The Evolution of Composite Repairs for Pipelines

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When operators look for a repair technology they want to select a product that will address issues that resolve the problems that are common to pipeline operations. They do not want to stock repair products that only address some of the problems or may, in fact, be a root cause to new problems. An example of this might be utilizing old technology like welding a repair product on a pipeline that sets up a stress scenario or corrosion cells that can compound the problem and would require an extremely high degree of skill and inspection to limit these potential problems from occurring.

Because of this the piping industry has steadily adopted the use of composites for Type-A repairs of pipeline anomalies such as wall loss, corrosion and gouges and dents resulting from third party damage. While answering some of these needs, to date most composite repairs fall short in some aspects of operational performance. Composites are relatively new and very few composite repairs address all of the needs of application. The pioneer composite repairs have been around the market-place for about 15 years. While composites being used in industries such as aerospace have continuously evolved, surprisingly there has been little real innovation in the area of piping repair using composites. Most were developed to get a piece of the market rather than to bring meaningful innovations that offer attributes addressing industry needs.

The piping industry looks for repair product that can meet the criteria of needs beyond just a spot repair or reinforcement of a weakened area found on a section of pipe. Some of the issues they would like to address when selecting a repair product or method would be: performance, ease of installation, installer's safety, high temperature performance, high modulus, arresting future corrosion, pressure cycling, excavation size, labor required, impact resistance, return to full service time, UV resistance, training requirements, special equipment needs, and no noxious odors or

environmental impact. While answering many of the above, no composites, until now, have satisfactorily addressed all of these needs.

We now find the composite market place cluttered with an array of me-too composite products or knock-off composite products that do little to address industry needs and are primarily gimmickry to get a piece of the market. Unfortunately some of these products have failed to meet the standards of the industry as permanent repairs and have caused operators to back away from an otherwise valuable option for pipeline repair and rehabilitation.

Meaningful innovation and evolution is taking place and a prime example of this is the Carbon-Ply Composite Repair system. This system is so unique that not only does the method qualify for a patent the resin system is also patented.
The Carbon-Ply product is the only true monolithic-cross linking composite that offers the operator a permanent repair that can return to full service within three hours of starting the installation process. The Carbon-Ply Composite Repair System is offered by Cross Link Composites, LLC.

The CARBON-PLY Epoxy Sleeve Repair (ESR) System is a non-metallic, crosslinking, monolithic, high-performance, carbon fiber composite repair system developed to repair damaged or corroded pipelines in high and low risk pipe and pipe work applications. This Patent Pending system is designed to repair non-leaking pipe (Type A repair) with up to 70% external pipe wall loss due to damage or corrosion. The CARBON-PLY ESR system is comprised of: CARBON-PLY DFRE (Defect Filling Repair Epoxy), CARBON-PLY ESR Primer, high modulus carbon fiber and CARBON-PLY ESR Resin.

The CARBON-PLY ESR system will permanently repair external corrosion on any pipe, restoring its structural integrity and preventing further deterioration. Also, external damage such as dents, gouges, fretting and wear can be repaired. For internal corrosion, the CARBON-PLY ESR should be considered as a temporary repair unless the operator can prove that the internal corrosion process has been stopped. The CARBON-PLY ESR System can be applied to curved pipe and to all pipe fittings. It is not, however, recommended for defects that run around the pipe circumferentially. The heat distortion temperature of the composite repair is >400 degrees F. (>204 degrees C.) when tested according to ASTM D-6604.

Advantages of the CARBON-PLY ESR system include:

Small excavation	Fast curing
No heavy equipment needed	UV resistant
No welding required	Impact resistant
Can be installed on pressurized pipe	Light weight
High operating temperature	Will not corrode
Requires minimal training	No noxious odors
Minimal cleanup needed	High modulus repair
Easy to install dry-wrap method	

The CARBON-PLY ESR system involves pipe preparation by grit blasting, application of CARBON-PLY Defect Filing Repair Epoxy (DFRE) and CARBON-PLY ESR primer, wrapping the affected area with high modulus carbon fiber cloth and pressure laminating the cloth with CARBON-PLY ESR Resin using a unique, patented installation procedure developed by Cross-Link Composites LLC. Contact Cross-Link Composites LLC for information about material quantities and methods based on the specific pipe size, pipe grade, configuration and defects.

