THALESNano

H-Genie® - High Pressure Hydrogen Generator

User Manual

H-Genie-1.7

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1. General Description

1.1 Introduction

The use of hydrogen gas in chemistry is limited due to the hazards associated with utilizing compressed gas cylinders. The H-Genie® is designed to overcome these hazards, but also help the chemist in their chemistry too.

The main features include:

- On-demand generation of 4.0 purity hydrogen (at 100 bar) from water to make use of hydrogen gas safer.
- A pressure range of 1-100 bar (14.5-1450 psi) to expand your chemistry capabilities.
- Hydrogen consumption monitoring abilities

An accurate gas flow-rate range of 100-1000 NmL/min for connection with flow reactors and to log how much hydrogen is consumed during a reaction.

1.2 H-Genie® System Overview

The H-Genie® high pressure hydrogen generator works by generating hydrogen gas up to 4.0 purity from deionized water using a patented electrolytic cell. The hydrogen gas is dried through a two-stage water separation system, mechanical separation and thermal separation. The water removed is then drained through an external vent. The now dry hydrogen gas enters the mass flow controller (MFC), which controls precisely the flow rate of hydrogen out of the H-Genie® between 100 and 1000 NmL/min. The H-Genie® generates hydrogen gas to the required pressure (up to 100 bar) by continuously generating hydrogen until this pressure is reached. In flow mode, it will do this internally first, before releasing the hydrogen at the set pressure. The H-Genie® will then continuously generate hydrogen to maintain that pressure.

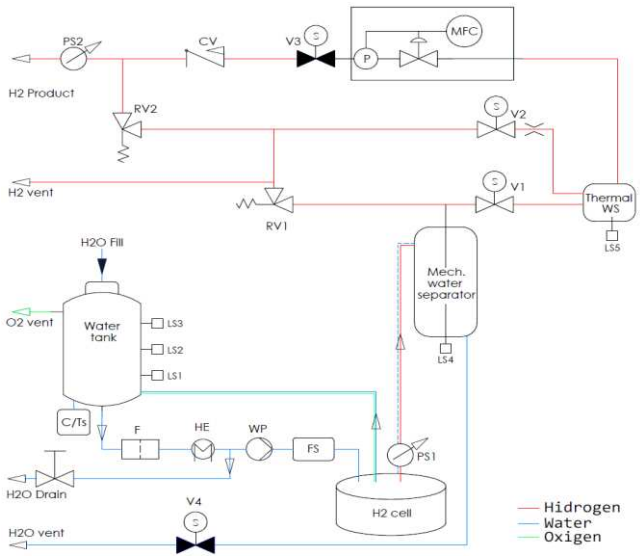

Figure 1: Schematic design of the H-Genie®

2. Overview of Parts

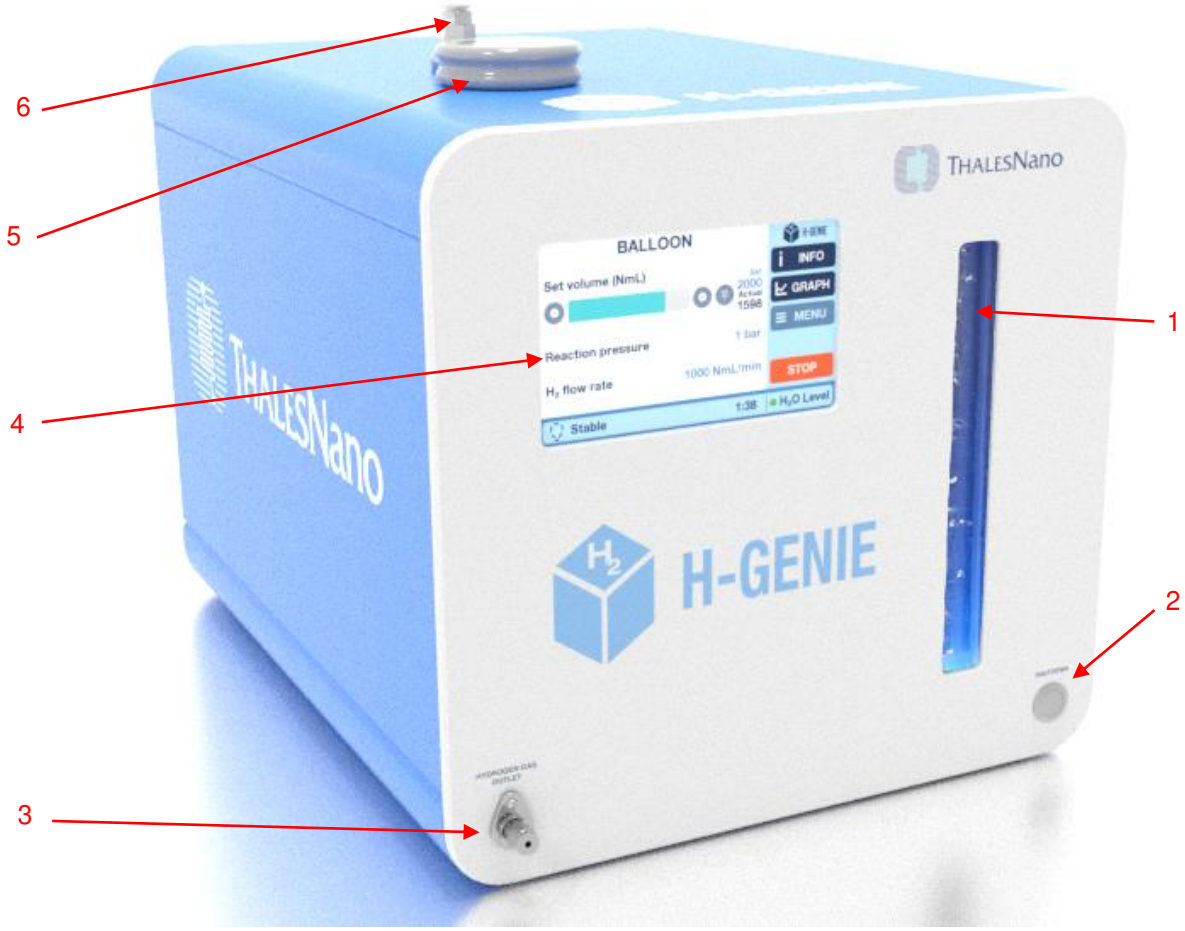

Figure 2: Front view of H-Genie®

1. Air bubble tank decoration
2. Shutdown button
3. Hydrogen gas outlet
4. Touch-screen
5. Water tank cap
6. Oxygen gas outlet

Figure 3: Rear view of H-Genie®

7. USB port
8. Hydrogen vent
9. Main ON/OFF switch
10. Power cable socket
11. Fuse sockets
12. Cooling vent (1 of 3)
13. External CAN connector sockets (for service purposes only; max cable length 3m)
14. Water drain outlet
15. Water vent from the mechanical water separator
16. Water drain open-close hand operated ball valve (horizontally-opened, vertically-closed)
17. RS-232 remote port (NON-DECOUPLED, max cable length 3m, user is recommended to use the THSE purchased optical isolator to function-contact THSE for details)
18. Emergency Stop button connector socket (must use original THSE device)

2.1 Touch-screen Interface

The touch-screen interface consists of a series of windows that enable you to manually control all aspects of operation.

