Technical Bulletin

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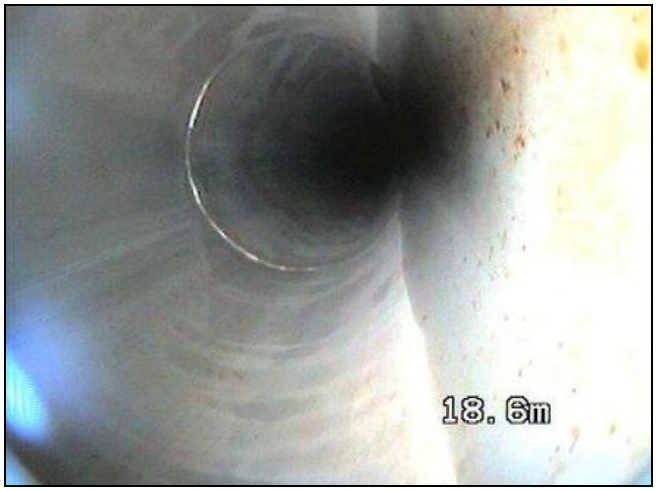
LEAKS IN CARGO TANK LINES ON BOARD A CHEMICAL CARRIER

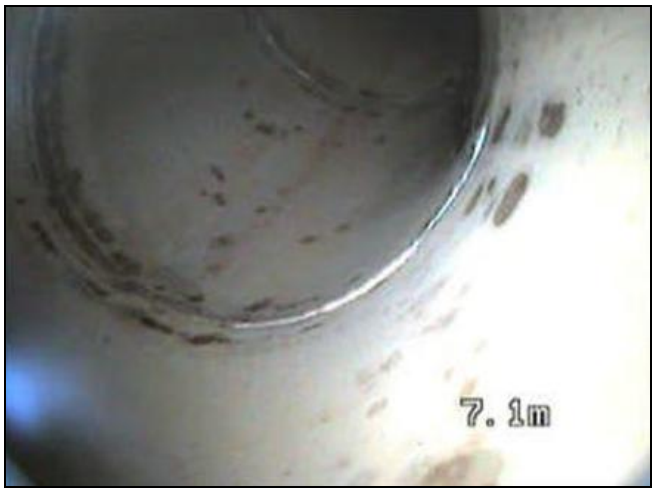
The tanker was built in 2005, and had, in its first few months of service, suffered several leaks in the cargo piping and in the cargo stripping lines. It was suspected that a possible cause of the leaks was galvanic corrosion. One source of galvanic corrosion in stainless steel piping is variation in corrosion resistance at adjacent points in the piping. These variations can be caused by inadequate surface preparation of the interior of the piping following welding during the vessel's construction. The weld seam and the adjacent heat affected zone (the "HAZ") will suffer from thermal oxidation, seen as dark oxide bands. At these areas the protective chromium oxide layer cannot adequately form, and the resistance to corrosion will be less than that of the surrounding stainless steel not affected by welding. Using a boroscope VECOM inspected the stainless steel (AISI 316L) cargo pipelines on the motor vessel and her three sister ships. Subject of the inspection was the dubious state of the welds and discoloration of the heat-affected zone.



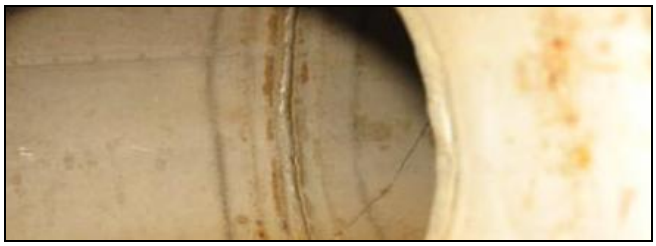
Line 1 – Extensive rust spots, most likely caused by free iron/oxides trapped on surfaces

Line 2 – Evidence that at one time the piping had been half submerged in a pickling acid, with the lower half circle of weld seam pickled and the upper half circle untreated

Line 3 at portable pump connection – weld seam contaminated and showing signs of extensive corrosion products



Line 4 – Extensive contamination, especially near weld seams, possibly caused by free iron/oxides trapped on surfaces



Line 5SB at portable pump connection (before treatment) – weld seam contaminated and showing signs of extensive corrosion products

Line 5SB (before treatment) – Weld seams contaminated with significant corrosion products

Diagnosis

The stainless properties of stainless steels are primarily due to the presence of chromium in quantities greater than roughly 12 weight percent. This level of chromium is the minimum level of chromium to ensure a continuous stable layer of protective chromium-rich oxide forms on the surface. The ability to form chromium oxide in the weld region must be maintained to ensure stainless properties of the weld after welding. In commercial practice, however, some stainless steels are sold containing as little as 9 weight percent chromium and will rust at ambient temperatures. Stainless steels are subject to several forms of localized corrosive attack. The prevention of corrosive attack is one of the concerns when selecting base metal, filler metal and welding procedures when fabricating components from stainless steel.

Discoloration of the heat-affected zone indicates the absence or lack of use of an inert gas during welding or pickling and passivation of the stainless steel afterwards. Another concern when welding the (austenitic) stainless steels, is the susceptibility to liquation cracking. Cracks can occur in various regions of the weld with different orientations such as micro cracks in the underlying weld metal or adjacent heat-affected zone.

