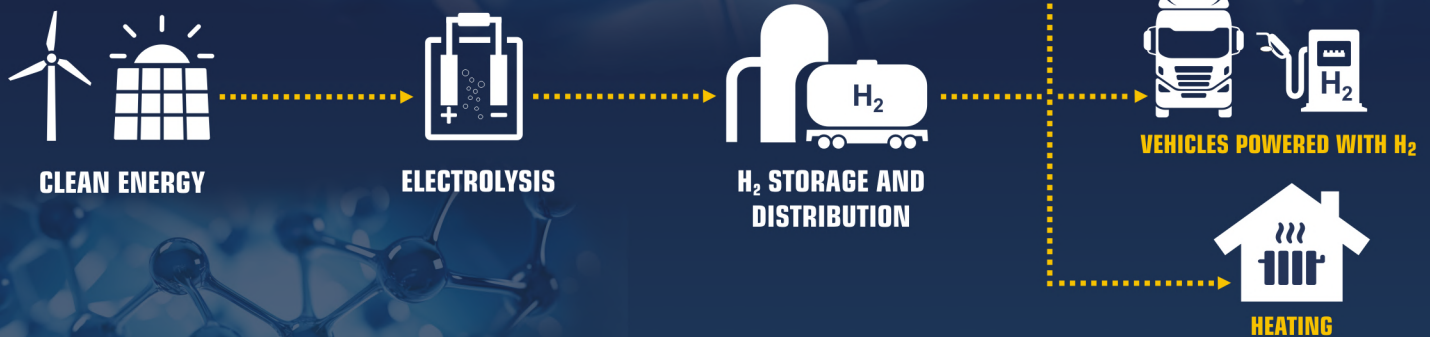


Hydrogen is one of the next key players for the future of energy and power generation, being a precious source to lower carbon footprint and to fight climate change.

THE FUTURE OF ENERGY AND POWER GENERATION



Hydrogen is the first element in the Periodic Table of the Elements as it shows the lowest Atomic Number and, in its free state, at atmospheric pressure and at room temperature, it exists in the gaseous state (H₂).

On average and at ground level it corresponds in mass to about 5ppm of the mixture of atmospheric gases; therefore, for industrial purposes, it must be mainly produced through the electrolysis of water, i.e. a process whereby, through the passage of electric current, the latter is broken down into gaseous Oxygen and Hydrogen. Since the sustainability of the process relies on the usage of renewable sources to generate electric energy, this chemical process is preferably performed applying clean energy, to produce "green hydrogen."

Once produced, hydrogen can be stored, transported and distributed, taking into account however that these processes require managing considerable engineering complexities such as its storage in the liquid state at cryogenic temperatures (-253°C) or its distribution at high pressures. The use of materials, specifically the choice of the most appropriate stainless steel grades, becomes a determining factor for the successful outcome of a project.

Hydrogen can be employed for multiple purposes such as, for example, as alternative fuel to the more traditional combustion engines or for the production of electricity through "Fuel Cells" and the power supply of electric vehicles. Beside mobility, hydrogen can be used as a source of energy for industrial processes and heating systems.

Typical applications do include:

- Valves
- Fittings
- Connectors
- Injector system
- Storage tank components (caps)
- Truck filling station components
- Vehicle tank system

HYVAL™ represents Valbruna stainless steel grades for hydrogen applications.

The following HYVAL™ grades are the most commonly required within the framework of Hydrogen economy.

International References

AV Grade	Steel Group	EN	UNS	AISI
APMLHY	AUSTENITIC	1.4404 / X2CRNI17-12-2	S31600	316L
APMLHYG	AUSTENITIC	1.4435 / X2CRNIMO18-14-3	S31600	316L
NTR50HY	AUSTENITIC	-	S20910	XM-19
X164MHY	MARTENSITIC	1.4418 / X4CRNIMO16-5-1	-	-
V257MHY	SUPERDUPLEX	1.4410 / X2CRNIMON25-7-4	S32750	F53