After turning on the equipment, the main window features a number of different options.

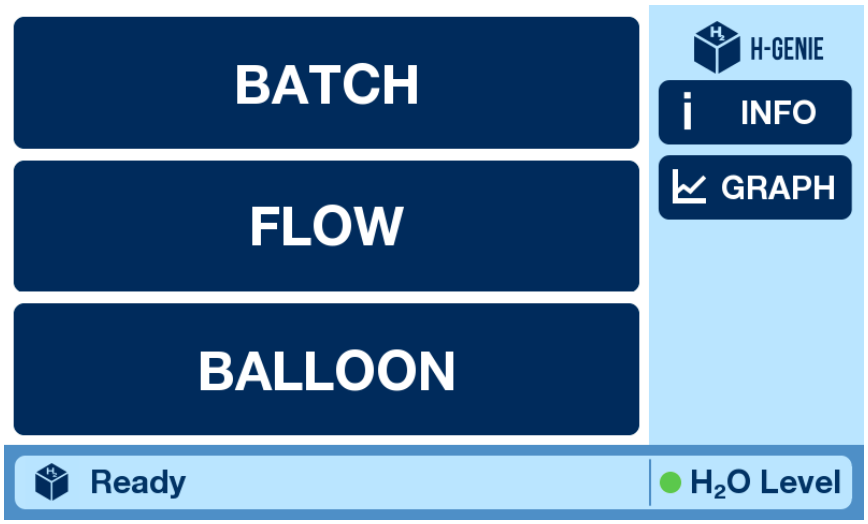

Figure 4: The Main screen

From the main screen you can choose three different options to start a reaction:

- Batch: To supply hydrogen to a batch reactor.
- Flow: To supply hydrogen to a flow reactor.
- Balloon: To supply hydrogen for filling a balloon.

There are also other options available:

- Info Screen: Displays technical information and data about the H-Genie®. The Info Screen may be accessed from any screen and under any status:

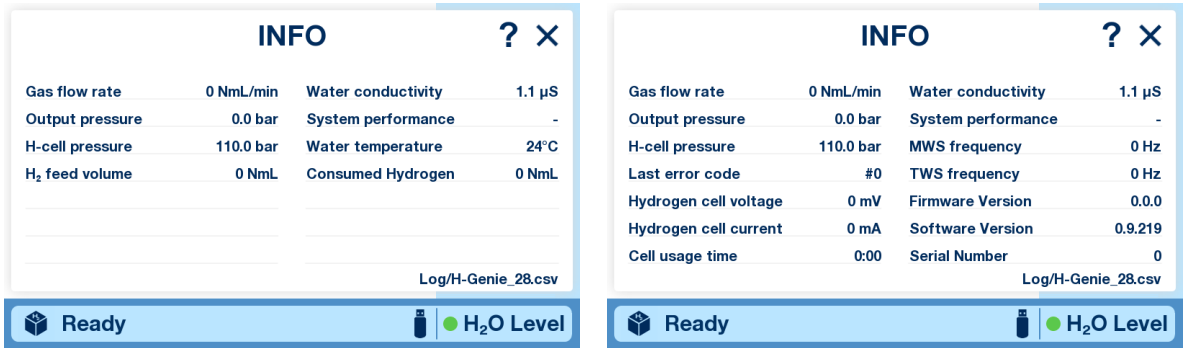

Figure 5: Info Screens

The information displayed is as follows:

- Gas flow rate: The flow rate of hydrogen leaving the H-Genie®.

- Output pressure: The pressure of hydrogen leaving the H-Genie®.
- H-cell pressure: The pressure of hydrogen inside the H-Genie®.
- H_2 feed volume: The amount hydrogen that has been released through the MFC since the Start button was pressed.
- Water conductivity: States the purity of the water in the H-Genie® in µS/cm. Before starting the H-Genie® make sure that the water conductivity is below 5 µS/cm. During operation of H-Genie® the allowed water conductivity 10 µS/cm, if it reaches this value then the H-Genie® will stop automatic. Recommended water conductivity: < 1 µS/cm.
- System performance: The software checks the hardware inside the H-Genie® and determines the performance level of the system. This is a value for a service engineer.
- Water temperature: Temperature of the internal water system.
- Consumed hydrogen: The amount of hydrogen consumed since the batch reactor reached set pressure.

Additional parameters can be displayed by pressing the touch screen continuously for 1 s (for service purposes only):

- Hydrogen cell voltage: Cell voltage measured in volts.
- Hydrogen cell current: Cell current in amperes.
- Cell usage time: The amount of time, in hours and minutes, the cell has functioned.
- MWS frequency: Measured water level frequency of the mechanical water separator.
- TWS frequency: Measured water level frequency of the thermal water separator.

Most of the measured system parameters are logged continuously internally. To export all files you can use the “export to USB drive” function located on the status bar in Info screen. Based on the status of the device three different icons could be displayed:

- When the “USB drive is available” symbol is pressed, all log files will be exported to the attached device.
- USB port is active, export in progress. Do not remove the connected USB drive during this state.
- Reaction in progress, export function is disabled.

- The Graph Screen

: displays H-Genie® parameters in graph form over time.

- Help Screen ? : Displays information of a descriptive nature about how the H-Genie® works, how to install and use it, and what to do if there's a problem. The Help Screen may be accessed from any screen and under any status. The touch screen language can also be changed here.

Figure 6: The Help Screen

Status Bar: Displays the status of the H-Genie®, the water (H_2O) level.

