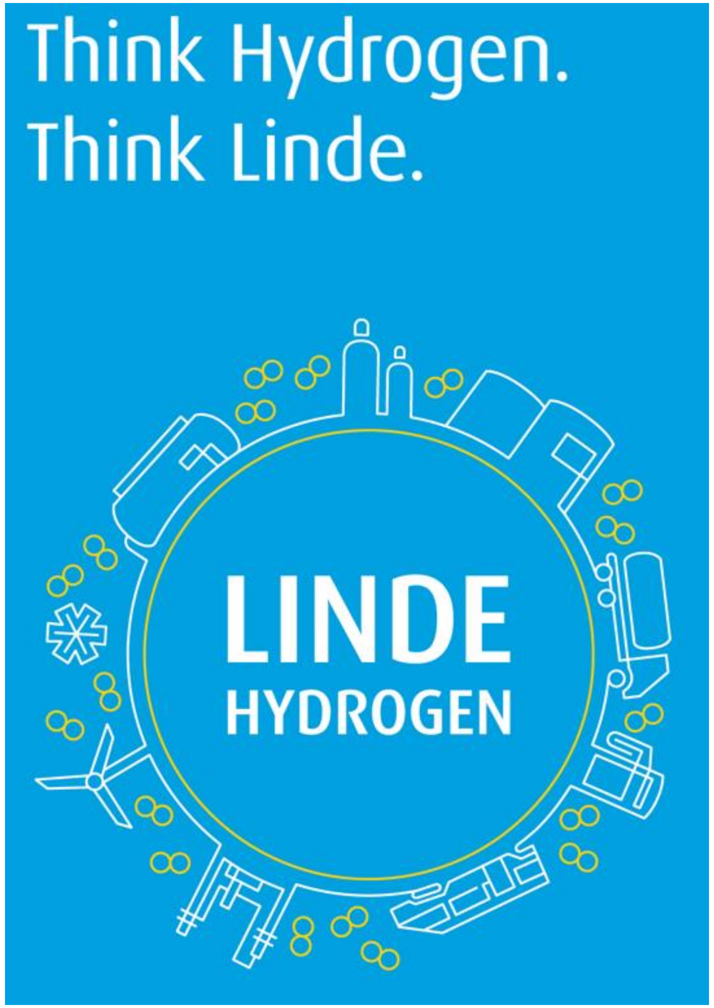
EPSC Conference on Plant & Process Safety



Process Safety Requirements for Electrolysis

Oliver Grosse/ Linde, Engineering Division

Barcelona, 02 & 03.12.2024

Speaker CV:
Oliver Grosse, Linde GmbH, Engineering Division

I joined Linde in 1994 and has held various Project Execution and Line Management positions including Process Safety Lead, Engineering Manager, Department- and Section Management with local and global responsibilities.

Presently I serve as Associated Director Engineering of Linde Engineering Pullach, Germany and serves for various technology driven development initiatives.

I represent Linde in ISO, DIN, CSE (Center of Safety Excellence) and EPSC (Europe Process Safety Centre).

Oliver is a Chartered Process Engineer and a graduate of the “Otto von Guericke” University of Magdeburg, Germany.

Tasks/ Responsibilities:

Global Engineering Interface Coordination

Project Management Special Projects

Product Safety Hydrogen and Oxygen Processes and Plants

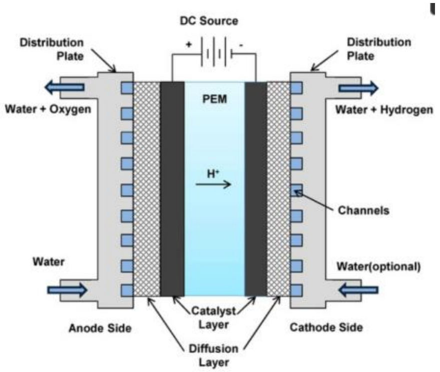
Introduction

- Green Hydrogen production rapidly increase.
- Proton membrane exchange (PEM) and Alkaline (AEL) electrolysers are main technologies.
- Both known and new OEM’s offer their electrolyser technology.
- Considerable safety risks exist e.g., as, H_2 and O_2 are only separated by a membrane.
- Safety design of electrolysers is determined solely by the OEM.

