SAFETY INSTRUCTIONS FOR

HYDROGEN USE

AND FOR

HYDROGEN PRODUCTION UNITS

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1 SAFETY REGULATION

During the installation and use of equipment for producing hydrogen, it is essential to follow the procedures for a hydrogen plant and safety instructions compliant to the European regulations and ATEX directives.

1.1 Safety of the Building

A - The hydrogen building shall content two separate rooms:

- One room for the electrolytic hydrogen plant (Min. dim: L= 4 m x W=5 m x H= 3.5 m)
- One room for the storage tank and the balloon inflation area (Min. dim: L= 4 m x W=5.5 m x H= 5 m)

B - Each room must have:

- sufficient dimensions to permit easy installation of the equipment forming the hydrogen station,
- Ventilation openings at the top and bottom is order to ensure effective replacement of the air,
- A concreted floor which is quite level and sufficiently strong to bear the weight of the unit (min: 1 ton),
- doors opening outwards,
- hydrogen-approved artificial lighting, (circuit-breakers and switches shall be installed outside the room)
- A 9-kg powder extinguisher.
- A hydrogen leak detection system in order to prevent any LEL & UEL mixing gas

C – All lighting and switches devices, installed in the premises in which are located the hydrogen generator, storage tank and the inflation station, are required to be explosion-proof and "hydrogen certified as "ATEX (Ex d IIC).

D - Avoid installing any electrical sockets inside the building even if they are explosion-proof and hydrogen type approved. There are no power outlets inside the hydrogen container.

F – The building shall be dedicated only to the production of hydrogen.

G - Local access shall be forbidden to anyone other than the personnal in charge of use of the equipment.

H – All metal parts (doors, frames, windows, ...)shall be connected to the ground.

1.2 Safety labels to display

1.2.1 Outside of the building

BUILDING FOR HYDROGEN PRODUCTION ONLY !

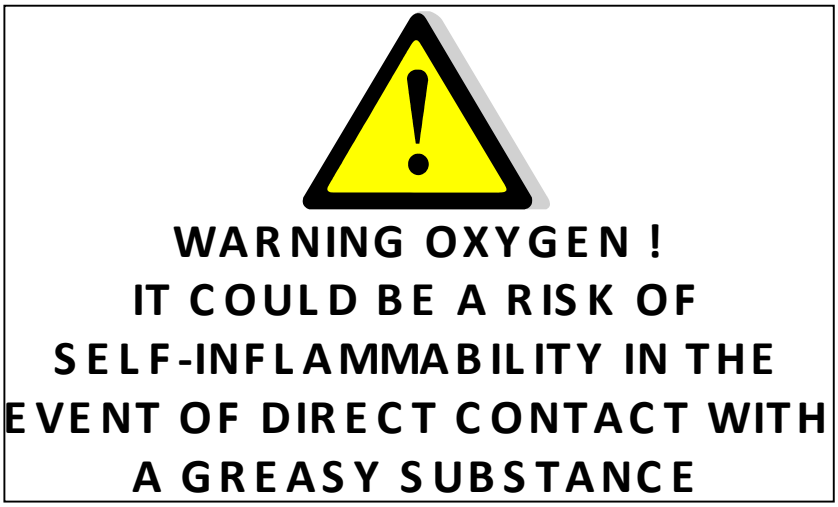
NO ENTRY TO ANYONE WHO DOES NOT BELONG TO THE SERVICE !

1.2.2 Inside of the building

NO SMOKING !

IT IS FORBIDDEN TO BRING IN FIRE UNDER WHATSOVER FORM

1.2.4 Near to the Oxygen vent



All parts in contact with oxygen must be degreased before reassembling the system.

1.3 Hydrogen draw off

Avoid wearing nylon or synthetic clothing during operation of the generator or handling hydrogen gas in order to prevent any risk of light due to static electricity..

Use only cotton clothing or antistatic fabric clothes

Do not squeeze or purge hydrogen abruptly

Never open a valve or tap quickly

1.4 Caustic potash

The electrolyte contained in the electrolysis cell contains caustic potash (potassium hydroxide) at a concentration of about 28%.

It is absolutely essential to protect the eyes against all splashes, hence the compulsory wearing of

protective goggles.
If potash splashes into the eye, wash it immediately with copious amounts of water. If the burn is minor, the pain should subside rapidly and disappear after 10 to 15 minutes. If it persists, it means that the burn is serious; consult a doctor.

If splashes of potash get onto the skin (hands, arms or face), wash the affected area with copious amounts of water and apply ample amounts of vinegar or lemon juice to the burn.

