Engineering Services for the Optimisation of Chlor-Alkali Plants

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Agenda

• The challenge of chlor-alkali
• INEOS experience and expertise
• Key areas for optimum cellroom design
  – Long term performance - power
  – Pressure
  – Brine purity and salt selection
  – Stray currents
  – Keeping the Plant Online
  – Keeping the Plant Safe
• Engineering services to meet the challenge
Key to successful, long term operation of a membrane cellroom, as well as good technology selection, is the correct design of the unit operations surrounding the electrolyser.
The Challenge of Chlor-Alkali - Why is it not so Easy

- Corrosive fluids
- Explosive gases
- Stray currents
- Exotic materials
- Fragile components
- Electrochemistry!
- Chemical sensitivity
- Toxicity
For Big Challenges...........

..... talk to someone who’s been there before
Meeting the Challenge for Over a Century......

INEOS have over 100 years experience of operating all chlor-alkali technologies

INEOS currently operate membrane technology on 3 major European sites

INEOS have been at the forefront of membrane cell technology since it’s inception

INEOS have installed chlor-alkali technology at over 100 sites worldwide

INEOS are experts in chlor-alkali design, engineering and operation
Key Areas for Optimum Cellroom Design

• For optimum long term performance……
  – Minimise power consumption
  – Maximise performance on day 1
  – Ensure high performance maintained day 2+

• Key design areas to achieve optimum performance
  – Cellroom pressure
  – Brine purity and salt selection
  – Stray Currents

• Keeping the plant online

• Keeping the plant safe
It’s all about Power – Ideal Power Consumption

Ideal power consumption

Years

Power

0  2  4  6  8  10
It’s all about Power – the Reality

**Power consumption over time**

- Current efficiency
- Pressure
- Temperature
- Ohmic loss
- Overpotential

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- Quality of operation
- Operability
It’s all about Power – a Marathon not a Sprint

Power consumption over time

Time

Power
It's all about Power – a Marathon not a Sprint

Power consumption over time

Time

Power

Power
Early Performance can be Easily Lost

20 mV start up voltage benefit

Saving = €0.1 million

4mV/month voltage rise penalty

Penalty = €0.9 million

100 ktpa plant
4 year cycle
European power price
Keeping the Power Down - Pressure

High pressures can be beneficial….
- Reduce day 1 power consumption
- Reduce plant capital cost
- Enable operation at altitude
- Reduce utility usage

But they can also……
- Increase day 2+ power consumption if transients are not managed

Sometimes low pressure has other advantages……….
- Reuse of low pressure equipment (mercury or monopolar conversions)
- Simple pressure control system
- Less vulnerable to pressure / differential pressure excursions

Is high or low pressure right for you………?

BICHLOR™ is designed to operate at high current density and low or high cellroom pressures and is robust to excursions
Staying in Control of Pressure

INEOS operate plants at high pressures and can mitigate risks

• Easy to control pressure and differential pressure during steady operation
• Not so easy to control pressure during transient events (e.g. trips)
• Removal / re-instatement of a single electrolyser from a multi-electrolyser cellroom
• Pressure protection and relief systems to cover all sources of overpressure (and underpressure) during all modes of operation

Risk of pressure and differential pressure excursions if the design of the pressure control system isn’t right

Excessive pressure excursions can reduce electrolyser performance
Staying in Control of Pressure - Typical System
Keys to good pressure and differential pressure control

- Correct valve sizing
- Trip logic
- Valve settings (stroke times)
- Tuning of valves

INEOS are experts in dynamic modelling of cellroom gas systems

- Simulate various transient events
- Optimise control valve selection
- Develop the optimum logic and timed responses
- Achieve excellent pressure control in all situations
- Check response of system prior to start-up
Model validated against a less than optimal pressure swing during a plant trip
Model used to evaluate optimal valve stroke times, within the constraints of the installed valves. Subsequent plant trip followed modelling results very well.
Low cost brine plants can reduce capital…..

………but they can seriously increase day 2+ power increase due to impurity excursions

How will specific impurities behave in the brine loop and electrolyser?
• Precipitation within the membrane (increased voltage, reduced CE)
• Plating on electrodes / attack of electrode coatings (increased over-potential)
Brine Purity and Salt Selection

What do we do in design to minimise damage due to brine impurities?

- Salt and brine selection
- Secondary purification design and resin specification
- Brine purge vs other brine loop purification techniques
- Hg residue for conversion projects
- Cost / benefit analysis of relaxation of specific impurities
- Full characterisation of brine
- Pilot trials for brine purification

INEOS are experienced in operating plants with different salt supplies and brine purification strategies. We design to avoid the pitfalls
**Electrolyser Stray Currents**

Relatively high voltages in membrane cells leads to current leakage via process fluids:
- Corrosion of electrolyser components
- Corrosion of up and downstream metallic equipment
What do we do to alleviate the problems caused by stray currents?

• Inclusion of sacrificial stray current collectors in cell feeds and exits
• Positioning of process fluid supply and discharge lines
• High resistance fluid paths
• Grounding electrodes
  – Protect up and downstream equipment
  – Positioned to minimise stray currents to earth
  – Prolong life of the grounding electrode
• Stray current modelling

INEOS understand the issues of stray currents and know how good cellroom design can minimise their effects
Keeping the Plant On-Line

Capital cost saving decisions may impact long term availability and revenue

- Materials of construction
  *It may cost less but how long will it last?*

- Maintainability
  *It may look neat but can you get at it?*

- Configuration and overcapacity
  *If one unit is off-line can another make up?*

- Maintenance window
  *How long to repair/replace an item?*

- Buffering and redundancy
  *Staying on line during upsets*

- Refurbishment planning
  *Does technology supplier look after you?*

As operators INEOS understand the importance of keeping the plant on line. INEOS technology is designed to be robust and easily maintained. We help clients throughout the plant life cycle
Safety is paramount in the INEOS culture. Our technology is designed for installation into facilities demanding the highest safety standards in all operating and maintenance situations.
INEOS will Bring Deep Understanding of Chlor-Alkali to your Project

- Design of wider chlor-alkali plant, whether for a technology conversion or new installation is by now generally understood

- Deep understanding of the chemical engineering science around the electrolysis section of the plant is required to ensure optimal design

- Several key areas, identified here, require very careful consideration to ensure prolonged efficient operation of the plant

- Operating Experience + Technical Expertise $\rightarrow$ Optimal Cellroom design
Where can INEOS add value?

- Plant performance assessment
- Plant capacity assessment
- Optioneering and financial analysis
- Feasibility studies
- Expert process engineering
- Hazard studies and technical risk
- SIL/LOPA
- Layout analysis
- Dynamic modelling
- Vendor analysis and selection
- Troubleshooting
- Technology knowledge
- Operating skills

Flowchart:

1. Process Definition
2. Process Design
3. Front End Engineering
4. Detailed Engineering
5. Procurement and Construction
6. Commissioning
Where can we help you?

Thank you for your time and attention

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