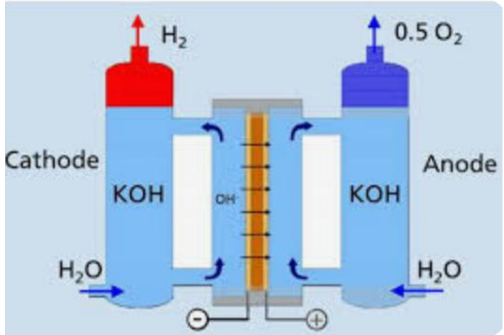
PEM and Alkaline Technology

Safety of Hydrogen Electrolyzers depends on

- Elextrolyzer - technology itself
- Scale in terms of dimensions, production rate and facility siting
- Safety Standards
- Operational & Maintenance



Proton Exchange Membrane (PEM)



Alkaline

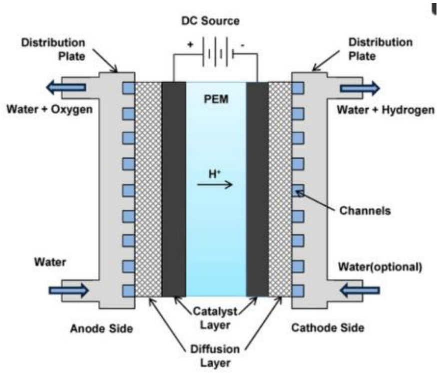
Container- Plant

Industrial Scale

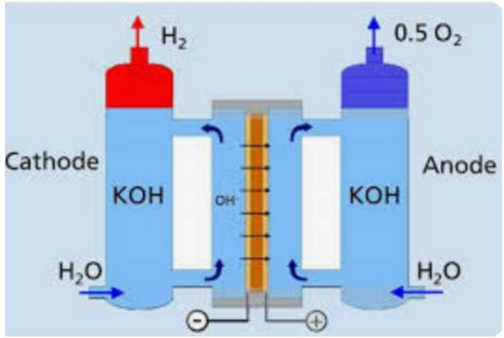
PEM and Alkaline Technology

Stack Design & Membrane/ Diaphragma Sensitivity

- Pressure
- Pressure Swing
- Temperature
- Hot Spots
- Current Density
- Degradation
- Water-/ Alkaline Quality



