Indian Farmers Fertiliser Cooperative Ltd.

Aonla Unit

Safety Measures Taken During Decommissioning and Recommissioning of Ammonia Storage Tank T-2301

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Ammonia Storage Tanks are an integral part of any ammonia plant or fertilizer plant, and their critical nature becomes evident considering the highly hazardous contents they store. Ensuring the safety and integrity of these tanks is of paramount importance to the operating company and the communities at the location. Ammonia Storage Tanks are known to be one of the most intricate and challenging pieces of equipment to inspect.

At the IFFCO Aonla unit, the Ammonia storage tanks were commissioned in 1998. The tanks were last inspected in 2001. Now, after 21 years of service, in 2022, as per API 653 code, it is necessary to ensure their integrity. The total service period of T-2301 is 33 years. After 33 years of service of fully refrigerated tank may likelihood of SCC (Stress corrosion cracking), pitting or any other discontinuities, so tank is required to ascertain its health and mechanical integrity. And it's mandatory to carry out third party inspection report for statutory requirements, which would be revived after thorough inspection, if there is any defect.

The Decommissioning, Inspection, and Re-commissioning of the Double Wall double integrity Ammonia Storage Tank with a capacity of 10,000 MT at IFFCO, Aonla, was carried out by M/s Gulachi ENGINEERS PVT LTD, INDIA.

Description of Ammonia Storage Tanks:

At IFFCO Aonla, to ensure efficient and continuous operation of the Ammonia and Urea plants, two fully refrigerated Ammonia Storage tanks, each with a capacity of 10,000 MT, have been installed. These tanks are responsible for storing the liquid ammonia produced by Ammonia Plant-I & II. The liquid ammonia is stored under specific conditions, maintaining a pressure of 450 ± 150 mmWC above atmospheric pressure and a temperature of -33°C. Slight pressure is maintained in the tank to simplify the refrigeration system.

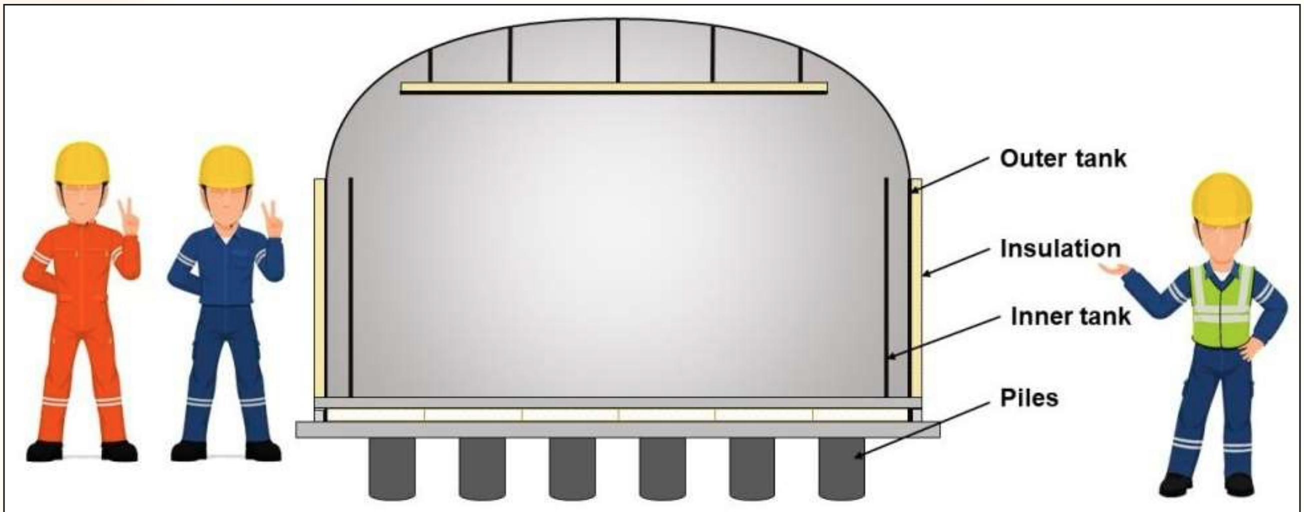
The tanks, commissioned in 1988, have been in service for 33 years. They are designed as cylindrical flat bottom double-wall tanks, situated over a raised foundation supported on piles. The inner tank, without a roof, is responsible for holding the liquid ammonia, while the outer tank, insulated and equipped with a roof, surrounds it. The annular space between the two tanks is filled with ammonia vapor. To ensure proper maintenance and inspection, both tanks can be inspected individually, with one tank remaining in service while the other is inspected. Each tank is equipped with three multistage pumps that supply liquid ammonia to the Urea plant or loading facilities. Before supplying hot ammonia to Urea Plant-I & II, the liquid ammonia from the pumps is heated to 10°C using the ammonia heater vaporizer system.

