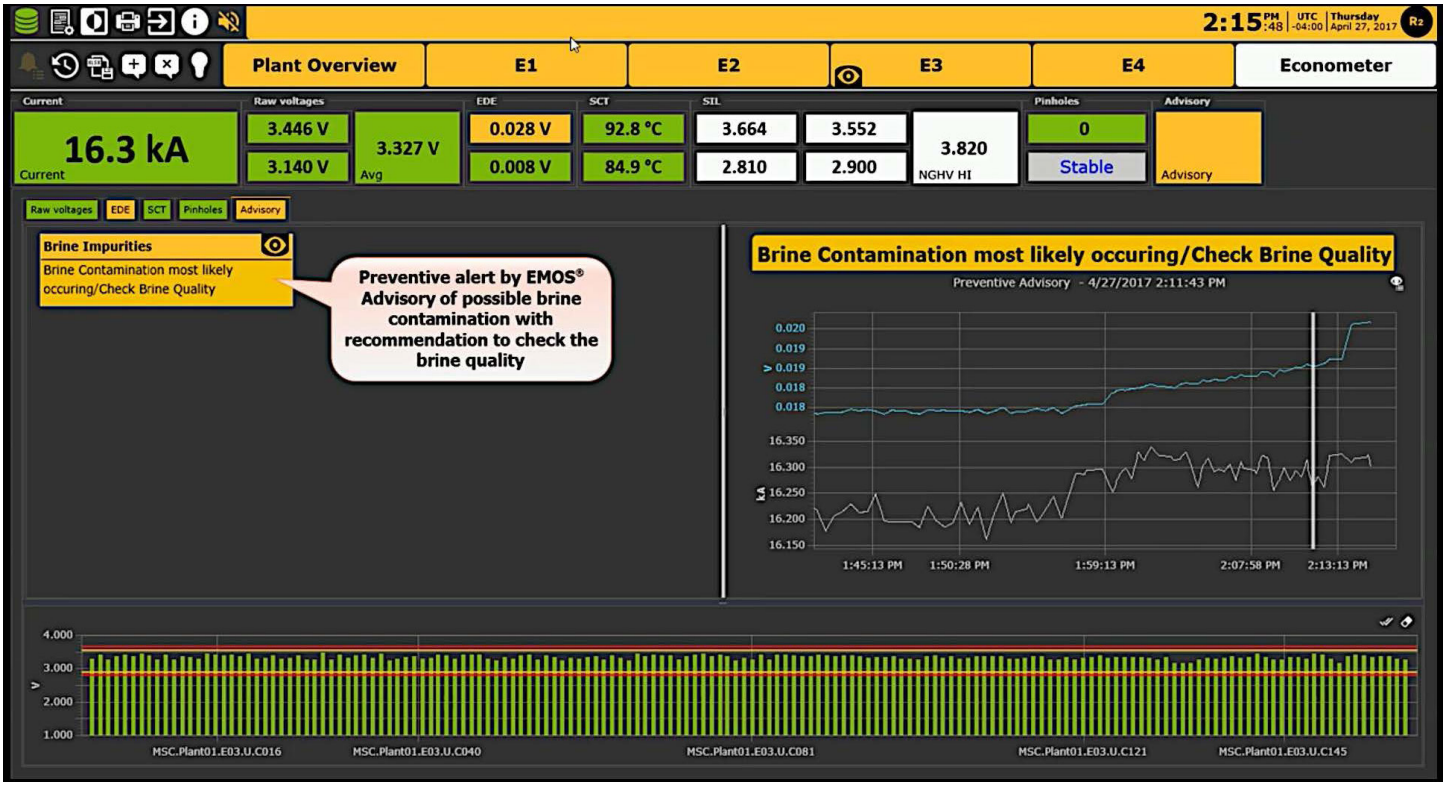
EMOS® ADVISORY

PROTECT YOUR MEMBRANES AND AVOID PLANT PERFORMANCE DECLINE

IMPROVE PLANT SAFETY WITH AUTOMATIC EVENT ROOT CAUSE ANALYSIS AND RECOMMENDED ACTIONS



KEY FEATURES AND BENEFITS

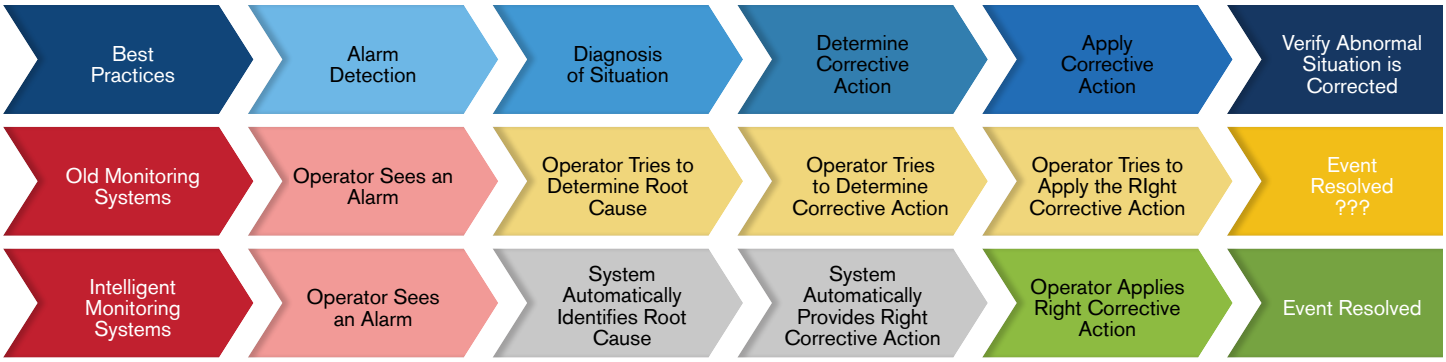
FEATURES	BENEFITS
Fewer unplanned shutdowns	Actionable insights to prevent and fix cell room incidents
Shorter downtime when resolving incidents	Root cause identification of each fault
Improved operator effectiveness and efficiency	Recommended corrective action for each incident
Increased throughput	100+ detectable hazard types (Advisory AI)
Reduced training time	Suited for the chlor-alkali, chlorate, and hydrogen industries
Fewer incidents escalated to shift supervisors/engineers	Covers all operation modes (startup, normal, shutdown, etc.)

"WHAT SHOULD I DO WITH THIS ALARM?"

This question raised by operators in control rooms epitomizes a key challenge of the chlor-alkali industry: preserving the technical know-how and expertise, in a context of experienced workers gradually retiring and young workers joining the industry. There indeed exists an important risk that knowledge might not be fully transferred between seasoned employees and new hires. Moreover, budget cuts sometimes lead to a reduction of staff in control rooms, which means that operators and engineers must now resolve more alarms in less time than before.

MORE MEANINGFUL AND ACTIONABLE ALARMS

This knowledge gap and need for greater efficiency in the control room can be addressed by using more intelligent monitoring systems that offer more meaningful alarms, with actionable information. The procedure to remedy an incident can broken down in 5 steps as shown below.



Automated Steps = Time Savings!

With older systems, successful incident resolutions depend on operator skills and the time required to carry out each step. However, more intelligent monitoring systems automatically diagnose a situation (root cause analysis) and determine the appropriate corrective action, reducing dependency on operator skill levels, and saving time.

ROOT CAUSE ANALYSIS AND RECOMMENDED CORRECTIVE ACTION

EMOS® Advisory answers these needs by specifying the cause of a hazard for each alarm and by recommending a precise corrective action, providing the following benefits:

