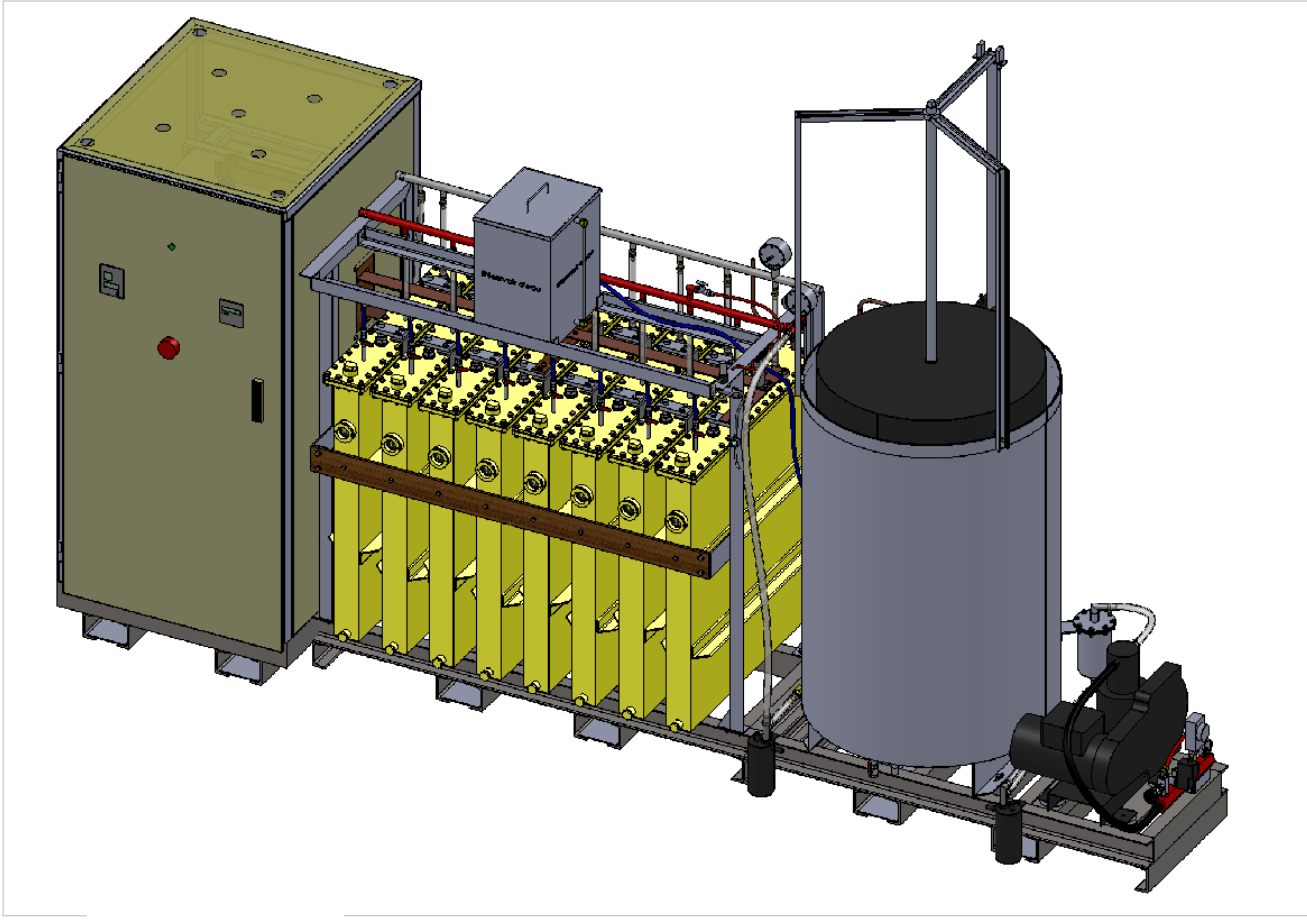
TECHNICAL SPECIFICATIONS

FOR AN ELECTROLYTIC HYDROGEN

GENERATOR TYPE M 5000



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SIRET 394 538 573 00012 – APE 2829 B – S.A.S. au capital de 376 229 €

SUMMARY

1 - MAIN OPERATING PRINCIPLE

1.1 ELECTROLYZER OPERATION

Regardless of the size of the GIP™ cell, the operating principle stays the same.

