AMMONIA

1a One Hundred Years of Ammonia Production – A Recap of Significant Contributions to Feeding the World

Venkat Pattabathula – *Incitec Pivot*

Q: Hanggara Parianta – Pupuk Indonesia
For future development, what is the emphasis on ammonia technology, technology itself, reliability, safety and other?

A: I believe the future ammonia technology would focus on large capacity plants with improved energy efficiency that would give better plant reliability.

1b Assessment of the Safety Risks in Running the Single Train Ammonia Unit with Partially Defeated Shutdown System

Nenad Zečević – *Petrokemija*

Q: Majed Al Solimani – Ma'aden Phosphate
In your experience, what is the frequency of flange leaks that you experienced?

A: Our experience was this was the first problem with such intensive leakage, which caused the failure of the pipeline PG-1016-16". During the operation period of one year there are some minor leakages in different type of the flanges and we can say that the frequency is in average three to four minor leakages per year.

Q: Majed Al Solimani – Ma'aden Phosphate
What type of device do you use to detect leaks?

A: We use always portable measuring device type Drager Xm-5000 with measuring probes for CO, CH_4, NH_3, H_2.

Q: Satyajit Mahapatra – OCI Fertilisers
Why did you not consider heat tracing on the bypass line to avoid condensation?

A: Heat tracing is not required according to the original project design basis. We never considered installing heat tracing due to high temperature of the syngas inside of the bypass pipe line. According to some experiences from literature, in such temperature and pressure conditions heat tracing is not an effective protective measure to avoid steam condensation.

Q: Satyajit Mahapatra – OCI Fertilisers
Did you consider free draining the line (slope the line) to avoid collection of condensate?

A: No, but we restricted the closing action of the temperature regulating valve TV141 to 25%, so that the valve is always partially opened to insure that the volume flow of process stream is present all the time.

Q: Jorge Camps – Jacobs Consultancy
I recommend that the risk assessment team should have had an outside consultant for credibility reasons – in case of an accident, insurance companies would have challenged the credibility of the group and its conclusions.

A: I agree with you, but due to the need for a very quick decision we must conduct the assessment procedure as fast as possible. Also in our fertilizer complex we possess highly qualified and trained experts in Safety Department which can deal with such demanding requests. In future possible actions we'll definitely consider setting up some communication channel with an outside consultant due to credibility reasons.

Q: Jaspal Singh – Notore Chemical
Was there any boiler feed water tube leakage history (the BFW is at high pressure and sudden expansion due to leakage can loosen flanges)?

A: Yes, we have a very long history with the tube leakages at our waste heat boilers 101-CA/CB, 102-C and auxiliary waste heat boiler. Due to this history, we replace the tube bundle of 101-CA/CB every 30,000 hours to be at the safe side. Regarding the 102-C, we are currently in the phase to construct the new tube bundle of 102-C, which will be made of two different materials. The bottom part of the tube bundle will be made from a material resistant to corrosion attack. After explosion of the auxiliary boiler in 2003 we replaced the tube bundle inside of the radiation chamber and since then we never had any kind of leakages.

1c Methanol Emission from Ammonia Plants and Its Reduction

Klaus Noelker – *ThyssenKrupp Uhde*

Q: Harrie Duisters – OCI Fertilisers
Does Uhde also have methanol absorption technology that could be installed upstream of the aMDEA section?

A: It is not shown in the paper, but methanol absorption into water or process condensate upstream of the CO2 absorber is also an option. Compared to absorption from the low-pressure CO_2 stream, absorption from the process stream requires less water due to the higher process pressure. The methanol-containing water can be sent to a dedicated stripper or to the existing process condensate stripper (if large enough or for a new-built plant) for re-processing.

1d A Conventional Ammonia Plant Revamp with Purifier™

Rajesh Aggarwal – *KRIBHCO*
Meghji Shah – *KBR*

Q: Majed Al Solimani – Ma'aden Phosphate
Did you solve the issue of lean / semi lean plugging after the change to the strainer type?

A: R Aggarwal - The problem was solved by strainer change and switching the plate exchanger to installed stand by on daily basis for about days. The second plant did not

experience much plugging problem as precautions were taken based on lessons learned from first plant cleaning procedure.

Q: Mukund Bhakta – Fluor
For improving coldbox performance (less pressure drop) have you tried reducing the waste gas pressure?
A: M Shah - The waste gas back pressure was lowered significantly. However, the improvement in expander pressure drop was marginal.

Q: Mukund Bhakta – Fluor
What is your limit for the waste gas pressure?
A: M Shah - The waste gas is burned in the auxiliary boiler. This limits the back pressure to about 1.3-1.4 kg/cm^2(g).

Q: Mukund Bhakta – Fluor
What is the size of the utility boiler?
A: M Shah - The auxiliary boiler is integrated with the reformer convection section. It has five burners, each with design firing of 60 MMBtu/hr.

Q: VK Arora – Kinetics Process Improvements
With higher pressure drop in the front end (with Purifier option) if the relief valve setting on the reformer was changed and/or any change in the pressure rating of the other parts of the convection section, process air compressor, etc.?
A: M Shah - The reformer outlet pressure was kept within the original design. The suction pressure of syngas compressor was lowered due to higher front end pressure drop.

Q: VK Arora – Kinetics Process Improvements
What was the 103-J suction pressure before and after revamp?
A: M Shah - The design 103-J suction pressure was lower by 3.8 kg/cm^2 after the revamp due to increased capacity and the purifier pressure drop.

Q: Widodo Sulistyo – Petrokimia Gersik
According to Table 2, can you explain why ammonia converter outlet is less for the Purifier option as compared to the conventional revamp option (18.75% vs 20.5%)?
A: M Shah - The conventional revamp case included an add-on single bed ammonia converter downstream of the existing converter.

Q: Israr Hazue – SABIC
What was the actual operating experience when you moved from hot potassium carbonate to OASE aMDEA?
A: R Aggarwal - Except for the initial cleaning issues in plant #1, the OASE system is working great with CO_2 slip from the absorber less than 100 ppmv versus design of 500 ppmv at higher than design revamp capacity. In hot summer days, the CO_2 slip exceeds 500 ppmv as lean solution air cooler capacity is limiting.

Q: Israr Hazue – SABIC
What changes were incorporated to the CO_2 removal flowsheet to accommodate the conversion to OASE technology?

A: M Shah - The details of changes in the CO_2 removal system are given in the body of the paper. OASE system is two stage system. The major changes include addition of bulk absorber, LP and HP flash and change of lean and semi lean solution pumps and addition of lean/semi lean solution exchanger.

