TECH BRIEF

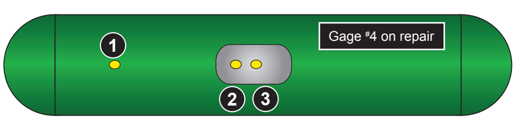
Pipelines

Long Term Performance of Composite Materials in Repairing High Pressure Pipelines

For over 17 years, Stress Engineering Services has been integrally involved in evaluating the use of composite materials in reinforcing piping and pipelines for the oil and gas industry.

From what started out as a single program for the Gas Research Institute in 1994 to evaluate the Clock Spring System, our efforts have evolved into numerous studies including the most comprehensive effort to date focused on evaluating the long-term performance of composite repair systems from around the globe. This program is a 10-year study that will be completed in 2019. Since 1994 Stress Engineering has had the unique opportunity to learn the ins and outs of what makes an effective composite repair system. We have developed strong relationships with both the pipeline industry as well as the manufacturers who develop and market composite repair solutions.

There is a wide range of topics that could be discussed in this article, considering the extent of work that has been done by Stress Engineering. However, the focus is going to be on the long-term performance of composite materials. In 2008 the Pipeline Research Council International, Inc. awarded to Stress Engineering a contract for developing and executing a program to evaluate the long-term performance of composite materials. Twelve composite repair companies were invited to participate in this study that involved repairing 12.75" x 0.375", Grade X42 pipe samples that were fitted with machined corrosion patches having depths of 40, 60, and 75% of the pipes' nominal wall thickness. The participating companies repaired the test samples by installing their composite repair materials on a total of 180 test samples. To evaluate long-term performance, the pipe samples are being buried at the Stress Engineering Waller Test Facility, where they will be pressurized and cycled for up to 10 years. At specified time periods (e.g. 1, 2, 3, 5, 7.5, and 10 years), three test samples from each manufacturer will be removed and burst tested. In addition to the buried test samples, 36 burst tests were conducted on the non-buried Year 0 test samples to serve as the baseline data set for the program. Additional details on this program can be found at www.compositerepairstudy.com.



Location of strain gages installed on the test sample

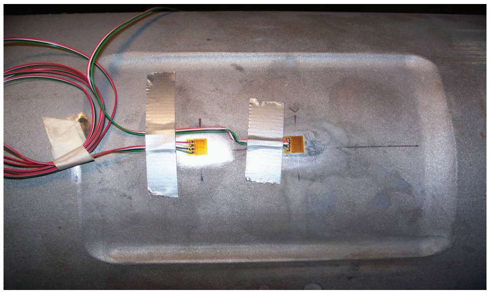


Photo of strain gages installed in the machined corrosion region

Figure 1: Details on PRCI test samples

Figure 1 shows the arrangement of the test samples, along with a close-up view of the machined region where strain gages were installed. These gages will monitor strain in the steel beneath the composite repairs during the burial period and the burst test results will determine if the capacity of reinforcement changes over time. Listed below are the companies participating in this program. The years in parentheses correspond to the maximum years of burial for each respective system.

- Armor Plate, Inc. (10 years)
- Air Logistics Corporation (3 years)
- Clock Spring Company, LLC (3 years)
- Citadel Technologies (10 years)
- EMS Group (10 years)
- Furmanite (3 years)
- Neptune (3 years)
- Pipe Wrap, LLC (3 years)
- T.D. Williamson, Inc. (10 years)
- Walker Technical Resources Ltd. (3 years)
- Wrap Master (3 years)
- 3X Engineering (3 years)

In addition to the long-term pipe burial program, in the past year Stress Engineering has performed an extensive number of pressure cycle fatigue tests on composite-repaired corrosion defects. Using the 75% deep defect geometry shown in Figure 1, test samples involving five different repair systems were repaired and pressure cycled to failure between 50 and 100% of the Maximum Allowable Operating Pressure (i.e., where MAOP is 72% SMYS). The most impressive of all test results achieved involved a carbon reinforcement system where a total of 532,776 pressure cycles were applied before a failure by leak occurred. Figure 2 shows the measured strain gage results for one of the tested repair systems at 150,000 cycles. Even after this many cycles, the alternating strain in the reinforced corrosion region is elastic and translates to only 30,000 psi.

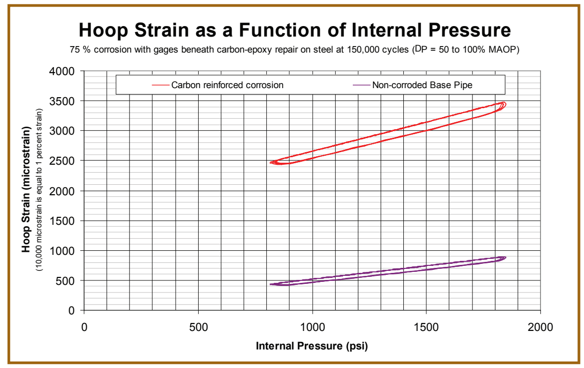


Figure 2: Hoop strains beneath carbon reinforcement at 150,000 cycles

Figure 3 is a photograph showing the cross-section of a fatigue sample that was removed after it had been cycled for more than 160,000 cycles. Test results such as these demonstrate the capacity that composite materials have to repair aggressive corrosion and cyclic pressure conditions.

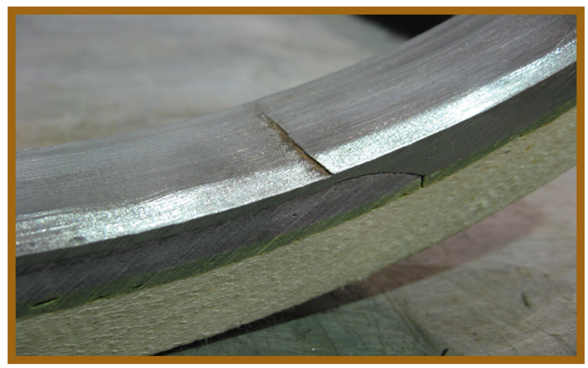


Figure 3: Fatigue failure in composite-repaired sample with 75% corrosion

Our goal at Stress Engineering is to continue our pro-active efforts in evaluating composite repair technology and partner with pipeline companies and composite repair manufacturers from around the world to ensure that only the safest and most reliable systems are used to repair damaged piping and pipelines. Great strides have been made and are expected to continue as innovative methods are introduced for using composite repair technologies.

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