Topics Covered

- **Electrolyser Monitoring**
  - Key process parameters to be monitored
  - Instrumentation Around Electrolyser

- **Electrolyser Safety**
  - Old Concept
  - New Concept

- **Process Controls**
Electrolyser Monitoring

Electrolysis process involve many process variables

Continuous Monitoring of process parameters is necessary for efficient plant operation

Selection of proper Instrumentation and control plays vital role in safe plant operation
Electrolyser Monitoring
Key Process Parameters to be Monitored

- Chlorine and Hydrogen Header Pressure
- Differential pressure
- Brine flow and Caustic flow to Electrolyser
- Catholyte and Anolyte Temperature
- Single Element Voltage
- Cell Rack Voltage
- Voltage deviation across Cell rack
- Corrected Voltage
Electrolyser Monitoring
Key Process Parameters to be Monitored

- Electrolyser/Rectifier current
- Anolyte Concentration and pH
- Catholyte Concentration
- HCl flow to Electrolyser
- Anolyte Header Pressure
- Catholyte Header Pressure
- Diff. press. between Anolyte & Catholyte header
- Hydrogen in Chlorine
Electrolyser Monitoring
Instrumentation Around Electrolyser

- Chlorine and Hydrogen Header Pressure
- Pressure transmitters for Chlorine & Hydrogen
- Brine flow and Caustic flow to Electrolyser
- Flow transmitter for Feed brine and feed caustic
- Differential pressure
- Differential Pressure transmitters
- Catholyte and Anolyte Temperature
- Temperature transmitter in Anolyte and Catholyte Header

- Brine flow and Caustic flow to Electrolyser
- Flow transmitter for Feed brine and feed caustic
- Catholyte and Anolyte Temperature
- Temperature transmitter in Anolyte and Catholyte Header
Electrolyser Monitoring
Instrumentation Around Electrolyser

Pressure transmitter for Chlorine and Hydrogen
Differential Pressure transmitter
Flow transmitter for Feed brine and feed caustic.

Temperature transmitter in Anolyte and Catholyte Header
Electrolyser Monitoring
Instrumentation Around Electrolyser

- Single Element Voltage
- Uhde Evaluator/ Voltage monitoring system
- Cell Rack Voltage
- Voltage transmitter on individual cell rack
- Voltage deviation across Cell rack
- Voltage deviation transmitter for each rack
- Corrected Voltage
- Voltage of Ely compared with corrected voltage based on temperature
Electrolyser Monitoring
Instrumentation Around Electrolyser

- Uhde Evaluator/ Voltage monitoring system
- Voltage transmitter
- Voltage deviation transmitter
Electrolyser Monitoring
Instrumentation Around Electrolyser

- Electrolyser/Rectifier current
- DC shunt/Current transducer
- Anolyte Concentration and pH
- pH transmitter and Coriolis flow meter in individual Electrolyser anolyte outlet
- Catholyte Concentration
- Coriolis flow meter in individual Electrolyser Catholyte outlet
- HCl flow to Electrolyser
- Flow meter in HCl to feed Brine for individual electrolyser.
Electrolyser Monitoring
Instrumentation Around Electrolyser

Current Measurement

pH meters and Mass flowmeter assembly
Electrolyser Monitoring
Instrumentation Around Electrolyser

- Anolyte Header Pressure
- Pressure transmitter for Individual Electrolyser Anolyte header
- Catholyte Header Pressure
- Pressure transmitter for Individual Electrolyser Catholyte header
- Diff. pressure between Anolyte and Catholyte header
- Calculation block with indication for Diff. pressure between Anolyte and Catholyte header
- Hydrogen in Chlorine
- Hydrogen in Chlorine analyzer
Electrolyser Monitoring
Instrumentation Around Electrolyser
**Principle:** Conversion of H₂ to HCl and then infrared photometric determination

\[ 	ext{H}_2 + 	ext{Cl}_2 \rightarrow 2\text{HCl} \]

- H₂ and Cl₂ is Oxidized by UV to HCl
- HCl is measured by INFRARED analyzer.
- Corresponding quantity \(2\text{HCl} = \text{H}_2\)

**Capabilities:**
- Measurement in presence of higher inert gas components possible, faster response, higher accuracy.
- This analyzer can detect high H₂ in Cl₂ levels and possible explosive mixture formation during following conditions:
  - At low loads / during start-up
  - During membrane leaks
- Detection limit approx. 100 ppm H₂ (equivalent 200 ppm HCl)
- Response time 60 … 100 sec.
- Stable operation, if proper maintenance of sample handling system is carried out.
- Relatively low maintenance

**Limitations:**
- High initial investment
Electrolyser Safety in Cell Room

Safety first is not just a slogan
it’s an attitude

Safety means safeguarding of your personnel & equipment from hazards
Safety makes us stronger

Living a reasonable Safety philosophy means Trust in Plant Safety
Electrolyser Safety in Cell Room

Safety model

Technology
- State-of-the-art technology – tkUCE generation 6 electrolyser
- Electrical safety in cell room
- Digitalization – Uhde Evaluator

Procedures
- State-of-the-art operating procedures
- Electrolyser bypass concept
- HAZOP

Personnel
- Operator training
- Cause-Effect instructions

Incident Level
- Emergency Interlocks (e.g. shut down of electrolyser)
Electrolyser safeguards
From the beginning

- **Element Voltage**
  - Manual Voltage measurement

- **Safety Valves**
  - Electrolyser high pressure protection

- **Neutral point & Insulation**
  - Manual insulation monitoring

- **DCS based Interlock**
  - Normalized voltage of each electrolyser calculated
Interlock for voltage increase of total electrolyser

Deviation of Alarm and Trip value

\[ EAH = (U_0 + k \times CD + 100) \times N_{\text{Cells}} \]

\[ EAHH = (U_0 + k \times CD + 200) \times N_{\text{Cells}} \]
Electrolyser High Pressure Protection
Use of Safety Valves at electrolysers

- Cost intensive piping to route
- Yearly maintenance and work bench recalibration of predefined opening pressure
- Chlorine can permeate through PTFE bellows and corrode metallic parts
## Limitations of old systems....