Any ammonia vapor generated due to boil-off is directed back to Ammonia Plant-I under normal operating conditions. However, in case of trouble or shutdown in Ammonia Plant-I, both tanks' pressure is controlled by their respective refrigeration systems. Additionally, individual flare stacks are available to burn off excess gas in the event of high pressure.

Two nos. of tanks can be inspected one by one by keeping one tank in service whenever needed. Each tank will have three nos. of multistage pumps to supply liquid ammonia to Urea plant or loading facilities. Liquid ammonia from pumps is heated through ammonia heater- vapourizer system to 10°C before supplying hot ammonia to Urea Plant - I & II. Ammonia vapour generated due to boil-off will be sent to Ammonia Plant-I under normal condition. In case of trouble or shut of Ammonia Plant-I both tanks pressure was controlled by respective refrigeration systems. Individual flare stacks are available to burn excess gas in case of high pressure.

By following these well-designed systems and procedures, IFFCO Aonla ensures the safe storage and supply of ammonia for the optimal operation of its Ammonia and Urea plants.

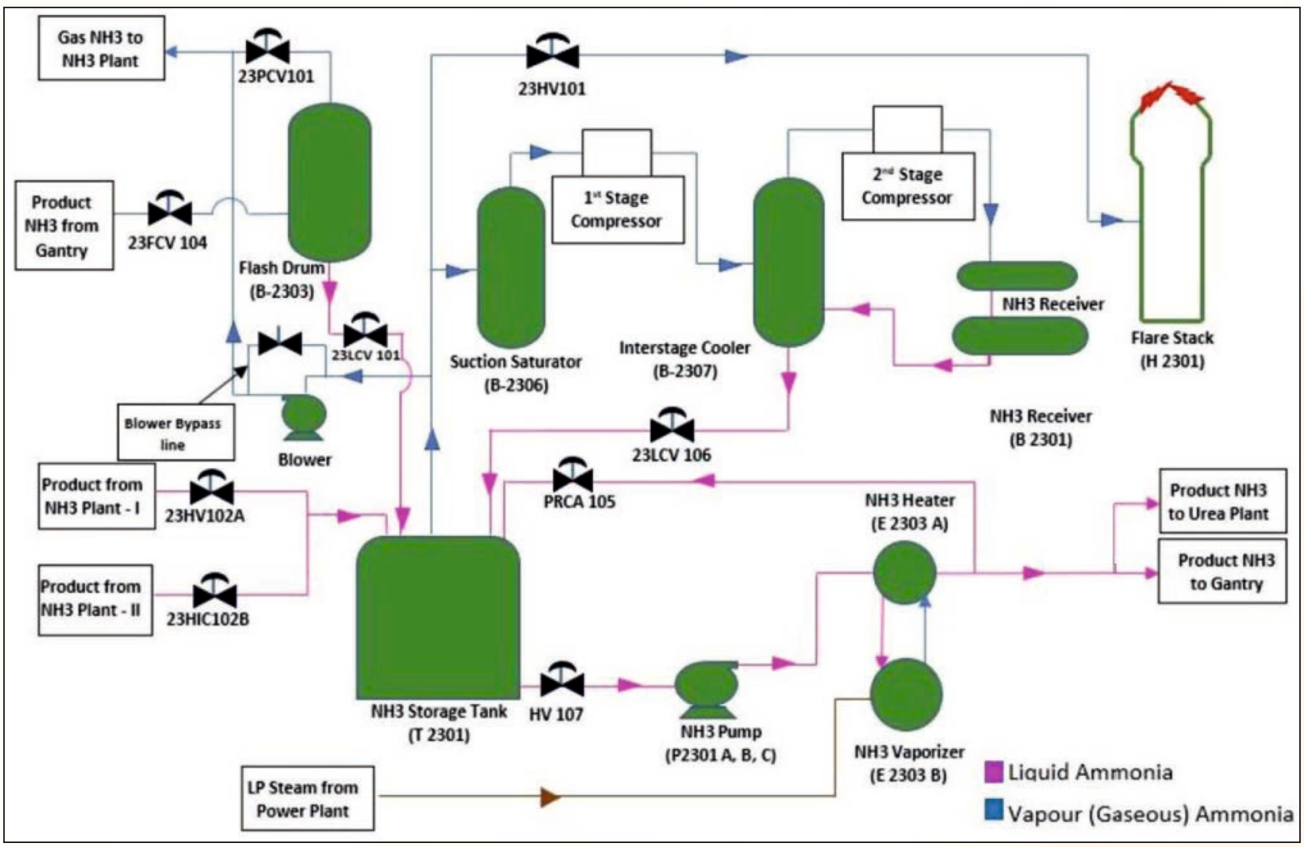
Tag Number	:	**T-2301**
Capacity	:	10,000 MT
Code	:	API 620 Appen R
Service Period	:	33 Years (1988)
Fluid	:	Anhydrous Ammonia
Temperature	:	(-) 340 C
Pressure	:	0.05 Kg/cm2
Inner Wall I.D.	:	27.5 meters
Outer Wall I.D.	:	29.1 meters
1st De-Commissioning	:	2001-2002