Q: Rob Junderhans – Consultant
I estimate that the feed and fuel gas can be reduced by 3% by operating the Purifier Cold Box in the following manner: recover all incoming hydrogen towards synthesis gas (at present at small amount of hydrogen is lost in the waste gas) and increase the heating value of the waste gas by purging nitrogen to the atmosphere. What gas price would make the above investment economical?

A: M Shah - We have looked at the possibility of recovering hydrogen from the waste gas. Our initial feeling is that it would not be cost effective. We have not gone into detailed calculations of the savings.

SESSION 2 – MONDAY, AUGUST 26, 2013

2a Safe Life Time Extension of High Pressure Urea Reactor by Re-Lining

Joost Roes – *Stamicarbon B.V*

Q: Pervez Fateh – Fauji Fertilizer
We at Fauji have been installing a new lining over the existing lining quite successfully with our three reactors for the last 20 years. Why do we need to remove the old liner to install the new lining?

A: At Stamicarbon we feel that a proper inspection of the C-steel shell side should be done. For that reason we recommend to remove the existing liner. In case of liner on liner one also needs to ensure that the leak detection system is operating in a proper way. In case carbamate enters between the liners a small cavity can create a huge area with lack of oxygen in order to obtain the passivity of the stainless steel.

Q: Pervez Fateh – Fauji Fertilizer
In presence of corrosion resistance surface (lining) why should there be any corrosion of the carbon steel pressure shell, especially since we are monitoring the weep holes?

A: It is impossible to determine for example stress corrosion cracking on the C-steel side, a clear example is given in the paper.

Q: Ruben Wageck – Petrobas
How do you ensure a remaining life of 3 to 6 years before relining – what kind of inspection must be done and how accurate must this inspection be?

A: The life time mentioned referred to SIICC, the crack depth can be determined by means of eddy current testing, a special probe needs to be used which eliminates the signals caused by the circumferential weld. The cracking mainly propagates during starts and stops of the synthesis. The crack depth by EC can be determined with an accuracy of + and - 0.5 mm. From experience we found that remaining liner thickness of approx. 3 mm is acceptable.

2b Six Sigma Methodology for Primary Reformer Reliability

Gastón Schulz – *PROFERTIL SA*

Q: Muhammad Idrees – Engro Fertilizers
You mentioned that in the initial 7 years you had only one tube failure, but in 2008 the frequency of failures increased. Did the increase in failure rate have something more to do with the aging of the plant versus the operational strategy?

A: In the initial almost nine years, we had no failures. They started in March 2008. HScan and metallurgical analysis of sacrificed tubes showed a degree of creep between 2 and 3. We sacrificed those that were above that, but failures continued. We relate this to operational issues, since failed tube metallurgical analysis showed a consistent message, short term overheating, which points to burner flame stability. From 2007 we have had to

shut down , raise and decrease load frequently due to natural gas shortages, and considering the advanced deterioration of burners, and that only two of us were able to fine tune the furnace, it is most probable that some sort of unstable flame pattern appeared from time to time. After replacing the whole set of burners, this has not happened again. It is worth noting that these burners were used only at two ammonia facilities of our technology, and were removed from approved vendor list, due to, amongst other things, that they were prone to resonance.

2c High Pressure Carbamate Condenser Leak Detection and Control
Khaled Al-Khuraimi – *SAFCO*

Q: Mark Brouwer – UreaKnowHow
Did you include in your risk assessment of SAFCO 3 the risk that the carbon steel could be corroded?
A: Yes, it was. Continuous analysis for Fe as well as external thickness measurement were being performed.

Q: Khaled Mohamed – Alexfert
Did you find the root cause (the reason) for the chloride stress corrosion cracking – was it a water treatment problem, or insufficient blowdown?
A: It was from the feed steam due to an upset in utility plant that occurred in the past.

Q: Khaled Mohamed – Alexfert
Did you change the material of construction to Safurex for the new equipment?
A: Yes, material was upgraded to Safurex.

Q: Dorothy Shaffer – Baker Engineering and Risk Consultants
Was the process licensor, or any other outside resource, used for the risk assessment?
A: Risk assessment was done by SAFCO team with involvement of SABIC FMU as well as the vendor.

Q: Dorothy Shaffer – Baker Engineering and Risk Consultants
Was the consequence of a sudden or multiple tube ruptures considered in the risk assessment – and how far would the ammonia release travel?
A: The possible scenarios were listed and an interim action as well as mitigation plans were developed. However ammonia release was not expected based on the assessment, an emergency plan was developed and awareness was given to the plant team.

Q: Dorothy Shaffer – Baker Engineering and Risk Consultants
Was the damaged carbon steel side evaluated metallurgically?
A: No. Due to access limitations it was not done.

Q: S.G. Gedigeri – Oman India Fertiliser
What are the on-line inspection methods you followed to detect a leaking tube?
A: There is no on-line inspection method to detect a leaking tube, however, an external on-line UT was done with the help of the vendor to assure that the leak was not from the periphery.

Q: S.G. Gedigeri – Oman India Fertiliser
What are the on-line inspection methods you followed to detect a tube-to-tube sheet weld joint leak?
A: There is no on-line inspection method to detect a leaking tube, however, an external on-line UT was done with the help of the vendor to assure that the leak was not from the periphery.

Q: S.G. Gedigeri – Oman India Fertiliser
Did you measure the ferritic content of the tube sheet weld overlay?
A: Yes, it is part of the QC checks and the values were within limits.

Q: Majed Al Solimani – Ma'aden Phosphate
Did you apply risk based inspection study for this unit?
A: Yes, it is inspected as per RBI study.

Q: Majed Al Solimani – Ma'aden Phosphate
Did you define the integrity operating windows, which would include the chlorine, conductivity and other limits?
A: Yes, it was developed as discussed in the published paper.

2d Fluid Sealed Box-Up – An Online Technique to Arrest Corrosive Service Leaks
Muhammad Idrees – *Engro Fertilizers*

Q: Gery Willemsen – BASF Antwerp
By installing the pressure box around the flanges, the square area under pressure is increased, resulting in an increase of the axial forces on the bolts. How did you take this increase in stress on the bolts into account in the design?
A: Yes the impact of box-up on bolts was catered through various considerations, in the mechanical design preparation phase. The increase of axial forces on bolts was balanced through seal welding the bolts on the box-up. Seeing number of bolts holding the box-up, calculating load on each bolt, and maximum allowable stress for each bolt, weld size (throat and leg) was adjusted to impart additional strength to bolts to hold.

