FIORDA
WWW.FIORDA.EU

FIORDA – Fertilizer Industry Operational Risks Database is launched.

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End of February this year at the Nitrogen and Syngas conference in Gothenburg AmmoniaKnowHow.com and UreaKnowHow.com introduced the FIORDA database created for collecting and sharing process safety and reliability information among participating companies in the fertilizer industry.

The concept of information exchange is not new in the industry and is being promoted during meetings and events. However, when we are looking for a focal point that collects technical information including process incidents and near misses and organizes it in a well-structured way, we will have difficulty finding it.

Traditional way

Nowadays various professional associations, governmental agencies and private companies develop incidents libraries where event reports (aka lesson leant) are collected for the future use. Despite those libraries being a great source of valuable information, the speeding world might find it too time and resources consuming to work with. We are looking for information and answers to our technical queries one click away: The FIORDA concept was born!

FIORDA way

Behind FIORDA structure lie several questions that we often face during operation and in projects:

1. If we face a technical problem in a plant section or equipment, what would be the best, safest and cost-effective way to solve that problem?
2. If we witness a near-miss incident, what would the worst outcome be, should it really happen and what is the best way to prevent such incident in the future?
3. Has this problem ever happened somewhere else?
4. How did other people manage to solve these problems?

In problem-solving the time is critical. The plant might be at risk of trip or shut down causing production and therefore financial losses. The fastest way to obtain information of the problem, validate it and implement it, would save us significant amount of time and money.

With these in mind, we design FIORDA.

FIORDA has been developed as a structured database allowing us to quickly extract data from near misses, process safety incidents, maintenance issues, operational lesson learned and EPCM projects and organize them by the following criteria:

- Plant code
- Incident code
- Technology (ammonia, urea, etc.)
- Plant section
- Main Equipment
- Sub-Main Equipment
- Operation phase (during event)
- Operating parameters (during event)
- Medium
- Risk category
- Hazard type
- Failure Cause
- Failure Mode
- Hours of operation
- No of failures last 6 months
- No of failures last 12 months
- No of failures last 24 months
- Deviation type
- Event description
- Immediate response action
- Findings
- Consequence – primary
- Consequence – primary cost
- Consequence – secondary

- Consequence – secondary cost
- Comments
- Risk Ranking
- Prevention Safeguards
- Mitigation Safeguards
- Corrective Recommendation
- Lesson Learnt

This structure allows us to filter large volume of data in a few mouse clicks and reach the case that we are interested in.

Case study:

A high pressure drop across the inlet and outlet of the secondary reformer in the ammonia plant suddenly occurred. The plant was shut down to determine the cause.
After the catalyst and support alumina balls were removed it was found that parts of the refractory support dome had collapsed, and that refractory balls and catalyst had filled the bottom of the vessel blocking the outlet transfer line.
Examination of the failed dome revealed that the bricks had primarily sheared at an angle close to 90 degrees to the major axis of the dome. It was concluded that the refractory dome failed as a result of high thermal stresses introduced as a result of the different thermal expansion between the refractory brick dome and the water-cooled vessel shell. The design had no allowance for thermal expansion.
The dome was replaced with a novel design using readily available alumina blocks. The plant was returned to service 30 days after the incident. [Ref 1]

