Energy Transition
Composite Pipe Solutions

For a sustainable future

FPI FUTURE PIPE INDUSTRIES

FPI WAVISTRONG GREEN

Green Solutions for your Green Projects

WAVISTRONG H_2

Production, Storage, Transmission, and Blending.

WAVISTRONG CO_2

Carbon Capture Utilisation and Storage, CO2 transmission.

WAVISTRONG UPW

Demineralised ultra-pure water for Green Electrolyzer H2 production.

Future Pipe Industries, founded in Dubai, U.A.E. in 1984, has established itself as a reliable provider of engineering excellence, dedicated to generating value for all its stakeholders. With more than 35 years of experience in high-integrity energy applications, and supported by manufacturing facilities, service centres, and sales offices around the world, Future Pipe Industries is uniquely placed to offer pioneering solutions to meet industry challenges in energy transition and decarbonisation.

Minimising the environmental impact of construction, along with addressing the unique technical challenges decarbonisation and the hydrogen economy presents in a cost-effective manner is essential to long term success. Failure to do so will result in the industry losing market share to other forms of renewable energy.

Future Pipe Industries is the world leader in the design and manufacture of Glass Reinforced Epoxy (GRE) piping and pipeline systems. As a material GRE presents some unique properties which are ideally suited to meet the demands of decarbonisation and the hydrogen economy.

GRE is unaffected by hydrogen embrittlement, has exceptional low temperature capabilities, offering long life and corrosion free service, in a cost-effective low carbon sustainable manner. Building on its extensive hydrocarbon experience and having undertaken extensive research Future Pipe Industries have developed a range of products each tailored to meet specific application and operational requirements.

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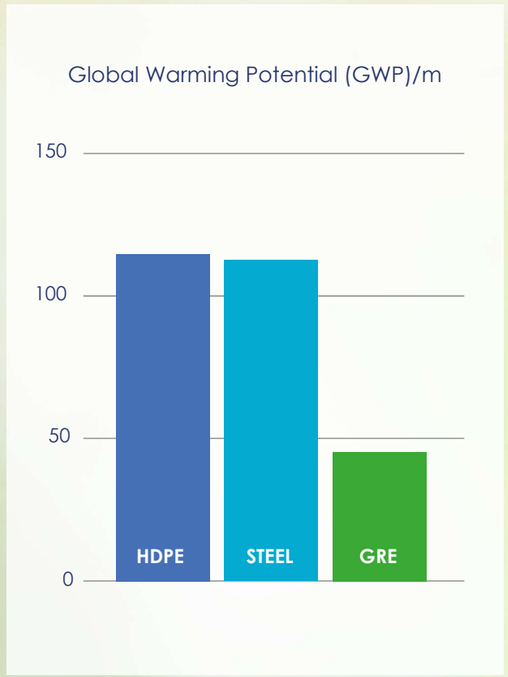
The principal unit of measure used in Environmental Product Declarations (EPD) for carbon impact is the Global Warming Potential (GWP) expressed in KgCO2eq being the relationship between 1kg of material and the amount of CO2 it equates to in Kg. This is a well-recognised system of measure however in the case of piping and pipelines materials are deployed by the meter of kilometre and not by weight.



WAVISTRONG H2

Hydrogen

To capitalize on the potential of Hydrogen, the industry must find ways to transport it safely and efficiently over long distances at scale cost effectively and environmentally sustainably compared to other forms of renewable energy. With the further development of Green Ammonia for global shipping of hydrogen dense liquids pipelines play a pivotal role in the Hydrogen Economy.

Hydrogen presents a unique challenge for steel, due to hydrogen embrittlement, low molecular weight, and low calorific value. The drive is to repurpose existing gas networks and while usable life can be extended through internal coatings, hydrogen will permeate barrier layers ultimately affecting the steel carrier pipe. New installations can be built using hydrogen resistant steels however these alternatives come at an environmental and material cost. Therefore, steel while being technically capable does not resolve the long term 100% Hydrogen solution. Thermoset GRE composites which are universally accepted in aerospace do however provide a long-term solution.

