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TECHNOLOGIES

Insulating Pipeline PEM Guard 5000

For Hydron Powerstack K500, K1000

User Manual

We pioneer motion

SCHAEFFLER

Contents

1 About the manual

This manual is part of the product and contains important information. Read the manual thoroughly prior to use and follow the instructions precisely.

1.1 About this user manual

This user manual contains all essential instructions that must be observed in relation to general safety, transport, installation, commissioning, operation, maintenance, decommissioning, and storage.

This user manual must:

- be followed, read, and understood by all persons working with the stack
- be freely accessible to all persons working with the stack and the associated insulating pipes
- be consulted when there is even the slightest doubt about safety

The user manual provides support on the following topics:

- hazard avoidance
- increasing the reliability and life of the device.

This user manual forms part of the device.

In this manual, the term “stack” is used to designate the proton exchange membrane water electrolysis stack.

1.2 Symbols

The warning and hazard symbols are defined in accordance with ANSI Z535.6-2011.

1 Warning and hazard symbols

Signs and descriptions	
DANGER	In case of non-compliance, death or serious injury will occur.
WARNING	In case of non-compliance, death or serious injury may occur.
CAUTION	In case of non-compliance, minor or moderate injury may occur.
NOTICE	In case of non-compliance, damage or malfunctions in the product or the adjacent construction may occur.

1.3 Signs

The warning, prohibition and mandatory signs are defined in accordance with DIN EN ISO 7010 or DIN 4844-2.

2 Warning, prohibition and mandatory signs

Signs and descriptions	
	General warning
	Electrical voltage warning
	Warning of hot surface
	Flammable substances warning

Signs and descriptions	
	Warning of pressurized gas cylinders bursting
	Observe the manual
	Wear safety shoes
	Wear eye protection
	General mandatory sign

1.4 Availability

This user manual is supplied with each item of operating equipment and can also be ordered retrospectively.

Ensure that this manual is always complete and legible and is available to all persons engaged in transporting, fitting, dismantling, commissioning, operating or maintaining the product.

Keep the manual in a safe place for immediate reference.

1.5 Legal guidelines

The information in this manual reflects the status at the time of publication.

Unauthorised modifications to or improper use of the product are not permitted. Schaeffler accepts no liability in these cases.

1.6 Images

The images in this manual may be schematic representations and may differ from the delivered device.

1.7 Directives and standards

The insulating pipe is, insofar as applicable, compliant with the relevant EC directives:

- Pressure Equipment Directive 2014/68/EU
- Low Voltage Directive 2014/35/EU

Other directives and standards to be observed when using the insulating pipeline depend on the system in which the insulating pipeline is integrated and the prevailing environmental conditions there.

1.8 Abbreviations

3 Abbreviations

Abbreviation	Description
AC	Alternating current
ATEX	EU directive for equipment used in potentially explosive atmospheres and for safety in potentially explosive atmospheres
BoP	Balance of Plant
DC	Direct current
PEM	Proton exchange membrane
PEMWE	Proton exchange membrane water electrolysis
PEMWE stack	Proton exchange membrane water electrolysis stack
PFD	Process flow diagram
PPE	Personal protective equipment
SAT	Site acceptance test
UPW	Ultrapure water

2 General safety regulations

2.1 Intended use

The insulating pipeline is used to electrically isolate the potential of a PEM electrolysis stack from the surrounding plant equipment and to reduce stray current via the media flow.

Intended use also includes:

- compliance with all information in the user manual
- adherence to all safety instructions
- compliance with maintenance and service regulations

Any other use or extended use of the insulating pipeline is deemed improper and is thus inadmissible. Schaeffler accepts no liability for any damage arising from inappropriate or improper use.

2.2 Improper use

Improper use and reasonably foreseeable misuse are not permitted as they may put the user, other personnel, or the device at risk.

Improper use across all operating modes is defined as follows:

- use of the insulating pipeline outside the scope of its intended use
- operation of the insulating pipeline outside the specifications provided in this user manual
- supply of fluids other than those described in the user manual
- use of electric currents and electric voltages outside the specifications provided in this user manual
- operation of the system outside the physical application limits described in the operating and ambient conditions
- operation of the system when obvious defects are present
- execution of repair, cleaning, or maintenance work while the system is in operation
- incorrect execution of maintenance work
- unauthorised modifications to the insulating pipeline

2.3 Operating environments and ambient conditions

The system with integrated insulating pipelines may only be operated under suitable operating conditions that comply with the product specification ➤33|13. Operation of the system under unsuitable operating conditions may lead to unsafe conditions or malfunctions.

The use of an enclosure is recommended. This serves to protect against contact and contamination.

Pollution degree III must not be exceeded. It is strongly recommended not to exceed pollution degree II. During operation, check regularly for contamination and clean if necessary.

2.4 Warranty and liability

Warranty and liability claims in the event of personal injury or property damage are excluded if they are attributable to one of the following causes:

- inappropriate use of the insulating pipeline
- incorrect installation, commissioning, operation, or maintenance of the insulating pipeline
- operation outside the specified operating conditions ➤33|13
- operation of the system using defective safety equipment
- failure to observe the user manual
- unauthorised modifications to the insulating pipeline
- inadequate maintenance, repair, or servicing
- disasters caused by external influences or force majeure
- use of fluids that do not comply with the specifications provided in this user manual

The technical and operational requirements must be in place to enable access to the measured process variables and their recording at defined measurement intervals.

