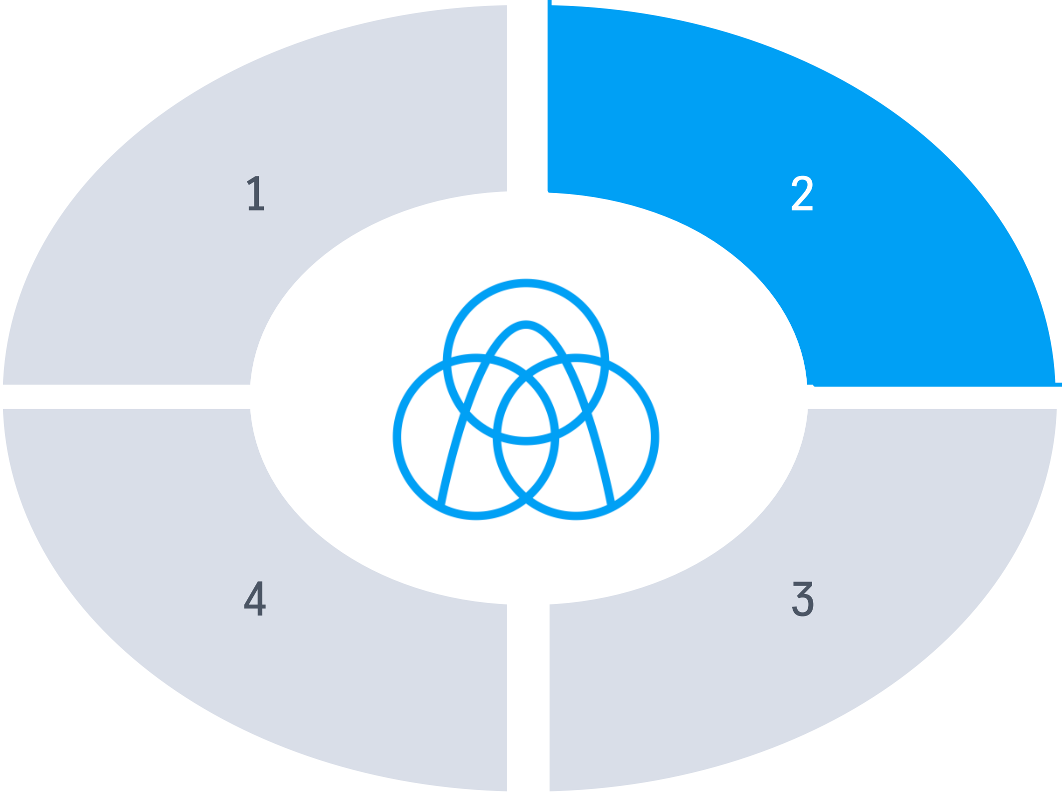

Overland belt conveyor

# Product Lifecycle

## thyssenkrupp Industrial Solutions



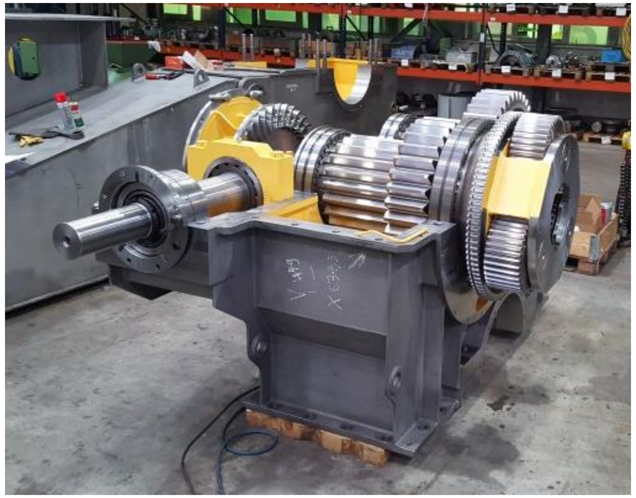
# Product Lifecycle – Spares & Maintenance
# thyssenkrupp mining systems

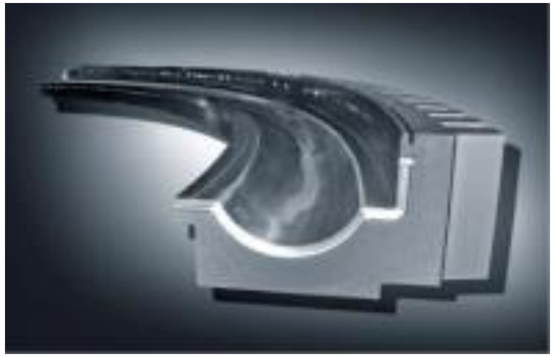



- Spare Parts & Maintenance:
  - spare & wear parts with or without installation
  - spare part packages
  - maintenance contracts

# Product Lifecycle – Spares & Maintenance

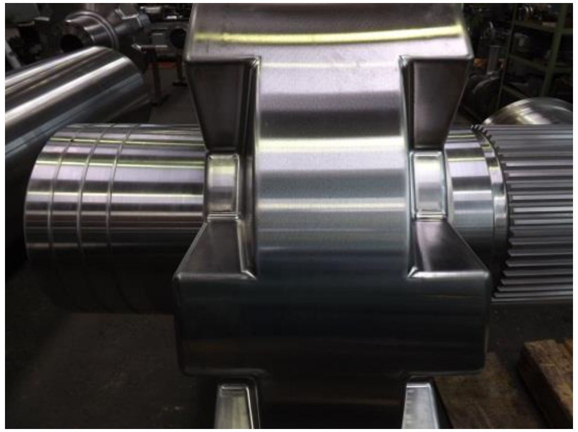
thyssenkrupp Industrial Solutions





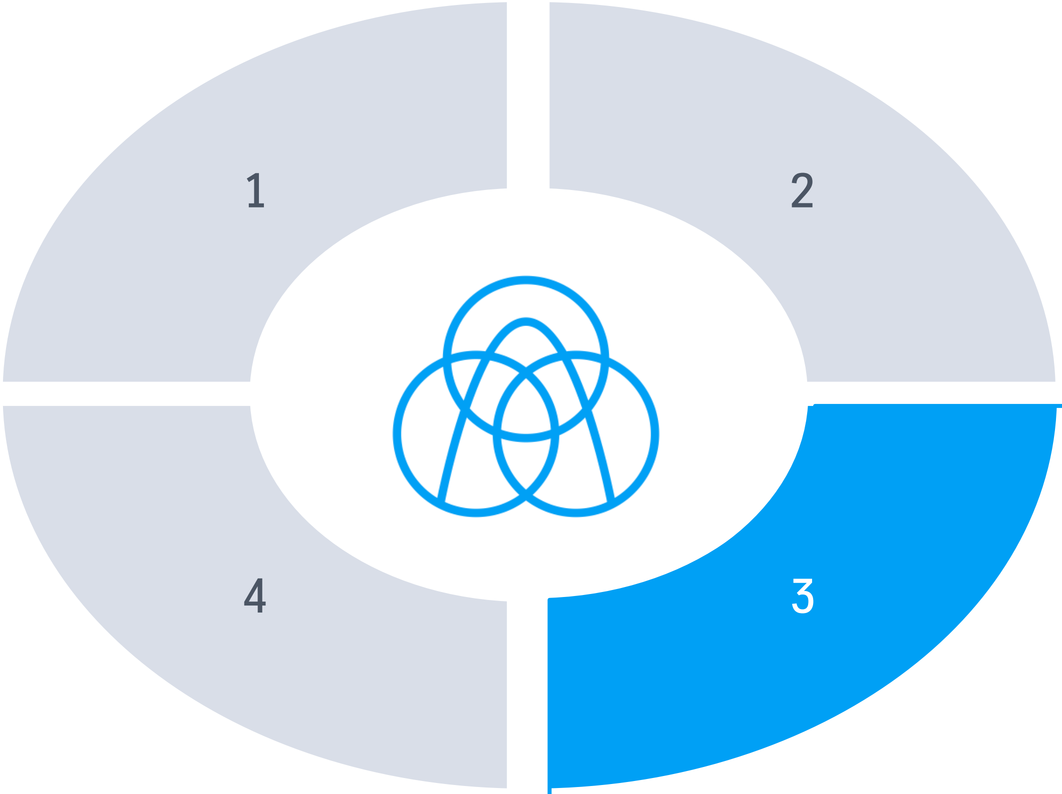
- TKIS supplies you with any kind of spare parts
  - simple wear parts for replacement
  - capital spares like heavy-duty gearboxes, slew bearings, etc.

- All components delivered from our end can be supplied with or without installation services



- spare part packages are also in our portfolio as well as maintenance contracts including spares

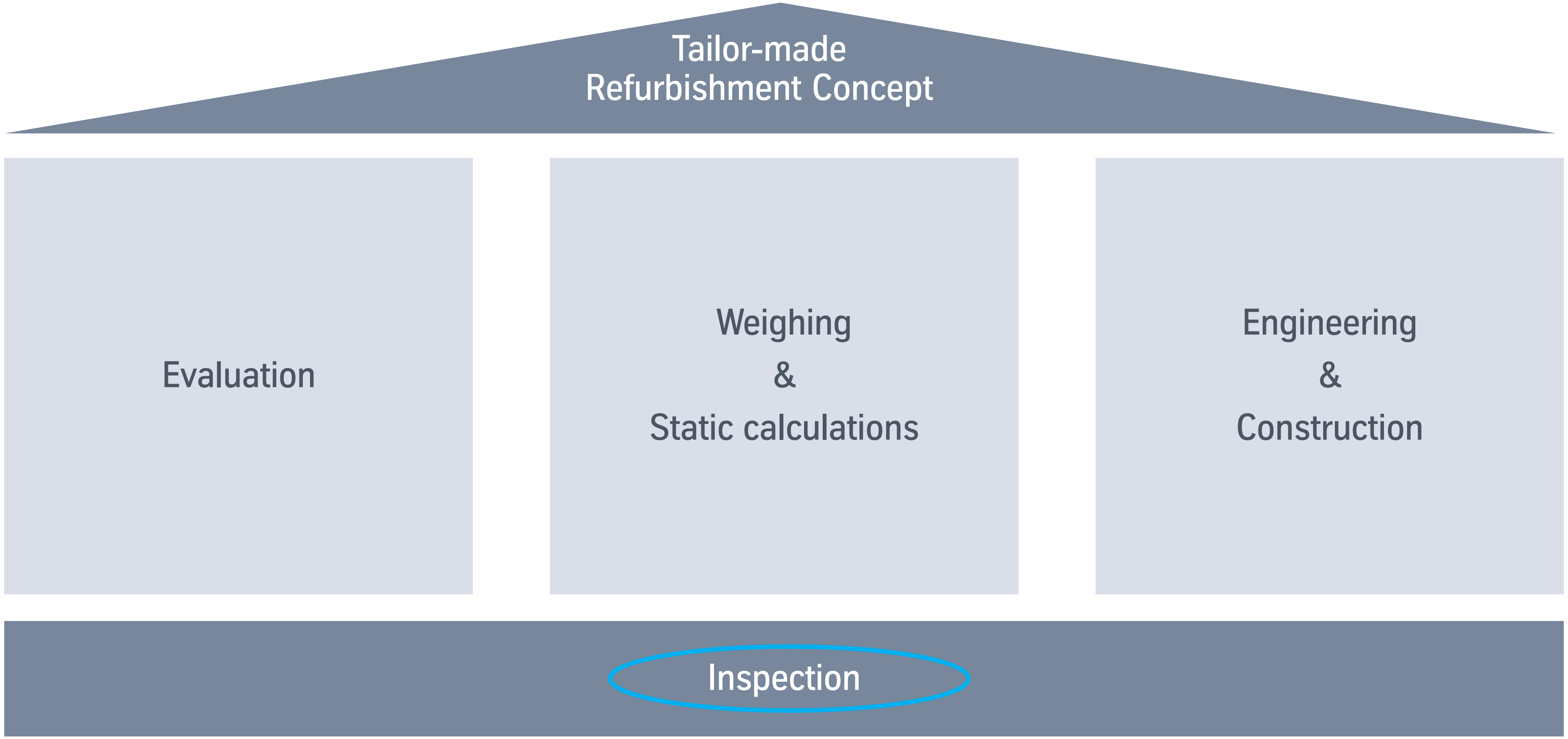
# Product Lifecycle – Inspection & Repair
# thyssenkrupp mining systems




- Spare Parts & Maintenance:
  - spare & wear parts with or without installation
  - spare part packages
  - maintenance contracts

- Inspection & Repair:
  - inspection on planned basis or on demand
  - inspection reports and recommendations
  - repairs & modifications

# Refurbishment – professional execution at every step

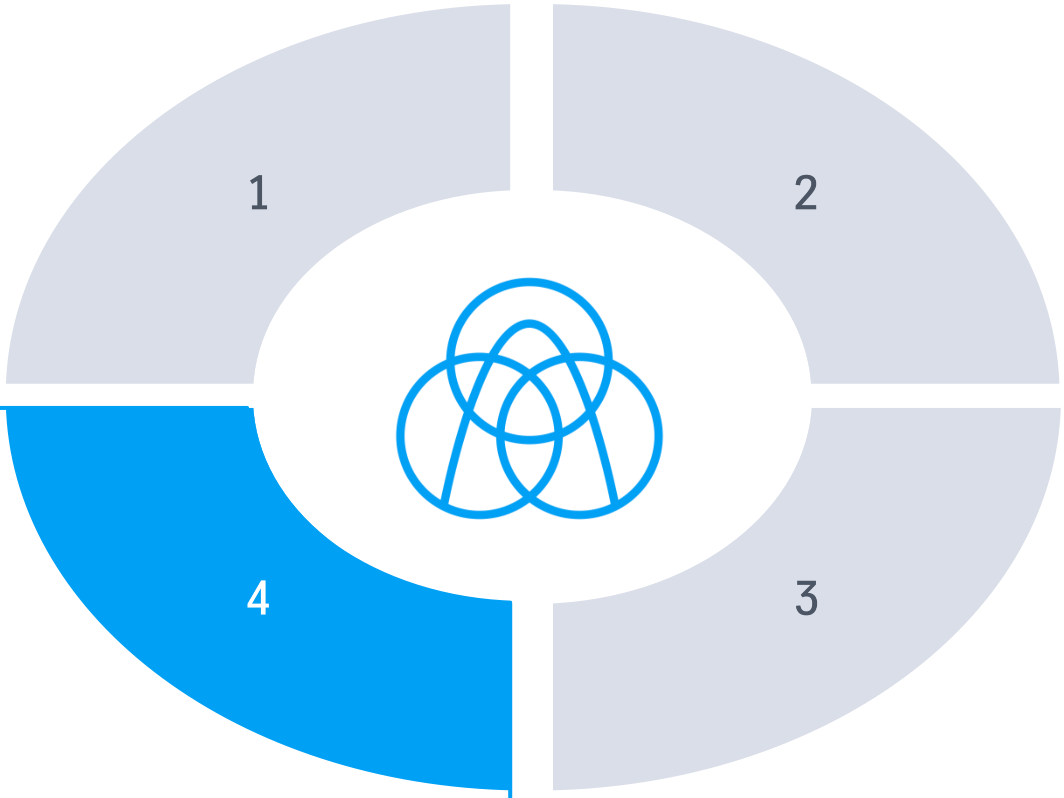


# Product Lifecycle – Inspection & Repair

## thyssenkrupp Industrial Solutions

- We are your partner for any kind of inspections on your existing equipment. This includes:
  - inspections on load bearing steel structures and rope systems
  - inspections on gears, gearboxes and any kind of drive systems and mechanical components
  - inspections on major assemblies like hydraulic systems, electric systems, etc.
- Findings/Results will be compiled in comprehensive reports comprising remedy solutions and the needed spare parts.
- Repairs, if any can be planned and executed by the thyssenkrupp service division.


# Product Lifecycle – Upgrade & Refurbishment
# thyssenkrupp mining systems




- Spare Parts & Maintenance:
- spare & wear parts with or without installation
- spare part packages
- maintenance contracts

- Upgrade & Refurbishment:
- bottlenecking & upgrade studies
- 3D local Surveying
- automation solutions, radar technology
- erection and commissioning

- Inspection & Repair:
- inspection on planned basis or on demand
- inspection reports and recommendations
- repairs & modifications

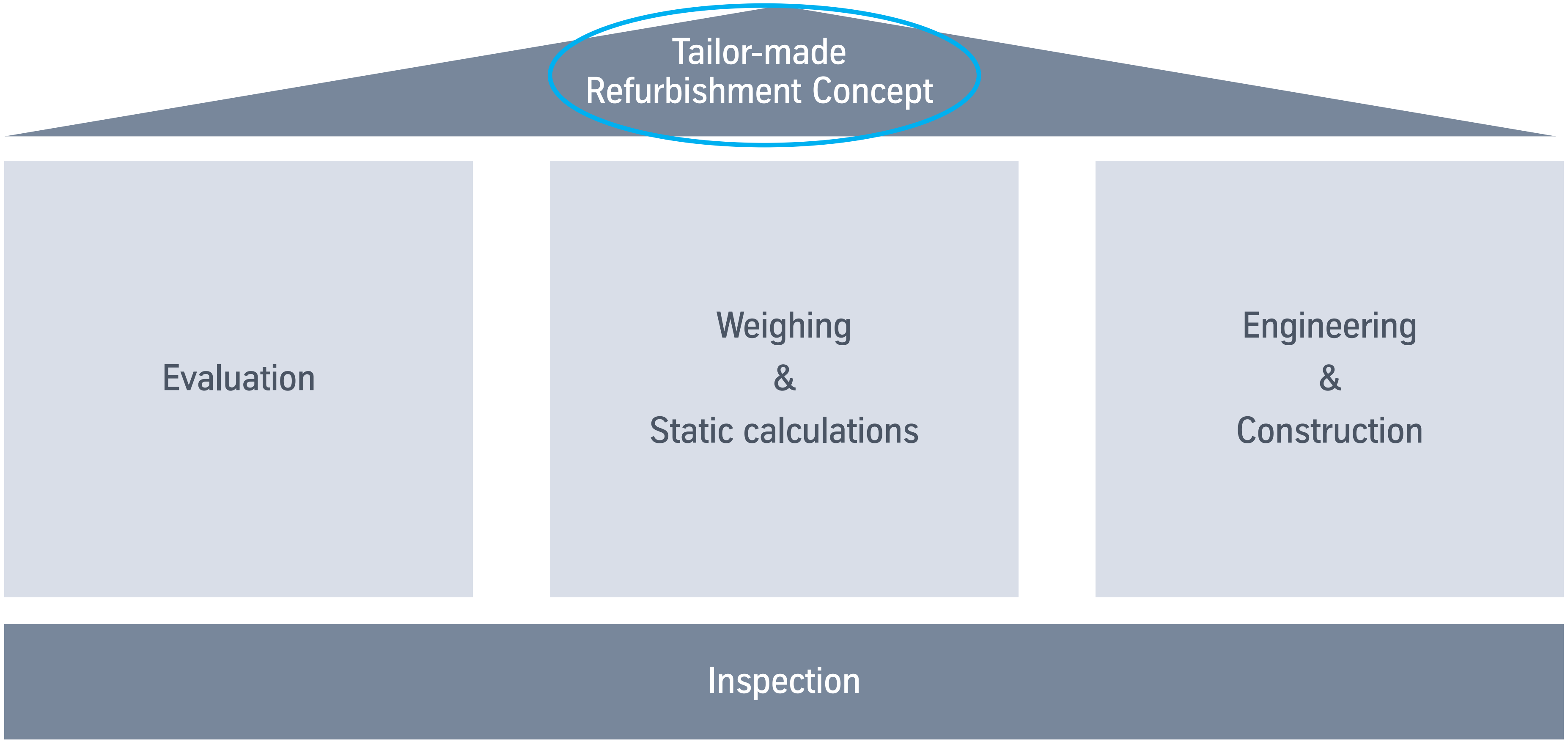
# Product Lifecycle – Upgrade & Refurbishment

## thyssenkrupp Industrial Solutions

- In close cooperation with you, we develop the production potential considering your existing equipment in refurbished, modified or upgraded condition.
- We are your partner for upgrades & refurbishments of equipment regardless of OEM. We, TKIS:
  - plan all steps of the modification
  - deliver all assemblies, components, parts and services required for the modification
  - put the equipment back into service in the modified condition comissioning, automation solutions upon request
  - Assembly sequences
  - Entire organisation and monitoring of dismantling, transport, installation and subsequent recommissioning procedures

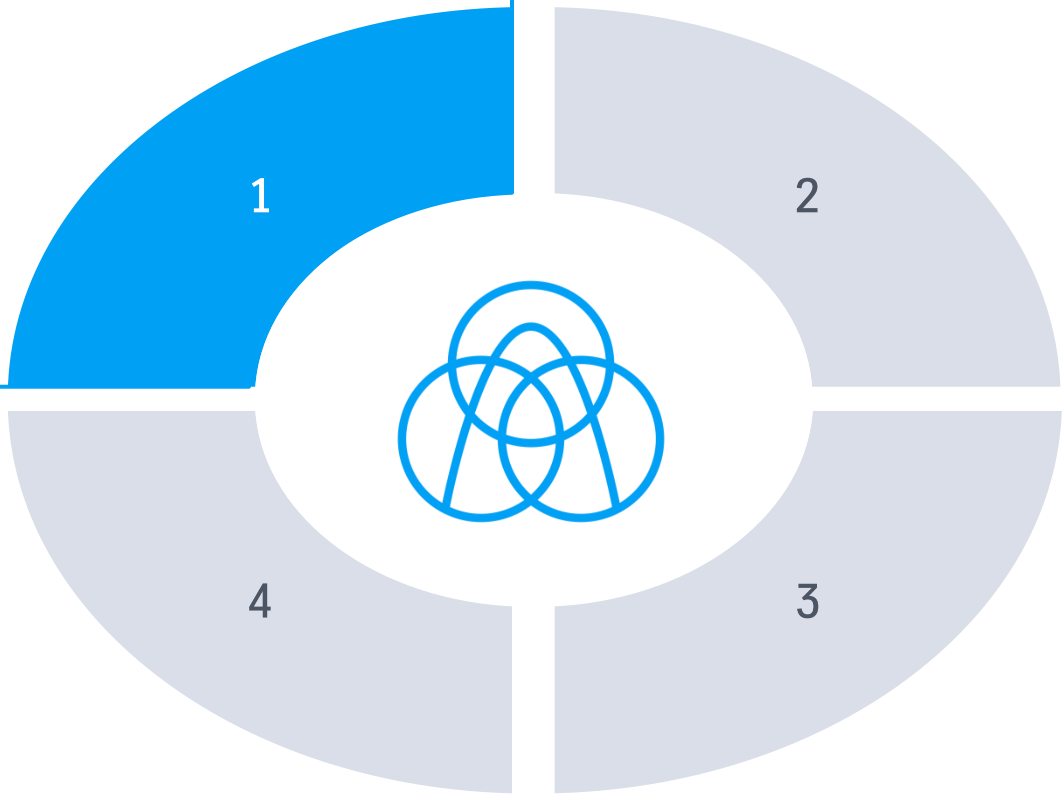



# Refurbishment – professional execution at every step



# Product Lifecycle – Deconstruction & Relocation
# thyssenkrupp mining systems

- Deconstruction & Relocation:
- engineering for deconstruction works
- planning, execution & supervision
- re-erection on demand




- Spare Parts & Maintenance:
- spare & wear parts with or without installation
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- maintenance contracts

- Upgrade & Refurbishment:
- bottlenecking & upgrade studies
- 3D local Surveying
- automation solutions, radar technology
- erection and commissioning

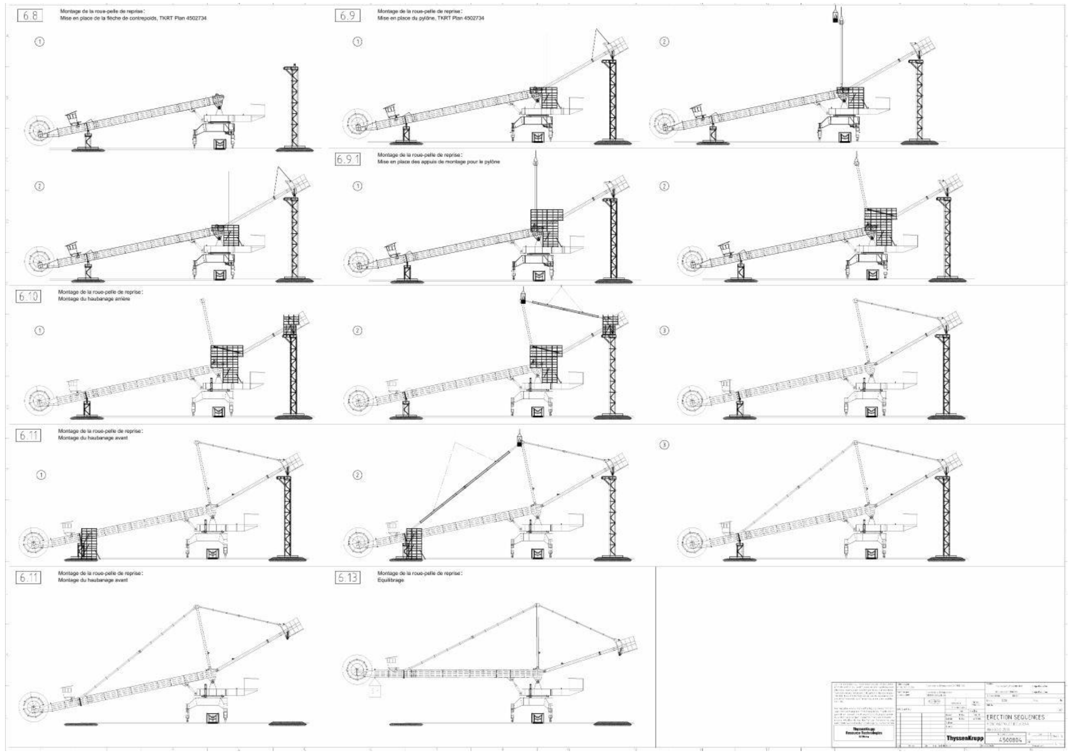
- Inspection & Repair:
- inspection on planned basis or on demand
- inspection reports and recommendations
- repairs & modifications

# Relocations

# Product Lifecycle – Erection Services

## thyssenkrupp Industrial Solutions

- Due to our long lasting experience we can offer you erection services at any kind for your construction site.
- Back office support for erection planning, stability investigations, jacking as well as lifting studies, etc. is granted at any time.
- Our qualified personnel at site will professionally realize your erection task suiting your specific construction site environment.



# Service products

## Repairs/Reengineering/Re-erections

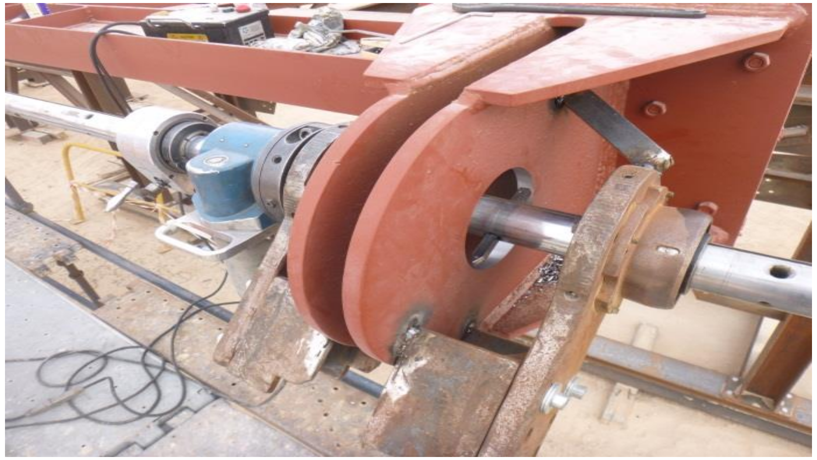
Germany, operating error

Greece, embankment slide

# Service products

## On site machining (Morocco 2014)



# Gearbox Services

## Service area

- Parallel gears
- bevel gears
- Planetary gears
- Worm gears
- Differential gear


Bucket wheel excavator 1550, Kolubara

# Gearbox Services: Inspection
## Measuring tools

- During operation
  - Temperature monitoring
  - Vibration monitoring
  - Noise control
  - Torque monitoring
- During downtime
  - Gearbox endoscopy
  - Metal particle check
  - Oil level monitoring
  - Oil quality analysis

**David Bovenkerk**
Technical Manager
Mining Service & Construction

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www.thyssenkrupp-industrial-solutions.com

# Crushing, Grinding & Pyroprocessing

## thyssenkrupp solutions for the mining industry


12.April.2016 | Tobias Koch
thyssenkrupp Industrial Solutions | Mineral Processing


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# thyssenkrupp Group – Structure

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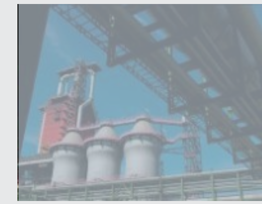
Components Technology


Elevator Technology


Industrial Solutions


Materials Services


Steel Europe

**Industrial Solutions** is a leading international supplier of refineries, chemical-, cement- and minerals plants, as well as an innovative solutions supplier for the minerals and mining industry and is also one of the leading companies in the worldwide shipbuilding industry.

# thyssenkrupp Industrial Solutions – Structure

## Industrial Solutions

| Unit | Process Technologies | Resource Technologies | Marine Systems | System |
| --- | --- | --- | --- | --- |
| Market | Chemicals  | Mining  | Submarines  | Automotive  |
| | Fertilizer  | Cement  | Naval Surface Vessels  | Aerospace  |

# thyssenkrupp Mining – Structure

| MINING | | | | |
|---|---|---|---|---|
| Business Units | BU Mineral Processing | BU Materials Handling | BU Mining | BU Local |
| |  |  |  |  |
| Head of BU | Papajewski | Dr. Wolpers | Jabs | |

# Contact:

| Name | E-Mail | Phone |
|---|---|---|
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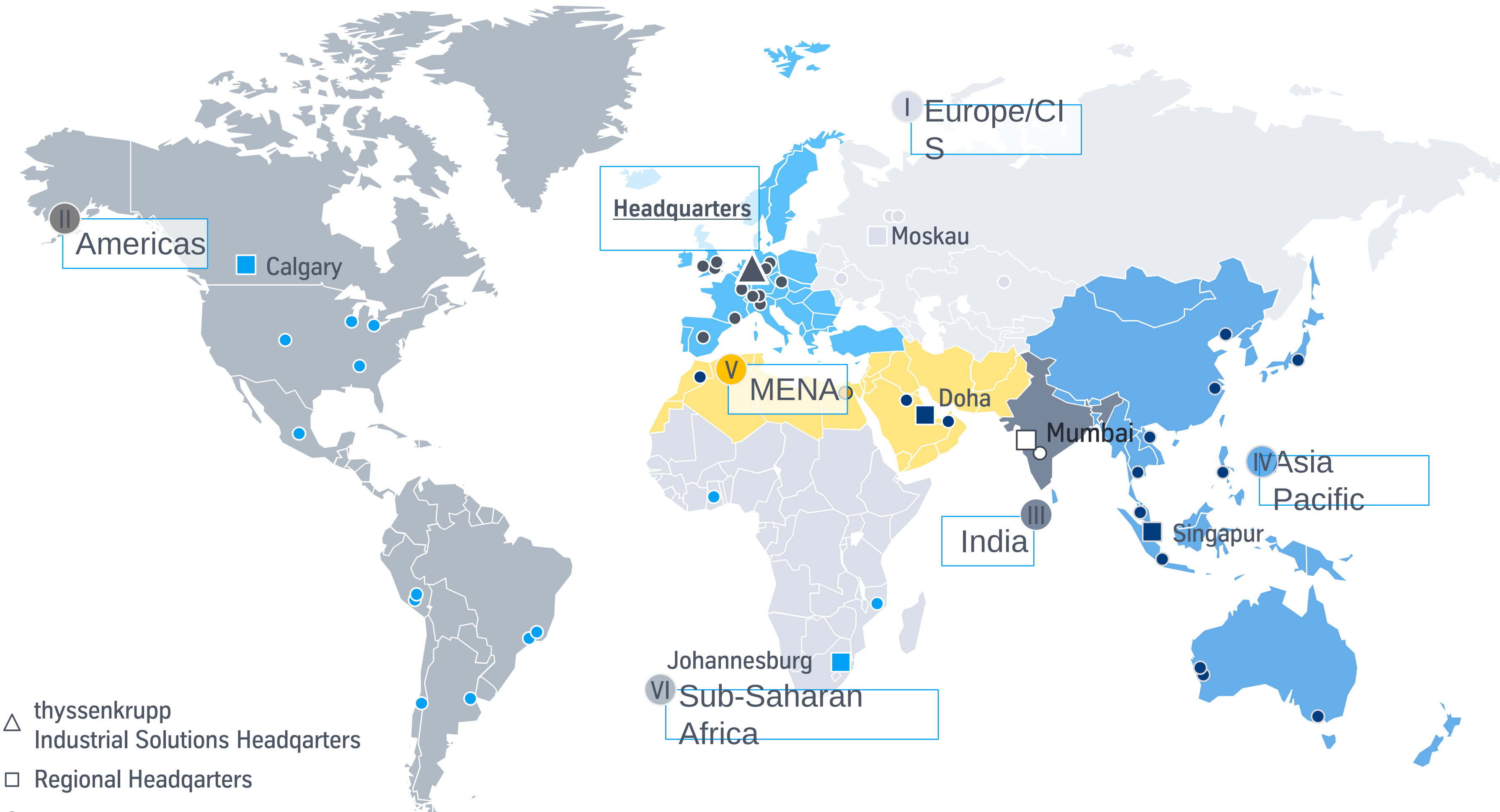
| Mr. Dr. Wolpers | franz.wolpers@thyssenkrupp.com | +49 (0) 6894 – 599 434 |
| Mr. Jabs | thomas.jabs@thyssenkrupp.com | +49 (0) 201 8284487 |

# Regional Clusterorganisation and Locations




△ thyssenkrupp Industrial Solutions Headqarters

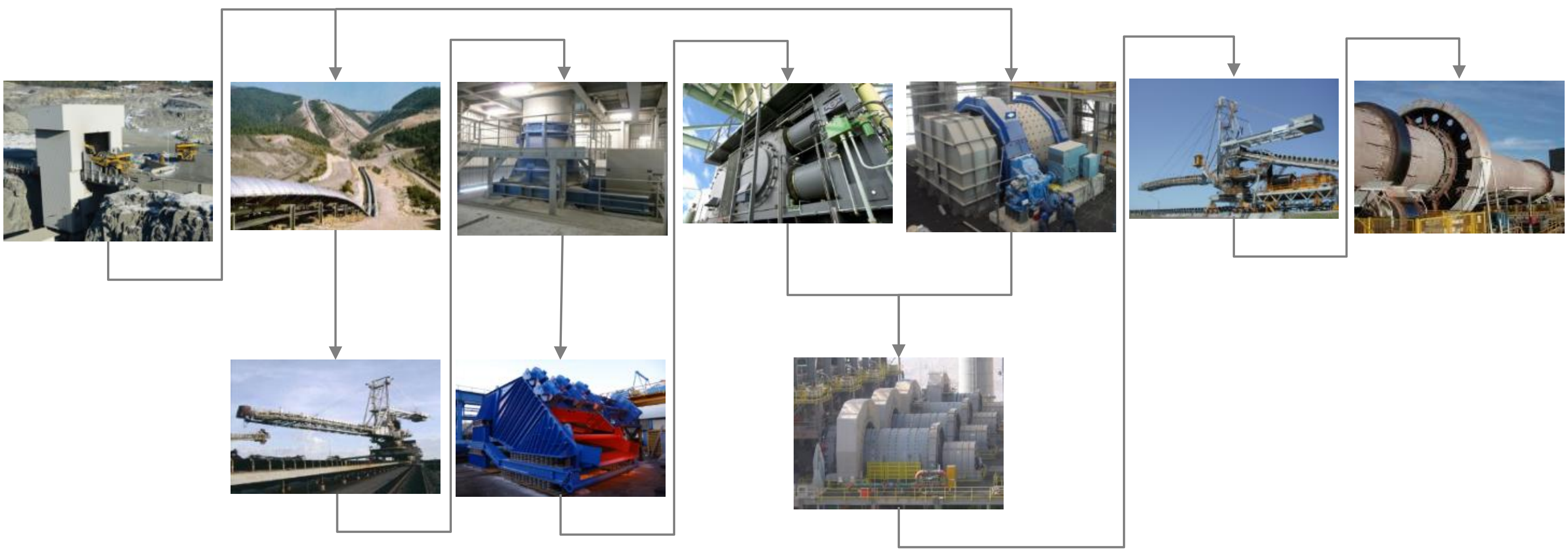
☐ Regional Headqarters

○ Local Representative office

# thyssenkrupp Resource Technologies: OSU Mining

## - Integrated Solutions -

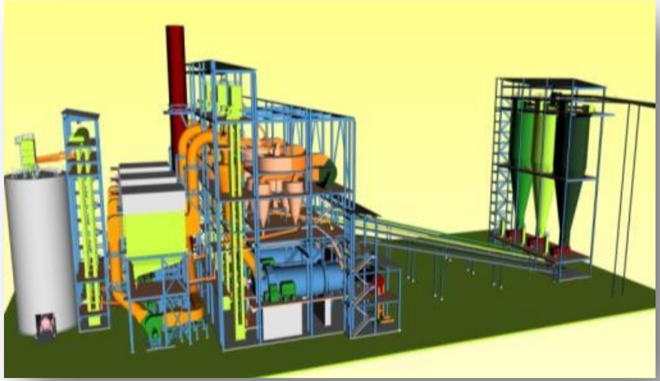
| Primary Crushing | Conveying & Stacking | Sec. Crushing & Screening | Comminution HPGR / SABC Grinding | Storing | Pyro-Processing |
|---|---|---|---|---|---|



# thyssenkrupp Resource Technologies: OSU Mining

## - Integrated Plants -

### Crushing and Grinding Plants



### Grinding & Pyro-processing Plants

### High Temperature Plants

### Fields of Expertise

- ✓ Planning and consulting
- ✓ Research and development
- ✓ Engineering
- ✓ Project management
- ✓ Manufacturing & Procurement
- ✓ Construction and Commissioning
- ✓ EPC/EPCM
- ✓ After sales service
- ✓ Financing Export and Projects

# BU Mineral Processing

Crushing Technologies

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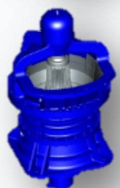
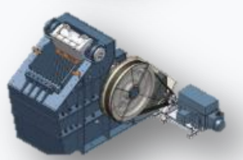
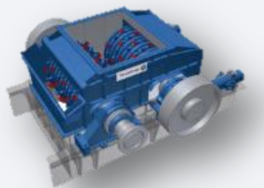
# Primary Crushing Plant Overview

| Plant Type | | Main Application |
|---|---|---|
| Fully Mobile |  | • Strip mining for coal, limestone; no trucks required |
| Semi Mobile |  | • IPCC systems for mining industry (iron ore, copper ore, overburden etc.); reduced truck fleet |
| Stationary |  | • Aggregates industries; standard feed by trucks |

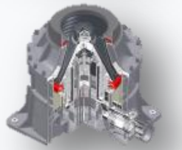
# Selection: Which Primary Crusher is most suitable/economical

| Primary Crusher Type | | Capacity [t/h] (@1.7t/m³) | Typical UCS [MPa] | Typical Crushing Ratio | Suitablility for high silica content | Suitability for high moisture content |
|---|---|---|---|---|---|---|
| Gyratory Crusher |  | 1,000 – 10,000 | < 250 | 6:1 | ++ | - |
| Jaw Gyratory Crusher |  | 1,000 – 3,000 | < 250 | 8:1 | ++ | - |
| Single Toggle Jaw Crusher |  | < 1,200 | < 250 | 4:1 | + | - |
| Double Toggle Jaw Crusher |  | < 1,000 | < 500 | 4:1 | ++ | - |

# Selection: Which Primary Crusher is most suitable/economical

| Primary Crusher Type | | Capacity [t/h] (@1.7t/m³) | Typical UCS [MPa] | Typical Crushing Ratio | Suitablility for high silica content | Suitability for high moisture content |
|---|---|---|---|---|---|---|
| Double Roll Crusher |  | < 14,000 | < 120 | 4:1 | + | ++ |
| Double Roll Sizer |  | < 5,000 | < 100 | 4:1 | ++ | + |
| Impact Crusher |  | < 2,500 | < 300 | 15:1 | - | - |
| Hammer Crusher |  | < 3,500 | < 200 | 50:1 (100:1) | -- | + |

# Crushers: Secondary / Tertiary Crushers

| Crusher Type | | Main Application |
|---|---|---|
| Cone Crusher Kubria® |  | • Minerals and aggregates, high abrasive and hard materials, up to 1,000t/h |
| Cone Crusher HKB |  | • Minerals, aggregates and slag, high abrasive and hard materials, up to 1,500t/h |
| Impact Crushers |  | • High reduction ratio, aggregates industry, low abrasive materials, up to 650 t/h |
| Impact Jaw Crusher |  | • Extreme hard material (up to 2,000 MPa) like Fe-Cr-alloys, up to 50 t/h |
| Vertical Impact Crusher ‚Multirock‘ |  | • Aggregates industry, for product shape control, up to 400 t/h |

# BU Mineral Processing

Grinding Technologies

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# HPGR (High Pressure Grinding Roll)

| Mill Type | | Main Application |
|---|---|---|
| HPGR Polycom® |  | • Hard ore grinding |
| HPGR Polycom® |  | • Pebble crushing |
| HPGR Polycom® |  | • Iron Ore grinding<br>- lumpy ore<br>- concentrate (grinding to pellet fineness) |
| HPGR Polycom® |  | • Kimberlite ore (liberation of diamonds) |

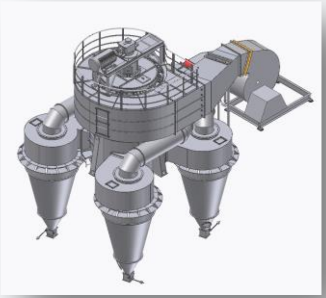
# Wet Mills

| Mill Type | Main Application |
|---|---|
| AG / SAG Mills  | • Soft and Medium hard ore<br>• Sticky material |
| Rod Mills  | • Replacement of quaternary crushers<br>• Steep product particle size distribution |
| Ball Mills  | • Final grinding for downstream process |
| Scrubber  | • Washing out of sticky material<br>• Disagglomerator of HPGR Polycom® product |
| Lime Slaker  | • Hydration of lime |

# Dry Mills (drying, grinding & classifying)

| Mill Type | | Main Application |
|---|---|---|
| Aerofall Mills |  | • Sticky materials which are difficult to handle<br>• High feed moisture content<br>• Water shortage |
| Dry Grinding Ball Mill<br>• 1 & 2 chamber<br>• Double Rotator ®<br>• Air swept |  | • Downstream process requires dry feed<br>• Water shortage |
| Hammer mills |  | • Sticky non-abrasive material<br>• High feed moisture content |

# Dry Mills (drying, grinding & classifying)

| Mill Type | | Main Application |
|---|---|---|
| Vertical roller mills |  | • Grinding of additives and coal<br>• Grinding of coal as fuel<br>• Grinding of burned lime |
| Separators<br>• Dynamic (Sepol®)<br>• Static (Statopol) |  | • Classification |

# BU Mineral Processing

Screens & Feeders

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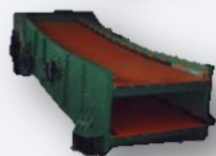
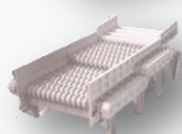
# Screen Overview

| Screen Type | Main Application |
|---|---|
| Linear Vibrating  | • Standard for high capacities (up to 10,000t/h @ 100mm cut) |
| Circular Vibrating  | • Standard for average capacities (up to 1,000t/h @ 50mm cut) |
| Elliptical Vibrating  | • Special type for high screening efficiency (aggregates industry) |
| Eccentric motion  | • Special type for sticky material |
| Rotating Screen/ Rotary Breaker  | • Special type for Oil sand extraction |

# Feeder Overview for R.O.M. Material

| Feeder Type | Main Application |
|---|---|
| Apron Feeders  | • High Capacity (built up to 14,000t/h), Heavy Duty, high abrasive material |
| Vibrating Feeders  | • Capacities < 3,000t/h |
| Vibrating Grizzly Feeders  | • Feeding and scalping with one machine; capacities up to 3,000t/h |
| Reciprocating Push Feeders  | • Capacities < 1,000t/h |
| Chain Feeders  | • Capacities < 2,000t/h, non abrasive material |
| Wobbler Feeders  | • Scalping of sticky, non abrasive R.O.M. |

# BU Mineral Processing

Pyroprocessing Technologies

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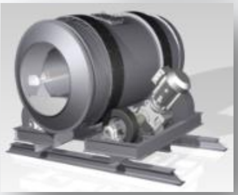
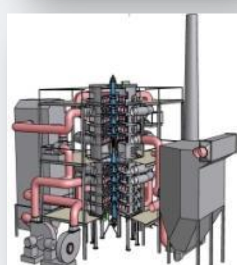
# Pyro-Processing Solutions

| Dryers | | Main Application |
|---|---|---|
| Flash Dryer |  | • Suspension dryer for fine material<br>• High efficiency heat and mass transfer<br>• Variable temperature distribution<br>• Suitable for fossil and waste fuels |
| Rotary Dryer |  | • Drying of lumpy materials<br>• Wide range of raw materials and sizes<br>• High process flexibility and simple operation |
| POLSHAFT Shaft Dryer |  | • Gentle material handling<br>• Low formation of fines |
| POLPELL Pelletizing Drum |  | • Pelletizing of dusts<br>• Uniform and adjustable pellet diameter |

# Pyro-Processing Solutions

| Kilns | | Main Application |
|---|---|---|
| Rotary Kilns |  | • Oxidation, reduction, calcination, volatilization roasting, sintering and melting<br>• Wide range of raw materials and sizes<br>• High flexibility under controlled conditions |
| Shaft Preheater |  | • Preheating of dolomite & limestone<br>• Roller screen for sulphur extraction (optional)<br>• Reduction of the $CO_2$ footprint<br>• Retrofit solutions |
| POLFLAME® |  | Rotary kiln burner<br>• solid, liquid and gaseous fossil or waste fuels<br>• temperature distribution, flame length, swirl<br>• unique shaping of flame during operation |

# Pyro-Processing Solutions

| Kilns | | Main Application |
|---|---|---|
| Multiple Hearth Furnace |  | • Suitable for calcining of magnesite, $Mg(OH)_2$, flexible also for other materials |
| POLSINT Sintering kiln |  | • Sintering/deadburning of magnesia, dolomite, Spinell, bauxite, etc. |
| Multiple Hearth Furnace POLTORR |  | • Specialized for low temperature applications: roasting/torrefying ➔e.g. biocoal<br>• Sustainable solution to small $CO_2$ footprint |

# Pyro-Processing Solutions

| Kilns | | Main Application |
|---|---|---|
| POLCAL® |  | • Gas Suspension Calciner for fine materials<br>• High thermal efficiency<br>• Low footprint |
| ATP Processor |  | • Processing of oil shale for fines and coarse material |
| Annular Shaft Kiln |  | • Calcination of dolomite & limestone<br>• Wide range of tonnage and sizes<br>• High $CO_2$-content in waste gas<br>• No washed limestone necessary |

# Pyro-Processing Solutions

| Coolers | | Main Application |
|---|---|---|
| Flash Cooler |  | • Especially designed for fine materials<br>• Rapid cooling/high efficient heat transfer<br>• No rotating parts |
| Rotary cooler |  | • Cooling of lumpy materials<br>• Wide range of raw materials and sizes<br>• High process flexibility and simple operation |
| Fluid Solid Cooler |  | • Indirect cooling system for fine material<br>• Agitation of fines for improved heat transfer<br>• No mobile parts |
| POLYTRACK® |  | • High throughput of coarse or lumpy materials<br>• High efficient walking floor cooling system<br>• Low-wear/low maintenance |

# Product Catalogues and Brochures

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# Product Catalogues and Brochures - MINING

| | Name | Type (Size) | Hyperlink |
|---|---|---|---|
|  | Continuous mining systems | PDF (1.5 MB) | http://www.thyssenkrupp-industrial-solutions.com/fileadmin/documents/brochures/Continuous_mining_systems_EN.pdf |
|  | In-pit crushing and conveying systems | PDF (1.5 MB) | http://www.thyssenkrupp-industrial-solutions.com/fileadmin/documents/brochures/In-pit_crushing_and_conveying_systems.pdf |

# Product Catalogues and Brochures – Mineral Processing

| | Name | Type (Size) | Hyperlink |
|---|---|---|---|
|  | Jaw Crushers | PDF (3.2 MB) | http://www.thyssenkrupp-industrial-solutions.com/fileadmin/documents/brochures/backenbrecher_en.pdf |
|  | Gyratory Crushers | PDF (4.5 MB) | http://www.thyssenkrupp-industrial-solutions.com/fileadmin/documents/brochures/kreiselbrecher_a_en.pdf |
|  | Kubria Cone Crushers | PDF (1.3 MB) | http://www.thyssenkrupp-industrial-solutions.com/fileadmin/documents/brochures/kubriakegelbrecher_en.pdf |
|  | Linear Vibrating Screens | PDF (1.0 MB) | http://www.thyssenkrupp-industrial-solutions.com/fileadmin/documents/brochures/linearschwingsieb_en.pdf |

# Product Catalogues and Brochures – Mineral Processing

| | Name | Type (Size) | Hyperlink |
|---|---|---|---|
|  | RollSizer | PDF (3.2 MB) | http://www.thyssenkrupp-industrial-solutions.com/fileadmin/documents/brochures/rollsizer_en.pdf |
|  | Mineral Processing | PDF (1.9 MB) | http://www.thyssenkrupp-industrial-solutions.com/fileadmin/documents/brochures/aufbereitungstechnik_en.pdf |
|  | IMPACT Crusher | PDF (1.6 MB) | http://www.thyssenkrupp-industrial-solutions.com/fileadmin/documents/brochures/prallbrecher_en.pdf |
|  | TITAN Double Shaft Hammer Crusher | PDF (0.8 MB) | http://www.thyssenkrupp-industrial-solutions.com/fileadmin/documents/brochures/titan_doppelwellen_hammerbrecher_en.pdf |

# Product Catalogues and Brochures – Mineral Processing

| | Name | Type (Size) | Hyperlink |
|---|---|---|---|
|  | Apron Feeder | PDF (0.7 MB) | http://www.thyssenkrupp-industrial-solutions.com/fileadmin/documents/brochures/plattenband_en.pdf |
|  | Systems around the Power Plant | PDF (1.8 MB) | http://www.thyssenkrupp-industrial-solutions.com/fileadmin/documents/brochures/kraftwerksysteme_en.pdf |
|  | Grinding systems | PDF (5.3 MB) | http://www.thyssenkrupp-industrial-solutions.com/fileadmin/documents/brochures/mahlsysteme_en.pdf |
|  | CHF vacuum belt filters | PDF (788 KB) | http://www.thyssenkrupp-industrial-solutions.com/fileadmin/documents/brochures/vakuumbandfilter_chf_en.pdf |

# Product Catalogues and Brochures – Mineral Processing

| | Name | Type (Size) | Hyperlink |
|---|---|---|---|
|  | Hydro-cyclones vacuum belt filters | PDF (3.8 MB) | http://www.thyssenkrupp-industrial-solutions.com/fileadmin/documents/brochures/vakuumbandfilter_en.pdf |
|  | Autogenous, semi-autogenous and ball mills for wet and dry grinding | PDF (3,8 MB) | http://www.thyssenkrupp-industrial-solutions.com/fileadmin/documents/brochures/Autogenous_EN.pdf |
|  | POLYCOM high-pressure roll | PDF (3,0 MB) | http://www.thyssenkrupp-industrial-solutions.com/fileadmin/documents/brochures/POLYCOM_EN.pdf |
|  | QUADROPOL roller mill (№ 1621) | PDF (1,3 MB) | http://www.thyssenkrupp-industrial-solutions.com/fileadmin/documents/brochures/QUADROPOL_1621_en.pdf |

# Product Catalogues and Brochures – Mineral Processing

| | Name | Type (Size) | Hyperlink |
|---|---|---|---|
|  | Metallurgical Injection Technology (№ 1628) | PDF (3,0 MB) | http://www.thyssenkrupp-industrial-solutions.com/fileadmin/documents/brochures/Metall_Einblastechnik_1628_en_2008.pdf |
|  | Pyroprocessing for the minerals industry (№ 1625) | PDF (3,9 MB) | http://www.thyssenkrupp-industrial-solutions.com/fileadmin/documents/brochures/MINERALS_2008_WAERMETECHNIK_1625_en.pdf |
|  | High-temperature technology (№ 1629) | PDF (3,3 MB) | http://www.thyssenkrupp-industrial-solutions.com/fileadmin/documents/brochures/Hochtemperaturtechnik_1629_en.pdf |

# Product Catalogues and Brochures – Materials Handling

| | Name | Type (Size) | Hyperlink |
|---|---|---|---|
|  | Rail car unloaders | PDF (2.5 MB) | http://www.thyssenkrupp-industrial-solutions.com/fileadmin/documents/brochures/Car-dumpers.pdf |

# thyssenkrupp Industrial Solutions


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# Operation with modern Crushing Technology

## Opportunities for process improvements

12.April.2016 | Tobias Koch
thyssenkrupp Industrial Solutions | Mineral Processing