Figure 7: The Status Bar with disconnected and connected USB drives

The status messages are:

- Self-diagnostic: internal system check upon switching on.
- Ready: Ready to start generating hydrogen for a reaction.
- Preparation: Building hydrogen for the reaction.
- Running: Producing hydrogen for the reaction.
- Shutting down: Releasing internally stored hydrogen and shutting down the system.
- Emergency shutdown: Releasing hydrogen and shutting down after an emergency event is triggered.
- You can turn the device off: Ready to switch off.
- Poor water quality
- Too high external pressure
- Water level is too low

3. H-Genie® Safety Features

The H-Genie® has the following safety features to ensure safe and reliable operation:

1. The H-Genie® is equipped with an internal hydrogen sensor, so in the unlikely event of a hydrogen leak the system will automatically shut down.
2. If the H-Genie® cannot generate hydrogen pressure internally, then the system will automatically go into emergency shutdown mode.
3. Water leak detection.
4. The flow of air inside the H-Genie® is enforced using 3 fans to ensure that the temperature inside the unit does not rise excessively and to prevent any build of hydrogen or oxygen in the event of a leak.
5. Upon power-up the H-Genie® performs a self-check for internal leaks.
6. The hydrogen pressure inside the generator should only reach a maximum of 115 bar (1668 psi) and this is controlled electronically via a pressure sensor and mechanically using a pressure relief valve (Fail Safe).
7. There is a water level detector to ensure that the cell never runs dry.
8. Water separator malfunctions are checked to avoid high water content in the high-pressure system.
9. Water purity is checked to avoid the degradation of the electrolytic cell.
10. When the H-Genie® is in emergency status the following occurs:
    a. The current to the cell is stopped.
    b. The internally stored hydrogen is evacuated into the fume hood.
    c. An audible and visual alarm will be heard.

4. Installation

4.1 Delivery Content

The H-Genie® delivery package includes the following items:

1 pc of H-Genie® - Generator	_____	☐
1 pc of Emergency Button and cable		☐
1 pc of Metal water tank cap		☐
1 pc of oxygen vent fitting		☐
1 pc of water vent outlet tube (10mm OD)	**2m length**	☐
1 pc of oxygen gas outlet tube (10mm OD)	**2m length**	☐
1 pc of H-Genie® User Manual		☐
1 pc of Declaration of Conformity		☐
1 pc of H2 silencer assembly		☐
1 pc of check valve		☐
1 pc of power cable – check type	**EU ☐ UK ☐ CH ☐ USA ☐**	☐
2 pcs of ss 1/8" tube, 0.1m and 1m lengths		☐
2 pcs of ss 1/8” nuts with ferrules		☐
1 pc of ss 1/8” to 1/16” reducer		☐
1 pc of ss 1/16” tube (1m length)		☐
2 pcs of ss 1/16” nuts with ferrules		☐
1 pc of Vici PEEK finger tight 1/16” nut		☐
2 pc of ScavCart™		☐
1 pc of balloon filler assembly		☐

Please ensure that all of the items listed above are present in the delivery package. Check for any visible damage to H-Genie® components. Should any item be missing or any parts visibly damaged, please contact your nearest ThalesNano representative or **info@thalesnano.com**.

4.2 Location

- The H-Genie® **must** be located on a flat, level surface inside a fully functional ventilated cabinet or ventilated area, such as a fume hood. This minimizes any risk related to a hydrogen leak into the environment.
- The fume hood or ventilated cabinet must be equipped with a standard electrical socket and a water hole.
- The oxygen and hydrogen vent tube outlets should be positioned as far apart as possible within the fume hood.
- It is recommended that any objects be placed a minimum of 15 cm away from the rear and the sides of the H-Genie® to avoid any obstruction to the airflow in the cabinet and to allow any warm air from within the generator to be released freely into the environment. Ensure that none of the rear vents are obstructed. Failure to ensure this may result in damage to the H-Genie®.
- Dimensions of the H-Genie® can be found in the Technical Data section.
- Please adhere to the operating temperatures below:
    - Minimum Operating Ambient Temperature: 10 °C (50 °F)
    - Maximum Operating Ambient Temperature: 35 °C (95 °F)

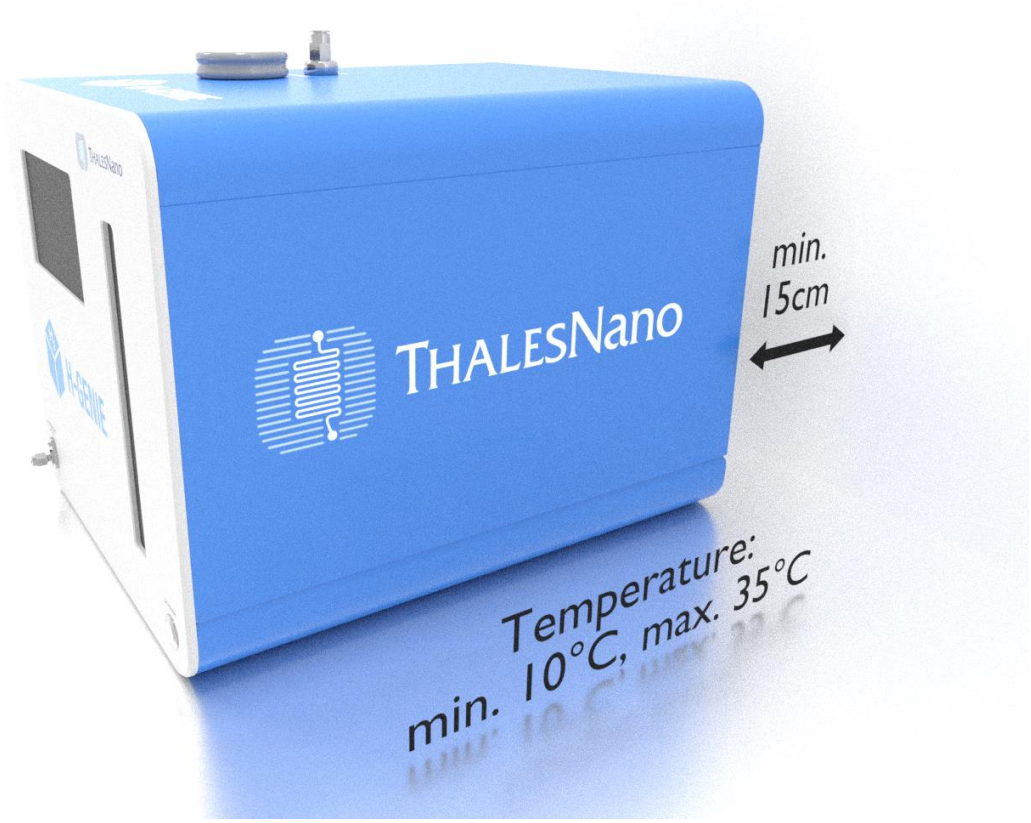

Figure 8: Operating requirements

4.3 Installing the H-Genie®

Open the packaging and remove all the contents.

4.3.1. Place the H-Genie® reactor box inside the selected fume hood cabinet.

4.3.2. Remove the temporary black water reservoir cap and fill the water reservoir with high-purity de-ionized water. Cover the water reservoir hole with the metal cap provided. Make sure a ScavCart™ is screwed into the metal cap. For further instructions please check “5.5 Using and Changing a ScavCart”.

