Hydrotest Water
Specification and Integrity Considerations

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Introduction

The pipeline and pressure vessel are required by code to perform hydrotest after their construction, maintenance to demonstrate the strength and integrity. Water is the most common media to be used in this test. There are several standards and code of practice in place for the quality of hydrotest water. Nevertheless, there is still multiple case of failure while the inappropriate water was used for the hydrotest, which have been proven costly in rectification.

Basic considerations for the hydrotest water specification (EFC39)

(1) Inlet concentration of SRB (i.e. purity of water source);
(2) Temperature;
(3) Residence time of water in the vessel/pipeline
(4) Residue sludge
(5) Materials of construction, particular for trims and special items

Hydrotest Water for Carbon Steel

Potable is widely accepted as hydrotest water, provided the water is not recycled for other hydrotest and limited time of residence water within pipeline and vessel under test. If these not possible, then chemical treatment options have to be considered

(i) The 'conventional package' is the preferred option for corrosion protection and should be used were possible and will contain the following three chemicals:

- corrosion inhibitor,
- biocide,
- oxygen scavenger,

The oxygen scavenger is necessary for internal coated pipeline and vessel which containing a small area of uncoated steel, e.g. at welds. The use of oxygen scavenger shall be in great care to verify its effectiveness during the each application.

The 'conventional package' s 3-in-1 cocktail is the most effective option from corrosion mitigation perspective. However, the water disposal becomes more and more difficult in practice. It must not contaminate ground water for potable use and must comply with any applicable local environmental regulations.

(ii) Alkaline addition is another viable option. Alkaline treatment comprises a mixture of caustic soda and soda solution. The attention should be paid to the water with high hardness. The alkaline addition will cause excessive sludge and made it difficult for the following dewatering process. The inherent total suspended solid can be measured by turbidity and/ or total suspended solid as an index to indicate settlement in the system. Considering the pH change by alkaline addition while adjusting the water chemistry (sulphate, pH) of the water, it is also important to understand the settlement can be introduced by the hardness in water. Settle and/or filter it to avoid introduce excessive settlement in the system shall be considered in alkaline addition process.

(iii) Chlorination, by addition of sodium hypochlorite solution, should be used only if neither the 'conventional package' nor the alkaline treatment is feasible. Chlorination should be to a concentration of free residual chlorine of 0.5 to 1.0 ppm by the addition of sodium hypochlorite solution to the hydrotest water. The oxygen scavenger shall never be used with hypochlorite. The residue chlorine should be closely monitored since excessive free chlorine may initiate the pitting corrosion.

The use of an oxygen scavenger (bisulphite) can affect corrosion resistant alloys; a bisulphite scavenger can depassivate the alloy surface. Therefore, any pipelines or vessel constructed in C-Mn steel but with bends fabricated from or lined with CRAs must be carefully assessed before the treatment is specified.

Hydrotest Water for Stainless Steel

Corrosion failures of fabricated stainless steel systems soon after hydrotest may result from one or more of three causes:

- Pitting & crevice corrosion (PCC)
- Stress corrosion cracking (SCC)
- Microbially induced corrosion (MIC)

Potable water, such as pH, dissolved oxygen and hardness, are unlikely to cause corrosion problems for stainless steel. Chloride is the most important single source of SCC. It destroys the passivation layer of stainless steel and causing pitting corrosion. The microbial growth accelerates the pitting corrosion. The hydrotest water for stainless steel need address these issues.

Use the cleanest water available – demineralised, steam condensate, potable treated , RO water if possible, is always the preferred option. Some fabricator states high chloride content water can be used without issue (table 1). However, it is always arguable that whether this should be allowed considering the risk of chloride enrichment in the system.

Table 1: Water with higher chloride content is somehow used for stainless steel hydrotest

Steel grade	Cl allowable, long term application, ppm	Short term allowable Cl, ppm
304	200	400
316	2,000	4,000
2205	4,000	8,000

- chloride leaching from some gasket
- Using biocide to minimise the possibility of MIC. While chlorine is used, controlled the residue free chlorine (normally 2 ppm for 304 or 5 ppm for 316 at point of entry)
- If the residual free chloride is below 0.2 ppm as the testing water is drained from the system, or the water contains sludge or particulate matter, flush the system immediately with properly prepared, clean sanitised water.
- However, particularly attention shall be paid for any localized chloride concentrating mechanisms to minimize the potential pitting corrosion, which includes but not limit to crevice, evapouration, adsorption, chloride leaching etc.

Standard and Code of Practice

NORSOK L-004 (NORSOK 2010)

L-004 piping fabrication , installation , flushing and testing states in section 8.3 that test media in general be fresh water. It also states that the flushing medium shall be fresh water, the chloride ion content shall be less than 50 ppm. and the pH value shall be between 6.5 and 7.5. antifreeze should be added in case of ambient temperature falling below 2 °C anytime

during the entire testing period (until dried system).
Acceptable preservation fluid shall be utilised for carbon steel system, even it didn't specify the particularly types of chemical to be used for antirust purpose.

