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Helium Leak Detection in High Pressure Urea Reactor

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OMAN INDIA FERTILIZER COMPANY

OMAN

Oman India Fertilizer Company was commissioned in April – 2005. The performance in the first ten commercial years of operation has been very good and the entire envisaged project target has been accomplished.This paper discusses high pressure reactor liner leakage issue in Urea-I unit. Leakage location could not traced by conventional methods until OMIFCO strove for helium leak detection.

INTRODUCTION:

OMAN INDIA FERTILISER COMPANY S.A.O.C (OMIFCO) was set up as a joint venture project under the initiative of Government of Sultanate of Oman and Government of India. OMIFCO is owned 50% by Oman Oil Company, 25% by Indian Farmers Fertilizer Co-Operative Ltd (IFFCO) and 25% by Krishak Bharati Co-Operative Ltd (KRIBHCO). OMIFCO was registered in the Sultanate of Oman as a closed joint stock company in the year 2000.

The Ammonia Urea complex comprises two trains, each with a design capacity of 1750 MTPD Ammonia and 2530 MTPD granulated Urea, along with all supporting Utilities. It is designed to produce 1.65 million tones of granulated Urea and 0.25 million tones of surplus liquid ammonia annually for export, using natural gas as the raw material. Storage facilities for Urea (2X 75000 MT) and Ammonia (2X30000 MT) as well as jetty with ship loaders are part of the project.

The complex has two service Boilers of capacity 2 X 70 MT/hr and two HRSG boilers of capacity 2X 110 MT/hr. Also the complex has its own captive power plant with two 30 MW Frame 6B Gas turbine Generators and import power connectivity with the national grid for backup power.

Fig. 1: (OMIFCO Image)

DESCRIPTION OF THE SYSTEM:

OMIFCO owns and operates two Urea Plants designed by M/S SAIPEM, Italy (Previously Snamprogetti). The Urea manufacturing technology used at OMIFCO is based on the Ammonia Stripping Process.

As per the process steps involved for producing Urea, feed Ammonia is fed to the reactor at elevated pressure. In the Urea plant the liquid Ammonia at about 15°.C (59°.F) and 23.5 Bar G (340.84 psig) pressure is initially received in an Ammonia receiver (V-105). Later by using an Ammonia booster pump (P-105-A/B), liquid Ammonia is pumped to the suction of the high pressure Ammonia feed pumps (P-101-A/B). The high pressure feed Ammonia pump transfers liquid ammonia to the Urea reactor through an ejector where the liquid Ammonia acts as a propellant for the high pressure Ammonium carbamate solution. CO_2 gas from compressor discharge at 158 bar and at 104°C temp enters into the Reactor.(Figure-02)