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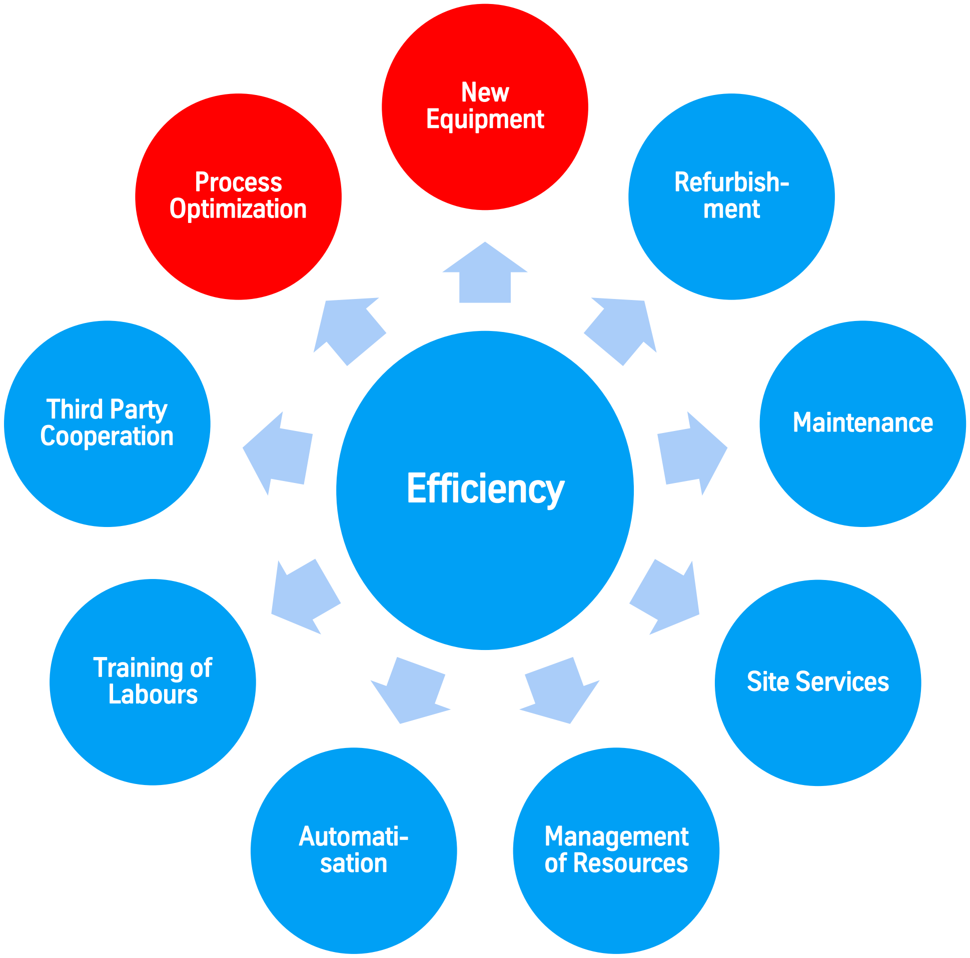
# Ways For Efficiency Improvement



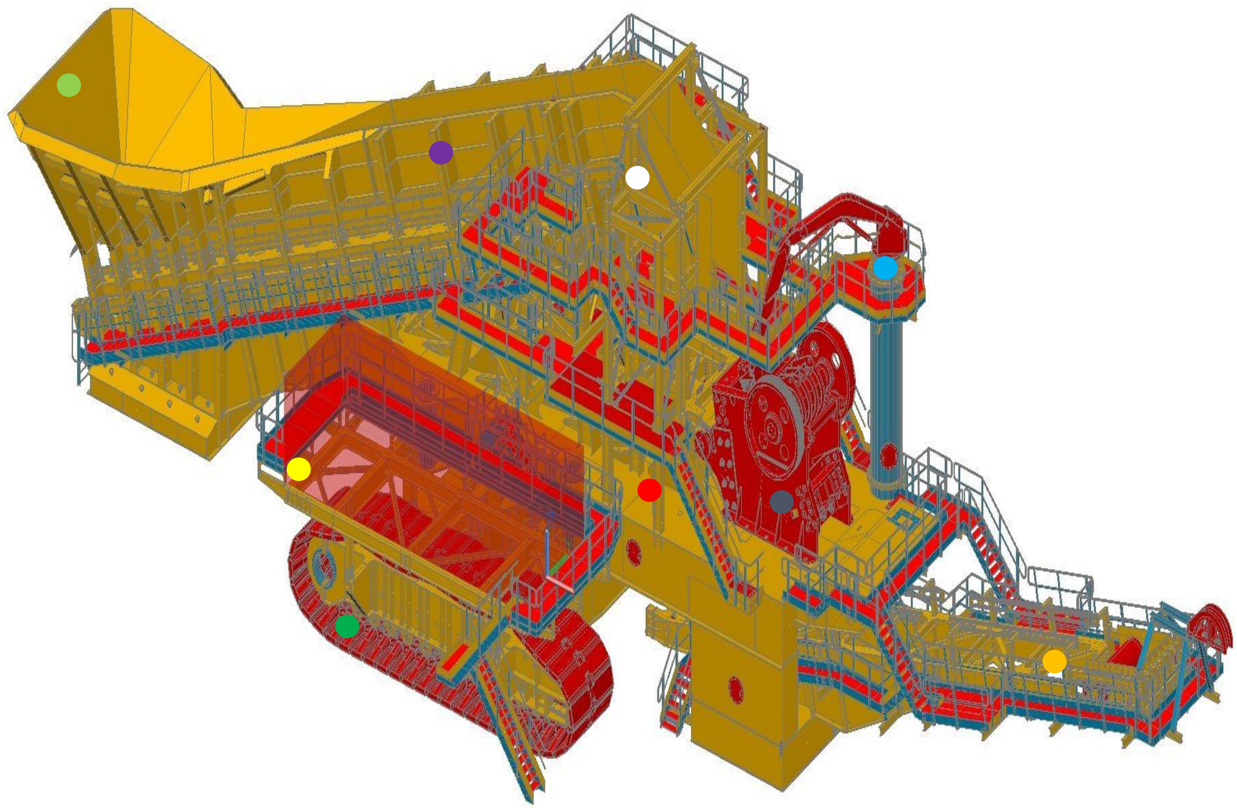
# POSSIBILITIES FOR CRUSHING

# Comparison Of Crushing Plants

| | Stationary Crushing Plant | Semi Mobile Crushing Plant | Mobile Crushing Plant |
|---|---|---|---|
| Capacity | ✓✓✓ | ✓✓✓ | ✓✓ |
| Felxibility | ✓ | ✓✓ | ✓✓✓ |
| Homogenization of ore | ✓✓✓ | ✓✓ | ✓ |
| Selective mining | ✓ | ✓✓ | ✓✓✓ |
| Minimized truck fleet | ✓ | ✓✓ | ✓✓✓ |
| Minimized efforts for infrastructure | ✓ | ✓✓✓ | ✓ |
| Minimized impact on operations during erection | ✓ | ✓✓✓ | ✓✓✓ |
| Ease of Maintenance | ✓✓ | ✓✓✓ | ✓ |
| Sum | ✓✓ | ✓✓✓ | ✓✓ |

# Mobile Crushing Plant Layout

- Main Module
- Feed Hopper
- Apron Feeder
- Grizzly Screen
- Jaw Crusher
- Rock Breaker
- Discharge Conveyor
- Crawler
- E-House



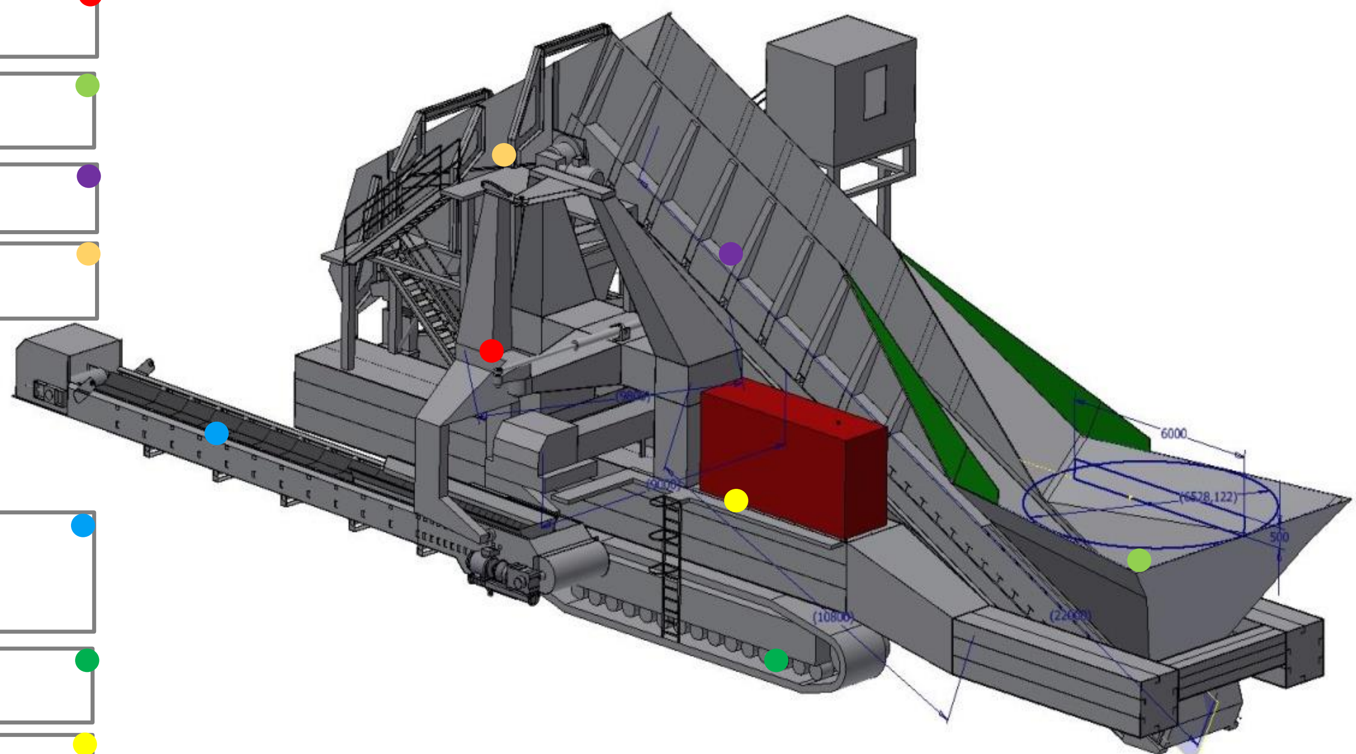
# Mobile Screening Plant

Main Module

Feed Hopper

Apron Feeder

Screen




Discharge Conveyor

Crawler

E-House

Project Profile:

# China Power EPCE

**Location:** China

**Year:** 2008

## Scope:

Mobile Crushing Plant, indirect feed with DRC 22/25

## Data:

Plant design: One module, fully mobile

Material: Overburden

Capacity: 3600 t/h

Product: <300 (X) mm

Feed: Apron Feeder

Discharge: Belt feeder

Drive: 2x450 kW

Service weight: 1400 t

-Overburden System with Double Roll Crusher DRC 22/25

Project Profile:

# MARTIN MARIETTA MATERIALS - Medina Plant

**Location:** USA

**Year:** 2015

## Scope:

Mobile Crushing Plant, indirect feed with Apron Feeder RKF 2.400x25.000 D9 and PB 250/250 CR

## Data:

Plant design: One module, fully mobile

Material: Limestone

Capacity: 3800 t/h

Product: <125 (X) mm

Feed: Apron Feeder

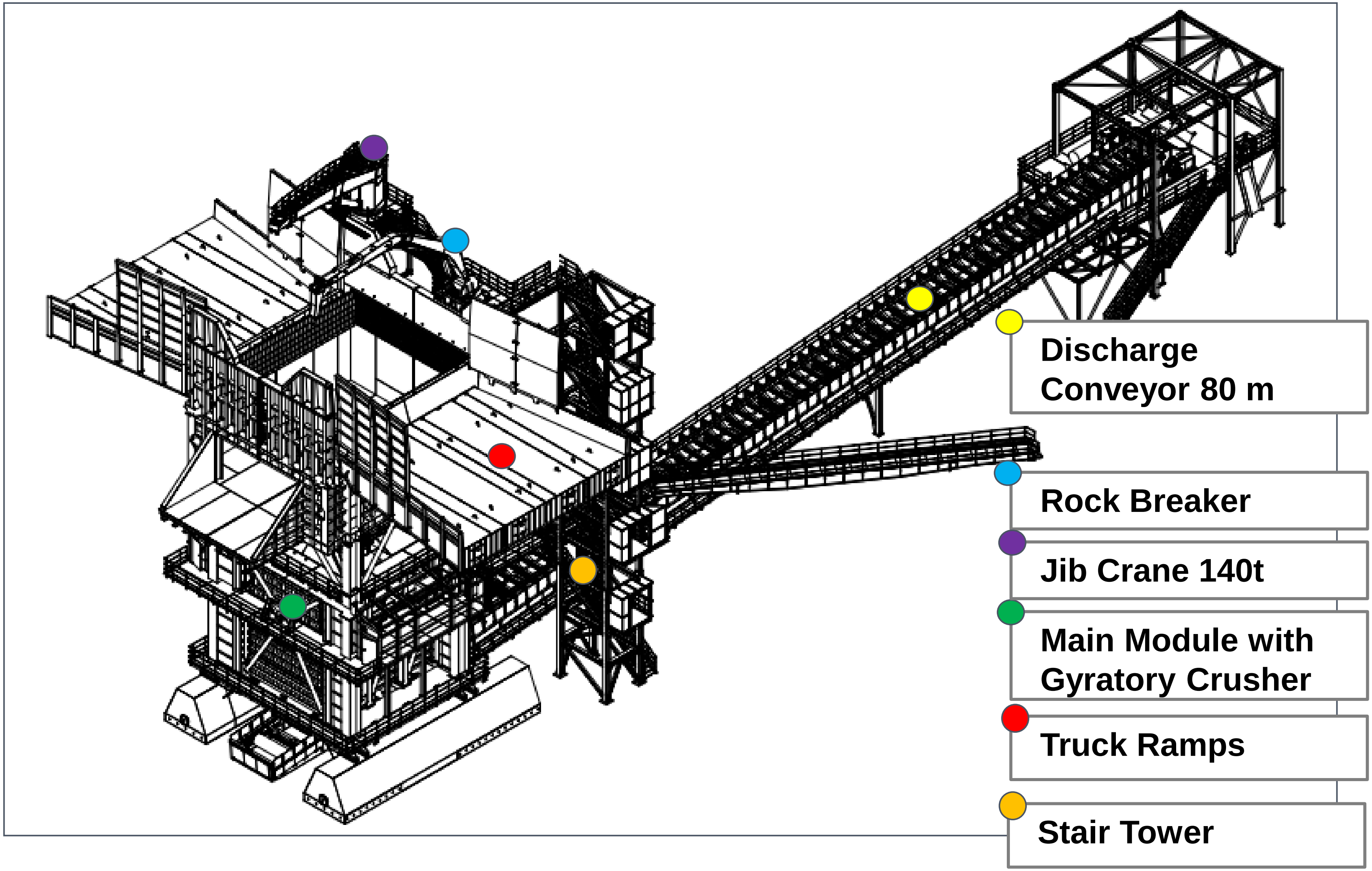
Discharge: Belt feeder

Drive: 2200 kW

Service weight: 1000 t

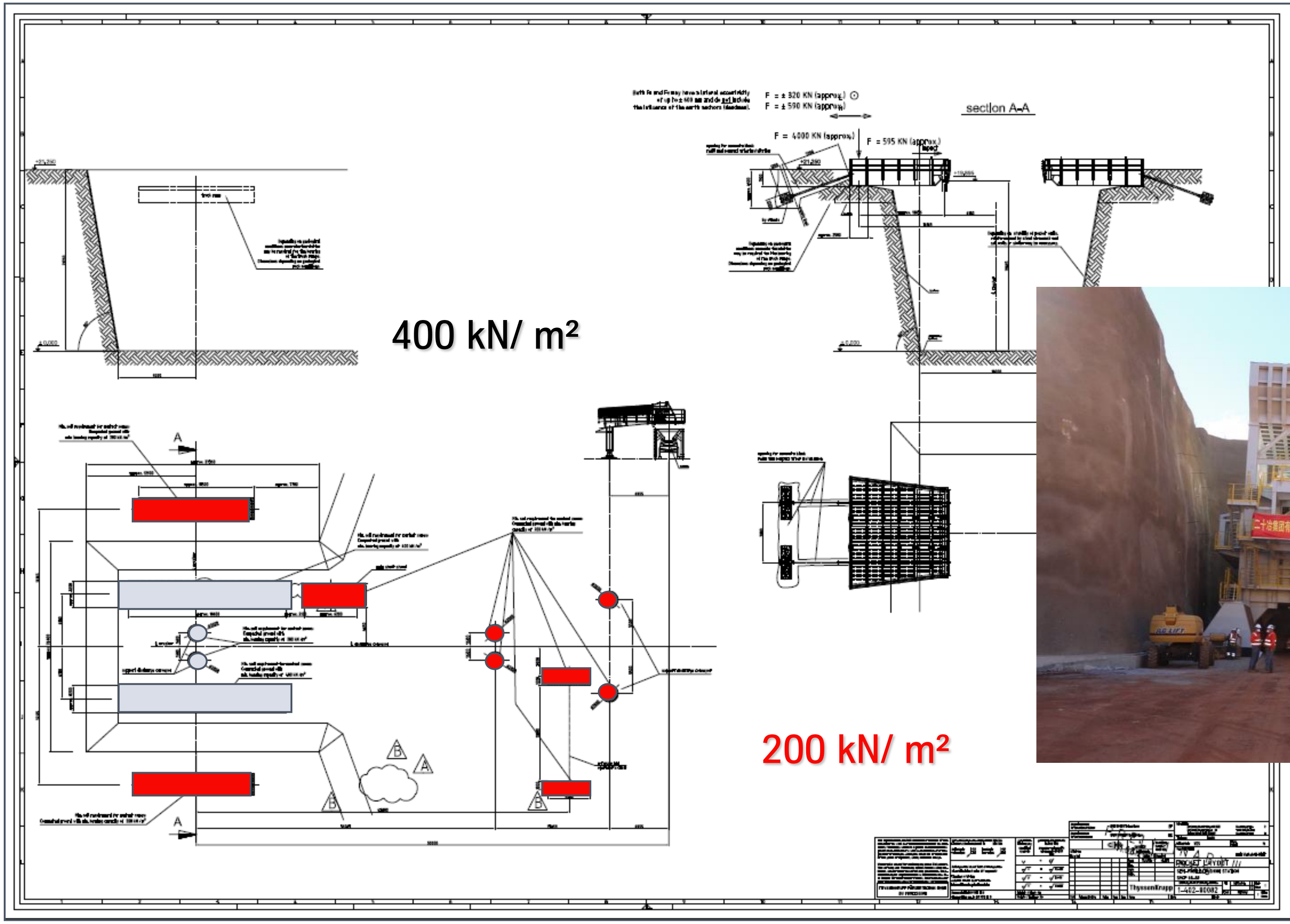
- Limestone Crushing System
- Hydraulic Walking Mechanism

# Semi Mobile Crushing Plant Layout

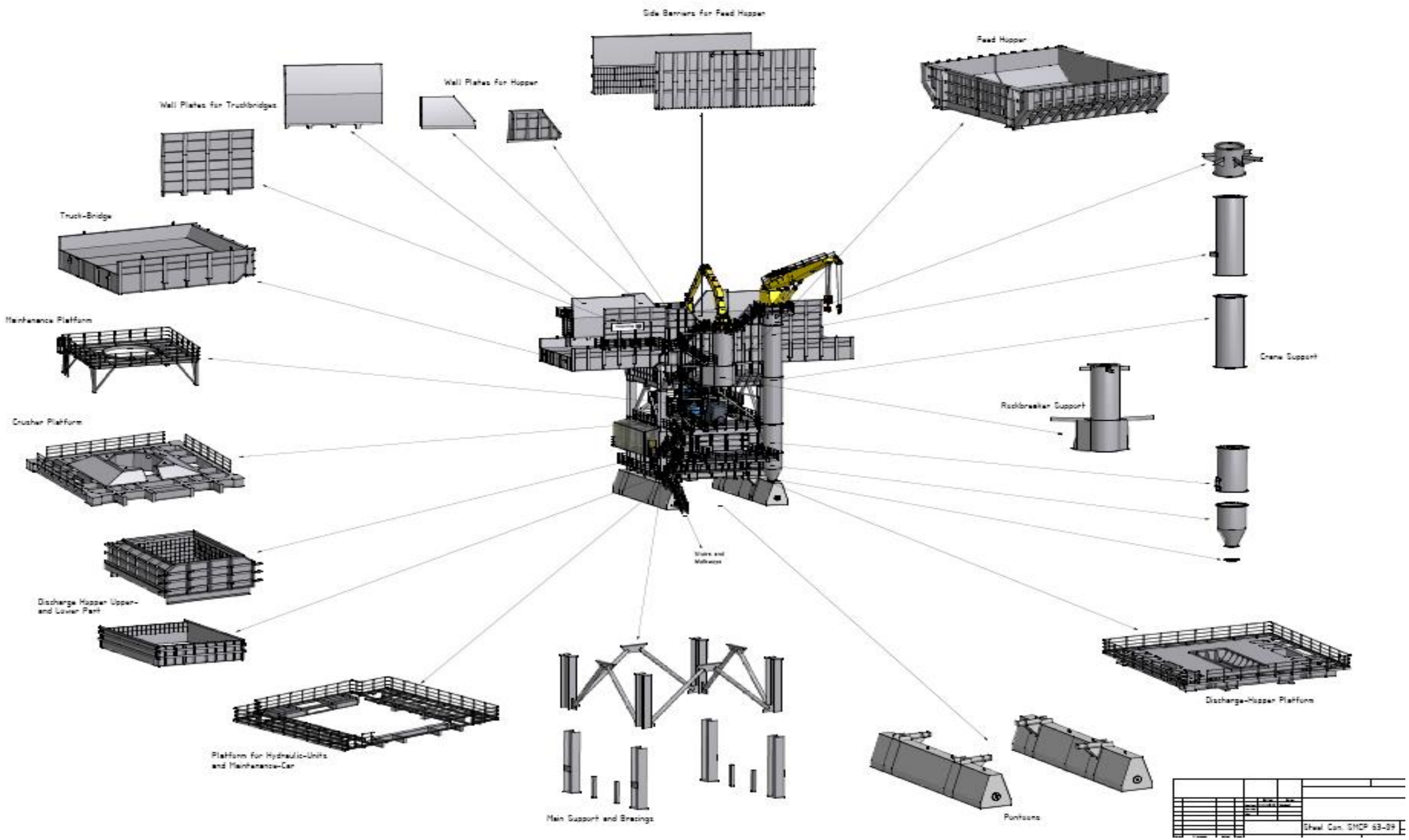


# In-Pit Crushing: Technologies with Continuous Conveyor Haulage

## Semi-Mobile Plants




# SEMI MOBILE CRUSHING PLANTS – MODULAR DESIGN



# Type Of Semi Mobile Crushing Plant

Project Profile:

# Assarel, Panagyurishte Mine

**Location:** Bulgaria

**Year:** 2011

## Scope:

Semi-Mobile Crushing Plant, indirect feed with Gyratory Crusher 63” x 89”

## Data:

Plant design: Two modules, semi mobile

Material: Overburden

Capacity: 5000 t/h

Product: 0-350 (X) mm

Discharge: Belt feeder

Drive: 600 kW

Service weight: 1700 t

-Overburden System with Crusher, Conveying and Spreader System

Project Profile:

# NORSK STEIN AS, Jelsa Mine

**Location:** Norway

**Year:** 2007

## Scope:

Semi-Mobile Crushing Plant, direct feed with Gyratory Crusher 63” x 75”

## Data:

Plant design: One module, semi mobile

Material: Granite

Capacity: 2,600 t/h – 2,800 t/h

Product: <280 mm

Discharge: Belt feeder

Drive: 600 kW

Service weight: 950 t

-Fully enclosed plant

-System supply with secondary crushing plant, conveying system, stockyard and shiploader in collaboration between TKF and TKMH Germany

Project Profile:

# CODELCO, Ministro Hales Mine

**Location:** Chile

**Year:** 2011

## Scope:

Semi-Mobile Crushing Plant, direct feed with Gyratory Crusher 63” x 89”

## Data:

Plant design: One module, semi mobile

Material: Copper Ore

Capacity: 4,500 t/h

Product: <250 mm

Discharge: Belt feeder

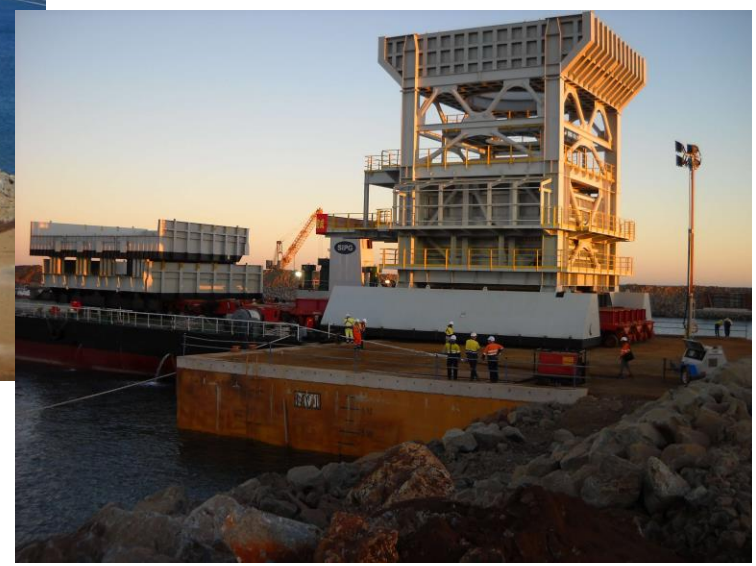
Drive: 1,000 kW

Service weight: 2,200 t

- With enclosed feed hopper and ramps for 360 t trucks
- System supply with semi-mobile primary crushing plant and overland conveyor in collaboration between TKIS Germany and TKIC Chile

# Design, Layout, & Features

## Erection – Example: SMCP 63x89, Australia

**Shipment with special vessel**

# DESIGN, LAYOUT, & FEATURES

## Erection – Example: SMCP 63x89, Australia


System Supplier

thyssenkrupp

thyssenkrupp Industrial Solutions AG

Engineering/ Design

Procurement

Expediting

Manufacturing

Quality Assurance

Supply

Erection Supervision/ Commissioning/ Training

Complete Crushing System

Process Warranty for the System

# THANK YOU FOR YOUR ATTENTION!


# ANY QUESTIONS?

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Arab Intl Organization
Arab Fertilizer Association
Since 1975

In co- operation with

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# AFA WORKSHOP
## Operation and Maintenance Optimization

Jordan - Aqaba: 11-14 April, 2016

# DAY 2: Tuesday 12 April, 2016

Sponsors:

Arab Potash

Jordan Phosphate Mines Co.

Indo Jordan Chemicals Co.

NJFC
Nippon Jordan Fertilizer Co.

KEMAPCO
KEMAPCO Arab Fertilizers & Chemicals Industries Ltd.

الإتحاد العربي للأسمدة
Arab Fertilizer Association

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# AFA WORKSHOP
## Operation and Maintenance Optimization

Jordan - Aqaba: 11-14 April, 2016

# Session 3

Sponsors:

Arab Potash
Jordan Phosphate Mines Co.
Indo Jordan Chemicals Co.
NJFC
Nippon Jordan Fertilizer Co.
KEMAPCO
KEMAPCO Arab Fertilizers & Chemicals Industries Ltd.

# AFA workshop

## Plant assessments (GAP analysis) - Identification of projects to improve O&M performance

Stefan Dähn

Aqaba, 12th April 2016

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# Plant Assessment

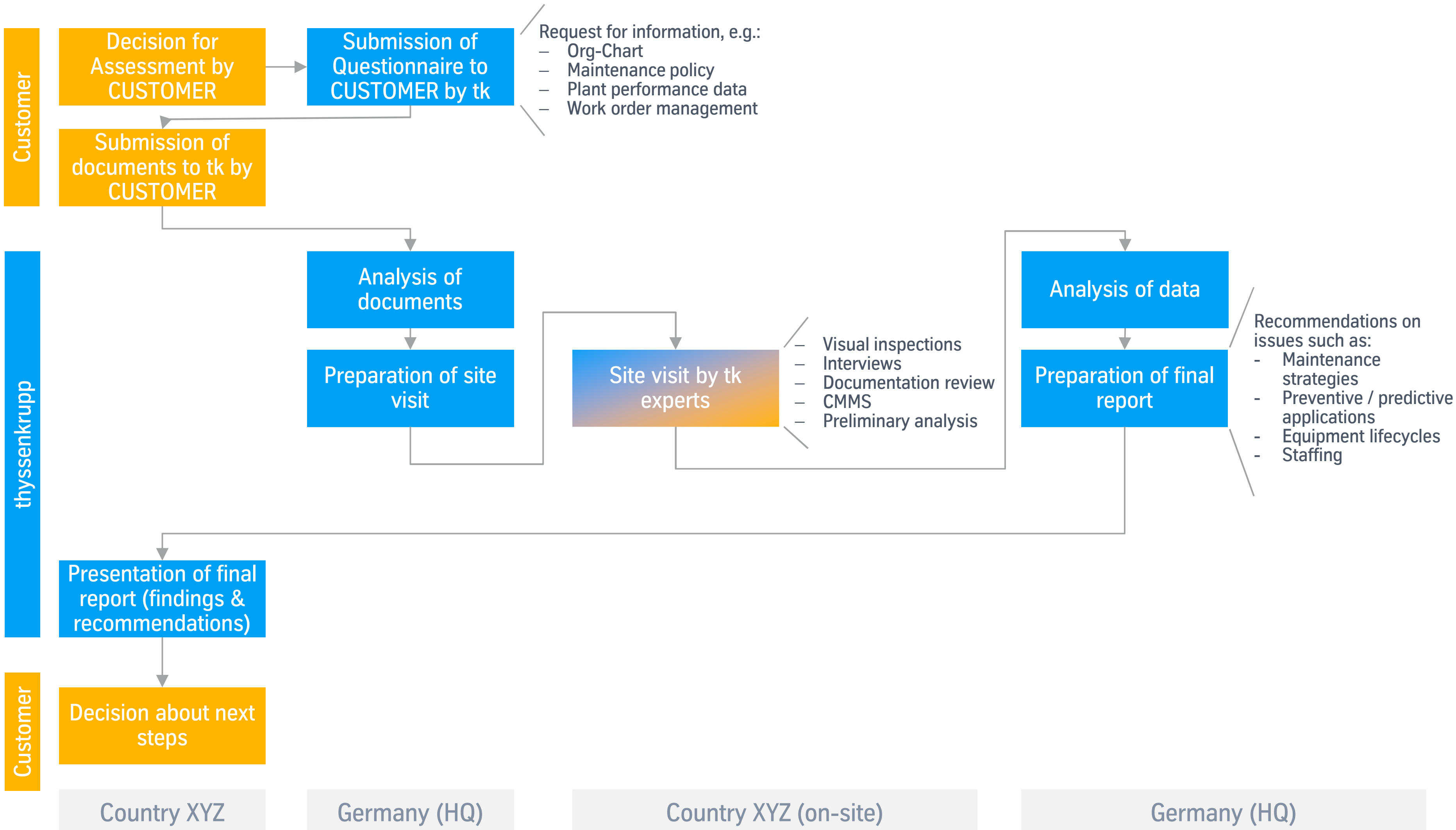
## Why conduct an assessment?

- **What is a plant assessment?**
  - Small team of tkIS experts evaluate customer's maintenance organization and performance
  - Emphasis on plant/equipment condition, qualification of personnel, maintenance processes
  - Structured process / GAP analysis (comparison of actual performance vs. desired/best practice performance)

- **Why conduct an assessment?**
  - Unbiased and objective evaluation of level of maturity of maintenance organization
  - Starting point / baseline to initiate improvement program
  - Check on the progress of an ongoing improvement program

# Plant Assessment

## The assessment follows a structured approach



# Plant Assessment

## Pre site visit questionnaire

- HSE data
- Org-Charts
- Plant description (units, equipment, plant layout, process flow diagram, etc.)
- Plant performance data
- Maintenance policy
- Maintenance cost
- Capital replacement value of total equipment / current value of new plant
- Spare parts
- Subcontractors
- Planned shutdowns
- Work order management
- CMMS
- Condition Monitoring program

**Not all information mandatory; but more information → more reliable results / shorter site visit**

# Plant Assessment

## Main activities on site

- Kickoff meeting
- Plant / equipment inspection
- Take pictures
- Interview with personnel from different disciplines and hierarchy levels
- Gather documents / review documentation
- Work on questionnaire together with customer / make notes
- Analyze data and prepare recommendations
- Create & present final report / discuss next steps

# Plant Assessment
## Assessment categories

### 1 General Topics

- Organization
- Training
- Document Management
- Asset Care & Continuous Improvement
- Cooperation between Operation & Maintenance
- Financial Optimization

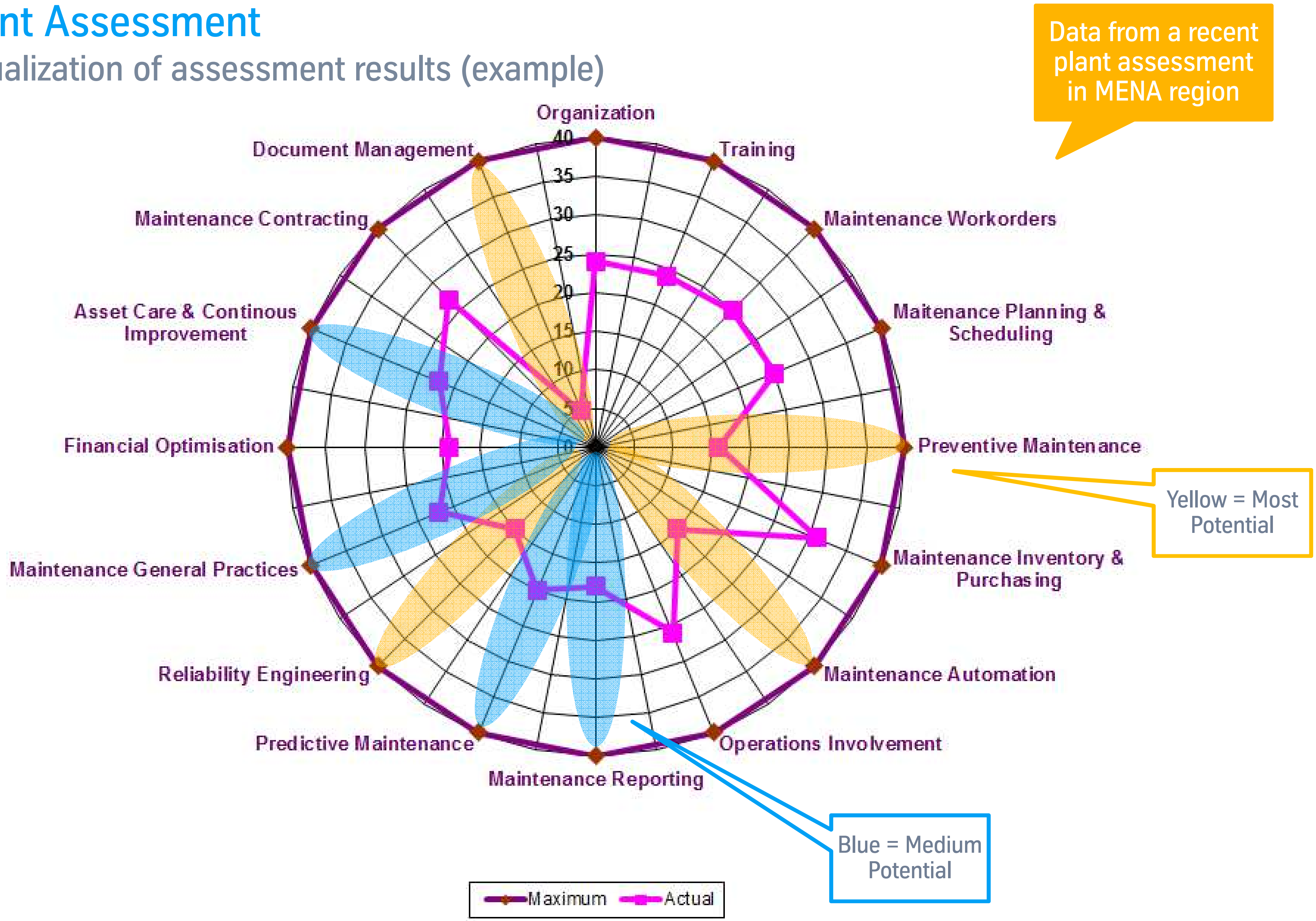
### 2 Maintenance Specific Topics

- Maintenance General Practices
- Maintenance Work Orders
- Maintenance Planning & Scheduling
- Preventive Maintenance
- Predictive Maintenance
- Reliability Engineering
- Maintenance Automation
- Maintenance Reporting
- Maintenance Inventory & Purchasing
- Maintenance Contracting

**Various categories ensure holistic view on maintenance organization**

# Plant Assessment

## Visualization of assessment results (example)



# Plant Assessment

## Results & recommendations (example)

Data from a recent plant assessment in MENA region

| Packet | Description |
|---|---|
| **Packet 1**<br>• Maintenance Process<br>• Advanced Maintenance Techniques | • Optimization of maintenance work order management<br>• Risk Based Inspections (e.g. review and update of criticality analysis, review and update of inspection plans/procedures)<br>• Condition Monitoring (e.g. optimization of data collection process, data analysis tools, reporting) |
| **Packet 2**<br>• Training | • Technical training (classroom / on-the-job)<br>• Special equipment training<br>• CMMS (SAP-PM) |
| **Packet 3**<br>• Additional Support | • Shutdown planning (e.g. minimization of shutdown period, integration of resource/cost planning)<br>• Spare parts for old equipment (sourcing, re-engineering) |

# Plant Assessment

## From innocence to excellence


**Excellence**
The Organization is continually reviewing systems and implementing improvements. The organization is recognized as having a leading edge industry wide.

**Competence**
The Organization has implemented systems throughout and these systems are accepted as part of the norm. (The systems are now in control.)

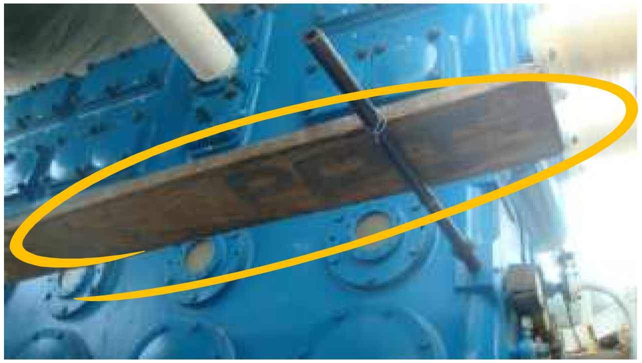
**Understanding**
The Organization, and individuals are developing improvement plans for the systems and the improvements are being implemented in varying degrees.

**Awareness**
The Organization, and individuals have become aware that current practices are inadequate and that changes are required to improve

**Innocence**
The Organization is not aware that alternatives exist. There is no plan or investigation for changing the current practices. (The system is not in control.)

# Plant Assessment

## What does innocence look like? (examples)



Climbing (HSE)

Dust / Instrumentation / Wiring

Eye / Head Protection (HSE)

Missing Bolts/Screws

Junk

New Equipment (idling in the field unprotected)

Tools / Workshop

# Plant Assessment

## How to change? Success factors

### External Partner

- Create awareness
- Unbiased view

### Organizational Culture

- Mindset
- Role model
- Training

### Processes

- Processes
- Standards / Norms
- (Software) Tools

# Plant Assessment

## What does excellence look like? (examples)

5S + HSE

Storage (clean, systematic, labeled)

Proper documentation

Clean working environment

Functional eye-shower

Tools & Processes

Laser Alignment (tools)

Thermography (tools)

Software / CMMS

5S (sort, set in order, shine, standardize, sustain)

# Plant Assessment

## Question for the audience

END of Presentation – Thank you for your attention!

&

BEGINNING of Discussions:

- Where are you in the pyramid? (excellence, competence, understanding, awareness, innocence)
- How do you track your improvement programs?
- How do you initiate new improvement programs?

# Plant Assessment

## Contact Us!

Industrial Solutions
Resource Technologies

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# Backup

# AFA workshop

Successfactor CMMS – Implementation and Optimization

Stefan Dähn & Olaf Kraska

Aqaba, 12th April 2016

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# Agenda

1. What is a CMMS?
2. What can a CMMS do for your business?
3. Implementation Strategies
4. What systems are available?
5. Summary

# What is a CMMS?

Two definitions:

1. A CMMS (Computerized Maintenance Management System) is a software solution, specified by managers to streamline maintenance operations and improve the bottom line.
2. A CMMS is a software that is used to schedule and record operation and maintenance activities associated with assets.

The main task of a CMMS is to handle large amount of data and turn it into useful information when required.

Two important statements:

1. A CMMS is just a tool. But it is "THE" tool for professional maintenance organizations.
   No success without CMMS!
2. Buying a CMMS will never solve operational problems.
   Only a combination of CMMS, comprehensive data and best systems and processes will do.

# What can a CMMS do for your business?

## The Objectives of a CMMS


| Category | Goal | Business Objective | CMMS Objective |
|---|---|---|---|
| Increase Performance | Improved availability, reliability and maintainability | Reduce failures | Analyze equipment history |
| | | Reduce stoppages | Manage equipment data |
| | | Reduce respond time | Keep skills profiles |
| | | | Keep bills of material |
| | | | Build PM routines |
| | | Reduce variance & rework | Monitor machine variance |
| | | Performance monitoring | Costs and performance data on equipment |
| Reduce Costs | Reduce overall maintenance costs | Reduce labour | Control jobs |
| | | | Plan labour / materials |
| | | Reduce spare parts | Analyze usage |
| | | | Analyze investment |
| | | Reduce emergencies | Schedule PM |
| | | | Analyze breakdowns |
| | | Reduce paper work | Automate work orders |
| | | | Automate POs |
| | | Performance monitoring | Costs by area, job, type and labour |

# Implementation Strategies
## General requirements 1

- Hardware or IT infrastructure
  - Server & Workstations
  - Network
  - Good Internet connection (cloud based solutions)
- Software
  - Purchase
  - Install
  - Setup, basic customization

**Can be done quickly with IT know-how**

# Implementation Strategies

## General requirements 2

- First question must be: What information do I need from the system?
- Select the right system
- Pre-work (Maintenance Engineering)
  - Equipment Hierarchy & Asset Codes
  - Bills of Material, Spare Parts, Wear Parts
  - Equipment Maintenance Plans
  - Tools and Consumables
  - Trade / Labour List
  - Processes for Work Flow, etc.
- All data must be available in an “easy to upload” format, depending on the system

| Category | Goal | Business Objective | CMMS Objective |
|---|---|---|---|
| Increase Performance | Improved availability, reliability and maintainability | Reduce failures | Analyze equipment history |
| | | Reduce stoppages | Manage equipment data |
| | | Reduce respond time | Keep skills profiles |
| | | | Keep bills of material |
| | | | Build PM routines |
| | | Reduce variance & rework | Monitor machine variance |
| | | Performance monitoring | Costs and performance data on equipment |
| Reduce Costs | Reduce overall maintenance costs | Reduce labour | Control jobs |
| | | | Plan labour / materials |
| | | Reduce spare parts | Analyze usage |
| | | | Analyze investment |
| | | Reduce emergencies | Schedule PM |
| | | | Analyze breakdowns |
| | | Reduce paper work | Automate work orders |
| | | | Automate POs |
| | | Performance monitoring | Costs by area, job, type and labour |

**Takes time and needs Asset Management know-how**

# Implementation Strategies

## Different scenarios

1. No system existing
   - New installation
   - Usually Excel sheets existing but no complete Maintenance Engineering performed
2. System existing but not well implemented. Optimization required!
   - Old system stays in place or will be updated
   - Databases will be updated & optimized
3. System existing but cannot be optimized now or later
   - Temporary or permanent new installation
   - Interfaces to old system, if necessary
   - Transfer data from temporary to old system at a later stage

**Depending on client's strategy and recommendation from Specialist (Process / System Audit)**

# Implementation Strategies

## Important recommendations based on experience

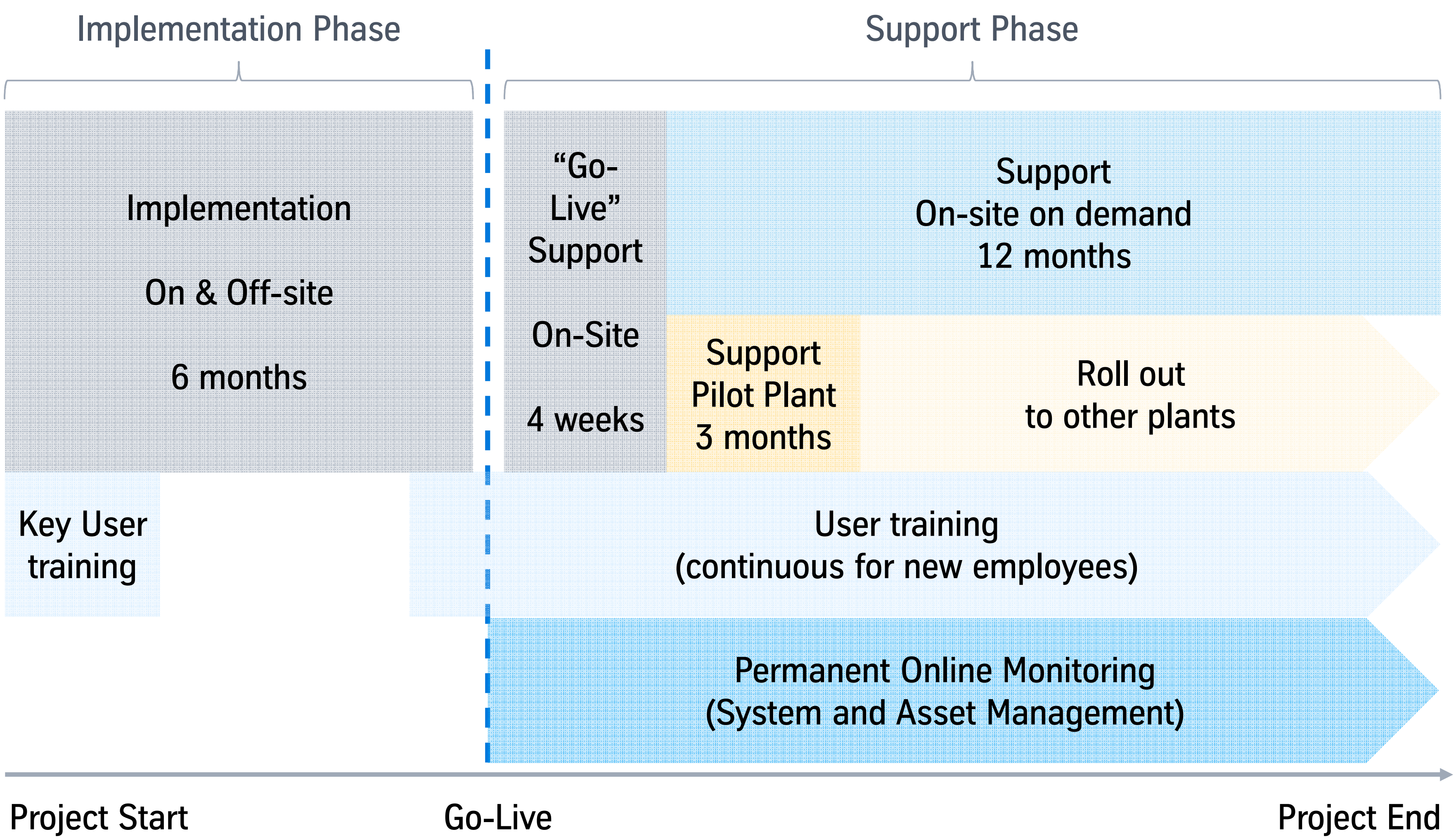
- Never try to roll out a new CMMS across your whole organization! Always start with a pilot!
- Check for / avoid structural breaks in database
- The PROJECT must be managed as a PROJECT by a joined team of
  - Maintenance Professionals
  - System Professionals
  - IT Professionals
  - Users
- Always listen to user's recommendations
- Training must be given to every user

Otherwise the Project will fail! You will not achieve the required results!

**There are more bad implemented CMMS than well implemented, world wide**

# Implementation Strategies

## Exemplary project timeline



# What systems are available?

## Different brands

There are many big CMMS software providers available worldwide, e.g.:

- SAP PM (Plant Maintenance)
- Oracle eAM (enterprise Asset Management)
- Oracle JD Edwards
- IBM Maximo

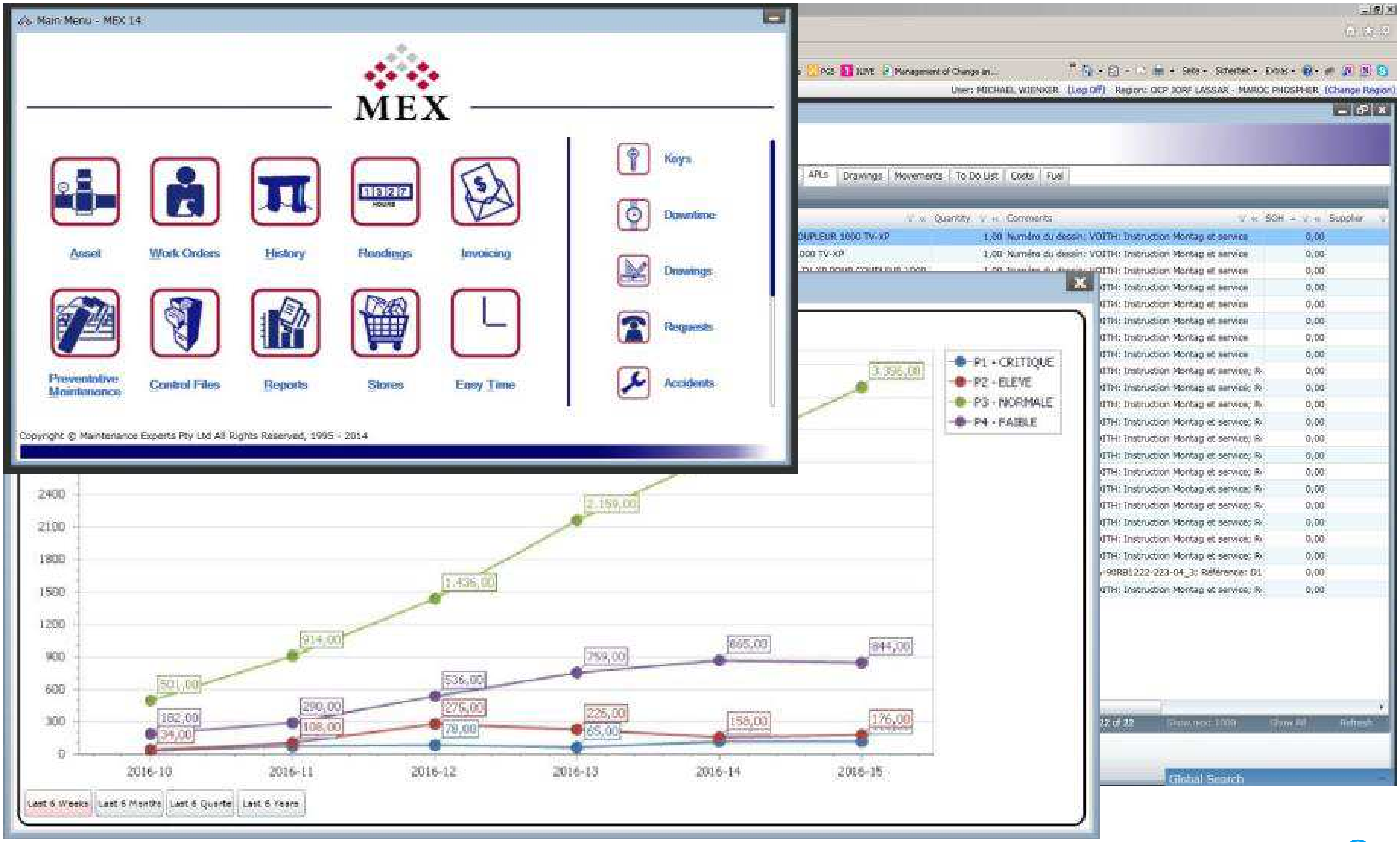
**thyssenkrupp Industrial Solutions**

- Can implement, optimize and work with all existing systems
- Has a partnership with MEX (Maintenance Experts, Australia)
  - tk IS has considerable expertise in the application of MEX
  - MEX can be installed by tk IS in one week
  - MEX can be installed web / cloud based
  - MEX has interfaces to other systems

MEX

# Summary

## Some impressions



# Summary

- A CMMS is THE mandatory tool for professional Asset Management
- IT installation and optimization can be done quickly or is already existing
- Database development and full system implementation
  - Is a PROJECT (Change Management)
  - Needs Asset Management Professionals with experience
  - Takes time
- The right system depends on client's strategy and recommendation by expert
- Only well implemented systems are accepted by users
- Only well implemented systems can help to increase performance and reduce costs


## "NO Work without a Work Order!"

# CMMS & Asset Management

## Contact Us!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# Spare Part Handling

AFA workshop Aqaba/Jordan

April 12, 2016 | Oliver Ghali, Service Manager tkis Egypt
&
Richard Kempken, Operations Manager Operating Unit Services tkis-Process Technologies
thyssenkrupp industrial solutions

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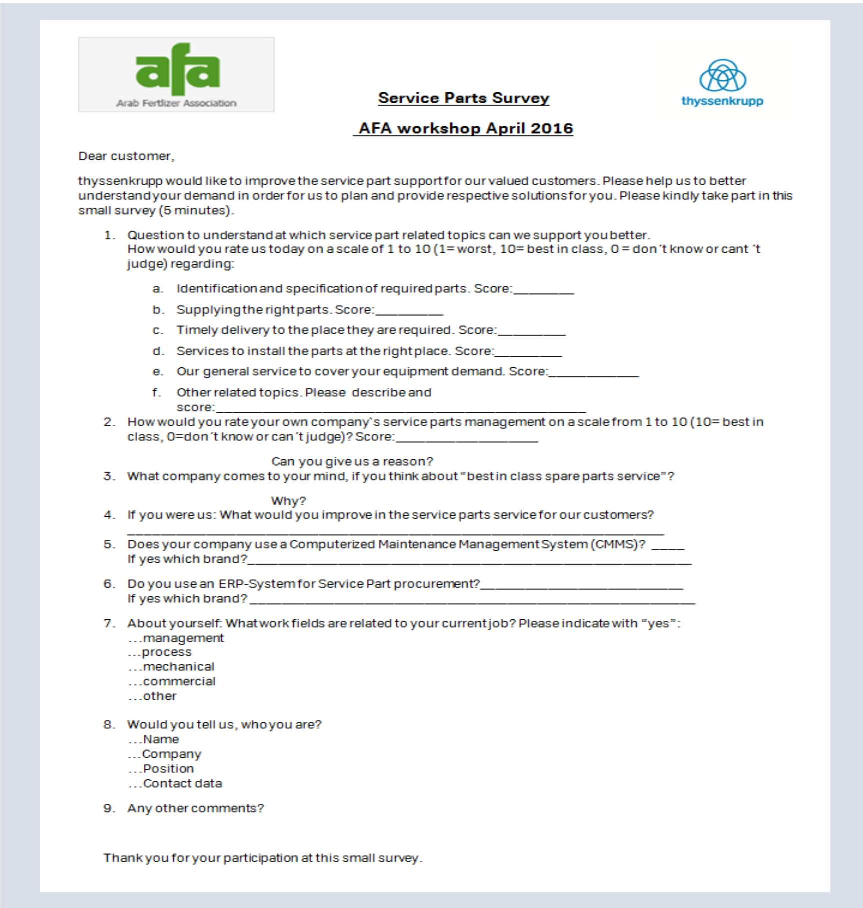
# thyssenkrupp Services would like to improve the service part support for our valued customers!