A single pole cathode makes up the carbon steel tank of the cell for the hydrogen generation.
A positive nickel plated carbon steel anode electrode for the generation of oxygen.

Each cell is serial connected to a current rectifier by the routing of a set of red copper bars 60 mm x 5 mm.

The hydrogen generated on the cathode is carried to the gas holder through pipes and a main manifold made of carbon steel. When the gas holder is filled with hydrogen, the compressor is started up automatically to fill the storage tank (high pressure).

When the gas holder is empty, the level detector stops the compressor until the gas holder is filled once again or on demand of pressurization from the high pressure tank.

When the storage tank is full, the rectifier that supplies the electrolysis cells with current stops automatically.

The checking system is identified by the choice of an automated assembly offering the best quality and safety standards.

To ensure the correct operation of the electrolyzer, the cell requires topping up with demineralized water every day. The demineralized water is stored in a 15-liter tank.

The hydrogen pressure at the outlet of the high pressure tank may be controlled by a pressure reducing valve.

1.2 PRINCIPLE DIAGRAM OF ELECTROLYZER

See diagram in annex N° 1.

1.3 OPERATION OF A GIP™ SINGLE-POLE CELL

The GIP™ unipolar cell is based on our service and experience since 1920 as shown on the process diagram.

Diagram of a single-electrode and single-pole GIP™ electrolyzer

A:	Tank cathode electrode (-)	F:	Anode current supply bar
B:	Anode electrode (+)	H:	Hydrogen outlet
D:	Oxygen gas holder	O:	Oxygen outlet
E:	Gas separator diaphragm		

Electrolytic solution to product high purity hydrogen and oxygen is using a solution of caustic potash purity 90% (free of iron and chlorine) and mineral or de-ionized water at a density of 1.275g.

The passing of a direct continuous current through electrolyte using GIP design electrodes dissociates it into its two elements to the ratio of:

One (1) volume of oxygen on anode (+)
Two (2) volumes of hydrogen on cathode (-)

To keep oxygen and hydrogen separated, a diaphragm is placed between anode and cathode.

In the gas holder, gas purities are greater than or equal to 99.9% for hydrogen and 99.7% for oxygen.

1.4 ADVANTAGES OF A GIP™ SINGLE-POLE CELL

a) Higher production reliability minimizing downtown
b) Higher maintenance design (less than two (2) hours) to replace a cell
c) Instant start up
d) Equipment skid mounted for easy installation
e) Higher cell shelf life more than 20 years
f) Competitive price and economical production cost
g) Higher safety explosion-proof design conforms with the customer country norms and training packages

2 - DESIGN OF EQUIPMENT

2.1 DESCRIPTION

NO.	QUANTITY	DESIGNATION
1	1	DC rectifier 36V-1250A (set at 900A)
2	1	Single pole electrolyser made up of 13 electrolysis cells 1000A type M26
3	1	Cylindrical gas holder with level detectors for 1000 liters of hydrogen
4	1	Raw water treatment system
5	1	PVC demineralized water tank, 50-liter capacity
6	2	Liquid drain trap at inlet and outlet of gas holder
7	1	Single stage explosion proof ATEX hydrogen certified safety compressor
8	1	Hydrogen safety relief valve
9	1	Non-return valve
10	1	Hydrogen explosion proof pressure switch ATEX certified
11	1	Hydrogen discharge solenoid valve ATEX certified
12	1	Hydrogen storage tank, 2000-liter water capacity, 7-bar working pressure (100 psi) including safety relief valve, isolating valve, pressure indicator
13	1	Draw-off panel including reducing valve for filling up balloons
14	1800 liters	Electrolyte mixture
15	1	On line analyzer for measuring the concentration of oxygen in hydrogen

