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AMMONIA LOADING LINES REPLACEMENT AT RUWAIS FERTILIZER INDUSTRIES (FERTIL)

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Abstract

This paper describes the findings of Under Lagging Corrosion on our cold insulated ammonia loading lines, which are in cyclic service for a period of time and have given us a cause for concern. It also describes the actions taken to replace the lines and the future plans for maintaining the lines reliability and integrity.

Even though Fertil have adopted the preventive & predictive maintenance & inspection philosophy for the ammonia loading lines, it was surprising to find, that on close visual inspection after opening the insulation, approximately 56% of the lines length was observed with severe under lagging corrosion, leading to full replacement of the lines. (The length of the supply and return line each is 1900 meters).

Analysis of the reasons for the under lagging corrosion, concluded that moisture from the air was allowed to condense or freeze on or within the insulation, or on the cold pipe surface, as a result of the following contributory factors:

- Initial project follow-up deficiency.
- Deterioration and insufficient thickness of the insulation.
- Deterioration of the vapour barrier
- Damage / loosening of the metal jacket.

Replacement of the supply line was carried out on adhoc basis, by procuring the materials from various sources. The shipments have resumed without compromising on safety and integrity of the tanks.

Introduction

Construction of Ruwais Fertilizer Industries (FERTIL), commenced in 1980 and production started in 1983. Fertilizer products comprising liquid and urea are manufactured from the associated lean gas supplied from the onshore fields. The plant comprises of ammonia and urea processing units, having installed capacities of 1,050 MTPD and 1,500 MTPD respectively.

The plants have fully integrated utility units and storage/loading facilities. With consistent production above the design capacity and extensive process optimization, the company has continually improved its technology & productivity. Today FERTIL has become a very competitive company in the fertilizer industry worldwide.

FERTIL

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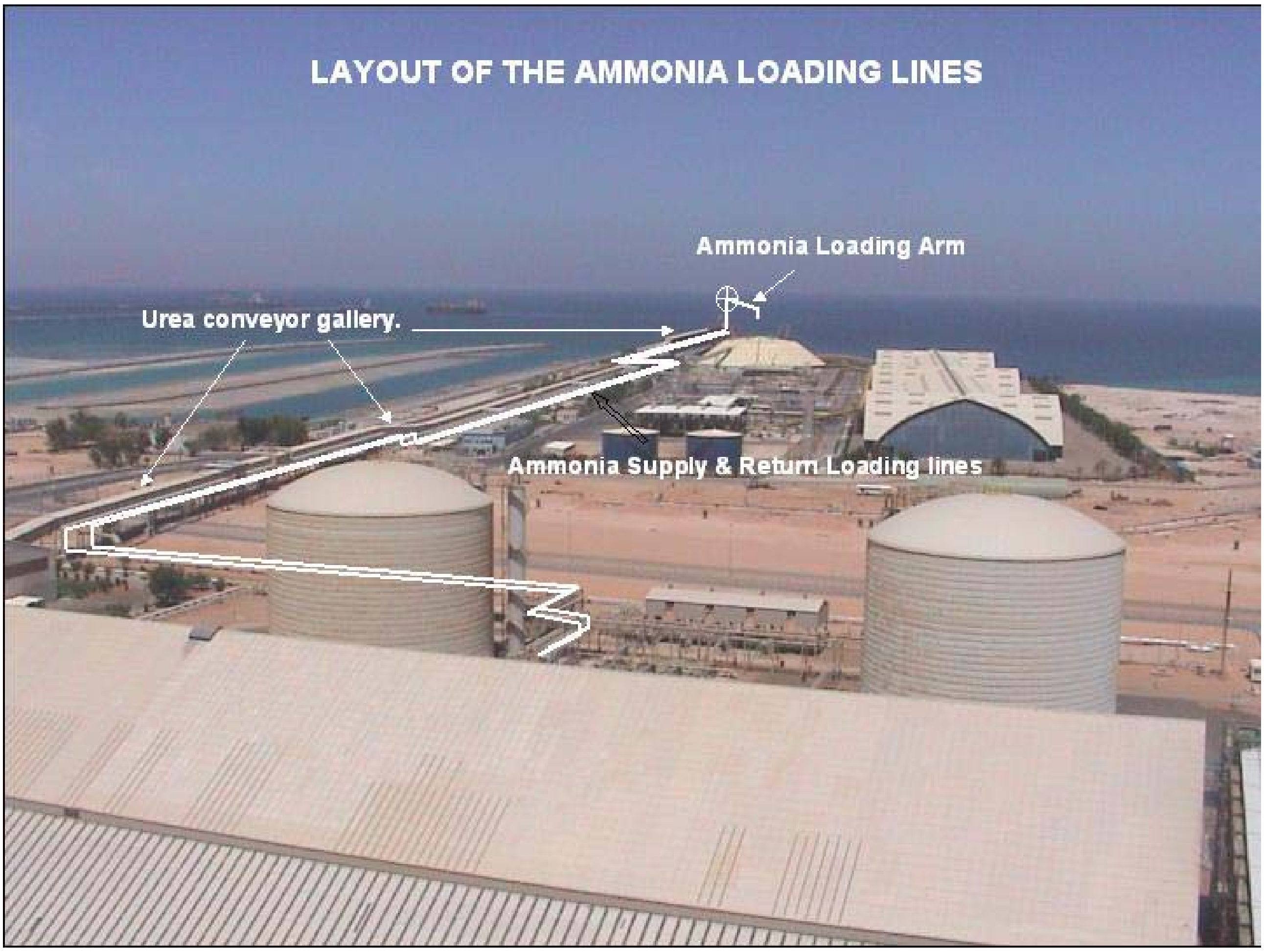
The complex was designed and constructed by Chiyoda Corporation of Japan, based on the technology, license and know-how of:

- Haldor Topsoe A/s, Denmark [Ammonia]
- Benfield Corporation, USA [CO_2 Removal]
- Costain Engineering, UK [Hydrogen Recovery]
- Stamicarbon b.v, Netherlands [Urea]



The ammonia plant initially had a rated capacity of 1,000 metric tons per day, which was later increased to 1,050 metric tons per day by incorporating the Hydrogen Recovery Unit.

Liquid ammonia is stored in two atmospheric storage tanks each having 20,000 MT capacities. The tanks, of double wall-integrated design, are kept at atmospheric pressure by a refrigeration system. Liquid ammonia from the tanks is transferred by 500 T/H capacity pumps, through the 12" (30cm) diameter supply and return ammonia loading lines directly to the ship. The lines are approx. of 1900 meters length each and cold insulated by polyurethane foam and metal lagging.

Under Lagging Corrosion

This paper describes the preventive and predictive maintenance of the ammonia loading lines and their replacement as a result of severe under lagging corrosion.

The management of FERTIL is committed to maintain the assets of the company in excellent physical condition even though operating the plants at much higher than the design capacities. Safety and reliability are the key words of the company policy and accordingly, the preventive and predictive maintenance programmes are in place.

Preventive Predictive Maintenance Program

During the early years since installation, with the lines found in good condition visually, the maintenance program was mostly based on reactive monitoring as a result of any evidence of deficient corrosion control and unacceptable visual damage.

Maintenance based on active monitoring of the lines, was regularized a short time later when regular checks and planned inspections were done to evaluate and ensure the agreed criteria were being met before things could go wrong.

In 1994, as a result of this active monitoring, all the vent tappings and drain points including the smaller diameter branch lines (4" diameter and below) from the main 12" diameter loading lines, found with severe under lagging corrosion and pitting due to condensation and also with considerable wall thickness loss as measured by ultrasonic testing, were replaced as recommended. No replacement of the 12" diameter piping was done.

Some other random locations on the 12" loading lines, where the insulation was found either loose or damp with moisture and condensation, mainly on the jetty deck, were opened for inspection. The exposed line sections at these locations were found with moderate coating damage, surface corrosion and isolated pitting within acceptable limits.

After surface cleaning, re-coating was done and the insulation was renewed. Based on the trend monitoring from Visual and Ultrasonic testing on the lines, predictive maintenance thereafter was increased proportionately.

