The Use and Application of Composite Repairs

By Andrew J. Patrick

Abstract

Composite repairs have now been utilised within the transmission pipeline, offshore, refinery and petrochemical industries for over the past 20 years for both the temporary and permanent repair to reinforce sections of the pipe wall which have been weakened due to internal/external corrosion, mechanical damage and third party interference.

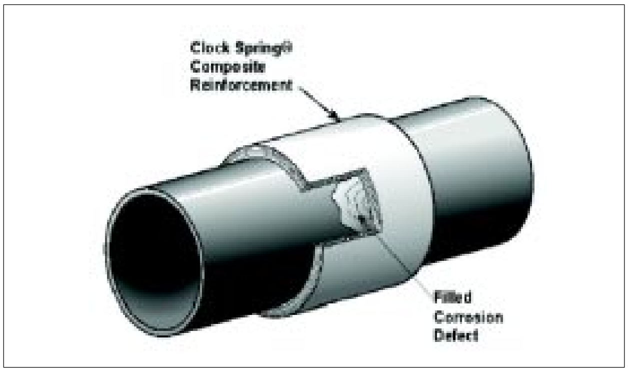
As such most E & P, transmission and down stream operators are familiar with composite repairs and the health, safety, technical and commercial benefits the utilisation of a composite repair provide.

The purpose of this paper is to provide case study information of specific repairs which have been completed using composite technology, the repair structure utilised and the overall benefits the use of a composite system provided for the specific repair solution.

What is a composite repair and how does it work?

Composite repairs can be classified into two types of architecture: composite repair sleeves – which utilise a factory manufactured and quality controlled full cure laminate repair sleeve which is sized for the particular pipe diameter and composite wraps which are a wet lay up system where the wetted fabric is hand applied around the substrate at site. In both instances the composite itself is a synergistic combination of two elements the strength member which is typically in fibre form (the most common fibre form being 'e' glass) which is then held within a resin matrix.

When applied to a non-leaking defect the composite repair works by sharing the loop load in the pipe wall and controlling the rate at which the steel substrate yields. A cross section of a typical composite repair sleeve is shown below. In this particular instance a high compressive strength filler material is applied to the defect, this is then overwrapped with the composite repair sleeve and the complete repair is bonded and held in place using an applied adhesive.



Approval and Regulatory Acceptance.

Full cured composite sleeve repairs have been thoroughly tested (over 10 years starting in the 1980's) by third party industry organisations for long term permanent repair performance for which they have been proven and accordingly are accepted and recognised in various repair codes such as ASME B31.4, B31.8, API 1160. In addition many national regulatory authorities as well as operating companies have reviewed, tested and approved the use of composite repair sleeves as a form of permanent repair.

In addition industry guidelines based on shorter term testing and in documents such as ASME PCC2 and ISO TS24817 can be applied for the design and manufacture of both composite sleeve and wrap repairs.

Repair case studies: 28" High Pressure Gas Pipeline Repair – Indonesia

During a routine excavation an excavator accidentally hit a 28" main gas transmission pipeline causing significant mechanical damage of an 8 metre continuous section of the pipeline.

As the pipeline is the main supply to a local power station and also part of the gas supply system to Singapore it was critical the pipeline remained in operation. In addition the damaged occurred in mid-summer with temperatures in excess of 39°C and accordingly a period of peak demand for electricity supply.

Figure 1 shows a portion of the total defect, the damage also extended through a girth weld on the pipe.

Fig 1 – Third party damage to the pipe wall.

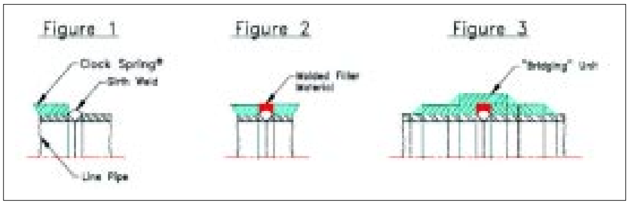
In choosing the repair option the client determined the line could not be shut down and hot work was also not possible and therefore a decision made to utilise a composite repair. The client made a thorough study and evaluation of the range of composite repair technologies available, long term testing, testing of specific technologies for third party damage repairs and girth weld repairs following which the decision was made to utilise a full cure laminate repair composite sleeve system.