2.5 Applicable documents

In addition to this user manual, the following points must be observed to ensure safe and proper operation:

- regulations applicable at the place of use, according to the system in which the insulating pipeline is integrated and the prevailing ambient conditions
- provisions of the supervisory authorities (accident prevention regulations)
- recognised technical rules for safe and professional working
- local laws and regulations
- environmental protection regulations
- other applicable regulations

2.6 Safety

Failure to observe the safety instructions may result in serious injury, possibly even death, and damage to property. It is extremely important to follow the user manual, including all safety instructions and warnings, in order to avoid potential hazards:

- Read the user manual carefully before installation, commissioning, and operation.
- Ensure that the required safety conditions are met before commissioning.
- Observe the general safety instructions as well as the special warnings provided in other sections.
- Comply with all local safety requirements relating to lifting and the handling of hydrogen, oxygen, compressed gases, and electrical systems.
- Ensure that the system complies with all local regulations, including building regulations and recommendations. The safety instructions and warnings listed here may not cover all situations.

2.6.1 Transport

Damage to the insulating pipeline due to storage and transport conditions. Improper storage or transport of the insulating pipeline may result in damage to the coating or sealing surfaces, which may lead to the formation of an ignitable hydrogen gas mixture in the immediate vicinity of the stack during operation. The presence of an appropriate ignition source can result in a pressure wave, potentially causing mechanical parts and hot, acidic fluids to be ejected with high energy.

When transporting or handling the stack, pay attention to the following:

- Use suitable transport packaging.
  Damage to the coating may impair the insulating properties and can result in serious injury or death due to live components. A visual inspection for coating defects or irregularities is recommended.
- Do not drop the insulating pipeline.

2.6.2 Installation

Observe the following when installing the insulating pipeline:

- Risk of electric shock from contact with live parts (e.g. DC conductors, terminals).
- Comply with electrical safety regulations.

Fluid discharge combined with improper handling can lead to the formation of a flammable hydrogen gas mixture inside and in the vicinity of the system. If an ignition source is present, a rapid thermal reaction or explosion may occur.

- Exercise caution when opening flange connections and fittings. Pressurized fluids may escape.
- Avoid contamination (for example, grease or burrs from the manufacturing process) when connecting the stack.
- Ensure that no foreign bodies can enter the system.
- Only fill the stack via pipelines using approved media.
- Carry out a leak test and vent the surrounding area in accordance with the customer's risk assessment.
- Connect the system components first. Only then disconnect the discharge resistor required for transport.
- Ensure that approved sealing materials and fastening materials are used and tightened to the correct torque.
- Use, for example, earthing clamps or another earthing solution to reduce electrostatic charge.
- Leak tests and electrical insulation tests after installation are recommended.

2.6.3 Operation

The pipelines are designed for the transport of UPW, hydrogen, and oxygen. Hydrogen is a colourless, odourless, and flammable substance, which is highly combustible in the presence of oxygen and burns with a colourless flame that is invisible to the human eye.

The following minimum requirements apply when operating the system:

- Ensure that the ventilation and extraction systems are switched on and have sufficient capacity.
- Operate the system within the specified temperature and pressure limits.
- Equip the work area in which hydrogen is used with safety devices, such as H_2 gas sensors and forced ventilation.
- Ensure compliance with the workplace exposure limits for hydrogen and oxygen concentrations when working on the stack.
- A DC voltage > DC 120 V can be lethal. Ensure that no hazardous voltage is permanently present at the stack when entering the area around the system. Ensure that the system is de-energised before touching or handling it.

2.6.3.1 Hydrogen production

Hydrogen is non-toxic but can act as a simple asphyxiant by displacing oxygen in the air. Loss of consciousness may occur.

Escaping hydrogen may be hot and pose a burn hazard. The very low ignition energy of hydrogen can cause it to ignite spontaneously if released at high speed.

The following parameters apply under standard conditions:

- flammability range in air: 4 Vol.-% to 75 Vol.-%
- auto-ignition temperature: +560 °C
- minimum ignition energy in air: 0,02 mJ

The formation of a flammable or explosive atmosphere caused by leaks at connection points such as fittings, pipe joints, or between the cells in the stack, can lead to death, serious injury, or property damage from fire or explosion.

In the event of an incident involving hydrogen, including the detection of leaks, proceed as follows:

- Carry out an emergency shutdown. The shutdown procedure must be automated and carried out without intervention by personnel. In the event of critical incidents, personnel must prioritise their own safety.
- Allow trained personnel to assess the situation and determine how to proceed.
- Avoid personal exposure to hydrogen and explosive atmospheres.

2.6.3.2 Oxygen production

An excessively high or low oxygen concentration in the air can cause death or serious injury from asphyxiation, lung damage, or organ failure.

The normal concentration of oxygen in air is around 21 Vol.-%. Air containing less than 19,5 % or more than 23 % oxygen constitutes a hazardous working environment. Although not inherently flammable, oxygen promotes the very rapid combustion of flammable materials and of some materials that are usually considered relatively non-flammable.

Although an ignition energy source is always required in connection with flammable substances and oxygen, controlling or eliminating flammable substances is advised as a precautionary measure. Lubricating oils and other hydrocarbon materials may react violently at higher oxygen concentrations.

