



# ON THE MEND

**Laurette Cuirot, 3X ENGINEERING, Monaco,**  
discusses pipeline repair using composite solutions.

Initially introduced in the aerospace industry, the efficiency of composites has been widely proved in various markets, especially in the oil and gas sector. Composite wrap for pipeline rehabilitation offers many advantages compared to pipeline replacement or steel sleeve installation. Because of their mechanical properties, composites are able to offer a solid solution with long-term guarantee (up to 20 years) and relative low cost compared to other methods. This repair technique is quick and can be installed without shutdown. Therefore, choosing to use a composite repair system is not only a fast and reliable solution, but also a cost-effective option for companies as it will minimise production loss.

For over 25 years, 3X ENGINEERING has developed a large range of composite products for pipeline rehabilitation and has performed many successful composite repairs all over the world. Not only does 3X manufacture and commercialise its own products, it also offers a complete integrated service, from the design of the repair to onsite installation. The company provides highly qualified engineers and technicians to perform and supervise repair operations. Today, represented by over 40 distributors all around the world, 3X is able to quickly operate onshore and offshore to reinforce and rehabilitate pipelines suffering from various defects, such as external and internal corrosion, dents, cracks, leaks, weld defects etc.

3X will propose the adapted solution to reinforce and extend the life of a damaged pipe, taking into account the defect characteristics and the environment. For this reason, the 3X research and development (R&D) team has developed a complete range of products dedicated to this application, called REINFORCEKIT® 4D (R4D). 3X products have been going through rigorous qualification and testing programmes to ensure they are in meeting performance objectives in accordance with international standards. All products' capabilities are certified by third party, such as ABS, Bureau Veritas, TUV, Lloyd's Register etc., and over 10 patents are pending or approved worldwide.

### Composite repair solution for lasting pipe reinforcement

Designed according to ISO/TS 24.817 and ASME PCC-2 international standards, R4D is a wet lay-up system wrapped helicoidally around the pipe in order to bring the mechanical resistance to the damaged pipe section. Made of Kevlar® tape and specific epoxy resin, this solution will restore pipe original integrity and prevent from further deterioration.

This technology can be applied online, except if it is a through wall defect. This is one of the main benefits of this solution because it avoids costly shutdowns and production losses. In case of leakage, the production must be temporarily decreased or stopped.

R4D can be used for operating temperatures ranging from -50°C to 150°C (-58°F to 302°F). It can be installed on all kinds of pipe geometry (straight, oval, elbow, tee etc.), transporting most common fluids (oil and water) and gas on all pipe diameters and in all environments (onshore, offshore and subsea).

The repair is designed for a lifetime of 20 years. A good surface preparation prior to wrapping and a proper installation by trained and certified applicators are essential to guarantee the long-term of the repair.



Figure 1. R4D wrapping in progress.

### Iran: pipeline repair with leaking defect

The objective of the repair, performed in August 2015 by 3X and its local exclusive distributor, was to reinforce and stop external corrosion on localised area of the pipe (several external corrosion spots plus one 1 mm dia. hole).

After analysis of the corrosion extent and geometry, calculations and finite elements analysis (FEA) were performed, concluding that 68 layers were needed to perform the repair and restore full operating pressure.

Because of the leak, the repair was performed after pipeline shutdown and depressurisation. An initial grit blasting was performed prior to the composite application, in order to get a good surface roughness (75 µm anchor profile).

Before composite wrapping, dew point and ambient temperature were checked and the surface was cleaned and degreased. The wrapping repair was performed as per the following steps:

- Special filler (F3XS1) application to rebuild the surface to its original shape.
- Metallic steel plate (with filler), fixed with straps during curing time, installed over the defective area.
- Second filler application performed to ensure the proper impregnation of the first layer.
- Wrapping using Kevlar and R3X1080 epoxy resin. 68 layers of composite (over 0.88 m in length) were applied to reinforce the pipe, i.e. 34 passes with 50% overlap.

Identification plate for traceability was positioned on the pipe. Curing time of the composite system required 50°C during three days. This curing process was initiated with heating blanket during 72 hrs.

Thanks to the efficient collaboration between 3X and its local distributor, the corroded area was repaired using R4D and the pipeline is now protected from external corrosion. The pipe's integrity was restored and the pipeline was successfully returned to service at 153 barg operating pressure.

### Specific solution for subsea application

Loss of production due to subsea repair operations can cost millions of dollars per day in lost revenue. As a result, online composite pipeline repair is an attractive option for operators, and is often preferred since it yields considerable flexibility and is highly efficient. That is the reason why more and more requests coming in recent years concerns the rehabilitation of subsea pipes.

To satisfy this growing demand, the 3X R&D department has developed R4D Subsea (R4D-S). Based on R4D technology (as described above) and using Kevlar tape and ceramic reinforced subsea curing epoxy resin, R4D-S can repair and reinforce pipe operating at temperatures from 5 - 50°C (41 - 122°F). It applies to both external and internal corrosion, dents and leaks (provided it has completely stopped prior to composite application) in underwater environments.