# How can we support you better?

Please help us to understand by your participation at a short survey.

# Spare part handling

## Small survey



Arab Fertilizer Association

thyssenkrupp

**Service Parts Survey**

**AFA workshop April 2016**

Dear customer,

thyssenkrupp would like to improve the service part support for our valued customers. Please help us to better understand your demand in order for us to plan and provide respective solutions for you. Please kindly take part in this small survey (5 minutes).

1. Question to understand at which service part related topics can we support you better. How would you rate us today on a scale of 1 to 10 (1= worst, 10= best in class, 0 = don´t know or cant ´t judge) regarding:
   a. Identification and specification of required parts. Score:________
   b. Supplying the right parts. Score:_________
   c. Timely delivery to the place they are required. Score:_________
   d. Services to install the parts at the right place. Score:_________
   e. Our general service to cover your equipment demand. Score:____________
   f. Other related topics. Please describe and score:_______________________________________________
2. How would you rate your own company´s service parts management on a scale from 1 to 10 (10= best in class, 0=don´t know or can´t judge)? Score:__________________

   Can you give us a reason?
3. What company comes to your mind, if you think about "best in class spare parts service"?

   Why?
4. If you were us: What would you improve in the service parts service for our customers?
   ______________________________________________________________________
5. Does your company use a Computerized Maintenance Management System (CMMS)? ____
   If yes which brand?__________________________________________________________
6. Do you use an ERP-System for Service Part procurement?__________________________
   If yes which brand? __________________________________________________________
7. About yourself: What work fields are related to your current job? Please indicate with "yes":
   …management
   …process
   …mechanical
   …commercial
   …other
8. Would you tell us, who you are?
   …Name
   …Company
   …Position
   …Contact data
9. Any other comments?

Thank you for your participation at this small survey.

- Please fill out the survey form as supplied (5 minutes) and leave it on your table for collection
- Let´s discuss …

Tk Services would like to improve the service part support for our valued customers!

## Question and discussion:
## How can we support you better regarding Service Part Handling?

Thank you very much for your input!

We will work on it…

الإتحاد العربي للأسمدة
Arab Fertilizer Association
Since 1975

In co- operation with

thyssenkrupp

# AFA WORKSHOP

## Operation and Maintenance Optimization

Jordan - Aqaba: 11-14 April, 2016

# Session 4

Sponsors:

Arab Potash

Jordan Phosphate Mines Co.

Indo Jordan Chemicals Co.

NJFC
Nippon Jordan Fertilizer Co.

KEMAPCO
KEMAPCO Arab Fertilizers & Chemicals Industries Ltd.

# The newest development for sulphuric acid and sulphur melting plants, emission reduction and improved heat recovery

AFA Workshop, Aqaba - Jordan

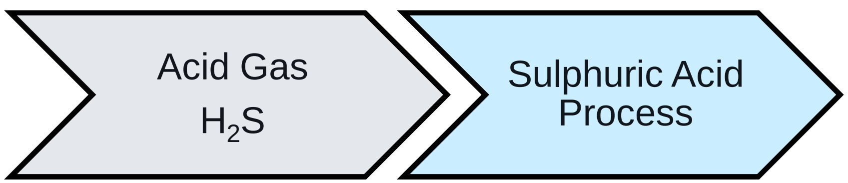
Dr.-Ing. Z. Guetta, 12.04.2016

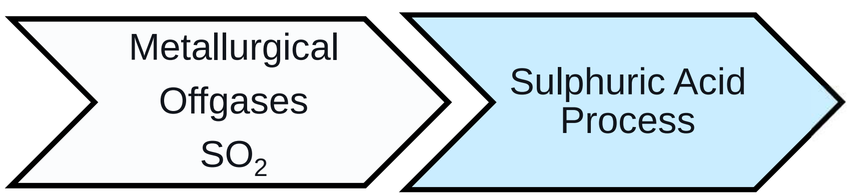
engineering. tomorrow. together.

thyssenkrupp

# The Expertise of the Division CP

## from acid gas treatment and up to sulphuric acid manufacturing


**Claus Process (Sulphur Production)**

$$H_2S + \frac{3}{2}O_2 \rightarrow SO_2 + H_2O$$ **Combustion**

$$2H_2S + SO_2 \rightarrow \frac{3}{n}S_n + 2H_2O$$ **Claus Reaction**

**Sulphuric Acid Process**

$$S + O_2 \rightarrow SO_2$$ **Combustion**

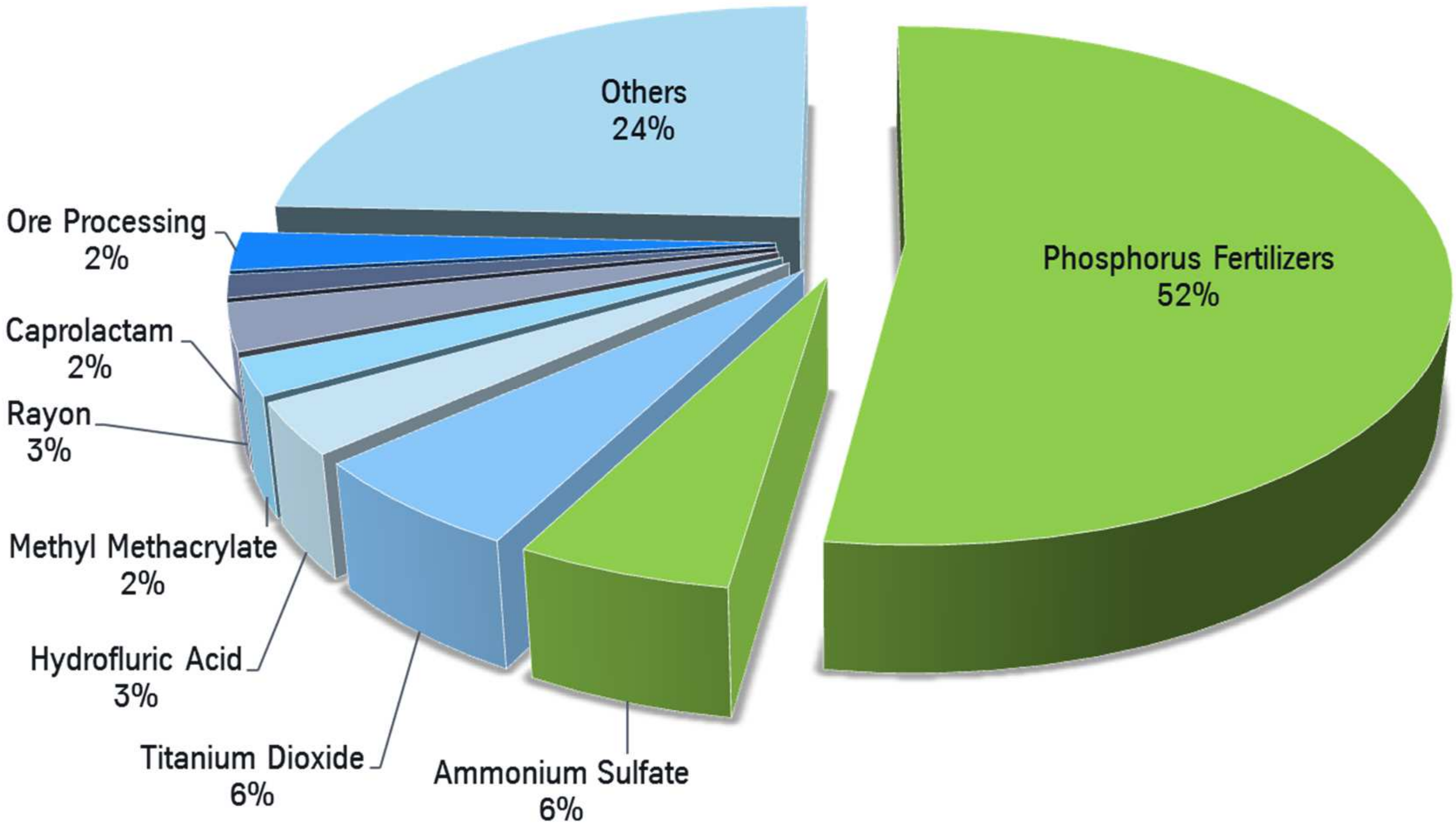
$$SO_2 + \frac{1}{2}O_2 \rightarrow SO_3$$ **Conversion**

$$SO_3 + H_2O \rightarrow H_2SO_4$$ **Absorption**

# tkIS Sulphuric Acid, Selected References

| Client | Gas Load (Nm³/h) | Process | $H_2SO_4$ Concentration | Commissioning | Size eq. to SB SA plant |
|---|---|---|---|---|---|
| Anshan Iron & Steel Group Co.<br>Yingkou Works<br>Liaoning Province, PR China | 18000 | Wet Catalysis | 78 wt % | 2008 | 210 MTPD |
| Shougang Jingtang United Iron & Steel Co., Ltd.<br>Caofeidian Works<br>Hebei Province, PR China | 20000 | Wet Catalysis | 78 wt % | 2008 | 240 MTPD |
| Sasol, South Africa | 53300 | WSA | 96 wt% | 2006 | 600 MTPD |
| Trinecke Zelezarny a.s.<br>Ostrava, Czech Republic | 34000 | WSA - 2 | 96 wt% | 1999 | 380 MTPD |
| ILVA Laminati Piani S.p.A.<br>Taranto Works, Italy | 28000 | Wet Catalysis | 78 wt% | 1999 | 310 MTPD |
| Redestillationsgemeinschaft GmbH<br>Zentraldestillationsanlage<br>Gelsenkirchen, Germany | 2400 | WSA - 2 | 96 wt% | 1997 | 25 MTPD |
| Hüttenwerke Krupp Mannesmann,<br>Duisburg Germany | 9500 | Wet Catalysis | 78 wt% | 1992 | 110 MTPD |

# World Consumption of Sulfuric Acid by End User (2014)



# Our field of Services for the Sulphuric Acid Industry

**Engineering & Technology**

**Procurement**

**Construction**

Further Services

- FEED and feasibility studies
- Delivering of spare parts: acid coolers, acid pumps, acid distributors
- Brownfield EPC services: e.g. replacement of acid towers
- Process intensification

# Some of Our Technological Partners

BASF
We create chemistry

SIEMENS

STEULER
KCH

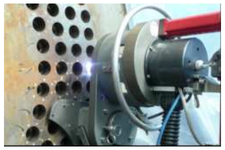
VDM Metals

OSCHATZ
Anlagenbau Energie und Umwelt

REMA TIP TOP

KROHNE

BERTSCH



Endress+Hauser
People for Process Automation

Anton Paar

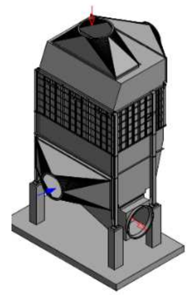
# Our Key Equipment

Converter

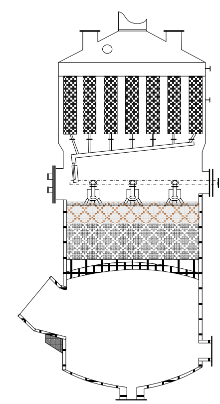
Acid Coolers
(Anodic protected)

Sulphur Melting Unit

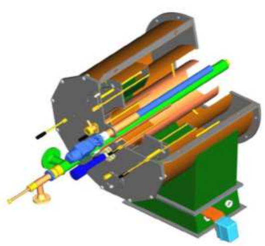
Process Gas Heater
special design



Acid Towers special design

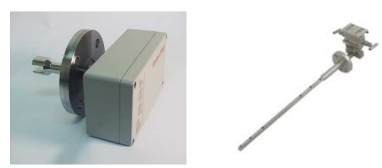


Sulphur Burner



Catalyst

Instrumentation



Materials-
Special alloys

Low pressure
drop saddles

# The newest Development for the Sulphuric Acid Industry

## Patented tkIS-design for sulfuric acid plants

- Close start-up system for sulphuric acid plants (DE102015114871.4)
  - No need for sulphuric acid for air dehydration during standby operation
  - Less emissions during start-up
  - Less corrosion

- Emission free sulphur melting process (DE102015114875.7)
  - External heat exchangers
  - Compact design
  - Automatic and simple cleaning with a screw conveyor
  - Manufacturing in the workshop
  - Closed system, no emissions

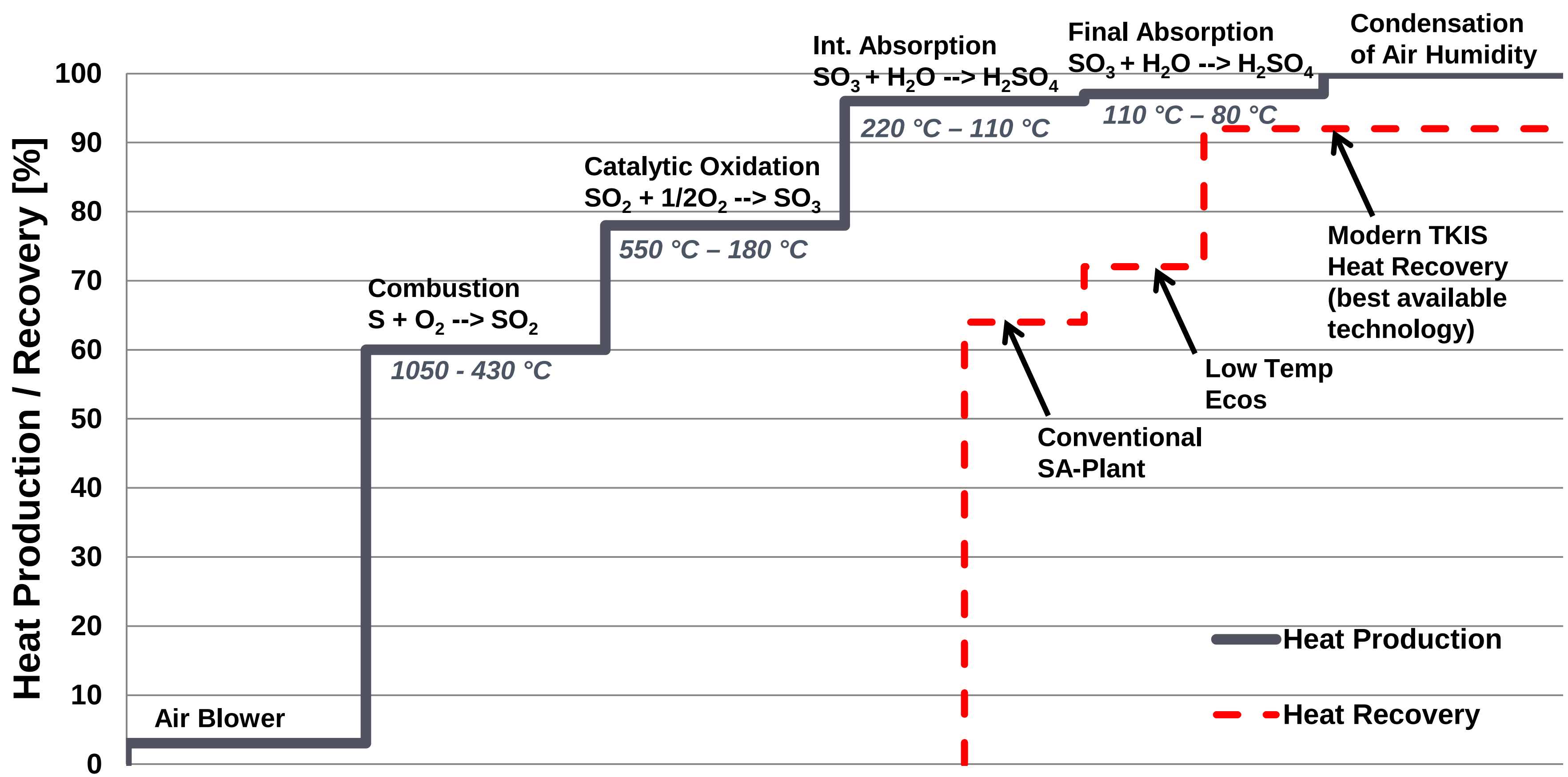
# The newest Development for the Sulphuric Acid Industry

## Patented tkIS-design for sulfuric acid plants

- Converter for sulphuric acid plants (DE102015114885.4)
  - 25 % less weight
  - Optimal gas distribution
  - Corrosion resistance due to special alloys

- Optimized heat recovery system for sulphuric acid plants (DE102016103976.4)
  - Less Equipment
  - More HP-Steam
  - Heat Recovery of up to 95 %

# Different Heat Recovery Levels of the tkIS Sulphuric Acid Processes

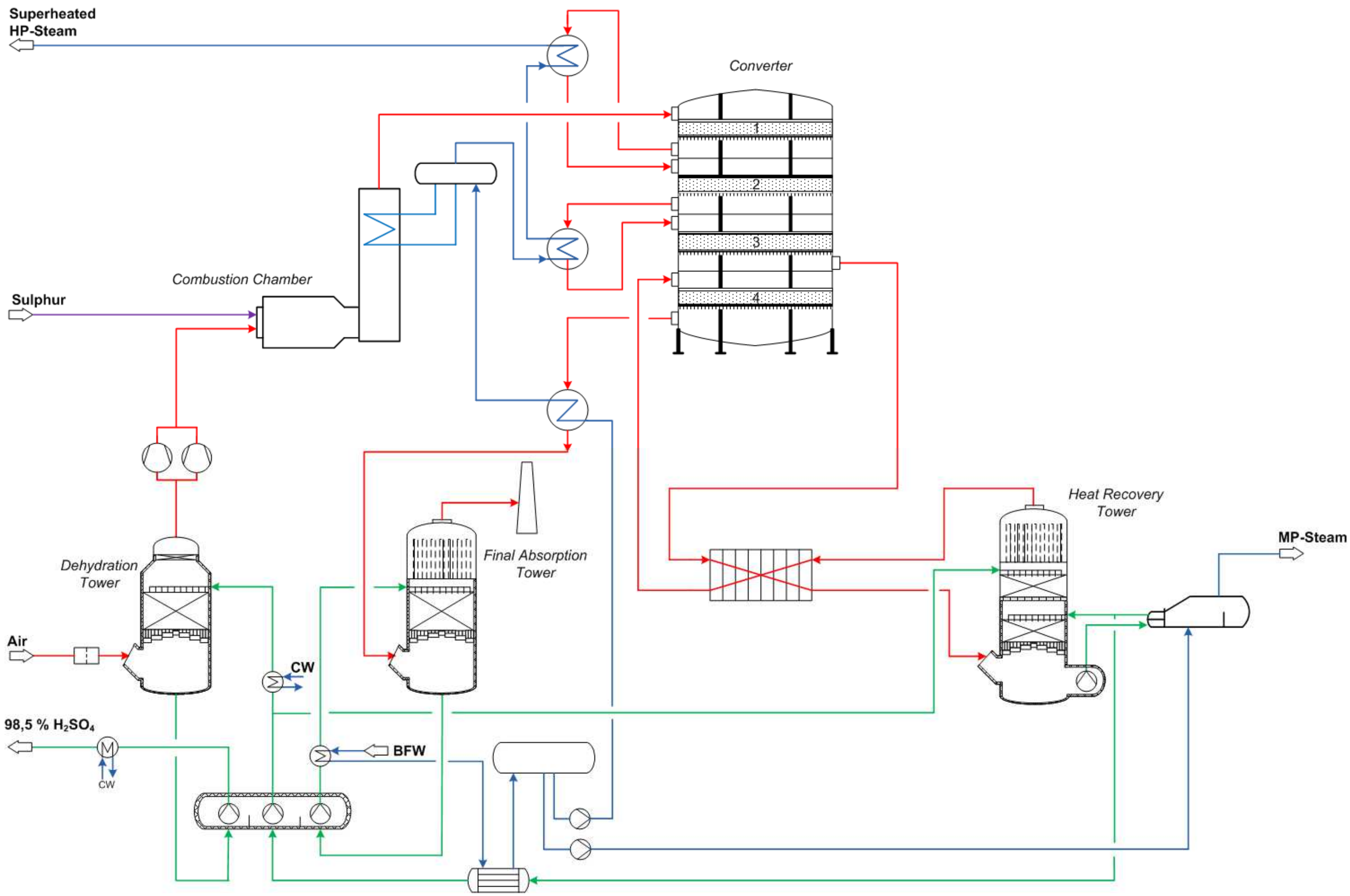



**Conditions: Wet bulb temperature 26 °C**
**At a lower wet bulb temperature the heat recovery can increase up to 95 %.**

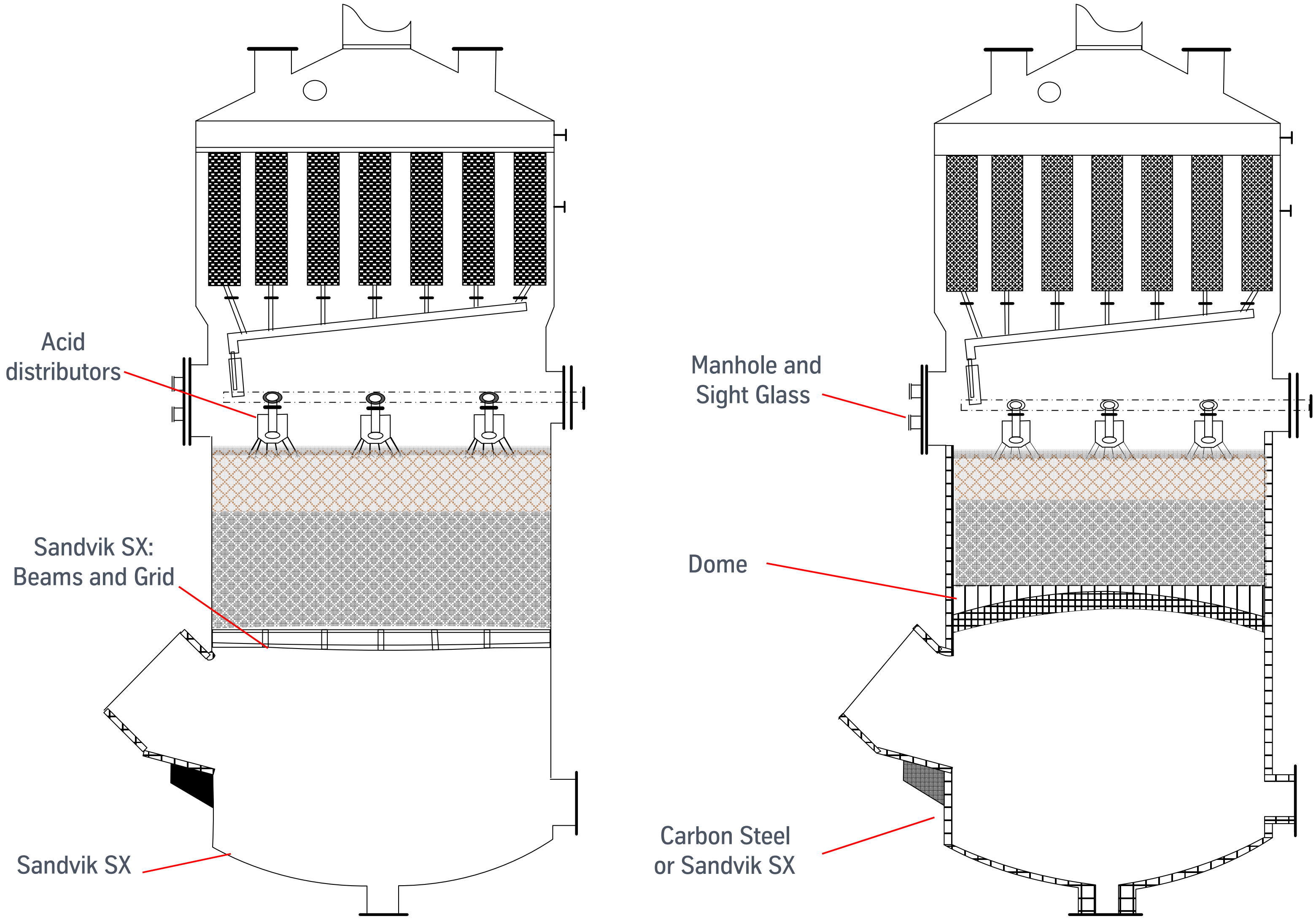
# Process Flow Diagram of tkIS Sulphuric Acid Process

## The most modern technology

**TKIS Patent**

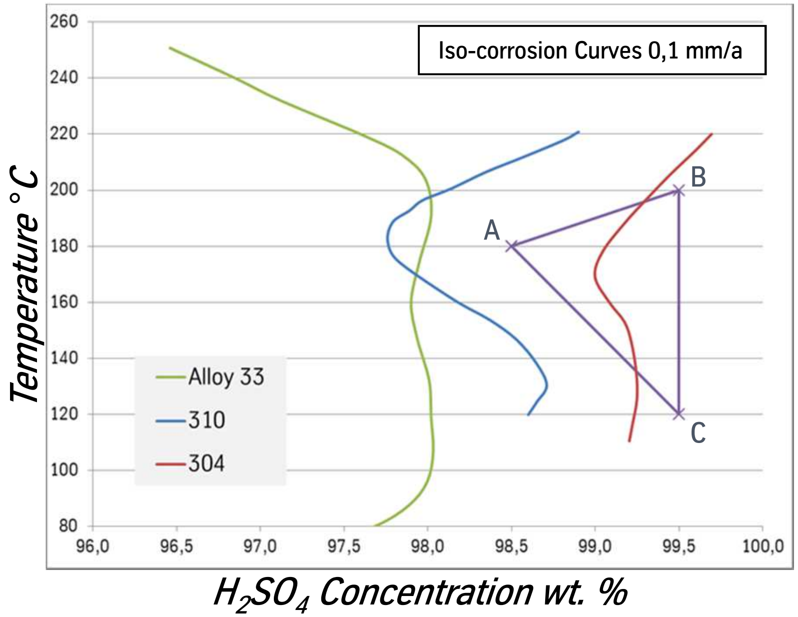


# Acid Tower - Design

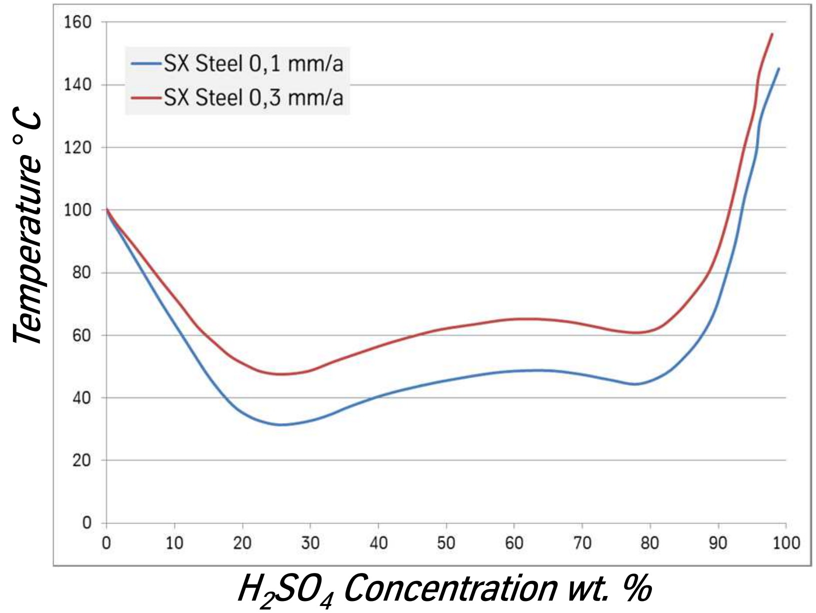


# Corrosions Resistant Alloys - Materials

Operating Conditions of Heat Recovery Systems




Iso-corrosion curves of Sandvik SX Steel




Alloy 33: Cr/Ni 34/31

310: Cr/Ni 25/21

304: Cr/Ni 18/8

A: Inlet to Heat Recovery Tower

B: Outet from Heat Recovery Tower

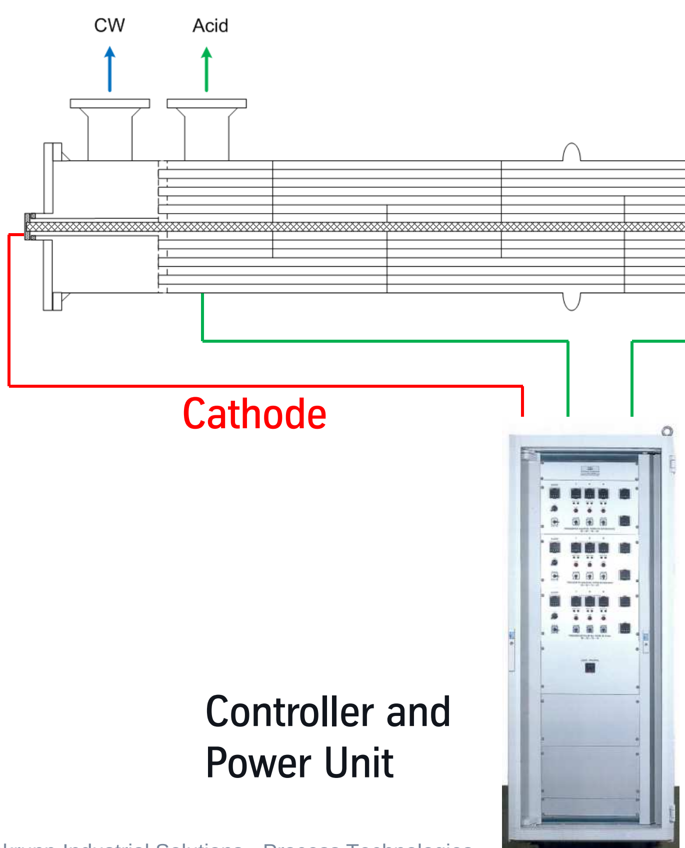
B-C: Heat Exchangers

SX Steel: Cr/Ni/Si 18/20/5

# Acid Coolers - Design

## Anodic protected acid coolers for large sulphuric acid plants

- **Anodical Protected**
- **High heat transport coefficients**
- **Improve plant reliability**
- **Long life time**
- **Corrosion resistant alloys for acid cooling with cooling water or sea water**

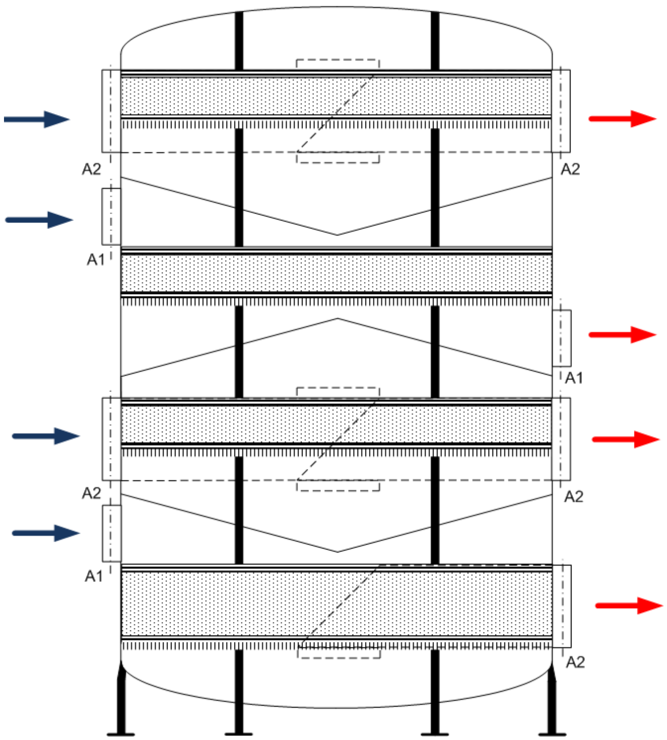


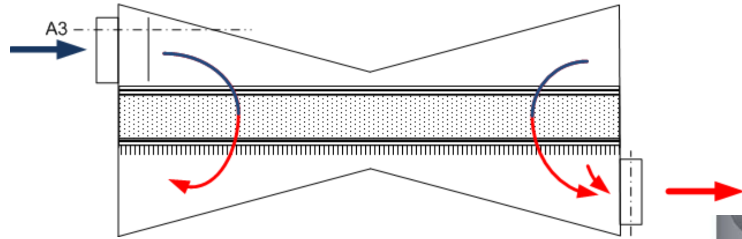

# Converter – Design

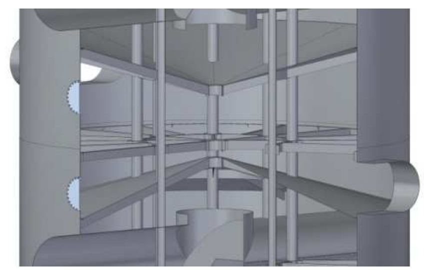
## The most modern technology

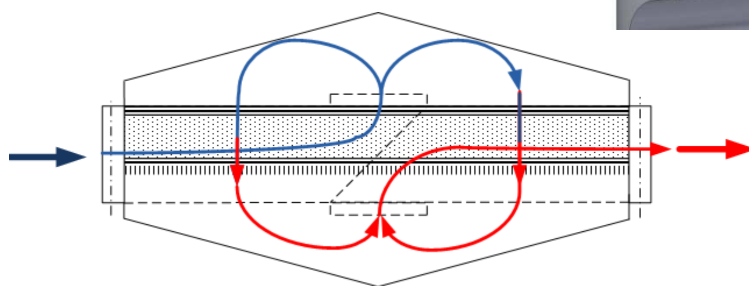
- 25 % Less Weight
- Optimal Gas Distribution
- Corrosion resistant alloys

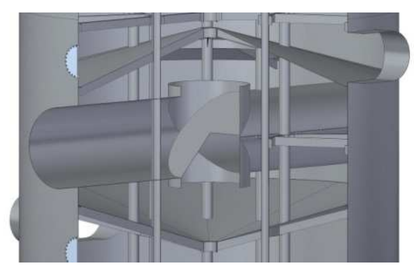
**TKIS Patent**



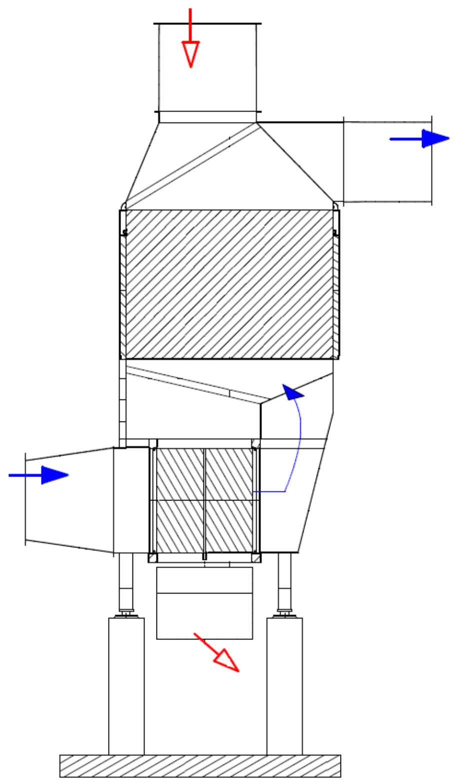


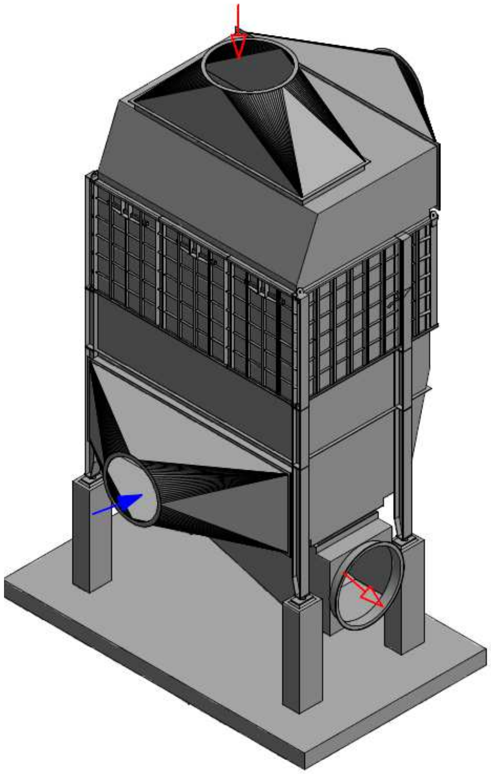


# Gas-Gas Heat Exchangers – Design

## The most modern technology

- **High heat transport coefficients**
- **Compact design**
- **Corrosion resistant alloys**
- **Uniform surface temperature (no cold spots)**





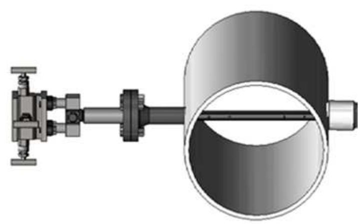
# Process Instrumentation

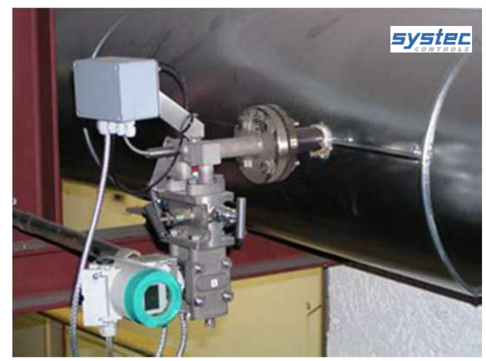
**Acid Concentration measuring**

- **Ultrasonic sensor**
- **Concentration range 90-100 wt. %**
- **Gold cell**
- **Accuracy < 0,05 wt. % $H_2SO_4$**


## Gas flow measuring

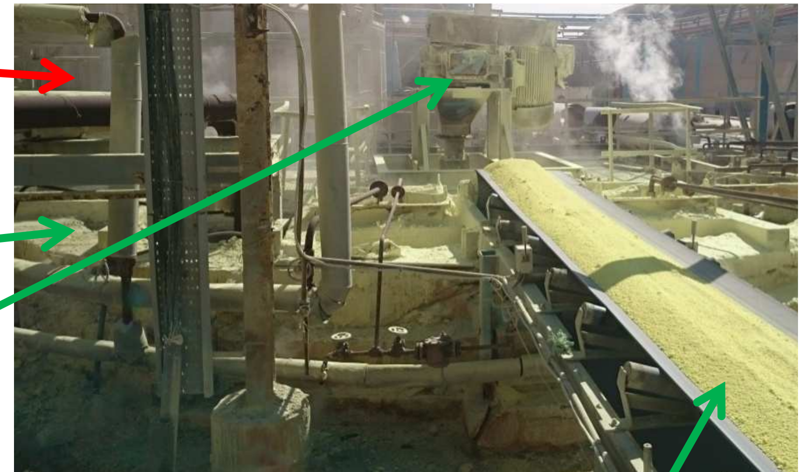
- **Measurement range > 1:30**
- **No pressure drop**
- **Accuracy 1 / 0,5 %**
- **Corrosion resistant alloys**





# Sulphur Melting System - Comparison to a Conventional System

Steam loss and $H_2S$ Emissions



Open Melting Tank

Stirrer

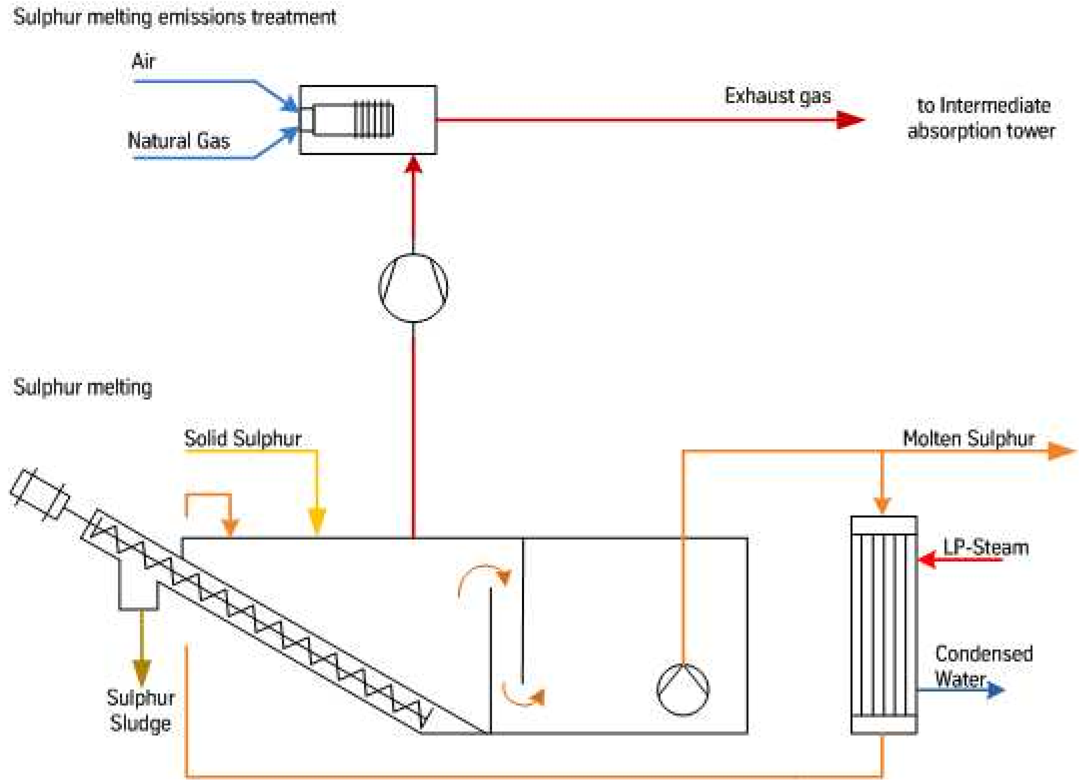
Molten Sulphur

Solid Sulphur

# Emission free Sulphur Melting Process

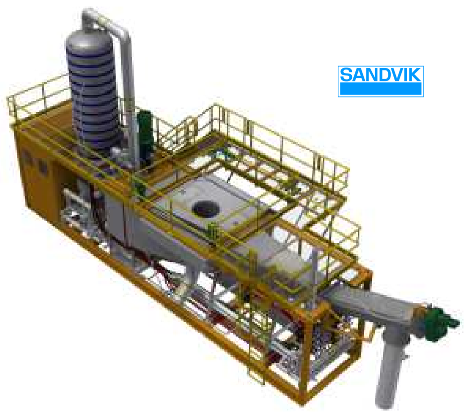
## The most modern technology

**TKIS Patent**




**The advantages of the TKIS design:**

- **External heat exchangers**
- **Compact design**
- **Automatic and simple cleaning with a screw conveyor**
- **Closed system, no emissions**
- **Heat recovery from the exhaust gases, possible**

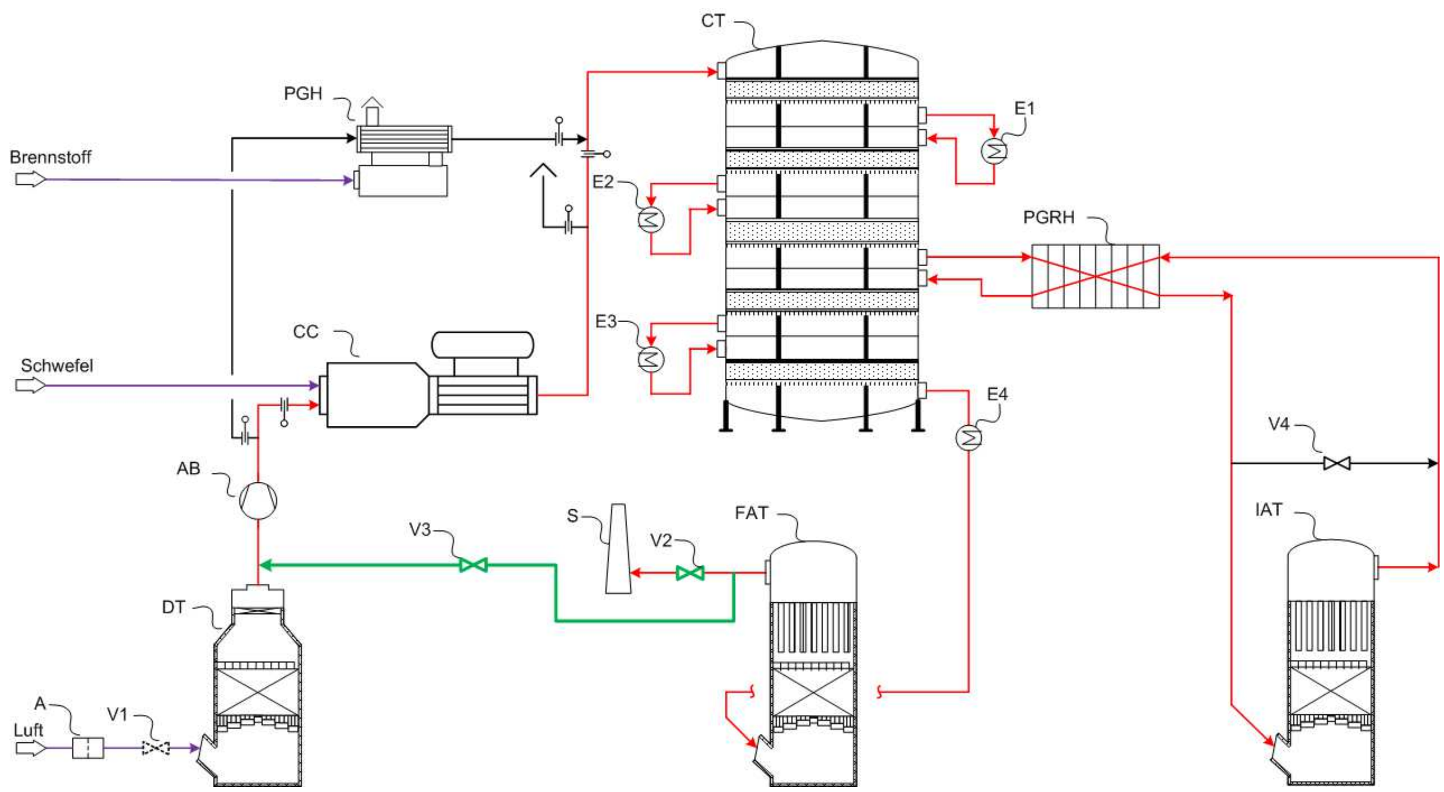


# Close Start-up System

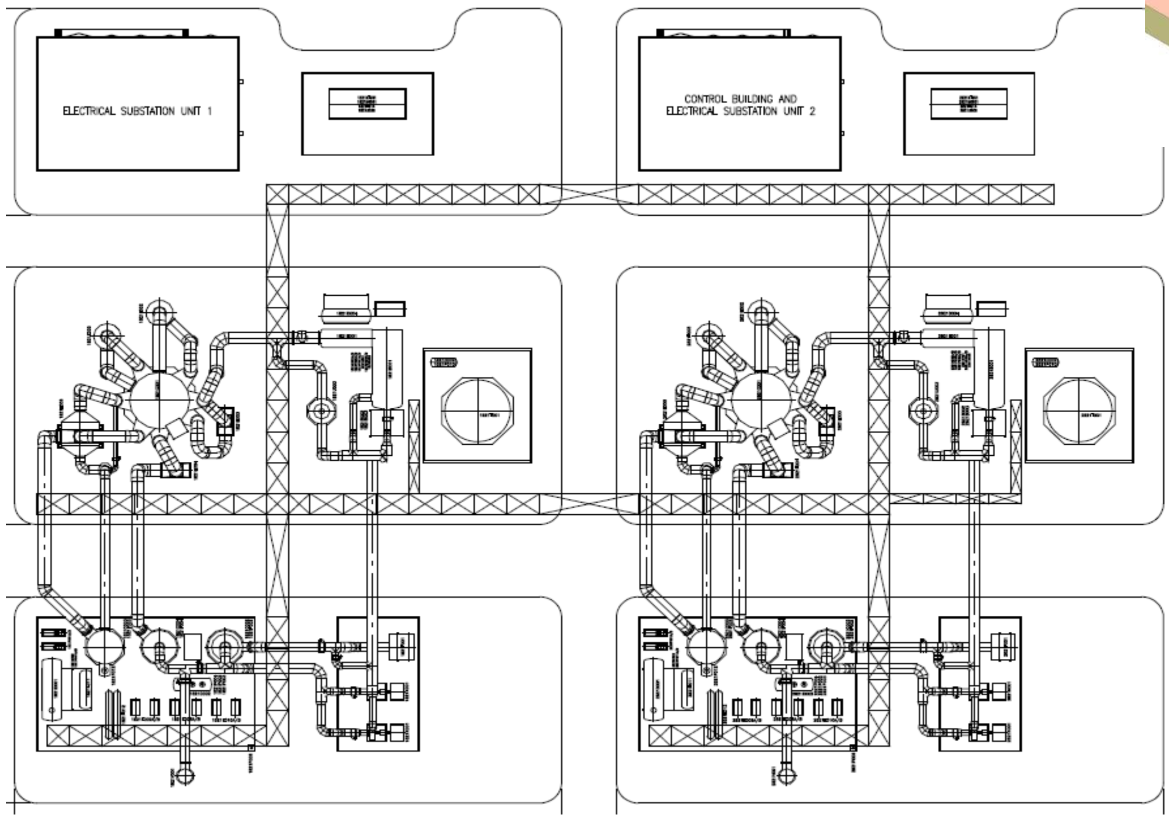
## The most modern technology

- **No need for sulphuric acid for air dehydration during standby operation**
- **Less emissions during startup**
- **Less corrosion**

**TKIS Patent**



# Plant Layout




# Thank you for your attention

# DH Phosphoric Acid Plants Upgrades: Inherited values in transforming DH-Based Processes to HH-Based Processes

AFA Workshop, Aqaba Jordan

11-14 April 2016 | Malik Aqel
thyssenkrupp Industrial Solutions

engineering. tomorrow. together.

thyssenkrupp

# Agenda

- Illustration
- DH vs. HH Operational Features
- DH PAP Capacity Expansion
- Other HH based Processes and More Value
- tkIS Approach

# Illustration

## JIFCO versus JPMC-IJC

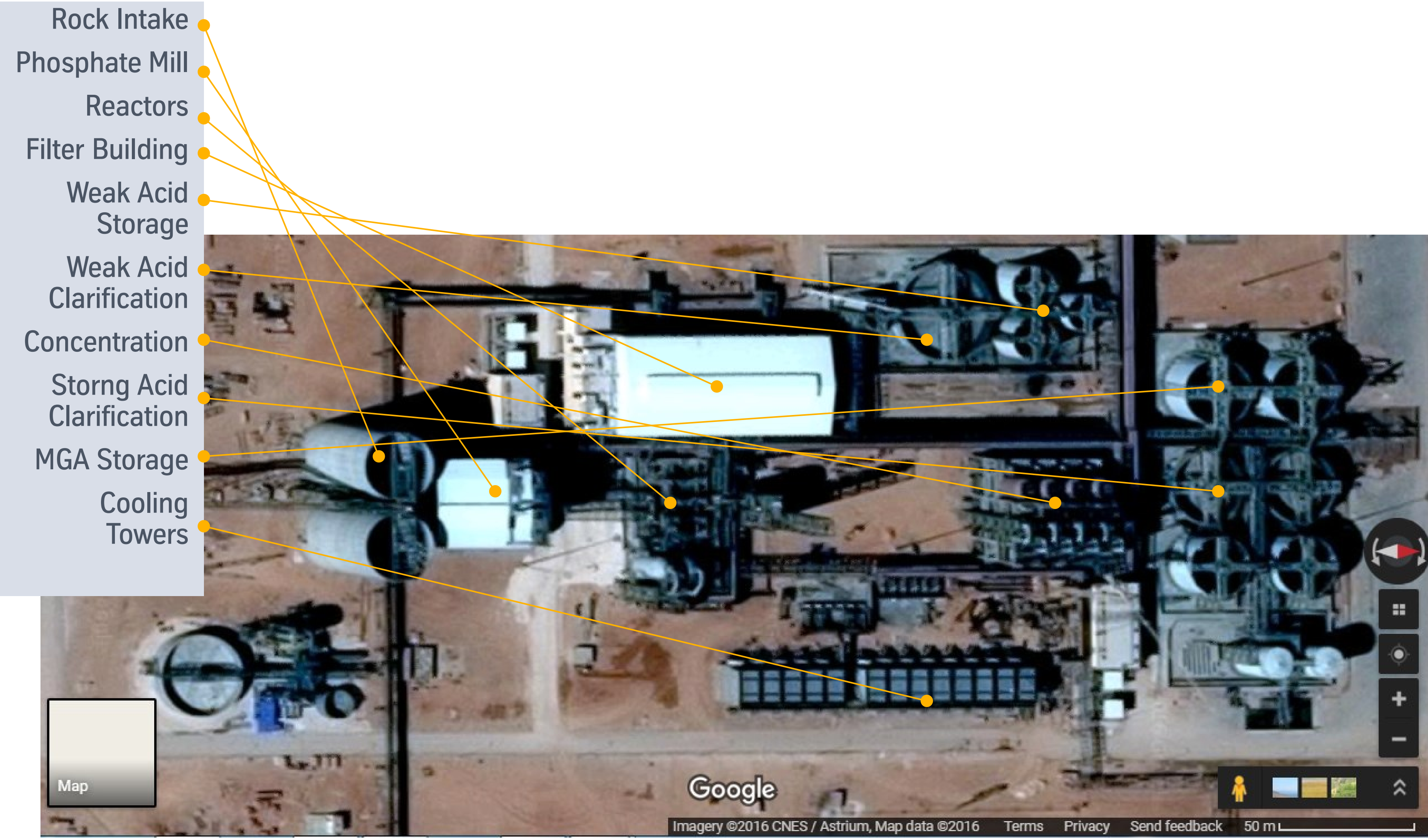
# DH PAP versus HH PAP

JIFCO-DH: Approximate Cap. of 500 ktpy P2O5

IJC-HH: Approximate Cap. of 250 ktpy P2O5

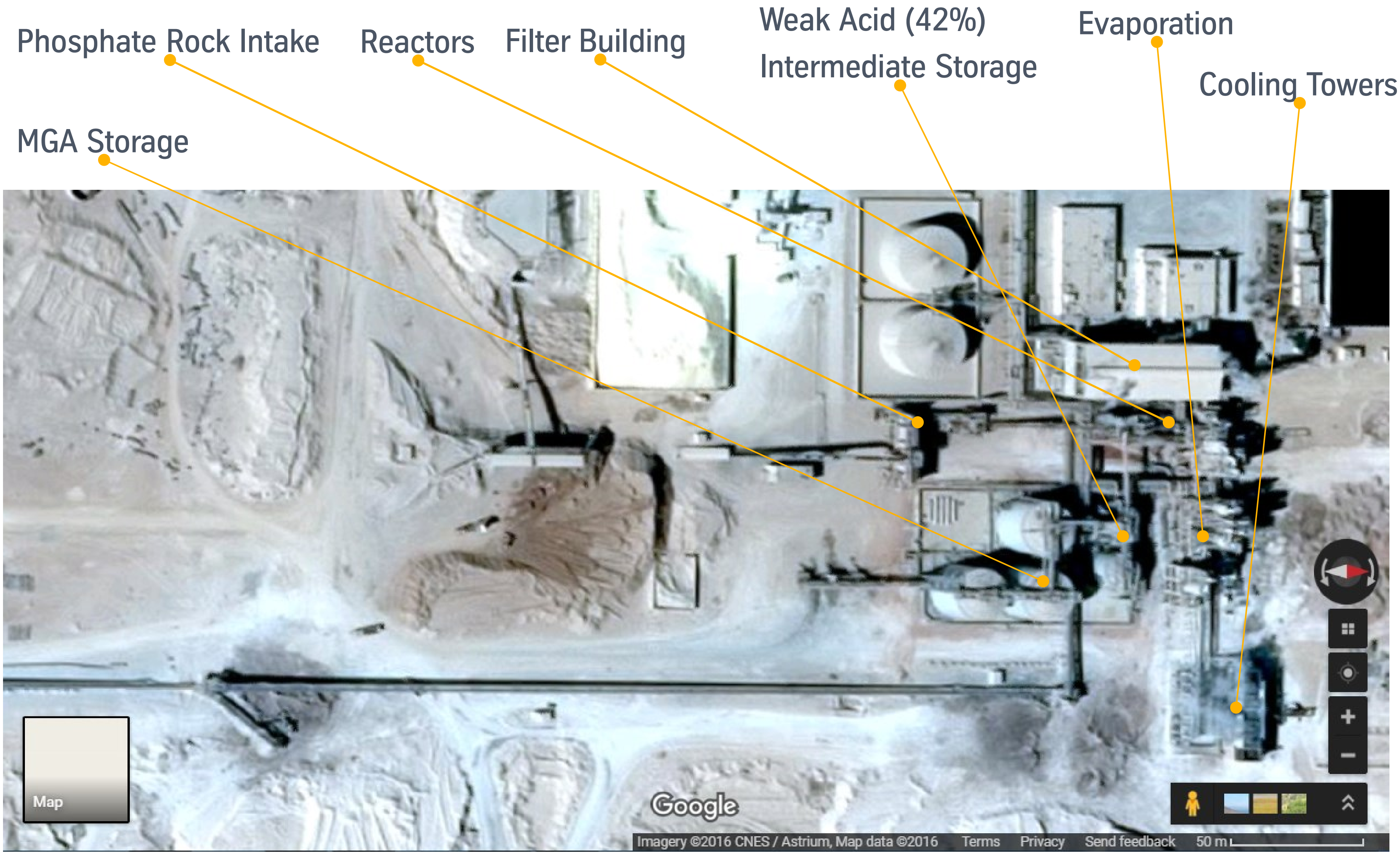

Reference Google Maps: Courtesy of JPMC's IJC HH PAP and JIFFCO's DH PAP in Eshidya

