F150 First Floor, Cherwell Business Village, Southam Road, Banbury OX16 2SP
t +44(0)20 7235 7938 f +44(0)20 7235 0074 e hqsec@pipeguild.com www.pipeguild.com

2023 TECHNICAL AWARDS ENTRY FORM

Entry Deadline: Thursday 30th March 2023

Please tick which categories you are entering (entries may be submitted in multiple categories using the same entry form)

Landbased Pipeline Project Award	☐
Landbased Pipeline Technology Award	x
Utility Pipeline Project Award	☐
Utility Pipeline Technology Award	☐
Subsea Pipeline Project Award	☐
Subsea Pipeline Technology Award	☐
iICE Award	X

1. **Brief title of entry:** A Novel Approach To Joining in Non-Metallic Pipe Systems..
2. **Company name:** The Non- Metallic Innovation Centre (NIC)..
3. **Signed:** ....
4. **Date:** 27/03/23..
5. **Company contact name:** Nick Verge ....
6. **Telephone:** +44 7736125078..
7. **Email:** nick.verge@twi.co.uk..
8. **Precis of your entry (50 words): The NIC in collaboration with Saudi Aramco Technologies Company and Future Pipe Industries have designed and manufactured prototypes for a novel method of joining and sealing reinforced thermosetting pipes. By replacing adhesive joints and sealing gaske ts, the approach contributes to a more reliable jointing solution for the O&G Industry.**

9. Summary of entry: For the transportation of hydrocarbons, chemicals, water and wastewater, there is a huge opportunity for replacing traditional metallic pipes with non-metallic alternatives with the promise of significant cost savings achieved by eliminating corrosion. Greater deployment of Non-metallic pipes can contribute to availing more sustainable solutions with lower carbon emissions, lower operational expenditure, and lower failure rates.

O&G operators, and utilities providers have invested significant resources in deploying composite pipes, including reinforced thermosetting pipes (RTR) for transporting hydrocarbons, other fluids, and gases, but they recognise that limitations have hindered further deployments. Previous studies including those conducted by the NIC (The NIC Foresight Review (NIC, 2019 - https://www.non-metallic.com/foresight-review)) concluded that one of the medium-term gaps in the industry is the development of new connections and sealing systems for large diameter (>24”) high-pressure (>1500 psi) applications.

The main issue with the current commercially available joints for large diameters is the rigorous surface preparation required to ensure a good adhesive bond between the pipe ends - a process that must be carried out in the field, or at point of installation where quality is more difficult to control, and may require specific training to undertake. Or when using a threaded joint there is the need to utilize o-rings, which may be susceptible to aging when exposed to certain service conditions (fluids, gases, etc.).

The Non-Metallic Innovation Centre (NIC) has developed an innovative method for joining or sealing reinforced thermosetting resin (RTR) composite pipes that has the potential to replace an adhesive joint and a sealing gasket, contributing to a more reliable joining solution for the oil and gas (O&G) industry.

The proposed solution is to replace the adhesive with a welded solution. Thermoset composites themselves cannot be welded in the same way their thermoplastic counterparts can, but a thermoplastic interlayer can act as both a joining element and a seal, if the right materials are selected and the welding process is process is carried out correctly.

The NIC’s innovation “Friction Welding of Glass Reinforced Epoxy using PEEK” replaces the current adhesively bonded pipe joining technology with a welding approach, where the adhesive is replaced with a thermoplastic layer that ensures the structural integrity of the joint is maintained. In addition, or as an alternative approach the thermoplastic acts as a sealing material, thus removing the need for o-ring or gasket seals necessary in some joint configurations.

Welding thermoset composites is, however, not straightforward. Depositing the thermoplastic layer on the surface of the thermoset has to be carried out in a way that not only provides sufficient adhesion strength, but is also compatible with larger pipe diameters. The idea of using a thermoplastic joining interlayer has been successfully used to join aerospace thermoset composites by modifying the composite’s surface layers, adding thermoplastic fibres, fillers or particles to the matrix, creating a pseudo-thermoplastic interface. However, this approach is not economical for joining resin pipes for the O&G industry, where thermoplastic tougheners are not commonly used in the thermoset matrix.

