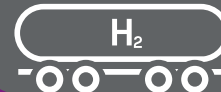


Liquid Hydrogen Applications - LH₂





Aperam offers a wide range of stainless steel and alloy products well-suited for cryogenic storage and hydrogen applications.

For many, hydrogen is the fuel of the future. When turned into electricity, only water is emitted – making hydrogen a carbon-free fuel. However, one of the main challenges related to hydrogen is its storage and transport.

Because hydrogen's density is very low, in order to store and transport it in bulk, it must be either compressed at high pressure or liquefied. As liquid hydrogen has a higher density, it is the preferred storage solution for ship transport, embedded fuel tanks, onshore storage, and pipe-in-pipe transfer.

Storing liquid hydrogen must be done at cryogenic temperatures, which in turn require a high-strength, ductile, fatigue resistant, and weldable material such as stainless steel or alloys.

High performance with liquid hydrogen at very low temperatures

Several grades of austenitic stainless steels achieve high strength and maintain their high ductility (A% > 30%) when used with hydrogen at cryogenic temperatures.

The advantages of stainless steel and nickel alloys



- > Low dilatation coefficient for INVAR® M93
- > Nearly constant or, in some cases, slight increase of Yield Strength (YS)
- > Significant increase in Ultimate Tensile Strength (UTS)
- > Increase in fatigue limit
- > High level of toughness

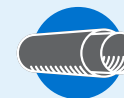


World Leader for Cryogenic Membrane Tanks

Since 1968, INVAR® M93 has been delivered to several shipyards (Korea, Japan, China, Europe) for the construction of more than 200 LNG carriers.

Aperam austenitic stainless steel grade 304L is already used in small-scale LNG and LH₂ storage applications.

All of these orders confirm Aperam's ability to combine precise logistics and quality plans for quick solutions that fulfill our customers' particular requirements.



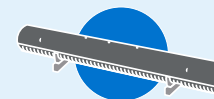
Supplier for Pipe-in-Pipe Technology

Pipe-in-pipe technology is used to transfer liquid gas at cryogenic temperatures.

INVAR® is already used in the transfer lines of subsea, onshore and offshore LNG terminals.

- > Easily manage pipe expansion caused by temperature cycling
- > Reduce costs by avoiding the need for a thermal compensation system (loops and bellows), trestles and jetties

Austenitic stainless steel grade 316L can be found in LH₂ transfer applications.



Supplier for Cryogenic Storage

Aperam austenitic stainless steel grade 304L is already used in small-scale LNG and LH₂ storage applications.

Aperam has developed an LN series portfolio of products that reduce the thickness of different applications. Our LN series is already used in trailer cylinders for transporting liquid gas under pressure and at low temperatures.

A Wide Offer

Aperam offers a broad portfolio of austenitic grades well-suited for cryogenic applications at very low temperatures, including liquid hydrogen temperature (-253 °C)

Aperam 304L - 2B - 2 mm			
Temperature (°C)	0.2% YS (MPa)	UTS (MPa)	E (%)
20	300	630	54
-163	420	1,260	33
-196	440	1,630	37
-253	500	1,630	33

INVAR M93		Long direction			Transverse direction		
Conditions	Temperature (°C)	0.2% YS (MPa)	UTS (MPa)	E (%)	0.2% YS (MPa)	TS (MPa)	E (%)
RT	24	360	520	35	350	510	36
N ₂ Liq. Temp.	-196	680	980	35	700	970	40
H ₂ Liq. Temp.	-253	850	1,140	40	860	1,130	40
He Liq. Temp.	-269	870	1,140	40	890	1,130	40

Other grades are available on request: Aperam 304, Aperam 310, Aperam 316, Aperam 316L, Aperam 321.

The evolution of mechanical properties for austenitic stainless steels and nickel based alloys with temperature decrease (from 20°C / 293K to -196°C / 77K to -253°C / 20K)

- > Yield Strength (YS) remains almost constant or slightly increases
- > Ultimate Tensile Strength (UTS) increases a lot
- > Fatigue limit increases
- > Toughness remains very high

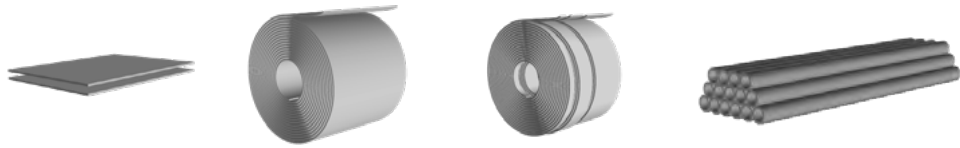
Proven expertise on welding applications

Aperam has a dedicated and skilled team to help customers develop hydrogen applications, including:

- > Selecting the optimum material solution for your application from a large range of stainless steels and nickel alloy grades
- > Improving the application's design and advising on welding



Product range (Stainless Steels)



- > **Forms:** sheets, blanks, coils, strips, tubes
- > **Thicknesses:** from 0.8 up to 13 mm (consult us for thicknesses < 0.8 mm)
- > **Width:** up to 2,000 mm according to thickness and grade
- > **Finish:** cold rolled, hot rolled according to thickness and grade

Product range (Nickel Alloys)



- > **Forms:** cold rolled strips, wires, plates and bars
- > **Thickness, diameter, width and length:** our size range is based on our production capabilities.

