Suited for the occasion

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Corrosion costs money – a lot of money. The World Corrosion Organisation estimates that US$2.5 trillion is lost to corrosion each year. That is enormous incentive for companies to mitigate corrosion damage, but unfortunately for pipeline asset owners, that goal historically has been much more easily envisioned than achieved. Today's technologies, however, are moving industry toward considerably more effective asset integrity management through the introduction of composite coating protection that inhibits coating damage during installation. This is particularly true in horizontal directional drilling (HDD) applications. Successes to date prove the efficacy of these composites, illustrating the truth of the adage, 'an ounce of prevention is worth a pound of cure.'

The challenges of HDD

HDD installations are becoming more and more commonplace and are occurring in a broad range of applications. In fact, today, HDD crossings are being undertaken in challenging geotechnical environments and in environmentally sensitive areas with steel pipe up to 48 in. (DN 1200 mm) in diameter and on crossings as long as 6560 ft (approximately 2000 m).

For decades, pipe coatings, supplemented with some sort of cathodic protection system, have been used to protect underground pipelines. Traditional solutions include fusion

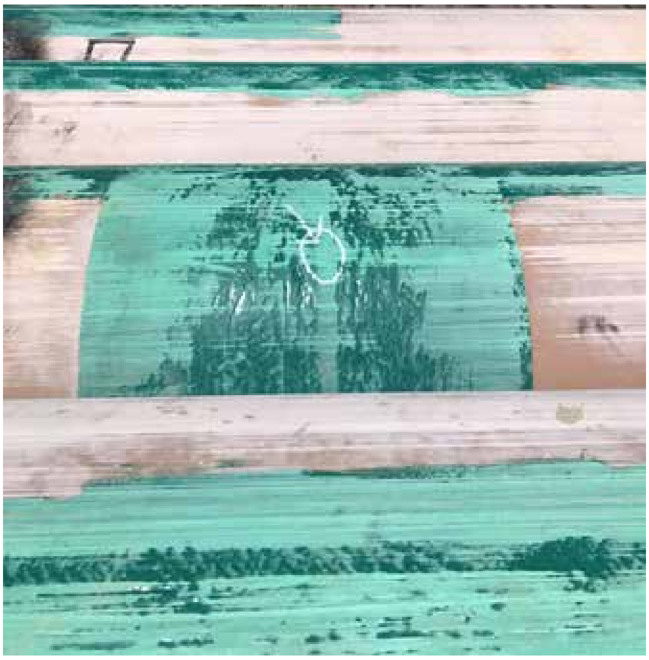

Figure 1. **Pipeline with only epoxy coating was pulled twice, resulting in damage to the steel in both cases. When Scar-Guard was applied to the line for the third attempt, the installation was carried out without incident. Photo courtesy of CSNRI.**

Figure 2. **After the line was installed with Scar-Guard applied, it was pulled back and examined for damage. A close inspection revealed that Scar-Guard provided the necessary protection to ensure a successful job.**

bonded epoxy (FBE), abrasion resistant overcoating (ARO), three-layer polyethylene (3LPE) and three-layer polypropylene (3LPP) mainline coatings and liquid epoxies for coating field joints. These solutions have been successful in some applications, but they are not consistent in performance. The problem with many of these types of coatings is that if they are damaged during HDD – either from the pulling process or mishandling – they fail to deliver adequate protection.

Often, anti-corrosion coatings are used in conjunction with cathodic protection on steel line pipe. These coatings are designed for impact resistance and good adhesion to the steel substrate and provide some degree of flexibility and moisture resistance. They generally are applied using industry standards like CSA Z245.20. While some of these coatings meet the requirements for external pipeline corrosion protection, they do not necessarily have the mechanical properties to withstand the rigours of an HDD crossing. The result is that even when the more robust of these anti-corrosion coatings is used, failures continue to happen.

A range of anti-abrasion coatings has been developed for application on top of anti-corrosion coating to protect it from mechanical damage. This includes coatings for joints, which are particularly susceptible to harm during installation. Unfortunately, while many of these coatings offer improvement, they cannot deliver the protection needed during demanding HDD installations.

Despite this fact, many companies continue to use inadequate anti-abrasion protection and simply recoat damaged sections with the same failed products and try the pull again. Some operators have even turned to increasing the pipeline wall thickness in anticipation of coating damage resulting in corrosion.

The problem is that re-pulling pipe can increase project costs by millions of dollars, and heavier pipe can increase the likelihood of coating damage. Neither approach truly resolves the installation issues.

Clearly, this flies in the face of logic. As Albert Einstein once said, the definition of insanity is doing the same thing over and over and expecting different results.

The pipeline industry cannot afford to perpetuate 'insanity.' It is time to consider a better alternative.