The approach adopted by the NIC is first to deposit a layer of thermoplastic onto both surfaces of the GRE components using a friction process. After trimming, the pipes and coupler can be joined in the field, again using a friction process or another welding process, such as induction welding.

An advantage of using friction for the initial weld is that the joint surfaces do not need to be exposed to an external heat source such as a laser or hot gas, and the parts can be assembled before joining starts. The process is applicable to large joint areas, unlike ultrasonic welding, which has historically been used on non-reinforced thermoplastic pipes. The friction process is self-limiting, with heat generation reduced as the polymer melts, and the forging phase of friction welding helps the molten thermoplastic flow inside the joint, filling any gaps and ensuring a strong, sealed joint.

The main advantage of this approach is that layers of thermoplastic can be applied to the joining surfaces at the manufacturing stage in-factory, where strict quality control measures can be relied upon.

Subsequent final joining of pipes at point of installation would then not require any further preparation; as the thermoplastic fusion bonding process is much less sensitive to surface finish as the surface melts during joining. This reduces the potential for incorrect surface preparation leading to premature joint failure, reducing the cost of repairs and improving the reputation of composite pipe connections.

All the rigorous surface preparation of the RTR pipe can be carried out in the factory in a controlled environment where quality control can more easily be applied and monitored. Pipes and connectors made in this way can be stored indefinitely without the surface degrading, before shipping to the final deployment site for joining without the need for any additional work.

An additional benefit of the process is that the final pipe to pipe joining process could be carried out at the point of installation by an automated process as the welding equipment can be programmed to not only deliver a pre-set weld program, depending on each particular joint, but also record the weld parameters and provide a digital quality record of every joint, confirming the integrity of every connection or indicating that a joint needs reworking before continuing pipe deployment. An additional benefit of this programmed welding approach is that, depending on the welding technique used, the weld process itself can include parameter feedback that automatically adjust the welding parameters on-the-fly, accounting for slight manufacturing variations in pipe diameter, wall thickness, orality or other important variables, providing even more robustness to the important joining process in the field. The quality of the joints could therefore be guaranteed, significantly reducing the chance of defective joints and the environmental of safety consequences of a failed joint.

The key advantages of our innovation are summarized below:

- Improved sealing and reliability: the sealing is provided by the thermoplastic tie layer after welding. This is the most important feature about the technology. In conventional joints, sealing is provided by contact pressure (O-ring for key lock-joints or Teflon wrap in threaded joints). Contact pressure degrades over time, which leads to joint leaks. In this innovation, the sealing is permanent (welded). In addition, the effective joining area is larger and thus the permeation path is longer, resulting in a lower long term leak of harmful substances to the environment.
- Increased joint strength: provided by a larger joining area (i.e., the length of the coupler) and controlled mainly by the strong bonding between the thermoplastic interlayer to thermoset parts.
- De-skilled installation: In conventional joints the quality of the joint often depends on the skills of the jointer (proper application of Teflon© sealing compound on site, installation of O-ring, torqueing, etc.). The single-step welding process, which can be performed directly in the field, with the potential for automation and digitisation, makes the technology easy to adopt at commercial scale. The welding process can be automated with minimum human interference
- Versatility: The joint design can be altered and optimised, even on-site, through modification of the pipe end taper geometry. The proposed innovation makes the joint easily repairable on site (thermoplastic welding is a reversible process unlike adhesive curing). In addition, the innovation can also be used as a repair technique on straight sections of RTR pipes that can be modified on site to incorporate the connecting coupler and the thermoplastic interlayers.
- Reduced carbon footprint vs traditional Carbon Steel based large diameter pipeline solutions.

From an operational/economical aspect, our proposed solution can be very competitive compared to the ones described in the prior art. Indeed, our innovation could even be retrofitted on existing pipes.

