INDUSTRY 4.0 AND IIOT: IS YOUR CHLOR-ALKALI PLANT READY?

White Paper

INTRODUCTION

Industry 4.0 and the Industrial Internet of Things (IIoT) both refer to the digital transformation taking place in the industrial/chemical world, that drastically changes many aspects of how companies operate. These two trends call for greater automation and interconnectivity of sensors and instruments, allowing plants to improve productivity and efficiency. By leveraging the additional plant data brought about by Industry 4.0 and IIoT, chlor-alkali operators and engineers can make better decisions and answer questions like “why did it happen” and “what will happen”, therefore moving towards the “smart factory”. An industry 4.0 maturity index has been developed by acatech, the German academy of science and engineering, to help manufacturing companies find out at which stage they are in their industry 4.0 transformation, and how they can progress. This white paper applies this industry 4.0 maturity index to chlor-alkali plants and cell-rooms and demonstrates how R2 can assist chlor-alkali producers in this journey.

WHAT IS INDUSTRY 4.0 AND INDUSTRIAL INTERNET OF THINGS (IIOT)

The expression “Industrie 4.0” (or Industry 4.0 in English) was coined by the German government and first introduced in 2011 as a strategy to establish Germany as a leader in manufacturing. The “4.0” relates to the fourth industrial revolution, that follows the third industrial revolution of the late 20th century (the rise of electronics, computers, telecommunications, etc). Industry 4.0 is the trend towards automation and real-time monitoring of every step in the manufacturing process to boost productivity and improve product quality.

Although the Industrial Internet of Things (IIoT) is not strictly speaking the same as Industry 4.0, they both share common goals and means. Interconnected sensors and devices are the foundation of IIoT in order to gather data that can then be exchanged and analysed to reap economic benefits. Advanced analytics and machine learning algorithms applied to this “big data” helps machines discover new insights and thus recommend specific actions. IIoT thus holds the promise of predictive analytics that move the course of action from sense and respond, to sense, predict and act.

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INDUSTRY 4.0 MATURITY INDEX

With so many aspects of the factory to look at and potentially change, managers willing to implement Industry 4.0 principles can be left wondering where to start. A powerful tool to assist companies is the Industry 4.0 maturity index, developed by acatech and FIR e.v. at RWTH Aachen University[1], that allows them to navigate through every stage of the transformation. Completing a maturity stage is required before reaching the next one. At the high level, the 6 stages are:

1. Computerization: using machines with a digital interface
2. Connectivity: connecting the machine with other relevant applications
3. Visibility: recording real-time data from the process by using sensors
4. Transparency: understanding why something is happening by using analytics
5. Predictive capacity: anticipate future events happening in the process
6. Adaptability: automating actions and decision making, without human intervention