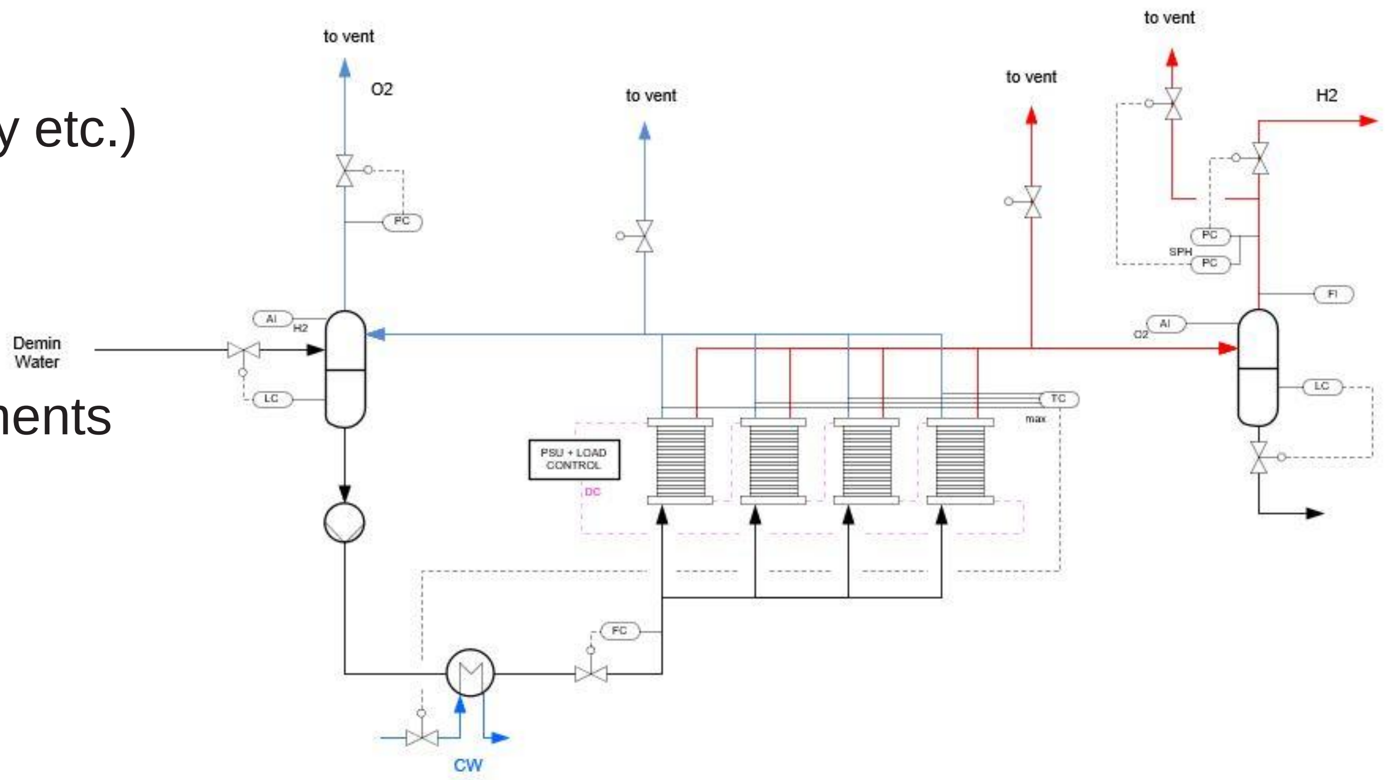
PEM



Alkaline

Process Safety Considerations downstream stack

- Process upset conditions (P/T/L)
- Hydrogen service (volatility, permeability etc.)
- Ignition Sources (electrostatic etc.)
- Explosion and Fire Risk and Impact
- Oxygen and Hydrogen service requirements



Process Safety Considerations

PEM vs. Alkaline

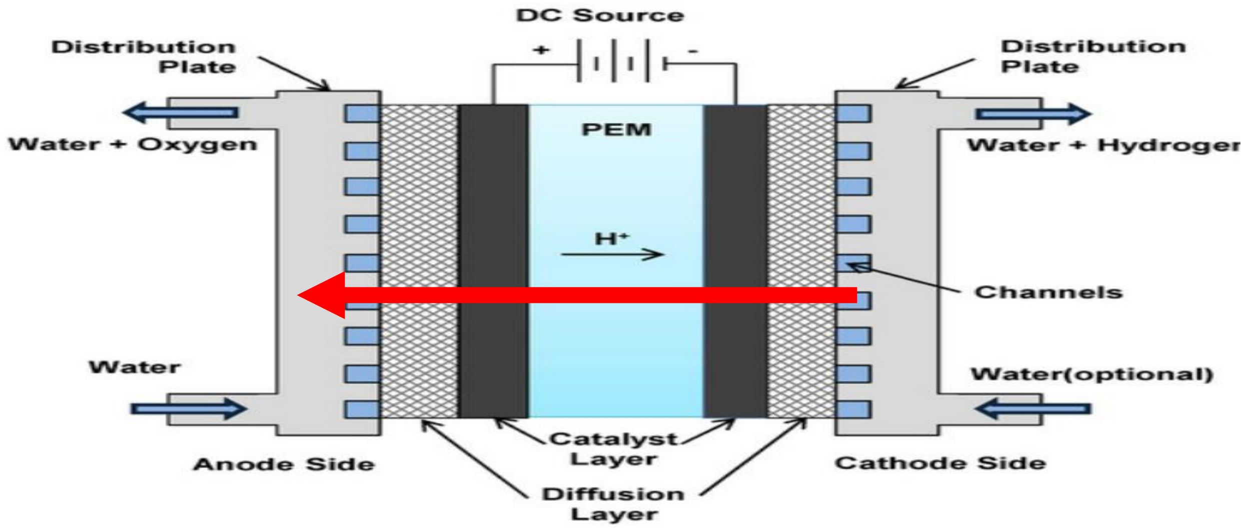
PEM	Alkaline
New technology.	Well proven technology.
Operational experience limited.	Operational experience available.
2-phase in cell partitions (valid for most PEM's).	Cells are flooded.
Risk of hot spots.	Temperature changes are moderate.
Difference pressures across separators.	Same pressure on both separators.
Spontaneous formation of an ignitible mixtures cannot be ruled out as a standard.	Safeguards allows prevention of spontaneous ignitable mixtures.
Other measures, such as pressure-resistant design may be necessary.	Innovations in stack design could also affect safety.

