Rupture of HP urea reactor

due to external Nitrate Stress Corrosion Cracking

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Summary

One main condition for atmospheric corrosion or corrosion under insulation to take place is moisture. Moisture which penetrates the insulation may originate from:

- Rain water
- Vapour resulting from "breathing" due to cyclic temperature changes, followed by dew formation
- Increased water exposure resulting from:
    - nearby cooling towers
    - water-jetting of heat exchangers
    - fire-fighting drills
    - sprinkler installations
    - leaking trace lines

Atmospheric corrosion or corrosion under insulation can have the following forms:

- Overall corrosion (crater-like attack at critical area's)
- Stress Corrosion Cracking
    - carbon steel: NO_3^- - ions
    - austenitic SS: Cl^- - ions
    - copper alloys: NH_3

This Paper discusses the catastrophic failure of a high pressure urea reactor due to external nitrate stress corrosion cracking.

Incident

During start up after a turnaround a rupture occurred in a high pressure reactor of a conventional urea plant. The on-stream time of the reactor was about 15 years. The fracture surface in a segment out of the reactor is shown in Photo 1.

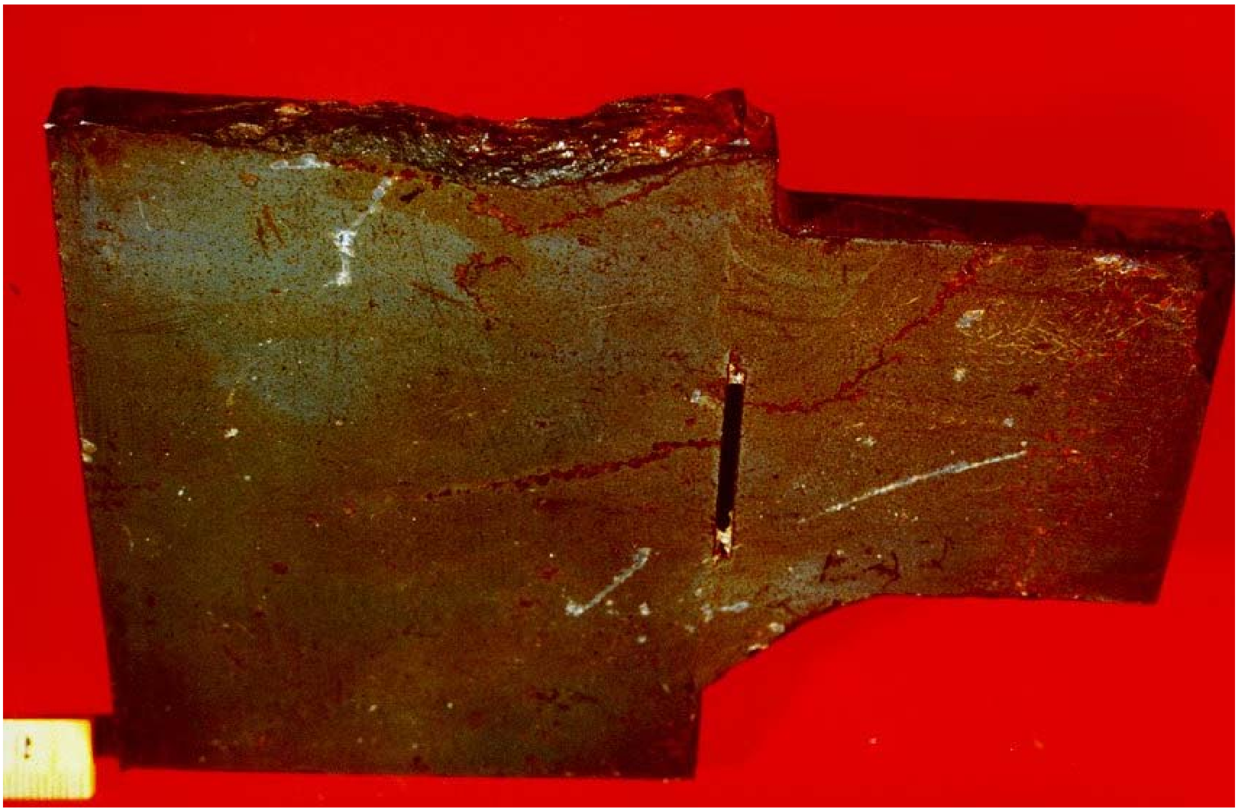


Photo 1: Fracture surface in segment out of the wall of a ruptured HP reactor of a conventional urea plant

The construction detail in Figure 1 illustrates that the cracking occurs at location of presence of a platform support ring where penetration of rainwater is likely to occur.