API 560 (API)

API 560 states that water used for hydrostatic testing shall be potable. For austenitic materials, the chloride content of the test water shall not exceed 50 parts per million. It also states to dewater the test fluid upon completion of hydrotest. To avoid the chloride concentration, it also requires that heating shall never be used to evaporate water from austenitic stainless steel tubes.

API 570 (API)

API 570 states that Piping fabricated of or having components of 300 series stainless steel should be hydrotested with a solution made up of potable water or steam condensate. After testing is completed, the piping should be thoroughly drained (all high-point vents should be opened during draining), air blown, or otherwise dried. If potable water is not available or if immediate draining and drying is not possible, water having a very low chloride level, higher pH (>10), and an inhibitor addition may be considered to reduce the risk of pitting and microbiologically induced corrosion (MIC).

NACE SP0170(NACE International.).

For sensitized austenitic stainless steel piping subject to polythionic stress corrosion cracking (PTA SCC, see Figure 1), consideration should be given to using an alkaline-water solution for pressure testing. The alkaline wash solution should contain 1-5 wt% soda ash. As a guideline NACE SP0170 states that 1.4~2 wt% soda ash solution provides a sufficient level of residue alkalinity on metal surfaces after the solution drains. Caustic soda should not be used for this purpose. Chloride content in the alkaline solution should be taken into consideration for chloride SCC even there is no direct evidence of chloride SCC. 250 ppm wt of Chloride is a generally accepted as a guideline for fresh makeup solution.
Attention should be paid to chloride pickup and accumulation in solution be removal of salt deposits. A low concentration sodium nitrate(0.4%) corrosion inhibitor is normally utilised to minimize the probability of SCC.
Alkaline washing solution must be drained from each low point the system prior to returning to service to prevent concentrating mechanism of chloride /carbonate salts by evaporation, which will lead to the caustic SCC and chloride SCC. In this case, 25 ppm of chloride content in fresh makeup solution shall be observed. As an alternative, ammoniated condensate solution may be used instead.
Ammoniated condensate may be used if equipment is not reopened or exposed to oxygen. Ammoniated condensate should have a pH greater than 9 and chloride content less than 5 ppm. Vessel and piping washed by Ammoniate condensate may ermain in place or displaced by nitrogen or dry hydrocarbon. The system shall not be exposed to oxygen after this dewatering.

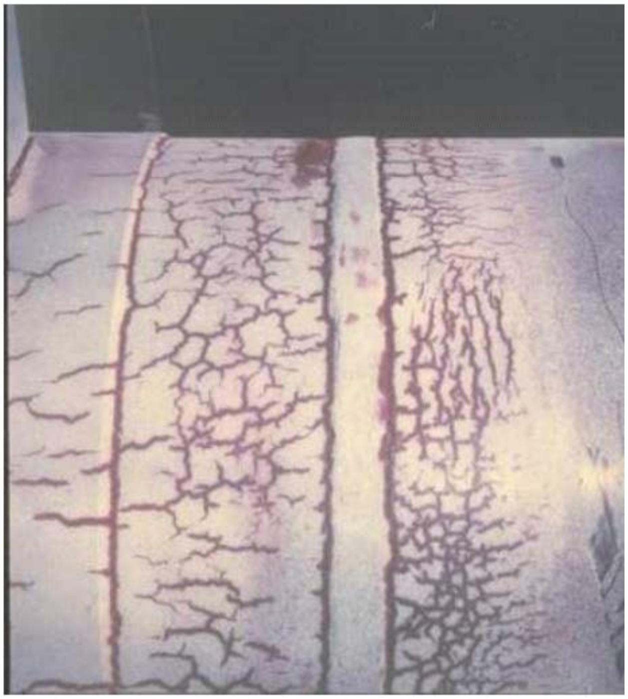

Figure 1 Extensive PTA SCC near welds (image adopted from NACE SP0170)

Clients' Special Requirements

It is not rare that some companies applying more stringent limits on the chloride content, some could be as low as 2 ppm. Others may allow a higher chloride content , say 25 ppm, however, specified the washing water with lower chloride content (2 ppm)

Failure Case

It was reported that several hundred leaks were reported in the type 304 stainless steel pipelines, vessels, and tanks of a chemical plant at a tropical location within a few weeks after startup. Investigation revealed that failure resulted from microbially induced corrosion promoted by the use of poor-quality hydrotest water and uncontrolled hydrotesting practice. It was reported that locally sourced water from mountain borehole was used for hydrotesting. Subsequently, the water was resident in the pipes and vessels for an extended period, until the process plant comes "on stream.. It was confirmed in the investigation that Chloride level is as high as 1250 ppm in the hydro test water. in addition to that, high sulphate (160 ppm) , high total suspended solids, as well as bacteria counts were found in the hydrotest water. The bacteria and settlement will deprive the dissolved oxygen access to the stainless steel surface and then prevent its re-passivation. The loss is significant, the stainless steel pipework at this particular plan required nearly complete replacement.(Jim Scott)

Reference

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