Fig 2 – Coil pass installation process

Fig 3 – Completed repairs.

The product was mobilised to site and installed (Figure 2) using both local staff from the repair manufacturer as well as the operator. In total 25 repair sleeves were installed in one continuous section (Figure 3) within a 3 day period with the pipeline remaining in operation and without the need for hot work or specialised installation equipment.

For the girth weld section a "bridging" technique was utilised as shown in the attached schematic.



With the final installed repair as shown in Figure 4.

Fig 4 - Girth Weld, bridging technique repair

10" Leaking Tee on LP Separator

A failure on a 10" tee on an LP separator (Figure 5) caused a complete field shut-in for a major offshore operator. The position of the leak was on the main body of the tee directly behind the branch and thus it was impossible to utilise a leak repair clamp for an immediate temporary repair solution.

Fig 5 – Ongoing leak on the separator tee.

Fig 6 –Leak sealed and completed surface preparation.

The particular operator has a continuous rehabilitation and upgrading operation in process and accordingly maintains a stock of composite materials on-site with a team of fully certified installers. The materials held at site included both full cure laminate sleeves and wet lay up wrap material. Due to the complex geometry the decision was made to utilise the wet lay up wrap material.

With the line shut in the initial operation was to seal the leak area with a ceramic based epoxy compound, once applied LEL levels were then monitored around the area to ensure gas levels were at zero. Once confirmed mechanical cleaning of the repair area was permitted. Figure 6 shows the sealed leak area and the surrounding area surface preparation.

Wet lay up wrap repairs differ from the use of composite sleeves and the installation must take place within very clean and controlled conditions. Prior to installing the repair it is also necessary to perform a design evaluation in accordance to the relevant industry guidelines to determine the overall length and number of layers of material applied. This design process was conducted by the qualified technicians at site. The stages of the repair are:

- Wetting out of the fabric (Figure 7).

- Applying a base coat to prime the steel surface (Figure 8).
- Hand lay up of the fabric and cutting to suit the repair geometry (Figure 9).
- Continual visual inspection of the layers of material as they are applied to ensure of no dry spots, sagging of the cloth, foreign debris in the repair etc (Figure 10).
- Once the total numbers of material layers have been applied a peel ply material is applied over the repaired area. This serves a number of purposes including: holding of the complete repair in position, allows excess resin to drain through and out of the repair and prevents any ingress of foreign matter into the repair (Figure 11).
- Once cured (up to 8 hours) the peel ply is removed (Figure 12). A final visual and depth measurement inspection of the repair is completed. A final corrosion coating (Figure 13) is then applied to the complete repair area.


Fig 7 – Wetting of fabric.


Fig 8 – Wetting of pipe surface.


Fig 9 – Cutting and sizing cloth applications.


Fig 10 – Inspection of each repair layer as applied.


Fig 11 – Application of peel ply.


Fig 12 – Completed repair.


Fig 13 – Final application of corrosion coating.

Utilizing both materials and personnel on-site the separator was back in production within 36 hours from the original shut down and the complete field back in operation.

42" Suction Line Repair

Inspection of a 42″ suction line at a storage terminal identified a 90′ section of serious external corrosion due to a breakdown of the originally applied corrosion coating in the region where the pipeline passed through the main bund wall. Initially it was not possible to determine the depth extent of the corrosion and initially manual excavation and coating removal (Figure 14) was conducted to allow initial detailed NDT inspection to take place.

