HYDROGEN
VALUE CHAINS

SAMSON

Application Solutions for

Alkaline Electrolysis (AEL)

SMART IN FLOW CONTROL

ALKALINE ELECTROLYSIS (AEL) SYSTEM DESCRIPTION

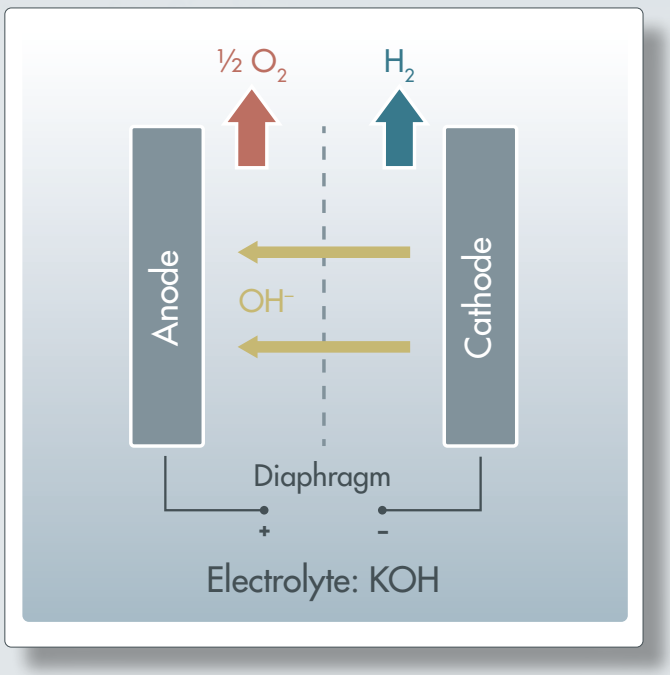
Alkaline Electrolysis

Alkaline electrolysis is used to separate hydrogen from water. The electrolysis cell comprises an anode chamber and a cathode chamber separated by a thin porous diaphragm. The metal electrodes are located at a small distance from the diaphragm, immersed in an aqueous alkaline solution. When a voltage is applied, hydroxide ions (OH^-) and hydrogen gas (H_2) are produced at the cathode. The negatively charged hydroxide ions move through the diaphragm from the cathode to the anode where oxygen gas (O_2) and water are produced:

Cathode reaction: $2\ H_2O + 2\ e^- \rightarrow 2\ OH^- + H_2$
Anode reaction: $2\ OH^- \rightarrow ½\ O_2 + H_2O + 2\ e^-$
Total reaction: $H_2O \rightarrow H_2 + ½\ O_2$

Benefits of alkaline electrolysis include a long durability and high plant performance. Based on the operating principle, water is introduced at the cathode using the alkaline electrolyte circuit.

Usually, alkaline electrolysis occurs at temperatures from 60 to 90 °C and at stack pressures slightly above atmospheric pressure, or when pressurized, at up to 30 bar.



ALKALINE ELECTROLYSIS (AEL)
BLOCK DIAGRAM

1

GAS SEPARATION
GAS CONDITIONING

H_2

2

GAS SEPARATION
GAS CONDITIONING

O_2

ELECTROLYSIS (STACK)

H_2O

WATER TREATMENT

3

ELECTROLYTE CIRCUIT

4

COOLING SYSTEMS

5

NITROGEN CONTROL

6

N_2

AEL Alkaline Electrolysis

ALKALINE ELECTROLYSIS (AEL) CONTROL VALVE SOLUTIONS

1 **Hydrogen separation and conditioning**
Exact combined control of the pressure and gas flow of the hydrogen produced in the electrolysis stack is essential: it must be sized in line with the desired wide performance spectrum of the electrolyzer to cover a wide gas range. Additionally, the applied valves must fulfill the strictest requirements concerning seat leakage and fugitive emissions and be rugged to handle liquids contained in the gas flow. For small to medium gas flow rates, globe valves have proven to be a viable solution while rotary plug valves are better suited to deal with high gas flow rates. Suitable valve types from the SAMSON portfolio include: SAMSON Type 3510, Type 3252, Type 3241, SAMSON VETEC Type 82.7 etc. Butterfly valves are a good option for (additional) shut-off features, ball valves for small nominal pipe sizes.

2 **Oxygen separation and conditioning**
Exact combined control of the pressure and gas flow is also essential for handling the oxygen produced in the electrolysis stack: it must be sized in line with the desired wide performance spectrum of the electrolyzer to cover a wide gas range, particularly when using the produced oxygen. All materials must be compliant with the specifications applicable to use in oxygen service. Additionally, the applied valves must fulfill the strictest requirements concerning seat leakage and fugitive emissions and be rugged to handle liquids contained in the gas flow. For small to medium gas flow rates, globe valves have proven to be a viable solution while rotary plug valves are better suited to deal with high gas flow rates. Suitable valve types from the SAMSON portfolio include: SAMSON Type 3510, Type 3252, Type 3241, SAMSON VETEC Type 82.7 etc. Butterfly valves are a good option for (additional) shut-off features, ball valves for small nominal pipe sizes.