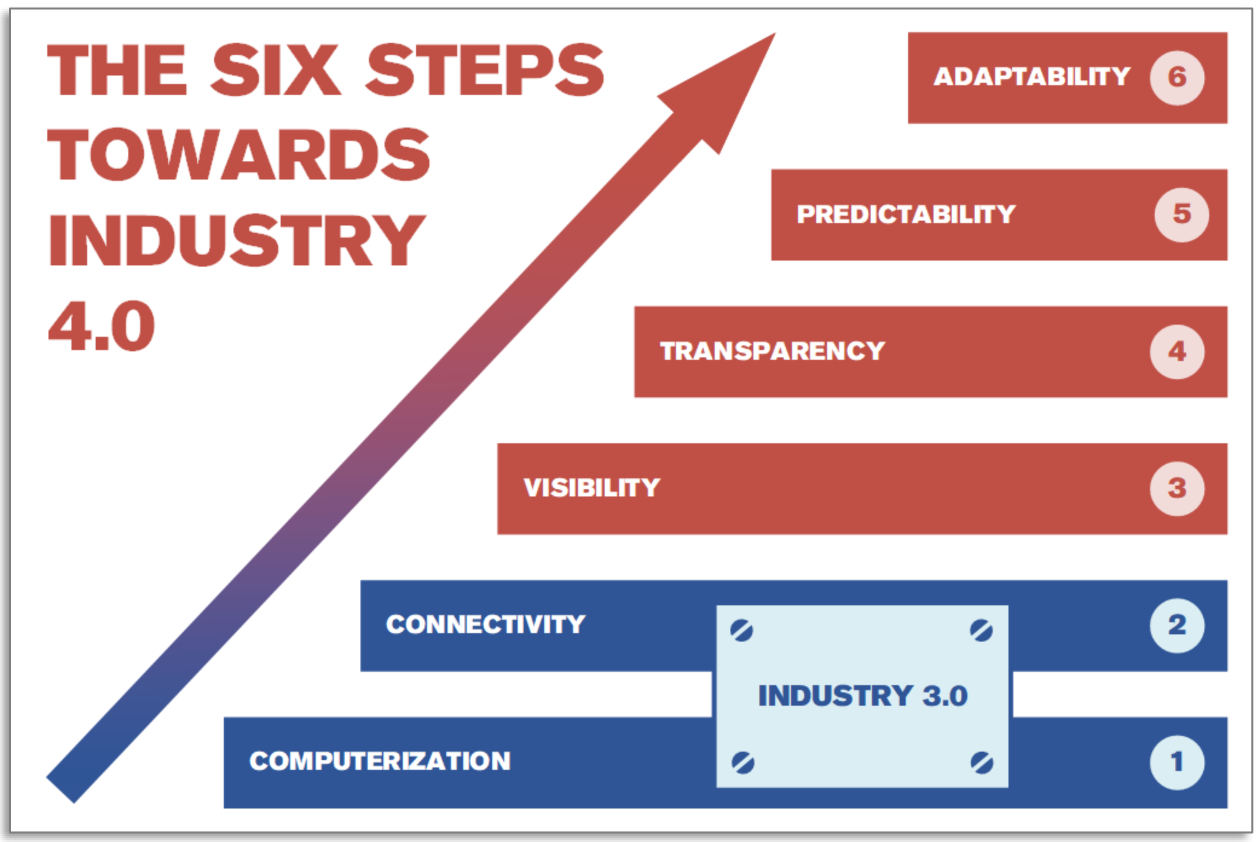

Figure 1: The 6 Steps Towards Industry 4.0

[1] Industrie 4.0 Maturity Index, Managing the Digital Transformation of Companies, acatech study, National Academy of Science and Engineering of Germany, https://www.acatech.de/wp-content/uploads/2018/03/acatech_STUDIE_Maturity_Index_eng_WEB.pdf

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THE MATURITY INDEX APPLIED TO THE CHLOR-ALKALI CELL-ROOM

Stage 1: Computerization

The first stage of industry 4.0, computerization, along with the next stage, connectivity, encapsulate the core of the previous industrial revolution (3.0) but also provide the foundation for the later stages of the complete maturity index.

Computerization refers to the use of digital interfaces for industrial equipment. A system or process in which most tasks are performed with digital interfaces and no longer via manual interventions at the equipment level can be said to satisfy the first stage of the maturity index. In terms of the chlor-alkali industry, this stage would include sensors and digital control systems (DCS) for example.

R2 can help to satisfy the requirements of this stage with the EMOS® SIL2 Safety System, a hardware system which automatically monitors cell voltages (using the MODA) and rectifier currents (via the SFOCOM) and uses intelligent algorithms (in both the MODA and SFOCOM) to provide alarms and plant trips if necessary (see stage 6). In the past, these measurements would have been sampled manually by a technician.