# JIFCO DH Phosphoric Acid Plant (Modern DH PAP by Prayon)




Reference Google Maps: Courtesy of JIFCO's DH PAP in Eshidya

# JPMC-IJC HH Phosphoric Acid Plant (1998 HH PAP by YFT)

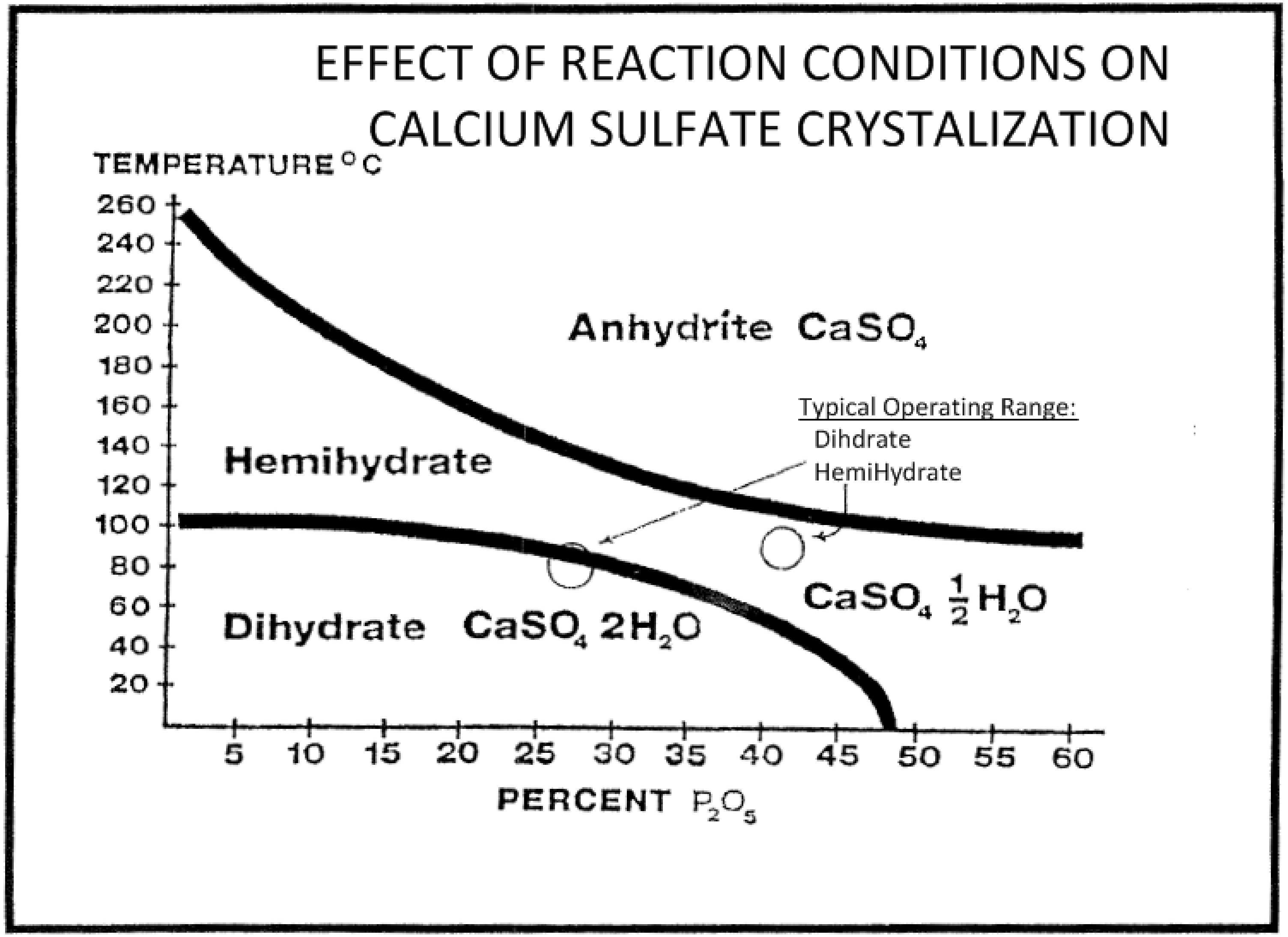



Reference Google Maps: Courtesy of JPMC's IJC HH PAP in Eshidya

# DH vs HH Operational Features

Including Opex Considerations

# DH and HH Operating Zones



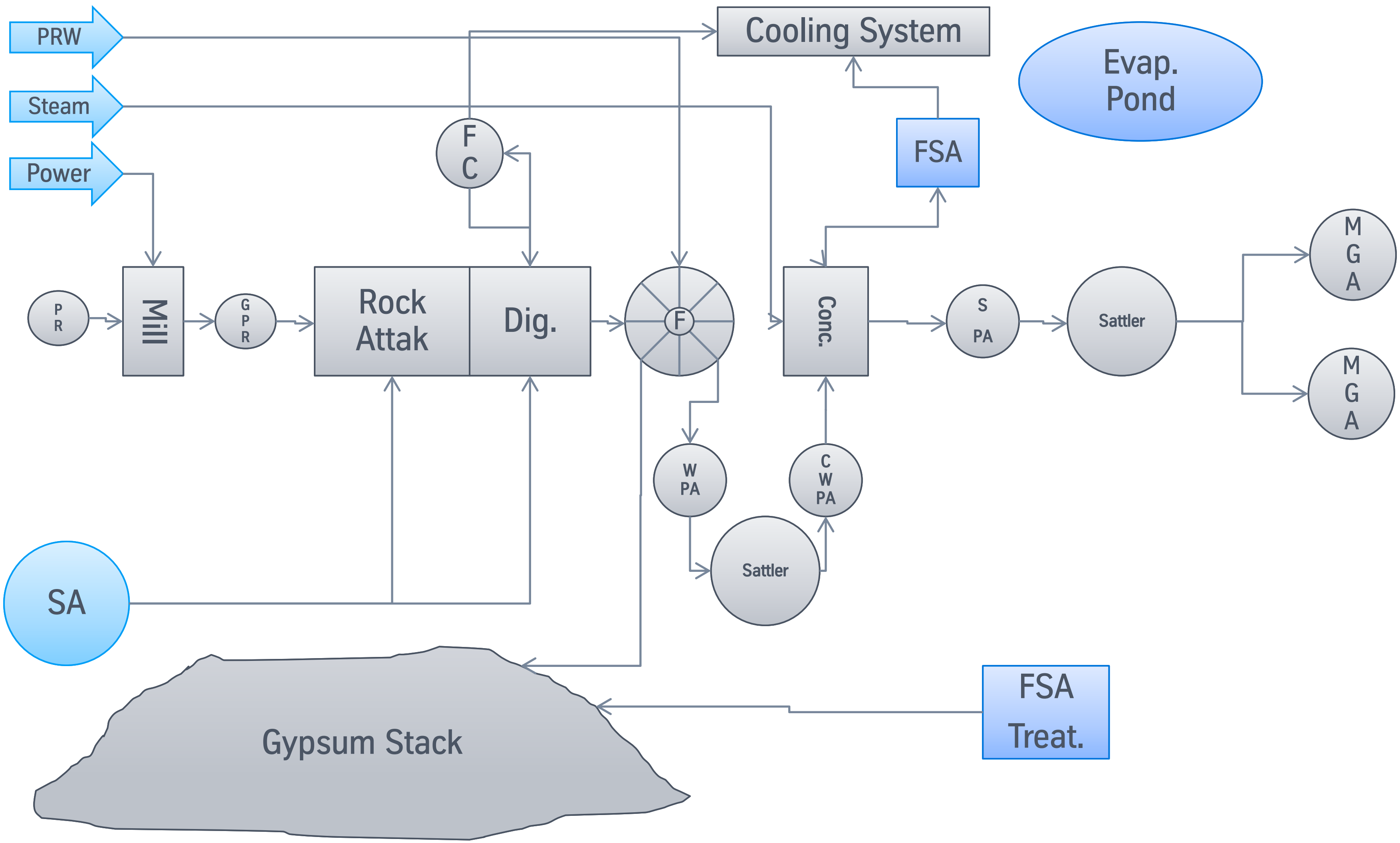
# Operational Comparison (B.L. from Phosphate to MGA)

| Parameter | Unit | Single DH PAP | Single HH PAP | HH/DH | Allawable Increase in Capacity with HH |
|---|---|---|---|---|---|
| P2O5 Recovery | % of P2O5 in Rock | 96% | 94% | 98% | Open |
| H2SO4 | t/t P2O5 Prod. | 3.3 (Base) | 3.0 | 91% | 110% |
| Filter Acid | % P2O5 | 28% | 42% | 150% | 150% |
| Clarification of filter Acid | | 100% | 33% | 33% | 300% |
| Clarification after Concentration | | 100% | 33% | 33% | 300% |
| CW makeup | M3/t P2O5 prod. | 70 | 22 | 31% | 322% |
| Cooling Capacity | | 100% | 33% | 33% | 300% |
| Steam | t/t P2O5 Prod. | 1,9 | 0,6 | 32% | 312% |
| Concentration Unit Capacity | | 100% | 33% | 33% | 300% |
| Process Water | M3/t P2O5 Prod. | 7 | 4 | 57% | 175% |
| Power | kWh/t P2O5 Prod. | 120 | 80 | 67% | 150% |

# DH PAP Capacity Expansion

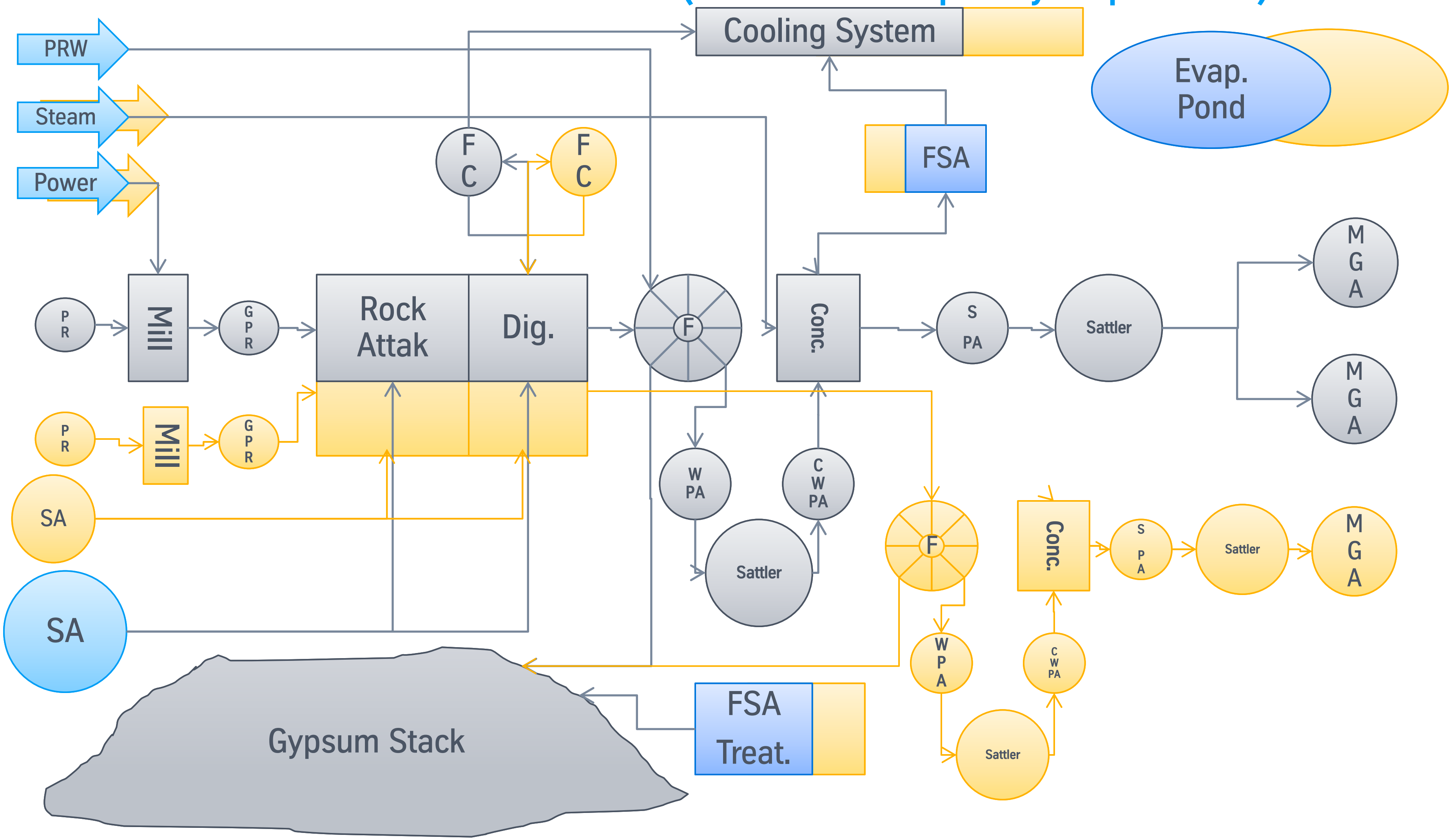
Capex considerations

# DH PAP with Utilities and Off-sites (Base Case 100% P2O5)



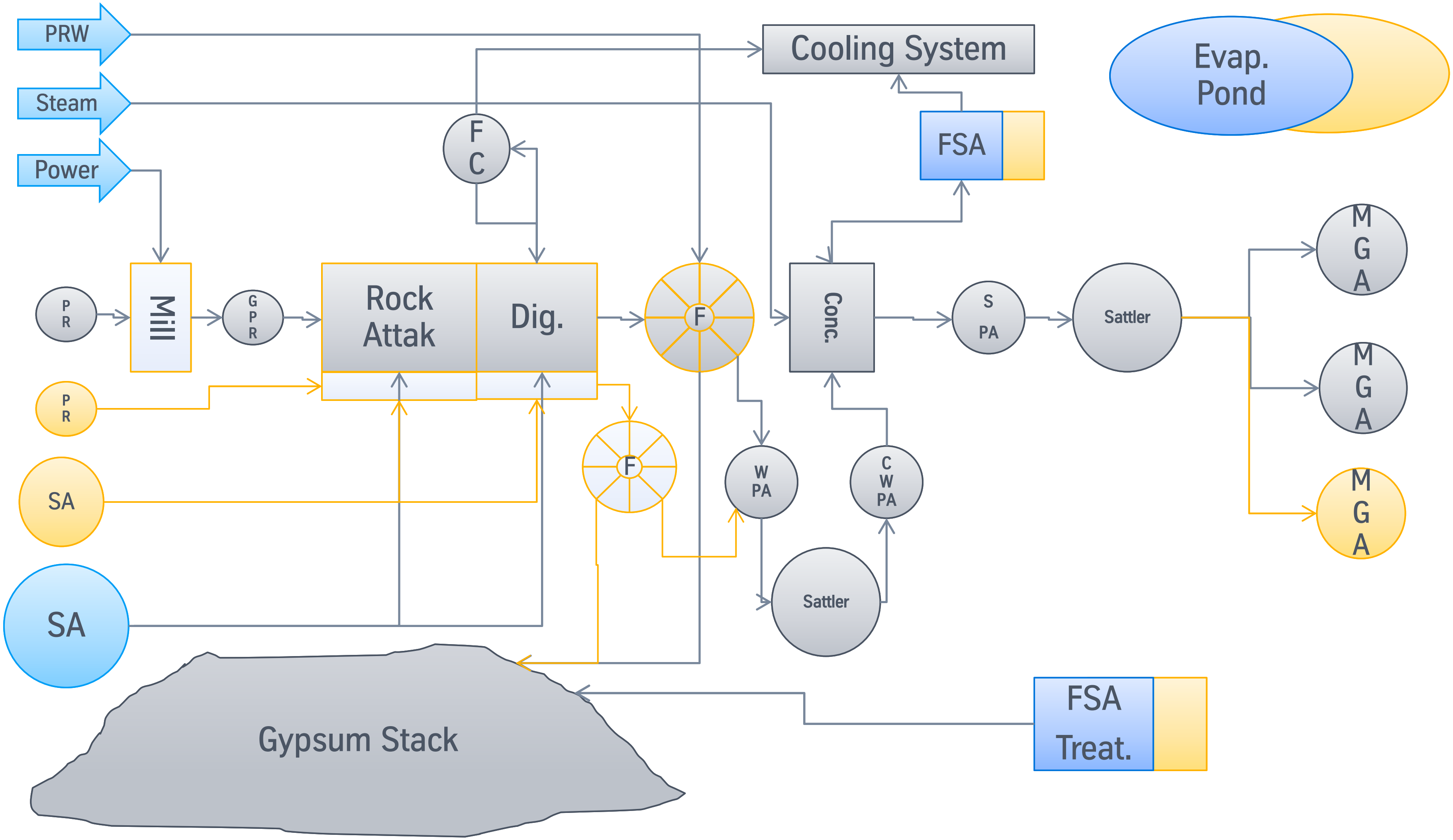

**Established DH PAP Investment with large Infrastructure and Off-sites Capacity**

# DH PAP with Utilities and Off-sites (50%+ DH Capacity Expansion)




50% increase in DH setup will require 80-100% of Equivelant Greenfield Investment.

# DH to HH, PAP with Utilities and Off-sites (50%+ HH Capacity Expansion)




**50% Increase in HH is Estimated to Cost 20-30% of Equivelant Greenfield Investment.**

# Other HH Based Processes and More Values

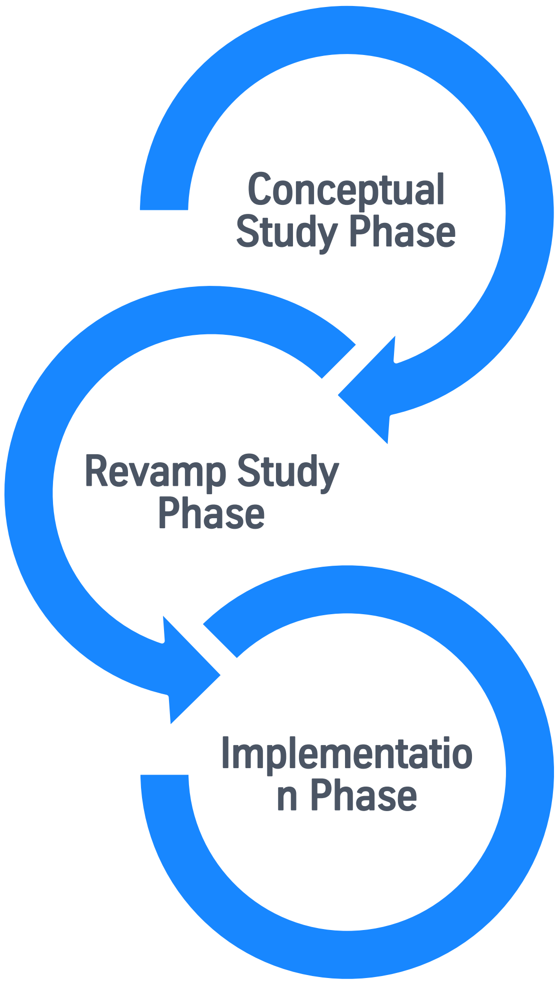
# Other Himehydrate Based Processes

- Conversion to DA-HF:
  - High Recovery Effeciency (>98,0%)
  - Pure HH Gypsum with low water content (Plaster Grade)
  - Low Cost of Transformation
- Conversion to HDH:
  - High Recovery Effeciency (>98,5%)
  - Pure DH Gypsum.
  - Upto 48% P2O5 direct from Filter.
  - Moderate Investment Cost for Transformation.

# tkIS Approach

## Basic Approach

# Proposed Approach by tkis




Target of the conceptual study is to collect the necessary information from the existing plant for a conceptual design of the revamp with a cost indication for the implementation of the revamp. The study gives a solid basis for decision to proceed with the revamp project or not.

After positive decision to proceed the revamp study elaborates more detailed technical basis (PFD, Plot Plan, identification of revamped/new equipment etc.) and a more accurate cost estimate.

The implementation of the revamp can be agreed on Engineering Services only, Engineering and Supply of Equipment or on full EPC

**tkis works closely with Phosphoric Acid Industry to secure profitable and sustainabel future**

# Back Up slides

# Hemi process key advantages

- Minimum capital cost
- Energy benefit from needing little or no steam to concentrate acid
- Eliminate 26-42% evaporators
- Usually eliminate rock grinding
- Low cooling water requirement
- Moderate phosphate recovery
- Added recovery benefit where gypsum water is recirculated
- Low sulfuric acid requirement
- Easy to run and maintain; tolerant of process upset
- Higher analysis fertilizer

**tkIS will assess your plant conditions, and propose you alternatives for Capacity Increase**

# Key Features of HH process

1. The Hemi (hemihydrate) process produces phosphoric acid directly from filtration at typically 40-43% P205 concentration.
2. Most Hemi plants use phosphate rock as received – without drying or grinding.
3. Two entire plant sections are usually rendered unnecessary – evaporation to ~42% P205 and rock grinding (when using concentrate or other rock smaller than 2 mm).
4. Cooling water, acid storage, clarification, and steam distribution systems are reduced to a small fraction of their conventional size.
5. Capital cost for the phosphate complex is roughly 20-25% less than for a dihydrate based complex, which would require rock grinding, evaporation, larger cooling water and steam distribution systems, and often elaborate acid clarification systems.
6. Modern Hemi phosphoric acid plants tend to be easier to operate and require less cleaning than dihydrate plants. One reason is that the reaction takes place in a stable range of hemihydrate crystals. In contrast, dihydrate plants must (out of economic necessity) operate near the unstable transition between dihydrate and hemihydrate.

**DH plant is significantly oversized compare to HH plant**

Placeholder for sources and footnote: footnotes are numbered (no *)

PRAYON

# The new Prayon DA-HF process High efficiency phosphoric acid process

# Contents

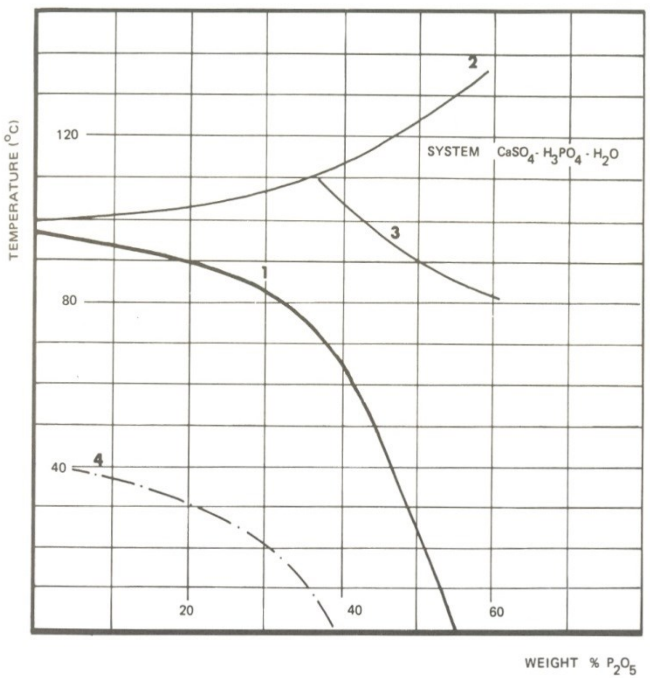
# Introduction

$$[Ca_3(PO_4)_2] + 3\ H_2SO_4 + x\ H_2O$$

$$3\ CaSO_4.2\ H_2O + 2\ H_3PO_4 + heat$$

or

$$3\ CaSO_4.1/2\ H_2O + 2\ H_3PO_4 + heat$$




From P. Becker, Phosphates and phosphoric acid

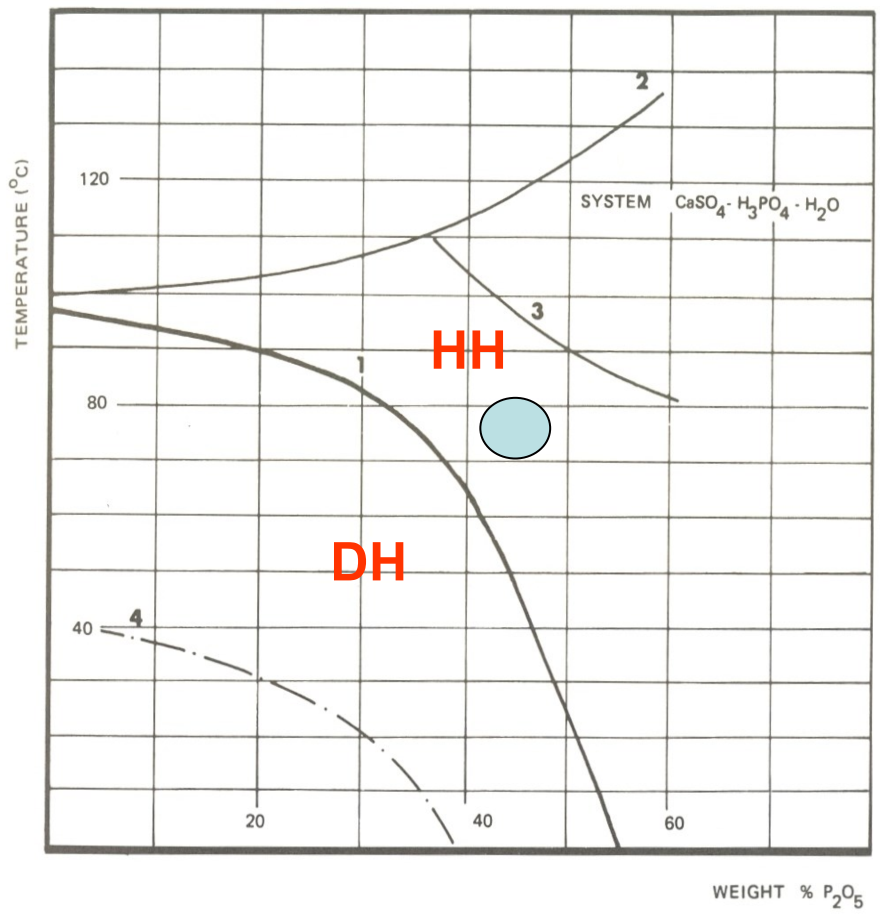
| Single Crystal | Double crystal Single filter | Double crystal Double filter |
|---|---|---|
| Dihydrate (DH) | New Di attack – Hemi Filtration (DA-HF) | Dihydrate-Hemihydrate (CPP) |
| Hemihydrate (HH) | Hemi Re-Crystalisation (HRC) | Hemihydrate-Dihydrate (HH-DH) |

PRAYON

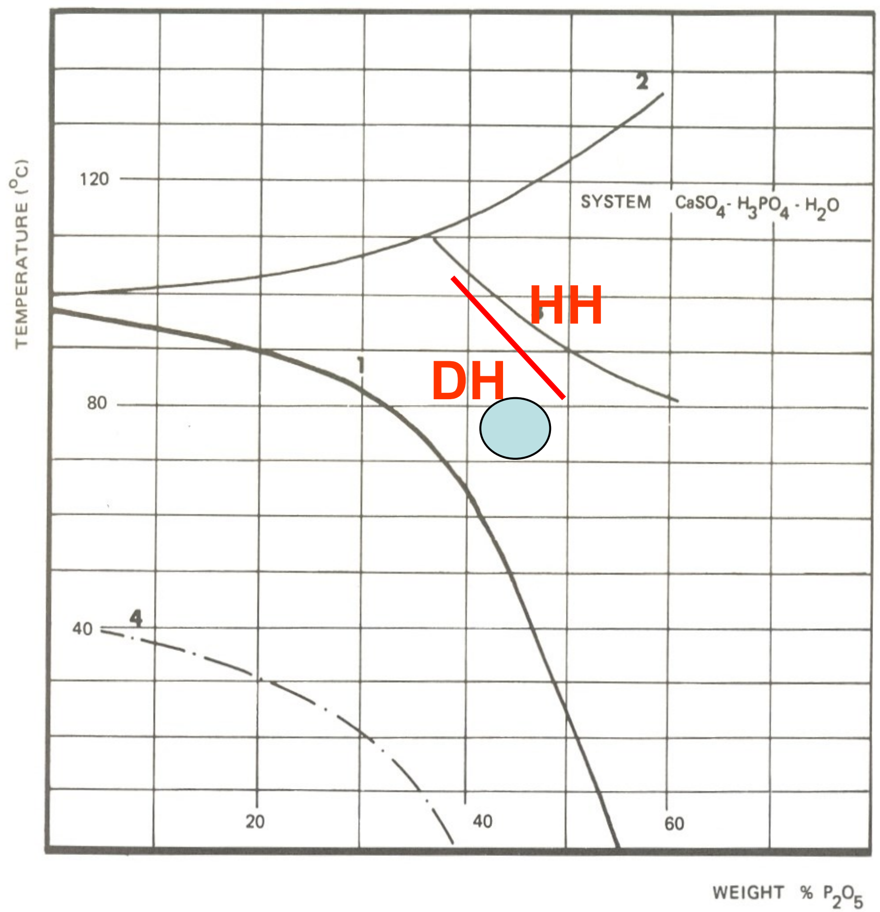
# Introduction

- Plant revamping
  - Double crystal processes considered
    - Extra filtration;
    - Extra conversion / crystallisation
- Prayon invests in R&D to improve plant efficiency and profitability
- One high newcomer: DA-HF process

# The DH –HH conversion limits



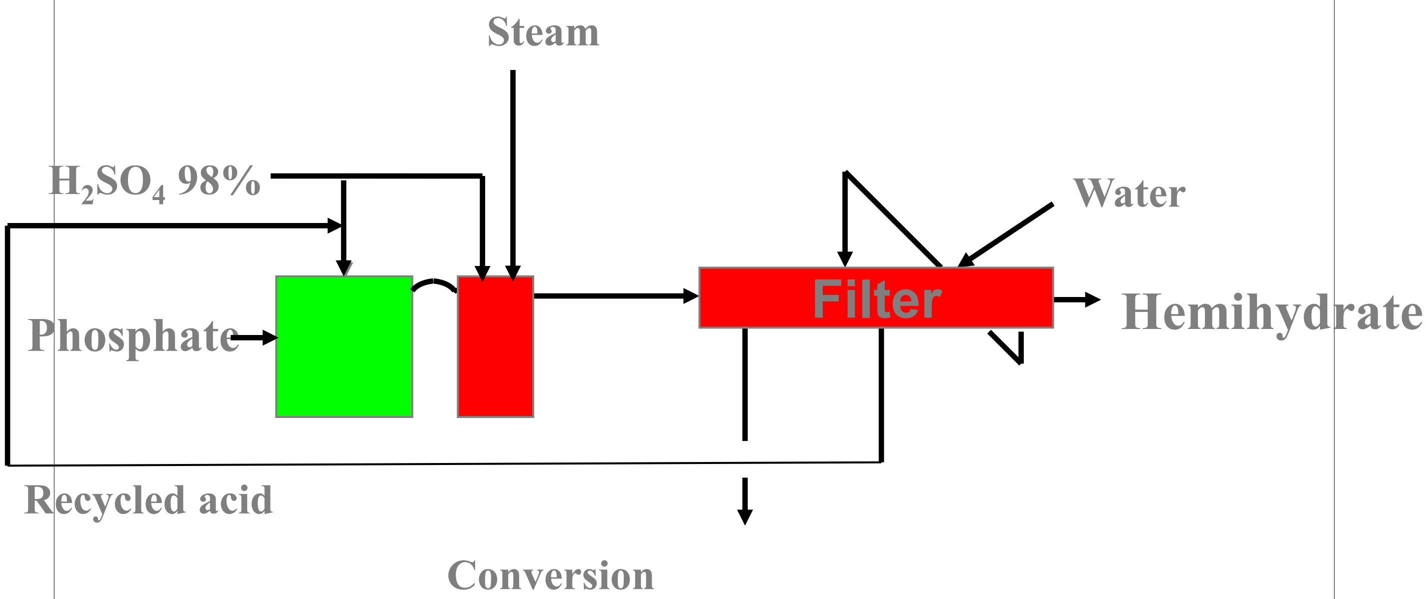
# The DH –HH conversion limits




At very low sulfate content ( 0.2-0.4% sulphate)

# Looking for a New Process route:

## Di Attack – Hemi Filtration




| Di Attack | Hemi Filtration |
|---|---|
| >37 % $P_2O_5$ | 32-36 % $P_2O_5$ |
| <0.8% $SO_3$ | 3% $SO_3$ |

# Pilot tests

## Several rocks tested successfully

- Morocco, Syrian, Jordan, Kola, Egypt…

## e.g. Syrian rock

**Rock analyses**

**28,3 % $P_2O_5$,**

**47,9 % CaO,**

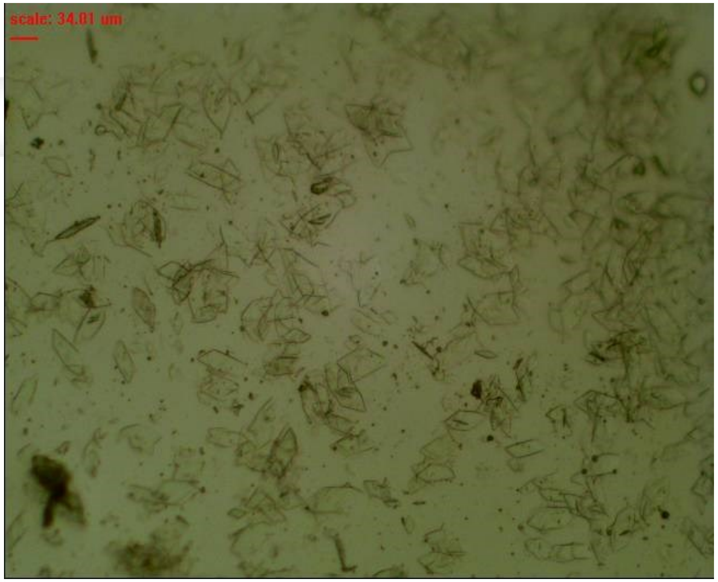
**3 % F,**

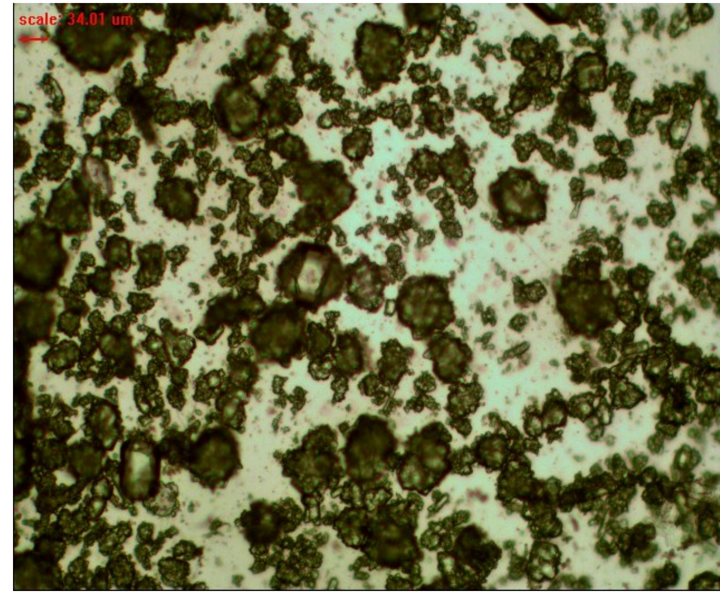
**6,8 % $CO_2$,**

# Pilot test with Syrian rock

| Elements | Unit | Phosphate Rock | Gypsum (250°C basis) | Acid C2 | Hémihydrate (250°C basis) |
|---|---|---|---|---|---|
| P2O5T | % w/w | 28,3 | | 36,08 | 0,2 |
| P2O5UN | % w/w | | 0,07 | | 0,11 |
| P2O5 CO | % w/w | | 1,57 | | 0,09 |
| % SO3 | % w/w | | | 3,5 | |
| Crystal water | % w/w | | 19,60 | | 6,23 |
| Efficiency | % | | | | 99% |
| Filtrability | tpdP2O5/m² (cycle 180s) | | | | 5,99 |

PRAYON

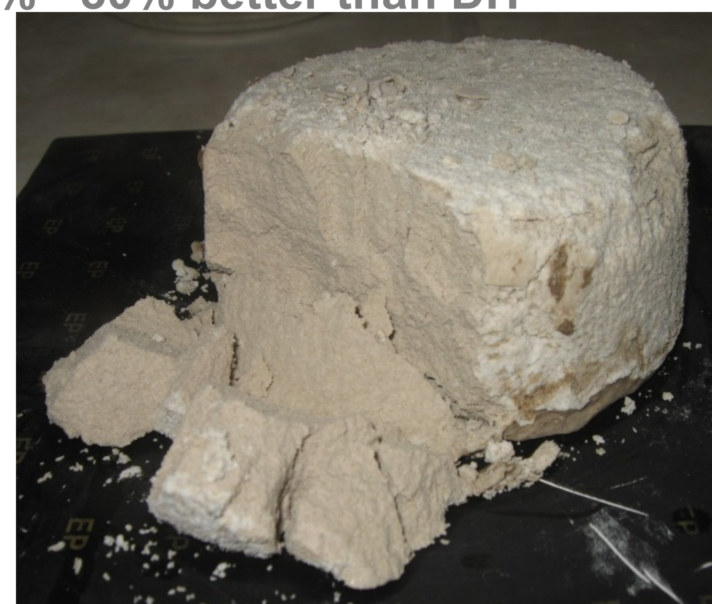



**For these conditions:**

**the $P_2O_5$ process recovery is > 2% higher than DH**

**the filtration rate is about 20% - 30% better than DH**

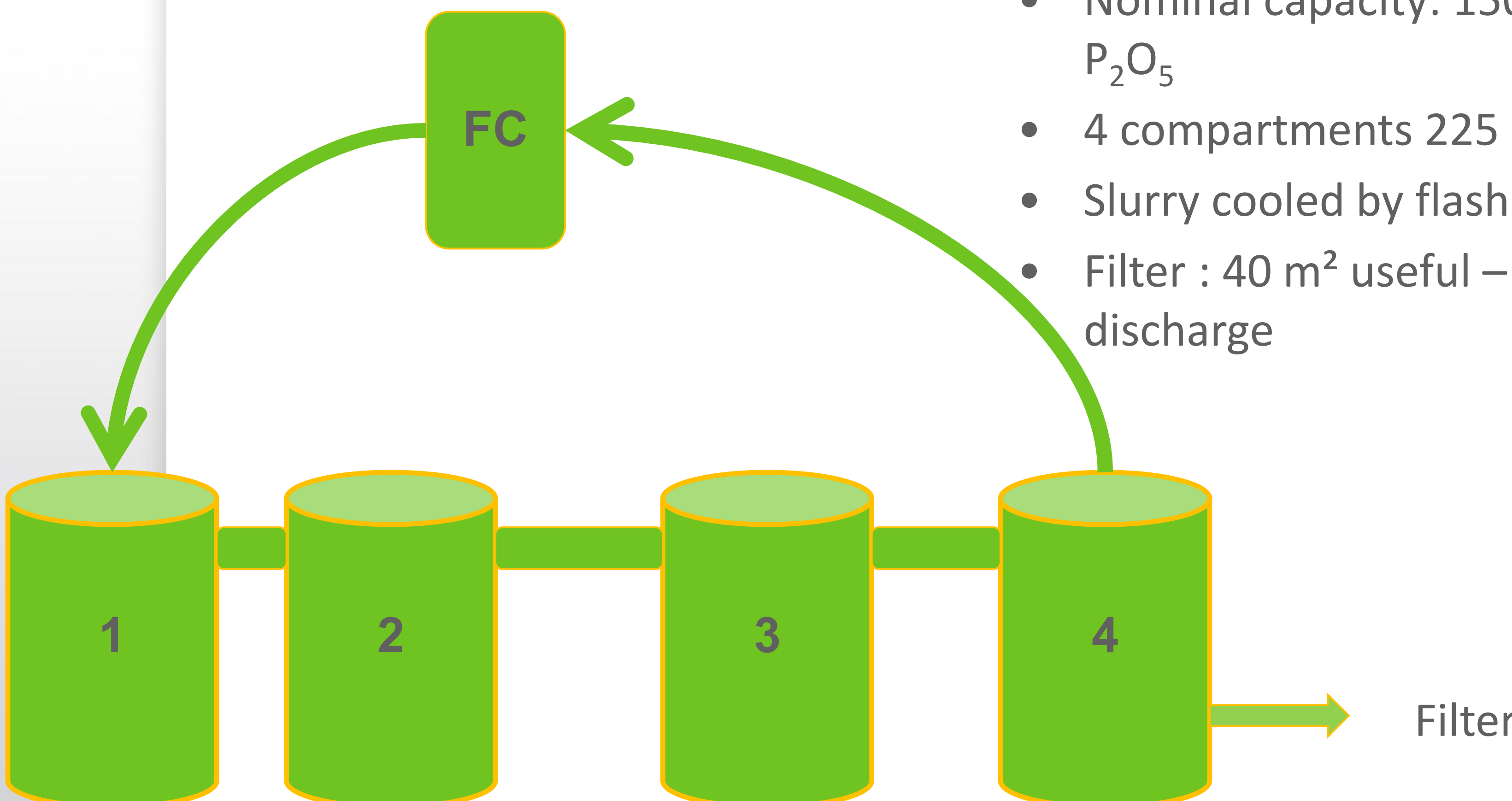


# Industrial Test Design

## Plant design - Dihydrate

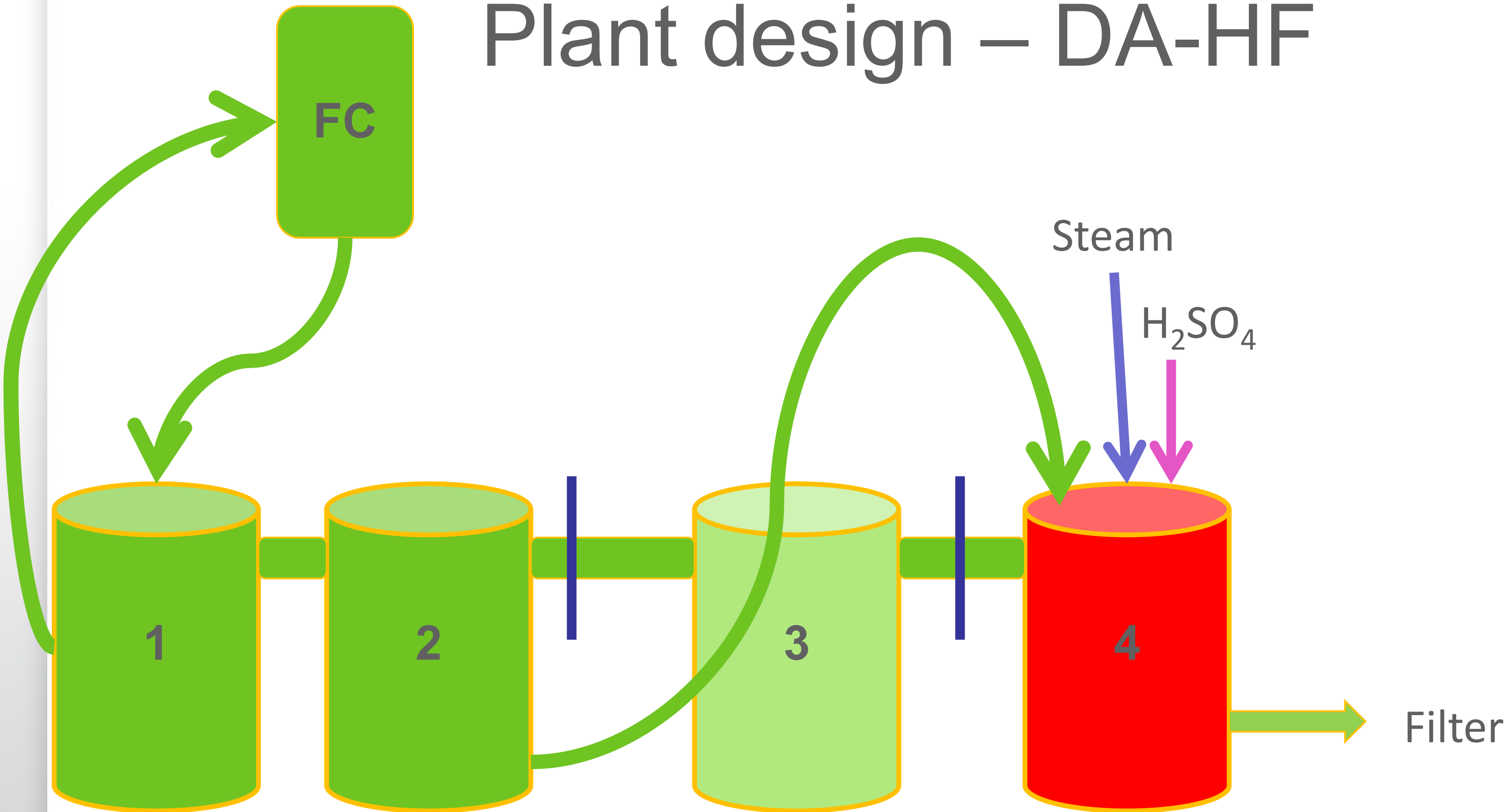
grupaazoty.com

- Nominal capacity: 150 tpd $P_2O_5$
- 4 compartments 225 $m^3$
- Slurry cooled by flash cooler
- Filter : 40 $m^2$ useful – dry discharge



# Industrial Test Design

## Plant design – DA-HF



# Test Results

- Quality of acid and gypsum
- Calcium sulphate filterability
- Efficiency
- Plant operation

# Test Results - Analyses with Moroccan Rock

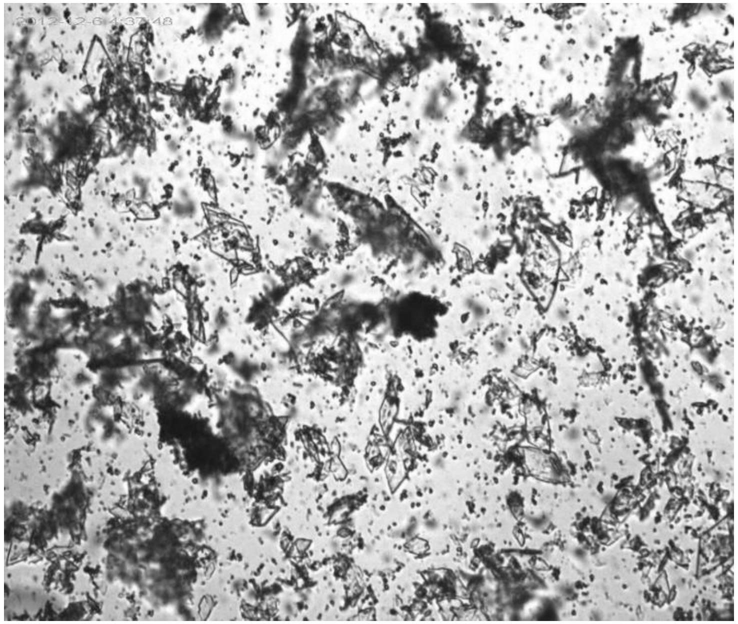
| Elements | Unit | Rock Morocco | Acid DH | Gypsum (250°C basis) | Acid HH | Hemihydrate (250°C basis) |
|---|---|---|---|---|---|---|
| $P_2O_5$ WS | % w/w | 30.7 | 37.4 | | 32.85 | 0.2 |
| $P_2O_5$UN | % w/w | | | 1.42 | | 0.11 |
| $P_2O_5$ CO | % w/w | | | 0.59 | | 0.32 |
| Crystal water | % w/w | | | 19.60 | | 6.3 |

# Test Results - Filterability

| | | *DH operation first test* | DA-HF operation Morocco rock |
|---|---|---|---|
| Conversion | | | |
| Slurry temperature | °C | *76* | 95 |
| Filtrate Density | 20°C | *1.308* | 1.460 |
| Filtration rate : | | | |
| Atm. Pressure (local) | (mmHg) | *760* | 760 |
| Filter Vacuum | (mmHg) | *500* | 500 |
| Filtration cycle | (s) | *180* | 180 |
| Filtration rate | (TPD $P_2O_5/m^2$) | *3.8* | 5.4 |

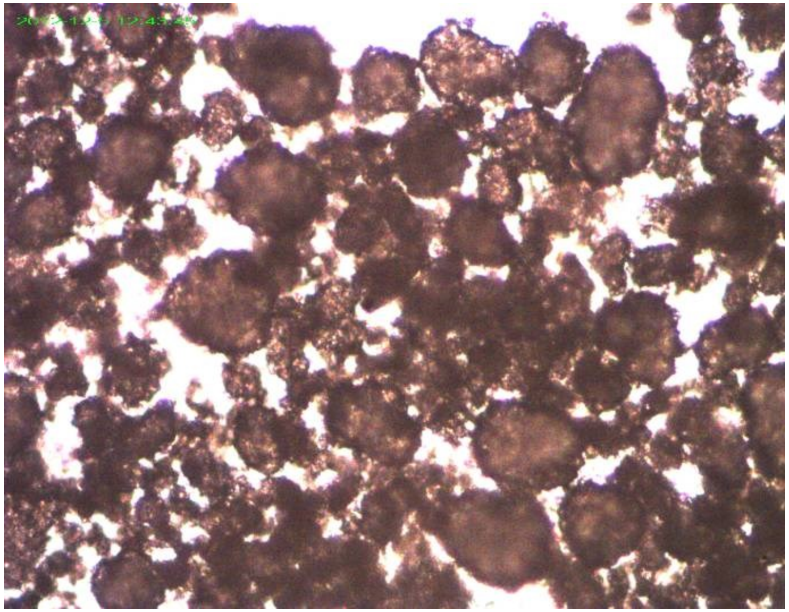
# Test Results – DH Crystals

- Small individual crystals
- No clusters
- Slurry easy to pump



# Test Results – HH Crystals

- Clusters
- Ball shape
- Aggregates easy to filter



# Test Results – Efficiency

- Industrial values observed: 97 – 98%
- To be compared with a DH process results : 94-95%

# Test Results – Plant Operations

- Some difficulties due to filter hopper not designed for HH operation (solids accumulation)
- Operators could easily operate the plant
- Start-up and shut downs are as easy as for DH process
- Flash cooler to be operated at lower pressure

# Lessons learned for conversion of existing DH plant

| | Check | Modify |
|---|---|---|
| Attack tank | Agitators, Cooling | |
| Digestion tank | Agitator,<br>lining<br>SA pipe | Steam injector<br>New tank |
| Filter | Barometric legs | prewash<br>Sectors |
| Cake discharge | Hopper<br>Conveying | |
| Gas scrubber | capacity | |

**Most DH plants can be converted to DA-HF technology**

# Profitability – preliminary study

- Profitability highly linked to local condition
  - •Energy cost;
  - •Utility cost;
  - •Usage of gypsum;
  - •Raw material cost.
- For a new plant producing MGA (500 tpd $P_2O_5$)
  - •Investment cost similar
  - •Lower steam, $P_2O_5$ consumption
  - •Profitability 7 to 25% higher
- For a revamping (500 tpd $P_2O_5$)
  - •Without capacity increase : 2 to 5 years depending local conditions (Raw mat and reagents prices; selling of gypsum…);
  - •With capacity increase: payback of less than 2 years.

# Concluding remarks

With the all the challenges ahead

(raw materials, energy, environment)

phosphoric acid production remains an exciting field for process developments

PRAYON

*Thank you for your attention !*

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الإتحاد العربي للأسمدة

Arab Fertilizer Association

In co- operation with

thyssenkrupp

# AFA WORKSHOP

## Operation and Maintenance Optimization

Jordan - Aqaba: 11-14 April, 2016

# DAY 3: Wednesday 13 April, 2016

Sponsors:

Arab Potash

Jordan Phosphate Mines Co.

Indo Jordan Chemicals Co.

NJFC

Nippon Jordan Fertilizer Co.

KEMAPCO

KEMAPCO Arab Fertilizers & Chemicals Industries Ltd.