Example: Crack Sensitivity of Membrane

Operational Condition and Failure Scenario

- H2/water separator is operated at approx. 20,0 bara
- O2/water separator is operated at approx. 1,0 bara
- Scenario: Spontaneous membrane failure due to e.g., aging, mechanical stress or faulty operation

Challenge: Damage mechanism, leak propagation, leakage rate and consequences



Firebug

Hot Spot

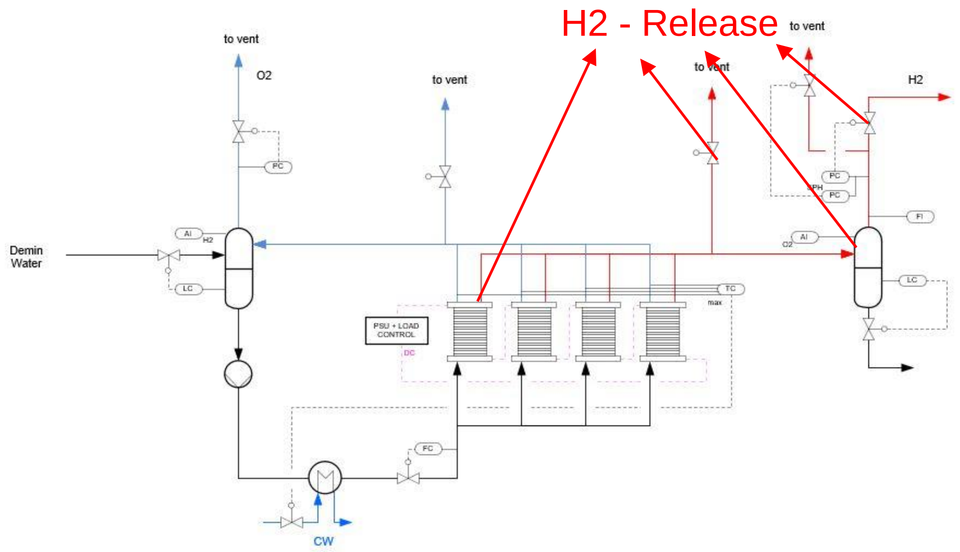
Electrostatic

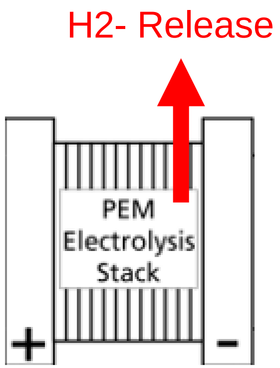
Material properties

Example: H2 Release to ELY- Machinery Building

Operational Condition and Failure Scenario

- ELY- Stack Cathode Side at approx. 20,0 bara
- H2/water separator is operated at approx. 20,0 bara
- Scenario: Leakage due to e.g., mechanical- or thermal stress, faulty operation or fatigue