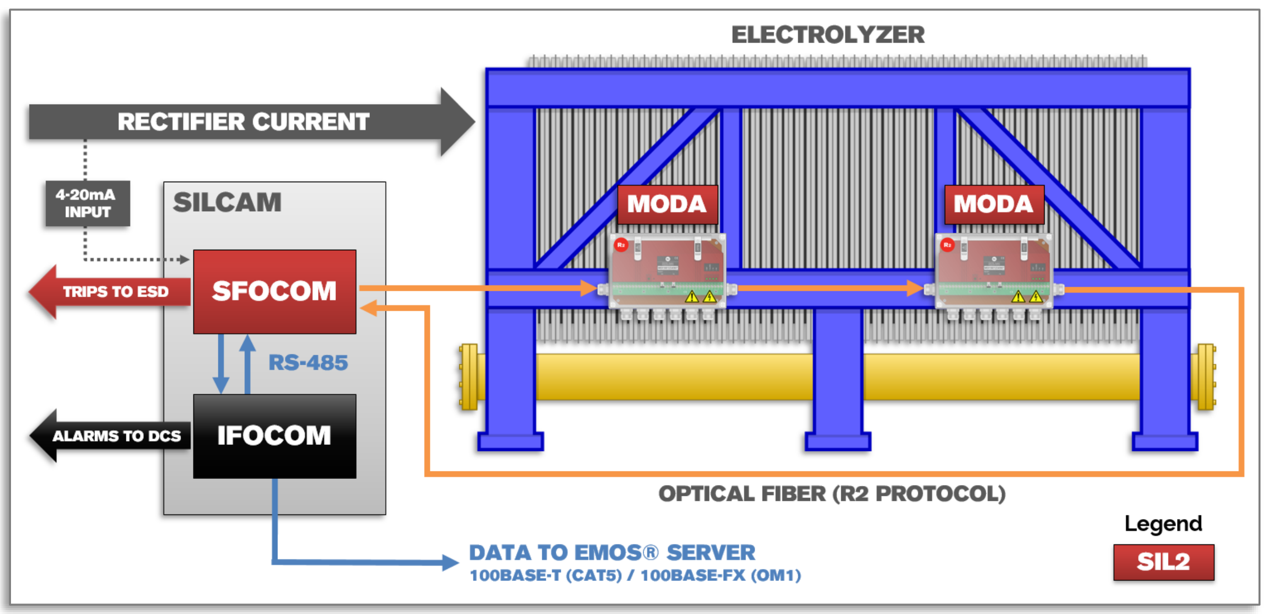

Figure 2: Computerization - EMOS® SIL2 Safety System

Stage 2: Connectivity

In order to meet the requirements for stage 2 of Industry 4.0, it is not sufficient that systems be computerized, but they must also be connected. This means that the various systems must be able to transmit their current status to each other, especially in cases where the input of a process depends on the output of another.

R2's EMOS® SIL2 Safety System satisfies this requirement by sending the process management data and alarms to the EMOS® server. From here, the data can be transmitted to historical servers and any other OPC-compliant system. The EMOS server can also receive real-time data from other OPC-compliant systems in order to include the values in its monitoring, advanced modeling, maintenance tracking, analysis, and advisory products.