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Arab Fertilizer Association

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# AFA WORKSHOP

## Operation and Maintenance Optimization

Jordan - Aqaba: 11-14 April, 2016

# Session 5

Sponsors:

Arab Potash

Jordan Phosphate Mines Co.

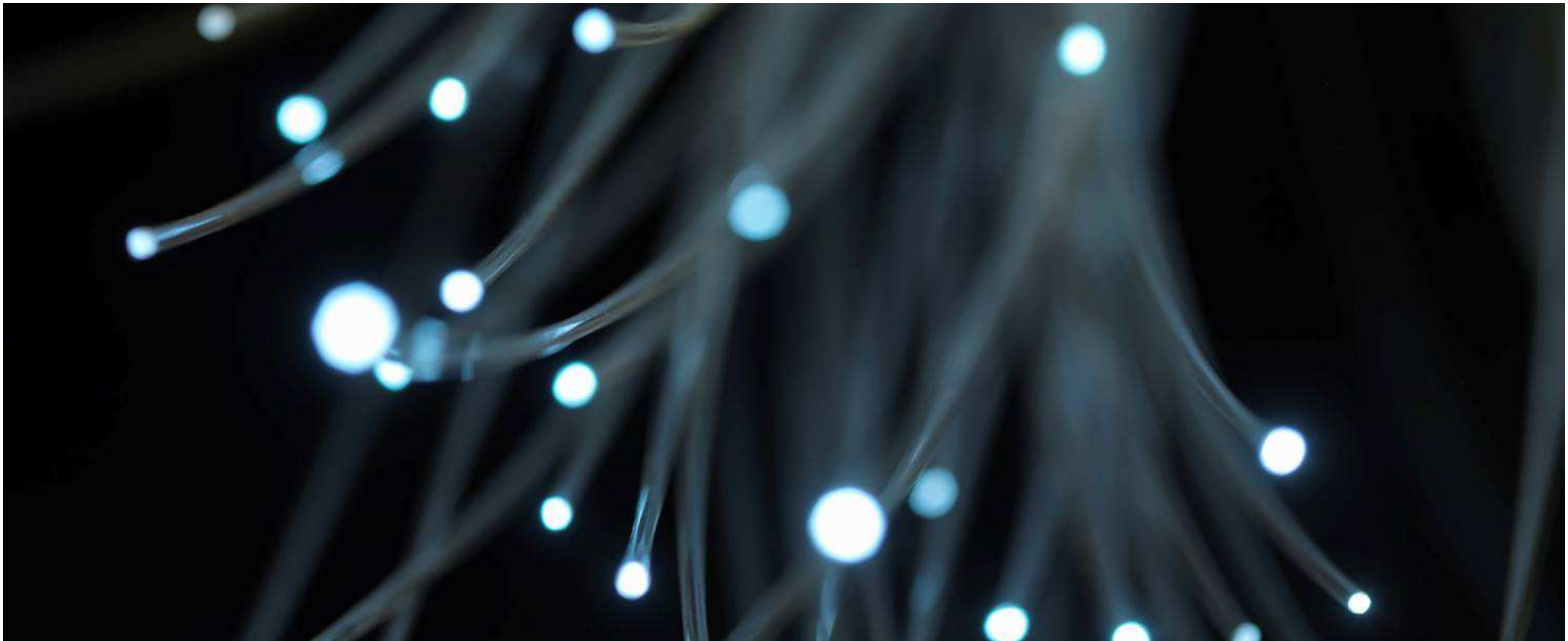
Indo Jordan Chemicals Co.

NJFC

Nippon Jordan Fertilizer Co.

KEMAPCO

KEMAPCO Arab Fertilizers & Chemicals Industries Ltd.



# Safe Start-up of Ammonia/ Urea Plants under Challenging Circumstances

11.-14.04.2016 | Christoph Meißner
thyssenkrupp Industrial Solutions - Arab Fertilizer Association

engineering. tomorrow. together.

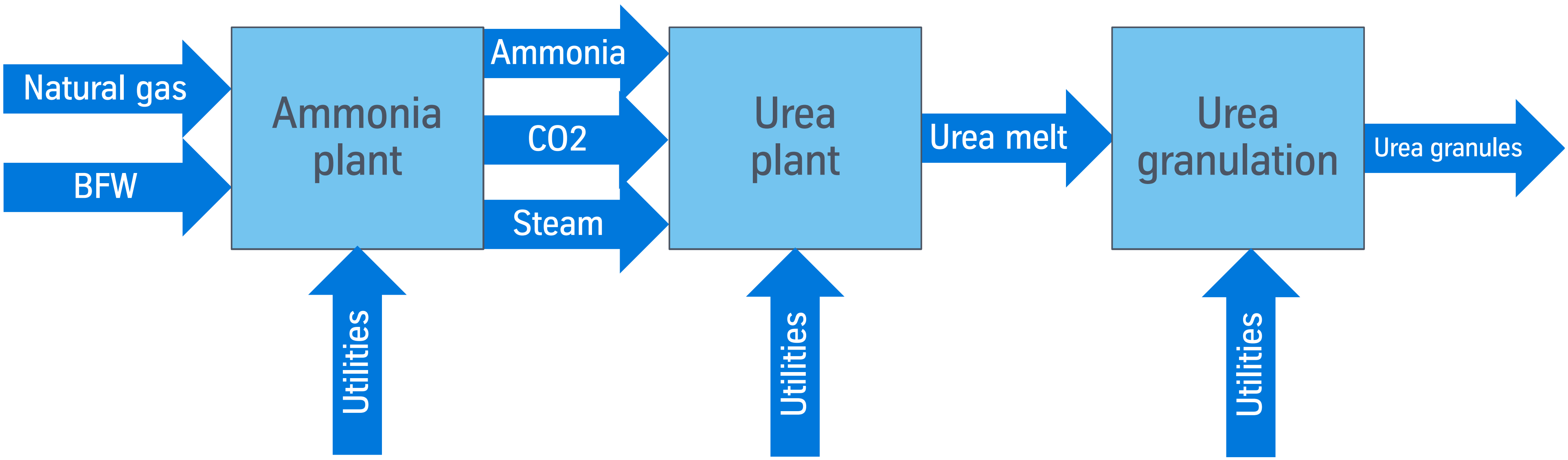
thyssenkrupp

# Safe start-up of ammonia/urea plants under challenging circumstances

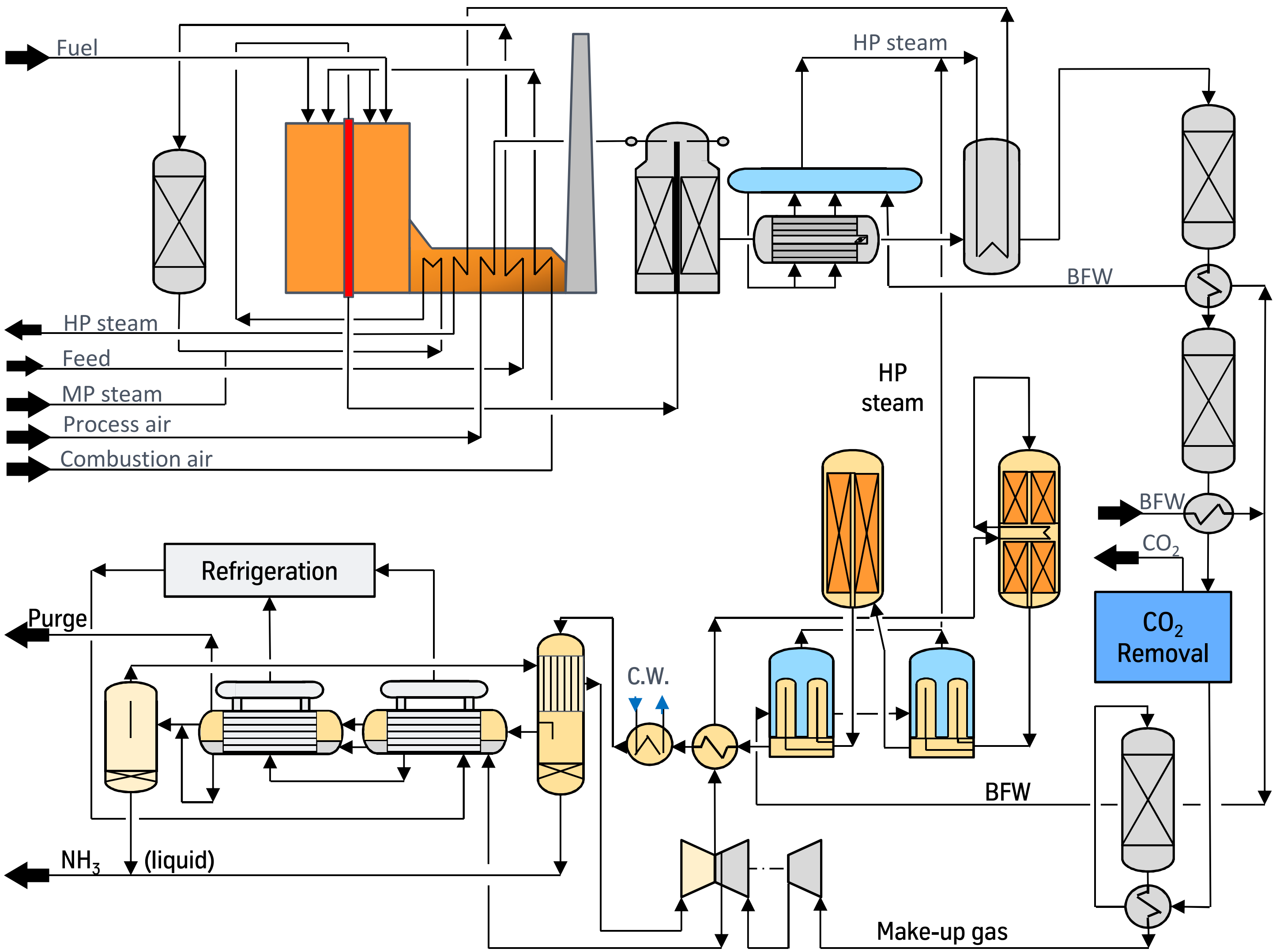
## Contents

# Safe start-up of ammonia/urea plants under challenging circumstances

## Fertilizer complex - simplified



# Safe start-up of ammonia/urea plants under challenging circumstances
## Ammonia plant



# Safe start-up of ammonia/urea plants under challenging circumstances

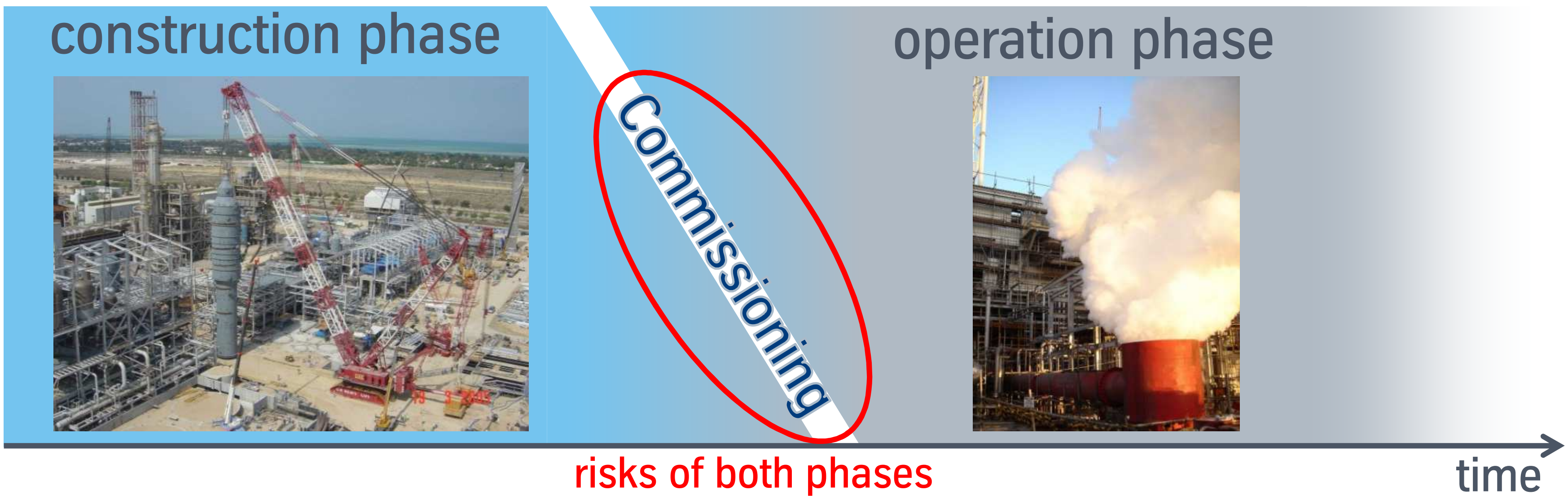
## Plant commissioning: risks from construction and operation

Construction risks

Crane operation, welding, …

Operation risks

Gas release, high temperatures, …




High number of construction staff familiar with construction risks

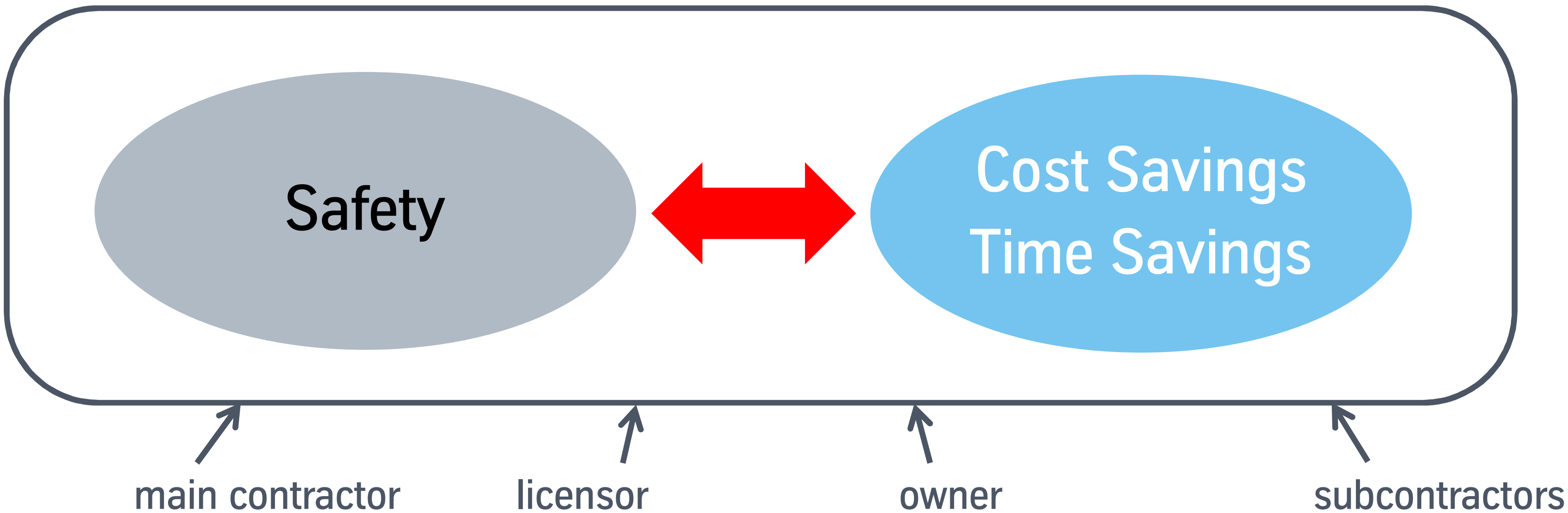
Communication for safety required

Operating staff familiar with operation risks

# Safe start-up of ammonia/urea plants under challenging circumstances

## Plant commissioning: risks from construction and operation

Many people see a conflict between safety and other targets of a project:




all with their different functions like HSE, operation, management etc.

# Safe start-up of ammonia/urea plants under challenging circumstances

## New ammonia and urea plants by TKIS in operation

# Safe start-up of ammonia/urea plants under challenging circumstances

New ammonia and urea plants by TKIS in operation

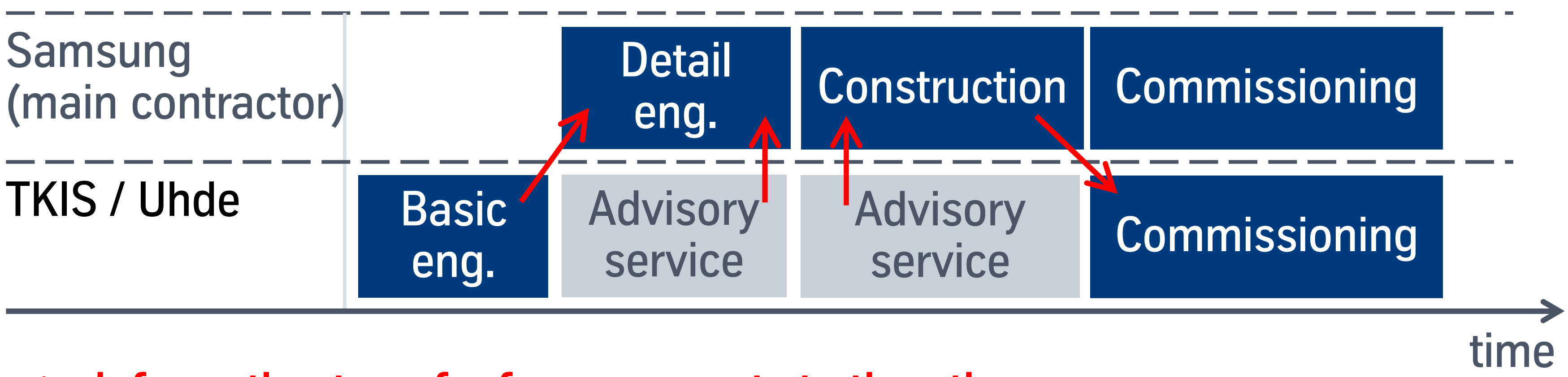
## Fertil 2

- Location: Ruwais, UAE
- Ammonia: 2,000 t/d (Uhde)
  Urea synthesis: 3,500 t/d (Stamicarbon)
  Urea granulation: 3,500 t/d (UFT)
- Contract: Engineering, procurement and commissioning assistance to Samsung
- Start-up: First product in 2013
- Highlights: Balanced plant (no NH3 surplus)

# Safe start-up of ammonia/urea plants under challenging circumstances

## Fertil 2 Project

Project phases (simplified):




→ information transfer from ony party to the other

Improvement of information transfer:
(1) Delegation of staff to each others office during all phases
(2) System of Technical Advice Notifications (TANs)

# Safe start-up of ammonia/urea plants under challenging circumstances

## Fertil 2 Project – Information Transfer

### Information transfer by Technical Advice Notifications (TANs):

- System established during engineering:
  - Answers by TKIS to questions by Samsung
  - Observations made by TKIS e.g. in 3D model reviews
  - Standard format, distribution, numbering
- Continued for commissioning

A company of ThyssenKrupp Technologies **Uhde**

**FERTIL-2 Project**
**UAN : 11-3126**

**Technical Advice Notification Sheet**

| | |
|---|---|
| **TA No :** | PR-U-005 |
| **Discipline :** | Urea process |
| **TA Title :** | Advice on configuration of psv collecting header |
| **Date of issue :** | During 30% model review, October 2010 |
| **Date of ans** | |
| **Origin** | |
| **Adv** | |
| **Referen** | |

**1. Query:**

Questions raised du

**2. Advice :**

1. All lines connecte shall have an inclinir towards the header. possible.

2. The lines 223118, header.

3. The line 222333 s shall be tangential.

4. The connection he chosen by Samsung

A company of ThyssenKrupp Technologies **Uhde**

**FERTIL-2 Project**
**UAN : 11-3126**

**Technical Advice Notification Sheet**

| | | | |
|---|---|---|---|
| **TA No :** | PR-A-017 | | |
| **Discipline :** | Ammonia process | | |
| **TA Title :** | Emergency depressurization | | |
| **Date of issue :** | 01.April 2011 | | |
| **Date of answer :** | 04.April 2011 | | |
| **Originator :** | S. H. Kim | | |
| **Adviser :** | N. Schlinge | **Signature :** | **PM/EM :** |
| **References :** | | | |

**1. Text of Query:**

Is a dedicated depressurization necessary as requested by QRA recommendation of Fertil?

# Safe start-up of ammonia/urea plants under challenging circumstances

## Fertil 2 Project

Main activities on site as advisory service by TKIS:

- Check of plant against P&ID
- Check of quality of plant assembly
- Monitoring installation of equipment internals, packing and catalysts
- Preparation of technology-related procedures (together with Johnson Matthey for catalyst issues)
- Co-operation with Stamicarbon and UFT for technology-related activities in urea plant
- Checking programmed trip logics
- Monitoring start-up and test operation

… under continuation of TAN system

- Proper trip check:
- Is a must for safety reasons
- Deviations against design detected and fixed
- Takes time…
- … but finally has saved project time and budget by smooth and trouble-free start-up

# Safe start-up of ammonia/urea plants under challenging circumstances

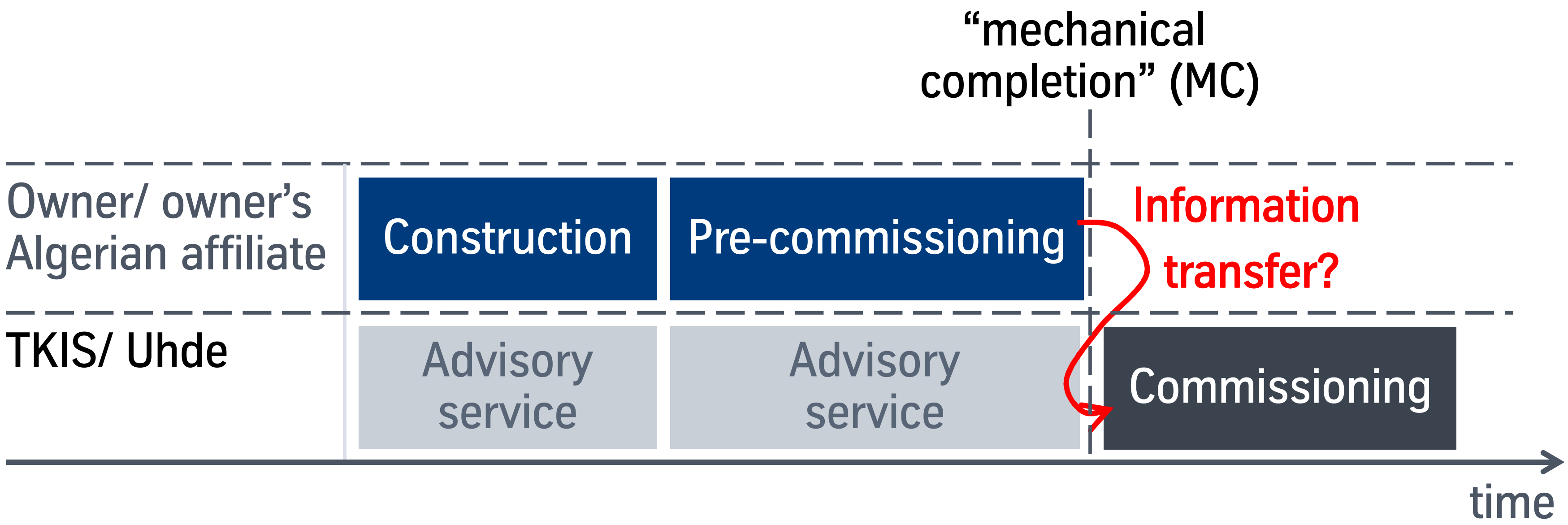
## New ammonia and urea plants by TKIS in operation

### Sorfert


- Location: Sorfert, Arzew, Algeria
- Ammonia: 2 x 2,200 t/d (Uhde)
  Urea synthesis: 3,450 t/d (Stamicarbon)
  Urea granulation: 3,450 t/d (UFT)
- Contract: EP contract with Sorfert, C-part by Orascom
- Highlights: Test runs finished in 2013, ammonia plant reached 105% nameplate capacity

# Safe start-up of ammonia/urea plants under challenging circumstances

Sorfert Project




Tools for information transfer at beginning of commissioning:

(1) Mechanical completion (MC) management system introduced by TKIS

(2) Pre-Start-up Safety Review (PSSR) at hand-over to TKIS for commissioning

(3) Live marking of systems

# Safe start-up of ammonia/urea plants under challenging circumstances

## Mechanical Completion Management System

Data base system ICAPS (Integrated Commissioning and Progress System) introduced by TKIS to organise MC:

- administration of MC and pre-commissioning activities
- tool for progress control
- contains status of all subsystems (e.g. task done/ not done, punch list)

**Uhde** — **PRECOMMISSIONING TEST SHEET**

**PIPING**

**CLEANING OF PIPEWORK PER SUBSYSTEM AND LINES RELATED TO PRESSURE TEST PACK**

COMPANY LOGO

**Description:**

**Subsystem**

FORM : **UAN_P_012T - CLEANING OF PIPEWORK PER SUBSYSTEM & PTs**

TASK LOCATION :

**DEGREE OF CLEANLINESS**

| ITEM | CHECK LIST | |
|---|---|---|
| 1 | Check that the preparation for cleaning, flushing, blasting and pickling procedures have been completed and all items have been removed according to the Pre-Commissioning Procedure. | |
| 2 | All removed items are stored in a safe and organized manner. | |
| 3 | Check that all pipelines related to this cleaning of pipework procedure are listed and correct. | |

**CLEANING OF PIPEWORK DATA**

| CLEANING DATE | | DURATION OF CLEANING | min | CLEANING FLUID | |
|---|---|---|---|---|---|
| CLEANING OF PIPEWORK EXECUTED BY (NAME) | | | | | |

**PIPEWORK INDEX**

| LINE NO. | Line Description | Sub-System | Degree of Cleanliness | PID-No. | From | To |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |

Example:
check sheet
for pipe cleaning

# Safe start-up of ammonia/urea plants under challenging circumstances

## Pre-Start-up Safety Review (PSSR)

- Procedure to ensure the plant is ready for start-up
- Some important elements of a PSSR checklist:

| Checklist | | Yes / No | Remark |
|---|---|---|---|
| **1** | **Pre-commissioning / Mechanical Completion** | | |
| … | … | | |
| 1.5 | All instrument and control loops checked | | |
| 1.6 | All trip and ESD functions checked | | |
| **2** | **HAZOP Comments Incorporated** | | |
| 2.1 | Did any of the a.m. P&ID had comments related to the instrumentation / ESD system | | |
| 2.2 | If yes, have these been incorporated into the design | | |
| **3.** | **Design Changes (Instrumentation)** | | |
| 3.1 | Is the P&ID Master Copy updated to as-built status | | |
| … | … | | |
| **4** | **Area Visit** | | |
| 4.1 | Scaffolding and barricades removed from the areas which need to be accessible during commissioning | | |
| 4.2 | Area with commissioning activities is properly roped-off or marked | | |
| 4.3 | System is live marked | | |
| 4.4 | Field Safety Equipment like safety showers, eye wash stations, fire-fighting equipment is operational | | |
| **5** | **Information** | | |

# Safe start-up of ammonia/urea plants under challenging circumstances

## Live Marking of Systems

Live marking of systems reduces the risks at a time when commissioning and final construction overlap.

Livening-up Notice:

- issued by commissioning team after successful PSSR
- contains:
  - number and description of subsystem
  - type of activity, e.g. blowing, flushing (temporary) or operation (permanent)
  - location, shown on plot plan
- standard format
- standard distribution to client and all subcontractors on site

Additionally: live marking in the field by stickers and tape

# Safe start-up of ammonia/urea plants under challenging circumstances
## Summary

Lack of information contributes to risk ⟷ Good communication avoids risk
… especially in multi-party projects … and speeds up the project

Tools to improve communication:
- Technical Advice Notification (all project phases)
- Mechanical Completion Database (final construction and commissioning)
- Livening-up Notice (commissioning)

Safety checks prior to start-up are proven methods to detect and fix dangerous conditions.
Tools:
- Check of trip and interlock system before start-up
- Formalised Pre-start-up Safety Review (PSSR)

# Safe start-up of ammonia/urea plants under challenging circumstances

## Plant commissioning: risks from construction and operation

Many people see a conflict between safety and other targets of a project:

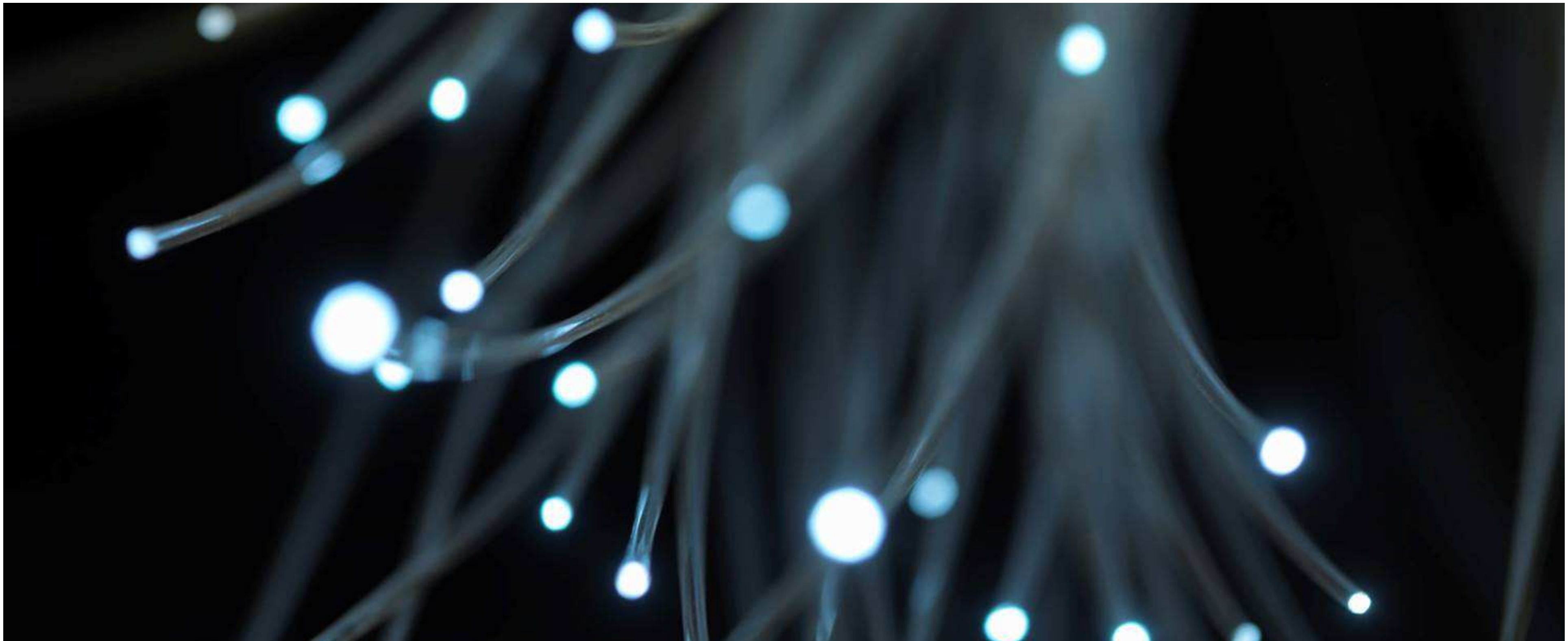

Safety and other targets of project execution go together.

Thank you for your attention!

Questions?

Comments?

christoph.meissner@thyssenkrupp.com
www.thyssenkrupp-industrial-solutions.com



# Energy Consumption for Ammonia/Urea Production: Analysis and Optimization

11.-14.04.2016 | Christoph Meißner
thyssenkrupp Industrial Solutions - Arab Fertilizer Association

engineering. tomorrow. together.

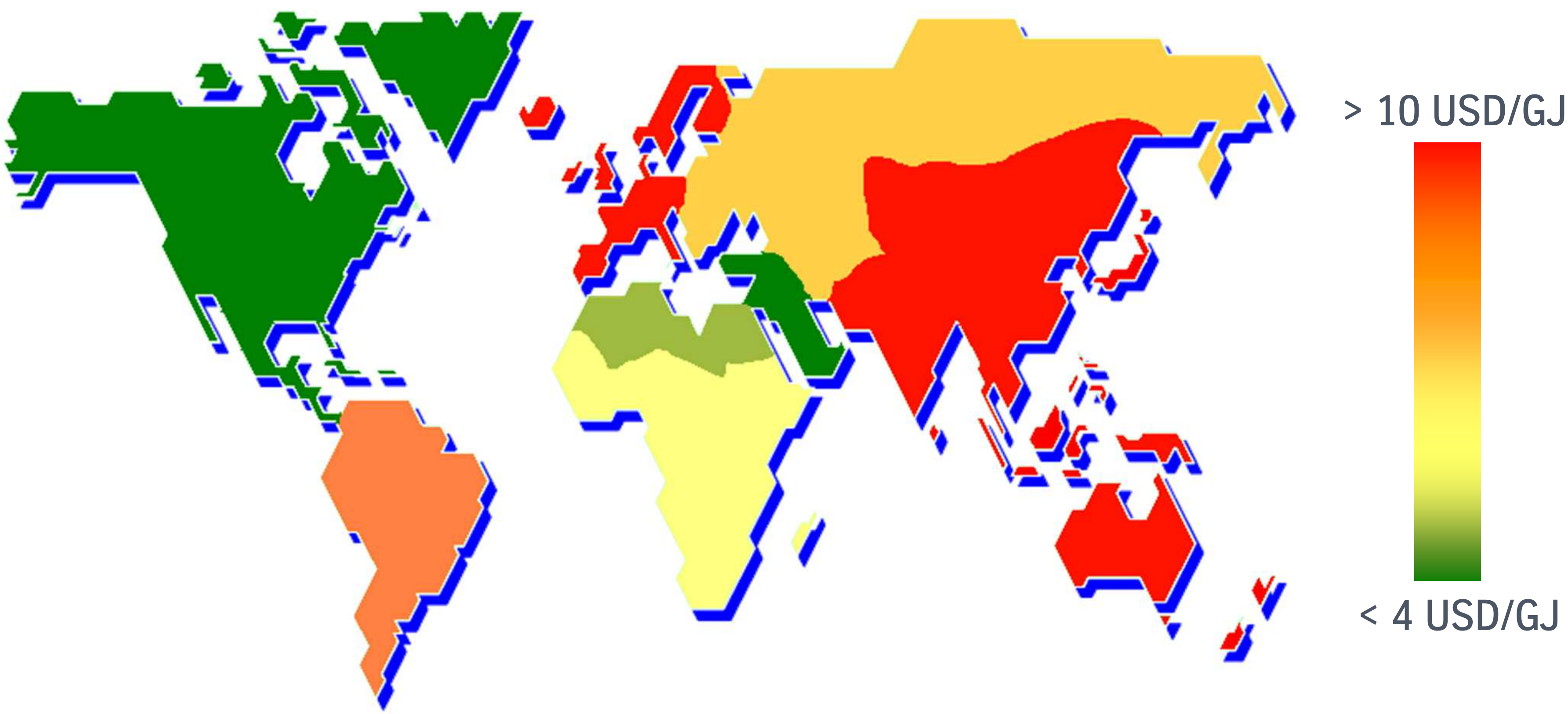
thyssenkrupp

# Energy consumption for ammonia/urea production

## Contents

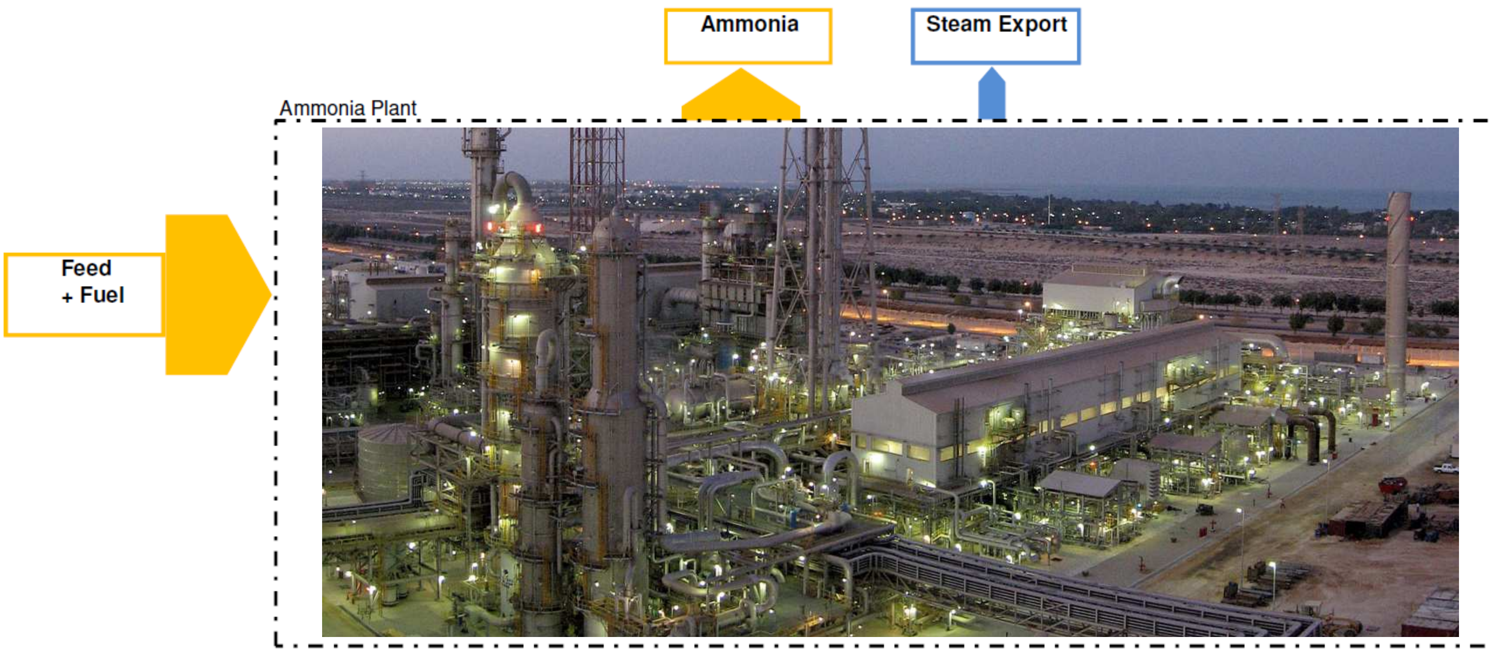
# Energy consumption for ammonia/urea production

## Natural gas prices are increasing all over the world



# Energy consumption for ammonia/urea production

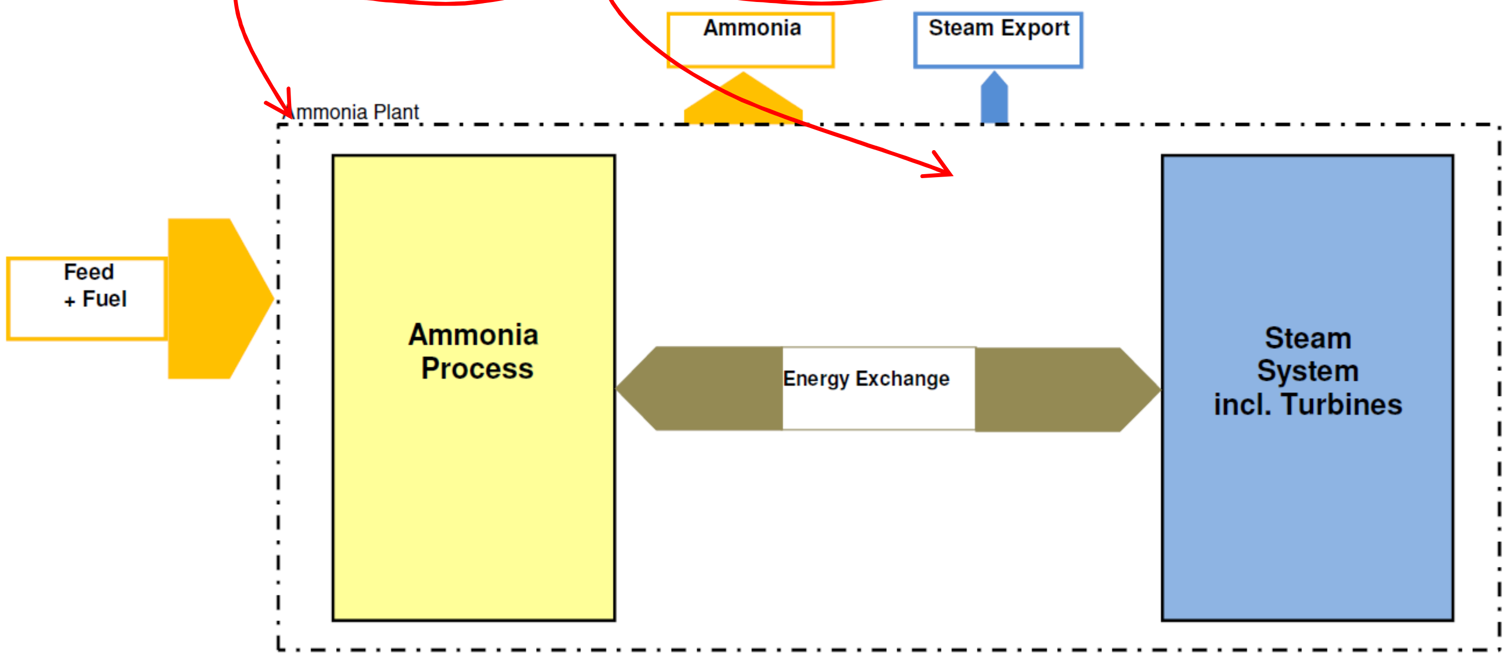
## Analysis of energy consumption



# Energy consumption for ammonia/urea production

## Analysis of energy consumption II

Separation into process plant and steam system:



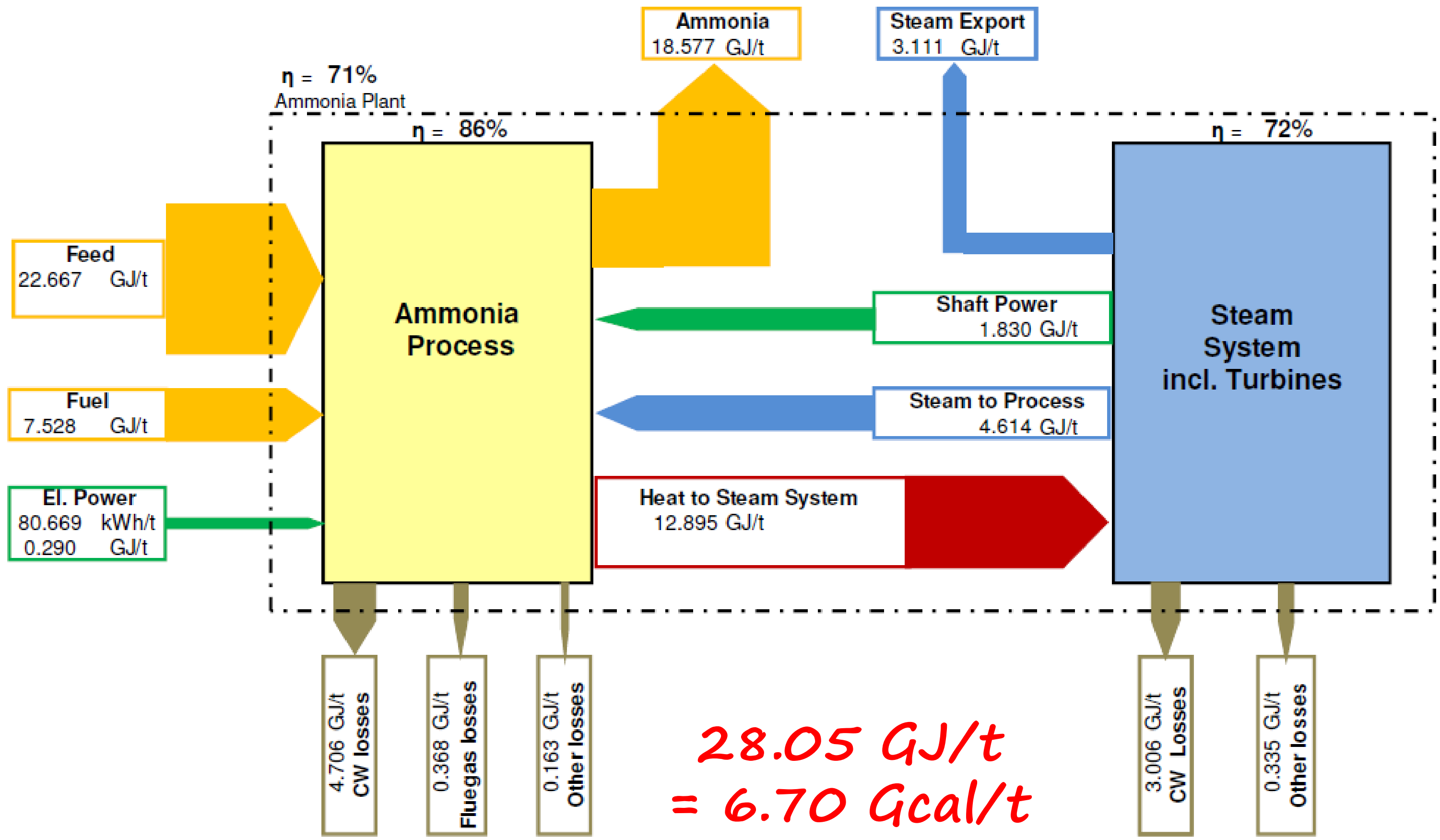

Basis:

- Analysis based on actual 3,300 t/d ammonia plant, using Uhde process…
- … but applicable to all kind of plant sizes and processes

# Energy consumption for ammonia/urea production

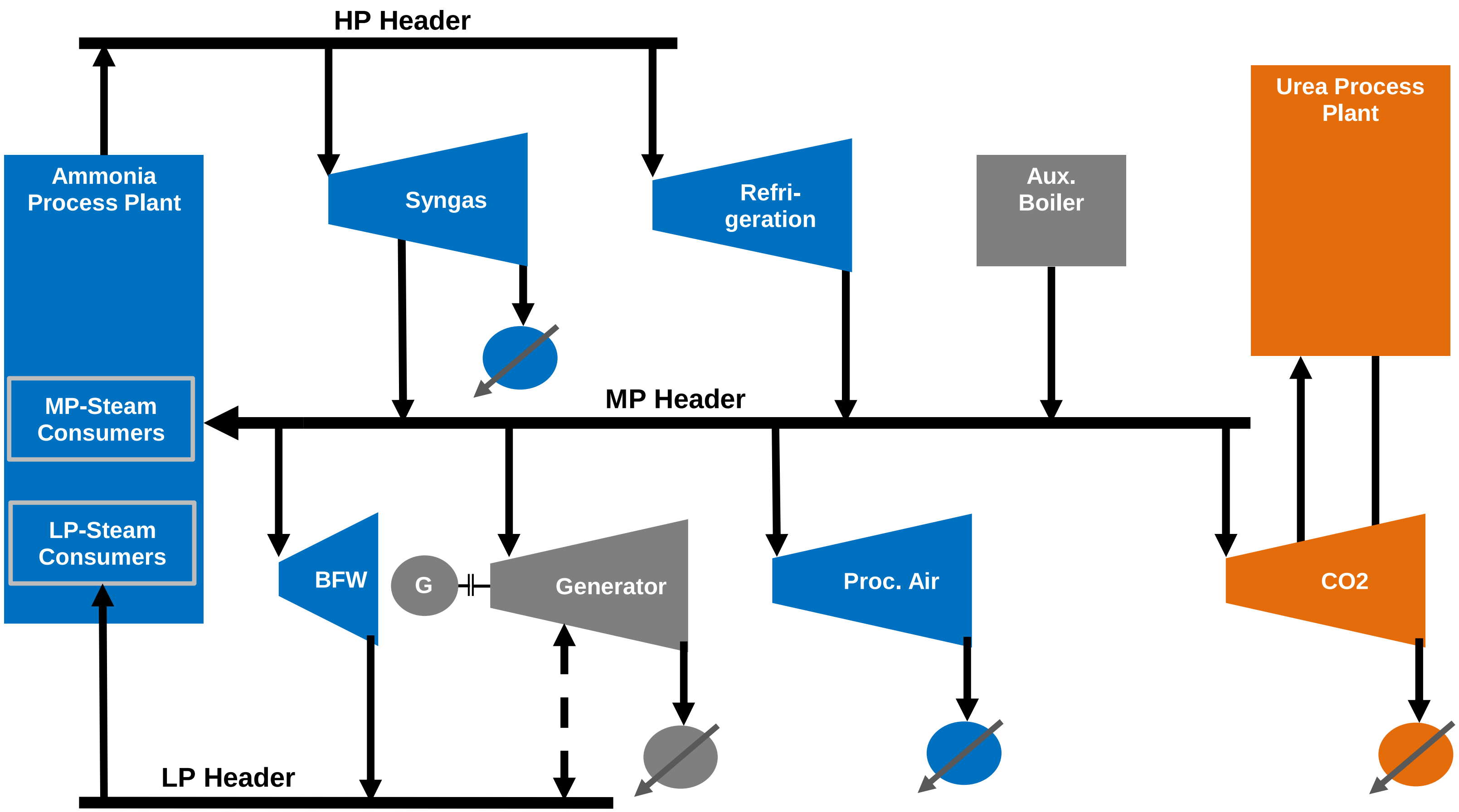
## Analysis of energy consumption III

Separation into process plant and steam system:



# Energy consumption for ammonia/urea production

## Conventional steam system



# Energy consumption for ammonia/urea production

## Definitions for energy efficiency

- Definitions for energy efficiency:

– Export steam: Use natural gas which would be needed for its production in a boiler

– Electricity:  Use natural gas which would be needed for its production in a in a boiler / steam turbine / generator combination:
  At overall conversion efficiency of 30%,
  1 kWh(el.) corresponds to 12,000 kJ(NG) = 2,866 kcal(NG)

Watch out: Everyone uses his own different definitions

Watch out for misleading figures:

– Plant concept with high steam export has low overall energy consumption

– Can this steam be used anywhere? If not, this concept is not feasible

# Energy consumption for ammonia/urea production

## Strategies on improvement

### Process

- Minimise energy input
- Minimise losses
- Maximise energy export to steam system

### Steam system

- Data for energy exchange with process already defined by process:
  - waste heat available
  - shaft power demand
- Minimise losses
- Maximise steam export

Note on feed gas:

- Usually close to its natural minimum set by reaction stoichiometry
- Can hardly be reduced

… but there is a limitation!

Is there anyone who can use the steam export?

