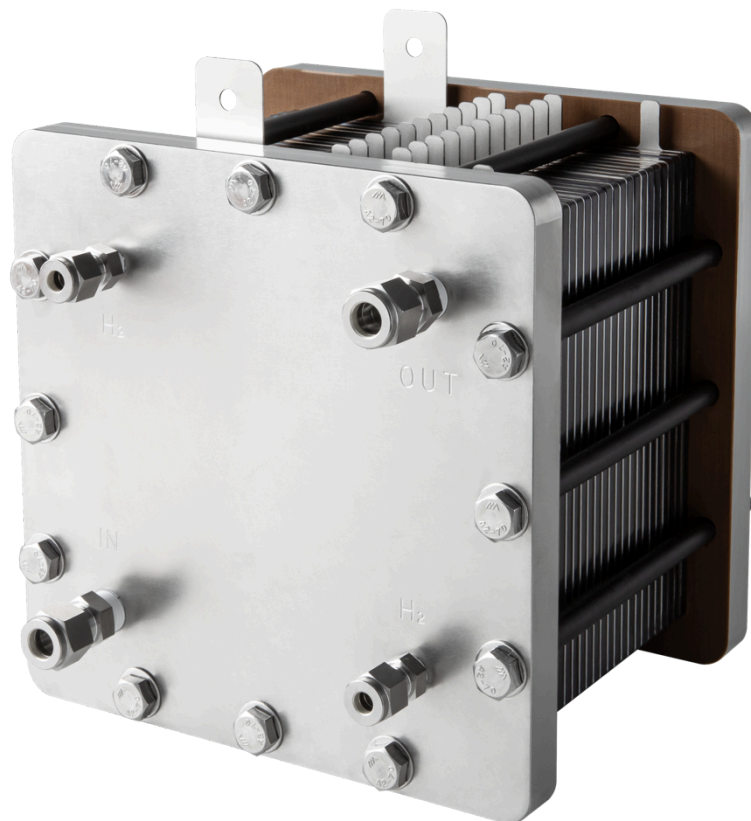


— HYDROXPAND · USER MANUAL

HXS-2

2 kW stack

User Manual



DOCUMENT CONTROL

Document control

Document information

Document no.	HX-MAN-HXS2-EN-001
Version	ver3.8
Issued	2026-10-08
Product	HXS-2 · 2 kW stack
Language	English

About this manual

This manual is the formal print edition of the HydroXpand web handbook. Its content is the same as the web handbook.

The web handbook is updated first. Where this print and the web differ, the web handbook is current. Each chapter shows its own update date at the top.

Read the safety chapter first. The meaning of the signal words (danger, warning, caution, notice) is in its first section.

Revision history

Rev.	Date	Description
1.0	2025-07-01	First version
1.1	2025-12-05	Fluid connection and warranty revision
2.0	2026-01-25	General revision
2.1	2026-03-11	Product photo revision
2.2	2026-08-23	Electrolyte replacement criteria revision
2.3	2026-09-08	Electrolyte revision (0.3 M → 0.1 M KOH, recommended temperature 60 → 50 °C)
3.0	2026-10-02	Full revision built from the web handbook, which is now the master text
3.1	2026-10-04	Power supply and cable for running up to 80 A added; supply voltage limit separated from a cell fault
3.2	2026-10-04	Symptom A cause count and a typo corrected, 50 A voltage about 38 V new and 40 V in service, in-text cross-reference links
3.3	2026-10-04	Safety messages reworked: consequences added, equipment-only matters moved to notices
3.4	2026-10-04	Warnings moved ahead of their steps; static ignition and hot-surface warnings added
3.5	2026-10-04	Check and if-not lines added to key steps
3.6	2026-10-05	Korean wording revised
3.7	2026-10-05	Voltage trend drawing (Figure 5-2) added
3.8	2026-10-08	Hydrogen output about 500 L/h restored (company decision, 8 Oct 2026)

CONTENTS

Contents

01	Safety	4
02	Receiving and storage	10
03	Quick start	14
04	Operation and shutdown	23
05	Maintenance	27
06	Decommissioning	35
07	Specifications and reference	38
	Troubleshooting	41

01 Safety

HXS-2 · updated 2026-09-30

The HXS-2 makes hydrogen and oxygen, takes a high direct current, and has a corrosive electrolyte running through it. Three hazards in one object, so the safety rules come in three strands.

Unlike a packaged system, a stack has no built-in safety functions. Detection, interlocks, overpressure protection and emergency stop all live in the system you build around it. The stack integration guide covers that design.

This chapter covers immediate safety actions only. Diagnosis is in the troubleshooting chapter, and that work happens after the area is secure and only by qualified people.

HAZARDS **Hydrogen · electricity · electrolyte** PPE **Depends on the task** WHEN TO READ **All of it, once, before installing**

HOW TO READ THIS CHAPTER

First time
There is no section here to skip. Read it through once before installing, and keep the emergency response section next to the equipment.

Done this before
Re-read the signal words and the emergency response. Use the rest when checking against your own site safety rules.

Signal words

This handbook and the manual use the same signal words. They differ in severity, so read them as such.

SIGNAL WORD	MEANING
 DANGER	A situation that will cause serious injury or death if not avoided
 WARNING	A situation that could cause serious injury or death if not avoided
 CAUTION	A situation that may cause minor or moderate injury if not avoided
 NOTICE	Information that is not about personal injury but prevents equipment damage or loss of performance

What this stack is for

HXS-2 is for producing hydrogen and oxygen from an alkaline electrolyte, and nothing else. Operate it within the limits in this handbook and the datasheet.

Do not

- Run it on a different electrolyte
- Run it outside the current, voltage, pressure or temperature limits
- Modify its structure, or dismantle or repair it without authorisation

Use of this kind can injure people and damage property or the environment.

Who should work on it

This document is for integrators designing a BoP around the stack, researchers running it in a lab or pilot facility, and trained operators running it inside a system. You should be familiar with four things.

- Hydrogen safety, and hydrogen and oxygen venting, ventilation and vent routing
- High-current DC power equipment and electrical hazards
- Alkaline electrolyte handling and chemical safety procedures
- The fundamentals of water electrolysis systems

NOTICE

Local regulations and site safety rules take precedence over this handbook.

Hydrogen

DANGER

Hydrogen is an explosion hazard.

- It is colourless and odourless, highly flammable, and forms explosive mixtures with air over a wide range. Confined spaces are especially dangerous, and a hydrogen flame is almost invisible.
- Keep the area ventilated and remove ignition sources. Check for leaks with leak-detection fluid or a hydrogen detector.
- Very little energy is needed to ignite it (about 0.02 mJ), so even a static spark can set it alight. Earth the hydrogen lines and equipment, and where a leak is suspected avoid clothing and plastic tools that build up static.

- Operate only in a well-ventilated area, or connect the vents to an engineered exhaust system.
- Do not operate in a sealed room or a small unventilated enclosure.
- Keep ignition sources away: no smoking, open flames, welding, grinding or spark-producing work near the stack or the vent outlets.
- Use electrical equipment suitable for the area classification where hydrogen may be present.
- Check for leaks by an approved method, such as an approved hydrogen detector. Never use an open flame to find a leak.
- Hydrogen collects at ceilings and other high points. Take that into account when planning ventilation.

Vent lines

DANGER

Never combine a hydrogen vent with an oxygen vent.

- Route each to its own safe discharge point. Mixed vent gases are an explosion hazard.

- Vent lines must stay open. Fit no valve or device that could inadvertently close one.
- Do not restrict a vent line or create backpressure.
- Keep vent and relief lines free of obstructions, kinks, debris and unintended liquid accumulation.
- Accumulated condensate can freeze a vent shut. Use slope, drain points, insulation or heat tracing as your site conditions require.
- Route the vent outlets away from ignition sources and follow local codes and site safety rules.
- An oxygen-enriched atmosphere raises the fire risk. Keep combustibles away from the oxygen discharge area and ensure ventilation around the outlets.

PRACTICAL NOTES

On this stack the oxygen leaves with the electrolyte.

- There is no dedicated oxygen port. Oxygen leaves through OUT with the electrolyte, returns to the tank and separates there, so the oxygen vent belongs to your tank rather than to the stack. The rules above apply to it just the same.

Electrical

DANGER

Risk of electric shock and arc flash.

- The HXS-2 runs on a high-current DC supply. Contact with a live conductor can cause serious injury or death.
- Contact with a live conductor causes serious injury or death.

- All electrical installation is done by qualified personnel.
- Provide overcurrent protection and a disconnecting device to your local code.
- Earth the DC supply and all connected equipment properly.
- Never connect or disconnect power cables under load.
- Confirm the polarity and make the terminations secure. A loose connection leads to overheating and arc faults.
- Keep electrical components dry and protected from contact with electrolyte.

⚠ WARNING

Voltage can remain at the terminals after shutdown.

- Turn the DC supply off, isolate it, allow time for discharge, and measure the terminal voltage before handling cables or terminals.
- Do not short the terminals with a tool.
- Touching the residual voltage gives an electric shock; shorting the terminals causes an arc and burns.

Electrolyte

⚠ WARNING

KOH solution is corrosive and can cause severe skin and eye burns.

- Handle it with safety glasses and alkali-resistant gloves. If it touches you, rinse at once with plenty of water.

⚠ CAUTION

In operation the electrolyte, lines and stack reach up to 80 °C. Touching them bare-handed causes burns.