2.2 ASSEMBLY AND LAYOUT DRAWING

See drawing in annexes N° 2 & 3

2.3 TECHNICAL SPECIFICATIONS

ITEM	DESIGNATION	SPECIFICATIONS
1	HYDROGEN GENERATOR	
1.1	Hydrogen flow rate at atm. pressure	5.1 Nm^3/hour (5100 Liters/hour)
1.2	Hydrogen pressure in gas holder	5 mbar mini / 8 mbar maxi
1.3	Temperature at gas holder outlet	65°C max
1.4	Hydrogen storage pressure	7 bars
1.5	Hydrogen storage volume	14 m^3
1.6	Hydrogen purity	99.9% at 20°C ambient temperature
1.7	Operating environment	0 to 50°C
1.8	Cooling system	Natural air
1.9	Monitoring system	Fully automatic and static

2	UTILITIES	
2.1	Standard electrical power supply	400 VAC -10%/+15 % Three Phase 50/60 Hz +/-2 % (230 Vac single phase available on demand
2.2	Input current on cell	900A
2.3	Input voltage on cell	2.3 – 2.5 VDC per cell
2.4	Electricity consumption	Std 42 kVA – Max 54.5 kVA – Mini 38.5 kVA
2.5	Water consumption	1 liter of water per m^3 of hydrogen produced
2.6	Required quality of water	Raw water, sea water not allowed – pressure minimum 0.5 barg
3	HYDROGEN GENERATOR CONFIGURATION	
3.1	Electrolyzer	13 GIP™ monopolar cells type M26 serial connected
3.2	Rectifier	Type MICROSWITCH – MIS 108 – Regulation by IGBT
3.3	Gas holder	Type 1000L – equipped by 4 limit switches - ATEXagréé H2
3.4	compressor	Type NV 17 K – single stage - ATEX certified H2
3.5	Size (L x W x H)	3350 x 1000 x 2000 mm
3.6	Weight	3800 Kg.
4	HYDROGEN GENERATOR OPERATING ENVIRONMENT	
4.1	Ambient relative humidity	0 – 100 %
4.2	Altitude range	Sea level to 1000 m
4.3	Ambient air temperature range	0 to 50 °C
4.4	Stress and climatic conditions	Tropical – saline atmosphere
4.5	Operating Conditions	Indoor

2.4 MAINS ADVANTAGES

- Instantaneous hydrogen production starting
- Hydrogen production adjustable from 0 to 100%
- Fully static starting / stopping system
- Automatic restart of the system after a mains cutoff
- Control system fully electronic
- 24 hours a day unattended operation
- Continuous hydrogen analysis interlocked with the system
- Automatic demineralized water filling system
- Alarm report terminal
- Audible warning for alarm
- Skid frame mounted offering:
  - Low space requirement
  - Quick and easy installation
- Low maintenance
- Electrolysis cells lifetime 30 years
- Explosion proof and tropicalized

2.5 LINK, CONNECTION AND TRANSFER

Connection and network connection of water

The connection of the water circuit of the generator to the connection point of the building is carried out by flexible connection ø12 mm.
The water supply of the building must be equipped with a ball valve (1/4 turn) and a male thread 1/2 "BSP.

Gas connection and network connection

The gas connection from the generator to the storage tank and from the storage tank to the draw off panel is performed by connecting copper pipes ø14 mm. The connection is made by brass union with olive

The gas filling connection table to balloon inflation device is provided by flexible antistatic ø 8 mm

The draw off panel is provided with a pressure regulator / flow (P 2 bars / Q: 120 m3 / h)

3 - MAINTENANCE

3.1 SPARE PARTS FOR A THREE YEAR OPERATION

The set of spare parts listed below is proposed as optional. This set ensures operation of the equipment for a period of 3 years.