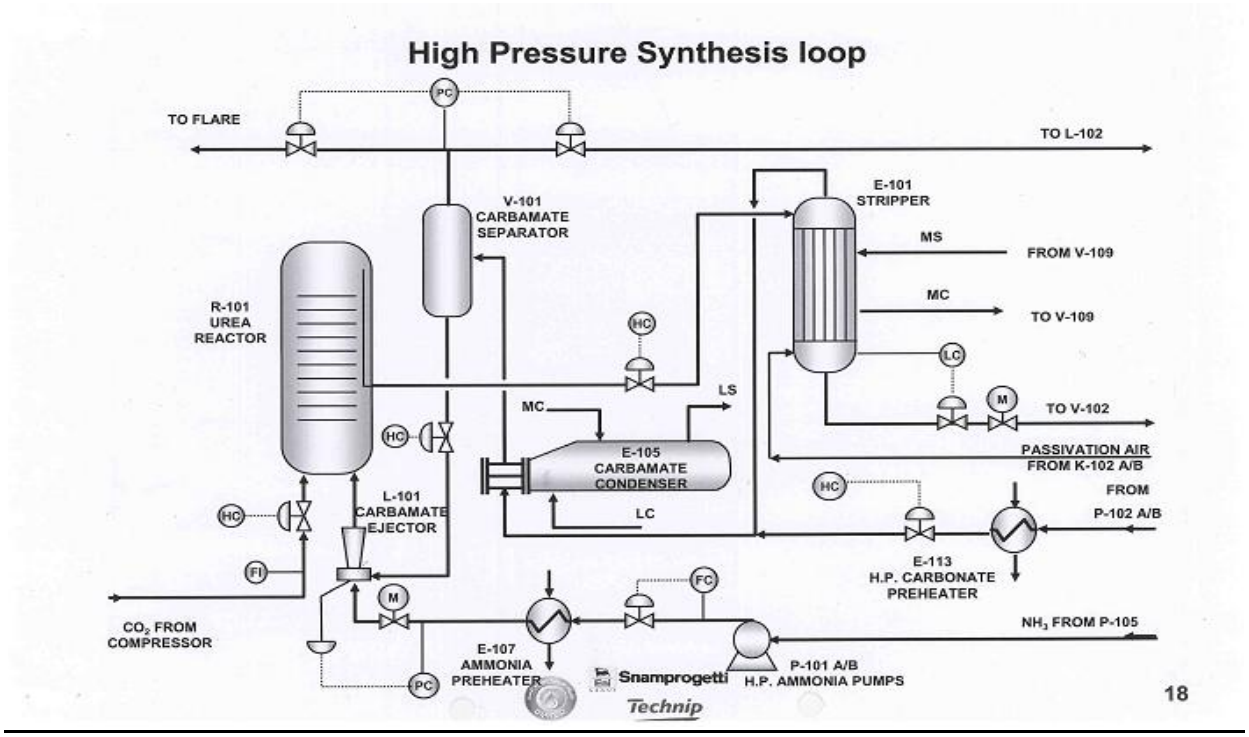


Fig. 2: (Urea HP Process Diagram)

INCIDENT SCENARIO OF HP REACTOR LEAKGE:

In Urea-11 unit during the plant shutdown inspection on 9th May 2014, a crystallized urea product is observed at the end of weep hole No.-56. This was the clear sign of leakage of the liner in progress during the operation of the plant. Also the same is confirmed by the lab reports. It was decided to ascertain the leakage location. No indication noticed on C-seam, L-seam & cleat joints by visual inspection & D.P.Testing corresponding to weep holes. (#55, 56, 23 & 24)

Fig. 3: (Leakage through Weephole)

REACTOR DETAILS:

Make: L&T
Design Code: AD-MERKBLATT 2000
Design Pressure: 167 Kg/cm2
Design Temp: 218 °C
Operating Pr: 152 kg/cm2
Operating Temp: 188 °C
Hydro test Pr: 238.91 Kg/cm2
Corrosion Allowance: Nil (5 mm thk liner)
Radiography: Full
Empty weight: 230650 Kg
PWHT: Yes
Shell Material: SA533 Gr. B Cl2
Shell Head (Top/Bottom): SA537 Cl2
Liner/Internals/Trays Material: SA240 Gr.316L MOD
Internal Bolting: 25.22.2

INVESTIGATION AND OBSERVATIONS:

Since the leakage was not traced by the visual inspection and dye penetrant testing, it was decided to perform conventional leakage detection test such as Soap solution test & Ammonia vapor leak test. Therefore the passage connection these weep holes were cleaned using steam from outside & subsequently by LW.

CONVENTIONAL TESTING'S:

First of all soap solution test was performed. In this test, air at 0.5 Kg/cm2 g pressurized through weep hole no. 55 & 56. Weep hole no. 23 & 24 kept plugged. No time given as soaking period. Soap solution was applied on inner surface of the liner. No leakage indication observed.

Further it was decided to perform ammonia vapor leak test as recommended by Saipem. In this test, ammonia at 0.5 Kg/cm2 g pressure is injected through weep hole no. 55 & 56. Weep hole no. 23 & 24 kept plugged. 6 hrs soaking time is given. Paper wetted in phenolphthalein solution was enveloped on the inner surface of liner. But no change in color is noticed.

Suspected Reason for No Detection may be low Test Pressure and Restriction in Air Flow

After getting gloomy results by above two tests, it was decided to start up the plant, but unfortunately leakage observed again from the same place (weep hole no. # 56). For few days plant was kept running in this condition. But after few days of plant running it is decided to stop the plant to pinpoint the leakage. Soap solution test & ammonia vapor leak test were performed again using same procedure but no positive indication came.

Now it is decided to perform helium leak testing. A vendor was called against the existing contract. On 10th Aug; Helium leak detection was performed.

HELIUM LEAK DETECTION:

Description

Helium Leak detection is based on mass spectrometry technique employing mass spectrometer sensitive to helium gas. It is commonly referred as Mass Spectrometer Leak Detector (MSLD). It is used to locate and measure the size of leaks into or out of a system or containing device. In this testing helium is used as tracer gas, and is introduced to a test part that is connected to the leak detector. The helium leaking

through the test part enters in the helium leak detector. The amount of the helium is directly proportional to the leak rate of the part. The partial pressure of helium is measured by the leak detector and the measured value is converted to display the leak rate of the part. Presence of helium is detected by MSLD. Depending on the test methods, qualitative or quantitative information about leak and leakage rate is determined. Helium is the best choice of tracer gas to find leaks for number of reasons. It is non-toxic, inert, non-condensable, non-flammable and not normally present in the atmosphere (< 5 ppm). Helium is the smallest molecule which is inert. Due to its small atomic size, helium passes easily through leaks.