3 **Water treatment**
Deionized water is needed as the basis for providing the required alkaline electrolyte. The associated process calls for an optimized selection of valve materials to guarantee ruggedness in operation and a long service life. Suitable valve types from the SAMSON portfolio include: SAMSON Type 3241, Type 3244, SAMSON SED Type 58x, SAMSON PFEIFFER Type 26d, Type 1b etc.

4 **Electrolyte circuit**
Water is mixed with hydroxide to form an aqueous alkaline solution that supplies ionic conductivity. Depending on the alkaline parameters (such as concentration, temperature), the valves are selected with a high-quality (PTFE or PFA) lining or made of suitable stainless steels. Suitable valve types from the SAMSON portfolio include: SAMSON PFEIFFER Type 10e, Type 20a, Type 20b, Type 1a, Type 1b, SAMSON Type 3241, Type 3244 etc.

5 **Cooling systems**
The heat produced during the electrolysis process is discharged over cooling systems and supplied to other heat consumers. Excess heat must also be dissipated from the alkaline electrolyte circuit. Suitable valve solutions to ensure precise control at partly high flow rates of the cooling agents include globe and rotary valves with high flow coefficients. Suitable valve types from the SAMSON portfolio include: SAMSON Type 3241, Type 3244, Type 3321, Type 3323, SAMSON PFEIFFER Type 11e, Type 10e, Type 14b etc.

6 **Nitrogen control**
In the electrolyzer, nitrogen is used for inertization and certain purification processes. For nitrogen handling, automated control valves or self-operated regulators are used that can ensure exact control and at the same time minimize nitrogen consumption. Suitable valve types from the SAMSON portfolio include: SAMSON Type 44-x, Type 2405, Type 41-23, Type 3510, Type 3252, Type 3241 etc.

ALKALINE ELECTROLYSIS (AEL)
SERVICE, SUPPORT AND DIGITAL SOLUTIONS

DIGITAL SOLUTIONS TO MEET YOUR REQUIREMENTS

We are working on becoming the first choice for smart, networked valves, flexible production processes and challenging applications. Backed by over 100 years of experience in the field of valves, actuators and positioners, our engineers are able to analyze the relevant data and draw the right conclusions.

Plant data: updating of tag data either by file transfer or continuous data transmission

Data analysis: efficient monitoring of operating states and relevant diagnostic data through automatic or manual data analysis

Optimization: prevention of costly unplanned plant downtime and efficient planning of service work

GLOBAL SPARE PARTS AND SERVICE NETWORK

Benefit from our international service network and consulting services provided by our experienced engineers backed by over 100 years of valve engineering expertise.

Spare parts management: an international network of service centers allows us to quickly respond to critical plant outages

Centers of competence for positioner repairs: more than eight certified positioner repair centers

Technical support: ensures plant availability and improves plant performance

Engineering services: customized solutions for our customers

Worldwide service network: our service engineers are at the ready to perform repairs on site around the globe

Global Training Center (GTC): training of MRO staff to transfer specialized knowledge

Plant walk-downs: support provided by identifying critical valve applications

Turnaround planning services: significant reduction of costly plant downtime and avoidance of unforeseen problems

