Choosing a composite repair

Composite repair technology is now approved for the permanent repair of defects common to high-pressure pipelines, including corrosion and other blunt defects, third party damage and mechanical damage.

The number and type of composite repairs available is increasing.

It is important to note that the regulatory language states that the composite repair should "permanently restore the serviceability of the pipe" as shown by "reliable engineering tests and analyses". This performance-based language puts responsibility for the effectiveness of the repair on the pipeline operator. It is up to the operator to evaluate the technical data available for each repair system and determine if meets the "reliable engineering testing and analyses" guideline. The decision on which repairs actually meet the language of the regulations can be somewhat confusing.

When considering repair methods for high-pressure steel pipelines Clock Spring® is the right choice.

Clock Spring®, a composite sleeve repair system, is the result of a rigorous development program directed by the pipeline industry through the Gas Research Institute (GRI), now Gas Technology Institute (GTI). The supporting documentation of the Clock Spring® development program was delivered to the Department of Transportation, Research and Special Programs Administration (DOT-RSPA) in 1998 and became the basis for changes to Title 49 of the Code of Federal Regulations regulating both gas and liquids pipelines.

Highlights:

- In 1987, GRI assembled a distinguished team of pipeline professional and research organizations for the purpose of formulating and directing a comprehensive program to verify the effectiveness, permanency and durability of a composite repair system.

- The performance requirement for a repair, which “permanently restores the serviceability of the pipe”, necessitated long-term testing under worst-case conditions.

- Based on the recommendations of the pipeline industry, DOT-RSPA allowed the use of the newly developed Clock Spring® composite repair under a waiver of
the requirements of 49 CFR Parts 192 and 195, which cover the operation of gas and hazardous liquid pipelines. A condition of the waiver was to establish a long-
term monitoring program to acquire data that would demonstrate the effectiveness
and durability of the repair under actual operating conditions. The results of this
validation program are reported in GRI 95/0071 “Long-Term Reliability of Gas
Pipeline Repairs by Reinforced Composites”, GRI 98/0032 “Field Validation of
Composite Repair of Gas Transmission Pipelines”, and GRI 98/0227 “Summary of
Validation of Clock Spring® for Permanent Repair of Pipeline Corrosion Defects”.

• At the end of this decade long program, GRI concluded that the system
developed, Clock Spring®, when properly installed, permanently restores the
serviceability of the pipe. (GRI 95/0071, GRI 98/0032, GRI 98/0227)

• The supporting documentation of the validation testing was delivered to
the U.S. Department of Transportation, Research and Special Programs
Administration (RSPA) in 1998.

• Based on the results of the validation testing, the Office of Pipeline Safety
(OPS) published the Pipe Repair Rule which permits the use of new repair
procedures, including Clock Spring®, to permanently repair pipeline defects. The
language of the rule allows operators to use a repair which “permanently restores
the serviceability of the pipe” as shown by “reliable engineering testing and
analyses”. (Federal Register Vol. 64 No 239/Tues Dec 14, 1999 Rules and
Regulations p69660)

The GRI program serves as the model of “reliable engineering testing and analyses”.

The permanency and durability of Clock Spring® was determined through both
laboratory evaluation and long-term exposure to real operating conditions. The
durability data is specific to the architecture and design of Clock Spring® and cannot
be used to assess or validate any other similar composite repair.

Each composite repair will have unique mechanical properties specific to that repair.
The mechanical properties and architecture of the composite will determine durability.

There are several key factors to consider.

Key Elements of Composite Architecture and Design:

• **Strength:** Composites degrade over time. The rate and degree of degradation
  is dependent on the design and architecture of the specific composite and the
  operating environment. Not all composites are the same. Each composite repair
  should have accelerated life and long-term durability data that demonstrate
  adequate strength at the end of the design life. Clock Spring® has a 50-year
  design stress of 20 ksi. This design stress contains a safety factor of two and was
  confirmed in the long-term durability and laboratory testing outlined previously. The
test protocol and results are reported in GRI 95/0071, GRI 98/0032 and summarized in 98/0227. These reports were prepared by Battelle and are available for review.

- **Architecture:** The Clock Spring® development program evaluated several composite architectures to ensure maximum durability. Moisture is detrimental to the life of a composite repair and any path for moisture ingress will decrease durability. Woven cloth and unidirectional glass, cross-stitched with “knitted” thread, did not pass the durability tests. Any composite repair with a structure or element that contaminates the strength member and could allow moisture absorption should be very carefully reviewed. Only the current Clock Spring® architecture of direct strand, unidirectional, non-stitched glass fibers passed the durability criterion established in the test protocol.

- **Stiffness:** Clock Spring® has a modulus of elasticity (Youngs modulus) of 5.5 x 10^6 psi, which is about 1/5 that of normal pipe steels. Because the pipe is stiffer than the composite the steel at a defect location will yield or strain before the load is fully shared by the Clock Spring® composite sleeve. A modulus of less than 5 x 10^6 psi will allow additional yielding, which could be detrimental to the effectiveness of the repair. According to work done during the development phase of Clock Spring® it was determined that the minimum elastic modulus for an effective repair was 5 x 10^6 psi. The Clock Spring® engineering and material property data is contained in GRI 95/0072 “Engineering Properties of Clock Spring® For Repair of Defects in Transmission Pipelines”.

