Patching up problems

Laurette Sapin Cuiret and Olivier Marin, 3X ENGINEERING, Monaco, take a look at composite solutions for storage tank repair and reinforcement.

Storage tanks and terminals and their contents are extremely valuable assets that need to be repaired when damage occurs.

The most common cause of damage, whether it results in a leakage or not, is corrosion. Tank corrosion leads to an increased likelihood of tank leaks, safety hazards, environmental damage, and productivity loss due to shutdowns.

The traditional repair method is to weld a patch plate on the defected area, but welding means hot work and this is difficult and time-consuming. Hot work also increases risk in potentially flammable or explosive environments. As a result, weld repairs often require a costly shutdown, emptying, and clean-out of the tank, carrying with it lost productivity costs. Moreover, operating conditions, complex geometries, and the severity of the damage can prohibit welded repairs.

Therefore, the question remains how can the repair be completed differently, in a quick and efficient manner?

Repairing using composite solutions

3X ENGINEERING (3X) has developed two products based on composite technology, designed to repair and reinforce tanks and pressured vessels suffering from corrosion defects and mechanical damages.

TANKIT® and REINFORCEKIT® PATCH are two composite patch repair systems. Both products are cold welding systems which allow damages to be repaired without altering the operation. The first is designed for emergencies, whilst the latter is a sustainable solution with a repair lifetime of up to 20 years.

The main advantage in using these composite repair solutions is that no cutting or welding is required during installation so the repair can be applied while the tank is still online (i.e. low environmental risks and low safety risks for workers). Beyond a decrease in safety and environmental risks, in-service installation results in cost savings because there is no downtime for production.

So, how do they work and how were these products developed?

Long-term solution for tank repair and reinforcement

The standards ISO 24817 and ASME PCC 2 are commonly used to provide guidance and requirements for the composite repair system of fluid system components.
Both standards cover the full process, from qualification, design, installation, testing to inspection. The repair of tanks is covered and designed with a variety of construction standards, such as AWWA D100, AWWA D103, API 620, API 650, BS EN 13121-2, and PD 5500.

REINFORCEKIT PATCH can be used as a long-term patch composite repair application.

The use of the patch is conceivable when it is impractical for the repair to encompass the full circumference. In the case of a large diameter tank, patch repairs are especially cost-efficient for localised damaged area vs full circumferential wrapping.

The original concept is a combination of Kevlar® tape patching and 3X bi-component epoxy resin. The dimensions and number of patches, the type and quantity of resin will depend on the defect and will be defined using the company’s software.

The product is tailor-made for each repair. The team first designs a specific solution according to the damage and then trained and certified applicators perform the repair in order to ensure the correct implementation and effectiveness of the product.

Being a customised solution, this product has no limits in terms of tank or defect size, no limitation in pressure, and the repair complies with international standards ISO 24,817 and ASME PCC-2.

This solution has been engineered to restore a tank’s original integrity without hot work, and does not require a shutdown unless there is an active leakage (Figures 1 and 2).

**Emergency solution for tank repair and reinforcement**

Based on market research and customer feedback, it was established that end-users were looking for an alternative solution. In emergency scenarios, the need for engineering calculations and supply time can be an issue. To address this, 3X developed its own pre-engineered composite solution, called TANKIT, dedicated to emergency and temporary cases. This solution is suitable for tanks up to 20 m and defects (leaking or not) up to 100 mm.

The product is delivered, ready to be used, in a box containing all necessary materials and tools, and is made of five Kevlar patches impregnated with a bi-component epoxy resin.

The application can be done online, unless there is a loss of containment. To apply it, the surface must firstly be cleaned and prepared (surface roughness [Rz] > 60 μm and Swedish standard sandblasting [SA] 2.5). Next, a steel plate is installed over the defective area and cold welded with filler using magnets. Finally, the Kevlar patches (impregnated with the specific resin) are positioned over the area.

As the TANKIT does not follow the design guidelines of standards, it was necessary to determine its performances and limitations, and it has undergone rigorous R&D tests:

- **Surface preparation:** a surface preparation is required to get a good bonding (Rz > 60 μm and SA 2.5).
- **Containment:** in case of loss of containment, it is preferable to use a first barrier. A steel plate is cold welded with F3X8 filler.
- **Choice of reinforcement:** Kevlar tape (plain weaving, 400 gsm) was selected due to its impressive performance.
- **Choice of resin:** as the composite may be in contact with harsh environment, it was decided to use the R3X5 resin to obtain excellent chemical resistance.

Dimensions of the patch and number of layers:

**Short-term testing/burst test**

As it was not possible to test the product on each tank configuration, the goal was to establish a correlation between full scale testing with 100 mm hole and finite element analysis (FEA).
The size of the patches was chosen to be 300 mm x 300 mm. It was observed that larger patches did not significantly improve the pressure resistance, most of the stresses being concentrated in the surrounding area of the defect.

The number of layers was set to five plies for cost-effective reasons. As expected, the more plies that are present, the better pressure resistance is. However, increases in pressure resistance are not proportional to the number of additional layers applied beyond five plies (Figure 3).

**Long-term**

Short-term testing cannot analyse the risk of long-term failure and up to two-thirds of the performance could be lost, which is known as degradation factor. Thus, TANKIT was successfully tested considering long-term safety factors.

Gathering all the testing and FEA data, the company was able to determine the maximum capability of this solution as a function of tank and hole dia. (Figure 4).

**Suitable solutions**

Both solutions are suitable for use with various tank designs and sizes and can be used in a wide range of industries and applications.

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**Reboiler repair in Vietnam**

The objective of the repair performed in August 2017 in Vietnam by 3X and its local distributor was to reinforce a reboiler located on a floating production storage and offloading (FPSO) vessel suffering from external corrosion.

The technical details were as follows: 64 in. outer dia., maximum operating temperature of 150°C, installation temperature 80°C, calculated pressure 20 bars, design lifetime of 20 years.

After analysis of the corrosion extent, calculations according to ISO 24.817 were performed, concluding that four layers were needed to reinforce the reboiler. Due to

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1 TANKIT = 1 repair

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Before composite patching, dew point, moisture and surface temperature were checked and the surface was cleaned and degreased.

Composite repair was performed as per the following steps:
- F3X51 filler was applied on the delimited patch area to fill metal loss and reshape the tank side.
- The surface was then covered with 3X specific epoxy resin (R3X1660) to ensure good wetting and impregnation of the Kevlar tape.
- The first patch was applied onto the wet surface using a paintbrush whilst making sure to remove all air bubbles. The patch was then impregnated with R3X1660 resin in order to create the wet surface for the next patch. This step was repeated until all four layers had been applied.
- The final layer of epoxy resin was applied over the repair for protection.
- Identification plate was positioned on the tank for traceability.

As a result, the corroded area of the reboiler was successfully repaired and reboiler integrity was completely restored (Figure 5).

Conclusion
Composite technology offers the best solutions to rehabilitate installations in a solid and durable manner; saving time and money. The integrity of storage tanks and terminals will be preserved as if they were new.

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