Please contact us for the latest information about available grades/forms.



Your Supplier of Choice

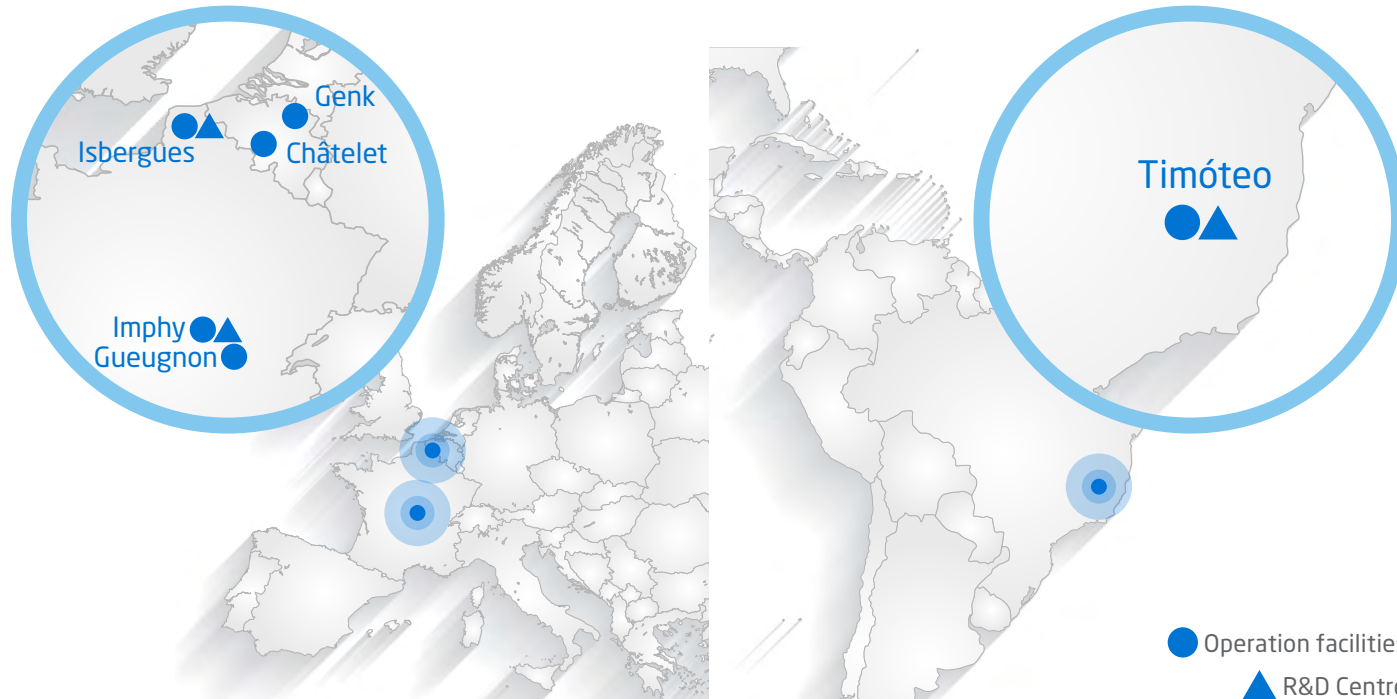
Our wide and always-evolving product portfolio is well-positioned to answer our customers' immediate application needs. We also maintain an industry leading product pipeline filled with the applications that will help define the future.

But Aperam is more than just products. We firmly believe that our success ultimately depends on your confidence in using our products. That's why we support all our customers through technical assistance and product co-development.

Our global presence includes 17 sales offices and 14 service centres, meaning no matter your location, Aperam can provide local, on-the-ground assistance. For more technical requests, our Research Centres serve as a one-stop-shop for all technical questions relating to the production and use of grades for LH₂ applications.

A Global Company with a Local Presence

Aperam is the leading stainless steel and specialty steels company in South America and the second largest in Europe. We are also a leading manufacturer of high value added specialty products, including electrical steels and nickel alloys. All of our products can be supplied from Europe or Brazil.



Europe

Châtelet: Meltshop & Hot-Rolling Mill
 Genk: Meltshop & Cold-Rolling Mill
 Isbergues: Cold-Rolling Mill & R&D Centre
 Gueugnon: Cold-Rolling Mill
 Imphy: Meltshop & Pierre Chevenard R&D Centre

Brazil

Timóteo: Meltshop, Hot-Rolling Mill,
 Cold-Rolling Mill & R&D Centre

A Sustainable Company

With Aperam, our customers have selected a partner of choice, offering them responsibly produced solutions that are also 100% recyclable and low carbon – solutions that are much needed for the sustainable society we strive to live in. At Aperam, we are convinced that true business success can only come together with social and environmental sustainability and we will pursue our strategy to further embed sustainability within all our processes.



In-line with this mission, Aperam Stainless Europe became the first stainless steel company to be certified by **ResponsibleSteel™**, the global sustainability standard for the steel sector. The certification follows an in-depth third-party audit of Aperam's European operations against exacting Environmental, Social and Governance (ESG) standards.



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