- Wear gloves when touching them in operation or just after a stop. Confirm they have cooled before opening a line or draining electrolyte.

- Handle it according to the SDS and your site procedures.
- Use only KOH-compatible materials, for containers, tubing and fittings alike.
- For a spill, contain it, clean it up by your site procedure, and dispose of the waste to regulation.
- On exposure, flush with water immediately and seek medical attention as required.
- Keep an eyewash station and a safety shower near where KOH is handled.

PPE

i NOTICE

Where your site rules are stricter than this table, follow your site rules.



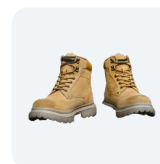
Safety glasses



Sealed goggles



Alkali-resistant gloves



Closed-toe shoes

Routine operation and monitoring	Safety glasses, closed-toe shoes and suitable work clothing
Handling electrolyte	Splash-proof goggles or a face shield, alkali-resistant gloves, and a chemical apron or lab coat
Working directly on the stack	Safety glasses and work gloves, plus whatever the task needs. Near power cables and terminals, add electrical protection

Emergency shutdown and response

DANGER

Do not delay an emergency shutdown.

- In any abnormal or hazardous situation, personnel safety comes first. If you are unsure, stop at once and evacuate by your site procedure.

A gas or electrolyte leak, an unusual noise, smoke, a nearby fire, or visible damage

1

If it is safe to approach, stop the DC output to the stack and leave it off.

2

Warn the people nearby, evacuate non-essential personnel and restrict access.

3

Do not touch terminals, cables or wetted lines until the area is safe and the equipment secured.

4

Follow your site emergency response plan and notify the responsible safety officer.

5

Do not resume operation until qualified personnel have identified and corrected the cause.

A hydrogen leak, or a suspected one

DANGER

Do not operate any switch or device in the area that could make a spark.

- Keep all ignition sources away.
- Increase ventilation by your site procedure, activating the exhaust system if there is one.
- Do not re-enter the area until authorised personnel declare it safe.

A vent suspected of being blocked or iced

DANGER

Overpressure and unsafe venting can result.

- Keep personnel away from the vent discharge locations.
- Do not attempt to clear a blockage until the pipework is fully depressurised and isolated.
- This work is for qualified personnel only, following site safety procedures.
- Undoing a blocked line carelessly makes trapped hydrogen and electrolyte spray out and injure you.

A spill or chemical exposure

WARNING

Avoid skin and eye contact with spilled electrolyte.

- Follow your site spill response procedure: chemical PPE, containment and clean-up, and disposal to regulation.
- For personal exposure, rinse with water immediately and follow the first aid in the SDS. Seek medical attention if required.

02 Receiving and storage

HXS-2 · updated 2026-09-30

From delivery to the stack in place: transport and handling, storage conditions, unpacking and inspection, and what is supplied against what is yours.

The connection procedure is in the quick start chapter. This one covers everything before it.

WEIGHT One person can move it **STORAGE TEMPERATURE** 5 °C or above at all times

ORIENTATION Upright, as marked on the packaging

HOW TO READ THIS CHAPTER

First time

Do the unpacking and inspection section on the day it arrives. If there is damage, we need to know before you connect anything.

Done this before

Read the storage conditions for a unit that waits. Freezing and port protection are what matter.

Transport and handling

CAUTION

Dropping it can injure your feet and damage the ports and gaskets.

- Ports, threads, seals and external fittings are what get damaged. Always move and transport it in a controlled way.

- Keep the stack in its original packaging for transport whenever you can.
- Follow every handling symbol on the packaging: fragile, keep dry, handle with care, this side up.
- Use a cart where practical and keep the box upright and level. For short moves, carry it with both hands.
- Lift an unpacked stack only by rigid structural areas such as the end plates or the frame.
- Never lift or support it by the ports, the protective caps and plugs, the fittings, or the electrical terminals and cables.

What to avoid

- Dropping it or subjecting it to severe impact
- Crushing loads on the box, and stacking heavy items on top
- Transporting it with the ports and fittings exposed
- Exposure to rain, standing water or high humidity

⚠ WARNING

After a severe shock, a tilt or an accident in transit, do not install or operate it.

- Do the unpacking and inspection below first, and tell us what you find.
- Running a stack damaged in transit can leak hydrogen or electrolyte and lead to fire or burns.

If it waits before installation

i NOTICE

Never let it freeze. Keep it at 5 °C or above at all times.

- We run a factory acceptance test and drain as much electrolyte as is practical before shipment, but the membrane and electrodes stay wet and residual liquid and moisture remain in the internal flow paths. Frozen, they damage the membrane, the seals and internal parts.

Required

- Keep the temperature at 5 °C or above at all times.
- Store it upright as marked on the packaging.
- Keep the stack in its original packaging while it is stored.
- Leave every port cap and plug fitted.
- Avoid excessive vibration, which loosens fittings and caps over time.

Recommended

- Indoors, dry, and out of direct sunlight.
- Avoid condensing conditions such as outdoor storage or rapid temperature swings.
- Keep it away from excessive dust and corrosive gases.
- Do not stack heavy items on top of the packaged unit.

Unpacking and inspection

The standard package is a corrugated box with PE foam cushions. Check first that yours matches the table below.

ITEM	STANDARD PACKAGE
Outer box	260 × 260 × 260 mm (W × D × H)
Cushioning	30 mm PE foam, surrounding the stack and holding it centred

Port protection	Every port capped or plugged
-----------------	------------------------------

Orientation	Shipped and stored upright, as marked on the box
-------------	--

 NOTICE

Package dimensions and foam layout can differ with the order, the destination and the logistics.

 NOTICE

Keep the blade shallow.

- Port threads and the protective caps and plugs are easily damaged. Open the box carefully.

1

Inspect the outer packaging first.

- Look for visible damage, deformation or signs of impact. Note anything on the delivery documents and photograph it if needed, for a claim against the carrier.

2

Cut the sealing tape along the top seam only, and open the box.

3

Take the stack out and set it on a clean, stable surface.

- Hold only rigid structural parts such as the end plates. Not the ports, fittings, caps and plugs, or terminals and cables.

4

Inspect the stack visually.

- Check the body for dents, cracks and deformation.
- Check the IN, OUT and H2 ports and their caps and plugs for mechanical damage, and that they are secure.
- Look for signs of leakage or residue around the ports and fittings.
- Check for fittings or caps that loosened in transit.
- Verify the model, serial number and revision on the product label. You will need them if you contact us later.

⚠ WARNING

If anything is damaged, missing or irregular, do not connect it.

- Do not connect it to the BoP or the power supply. Record the condition, photograph it, tell us and the carrier at once, and agree the next step before operating.
- Keep the original packaging where you can. You will need it if the stack is moved, returned or sent for service.
- Connecting and running a damaged stack can leak hydrogen or electrolyte and lead to fire or burns.

What is supplied, and the boundary

Included	The HXS-2 stack, and the user manual sent electronically.
Factory test	Every stack goes through a factory acceptance test (FAT) before shipment. Where applicable, the results and delivery documents come with it.
Not included unless ordered	Electrolyte (KOH solution) and DI water.
You provide	The DC supply, the electrolyte tank, the circulation pump, the heat exchanger, KOH-compatible tubing and fittings, and whatever valves, sensors and safety devices your site and system design require.
Who repairs what	Repair and replacement of external BoP components is yours: the pump, heater, heat exchanger, sensors and power supply. We interpret the stack's behaviour and judge whether stack service is needed.

i NOTICE

The HXS-2 is a stack-only product.

- External equipment, utilities and consumables are yours to prepare, and they have to be in place to this handbook before installation and operation.

03 Quick start

HXS-2 · updated 2026-09-30

The sequence from delivery to your first hydrogen. Nine steps, and half a day is enough once the external BoP is ready.

HXS-2 is a stack. You build the power supply, electrolyte circulation, gas handling, instrumentation and interlocks around it. The sizing rationale for that design is in the stack integration guide.

TIME Half a day if the BoP is ready **PREREQUISITE** An external BoP and a DC supply

PPE Eye protection · alkali-resistant gloves **PRIOR KNOWLEDGE** Hydrogen safety and DC power handling

HOW TO READ THIS CHAPTER

First time

Work through the nine steps in order. This is a bare stack, though, so the BoP has to exist first. Step 1 lists what you need, and the reasoning behind the numbers is in the stack integration guide.

Done this before

Re-check the ports and the loop, then jump to the first run. The operating range and the shutdown sequence are in the operation and shutdown chapter.

1. What you need in place



1 × DC power supply

For rated operation at 50 A, 0–45 V and 0–50 A is enough. If you plan to use the stack up to its maximum (80 A, 50.6 V), choose 0–51 V and 0–80 A or more. It needs a constant-current mode.



1 × electrolyte loop

A tank, a circulation pump and a heat exchanger, all in KOH-compatible materials. A tank heater is optional, but you need one for extended low-current running.



Three lines

The electrolyte inlet, the hydrogen outlet, and the outlet that carries oxygen and electrolyte together. That third one is particular to this product.



Electrolyte and DI water

For the first fill, 0.1 M KOH in DI water; for make-up during operation, DI water. Keep the DI water in its own reservoir.



Valves, sensors and safety devices

Whatever your site and system design require, provided by you. Where they go is covered in the stack integration guide.