Q: Gastón Shulz – Profertil
How could you know that the bolts of the flange should not fail when exposed to carbamate after installing the high pressure box with CO_2 purge?
A: Bolts could have failed if:
(i) Carbamate slips out of the flange while CO_2 positive pressure was maintained at the annular region between CS box and flange. Pressure indicators were installed on box-up to maintain positive delta pressure between CO_2 and the process side pressure.

(ii) Mechanical strength of bolts was improved by enforcing seal welds on bolts with box-up.

Both these facts were considered during design phase of box-up.

Q: Jaspal Singh – Notore Chemical
How did you do the welding with the flange leaking, and what was the risk management in case the leakage increased?

A: After detailed safety analysis, hazards identification and communication of control measure (positive isolations were proactively identified to cope with uncontrolled situation) welding job was initiated. Box-up was in two halves from horizontal. Bottom half was provided with bleeder and an ejector installed to it which was routed to the safe location. During installation, caked carbamate deposition on flange was completely removed mechanically, while the carbamate leakage was 100 drips per minute.

Q: Jaspal Singh – Notore Chemical
Is it admissible to take the risk of damaging the flanges by boxing in?

A: The design does not pose any damaging threat to the flanges, which is evident from our experience. When box-up was removed, and flanges/stubs were investigated. Even the CS box-up was intact against wear/tear and thickness s(which was also monitored on-stream) was fine. If calculated flow of CO_2 (inert) is maintained, in proportion to the flange/gasket cavity, flange can`t come in direct contact to the corrosive mass. The instrumentation and indications installed on box-up is an obvious measure to ensure that flange or box-up material is not under direct risk.

2e Planning for Hundred-Fold Increase in Global Ammonia Production

William Ahlgren – *California Polytechnic State University, SLO*

Q: Harrie Duisters – OCI
What is the ratio between the number of power plants worldwide and the number of ammonia plants when the ammonia plants are built for the 100-fold increase in production?

A: To take advantage of economy of scale in CO_2 capture and sequestration (CCS), each natural-gas-to-ammonia conversion complex should supply many (hundreds) of electric power plants. How big must such an ammonia production complex be? In the following I suggest that a suitable size to consider would consist of four ammonia production units, each of 5 kt/day capacity, for a total capacity of 20 kt/day. Such a complex can supply fuel for 10 GW of electric power (denoted 10 GWe), corresponding to hundreds or even thousands of individual generating units.

A 1-GW electric power plant requires 3 GW of fuel power input, which is 259×10^3 GJ/day. The HHV energy content of ammonia fuel is 142 GJ/t and the LHV figure is 120 GJ/t. Take 130 GJ/t as an intermediate value. Then an ammonia plant of capacity $(259\times10^3)/130$ = 2 kt/day can supply a single 1-GW electric power plant. Dybkjaer, in his Symposium presentation, cited 3.3 kt/day as the largest existing ammonia plant, and 5 kt/day as the largest plant that has been designed (although not built). An ammonia production complex consisting of four 5 kt/day units, for a total capacity of 20 kt/day, would supply an electric

power production capability of 10 GWe. The State of California consumes about 20-30 GW of electric power. Thus, such a complex would supply about one-third to one-half of California's electric power. There are currently about 400 natural-gas-supplied electric power plants (most of them smaller than 1-GW capacity) operating within the state. The envisaged complex would supply all of these power plants, and more. Instead of doing CCS at all these 400 power plants, we can do CCS at just the one ammonia production complex. This is the economy of scale advantage for CCS. Is this advantage sufficient to balance the disadvantage of the extra cost incurred in the front-end conversion of natural gas to ammonia? This question remains to be answered. In addition to CCS, there are other savings in the energy chain (transport, storage, distribution) that can be credited to ammonia fuel. Can these savings compensate the 30-40% energy loss in conversion from natural gas to ammonia? Further analysis is needed!

2f Fast Detection and Localization of Small Ammonia Leaks Using Distributed Fiber Optic Sensors

Rob de Bont – *YARA France*

Q: Dorothy Shaffer – Baker Engineering and Risk Consultants
What is the sensitivity of location of a leak with the system?

A: The leakage can be localized with an accuracy in the of the order of 1 meter. This spatial resolution was defined after the field tests in Le Havre, where a spatial resolution of 2 meters was not precise enough, especially for very small and localized leaks.

Q: Dorothy Shaffer – Baker Engineering and Risk Consultants
Is it effective only on liquid ammonia lines, or can it also detect leaks from vapor ammonia lines?

A: From a process safety point of view we haven't done tests with ammonia gas leaks since the impact / consequences are far less compared to a pressurized liquid spill. Our presentation is focused on liquid ammonia. In general the system can detect any leakage where the leaking fluid has a temperature which is clearly different from the ambient temperature. In case of the possibility of detecting an ammonia gas leak, the optical fiber should be positioned on the top of the pipe or inside the thermal insulation. We have successfully installed similar system to detect gas leaks in buried pipelines, based on the temperature drop due to pressure release.

Q: Mohamed Ali Ahmed – Alexfert
What is the life expectancy of the cable once in service?

A: In normal conditions, the expected lifetime is in the order of 30+ years. This is based on telecom cable track record.

Q: VK Arora – Kinetics Process Improvements
Can this technology be used to detect leaks in propylene pipelines?

A: Detection of liquid propylene leakages would be very similar to ammonia due to comparable boiling temperatures.

3b Plant Reliability Improvement Through the Replacement of Ammonia Converter Baskets
Venkat Pattabathula – *Incitec Pivot*

Q: Khaled Mohamed – Alexfert
After 50 years of operation of the converter, what kinds of inspection for the pressure vessels did you perform?
A: There was ultrasonic testing performed on the shells to look for HTHA. No HTHA was found on the shells, nozzles, or heads. Heads from vessels A & C were evaluated using Liquid Penetrant testing, and confirmed to have full circumferential cracks on the ID, bottom corner of the ring joints. Crack depths were verified ultrasonically. Repairs were made to the heads with appropriate post weld heat treatment and mag particle and liquid penetrant testing to check for any cracking after each repair step.

Q: Muhammad Idrees – Engro Fertilisers
Did the recycle compressor get damaged from running in reverse?
A: After re-starting the compressor on the same motor but with proper direction, at full rates we did notice some vibration that was not normal. We took a one day outage preventively to change out the motor with a spare to avoid an unexpected failure. This motor was sent out to be rebuilt and I did not hear of any permanent damage to the motor or compressor itself.