To avoid hazardous situations, take the following measures:

- Thoroughly clean all components used in oxygen production in accordance with applicable standards and regulations (e.g. ASTM G93).
- Ensure that all relevant components are earthed to prevent static charge build-up.
- Ensure that no flammable materials are located near the system or its flanged connections.
- Due to the increased fire hazard, do not expose personnel to an oxygen-enriched atmosphere:
  - At an oxygen concentration above 23 %, the flammability of clothing increases drastically. Once ignited, even by a relatively weak ignition source such as a spark or cigarette, clothing can catch fire and burn at a rapid rate.
  - At an oxygen concentration above 60 %, flash ignition may occur on clothing and even on body hair, lubricating oils, and other hydrocarbon materials, spreading rapidly to surrounding areas.

2.6.4 Qualification of personnel

Only qualified personnel with the following skills are authorised to work on the system.

4 Qualification of personnel

Work area	Skill
Transport	Qualified personnel: • employed by the operator of the stack • employed by the manufacturer • employed by the external specialist company
Installation	
Commissioning	
Decommissioning	
Troubleshooting	
Operation and handling	

2.6.4.1 Qualified personnel

Specially trained technical personnel are persons authorised by the individual responsible for the safety system to carry out the necessary tasks. Based on their training, experience, instruction, and knowledge of the pertinent standards, specifications, accident prevention regulations, and operating conditions, they are capable of recognising and avoiding potential hazards.

2.6.5 Residual hazards

The possible release of flammable and explosive gases caused by leaks at connection points such as fittings or pipe joints can lead to death or serious injury from fire or explosion.

Even after the stack has been shut down, electrochemical processes may generate a voltage greater than DC 60 V, which may lead to burns, electric shock, sparks, or arcing.

The presence of high direct current voltage can lead to serious injury.

Released energy can result in hazardous situations:

- in set-up mode and other operating modes
- during maintenance and cleaning

Oxygen has a combustion-promoting effect on flammable materials such as lubricants or clothing. These materials burn easily in contact with pure oxygen.

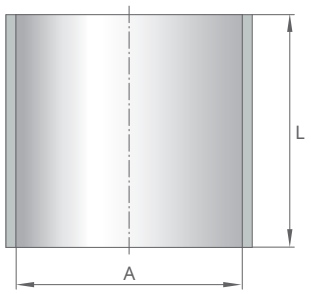
The user manual for the electrolysis system (system documentation) must define the framework conditions for operating the stack and include workplace health and safety requirements.

3 Product description

3.1 Functional principle

The insulating pipeline is dimensioned in accordance with the applicable air clearances and creepage distances for the operating voltage limits. The selected insulating material provides sufficient dielectric strength and corrosion resistance.

1 Insulation in pipelines towards balance of plant (BoP)



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$$I = \sigma \cdot U \cdot \frac{A}{L}$$

A	cm^2	Line cross-section
I	mA	Leakage current
L	cm	Line length
U	kV	Potential difference
σ	µS/cm	Conductivity

Conditions for media connections using the example of stack EL2200:

- total insulation resistance of 100 Ω/V in accordance with EN 60664-1:III.
- alarm threshold 50 Ω/V for IT networks in accordance with DIN VDE 0105-100

In order to remain below a leakage current of I < 10 mA and to fulfil both conditions, a minimum insulation resistance of R < 28,8 kΩ is required for a single stack at a potential difference U of 288 V.

3.2 Design of the insulation resistance

The anode circuit is supplied with ultrapure water (UPW) with a quality of 10 MΩ · cm (in accordance with ISO 3696, Grade 1). The stack must not be operated with water that has a conductivity greater than 0,1 µS/cm (measured at +25 °C). The quality of the process water must be continuously monitored with regard to the threshold value of 0,1 µS/cm. The process water must be free from particles larger than 5 µm.

Media connections act as electrically parallel resistances. The more stacks are connected in series, the higher the resistance of each individual stack must be.

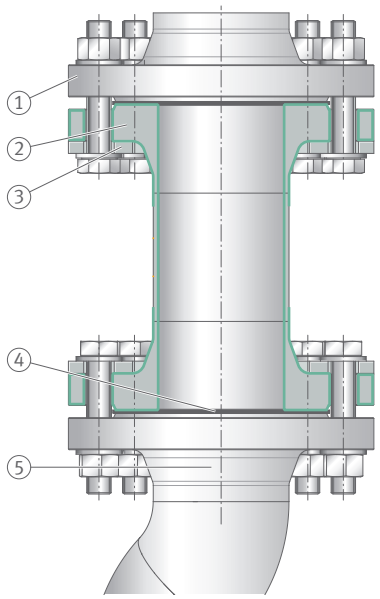
Depending on whether the stack is operated in a series connection, the quality of the cooling water must also not exceed a certain purity. For precise design of suitable insulation lengths for the specific application, contact Schaeffler.

$$\frac{1}{R_{tot}} = \sum_{n=1}^{N} \frac{1}{R_n}$$

R_{tot}	Ω	Insulation resistance, total
R_n	Ω	Insulation resistance, individual

3.3 Design and function

2 Design and function of the insulating pipeline



001D8926

1	Connection to plant equipment DN25, DN80, DN100	2	Insulating pipeline
3	Washer	4	Seal, novaflon 500
5	Stack connection		

Insulating pipeline

- CE according to LVD
- coating thickness > 0,6 mm to ensure required dielectric strength for max. 1500 V (5 stacks)
- dielectric strength 40 kV/mm
- borehole inside diameter coated to electrically isolate the screws from the insulating pipeline
- shrink tubing and expansion shank screws in the bore area to protect the coating at the borehole inside diameter

Washer

- special component for distributing surface pressure
- for distributing axial force
- for protecting the coating
- e.g. Durostone for high compressive strength

Seal Novaflon 500

- made of PTFE to prevent ion leaching
- results in increased axial loads on the fastening screws

4 Scope of delivery

The scope of delivery includes geometrically adapted insulating pipelines for the coolant circuit, anode circuit, or cathode circuit of a PEM electrolyser.