Double-wall, Double Integrity Tank
(Full Containment) with insulation on outer tank

Under normal operating conditions, the ammonia storage tank maintains a pressure range of 450±150mmWC. If the pressure exceeds 750mmWC, HIC-101 will open to direct ammonia vapor from the tank to the dedicated flare stack. Each tank has its separate flare stack for safety measures. When the pressure reaches 1050mmWC, the Ammonia storage tank's Pressure Safety Valve (PSV) will open to release ammonia vapor into the atmosphere, ensuring that the pressure remains within safe limits.

On the other hand, when the pressure starts to reduce and reaches 250mmWC, the refrigeration process will be halted. At 200mmWC, PRCA-105 will open, allowing hot ammonia to flashback into the tank. Moreover, when the pressure drops to a range of -26 to -30mmWC, the vacuum breather will open to intake atmospheric air into the tank, stabilizing the pressure. These pressure control measures are vital for the safe and efficient operation of the ammonia storage system, preventing potential hazards and ensuring the integrity of the equipment.



Decommissioning Activities

1. ***Kick-off Meeting and HAZOP:***

The Project began with a Kick-off meeting with the Client team on April 30th, 2022, during which approximately 24 nos. of IFFCO team members from various disciplines attended and actively participated. The meeting involved a comprehensive discussion and mutual agreement on the entire project flow between IFFCO and Gulachi teams. For reference, the list of participants in the Kick-off meeting is provided in Appendix 1, and the HAZOP Participant list is available in Appendix 2.

Following the Kick-off meeting, the teams actively engaged in the HAZOP study, examining various project scenarios, and deriving the SOP.s, Check lists and Blinding list. The HAZOP Report, containing the findings and analysis, is enclosed in Appendix 3, and the Blinding list is included in Appendix 4. These documents serve as essential references for the project's safety and procedural aspects.

Throughout the project's execution, collaboration and effective communication between IFFCO and Gulachi teams have been instrumental in ensuring a successful outcome. The enclosed appendices offer valuable insights and documentation of the project's critical stages, contributing to its smooth progress and adherence to safety standards.

2. ***Pre-Decommissioning Activities: Isolation of tank from Ammonia Product Inlets.***

A decision has been made to isolate the Ammonia Storage tank from the Process Plants (Ammonia & Urea Plant) and Gantry. In April 2022, the liquid ammonia from the tank was efficiently transferred to the Urea Plant, utilizing the maximum dead level achievable. This was accomplished by connecting both the Inner and outer tank drains to the pump. The remaining liquid ammonia is vaporized and directed to the Ammonia plant and flare.