Figure 9: Water reservoir caps

Attention

The H-Genie® generates hydrogen through in-situ water electrolysis. The operation of high-pressure cells requires high purity, de-ionized water. Millipore Milli-Q®: <1µS/cm is strongly recommended!!!

Using low quality water can cause irreparable damage of the instrument.

The volume of the water reservoir is an approx. 3500 mL. Take care not to overfill. The maximum water level should be 2 cm below the water tank neck.

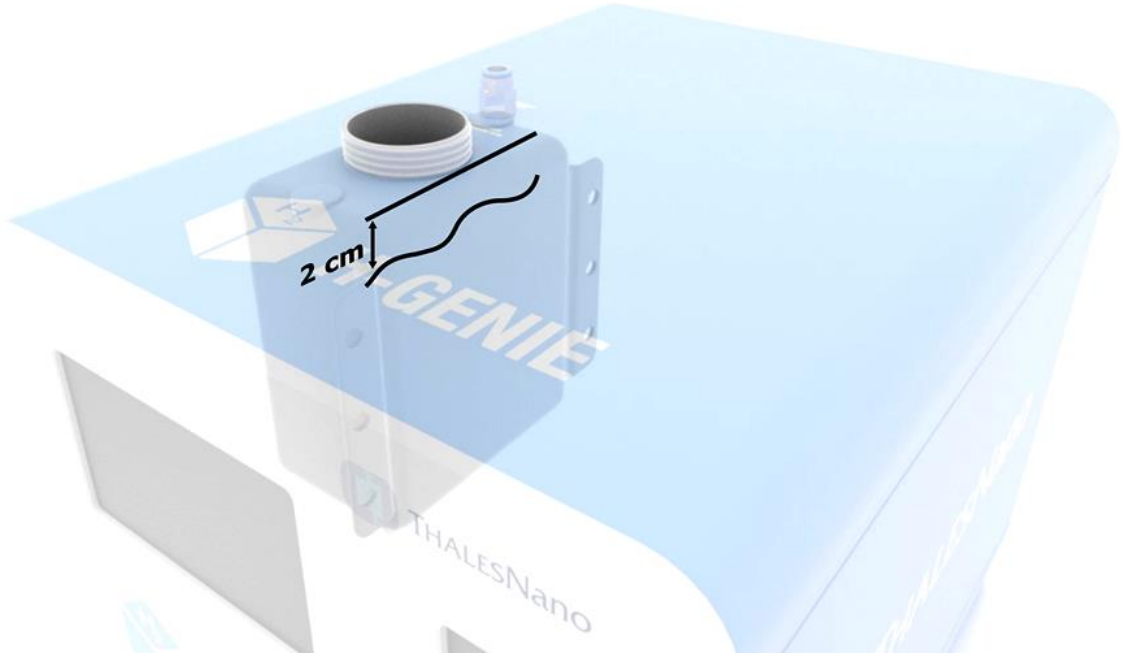

Figure 10: Maximum reservoir water level

Ensure the water tank is topped up every day before using H-Genie®.

4.3.3. Remove the yellow plug from the oxygen outlet port using a flat-headed screwdriver. Screw the oxygen line adapter into the hole. Attach the oxygen gas outlet tube to the outlet at the top of the H-Genie®. Ensure the other end is attached to the rear of the fume hood cabinet to ensure the tube does not move when oxygen gas is released.

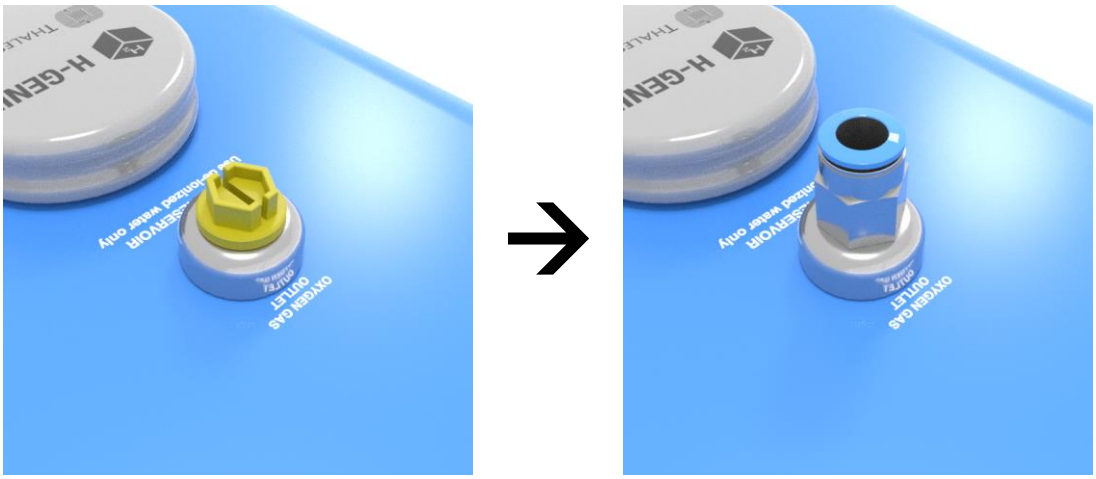

Figure 11: Remove the yellow plug and screw the oxygen line adapter in place

Do not impede or block the oxygen gas outlet at the top of the water reservoir while the machine is switched on. Only use the cap provided with the machine.

4.3.4. Connect one end of the water gas outlet tube to the water drain outlet and the other end to a sink or a wastewater receptacle located in the fume hood. Turn the blue switch to open and watch the water flowing out of the H-Genie®. Pay particular attention to the bubbles in the water stream. Wait until no more air bubbles appear in the water stream (this may take a minute) and then close the blue valve switch. Take the tube out of the water drain outlet and place it in the water vent outlet. Please ensure the open end of this tube is fastened to avoid movement when hydrogen gas is released. Top up the water tank.

Do not attempt to drain any of the water tank unless the H-Genie® is switched off.

4.3.5. Attach the stainless steel L-shaped hydrogen vent tube to its respective connection.

Figure 12: Attached hydrogen vent, oxygen vent and water vent tubes. Use water drain port with tubing from water vent if needed

Important! The hydrogen vent tube and the water vent tube will release hydrogen into the fume hood. Please ensure that the ends of these pipes are at least 1.5 m away from the outlet of the oxygen outlet to ensure hydrogen and oxygen do not mix or, if possible, in separate fume hoods.

4.3.6. Attach the emergency stop button to the connector at the rear of the H-Genie® and ensure that the button is located in an easily accessible place. Ensure that a green band is showing underneath the red button. If not, then turn the red button counter clockwise to release the button.

4.3.7. Make sure to switch the main power switch to the „0" (off) position before inserting the power cable into the rear of the H-Genie®. Connect the power cable to the mains power supply as well.

