HYDROGEN GAS GENERATOR

BY-WATER ELECTROLYSIS SYSTEM

Onsite Hydrogen Gas Generation – Clean Energy from Water

Always In Pursuit Towards Excellence

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HYDROGEN GENERATORS
PRESSURISED WATER ELECTROLYSIS (BIPOLAR)

SY GREEN ENERGY HYDROGEN GENERATORS comes from a long experience of build in high-performance water electrolyzers. The combination of experience and a constant drive to improve, has made SY GREEN ENERGY the winning choice for a wide range of applications.

SY GREEN ENERGY HYDROGEN GENERATORS are designed and built in SY GREEN ENERGY's manufacturing facility in Ahmedabad Gujarat India. A dedicated Team of 60 skilled personnel brings a common purpose to work every day to design and manufacture the world's best onsite hydrogen generator.

SY GREEN ENERGY On-Site hydrogen generator uses water and electricity to produce high quality hydrogen on demand. Since its inception SY GREEN ENERGY has Hydrogen Generators have been subjected to a continuous improvement process, increasing performance, capacity, quality, and durability. By taking our customer's feedback seriously, the result is a product with no compromises at a reasonable cost.

A basic SY GREEN ENERGY HYDROGEN GENERATORS for On-Site hydrogen generation consists of

- Hydrogen generating Skid with Electrolyzer, Oxygen Gas separator, Hydrogen Gas Separator, Gas cooler, Electrolyte Circulating Pumps along required instruments and interconnecting piping
- A Power Source of Transformer & Rectifier & A Power Distribution Panel
- A PLC with HMI Based control panel
- All Electrical accessories and instruments in the generation area are minimum Explosion proof / Atex
- With safety as a key priority every Hydrogen Generator comes with
- A hydrogen in atmosphere detector & • Oxygen in Hydrogen measurement with the best conversion efficiency in the industry, SY GREEN ENERGY On-Site hydrogen generators are flexible and economical sources of hydrogen and can be equipped with a variety of options. Hydrogen Purification System (HPS), Closed loop cooling system
- Online gas quality measurement, Reverse osmosis water purification system.
- Hydrogen Booster Compressor for Increased Pressure or bottle Filling
- Container for Out Door Installation (Containerized Solutions)

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Process Description of the Pressurized Water Electrolysis System

The Hydrogen Generator offered is based on Bipolar - Pressurized Water Electrolysis System. The Electrolyser can be designed, manufactured, and operated from 5 – 32 BarG.

Each Hydrogen Generator and its Electrolyser is tailor-made and designed to suit the customer's requirement with respect to the application, capacity, pressure, purity, storage requirement, power & other utilities available at the site.

Electrolyzers are filled with electrolytes (30 % KOH in Water). Hydrogen & Oxygen are generated in Electrolyser when DC Power is connected to the Electrolyser. The Main Equipment of the hydrogen generator is an Electrolyser, in which, water is decomposed into hydrogen and oxygen through electrolysis –

The equation is $2H_2O$ --□ $2\ H_2+O_2$

The Electrolyzer is a bipolar pressurized type. The cell of Electrolyzer is divided into an anode cell and a cathode cell.

Hydrogen is generated on the cathode side. Oxygen is generated on the anode side.

DC Power is given from a Transformer Rectifier. Hydrogen and Oxygen thus generated in the Electrolyser along with Electrolyte are sent to Gas Separators, wherein the Gases are allowed to travel further and the liquid electrolyte is pumped back into the Electrolyser. The pressure of the system is raised to and maintained at the set pressure by means of regulating valve.

The positive pole of DC power is connected to the anode of the Electrolyzer, and the cathode of the Electrolyzer directly comes from a transformer.

The cathodic reaction is $4H_2O+4e \rightarrow 2H_2+4OH^-$

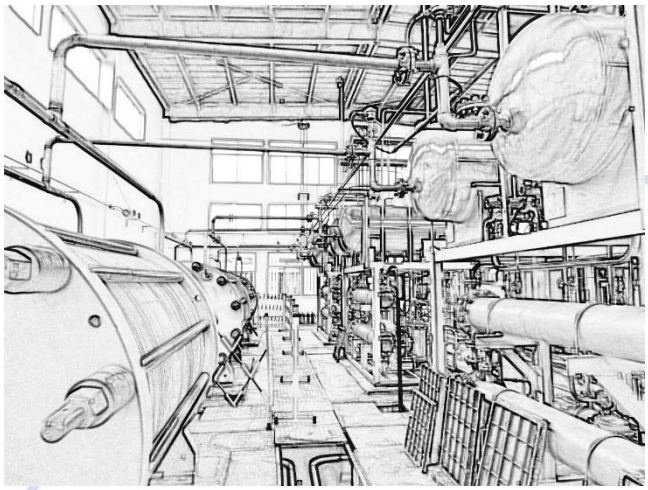
The anodic reaction is $4OH^- \rightarrow O_2+2H_2O+4e$

DM Water is continuously supplied by a Feed water pump which operates at the operating pressure of the system. This DM Water is used to generate the Hydrogen and is consumed @ about One liter per Nm3 of Hydrogen Generated.

The electrolyte at the bottom of hydrogen and oxygen separators is pumped back to Electrolyser after filtering and cooling, to complete one process cycle.