# Energy consumption for ammonia/urea production

## Guideline

- Steam export as deciding criteria:
  - Many optimisation strategies for process and steam system lead to higher steam export
  - No helpful strategy if no consumer for steam present

| A: Steam export | B: No steam export |
| --- | --- |
| Any improvement measures is welcome, e.g.: | More constraints for selection |
| • Better energy recovery from process | • Energy to be kept inside process |
| • More efficient machinery etc. | • Often more expensive |

# Energy consumption for ammonia/urea production

## Scenario A: Optimisation without Steam Export

- Steam export as the deciding criterion:
- Scenario A: Steam export not welcome, e.g. in a stand-alone ammonia plant

- Feed consumption: no big reduction potential
- Lower fuel consumption of reformer:
  - More feed / steam preheating by waste heat, less by firing
  - Less steam superheating duty available from waste heat: less steam production

  $\Rightarrow$ Keep the energy inside the process, don't send it to the steam system
- Consume more steam inside ammonia plant, e.g. by turbine-driven natural gas compressor (additional investment cost)

# Energy consumption for ammonia/urea production

## Scenario B: Optimisation with Steam Export

- Steam export as the deciding criterion:
- Scenario B: Steam export welcome, e.g. in ammonia / urea complex

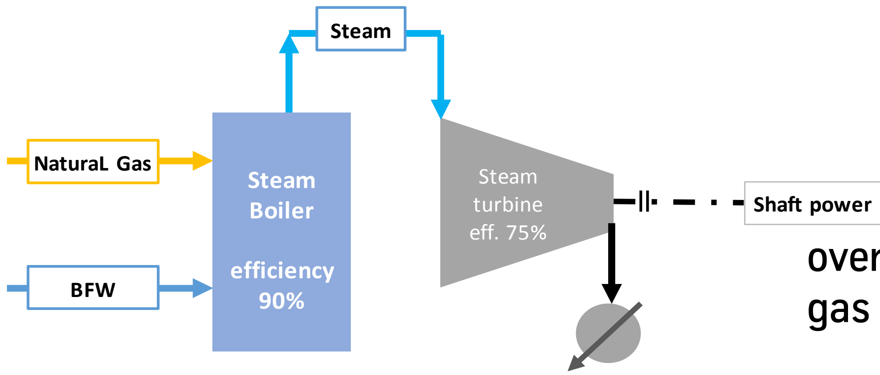
- Steam system of an ammonia / urea plant:
- Steam consumption side: distributes steam to the consumers:
  - generation of shaft power according to process demands
  - other steam consumers, like process steam.
- Steam production:
  - picks up steam generated by waste heat from process
  - generates additional steam (e.g. in a gas-fired boiler) according to needs of process

There are several ways to fulfil and optimise these tasks. See next slides…

# Energy consumption for ammonia/urea production

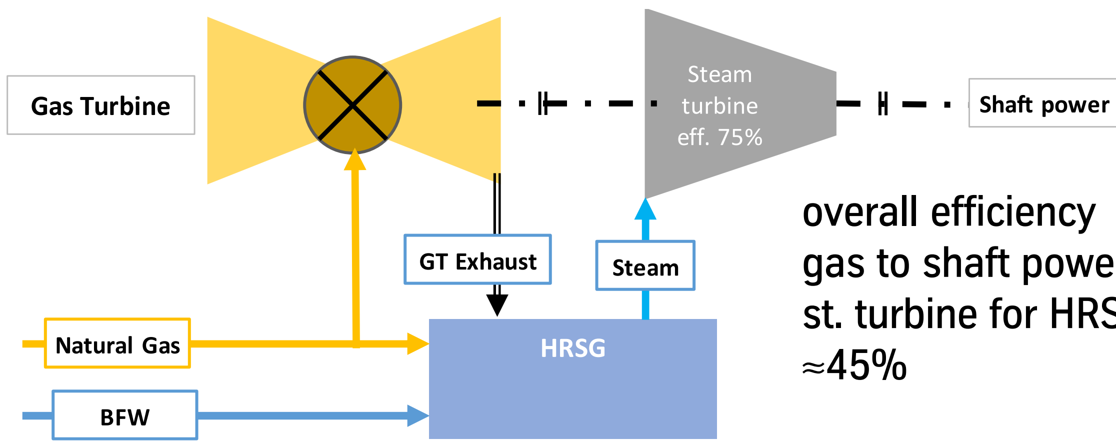
## Scenario B: Optimisation with Steam Export

- Steam turbine:




overall efficiency
gas to shaft power: ≈30%

- Gas turbine:




overall efficiency
gas to shaft power, with
st. turbine for HRSG steam:
≈45%

⇒ Application of gas turbine gives great advantage in efficiency

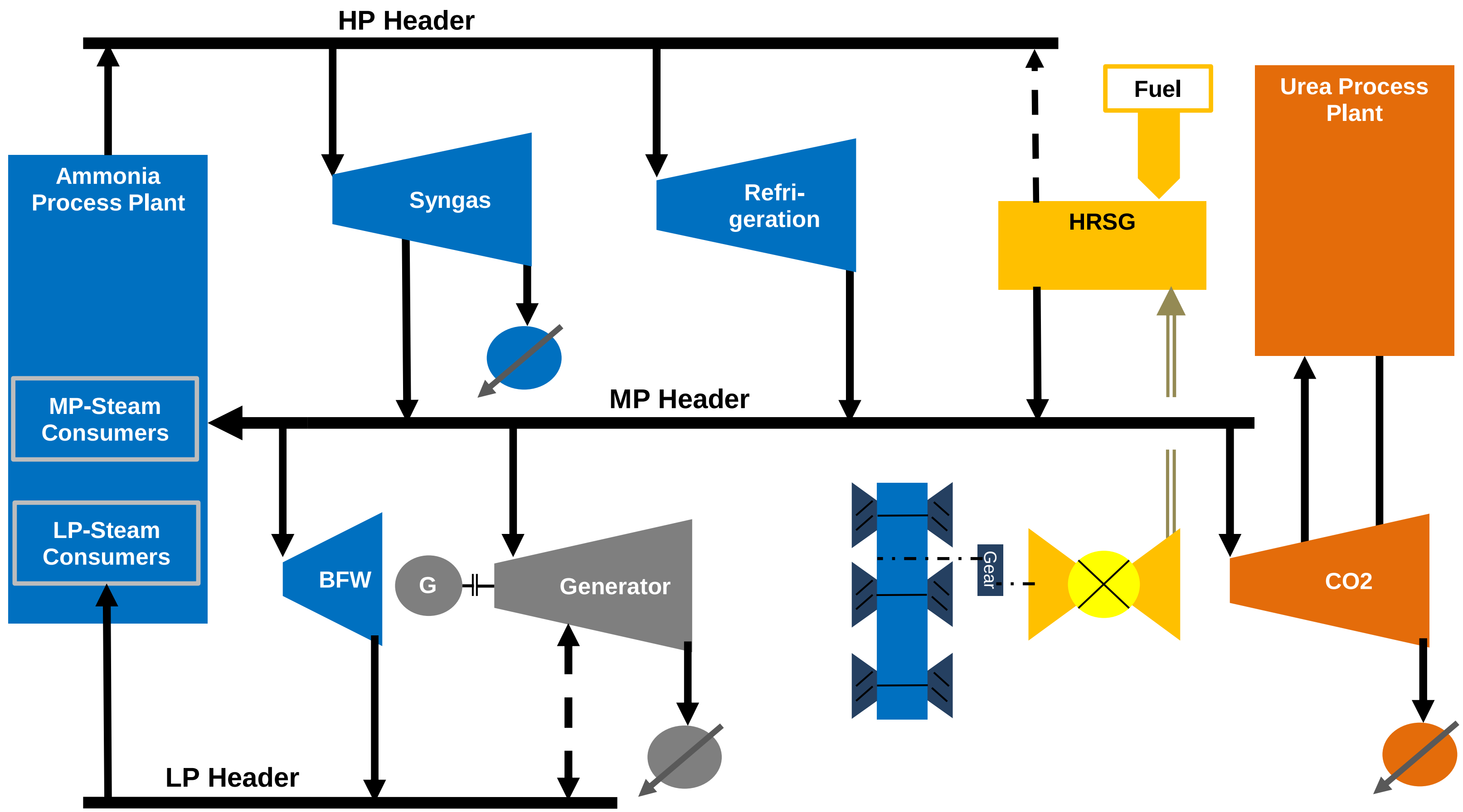
# Energy consumption for ammonia/urea production

## Case overview I

| Gas turbine | Exhaust gas utilization | | Advantage (+) / disadvantage (-) |
|---|---|---|---|
| None (base case) | n.a. | | n.a. |
| Option #1:<br>Driver for process air compressor (single shaft or gear type) | MP or HP steam generation | +<br>+<br><br>- | high energy efficiency<br>operation of ammonia/urea complex without package boiler possible<br>large amount of auxilliary firing required to cover entire complex |
| Option #2:<br>Driver for gear type process air compressor and power generator | MP or HP steam generation | +<br>+ | very high energy efficiency<br>operation of ammonia/urea complex without package boiler possible |
| Option #3:<br>Driver for process air compressor (single shaft or gear type) | Used as combustion air for primary reformer | +<br>+<br>-<br>- | high energy efficiency<br>no combustion air blower required<br>high reformer stack temperature<br>installation of GT close to reformer |

# Energy consumption for ammonia/urea production

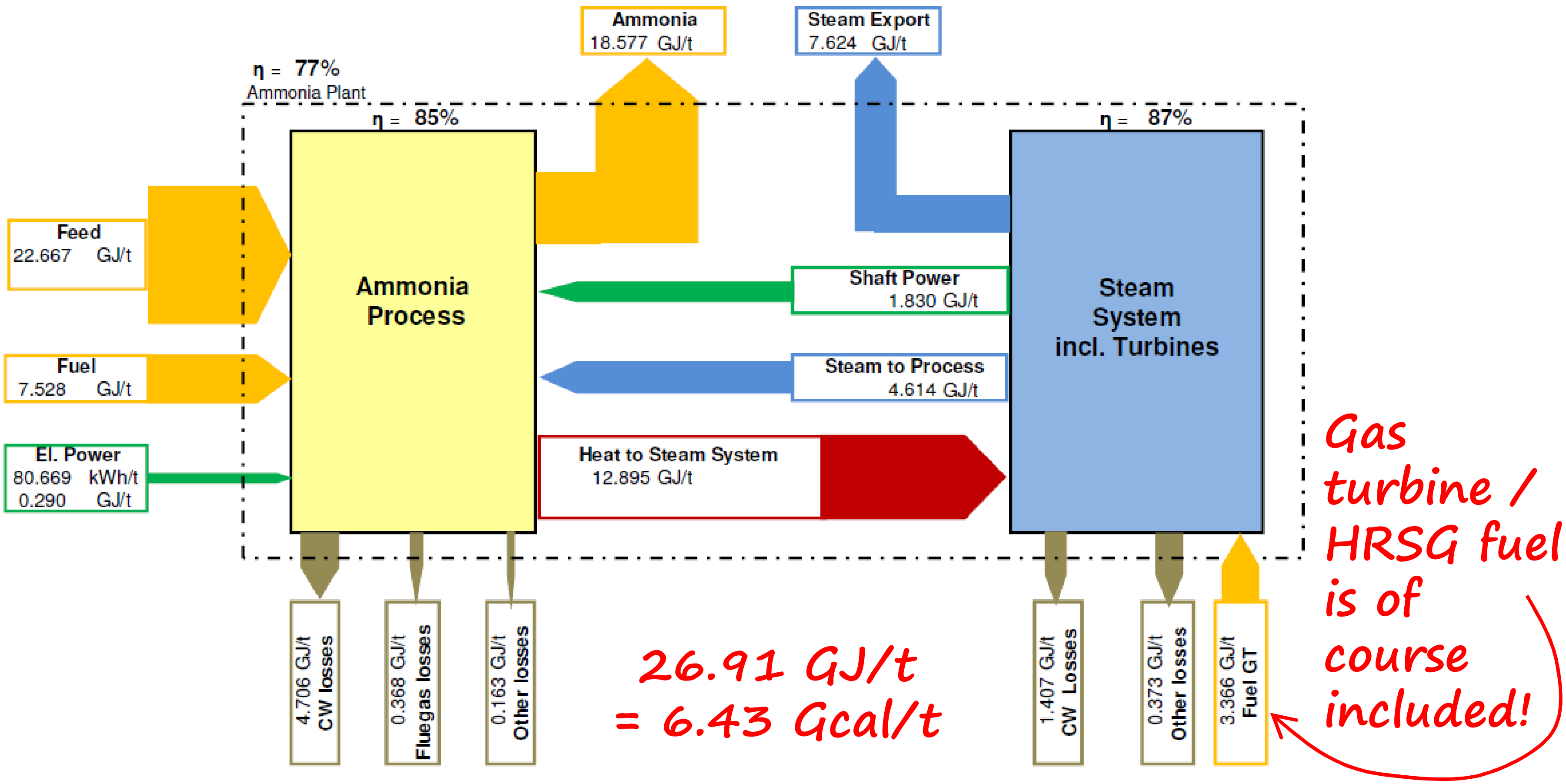
## Option #1: GT as Driver for Process Air Compressor



# Energy consumption for ammonia/urea production

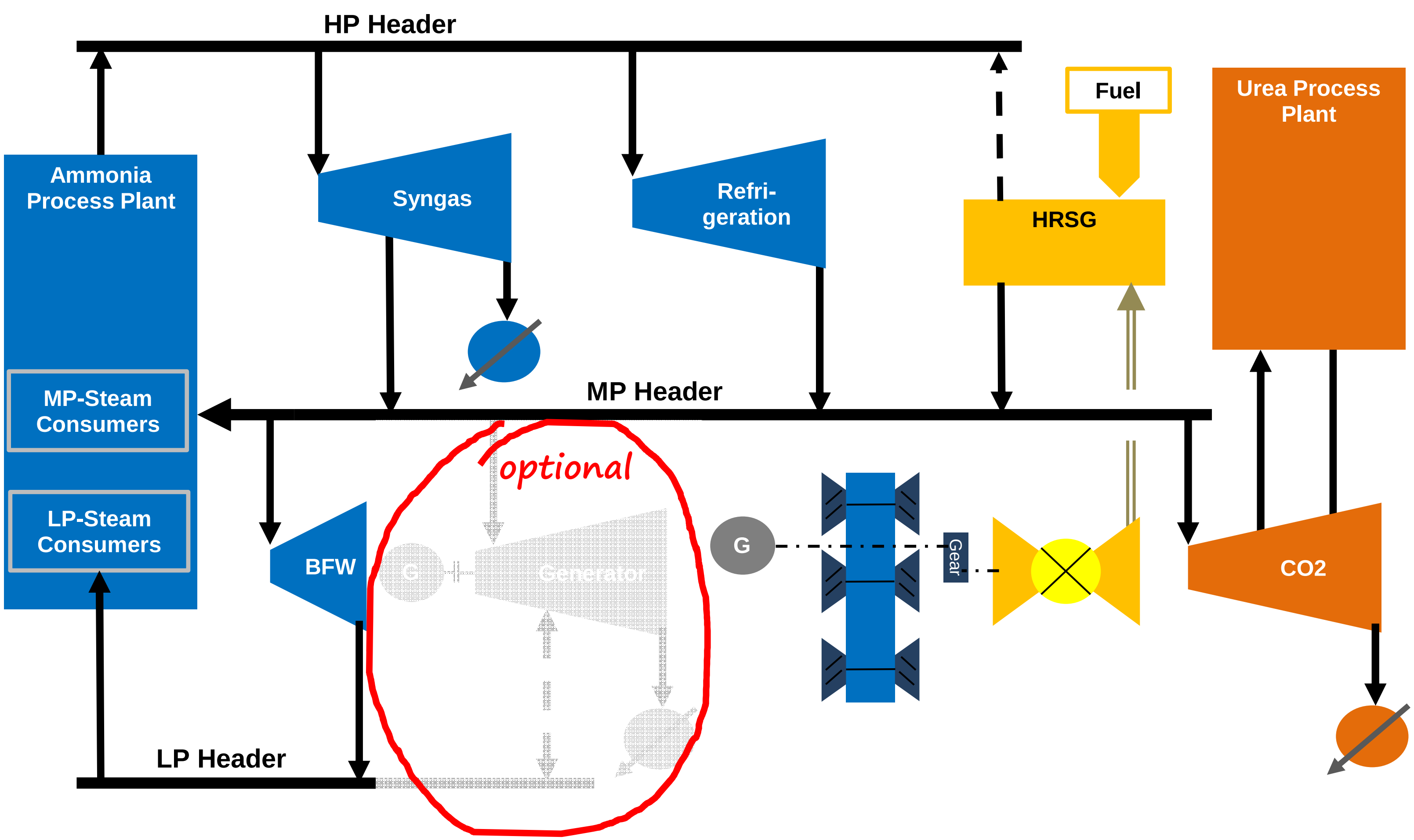
## Option #1: GT as Driver for Process Air Compressor

- Energy flow diagram: left side unchanged – right side changed



# Energy consumption for ammonia/urea production

## Option #2: GT as Driver for PAC and Generator



# Energy consumption for ammonia/urea production

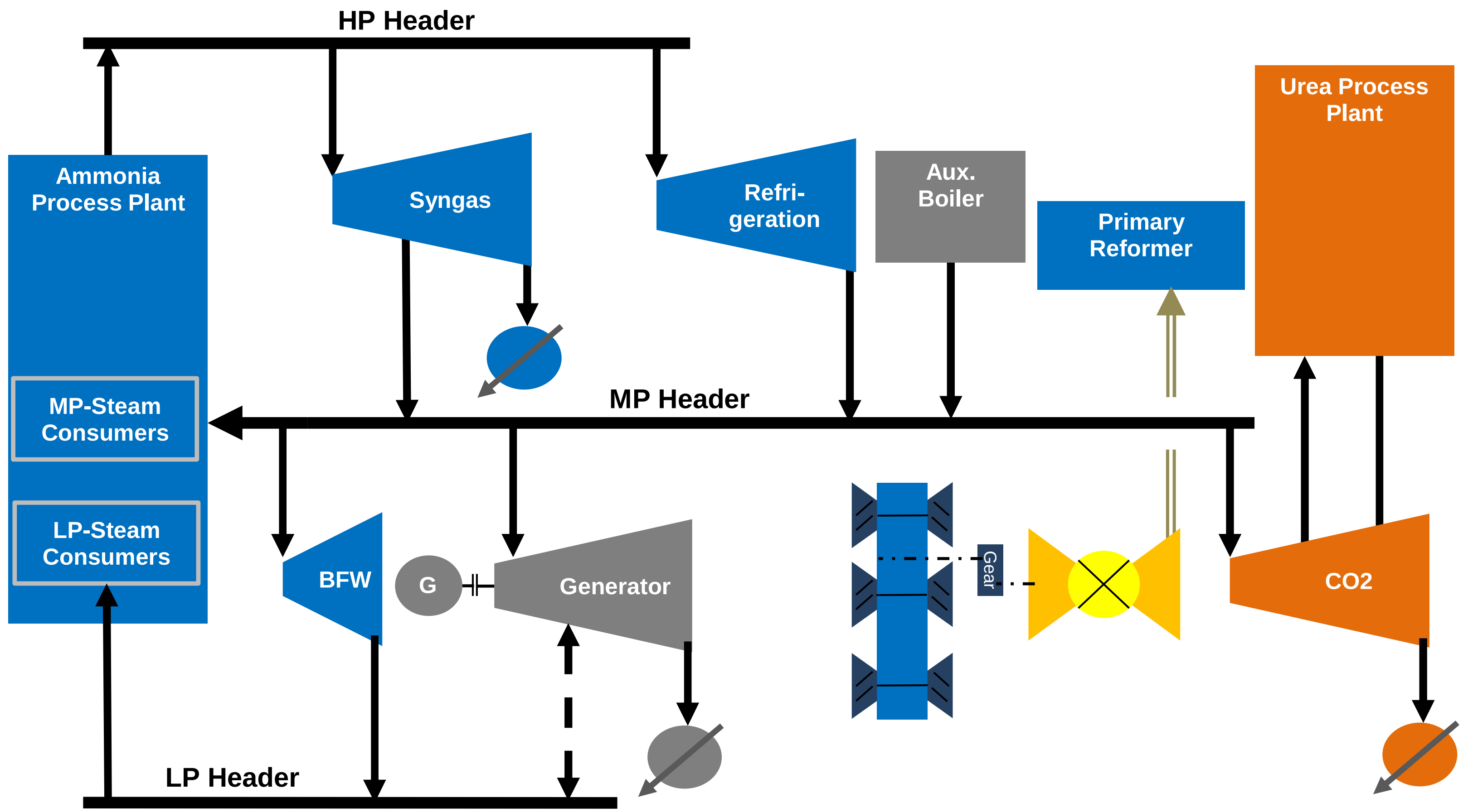
## Option #2: GT as Driver for PAC and Generator

Idea: Steam system of option #1 is very efficient – increase its efficiency by use of even larger gas turbine and HRSG.

- Steam system similar to option #1
- Consumer for the additional shaft power is a generator on same shaft with the process air compressor
- Generator running at fixed speed: need to use a gear type air compressor
- Gas turbine waste heat for steam generation
- Eliminates need for auxiliary boiler in normal operation

# Energy consumption for ammonia/urea production

## Option #3: GT at Process Air Compressor, Flue Gas to Reformer



# Energy consumption for ammonia/urea production

## Option #3: GT at Process Air Compressor, Flue Gas to Reformer

Difference to Options #1 to #2: No steam generation from GT waste heat, but exhaust gas (about 16 % oxygen) used as combustion air in prim. reformer

- Changes to steam system <u>and</u> process (reformer comb. air and flue gas)
- Eliminates reformer combustion air preheater:
  - More low-temperature waste heat available at the end of the reformer flue gas duct (which in other processes is used for air preheating)
  - Hard to find a use for it – if flue gas temperature gets higher, also losses get higher than in other Options
- Disadvantage: necessary to install GT close to reformer
- Disadvantage: linking process air compressor operation to reformer operation: any process air compressor problem impacts the reformer
- Therefore, Option #3 is not recommended. The good consumption figures of option #3 can also be reached by other gas turbine steam systems

# Energy consumption for ammonia/urea production

## Check for Application of Options #1 to #4 to Existing Plants

| Gas turbine | Advantage (+) / disadvantage (-) | |
|---|---|---|
| Option #1:<br>Driver for process air compressor (single shaft or gear type) | +<br>o | Can be applied to revamp<br>Makes sense if PAC needs replacement |
| Option #2:<br>Driver for gear type process air compressor and power generator | +<br>o<br>o | Can be applied to revamp<br>Makes sense if PAC needs replacement<br>Makes sense if electricity can be used |
| Option #3:<br>Driver for PAC, exhaust gas as combustion air for primary reformer | - | Not suitable for revamp, complete change of reformer combustion air and flue gas system |

# Energy consumption for ammonia/urea production

## Improvement of Steam System

Why is it so difficult to improve the efficiency of the steam system?

- Efficiency of steam system determined by:
  - efficiency of its components
  - steam header conditions: Lower T makes system inherently inefficient:

| | | Base Case | Lower header conditions 1 | Lower header conditions 2 |
|---|---|---|---|---|
| Superheated steam | | | | |
| Pressure | bar | 115.0 | 52.0 | 40.0 |
| Temperature | °C | 535.0 | 490.0 | 450.0 |
| Overall cycle efficiency | % | 30.0 | 27.6 | 26.4 |

- Header conditions are difficult to change
- The solution: Replacement of steam turbine by gas turbine also here can improve efficiency, with HRSG matching the existing header conditions

# Energy consumption for ammonia/urea production

## General Design Considerations for Application of Gas Turbines

- Steam production from GT exhaust: 1.9 – 2.2 t/h superheated 50 bar steam per MW shaft power – this plus the motive steam of the steam turbine which is replaced by GT is additionally available
- GT power output varies considerably with ambient conditions,
  e.g. temperature difference between winter and summer of 40 K
  $\Rightarrow$ 25 % change in power output
- Gas turbines are highly standardized. Adaptation to buyer's requirements is limited
- Gas turbines available for liquid or gaseous fuels
- Gas turbines require more maintenance efforts than steam turbines
- Time between scheduled maintenance stops depends on operating hours, number of starts / stops, and other
- Time between scheduled shut downs of up to 3 years possible

# Energy consumption for ammonia/urea production

## Summary

- Energy efficiency of modern ammonia / urea plants (based on steam reforming and conventional steam turbine drives) is already high
- Energy optimisation criterion: Is steam export is allowed or not?
  - Steam export not allowed: Keep energy inside the process, e.g. for preheating of process streams
  - Steam export allowed: fewer restrictions, improvement can also come out of steam system efficiency
- Gas turbine drives with waste heat utilization can significantly improve the energy efficiency by higher steam export from ammonia plant
- Existing plants: efficiency of steam system limited by given header conditions – very costly to change
- GT investment and maintenance cost higher than for steam turbine – but payback time only few years at high gas prices $\Rightarrow$ worth the investment

thyssenkrupp

Thank you for your attention!

Questions?

Comments?

christoph.meissner@thyssenkrupp.com
www.thyssenkrupp-industrial-solutions.com

# tkIS' Technology Services for Your Ammonia Plant

11.-14. April 2016 | Guenter Voelker
thyssenkrupp Industrial Solutions - Arab Fertilizer Association

engineering. tomorrow. together.

thyssenkrupp

# tkIS’ Technology Services for Your Ammonia Plant

- Performance Improvement (Revamps)
- Engineering Services (Service Agreement, Trouble Shooting, etc.)
- Engineering and Supply of improved Equipment and Spare Parts
- Ammonia Synthesis Catalyst / Cartridge Replacement

→ New Catalyst Loading Method for $NH_3$ Converter

# tkIS' Technology Services for Your Ammonia Plant

- Performance Improvement (Revamps)
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- Ammonia Synthesis Catalyst / Cartridge Replacement

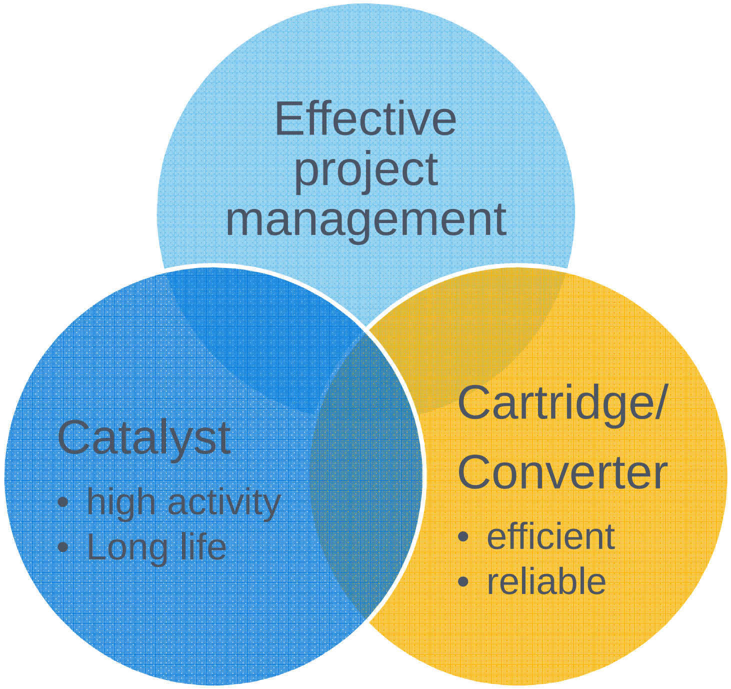
→ New Catalyst Loading Method for NH3 Converter

# Ammonia Synthesis Catalyst / Cartridge Replacement

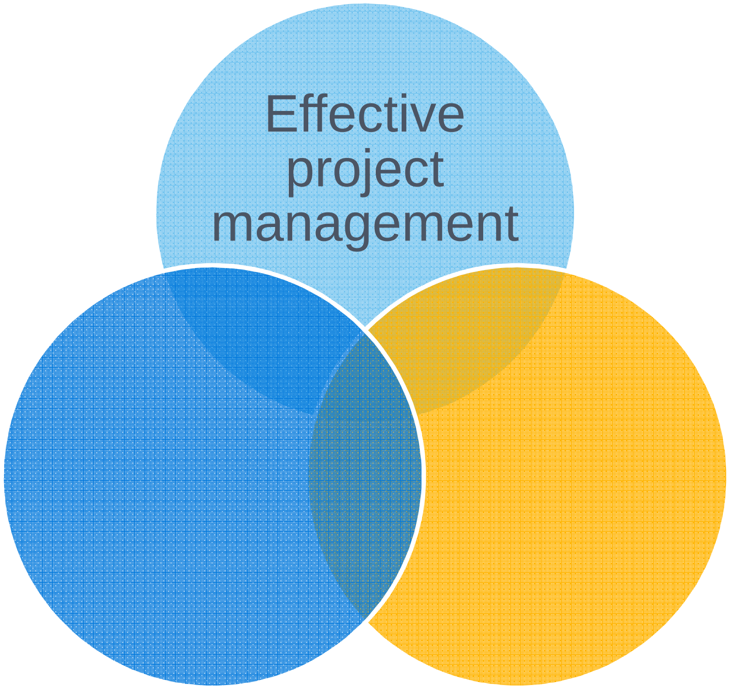
- a critical task during a turnaround ?

- Key item for the good plant performance
- Critical decisions before a turnaround
  What should be replaced?
  - Catalyst
  - Catalyst and cartridge / converter
- Critical path during turnaround
- Unfamiliar task
  - replacement every 10-20 years
  - complex reactor design
  - cost & safety risk

# Requirements for effective catalyst and cartridge replacement



# Requirements for effective catalyst and cartridge replacement



# Decisions

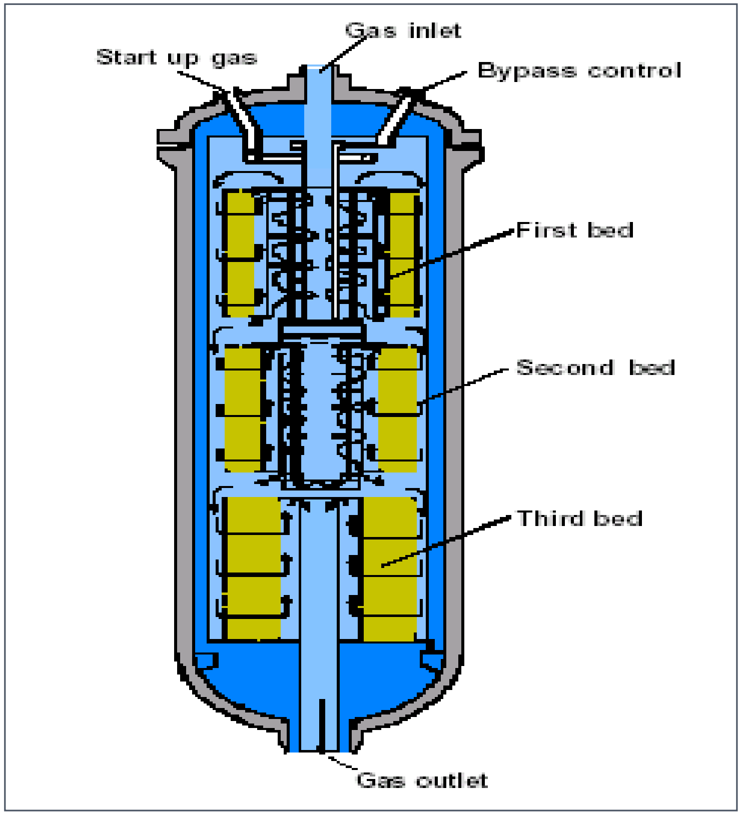
- Cartridge / Converter Shell
  - Inspect and repair
  - Replace
    - Same design
    - Improved design
- Catalyst
  - Standard catalyst such as **KATALCO$_{JM}$** 35 series
  - High activity catalyst such as **KATALCO$_{JM}$** 74 series
    - High activity does not always mean more production
    - Mechanical limits
- Debottlenecking

Process simulation required to quantify effect on syn loop as well as converter performance

# Ammonia Synthesis Catalyst / Cartridge Replacement

Effective Project Management required due to:

- schedule constraints
- many parties involved
- coordination of departments
- managing contractors and specialists
- high complexity of the task



# Ammonia Synthesis Catalyst / Cartridge Replacement

High Complexity → tkIS offers a **Full-Service-Package**:

- Project Management incl. Site Management
- Procedures and Method Statements
- Inspection of Internals and Shell
- Supply
  - Cartridge
  - KATALCO™ catalyst
  - Spare Parts & Tools recommended by tkIS specialists
- Catalyst Handling & Mechanical Works
- Performance Optimization

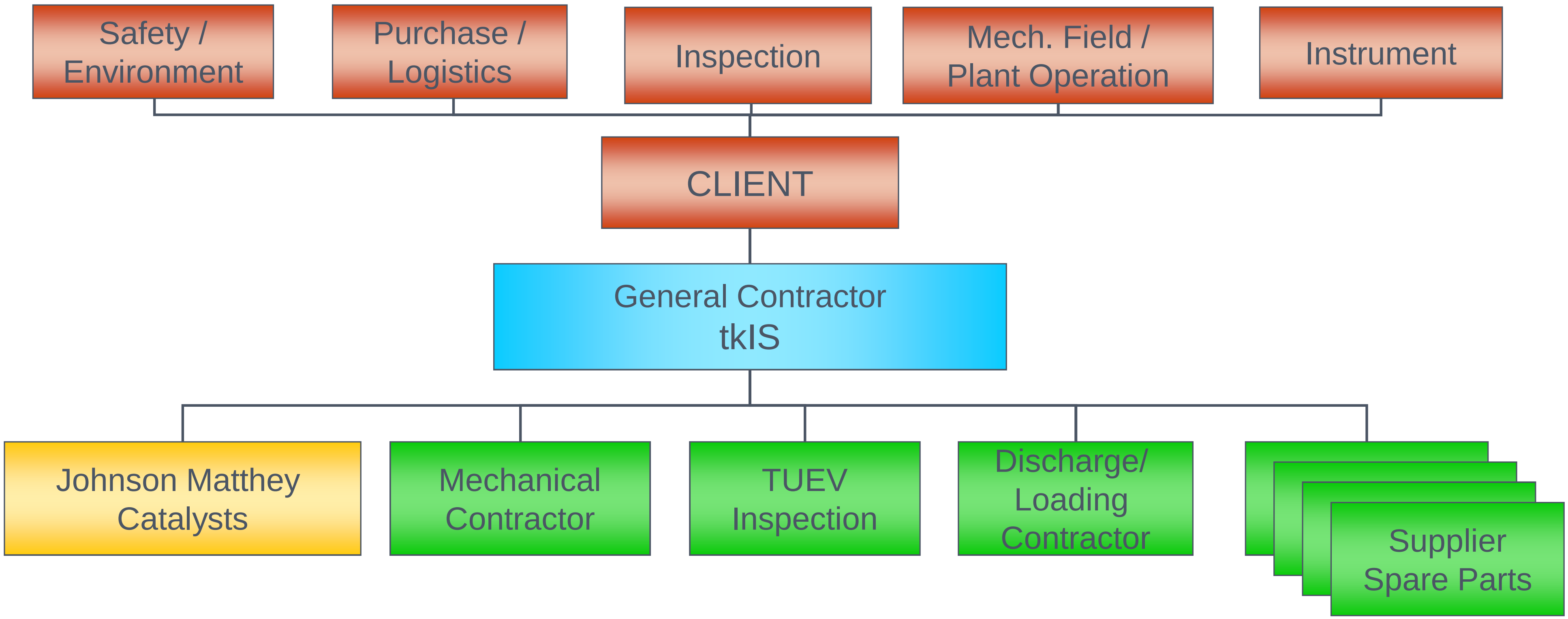
# Ammonia Synthesis Catalyst Replacement

**Sequence of Main Activities:**

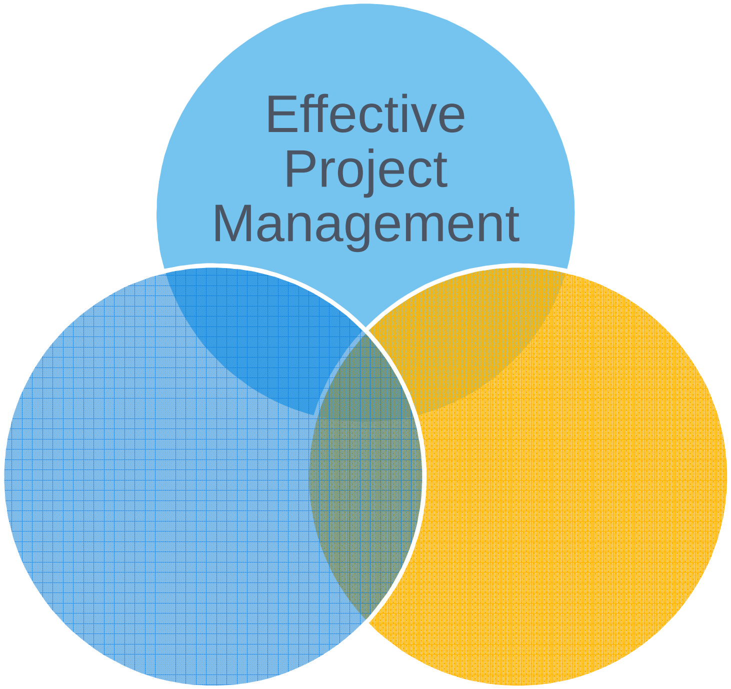
- Cooling down
- Nitrogen purging of synthesis loop
- Opening of converter
- Catalyst unloading and disposal
- Inspection & repair works
- Catalyst loading
- Closing of converter / boxing up
- Start up
- Performance test
- Optimisation

# Ammonia Synthesis Catalyst / Cartridge Replacement

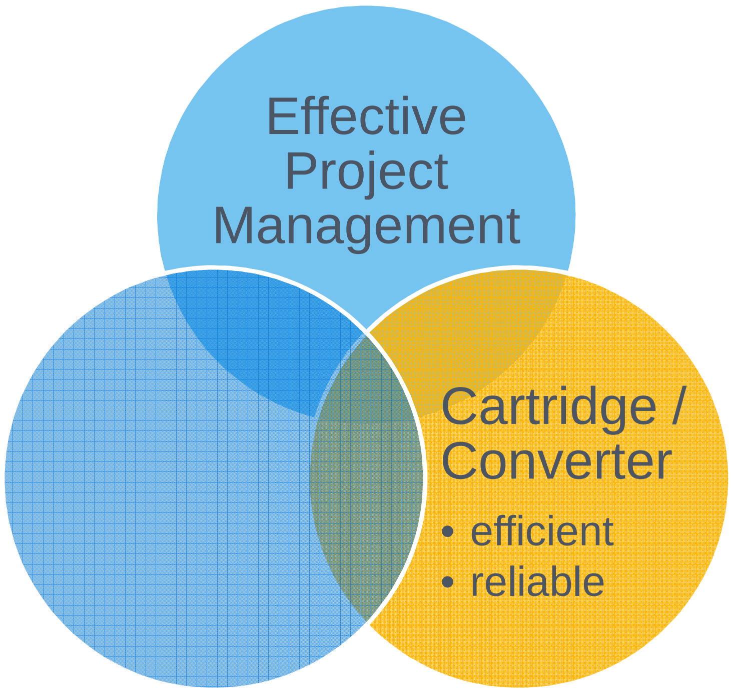
## Project Organization Chart – reflects execution concept



# Requirements for effective catalyst and cartridge replacement



# Requirements for effective catalyst and converter/cartridge replacement

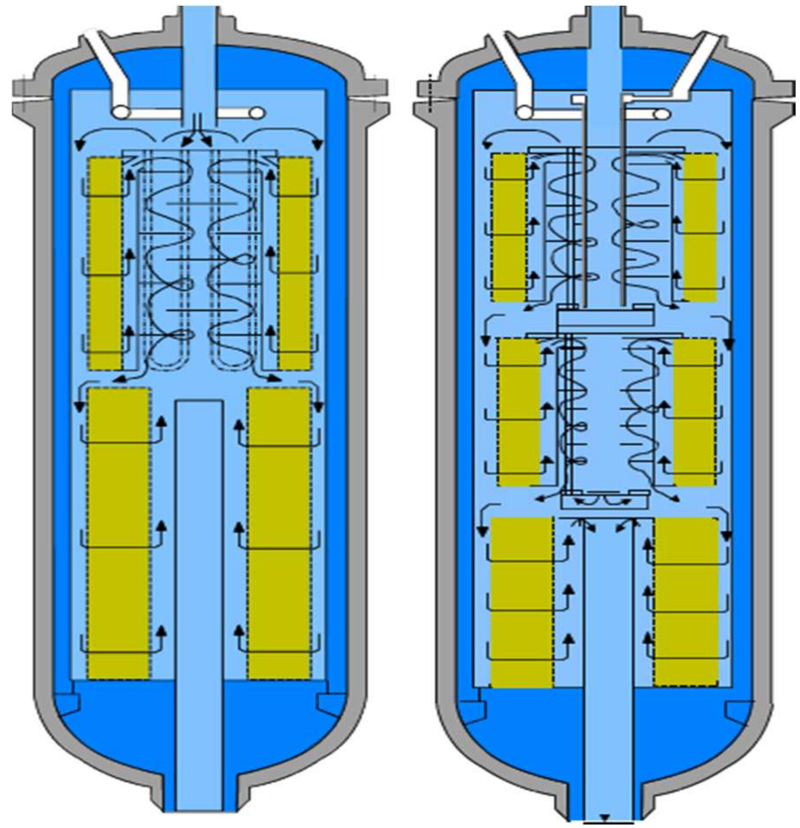


# Uhde ammonia converters

- First Uhde converter installed in 1927
- > 100 converters since 1950
- 20 second or booster converters
- 90 – 210 bar (in earlier times up to 475 bar) synthesis pressure range
- 20 – 3,300 tpd nameplate capacity range
- New and retrofit

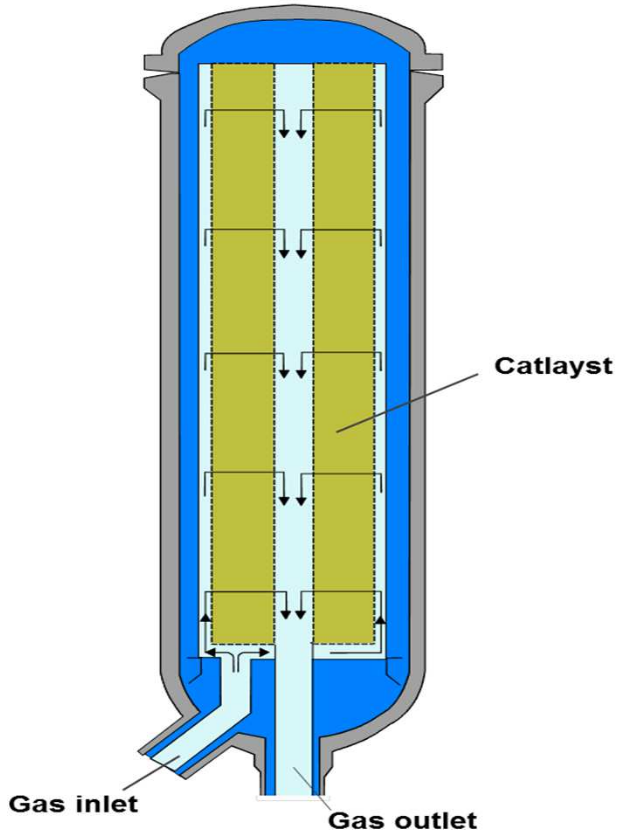
# Uhde 2 & 3 bed converters

- Simple and reliable design
- Radial flow
- Heat exchanger between catalyst beds
- Functional design / Easy Handling
  - Heat exchangers extractable without removal cartridge and catalyst
  - Comfortable access for catalyst removal without removing cartridge



# Uhde 1-bed converter

- Simple and reliable design
- Comfortable access for catalyst removal without removing cartridge
- Reasonable dimensions and weights even for high plant capacity
- Cold-wall design, no cooling gas stream necessary



# Continuous improvement

- Better use of cartridge volume
  - Capacity increase and/or
  - Lower synthesis loop pressure
- Effective gas mixing at the catalyst outlet
  - Mild conditions for the catalyst
  - Shorten the catalyst reduction time
- Mechanical improvements
- Faster and easier catalyst charging
  - Reduce shutdown times

# Converter Reliability Highlights

- Can withstand a Turkish earthquake!
- No damaged converter shell in Uhde history
- Qafco IV ammonia converter (YOB 2004; nameplate 2.000 t/d; original design)
  - 2,395 t/d average production (2009-2012)
  - 0.98 onstream factor (2009-2012)

# tkIS‘ Technology Services for Your Ammonia Plant

- Performance Improvement (Revamps)
- Engineering Services (Service Agreement, Trouble Shooting, etc.)
- Engineering and Supply of improved Equipment and Spare Parts
- Ammonia Synthesis Catalyst Replacement

  → **New Catalyst Loading Method for $NH_3$ Converter**

# Conventional Catalyst Loading Method  and Motivation for Change

## Catalyst Loading by Vibration

Two steps:

1. Manual filling of catalyst in layers of 30 cm via hoses – bulk density 2.3 to 2.7 kg/l
2. Vibration – bulk density 2.8 to 3.0 kg/l

→ time-consuming (vibration for one layer >60 min! → Loading rate of ~3 t/h)
→ time critical path during plant turnarounds

Photos: R. Michel (TKUhde)

# Idea: Catalyst Filling by Dense Loading

Final Density in One Step

## Catalyst Filling by Dense Loading

One Step:

- Continuous loading with “single” distribution of particles over cross-sectional area
- Enough time for random orientation →”dense packing”

Advantages of Dense Loading:

- Higher loading rate
- Higher bulk density

# Challenges for Catalyst Loading in $NH_3$ Converter

- **Challenges for catalyst loading:**

  Reactor internals: 3 thermowells, cover plates,

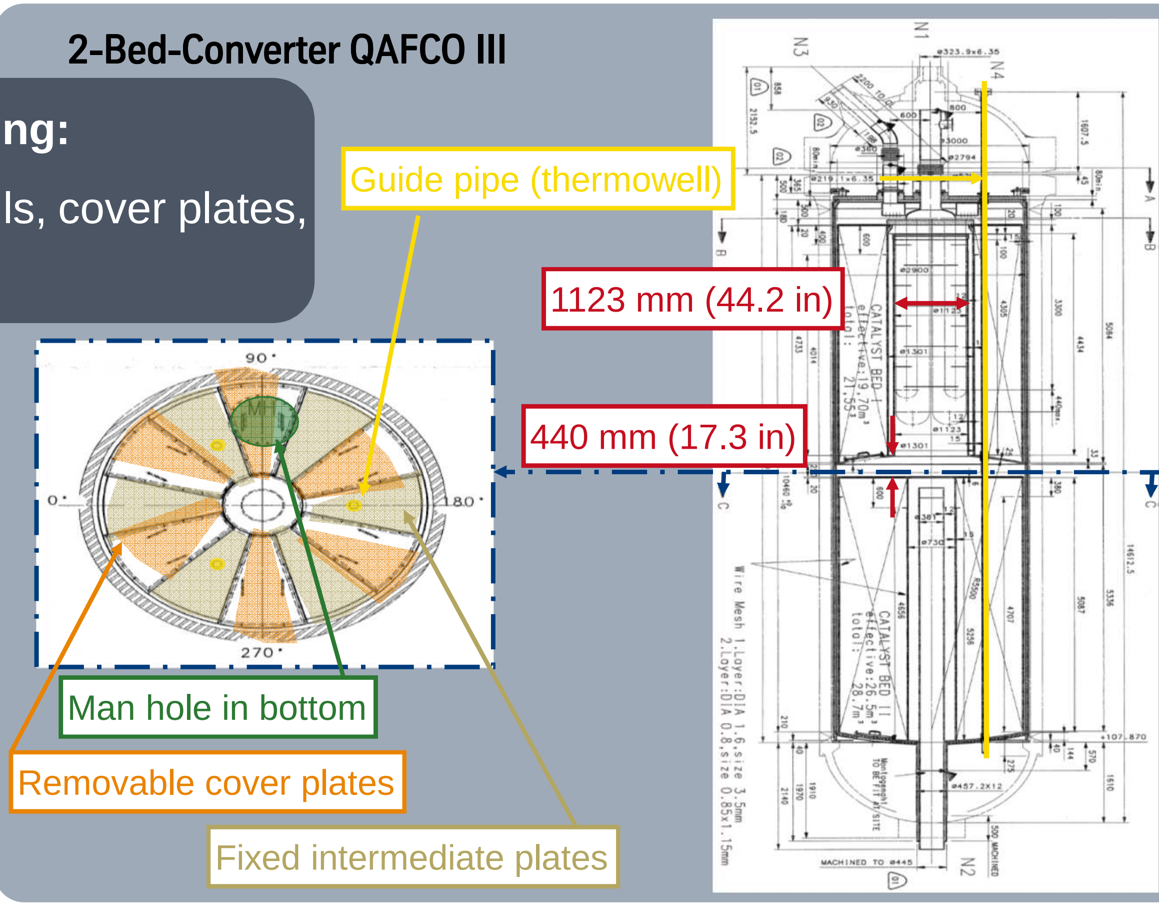
  Confined space between beds

Limited Access

**Idea:**

Development of new loading method for $NH_3$-Converter

**2-Bed-Converter QAFCO III**



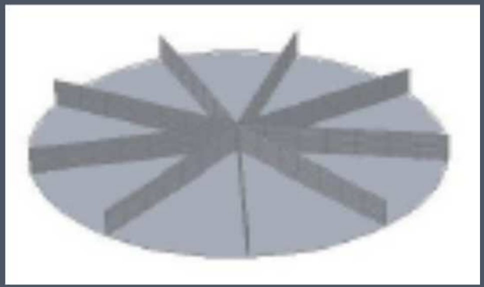
## Starting Development Project "New Loading Method"

### Diploma Thesis 2011

- Concept study of a new $NH_3$ converter loading method
- Main aim: increase loading rate

→ Most promising solutions / devices

a) Static head

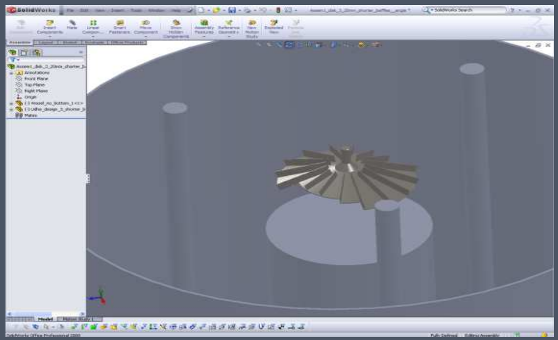


b) Rotating device (spreader)

### Simulation Programme 2012

- Task: Further development of devices
- Improve geometries and performance

a) Static head



b) Rotating device (spreader)

# Experimental Set-up in Billingham / UK 2012

Loading hopper

Crane

Lifting hopper

forklift

Technical scale test reactor Ø 2m, H 3m

Platform for loading of lifting hopper

$KATALCO_{JM}$ 35-4A

Photos: L. Porz (TKUhde)

# Simulations and Experiments for Static Head

## Discrete Element Method Simulations
**R**ing **S**hadow **K**iller (RSK)

7 different geometries simulated

Simulations: M. Marigo (JM)

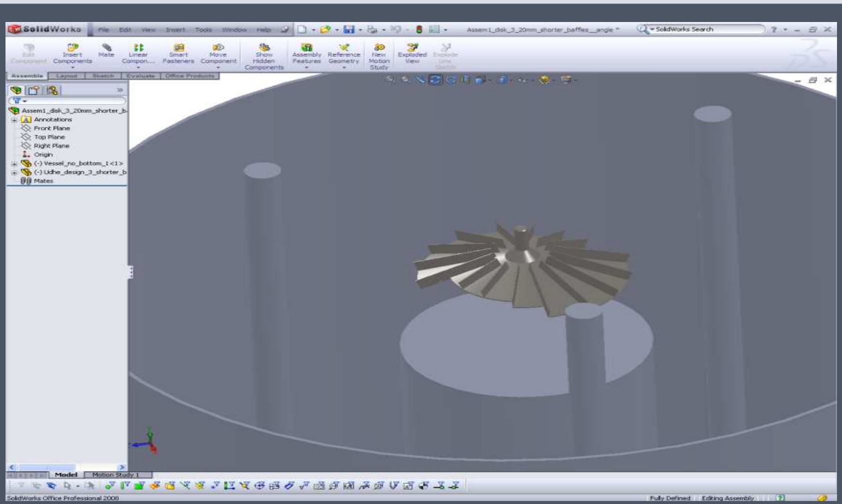
## Experiments
**R**ing **S**hadow **K**iller

3 RSKs on a turning ring
with tangential spacing of 120°

Photo/ Film: L. Porz (TKUhde)

# Simulations and Experiments for Spreader

Discrete Element Method Simulations
**Spreader**



Screenshot of disc #4 simulation

5 different geometries simulated

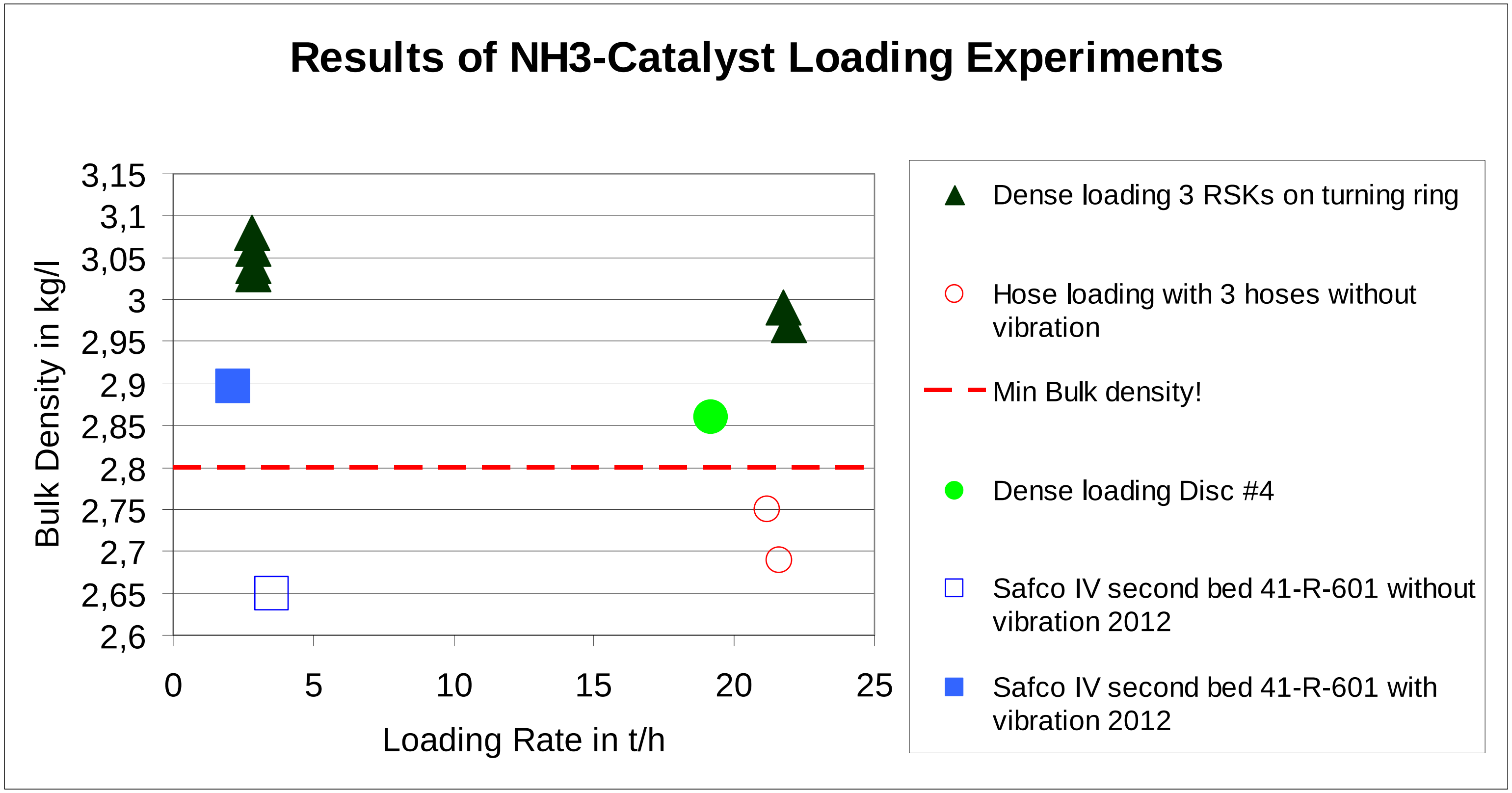
Simulations: M. Marigo (JM)

Experiments
**Spreader**

Spreader with rotating disc:
- continuous speed control
- reversible rotation direction to avoid shadow effect

Photo/ Film: L. Porz (TKUhde)

# Results of Experiments



# Comparison of Old and New

| | Vibration method | Uhde / JM Dense Loading (NEW) |
|---|---|---|
| **Method** | discontinuous:<br>1) 30 cm loaded with hose<br>2) each layer vibrated for approx. 1 h | continuous:<br>two different methods:<br>a) static head<br>b) rotating spreader |
| **Bulk density** | 2.8 to 3 kg/l after vibration ✓ | 2.8 to 3 kg/l ✓ |
| **Loading rate** | ~ 3 t/h<br>~ 1 m³/h<br>inclusive vibration ✗ | 15 to 20 t/h<br>~ 5 to 7 m³/h ✓ |

Photos:R. Michel and L. Porz (both TKUhde)

## Summary of Development Project

Low loading rate with vibration method (~3 t/h)

New dense loading method:

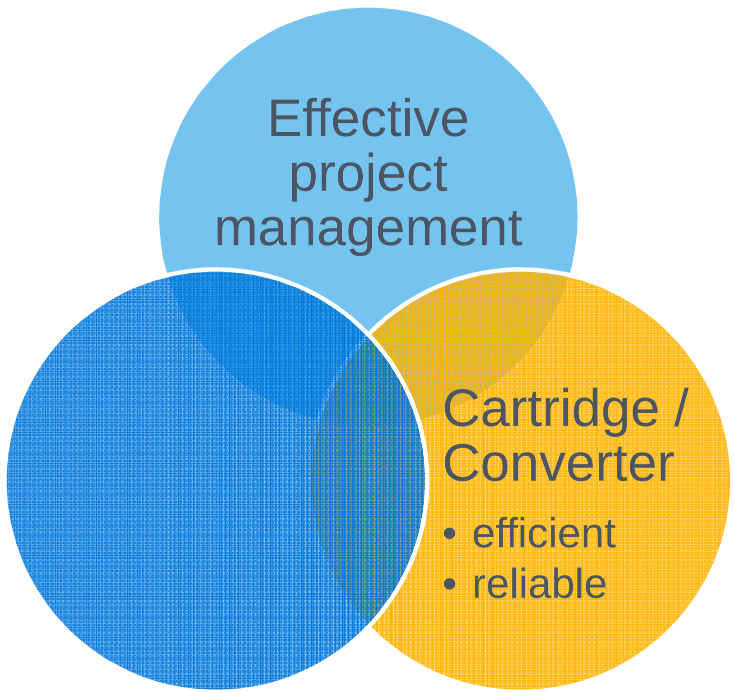
→ bulk densities ≥ 2.8 kg/l

→ loading rate ≥ 15 t/h

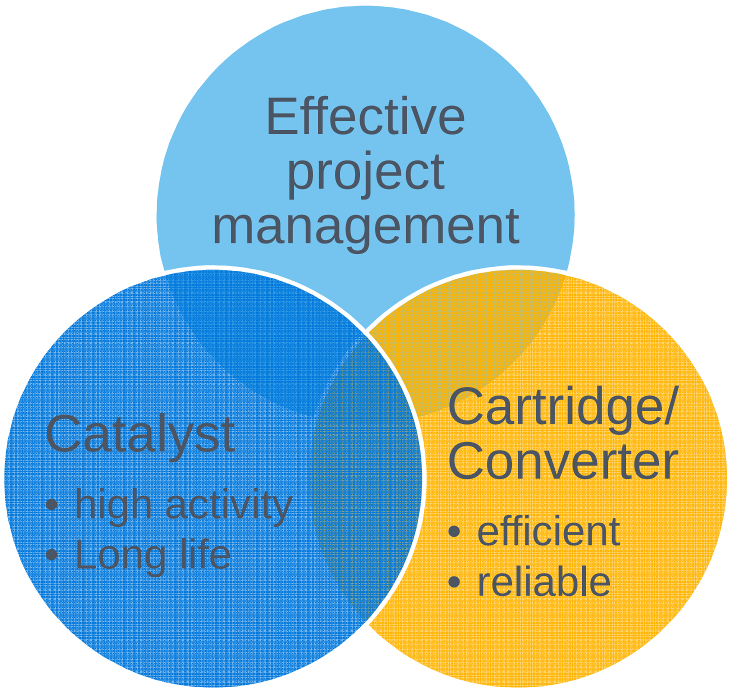
YOU save time and money on turnarounds

Successful loading of 5 commercial reactors

# Requirements for effective catalyst and converter/cartridge replacement



# Requirements for effective catalyst and converter/cartridge replacement



# Ammonia synthesis catalyst – heritage Johnson Matthey

1913 converter

BASF
The Chemical Company

1913–2013
100 YEARS
AMMONIA
SYNTHESIS

2014 ammonia converter using

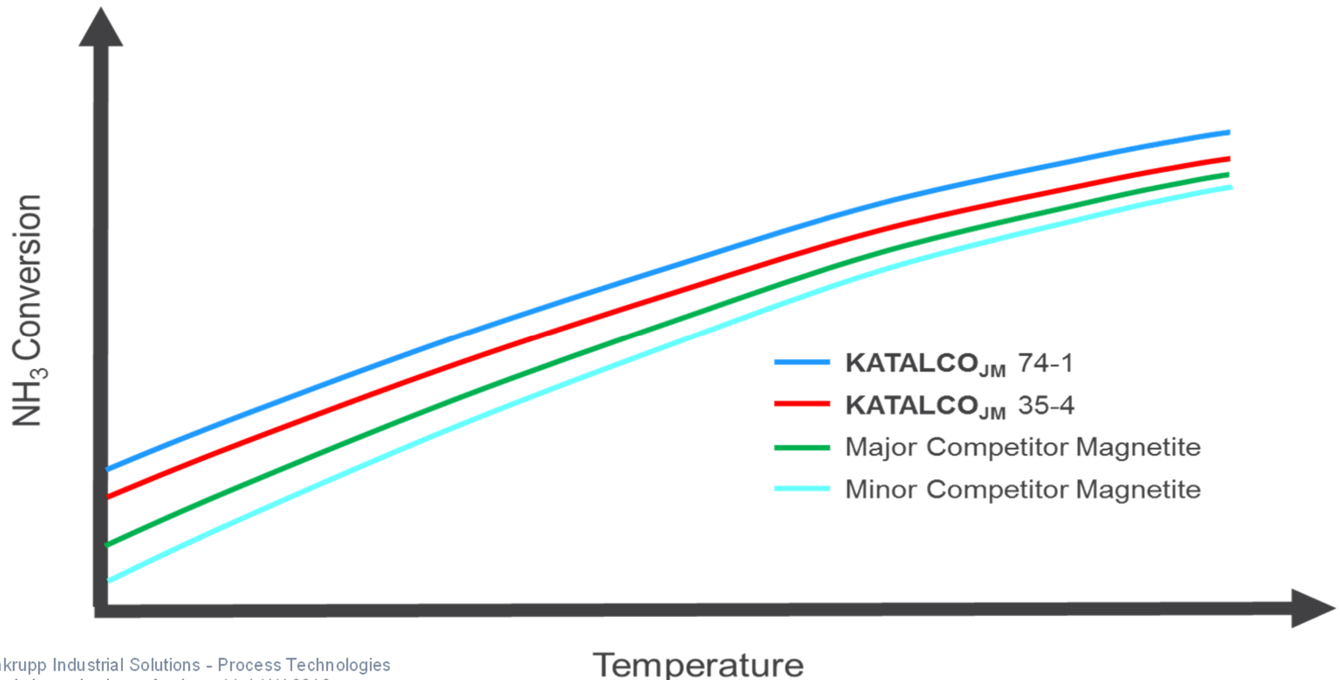
**KATALCO**$_{JM}$ 35-series magnetite



**Images courtesy of BASF**

# Magnetite based catalysts

- Generically called “conventional magnetite”
- BUT magnetite catalysts are NOT “all the same”!