If the burn is very painful with very pronounced redness and with the epidermis affected completely, its surroundings must be disinfected by washing the surrounding skin with soap and water and applying ether or alcohol; then apply a pad of cotton wool or gauze soaked in sterilized grease to the burnt area. A serious burn needs medical attention.

1.5 Hydrogen storage vessel

A safety valve set at 8b shall be installed on the storage tank

This device must be calibrated once a year by a competent laboratory (a certificate of calibration must be established).

The system drain tank shall be equipped with a quick stop valve and a needle valve to limit the flow of hydrogen during the purging or drain tank sequence.

The storage tank shall be connected to the ground.

1.6 Fire cutter and anti detonation system

At the exhaust of the hydrogen storage tank, a fire cutter device equipped also with an anti-detonation system shall be installed us prevent any risk of flame return to the hydrogen tank during filling and inflation phase of the balloon.

1.7 Hydrogen compressor

A safety valve set at 8b shall be installed on the compressor exhaust

This device must be calibrated once a year by a competent laboratory (a certificate of calibration must be established).

1.8 Power supply

The frame of the generator shall be connected to the ground as well as the storage tank and all metallic parts of the hydrogen building.

Never work on an electrical component or device without having first, cut the mains power of the building via the general circuit breaker but also from the electrical switchgear of the hydrogen generator.

2 PROPERTIES OF THE HYDROGEN

2.1 Particularités

Hydrogen is a highly flammable gas and becomes explosive when it is combined with air or oxygen at a concentration greater than 4%.

In case of ignition of hydrogen, the flame is invisible hence the absolute necessity to never approach without appropriate protection in the event of hydrogen leakage.

Hydrogen is odorless and colorless, making it very difficult to detect in case of gas leaks.

Hydrogen is a non-toxic gas.

2.2 Characteristics of the hydrogen gas

The table below summarizes some physicochemical characteristics of flammable and explosive hydrogen.

Property	Value
Heat of combustion, [kJ/g]	119,93 (Lower value), 141,86 (Upper value)
Explosivity limits, in fraction volume, [%]	4,0 to 75 (in air) 4,1 to 94 (in oxygen)
Detonation limits, in fraction volume, [%]	18,3 to 59 (in air) 15 to 90 (in oxygen)
Stoichiometric composition in air, in volume fraction, [%]	29,53
Auto ignition temperature, [K]	858
Temperature of the flame when ignited in air [°C]	1430
Temperature of the flame when ignited in oxygen [°C]	2830
Minimum auto ignition energy in air, [mJ]	0,017
Vitesse de combustion dans l'air à TPN, [m/s]	2,65 to 3,25
Vitesse de propagation de la détonation dans l'air à TPN, [m/s]	1480 to 2150

Explosive limits are used to determine the concentration range within which miss-diapers fuel and air are liable to ignite. This is the lower limit of explosiveness (LEL) and the upper explosive limit (UEL) corresponding to the quantity minimal and the maximum amount of fuel beyond which combustion cannot not boot. Both limits are commonly expressed as volume fraction (percentage).

Under ambient conditions, the explosive limits of hydrogen in air run from 4% to 75% expressed in volume fraction in the air.

3 RISKS LINKED DUE TO H2/AIR OR H2/O2 MIXTURE

The combination of hydrogen gas with another gas such as air or oxygen at greater than 4% concentrations creates an explosive mixture.

- In case of mixture created within an unconfined area, there will be a risk of explosion.

- In case of mixture created within a confined area, there will be a risk of detonation

A deflagration is a propagation of a combustion zone at a velocity less than the speed of sound, speed about 10m/second.

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A detonation is a propagation of a combustion zone at a velocity greater than the speed of sound. Supersonic speed > 340 m/second

PURE HYDROGEN IS A FLAMABLE GAS AND NOT EXPLOSIVE GAS!

4 HARMFUL EFFECTS LINKED TO HABITUATION RISKS

As for all dangerous gas, it is absolutely necessary to stay extremely vigilant during the use of hydrogen gas.

Even if all users in charge of the hydrogen plant are informed about the risks due to the hydrogen gas, users become generally less vigilant after several years of experiment. This is due to a too big trust in the use of hydrogen gas and that trust is increasing with years.

The direct consequence of this kind of comportment brings harmful effects on the safety measures and on the conditions of hydrogen use, for example :

Risk to forget to wear antistatic clothes

Risk to forget to switch off its mobile phone during the filling of a balloon

Risk to open brutally or too quickly the hydrogen cock of the draw off panel

Risk to increase the hydrogen pressure of the draw off panel in order to «accelerate» the filling of the balloon,

Lack of vigilanceduring the hydrogen production or where the balloon is filled
(lack of daily verifications on the plant)