Photos show the type of item only. Tubing photo by Best Tech Nick 25 (Wikimedia Commons, CC BY-SA 4.0, background removed and edited). The edited version is released under CC BY-SA 4.0.

i NOTICE

The stack is what ships.

- A standard delivery is the stack and the user manual, sent electronically. Electrolyte and DI water are not included unless the order says so, and the BoP and utilities above are all yours to prepare.

PRACTICAL NOTES

Plan on long low-current runs? Fit a heater.

- At high current the stack makes enough heat that the electrolyte warms up on its own. At low current it does not, and the temperature stays below the recommended range.
- Put a heater on the tank and add temperature monitoring and overtemperature protection in the external BoP. The heater has to be KOH-compatible too.

2. Identify the ports

Find the labels on the stack and confirm the three kinds below. Naming can vary by revision, so follow the labels on the unit you received.

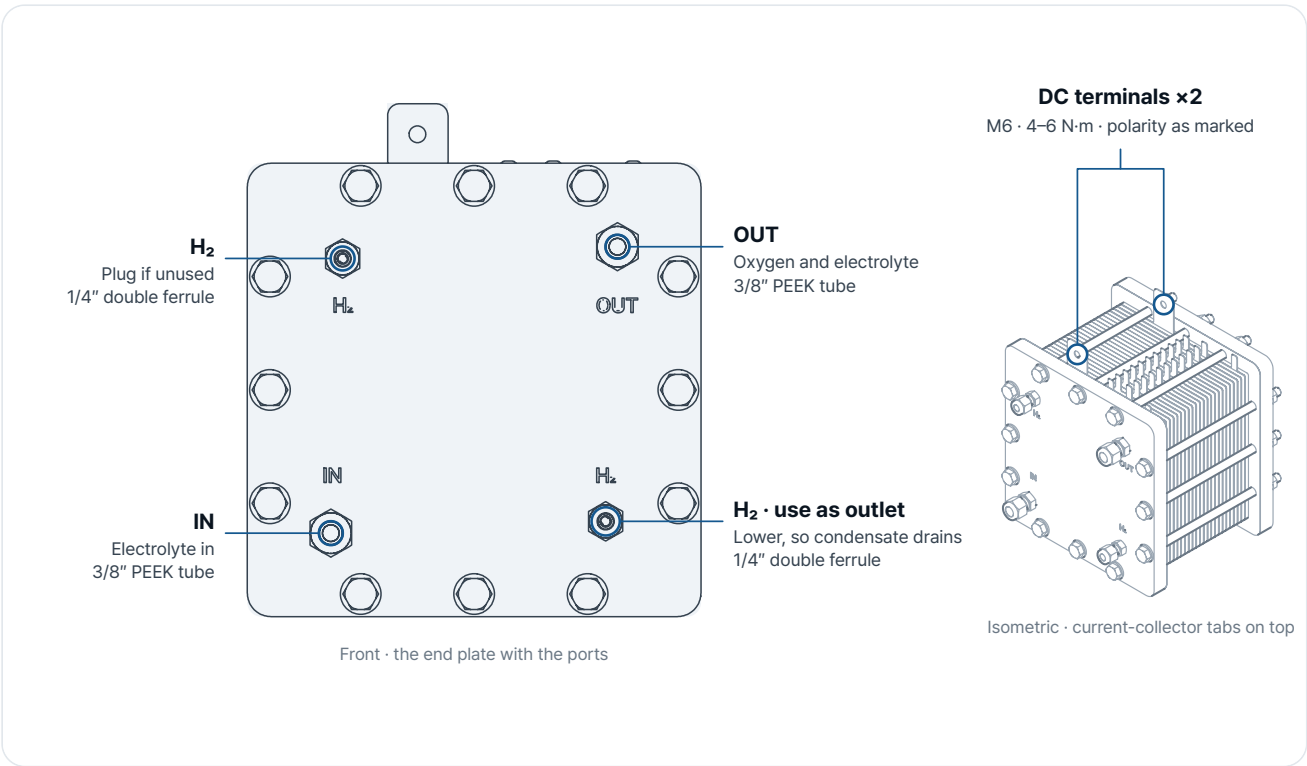


Figure 3-1 HXS-2 ports and DC terminals. Drawn from the 3D model; port positions match the front view of the outline drawing. They can differ between revisions, so follow the markings on your stack.

PORT	QTY	POSITION (FRONT)	WHAT PASSES THROUGH	FITTING
IN	1	Lower left	Electrolyte in	3/8-inch PEEK tube
OUT	1	Upper right	Oxygen and electrolyte out, together	3/8-inch PEEK tube

PORT	QTY	POSITION (FRONT)	WHAT PASSES THROUGH	FITTING
H2	2	Upper left · lower right	Hydrogen out. Use one and plug the other	1/4-inch double ferrule
DC terminals	1 set	—	DC power in	M6 threaded tabs · torque 4–6 N·m

NOTICE

Prepare fittings in two sizes.

- IN and OUT are 3/8 inch; H2 is 1/4 inch. If you order everything in 1/4 inch, the electrolyte side will not fit.
- The H2 side follows the standard double-ferrule pattern, so off-the-shelf 1/4-inch double-ferrule fittings and tubing fit directly.
- Port coordinates are on the front view of the outline drawing. The front is the end plate that carries the ports.

PRACTICAL NOTES

OUT is a wet outlet: gas and liquid leave together.

- There is no separate oxygen port. Oxygen leaves with the electrolyte through OUT, returns to the tank, and separates there. How you vent the tank therefore becomes part of the system design.
- A blocked or kinked OUT line makes the return unstable. It is one of the things to watch during operation.

3. Connect the electrolyte loop

A typical arrangement leaves the tank and comes back to it.

- Tank → pump → heat exchanger → stack IN → stack OUT → tank

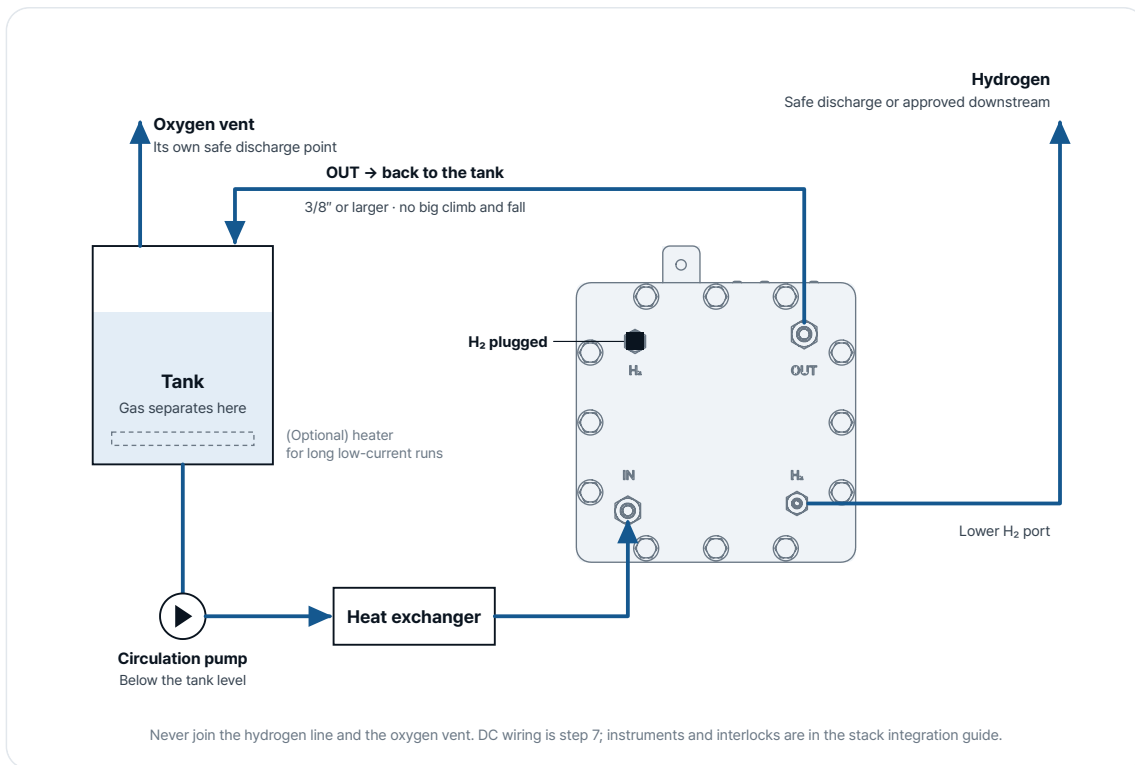


Figure 3-2 Minimum electrolyte loop and hydrogen line. The stack is the front view from figure 3-1, with the ports in their true positions. Valves, instruments and interlocks are in the stack integration guide.

⚠ WARNING

Do not let the pipework load the stack ports.

- Support the tubing and clamps separately. A port carrying the weight of a line starts to weep. It is on the weekly check list as well.
- Electrolyte that leaks out causes chemical burns on contact.

1

Connect the tank outlet to the circulation pump inlet.

- Place the pump below the tank liquid level. With the suction side always flooded, it does not draw in air.
- Do not use the pump to pressurise the anode loop. It is there to circulate.

2

Connect the pump outlet to the heat exchanger inlet.

3

Connect the heat exchanger outlet to IN on the stack.

4

Return stack OUT to the tank.