To achieve the isolation of the tank, blinding at the battery limit was initiated using the Valve. Additionally, a temporary line fabrication and installation were put in place to facilitate the transfer of compressor hot Ammonia Vapor to the tank through the pump line and tank drain line. These measures ensure a smooth and safe process during the isolation procedure.

3. ***Introduce the Hot Ammonia Vapour to Vaporise the Liquid Ammonia.***

After isolating the tank, hot ammonia vapor was introduced into it using a temporary connection between the holding compressor's 2nd stage outlet and the inner tank's drain nozzle. The compressors were operating at their maximum capacity, capable of generating ammonia vapors at a rate of 732 Kg/hr at 130°C. Initially, these ammonia vapors were directed to the Ammonia Plant.

However, if the tank pressure showed no signs of rising, the flare stack was brought into the line to handle the excess vapor. This process continued until the bottom temperature of the tank approached the ambient temperature of 23°C.

4. ***Displacing of the Vapour Ammonia by Nitrogen.***

Nitrogen was introduced into the tank through the Tank Drain Nozzle, which includes both the inner and outer drains. Simultaneously, Ammonia Vapours were displaced from the tank's top and directed to the Flare through HIC-101. The Nitrogen flow rate during the purging process was maintained at approximately 300 to 350 Nm3/hr. A cautious approach was taken during the purging process, avoiding the direct use of air to prevent the formation of explosive mixtures inside the tank and ensuring safety.

The purging operation continued for 10 days until the Ammonia level in the inner tank was reduced to below 2%. Once this limit was achieved, the Flare operation was safely turned off. By employing these safety measures and proper purging techniques, the operation was effectively managed, mitigating potential risks associated with the presence of Ammonia vapors and ensuring a secure working environment.

5. ***Line Purging***

Line purging was conducted to eliminate all traces of Ammonia liquid or vapor from the designated battery limits. This purging process spanned three days to ensure thoroughness. During this operation, all spectacle blinds were reversed, and the tank was brought to a state of positive isolation. However, a minor issue was encountered during the process. One of the valves on the Tank Vapour outlet line failed to close at the battery limit, leading to difficulties in achieving the desired positive isolation.

Despite this isolated challenge, the line purging was overall successful in achieving the primary objective of removing Ammonia liquid or vapor, making the system ready for subsequent tasks. Further corrective measures will be undertaken to address the valve issue and maintain the integrity of the isolation process in future operations.

6. ***Making tank safe for Man Entry***

Plant air was introduced into the Inner Tank through the Drain Nozzle and then discharged through the Dome Vent. Additionally, the Roof Manhole was kept open during this process. The air purging operation was carried out until the oxygen level inside the tank reached 20% and the concentration of Ammonia gas decreased to 20 ppm.

The air purging was performed at an approximate rate of 400 Nm3/hr with a pressure of 3 Kg/cm2. As a result of this procedure, the tank is now safe for personnel entry, and all necessary precautions have been taken for the decommissioning process.

IFFCO Aonla Unit adhere that safety protocols should be followed throughout the decommissioning process to ensure the well-being of personnel and the environment.

During roof manhole opening job following safety protocols were taken -

- A safety permit was obtained to proceed with the task.
- As a precaution, the central nozzle 6" valve was opened first to prevent any sudden exposure to vapors.
- Only responsible individuals and specific job workers were allowed to be present at the top of the tank to prevent overcrowding.
- Fire personnel were prepared with a fire hose and charged hose line on top of the tank to handle any emergency.
- Safety personnel ensured that all workers wore the necessary Personal Protective Equipment (PPE) and respiratory equipment.
- The escape route was kept clear and easily accessible.
- Once the top manhole was successfully opened, it was covered with an iron grating and securely tied with a wire rope.
- The area around the top manhole was cordoned off with safety barricading tape to ensure a safe working zone.

- By adhering to these safety measures, the team ensured a secure environment for conducting the roof manhole opening job.

