

Zerust® ReCAST - R

CORROSION MANAGEMENT FOR AST ROOF TOPS

PREVENTION OF ACID GAS CORROSION IN VAPOR SPACES OF ABOVEGROUND STORAGE TANKS

NTIC'S OIL & GAS CLIENTS

Over 17 years of providing various solutions to Oil & Gas clients that include:

- Petrobras, Brazil
- Emirates Petroleum Products Company (EPPCO), UAE
- Conoco-Philips, USA
- Shell, Malaysia
- Shell, Philippines
- Exxon-Mobil, USA
- Baker-Hughes, USA
- Halliburton, USA

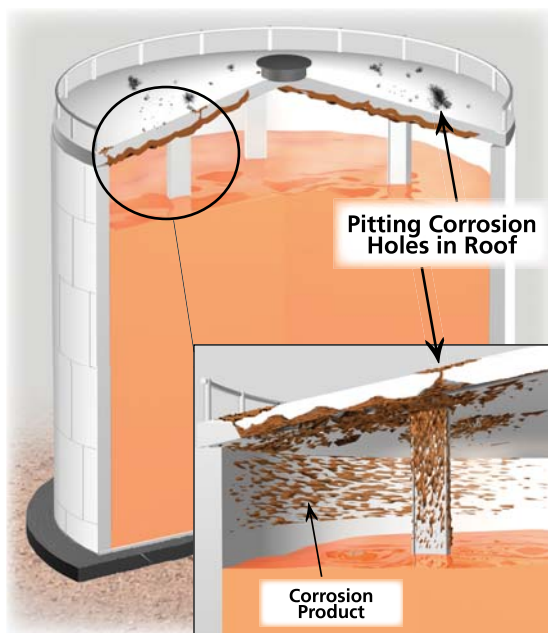
CREDENTIALS

- 30+ years of experience in corrosion prevention
- Client support in 50+ countries
- Member of API
- Chair key task group at NACE International

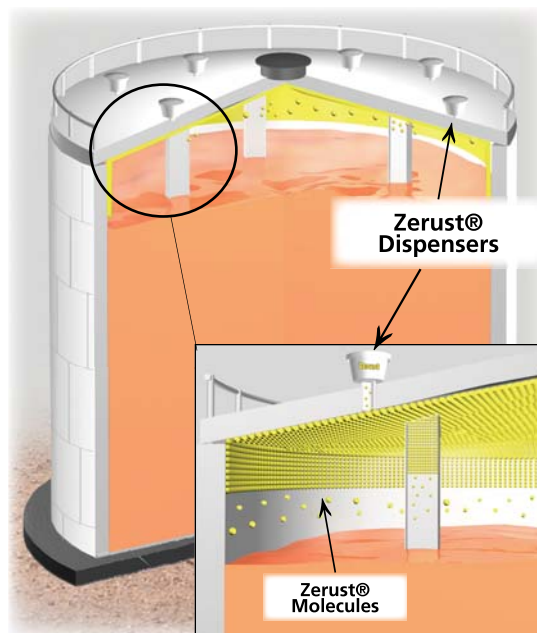
THE PROBLEM

Certain grades of oil that contain sulphur emit corrosive vapors that destroy the internal surfaces of storage tank roofs and their support structures above the product layer. Aggressive pitting and crevice corrosion create holes in the tank tops that cause unsafe operating conditions and environmental problems. Internal tank coatings decrease surface corrosion but have proven to be ineffective in preventing dangerous pitting and crevice corrosion – especially in the interstitial spaces between the roof and support structures.

PROBLEM



SOLUTION



IMPACT TO OPERATORS

This problem impacts petrochemical facilities causing stoppage of tank operations and necessitating periodic roof replacements.

- Hard Dollar Losses
 - Capital and labor required to replace a tank roof
 - Loss of stored product due to evaporation when there are holes
 - Opportunity cost of tanks being out of operation
- Intangible Costs
 - Significant loss of efficiency during the operating life of the tank
 - Contamination of stored products (rust, epoxy flakes, water, etc.) that affects product quality
 - Risk of environmental, health and safety problems
 - Risk of explosions and/or fire



CASE STUDY: INSTALLATION AT A REFINERY

The data presented below is from an NTIC corrosion protection system which has been operational at a client site for over two years. The client has validated the data gathered and has provided a very positive reference letter. They are now working with NTIC to expand the program to include several additional tanks and other pilot projects.