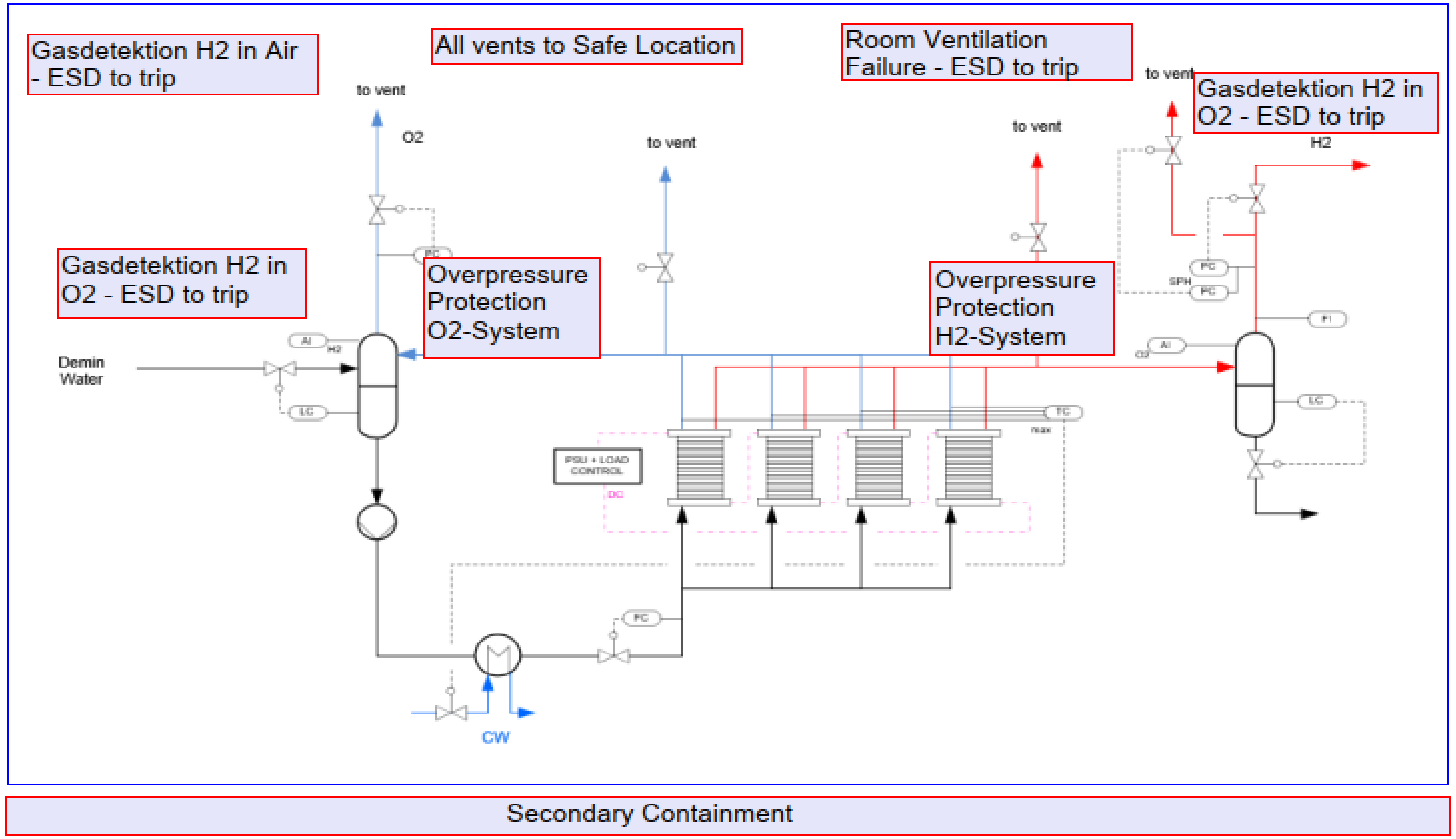




Challenge: Leakage rate, Detector Selection- & Allocation, ESD Functions and Ventilation Design