- The return has to flow smoothly. A line that climbs and falls traps gas and interrupts the return.
- Keep the return line at 3/8 inch or larger. Do not neck it down below the port size.

i NOTICE

Resistance downstream of the stack raises the anode outlet pressure.

- Past a certain level, electrolyte is pushed across the membrane into the hydrogen side. That makes the line from OUT back to the tank the one that matters most.
- If you must use 1/4-inch tubing, keep it short and upstream, between the pump and the stack. Upstream resistance is taken by the pump, not by the cells.
- Measure the anode pressure close to the stack outlet so you can see it directly during commissioning. The instrument positions are in the stack integration guide.

4. Connect the hydrogen line

⚠ DANGER

Never combine a hydrogen line with an oxygen discharge line.

- Route each to its own approved discharge point. Mixed, they are an explosion hazard.
- If the mixture ignites it explodes inside the line and can seriously injure people nearby.

1

Use the lower of the two H2 ports as the outlet.

- Condensed moisture drains out more easily, which is why the lower one is recommended.

2

Fit a plug on the H2 port you are not using.

3

Route the hydrogen outlet to a safe, well-ventilated discharge point, or to approved downstream equipment.

5. Fill the electrolyte

Before filling, check the loop connections and the tightness of the fittings again.

⚠ WARNING

KOH is corrosive. It causes severe skin and eye burns.

- Add KOH to water, never the other way round, which spatters. Wear goggles or a face shield, alkali-resistant gloves and a chemical apron while making up and handling it, and follow the SDS and your site procedures.
- A splash in the eye can cost you your sight.

1

Make up 0.1 M KOH in DI water.

- KOH of 95% purity or better, and water to ASTM D1193 Type II (1.0 µS/cm or below at 25 °C) recommended. The maximum is 30 µS/cm.

2

Fill the tank to a level that suits your circulation loop.

- **Check** There is no leakage at the fittings and ports.
- **If not** If anything leaks, stop circulation and retighten that fitting.

6. Set flow and temperature

1

Start circulation and set the flow to 4 L/min.

- **Check** Flow settles near 4 L/min. A brief wobble at first while air clears is normal.
- **If not** If it keeps fluctuating or will not rise, check that the pump suction is flooded and no gas is trapped in the return line.

2

Control the electrolyte temperature to 50 °C.

- At high current it rises on its own from stack heat. At low current you need the tank heater.

PRACTICAL NOTES

Both are recommendations, not requirements.

- The limits are wider: 1 to 10 L/min for flow, and room temperature to 80 °C for the electrolyte. Running at 80 °C does accelerate degradation and shorten life, though.
- Considering a higher-than-standard flow, or asking for a change to the internal flow field, is covered separately in the stack integration guide.

7. Connect the DC supply

 **DANGER**

Risk of electric shock and arc flash.

- Electrical work is for qualified personnel. Turn the DC supply off and isolate it before connecting.
- Contact with a live conductor causes serious injury or death.

 WARNING

A loose terminal leads to overheating and arcing.

- Never connect or disconnect cables under load. Keep the terminal area dry and away from electrolyte.
- Overheating and arcing lead to burns and fire.

1

Connect supply + to stack + and supply – to stack –.

- Size the cable for 50 A continuous, or for 80 A continuous if you plan to run up to 80 A.

2

Tighten the M6 terminals to 4–6 N·m.

- Do not go past 6 N·m. Over-torque damages the terminal.

3

Verify the polarity again before switching on.

- **If not** If it is reversed, do not apply current; reconnect it correctly.

8. Start the first run

1

Confirm circulation is running and the flow is stable before applying current.

2

Set the DC supply to constant current.

3

Ramp the current in steps.

- 0 to 10 A for two minutes, then 20 A, 30 A and 40 A for two minutes each, then the rated 50 A.
- Stepping up on the first run lets you confirm flow, temperature control and voltage response at each level.
- **Check** At each step the voltage rises then settles, and flow and temperature hold. A new stack reads about 38 V at 50 A.
- **If not** If the voltage keeps climbing or you see a leak or a temperature problem, take the current to 0 A and see Symptom A in Troubleshooting.

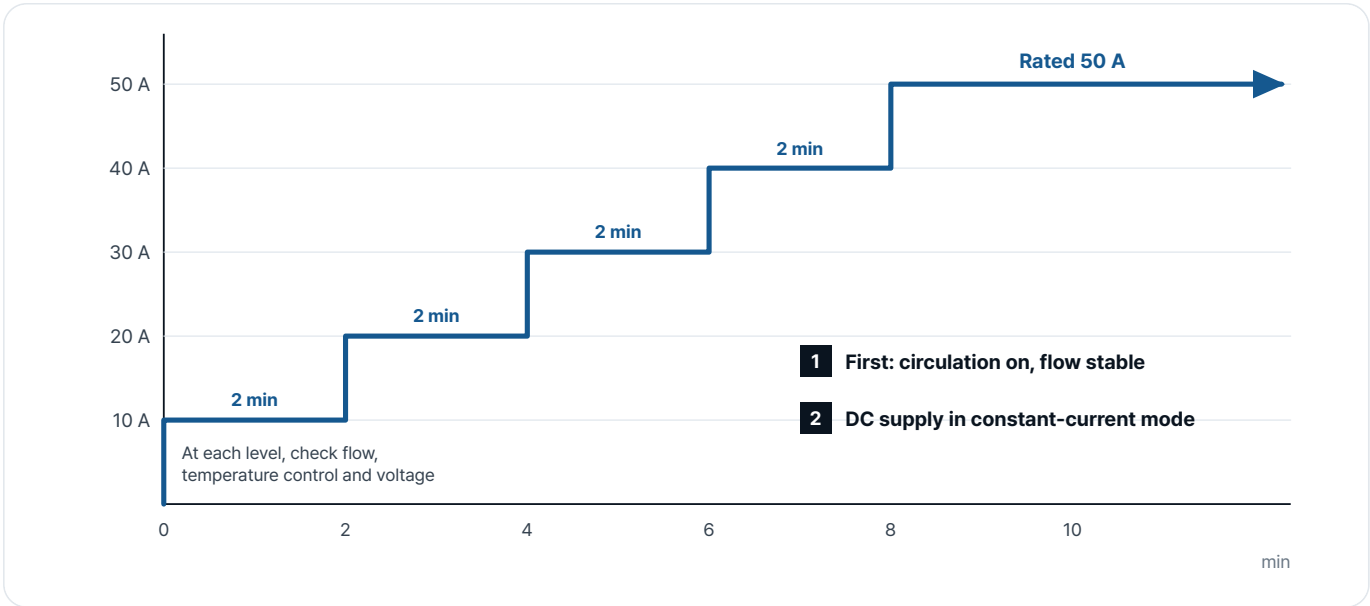


Figure 3-3 First-run current steps. After the ramp and a short hold, make the three checks in step 9.

9. First-run checks

After the ramp and a short hold, confirm three things.

- No electrolyte leaking at the stack ports and fittings, by eye.
- The electrolyte flow is stable.
- Stack voltage rises sensibly with current: about 38 V at 50 A when new (datasheet 37.8 V), rising to typically about 40 V in service.

⚠ WARNING

If anything looks wrong, reduce the current or stop at once.

- Keep circulation running briefly to cool down if needed. Inspect the external loop routing, the fittings and the operating conditions before restarting.
- Carrying on in an abnormal state can lead to leaks, overheating or hydrogen and oxygen mixing.

What to record

Once the first run is stable, write that day's values down once. It becomes the starting point when you read the voltage trend later.

ITEM	WHAT TO WRITE DOWN
Identification	Model, serial number and revision, from the label
Operating point	Stack current and voltage, electrolyte flow and temperature, at the operating point you have chosen

ITEM	WHAT TO WRITE DOWN
If instrumented	Hydrogen flow and pressure, hydrogen purity, oxygen purity
Electrolyte and water	Make-up date and concentration, feed-water quality
Loop layout	Tank, pump and heat exchanger arrangement; routing of the IN, OUT and H2 lines and the vents

PRACTICAL NOTES

Fix one operating point and measure at the same conditions every time.

- If the conditions change each time you get noise, not a trend. Using the recommended point, 50 A · 50 °C · 4 L/min, lets you set it beside the datasheet.
- Every stack gets a factory acceptance test (FAT) before shipment. If you received the results with delivery, keep them with this record.
- These are the same items we ask for when you contact us. Having them written down speeds up the reply.

04 Operation and shutdown

HXS-2 · updated 2026-09-30

Running it day to day: what to watch in normal operation, how to manage level and water make-up, how far the operating range goes, what changes at low current and with frequent starts and stops, and the normal shutdown sequence.

The first start-up is in the quick start chapter. This one picks up after it.

RECOMMENDED POINT 50 A · 50 °C · 4 L/min WATER USE 420 mL/h at 50 A MAKE-UP Yours, by your BoP procedure

HOW TO READ THIS CHAPTER

First time

Read the four sections in order. The first is what you watch every day; the second is what people most often miss on this product.

Done this before

The limits table and the shutdown sequence are enough.

What to watch in normal operation

Keep the circulation steady and watch four things.