NO.	QUANTITY	SPARE PARTS LIST FOR 3 YEARS
1.	ELECTROLYZER	
1.1	13	EPDM rectangular cell bell seal
1.2	65	EPDM : 2 diaphragm bell seal, 2 cell cover seal, 1 O2 outlet tube seal
1.3	26	PTFE insulator : Diaphragm Bell/Cell cover
1.4	39	PTFE Cell cover insulator
1.5	13	EPDM drain plug seal
1.6	1	EPDM demister seal
1.7	13	EPDM filling plug seal
1.8	13	Level gauge glass
1.9	26	PTFE/EPDM level gauge glass seal
2.0	1	Alumina load cartridge for particle filter
2.	CURRENT RECTIFIER	
2.1	1	CI regulator (MS-DEC 1021 G3)
2.2	1	CI Power supply (MS ALIM 1028 F1)
2.3	1	CI driver (IGBT SKHI 22A GM)
2.4	1	Primary bridge (SKD 82-16)
2.5	1	IGBT (SKM 50GB 123)
2.6	3	Ventilator
2.7	1	Vigitherm 85°C
2.8	1	Vigitherm 105°C
3.	GAS HOLDER	
3.1	1	Level contact
4.	DEMINERALIZED WATER UNIT	
4.1	1	Resin refill
5.	HYDROGEN COMPRESSOR	
5.1	1	Set of seal / gaskets
5.2	1	Set of 4 valves
5.3	1	Valve box
5.4	2 litres	Compressor oil

3.2 DAILY CHECKS

NO.	DAILY CHECK	FREQUENCY
1	Level of electrolyte in cell	1
2	Check of oxygen content in hydrogen	1
3	Check the water level in the drain vats of the gas holder	1
Note	During checks or measurements, the electrolyzer does not have to be stopped	

3.3 PREVENTIVE MAINTENANCE

NO.	PREVENTIVE MAINTENANCE	FREQUENCY
1	Drain the hydrogen compressor oil	12 months
2	Replacement of the alumina load in the particle filter	12 months
3	Replacement of the resin in the water treatment system	12 months
4	Greasing of the central guide of the gas holder	12 months

Note

The spare parts list and timetable for checks and maintenance have been drawn up on the basis of operation of the unit at 8,000 hours per year.

The tooling required for the commissioning and maintenance of the equipment is included in the scope of supply.

4 - SAFETY

4.1 SAFETY OF EQUIPMENT

- A hydraulic safety valve is fitted at the inlet and outlet of the gas holder in order to protect the cells against any over pressure in the generator.

- The generator is equipped as standard with an oxygen analyzer ensuring supervision of good functioning of cells.

- The hydrogen compressor is provided with a safety valve set at 8 bar preventing any risk of over-pressurization of the compression head and casing.

- The high pressure circuit is protected by a safety valve set at 1 bar above the nominal pressure storage.

- Automatic production stop in the event of production failure and signaling alarm alert local and distance (300 m) if:
- O2 concentration ≥ 1% in H2
- Failure of compressor operation (FDC TH on gasometer)

- emergency stop device production

4.2 REGULATION

4.2.1Conformity

The entire system complies with European standards for explosive atmosphere. (See table below standards applied)

ITEM	DESIGNATION	CONTROL	DOCUMENTS	STANDARD OR NORM
0	Hydrogen Generator	Manufacturing	International standard	ISO 22 734 - 1
1	Current rectifier	Manufacturer test	Test records	Standard Supplier
		EC Compliance	Declaration of conformity	E.M.C 2004/108/CE L.V. 2006/95/CE
2	Electrolytic cell vat	Matter	Matter certificate	Standard upplier
		Welding and conformity	Visual welding and conformance certificate	SAGIM Standard
		Tightness	Testing Penetrant certificate	SAGIM Standard