Damage and loosening of the insulation, insufficient insulation thickness and inadequate vapor barrier applied to piping operating at temperatures lower than the ambient air temperatures, will allow moisture and marine spray (in our case also mixed with urea dust) to condense or freeze on or within the insulation surface, or on the cold pipe surface. The inadequacy of the insulation and vapor barrier will lead to moisture migration through the joints, seams, penetrations and supports allowing the insulation to get wet, causing under lagging corrosion and causing it to become ineffective.

The insulated ammonia loading lines are in operation since 20 years and are constantly subjected to the following stresses and detrimental conditions:

- Movement of the lines due to expansion / contraction from extreme weather conditions in the area.
- Movement of the lines due to contraction / expansion when they are charged with liquid ammonia.
- Flow induced vibrations.
- Structural vibrations transferred to the lines during operation of the adjacent Urea conveyor gallery.
- Structural vibrations transferred to the lines on the jetty, due to tidal movements.
- Structural vibrations transferred to the lines from other operating lines.
- The corrosive action of marine spray.
- The effect of wash down on the Jetty deck.
- Extreme humid conditions with the moisture and condensation mixed with large amounts of Chloride and Urea dust.

In 2001, to check and ensure the reliability, safety and the integrity of the complete length of the Ammonia loading lines, the "Long range low frequency guided waves" technique to inspect insulated lines, was carried out through an external inspection agency. This method of inspection was considered suitable, as it saved on downtime of the loading operations and also that the more tedious part of complete insulation removal was avoided.

The principal advantage of this technique is that it provides thorough initial screening and only requires local access to the pipe surface (i.e. removal of a small amount of insulation) at those positions where the transducer unit is to be attached.

This method uses low frequency guided ultrasonic waves, which can propagate over long distances. Depending on the attenuation caused by the insulating material, pipe condition or contents, it is possible to screen up to 30 ~ 50m of pipe from a single location.

The response to the metal loss feature, such as, corrosion or erosion, is a function of both the depth and circumferential extent of the material loss. Analysis of the waves distinguishes, symmetrical features such as circumferential welds, bends or flanges, but at the same time asymmetric features of local metal loss are identified by this technique, as top/bottom or mid-side wall losses.

The total length of approx. 3800 meters covering both lines, were inspected in 10 days, using this technique.

As a result of this exercise, a total of 250 meters of the line found with severe metal loss was earmarked for replacement.

Apart from the above long range guided wave inspection, visual inspection and ultrasonic wall thickness checks were also carried out at all locations on the pipe, exposed for placement of the transducers.

<u>The findings are as follows:</u>

- The metal lagging itself was found with few thru holes and showed signs of deterioration from aging.
- The vapor barrier and mastic compound were damaged.
- The polyurethane foam insulation was mostly damp from condensation & rust coloured, due to the line corrosion.
- The coating applied to the pipe was mostly deteriorated.
- The pipe surface was found with external moderate scaling corrosion & random pitting, with depths up to 4.0 mm, against the sound wall thickness of 6.4 mm.
- The welds, heat affected zones, anchor points and saddle supports wherever exposed, were also found in a similar condition with moderate external corrosion & pitting.

UT wall thickness measurements were carried out where the pipe surface was found satisfactory and the thickness loss was to a minimum as compared with the nominal pipe thickness.

<u>Maintenance actions as follows, were carried out after the inspections:</u>

- The pipe surface was hand cleaned by wire brushing.
- Deep pitting and external corroded areas on the pipe, welds and HAZ were reinforced with the application of supermetal compound.
- Re-coating of the pipe surface was done.
- Existing insulation and metal lagging was re-used over the application of new vapour barrier and mastic.

Having reservations about the inspection results of the Long Range Guided Wave technique, plans were drawn not only to replace the recommended 250 meters of pipe section recorded with metal loss and the full length of insulation and metal lagging due to its aging factor, but also to carry out a thorough visual inspection of the complete lines after they were sweep blasted.