Flow and temperature	Confirm the flow is stable (4 L/min recommended) and the temperature is near target (50 °C recommended). If it keeps rising despite available cooling, reduce the current or stop.
Voltage	Monitor the stack voltage continuously. A sudden jump or abnormal fluctuation at constant current means reduce the current or stop, then inspect the loop and the conditions.
Leaks	Check around the IN, OUT and H2 ports and the external fittings periodically. Wetness or white crystals mean stop, correct the cause, then resume.
The wet outlet return	Confirm the OUT return is unobstructed and flows smoothly back to the tank. Gas trapping, gurgling or an unstable return means inspect the routing and the backpressure and correct it before continuing.

WARNING

Reduce or stop first, then investigate.

- Unstable flow, leakage, an uncontrolled temperature rise or abnormal voltage behaviour all mean reduce the current or stop at once. Do not diagnose while it runs.
- Carrying on in an abnormal state can lead to leaks, overheating or hydrogen and oxygen mixing.

Level and water make-up

This is what people most often miss on this product. Unlike a packaged system there is no automatic top-up, so make-up depends on your procedure.

- 1** **Electrolysis consumes water.**
 - In dry-cathode operation with KOH solution fed to the anode loop, water is what is consumed and KOH is not. At 50 A that is 420 mL/h.
- 2** **So the tank level falls over time.**
 - Keep the level high enough for stable circulation and cooling.
- 3** **Add DI water to the tank by your external BoP procedure.**
 - Running at a low level brings pump cavitation and unstable flow.
- 4** **If the level gets too low or the circulation becomes unstable, stop and correct it before continuing.**

NOTICE

Insufficient make-up concentrates the electrolyte.

- Only water leaves, so the concentration rises. A more concentrated electrolyte accelerates degradation and shortens life.
- A low level also reduces the effective cooling capacity and makes temperature control harder. The two problems arrive together.

PRACTICAL NOTES

The voltage tells you which way the concentration drifted.

- At the same current, an unusually high voltage points to dilution and an unusually low one to over-concentration. The two symptoms in the troubleshooting chapter split along that line.

NOTICE

Make-up water follows the same quality basis as the first fill.

- Use DI water from a stable, maintained purification system. Avoid sources high in organics, silica or particles.
- The water-quality figures are in the electrolyte fill section of the quick-start chapter.

Limits and recommended values

PARAMETER	RECOMMENDED	LIMIT
Current	50 A	80 A maximum
Stack voltage	About 38 V (new, 50 A), typically about 40 V in service	50.6 V maximum (2.2 V per cell × 23)
Electrolyte temperature	50 °C	Room temperature to 80 °C
Electrolyte flow	4 L/min	1 to 10 L/min
Hydrogen pressure	0 barg	10 barg maximum

NOTICE

Where your datasheet or contract specification sets a lower ceiling, that value applies.

PRACTICAL NOTES

Stack temperature is controlled through the electrolyte temperature.

- There is no way to heat or cool the end plates or individual cells separately. To change the temperature, change the electrolyte temperature with the tank heater and the heat exchanger.

NOTICE

It will run to 80 °C, at the cost of life.

- Higher temperature degrades the stack faster. If your test needs it, tell us the conditions and we will look at what to expect together.

TECHNICAL BACKGROUND

If you are planning non-standard operation

- Higher-than-standard flow, changes to the internal flow field and pressurised operation are covered separately in the stack integration guide. The differential pressure limit and trip settings for a bare stack are not yet established; pressurised full-stack validation is under way.
- Tell us in advance if you are heading that way, and we will confirm the safe limits and the recommended practice.

Low-current and part-load operation

Running below rated current changes two things: the electrolyte heats less, and the hydrogen-in-oxygen ratio rises.

WHAT	WHY	WHAT TO DO
Electrolyte temperature	Less heat is generated, so it does not reach the recommended temperature	Fit a tank heater and put temperature monitoring and over-temperature protection in the external BoP
Hydrogen in oxygen (H₂-in-O₂)	Hydrogen crossing the membrane barely depends on current, while oxygen output is proportional to it. At lower load the same hydrogen mixes into less oxygen	Below 40–50% of rated load, the 2 vol% control limit becomes the practical design limit. Fit at least one of: a minimum-load limit, reduced pressure at low load, or a 2 vol% interlock

PRACTICAL NOTES

If you run several stacks, stop some of them rather than turning all of them down.

- When demand falls, shut stacks down one at a time instead of taking every stack to low current. The ones still running are easier to keep within the hydrogen-in-oxygen limit near rated load.

Normal shutdown

1

Reduce the current step-wise to 0 A.

2

Turn off the DC output.

3

Keep circulation running as long as needed to cool down.

4

Stop circulation once it has cooled.

5

Turn off the tank heater if you used one, and secure the system by your site procedure.

6

Do a visual leak check around the ports and fittings.

PRACTICAL NOTES

Do not stop circulation first.

- Heat remains in the stack after the current reaches zero, and the circulation is what carries it away. Reversing the order can cause local overheating.

05 Maintenance

HXS-2 · updated 2026-09-30

The daily, weekly and monthly check lists, when to change the electrolyte, how to clean, and how to read the stack voltage trend.

The intervals here are guidance. Actual frequencies depend on run hours, load profile, ambient conditions, electrolyte condition and your test plan.

ELECTROLYTE CHANGE **No fixed interval; judged by condition** RECORD AT MINIMUM **Voltage · current · flow · temperature**
BEFORE ANY WORK **Current to 0 A · DC supply isolated**

HOW TO READ THIS CHAPTER

First time
Print the check lists and remember the three criteria in the electrolyte section. Those three are the heart of this chapter.

Done this before
Go to [the performance trend section](#). That is where normal degradation is separated from an abnormal change.

The intervals are guidance, not rules

 **WARNING**

Before any maintenance, stop electrolysis, set the current to 0 A and isolate the DC supply.

- That applies to any work on a connection. The safety guidance is in the safety chapter, and chemical handling in your site procedures.
- Touching a connection while energised gives an electric shock or an arc burn.

Inspections	Split into three layers: daily or per shift, weekly, and monthly.
Electrolyte	Replaced by condition, not on a schedule. The criteria are below.
Records	Record at least the stack voltage and current and the electrolyte flow and temperature. Where you have the instruments, add hydrogen purity, flow and pressure, and oxygen purity.

 **NOTICE**

Intensive research use calls for more frequent inspection and replacement.

Replacing the MEA yourself means opening the stack.

- The stack is a compression assembly, so it can be taken apart and put back together, and we provide the assembly guide. Performance and leakage after opening do depend on the quality of the reassembly, though.
- Opening it yourself needs a hydraulic press: on reassembly the stack is compressed in the press before the bolts are tightened. Open it without a press and you will not be able to close it properly. The compression and bolting sequence is in the assembly guide.
- The bolts around the edge of the end plates are the stack compression bolts. Do not loosen them while working on tubing or cables; loosening them opens the stack.
- Alternatively send us the stack: we open it, replace only the MEA, reuse the hardware and send it back. Ask us for the terms.

The check lists

Daily or per shift

- Scan the stack and the external loop. No electrolyte, water or gas leaking at the IN, OUT and H₂ ports or the fittings.
- No white crystals around the ports or fittings, which can be dried KOH.
- No mist, wetness or splashing consistent with a leak.
- The electrolyte flow is stable, around 4 L/min as recommended.
- The electrolyte temperature is controlled near target, around 50 °C as recommended.
- The stack voltage is stable for the current setpoint, with no sudden jumps.
- The hydrogen outlet and the OUT return are correctly routed and unobstructed.
- The hydrogen and oxygen paths are not mixed and the discharge points are clear.

Weekly

- Review the records and trends: stack voltage against current, the stability of flow and temperature, and any recurring abnormal events.
- Where you have the instruments, review the hydrogen purity, flow and pressure and the oxygen purity trends too.
- Inspect the tubing and fittings for wear, discolouration, salt or crystal residue, and weeping leaks.
- Check the tube supports and clamps: no mechanical load on the stack ports.
- Inspect the DC cable routing and the terminal area for mechanical damage, looseness and corrosion.

Monthly

- Check the electrolyte condition for excessive discolouration or visible solids. Replace it if any criterion in the next section applies.

- Check the stability of the wet outlet return: the OUT path unobstructed and flowing smoothly back to the tank.
- Review and update the maintenance and operating records: run hours, operating history, electrolyte replacement dates, observations and corrective actions.

An example log line

Leave one line per measurement. Current, voltage, flow and temperature every time; the rest when they apply.

COLUMN	WHAT GOES IN IT
Current · voltage	Stack current and voltage at your fixed operating point
Flow · temperature	Electrolyte flow and temperature
Run hours	Cumulative run hours, and the number of starts and stops since the last line
Electrolyte	Date of the last change, and how much DI water was added
Gas	If instrumented: hydrogen flow, pressure and purity, and oxygen purity
Observation · action	What you saw and what you changed: leaks, crystals, gurgling, parts replaced

Changing the electrolyte


WARNING

Risk of chemical burns and corrosion.

- Follow the electrolyte and PPE sections of the safety chapter and the SDS. Before opening any line, stop electrolysis, cool down as needed, and depressurise and secure the external loop.
- A splash in the eye can cost you your sight.

When to replace it

KOH is not consumed by electrolysis. Water is, and you make that up during operation. The electrolyte is therefore replaced by its condition and the performance trend rather than on a fixed interval. Consider replacing it when any of the following appears.

- Cell voltage rises continuously at the same current compared with earlier operation.
- Where you measure individual cells, the spread between them widens over time.
- The colour or clarity changes, or precipitate appears in the tank or the loop.