Ancillary Entry Information

(Entry restricted to normal type face and font size on this form plus no more than 3 pages of A4 drawings or photographs)

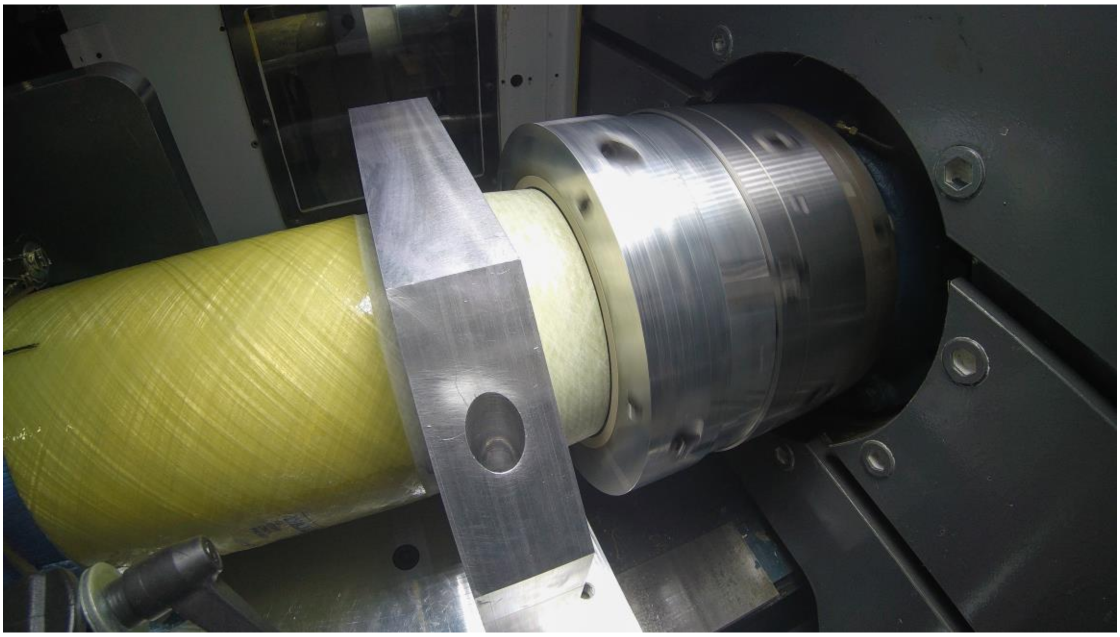

Figure 1 Rotary Friction welding of thermoplastic to 8" Glass Reinforced Thermoset Pipe

