CO_2 pressurized box-up
A new technique to averting shutdowns on corrosive service leakages

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Abstract
Corrosion is an inevitable natural occurring, that leads to the destructive failure of the metallurgy, and loss of strength of the metal. Synthetic and specialized high resistivity materials have been developed to take on with highly corrosive services. Unusual care is taken while handling corrosive materials at elevated temperatures and pressures. Engro had experience of handling and containing highly corrosive mass leakage at Urea stripper liquid

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INTRODUCTION

ENGRO Fertilizers Ltd is the second largest Urea manufacturer in Pakistan, serving for more than 45 years. During its operational life, Engro has countless experiences in the field of machinery and equipment maintenance, in house repairs, and ingenious modifications. Engro holds Toyo ACES make 2050 TPD Urea plant, to produce prillgrade urea. Pressure as high as 2300 psig is maintained in the synthesis loop of plant. Synthesis loop where 65% per pass CO_2 conversion is achieved in plug flow reactor, passes its solution over to high pressure CO_2 stripper, where excess ammonia, and unconverted mass is recovered back to reactor within high pressure loop. Urea Stripper is Duplex lined vessel operated under high temperature with heat transfer from shell side to decompose unconverted ammonium carbamate into NH_3 & CO_2. Passivation air is provided on continuous basis to maintain protective layer, so that active corrosion can be controlled. Elevated conditions under this corrosive service pose a serious potential of equipment failure, in case protective layer breaks.

Engro experienced leakage of corrosive mass at high pressure stripper outlet, carbon steel faced male-female flange. Leakage turned to a continuous stream in the span of 2 months, various ideas were

implemented to hold the leakage, and to keep Urea facility operational. Various internal experts were consulted, however all ended up with the advice to shut down the plant, and repair the flange. This could have taken more than 4 production days. In the meantime, brain storming sessions were conducted to get an idea on holding this situation. An idea that came up and proved practical was the installation of carbon steel box up with high pressure CO_2 sealing. Since CO_2 raw material for Urea process was available at CO_2 compressor discharge at a higher pressure then that inside the stripper. Plant was kept operational for next 6 months, with various NDT inspections to monitor the performance of this invention. Inspection results showed no loss to the thickness of box up material, certifying that the leak had been properly seized inside the CS box up with pressurized seal.

A similar leak was developed later at Reactor outlet level control valve (angle type), from upstream flange, again the CO_2 pressurized design was utilized, and it did the trick another time. This time the box up was welded, installed in horizontal axis(as the leak was developed in very narrow area).