Once it was determined the corrosion was within safe limits (in this instance below 80% wall loss) the operator permitted blasting of the complete work area to take place (Figure 15) prior to the composite repair installation. Although nearly the complete circumference of the pipe was affected the area of significant concern was between 3 to 9 o'clock positions where the corrosion extended for the complete 90′ length (Figure 16).


Fig 14 – Manual excavation and surface preparation.


Fig 15 – Grit blasting in operation.


Fig 16 – Significant external corrosion.

In this instance the line could not be isolated and no hot work was permitted. In addition there was very limited access to either side or beneath the pipe. Due to the memory matrix within a composite repair sleeve it is possible to install the sleeve using a "spool feeder" technique which is providing you have access from one side only requires 2″ of clearance around the remaining pipe circumference. Figures 17 and 18 show the spool feeder system with the coils being applied in addition the high compressive strength filler material can also be clearly seen applied to the pitted and corroded areas of the pipe surface (the filler material acts to transfer the hoop stress to the composite and prevents the remaining steel ligament from yielding).

Fig 17 – Application of filler into defect.

Fig 18 – Spool feeder operation.

Fig 19 – Completed composite coil installations.

Fig 20 – Application of final corrosion coating.

In total over 90 repair sleeves were installed (Figure 19) to cover the complete corroded area and to reinstate full load carrying capacity back to the pipeline. A suitable corrosion coating is then applied and the bund wall reinstated (Figure 20).

Splash Zone and Holding Clamp Corrosion Repairs on Risers

Corrosion underneath holding clamps and at the splash zone are often encountered on offshore platforms examples of such corrosion are shown in Figures 21 and 22.

In these particular instances due to the high service pressure +750 psi, commercial and technical considerations and for ease of installation a full cured composite sleeve is the most suitable composite repair option as a wet wrap system would have to be of a significant thickness and hence would necessitate a large volume of product which impacts all of the above factors. In addition the composite sleeve provides a fixed and controlled final repair thickness and a structure that allows the riser repair clamp to be reinstated over the installed composite sleeve once the repairs have cured (the repair sleeve will cure within 2 hours from the start of the installation Figure 23).

The overall length of the repair sleeves can be cut to accurately fit the axial length to be repaired and as previously discussed can be used to bridge girth welds where applicable (Figure 24).

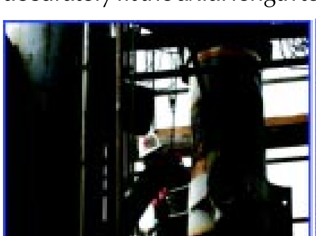


Fig 21 – Clamp removal.

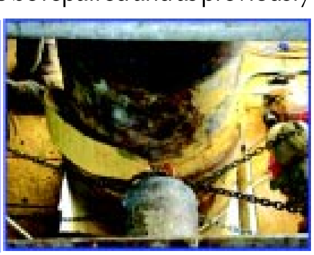


Fig 22 – Corrosion underneath the clamp.

Fig 23 – Reinstating the support clamp over the composite repair.

Fig 24 – Repair sleeves cut to suit the axial length plus bridging girth welds.

Fig 25 – Final coated and clamped riser repair.

Once installed the complete repair area including the holding clamps are sealed with a suitable corrosion coating Figure 25.

CONCLUSION:

As shown composite repairs are a viable repair solution for a wide range of applications including: high pressure pipelines, pipe work, risers and complex geometries within a wide range of operating facilities and environments.

In general a composite repair will provide a long term repair solution providing many benefits in terms of health and safety (no hot work, heavy lifting equipment etc) with associated technical and commercial benefits. In addition some repairs have now been utilised within the industry for over 20 years and have a significant amount of test and user reference data to support their use and application.

However although the use and range of composite repair applications is expanding it should always be prudent for the operator to confirm the repair supplier is able to provide test and technical information to support and justify the use and long term performance of the repair material being presented for each particular repair application. PP

PetroMin PipeLiner would like to show appreciation to Mr. Andrew J. Patrick, Vice President – Clock Spring Company, L.P for this article.