PM INTERNATIONAL SUPPLIERS, LLC

Duplex & Super Duplex Intermetallic Phases

Issue

Leaks occurred during construction/commissioning in Super Duplex Stainless Steel fittings attributed to rapid seawater corrosion in sigmatised material. In addition, during early operations, a pinhole leak occurred on the Duplex Stainless Steel manifold.

Original Testing Requirements

Original project purchase specification did not require ferrite testing to screen for deleterious intermetallic 3rd phases such as sigma, which would be caused by improper heat treatment.

Manufacturers and particularly their heat treatment facilities were audited for appropriate controls, procedures and awareness of potential problems. Project specifications included charpy-v notch impact testing by heat lot to ensure toughness, thereby precluding sigma.

Proposed Cause

Improper heat treatment resulting in intermetallic phases.

Foundation for Our Conclusion

PM International focuses on difficult specifications and requirements needed for the Exotic Alloys such as Duplex and Super Duplex. Our area of expertise has exposed us to many different scenarios and challenges thus enabling us to compile data from various other encounters of similar issues across several projects all of which leads us to our final, proposed cause.

An Additional Concern

While we submit our proposed cause of protracted, detrimental heat treatment, we do have a concern regarding the specific technique used in this case for the welding of Ferritic/Austenitic Stainless Steels. This is based on reports from several clients who have had serious issues due to improper welding procedures, specifically for Super Duplex (25% Chromium). So, while the welding is in our opinion not the cause of the problem, we do recommend a review of the welding process and submit documentation that may be of assistance in this review.

Resolving the problem

Having made the above statement, we continue to address the issue we propose is at hand with first a look at the materials, then various testing platforms for consideration and finally potential pitfalls in stringent testing requirements contra product procurement. We also offer contact information for technical support who we believe can assist in resolving the problem.

MATERIAL

UNS S31803 While 22% Cr does have the benefits of both the toughness of Austenitic Stainless Steel and the higher strength and corrosion resistance of Ferrite Stainless Steel, it is only considered superior to the standard austenitic alloys in this respect. We would not suggest 22% Cr for seawater application.

UNS S31803								
C	Cr	Mn	Mo	N	Ni	P	S	Si
0.030 max	21.0-23.0	2.00 max	2.50-3.50	0.08-0.20	4.50-6.50	0.030 max	0.020 max	1.00 max

UNS S32750 25% Cr however has the optimum pitting resistance and crevice corrosion in the Duplex family and is commonly referred to as Super Duplex. As this material is better for seawater applications, in our experience it performs well only in controlled temperatures and begins to fail if exposed to large variations in temperature.

UNS S32750								
C	Cr	Mn	Mo	N	Ni	P	S	Si
0.030 max	24.0-26.0	1.20 max	3.50-5.0	0.24-0.32	6.0-8.0	0.035 max	0.020 max	0.8 max

SUCCESSFUL TESTING

In PM's experience, the following testing has been successfully conducted in the combat against the problems encountered:

Terra Nova Project (PetroCanada)

PREN Requirement: (Pit Corrosion Equivalent Number %Cr + 3.3%Mo + 16%Ni)
22% Cr must meet 34.5% Min while 25% Cr must meet 40% Min

Max Hardness: In acc to NACE MR-01-75
22% Cr requires 28 HRC
25% Cr requires 32 HRC

100% Liquid Dye Penetrant required for all seamless fittings, flanges and hubs. 10% per heat per purchased line item with a minimum of one, both externally and internally where accessible.

Impact Testing:
22% Cr required at -40 C, results to meet Average of 3 Specimens 40J/Single 30JMin
25% Cr required at -20C, results to meet Average of 3 Specimens 45J/Single 32JMin

Terra Nova Project, continued…

Micrographic Examination:
25% Cr Only: All items to be supplied with Micrographic Examination in acc to ASTM E562, examined at 400x and shall be free from intermetallic phases and precipitates

Corrosion Test:
25% Cr Only: All items to be supplied with Corrosion Testing in acc to G48 Method A @ 50°C, no pitting at 20x with weight loss less than 4.0g/m²

NORSOK Standard
NORSOK has a different standard for Duplex and Super Duplex as well as for each form of material. Rather then listing each of the requirements, we attach each standard.

Please note the requirements for Impact Testing, Micrographic Examination and Liquid Dye Penetrant testing required for both 22% and 25% Cr. Corrosion Testing also required for 25% Cr.

Kizomba Project
The most detailed specification PM successfully managed was for a valve manufacturer who produced valves for the Kizomba project (ExxonMobil). The project experienced similar issues with pit corrosion attributed to intermetallic phases. It was determined that improper heat treatment caused deleterious sigma phases in the material. The attached specifications for Duplex and Super Duplex material were utilized on the project and the issue was resolved.

STANDARD TEST METHOD

We attach ASTM A923 which specifically deals with detrimental sigma phases (3rd phases or intermetallic phases) in Duplex Stainless Steels and the tests recommended to detect them.

TESTING CONSIDERATIONS

Engineering and Quality must come to an understanding as testing should not become so stringent that it deteriorates the pricing and availability of a product. The more testing required and the more in depth that testing becomes, the more difficult it is to source a product. This especially applies to ASTM A923 compliance. Therefore, it is essential to determine the least amount of testing that provides the maximum assurance of quality.