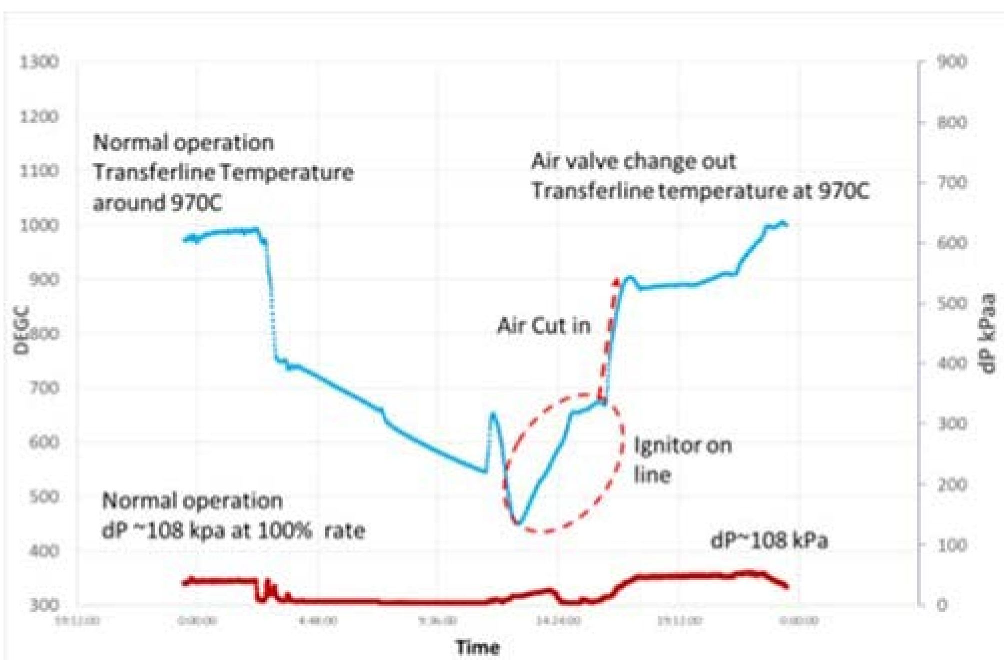
Parameters	FIORDA data
Plant code	
Incident code	
Technology (ammonia, urea, etc.)	Ammonia
Plant section	Reforming
Main Equipment	Secondary reformer
Sub-Main Equipment	Refractory support dome
Operation phase (during event)	Startup
Operating parameters (normal conditions)	Pressure = 3400 kPag Temperature = 950 - 985°C Normally 115kPa (17psi)
Operating parameters (during event)	Pressure drop at failure 900kPa (130psi)
Medium	Reformed gas
Risk category	Material failure
Hazard type	Process
Failure Cause	Thermal stress
Failure Mode	Refractory dome failed at Site 1 as a result of high thermal stresses introduced as a result of the different thermal expansion between the refractory brick dome and the water-cooled vessel shell. The design had no allowance for thermal expansion.

Hours of operation	8 h
No of failures last 6 months	0
No of failures last 12 months	0
No of failures last 24 months	0
Deviation type	High pressure drop
Event description	Ammonia plant tripped at 2:11 am due to natural gas compressor discharge temperature high high. At 9:30am plant start-up commenced. At 17:09 pm after air cutting to the secondary reformer, the pressure drop suddenly increased from 104 to 825kPa (15 to 120psi) in 8 mins and to 909kPag (130psi) in 5 mins, see attached trends. The plant tripped during the start-up due to secondary reformer outlet temperature high high (1080°C (1950°F))
Immediate response action	Plant total shut down. The catalyst and alumina balls were removed from the vessel. The bricks from the dome were removed. Plant inspection was performed.
Findings	Examination from above revealed that bricks had completely failed and were missing in three locations. In total 14 bricks in row 0, 7 in row 1, 2 in row 2 and 2 in row 3 had fallen out of the dome after failing. Examination of the skew blocks revealed that a large number had cracked and section had fallen off. After the removal of the skew blocks no damage was found to the inside of the shell or the steel support row which was present below the skew blocks. The shell diameter was measured and found to be within ±5mm (0.2in). Examination of the broken pieces of the dome showed that the failure of all the bricks was consistent with the dome trying to expand and being restrained from expanding; i.e. the resultant force was radial. The damage in the rows 0, 1 and 2 bricks is all consistent shear loading across the bricks with the failures running near to parallel with the horizontal. The damage to the skew bricks is consistent with high point loading where contact had occurred with top edge of the row 0 bricks, i.e. the loading was no longer evenly spread across the face of the skew bricks. The centre plug failed as a result of the compression point loading at the contact points with the tops of the row 4 bricks. A shutdown inspection revealed that all four of the quadrant centre bricks had fractured horizontally across the Z step line. The fractured centre plug bricks were removed and a new insert was cast in place.
Consequence - primary	Loss of production