The electric cables must be guarded against moisture.

5. Performing a reaction with the H-Genie®

Safety instructions:

During use the fume hood MUST be switched on, and the fume hood sash pulled down.

The H-Genie® generates hydrogen internally. In normal operation, hydrogen will be released from the rear ports. It is essential that adequate precautions are taken to allow this to be safely ventilated by a fume hood cabinet.

Ensure that the reactor vessel is connected to the H-Genie® and gas tight. Check to ensure that there are no leaks.

Please ensure the water reservoir is topped up at all times. It is vital that the electrolysis cell membrane is kept constantly wet. The cell must not be allowed to run dry or the cell will immediately and irreversibly cease to function.

Once the installation is complete, switch the main power switch, located at the rear of the H-Genie® to the „I" (on) position. When the initialisation process is ready to start the following screen will appear. Press „OK" to begin the H-Genie®'s selftest.

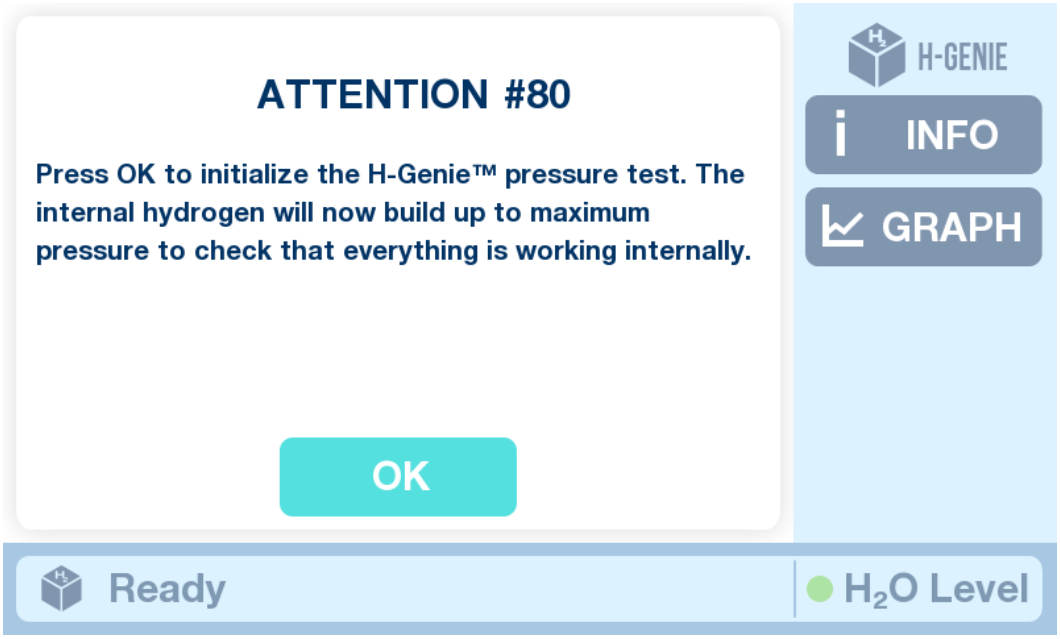

Figure 13: Self-test is ready to start

The screen will then change to the following, while the system will run through a self-test in order to check that the internal H-Genie® hydrogen system can build pressure to the maximum settable limit. Do not switch the H-Genie® off while the system is initializing. During this time a small amount of hydrogen may sporadically release. This is normal. The self-test may last as long as 10 minutes.

Figure 14: Initialization screen and Ready screen.

Once the system has finished the self test and the initializing, the main screen will appear and the term „Ready" will appear in the status bar. You're ready to get started.

Please note!

During hydrogen production, the H-Genie® will, from time to time, release the water extracted from the hydrogen gas out the back of the system. A small amount of

hydrogen may also be released and make a noise. This is completely normal and you shouldn't be alarmed.

- The H-Genie® is designed to run on a single tank of water for a minimum of 12 hours at maximum consumption. Before running out of water the below warning screen will appear. Once the water level of the H-Genie® reaches the critical level, an error message will appear and the H-Genie® will shut down to ensure the hydrogen generation cell is not harmed.

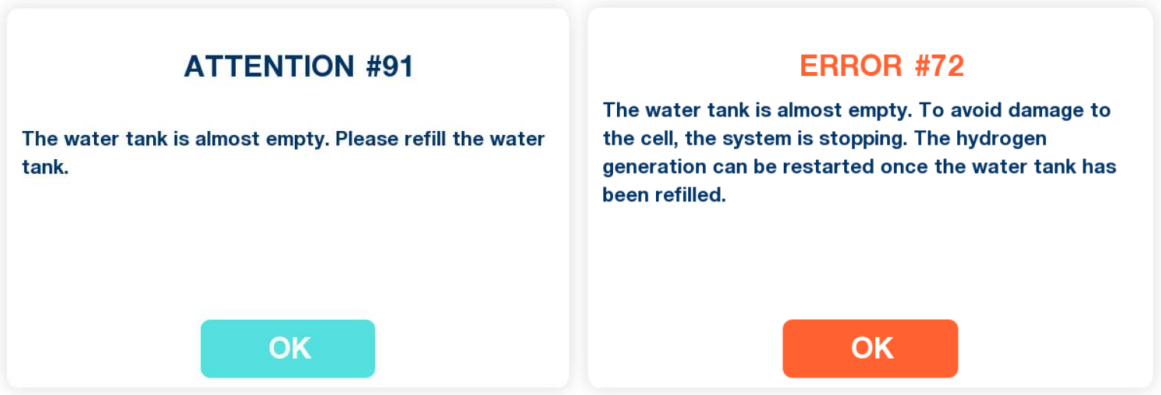

Figure 15: Warning and Emergency stop low water tank message

Please note!

The external vessel attached to the H-Genie® must be at 1 bar or the H-Genie® will not allow the reaction to proceed.

5.1 Setting a BATCH reaction

5.1.1 Connect your batch reactor to the front of the H-Genie® using the appropriate tube and connection. Ensure there are no leaks and connections are tight.