COMMON METHODS OF HELIUM LEAK TESTING:

Mainly there are two methods to leak test parts using helium: Vacuum Testing (outside-in) and Pressure Testing (sniffer technique). The detection method should be selected based on the working conditions of the part to be tested. It is important to maintain the same pressure conditions during the test as they will exist during the actual use of the part. Vacuum systems should be tested with a vacuum inside the chamber. A compressed air cylinder should be tested with high pressure inside the cylinder.

Vacuum Testing (Outside-in)

In vacuum testing, the part is evacuated with a separate pumping system for larger volumes, or by detector itself for smaller volumes. To locate a leak, helium is sprayed to the suspected leak sites of the part using a spray probe with an adjustable flow.

Pressure Testing (Inside-out/Sniffer method)

In Pressure Testing, the part is pressurized with helium or a mixture of helium and air. To Locate a Leak, the potential leak sites of the part are scanned using a Sniffer Probe connected to the inlet of the leak detector.

Figs. 4&Fig 05: (Testing Machine)

PROCEDURE USED IN REACTOR:

It was decided to perform helium leak detection using Sniffer probe method. Suspected area circumferential seam # 7, 8, interconnecting long seam & cleat joints are masked with polythene sheet divided into a number of segment and edge of polythene sheet is sealed with suitable tape. This polythene envelope over leak susceptible area segment acted as a reservoir for accumulating leaking helium. Thus helium concentration in the envelope would increase with holding period and probability of detection of

minute leakages is increased. Instrument air is injected to dry the annular space then Helium was instilled through weep hole no. # 55 & 56 (weep hole no. # 23 & 24 kept plugged).