Q: Muhammad Idrees – Engro Fertilisers
How did you find out that the recycle compressor was rotating in reverse?
A: At the end of the reduction, when we went to increase flow to the loop, we could not push more gas flow from the front end and the syn loop pressure went higher than expected at 4500-4600 psig. This has been experienced before, but only by a few people at the plant site. One of those people recognized the problem and suggested a reversed motor may be the issue. We brought the syn-loop down and checked rotation of the motor. It was then verified that the wires in the MCC room had been reversed when electrical systems were overhauled during the shutdown.

3c Successful Installation and Startup of an S-300 Ammonia Converter Basket
W. Clark Liddon – *CF Industries*

Q: Hal Cain – Cain & Associates
In hindsight, would the transportation of the basket been performed differently, possibly barge up the river?
A: The transportation was sent out for bid (firm lump sum) to three contractors. The transportation contractors did consider river, rail, and land. After the job was complete the contractor mentioned that they would probably go rail if done again.

Q: Hal Cain – Cain & Associates
Did police and city officials complain substantially due to the overland transportation?
A: Yes, but the permits were in place.

Q: Khaled Mohamed – Alexfert
Considering the loading of all three beds with pre-reduced catalyst, while it may make the start-up faster, safety considerations for doing it under a nitrogen atmosphere makes it more dangerous. What is your opinion?
A: As long as there are provisions to keep out any moisture (rain) and the catalyst temperature remains ambient there are no additional concerns. Nitrogen atmosphere is not necessary. We did have nitrogen available in case a temperature rise was detected. It is my opinion that there is very little risk with all pre-reduced catalyst. I would discuss this with your catalyst supplier.

Q: Jim Affleck – Queensland Nitrates
Had you seen any significant loss in catalyst activity over the 23 years of operation, and, if not, why not?
A: Yes, we did see some loss of catalyst activity. One of the reasons this unit ran so well was the large volume of catalyst initially installed (~3,500 ft3 for 1,400 stpd). The design was very conservative. It is also a tribute to good operations for many years.

Q: Muhammad Idrees – Engro Fertilisers
You had a planned schedule of 29 days – did you benchmark this schedule with some of the earlier upgrades from S-200 to S-300?
A: We did see similar retro fits from 17 day to 45 day outages. Our schedule was developed with input from the basket manufacture, catalyst supplier, and several sources of similar projects. The 33 days actual was 4 days longer than planned but reasonable.

Q: Muhammad Idrees – Engro Fertilisers
What was the percent change in catalyst volume from the S-200 to the S-300?
A: Very near the same, the S-300 has less than 100 ft3 more (~3,600 ft3 total).

Q: David Firth – Quest Integrity
Was there any damage found on the shell of the converter?
A: No. We did clean the walls and inspect every weld, outlet nozzle, and bottom forging with no significant indications.

Q: David Firth – Quest Integrity
Was there any significant damage to the basket?
A: We did not do a full inspection but we have no indications there was a problem with the old basket outside of normal expected wear.

Q: Ahmed Nuruddin – GPIC Bahrain
What was the plan versus actual time from mechanical completion to full production?
A: The project was mechanically complete in 33 days with 11 days catalyst reduction to full production. The catalyst reduction process could have been faster due to issues with the startup heater. The expected catalyst reduction should have taken 8 days.

Q: Ahmed Nuruddin – GPIC Bahrain
Were there any safety or process issues associated with the project that you would like to share?
A: There were no significant safety issues but there was much planning starting a year in advance to make sure all contingencies were considered. From a process standpoint, the converter is performing better than expected and has run well since startup.

Q: Pervez Fateh – Fauji Fertilizer
Why did the mechanical work take 4 days more than scheduled?
A: This was due to clearing the combustibles for catalyst removal (this had to be done a second time), weather delays, longer than expected inspection process, and nitrogen delays during catalyst removal.

Q: Pervez Fateh – Fauji Fertilizer
Did the increased inspection time mean that something unexpected was found, or was the additional inspection an afterthought?
A: No additional concerns just the process to clean, inspect each weld, and the time required for an inspector to complete this process took longer than expected. No issues or repairs.

Q: Pervez Fateh – Fauji Fertilizer
As per accepted industry practice, MPI of all T-joints is done and in case of any abnormality all weld seams are then inspected. Why did you decide to inspect all weld seems and increase the mechanical inspection time?
A: It is our practice to inspect all weld seams.

3d Strange Operation Experience in Synloop Boiler Ends in Extensive Repair of Ammonia Converter Cartridge
Reinhard Michel – *ThyssenKrupp Uhde*

Q: Majed Al Solimani – Ma'aden Phosphate
Is it the first experience of this kind of failure with this waste heat boiler?
A: The failure was not originally at the waste heat boiler. This was blocked by debris from the failed outlet pipe of the converter and suffered a consequential damage. Without these undetected defects in the plate material used for fabrication of the outlet pipe of the converter the boiler would have been without any damage. So this is a damage not due to manufacturer's or operator's mistake or design deficiencies. It was simply a rare undetected defect in plate material being tested in full compliance with the design code.

Q: Majed Al Solimani – Ma'aden Phosphate
What will be the changes in future designs?
A: There is no reason for a design change as the root cause was a material defect. However independent from code requirements we shall 100% UT test the outlet pipes of new cartridges to avoid reoccurrence of this mistake which was never experienced before in the Uhde history.

Q: Sherif Shams - EBIC
What is the temperature of the converter outlet?
A: The outlet temperature is in the range of 480-485°C.

Q: Sherif Shams - EBIC
You said that nitrite formed, which is related to temperature, so does the material of the tube have to be upgraded?
A: No, this is not necessary. All materials used in this atmosphere will suffer a certain degree of nitriding on the gas contacted surface. Ferritic material would suffer nitriding to the full extent of the wall thickness over the years. For austenitic materials the nitride layer thickness goes asymptotic at a thickness of ~ 0.4mm for long time exposure. High nickel alloys suffer negligible nitriding only a few atom layers thick. So for relatively thick walled parts like converter cartridges normal SS is sufficient. As long as there is no plastic deformation this nitriding depth does no harm to the equipment. High nickel alloys as alloy 600 must be used only for thin walled parts like thin walled bellows or wire mesh in the cartridge. This is based on long term material tests published by Hans-Dieter Marsch in an AIChE symposium paper published in 1983.

Q: Ali Jama – QAFCO
What lessons were learned in the repair and inspection of the SAFCO plant that can be applied to the QAFCO 4 shutdown in September 2013?
A: Basically nothing because if a similar defect in the plate material would have been present at Qafco 4 this should have been noted before. Safco has a lesser operating time than Qafco 4. Unless there is an increase of pressure drop in one of the waste heat boilers there is no need for inspection of the channel of the waste heat boiler. The outlet pipe of the first converter can be easily inspected visual by inspection during the catalyst replacement via the central gas collector and from top of second catalyst bed by removal of a bolted cover.