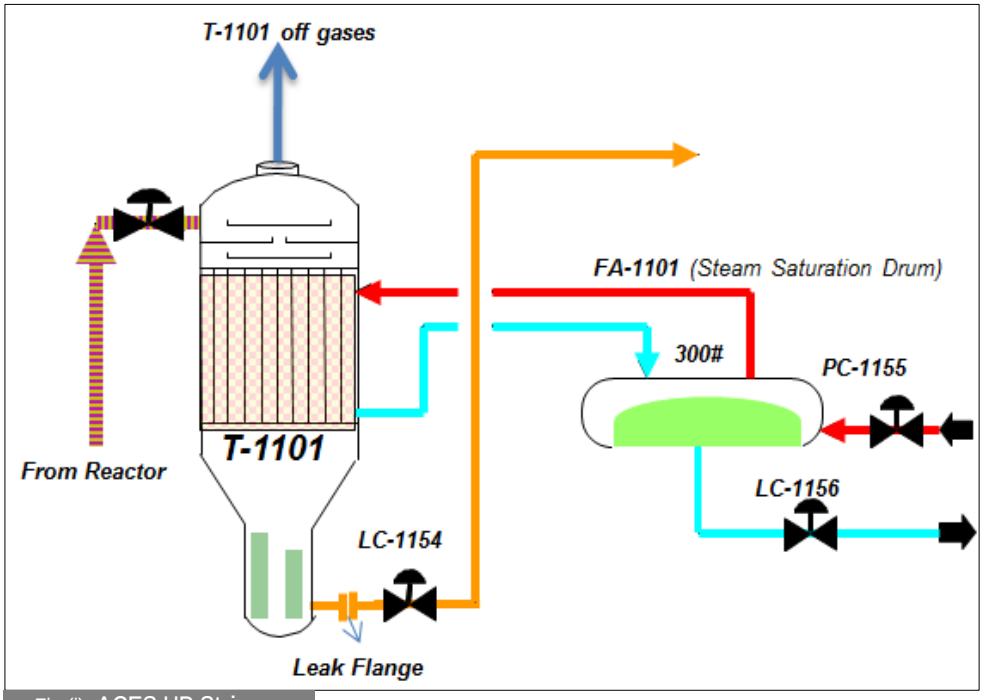


Fig (i): ACES HP Stripper

CARBAMATE LEAKAGE AT HP STRIPPER LIQUID OUTLET

Carbamate deposition on CS flange

In Feb 2012, drop wise leakage was reported from stripper liquid outlet flange (male-female) and extent was 8-10 drop per minute (dpm). Carbon steel flanges are susceptible to corrosion when come in contact with highly corrosive Ammonium carbamate mass. Flange bolts were tightened for possible gap available to contain leakage based on the available margin lestit should damage metallic titanium gasket. The extent of leak kept on increasing as it started composing a solid rock mass of dried carbamate over the leaking flange. Maintenance team was not of the view of carrying out further tightening, as it might result into extreme carbamate leakage from Stripper liquid outlet flange will pledge as result gasket fracture.

Deposit mass helped in containing the leakage for some time, as it sealed the flange. In the meantime, various options were explored to avoid evident shutdown of urea plant.

Fig (ii): Solid Carbamate mass encapsulating

Air Cooling arrangement around the CS flange

An air sparge was installed along the flange to cool the carbamate mass and transform it into solid pile that will frame the flange and will hold the carbamate seepage. This suggestion seemed to be working since after installation of air sparger, carbamate rock formed outside CS flange and contained the solution from coming out. Obviously, the leakage of NH_3 and CO_2 to the atmosphere was stropped due to crystallization of ammonium carbamate. However, this was not a guarantee that the flange leakage had stopped. There was a real risk that behind the crystallized product (crevice) corrosion was continuing. Beside the crevice corrosion at the stainless steel gasket area it could not be excluded that corrosion was occurring at strength bearing carbon steel flange which might have introduced a higher risk, so the air sparge was removed. In the interim, world renowned corrosion and material experts were contacted to give their verdict so that more than 90 hours of production loss can be saved. International experts and vendors suggested going for immediate shut down of the plant to avoid catastrophic failure of liquid out flange of high pressure urea stripper. It was in May 2012 when situation aggravated and fumes started coming out of flange with leak extent rose to 100dpm.

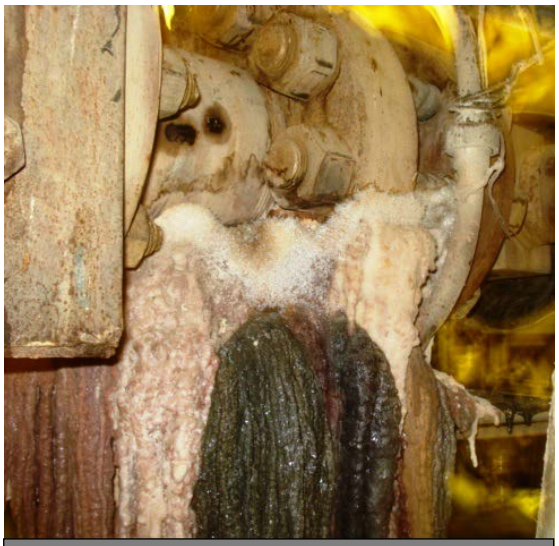


Fig (iii): Carbamatedeposition with air sparge

Fig (iv): Air Sparge over Leak Flange

Carbon Steel Cold Box up with Furmanite Sealant

Due to leakage from highly corrosive service, carbon steel shell was not recommended for installation owing to the interfacial contact of liquid carbamate. It was thought to install a cold box up shell with

furmanite filling. Various technical reviews were carried out, but this suggestion was also dropped due to the fact that proper sealing of leak was impossible even with the furmaninte filler and possibility of active corrosion in the crevice could not be excluded.