		Tightness	Tightness control certificate	SAGIM Standard
		Welding	Welder qualification certificate	NF EN 287-1 : 2004
3	Complete electrolytic cell	Cell mounting conformity	Step control list to be performed	SAGIM Standard
4	Gas holder 1000 liters	Conformity and operating test	Conformance certificate and	SAGIM Standard
		Tightness	Tightness control certificate	SAGIM Standard
		Welding	Welder qualification certificate	NF EN 287-1 : 2004
5	Compressor	Specifications, performance and operating	Specifications, performance and operating certificate	SAGIM Standard
			Test Certificate	Standard Supplier
		EC Compliance	Declaration of conformity	NFL 00.015
6	Compressor motor	EC Compliance	Declaration of conformity	PTB 10-ATEX-1028 X
7	M 5000 Assembling	Assembling conformity	Step control list to be performed	SAGIM Standard
8	Limit switch for gas holder	EC Compliance	Declaration of conformity	ATEX + 94/9/CE
9	Solenoid valve for discharge compressor	EC Compliance	Declaration of conformity	LCIE 03 ATEX 6451 X/04 LCIE 02 ATEX
10	Pressure switch	EC Compliance	Declaration of conformity	ATEX + 94/9/CE Standard
11	Analyzer O2 in H2 content	Calibration and test	Calibration and test certificate	SAGIM Standard
12	Oxygen pipe	Degreasing	Degreasing certificate	SAGIM Standard
13	M 5000 generator	Painting specicication	Specification painting certificate	SAGIM Standard
14	Packaging	Shipping identification marks	Packaging control certificate	SAGIM Standard
15	Storage tank	Trial test	Trial test certificate	PED (DESP) 97/23/CE + Decree N° 99-1046 of 13/12/1999
16	M 5000 generator	Factory acceptance	Factory Acceptance Test Certificate (FAT)	SAGIM Standard according to „Trial test

4.2.2 Agreements and certifications

The Electrolytic hydrogen generator type M serial 5000 complies with the international standard ISO 22734-1dated 01/07/2008 building on hydrogen generators using the water electrolysis process; Part 1: Industrial and commercial applications

All electrical components comply with the Low Voltage Directive 2006/95/EC of 12/12/1995, the Electromagnetic Compatibility Directive 2004/108/EC of 15/012/2004 and the ATEX Directive 94/9/EC of 23/04/1994

All pressurized components comply with the European Directive 97/23/EC of 29.05.1997, the legislation of the Member State of the European Union, on the transposition of EU directives above Decree n ° French State 991046 of 13.12.1999 and that the regulations defined by Annex I of the European Directive

4.3 ELECTROMAGNETIC COMPATIBILITY (EMC)

All constraints of EMC have been taken into account for all electrical components constituting the electrolytic hydrogen generator.

All metal parts constituting the electrolytic hydrogen generator, a storage tank, and draw off panel as well as copper pipes link are ground connected.

Para arrester installed at the head of the line shall protect against lightning protection, the general power of hydrogen generation system and its additional components.
The possible establishment of a system of prevention / lightning detection, lightning or any other device for protection against lightning is not included in the supply and remains, therefore, the responsibility of the operator

4.4 USER AND TRAINING MANUAL

A technical and detailed manual is provided in duplicate with the equipment. This manual includes the following parts:

Various installation instructions, storage and security

- Procedures for the first start, daily start and start following maintenance or an extended shutdown

Procedures relating to routine maintenance

Various site plans, components and maintenance support

various electrical drawings and diagrams

Scheme detailed process

Etc.

5 - CUSTOMER SERVICE

5.1 INSTALLATION AND SERVICE ON SITE

5.1.1 Services included

The installation, preliminary testing and performance, safety check and a specialist engineer SAGIM provides final commissioning of the hydrogen production unit.

The estimated delivery time is 8 calendar days and is distributed as follows:

- 2 days for the return trip

- 5 working days on site (based on 8 hours per day) for the installation, startup and commissioning of equipment including:

- Positioning of electrolytic hydrogen generator, the storage tanks 3 and table racking

- The completion of the copper piping, installation and connection of various devices

- The electrical connection of the hydrogen generator

- Preliminary, intermediate and final tests

- The leak testing

- The final commissioning of the system

- 1 day training staff in charge of the generator.