Testing proves performance

Composite technology has been used for pipeline integrity repairs for more than 20 years. Approximately 10 years ago, a very concerned industry started to experiment with using pre-impregnated composites applied over field joint coatings, initially trying test pulls at the front edge of the bore to see if composites were robust enough to constitute a solution. Brushing aside concerns about the additional work and expense, pioneers of this technology committed to testing composites to find a way to install safer pipelines. These industry leaders are responsible for the work that established composite technology as a viable way to provide mechanical protection of pipeline coatings installed via trenchless methods.

Because composite solutions do not fall under the ISO21809 and CSA Z245.30-14 standards, appropriate tests had to be developed to determine their effectiveness. CSNRI engineers referred to abrasion, impact, and gouge testing data found on liquid epoxy technical data sheets to develop test criteria.

Using a universal tensile machine, with the only difference being specimen geometry, engineers conducted tests that proved glass composites are eight times stronger than epoxy coatings. Composites also outperformed epoxy coatings in terms of stiffness, with composites performing to 4000 ksi, compared with epoxy coating, which achieved only 250 ksi.

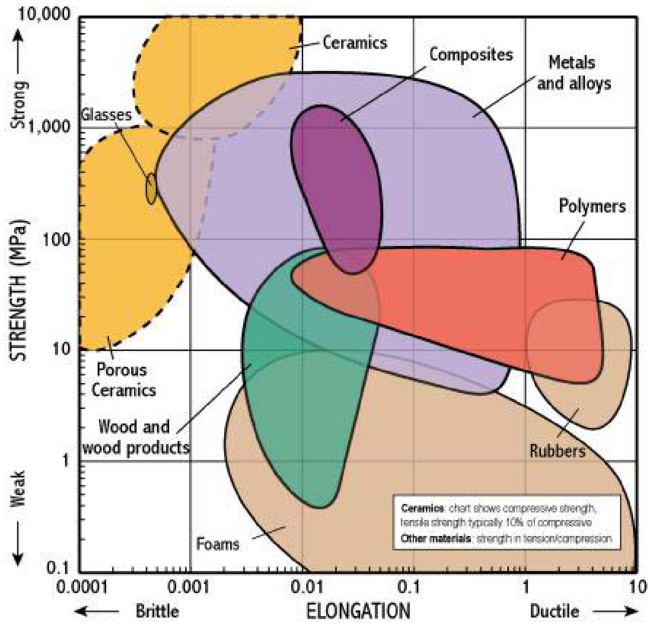

Figure 3. **Test data show that glass composites are eight times stronger than epoxy coatings. Data courtesy of CSNRI.**

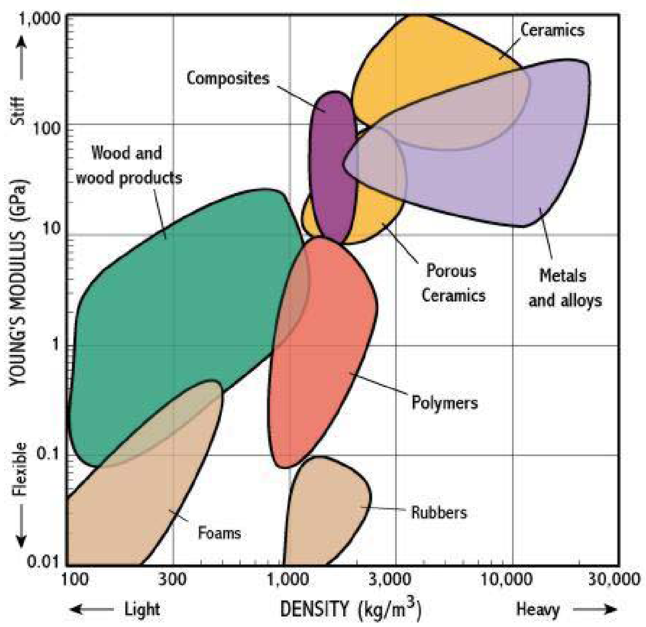

Figure 4. **Composites outperformed epoxy coatings in terms of stiffness, with composites performing to 4 000 000 psi, compared with epoxy coating, which achieved only 250 000 psi.**

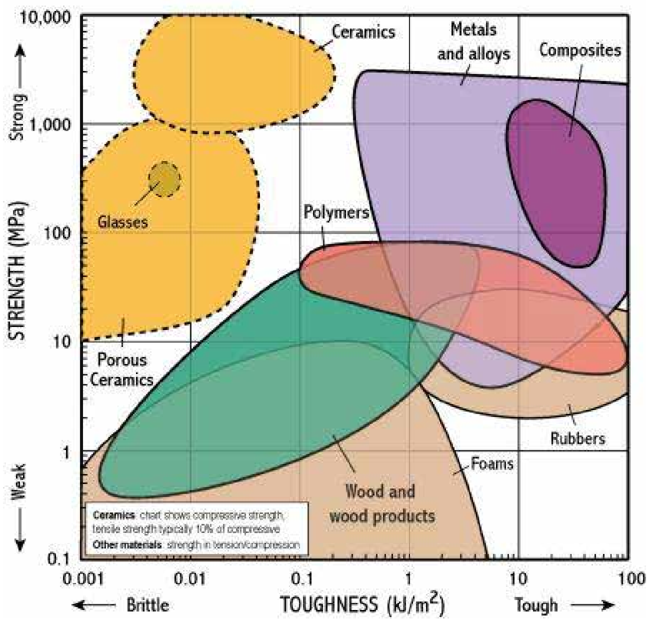

Figure 5. **Lab results show the fracture toughness of composites is superior to other materials tested.**