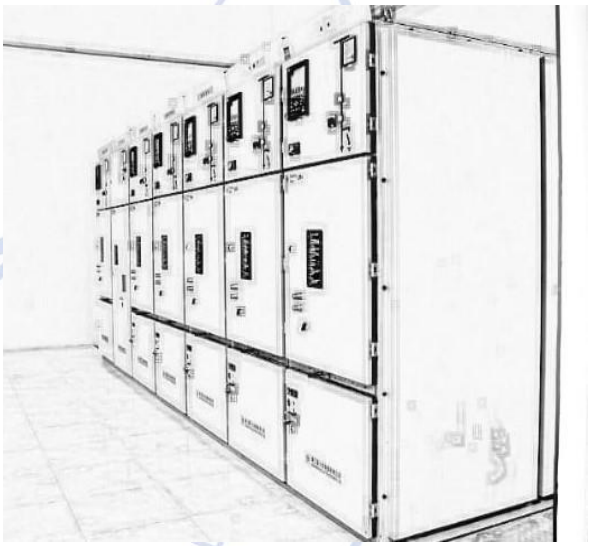
Process Description of the Pressurized Water Electrolysis System

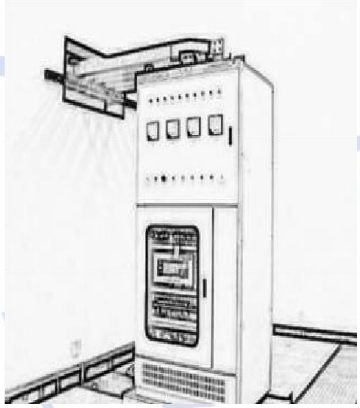
Hydrogen & oxygen generated in an Electrolyser mixed with electrolyte are sent to hydrogen and oxygen separators, where hydrogen and oxygen are separated with electrolyte due to gravity. Hydrogen and oxygen gases are allowed to pass through hydrogen and oxygen coolers separately and are cooled to the temperature of 30~40°C.



The hydrogen coming out of the Hydrogen separator is allowed to pass through a PD Deoxo unit and hydrogen dryer to remove its moisture and oxygen if the process needs dry and pure Hydrogen

Transformer & Rectifier - transformer changes the incoming AC voltage of 11 KV/33 KV/6.6 KV or 415- 440 V (as may be available at the site) to the low voltage value required. And Rectifier changes the Low AC Voltage to the desired DC Power. The positive pole of DC power is connected to the anode of the Electrolyser and the Negative to the cathode of the Electrolyser

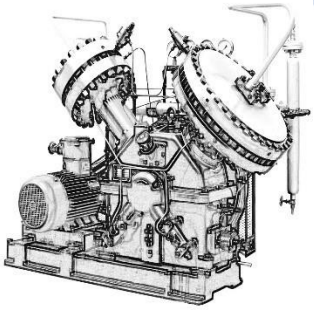




Power distribution panel (PMCC) is used to distribute incoming power to all electrical consumption points.

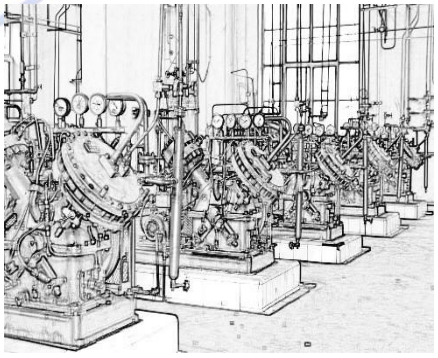
PMCC Controls and Operates all Electrical Load Motors through PLC

A PLC with HMI is used to operate and control the whole system which is completely Automatic complete system is provided with the desired instrument as per process for Level, Pressure, and Temperature.



Hydrogen Compressor

(Optional) – An Oil Free Diaphragm type Hydrogen compressor is used to boost the pressure of purified hydrogen to required pressure of 150 – 500 Bar G (as desired) for Cylinder filling. The booster Compressor is supplied with associated accessories, suction pot, hydrogen manifold etc.



ADVANTAGES - PRESSURISED WATER ELECTROLYSIS (BIPOLAR)

The SY GREEN ENERGY Hydrogen Generators have many Advantages over conventional obsolete Uni- Polar Design and they are:

Higher Working Pressure

- The Bipolar Electrolyser can be designed to work from 5 - 32 Bar G pressure and thus This reduces size of hydrogen storage tank and can eliminate booster compressor requirement.
- Large amount of hydrogen can be stored without using hydrogen compressor.

Lower Space Requirement (Lower Foot Print)

- As our System is pressure water electrolysis it does not require large area and It does not require any bulky hydrogen holders

- Electrolyser, Hydrogen and electrolyte treating equipment like separators, cooler, filter, demister etc. as well as the hydrogen purification equipment are mounted in one frame, so it occupies a less space and of course, save the area required to install the system.

Better material of construction and longer Equipment life

- The major equipment and internal skid piping is of Stainless Steel
- The Equipment is designed for 30 Bar g Pressure and for a longer life of 20 – 25 years

High-Level Automation makes it Reliable and Safe

- Whole system is automatically controlled with PLC.
- The PLC is designed as per system requirement.
- HMI is selected as per requirement
- The switch-over of dryers is also automatic.
- Customized solution is incorporated
- All parameters are controlled automatically through PLC, for example, working pressure, working temperature, pressure difference, liquid level, switch over of dryers, heating time of dryers etc., and all process measurements, alarming points and interlock points are linked to PLC to ensure guaranteed safety of the system.