5.1.2 Press the BATCH function on the main screen.

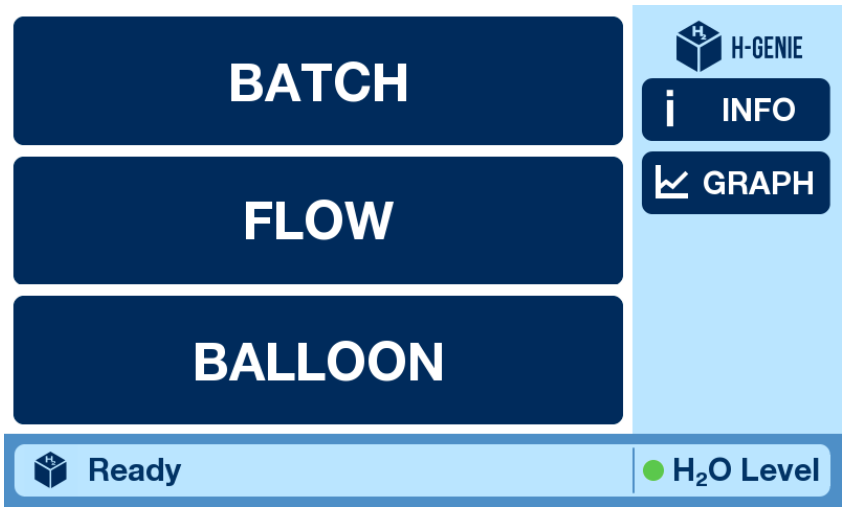

Figure 16: Main Screen

5.1.3 Press the button to enter a reaction pressure and hydrogen gas flow rate value. Press OK after you have set the appropriate value. The or buttons may be used to raise the set value by + or – 1 value.

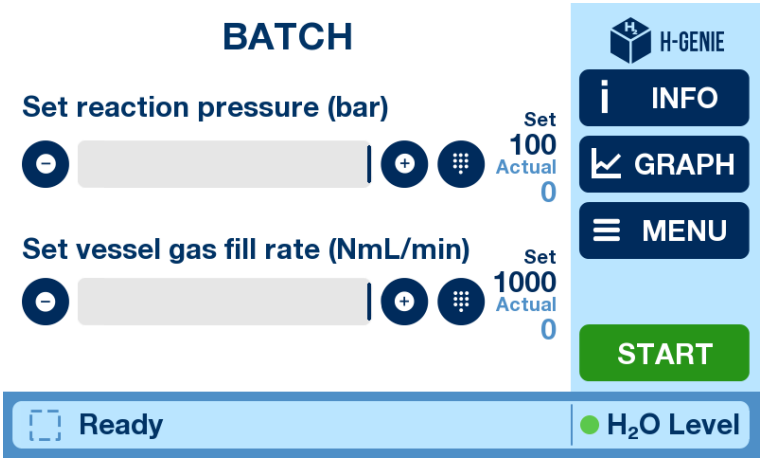

Figure 17: Batch mode ready to start

5.1.4 Once all the parameters have been set, then press START. The H-Genie® will now start filling up the batch reactor with hydrogen. The “Actual” value will start to rise and indicate the external pressure. If this number does not rise or rises extremely slowly (when taking into account the reactor size and gas flow rate), then check both the tubing and reactor for leaks.

5.1.5 Once the reactor reaches the set pressure, then the H-Genie® will stop generating hydrogen and wait. If a fall in pressure is detected (i.e. because of the consumption of hydrogen in the reaction) then more hydrogen will be generated. The amount of this hydrogen is logged in the Consumed Hydrogen section on the Info Screen. If you ever need to reset this amount, then quickly press STOP and START button.

5.1.6 Once the reaction is completed or you have no more need of the H-Genie®, then STOP the H-Genie®. Never disconnect the H-Genie® from the reactor while the reactor or tubing is under pressure or the H-Genie® is still running.

5.1.7 The H-Genie® will stop automatically after 1 hour if no hydrogen consumption is detected.

5.1.8 Once the H-Genie® has stopped providing hydrogen, the system will enter a "Ready" state. After a period of 1 hour without use, the H-Genie® will enter "Standby" state.

5.1.9 Do not restart the H-Genie® during an ongoing reaction. The self-test will recognize that the external pressure is higher than the internal pressure and the H-Genie® will enter Emergency mode.

5.2 Setting a FLOW reaction

5.2.1 Connect the check-valve to the front of the H-Genie®. **Ensure that the arrow on the check-valve is pointing "out" from the H-Genie®.** This is the direction of the hydrogen flow.

5.2.2 Connect your flow reactor to the check-valve using the appropriate tube and connection. Ensure there are no leaks and connections are tight.

5.2.3 Press the FLOW function on the main screen.

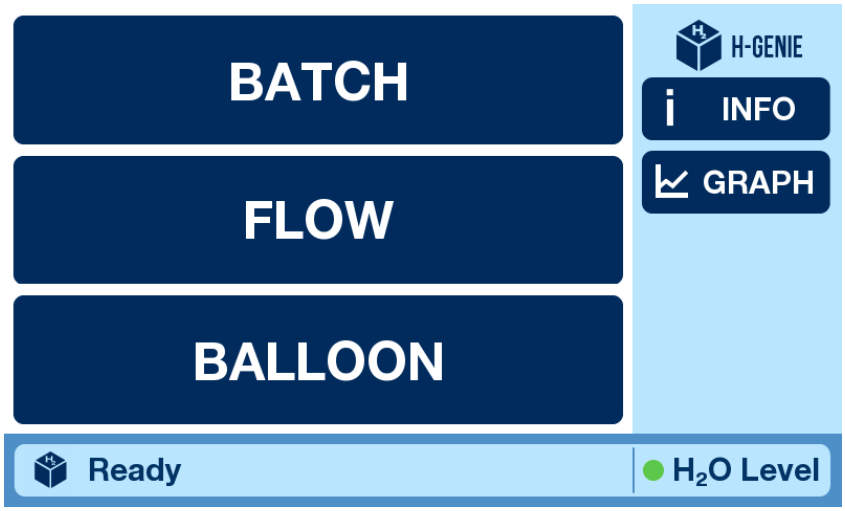

Figure 18: Main Screen

5.2.4 Press the button to enter a reaction pressure and hydrogen gas flow rate value.

The set value should be 10 bar above your planned flow reaction pressure to ensure a positive flow of hydrogen out of the H-Genie® and into the flow reactor.

5.2.5 Press OK after you have set the appropriate value. The ⊕ or ⊖ buttons may be used to raise the set value by + or – 1 value.

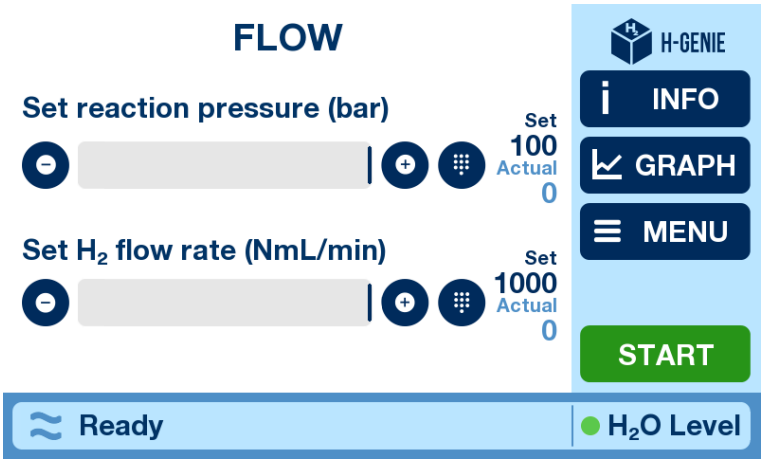

Figure 19: FLOW mode ready to start

5.2.6 Once all the parameters have been set, then press START.

5.2.7 Once the H-Genie® has generated the set pressure and the hydrogen is eluting from the system, pressurize your flow reactor.