- Transform Operators Into Experts
- Shorten Downtime Required to Resolve an Incident
- Increase Throughput Using Fast Fault Resolution
- Reduce Training Time
- Reduce the Number of Incidents Escalated to Shift Supervisors/Engineers by Proposing Corrective Action

ADVISORY AI: EARLY DETECTION OF FAULTS

EMOS® Advisory is offered in two product tiers: **Advisory** and **Advisory AI**. Leveraging machine learning, **Advisory AI** can detect faults hours before they occur by comparing, in real-time, the actual cell voltage with the predicted voltage, for the specific process conditions. Any important discrepancy between the two prompts an Advisory alarm, which enables operators to plan their intervention before an emergency shutdown is set off. This early detection of faults is unmatched in the industry!

UNIQUE FAULT DETECTIONS: BRINE IMPURITIES AND INSUFFICIENT ELECTROLYTE FLOW TO CELL

EMOS® Advisory AI protects chlor-alkali plants against many faults such as brine impurities or insufficient electrolyte flow to an individual cell, which are impossible to uncover using other vendor equipment. Based on its unique experience of analyzing over 67 000 electrolyser cells worldwide, R2 has developed best-in-class proprietary algorithms that increases plant safety and decreases the number of unplanned shutdowns.

ADVISORY TIER: PRE-CONFIGURED FOR CHLOR-ALKALI

Contrary to software packages offered by distributed control system (DCS) vendors that address many applications (oil refineries, power plants, etc) and that require heavy customization, **Advisory** is 100% optimized for chlor-alkali and it comes with built-in root causes and corrective actions for each alarm. Accordingly, chlorine and soda producers do not have to spend money hiring external engineering firms to configure their “alarm assistance” software. In addition, the **Advisory** tier does not require any voltage measuring hardware: just a connection to the DCS and the easy installation of a server.

Features	Advisory Tier	Advisory AI Tier
Number of Faults Detected	60	100+
Early Detection of Some Faults, Hours Before they Occur		
EMOS® Voltage Measuring Hardware	Not required	Required

KEY FAULTS DETECTED

The key incidents that Advisory and Advisory AI can detect are listed below, as well as their frequency of occurrence and their impact.