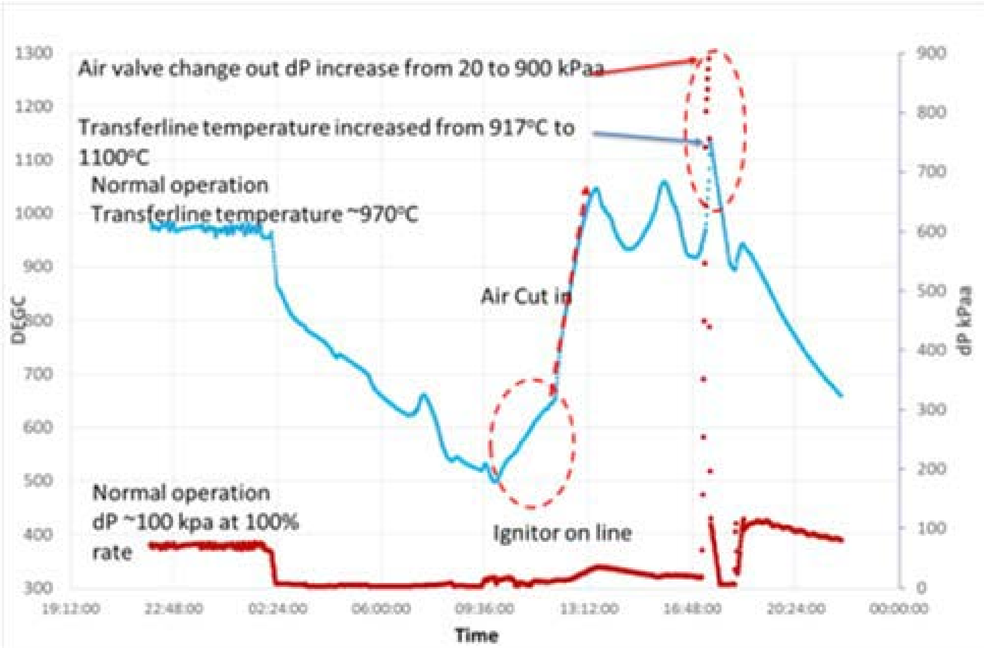
Consequence – primary cost (estimate)	$ 9,450,000 *
Consequence – secondary	Extensive maintenance
Consequence – secondary cost (estimate)	Unknown
Comments	There are very few complete failures of secondary reformer domes that have been reported to have occurred. However, a failure occurred in a single layer brick design dome in a different site in an identical manner to the Site 1 event. However, the cause of the failure was not identified. In addition, it was reported that damage occurred to the dome of the Site 1 vessel when it was operated by previous owner in another site. Company operates four secondary reformers worldwide and this case was the first incident of a dome failure or any significant damage being seen to the domes.
Risk Ranking	High
Prevention Safeguards	Design allowance for thermal expansion and high number of thermal cycles. Material selection during design phase. Site inspection and material certification (QA/QC). Operating procedures detail the startup sequence to prevent extensive gap in thermal expansion between refractory brick and water-cooled vessel shell.
Mitigation Safeguards	Review and consider alarm and trip sequence for high pressure drop on secondary reformer to limit the damage of internal refractory liner. Perform a Root Cause Failure Analysis to identify the cause of multiple plant trips that result in rapid automated depressurization and lead to additional material stress.
Corrective Recommendation	When the incident occurred at ammonia plant in Site 1 the plant had suffered numerous issues and a spare refractory dome was not available. For a dome the bricks designs vary between each row and as result it is not possible to get delivery of high alumina bricks urgently off the shelf. In addition, it was considered highly risky replacing the dome with the same design considering the history of the vessel. The company has a secondary reformer at Site 2 that has a catalyst support structure made from alumina blocks spaced in lattice to allow gas flow. This had been in service for 10 years and no major issues had been seen. A number of alternative designs were considered. It was decided to create a structure out of alumina blocks similar to that at Site 2 using readily available material. Design is shown in attached Figure 1