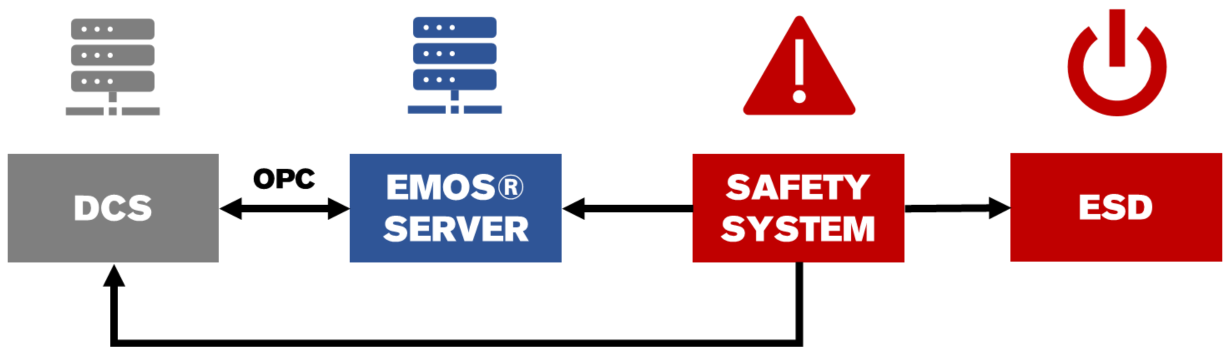

Figure 3: Connectivity

Stage 3: Visibility

Stage 3 consists in building upon the data gathered in the computerization and connectivity stages to obtain complete visibility of the process, thanks to end to end process data acquired in real-time (the so-called digital shadow). The data collected in this fashion can then be used to update real-time models and visualize historical trends.

For the chlor-alkali industry, R2's EMOS® View displays the real-time individual cell voltage data (and other process data obtained from the DCS) both numerically and graphically, with the help of bar graphs and trends. Alarms are color-coded by severity and clearly assigned to the appropriate equipment. Visibility can also be increased by maintaining a complete picture of which elements are installed where using the EMOS® Asset Management Database (AMD).

Stage 4: Transparency

For industry 4.0, it is not sufficient to have access to the data, but understanding must also be gleaned from the underlying patterns. While the visibility stage unveils the behavior of a process, the transparency stage helps explain the possible reasons for this behavior (e.g. repairs needed, alarms, performance issues.)

When knowing what is going wrong is simply not enough, the EMOS® Advisory system can help by providing probable causes and appropriate actions for all known process-related events that can occur in a chlor-alkali cell room, as most events can be modeled from the behavior of cell voltages. Transparency can also be applied to maintenance activities, using the asset tracking history provided by AMD, it is

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possible to determine if specific locations or equipment types require more frequent repairs or whether they are more prone to failure.

Stage 5: Predictability

The explanations obtained in the previous stage can be then be extrapolated to model patterns of behavior and help to predict future occurrences of those behaviors. Prediction models can greatly increase the time between identifying a potential issue and taking the appropriate action. These models can also facilitate the identification of re-occurring failures on specific component types or even entire systems. Breakdowns can be anticipated, encouraging proactive maintenance strategies.

The models that power the EMOS® Advisory system notify users of current problems and of upcoming events that are likely to occur if corrective actions are not taken. The predictability prowess of R2 products is not limited to the monitoring system, it is also included in the EMOS® Cell Performance Analysis (CPA) service which can help diagnose problematic components (e.g. anodes, cathodes, and membranes) that require maintenance or replacement. Using historical process data and asset tracking information, CPA facilitates the implementation of a predictive maintenance strategy, including an estimate of the potential savings that can be incurred by identifying which components need to be replaced.

Stage 6: Adaptability

The adaptability stage relies heavily on the outputs of the previous stages (the root cause analysis of events, and the anticipation of future events) in order to automate actions. Full completion of the adaptability stage is reached when process data is used to make the best decisions in the shortest time, without human intervention. Depending on the cost/benefit analysis, some chlor-alkali producers might decide to partially automate some processes rather than fully automate them.

R2 offers two products that fit in the adaptability stage: the SIL2 safety system trips, and EMOS® Advisory recommendations of corrective actions. First, the SIL2 safety system establishes at any given moment and in all operating regimes (startup up, normal operation, etc.) a range of acceptable voltages for each cell. If the individual cell voltage, as measured by R2 intelligent sensors, reaches a warning level, a yellow alarm is issued. If the voltage evolves towards more critical values, the electrolyzer will be immediately and automatically shut down (trip). The acceptable voltage range varies with the current and is based on 4 advanced algorithms (Figure 4), that prevent key incidents such as short circuits, membrane pinholes and leaking cells. More details can be found in the blog post “Going beyond HIHI voltage trips” (INSERT HYPERLINK).