5.3 Setting a BALLOON reaction

5.3.1 Press the BALLOON function on the main screen.

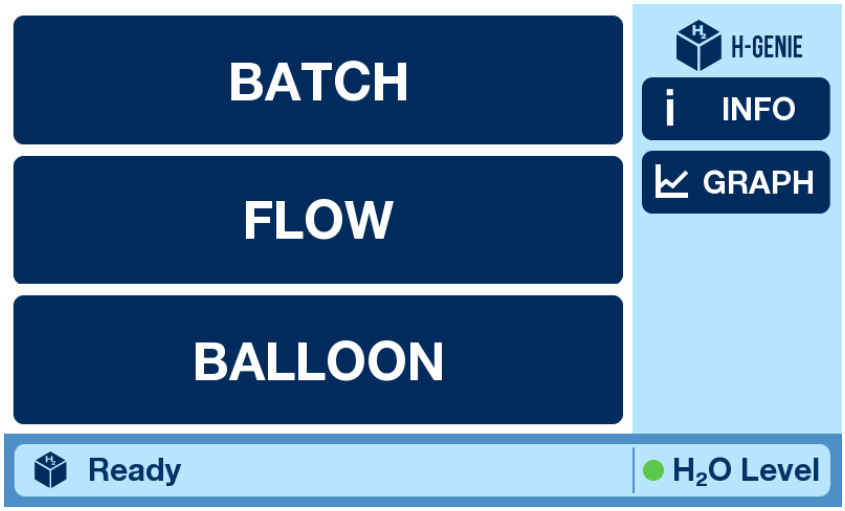

Figure 20: Main Screen

5.3.2 For the BALLOON mode, the pressure is limited to 1 bar and the hydrogen flow rate is set to a maximum 1000 mL/min (and cannot be changed). The user need only set a balloon volume.

Figure 21: Balloon attached to the H-Genie® - Actual balloon adaptor has different appearance.

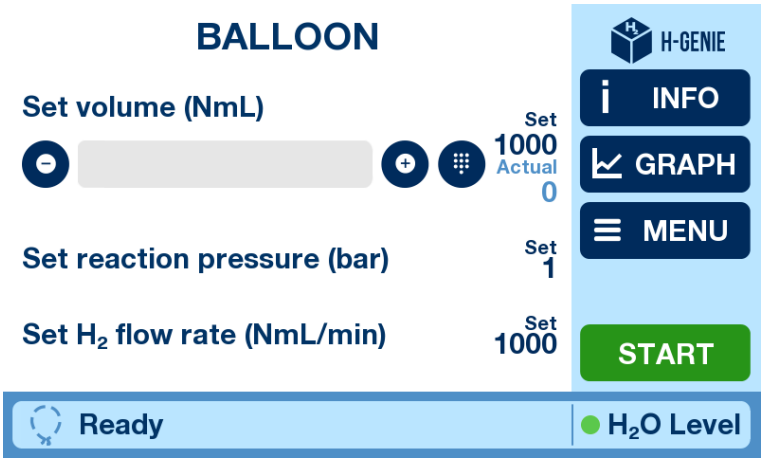

Figure 22: Balloon mode ready to start

5.3.3 Press the button to enter a balloon volume.

5.3.4 Press OK after you have set the appropriate value. The or buttons may be used to raise the set value by + or – 1 value.

5.3.5 Connect your balloon via a tube to the front of the H-Genie®.

5.3.6 Once all the parameters have been set, then press START.

5.4 Visualize Experimental Data – Graph screen

Pressing the GRAPH symbol on the Main menu opens the graph screen.

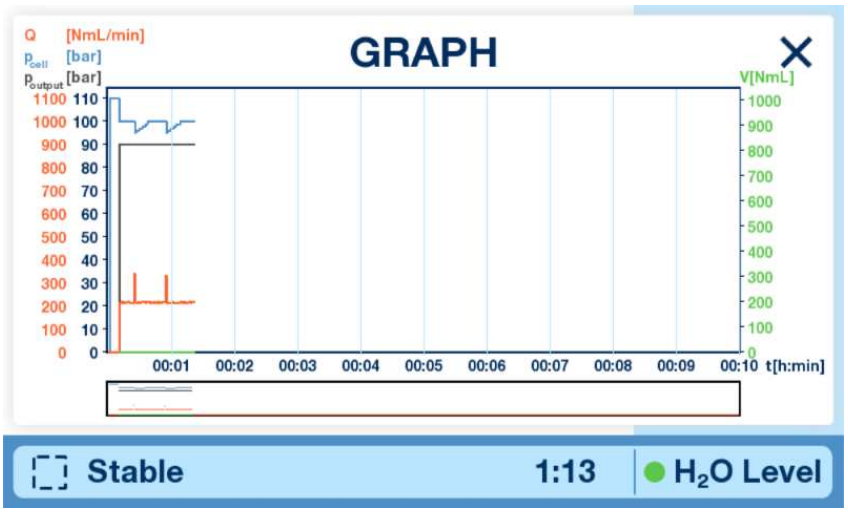

Figure 23: The Graph screen

The graph screen will display the following data over time (hours and mins) for the pressure of the cell (bar), the output pressure (bar), the flow rate of hydrogen (NmL/min) out of the system, and the consumed hydrogen (NmL).

5.5 Using and Changing a ScavCart™

In order to maintain water purity at an acceptable level for the H-Genie® and to ensure a good hydrogen cell longevity, then it is mandatory to use a ScavCart™. The ScavCart™ should be changed every 2 months. ScavCart™s can be ordered directly from ThalesNano. Contact info@thalesnano.com for ordering information.

Warning!

Do not use your own resin as a water purity scavenger. Only use official ThalesNano certified products. Failure to do so will invalidate product warranty. A special resin with a particle size is used in ThalesNano ScavCart™s. Only use a ScavCart™ for a maximum of two months. Using ScavCart™s beyond this timeframe may cause leaching of the resin into the water tank.

Figure 24: How to attach the metal cap to the ScavCart™ and how to install it in the H-Genie®

To use the ScavCart™, take the plastic holder and screw it into the metal cap. Place the ScavCart™ into the H-Genie® water tank. Please ensure water tank is full every day before use.