KEY INCIDENTS DETECTED BY ADVISORY TIER

Fault	Description	Frequency	Impact
Insufficient brine flow (normal operation)	Low brine flow rate, reducing level in anolyte compartment. Can cause membrane damage.	Often	Severe
Insufficient catholyte flow (normal operation)	Low catholyte flow rate. Increases cell temperature. Might harm the membrane.	Often	Severe
Electrolyzer temperature too hot	Electrolyzer temperature too high, causing membrane (swelling, blistering) and cell damage.	Often	Severe
Electrolyzer temperature too cold	Electrolyzer temperature too low, causing cell voltage increase and membrane damage (salt deposition).	Often	Severe
Corrosive brine in catholyte mixture	Corrosives from last shutdown still present in brine. Corrosives migrate in membrane, poisoning it.	Often	Severe

KEY INCIDENTS DETECTED BY ADVISORY AI TIER

Fault	Description	Frequency	Impact
Insufficient electrolyte flow to individual cell	Brine or catholyte flow to cell insufficient, due to plugged inlet tube or other reasons. Can cause membrane damage.	Often	Severe
Severe Pinhole	Important pinhole in membrane, reducing current efficiency to <88%. Causes increase in power consumption.	Often	Severe
Severe brine impurities	High concentration of impurities in brine, degrading membrane quality through precipitation of hydroxides or sales in membrane. Current efficiency decreases.	Average	Severe
Fast instrument failure	Electrolyzer sensor fails, giving wrong readings. Can cause electrolyzer to operate in inadequate conditions, damaging membranes, cathodes, or anodes.	Average	Severe
Cell temperature too hot	Cell temperature too high, causing membrane degradation (decarboxylation) and cell damage.	Often	Severe

FAULTS DETECTED BY ADVISORY TIER

Operation Mode	Faults Detected		
General	• Installed cell not monitored • Busbar overheat • Cell temperature too hot	• Severe pinhole • Pinhole at polarization • Electrolysis without flow	• Partially filled and powered • Partially filled and powered, no polarization • Short circuit
Circulation	• Polarization still on • Polarization off	• Brine purge incomplete • Polarization, no flow	• Polarization rectifier too strong • Polarization of cells not uniform
Low Load	• Cell temperature too cold	• Feed brine pH too high during startup	
Normal	• Cell temperature too cold • EDE precision bad	• Severe brine impurities • Fast instrument failure	• Fast instrument failure in cell room • Insufficient electrolyte flow to cells
Draining	• Cells not chlorine free	• Polarization still on	

FAULTS DETECTED BY ADVISORY AI TIER

Operation Mode	Faults Detected		
General	• Overload from load increase • Reverse pressure electrolyzer • Chlorine pressure high • Hydrogen pressure high	• Hydrogen pressure low • Outlet temperature high • High membrane tension	• Temperature difference of electrolyte high • Electrolyzer temperature too hot • DCS tag not plausible
Idle	• Brine inlet valve leakage • Cahtolyte inlet valve leakage • HCl inlet valve leakage	• Brine overflow • Acified brine • Catholyte overflow	• Corrosive brine catholyte mixture • Electrolyzer pressurized with chlorine • Electrolyzer pressurized with hydrogen
Filling	• Corrosive brine catholyte mixture • Anode side level higher than cathode side level	• Feed electrolyte too cold • Feed electrolyte too hot	• Electrolyzer pressurized with chlorine • Electrolyzer pressurized with hydrogen
Circulation	• Insufficient brine flow	• Insufficient catholyte flow	• Electrolyzer not overflowing
Low Load	• Insufficient brine flow • Insufficient catholyte flow • Brine acidification at too low of a load	• Startup too fast • Electrolyzer too cold	• Catholyte outlet concentration high • Catholyte outlet concentration low
Normal	• Insufficient brine flow • Insufficient catholyte flow	• Electrolyzer too hot • Electrolyzer too cold	• Catholyte outlet concentration high • Catholyte outlet concentration low

TWO OPTIONAL VIEWS FOR EACH USER

Since operators and engineers have different needs, **EMOS® Advisory** supports a different view for each user type:

OPERATOR VIEW

Only the most critical information is displayed to reduce information overload.

ENGINEER VIEW

All process data is displayed for comprehensive electrolyzer assessment.

Data Displayed	Operator View	Engineer View
Raw Voltages		
Load		
Pinhole Detection		
Advisory Root Cause and Corrective Actions		
Normalized Voltages		
Single Cell Temperature		
EDE Residulas		

SYSTEM REQUIREMENTS

EMOS® Server Minimum Requirements	
Operating System	Microsoft Windows Server 2022
CPU	Intel® Xeon® processor
Hard Drive	2x1TB RAID1 SSD (Solid State Drive) recommended
RAM	16 GB
Network Ports	(4) 100/1000
Communication	OPC Link with DCS

EMOS® Advisory will be provided by R2 on a separate PC.

NOTE: Since computer technologies are constantly changing, please contact us to verify if your existing server can run EMOS® Advisory.

ADVISORY AI PREREQUISITES

Part Number	Description
----	EMOS® Hardware
SWSTD	EMOS® Safety Software Package
SWSTD	EMOS® Single Cell Temperature Evaluator
SWSTD	EMOS® Pinhole Detector

ORDERING INFORMATION

Part Number	Description
SW400	EMOS® Advisory Annual License
SW410	EMOS® Advisory AI Annual License