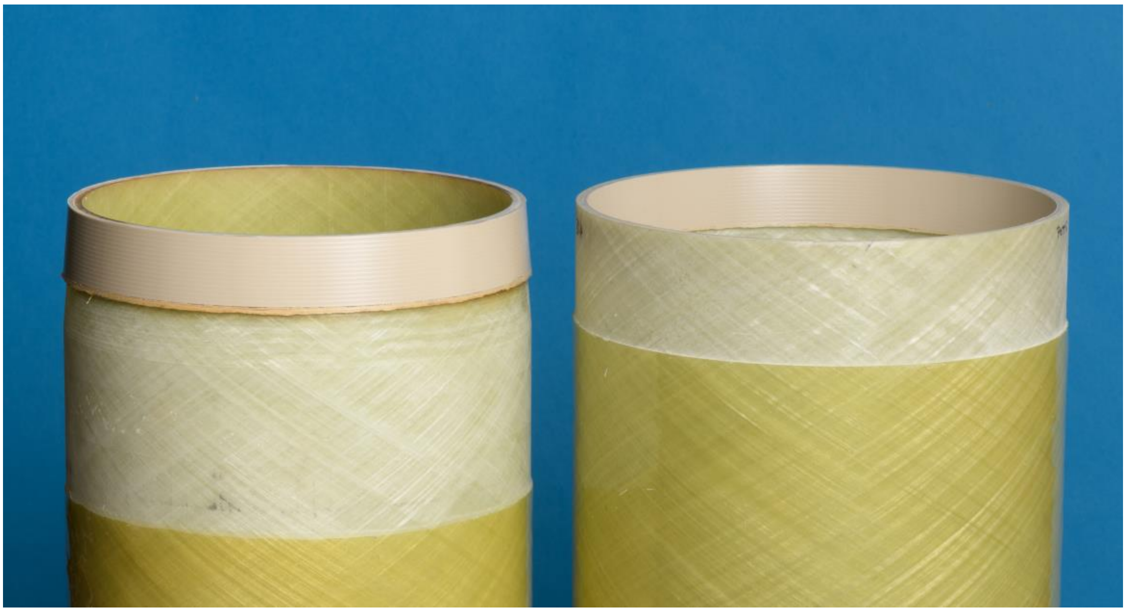

Figure 2 Pipes Post Friction Welding - Prior to Final Pipe to Pipe Joint Assembly (8" Pipe)

F150 First Floor, Cherwell Business Village, Southam Road, Banbury OX16 2SP
t +44(0)20 7235 7938 **f** +44(0)20 7235 0074 **e** hqsec@pipeguild.com **www.pipeguild.com**

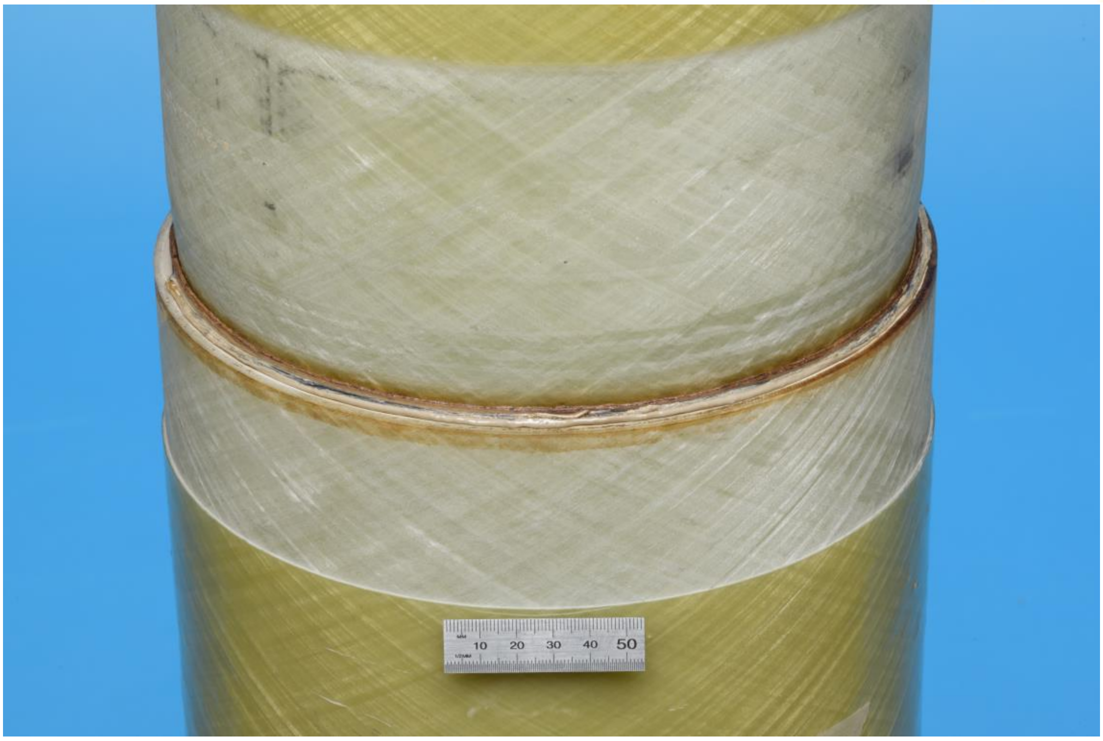

Figure 3 Fully Thermoplastic Welded/Assembled Glass Reinforced Thermoset Pipe (8" Pipe)

Figure 4 Two Fully Thermoplastic Welded/Assembled Glass Reinforced Thermoset Pipes (8" Pipe, 2m Demonstrator)

F150 First Floor, Cherwell Business Village, Southam Road, Banbury OX16 2SP
t +44(0)20 7235 7938 **f** +44(0)20 7235 0074 **e** hqsec@pipeguild.com **www.pipeguild.com**