8th Chemical Process Safety Sharing (CPSS)

Webinar (MS team)
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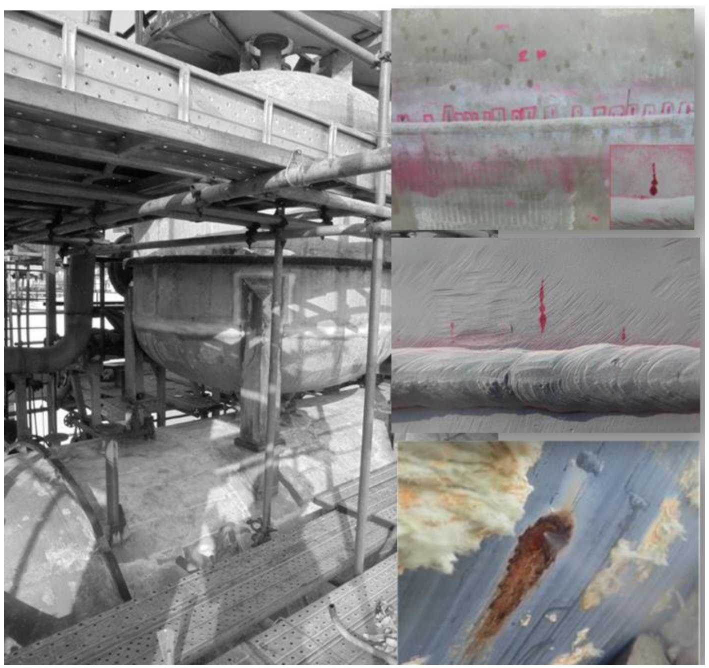
Cracking in Deaerator (V-4634)

In December 2020, Carbon steel storage vessel and stainless steel deaerator vessel (V-4634) were found crack through wall during operation.

Stainless steel deaerator vessel (SS304), cracks were observed at circumferential welds between head to shell.



Carbon steel storage vessel, Cracks were observed at circumferential welds between head to shell and fillet weld at attachment . No PWHT was applied during fabrication

“Their characteristics were straight line, perpendicular to the weld”

EQUIPMENT	V-4634
FLUID NAME	DEMINERALIZED WATER
OPERATING PRESS	2.8 barg
OPERATING TEMPERATURE	142 ℃
DESIGN PRESSURE	3.6 barg
DESIGN TEMPERATURE	170 ℃

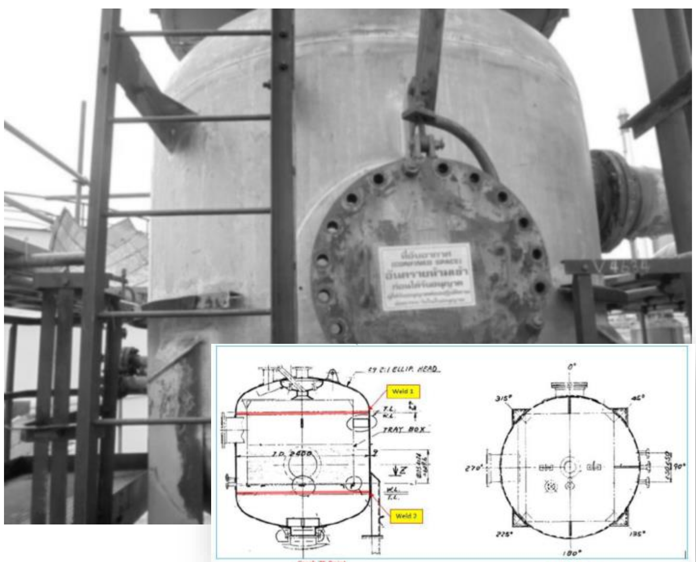
Failure History	
1986	1986
2011	Storage vessel crack
2020	Both storage and deaerator vessel crack

Cracking in Deaerator (V-4634)

Stainless steel deaerator vessel (SS304)

Possible root cause:

Corrosion fatigue initiated by SCC was suspected due to corrosion product either from pitting or crevice in combination with thermal stresses and vibrations propagate from inside to outside of the vessel.



Mitigation plan

Short term:

1. Install internal strip lining plate in order to stop crack propagation
2. Full NDE
3. Partial weld repair
4. Hydrostatic test at Design pressure

Long term:

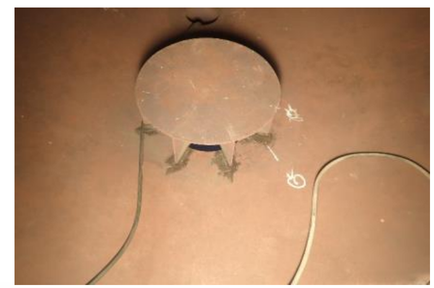
- Replace with new vessel.