Once the ScavCart™ has expired, then dispose in solid waste or ship back to ThalesNano for recycling. Address is given at the end of the manual.

5.6 Turning off and shutting down the H-Genie®

To turn off/shutdown the H-Genie®. Press the Shutdown button on the front of the system.

Figure 25. Shutdown button

The H-Genie® will now start to shutdown. If there is any internal hydrogen present, then it will be released out the back and through the water vent. This will make a noise, but do not be alarmed, this is completely normal. The entire procedure takes ~60 seconds. Once it is finished, the status will change to “You can turn the device off”.

Please note! If you intend to switch back on the instrument straight away after shutting down, then please wait a minimum of 30 seconds before switching on.

Figure 26: Shutdown phases.

The same procedure will take place if the emergency button is pressed or the software triggers an emergency shutdown, such as if there is a cell failure or hydrogen leak detected. The below screens will appear.

Figure 27: Emergency shutdown phases.

6. Troubleshooting

Problem	Possible Cause	Corrective Action
The H-Genie® does not release hydrogen.	There may be a blockage in the MFC.	Call for service.
The H-Genie® does not build hydrogen internally.	Cell malfunction.	Call for service.
The H-Genie® won't switch on after Emergency button has been triggered.	The emergency button is in the fixed off position.	Turn the button to release it.
The H-Genie® fails the initialization start-up.	Internal fault	Turn off the H-Genie® and try again. If it fails repeatedly, call for service.
Water is seen leaking out the bottom.	Water leak	Switch off immediately and Call for service.
There is a continuous hydrogen gas sound out of the rear of the H-Genie® during a reaction.	Valve failure	Switch off immediately and Call for service.
Error 99	The Emergency button is in the used position.	Turn the red button in a counter clockwise motion to release the button. A green band underneath the button should be visible.
Error 18	Too much water has collected within the water separator and couldn't be released.	Remove the waste water tube from connector 15. Press the Emergency Button. Switch off the H-Genie® and then switch back on the system 1 minute later with the emergency button pressed down. An error 99 message will be shown(this is fine). Leave the system alone for 15-30 minutes. Reattach the tube to port 15, unscrew the red emergency button until the green band shows. Ensure that the waste water tube at the back of the H-Genie® slopes down into the sink or waste container and there are no loops. Switch back on the system.

If you are experiencing problems with the H-Genie® and a service engineer is required, please e-mail a short description of the problem, along with your contact details, to the following address: service@thalesnano.com.

We will try and respond within 24 hours on work days.

7. Daily Maintenance Checks

Opening of the H-Genie® reactor box, and any necessary repairs can only be performed by ThalesNano service experts. Unauthorized opening of the device will render the warranty null and void.

Ensure you check the following on a daily basis.

- Top up the water tank
- Ensure all tube connections and fittings are intact and secure
- There is no water spillage or leak around the device.
- The touch screen and other surfaces are clean and free of chemicals.
- Check the purity of the water on the Info Screen

8. Accessories

For a list of up to date accessories, please visit thalesnano.com or contact **sales@thalesnano.com**.

9. Technical Data

Pressure Range of H-Genie®:	From 1 bar to a maximum of 100 bar
Internal hydrogens pressure limit:	115 bar
Hydrogen flow rate range:	100-1000 NmL/min
Water purity at 100 bar:	99.99% (4.0)
Internal hydrogen volume:	< 150 mL
Water consumption rate:	< 200 cm^3/h
Water reservoir capacity:	Internal: 3L
Recommended environment:	Ventilated laboratory fume hood
Power requirements:	Mains: 100V to 240V AC, 47-63Hz
Power consumption:	max. 1500 VA
Unit dimensions (H x W x D):	345 mm x 365 mm x 460 mm
Outlet parameter:	Tubing OD: 1/8”
	The output valve can accept any connector with a male thread Press 1/8”

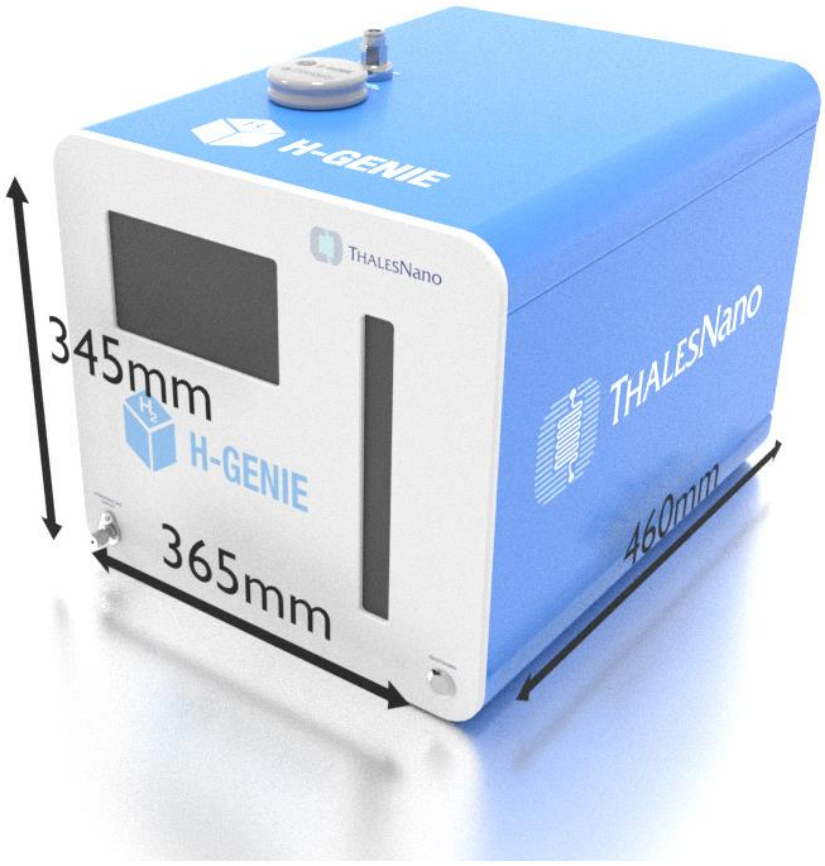

Figure 28: H-Genie® dimensions

10. Warranty Information

The H-Genie® is delivered in accordance with ThalesNano standard terms and conditions, a copy of which is attached to the purchase invoice and is also available on request.

The guarantee period of H-Genie® is 12 months, starting from the date of delivery to the client. Operation inconsistent with the manufacturer's instructions is excluded from the warranty, while the unauthorized opening of the device will render the warranty null and void.

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If we find a defect covered by the warranty, repair, or replacement, at our discretion, will be carried out free of charge. Packing and transport costs are borne by the customer.