Our Group Mission Statement
thyssenkrupp Uhde Chlorine Engineers – a reliable partner
Building on a strong past

- UHDENORA founded as JV 2001 between DeNora (founded 1923) and Uhde (founded 1921)

- Chlorine Engineers founded 1973, acquired in 2011 by Industrie de Nora S.p.A., the parent holding company of De Nora

- ThyssenKrupp Electrolysis GmbH (former Uhde Product Unit Electrolysis, founded in 1960)

Since 1.4.2015 =
thyssenkrupp Uhde Chlorine Engineers
To ensure excellent support on a global scale, thyssenkrupp Industrial Solutions and Industrie De Nora joined forces.

**tk Industrial Solutions**
- Support: Engineering, Procurement, Construction, Financing etc.
- 66%

**Industrie De Nora**
- Supplies: Coating and cell manufacture
- 34%

thyssenkrupp Uhde Chlorine Engineers
- Technology, Plant Business (EPC), Services
Being closer to our customers
Together with more than 300 experts and strong shareholders we provide technological and execution power

Management Board
- Denia Krude, CEO
- Shinji Katayama, CTO
- Arno Pfannschmidt, CFO

Local Head of Management
- Dortmund: Roland Beckmann
- Okayama: Christoph Noeres
- Tokyo: Christoph Noeres
- Shanghai: Keisho Cho
- Milan: Albert Zimmermann
- Houston: Jürgen Grasinger

Global functions
- Sales: Adrian Schervan
- Product Development: Fulvio Federico
- Service: Dmitri Donst
- Business Development: Christopher Papile

Customer
Worldwide: close to the customers
We offer complete scope from Sales to EP/EPC and Technology Service

Shared services agreements

- Support by tkIS/DN sales offices
- DN: manufacture/Coatings tk: lab/energy storage
- DN Manufact. and coating
- tkIS (DE, IND) Support in Basic Eng.
- tkIS and its regional organisations support in all functions
- DN repair and coating

thyssenkrupp Uhde Chlorine Engineers (tkUCE)
thyssenkrupp Industrial Solutions (tkIS)
Industrie DeNora (DN)
Some Technology service products can be used immediately after commissioning of the plant.
Uhde Integrator™ is a system for comprehensive data recording and analysis.
Remembraning/recoating/remeshing campaigns and associated services are points of intense cooperation client/tk UCE
Some technology service products are especially interesting for plants being already in operation for a longer time.
Element upgrade/retrofit and element replacement reduce power consumption significantly.

> 12 years

Element upgrade/retrofit

Element replacement
Replacement of old elements by latest generations reduces power consumption

- Flooded cell
- Improved safety level
- No internal $\Delta p$ fluctuations
- Enhanced feed system
- Brine acidification possible
- Increased current density
- Minimized investment
  - Lowest power consumption

Replacement of old elements by latest generations reduces power consumption
thyssenkrupp Uhde Chlorine Engineers service concept allows to use modules or full service packages

System Service
- Customer Support
- Benchmarking
- Performance Investigation
- Delivery of Elements
- Delivery of Accessories
- Training
- Element Assembly
- RCM, Uhde Integrator™
- Remembr./Recoat./Remesh.
- Uhde PipeTech™
- Gasketing

Performance Service
- Element Replacement
- Element Upgrade/Retrofit
- Process Improvements

Consulting Service
- Plant Upgrade Study
- Risk Analysis
- Project Management

Full Service
Technology Service - Full Service reference
Conventional Chlor-Alkali Electrolysis

Customer: Confidential
Location: Western Europe
Capacity: Confidential
Process: tk UCE
Speciality: EPCm

Key Highlights of Full Service 2014/2015:
Scope of Supply: New v5 anode halfshells and cathode recoating for 6 electrolyzers
Recoating of anode and cathode electrodes for 12 electrolyzers
Element accessories

Scope of Services: Removal of elements from electrolyzers
Disassembly and reassembly of elements
Installation of recoated/upgraded elements in electrolyzers
Latest Improvement in product portfolio

Electrolyzers
• Uhde BM 2.7 Single Element electrolyzers
• BiTAC filter press electrolyzers

NaCl – Oxyden Depolarised Cathode (ODC) Technology
• Uhde Single Element BM 2.7 - ODC Technology

HCl - ODC Electrolysis
• HCl recycle through HCl electrolysis from MDI/TDI and other sources

Skid Mounted Chlorine Plants
• Cost competitive plants for reduced chlorine production

Water electrolysis and Electrochemical energy storage systems
• Electrochemical Renewable Products
Our technologies and competencies have been attractive

Accumulated contract awards

About 50% of world installed capacity with over 400 projects in 48 different countries
BiTAC (Chlorine Engineers) and BM (Uhde) – two success stories

