ICR.

Technowrap™

Engineered Composite Repairs

Engineered Composite Repair Solutions Overview

ICR's engineered composite division (formerly Walker Technical Resources), has over twenty years' experience in the provision of composite repairs to the oil and gas industry worldwide. With an expanding global footprint, ICR currently has operational bases in the UK, Norway, Australia, USA and UAE. These regional hubs allow us to deliver a responsive service to our clients globally. We have developed our own installer competence programs and our global teams all follow the same procedures. These controls enable our full, global expertise to be made available from each location.

The ICR suite of Technowrap™ products offer bespoke repair solutions capable of rehabilitating damaged pipework, pipelines and structural components. The materials used in engineered composite repairs include either glass or carbon fibre stitched cloths along with a variety of two-part epoxy resins (resin plus hardener). ICR can offer a solution that is cost effective, easy to install and provides a long-term alternative to replacement, supporting safe operations and production uptime. Our repairs can currently be designed for service at up to 230°C and are qualified for non-through wall defects of up to 250bar (based on a 12" diameter pipe, for smaller diameters this value will be higher, we tested a 0.5" repair to failure at 1200bar, similarly, larger diameters will be designed to a lower pressure). Pressure limits are reduced when the repair is through wall, with designs typically up to 50 bar; the exact design detail depends on the defect sizes and relative design conditions. The limits are confirmed by design in line with the ASME PCC-2 Article 401 Non-metallic Composite Repair Systems (ASME) and ISO 24817 Composite Repairs for Pipework (ISO) standards and supported by extensive testing.

ICR has led the industry in the development and adoption of Composite Repair technology and as a key member of both ASME and ISO committees, ICR's technical expertise is now reflected in the published standards, with their Engineering Technical Authority being an active committee member within both standard workgroups. Additionally, ICR is actively supporting various joint research projects into various aspects of engineered composite repairs in the offshore environment by supplying materials, test specimens, information and knowledge.

Code and Industry Regulations

The ISO and ASME standards specify how an engineered composite repair should be tested, engineered and inspected, with the application and training procedures defined by repair system supplier. Technowrap™ fully complies with these international standards - and in many cases exceeds - testing requirements. Our integrated service (including testing, design, training and delivery) has been audited by independent third parties (Lloyd's Register, ABS and DNV) and have been certified as fully compliant with the standards. The Technowrap™ materials used have been tested and qualified inhouse and independently verified by the aforementioned third parties. ICR complete all engineering designs in-house in accordance with the ASME and ISO standards and the engineering teams will specify the product best suited for each application.

The international standards applicable to the use of Technowrap™ composite repairs in terms of component type are:

- ISO 24817 - composite repairs for pipework
- ASME PCC-2 - Article 401 - Non-metallic Composite Repair Systems

In-house procedures developed for structural repairs to various components and geometries using safety factors taken from ISO 24817 and ASME PCC-2 and established stress equations

Most Common Uses For Technowrap™

- Pressurised Systems (pipework repairs), critical and non-critical all components, including bends, tees and flange overwraps
- Pipeline repairs
- Repair of corroded roofs, floors, panels and decks
- Structures, e.g. I-beams, Circular Hollow Section (CHS) members
- Strengthening and repair of tanks and vessels (shells, supports & nozzle attachments)
- Sealing or strengthening of caissons and risers
- Splashzone and subsea repairs (including all wet environments i.e. high humidity, subsea). NOTE, this is not suitable for leaking defects. Leaks should be sealed prior to repair application. Subsea repairs will be diver applied so this will determine water depth (Deepest has been 32m)

Generic Defect Types

The generic defect types that can be repaired include:

- Internal defects, e.g. corrosion pits, general wall loss
- External defects, e.g. dents, corrosion under insulation (CUI)
- Through wall defects, e.g. leaks

However, the generic defect type that may, without certainty, be repaired is cracks. Only an individual case by case assessment can provide an indication as to whether a composite repair is an effective solution for crack like defects assuming that the ends of the cracks cannot be terminated

Composite Repair Process

The following steps towards implementation of a composite repair are as follows:

- Identification and assess the problem
- Complete the problem definition form (repair data sheet), i.e. provide details of the design conditions, service fluid, type and size of defect and design lifetime
- ICR provides the repair design solution according to the relevant standard
- Client design approval
- Surface preparation
- Installation - Mobilisation of trained, competent applicators
- Application of repair according to the method statement
- QA/QC completed
- Close out submitted to client

Service Capabilities

- Design/Engineering
- Provision of materials
- Surface preparation (ST3 only - mechanical preparation - bristle blasting). Client to provide grit glasting equipment and service.
- Installation

- Current pool of 38 technicians/supervisors available
- Training for 3rd Parties
- Rope access (level 1 only) - can outsource level 3 if required.