On the vessel, VECOM inspectors found welds of different quality and welds with embedded slag and undercut welds. In general, weld seams found near the cargo pumps were fully discoloured in the HAZ. The cargo Lines on the back of the deck however were less affected. In addition, several cargo Lines were grossly contaminated by heavy, adherent, particulate debris. Samples of this debris were taken for further analysis by the VECOM laboratory. Discoloration of stainless steel welds may cause serious problems. First of all it reduces the corrosion resistance by preventing a passive protective chrome layer to form. Secondly, as these areas are more porous, they tend to absorb chlorides causing a corrosive micro environment within the heat-affected zone. Even low amounts of chlorides may cause severe corrosion problems on stainless steel surfaces such as chloride stress-corrosion cracking and pitting corrosion. For use in a marine environment Duplex stainless steels are usually recommended as they have a higher resistance to acids and aqueous chlorides.

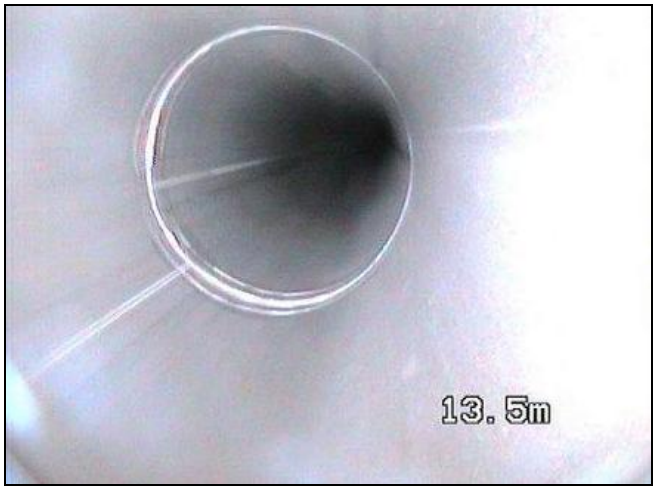
Recommendation

The report's recommendation was to perform a chemical cleaning of the deck cargo lines and cargo stripping lines. The effect of this chemical cleaning (pickling) is to remove the oxides at the heat affected zones along the piping length where welding was done, thereby allowing the steel surface to come into contact with oxygen from the air, and form the protective chromium oxide layer that gives stainless steel its characteristic corrosion resistance.

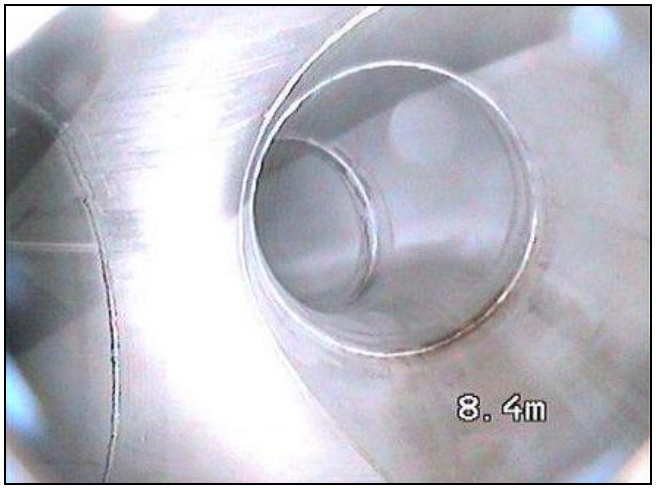
Physical faults within the piping, such as incomplete or substandard welding, cannot be corrected by chemical means.
The work involved circulating aqueous solutions of degreasing compounds, fresh water, aqueous solutions of pickling acids, and again fresh water, through the piping.
In order to achieve this, it was necessary to divide the work into 4 "systems". Each system, or loop, comprised one or more cargo lines and the associated stripping lines. VECOM was asked by the Superintendent to complete the job in just 14 days.

Conclusion:

The cargo and stripping lines of all four ships were successfully chemically cleaned.
The result of the removal of contaminants such as heavy oxides from the HAZ and also other contamination is that the entire stainless steel surface has a uniform character in terms of chemical composition.



Line 1 (after treatment) – Cleaning and pickling successful



Line 4 (after treatment) – Pickling successful, some evidence of trapped air pockets caused by vessel trim

Photos and boroscope inspection of line 5SB – successful pickling

By maintaining a clean stainless steel surface, and by thorough removal of chlorides derived from seawater used for cleaning (using a thorough follow-up cleaning using fresh water) the opportunity that galvanic corrosion will occur is greatly reduced. Maintenance of clean and chloride-free surfaces cannot be over-emphasized when discussing the passivity of stainless steels. It is not possible to entirely remove all crevices or crevice-like phenomena. In such areas the possibility for corrosion exists. However by keeping the areas clean and exposed to oxygen, the stainless steel will maintain its resistance to corrosion over a prolonged period of time. The vessel experienced fewer cargo/ stripping line leakages either during pickling or during subsequent pressure testing with water than was the case for the other vessels to date. The overall condition of the welding when seen using the boroscope appeared better than that seen in reports on other vessels in the series. During the project on this vessel there was a need to trim the vessel more than 7m forward to expose the rudder for already planned essential repair. The consequence of this is that lines 4, 5P, 5SB and Slop could not be properly drained of liquid, since, unlike lines 1 and 2, there is no connecting line/ valve between the cargo line and stripping line where the cargo line tee is positioned at the manifold. We recommended, therefore, to allow for a proper drain of liquids from the other lines, a ½ " socket be added as indicated in this photo taken of line 4:

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