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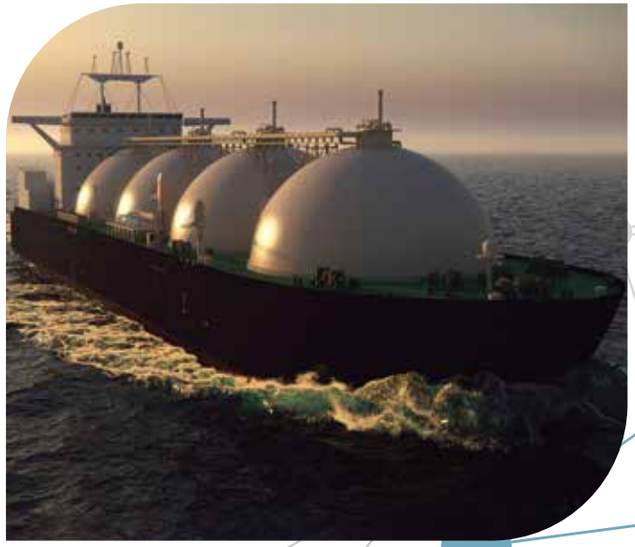
JSL
JINDAL STAINLESS

STAINLESS STEEL
FOR HYDROGEN SERVICE



A LEGACY BUILT ON **SAFETY & TRUST**

Founded by Shri O P Jindal in 1970, Jindal Stainless is one of the largest stainless steel conglomerates in India and ranks amongst the top 5 stainless steel conglomerates in the world. It's not only the magnitude of our operations that determines our credibility and name, but we remain inspired by our vision for innovation and enriching lives. Jindal Stainless has an annual turnover of INR 38,562 crore (USD 4.7 billion) in FY24 and is ramping up its facilities to reach 4.2 million tonnes of annual melt capacity.

Our growth has been backed by the excellence of our people, value-driven business operations, customer centricity and best safety practices in the steel industry, and a commitment towards social responsibility.

The company focuses on creating value by providing synergy within the group companies, working on a prime repository of global best practices and frameworks with the help of a talented team.

SIGNIFICANCE OF HYDROGEN IN THE ERA OF ENERGY REVOLUTION

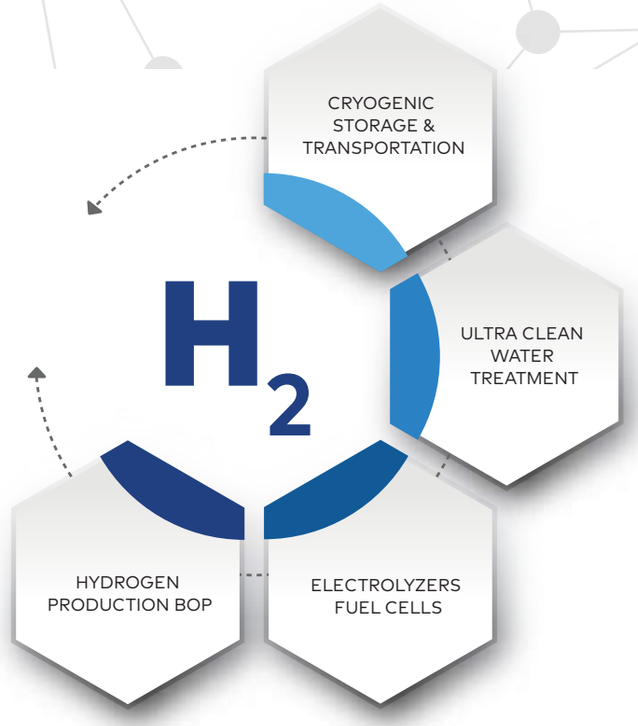
Hydrogen is the lightest and most abundant element in the universe, serving as a versatile energy carrier with applications ranging from fuel cells for clean power generation to industrial processes, aiming for decarbonization. Its potential lies in its ability to contribute to a more sustainable and low-carbon future.

Green hydrogen is a promising fuel for the future, and it has gained significant attention in recent years due to its potential to decarbonize various sectors of the economy.

Traditional methods for producing Hydrogen are Steam Methane Reforming (SMR), Pyrolysis of Natural Gas, Biomass Reforming and Electrolysis, as the most common method for Hydrogen Production.

Storage, transportation and distribution of Hydrogen has been a long lived challenge for the industry due to:

- Hydrogen Induced Corrosion (HIC) and Hydrogen Embrittlement
- Impact toughness at cryogenic temperature
- Safety concerns



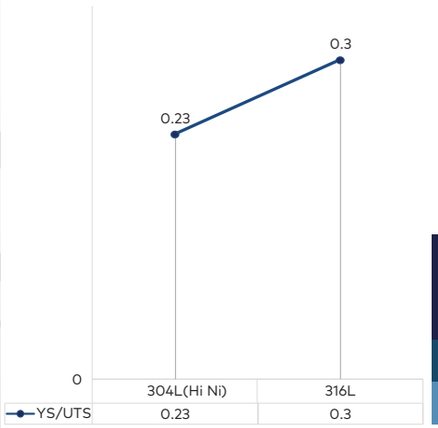
CRYOGENIC STORAGE & TRANSPORTATION

With the increasing demand for liquid hydrogen storage and transportation, Jindal Stainless Limited finds it necessary to carry out systematic comprehensive research on stainless steel materials for liquid hydrogen storage and transportation vessels to establish the performance characteristics of different types of stainless steel.