5.1.2 Exclusions

A client performs the operations described below, namely:

- The transport and handling of equipment from the storage area to the client hydrogen building

- The positioning of equipment in their location in the building of hydrogen

- Devices for grounding the building hydrogen

- The connection to grounding of all metal parts as metal doors, metal frames included in the construction of the building and the hydrogen generator frame hydrogen

- The supply of the power supply cable of the hydrogen and the connection of the latter unit in the three phase power Client

- The installation of gutters drain:
Water from the overflow drain pots gasometer
To purge the "overflow" of the tank gasometer
Points purge compressor output filters

- The remuneration of local staff to support the handling and installation of equipment

6 - QUALITY INSURANCE

All our services, beginning with the order and following through to the commissioning of our installations at Customers' as well as the development stage, production, installation and after-sales service at Customer are **ISO 9001-ed: 2015** quality certified.

QUALITY SYSTEM CERTIFICATION
DNV·GL
ISO 9001

COMPANY WITH QUALITY SYSTEM CERTIFIED BY DNV GL = ISO 9001 =

DNV·GL

MANAGEMENT SYSTEM CERTIFICATE

Certificat N°:/Certificate No.:
77577-2010-AQ-FRA-COFRAC Rev.5

Certificat valable depuis le/Initial date:
15 janvier 1993

Dates de validité:/Valid:
21 mai 2019 - 01 juin 2022

Ceci certifie que le système de management de la société /This is to certify that the management system of

SAGIM
35, Rue Scheurer-Kestner, 42000, Saint-Etienne, France

a été jugé conforme à la norme de système de management de la Qualité /
has been found to conform to the Quality Management System standard:
ISO 9001:2015

La validité de ce certificat couvre les produits ou services suivants :

Conception, fabrication, vente et mise en service d'appareils de génération d'hydrogène. Prestation de formation et support technique aux clients. Négoce de consommables et accessoires météorologiques.

This certificate is valid for the following scope:

Design, manufacturing, sale and commissioning of equipments for generating hydrogen. Providing training and technical support to customers. Trading meteorological consumables and accessories.

Lieu et date/Place and date:
Genas, 22 mai 2019

cofrac
CERTIFICATION DE SYSTEMES DE MANAGEMENT
ACCREDITATION
N°4 – 0009

Pour l'Organisme de Certification /
For the Certification Body
DNV GL - Business Assurance
Parc Everest, 54 Rue Marcel Dassault, 69740, Genas, France

Estelle Mallier
Représentante de la Direction /
Management Representative

Le non-respect des conditions énoncées dans l'accord de certification peut rendre ce certificat invalide/
Lack of fulfilment of conditions as set out in the Certification Agreement may render this Certificate invalid.
Organisme accrédité: DNV GL Business Assurance France, Parc Everest, 54 Rue Marcel Dassault,69740, Genas, France.
TEL: +33 (0)4 78 90 91 40. www.dnvgl.fr/certification

7 - TRAINING ON SITE

At the end of the installation and commissioning of the system, training is provided to enable staff to ensure the operation and routine maintenance of the system, namely:

- Use and supply of the system
- Monitoring and verification of the system
- Management of alarms and vents
- Safety procedures
- Periodical operations & maintenance