H₂

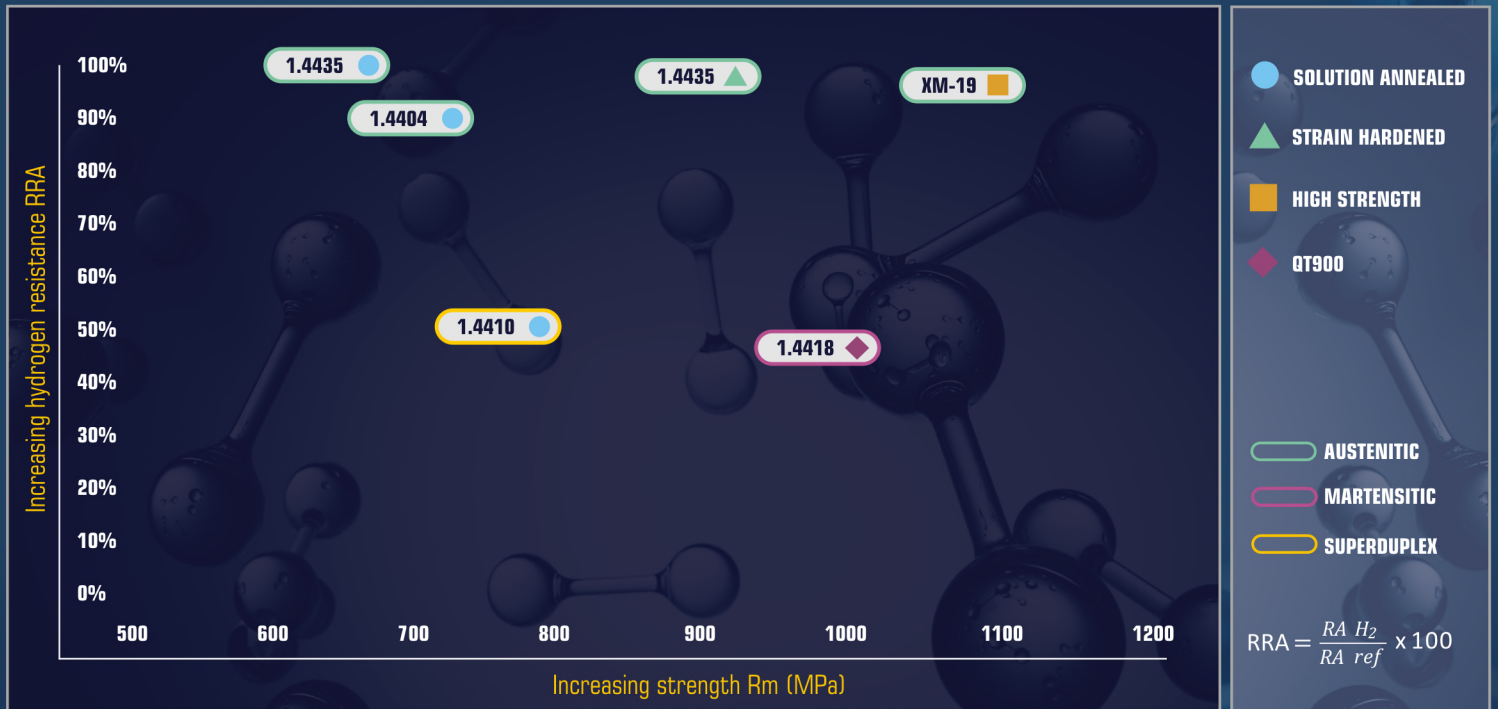
Chemical Composition

AV Grade	International Reference	C%	Si%	Mn%	Cr%	Ni%	Mo%	N%	P%	S%	Others %
APMLHY	1.4404	≤0,030	≤1,00	≤2,00	16,50 ÷ 18,00	10,00 ÷ 12,00	2,00 ÷ 2,50	≤0,10	≤0,040	≤0,020	-
APMLHYG	1.4435	≤0,030	≤1,00	≤2,00	17,00 ÷ 18,00	12,00 ÷ 14,00	2,50 ÷ 3,00	≤0,10	≤0,040	≤0,020	-
NTR50HY	XM-19	≤0,060	≤1,00	4,00 ÷ 6,00	20,50 ÷ 23,50	11,50 ÷ 13,50	1,50 ÷ 3,00	0,20 ÷ 0,40	≤0,040	≤0,030	Nb=0,10 ÷ 0,30 V=0,10 ÷ 0,30
X164MHY	1.4418	≤0,060	≤0,70	≤1,50	15,00 ÷ 17,00	4,00 ÷ 6,00	0,80 ÷ 1,50	≥0,020	≤0,040	≤0,030	-
V257MHY	1.4410	≤0,030	≤0,80	≤1,20	24,00 ÷ 26,00	6,00 ÷ 8,00	3,00 ÷ 4,50	0,24 ÷ 0,32	≤0,020	≤0,015	Cu≤0,50

Mechanical Properties

AV Grade	International Reference	Condition	Rp0,2% [MPa]	Rm [MPa]	A5d-E4d [%]	Z-RA [%]	RRA [%]
APMLHY	1.4404	Solution Annealed	≥200	500 ÷ 700	A5d≥40	≥50	90,3
		Strain Hardened	≥500	800 ÷ 1000	A5d≥12	-	-
APMLHYG	1.4435	Solution Annealed	≥200	500 ÷ 700	E4d≥40	≥50	100
		Strain Hardened	≥500	800 ÷ 1000	A5d≥12	-	96,3
NTR50HY	XM-19	Solution Annealed	≥415	≥690	E4d≥35	≥55	-
		High Strength	≥800	≥930	E4d≥25	≥50	95,8
X164MHY	1.4418	QT900	≥700	900 ÷ 1100	A5d≥16	≥50	46,2
V257MHY	1.4410	Solution Annealed	≥550	≥800	E4d≥25	-	50,0

Schematic "Family tree" of high-pressure hydrogen susceptibility of stainless steels



Values based on tests performed with hollow specimens at 150 bar

Valbruna is constantly pursuing research and development activities and performing tests to gather additional data and develop new grades to meet the Customers' requirements.

Data reported within this document are average values for reference only and are not contractually binding. The list of application is for illustration purpose only.