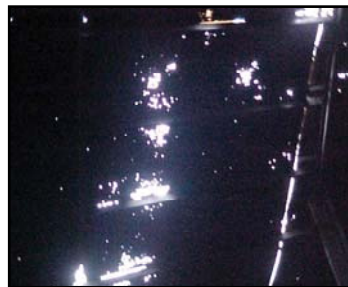
OPERATING ENVIRONMENT INSIDE THE ASTs: Each AST tends to have a unique and unpredictable internal environment due to vast variations in the quality of the stored product, the ambient temperature ranges, the temperature of the stored product, the method of construction/design of the tank, and any additional systems that might be in place (e.g. scrubbers, nitrogen blankets, vent systems). The Zerust® ReCAST-R system has been successfully deployed in such aggressive internal corrosion environments as illustrated by the key parameters below:

Parameter	Range in 2-year Field Trial	Range in Laboratory Tests
Ambient Temperatures, °C	22 - 40	20 - 55
Inside Tank Temperatures, °C	22 - 55	20 - 55
Relative Humidity, %	90 - 100	60 - 100
H ₂ S, ppm	20 - 50	1,000 - 4,600
O ₂ , %	10 - 21	10 - 21
SO ₂ , ppm	>20	500 - 3,600

ACTUAL CLIENT SITE CORROSION: The corrosive gases inside the AST had caused significant pitting corrosion holes in the roof and considerably weakened other sections.



HOLES IN THE ROOF OF AN AST



THE VIEW FROM INSIDE AN AST (SUNLIGHT SHINING IN)



CORROSION AT A SUPPORT BEAM



A CLOSE VIEW OF HOLES IN THE ROOF OF AN AST

COST IMPACT OF ACID GAS CORROSION: There are significant costs associated with acid gas corrosion damage to ASTs. The table below illustrates the cost of corrosion associated with a 50m diameter fixed roof AST storing intermediate distillates (fuel oil, etc.).

Cost Elements	US Dollars
Purging/cleaning/inspections	\$180,000
Cutting/removal of roof and replacement	\$800,000
Cost of roof materials & fabrication	\$120,000
Miscellaneous additional costs	\$100,000
Opportunity costs of idle tank	\$450,000
TOTAL	\$1,650,000

Note: For tanks with floating roofs inside fixed roofs, add ~US\$200,000 for periodic removal of rust and debris from the upper deck of the floating roof.

The high rate of corrosion means that currently rooftops have to be replaced, or undergo significant downtime for patchwork maintenance, every 5-8 years. Taking even 8 years of roof life, these costs translate to over US\$200,000 per tank per year at refineries and tank farms. This cost is incremental to the costs of routine API specified tank stoppage and inspections that need to be conducted periodically.

THE NTIC SOLUTION

The client deployed NTIC's proprietary Zerust® ReCAST-R solution to protect the interior surface of an AST roof at a 240,000 barrel/day refinery. NTIC connected dispensers to the rooftop of a 'demonstrator' tank that delivered the proprietary inhibitor system into the vapor space between the surface of the product and roof of the tank. The Zerust® inhibitor then formed a protective layer that successfully prevented corrosion in this highly aggressive environment (H₂S, SO₂, etc.).

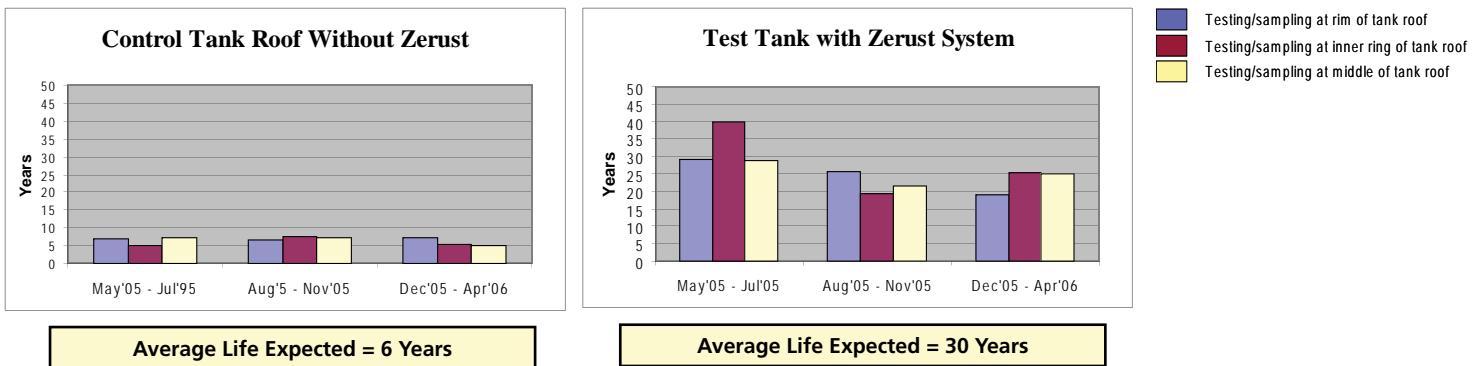


ZERUST® ReCAST-R DISPENSER



VIEW OF DISPENSER ON TOP OF 54m DIAMETER TANK

SOLUTION EFFECTIVENESS: The efficacy of the Zerust® ReCAST-R solution was established by comparing the degree of corrosion formation on the 'demonstrator tank' with that of a 'control tank' (an identical tank that was not equipped with the NTIC solution), containing the same stored product. This side-by-side comparison demonstrated that NTIC's solution dramatically reduced the rate of corrosion by 4 to 5 times, so that the expected life of the roof is increased from about 5-7 years to more than 25 years. The effectiveness of the NTIC solution, as shown by these field results, was independently verified by the Client Maintenance & Inspection team.