7. ***Manway opening and man entry inside the tank.***

Both the Manways of the Inner and Outer tanks were opened. The flange joint was removed, and the convex dish was cut open. The cutting and removal of the Manway cover and dish end were done with the help of a grinder, following all HSE and safety precautions. Oil sludge was found at around 125mm height. Below are the safety measures taken for the above job:

- Worker setting of the Tank's Outer shell bottom manhole through a grinder was carried out in the presence of the fire and safety department, and the worker wore the necessary PPEs.
- Air was inlet into T-2301 annular space through one blower, one big fan, and two air hoses. The air outlet was through PSV-160, the central nozzle, and an exhaust fan was provided on top of the tank's manhole.
- T-2301 inner tank manhole cover was opened, and the cutting of the cup was carried out through a grinder.
- Several blinds and slip plates were provided for all the inlet and outlet piping of the tank.
- 23-unit Flare stacks were put out of service before confined space entry, and a blind was provided to the 23-unit NG line from the battery limit.

8. ***Confined space entry for Oil/sludge cleaning***

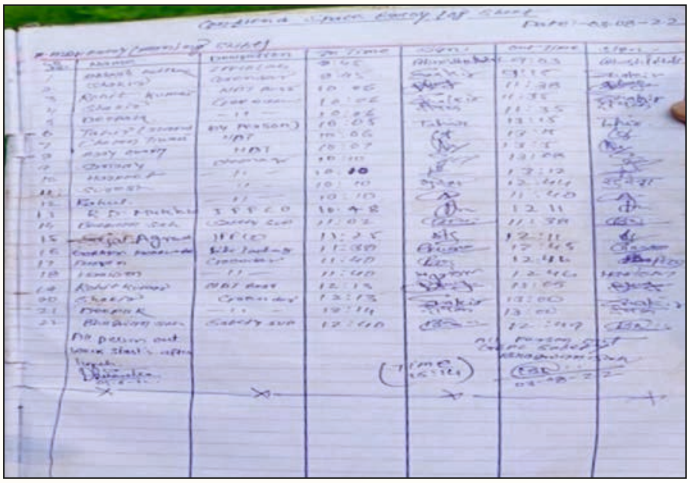
After the Manway was opened, a small sample was withdrawn from the tank, and oil with saturated Ammonia was noticed. Venting of the tank was carried out for two days to remove as much Ammonia vapor as possible, making it safe for confined space entry.

The following safety measures were implemented before entering the tank:

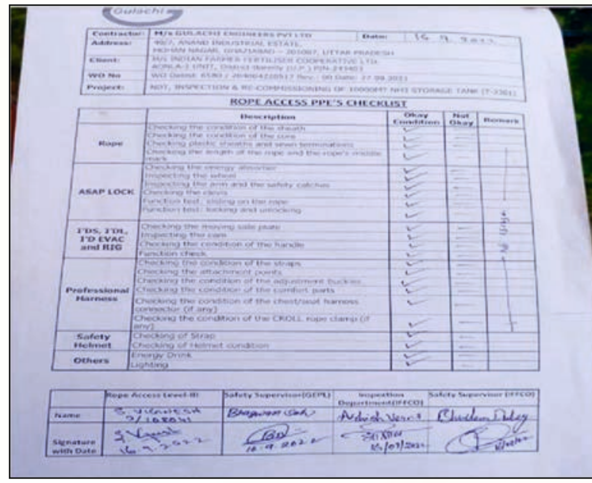
- A safety permit should be obtained for confined space entry.
- Workers must receive a toolbox talk before starting the job.
- A separate confined space entry checklist should be prepared and reviewed.
- A confined space attendant should be stationed near the tank manhole, maintaining a confined space entry register for recording each entry and exit.
- Daily air sampling should be conducted by the laboratory before any man entry, documenting ammonia concentration in ppm and oxygen levels in %.
- Workers inside the tank must have a continuous respiratory supply, even if Ammonia concentration is below the TLV value, to protect them from entrapped ammonia gas.
- Adequate provisions for communication, 24V lighting, and ventilation inside the tank should be made.
- General safety talks should be conducted to provide instructions on daily planned specific jobs.