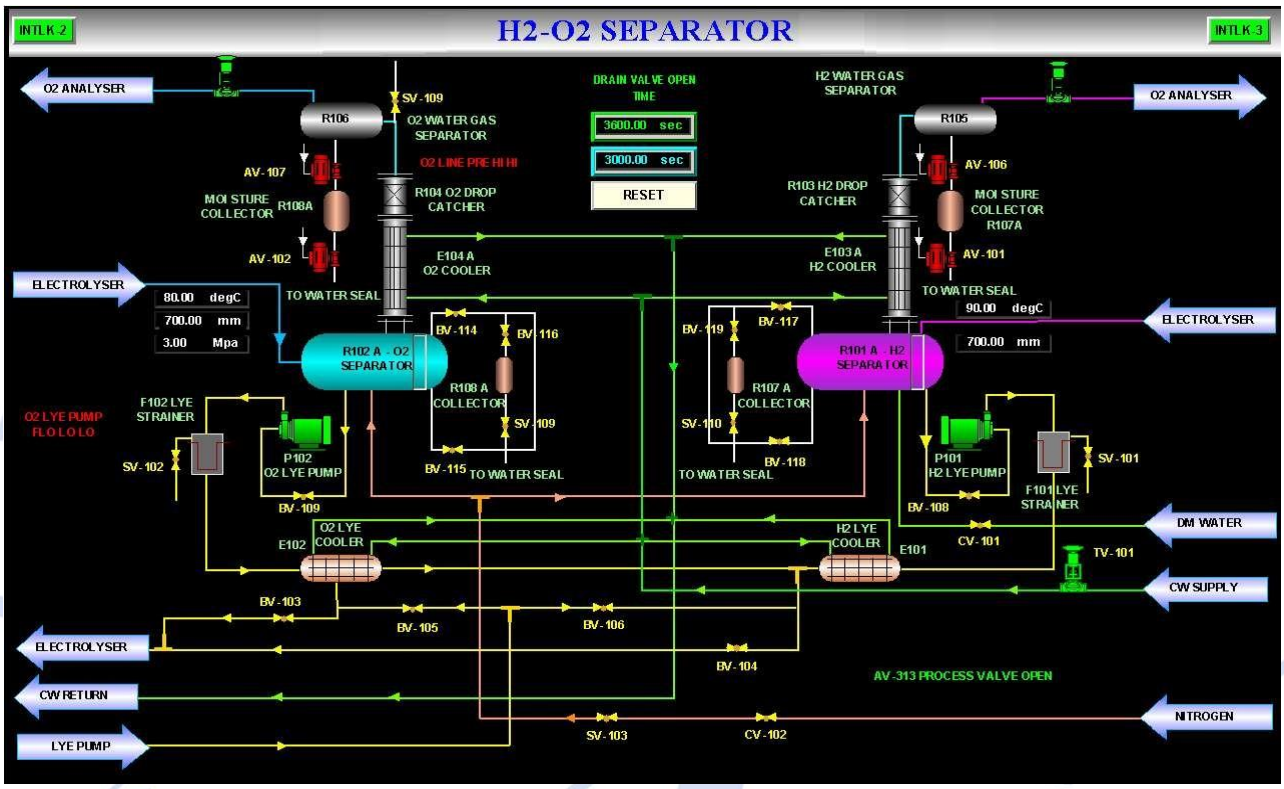
And Unipolar System Comes with following inherent Disadvantages

o Working life of system is only 3 to 5 years o Requires frequent maintenance.

- Material of construction is with Mild Steel, whereas the bipolar equipment comes with Ni plated steel or SS.
- It is out dated technology. All vendors across the world have stopped making this equipment except one in India.

CONTROL & OPERATION PHILOSOPHY OF THE SYSTEM

SY GREEN ENERGY PWE HYDROGEN GENERATOR is operated and controlled by P along with HMI. PLC/HMI can be User defined. The Third-party Communication is by Ethernet/Modbus. PLC controls the whole operation of the system and Can do the emergency stop/trip of the system.If the system major parameter are different then the required system immediately give audio visual alarm and would take corrective action as required.



- The system can be started by just switching on a switch or by one command through HMI.

- On a getting a Start Command the PLC checks the process variables of the system that must be within certain parameters before the program will execute and progress to a further phase.

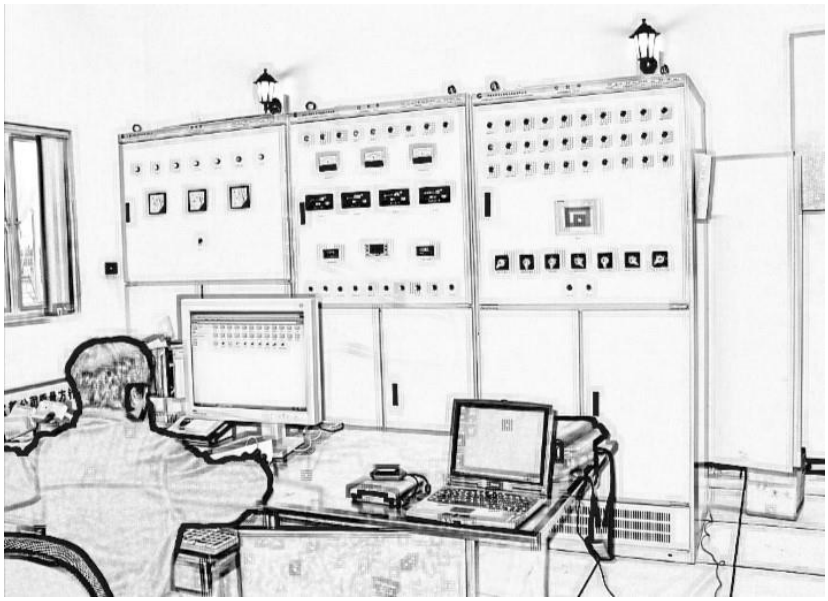
- The start-up conditions can also become shut down conditions, if a start-up condition fails during the normal operation of the unit and finds the basic parameters are not in order giving you the audio visual signal on the PLC.