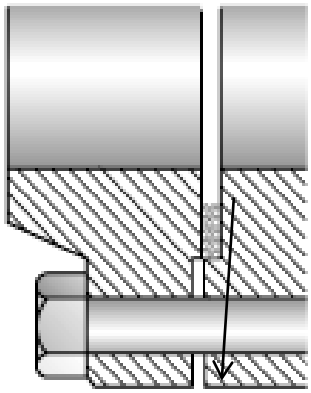
CO_2Pressurized Carbon Steel Box Up

The Operations team refused to give up to the situation and strived to resolve the issue. Various brain storming sessions were kept on going during this course to bring out-of-the-box solution that eventually, came in with the form of pressurizing the CS box up with a gas having a pressure higher than that of the process, sealing the surface from direct corrosive mass attack. In-house fabricated carbon steel box up was finally decided to be installed over flange with high pressure CO_2 establishing an interfacial layer to avoid direct contact of carbamate mass with carbon steel metallic interface, due to CO_2 pressure higher than that of carbamate inside stripper. Thorough safety reviews& hazard analysis were carried out. Box up was fixed after rigorous welding activity of around 20 hours. Bolts of flanges were grinded and seal welded (refer to fig-vii).

CO_2 tubing was injected from one port and option of high pressure flooding water (KPFW)was given from other port to flush carbon steel box up in caseCO_2 pressure dropped below the carbamate pressure, which was possible during tripping of CO_2compressor.

After 02 months, another leak was developed on urea reactor outlet level control valve upstream flange of the similar make and kind. The pressurized box up technique was again utilized over there safely and it served the purpose successfully. In this way, this new technique averted imminent plant shutdown twice for 4 days and collectively saved production loss of 8 days corresponding to remarkable monetary savings of more than a million USD.

Box Up Mechanical Design



Damaged Gasket of Male-Female Flange (Leakage Spot)

Health Check

In order to provide an immediate health check of high pressure box up, the drain bleeder was kept slightly opened, so that CO_2 coming out of it could be hand-felt all the time, endorsing that positive pressure than process side had been maintained inside and ensuring that leak is properly sealed. Also a pressure indicator was installed on HP box up to log pressure delta between CO_2pressure in the box-up and pressure of stripper outlet stream. This delta was another check that leaking point is intact. In case, the delta had reduced that would have indicated the extension of leakage point and hence the extent of leakage.

Safety reviews

Job safety analysis (JSA) was carried out before initiating the installation activity of Box up. Special Personal Protective Equipment (PPEs) was suggested for the particular job, and the activity was executed under higher safety focus and checks.

Procedure for box-up commissioning with CO_2 was developed to line up & isolate box up during interim phases or disturbances in plant operation. Additional procedural coverage was provided on emergency shutdown actions, to immediately isolate CO_2 tube inlet, in case of CO_2 failure (followed after compressor tripping) & flush the carbamate box up with high pressure flooding water.

Box Up Inspection

NDT techniques were used to verify the integrity of the box-up. Ultrasonic testing (UT) technique was used to identify CS shell thickness loss. This was the online test that could predict the impact on CS shell.

Throughout the six months, zero thickness loss was reported by inspection team, as this was the sign of no deterioration of CS shell.

Fig (v): Pressure Indication for Positive

Fig vii): Commissioned CO_2 high pressure box up

Box up metallurgy after removal

Plant remained operational for 6 months till the turnaround, during which CS box up was removed. Internal surface showed no evidence of internal grooving or corrosion on the exposed part.

Box up was removed, by cutting and grinding, as it was welded over the spool.

Inspection was carried out to verify the internal surface of the metal box up.

It was revealed that the internal surface was smooth, with no internal grooves or pitting indications from the seam. Also the metallic color was intact with no corrosion clue through visual inspection.

Fig(viii):*High Pressure Box-Up(Internal MetallicSurface)*

Industrial application:

This invention can be used for various scenarios to seal the leakage without shutting down the facility, reducing the downtime and saving hefty amount of cost related to production loss.

- Line leak of flammable mixture, high pressure gas, acidic/basic solution, high / low viscous fluid leakage, this model is a perfect as a tool.
- Sealing fluid (CO_2 in our case) can vary depending upon the readily availability of fluid& nature of material being sealed. Sealing fluid can be a gas or a liquid.
- Inert media like high pressure N_2(blanketing), can be used for flammable gases.
- In off shore rig foundations and under water piping network, where water is highly saline and high corrosion is expected.
- At the plants where sea water is used for cooling, a fresh water sealing box-up can be used in case of leakage.

Acknowledgements

Urea operator, Mr Ghulam Qadir came up with the idea of using high pressure gas for perfect sealing of the leak during the brainstorming sessions, which ultimately saved 08 days of production loss on successful implementation. Hewas awarded with Engro's Manufacturing Excellence award for this unmatchable contribution in enhancing the operational reliability of Urea plant and advancing *towards a new gateway for handling Corrosive services at high pressure and temperature without disturbing the operation.*

Ghulam Qadir