1. Manual voltage measurement is not continuous monitoring.

2. DCS based calculated voltage needs k-factor adaptation by time. No adaptation causes unintended shutdowns.

3. Safety valves need regular and frequent maintenance/testing, no automated Nitrogen purge.

4. Simple earth fault detection method with Mega Ohm Test.
Electrolyser safeguards

What is now?

- **Uhde Evaluator™ system/Voltage Monitoring system**
  - Monitoring and Safeguarding of each single element and busbar symmetry

- **On/Off bypass valves and automatic Nitrogen purge**
  - bypass valves operated by DCS/ESD
  - Immediate N2 flushing of single header

- **Symmetric-electrolyser earthing**
  - Symmetric earthing at defined locations around each electrolyser and cell room thus as second line of defense

- **Insulation monitoring system**
  - Insulation Monitoring of platform and single racks (100 kΩ)
Safeguarding by Uhde Evaluator
Monitoring and tests

- Alarms
- Pinhole detection / voltage test
- Polarization test
- Single Element voltage start-up curves
- Monitoring membrane operate. window
- Display of Single Element volt. & temperature
Main components of the Uhde Evaluator™

- Cell room
- Electrolyser A
- Electrolyser B
- DAU A
- DAU B
- Masterbox
- ESD
- Laboratory
- Control room
- DCS
Automatic insulation monitoring of platform & electrolyser rack

Take Insulation monitoring serious

The lower the ohmic resistance, the higher the risk for operators!

Experience for typical resistance values
1) MOhm – No risk
2) kOhm – salt bridge by leakages or dirt in wet atmosphere (maintenance case!)
3) Ohm – short cut via direct metallic contact
Earth fault in the service platform or electrolyser steel structure

**Alarm by Insulation monitoring device!**

- Fatal risk by touching live parts and a second part with earth fault!
- Only trained operators are allowed to enter service-walkway
- Appropriate safety gear required (protective boots and gloves)
On/Off Automatic Bypass-valves & Electrolyser Pressure Monitoring via DCS

The pressure transmitter and the ON/OFF valve on each anolyte and catholyte header enables to monitor and protect each single electrolyser header with respect to pressure and differential pressure.

Bypass valves automatically ramp close or open at electrolyser pressure upsets:
- for example: High dp / high H₂ pressure
  - Catholyte bypass valve opens

Cost intensive piping, maintenance of safety valves no more needed
Electrolyser protection by automatic N$_2$ Purge

- Automatic N$_2$ purge ensure immediate flushing of outlet headers
- Accumulation of H$_2$ and Cl$_2$ to ignitable mixtures due to membrane defects is prevented
New cell room safety concept summary

- On/Off Automatic Bypass-valves & Electrolyser Pressure Monitoring
- Automatic insulation monitoring of platform & electrolyser rack
- Uhde Evaluator Safeguard on cell voltage absolute and deviation from threshold, bus bar symmetry, first out indication
- Automatic N₂ purge ensures immediate flushing of outlet headers and prevents accumulation of H₂ and Cl₂
Process Controls

Process controls maintain the process at the desired state or set of conditions – “keep it out of the ditch”

Desire state means Maintain emission norms, safe operation and desire output

It’s not just about optimization; it’s about successful operation of the entire plant
Process Controls - Electrolyser

Cl₂ to compressor

Waste gas

H₂ to consumer

Cl₂ to compressor

Coolers

Electrolyser

Anolyte Catholyte

Feed Brine

Feed Caustic

PIC

PDIC

DPI

PI

TI

FIC

HCl
Process Controls- Electrolyser
Differential Pressure Across Membrane

- Most important parameter to be monitored and controlled
- Operating value: “Fixed” mmwc
- Depends on Hydrogen pressure and Chlorine pressure
- Transmitters are provided in cell house to measure directly differential pressure between Hydrogen and Chlorine.
- Special Rotary plug control valve are used
- Interlock is provided to trip plant on HH, HHH, and LL values of Differential pressure
Process Controls - Electrolyser
Differential Pressure Across Membrane
**Process Controls- Electrolyser**

**Pressure Control-Chlorine**

- Very crucial parameter as it directly affect DP, operation of downstream equipment/ units
- Operating Range : Up to 3500 mmwc
- Transmitters are provided at chlorine header in cell house
- Interlock is provided to trip plant on HH and HHH values of Chlorine pressure
Process Controls - Electrolyser
Flow Control - Feed Brine, Feed Caustic and Acid

- Flow of feed Brine, Feed Caustic and feed HCl to be adjusted based on Electrolyser load
- Flow Transmitters with control valve provided for each service
- Interlock is provided to trip of Electrolyser on LL flow of Feed brine and feed caustic. The interlock value is dynamic and keep on changing based on electrolyser load.
Process Controls - Electrolyser
Flow Control - Feed Brine, Feed Caustic and Acid

Cl₂ to compressor

Waste gas

H₂ to consumer

PIC

Coolers

PDIC

Electrolyser

H₂

220 mbar

Cl₂

200 mbar

Anolyte Catholyte

Coolers

Feed Brine

Feed Caustic

HCl
Thank You