Technowrap™ Products and Services

	Fibre Type	Application	
2K	Tri Axial Fibre Glass Cloth + Various Epoxy Resins	General Piping systems	Engineered/Defined Life Repair
Structural (SRS)	Quadriaxial Carbon Fibre Cloth + Various Epoxy Resins	All structural components	
High Pressure Pipeline Repair System (HP PRS)	Uni directional carbon fibre, 99 GPa (anisotropic)	High axial loading scenarios	
Core	Water activated Polyurethane resin and fibre glass	Emergency repairs to pipework. Clients apply themselves. Little training required.	Temporary

Resin Type	
High Temp (HT)	Suitable for service temperatures up to 230°C (428F)
High Ambient (HA)	Developed for longer working life at high ambient temperatures, ideally 25°C to 45°C
Low Temperature (LT)	Developed to be used in North Sea conditions, ideally between 10°C and 25°C
Deck Repair System (DRS)	Rubber toughened to withstand impacts
Glycol	Compatible with 100% glycol at 90°C
Splashzone	Pipework in wet areas, Splashzone, subsea or high humidity (and CuNi)
Splashzone	Pipework in wet areas, Splashzone, subsea or high humidity (and CuNi)
Potable	Potable water systems (Drinking water)

Limitations Of Technowrap™ Products & Service

In terms of the application of **Technowrap™** composite repairs the following table provides a summary of the performance envelope in terms of temperatures, pressures and loads (based on two layers of **Technowrap™** Structural repairs).

Pressure (BarG)
Through Wall - 50 BarG / 725 psi
Non-Through wall defect - 250 BarG / 3626 psi (12” diameter)
Temperature
In service -75°C to 230°C / -103°F to 446°F
Application up to 80°C / 176°F
Loadings (Structural)
Dependant on geometry
Surface Preparation
Hand Preparation (to ST2 level of cleanliness)
Mechanical Preparation e.g. Bristle Blaster (to ST3 cleanliness and 40µm angular profile)
Grit Blasting (to SA2.5 cleanliness and 65µm angular profile)

Key Features & Benefits

Technical Expertise - With over 20 years of expertise ICR are world leaders in the field of composite technology. ICR has been and remains a key-player in developing this technology and is internationally recognised as a service-leader.

Engineered Solution – ICR offers fully engineered design solutions, each presented with calculations and sketches.

HSSEQ /QAQC - We are fully committed to the operation of our quality, occupational health, safety and environmental management systems. We also have a traceable, auditable and robust quality management system used to guarantee that the expected service is delivered.

Technowrap™ composite repairs are internationally recognised and qualified to both ISO 24817 and ASME PCC-2 Article 401. ICR also hold approvals through, Lloyds Register, ABS Design & Manufacturing as well as DNV Type Examination.

Testing is rigorous and exceeds both ISO and ASME standards.

Emergency response and Support -from design to mobilisation within 24hours if required. Allocation of a dedicated key account manager and project manager to ensure efficient response times service satisfaction and compliance.

Global Scale - With offices and trained staff across the globe, we can respond safely, quickly and locally.

ICR has unparalleled training and competence schemes in place. Aligned to OPITO approved standards (ICR only allow trained applicators to apply our supplied composite repair solutions). There is currently no external training body or certification agency for engineered composite repairs. As a result, ICR have developed their own internal competency assurance system that has been audited and verified as part of ICR's ISO: 9001/14001/18001 accreditations.

R&D – ICR has its own R&D function to develop technological advances and as a result continuously improve the products and services

Technowrap™ Engineered Composite Repairs

Cost Effective – comapred with than replacement, allowing for repair of a target area rather than full replacement.

Most defect types and service conditions found in Oil & Gas applications can be repaired

Corrosion resistant - The composite repairs supplied by ICR require no maintenance during the defined life (risk-based inspection is recommended). They are corrosion resistant and UV tolerant meaning the composite material will not degrade due to environmental factors.

Applied live – No shutdown required and no impact on production (in most cases)

Geometry - Can be applied to any geometry allowing for flexibility of application and ease of installation.