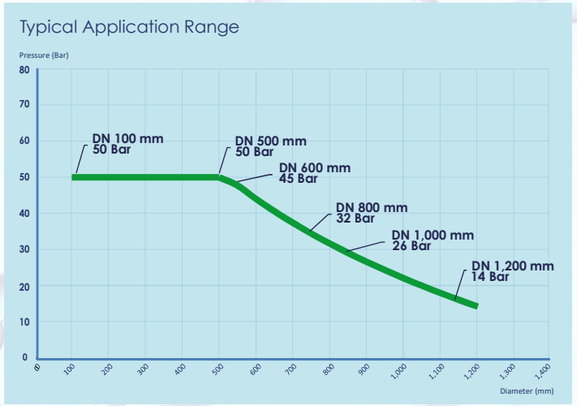
Wavistrong H2 GRE is a development of Future Pipe Industries highly successful Wavistrong oil & gas product range tailored to meet the needs of the hydrogen industry. Key challenges for Hydrogen and Ammonia service is mechanical integrity and permeation management. As hydrogen specific standards for non-metallics are still evolving Future Pipe Industries design philosophy for mechanical integrity is based on ISO14692 (2017) which is widely accepted within the Oil & Gas industry as the most arduous non-metallic standard available. Permeation control has been developed through third party independent testing resulting in a design and manufacturing process that provides a permeation level many times lower than the equivalent steel component.

Wavistrong H2 can also be supplied with an external PU impact resistant coating for above ground service where required and pre-insulated for Ammonia service.

GRE-RTR Benefits:

- Has exceptional capabilities against low temperatures
- Has an extremely low co-efficient of diffusion
- Designed to ISO14692 an internationally recognised oil & gas standard
- Has an exceptionally low Global Warming Potential (GWP)
- Has a comparable CAPEX to steel

Current Typical Application Guideline



- Size Range: **Up to DN 1,200 mm (48")**
- Pressure Range: **Up to 50 Bar (720 psi)**
- Temperature Range: **-60°C to +121°C**
- Type: **Conductive**
- Design Code: **ISO14692 (2017)**

Adhesive Bonded Joint

Lamination Joint

Flanged Joint

WAVISTRONG CO_2

Carbon Dioxide

Carbon Capture Utilisation and Storage (CCUS) will play a vital role in fighting climate change, both in industrial decarbonisation and energy transition. The ability to move safely at scale, over distance, in a cost effective and environmentally responsible manner, is vital in the development of CCUS.

However, carbon steel pipelines present some unique operational and safety challenges. Steel is susceptible to low temperatures which can occur during a Rapid Gas Decompression (RGD) event.

At low temperatures cracking can occur leading to running brittle fracture. Therefore, a carbon steel CO2 line cannot be rapidly depressurised in the event of 3rd party incident without the risk of inducing further damage to the line. In addition to operational and safety issues mitigating the effects of corrosion, requires increased corrosion allowances, external coating and the use of cathodic protection adding to increased ongoing maintenance costs.

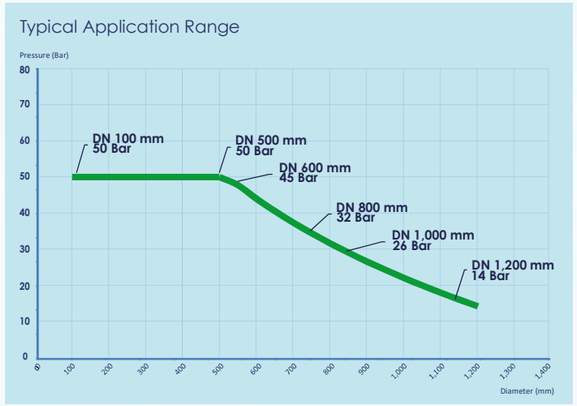
Wavistrong CO2 GRE composites are ideally suited for use within CO2 piping and pipelines. Epoxy composites have exceptional low temperature capabilities compared to carbon steel in excess of -60°C. This low temperature performance combined with being of a filament wound construction means that not only is the potential for low temperature cracking reduced the potential for any form of running fracture is eliminated. Therefore, in the event of an emergency shutdown a Wavistrong CO2 pipeline can be depressurised rapidly therefore providing offering potentially safer operation than traditional carbon steel. Additionally, Wavistrong CO2 is unaffected by corrosion and supercritical CO2.

Wavistrong CO2 can also be supplied with an external PU impact resistant coating for above ground service where required.