3e Safe Reduction of LK-853 FENCE at High Pressure

Mohadeb Hazra – *Agrium, Inc.*
Tim Reiter – *Haldor Topsoe Canada Ltd.*

Q: Venkat Pattabathula – Incitec Pivot
What was the advantage of carrying out the reduction at high pressure?
A: M Hazra - There was no advantage of carrying out reduction at high pressure. Actually it is a disadvantage. We use natural gas in a recirculation loop. Hydrocarbon induced reduction

reaction temperature decreases with increasing pressure. Lower the pressure, less possibility of crating hot spot and run away situation and safer the reduction.

Q: Venkat Pattabathula – Incitec Pivot
How did you manage the risks during the catalyst reduction?
A: M Hazra - We have managed risks by following the below factors:
a. Using a conservative, clearly laid out reduction procedure. The development of the procedure involved all stakeholders to identify and mitigate hazards before putting the procedure into practice.
b. Assigning specific staff who were dedicated to monitoring and controlling the LTS reduction and the LTS reduction only
c. Maintaining a sufficient amount of moisture in the reduction gas by maintaining a water level in the knockout pot to reduce the risk of hydrocarbon reduction by raising the hydrocarbon reduction initiation temperature.
d. Continuous monitoring of temperature and concentration with state of the art instrumentation.

Q: Muhammad Idrees – Engro Fertilisers
Did you put some type of physical strainer to prevent the LTS catalyst dust from getting into upstream equipment such as the desulpherizers during the recycling of reduction gas?
A: M Hazra - No. We don't put any extra physical strainer to remove LTS dust but the reduction loop contains a drum with demister pad.

3f Rehabilitation of a 1440 MTPD Ammonia Plant After 10 Years Out of Service
Francisco Morales Olán – *Petróleos Mexicanos (PEMEX)*

Q: Bode Agagu – Notore Chemical
Why was the plant shutdown for 10 years?
A: By the high international cost of natural gas, this plant was out of service and was declared unavailable on December 14, 2001.

Q: Bode Agagu – Notore Chemical
What were the challenges faced during the rehabilitation project?
A: In the beginning the dismantling of all the conditions of risk and the removal of all insulation of towers and lines without any accidents.

During the stage of rehabilitation was the coordination of the various works by all the contractors since activities of different specialties intersected (both floor-level and aerial). At the peak of the project there were about 1500 people working. All was completed without any accidents.

At the end, during the tests and startup, was eliminating all leaks that arose during the commissioning of the equipment.

Q: Bode Agagu – Notore Chemical
Did you experience cost or schedule overrun?

A: No, the project was estimated to be executed in an approximate time of 18 months. The plant was repaired, pipelines tested, equipment tested and started in 15 months. About 90% of the budget assigned was spent.

4c Reformer Component Management After an Overheating Incident that Resulted in Tube Failures

Manoj Thakur– *CSBP Ltd.*
David Firth – *Quest Integrity Group*

Q: Majed Solimani – Ma'aden Phosphate
Do you mean that eddy current testing is overly sensitive or more conservative?

A: D Firth - Eddy current testing alone is influenced by a range of factors in addition to creep damage. This can make interpretation and prediction of the life of reformer tubes difficult and can produce false negative results.

Q: Majed Solimani – Ma'aden Phosphate
Can we do Life Quest assessment with one eddy current result after two years of operation?

A: D Firth - An initial Life Quest Assessment can be carried using operational data and estimated tube temperatures. However, for a detailed life assessment creep strain data from LOTIS or MANTIS inspection combined with the past and future operational conditions is required.

Q: Carl Jaske - DNV
Using creep strain alone to predict tube life gives large uncertainty in the results because creep damage does not correlate with strain alone. Aging cannot be modeled unless you know the complete thermal history of the material. Strain is a highly variable measure of creep damage. Using 80% factor on life can be non-conservative if applied to average life. Comment?

A: D Firth - I disagree that aging requires knowledge of thermal history. The LifeQuest-Reformer software does not require temperature as an input. Rather the temperature is an output of the analysis. Both physical creep damage (plastic strain) and aging are thermally driven processes. By measuring strain, one can determine the temperature that was required to establish that level of strain. In the same way, the creep versus aging database study that Quest Integrity has undertaken allows that calculated temperature to be used iteratively to assess the level of aging that has occurred.

I also disagree that strain is a highly variable measure of creep damage. Strain is what is measured in a laboratory creep test to assess the level of damage. It is the most pure measure of creep damage possible.

I assume that you allude to cycling damage as influencing strain measurement. Cycling certainly was a problem and a major contributor to creep damage in old HK 40 tubes that had high wall thickness and hence thermal gradient and also very poor creep ductility; i.e. the ability to withstand repeated reverse strain. However, modern HP alloys with high strength and high ductility are much better able to cope with cycling due to lower wall thickness and much higher ductility and the contribution that cycling makes to damage in

these alloys is very small. In any case, the LifeQuest Reformer model takes cycling into account through its FE modeling of through wall stress gradients.

The Life Quest model takes into account the normal aging of the tube material. Strain is not a highly variable measure of creep damage. However, the creep strain to failure does vary on the past history and thermal cycling of tubes. These are all taken into account in the Life Quest model. In addition the Life Quest model considers the variation in creep properties of "new material" so the 80% factor on life recommended by API 579 is applicable.

Q: John Brightling – Johnson Matthey
Has the plant considered in-tube temperature measurement to protect the reformer at start-up / low flow conditions?
A: M Thakur - CSBP are currently reviewing this option.

Q: Brain Shannon – H Scan International
The paper states that eddy current testing can provide false negative indications due to magnetic permeability changes in the material (scale / microstructure). Do you agree that it is advisable to employ multiple techniques that will reduce the "false call" of damage in reformer tubes?
A: D Firth - It is advisable where ever possible to use multiple techniques to reduce false calls provided all the techniques are reliable. Providing recommendations on eddy current testing without carrying out a cross correlation with creep strain or sampling was shown to be over conservative. Utilizing the metallurgical examination of the worst case tube, considering creep strain, past history of operations and LifeQuest life assessment were, in this case, the best techniques to provide a consistent and reliable solution.

Q: Pervez Fateh – Fauji Fertilizer
What steps were taken to facilitate plant operation and extend tube life? (Note: we had a similar incident and we have de-rated design TMT from 905 C to 880 C. Reformer has been in service for last 3 months at 107% load.)
A: M Thakur - Initially prior to changing damaged tubes the following mitigations were implemented; operation of the furnace was limited, areas of tubes with high creep strain were insulated and the firing adjacent to damaged areas of tubes was reduced to lower the operational temperature in the damage areas of the tubes.