Rope Access/Leg Entry – Reaching difficult areas & reducing scaffolding requirements.

Materials – Our materials are lightweight and readily available. They are easy to handle and transport and are stocked in our warehouse meaning no lead time.

Strengthening of Structures

Technowrap™ structural strengthening repair system consists of the following combination of materials; Fibres: Carbon (stitched cloth architecture), Resin (matrix): Epoxy (up to a temperature of 220°C / 428°F) and a primer an adhesion promoting layer (silane based).

ICR offer two key carbon fibre offerings: Technowrap™ SRS and Technowrap™ HPPRS. Technowrap™ SRS is a quadraxial stitched fabric, generally used where a uniformly distributed load is considered as it forms a quasi-isotropic laminate. Technowrap™ HP PRS is a unidirectional stitched fabric, primarily used to restore strength where there is a single load path forming an isotropic laminate. Carbon fibre can be engineered to provide the same stiffness as steel resulting in a repair capable of carrying the applied loads.

As there is no widely accepted industry standard for the design of structural repairs, ICR have developed our own in-house practices which refer to the principles from ISO 24817 / ASME PPC2, DNV and ABS which we can then incorporate hand calculations or Finite Element Analysis and are supported by in house or third-party testing. There is also no available type of approval for structures due to the complexities and varieties of geometries however, ICR has a long history working with the approval bodies (Lloyds/DNV/ABS) for case-by-case application/approvals where necessary by review of the engineering principles and application methodology.

The strengthening solution of our structural repairs is designed on a bespoke basis including laminate design (i.e., laminate lay-up sequence) and structural design (i.e. analytical design code solutions supported by Finite Element Analysis where appropriate). Each fabric can be used with various Technowrap™ resins, to best suit the repair scenario. Different design methodologies and calculations are required dependant on the structural component that requires repair, e.g., decks or flat plates, beams, or caissons etc and we have extensive case history and testing to support this.

The design of a structural composite repair seeks to answer the following questions.

- Is the repair strong enough to support the applied pressure loads? (strength calculation)
- Will the repair remain bonded to the surface? (adhesion strength calculation)
- Will the repair be able to withstand the applied impact loads (impact calculation) – where appropriate
- Is the extent of repair sufficient to ensure load transfer between repair and substrate?

From the above we achieve a design output which demonstrates the thickness of composite repair (generally between 2 – 50mm / 0.08 – 2.00in), the extent of composite repair beyond defect (between 100 – 250mm / 4 – 10in as well as the layup procedure and material selection.

For tensile loads the strength of the composite laminate determines the repair thickness and is calculated from both in-plane and bending loads. For compressive loads the modulus of the composite laminate determines the repair thickness, i.e. it is assumed that stability (buckling) is the design criterion. The extent of the repair is determined from the stress concentration around the defect. It should be noted that the composite repair can be designed to withstand the applied loads with or without allowance for the remaining thickness of steel component.

Seamless Restoration: Efficient Repairs Beneath a Helideck

Client: Major Norwegian Operator

Date: January 2006

Location: Norwegian North Sea

Client challenge

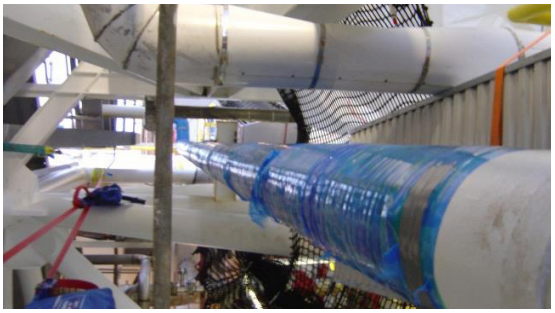
Our client faced a critical challenge as various sections of pipework beneath the helideck had suffered severe corrosion, resulting in wall thinning that fell below the maximum allowable thickness. As the pipework was located under the helideck, any repairs had to avoid causing any shutdowns, prompting the choice of an engineered composite composite solution, Technowrap. The project's scope aimed to deliver an engineered design with a 20-year repair lifetime, along with Technowrap™ trained personnel and Technowrap™ 2K materials to complete the repair. The line's design temperature was set at 90°C.