⚠ WARNING

If hydrogen in the oxygen exceeds 2%, stop and inspect.

- This is a stop-and-inspect condition, not a replacement criterion. Stop electrolysis, perform a normal shutdown, investigate, and do not restart until you know the cause.
- Hydrogen building up on the oxygen side can explode in the line and separator.

PRACTICAL NOTES

The interval varies widely with operating conditions.

- It gets shorter as temperature, concentration and current rise. If you want a recommended range for your own conditions, send us those conditions.

Measure the concentration first

When voltage creeps up at the same current it looks like stack degradation, but often the electrolyte concentration has fallen. Measure it with a conductivity meter or by titration, and replace it if it has moved noticeably from the initial fill. Replace all of it after fixing a leak or replacing parts, too: while it leaked, KOH escaped and make-up water took its place.

Where electrolyte escapes

In normal operation the KOH does not decrease. If the concentration falls anyway, KOH is escaping somewhere and pure water is replacing the loss. Leave the cause in place and fresh electrolyte will go the same way.

WHERE	HOW YOU CAN TELL
Out of the stack	A seal between cells is leaking. The stack perimeter gets wet or grows white crystals. A small leak may never trip leak detection and show only as a slow fall in concentration.
Inside the stack, across to the hydrogen side	Electrolyte crosses the membrane from the oxygen side (anode) to the hydrogen side (cathode) and leaves with the hydrogen. Moisture from the H2 port tests alkaline on pH paper. A fast depressurisation after pressurised operation can give briefly alkaline moisture, so check during steady operation.
From the tank or the external loop	A tank gasket, joint or fitting is leaking. The area under the tank and tubing gets wet.

If the stack is leaking, contact us rather than replacing the electrolyte again and again.

The procedure

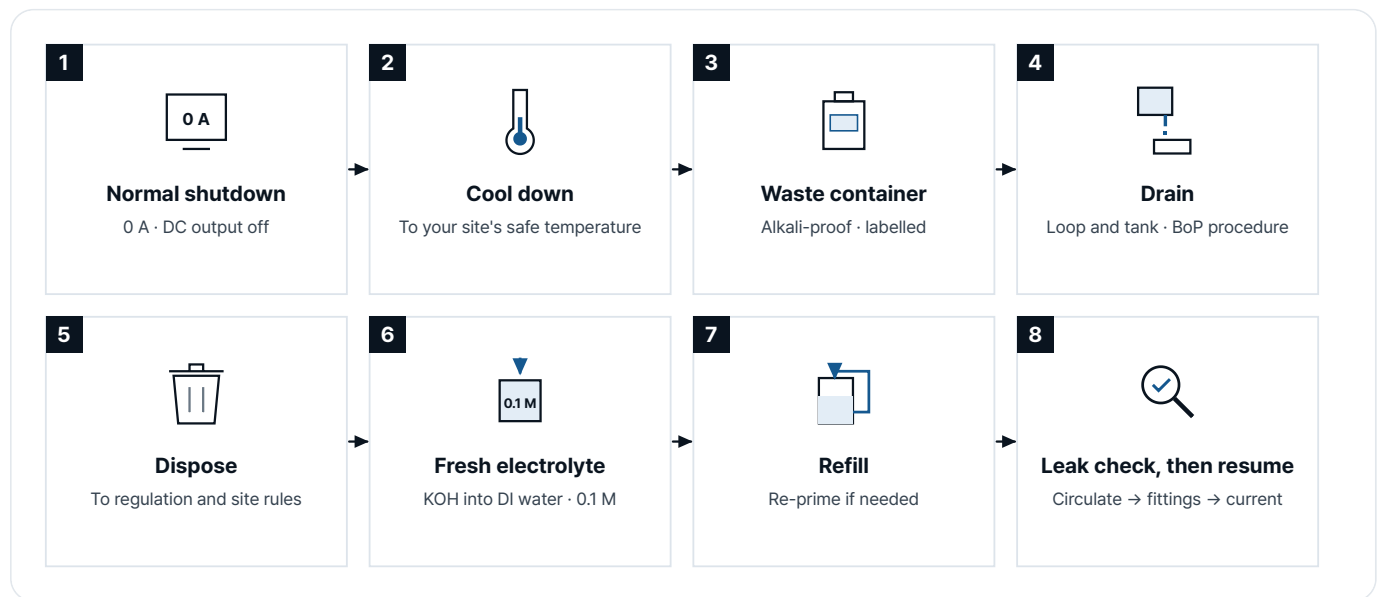


Figure 5-1 Electrolyte change sequence. Numbers match the steps below.

1

Perform a normal shutdown: current to 0 A and DC output off.

2

Let it cool to a safe temperature by your site practice.

3

Prepare a container for the drained electrolyte: alkali-compatible, and labelled.

4

Drain the electrolyte from the loop and tank by your BoP procedure.

5

Dispose of the used electrolyte to regulation and your site procedures.

6

Make up fresh electrolyte: 0.1 M KOH in DI water, with the water to the required quality.

7

Refill the tank and re-prime the circulation loop if needed.

8

Restart circulation, check for leaks at every fitting and stack port, then resume electrolysis.

i NOTICE

Do not mix old and new electrolyte.

- Unless your own procedures say otherwise, keep them separate. Use only alkali-compatible containers and tools, and label everything with contents, concentration and date.

Cleaning

i NOTICE

No aggressive solvents and no high-pressure jets.

- Use only methods compatible with KOH and with the materials in your installation.

Exterior

- Wipe with a disposable paper towel or a soft cloth dampened with clean water.
- For white crystals, wipe with a water-dampened cloth (KOH is water-soluble), then wipe again with clean water.
- Dry it thoroughly afterwards.

After a spill

- Stop the source if it can be done safely, and ensure ventilation.
- Follow your site spill response procedure: containment, neutralisation or absorption, and waste disposal.
- After clean-up, wipe the affected surfaces with clean water and dry them thoroughly.

i NOTICE

Significant leakage at a stack port, or leakage that recurs after tightening or replacing fittings, means stop and contact us.

Reading the performance trend

Stack voltage rises gradually over time, from degradation of the electrodes and the membrane together with the operating history. The point of watching the trend is to separate normal, gradual degradation from an abnormal change caused by off-nominal conditions.

What pushes the voltage up

Rising ohmic resistance

Conductivity loss in the membrane and ionomer, conductivity loss in the electrodes, and rising contact resistance at the interfaces.

Rising kinetic overpotential	Loss of catalytic activity, catalyst detachment and agglomeration, and surface oxidation and reconstruction.
Rising mass-transport loss	Gas and liquid transport limits, blockage and poor wetting, and bubble management problems.
Electrolyte effects	Concentration drift from unbalanced water make-up, carbonate formation and precipitation from CO ₂ exposure, and contamination.

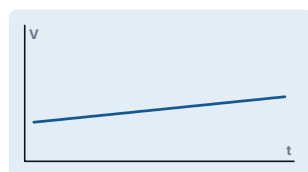
How to record it

- Record the stack voltage periodically at one or more fixed operating points. Conditions that change every time give you noise, not a trend.
- Keep the operating context with it: run hours, start-stop cycles, setpoints and any abnormal events.

How to read it

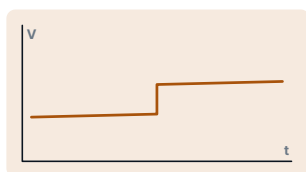
WHAT YOU SEE	WHAT IT MEANS
A slow, gradual rise	Consistent with normal degradation.
A step change at constant current	Abnormal. Start with the checks below.
A rapid change over a short period	Abnormal either way. If the stack or electrolyte temperature rises with it, suspect insufficient water make-up, concentration drift or reduced cooling.
Large fluctuations at constant current	Abnormal.

Stack voltage over time, at one fixed operating point (same current, temperature, flow)



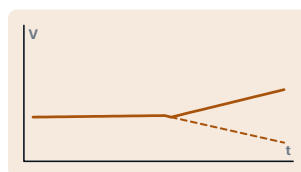
A slow, gradual rise

Consistent with normal degradation.



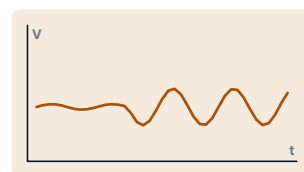
A step at constant current

Abnormal.



A rapid change, short period

Abnormal either way.
If temperature rises too:
make-up, concentration, cooling



Large swings at constant current

Abnormal.

First checks when abnormal: electrolyte condition and concentration · DI water · flow, temperature, cooling · wet outlet and backpressure · sensors and wiring

Figure 5-2 Reading the voltage trend. The rows of the table above drawn as shapes; schematic, with no values on the axes.

First checks when it looks abnormal

- The electrolyte condition and concentration drift
- The DI water quality and possible contamination sources
- The stability of flow and temperature, and the cooling capacity
- The wet outlet routing, backpressure and gas trapping
- Sensor and analyser problems, and the integrity of the wiring and connections

NOTICE

This handbook does not give a conditioning procedure.

- Do conditioning within your own test plan or with our guidance, and stay inside every operating limit. If abnormal behaviour appears, reduce the current or stop, and perform a normal shutdown if needed.

06 Decommissioning

HXS-2 · updated 2026-09-30

The sequence for taking the stack out of the system. It is the same procedure for a long stand-down, a move, or shipping it in for service.

Storage after decommissioning follows the same conditions as in the receiving chapter. Preventing freezing matters most.