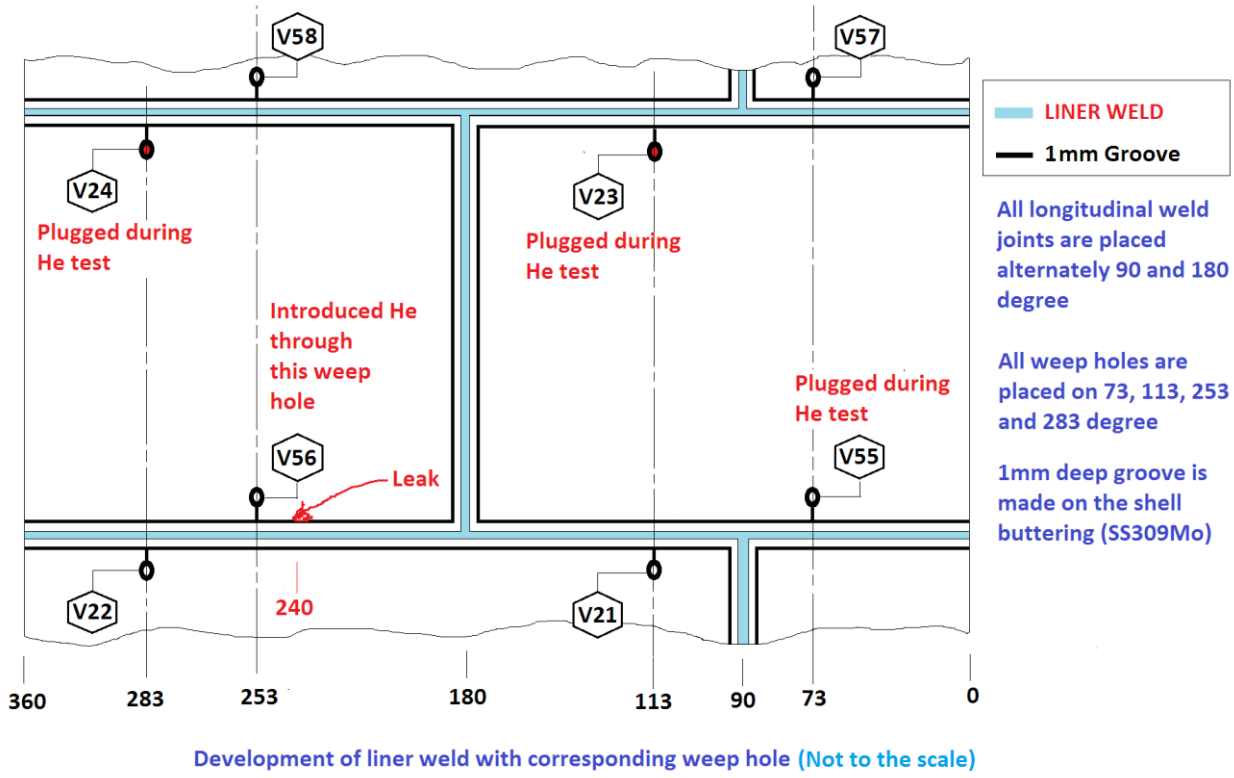
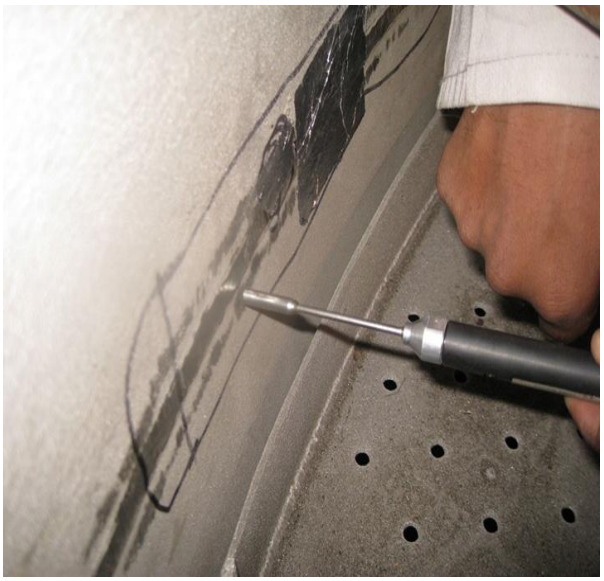
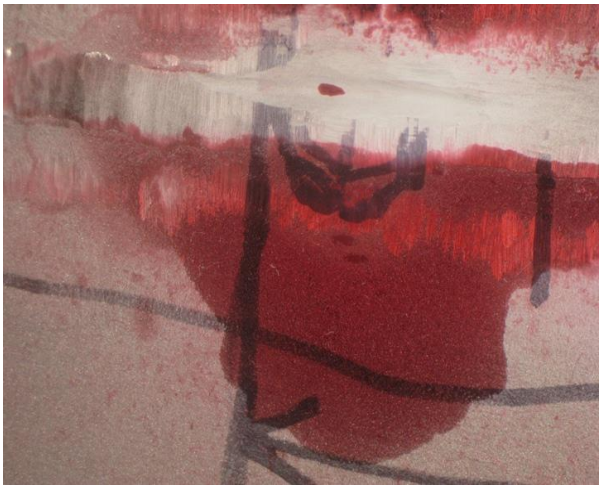


Fig. 6: (Liner Weld Area)

The annular space between inner lining and shell is pressurized with helium gas. Pressure is maintained around 0.5 Kg/Cm2 g. Since gas/air is already present in the annular space, concentration of helium gas reduces in the annular space. Four hour holding time was given. Presence of any helium under polythene sheet was checked by inserting tip of detector probe. Leakage is identified by Helium test in the 8th tray's circumferential liner weld joint. It was observed in the upper side wall of the weld approximately at 240 ° (Referred 0° from the internal overflow pipe clockwise).



Figs 7 & 8: (Test in Progress) & (Polythene sheet masked by sheet)



Figs. 9 & 10: (Leakage Area) & (Pinpoint Location)

REPAIR & REHABILITATION:

The suspected area (approx 150 mm weld length) was grinded and the area is checked by DP Testing which revealed a defect indication. It was arrested by welding and followed by DP test for root and final run. Repaired portion was checked with detector probe and no further indication was observed by Helium Leak testing.

Figs.11 & 12: (Repaired area) &(Repaired Weld)

CONCLUSION:

It was the first incidence of any HP vessel liner leakage in OMIFCO history.

Conventional testing's were failed to identify the leakage location.

This was the first time when any company in Middle East & India region used Helium leak detection for detecting such type of leakage.

Repair & recommendation procedure followed as per Saipem recommendation.

After OMIFCO experience, few companies in India tried helium leak testing for detecting such type of leakage and thrived.

OMIFCO used helium leak detection used again successfully in June, 2015 for detection of liner leakage in HP Carbamate Condenser.

OMIFCO is planning to buy above instrument in year 2016.