	The new installed dome and repaired refractory required a very delicate dry out process this included four major steps as shown in attached trend 3. The catalyst support structure was installed, new catalyst was used and the plant was returned to service 30 days after the incident. Since installation the pressure drop has been within normal design window ranging from 101 to 108kPa (14.6 to 15.6psi). The support structure was inspected in March 2014. Upon inspection by a refractory expert it was seen that the refractory was in serviceable condition with no areas of spalling or significant cracking. Minor repairs were required to the refractory on the associated transfer piping to remove minor hotspots.
Lesson Learnt	The Site 1 catalyst support dome failed as a result of high thermal stresses introduced as a result of the different thermal expansion between the refractory brick dome and the water-cooled vessel shell. The design had no allowance for thermal expansion and high number of thermal cycles. The dome was replaced with a novel design using readily available alumina blocks and the plant was returned to service after being shutdown for 30 days.

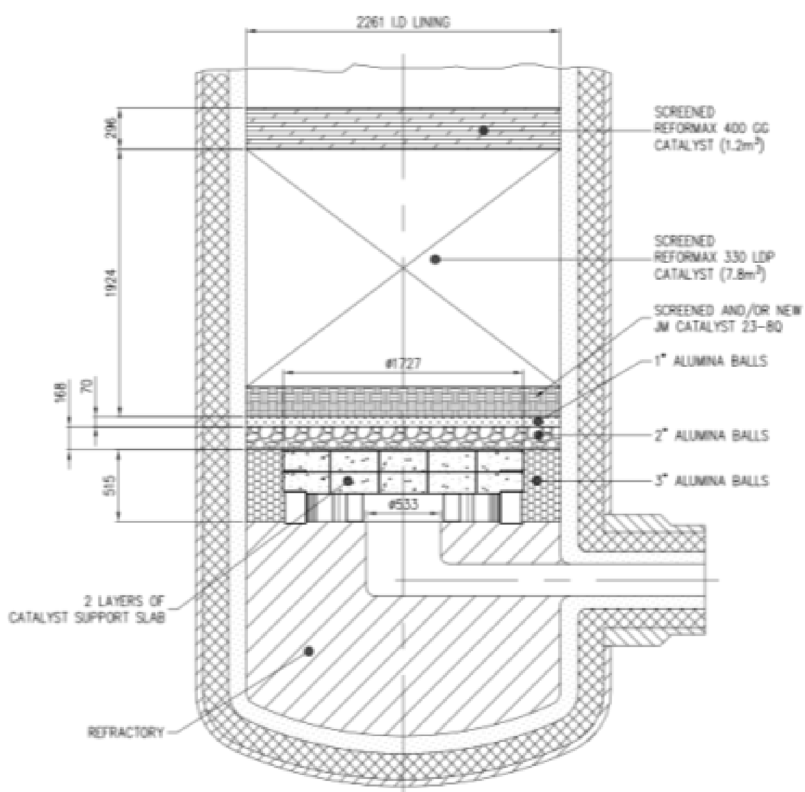
*Note: Loss of production estimated for 30 days x 450 TPD x 700 $/average ammonia price in 2013.



