

Executive Summary Hydrogen Embrittlement test on Doxsteel Electroplating

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- Shell personnel contacted Doxsteel Fasteners to investigate the feasibility of performing Ni-Co electroplating ASTM B994 on ASTM 490 bolts.
- The Doxsteel Fasteners' electroplating procedure was tested for hydrogen embrittlement according to ASTM F519 and the results were positive (passed).

ACTIVITIES SUMMARY

- In a phone call between Doxsteel Fasteners and Shell teams last May 25th, it was clarified that ASTM F3125 replaces ASTM A490. According to ASTM F3125, the permitted coatings must be qualified in accordance to ASTM F1940 and ASTM F2660 for sacrificial coatings. Ni-Co plating is not sacrificial, hence, ASTM 2660 does not apply and Doxsteel Fasteners will comply only to F1940.
- Doxsteel team proposed to do the hydrogen embrittlement (HE) tests according to ASTM F519-1a1-13 (Annex I) instead of ASTM F1940 since it also applies to bolt materials, Shell team agreed in those tests provided that they received the procedure and corresponding timing to do so.
- According to ASTM 519-1a1-13, a minimum of four tensile tests are loaded to 75% notch tensile strength (NTS) for 200 hours, if one of the samples breaks, it can be replaced and the fracture time will be added to the 200 hours, if this breakdown continues happening, the material is marked as a failed test. A failed test indicates the likelihood of the presence of hydrogen in the material due to the electroplating process.
- ASTM F519-1a1 samples were sent to Doxsteel Fasteners for the Ni-Co electroplating process. After the plating, the samples were sent to IMR Test Labs on September 18th, 2017.

OUTCOME

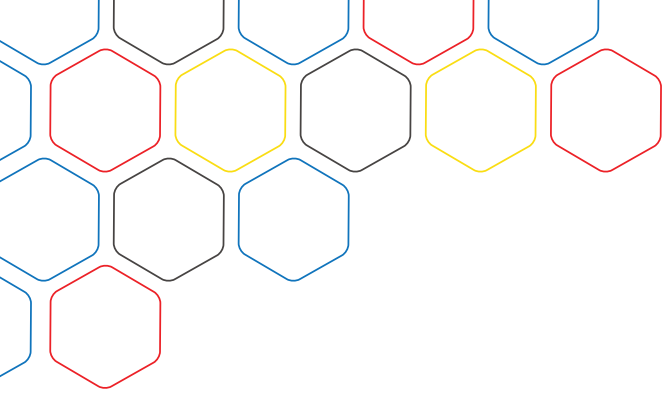
- The Ni-Co electroplating carried out on the ASTM F519-1a1 samples passed the quality control at Doxsteel Fasteners.
- IMR Test Labs sent the results from the tests indicating that the samples passed the test as it is shown in the table below.
- From the results, it is implied that the Doxsteel Fasteners Ni-Co electroplating process does not induce hydrogen embrittlement in steel.

Sample ID	NFS	Load with 50:1 Arm (lbs)	Time (hrs)	Pass/Fall
3/8- 16	8509	128.0	261.7	Pass
1/2- 13	8509	128.0	261.7	Pass
5/8- 11	8509	128.0	261.7	Pass
3/4- 10	8509	128.0	261.7	Pass

STEPS TO TAKE

- Communication between Shell personnel and Doxsteel Fasteners to discuss these results.

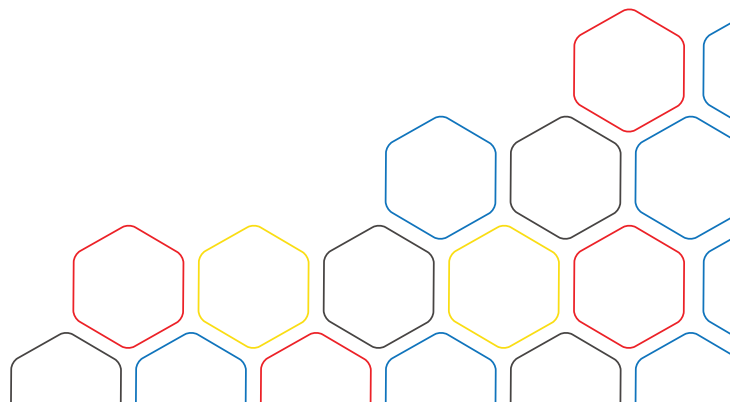
NOTE: THE TEST REPORT IS ATTACHED TO THIS SUMMARY.



doxsteelfasteners

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ASTM F519-A490 Test Report



HYDROGEN EMBRITTLEMENT TESTING

IMR Report Number 201702470-1

SUMMARY

One (1) group of four coated ASTM F519 Type 1a.1 specimens was submitted for testing. It was requested that hydrogen embrittlement testing be performed in accordance with ASTM F519. A customer supplied Certification of Manufacture was provided to determine the required load. The testing results **satisfied** the requirements.

October 04, 2017

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ANALYTICAL PROCEDURES & TEST EQUIPMENT

I. Mechanical Testing:

A. Hydrogen Embrittlement Testing, ASTM F519-17

Date Received

September 18, 2017

RESULTS

Hydrogen Embrittlement testing was performed on the submitted specimens in accordance with F519-17, in ambient air. The results are summarized in the table below.

Sample ID	NFS	Load with 50:1 Arm (lbs)	Time (hrs)	Pass/Fail
RONDA 1 (15D)	8509	128.0	261.7	Pass
RONDA 1 (15D)	8509	128.0	261.7	Pass
RONDA 1 (15D)	8509	128.0	261.7	Pass
RONDA 1 (15D)	8509	128.0	261.7	Pass

Notes: Load values are rounded up to the nearest 0.5 lbs.



Reviewed by

Daniel Shumate
Metallurgical Technician

Reviewed by

Dennis Johnson, CWI
Lead - Machine Shop

All procedures were performed in accordance with the IMR Quality Manual, current revision, and related procedures; and the PWA MCL Manual F 23 and related procedures. The information contained in this test report represents only the material tested and may not be reproduced, except in full, without the written approval of IMR Test Labs ("IMR"). IMR maintains a quality system in compliance with the ISO/IEC 17025 and is accredited by the American Association for Laboratory Accreditation (A2LA), certificates #1140.03 and #1140.04. IMR will perform all testing in good faith using the proper procedures, trained personnel, and equipment to accomplish the testing required. IMR's liability to the customer or any third party is limited at all times to the amount charged for the services provided. All samples will be retained for a minimum of 6 months and may be destroyed thereafter unless otherwise specified by the customer. The recording of false, fictitious, or fraudulent statements or entries on this document may be punished as a felony under federal statutes. IMR Test Labs is a GEAE S-400 approved lab (Supplier Code T9334).