- When the PLC is first started, its program performs a form of self-diagnostic checking, including its own power supply ,sub modules , networking , network traffic , execution speed , serial ports etc before any other operations can be initialized. Only after the self diagnostic is completed successfully the plc starts further function , in case of any issue an alarm will be generated, an operator can take corrective action. Once this is done , then the system is prepared to perform a Nitrogen Purge,

provided conditions are correct and system is required to perform nitrogen purge

CONTROL & OPERATION PHILOSOPHY OF THE SYSTEM

- Nitrogen is made available from a bank of few cylinder installed for purging and all are kept filled at regulated pressure ready for purging however with isolation valve closed which needed to be opened manually when ever nitrogen purging is required.
- Nitrogen purge is done if the plant was in shutdown condition for a long time This is in order to drive all the air from the system before hydrogen is permitted to enter. The program first checks what are called the Nitrogen Purge Start-Up Conditions i.e. the electrolyte levels, pressure and temperature are checked before the purge of the system can be started.
- The conditions for nitrogen purge are different to those of hydrogen production due to the difference in the gases. Once a specific volume of nitrogen, enough to entirely purge the system has entered, the system progresses to the next stage, of Hydrogen Production.
- Before hydrogen production can begin and send for further purification and consumption and storage or compression , the nitrogen in the system has to be replaced with hydrogen gas by process called the Hydrogen Purge.
- Once the hydrogen production is initialized and the purity required is achieved then the hydrogen is sent further to deoxo system for purification and then consumption or compression after meeting the process condition and parameters being in acceptable limits.



- •System then continues to operate all consecutive steps till the hydrogen compression is started unless some parameter is wrong and detected and the same would have an alarm generated for which corrective action is to be taken.

•During normal operation all the parameters are continuously monitored and recorded. parameters like pressure, temperature, electrolyte flow rate, electrolyte level, DM water quality , purity of gas at dryer exit is all recorded and ensured that the gas and the equipment does not goes off specifications. For all the above parameters the instruments are provided.

• System shut down can be performed whenever the plant is not needed to be operated. The shut down can be

♣ Normal shut down wherein you need to restart the system in a day or two.

♣ Emergency shutdown – due to fault generation or detected.

♣ Long shut down – wherein you do not need to use the plant for a longer time and then you need to purge out hydrogen from system and purge in nitrogen to keep it in safe shut down condition.

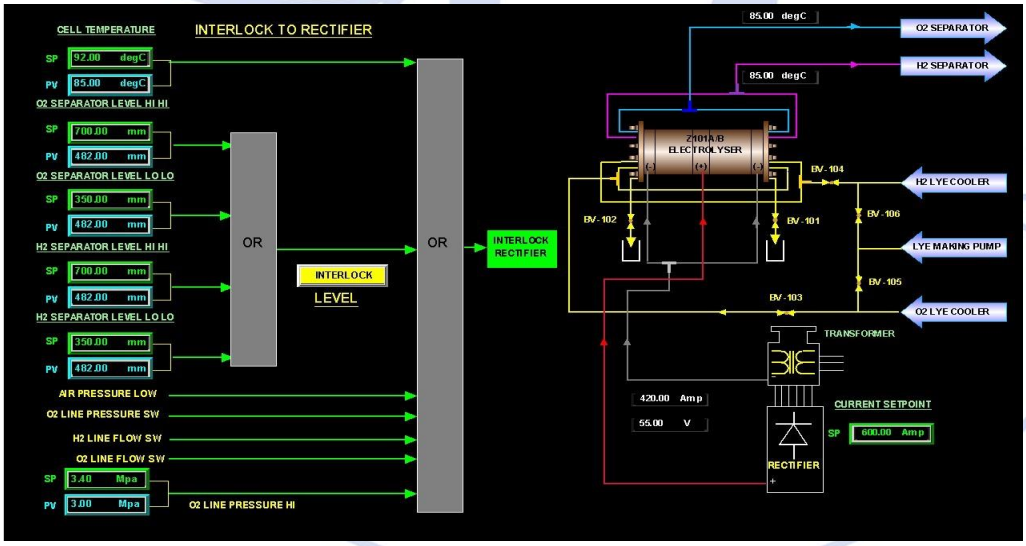
SAFETY FEATURES OF HYDROGEN PLANT

Hydrogen is a combustible gas, its combustion and explosive ranges are wide. In the air, its combustion and explosion ranges is 4.0~75 %(v/v) and 18.0~59%(v/v), in oxygen, they are 4.65~94% and 18.3~58.9%, the energy for firing is only 0.02mJ, the flame speed is 270cm/s.

So, for hydrogen, One has to be careful enough to ensure safety, and in so while manufacturing and designing of hydrogen equipment, we strictly obey all of the rules of concerned standards.