Additional washers made of insulating material are included in the scope of delivery to protect the insulating coating from scratches and deformation.

The customer must provide suitable seals, fastening elements, and earthing devices.

5 Transport and storage

⚠ WARNING

Hazard posed by the weight of the insulating pipeline

Intended or unintended movement of the insulating pipeline may result in serious injury, for example due to crushing.

- Use suitable lifting equipment.
- Always comply with local laws and regulations regarding the lifting of heavy loads.

⚠ WARNING

Damage to the insulating pipeline due to storage or transport conditions

Improper storage or transport of the insulating pipeline may result in damage to the coating or sealing surface, which may lead to the formation of an ignitable hydrogen gas mixture in the immediate vicinity of the stack during operation.

- Observe the specified transport and storage conditions.

⚠ WARNING

Hazard due to the weight of the insulating pipeline or incorrect securing of the insulating pipeline during transport

Intended or unintended movement of inadequately secured heavy objects can lead to injury.

- Secure the insulating pipeline adequately.

6 Mounting

6.1 Installing the insulating pipeline

⚠ WARNING

Electric voltage

Risk of electric shock from contact with live parts.

- Comply with electrical safety regulations.
- Disconnect the power supply before starting work on the system.

Observe the following during installation:

- Only install the insulating pipeline in a cleaned system.
- When installing the insulating pipeline in a system, ensure that live parts on the stack do not come into contact with any other components or frames. Any electrical connection of these parts to peripheral equipment may cause a short circuit and put the operator at serious risk due to high electric current and voltage. Comply with local laws and regulations.
- When designing the integration of the insulating pipeline into a water electrolysis system, include access points for maintenance, e.g. inspection openings in the pipelines that enable endoscopic inspection during maintenance .

6.2 Connecting process connections and piping

⚠ WARNING

Formation of an explosive atmosphere due to the presence of an ignitable hydrogen gas mixture

Process connections may be transposed, which can lead to the formation of an ignitable hydrogen gas mixture in the stack. The presence of an appropriate ignition source can result in a pressure wave, potentially causing mechanical parts and hot, acidic fluids to be ejected at high speed.

- Ensure that process connections (cathode, anode, and coolant) are marked and distinct.
- The use of gas sensors for H_2 and O_2 is required on both the anode and cathode sides.

⚠ WARNING

Formation of an explosive atmosphere due to contamination

Contamination within the system and resulting membrane failure can lead to the formation of an ignitable hydrogen gas mixture. The presence of an appropriate ignition source can result in a pressure wave, potentially causing mechanical parts and hot, acidic fluids to be ejected at high speed.

- Avoid contamination of the stack, connections, and insulating pipeline.
- Monitor the conductivity of the process water and coolant.
- The integration of gas sensors for H_2 and O_2 on the anode and cathode sides is required as a safety measure.

⚠ WARNING

Formation of an explosive atmosphere due to the presence of an ignitable hydrogen gas mixture

Possible leaks at the process connections can lead to the formation of an ignitable hydrogen gas mixture in the vicinity of the system. The presence of an appropriate ignition source can result in a pressure wave, potentially causing mechanical parts and hot, acidic fluids to be ejected at high speed.

- Use of gas sensors for H_2 required at the place of use.
- Carry out leak testing.
- Carry out all work, including repair and maintenance, only when the electrolysis system is in a safe condition.
- Use PPE.

⚠ WARNING

Damage to the system due to foreign bodies inside the stack

The ingress of foreign bodies into the stack may damage the system, which can lead to the formation of an ignitable hydrogen gas mixture inside or in the immediate vicinity of the stack during operation. The presence of an appropriate ignition source can result in a pressure wave, potentially causing mechanical parts and hot, acidic fluids to be ejected with high energy.

- Ensure that no foreign bodies or contamination can enter the system.
- Visually inspect the connections for foreign bodies and contamination.

NOTICE

Risk of damage due to incorrect installation

Installation must be carried out in accordance with the specified instructions, materials, and installation steps in order to avoid damage to the stack or the system.

- Regularly check for leak tightness and mechanical integrity.
- Ensure proper installation using the specified tightening torques.
- Check material compatibility with the media used.

Process connections

The stack has the following process connections, which are identified by labels on the pressure plate:

- Anode in:
  Process water inlet
- Anode out:
  Oxygen outlet and process water outlet
- Cathode out:
  Hydrogen outlet, transfer water
- Coolant in:
  Coolant inlet
- Coolant out:
  Coolant outlet

The process connections must be designed so that no loads act on the stack interfaces. If such loads cannot be avoided, contact Schaeffler to verify the specific load conditions.