Austenitic stainless steel can be selected for safe and reliable design of storage and transportation vessels for a liquid hydrogen environment, owing to their high solubility, lower diffusivity, and resistance to material degradation from hydrogen.

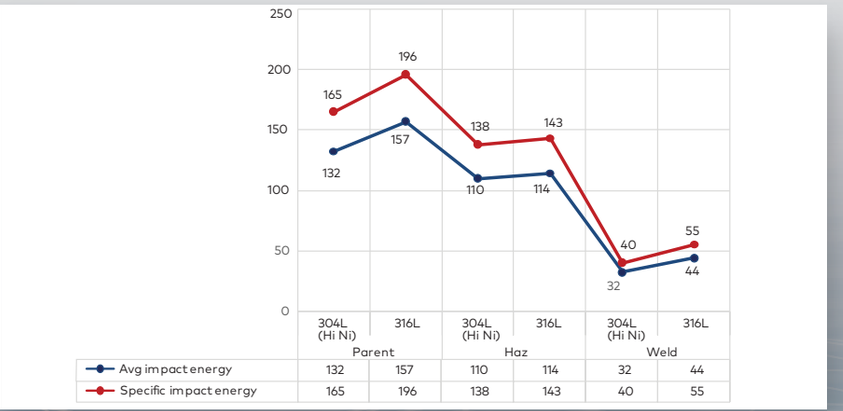
Based on the experiments, Austenitic 316L and 304L (Hi Ni) can be used in liquid hydrogen storage and transfer application. Both the grades have greater phase stability and resistance to hydrogen embrittlement.

Fig1: YS/UTS ratio at (-) 196° C



	Yield Strength (MPa)	Ultimate Tensile Strength (MPa)
304L (Hi Ni)	248	1058
316L	352	1181

Fig2: Impact energy comparison at (-)196° C



For knowing the suitability of the material for cryogenic applications, it is important to carry out the impact toughness test at -196° C as per ISO 21028-1, ISO 21009-1 standards. Impact test is carried out for parent metal, HAZ and weld.

ELECTROLYZERS & FUEL CELLS - BIPOLAR PLATE APPLICATIONS

Bipolar plates are critical components in hydrogen systems, requiring materials with superior gas impermeability, mechanical strength, thermal stability, and cost-effectiveness for mass production.Austenitic stainless steel emerges as an ideal choice, offering an optimal balance between performance, corrosion resistance, durability, and cost-effectiveness making them ideal for these critical applications. Leveraging robust R&D capabilities, Jindal Stainless Limited (JSL) has developed stainless steel solutions specially optimized for bipolar plate applications, supporting diverse hydrogen-production technologies including Alkaline Water Electrolysis (AWE), Proton Exchange Membrane (PEM), and Solid Oxide Electrolysis Cells (SOEC/SOFC).

BALANCE OF PLANT APPLICATIONS

The Balance of Plant encompasses critical elements that ensure the safe, efficient, and reliable operation of hydrogen systems. Operating under demanding conditions, these applications require durable, corrosion-resistant materials with exceptional mechanical strength. Leveraging advanced material engineering and dedicated research capabilities, Jindal Stainless Limited (JSL) has developed specialized stainless steel grades—including custom alloys—precisely tailored to meet the stringent requirements of Balance of Plant applications, ensuring long-term operational reliability and efficiency.

Typical Applications: Separator Tanks | Dryers | Bubblers | Heat Exchangers | Filters | Pump | Pipes

There are variety of stainless steel grades that can potentially used for Fuel Cell Application

Grade	Category	YS (MPa) (min)	UTS (MPa) (min)	%El	Hardness (HRB)	%C Max	%Mn Max	%Cr	%Ni	%Mo	N (ppm) Max
304L	Austenitic	170	485	40	92	0.030	2.0	17.5-19.5	8-12	-	1000
316L	Austenitic	170	485	40	95	0.030	2.0	16-18	10-14	2-3	1000
441	Ferritic	250	430	18	88	0.030	1.0	17.5-18.5	-	-	-
446	Ferritic	275	515	20	96	0.025	1.5	23-27	0.75	-	350
2101	Duplex	530	700	30	106	0.040	4-6	21-22	1.35-1.70	0.1-0.8	2000-2500
2205	Duplex	450	655	25	106	0.030	2.0	22-23	4.5-6.5	3-3.5	1400-2000

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