<table>
<thead>
<tr>
<th>BiTAC</th>
<th>BM</th>
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<tbody>
<tr>
<td>1989</td>
<td>1989 BM2.7v2</td>
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<tr>
<td>1994</td>
<td>1994 BiTAC</td>
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<td>1997</td>
<td>1997 BM2.7v3</td>
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<td>2005</td>
<td>2005 BM2.7v4</td>
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<td>2008</td>
<td>2008 BM2.7v5</td>
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<td>2012</td>
<td>2012 BM2.7v6</td>
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<tr>
<td>2013</td>
<td>2013 nx-BiTAC</td>
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- Louver electrodes
- First zero-gap cell @6kA/m²
- Pure brine acidification, first laser welded cell
- Collecting channel, inclined cell top
- Fine cathode mesh
- Prebent C-profile anode
- Full zero gap, elastic element
- Fine anode mesh

Power Consumption
- *) >2200kWh/t
- Power Consumption 2200 kWh/t
- Power Consumption 2200 kWh/t
- Power Consumption 2130 kWh/t
- Power Consumption 2060 kWh/t
- Power Consumption 2070 kWh/t
- Power Consumption 2025 kWh/t
- Power Consumption 2025 kWh/t

*) At 6 kA/m², 90°C, 32 % NaOH
Our newest product was launched in June 2013…
.... the tk Uhde Chlorine Engineers NaCl-ODC technology
NaCl – ODC: 25% reduction of electrical energy consumption

**Conventional Membrane Cell**

- Cell Voltage: 3 V
- Chlorine, Hydrogen, Caustic
- Anode
  - membrane – electrolysis cell
  - NaCl → 2Cl₂ + 4e⁻
  - 4H₂O + 4e⁻ → 4OH⁻ + 2H₂

**ODC Membrane Cell**

- Cell Voltage: 2.3 V
- Chlorine, Caustic
- Anode
  - membrane – electrolysis cell
  - NaCl → 2Cl₂ + 4e⁻
  - O₂ + 2H₂O + 4e⁻ → 4OH⁻
The NaCl-ODC Technology is Demonstrated for 4 years by now

- **Over 25% Energy Saving** Vs Conventional Electrolysis
- Operation up to **5 kA/m²**
- Stable operation proofs a **robust technology**

Dr Albert Zimmermann
RusChlor's tenth international scientific-and-technological conference
“Chlorine and its derivatives 2016: Best Available Techniques”
Selected References
Oxygen Depolarized Cathode (NaCl-ODC) Chlor-Alkali Electrolysis

Customer: Befar Group Co, Ltd
Location: P.R. China
Capacity: 40,000 t/year of NaOH
35,500 t/year of Cl₂
Process: tkUCE / Bayer
Commissioning: 2015
Specialty: First commercial NaCl – ODC plant worldwide

Key Highlights:
Technology: NaCl-ODC (Oxygen Depolarized Cathode)
Project: Plant Expansion
Scope of Supply: BM 2.7 – ODC Electrolyzers
Electrolysis Room Accessories
Key Catholyte Circulation Equipment
Uhde EVALUATOR Monitoring System
Growing HCl-ODC market due to growing isocyanate business

- Sustainability, careful use of resources and ecological responsibility.
- Generation of Cl₂ with very high purity (99.8 % vol., O₂ (20 ppm/wt.).
- ~100 % conversion rate (HCl/Cl₂) at flexible plant operating window
Skid Mounted Chlorine Plants
Cost competitive plants for reduced chlorine production

Pre assembled – skid mounted chlorine plant
Capacity up to 15,000 t/year of Cl₂
Standardized engineering and configuration
40” container transportation
Fast plant implementation

Pre assembled – skid mounted chlorine plant
Capacity up to 5,000 t/year of Cl₂
Standardized engineering and configuration
Designed for water purification inorganic chemicals production
Fast plant implementation
## Selected References (EP – Skid mounted plants business)

### Skid Mounted Chlorine Plants

<table>
<thead>
<tr>
<th><strong>Customer:</strong></th>
<th>Produquimica Industria &amp; Comercio</th>
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<tbody>
<tr>
<td><strong>Location:</strong></td>
<td>Brazil</td>
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<tr>
<td><strong>Capacity:</strong></td>
<td>17,000 t/year of NaOH 15,000 t/year of Cl₂</td>
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<tr>
<td><strong>Process:</strong></td>
<td>tk UCE</td>
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<tr>
<td><strong>Commissioning:</strong></td>
<td>2014</td>
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<tr>
<td><strong>Specialty:</strong></td>
<td>EP</td>
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### Key Highlights:

- **Project:** Skid Mounted Chlorine Plant (total 7 skid mounted process units)
- **Scope of Supply:** Electrolysis, Catholyte Circulation, Brine Dechlorination, Cl₂ and H₂ Cooling and Filtration, Brine Filtration, Secondary Brine Purification, Waste Gas Dechlorination, Sodium Hypochlorite Production, Chlorine Drying
Portfolio of Electrochemical Renewable Products

Production
- Renewable Energy
  - Power grid
- Conventional Energy
  - Gas grid

Consumption
- Power-to-Power
- Power-to-Gas
- Power-to-(Sustainable) Chemicals
- Power-to-Power

Production:
- Water electrolysis
  - Short- to mid-term storage
  - Production: H₂, O₂

Consumption:
- Methane
  - Application:
- Ammonia
- Methanol

Application:
- Water electrolysis
- CCG Turbine
- Mobility
- Chemicals

thyssenkrupp portfolio
Thank you for your attention!

For any information:

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