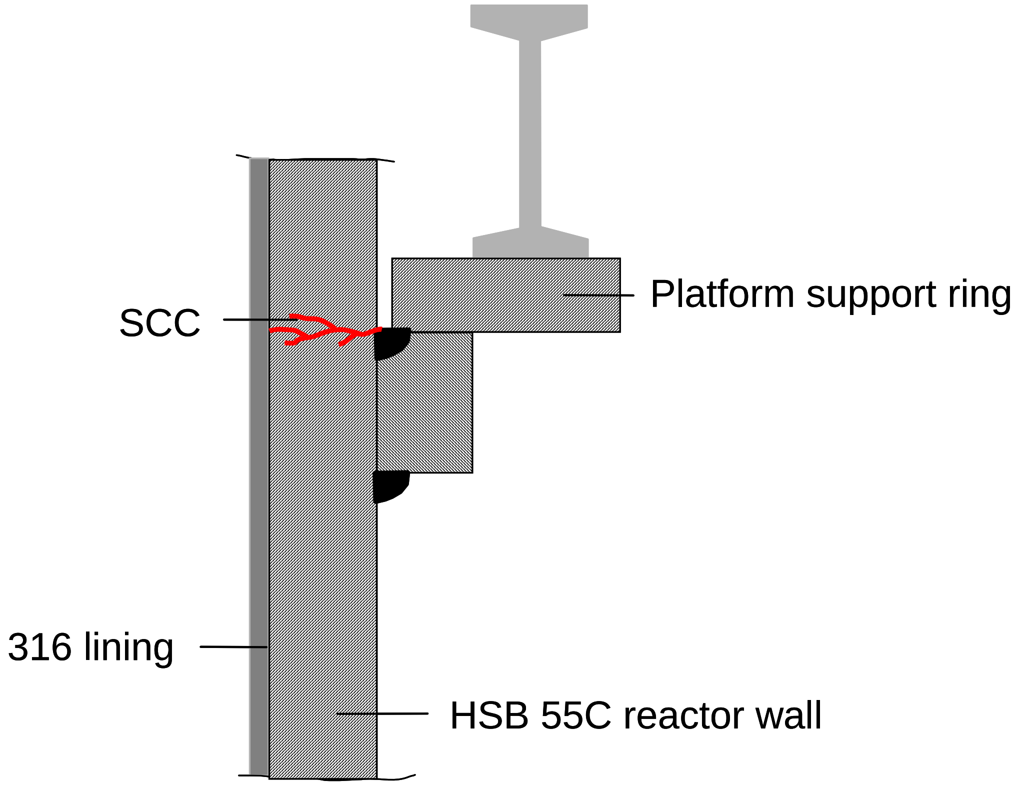


Figure 1: Construction detail of HP urea reactor vessel.

Cause of cracking

Microscopic examination did show clearly that the rupture was caused by branched, intergranular cracking. Analyses of the salt deposit present on the wall of the reactor revealed presence of some 3000 ppm nitrates.

The urea plant was located at a site with several nitric acid and fertilizer plants. The atmosphere at these sites is likely to contain trace quantities of nitrate. The cause of cracking is without any doubt nitrate stress corrosion cracking.

Conclusions

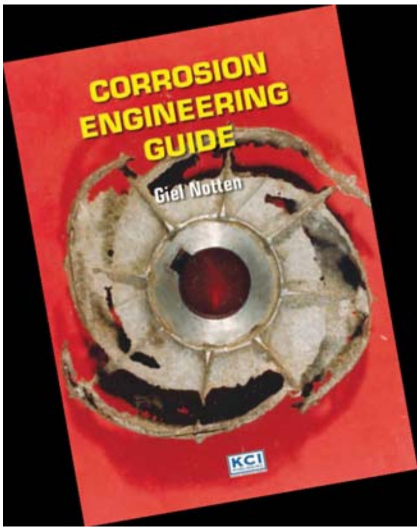
- The rupture of the HP urea reactor vessel is caused by nitrate stress corrosion cracking.
- Rainwater with traces of nitrates could penetrate the insulation cover sheeting at location of the platform support ring.

Recommendations

- Avoid penetration of nitrate containing rainwater through the aluminium cover sheeting by proper application of cover sheeting.
- Apply a protective coating system or change from outdoor equipment to indoor equipment by construction of aluminium cabin around equipment as shown in Photo 2.

Photo 2: Indoor design of HP equipment of urea stripper plant by means of aluminium cabins

Giel has written the Corrosion Engineering Guide, a valuable asset for any engineer working in a urea plant.



This guide is available via:
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Please find the Table of Content of this Corrosion Engineering Guide herebelow.

About Giel Notten

Giel is a true materials and corrosion expert who, before his retirement in 2004, spent thirtyeight years working with DSM in The Netherlands. After gaining his Engineering degree at the Higher Technical School of Heerlen, The Netherlands, he joined DSM's central laboratory.
He was to remain with the company for the rest of his career and held several positions as a materials and corrosion expert there. For the last twenty years before he retired, Giel worked in the Corrosion Department as Managing Senior Corrosion Engineer. He has further participated in numerous conferences spreading the word about his broad experiences as a corrosion and materials specialist in chemical process plants.
For Stamicarbon, a subsidiary company of DSM, and licensing DSM's know-how, he set up programmes for lifetime extension studies in urea and ammonia plants and supervised them.
He was also involved in the development of Safurex®, the super-duplex stainless steel grade (developed by Sandvik in cooperation with Stamicarbon) for application in Stamicarbon urea plants.
Giel has always enjoyed teaching so, after only five years working in the field at DSM, he already began to develop a Corrosion Engineering course. Since then he has taught many young engineers from both inside and outside DSM about the ins and outs of corrosion control in chemical plants. He was also a board member of NACE Benelux and a member of the Contact Group Corrosion of the Dutch Chemical Process Industry and the Studiekern Corrosion of the Dutch Corrosion Society (NCC).
Since his retirement from DSM, Giel Notten has remained active as a corrosion engineering consultant. He has devoted much of his time to passing on his extensive knowledge and experience on the complicated topic of corrosion engineering to a new generation of engineers.
He has done this in the form of numerous corrosion courses and workshops.
Alongside his professional career, Giel has been very active in local societies and has been a Rabobank board member for about thirty-five years, twenty-five years of which as Chairman of the Board. Furthermore, he is an active cyclist. Together with his wife, Lianne, he has made trips up to 2500 km by bicycle to Santiago de Compostela, Spain and Rome, Italy.

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