MII CHRONICLE

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" FROM THE FIELD "

Featuring:

Tank Failure

Above Ground Storage Tank

Excellence in Eddy Current

Inspection Technology & Failure Analysis

Magnetec Inspection, Inc.

Phone# 815-802-1363 Cell# 847-542-2810 ew@magnetec-inspection.com

FAILURE INSPECTION OF ABOVE GROUND STORAGE TANK

Magnetec Inspection was contracted to inspect a failed aluminum above ground storage tank via surface eddy current techniques.

The client has two acetic storage tanks (AC102 and AC103) each of approx. 70,000 gallons capacity for storage of 80% acetic acid at near atmospheric pressure and at ambient room temperature in their production facility. The tanks were commissioned in 1972 and had operated without incident until product was noted leaking from the tank in early April 2017. The tanks are vertical cylindrical type with domed roof and were approx. 75% full at time of leakage.

Upon cleanup of the adjacent floor of the acetic product it was determined that the AC103 tank was the tank that had the failure. The tank was removed from service, drained and cleaned prior to inspection work. All inspection work was performed by two man crews over a two day period utilizing array eddy current probe designs to determine failure sites. There was no prep of the aluminum surface other than steam blasting of the surface as the tank was relatively clean and only required limited cleaning.

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Construction Detail of Tank:

- Tank Diameter: 20' feet
- Height: 30' feet
- Roof type: Self supporting, Dome type
- Roof thickness: .250
- Bottom type: Flat
- Bottom thickness: .250
- Material of bottom plate: ASTM B-209, A6061
- Code of design: API 650
- Medium of storage: Anhydrous acetic acid (80%)
- Operating Pressure: Atmospheric
- Corrosion allowance: 0 mm
- Bottom and roof plate: lap weld construction.
- Year of commission: 46

The tanks had recently been assessed for fitness for service based on usual information as outlined in API standards. Based on the service assessment no issued or concerns were determined which would require immediate action. This assessment occurred 3 months prior to the recent failure. The risk assessment with regard to risk and probability followed the standard API risk criteria as listed below:

Based on API RBI the risk and probability associated with tank failure is calculated as a function of time as follows:

Risk of Failure:

R(t)=POF(t).COF

(The probability of failure is a function of time. This is true for most damage mechanisms as failures increase with age of the tank.

Probability of Failure:

POF (t) = gff x D f (t) x F ms

POF = The probability of failure as a function of time.
gff = Generic failure frequency.
D f (t) = Damage factor as a function of time.
F ms = Management systems factor