Fracture toughness results told a similar story. Most field joint coating failures are the result of shearing, tearing, and crack opening, which are fundamentally related to their fracture toughness properties. The research team selected two commercially available liquid epoxies used for field joint coating and two popular composites used to protect field joint coatings, conducting multiple tests to validate the properties. For the test, specimens were pre-cracked and then tested to failure using a tensile machine. In the end, results showed that the composites outperformed the other materials by a factor of 20 to 60.

In terms of performance, this means that because of its lower strength, stiffness, and fracture toughness, an epoxy will chip, crack, peel, spall, flake, and/or blister before a composite under similar loading.

Applications in the field illustrate that composites perform very differently from traditional AROs, delivering significantly more protection to pipelines being installed using HDD. After more than a decade of field demonstrations followed by post-construction coating inspections on a range of very aggressive soil conditions, composites have consistently outperformed epoxies.

Composites at work

On a project for a natural gas utility company, Scar-Guard, a composite ARO made of fibreglass cloth pre-impregnated with a polyurethane resin, provided protection that allowed installation in a challenging geotechnical environment.

The company was installing a new, 24 in. (609.6 mm) steel pipeline via HDD and was concerned that the field-applied field joint coating would sustain damage during the estimated 1600 ft (488 m) pullback through granite. Steps had been taken to mitigate the risk of damage – using an ARO to protect the FBE – but there was uncertainty about how well this would work given that the previous installation was unable to pass a post-construction coating inspection.

If any damage occurred during installation – leading to the pipeline entering service with holidays or unseen scarring – the line would have to be pulled and the damaged areas restored. The cost to remove the pipeline and re-install it would have pushed this project over budget. Hoping to find a way to ensure a reliable installation, the company requested that a section of line be prepared with Scar-Guard and tested to determine if it would meet the installation requirements. Shawcor, the exclusive distributor for Scar-Guard, provided the material for the test.

Technicians welded a length of pipe to the line and applied four layers of Scar-Guard over the first field joint 40 ft (12 m) behind the bore head as a sacrificial, mechanically protective coating. The location was specifically chosen to ensure that the composite reinforced coating would be exposed to the brunt of all forces to which the pipeline would be subjected.

With the composite applied, the pilot section of pipe was installed following the same methodology that would be used for the pipeline. After the line was installed, it was pulled back and examined for damage. Although there were some areas of the sacrificial composite coating that experienced abrasion, there was no damage to the anti-corrosion coating protecting the pipeline. A close inspection by the coating inspector, utility engineer, and contractor's superintendent revealed that the composite had provided the necessary protection to ensure a successful job.

On the basis of this test, the company completed the job using Scar-Guard to protect the pipeline and avoided the need to re-pull sections because of damage during installation.

In another application, a company was installing a new, 24 in. (609.6 mm) regulated pipeline and encountered a challenging bore path approximately 1200 ft (366 m) long, under a river. The pipeline, which was being placed through cobble, was contending with one of the most difficult soil conditions the contractor had ever seen.

The first run set the tone for the project. Not only was the carbide cone lost in the hole, but this section of pipeline was being pushed through the cobble, which resulted in the coating being scarred down to metal loss. A site engineer assessing the damage suggested the scarring on the pipe had resulted from the cone dragging at a tangent along the line. While this seemed likely, the team could not remove the carbide cone, and drilling another hole would be cost prohibitive, amounting to approximately US$1.5 million.

It was apparent that running the pipe as originally intended would not be feasible. The crew needed a better plan.

The team decided to perform a test pull on a 300 ft (91 m) section of pipe protected with Scar-Guard to determine if it could withstand the abrasion from the cobble and carbide. A successful test proved that the composite was equal to the task.

The field team wrapped the 300 ft (91 m) section of line, as well as every weld, with Scar-Guard to provide maximum protection during the pull, enabling the successful HDD installation with full encapsulation of the 1200 ft (366 m) of pipe. Using the composite for line protection, the company saved the exorbitant cost of drilling a second hole and achieved a successful and reliable installation.

Then and now

Once upon a time, pipeline planning meant using an approved coating for the intended operating conditions of the pipeline, but HDD installation techniques are now part of the equation. When it is evident from the outset that a pipeline will be installed at maximum flexibility, or the core samples indicate aggressive soil conditions, there is no need to roll the dice because there is a proven solution that can contend with installation challenges that traditional methods cannot.

Anecdotal observation has been replaced by empirical evidence that composites do provide better protection during HDD installations. Real-world results prove the industry could save time and money by more broadly applying composite technology in HDD work programmes.