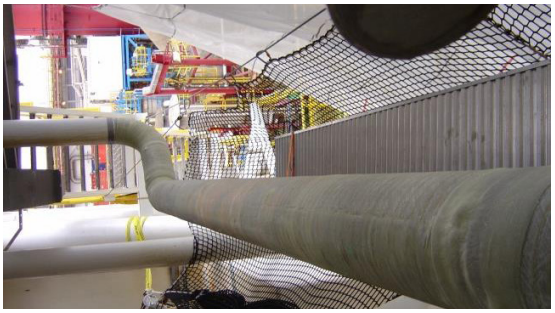
What we did

After a thorough review of inspection reports and process operating information, it was determined that an engineered composite solution could restore the line's integrity while allowing the repairs to proceed without platform downtime or shutdown. Given the challenging location underneath the helideck, access presented a significant issue for our client in terms of both cost and operational impact. To mitigate the need for extensive scaffolding, multi-skilled rope access-trained composite repair technicians were deployed to implement the repairs. Comprehensive risk assessments were conducted to minimise potential risks associated with the work. Achieving excellent adhesion between the pipe work substrate and the Technowrap™ 2K repair was critical, necessitating surface preparation to SA 2.5 standards.

Results

The project was executed successfully on time and budget, and most importantly, with no incidents or accidents. The mobilisation of rope access technicians for the repairs eliminated the need for extensive scaffolding, resulting in substantial cost savings and no disruption to platform operation. The repair was completed efficiently, with no shutdown or downtime required, and the solution was designed to provide a 20-year lifetime, ensuring long-term integrity for the pipework beneath the helideck. This case study highlights our ability to provide efficient and effective solutions, even in challenging locations, while prioritizing safety and minimizing operational impact.





Time & cost savings

Tailored, innovative engineering

Design life of 20 years achieved

Accredited & validated solution

Multi-skilled technicians

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Structural repair of bridge link beams in the Dutch North Sea

Date: May 2023

Client: International independent E&P company

Location: Dutch North Sea

Client challenge

Our client is an international independent exploration and production (E&P) company operating in the Dutch North Sea. They approached our team with a critical structural repair project involving the repair of ten beams with complex geometries and required a solution that could achieve compression on corroded beams. The objective was to provide a long-term, cost-effective repair solution while ensuring the safe operation of the bridge link. The structural repair of the bridge link beams presented several challenges that needed to be addressed.

The complexity of the beams required a solution capable of forming around the unique geometry. Additionally, achieving compression on corroded beams was crucial to ensure adequate adhesion of the repaired elements. The repair was carried out without the need for fabrication, hot work, or heavy lifting to minimise downtime and associated costs. The chosen solution required a design life of 20 years to align with the remaining lifespan of the asset.

What we did

To meet the specific requirements of the structural repair, our team employed a combination of two advanced fabric systems:

- Technowrap™ SRS (Structural Repair System)
- Technowrap™ HPPRS (High-Pressure Pipe Repair System)

By combining these fabrics, we created a bespoke laminate solution tailored to the unique repair scenario of the bridge link beams.

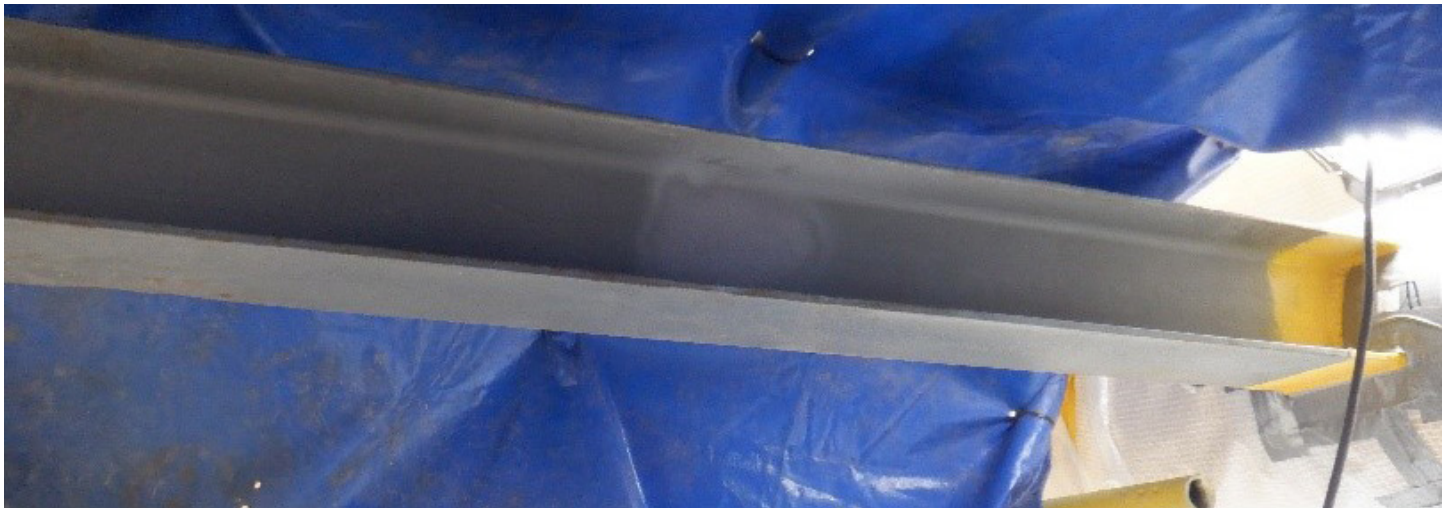
The repair process involved the following steps:

Assessment and preparation: The bridge link beams were thoroughly assessed to identify the extent of corrosion and damage. The corroded areas were cleaned and prepared for the application of the composite repair system.

Fabric selection and laminate formation: Technowrap™ SRS and Technowrap™ HPPRS fabrics were selected based on their individual strengths and characteristics. A customised laminate was created, leveraging the unique properties of each fabric to achieve optimal strength in the correct load path.

Application: A supervisor and two technicians were deployed to carry out the repair. The laminate system was applied to the bridge link beams, ensuring full coverage and conformity to the complex geometries of the structures. The installation process required no fabrication, hot work, or heavy lifting, streamlining the repair and minimising downtime.

Quality assurance and longevity: Rigorous quality assurance measures were implemented to verify the effectiveness of the repair. The composite laminate solution was designed to provide a 20-year design life, aligning with the remaining asset life.



Beam after surface preparation, ready for composite repair.

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Structural repair of bridge link beams in the Dutch North Sea

Results

The successful implementation of the composite repair solution for the bridge link beams provided several outcomes and benefits, providing a long-term solution designed to last the remaining 20-year life of the asset. This ensured the continued safe operation of the bridge link and minimised the need for future repairs or replacements. Additionally, the repair solution required no fabrication, hot work, or heavy lifting. This streamlined the installation process, reducing downtime and associated costs. In terms of cost, the composite repair solution offered a cost-effective alternative to full beam replacement, saving the client significant expenses while maintaining structural integrity.

The quick application of the repair solution ensured the safe future operation of the bridge link and the repaired beams were capable of withstanding the operational loads and environmental conditions in the Dutch North Sea.

The structural repair project for the bridge link beams showcased our team's expertise in developing and implementing advanced composite solutions for complex geometries. By combining Technowrap™ SRS and Technowrap™ HPPRS fabrics, we successfully addressed the challenges posed by the client. The efficient, cost-effective, and reliable repair solution enabled the client to continue safe operations and provided longevity of the asset in the Dutch North Sea.

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DRS Pipe Deck Repair

Date: December 2019

Client: Major Operator

Location: North Sea

Client challenge

Two large laydown areas onboard an operator's asset offshore in the North Sea were suffering from external corrosion and multiple through wall defects resulting in water ingress. As the roof was classified as a laydown areas and subjected to personnel traffic there was a requirement that the load capacity of the roof was factored into the design. This unique design ensured that the laminate could withsta nd the applied loads and impacts associated of +5kN/m².

What we did

ICR provided an engineered design using four layers of Technowrap™ DRS. Combining the properties of the Technowrap™ SRS (Structural Rehabilitation System) carbon fibre and DRS a rubber toughened epoxy resin system. Our integrated approach, providing engineering, materials, technician training and installation, all in-house, has enabled ICR to become an industry specialist. Third party training for the contractor on application and QA/QC procedures was provided and the contractor was subsequently supervised by a ICR technician.

Results

- Repair reinstated the original strength of the floating tank roofs providing long term integrity solution for the life of the repair (20year design life)
- Long term corrosion protection
- No hot works
- 90% reduction in dust eliminated need for scaffold based encapsulation
- Cold work application of lightweight, portable composite materials offered a flexible solution to address varying roof geometries
- Multi-skilled technicians resulted in a small execution team reducing personnel and logistics costs
- Technowrap™ moves with the steel as one structural component
- No heavy lifting or large steel components
- Works completed live with no disruption to tanks being continuously operated
- A commitment to the client's safety processes ensured the job was completed safely with high productivity

Time & cost savings

Accredited & validated solution

20year design life achieved

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