The following is a step-by-step procedure for installing the CARBON-PLY ESR System:

1. **Pre-Repair Conditioning** – The CARBON-PLY ESR System can be installed on pressurized pipe. As a safety precaution, it is recommended that the pressure on the pipe be reduced by 20% or more prior to installation. If buried, a trench must be dug around the pipe providing a working clearance of at least 3 feet on the sides and one foot under the pipe.
2. **Pipe Surface Preparation** – With a file or hand grinder, remove all burrs, sharp corners, and other stress-concentrating anomalies leaving smooth contours on any damaged areas. The key to a tight, long-lasting pipe repair system is the adhesion of that system to the pipe. The better the adhesion, the longer the repair will last. The adhesion of the laminate and epoxy is determined by the quality of the surface of the pipe. For this reason, the pipe must be White-Metal Blast Cleaned.
3. **Filler Application** – Mix a sufficient amount of the CARBON-PLY DFRE resin and hardener together in a 2 parts resin to 1 part hardener by volume. The resin is black and the hardener is white. Mix until a

consistent grey color is achieved with no streaks. Apply the DFRE to the damaged areas of the pipe using a putty knife. Push the epoxy paste into every corner of the damaged area while pushing out any trapped air to eliminate voids and ensure that the surface is completely covered with epoxy. The DFRE is a fast curing epoxy repair paste. As the epoxy is curing shape the surface of the DFRE with a scraper. Once the epoxy is fully cured, finish shaping the surface around the circumference of the pipe. When completed, the surface of the DFRE must be even with the surrounding surface of the pipe and free of divots, bumps and imperfections.

4. **Prime Repair Area** – Using a small short ¼" nap roller working out of a paint pan, apply a thin coat (2 to 3 mils) of CARBON-PLY ESR Primer to the repair area and at least 2 inches on either side of the area to be wrapped. The primer is green in color and must be worked into the surface of the metal to maximize the bond strength.
5. **Wrap Area with Carbon Fiber** – Wrap the carbon fiber cloth hand-tight around the pipe and centered over the area to be repaired. Tight fitting / tensioned carbon is essential to a good repair. Apply a small amount of CARBON-PLY ESR Primer to the last 1 to 2 inches of the carbon fiber cloth to help secure it and press it firmly into place.
6. **Install Containment System** - Install the patented containment system provided by Cross-Link Composites LLC over the carbon fiber cloth following the manufacturer's recommendations. The containment system is a specially designed non-stretch, polyurethane coated nylon sleeve. Wrap the mold around the pipe with the neck at the 12 o'clock position and centralize the mold over the carbon fiber mesh.
7. **Banding** – Band the end of the mold to the pipe effecting a seal.
8. **Install Containment System** – Install the patented containment system provided by Cross-Link Composites LLC over the carbon fiber cloth following the manufacturer's recommendations. The containment system is a specially designed flexible metal jacket called a Tambour. The Tambour is held in place using nylon straps.
9. **Mix and Install CARBON-PLY ESR Resin and Hardener** – The CARBON-PLY ESR Resin comes in a slack-filled, one gallon can. Pour the entire contents of CARBON-PLY ESR Hardener can into the resin can, and mix thoroughly for three minutes. Time the mixing of the resin and hardener so that all of the required epoxy is poured into the containment system within ten minutes.

10. **Pressurize the Containment System** – Thread the fiberglass rod through the holes in the funnel, and gather the neck together leaving the rod protruding 1/3 and 2/3. Squeeze the neck closed just below the rod with one hand. Hold the longer end of the rod with the other hand and twist it around clockwise to twist the neck from the top down. Continue twisting until the gauge reads 10 psi to 12 psi maximum. While maintaining pressure on the rod, slide the Velcro strap loop over the long end of the rod. Bring the rod into a vertical position and lock it off by wrapping the Velcro strap around the Velcro on the neck base. Allow the resin to cure for 30 – 60 minutes. CAUTION: the resin/hardener mix will heat up to approximately 350 degrees F as it cures. Allow the resin to heat up, then cool down to 150 degrees F (65 degrees C.) before handling the repair.
11. **Inspect and Test the Repair** – After the resin cools to room temperature, remove the containment system and urethane bag. Inspect the ESR and note any anomalies. Dry areas may be repaired by abrading and cleaning the affected areas, then mixing and applying DFRE to fill the affected areas. The ESR wrap can be buried as soon as the temperature of the ESR System drops below 130 degrees F. (54 degrees C.).

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