Engineering Consulting & Training Services

CARMAGEN Engineering, Inc.

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Article 4 – API 579-1 Fitness-For-Service (FFS) – Pitting Assessment

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Did a recent external inspection on an exchanger reveal pitting corrosion under the insulation? Did a unit upset result in internal pitting on the bottom head of the reactor? If you answered yes to these questions, or if pitting corrosion due to other factors is occurring in your plant, an API-579-1 FFS pitting assessment may provide an alternative to costly repairs.

In this article, we will take a look at evaluating widely scattered pitting by applying API 579-1 / ASME FFS-1 2007 Fitness-For-Service Level 1 assessment procedures.

What is Pitting?

Pitting is defined by API 579 as localized regions of metal loss characterized by a pit diameter on the order of the plate thickness or less. Widely scattered pitting is pitting that occurs over a significant region of the component.

Level 1 Pitting Assessment Limitations

Level 1 pitting assessments are permitted only if certain conditions are satisfied. The complete list of limitations in Parts 2 and 6 of API 579 should be reviewed before proceeding with a Level 1 pitting assessment. Some of the limitations are:

- The pitting damage must be:
  - arrested.
  - located on only one surface of the component, e.g., internal or external.
  - composed of many pits.
- The component is:
  - a type A component subjected to internal pressure. These are components that have a design equation that specifically relates pressure or liquid fill height, and other loads, to a required wall thickness, such as pressure vessel cylindrical and conical shell sections.
  - not in cyclic service.
  - not operating in the creep regime.
  - considered to have sufficient material toughness.

Level 1 Methodology

In a Level 1 assessment, surface damage, quantified by the pitted area and pit depth, is compared to standard pit charts to determine acceptability. If the depth of all the pits is less than the specified corrosion allowance, then a pitting assessment is not required.

Reliability & Maintenance

Provided onsite planning support for repairs to be made to the skirts and shells of multiple drums on a delayed coker unit in the US. Recommendations were made that will result in significant time and cost savings, some of which will be applicable to other future maintenance work at the refinery.

Provided an onsite, mechanical and fired equipment reliability assessment of four hydrogen plants located at two refineries located in South America. Recommendations were made to improve overall furnace operations in all units, and to reconsider the client's original intention to replace furnace outlet headers since such replacement may not be required.

Miscellaneous

Provided machinery engineering litigation consulting support for a case involving the failure of a fan installed on a thermal oxidizer unit. The case settled out of court, and our client was very pleased with our support.

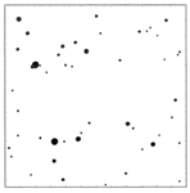
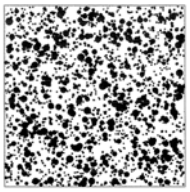
However, if the pit depth exceeds the corrosion allowance, then a pitting assessment should be considered. Note that for a Level 1 assessment, the future pitting damage (FCA) is assumed to be zero, e.g., pitting corrosion due to corrosion under insulation that has been mitigated by application of an epoxy coating and permanent removal of the insulation. Below is a summary of the assessment process. Details of the process, as well as the nomenclature, can be found in API 579-1 Part 6.

Assessment Summary:

- Review the limitations for a Level 1 assessment.
- Characterize the pitting damage, e.g., diameter, area, depth.
- Evaluate the component as detailed in API 579 Paragraph 6.4.2.
  - Determine the uniform measured thickness t_{rd} away from the pitted area.
  - Calculate the MAWP using the thickness measured above.
  - Locate the area of the component that has the highest density of pitting damage.
  - Obtain photographs and rubbings of the damaged areas.
  - Determine the maximum pit depth w_{max}.
  - Determine the ratio below. If $R_{wt} < 0.2$, the Level 1 assessment is not acceptable.

$$R_{wt} := \frac{(t_c + FCA - w_{max})}{t_c} \qquad \text{where:} \qquad t_c := t_{rd} - FCA$$

  - Compare the surface damage from the photographs and rubbings to the standard pit charts and select the chart that approximates the actual damage of the component. Examples of different grades of pitting are shown below, where black indicates pitting of the component.

  - Determine the remaining strength factor (RSF) from the table related to the pit chart selected. A typical RSF table is shown below.

R_{wt}, see Equation (6.3)	Level 1 *RSF*	
	Cylinder	Sphere
0.8	0.91	0.89
0.6	0.82	0.78
0.4	0.73	0.67
0.2	0.64	0.56

  - If RSF > RSF_a, then the pitting damage is acceptable for the MAWP calculated above. RSF_a is the allowable remaining strength factor. It is typically set at 0.90 for ASME Section VIII Division 1 equipment.
- If the pitting is unacceptable:
  - Repair, rerate or replace.
  - Lower the FCA.
  - Conduct a Level 2 assessment.

Please contact Vince Carucci if you'd like more information on Carmagen's expertise in these areas.