A bench marking study was carried out with few other producers of ammonia in GCC and Asian countries. No serious problems were reported except for corrosion at the branch piping joints, vents and drains. Some of the producers checked the lines at random by removing the insulation, whilst some others monitored the lines with the help of wall thickness surveys using the radiographic technique at selected locations.

The work was initially planned for execution and completion in October 2002 between two consecutive ammonia shipments, but was extended up to end December 2002 due to the following:

The results from the thorough visual inspection concluded that 2,128 meters (56%) of the total line length was found in a severe condition, with extensive external corrosion and deep pitting. At one location after removing the external scaling corrosion on top of the pipe by sweep blasting, 3 holes were also found. The external corrosion on the pipe was more severe at the insulating joint locations, (both circumferential and longitudinal insulation layer joints and at the insulation contraction joints), as well as at the heat affected zones, where the ingress of moisture with dissolved salts had accumulated over time due to damage of the insulation joint sealer. The under lagging corrosion at these locations, was found with wide and deep grooves, having depths up to 4.0 mm. Pitting also with depths ranging from 0.5 mm to 5.5 mm was found randomly located throughout the lines length.

This problem was found to be unique to Fertil plant as compared with other producers of ammonia, using similar loading operations. The worst affected locations due to under lagging corrosion on both the supply and return lines, were in the off-plot areas up to the loading arm, (1700 meters line length each). The lines here are routed alongside the urea conveyor gallery. These sections need to be replaced.

The on-plot section of the lines (approx. 200 meters line length each), suffered little and isolated damage from under lagging corrosion and pitting. Replacement work required in these sections was minimal.

The problem of pitting over the pipe surface was found scattered randomly over the full line length, where a few meters were found in absolutely good condition, intertwined with areas where the pipe was found with moderate or severe pitting. No internal corrosion was observed at any section of the piping.

The original replacement plans were changed thereafter and it was decided to replace the off-plot sections of the lines with new pipes and the total line insulation, in phases.

This sudden change of plans made it difficult to source piping suppliers with available stock of better grade pipes, as only 300 meters of pipe had been procured to meet the line replacement recommended, following the long range guided wave inspection technique.

As the total requirement of replacement pipe (3,400 meters) of special material and of wall thickness as per original (Sch.20 pipe) were unavailable with the local stockists, it was decided to procure the length of pipe and fittings, sufficient to replace only the off-plot section of the supply line (1,700 meters). The available pipes procured were of Sch. 20, Sch.30, Sch.40 & Sch. STD. wall thickness.

Phase-1 : Was acted upon immediately, and the supply line was replaced at a cost of US$ 1,254,000 inclusive also of initially sweep blasting the return line.

Phase-2 : For replacing the return line the following year, was based on the availability of pipes. The same is now scheduled for Oct ~ Nov. 2003. As we wish to maintain the original project planning of using either of the lines for loading, the same size and insulated line is planned

Replacement activities of the supply line during Phase-1 included the following:

- Cutting and removal of the damaged pipes and insulation to the scrap yard. This included initial cold cutting of the line.
- Material verification of the new pipes at the vendors yard and on site.
- Stringing / erection of the new pipes. (The heavier wall thickness pipes were laid only at the ground level to avoid overloading the overhead steel piperacks.)
- Qualification of required number of welders to the specific WPS.
- Welding of the pipes and fittings on site.
- NDT requirements as per the line class including, preheat temperature checks, hardness tests, dye penetrant, ultrasonic tests and radiography, carried out by an external third party inspection agency.
- Inspection and testing of the isolation and remote operated isolation valves.
- Flushing, filling, hydrotesting and dewatering the line in sections of approx. 250~300 meters each for the complete off-plot replaced line. In case of the existing on-plot section of the line where only minimal replacements were carried out, this section
- was pressurized and depressurized in a cyclic manner, reaching 50%, 75% and finally 100% test pressure of 17Kg/cm2G.
- Surface preparation and coating of the reinforced concrete pipe sleepers.
- External coating after grit blasting, insulation and metal lagging application.
- Re-commissioning activities including drying of the lines after hydrotest, air blowing to remove dust, weld slag and internal debris, nitrogen purging, ammonia purging.
- Cooling down of lines after connecting the loading arm to the ship.