Media connections

Only use materials for fittings, flanges, and pipelines that are compatible with ultrapure water (UPW), hydrogen, and oxygen, and that comply with the temperature and pressure values associated with the process. The use of suitable plastics or stainless steels is recommended for the process water side (anode circuit). For the hydrogen side, stainless steel (1.4404) may be used.

Coolant connection flange DN100

- Connection system for industrial applications
  - with flange EN 1092-1/11/B1/DN100x3,6/PN40/1.4404
  - leakage class L0.01:
    technical tightness ensured
  - recommended sealing material:
    novaflon® 500 2 mm Rev.1 168 × 115 × 2, by Frenzelit, in accordance with EN 13555
- Use 8 screws M20×90 mm A2-70 in accordance with EN ISO 4014:2001, product class A, with a recommended tightening torque M_A of 210 Nm applied in installation steps (30 %, 60 %, 100 %):

1. M_A = 60 Nm
2. M_A = 120 Nm
3. M_A = 210 Nm

- Provide nuts and washers in accordance with ISO 4032 and DIN EN ISO 7089.

Lubrication of threads and washers with PTFE spray is required. The resulting additional axial load of 100 kN in accordance with EN 1092 has been taken into account.

Anode connection flange DN80

- Connection system for industrial applications
  - with flange EN 1092-1/11/B1/DN80x3,2/PN40/1.4404
  - leakage class L0.01:
    technical tightness ensured
  - recommended sealing material:
    novaflon® 500 2 mm Rev.1 142 × 89 × 2, by Frenzelit, in accordance with EN 13555
- Use 8 screws M16×80 mm A2-70 in accordance with EN ISO 4014:2001, product class A, with a recommended tightening torque M_A of 120 Nm applied in installation steps (30 %, 60 %, 100 %):

1. M_A = 40 Nm
2. M_A = 80 Nm
3. M_A = 120 Nm

- Provide nuts and washers in accordance with ISO 4032 and DIN EN ISO 7089.

The resulting additional axial load in accordance with EN 1092 has **not** been taken into account. Additional loads on the flange are not permitted.

Cathode connection flange DN25

- Connection system for industrial applications in the following sequence, starting from the stack
  - fitting SS-1610-1-16R in accordance with the applicable instructions from Swagelok
  - fixed piping using standard pipework or, for example, a hose
  - with flange EN 1092-1/05/DN25x2,6/PN40/1.4404 with BSPP 1" female thread
  - mating flange EN 1092-1/11/DN25x2,6/PN40/1.4404
  - leakage class L0.01:
    technical tightness ensured
  - recommended sealing material:
    novaflon® 500 2 mm Rev.1 71×34×2, by Frenzelit, in accordance with EN 13555
- Use 4 screws M12×110 mm A2-70 in accordance with EN ISO 4014:2001, product class A, with a recommended tightening torque M_A of 120 Nm applied in installation steps (30 %, 60 %, 100 %):

1. M_A = 15 Nm
2. M_A = 30 Nm
3. M_A = 50 Nm

- Provide nuts and washers in accordance with ISO 4032 and DIN EN ISO 7089.

The resulting additional axial load in accordance with EN 1092 has **not** been taken into account. Additional loads on the flange are not permitted.

Measuring equipment

The following measuring equipment must be provided on site:

- temperature sensors in the anode inlet and outlet lines
- temperature sensors in the cooling inlet and outlet lines
- temperature sensor in the cathode outlet line
- temperature-compensated conductivity sensors at the process water inlet and coolant inlet
- pressure sensors for each anode inlet line and each anode outlet line
- pressure sensors for each coolant inlet line and each coolant outlet line
- pressure sensors for the cathode
- insulation monitoring of the stack

7 Commissioning

The purpose of commissioning is to verify correct installation and to check the performance of both the stack and system. Commissioning should only be carried out by trained personnel; Schaeffler can provide support if required. Any discrepancies should be thoroughly investigated.

7.1 Site acceptance test (SAT)

The following tests are defined for the site acceptance test (SAT) to verify the correct installation and operation of the insulating pipeline. The SAT consists of 4 different parts:

- visual inspection
- preliminary inspection
- leak testing
- functional testing

Visual inspection of the insulating pipeline and interfaces to the system:

- All legally binding documents are available for commissioning.
- Visual inspection of the system:
  - All screws are properly tightened.
  - BoP is connected to the stack.
  - The electrical connection is duly established.

Preliminary inspection:

- Before operating the system with the integrated insulating pipeline, the following tests must be completed, as a minimum, in order to comply with warranty conditions:
  - safety loop tests
  - I/O tests
  - leak testing of the system
  - strength testing of the system

Electrical testing:

- Electrical validation tests in accordance with local laws and standards (e.g. harmonised LVD requirements)

Leak testing:

- Leak testing of the cooling circuit at maximum operating pressure, use of ultrapure water recommended as the test fluid
- Leak testing of the cathode loop at maximum operating pressure using inert gas, helium, or forming gas (H_2/N_2)
- Leak testing of the anode loop at maximum operating pressure using inert gas, helium, or forming gas (H_2/N_2)

⚠ WARNING

High system pressure

Exceeding the permissible pressures may result in leaks with fluid discharge and may cause the stack to rupture.

- ▸ Ensure that the maximum permissible pressures for the anode area, cathode area, and coolant area are not exceeded.
- ▸ Ensure that H_2 crossover sensors are installed at system level (anode side) and integrated as a safety device.