In order to meet the needs of explosion-proof, the system is designed according to the requirements of concerned standards for hazardous location. All Instruments in Hydrogen Generation area are explosion-proof (confirming to Group Gas IIC).In order to guarantee the safety of system, many alarming and interlocking points are installed.

Pressure control - In normal operation, the control system monitors the pressure value, compared it with the set values, once the measured value overpasses the set value, there will be a alarming signal to tell operator to tackle the problem. If the problem is not solved timely and the pressure increases



continuously, a signal come from the pressure transmitter on site will trip the rectifier to stop the generation of hydrogen. Consideration the reliability, the signals for alarming and interlocking come from different instruments .

Temperature control - The temperature control is very important and critical as well, the temperature are monitored by PLC, when the temperature overpasses the set value, it will alarm, when the temperature is higher than required, the control system will trip the rectifier.

Level control - The control system compares the measured values of hydrogen and oxygen liquid level in the separators with their set values, and operates the valves to maintain the level and gas generation , once the values are beyond of the set ranges, the control system will generate alarm to tell the operator to tackle the problems, if the problems are not solved timely, the rectifier will trip the system . This measurement and control is so important that if the level difference goes uncontrolled then it can result in explosion

Flow control of electrolyte : The System measures the flow of circulation electrolyte on electrolyte pipeline, when it is lower than the set value of minimum flow, the control system will raise alarm and trip the rectifier. This Flow measurement prevent the damage of electrolyser because of the rapid increase of electrolyser's temperature due to low electrolyte flow.

Control of the pressure of instrument air : Most of the actuators are actuated by instruments air, the air pressure must be higher enough to actuate the actuators, so, we monitor the pressure value of instruments air , when it is found lower than needed, the control system will give alarm.

Over high temperature protection of thyristor : Thyristor is the key part of rectifier, There is temperature measuring point and over high temperature alarming on every thyristor.

Protection of current overflow of rectifier **:** When the current output of rectifier overpasses the set upper value, it will be trip the input of transformer and thus this protection prevents the damage of rectifier caused by current overflow.

Phase lack protection of rectifier : When phase lack of input of rectifier occurs, rectifier will be tripped and the cut the input of transformer

Abnormal of gas purity / Composition -When the purities of hydrogen and oxygen are too low, control system will alarm and trip / stop the hydrogen generation system or supply of hydrogen to consumption point.

ENVIRONMENT PROTECTION – THIS SYSTEM DOES NOT GENERATE ANY CONTAMINANTS

Safety Data Sheet for Hydrogen

Common synonyms	:	None
Formula	:	H_2

Physical properties

Form	:	colorless gas
Stability	:	Stable, but highly flammable
Melting point	:	-259 deg C
Boiling point	:	-253 deg C
Critical temperature	:	-240 deg C
Flammability range	:	4% - 75% in air
Vapor density	:	0.0696 (air = 1)
Vapor pressure	:	(n/a at 20 C)
Auto ignition temperature	:	560 deg C
Molecular weight	:	2.016 grams/mole.
Density, in gaseous state	:	(1 bar, 15°C) 0.8481 kg/m3.
Evaporation heat(in sublimation point)	:	454.6 J/grams
Specific heating capacity	:	at 20 °C - 14.32 j/g
Heat conductivity factor	:	at 0 °C 1710 MV/cm

Principal hazards : Hydrogen is very flammable. It forms a potentially explosive mixture with air over a wide composition range (4%- 75% hydrogen by volume).

Stability : Stable, highly flammable, readily forms explosive mixtures with air. Upper composition limit (in most countries) for use of a nitrogen/hydrogen mixture in the open lab is 5.7% hydrogen.

Toxicology : Generally considered as safe, apart from the physical risks which arise from flammability.

Safety note : Inhalation of hydrogen is a dangerous practice in view of the possibility of explosive reaction of the hydrogenair mixture either outside or within the body, caused by static electricity discharge.

Safe handling : Wear safety glasses. Work in a well-ventilated area, preferably using a fume cupboard. Remove any source of ignition, such as naked flames or hot air guns, from the working area before starting.

Emergency : Eye & Skin contact : Unlikely to occur If inhaled : Hydrogen is not poisonous, but is an asphyxiant. Accidental inhalation of sufficient hydrogen to cause breathing problems is unlikely but if it occurs, remove the patient to fresh air. If breathing has stopped, immediately start artificial respiration and call for medical help.

Disposal : Small amounts of hydrogen can be allowed to disperse naturally, preferably through a fume cupboard.