During confined space entry, it had been insured that at least one safety personnel from the IFFCO fire & safety department and one safety supervisor from the contract company were present at all times."

The Aonla Unit followed that proper safety measures are crucial to ensure the wellbeing of workers during confined space entry, and adherence to safety protocols is of utmost importance.



Confined space entry log sheet

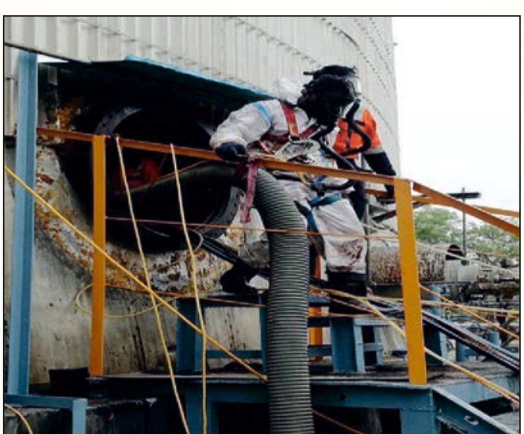


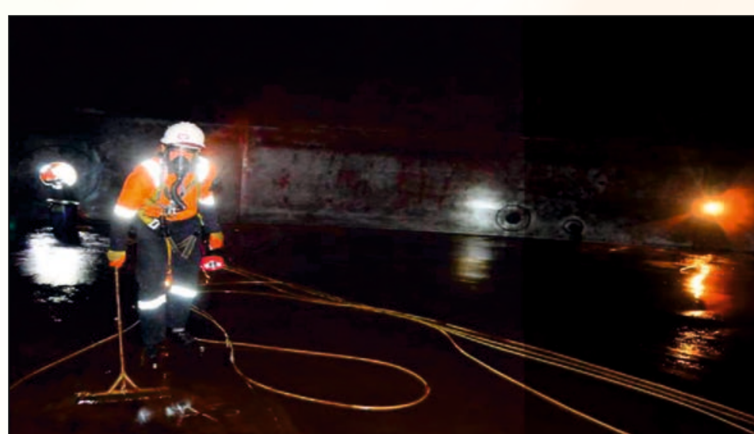
ROPE ACCESS PPE'S CHECKLIST

	Description	Okay Condition	Not Okay	Remarks
Rope				
ASAP LOCK				
I'DS, I'DL, I'D EVAC and RIG				
Professional Harness				
Safety Helmet	Checking of Strap			
	Checking of Helmet condition			
Others	Energy Drink			
	Lighting			

Confined space entry Safety

Safety training & instructions given to contract workers about hazards and safety





Airline masks used for continuous respiration along with PPE dress to avoid possible skin contact with ammonia vapour

9. ***Innovatively reducing ammonia gas concentration inside tank for Confined space entry followed by NDT testing-***

After cleaning the inside of the tank, the concentration of ammonia was found to be around 300 ppm. To Confined space entry and carry out reasonable visual inspection without respiratory equipment, the ammonia concentration needs to be reduced below 300 ppm. Therefore, innovative measures were taken to achieve the vacuum in the inner tank, a vacuum blower was placed outside the tank, with one end placed in the center of the inner tank to suck air from the top manhole and expel it through the blower vent into outside.

Fine water spray was applied inside the tank using the fire water hose and nozzles to remove the residual ammonia and to further decrease the concentration of ammonia gas in tank, to provide ammonia free atmosphere As low as reasonably practicable (ALARP) to start the inspection effectively and without any ill health effect.

After implementing the fire water spray, a significant reduction in ammonia concentration was observed, dropping from 300 ppm to approximately 25 ppm in different samplings. Subsequently, personnel were permitted to enter the tank without an airline mask to conduct the NDT (Non-Destructive Testing) tests effectively, which were found to be normal and within permissible limits.