⚠ WARNING

Electric shock

Contact with live parts may lead to electric shock and life-threatening injuries.

- ▸ Comply with electrical safety regulations.
- ▸ Disconnect the stack from the power supply before carrying out any work.
- ▸ Set up an inherently safe system, such as shutdown on entry.

⚠ WARNING

Death or serious injury due to burns, electric shock, sparks, or arcing

Electrical energy may be generated after shutdown due to chemical processes.

- Work may only be carried out by trained personnel.
- Observe electrical safety regulations.
- Ensure that no hazardous voltage is present on the stack or connected components at any time when entering the area around the stack.

8 Operation

8.1 Notes on system operation

⚠ WARNING

Fluid discharge

The settling behaviour of materials over a longer period of time can lead to a loss of preload in mechanical connections. This may result in leaks and consequently to the formation of a flammable hydrogen gas mixture in the vicinity of system. If an ignition source is present, a rapid thermal reaction or explosion may occur.

- Carry out regular visual inspections for the discharge of water droplets.
- Ensure that gas sensors for H_2 are available at the place of use and integrated as a safety device.
- Carry out leak tests at regular intervals .

⚠ WARNING

Electric shock

Contact with live parts may lead to electric shock and life-threatening injuries.

- Comply with electrical safety regulations.
- Disconnect the stack from the power supply before carrying out any work.
- Set up an inherently safe system, such as shutdown on entry.

⚠ WARNING

Death or serious injury due to burns, electric shock, sparks, or arcing

Electrical energy may be generated after shutdown due to chemical processes.

- Work may only be carried out by trained personnel.
- Observe electrical safety regulations.
- Ensure that no hazardous voltage is present on the stack or connected components at any time when entering the area around the stack.

⚠ WARNING

Risk of burns due to high surface and media temperatures

Contact with hot surfaces is possible and may lead to superficial skin injuries.

- Use PPE.

⚠ WARNING

Hot fluid discharge

Risk of burns from leaking or splashing fluids. Operating temperature +70 °C.

Hot fluids may escape.

- Allow the electrolysis system to cool down before working near the stack.
- Use PPE.

⚠ WARNING

High system pressure

Exceeding the permissible pressures may result in leaks with fluid discharge and may cause the stack to rupture.

- Ensure that the maximum permissible pressures for the anode area, cathode area, and coolant area are not exceeded.
- Ensure that H_2 crossover sensors are installed at system level (anode side) and integrated as a safety device.

⚠ WARNING

Electric shock due to static charge

Static charge generated during operation or maintenance may result in electric shock and life-threatening injuries.

- Ensure that personnel carrying out maintenance work are earthed and that equipment, including clothing, does not generate static charge during maintenance activities.
- Clean with a damp cloth only to prevent static charge.
- Carry out regular earthing measurements. If necessary, connect fittings or flanges to earth (if galvanically isolated).

⚠ WARNING

Death or serious injury due to fire or explosion

Static charge generated during operation or maintenance can result in an ignition source, for example in the form of sparks.

- Ensure that personnel carrying out maintenance work are earthed and that equipment, including clothing, does not generate static charge during maintenance activities.
- Clean with a damp cloth only to prevent static charge.
- Carry out regular earthing measurements. If necessary, connect fittings or flanges to earth (if galvanically isolated).

⚠ WARNING

Death or serious injury due to fire or explosion

Increased oxygen concentration in the vicinity of the stack may cause ignition of flammable materials (e.g. oil or other organic materials).

- Ensure that no flammable materials are present near the stack.
- Carry out leak testing.

8.2 Monitoring operating parameters

When using the insulating pipeline during operation, the stack parameters specified in the operating range must be maintained and monitored at all times.

The most important parameters are listed as reference values .

The insulating pipeline is designed for a maximum of 10000 pressure cycles. The number of full pressure cycles and, where applicable, the equivalent number of full pressure cycles must be monitored in the electrolysis system to ensure safe operation.

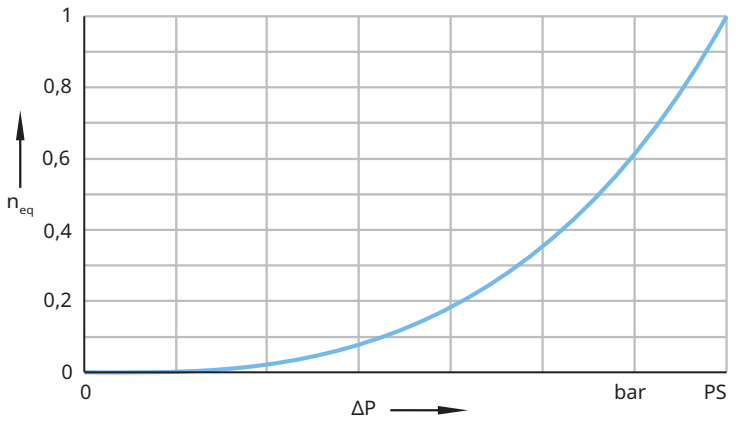
The calculation of the number of pressure cycles is carried out according to the following equation in accordance with :

3 Calculation of the number of pressure cycles

$$n_{eq} = \sum_i n_{P,i} \cdot \left(\frac{\Delta P_i}{P_{max}} \right)^3 \leq N_{eq}$$

n_{eq}	–	Equivalent number of full pressure cycles
N_{eq}	–	Permissible number of full pressure cycles
$n_{P,i}$	–	Number of pressure cycles within the pressure fluctuation ranges $\Delta P_i \leq P$
ΔP_i	bar	Pressure fluctuation range
P_{max}	bar	Respective maximum operating pressure

3 Contribution of ΔP to one pressure cycle



In the equation according to EN 13445-3, ΔP represents the symmetrical pressure difference. P_{max} corresponds to the respective maximum operating pressures. These must be taken into account for each circuit. The effect of different ΔP values and their contribution to one pressure cycle is shown in the digram. All cycles with ΔP < 2 bar can be disregarded when calculating the number of cycles.