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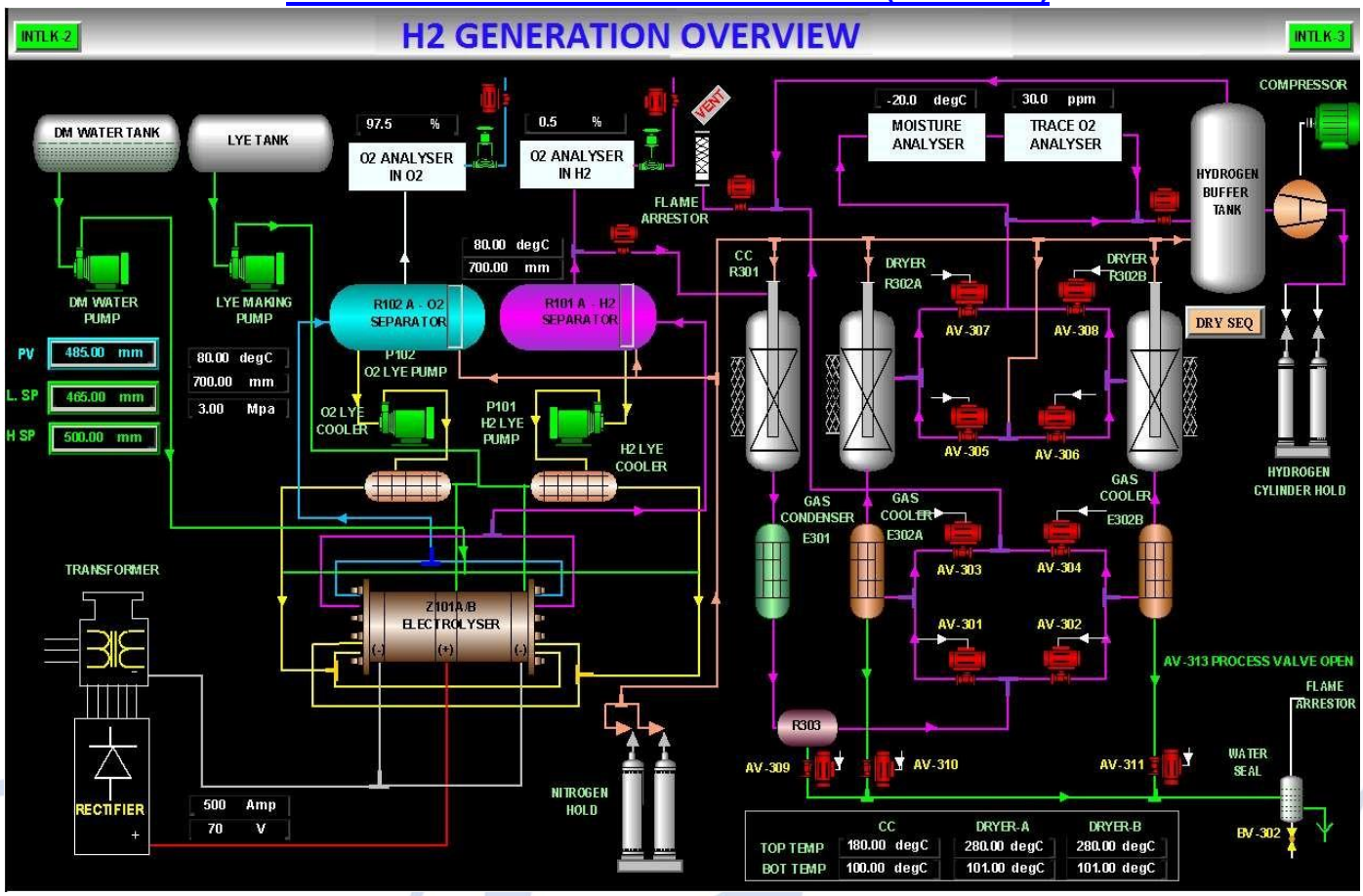
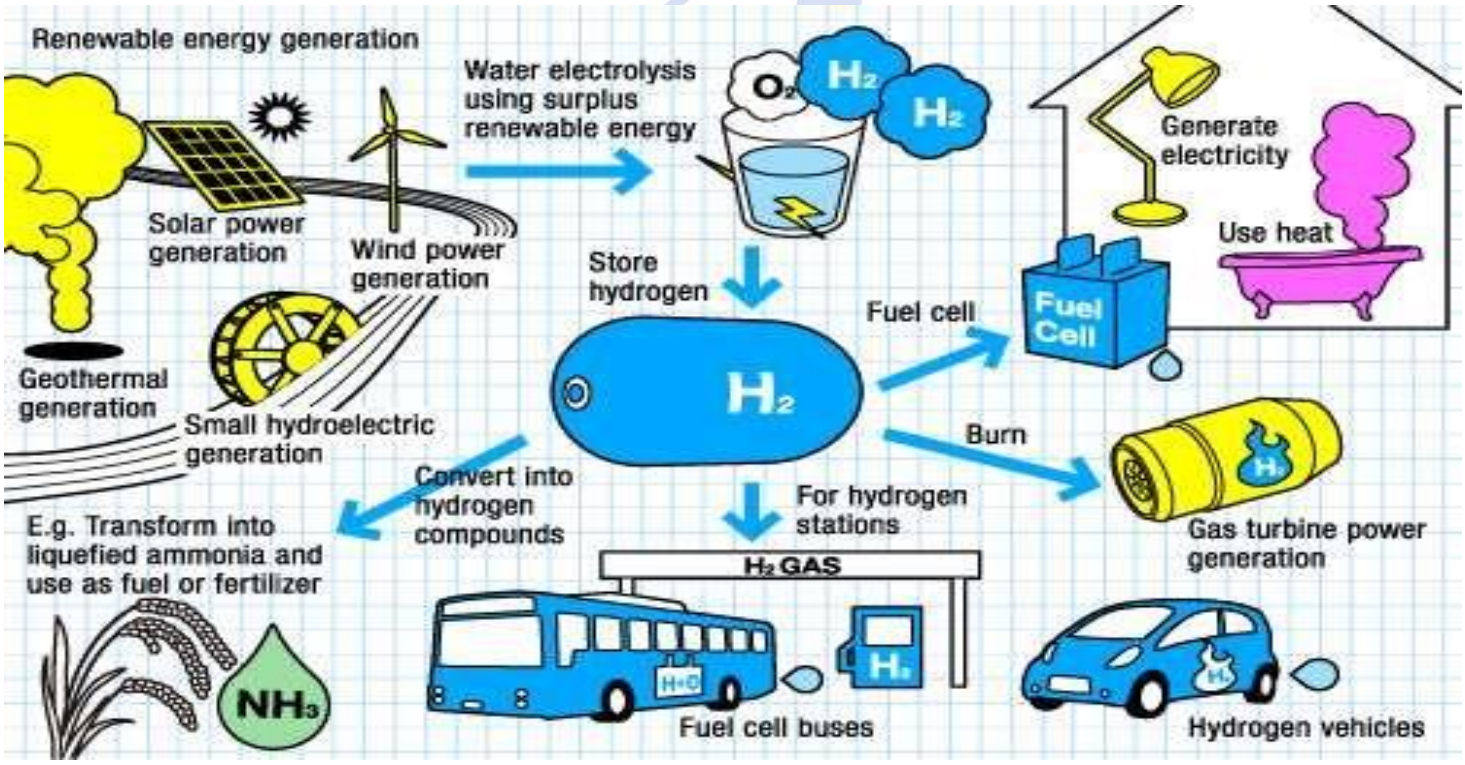