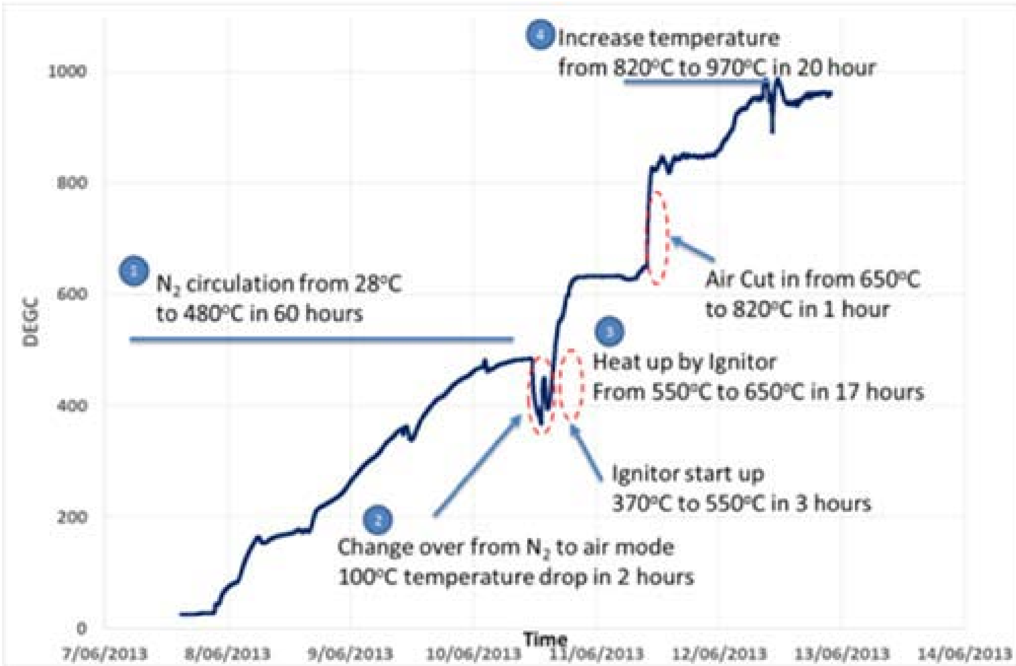
Attached trend 1: Normal temperature and pressure drop profile during start-up of the secondary reformer.



Attached trend 2: Pressure drop increase from 20 to 900kPa and temperature during the start-up.



Attached Figure 1: The new design for catalyst support for the Site 1 secondary reformer



Attached trend 3: Refractory dry out and initial startup of the secondary reformer after the installation of the new catalyst support structure over a five-day period
We can see the recommendation and solution used in this case and compare with our ideas.

As mentioned in the comment section “There are very few complete failures of secondary reformer domes that have been reported to have occurred.”

How fertilizer industry can benefit if companies around the world anonymously share their incidents libraries?

1. FIORDA can identify patterns and trends of similar safety and reliability issues based on repetitive problems occurring in the same plant units or equipment and alert operators to the occurrence of these events,
2. Through FIORDA database, operators can compare the experiences from different plants such as frequency of an event, severity of the outcome and applied corrective actions,
3. Corrective actions developed by other operators may be less costly than those tried in the absence of this information,
4. FIORDA members can develop their own internal incidents database using FIORDA free provided software HAZARDO®.

How does FIORDA membership work?

1. FIORDA members provide de-identified safety and reliability operational data anonymously. Any information regarding plant location, technology licensor, proprietary equipment, including equipment tag number, is removed,
2. FIORDA team reviews data quality and uploads information into the database,

3. A monthly bulletin is issued to FIORDA members informing about new data and existing recommendations for similar issues,
4. All FIORDA members have unrestricted access to FIORDA risk registers database.

Technical Queries

Member companies can submit TQs (Technical Queries) for a specific issue to FIORDA team of advisors.

FIORDA team evaluates the TQ and provides either an answer or a budget cost estimate for a detailed technical answer.

Procedures and Guidelines development

FIORDA technical team supports fertilizer manufacturers in development of dedicated guidelines and procedures based on their technology covering engineering for internal projects / revamps, operation, process safety and maintenance.

Lesson learnt from FIORDA database are incorporated in the guidelines to reduce the probability of unwanted events and increase safety and reliability in operations.

Software: Purpose made FIORDA software (HAZARDO®) has been developed to handle data collection and risk assessment analysis.

The HAZARDO® concept is flexible and can be configured to user defined applications. The HAZARDO® includes features for advanced data search and selection, and commonly used risk assessment analyses and action tracking functionalities.

All FIORDA member companies are eligible to receive HAZARDO® software free of charge.

[Ref 1] – White paper presented at AICHE Safety in Ammonia Plants & Related Facilities Symposium in 2016