HYDROGEN
VALUE CHAINS

SAMSON

Application Solutions for

Polymer Electrolyte Membrane (PEM) Electrolysis

SMART IN FLOW CONTROL

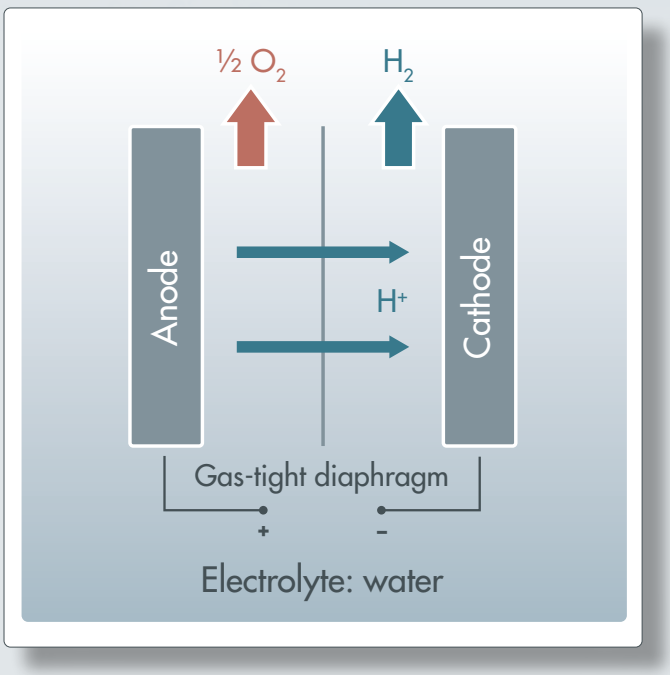
PEM ELECTROLYSIS SYSTEM DESCRIPTION

Polymer Electrolyte Membrane (PEM) Electrolysis

PEM (Proton Exchange Membrane or Polymer Electrolyte Membrane) electrolysis is a process to produce hydrogen from water. In the electrolysis cell, a conductive proton exchange membrane is immersed in water. When a voltage is applied, oxygen gas (O_2) and hydrogen ions (H^+) are produced. The positively charged hydrogen ions move through the membrane from the anode to the cathode where hydrogen gas (H_2) is produced:

Anode reaction: $H_2O \rightarrow ½\ O_2 + 2H^+ + 2\ e^-$
Cathode reaction: $2\ H + 2\ e^- \rightarrow H_2$
Total reaction: $H_2O \rightarrow H_2 + ½\ O_2$

PEM electrolysis is capable of handling severe load fluctuations, which means that the process can respond very quickly to fluctuations in the power supply. Fundamentally, PEM electrolysis is compact in its design with the water being introduced directly at the anode.
PEM electrolysis usually occurs at temperatures from 50 to 80 °C. While the anode is basically pressureless, the cathode can also be operated at high pressures (typically up to 50 bar with the possibility and target of up to 350 bar). This helps reduce the amount of energy later needed to condense the hydrogen for transport and storage.



PEM ELECTROLYSIS
BLOCK DIAGRAM

1

GAS SEPARATION
GAS CONDITIONING

H_2

2

GAS SEPARATION
GAS CONDITIONING

O_2

ELECTROLYSIS (STACK)

H_2O

WATER TREATMENT

3

COOLING SYSTEMS

4

NITROGEN CONTROL

5

N_2

PEM Polymer Electrolyte Membrane Electrolysis

PEM ELECTROLYSIS
CONTROL VALVE SOLUTIONS

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3 Water treatment
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SAMSON AT A GLANCE

STAFF

- Worldwide 4,500
- Europe 3,700
- Asia 600
- Americas 200
- Frankfurt am Main, Germany 2,000

MARKETS AND APPLICATIONS

- Chemicals and petrochemicals
- Food and beverages
- Pharmaceuticals and biotechnology
- Oil and gas
- Liquefied Natural Gas (LNG)
- Marine equipment
- Power and energy
- Industrial gases
- Cryogenic applications
- District energy and building automation
- Metallurgy and mining
- Pulp and paper
- Water technology
- Other industries

PRODUCTS

- Valves
- Self-operated regulators
- Actuators
- Positioners and valve accessories
- Signal converters
- Controllers and automation systems
- Sensors and thermostats
- Digital solutions

SALES SITES

- More than 50 subsidiaries in over 40 countries
- More than 200 representatives

PRODUCTION SITES

- SAMSON Germany, Frankfurt, established in 1916
  Total plot and production area: 150,000 m²
- SAMSON France, Lyon, established in 1962
  Total plot and production area: 23,400 m²
- SAMSON Turkey, Istanbul, established in 1984
  Total plot and production area: 11,053 m²
- SAMSON USA, Baytown, TX, established in 1992
  Total plot and production area: 9,200 m²
- SAMSON China, Beijing, established in 1998
  Total plot and production area: 10,138 m²
- SAMSON India, Pune district, established in 1999
  Total plot and production area: 18,000 m²
- SAMSON Russia, Rostov-on-Don, established in 2015
  Total plot and production area: 5,000 m²
- SAMSON AIR TORQUE, Bergamo, Italy
  Total plot and production area: 27,684 m²
- SAMSON CERA SYSTEM, Hermsdorf, Germany
  Total plot and production area: 14,700 m²
- SAMSON KT-ELEKTRONIK, Berlin, Germany
  Total plot and production area: 1,060 m²
- SAMSON LEUSCH, Neuss, Germany
  Total plot and production area: 18,400 m²
- SAMSON PFEIFFER, Kempen, Germany
  Total plot and production area: 35,400 m²
- SAMSON RINGO, Zaragoza, Spain
  Total plot and production area: 18,270 m²
- SAMSON SED, Bad Rappenau, Germany
  Total plot and production area: 10,370 m²
- SAMSON STARLINE, Bergamo, Italy
  Total plot and production area: 26,409 m²
- SAMSON VDH PRODUCTS, Netherlands
  Total plot and production area: 12,000 m²
- SAMSON VETEC, Speyer, Germany
  Total plot and production area: 27,090 m²

SAMSON AKTIENGESELLSCHAFT

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2022-06 · WA 457 EN

SMART IN FLOW CONTROL