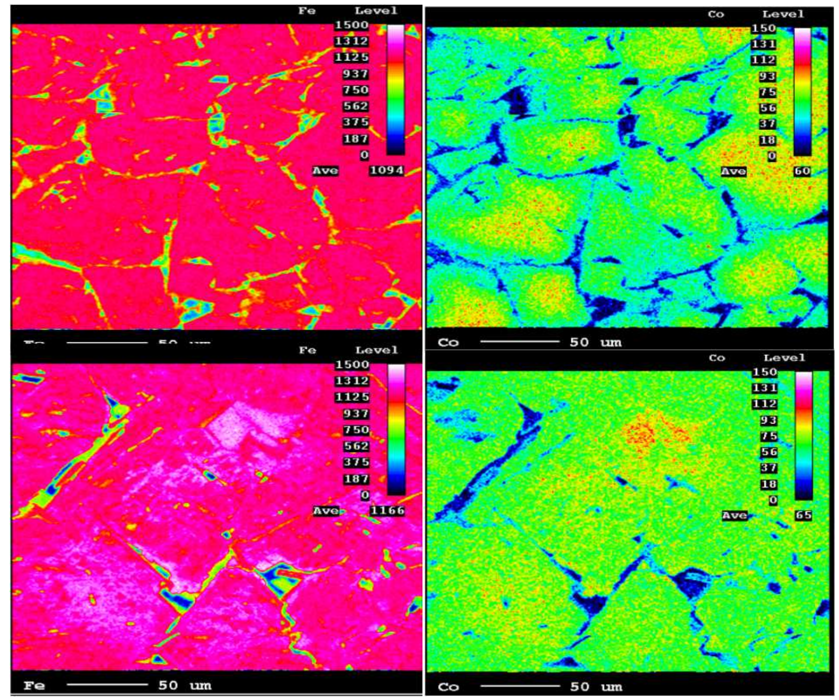


# Promoters in KATALCO$_{JM}$ 74-series

- SEM Images of 74-1
  - Bulk magnetite material shows significant cobalt incorporation
  - Between the magnetite grains show no cobalt.

- Cobalt enters the magnetite lattice and remains after reduction
  - Increases nitrogen adsorption
  - Increases activity (N2 dissociation)
  - Increases ammonia desorption

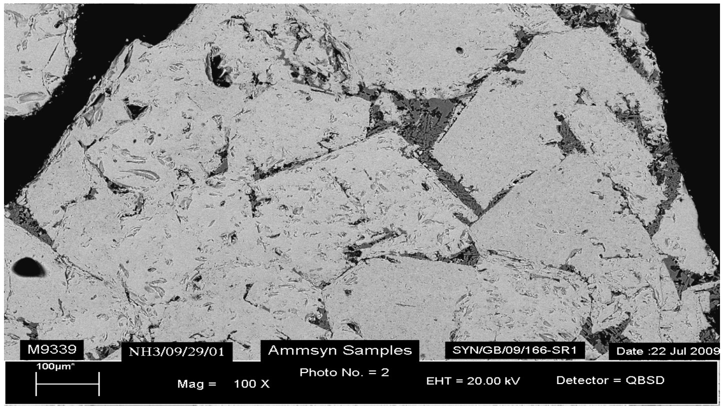
74-1 (oxidic) Fe map | 74-1 (oxidic) Co map

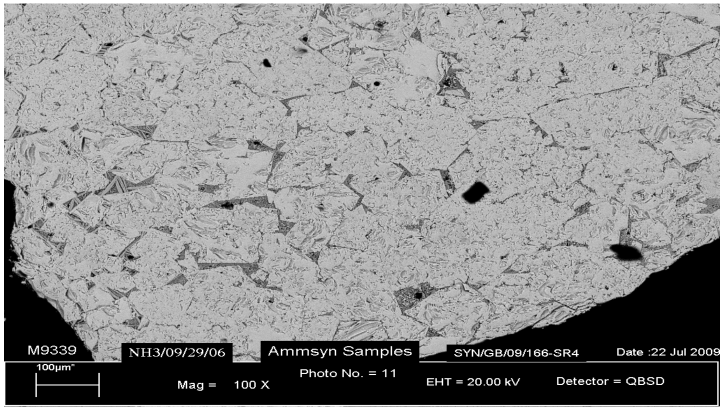



74-1R (reduced) Fe map | 74-1R (reduced) Co map

# KATALCO$_{JM}$ 74-1 crystal structure

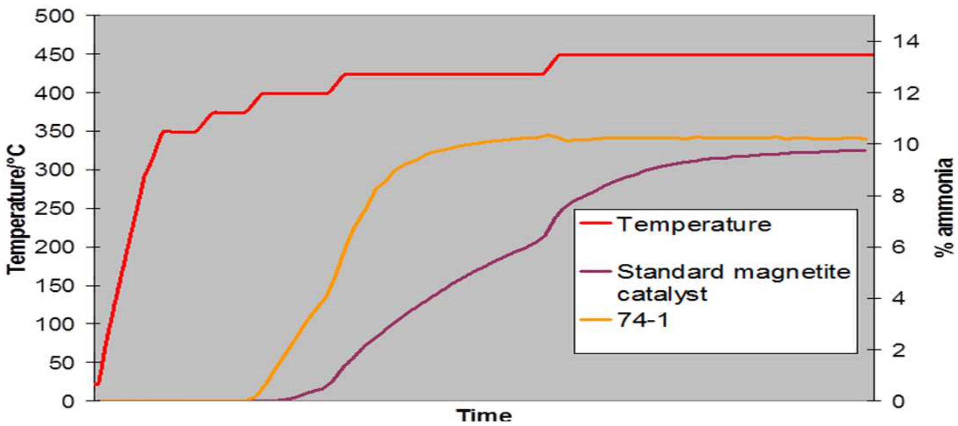
- Bottom SEM shows smaller iron oxide crystal size of KATALCO$_{JM}$ 74-1 compared to standard catalyst

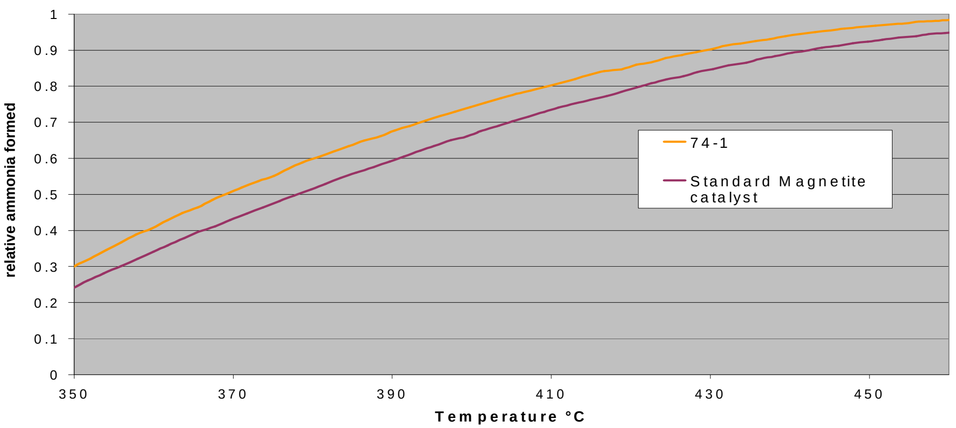


# KATALCO$_{JM}$ 74-1: performance

- Consistently higher activity throughout catalyst lifetime
- Lower temperature reduction
- Lower strike temperature
- Long lifetime
- **The highest activity iron catalyst available**
- **Proven at low pressure**
- **Proven at higher pressures**



# Proven performance – ammonia synthesis catalysts

= **KATALCO$_{JM}$ 35-series**

= **KATALCO$_{JM}$ 74-series**

## Uhde converters and JM catalysts

- Installed in world's largest ammonia plant
- Installed in world's most efficient ammonia plant
- Installed in low and high pressure applications
- Catalyst life in excess of 20 years and still going
- Oldest known converter still in service is from 1969

***The lowest risk, highest performance, option for your plant***

# Ammonia Synthesis Catalyst / Cartridge Replacement

## Summary

Ammonia synthesis catalyst / cartridge replacement is:

- a non routine and complex task
- on the critical path of a shutdown
- vital to plant performance

## Benefits for customers:

- Full-Service-Package from General Contractor
- Fast Execution within cost budget and time schedule
- Performance Guarantee for Ammonia Converter
- Seamless partnership with the world's leading Syngas catalyst supplier

# tkIS’ Technology Services for Your Ammonia Plant

## Overview

- Ammonia Synthesis Catalyst & Cartridge Replacement
- Performance Improvement (Revamps)
- Engineering and Supply of improved Equipment and Spare Parts

## Performance Improvement (Revamps)

### Why Revamp?

- Improve annual production
  - higher on-stream time
  - improvement of daily capacity
- Improve energy efficiency
- Extend remaining lifetime
- Improve plant reliability
- Reduce emissions

# Performance Improvement (Emission Reduction)

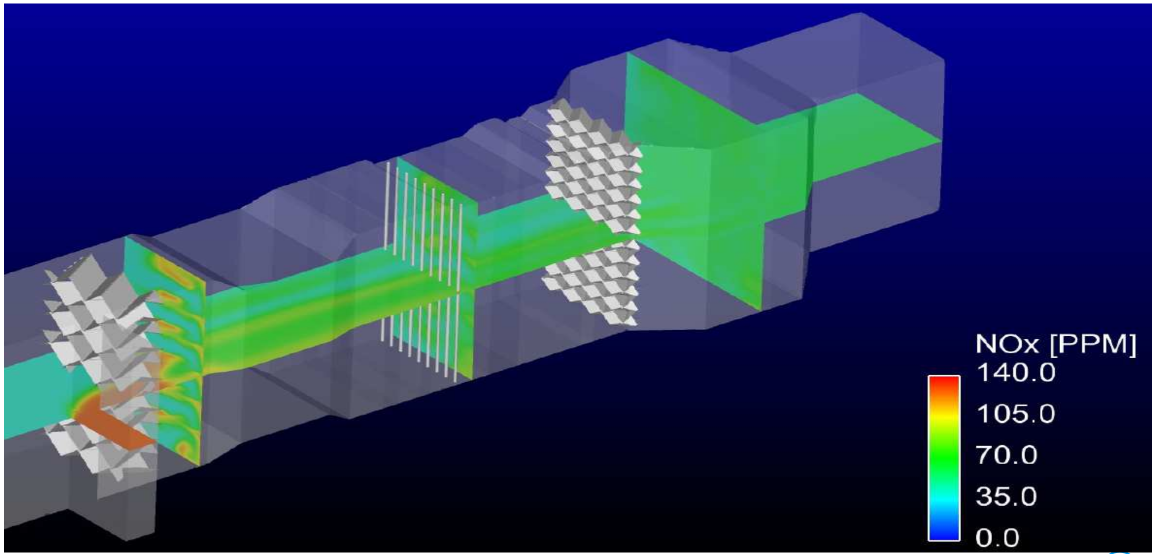
## Reduction of NOx-Emissions from Ammonia Plants

tkIS' Reformer Technology SCR & SNCR

→Selective Catalytic Reduction Process (SCR) & Selective Non Catalytic Reduction Process (SNCR)

- **Reaction:** $4\ NO + 4\ NH_3 + O_2 \Rightarrow 4\ N_2 + 6\ H_2O$
- **SNCR:**
  - uses NH4OH as chemical
  - lower investment and operating cost than SCR
  - small space requirements
- **SCR:**
  - uses NH3 or NH4OH/Urea as chemical
  - lower NH3-consumption
  - higher NOx- reduction
  - lower NH3-slip
  - catalyst lifetime between 3 to 7 years

CFD-Model of SCR-Unit, NOx Profile



# Performance Improvement (Emission Reduction)

## Urea Plant – Type and Frequency of Emission

**Type of Emissions**

→Urea dust (from granulation plant)

→Ammonia (from synthesis and granulation plant)

**Frequency of Emissions**

→ Emissions during normal operation

→ Emissions from tank vents and safety valves (PSVs)

→ Emergency releases

# Performance Improvement (Emission Reduction)

## Urea Plant Emission – Mitigating Measures

| | |
|---|---|
| Continuous emissions | ⇨ Water scrubbing (dust)<br>⇨ Acidic scrubbing (ammonia)<br>⇨ ~~Flaring~~ -> negative environmental balance<br>-> continuous consumption of nitrogen and fuel gas |
| Vents from tanks and PSVs (ammonia containing) | ⇨ Vent stack (standard)<br>⇨ Acidic scrubbing<br>⇨ Flaring |
| Emergency emissions (tube rupture in HP equipment) | ⇨ Vent stack<br>⇨ Water or acidic scrubbing<br>⇨ Flaring |

**Most appropriate mitigation measure depend on applicable requirements and risk evaluation!**

# Performance Improvement (Revamps)

## Capacity Increase

### Ammonia Plant Revamps

- Case 1: Capacity Increase by 10-15 %
- Case 2: Capacity Increase by 30 %
  - Syngas Generation: stand-alone ATR parallel to existing syngas generation
  - Ammonia Synthesis: Uhde’s Dual-Pressure Concept

    + minimum interference with existing plant → short shutdown time

See presentation “*Increase of Production Capacity of Existing Ammonia Plants*” *in Session VI*

# Performance Improvement (Revamps)

## Remaining Lifetime Assessment / Fitness for Service Evaluation

- a methodical engineering evaluation

→ to assess the projected remaining life of equipment

→ to assess the structural integrity of an in-service component

- to help ensure that equipment can continue to operate safely
- limited to equipment in vital and essential duty
- results in Long Term Asset Replacement Plan

**→ to support run-repair-replace decisions**

# Performance Improvement (Revamps)

## Remaining Lifetime Assessment / Fitness for Service Evaluation

**FFS/RLA assessment includes the following steps:**

- Analysis of equipment condition
- Identification of flaw and associated damage mechanism
- Assessment procedure resulting in
  - an estimate of future damage of equipment
  - determination of inspection interval
- Determination of remediation methods for each equipment under review
- Cost calculation for the mutually agreed plant modifications

# Performance Improvement (Revamps)

## Remaining Lifetime Assessment / Fitness for Service Evaluation

**Final Report / Results of Assessment:**

- Selection of Equipment to be modified / replaced in the future
- Definition and specification of inspections, repairs and modifications
- Cost Estimate / Investment Plan for equipment modifications and replacements
- Documentation Package

**→ in order to ensure safe plant operation for a specified period**

# Performance Improvement (Revamps)

## Execution of a Revamp Job / Typical Time Schedule

4 - phases approach for project execution !

| | | |
|---|---|---|
| 1. Familiarization, pre- and final evaluation | 3 - 4 | months |
| incl. final study report | | |
| 2. Basic Engineering | 3 - 5 | months |
| 3. Detail Engineering and equipment supply | 13 – 20 | months |
| 4. Erection and start-up | 1 - 2 | months |
| | | |
| **Total execution time** | **20 – 30** | **months** |

# Performance Improvement (Revamps)

## Examples for Ammonia Plant Revamps by Uhde

| Plant | Year | Description |
|---|---|---|
| ABF;<br>Bintulu, Malaysia | 2010 | Extension of remaining lifetime<br>Equipment Supply by Uhde |
| Duslo;<br>Sala, Slovakia | 2007 | Capacity increase by 30 % to 1300 t/d (Uhde Dual Pressure Process)<br>Reduced energy consumption by 5 %<br>Basic engineering and proprietary equipment by Uhde |
| ABF;<br>Bintulu, Malaysia | 1990,<br>1997,<br>2003 | Capacity increase by 35 % to 1350 t/d in three steps<br>Reduced energy consumption by 8 % |
| BASF;<br>Antwerp, Belgium | 2002 | Capacity increase by 11 % to approx. 2000 t/d<br>Execution in parts by Uhde |

# tkIS' Technology Services for Your Ammonia Plant

## Overview

- Ammonia Synthesis Catalyst & Cartridge Replacement
- Performance Improvement (Revamps)
- Engineering and Supply of improved Equipment and Spare Parts

## Engineering and Supply of Equipment and Spare Parts

### tkIS as a Supplier – Benefits for Customers

tkIS offers the whole range of services:

Project Management, Engineering, Procurement and Commissioning of Equipment

➔ Access to tkIS' Engineering Skills:

+ Equipment Engineering ➔ Mechanical Guarantee !

+ Process Engineering ➔ Performance Guarantee !

+ Design improvements of equipment and new technological developments

➔ reliable state-of-the-art equipment !

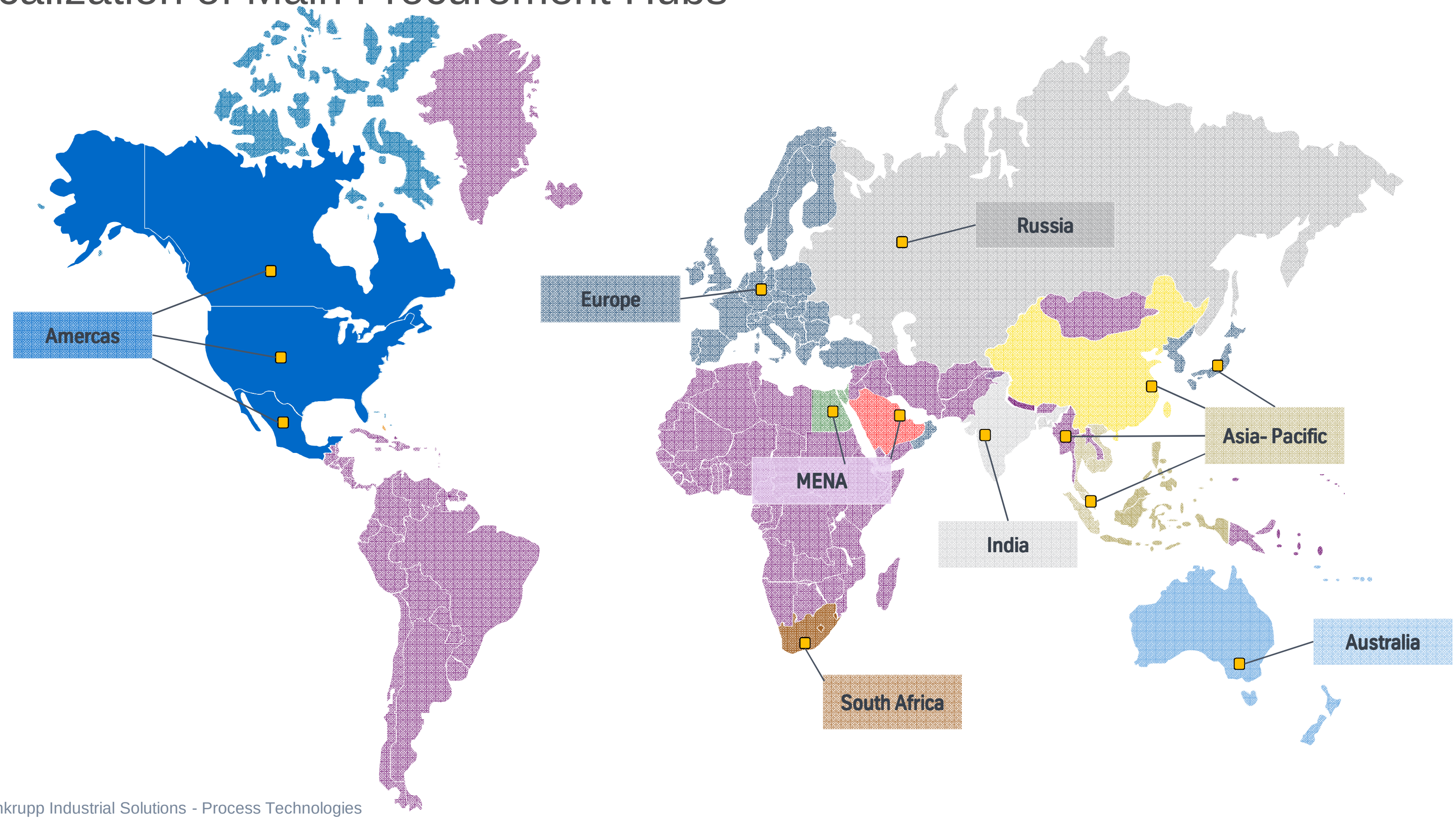
## Engineering and Supply of Equipment and Spare Parts

tkIS as a Supplier – Benefits for Customers

➔ Access to tkIS' Global Procurement organisation:

# TKIS BU PT - Global Procurement

## Localization of Main Procurement Hubs



# TKIS BU PT - Global Procurement

## Advantages of Global Procurement Organisation

- 14 offices with more than 250 employees in procurement interconnected in a global network of TKIS PT with one billion Euro purchasing volume per year
- Harmonized procedures
- Standardized tool set
- One face to the manufacturer
- Best and direct market intelligence
- Shorter response times for purchasing, expediting and inspection
- Utilization of regional teams to ensure high quality and schedule compliance

# Engineering and Supply of Equipment and Spare Parts

## tkIS as a Supplier – Benefits for Customers

➔ Access to tkIS' Global Procurement organisation:

+ Professional buyers, quality inspectors and logistics experts ensure

  reliable, quality-conscious, global, just-in-time sourcing

+ Extensive expediting and inspection ➔ Supply with guaranteed delivery time and quality !
+ Long-term relationship with manufacturers for critical equipment
+ Knowledge of strengths and weaknesses of manufacturers
+ Favourable purchase conditions due to huge purchasing volume
+ Emergency supplies due to excellent contacts with suppliers

# Engineering and Supply of Equipment and Spare Parts

## tkIS as a Supplier – Benefits for Customers

### Typical Scope of Services for Engineering and Procurement of Equipment

1. **Scope of Supply**

   Delivery of 1 pc. Equipment

   Delivery of Procedures for Shutdown Activities

2. **Scope of Engineering Services**

   Project management and coordination activities

   Equipment engineering, incl.

   - preparation of order specification
   - review and approval of manufacturer's documents
   - inspection and expediting at manufacturer's workshop

3. **Supervision Services on site during shutdown**

# tkIS' Technology Services for Your Ammonia Plant

## Summary

- Performance Improvement (Revamps)
- Engineering and Supply of improved Equipment and Spare Parts
- Ammonia Synthesis Catalyst & Cartridge Replacement
  - ✓ New Catalyst Loading Method for NH3 Converter

In co- operation with

thyssenkrupp

# AFA WORKSHOP

## Operation and Maintenance Optimization

Jordan - Aqaba: 11-14 April, 2016

# Session 6

Sponsors:

Arab Potash

Jordan Phosphate Mines Co.

Indo Jordan Chemicals Co.

NJFC

Nippon Jordan Fertilizer Co.

KEMAPCO

KEMAPCO Arab Fertilizers & Chemicals Industries Ltd.

# Challenges in integrated AN Complexes

## AFA Conference Aqaba 2016

13th April 2016 | Dr Jens Mathiak
thyssenkrupp Industrial Solutions

engineering.tomorrow.together.

thyssenkrupp

# Challenges in integrated AN Complexes

## Table of Contents

# Challenges in integrated AN Complexes
## Introduction

Development approach considers usually total life cycle assessment:

**CAPEX**

| | |
|---|---|
| Investment: | Client (owner's cost)<br>Contractor's cost |
| Execution time: | Time to market |

**OPEX**

Plant concept and configuration

Raw material consumption (plant efficiency)

On-stream time (availability)

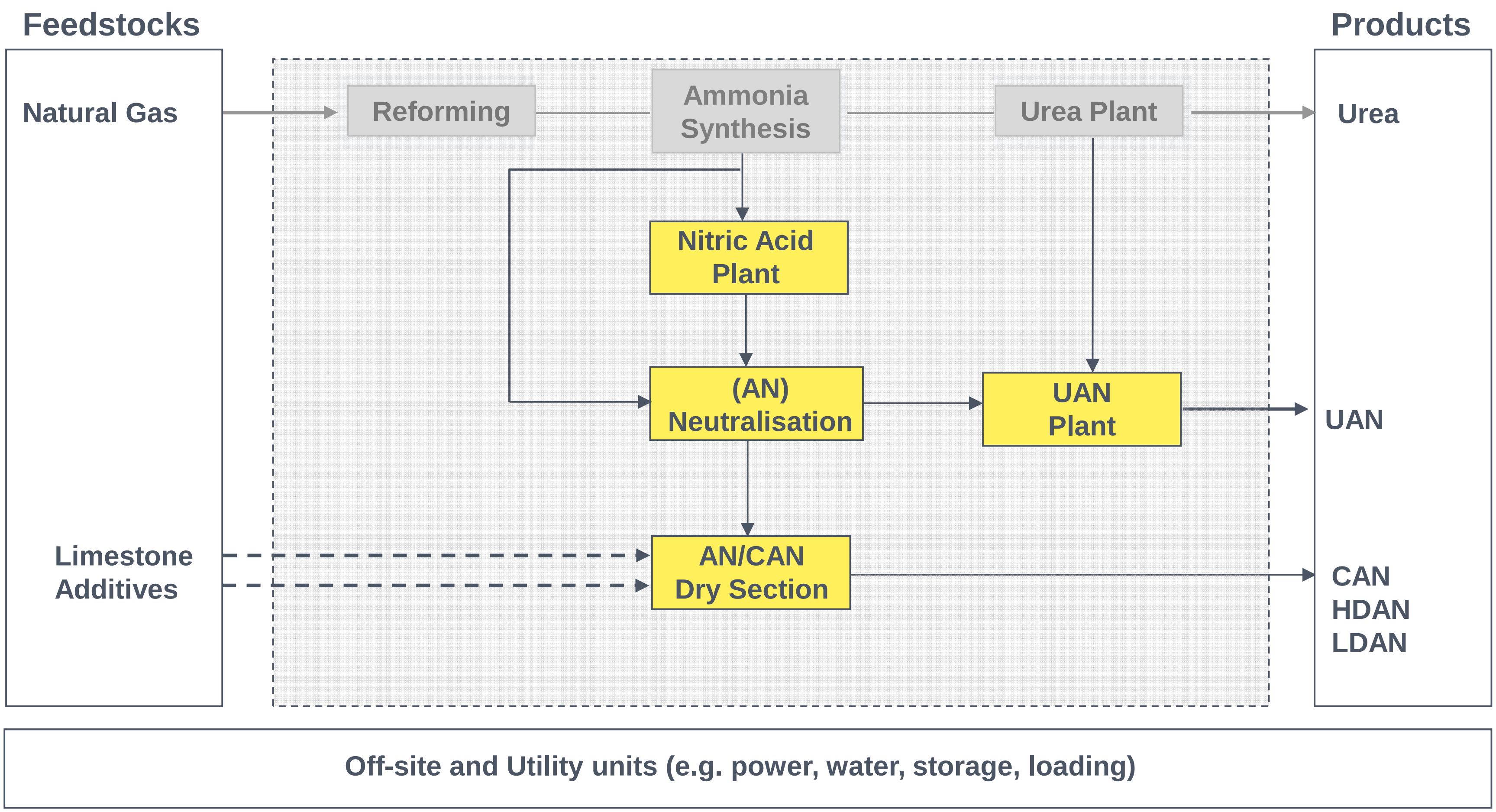
Operating and maintenance cost

Emissions (certificates)

Financial services and cash flows

# Challenges in integrated AN Complexes

## Introduction



# Challenges in integrated AN Complexes

## Integration Opportunities

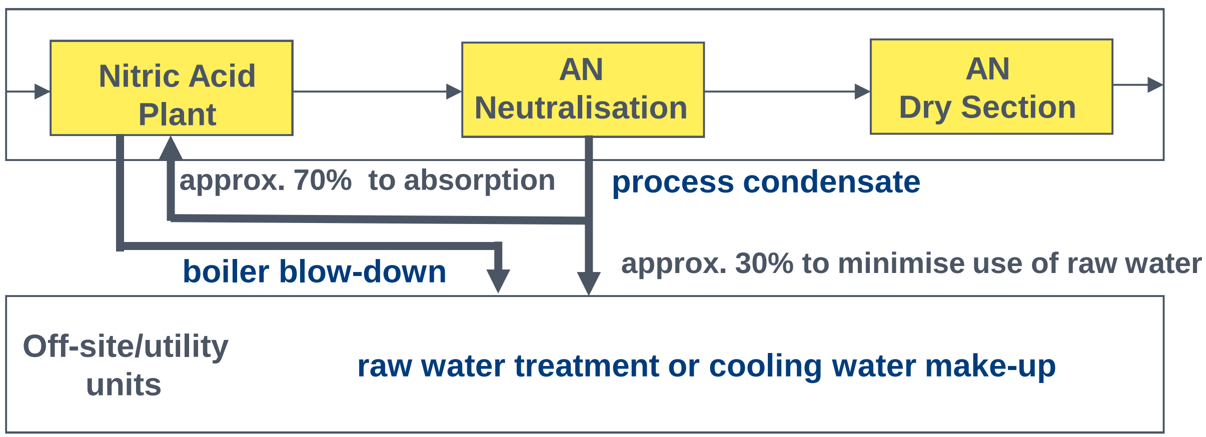
| Horizontal Integration | Vertical Integration |
|---|---|
| • Process integration (e.g. re-use of waste streams of one plant as feedstock to the other plants)<br>• Consistent HSE concept from feedstock intake to product delivery | • Technology, design and engineering from **one** partner with **execution expertise in these technologies**<br>• Involvement of the same specialists through all project phases |

- Integrated process / O/U concept
- Integrated plant layout
- Integrated execution schedule with minimised number of interfaces
- Realistic planning, budget development and implementation

# Challenges in integrated AN Complexes

## Horizontal integrity - Re-use of process waters

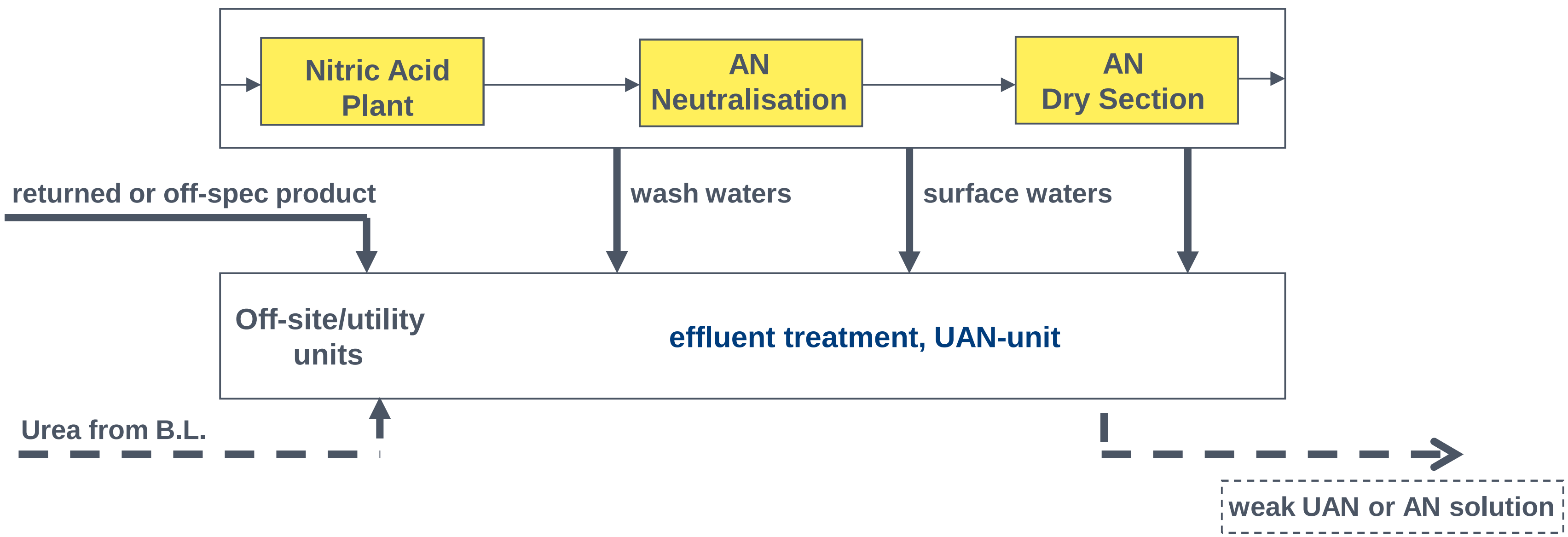
- Use of process condensate from AN Neutralisation to reduce raw water intake
- Boiler blow-downs can be used to further minimise raw water intake
- Important for steady state, transient, upset and individual operation



# Challenges in integrated AN Complexes

## Horizontal integrity - Effluent streams and effluent management

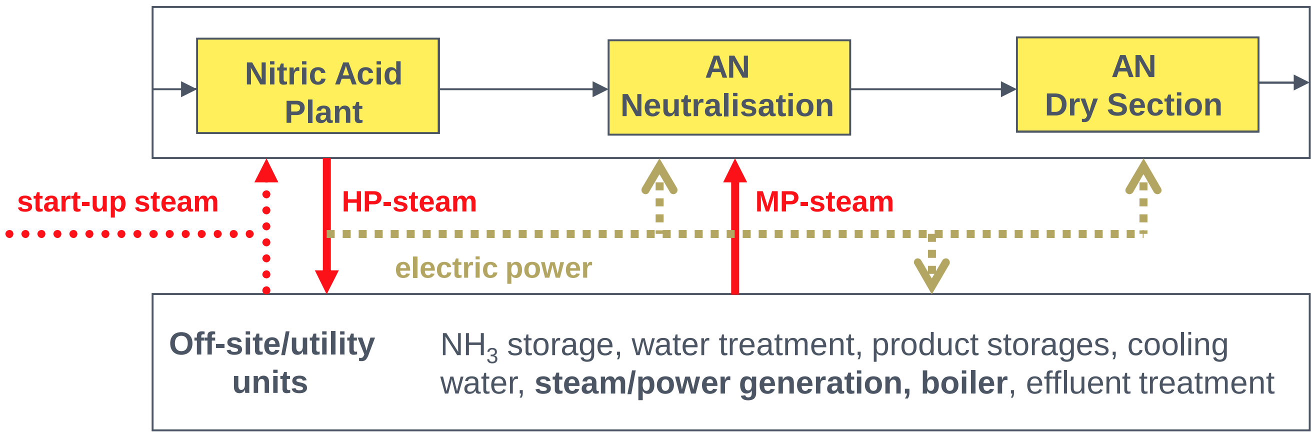
- Waters are used as basestock for additional (low grade) products
- Waters are collected either separately and used separately or collectively, based on applicable safety standards or client standards



# Challenges in integrated AN Complexes

## Horizontal integrity - Power/steam concepts – energy management

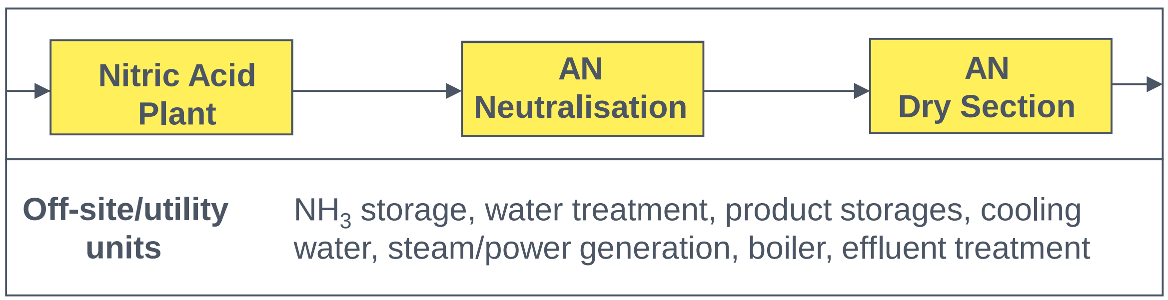
- Maximise number of plant units that can be kept in operation in case of shut-down of one plant unit or failure from incoming side
- Tie-in of NA-plant as major steam/power exporter/importer is most important
- DCS/substation design to consider potential or plant unit power production failures



# Challenges in integrated AN Complexes

## Horizontal integrity - N-recovery

- N-conversion modern NA-plant — combustion: ~ 97 %; absorption: ~100 %
- N-emissions — NOx: ~ 0 ppm (EnviNOx® ); $N_2O$: ≤ 20 ppm

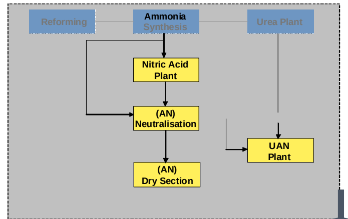



| | | |
|---|---|---|
| N-conversion AN vacuum neutralisation | | ~100% |
| N-emissions in condensate | <N>: | ≤ 15 ppm |
| Dust | PM: | ≤ 10 ppm (2-stage scrubber) |

(add minor losses from spillages of e.g. conveyor belts)

# Challenges in integrated AN Complexes

## Horizontal Integrity - Integrated Complex Lay-out




Layout strategy optimimized for:

Maintenance & Operation

Erection: Modul prefabrication

Footprint & Minimum steelstructure, piping

**Integrated Layout:**

Optimized complex-layout based on site specific requirements acc:

- material flow
- operation and maintenance
- safety
- cost

# Challenges in integrated AN Complexes
## Vertical integrity

- Consistent safety level through entire processing cycle: inherently safe design
- Process HAZOP/SIL during FEED, for sub-suppliers after P&ID-availability
- Defined review stages for plant model and P&IDs in case of third-party detail engineeering/execution
- Key equipment enquiry only to and supplies only by approved vendors
- Installation check of technology provider prior to MC
- Commissioning and start-up with technology/key equipment provider assistance
- Same key-personnel of technology provider to be involved during all phases

# Challenges in integrated AN Complexes

## Vertical Integrity - Project Execution Phases

Concept phase | Basic engineering | Detail engineering | Procure-ment | Erection and commis-sioning | Plant oper-ation

| FEL 1, +/-40 % TIC | FEL 2 (PDP), +/-20% TIC | FEL 3 (FEED), +/-10% estimate | Project realisation |
|---|---|---|---|

### Project Development
- ⇨ Plant concept, process selection & optimization
- ⇨ Project execution concept
- ⇨ PFD, mass balance
- ⇨ Design basis
- ⇨ Plot plan

### E – Engineering design
- ⇨ HMB, P&ID
- ⇨ Gen. engineer. specs for all disciplines
- ⇨ Equipment/ mat. specs
- ⇨ 3D- piping model
- ⇨ HAZOP/SIL

### P – Procurement
- ⇨ Purchasing
- ⇨ Materials management
- ⇨ Inspection/ Expediting
- ⇨ Transportation/ Logistics
- ⇨ Spare parts procurement
- Vendor document.

### C / C – Construction and commissioning
- ⇨ Civil works
- ⇨ Erection works
- ⇨ Site Management
- ⇨ QM & Material Management
- ⇨ Pre-commis-sioning and commissioning

### Technical Assistance
- ⇨ Start-up

**Project Management** | **Scheduling & Cost control** | **Technical Assistance**

# Challenges in integrated AN Complexes

## Planning and Budget Development

- Substantiated support for project specific evaluation of different process variants (CAPEX/OPEX optimisation to determine best concept)

  tkIS is a full-liner that can design and offer all process variants (e.g. NA MP, HP and DP technology; AN, CAN, UAN, AS, …)

- Project development and execution is often in phases (e.g. FEL 1,2,3) combined with increasing accuracy of cost estimates (+/-40%, +/-20%, +/-10%, fixed price)
- Realistic budget developments due to available as-just-procured data base from actually executed projects (incl. MTOs for bulk and construction costing)
- Besides technological competence also execution competence that ensures feed-back from executed projects and development of appropriate execution concepts

# Challenges in integrated AN Complexes

## Examples of integrated NA/AN Complexes

**Customer:** Abu Qir Fertilizers

**Location:** Abu Qir / Egypt

**Plant Units:** NA: 1,830 MTPD

AN: 2,400 MTPD

**Start-up:** 1991

# Challenges in integrated AN Complexes

## Examples of integrated NA/AN Complexes

| | | |
|---|---|---|
| **Customer:** | VINACOMIN | |
| **Location:** | Thai Binh / Vietnam | |
| **Plant Units:** | NA: | 500 MTPD |
| | LDAN: | 625 MTPD |
| **Start-up:** | 2015 | |

# Challenges in integrated AN Complexes

## Examples of integrated NA/AN Complexes

| | | |
|---|---|---|
| **Customer:** | EHC | |
| **Location:** | Ain Sukhna / Egypt | |
| **Plant Units:** | NA: | 850 MTPD |
| | LDAN: | 1,060 MTPD |
| **Start-up:** | 2015 | |

# Summary and conclusion

## Why integrated developments and project implementations?

### Horizontal and vertical integration is beneficial to customer:

Horizontally and vertically integrated complexes maximise investment sustainability, minimises interfaces and therefor commonly overall cost

### Instead of managing interfaces, each partner can concentrate on his strength:

Owner on production, plant operation, maintenance, product sales and marketing

Technology provided to build, start-up and hand-over the plant

### Technology provider who also build the plant has usually broader interest:

Higher chance of continuing support through the plant life-time

# Granulated Ammonium Sulphate Plant

## AFA Conference Aqaba 2016

13th April 2016 | Dr. Jens Mathiak
thyssenkrupp Industrial Solutions

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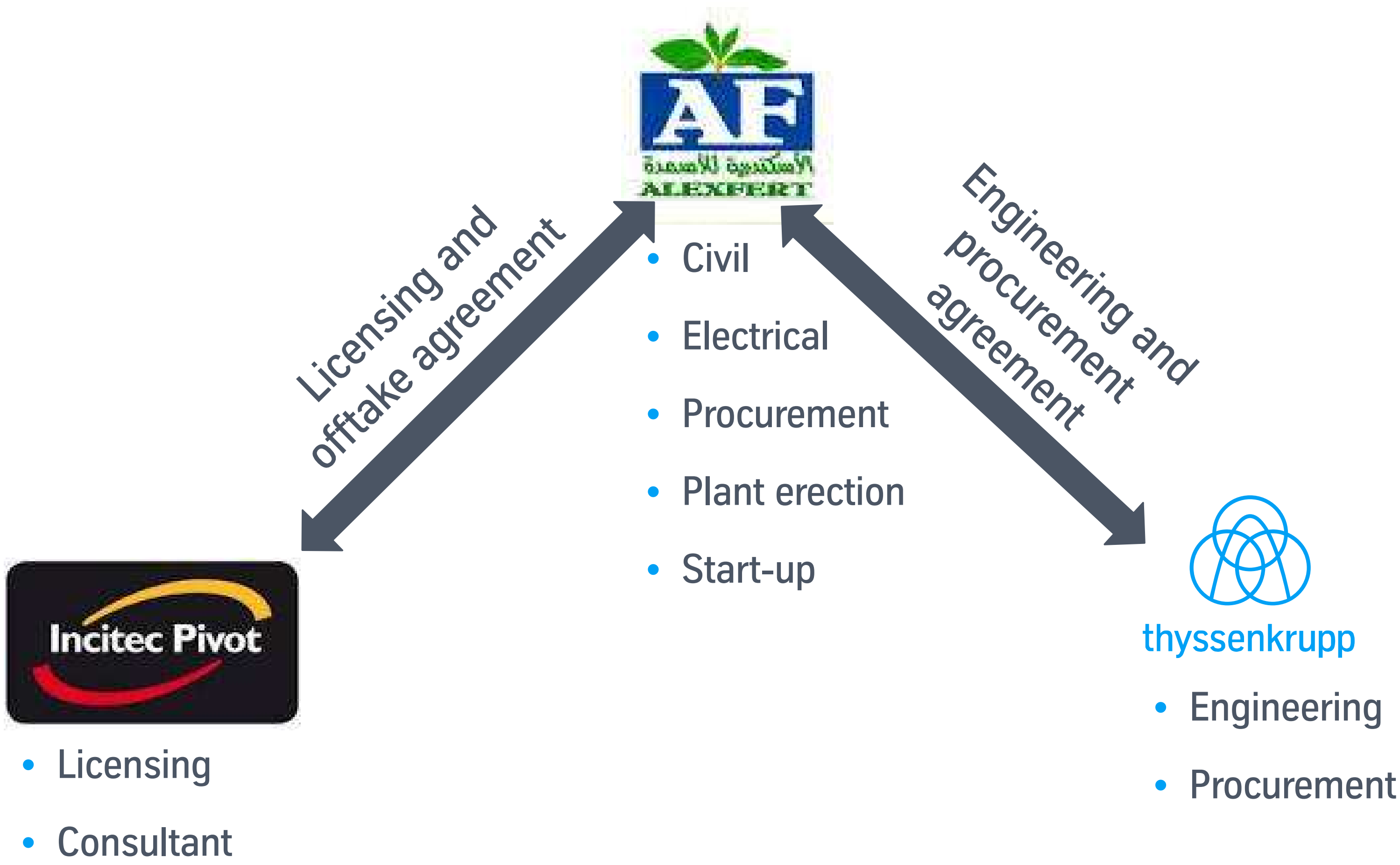
# Content

# Successful setup of cooperation

## Agreements and responsibilities



# AlexFert
## Company Profile

- Established as a joint stock company in Oct 2003
- Located on the coast of Abu Qir bay in Alexandria, Egypt
- 1200 MTPD ammonia 2000 MTPD urea commissioned in Aug. 2006
- New 720 MTPD AS plant commissioned in May 2013

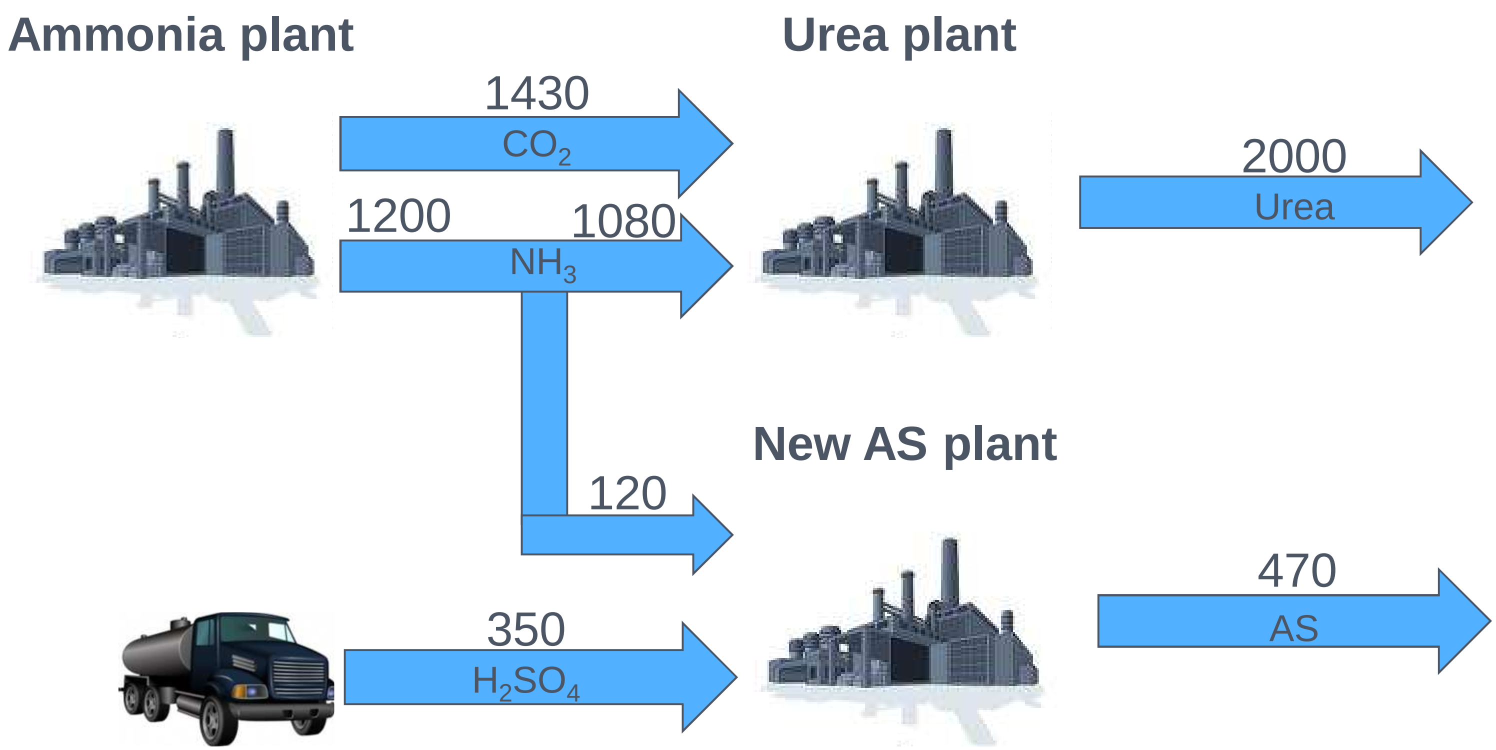
# Incitec Pivot Limited
## Company Profile