9 Maintenance and service

The insulating pipeline forms part of a pressure device that requires regular maintenance and inspection to ensure safe use.

For maintenance, use the access points provided by design, e.g. inspection openings in the pipelines that allow endoscopic inspection during maintenance.

⚠ WARNING

Death or serious injury due to burns, electric shock, sparks, or arcing

Electrical energy may be generated after shutdown due to chemical processes.

- Work may only be carried out by trained personnel.
- Observe electrical safety regulations.
- Ensure that no hazardous voltage is present on the stack or connected components at any time when entering the area around the stack.

⚠ WARNING

Electric shock due to static charge

Static charge generated during operation or maintenance may result in electric shock and life-threatening injuries.

- Ensure that personnel carrying out maintenance work are earthed and that equipment, including clothing, does not generate static charge during maintenance activities.
- Clean with a damp cloth only to prevent static charge.
- Carry out regular earthing measurements. If necessary, connect fittings or flanges to earth (if galvanically isolated).

⚠ WARNING

Formation of an explosive atmosphere due to the presence of an ignitable hydrogen gas mixture

Possible leaks at the process connections can lead to the formation of an ignitable hydrogen gas mixture in the vicinity of the stack. The presence of an appropriate ignition source can result in a pressure wave, potentially causing mechanical parts and hot, acidic fluids to be ejected at high speed.

- Use of gas sensors for H_2 required at the place of use.
- Carry out leak testing.
- Carry out all work, including repair and maintenance, only when the electrolysis system is in a safe condition.
- Use PPE.

Comply with local laws and regulations relating to pressure equipment.

9.1 Scope of services

Critical damage mechanisms of the pressure device

- fatigue in metallic components
- internal and external corrosion due to improper storage or incorrect operating parameters of the coolant and process media
- deformation due to incorrect temperatures and pressures

⚠ WARNING

Improper use may lead to unforeseen failures

Operation of the stack under unsuitable operating conditions may result in unsafe conditions or malfunctions. Failure to comply with the permissible operating parameters may result in leaks with media discharge or rupture of the system.

- Always adhere to the operating parameters.
- Ensure that the required operating parameters are monitored.

External inspection

- visual inspection for corrosion or other discolouration or damage
- visual inspection for signs of leakage
- visual inspection for external contamination (pollution degree in accordance with operating parameters)

Internal inspection

- visual inspection for corrosion or other discolouration or damage
- visual inspection for residues or particles in the insulating pipeline
- evaluation of water samples

Pressure testing

Carry out regular pressure testing to ensure that the pressure vessel is mechanically intact.

Pressure testing is carried out at the value PT indicated on the nameplate or in accordance with local regulations.

⚠ WARNING

High system pressure due to incorrect operating parameters

Exceeding the permissible pressures can result in leaks with fluid discharge as well as rupture.

- ▸ Monitor the maximum permissible pressure and overpressure for the anode area, cathode area, and coolant area.

- Test the anode circuit and cathode circuit at balanced constant pressure.
- The cooling circuit must also be subjected to a pressure test. The test may be performed together with the anode and cathode circuits or separately.

Leak testing

Schaeffler recommends following an industry standard or local regulations when developing the leak testing procedure for the electrolysis system.

Screw connections

Screw connections can become damaged due to corrosion or fatigue. Due to the settling behaviour of materials, it may be necessary to re-tighten screw connections.

⚠ WARNING

Risk of death or serious injury from flying parts

Incorrect release of the preload on screw connections can cause parts to fly off and lead to life-threatening injuries.

- ▸ Only qualified personnel are permitted to work on the stack.

- Visually inspect screw connections for corrosion or fatigue.

⚠ WARNING

Fluid and gas discharge

Improper handling or incorrectly adjusted preload of screw connections can lead to the formation of a flammable hydrogen gas mixture in the vicinity of the system. If an ignition source is present, a rapid thermal reaction or explosion may occur.

- ▸ Avoid contamination.
- ▸ Use gas crossover sensors on the anode and cathode sides.
- ▸ Provide H_2 gas sensors in the area around the stack.
- ▸ Only fill pipelines with approved media.
- ▸ Only qualified personnel are permitted to work on the system.