WHO **Qualified personnel only** ORDER **Stop, depressurise, drain, seal** STORAGE **5 °C or above at all times**

HOW TO READ THIS CHAPTER

First time

Do the three sections in order. Changing the order is dangerous: never open a line that is still energised or still pressurised.

Done this before

The draining procedure is what you need. Opening the pump inlet to atmosphere is the key step.

Safe shutdown and electrical disconnection

DANGER

Do not decommission a stack that is still energised or pressurised.

- Before any disassembly or disconnection, confirm the stack is safely shut down and no longer producing hydrogen and oxygen.
- Live power means electric shock; trapped pressure makes hydrogen and electrolyte spray out when a fitting is undone, leading to fire or burns.

1

Reduce the stack current to 0 A and stop electrolysis.

2

Turn off the DC output, then turn off the external disconnect or breaker.

3

Do not disconnect the DC cables straight away.

- Stored charge can remain in the DC circuit even at 0 A: the supply, the cables and the stack.
- Wait until the supply is fully off and enough time has passed for the charge to dissipate, then disconnect the cables with tools.

Turn off the circulation pump and any temperature control devices.

Depressurise the gas paths

WARNING

Flammable gas can remain in the connected lines.

- Depressurise through the designated discharge path. Do not loosen a fitting to vent gas.
 - Undoing a fitting releases the remaining hydrogen, which can ignite.
-
- Depressurise the connected hydrogen and oxygen discharge paths to ambient, using the normal vent route you used during operation.
 - Where there is a pressure indication, confirm there is no residual pressure.

Drain the electrolyte and seal it

WARNING

Electrolyte remains in the stack and the lines.

- Wear PPE and follow the electrolyte section of the safety chapter.
- It causes chemical burns on contact.

1

Prepare for draining.

- Place a labelled, alkali-compatible container under the discharge point and use secondary containment.
- Route the wet outlet path safely into the container.

2

Reconfigure the pump so it does not draw from the tank.

- Disconnect the line between the electrolyte tank and the pump inlet.
- Leave the pump inlet open to atmosphere so air can enter, which stops it pulling electrolyte back out of the tank.

3

Provide an air break at IN.

- Disconnect the IN line from any liquid supply and leave it open to atmosphere, so air can enter as liquid leaves through OUT.

4

Pump the electrolyte out of the stack.

- Turn the pump on and discharge until no more liquid comes out of the stack OUT line.

5

Tilt-drain what remains.

- Turn the pump off, tilt the stack so the OUT port faces downward, and drain the remainder into the container.

6

Disconnect and cap.

- Disconnect the OUT line and cap or plug the OUT port. Cap the IN port as well.
- Disconnect the external tubing from the H2 ports and plug them as required.
- Disconnect the DC cables from the stack terminals, taking care that a tool does not cause a spark.
- Protect the terminals from accidental contact and from moisture.

7

Confirm every port is securely capped and there is no active leakage.

NOTICE

Even drained, never let it freeze.

- The membrane and electrodes stay wet and residual liquid and moisture remain in the internal flow paths. Store it at 5 °C or above, upright, with the ports capped.

NOTICE

Shipping it in for service needs prior confirmation.

- Contact us first for a return authorisation and packing instructions. Items arriving in a leaking condition may be refused for safety reasons.
- If you kept the original packaging from delivery, use it. Plug every port and pack the stack upright.

07 Specifications and reference

HXS-2 · updated 2026-09-30

What the HXS-2 is for, how it looks, its specifications, and the terms used in this handbook.

Intended use

The HXS-2 is a stand-alone 23-cell, 2 kW AEM water electrolysis stack. It makes hydrogen once integrated with your DC power, electrolyte circulation, gas-liquid separation and safety systems. Everything before and after the stack is in your design scope.

WARNING

Do not use it like this.

- Passing current without electrolyte circulation
- Running outside the recommended conditions (electrolyte, temperature, current, pressure) without checking with us first
- Joining the hydrogen line and the oxygen vent in one line or vessel
- Opening the stack without authorisation (we do not warrant performance or leak-tightness after disassembly)
- Doing so can lead to fire, explosion, electric shock or chemical burns, or damage the equipment.

Product view

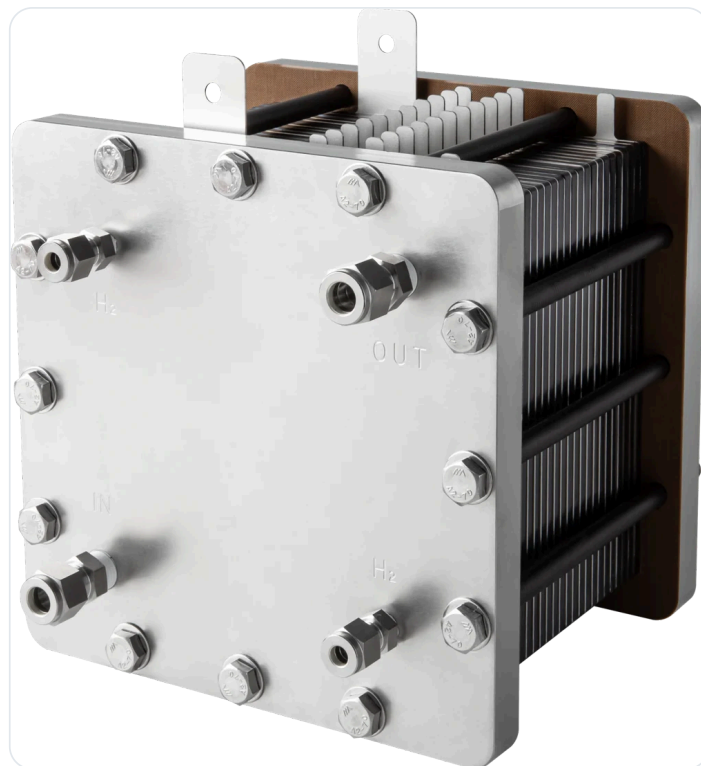


Figure 7-1 The HXS-2. For the ports and DC terminals, see figure 3-1 in Quick start.

Specifications

The specifications below are the same values as the product page and datasheet. They are beginning-of-life values unless stated otherwise.

H ₂ production	500 L/h · 1 kg/day (at rated 50 A)
Efficiency (HHV)	90.0% (BOL · 0.1 M KOH · 50 °C · ambient pressure) · 44 kWh/kg-H ₂
Long-run validation	More than 3,000 hours of cumulative operation (23 cells) · long-run data and test conditions in the durability note
Rated operating condition	0.1 M KOH · 50 °C (adjustable)
Operating temperature	Up to 80 °C
Energy use	2 kW (at 50 A)
Water consumption	420 mL/h (50 A)
Number of cells	23
Active area	100 cm ² (anode) / 79 cm ² (cathode)
Dimensions	190 × 198 × 215 mm
Weight	19 kg
Structure	NiFe anode · Pt/C or PtRu/C cathode · AEM
Fluid ports	KOH IN 3/8" PEEK tube · O ₂ +electrolyte OUT 3/8" PEEK tube · H ₂ two ports 1/4" double-ferrule
DC terminals	M6 · torque 4–6 N·m
External circulation	4 L/min (standard)
Instrument calibration	Flow and gas analysers calibrated under KOLAS
End plate	SUS316L
Bipolar plate	Nickel-based metallic plate
Material change	Yes · we confirm the operating window and validation scope together

Terms

TERM	MEANING
AEM	Anion exchange membrane: a membrane that passes hydroxide ions (OH ⁻).
KOH	Potassium hydroxide, used as a 0.1 M solution for the electrolyte.
DI water	Deionised water. Quality is judged by conductivity (μS/cm at 25 °C).
MEA	Membrane electrode assembly: the electrodes and membrane that make up the heart of a cell.
BoP	Balance of plant: everything around the stack, such as power, pumps, tank, heat exchanger, piping, sensors and controls.
barg	Gauge pressure in bar, relative to atmosphere.
NL/h	Gas volume per hour in litres at standard conditions (0 °C, 1 atm).
BOL	Beginning of life. Specifications are BOL values unless stated otherwise.
SDS	Safety data sheet. Check it before handling KOH.

Manufacturer

Manufacturer	HydroXpand Inc.
Address	3F, 59 Dongtansandan 6-gil, Hwaseong-si, Gyeonggi-do 18487, Republic of Korea
Contact	+82 70-4110-1201 · info@hydroxpand.com · hydroxpand.com

Troubleshooting

HXS-2 · updated 2026-09-30

What to check when the stack voltage behaves oddly. Voltage symptoms come in two kinds, and the cause is usually in the external loop rather than in the stack. Visible symptoms such as leaks, an unstable return or a falling level are gathered in one table.

Repair and replacement of external BoP components is yours. We interpret the stack's behaviour and judge whether stack service is needed.

FIRST **Judge the hazard, then make it safe** ONE AT A TIME **One change, then re-check** RESTARTING **From low current**

HOW TO READ THIS CHAPTER

First time

Start with the order-of-checks section. Jumping straight to the symptoms skips making the area safe.

Done this before

Find the line for what you are seeing in the find-by-symptom table. For a voltage symptom, go to symptom A or B depending on whether it went up or down.

The order of checks

WARNING

This work can expose you to live electricity, hydrogen and corrosive electrolyte.