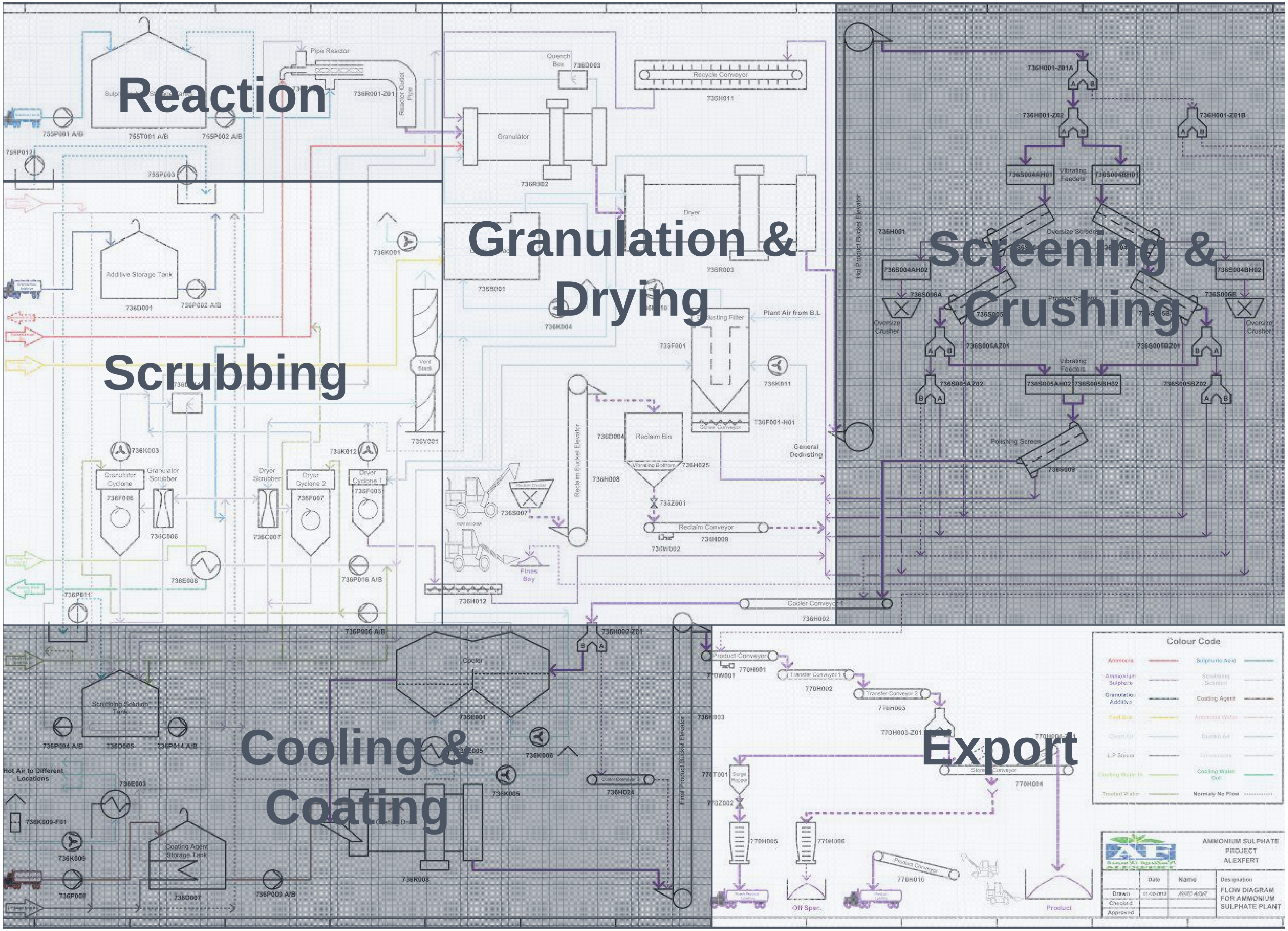
- Global manufacturer and marketer of commercial explosives and fertilizer
- Owning and operating 20 plants in US, Canada, Australia, Mexico, Indonesia and Turkey
- Joint Venture operations in South Africa, Malaysia, China and Australia
- Australia´s largest supplier of fertilizers – dispatching around three million tonnes per year
- Products: Ammonium phosphates, ammonia, urea, sulphuric acid and superphosphates
- Licensed ammonium sulphate plants in Canada, Mexico and now Egypt

Incitec Pivot

# Process Description

## Plant integration at AlexFert - in MTPD





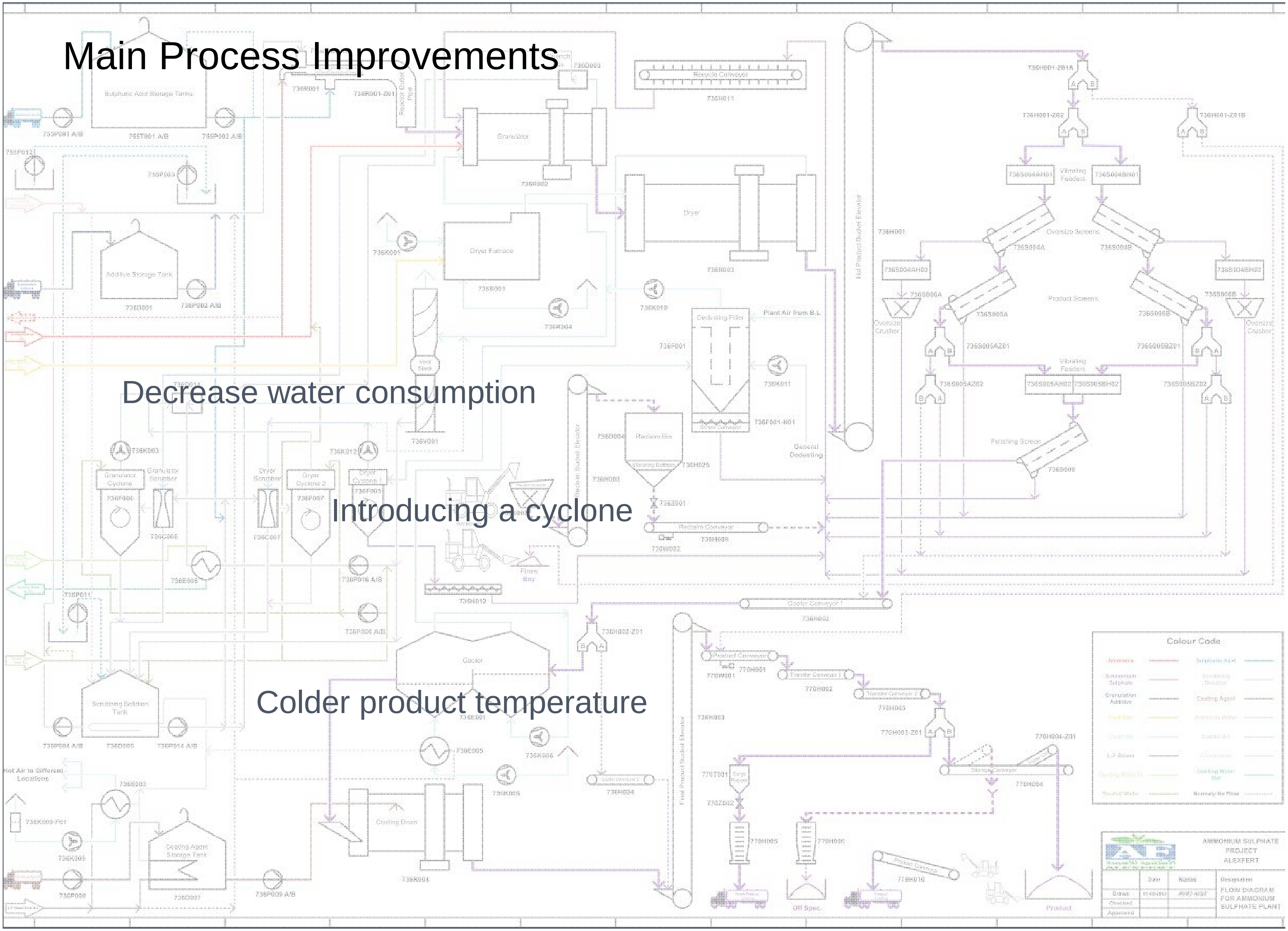
Reaction
Granulation & Drying
Screening & Crushing
Scrubbing
Cooling & Coating
Export
Pipe Reactor
736R001-Z01
Reactor Outlet Pipe
755P001 A/B
755T001 A/B
755P002 A/B
755P012
755P003
Quench Box
736D003
Recycle Conveyor
736H011
Granulator
736R002
Dryer
736R003
736B001
736K004
736K001
Plant Air from B.L
Dusting Filter
736F001
736K011
736F001-H01
General Dedusting
Reclaim Bin
736D004
Vibrating Bottom
736H025
736H008
736Z001
Reclaim Conveyor
736H009
736WD02
Reclaim Bucket Elevator
736S007
Fines Bay
736H012
Cooler Conveyor 1
736H002
Hot Product Bucket Elevator
736H001
736H001-Z01A
736H001-Z02
736H001-Z01B
736S004AH01
Vibrating Feeders
736S004BH01
Oversize Screens
736S004AH02
736S004BH02
736S006A
736S006B
Oversize Crusher
Product Screens
736S005AZ01
736S005BZ01
736S005AZ02
736S005AH02
736S005BH02
736S005BZ02
Polishing Screen
736S009
Additive Storage Tank
736D001
736P002 A/B
736V001
Vent Stack
736K003
Granulator Cyclone
736F006
Granulator Scrubber
736C006
Dryer Scrubber
736C007
Dryer Cyclone 2
736F007
Dryer Cyclone 1
736F005
736K012
736E006
736P016 A/B
736P011
736P006 A/B
Scrubbing Solution Tank
736P004 A/B
736D005
736P014 A/B
Hot Air to Different Locations
736E003
736K009-F01
736K009
736P008
Coating Agent Storage Tank
736D007
736P009 A/B
736R008
Cooler
736E001
736E005
736K006
736K005
Cooler Conveyor 2
736H024
736H002-Z01
Final Product Bucket Elevator
736H003
Product Conveyor
770H001
770W001
Transfer Conveyor 1
770H002
Transfer Conveyor 2
770H003
770H003-Z01
770H004-Z01
Store Conveyor
770H004
770T001
Surge Hopper
770Z002
770H005
770H006
Product Conveyor
770H010
Off Spec.
Product
Colour Code
Ammonia
Sulphuric Acid
Ammonium Sulphate
Scrubbing Solution
Granulation Additive
Coating Agent
Fuel Gas
Ammonia Water
Clean Air
Dusty Air
L.P. Steam
Condensate
Cooling Water In
Cooling Water Out
Treated Water
Normally No Flow
AMMONIUM SULPHATE PROJECT ALEXFERT
Date
Name
Designation
Drawn
Checked
Approved
FLOW DIAGRAM FOR AMMONIUM SULPHATE PLANT

# Main Process Improvements

Decrease water consumption

Introducing a cyclone

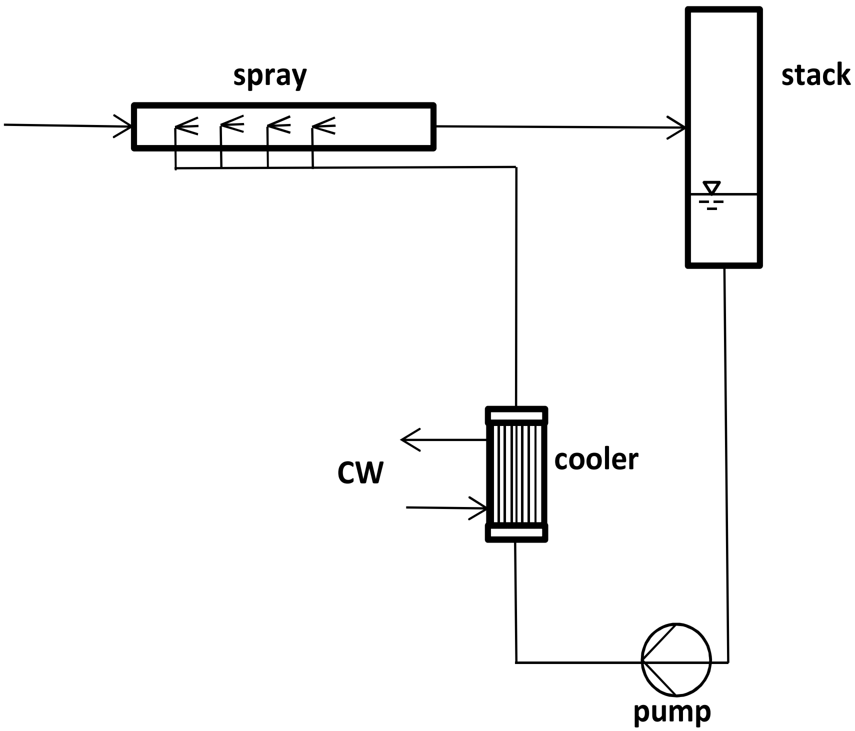
Colder product temperature



# Main Process Improvements

## Decrease water consumption

- Exothermic reaction requires water as cooling agent
- Water recovery upstream stack by injection of cooled water
- Reducing water consumption from 21 t/hr down to 6 t/hr
- Improved stack appearance with less visibility of exhaust



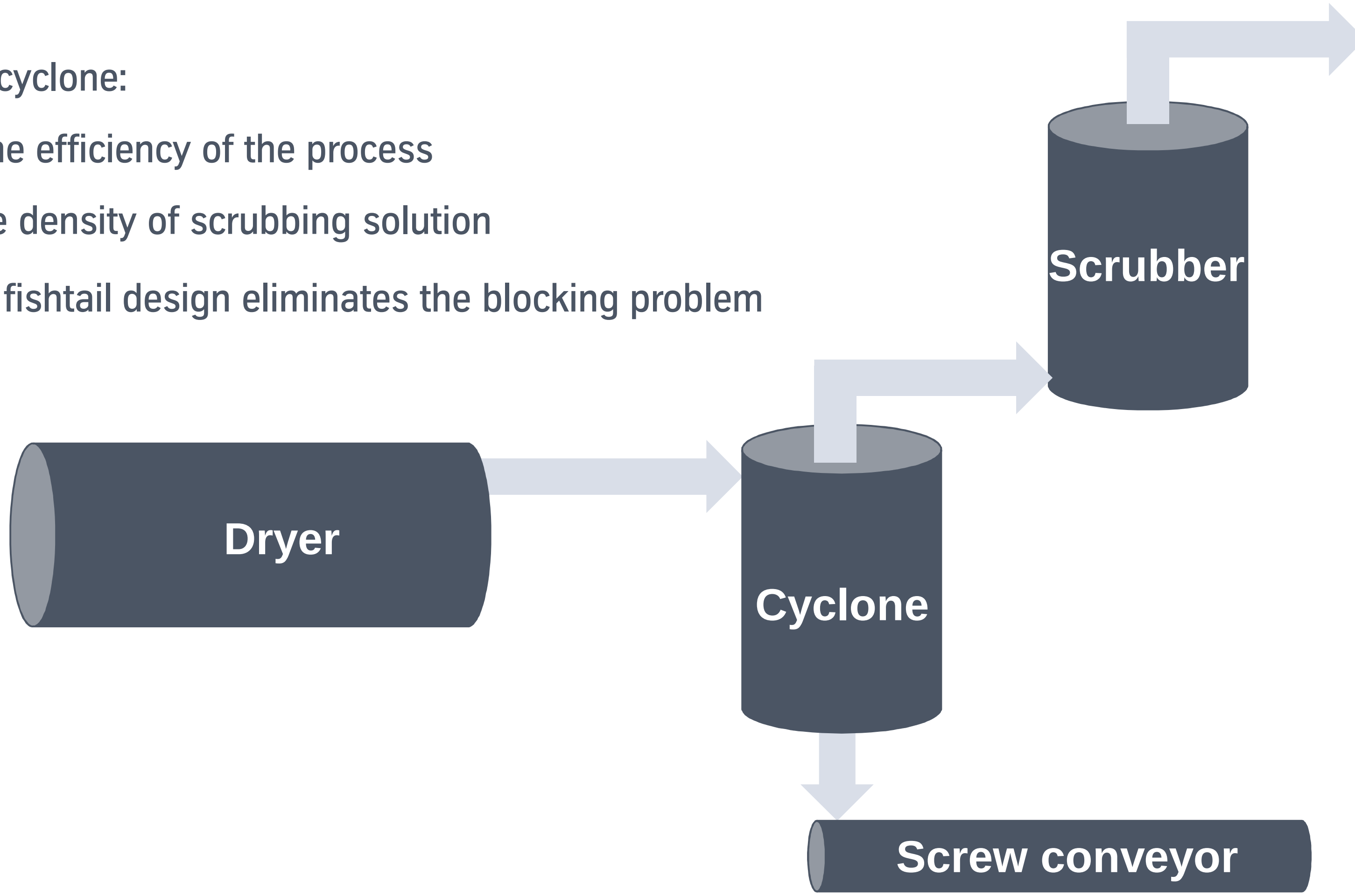
# Main Process Improvements
## Colder product temperature

- Integration of a fluidized bed cooler
- Efficient heat integration
- No caking of product
- Improved dedusting of the product

# Main Process Improvements

## Introducing a cyclone

- Integration of a cyclone:
  - Increases the efficiency of the process
  - Reduces the density of scrubbing solution
- Improvement of fishtail design eliminates the blocking problem



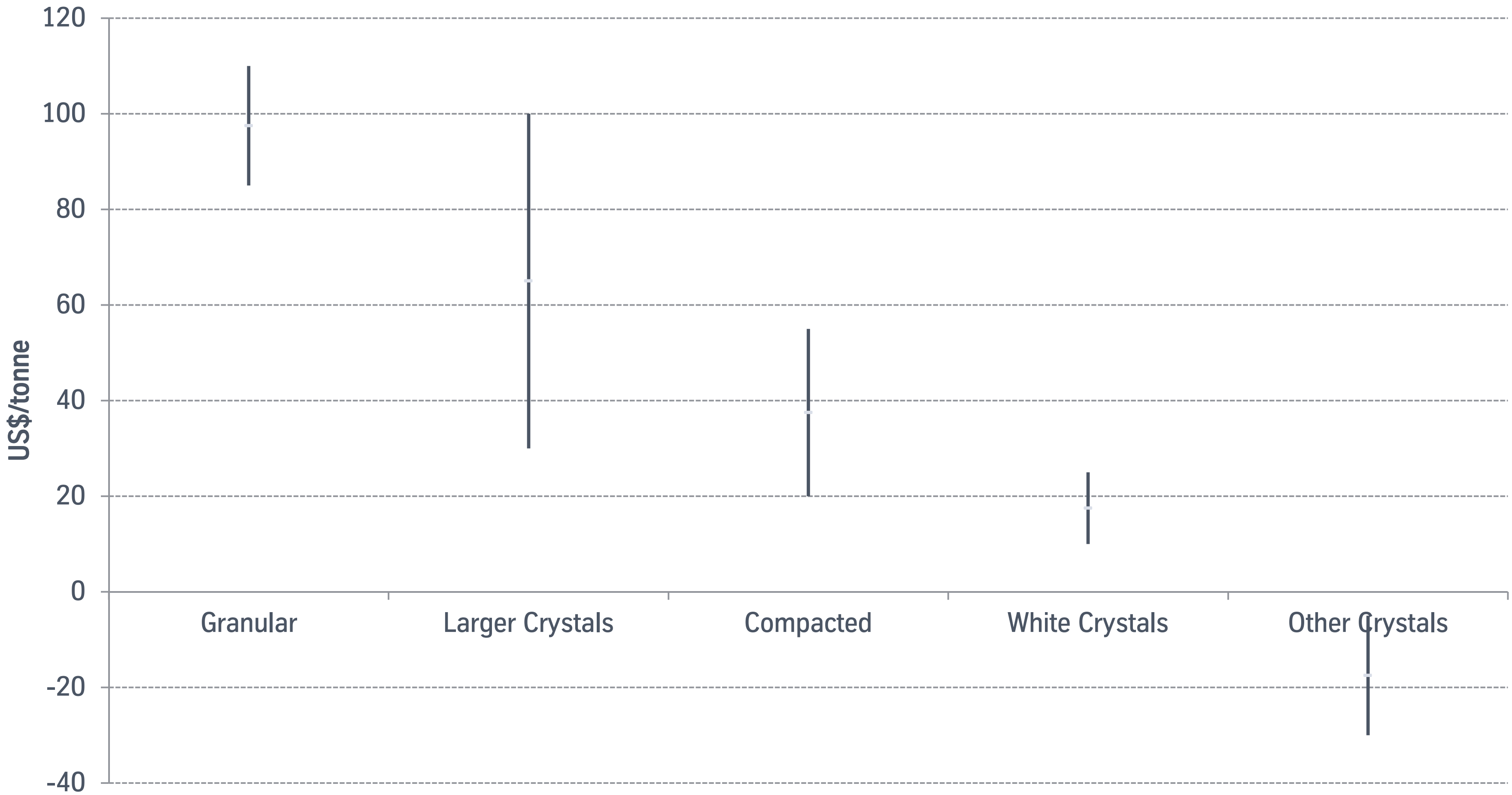
# Product Characteristics

## Crystals vs. granules

- Typical by-product from e.g. caprolactam
- Difficult distribution on the field
- Low-cost product

- On-purpose production
- Perfect bulk blending with e.g. urea
- Premium prices on the market

# Product Characteristics
## Premium Market Prices



# Product Characteristics

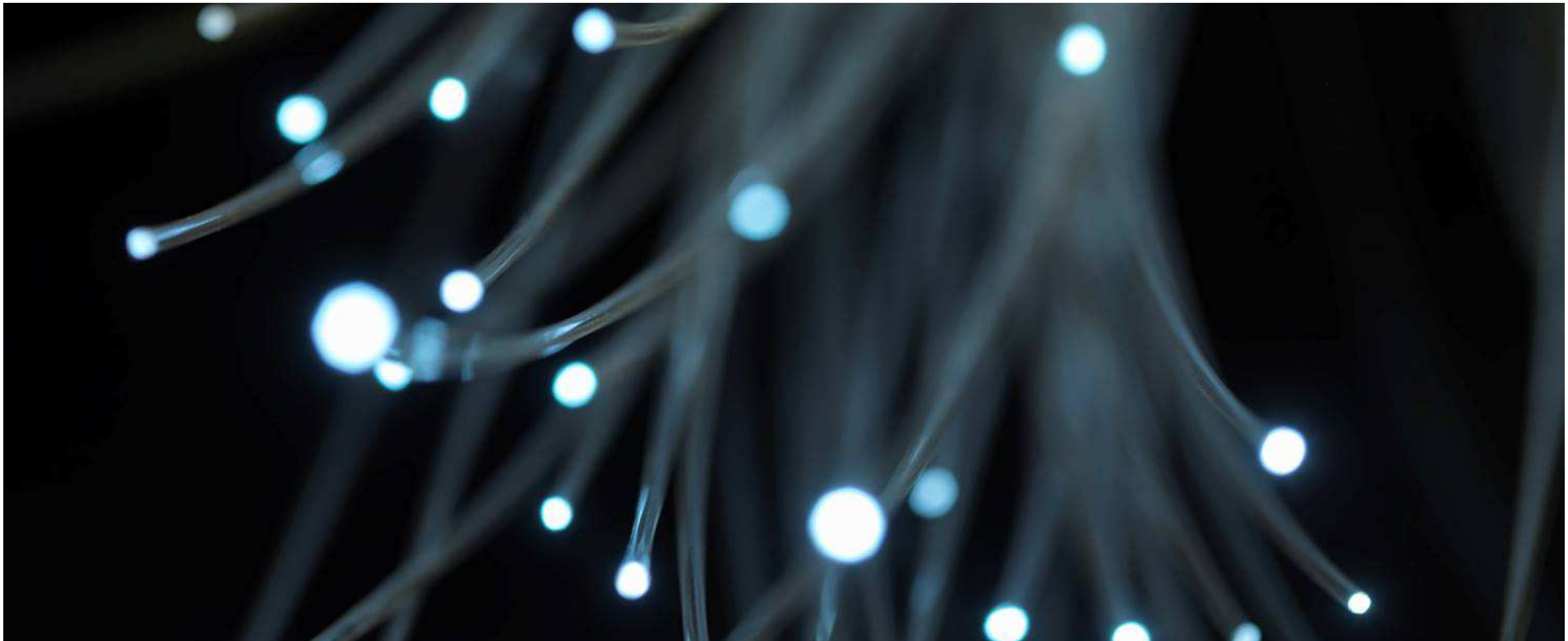
## AS granules parameter

| | | |
|---|---|---|
| • Sulphur content: | 23.8 | % |
| • Nitrogen content: | 20.6 | % |
| • Moisture: | <0.2 | % |
| • D50: | ~3 | mm |
| • Bulk density: | ~850 | kg/m³ |
| • Hardness: | ~3.5 | kg |

# Summary

- AS plant was successfully commissioned by joint collaboration of AlexFert, IPL and tkIS
- Process improvements were realized for less water consumption and colder product
- High valuable granular product achieves premium prices compared to crystals

# Summary



# Increase of Production Capacity of Existing Ammonia Plants

11.-14.04.2016 | Christoph Meißner
thyssenkrupp Industrial Solutions - Arab Fertilizer Association

engineering. tomorrow. together.

thyssenkrupp

# Increase of production capacity of existing ammonia plants
## Contents

# Increase of production capacity of existing ammonia plants

## Targets and Requirements of a Revamp

Typical targets for a revamp of a fertilizer plant:

- Capacity increase
- Reduction of operating cost / energy consumption
- Environmental improvements (e.g. reduction of emissions)
- Increase of reliability and availability

this project

applicable to
all projects

Important things to consider to make the project a success:

- Use a well proven and reliable technical concept
- Keep the plant downtime for implementation and modification as short as possible

# Increase of production capacity of existing ammonia plants

## Plant before Revamp

Ammonia plant profile:

- Design by: GIAP (former State Institute of Nitrogen Industry of the USSR)
- Year of commissioning: 1977
- Nameplate capacity: 1,360 tons per day
- Pre-Revamp capacity: 1,600 tons per day

?

What is the relevance of this plant
and the Case Studies presented here

!

The plant is a standard GIAP design of the 1970s.
Several dozen of this plant type exist in Russia
and other states of the former Soviet Union

# Increase of production capacity of existing ammonia plants

## Plant before Revamp

Profile of the Original Ammonia plant:

Fairly conventional process – applicable to the whole “family” of such plants:

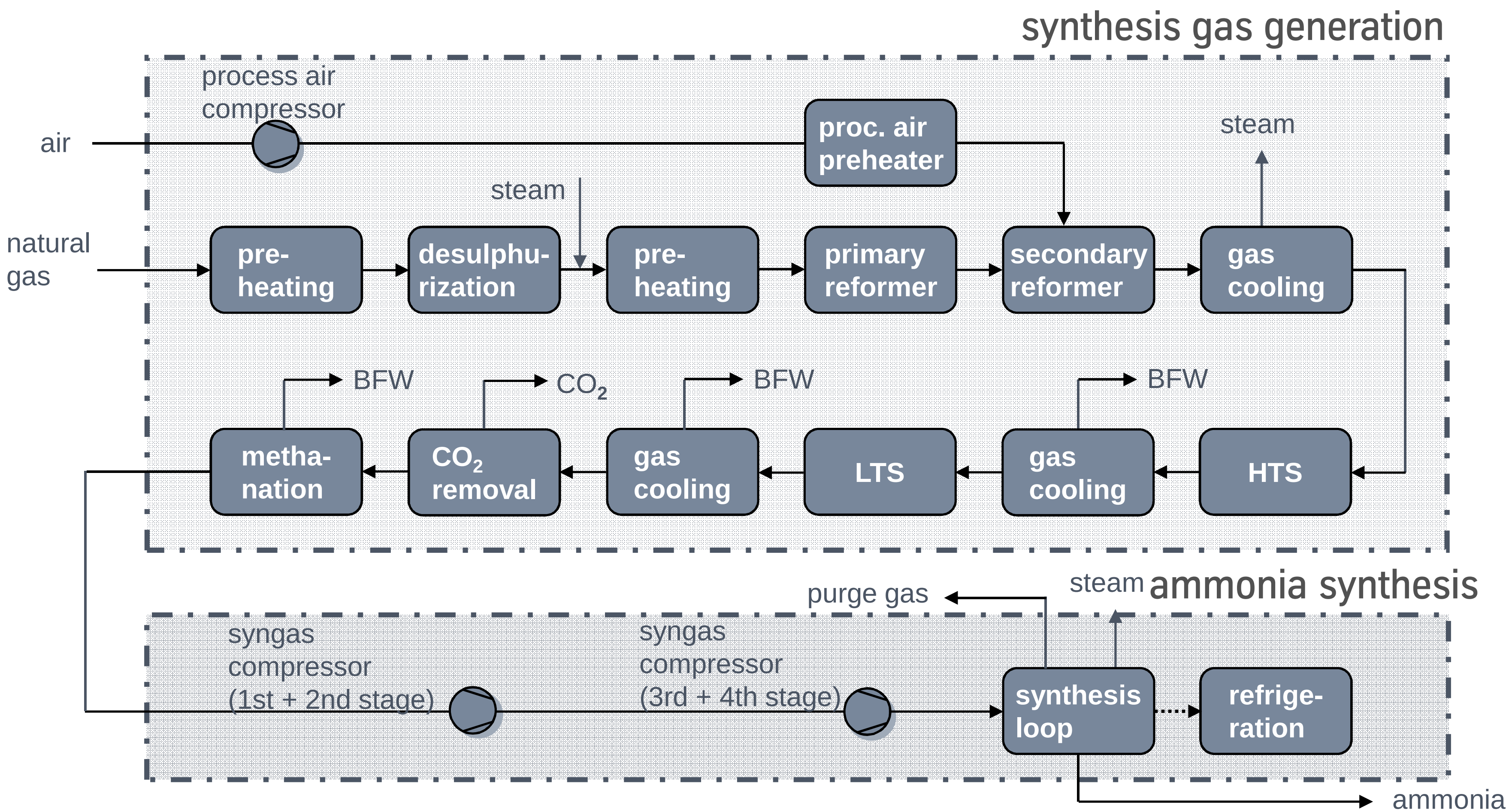
- top-fired primary reformer
- HP steam boiler downstream of the secondary reformer
- CO shift with one vessel for HT and two parallel vessels for LT shift
- MEA CO2 removal system
- methanation
- synthesis gas compression by steam-turbine driven centrifugal compressor
- synthesis loop with one ammonia converter

Modifications made in earlier revamp:

- change from MEA to activated MDEA as CO2 removal solvent
- new ammonia converter cartridge with axial/radial flow pattern

# Increase of production capacity of existing ammonia plants

## Plant before Revamp



# Increase of production capacity of existing ammonia plants

## Case Study 1: Successfully Completed Capacity Increase

Kuibyshev Azot's target for the revamp:

- production increase to 1,800 tons per day (+ 12.5 % on current / + 32 % on original nameplate capacity)
- improved energy efficiency

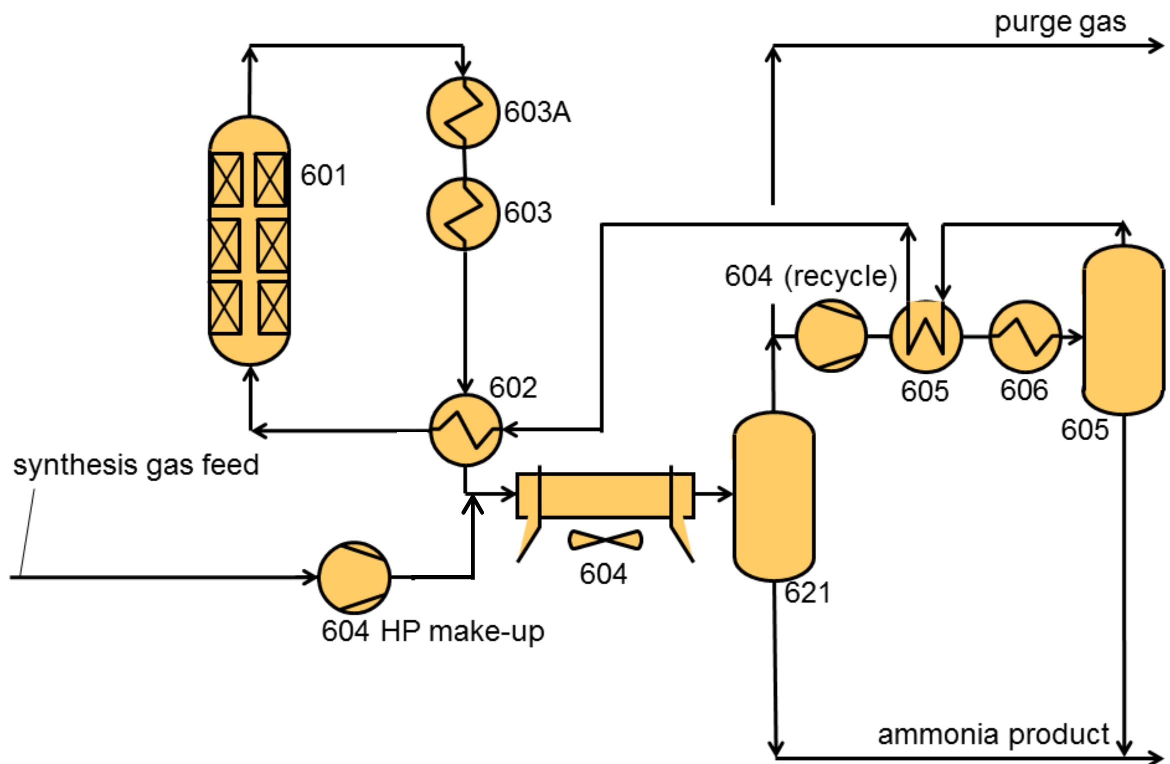
Technical solution, main changes in syngas generation ("front end"):

- deletion of fired heater for feed preheating, replacement by new preheat coil in reformer flue gas duct
- addition of blower to suction side of process air compressor
- lower steam-to-carbon ratio
- increased feed / steam inlet temperature

# Increase of production capacity of existing ammonia plants

## Case Study 1: Successfully Completed Capacity Increase

## Technical concept, main changes in synthesis ("back end")

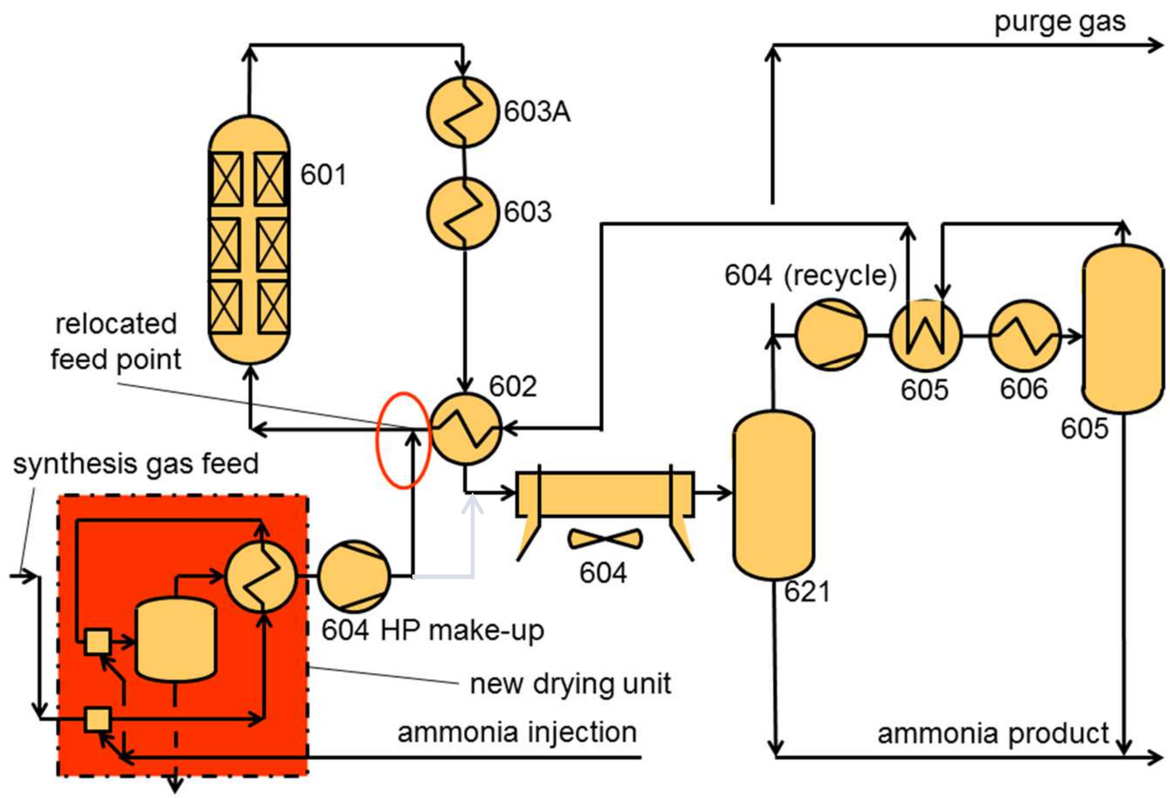


# Increase of production capacity of existing ammonia plants

## Case Study 1: Successfully Completed Capacity Increase

### Technical concept, main changes in synthesis ("back end")

- new synthesis gas drying unit for
  - move feed point for fresh syngas to directly upstream of ammonia converter
  - reduces converter inlet ammonia concentration, increasing driving force for reaction
  - operating principle: ammonia injection → cooling → condensation → separation of water (no vessels filled with adsorbent)

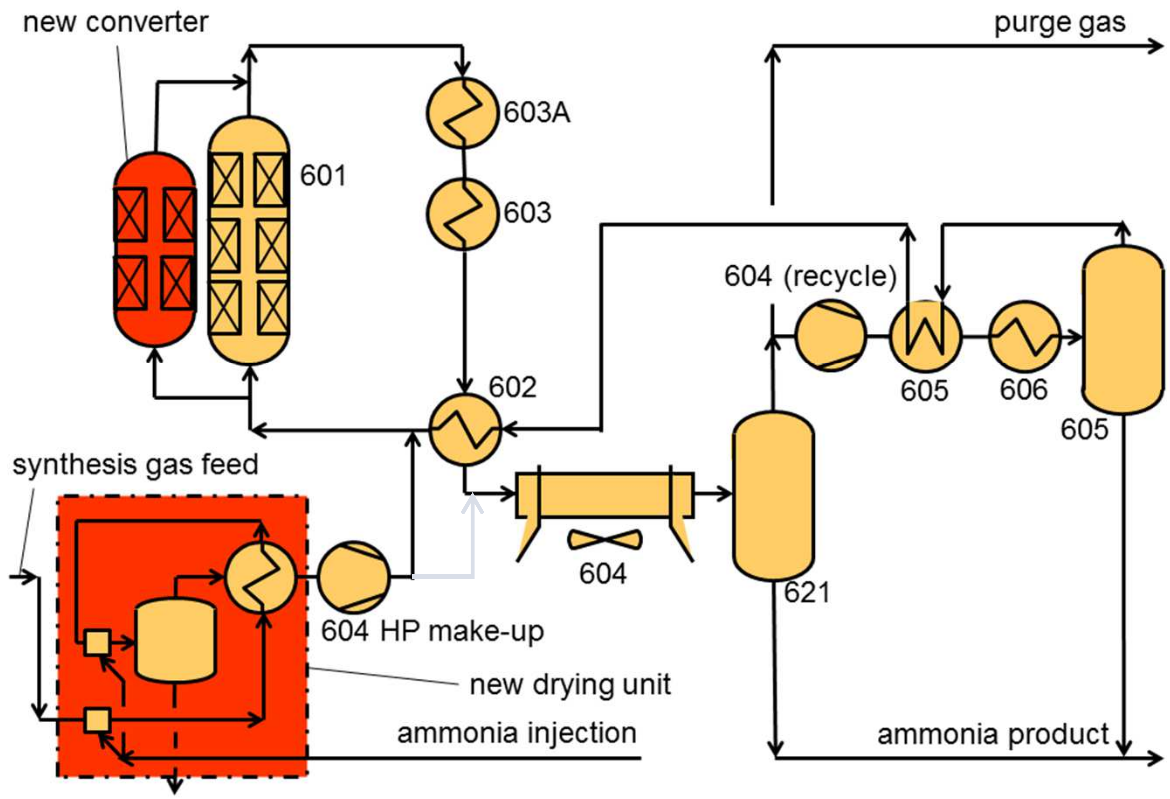


# Increase of production capacity of existing ammonia plants

## Case Study 1: Successfully Completed Capacity Increase

### Technical concept, main changes in synthesis (“back end”)

- addition of second ammonia converter:
  - two radial catalyst beds
  - two internal heat exchangers
  - in parallel to existing converter to keep pressure loss low



# Increase of production capacity of existing ammonia plants

## Phase Concept for Project Execution

| Project phase | Main contents | Done by | Cost estimate |
|---|---|---|---|
| 1<br>Revamp study | Collection of operating data, Process concept, first cost estimate | TKIS Germany | First, rough estimate, typ. +/- 30 % |
| 2<br>Basic engineering | Equipment specifications, P&IDs, layout and civil engineering | TKIS Germany | Better estimate, typ. +/- 10 % |
| 3<br>Detail engineering | Piping and equipment design, procurement of equipment | TKIS Germany, TKIS Russia, Kuibyshev Azot | Accurate cost |
| 4<br>Construction, commissioning, start-up | Construction, procurement of remaining equipment, commissioning, start-up | Kuibyshev Azot, Commissioning assistance by TKIS | |

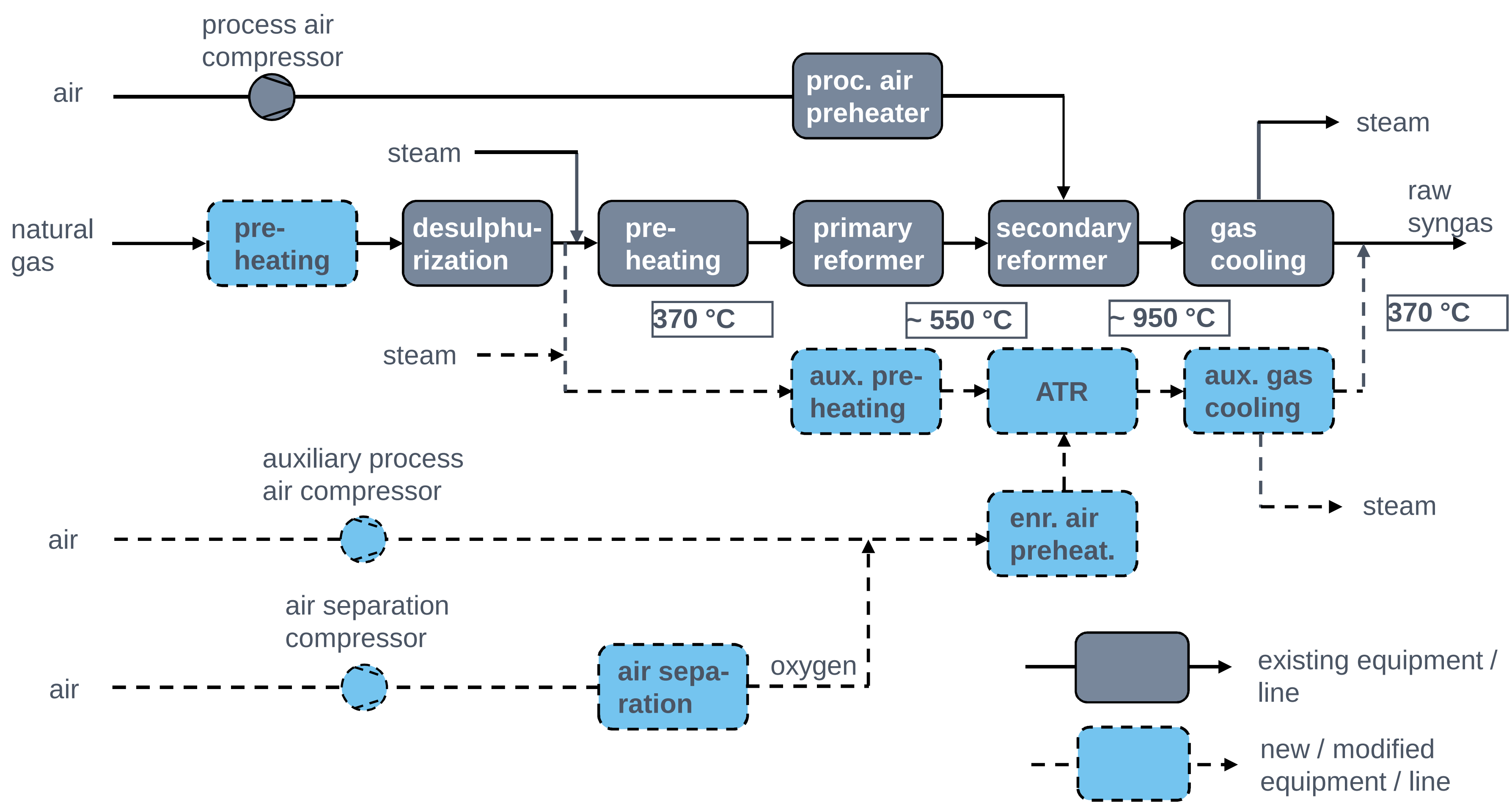
# Increase of production capacity of existing ammonia plants

## Case Study 2: Concept for Alternative Revamp

- Same plant as in Case 1
- Capacity increase by 30 %
- Discussion of most critical items:
  - Reforming
  - Synthesis gas compression
  - Synthesis

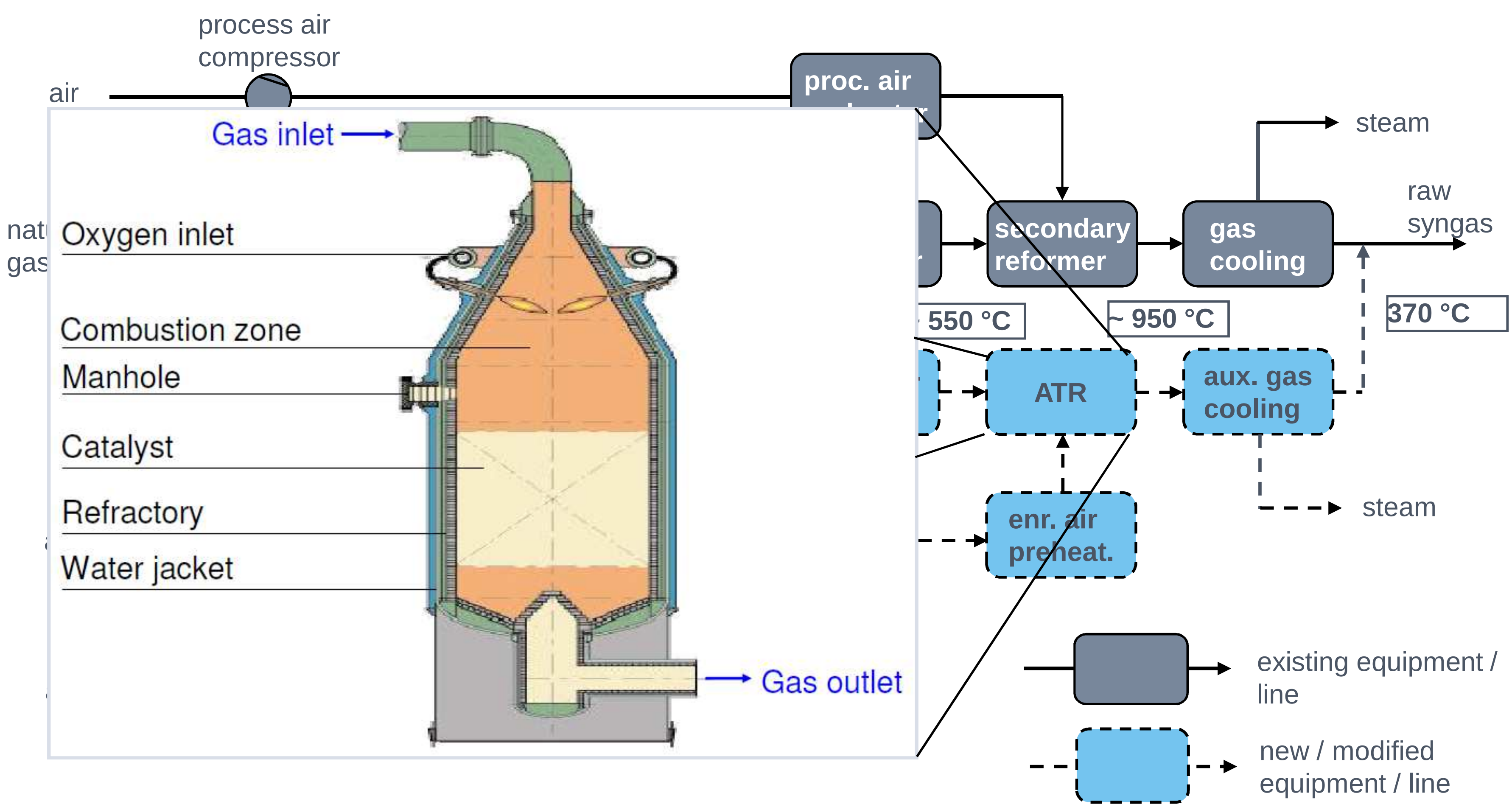
# Increase of production capacity of existing ammonia plants

## Case Study 2: Reforming - New autothermal reformer in parallel to existing reformer



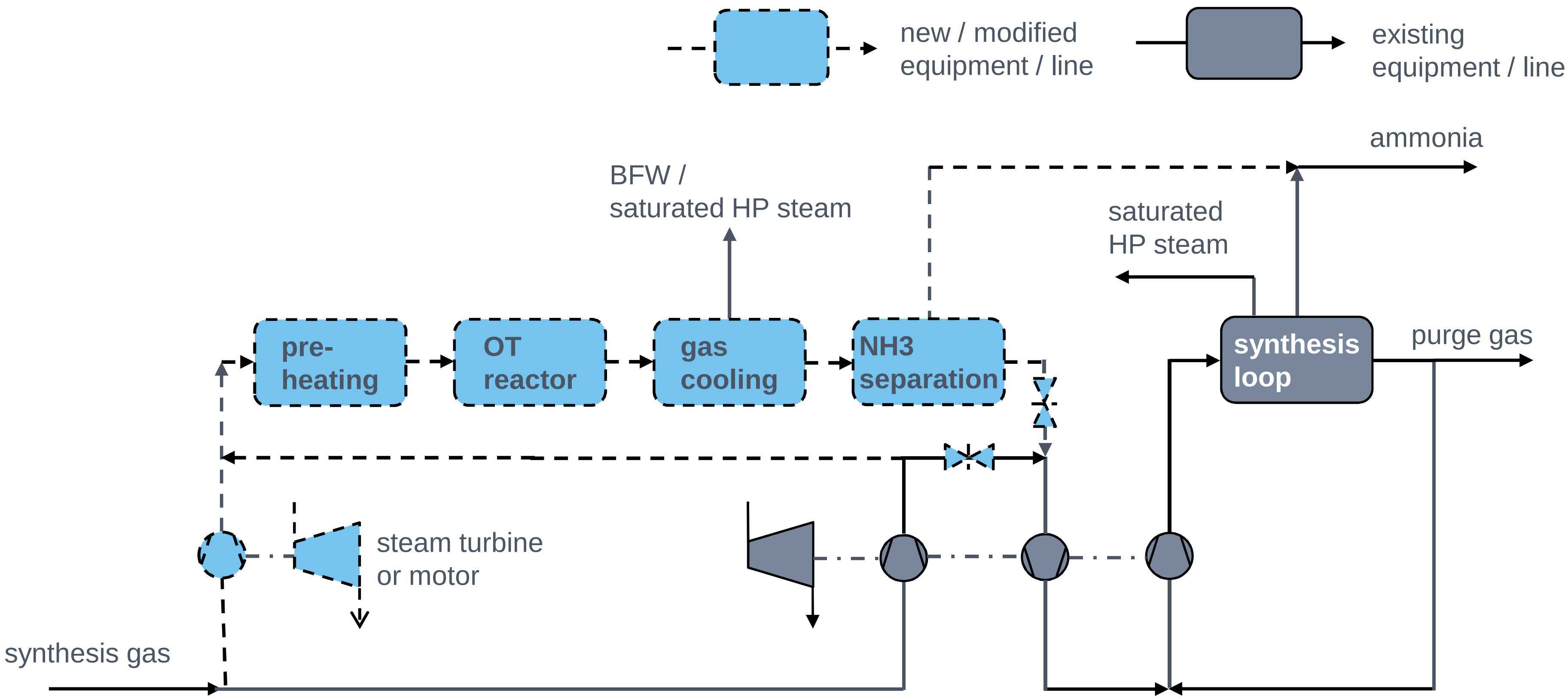
# Increase of production capacity of existing ammonia plants

## Case Study 2: Reforming – tkis autothermal reformer design



# Increase of production capacity of existing ammonia plants

## Case Study 2: Syngas Compression and Ammonia Synthesis



# Increase of production capacity of existing ammonia plants

## Case Study 2: Syngas Compression and Ammonia Synthesis

- Uhde Dual Pressure Process:
- Advantages:
  - avoids modifications at high-pressure synthesis equipment
  - easy installation while plant remains in operation
  - few tie-ins only while plant is in shutdown
  - if plant area is congested: new once-through section can be installed in a different plot area than the existing plant

# Increase of production capacity of existing ammonia plants

## Case Study 2: Economic Evaluation of Revamp Concepts

Why is Case Study 2 superior to other revamp concepts ?

| Case Study 2 | Other Concepts |
|---|---|
| Parallel ATR | • Replacement of secondary reformer<br>• Increase of primary reformer size<br>• Installation of pre-reformer<br>• Modification of convection section<br>• … |
| Once-through synthesis | • New booster converter in synthesis loop<br>• Replacement of heat exchangers in cooling train |

# Increase of production capacity of existing ammonia plants

## Case Study 2: Economic Evaluation of Revamp Concepts

### Why is Case Study 2 superior to other revamp concepts

?

Principles of economic evaluation of different revamp concepts:
Comparison of:

- Operating cost: feed, fuel, electricity, steam export,…
- Capital cost: new equipment, piping, installation, commissioning,…
- Cost of lost production: downtime for revamp installation

Example:

**4 weeks** additional downtime by an unfavourable concept are equal to an additional CAPEX of **15.7 million USD**

!

# Increase of production capacity of existing ammonia plants
## Summary and Conclusion

- Many similar GIAP-design ammonia plants in Russia and other countries
- Case Study 1 – Completed Project:
  - Capacity of one of them increased to 1,800 t/d by TKIS
- Case Study 2:
  - Concept developed for revamp to 2,080 t/d
    Make use of autothermal reformer and Dual Pressure Synthesis
- Takeaways:
  - Revamp realization is best done in phases:
    Study – Basic Engineering – Detail Engineering and Procurement – Construction and Commissioning
  - Economic evaluation of revamp concepts must include production loss by downtime for installation
  - Favor revamp concepts with short downtime

Thank you for your attention!

Questions?

Comments?

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# AFA WORKSHOP
## Operation and Maintenance Optimization

Jordan - Aqaba: 11-14 April, 2016

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Sponsors:

Arab Potash

Jordan Phosphate Mines Co.

Indo Jordan Chemicals Co.

Nippon Jordan Fertilizer Co.

KEMAPCO Arab Fertilizers & Chemicals Industries Ltd.

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