General Safeguarding - Process- and Plant Safety

ISO 22734: Hydrogen Generator using Water Electrolysis



ISO requires safety functions based on risk analysis

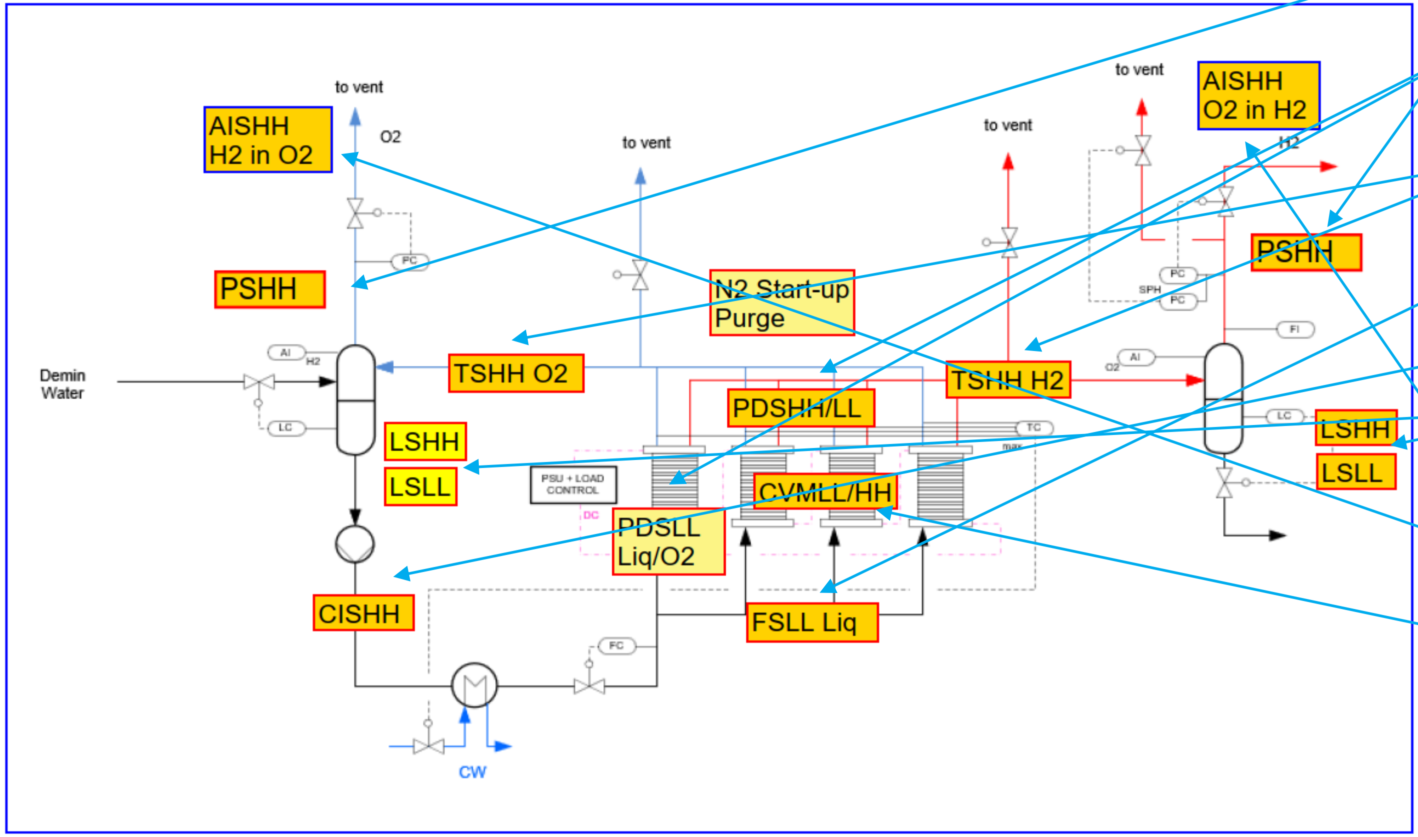
- Stop H2 Generation
- Depressurization
- De-energization
- Ventilation to maximum

Applicable Codes currently define only general requirements and do not stipulate specific safeguarding systems!

Process Safety - Safeguarding

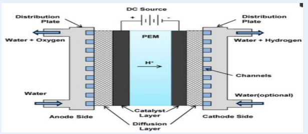
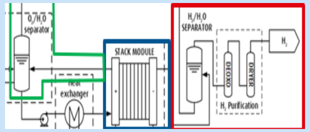
Set of Process Safeguards

The safety features for electrolyzers are multi-faceted and depend on the OEM's design solutions!



- Pressure High in O2 and H2 partition
- Differential Pressure H/L over O2 and H2 Partition of ELY- System
- O2- & H2- Stack Outlet temperature
- Liquid- Flow measurement
- Conductivity measurement (CIS)
- Level High and Low in H2 & O2 water separator
- H2 in O2 / O2 in H2 Concentration
- Cell Voltage Measurement

Areas for Standardisation

Topic	Description
	Explosion Protection
	Facility Siting and Safety Distances
	Building Installation Requirements
	H2/O2/Liquid - Crossover Impact on Design
	O2/ H2 - Compatibility

Summary

Technology

- PEM currently being introduced an industrial scale but is still under development.
- Alkaline is a proven technology, but innovations in stack design could also affect safety.
- If proven safety philosophies are considered both technologies can be seen as safe.

Designer/ OEMs/ Operators

- Lack of adequate definition of safety requirements.
- OEMs differ in terms of engineering and manufacturing maturity.
- Steep learning curve because of technology development and scale-up.
- New operators with limited knowledge of hydrogen and oxygen hazards.

Conclusion

- The development of uniform and detailed safety standards is a challenge but is required.
- Exchange of information on the technical safety practices is important.
- EPSC can help to bring stakeholders together.
- EPSC can drive safety design initiatives.
- EPSC can support in exchange of lesson learned from operation.

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Linde Engineering
Oliver Grosse
oliver.grosse@linde.com
www.linde.com

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