- Follow the safety chapter and, where they apply, your site's energy isolation and re-energisation prevention procedures and chemical handling procedures first.
- This can lead to electric shock, fire or chemical burns.

1

Stop and assess the hazard level.

- Any sign of a hydrogen leak, fire, arcing, a burning smell, severe overheating or uncontrolled electrolyte leakage means stop at once and follow the emergency section of the safety chapter.

2

Make it safe before touching anything.

- Ramp the stack current down to 0 A, then turn off the DC output.
- Electrically isolate the DC supply from the stack and apply your site procedure to prevent accidental re-energisation.

- Secure the external loop: confirm the vent and relief lines are safe and unobstructed, and manage residual pressure and electrolyte by your site procedures.
-

3

Record the as-found condition.

- Record at minimum the stack current and voltage and the electrolyte flow and temperature.
 - Add hydrogen flow, pressure and purity and oxygen purity if you measured them.
 - Write down what you observed too: pump noise or cavitation, gurgling, an unstable wet outlet return, unusual vent behaviour, visible leakage.
-

4

Check the most likely external causes.

- Flow and heat: valves open, tubing not kinked or blocked, no trapped air, tank level adequate; the filter not clogged if you use one, and cooling available at the heat exchanger.
 - Wet outlet and backpressure: no restriction or blockage in the OUT line, no kinks or pinches, and a stable return to the tank.
 - Electrical: DC cables tight, no discolouration or overheating marks, correct polarity and clean terminal contact.
 - Vent and relief: outlets not blocked, iced or covered, and nothing placed in front of them.
-

5

Apply one corrective action at a time.

- Change one thing, check whether the symptom improves, then change the next. Change two together and you lose which one it was.
 - When you restart, begin at low current and confirm stable flow and a stable voltage trend before ramping up.
-

6

Know when to stop.

- If the issue persists, repeats or suggests hardware damage, stop operating and contact us.
 - If you are unsure about the vent and relief routing, backpressure or the safe limits, ask us before continuing.
-

7

Document the outcome.

- Write down what you changed and what happened. It prevents repeating the same misdiagnosis and speeds up our reply if you do contact us.
-

Find by symptom

Find the line for what you see, take the first action, then go to the section in the right-hand column. Lines run from most to least severe.

WHAT YOU SEE	SUSPECT FIRST	FIRST ACTION	DETAILS
Signs of a hydrogen leak, fire, arcing, a burning smell, severe overheating	—	Stop at once and follow the site emergency procedure	Safety · emergency
A vent blocked or iced	Condensate in the vent line	Keep people away from the discharge. Do not touch the blockage until the line is depressurised and isolated	Safety · emergency
Hydrogen in oxygen above 2%	Gas crossing the membrane	Stop electrolysis and shut down normally. Do not restart until the cause is found	Maintenance · electrolyte
Current drops on its own with no setting change, and voltage sits at the supply limit	One cell's voltage running away	Stop. Do not keep restarting	Symptom A · 5
Voltage rising fast at the same current	Low temperature, dilute electrolyte, low flow	Reduce current or stop, then check temperature, concentration and flow	Symptom A
Voltage falling fast at the same current	High temperature, concentrated electrolyte, low flow	Reduce current or stop, then check temperature, concentration and flow	Symptom B
Temperature keeps climbing although cooling is available	Poor circulation, not enough cooling	Reduce current or stop	Operation · watch
Wetness or white crystals around a port or fitting	A loose fitting, tubing weight on a port	Stop, fix the cause, then resume. Wipe crystals off with a damp cloth	Maintenance · cleaning
The OUT return gurgles or keeps breaking	Line routing, back-pressure, trapped gas	Correct the routing and back-pressure before continuing	Operation · watch
Pump cavitation noise, or the flow wanders	Low tank level, air in the loop	Stop, correct the level, then bleed the air	Operation · level

WHAT YOU SEE	SUSPECT FIRST	FIRST ACTION	DETAILS
Moisture from the H2 port tests alkaline on pH paper	Electrolyte crossing the membrane to the hydrogen side	Re-check during stable running. If it persists, contact us with your records	Maintenance · electrolyte
Concentration falls again after a change	KOH escaping somewhere	Find the escape path first. Do not just keep changing it	Maintenance · electrolyte
Raising the flow makes the pump noisy or the flow unsteady	Narrow suction or return tubing, or an abrupt change in diameter	Use larger tubing and put any change in diameter close to the tank	Quick start · electrolyte loop

Symptom A: the voltage rises rapidly

At the same current the stack voltage climbs quickly or sits unusually high. Work through the five causes from the top.

1. The electrolyte temperature is too low

- Verify the temperature reading and confirm the heater is running: power, status, setpoint.
- Bring the temperature back into the normal range, typically around 50 °C.
- If the heater is not working or the temperature cannot be restored, stop and repair or replace the heater.
- If the voltage stays abnormal after the temperature is restored, contact us.

2. The electrolyte is too dilute

- Confirm the electrolyte specification is 0.1 M KOH and review the recent DI water make-up and refill history.
- If dilution is suspected, stop and replace it with fresh 0.1 M electrolyte.
- Restart at low current and confirm a stable voltage trend before ramping up.
- If the abnormal voltage persists with fresh electrolyte, contact us.

3. Internal crossover or membrane damage is suspected

- Stop operating.
- Record the evidence: the electrolyte level trend, the DI water make-up events, and the stack current and voltage.
- Contact us with those records. This is not something you can resolve on site.

4. The electrolyte flow is low or unstable

- Confirm the pump is powered and commanded on: the indicator or controller status, and the fuse or breaker where applicable.
- If the pump is on but there is no flow, it does not start reliably, or it behaves abnormally, stop and repair or replace it before resuming.
- Confirm all the relevant valves are open.
- Remove obvious restrictions: straighten kinked tubing, clear blockages, and check or clean the filter if you have one.
- Remove air from the loop and make sure the pump is properly primed.
- Restore a stable flow, 4 L/min as recommended.

5. A single cell voltage shoots up

- If you measure individual cell voltages, one cell climbs far above the others. If you do not, the stack voltage reaches the supply's limit and the current falls by itself although no setting was changed.
- In our tests a slow rise of stack voltage at the same current appeared first, 10-24 hours before the stop.
- If the cell voltages are even, it may be the supply limit rather than a cell. A 45 V supply hits its limit at about 1.96 V per cell, so a stack that slowly ages shows the same picture. First check whether the supply has switched to constant voltage.
- Stop operating and do not restart repeatedly. Send us the current and voltage trends, and the cell voltages if you record them.

Symptom B: the voltage falls rapidly

At the same current the stack voltage drops quickly or sits unusually low. The causes fall on the opposite side from symptom A.

1. The electrolyte temperature is too high

- Verify the temperature reading.
- Restore temperature control: confirm cooling is available at the heat exchanger and the circulation is working.
- If the temperature cannot be controlled, stop and service or repair the external cooling and circulation equipment.

2. The electrolyte is too concentrated

- Check the tank level and verify the DI water make-up is working.
- Correct the electrolyte back to specification, 0.1 M KOH, by your site procedure.

- Restart at low current and confirm a stable voltage trend before ramping up.

3. The electrolyte flow is low or unstable

- Work through it the same way as cause 4 under symptom A: the pump, the valves, restrictions, trapped air, and restoring the flow.

4. An abnormal stack condition is suspected

- If the voltage stays unusually low after temperature, concentration and flow are all restored, stop operating.
- Record the evidence and contact us: the stack current and voltage trend, the electrolyte temperature, the flow, and the recent maintenance history.

PRACTICAL NOTES

Rare, but it matters.

- It is what remains after the three external causes are eliminated, so the order matters. Skip the first three and you will not find the cause.
-

When to contact us

- Abnormal voltage behaviour persists after you have restored the electrolyte flow, temperature control and condition.
- Leakage recurs despite correcting the fittings and tubing and confirming material compatibility.
- You suspect damage to the stack hardware: the ports, end plates, compression hardware or terminals.
- The same problem persists or recurs under normal operating conditions and the symptom guide does not resolve it.
- You are planning non-standard operation and want the safe limits and recommended practice confirmed.

What to send

Having the following ready speeds up diagnosis. If you kept the record at the end of the quick-start chapter, half of it is already done.

GROUP	CONTENTS
Identification	Model (HXS-2) and serial number
Conditions at the time	Stack current and voltage, electrolyte flow and temperature. If measured, hydrogen flow, pressure and purity, and oxygen purity
Symptom	What you saw, and when: during start-up, while ramping, in steady running, or during shutdown

GROUP	CONTENTS
Installation	External loop layout (tank, pump, heat exchanger), routing of the IN, OUT and H2 lines including the wet-outlet return, and any vent and relief routing
History and changes	Electrolyte specification and change date, the water quality used, and anything changed recently (new stack, new electrolyte, piping, a replaced component)
Evidence	Photos of the terminals, any leak points and the overall routing. Logs or screenshots of current, voltage, temperature and flow around the event

Before confirming a return we may ask for more data or troubleshoot remotely first. Once a return is confirmed we send packing and shipping instructions. Draining and packing the stack so it does not leak or corrode in transit is yours to do.

NOTICE

Repair and replacement of external BoP components is yours.

- That covers the pump, heater, heat exchanger, sensors and power supply. We interpret the stack's behaviour and judge whether a stack service action is needed.
- Returns for inspection or service go ahead only after we confirm them. Do not ship without prior confirmation.