The return vapour line was taken in operation as it is, without any external insulation, since it serves just to return the liquid ammonia contained within the loading arm and any ammonia vapour from loading operations, to the evaporation tank / compressors, to be returned back to the storage tanks. The loading arms are then purged by inert gas or ammonia vapour. Some plants are using the return line without insulation. In our case, our original proposal was to use either of these lines for loading with minor modification, hence the same size line with insulation was installed.

Ammonia loading operations are on-going without any problems so far, even though the return vapour line is temporarily left un-insulated.

This paper has mainly highlighted the importance of inspection to check for corrosion under insulation right from follow-up of the contractors job at the plant construction stage.

As a result of our experience on the ammonia loading lines, other critical insulated piping of similar service within the process and off-plot areas, for both high and low temperature service, are under rehabilitation.

The following activities are on-going:

- Long sections of the piping insulation found ineffective where ice formation and condensation are observed are being replaced with new insulation of higher thickness, improved vapor barrier and metal jacketing.
- Some sections of the piping were also replaced in the last turn around in 2001, where moderate under lagging corrosion was found.
- Planning to inspect such critical lines line periodically , utilizing the development of pigging technique for the inspection of piping with lower diameter with short radius 90 degree elbows.

The following table includes the basic information & specifications for the above ground Ammonia, Supply and Return loading lines:

ITEM	As constructed (both supply & return lines)	As replaced (Phase-1, supply line only)
Line Diameter & Number	12" LA-41015 / 16	No change
Line Class	A2	No change
Line Length M	1900 each.	1700 (Supply line only)
Line Installation & Routing	Routed off-plot in Marine Environment and in parallel close proximity with the Urea Conveyor Gallery.	No change
Insulation type	Cold Insulation (C45)	Cold Insulation
Design Pressure Kg/cm2G	17 Kg/cm^{2}G	17 Kg/cm^{2}G
Design Temperature ^oC	-35~70^oC	-35~70^oC
Operating Pressure Kg/cm^{2}G	Kg/cm^{2}G	Kg/cm^{2}G
Operating Temperature ^oC	-33^oC	-33^oC
Test Pressure	Piping on-plot : 25.5 Kg/cm^{2}G off-plot : 31.5 Kg/cm^{2}G	(Old)Piping On-plot : 17.0 Kg/cm^{2}G (New)Piping Off-plot: 25.0 Kg/cm^{2}G
Fluid	Liquid ammonia / ammonia vapor	Liquid Ammonia / Ammonia Vapor
Line Pipe Material / Schedule.	ASTM A-333 Gr. 6 / Sch. 20	Dual Spec..ASTM A-333 Gr-6, API 5L X52 / Sch.20,30,40,STD
Line Fittings Material	A420 WPL6, SMLS, BW	A420 WPL6, SMLS, BW
Welding Process (Root/ hot pas	GTAW	GTAW
Filler wire	ER70S-2 (only root pass)	ER70S-2 (Root & Hot)
Welding Process (Fill & Cap)	SMAW	SMAW
Electrode	E7018	E7018-G
Line Expansion taken care by	Expansion Loops (7 Nos.)	No change
Line Supports type	Saddles, mounted on concrete sleepe	No change
No of Anchor Points	11 Nos. on each line	No change
Line External Coating	Primer 50 microns after grit blasting	Solventless 2 component amine cured epoxy. Carboguard 703 , 600 microns DFT. after grit blasting SA 2.5
External Insulation Material	Polyurethane foam 45 mm thk. x 1 layer. Density : Min. 2 lbs/cu.ft (6 lbs/cu.ft) at supports.	Polyurethane foam 45 mm thk. 60 Kg/m3 outer and inner layers. (120 Kg/m^3 at supports)
Weather Proofing	Mastic weathercoat, reinforcing fabric and vapor barrier.	Fibre Glass Fabric + Vapor barrier Mastic
Metal Jacketing Material	Aluminium Jacket, 0.4 mm thk. with moisture barrier.	Stainless Steel grade 316L Jacket of 0.8 mm thk with moisture barrier.