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TEST REPORT150XT – Diffusible Hydrogen

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Background

Hydrogen induced cracking is a phenomenon where hydrogen atoms, being the smallest, are mobile in solid materials, including steel. Atomic hydrogen atoms are theorized to migrate to voids or disruptions in the crystalline lattice and remain in this place. When another hydrogen atom also enters this space, the two join to form H2, or molecular hydrogen which is no longer mobile due to its size. As other atomic hydrogen atoms enter this same space and join, pressure builds to the point of exceeding the yield strength of the material resulting in cracks. These cracks often initiate in the heat affected zone (HAZ) of welds and propagate into the weld and surrounding base material. Importantly, these cracks develop over time, from hours to days. They do not occur immediately upon solidification of the weld.

Scope

150XT and other welding wires used for hardbanding of tool joints on drill pipe have the potential to impart hydrogen to the weld deposit which could cause hydrogen induced cracking (HIC). For hydrogen cracking to occur, there must be a combination of the following:

1. Susceptible microstructure
2. High stress
3. Sufficient hydrogen

1. Tool joint steels are hardened, martensitic low alloy steels and can have very hard heat affected zones, which are susceptible microstructures for HIC.
2. Stress is present due to the heating and rapid cooling of welding and the shrinkage of the weld deposit upon microstructure transformation. Stress levels are lowered by preheat, interpass temperature and especially post weld stress relieving.

When tool joints are hard surfaced by arc welding, they should be carefully thermally managed by preheat (typically 500F) and slow cooled by wrapping in insulation. However, they are not stress relieved after welding and high stresses remain in the HAZ.

3. Hydrogen enters the weld pool, typically via the weld wire, although it can also come from contaminants on the steel (usually removed by preheating, wire brushing, grinding, etc.), wet shielding gas (CO_2 should have a dew point of -40F, although this is rarely checked) or loss of shielding in humid, ambient conditions. Keeping the available hydrogen low is important as a preventative to hydrogen cracking.

Purpose of Tests

Tests were performed on the new 150XT to ascertain diffusible hydrogen levels in three conditions.

Test Method

The currently accepted test method is defined in American Welding Society (AWS) document, A4.3. Results are expressed in milliliters of hydrogen per 100 grams of weld metal. Values lower than 5 ml/100gm are considered “low hydrogen”.
These tests were performed by the Edison Welding Institute (EWI), Columbus, OH.

Test Samples and Conditioning

Two samples of 150XT wire were supplied to EWI.
One sample was from normal production and tested upon removal from the vacuum bag. This sample was then subjected to controlled exposure to temperature and humidity – 8 hours at 80F and 80% Relative Humidity.
The second sample was baked on the spool at 320F for 12 hours. This is a standard reconditioning treatment for cored wires already packaged onto fiber spools.

Results

Standard Production:	**4.41 ml/100gm**
Baked at 320F, 12 hrs.	**4.02 ml/100gm**
After 8 hrs at 80F/80%RH	**4.88 ml/100gm**

User Steps to Avoiding Hydrogen Cracking

1. Preheat – hydrogen moves and diffuses to the air. Its movement is an exponential function of temperature, that is, the warmer the steel the more hydrogen will diffuse out of the steel.
2. Slow Cooling – slow cooling the tool joint after welding allows hydrogen more time to diffuse, lowering the available amount of hydrogen to cause cracking.
3. Care of the Wire – these tests indicate that the processing of metal cored wires results in low hydrogen levels. Even after exposure for an 8 hr. shift the wire is still in a low hydrogen condition. However, wire should not be left indefinitely exposed, but should be stored in a heated, dry room when not in use. The wire can be returned to a low hydrogen condition after extended exposure by baking it at 300-325F for 12 hours. DO NOT EXCEED 325F AS THE GLUE IN FIBER SPOOL WILL BREAK DOWN OR CHAR AND THE LABEL WILL BURN.

Metal Cored versus Flux Cored Wires

There is a distinct difference in hydrogen potential from moisture absorption between pure metal cored wires and cored wires that have flux or slag forming materials. Typically, metal powders will only attract surface moisture where flux components flux cored wires will absorb moisture at much higher levels.

Summary

Arnco wires are designed and manufactured to minimize hydrogen. The packaging consists of a Vapor Corrosion Inhibitor paper wrapped around the faced of the spool, vacuum packaging in a moisture proof, multi-layered bag and placed in a carton for protection. The shelf life should be indefinite if the vacuum bag is undamaged.