Q: Pervez Fateh – Fauji Fertilizer
Have you implemented any precautions to be taken while operating with tubes exposed to very high temperature?
A: M Thakur - In addition to the precautions stated previously, procedures have been modified to ensure tubes are not exposed to very high temperature during start up.

Q: Pervez Fateh – Fauji Fertilizer
Have you implemented any modifications in trip logic to avoid reoccurrence of such an incident?
A: M Thakur - Yes as indicated in the paper.

Q: Khaled Mohamed – Alexfert
What did you do for rectifying the steam flow measurement location in order to not repeat the problem again?
A: M Thakur - The location of steam flow measurement was changed to ensure it reflects the actual flow into the tubes.

Q: Khaled Mohamed – Alexfert
Did you implement the flue gas exit trip with one element or 2 out of 3 (because one element may cause false trips and reduce reliability)?
A: M Thakur - Flue gas exit trip is based on 2 out of 3 setting with the provision for bypass if needed (mainly for maintenance and calibration).

4e Experiences During Manufacturing of Reformer Outlet Pigtails
Pedro Imizcoz – *Schmidt + Clemens Spain*

Q: Wayne Chow – PCS Nitrogen Trinidad
What testing does S+C perform on pigtail post weld heat treatment?
A: We understand that the question refers to the last stage in the manufacturing process, which is the final solution annealing, since pigtails are commonly supplied as loose items, to be welded on site. In any case, post weld heat treatment would be necessary if pigtail is welded to a component requiring it, which is not common. After PWHT common inspections of Penetrant Test and Radiographic Test would be executed in this case.

The final quality control of pigtails after final solution annealing, commonly includes: visual inspection, final dimensional control and grain size control of representative samples of each heat treatment batch.

Q: Wayne Chow – PCS Nitrogen Trinidad
What is the accept / reject criterion with respect to grain size?
A: The most typical acceptance criterion is that the average grain size, as per ASTM E112 has to be coarser than 5.

4f Achieving Ultra-Low NO_x Emissions in Downfired Reformer Applications
Nigel Palfreeman – *Zeeco Europe Ltd.*

Q: Satyajit Mahapatra – OCI
What is the turn down ratio of these burners?
A: The turndown of the burners was 12.7:1 for the GLSF-10 Inner Burners and 13.94:1 for the GLSF-7 Outer Burners.

Q: Satyajit Mahapatra – OCI
Is the flame stable at low turn down ratio when tip is being cooled by more flue gas?
A: Yes, the flame is stable at the low turn down ratio. Zeeco did carry out burner testing in our Test Facility and one of the points was to demonstrate the turn down for the client.

Q: Satyajit Mahapatra – OCI
How much reduction was done in burner tip temperature in reducing NO_x formation?
A: Zeeco's major focus in the Free-Jet burner development was to reduce the adiabatic flame temperature, and not a specific reduction in the burner tip temperature.

Q: István Blaszek - Nitrogénmüvey
Do you have any measurement of the noise emission level of your new type burners?
A: During the burner combustion test for this project, the burner noise emissions were 78 – 79 dBA at 1 meter from the burner at maximum and normal heat release. As a general rule, the GLSF Free-Jet burner does not have any issues meeting 85 dBA at 1 meter from the burner noise emissions.

Q: Ken Lamb – Linde Engineering
What was your experience / results for CO emissions, especially at turndown?
A: During operation between Maximum and Normal Heat Release the CO emissions were essentially zero (less than 5 ppmv). At turndown the CO emissions would range from 10 ppmv – 50 ppmv depending on the fuel composition.

Q: Ken Lamb – Linde Engineering
As opposed to burner test stand conditions, where is 12:1 turndown achievable?
A: The 12:1 turndown is achievable in actual reformer operation if higher fuel gas pressure is available. Otherwise the turndown is reduced due to the low pressure trip point in the reformer control system.

Q: Ken Lamb – Linde Engineering
What is the achievable turndown in an actual reformer operation?
A: Depending on the low pressure trip point setting, the actual reformer should be able to achieve 7:1 – 8:1 turndown with no issues. Again, this actual turndown will depend on the End User's low pressure trip point setting.

Q: Ken Lamb – Linde Engineering
When would you suggest turning off burners versus relying on the turndown?
A: Zeeco would recommend turning off burner versus turning down all burners once the reformer capacity is reduced to 50% of rated capacity. This will allow fewer burners to operate at higher heat releases where the emissions guarantees are in effect.

Q: Venkat Pattabathula – Incitec Pivot
Can these burners achieve less than 10 ppmv of NO_x?
A: The GLSF Free-Jet burners can achieve less than 10 ppmv NO_x for some applications. For reformer operations, where the radiant firebox temperature is quite high, the 10 ppmv NO_x emissions requirement would be overly aggressive.

Q: Mohammed Ali Ahmed – Alexfert
What is the relationship between the excess O_2 in the flue gas and the level of NO_x?

A: Generally speaking, the lower the excess O_2 in the flue gas will reduce the level of NO_x emissions from the burner. The lower excess oxygen provides less of an opportunity for nitrogen radicals in the radiant section to combine and form NO_x.

Q: Mohammed Ali Ahmed – Alexfert
What is the optimum excess O_2 to give minimum NO_x emission?

A: The optimum excess O_2 level will depend on the fuel gas being fired. The optimum excess O_2 level for minimum NO_x reduction is generally in the 1% - 3% range depending on the fuel gas being fired.

5b Improvements in Reformer Monitoring Via In-Tube Temperature Measurement
Oliver Smith – *Air Products and Chemicals, Inc.*

Q: John McGrath – Incitec Pivot
We have found a surprising spread in outlet temperature of various catalyst tubes in our Foster Wheeler Reformer. What spread have you found?
A: The large spread in reformer tubes temperatures can have a negative effect on tube reliability and plant efficiency therefore we strive to operate with a spread of between 30-40 °F between the maximum and average tube temperatures.

Q: Muhammad Sheikh – Fauji Fertilizer
The maximum temperature in a catalyst tube is at the bottom half, then why is it needed to monitor tube metal temperature in the top half as well as the bottom half?
A: The top half of the tube is the best place to estimate the activity of the catalyst since it is where the largest temperature gradient is observed, which gives the best estimate of remaining catalyst activity.