RISK SHARING: NTIC monitors the efficacy of its installed solution on AST roofs at agreed upon inspection intervals by measuring metal loss due to corrosion. Tank operations do NOT need to be stopped during inspections and/or maintenance of the Zerust® ReCAST-R solution. The measured rate of corrosion is compared against agreed upon corrosion rate baselines and is validated by the client's Maintenance and Inspection staff. Payments to NTIC are based on the demonstrated corrosion inhibiting results of the solution. This risk-sharing approach minimizes any upfront capital outlays by the client and ensures continued long term support from NTIC.

NTIC DELIVERS: NTIC, a pioneer in corrosion management, offers an innovative and unique new method to protect AST roofs. This system has demonstrated results far superior to any alternatives previously available and has been validated by clients with serious corrosion problems. NTIC offers pay-for-performance programs with a long-term contractual relationship that minimize client risk in deploying the solution. The NTIC team is positioned in over 50 countries across the globe to analyze corrosion issues on a case-by-case basis and apply and manage this system to meet client-specific needs.



FREQUENTLY ASKED QUESTIONS

1. How does the solution work?

Dispensers attached to the tank roof release proprietary vapor phase inhibitor formulations into the tank that forms a vapor barrier which separates the corrosive environment from the metallic surface of the tank roof support structures.

2. What kinds of vapor spaces within tank roofs can be protected?

Any vapor space within the tank roof can be protected. This even includes sections of the side walls of the tank above the level of the stored product (parts covered by the oil/product typically do not need to be protected) and support structures. Intended service life and inspection requirements will need to be considered in determining dispenser positions.

3. Will the inhibitor leak out of the tank – especially if there are vents? Will this affect the efficiency of the system?

A small amount of inhibitor will escape if the tank is vented. However, this does not decrease the efficiency – the vapor pressure of the inhibitor generates a level of inhibitor significantly higher than that needed to protect the roof parts. Once the venting is completed the concentration will return to its normal protective level.

4. How quickly does the inhibitor get depleted?

The rate of inhibitor depletion depends on how often the tank is emptied and refilled and any venting that occurs. However, the dispensers are sized to contain extra inhibitor to compensate for additional losses between monitoring inspections. NTIC periodically inspects the tanks and dispensers and replenishes the inhibitor as required.

5. Will the pressure build up inside the tank and cause risk of over-pressure?

The quantity of inhibitor vapor released is very small (molecular level layer), compared with the volume of the tank vapor space, and will not cause a rise in the pressure of the tank. Therefore, “over-pressure” conditions will not exist.

6. Does the inhibitor contaminate the product stored in the ASTs?

The inhibitor does not contaminate the stored oil product(s). NTIC will work with clients on a case-by-case basis to revalidate this issue based on the specific tank, stored product and client contamination allowances.

7. Can the solution be applied to old tanks, or only new tanks/roofs?

The solution can be applied to both new and old tanks. On old tanks, even if corrosion has started, the solution, once deployed, would inhibit further corrosion. There is a minimum thickness of roof material required for the solution to be deployed. NTIC will work with clients on a case-by-case basis to ensure this requirement is met.

8. When can the solution be implemented and how long does it take to install it?

Installation of the dispensers can be done during any routine tank stoppage (maintenance) and currently is estimated to take 4-5 working days for a tank that is 50m in diameter. NTIC will coordinate installation with the client. After the initial installation, routine maintenance and replenishment can be done without stopping tank operations.

9. What is the service life of the solution?

The dispensers, once installed, can be expected to last 30-40 years. The inhibitors need to be replenished periodically. The frequency of replenishment will depend on client requirements (3 months, 6 months, even 24 months) and will be done by NTIC throughout the life of the solution contract. The dispensers can be removed and may be re-installed on other tanks.

10. Are there any environmental, health and safety issues to consider?

The inhibitor formulations comply with relevant EPA and OSHA guidelines in the US. NTIC operates the overall system, but also provides clients with safe handling guidelines and training. The dispenser meets UN Group II (oil & gas) criteria for equipment with no electrical or moving parts. The dispensers also have been designed to withstand winds over 130mph (Category 3 hurricane) and to minimize any risk of lightning strikes. There are no moving or electrical parts involved in the device.

11. What kind of ongoing maintenance is required?

The system is hermetically sealed and requires little/no maintenance. The system only requires that NTIC replenishes the inhibitor in the dispenser to ensure continuous corrosion mitigation. This system can be serviced during normal operations of the tank (i.e. without tank stoppage).

12. What is the cost to deploy this solution?

The system pricing depends on multiple factors. The inhibitor formulation needs to be selected based on the corrosive environment generated by the product and other factors generated by the application conditions and the operating environment. The age of the tank, the service life required by the client, the size of the tank, etc. are all considerations that affect the price. Clients can expect significant savings on their lifetime cost to maintain/replace tank roofs.