Scada Operation for SY GREEN ENERGY Hydrogen Generator by PLC

Applications Of Hydrogen



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Capacity offered	-	2 Nm^3/hour to 1000 Nm^3/hour
Power Consumption-Kw/Nm3 -		~ 4.6 to ~ 4.8 DC Power
Hydrogen Purity	-	99.8 % to 99.9998%
Dew Point	-	≤ - 40 ° C to ≤ - 70 ° C
Trace O_2	-	≤ 2 PPM to ≤ 5 PPM
Oxygen Purity	-	≥ 99.5%
Working Pressure	-	10 Bar G to 32 Bar G
Booster Compressor(Optional)	-	Offered for 150-500 Bar G

Model	Hydrogen Nm^3/Hour	Oxygen Nm^3/Hour	Connected Power KVA	DM Water Liters / Hrs
SYG002	2	1	16	2
SYG005	5	2.5	40	5
SYG007	7	3.5	56	7
SYG010	10	5	80	10
SYG012	12	6	96	12
SYG015	15	7.5	120	15
SYG020	20	10	160	20
SYG025	25	12.5	200	25
SYG030	30	15	240	30
SYG040	40	20	320	40
SYG050	50	25	400	50
SYG060	60	30	480	60
SYG075	75	37.5	600	75
SYG090	90	45	720	90
SYG100	100	50	800	100
SYG125	125	62.5	1000	125
SYG150	150	75	1200	150
SYG180	180	90	1440	180
SYG200	200	100	1600	200
SYG250	250	125	2000	250
SYG300	300	150	2400	300
SYG400	400	200	3200	400
SYG500	500	250	4000	500

The capacity shown here is of standard Models.

We can design and manufacture any Capacity as per user requirements.

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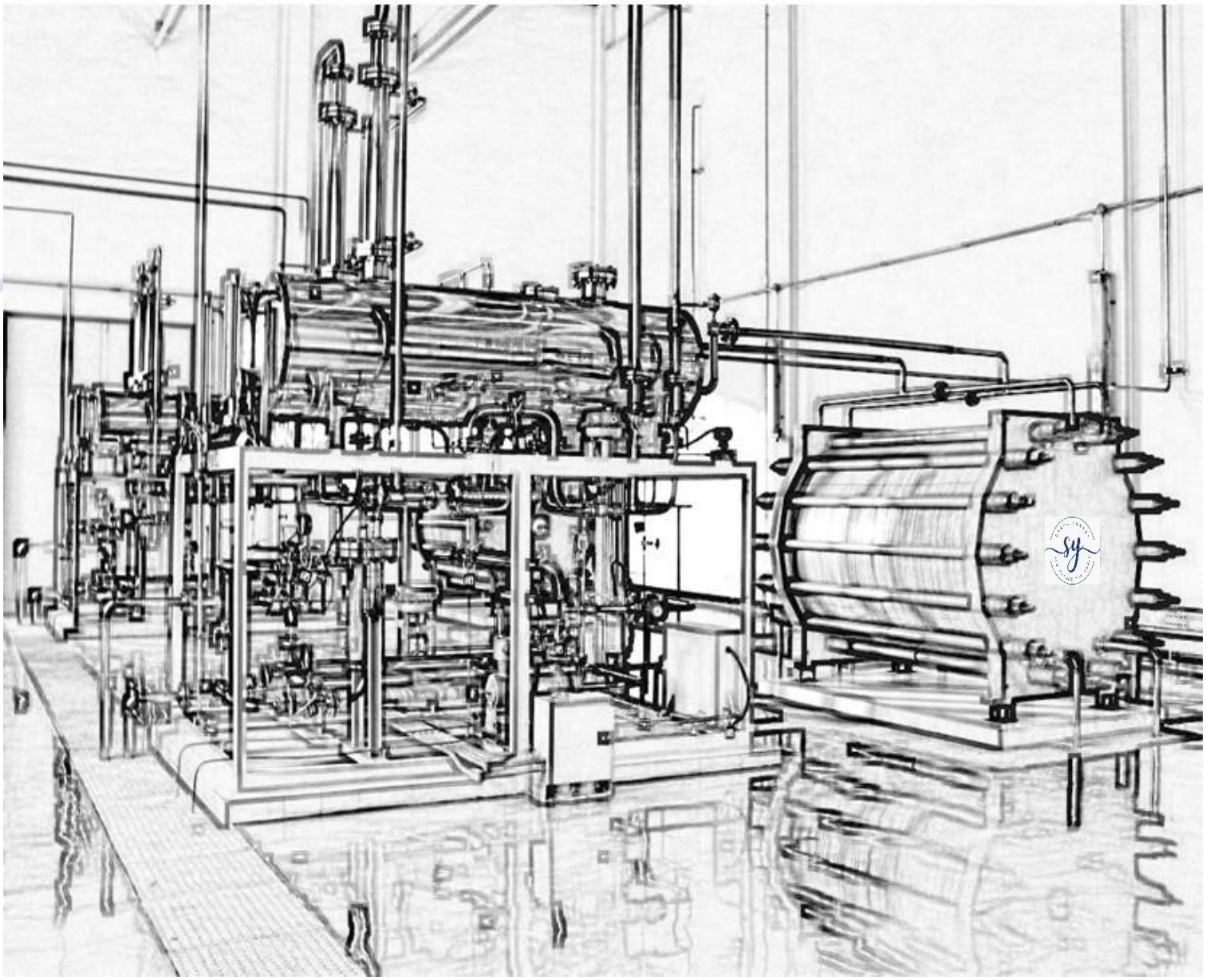