GRE-RTR Benefits:

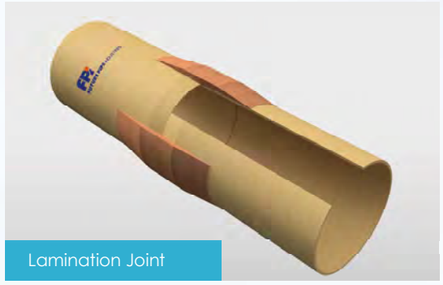
- Exceptionally low permeation rates
- Is unaffected by low temperatures (-60°C)
- Eliminates running fracture risk. (Brittle and ductile)
- Eliminates corrosion. ISO14692 an internationally recognised oil & gas standard
- Has an exceptionally low Global Warming Potential (GWP)
- Has a comparable CAPEX
- And a lower OPEX

Current Typical Application Guideline



- Size Range: **Up to DN 1,200 mm (48")**
- Pressure Range: **Up to 50 Bar (720 psi)**
- Temperature Range: **-60°C to +121°C**
- Type: **Conductive, Non-conductive**
- Design Code: **ISO14692 (2017)**

Adhesive Bonded Joint



Lamination Joint

Flanged Joint

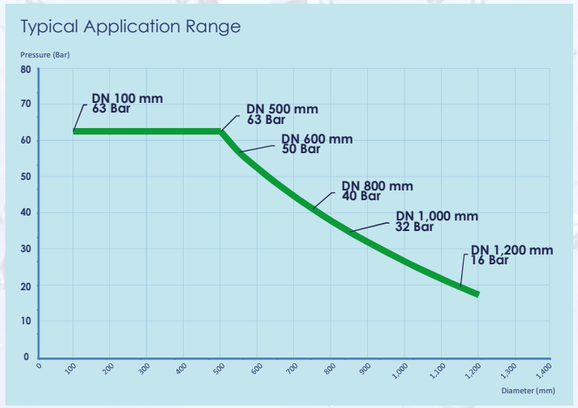
WAVISTRONG UPW

Ultra-Pure Water

Hydrogen produced through the electrolysis typically referred to as a Green Hydrogen, is produced by the electrolysation of ultra-pure demineralised water. The Alkaline production process utilises the addition of potassium hydroxide to form an electrolyte, however the Proton Exchange Membrane process (PEM) splits the demineralised water directly.

While the internal pipework of the individual cells is typically small in diameter, when combining multiple cells on a large scale PEM electrolyser, the volume of water requirements can increase significantly. Increased demand leads to increased pipework diameters. Dealing with ultra-pure demineralised water is particularly challenging due to the interaction between the demineralised water and the metal pipes, as demineralised water dissolves metal ions from the steel due to its high balancing potential and thus contaminates the water. Ensuring that the water is ultra-pure and free of impurities is crucial for the long-lasting operation of a PEM electrolyser. The combination of the in-house manufacturing process and independent suitability testing ensures that Wavistrong UPW is free from contamination and suitable for safe and sustainable use in the electrolysis process. Therefore, Wavistrong UPW offers an extremely cost-effective, low carbon solution for Ultra Pure Water service.

Current Typical Application Guideline



- Size Range: **Up to DN 1,200 mm (48")**
- Pressure Range: **Up to 63 Bar (900 psi)**
- Temperature Range: **-60°C to +121°C**
- Type: **Conductive**
- Design Code: **ISO14692 (2017)**

Conductive Spool

Adhesive Bonded Joint

Lamination Joint

Flanged Joint

WAVISTRONG®

Balance of Plant

In addition to specific process related applications in the decarbonisation and energy transition industry, there are numerous opportunities where environmental benefits can be gained through careful material selection. The aim of green initiatives is to lower operational CO2 emissions, yet constructing such projects produces CO2. As a result, the advantages of these projects cannot be fully realized until the carbon debt incurred during construction is compensated.

Within large scale Blue and Green Hydrogen production facilities there are many applications where standard Wavistrong can be utilised offering long life and major reductions in carbon impact.
Typical production facilities will have a vast array of ancillary services including but not limited to

- Fire Mains
- Cooling Water
- District Heating
- District Cooling
- Potable Water
- Wastewater
- Intakes and Outfalls

Future Pipe Industries has decades of reliable service and experience in high integrity oil & gas, power generation and industrial applications utilising Wavistrong GRE piping and pipeline systems.

Wavistrong offers a cost-effective low carbon solutions for general service applications.

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