Q: Ken Lamb – Linde Engineering
What is your experience with tube skin thermocouples (it is understood that hydrogen reformers operate at higher outlet temperatures than ammonia reformers)?
A: Due the high temperatures and aggressive oxidative environment on the furnace side of a reformer, skin thermocouples have been found to have a very limited life. Well insulated skin thermocouples have found to be the best but can cause tube-to-tube temperature differences.

Q: Dorothy Shaffer – Baker Engineering and Risk Consultants
How robust are the thermocouples?
A: Our current experience is that we have installed ~25 with 11 thermocouples in each. Of those ~275 thermocouples we have had 2 that have failed after ~4 years of operation. These were also some of the first installed and since then Daily Thermetrics have claimed an improved design but as of yet we have not been able to remove the failed ones to determine the root cause of failure.

Q: Dorothy Shaffer – Baker Engineering and Risk Consultants
What happens to the sheath when the catalyst is removed?
A: Upon removal of the catalyst, the CatTracker is removed from the tube so as to do normal tube visual inspections to ensure no residual catalyst. The CatTracker can then be reinstalled with the subsequent load of catalyst if desired. Before it is reinstalled it can be checked for accuracy by the manufacturer.

5c Operational and Safety Improvements in Foster Wheeler Terrace Wall™ Reformers
Rainer Basse – *Foster Wheeler*

Q: Ken Lamb – Linde Engineering
Some of the original installations had a double-row or radiant tubes – also called staggered row. What is the current opinion of FW with respect to single versus double row?
A: All current designs are single row designs; we have not offered a staggered row design in the past 30+ years. The reason we went away from staggered rows is that the tubes bowed and overstressed the horizontal pigtails, resulting in tube and pigtail failures. With the current single row design we also get the heat more uniformly into the tubes.

Q: John McGrath – Incitec Pivot
With the rectangular style burners in the side fired FW reformer, what NOx improvements can be achieved, and is the improvement easily maintained?
A: Foster Wheeler uses a variety of burner suppliers with constantly improving combustion emissions. We fire and stabilize the lean PSA or other off gases adjacent to a brick firing wall and do not see a significantly different NO_x value compared to other designs. The advantages of the Foster Wheeler firing method are:
- Stabilized flame pattern on and up a target brick firing wall
- No flame impingement
- Upwards firing with all burners visible from sight doors
- Ease of burner maintenance.

Q: Israr Haque - SABIC
What is FW's experience on adding tubes in existing radiant box (single cell furnace)?
A: It has been done. Limitations are: the sizes of the inlet and outlet manifolds for the additional flow rate and distribution considerations; exhausting the flue gas into the convection section and can the auxiliary equipment handle the additional process loads. There are other options to increase the capacity which should be discussed first.

Q: Israr Haque - SABIC
Do we need to expand the size of the convection section in the FW reformer when radiant box is extended?
A: To lengthen the convection section would be difficult and costly; rearranging the convection coils and ducting the flue gases from the lengthened radiant section are the design issues to address.

Q: Mohadeb Hazra - Agrium
What is the expected flue gas temperature at the stack (no FD fan with heat recovery in combustion air to achieve highest possible efficiency)?
A: The flue gas temperature at the stack depends on the design of the heat recovery system, a generic figure cannot be given. For a design with natural draft, the temperature is of course higher than for a design with air preheat.

If BFW preheating and Steam Generation for export are allowed the efficiencies (without APH) will be in the mid to high 80's depending on steam pressure. On APH units number 6 below addresses the limits on efficiency.

Q: Muhammad Ibrahim – Fauji Fertilizer
In a typical FW reformer of the 1960's the stack design temperature is 235 C. With the changes you have made, how much has it reduced, and what is the current stack design temperature?

A: During this time (1960's-1970's) the plant designers used the Steam Reformer for the steam boiler to start up the plant. The Terrace Wall Reformer could be designed as a natural draft reformer and start up with auxiliary burners only (i.e. radiant section off line) and generate huge amounts of steam needed to 'bootstrap' the unit into production. The radiant section (reforming) eventually came on line and production began.

The Terrace Wall Reformer had a great advantage at this time due to the natural draft capability and steam production flexibility such that many units were sold. The robustness and quality of these units mean that they are still around today.

Today's design often includes an air preheat system to increase efficiency. The limiting factor for flue gas temperature is the sulphur dew point. To avoid condensation in the air preheater or the stack the flue gas discharge temperature should be 10 to 15 °C above the sulphur dew point. This is usually a temperature of 135 to 150 °C.

Q: Dorothy Shaffer – Baker Engineering and Risk Consultants
Considering the new design for the peep hole cover, have considerations been given to human factors – specifically, if the firebox is under positive pressure when an operator opens the cover, will it reclose or will it continue to expose the operator to hot gases if he lets go of the door?

A: Foster Wheeler Terrace Wall designs use natural aspirating burners even with the air preheat system. What this means is that we do not require fans to provide the air to the burners, fans are only to overcome the air preheater and duct work pressure losses. With our units there is a chance to have the reformer go positive as in any heater but only from a drafting standpoint and not from air supply. The sight doors have bottom hinges and allow better viewing of the tubes and burners as the door is out of the way. Once the door is closed, it has sloped tabs on the frame that the door slides upon to securely close and eliminate tramp air infiltration.

When opening the bottom hinged door it must first be lifted a couple of inches before it can be opened. If the operator observes overpressure just in the beginning and lets the door go, it would slide back into the closed position. If he observes overpressure later, the door would swing open. If operations are concerned about leaving sight doors open or have history of going positive, there are sight doors with glass that would prevent hot gases from escaping.

5d Implementation of Process Safety Key Performance Indicators in a Large Fertilizer Complex

Geoff Blewett – *QAFCO*

Q: Muhammad Idrees - Engro Fertilisers
These KPI's look more like operational KPI's. Have you also implemented leading indicators?

A: These performance indicators were intended to achieve the following objectives:

i. identify operational deviations
ii. take short term action to mitigate any risk associated with the deviation
iii. implement actions to eliminate these deviations
iv. raise awareness of deviations by involving operations staff in reporting and resolving these deviations
v. reduce the number of new deviations though increased operator awareness and improved systems and controls
vi. use this intervention as a stepping stone towards implementation of PSM and related leading indicators.

This is still to be implemented.

Q: Muhammad Idrees - Engro Fertilisers
Do you have a plan for implementing behavior based personnel safety?

A: QAFCO have conducted a pilot BBS study and consulted various consultants who specialize in BBS. Based on the information available, it is not proposed to implement BBS in QAFCO.

Q: Satyajit Mahapatra - OCI
Why are so many control valves in manual and trip / interlocks bypassed, in spite of having rich experiences at QAFCO?