- **Adhesive Durability and Strength:** Composite repairs are bonded to the pipe and interlayer using adhesive. The adhesive is a critical component of the repair and must be rigorously tested for both long-term strength and durability. The surface condition on which the adhesive is applied has a significant affect on performance.

An early generation of Clock Spring® had a significant texture integrated into the composite. The premise was that this would maximize the effective bond area and thus the ultimate strength. During testing, it was found that the irregular bond line actually degraded performance. Adhesive performance is discussed in Appendix C “Assessment of Adhesive Stresses and Potential for Creep” of GRI 98/0032. A smooth surface with a slight anchor pattern is the best surface preparation to ensure maximum adhesive performance.

Long-term test data is required for all components of the repair system. Clock Spring® adhesive was developed specifically for the Clock Spring® repair and was tested in both the validation studies previously mentioned and in detailed laboratory testing. The results are reported in GRI 98/0032 and in GRI 98/0151.

- **Field Validation:** (GRI 98/0032, GRI 98/0227) GRI managed a comprehensive 10-year program of laboratory research, development and field validation that
demonstrated that properly installed Clock Springs are a sound, permanent repair system for non-leaking, blunt defects in high pressure pipelines. This 10-year program was conducted with the direct support and involvement of the pipeline industry and the United States Department of Transportation, Office of Pipeline Safety.

The detailed monitoring, evaluation and testing programs measured durability and performance of 69 Clock Spring units under actual operating conditions at more than 20 installation sites throughout the United States. None of the 69 Clock Springs excavated and inspected after 2 to 7 years in service on operating pipelines showed any evidence of degradation. Similar testing should be required for any new composite being introduced for this critical repair application.

- **Engineering Critical Assessment**: It is important to evaluate a repair based on both the mechanical properties of the pipe and the composite. If the composite properties are not well defined this evaluation is not possible. Clock Spring® developed an analysis technique based on the ASME Pipeline Codes and the well defined properties of the Clock Spring® composite. This repair assessment is known as GRIWrap and is available as an Excel spreadsheet from Clock Spring. This analysis uses the geometry of the defect being repaired, the strength and modulus of the pipe and the strength, modulus and thickness of the composite to endure that the repair will be effective. This is just one more way to demonstrate that Clock Spring® meets the requirements of “reliable testing and analyses”.

- **Manufacturing Process (Cure)**: Clock Spring®, as a fully cured product, controls the pedigree of raw materials and the manufacturing process to provide well defined engineering properties. A wet wrap repair will introduce variables such as angle and tension of the strength member (glass or other), resin saturation and pre-stress that will all affect the properties of the final repair. If the properties of the repair are not well known and controlled the effectiveness of the repair cannot be demonstrated. A fully cured composite was set as a design requirement early in the GRI program to eliminate the potential for field variables that would jeopardize the repair.

- **Compatibility with Cathodic Protection Systems**: Cathodic shielding and disbondment testing must demonstrate that the repair is compatible with the corrosion protection systems used on pipelines.

- **Electrically Conductive Material**: Potential for induced currents, cathodic effects, stored charges and other issues may need to be evaluated if conductive material is used in the composite sleeve.

Clock Spring® offers the peace of mind that, “reliable engineering testing and analyses” has demonstrated its ability to “permanently restore serviceability to the pipeline”. Clock Spring® is the right choice!
**Economics:**

Clock Spring® provides cost savings to the pipeline industry. Once a pipe is exposed, the marginal cost to repair a standard corrosion defect is often just a few hundred dollars. Operators sometimes spend thousands of dollars to analyze defects to justify making no repair. Clock Spring® offers a cost effective solution that has withstood the rigors of peer review, management questions, and real world conditions. “*It is simply the smartest pipeline repair decision you can make.*”

**Summary:**

Clock Spring Company L.P. knows that many composite architectures do not possess the properties necessary to ensure permanency and will not be capable of demonstrating the “reliable engineering testing and analyses” required by the regulations. To our knowledge, only Clock Spring® has the peer-reviewed documentation of “reliable engineering testing and analyses”. Make the right choice.

While DOT does not approve or endorse any specific product, they did participate in the GRI program for Clock Spring® and agreed that that program demonstrated “reliable engineering testing and analyses” and that a properly installed Clock Spring® “permanently restores the serviceability of the pipe”.

Under the performance based language of the current regulations, the responsibility for pipeline safety rests with the operator. The decision to use Clock Spring® can not be questioned. If you use Clock Spring® you are justified in feeling secure that your pipeline is safe and that you have made the right choice.

**Documentation:**

All reports referenced in this document are available for review.

Additional information is also available on our web site, including a bibliography of the many GRI reports detailing the Clock Spring® development and validation programs.

Demand supporting documentation of the repair you choose. Make the right choice.

**Simply the smartest pipeline repair decision you can make!**

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