Inspection and Testing

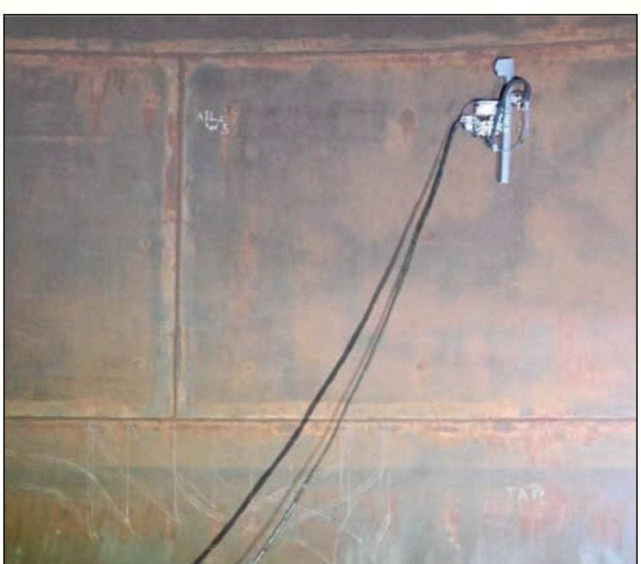
After the reduction in the concentration of ammonia below the permissible limit, man entry was permitted without an airline for visual inspection, but online airline masks were kept ready for any situation. The following are the tests that were carried out for the inspection of the tank:

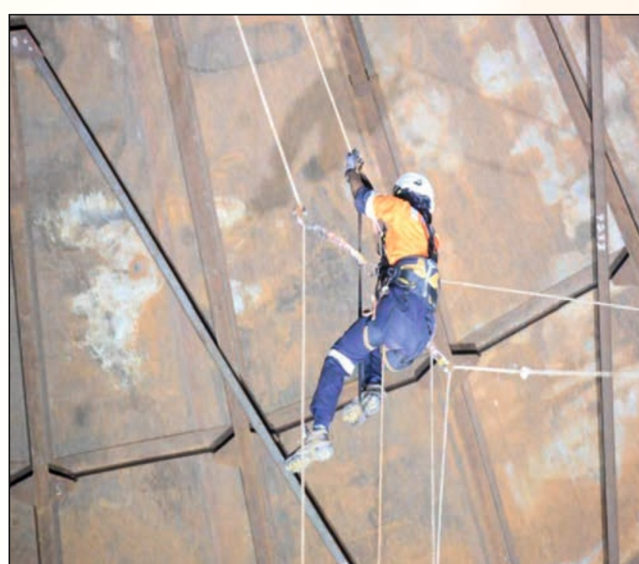
1. Bottom Plate Visual Test (VT)
2. Ultrasonic Thickness Gauge (UTG)
3. Die-Penetrating Test (DPT)
4. Phase Array Ultrasonic Test (PAUT)
5. Magnetic Particle Testing (MPT)
6. Magnetic Flux Leakage (MFL)
7. Metallography Analysis
8. Radiography Test (RT)
9. Carbonation Of Concrete

10. Rebound Hammer Test (RHT)
11. Ultrasonic Pulse Velocity (UPV)
12. Half-Cell Potentiometer Test
13. Hydro Pneumatic Static Test Testing
14. Wet Fluorescent Magnetic Particles Inspection (WFMPI)
15. Vacuum Box Leak Testing


DPT testing


Visual inspection


Corrosion mapping test


Roof inspection using Rope Access gears.

Recommissioning Activities:

1. ***Hydro-Pneumatic testing-***

Hydrostatic or Hydro Testing is a process that uses liquid (water) to pressurise the tank for strength and leaks. After shutdown and repairs, a Hydrostatic test is often required to validate that the equipment is prepared to operate under desired conditions once it is returned to service.