The following intervals are recommended:

▦5 Intervals for external inspection, internal inspection, pressure testing, leak testing, and inspection of screw connections

Scope	External inspection	Internal inspection	Pressure testing	Leak testing	Screw connections (M36)
Commissioning	Required	As required	Required	Required	Required
First inspection (6 months after commissioning)	Required	Required	As required	As required	Re-tighten screw connections
Standard interval (from date of commissioning) [1]	Every 2 a (years) or before reaching 50 % of the permissible calculated full load cycles [2]	Every 2 a (years) or before reaching 50 % of the permissible calculated full load cycles [2]	Every 3 a (years) or before reaching 50 % of the permissible calculated full load cycles [2]	Annually or before reaching 50 % of the permissible calculated full load cycles [2]	Every 2 months check screw connections and tighten if necessary
Qualification	By Schaeffler-trained personnel	Qualified Schaeffler personnel	Schaeffler personnel, notified body (NOBO), or authorised expert	By Schaeffler-trained personnel	Qualified Schaeffler personnel together with an authorised expert for tests in accordance with the Pressure Equipment Directive

[1] Re-tightening of screw connections (M36) must be carried out prior to the first inspection after 2 months (see standard interval).

[2] Formula for calculating full load cycles ➤26 | 𝑓3

Contact Schaeffler in the event of unusual occurrences or significant changes.

Mandatory legal requirements may vary depending on local regulations. The operator must comply with local rules and regulations, which may deviate from the values specified in the table above.

9.2 Cleaning the insulating pipeline

⚠ WARNING

Electric voltage

Risk of electric shock from contact with live parts.

- Comply with electrical safety regulations.
- Disconnect the power supply before starting work on the stack.

The defined maximum pollution degree of the stack must be maintained at all times ➤33 | ▦7.

1. Switch off the electrolysis system.
2. De-energise the electrolysis system and ensure that it is in a safe condition. Install a discharge resistor to shorten the process.
3. Clean the surface of the insulating pipeline with a damp cloth.
4. Allow the surface of the insulating pipeline to dry thoroughly before putting the system back into operation.

9.3 Manufacturer service

For maintenance and service offers, please contact Schaeffler.

Schaeffler Technologies AG & Co. KG
Industriestraße 1 – 3
91074 Herzogenaurach
Germany
service-hydrogen@schaeffler.com

10 Decommissioning

Before the insulating pipeline is taken out of service and disconnected from the system, the system must be purged with nitrogen to remove all flammable gases. Ensure that the system is de-energised and wear the required PPE.

Decommissioning steps:

1. Switch off the system.
2. Ensure that the system has cooled down to ambient temperature.
3. Disconnect the electrical connections.
4. Carry out nitrogen purging.
5. Disconnect the cathode line. Watch for escaping water or gas.
6. Disconnect the anode line. Watch for escaping water or gas.
7. Disconnect the cooling circuit lines. Watch for escaping water or gas.

After disconnecting and removing the insulating pipeline from the system, all process connections must be sealed in the appropriate manner. This is necessary to prevent the stack from becoming damaged or contaminated.

11 Troubleshooting and rectification

11.1 Troubleshooting

6 Troubleshooting

Fault	Cause
Limited hydrogen production	(External) electrical short circuit
	Leaks in the stack and/or system caused by: • loose fittings/flanges • loose tie rod on the stack • blockages
	Voltage limitation at the stack (high resistance in a component)
	Internal stack leak, increased hydrogen crossover
Low efficiency	Stack operating temperature too low
	Stack at end of service life
	Faulty cell voltage monitoring connections
	Contamination of the stack due to inadequate water quality
	Operating current above the specified current
Unexpected behaviour	Temperature outside the operating window due to: • limited coolant flow • limited cooling capacity
	Operating current above the specified current
	Reversed polarity of the power lines
Water purity at stack outlet	Reversed polarity of the power lines
	Internal stack leakage

12 Disposal

- Return the insulating pipeline to Schaeffler for disposal.

13 Technical data

Technical details and components are subject to change without prior notice and may have a tolerance range of up to ±5 %.

7 Technical data

Parameter		Value	Unit
		Insulating pipeline	
Performance parameters			
Full load cycles	–	10000	–
Dielectric strength	–	40	kV/mm
Energy consumption and electrical connection requirement			
Operating voltage	DC	150 ... 1500	V
Operating current	nominal	445 ... 4450	A
Ambient conditions			
Permissible ambient temperature range		5 ... 40	°C
Permissible operating temperature [1]		5 ... 70	°C
Maximum installation height above sea level		2000	m
Maximum pollution degree	in accordance with EN 60664-1	III	–
Insulation resistance	in accordance with EN 60664-1:III	100	Ω/V
Process water requirements			
Specification [2]	–	Ultrapure water (UPW)	–
Resistance	at +25 °C	> 10	MΩ · cm
Conductivity	at +25 °C	< 0,1	µS/cm
Cooling water requirements			
Specification [3]	–	Ultrapure water (UPW)	–
Resistance	at +25 °C	> 0,2	MΩ · cm
Conductivity	at +25 °C	< 5,0	µS/cm
Operating pressure	max.	35	bar (g)
Regulations and standards			
Product is CE-compliant in accordance with the following underlying directives: Pressure Equipment Directive (PED) and Low Voltage Directive. No certification in accordance with ATEX Directive.			

1) nominal operating temperature +60 °C (definition of TS_{max} = +80 °C in accordance with article 2 PED 2014/68/EU)

2) in accordance with ISO 3696 Grade 1

3) in accordance with ISO 3696 Grade 3

Interfaces

Media connections:

- process water/oxygen:
  2× flange EN 1092-1/11/B1/DN80×3,2/PN40/1.4404
- coolant:
  2× flange EN 1092-1/11/B1/DN100×3,6/PN40/1.4404
- hydrogen:
  2× flange EN 1092-1/11/B1/DN25×2,6/PN40/1.4404

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