A: There are many different reasons for valves being on manual and each case is being assessed to determine if this is justified or if, with either process or equipment changes, the valve can be operated on auto. Typical examples are issues relating to stable control of level, variations in natural gas density, valves that are fully open during normal plant operation, etc. Override conditions are normally short term and related to maintenance work or, in some cases due to unreliable indications. In all cases, risk is assessed and mitigated.

Q: Phillip Mak – BP Chemicals
Given the large amount of data you have collected to develop your process safety performance indicators, how are you prioritizing KPI's for your team to address gaps?

A: You are correct in saying there is a large number of deviations identified. These are being prioritized by each Head of Section based on several criteria. Firstly, any deviations that are assessed to be of moderate risk are corrected or further mitigated where a long term solution has been identified and actioned. This can be done by reviewing each KPI with the operational team. Secondly, where deviations can be eliminated by amending

procedures this is done. Where temporary changes have been made, a review of the MOC documentation supporting this change is done to ensure that all requirements are met.

This is an ongoing process as many deviations are removed but others are added. However, as the awareness of the Process Safety issues increases, the number of deviations is decreasing.

5e Catastrophic Failure of Ammonia Synthesis Loop Boiler Feedwater Heater
Eugene Britton – *Mosaic Fertilizer, LLC*

Q: Pervez Fateh - Fauji Fertilizer
Although positive material identification was done but the supplier / vendor was legally bound to provide the correct material. What action, if any, was taken against the vendor?
A: A settlement was reached between the parties involved and their respective insurance providers. The terms of this settlement do not allow discussing the outcome of the settlement agreement.

Q: Jaspal Singh – Notore Chemical
What was the safety measures and frequency of monitoring in the field, since the complete circumferential failure could not have occurred in one incident (suggesting that detection of the leak before failure should have been possible)?
A: There was no indication of a leak before failure. Operators make rounds and walk through the area on a regular basis (at least every 2-3 hours) and based on prior experience even a small leak would have been audible and detected prior to the failure.

Q: Jaspal Singh – Notore Chemical
Were you able to save the converter catalyst?
A: The converter catalyst was not removed from the ammonia converter and following the plant's restart performed as it had prior to the failure.

Q: Wayne Chow – PCS Nitrogen
Did the previous inspection reports show any indications of cracking or hydrogen induced cracking on the 123C inlet?
A: Because hydrogen cracking was not the anticipated damage mechanism normal ultrasonic thickness testing and visual inspections were periodically performed in accordance with API 510. Those tests did not reveal any cracking or other damage mechanisms.

Q: Edgar Remedios – Ma'aden Phosphate
Was there a risk based inspection program to inspect this equipment in the 14 year period of operation?
A: This equipment was inspected as part of our RBI program. However, hydrogen cracking was not an anticipated damage mechanism so inspections were limited to ultrasonic thickness testing and visual inspection.

Q: Edgar Remedios – Ma'aden Phosphate
Was the equipment ever inspected internally on the gas side (tube side)?
A: This heat exchanger was never opened for internal inspection after the initial installation.

Q: Muhammad Idrees – Engro Fertilisers
It seems clearly that mechanical integrity and quality assurance were neglected in this case, however, did somebody ask the supplier why the material was not according to specification?
A: Agrico (Mosaic's predecessor), the NBIC Authorized Inspector, and the Vendor Quality Control Department were lead to believe that the upper channel was fabricated using the proper 1.25 chrome, .50 moly material. Documentation and material stampings were verified by all (3) parties. Positive material Identification was not widely used at the time the heat exchanger was fabricated, and it is still not a requirement of ASME Section 8.

Q: Muhammad Idrees – Engro Fertilisers
Do you conduct simulated emergency drills with government officials?
A: Mosaic regularly participates in emergency response drills with the St. James Parish Office of Emergency Preparedness, our local government emergency response authority.

Q: Bode Agagu – Notore Chemical
In respect to the 123-C, how did the original design perform in service in terms of leakage, and how is the current replacement unit fairing in terms of leakage?
A: The 123-C which failed had no process leaks prior to the failure. The replacement unit has operated with no leaks as well.

Q: Bode Agagu – Notore Chemical
Hydrogen induced cracking was identified as the reason for the failure. What inspection program have you put in place to avoid a repeat of the failure, and how often is the inspection conducted?
A: All equipment containing alloy materials are now subject to PMI testing at the vendor shop and when received on site.

5f Catastrophic Fire in Ammonia Plant Compressor Room
Patrick Le Calvé – *GPN*

Q: Muhammad Idrees - Engro Fertilisers
Why did it take so long to depressure the synthesis loop (comment from question: it should've been depressured in 3 to 5 minutes and avoided the extent of damage)?
A: The complete depressurization of the synthesis loop (from 200bar to 2bar) took 80 minutes in total. The depressurization was done through the normal synthesis purge gas valve, therefore the gas flowrate was limited. There is a bigger valve in the compressor room for that purpose, but this valve was not working any more (burnt cables) and of course, access to the building was impossible during the fire. As a corrective measure, a new depressurization valve has been installed outside the building in a safe location.

Q: Edgar Remedios – Ma'aden Phosphate
Have you considered inspecting small diameter tappings (e.g. ½", 3/4", 1") which are normally stagnant for most of the time (especially in plants which are old and have fluctuating weather conditions)?
A: Yes. All small tappings and instruments lines have been inspected, and a lot of them, which were suffering from outside corrosion (under insulation) have been replaced by stainless steel tubing. Now all these instrument connections are part of the plant regular inspection program, regardless of their size.

Q: David Firth – Quest Integrity
Was there any vibration modeling carried out to assess the resonance frequency of the small bore piping on the compressor discharge?
A: No. There was no evidence of vibration on this line and the vibration level of the compressor itself was very low.

Q: David Firth – Quest Integrity
When was the valve in question last maintained?
A: It was not possible to find out, because at that time, these small valves did not have individual tag numbers. Today, all manual valves regardless of their size have tag numbers, and the maintenance of each valve can be traced in the system.

Q: Muhammad Ashari – PT Pupuk Iskaordar
Did you inspect the failed pipe for creep with a metallurgical lab?
A: Yes. Metallurgical analysis confirmed that the cause of the pipe rupture was creep failure, the carbon steel pipe having been exposed to temperatures between 500°C and 600°C.

Q: Muhammad Ashari – PT Pupuk Iskaordar
What inspection technique do you use on your piping and how often is the inspection done?
A: Inspection techniques and frequency depend on the risk rating (risk based inspection). For carbon steel piping at ambient temperature, and non-corrosive fluid, visual inspection every 1 to 3 years (max) and thickness measurements every 3 to 6 years.