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PHOTO #1
Sump/Drain

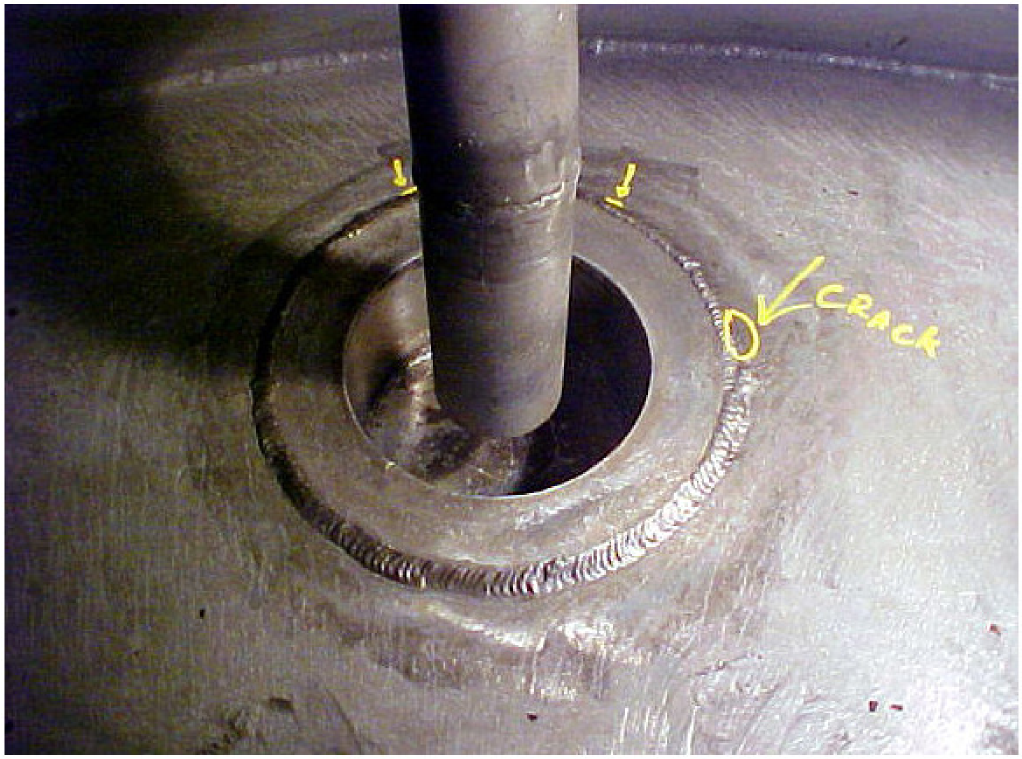


PHOTO #2
Crack Locations in Association with Sump/Drain

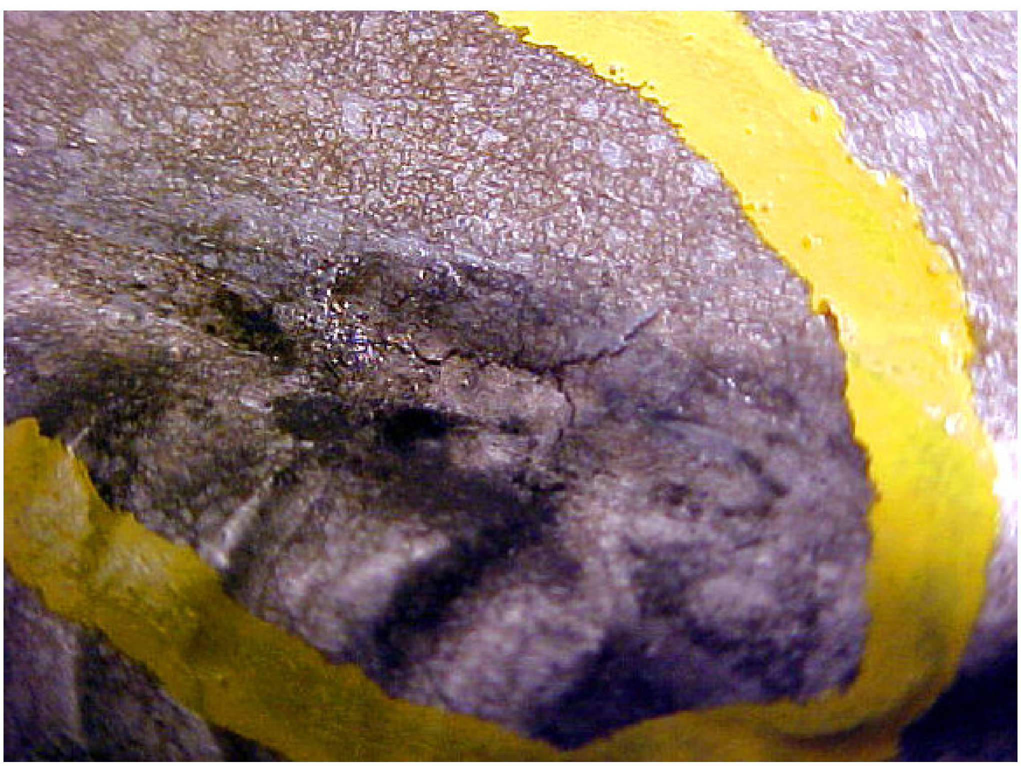
PHOTO #3

Crack Locations around Perimeter of Sump/Drain

3 Locations

PHOTO #4

Crack Structure -- Branched Surface Defect



Inspection Findings:

- PHOTO 004&7
- PHOTO 010
- PHOTO 013

The inspection found crack structures in the HAZ (heat Affected Zones) of the fillet welds of the plate to sump/drain. The cracks were found as multi-branched type crack structures with orientations parallel with the weld contour of the sump/drain. The welds were free of defects which allowed for initiation of the crack structures. The cracks were open to the surface and determined (via ECT techniques) to have additional crack faces of greater geometry under the surface. One pin-hole type defect was detected however this was determined to be original weld porosity. Based on the service, the initiation factor of the tank product was not considered a driving factor in the crack formation.

The influences of several factors on heat-affected zone cracking of aluminum Alloy A6061 were reviewed. This review took into consideration the age of the tank, susceptibility of the alloy, thermal, mechanical, design, operation and tank support aspects. The review tended to lead to the following three factors of applied forces which initiated the cracking phenomena.

These Are as Follows:

1. **Metallurgical factor, crack susceptibility of a material. Age dependency, welding factors, grain sizing, etc..**
2. **Mechanical factor, force/deformation necessary to open grain boundaries.**
3. **Structural, the differential settlement which may cause three modes of failure (a) buckling (b) high stresses in tank bottom (c) high stresses at the base of shell where it joints the annular plate in the region of settlement.**

Of the above forces 1) was ruled out rather quickly or was considered to have played a very minor role in the crack formation as the metallurgical factors would have tended to have exhibited problems early in the life of the tank and based on age would not be considered a driving factor. Additional mechanical measurements of the tank floor for flatness, buckling and settlement did indicate that there was a visually imperceptible settlement which occurred toward the edge of the tank adjacent to the sump/drain location. The measurements identified the angles associated with the maximum radial displacement and geometric change in the shape of the structure. This settlement while not severe did allow for selective movement of the orientation of the sump to floor plate which put a bending/buckling force on the floor plate. As viewed in photos of the crack locations the failure were located on the leading edge of the sump facing the exterior of the tank. This location experienced the greatest deflection of floor plate to sump/drain materials.

No previous survey had been made for measurement of precise settlement values and as such no history for the degree or rate of settlement is available. For purposes of repair work it was concluded that the settlement had occurred slowly over the life of the tank and was not a quick acting phenomena. For this reason the tank was determined to be serviceable as no structural deficiencies were noted. The repair plan was prepared which addressed the area of cracking and mitigation.

Recommendations/Repairs:

1. **Due to the findings of a small settlement of the tank the driving force for crack formation was considered a singular event and repairs were made accordingly.**
2. **Any buckling force acting on the tank floor appeared in one defined location and did not appear to be an ongoing scenario and therefore no structural additions/repairs were made.**
3. **A reinforcement ring was manufactured which covered the sump and HAZ of the floor materials and was welded in place.**

PHOTO #5
Pinhole Porosity Defect