Even if this technology is very attractive, it is technically challenging, as applying composite products in a subsea environment needs to be performed with highly qualified staff

and specially designed equipment. To this purpose, 3X technicians and engineers are trained and certified to work offshore. For subsea repair requiring divers to perform the composite wrapping, 3X provides subsea operation supervision and co-ordination of technical repair divers (including saturation divers). The company developed a range of subsea tools to apply the composite repair in controlled conditions. These specific tools (i.e. BOBiPREG® – a unit designed to perform a good, regular and quick impregnation of the Kevlar tape with the resin before immersion) will guarantee the performance of the repair.



Figure 2. View of the finalised composite repair in Iran.

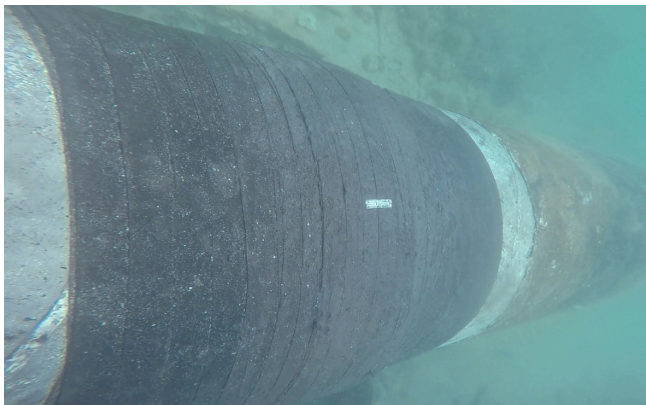


Figure 3. R4D-S reinforcement.

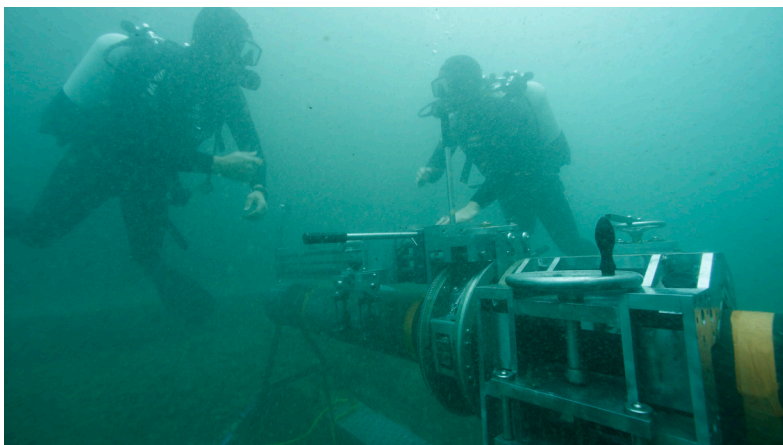


Figure 4. BOBiWRAP – 3X subsea repair machine.

3X has performed several risers' repairs and reinforcements in various countries. In the last few years, their experience and know-how in subsea repair (including deepwater) has been steadily increasing with successful repairs performed in India, Vietnam, Colombia, UAE, Nigeria, Iran, Saudi Arabia etc.

### Nigeria: subsea pipeline repair

In September 2016, an important subsea job was completed for a major oil and gas company in Nigeria. The objective of the repair job was to restore a damaged subsea pipe section over 2.5 m long due to dent defect, which was located in 16 m water depth with zero visibility.

After FEA, it was determined that 50 composite layers of R4D-S were needed to achieve the reinforcement, designed for five years life. Underwater, several preliminary operations (such as sediments excavation, removal of concrete and corrosion coating, identification of the surface to be wrapped etc.) were performed before grit blasting, which was needed to obtain the required surface roughness (60 µm minimum anchor profile). Wrapping reinforcement was then performed as follows:

- A print of the dent was taken in order to confirm calculations and design, as well as manufacture the appropriate composite rigid plate, acting as mold.
- Primer (P3X32) was applied on the defect using a dispensing gun, to restore the pipe shape and provide a good adhesion of the composite materials.
- Five rigid composite plates covered with F3XSS filler were positioned over the dent and strongly fixed with ratchet belts during the three hours curing time.
- Kevlar tape pre-impregnated with R3X1050-S resin (using BOBiPREG) was then wrapped around the pipe with 82 Kevlar rolls necessary to cover the dent with the composite thickness needed.
- Finally, a neoprene soft cover was applied to protect the repair from fouling.

Zero injury, schedule respected and repair according to design concluded this successful job.

### Looking to the future

3X is now focusing its energy to develop high technical solutions for repairing pipes in extreme conditions of deep offshore.

This ambitious project is the result of a close partnership between 3X and big players in the petroleum industry. 3X had already developed a specific subsea machine called BOBiWRAP®, aimed at applying composite products with divers in an efficient and repeatable manner. The company is now working on adapting this machine to the deepwater environment.

The company keeps exploring new technologies to continuously improve the quality of its products and services, and to develop new repair solutions. 