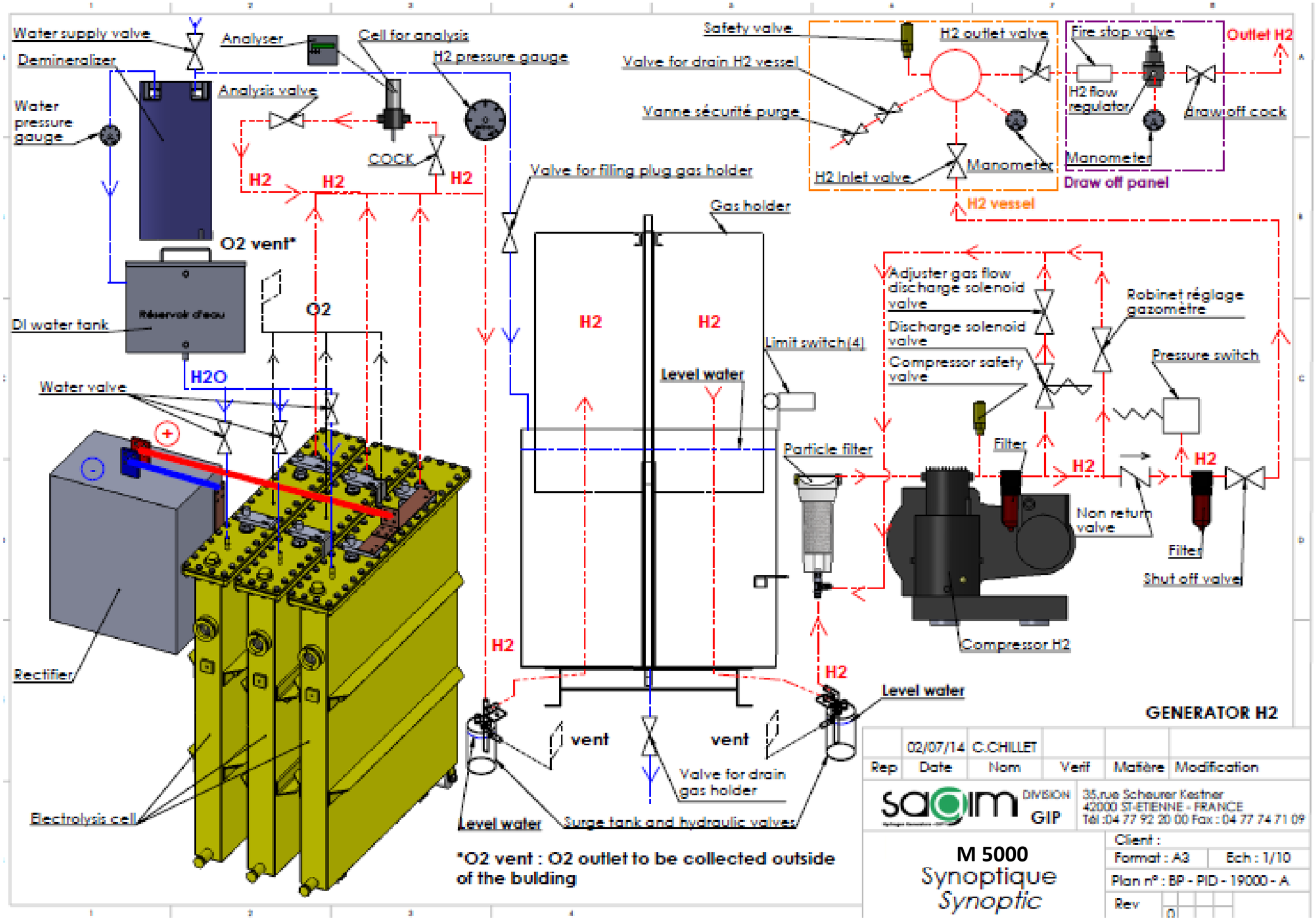
It is held up on one day according to the following program:

A. Introduction to the Company
B. Description and operating principle of generator
C. Generator layout
D. Safety, gas, installation instructions
E. Design of a hydrogen generator
F. Role of the current rectifier
G. Role of the electrolyzer
H. Design of an electrolytic cell and role
    a. Anode
    b. Cathode
    c. Diaphragm
    d. Electrolyte
    e. Electrical insulation
I. Design of the current rectifier
J. Design of electrolyzer
K. Purity of hydrogen
L. Role of analyzer
M. Design of analyzer
N. Calibration of analyzer
O. Preparation of unit before start up
P. Practice
Q. Commissioning
R. 1st time start up of unit
S. Operation of unit
T. Periodical operations
U. Handling and start up of unit by trainees
V. Maintenance of the plant
W. Breakdowns, causes and remedies
X. Troubleshooting of unit by trainees
Y. Different questions
Z. Written examination

8 – ANNEX

- ANNEX N°1: Process Diagram
- ANNEX N°2: General Layout Drawing
- ANNEX N°3: General Assembly Drawing

ANNEX N°1 : M 5000 PROCESS DIAGRAM



ANNEX N° 2 : M 5000 GENERAL LAYOUT DRAWING

TO BE DEFINED

ANNEX N° 3 : M 5000 GENERAL ASSEMBLY DRAWING

TO BE DEFINED