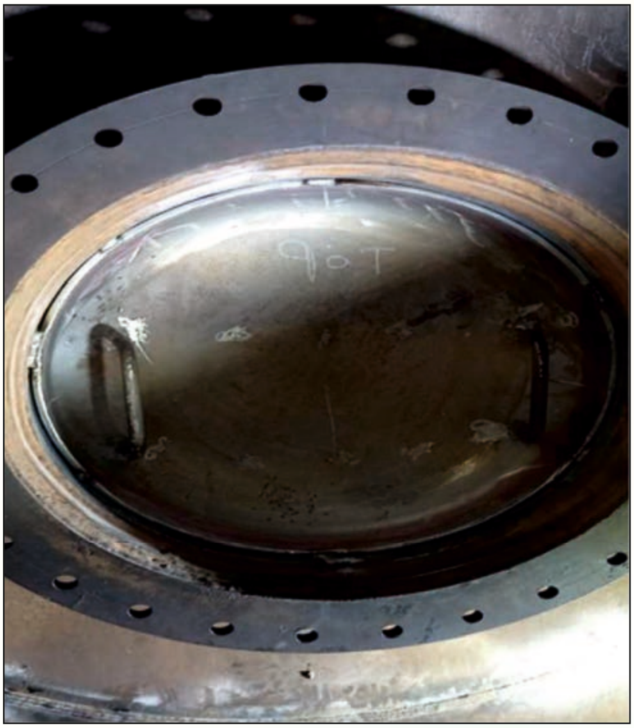
Water filling height in Inner tank was decided to do up to liquid ammonia equivalent in terms of 10,000 MT capacity which comes to 16.83 meter, however considering the life of tank, PDIL Noida has suggested to perform hydro test by filling water up to 80% level of the maximum capacity i.e., 8,000 MT. Hence, the water was filled to 80% of 16.83 which is equal to 13.4 meters.

The hydrotest of the inner tank was carried out by filling the tank with water up to 13.40 meters at the rate of 60 m3 per hour. The water level was maintained in the tank for a period of 24 hrs. and no leak was observed. Water was filled in the tank in 4 phases i.e., 25%, 50%, 75% and 100% of the Maximum height of 13.4 m. Tank was pressurized by air up to 850 mm WC with 13.4 Mt. height of water inside the inner tank. Soap solution test was carried on the Nozzle which were non insulated at the given point of time including Roof Man way. PSV pop test was performed by increasing the air pressure and after PSV pop test, Tank water was drained out. Further, water was removed below the tank drain level and cleaned.

2. ***Re-welding of the Convex Manways-***

Rewelding of Inner and Outer tank convex Manway was carried out. After Man ways, covers including Roof and Shell Manways was sealed using SS spiral wound gasket.

Tig welding of manway



Fit up after welding.

3. ***Re-commissioning Preparation***

All instruments were checked for working, SS tubing was checked for any leakages. Tank was pressured and Soap Solution test was performed to check for any leakages in Flange joints, pipes, supports, hangers, Nozzles. All Calibration of Instruments were checked. Flare start-up check was performed. Compressor start-up checks were performed. All Open pipes were re-insulated which will come with cold or hot process Material. All the safety equipment, safety showers, fire-fighting devices were checked and operating smoothly. Checked all isolation valves were in closed position.

4. ***Nitrogen Purging of Tank***

Nitrogen was introduced from the Tank top sparger Nozzle and PRC 105 Nozzle to displace air inside the tank to avoid formation of possible explosive mixture of Ammonia and air inside the tank. Nitrogen purging was done for 6 days until Nitrogen in the inner and outer tank reached below 2%.

5. ***Nitrogen - Ammonia vapour Exchange & liquid ammonia filling in Tank.***

It took 4 days to purge Ammonia and displace the Nitrogen inside both the Inner and Outer tank. Ammonia was purged via Tank top Sparger Nozzle and discharged from tank inner and outer drains to the flare. Liquid Ammonia dead level in the tank was built-up and the tank has been recommissioned at its normal operating conditions.

Recommendation & Conclusion:

- As the tank has been in continuous operation for the last 33 years, it may be planned to be inspected by/before 04/12/2032.

  Note: Basis of recommendation was considered based on the following:

1. Tank has lived a life of 34 years and has gone 2 Decommissioning cycle.
2. EFMA Guideline which guides to reduce the interval of Decommissioning as the tank is old and follow other counter which is closer to 10 years interval.

- The entire project was completed with following:

◆ Zero Incident

◆ Zero Near Miss

◆ Very Minimal Modification

◆ Minimum consumption of Utilities including Nitrogen, Water and Electricity

◆ Extensive Coverage of Inspection

◆ Entire Schedule was completed in 7 months.