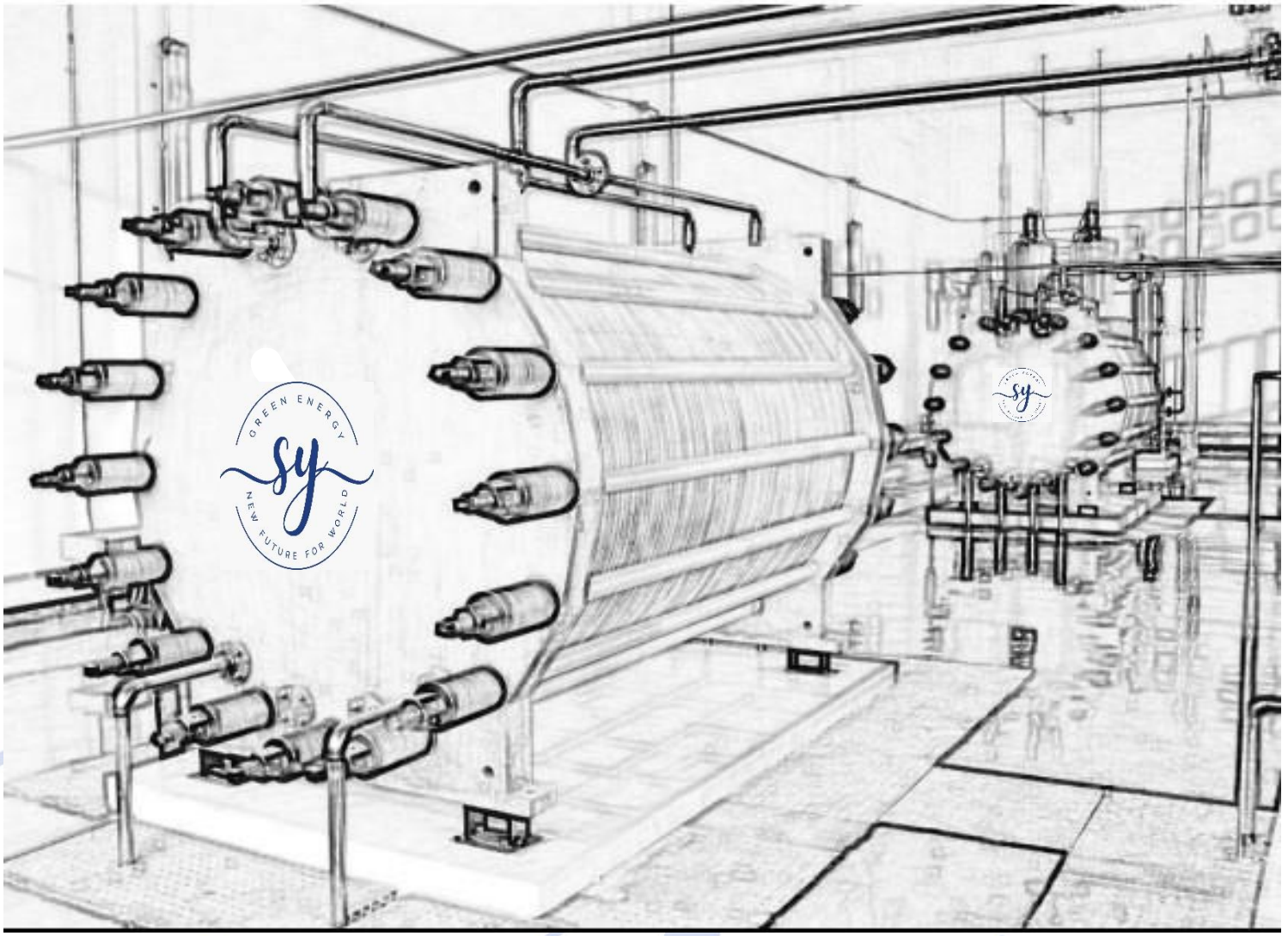

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