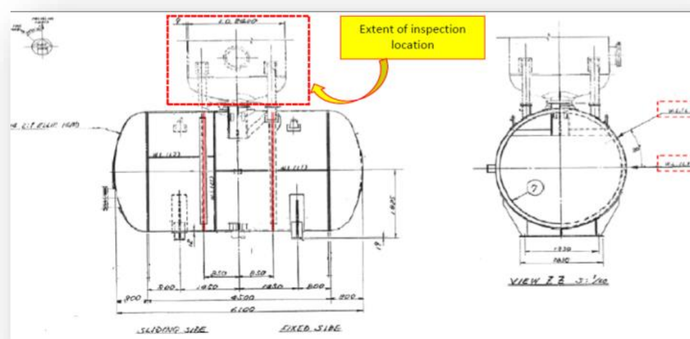
Cracking in Deaerator (V-4634)

Carbon steel storage vessel

Possible root cause:
Corrosion fatigue (CF) which can happen due to residual welding stresses (No PWHT required for this vessel) /stress riser (Fillet weld at stiffener ring) initiated by corrosion product in combination with thermal stresses and vibrations.

Mitigation plan
1. Welding repair
2. PWHT in Furnace
3. Full NDE
4. Hydrostatic test at Design pressure





Failure History in Thai Oil

Tag	Heat Treatment	Commissioning	Area	Remark
V-9421	PWHT	1997	Area A : HMU-2	-
V-4634	Non PWHT	1987	Area B : Utility	c) 2011 : Storage vessel (Lower vessel, Carbon steel non PWHT) - found crack around Bottom nozzle (Treated water outlet nozzle). d) 2020 – Storage vessel (Lower vessel, Carbon steel non PWHT) found a lot of transverse crack across weld seam (most liquid zone around bottom half section) by approx. 60 points. e) 2020 – Deaerator vessel (Upper vessel, SS 304) found transverse crack at HAZ of dish head, along circumference weld seam by approx. 273 points. Residual stress from forming process is suspected.
V-4637	PWHT	1989	Area B : Utility	Near B-4011
V-4697	PWHT	1992	Area B : Utility	Near B-4011
4600L-V-102	PWHT	1995	Area B : Utility	Near B-4011
V-4655	PWHT	1996	Area B : ThaiOil Power	Near Demin. 5
A-4607-V01	PWHT	2015	Area B : TOP SPP	-
A-4607-V02	PWHT	2015	Area B : TOP SPP	-
V-2421	Non PWHT	1987	Area C : HMU-1	a) Same fabricator of V-4634 (Nippon Rensui) b) 2014 – Deaerator vessel (Upper vessel, SS 304) found transverse crack at HAZ of dish head, along circumference weld seam by 13 points. Residual stress from forming process is suspected. c) 2016 - Deaerator vessel (Upper vessel, SS 304) follow up crack from 2014 by PT without propagated crack. d) 2019 - Deaerator vessel (Upper vessel, SS 304) follow up crack from 2014 by PT without propagated crack. e) 2022 – Both Deaerator & Storage vessel are planned to do full inspection during S/D (Statutory inspection) to quantify crack locations. Repair scope will be quantified upon result.

Reference Code & Standard

2.5.2 Corrosion Fatigue

2.5.2.1 *Description of Damage*

A form of fatigue cracking in which cracks develop under the combined affects of cyclic loading and corrosion. Cracking often initiates at a stress concentration such as a pit in the surface, and can initiate at multiple sites

2.5.2.2 *Affected Materials*

All metals and alloys.

2.5.2.3 *Critical Factors*

a) The critical factors are the material, corrosive environment, cyclic stresses and stress risers.

b) Cracking is more likely to occur in environments that promote pitting or localized corrosion under cyclic stress due to thermal stress, vibration or differential expansion.

c) Contrary to a pure mechanical fatigue, there is no fatigue limit load in corrosion-assisted fatigue. Corrosion promotes failure at a lower stress and number of cycles than the materials' normal endurance limit in the absence of corrosion. and often results in propagation of multiple parallel cracks.

d) Crack initiation sites include concentrators such as pits, notches, surface defects, changes in section, or fillet welds

2.5.2.4 *Affected Units or Equipment*

Rotating equipment, deaerators and cycling boilers as well as any equipment subjected to cyclic stresses in a corrosive environment. Some examples:

a) Rotating Equipment:

Galvanic couples between the impeller and the pump shaft or other corrosion mechanisms may result in a pitting problem on the shaft. The pitting can act as a stress concentrator or stress riser to promote cracking. Most cracking is trangranular with little branching.

b) Deaerators:

In the late 1980's, deaerators in the pulp and paper, refining and petrochemical and fossil fueled utility industries had major deaerator cracking problems. Complete vessel failures in the pulp and paper industry resulted in a diligent inspection program that found major cracking problems across the various industries. It was concluded that residual welding and fabrication stresses, stress risers (attachments and weld reinforcement) and the normal deaerator environment could produce multiple corrosion fatigue cracking problems.

API-571

NACE INTERNATIONAL
THE CORROSION SOCIETY

NACE Standard RP0590-96
Item No. 21046

Standard
Recommended Practice

Recommended Practice for Prevention, Detection, and Correction of Deaerator Cracking

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