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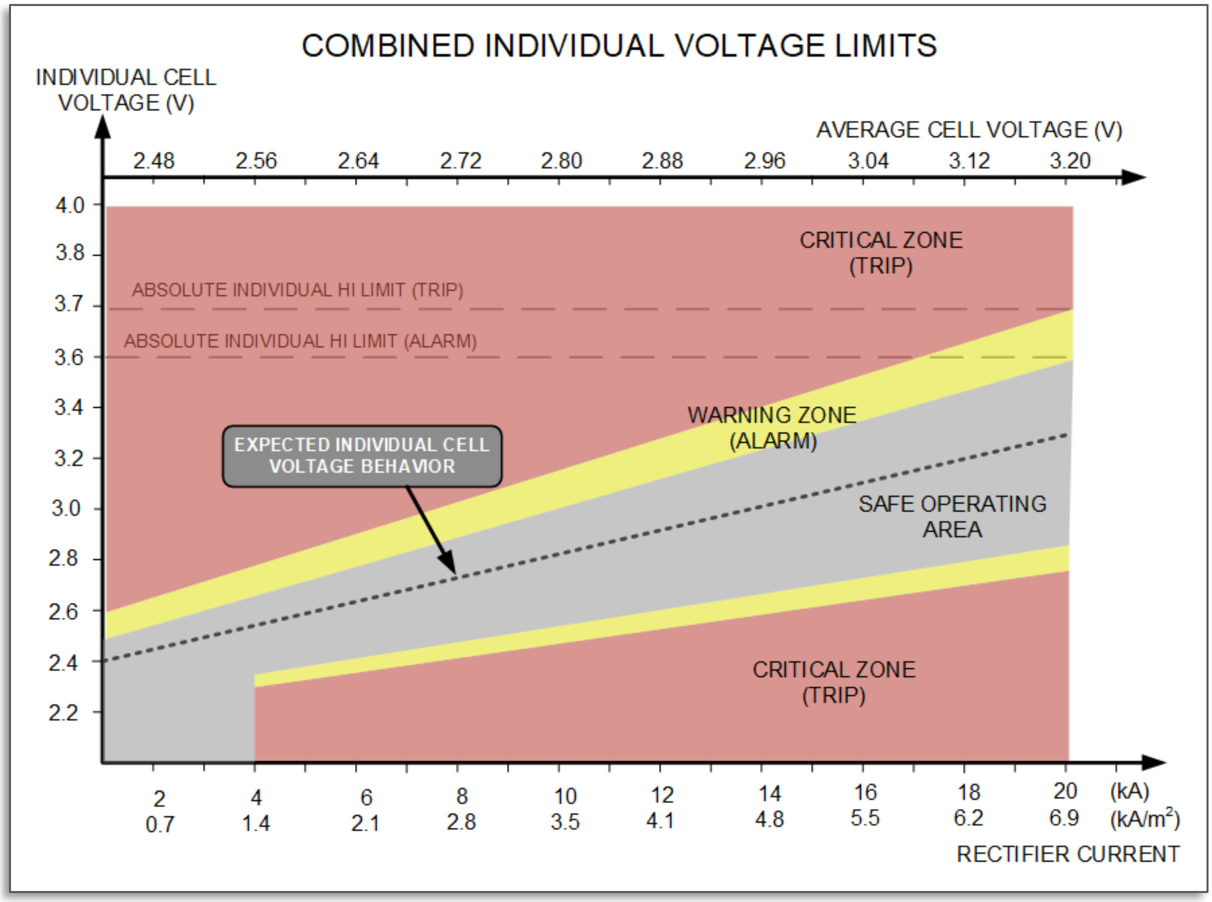

Figure 4: Combined individual voltages limits

Second, EMOS® Advisory, which has been discussed previously in stages 4 and 5, offers partial automation by providing, for each detected event, precise recommendations of corrective actions, of how to fix the event. It therefore decreases the number of steps for the operator to resolve the event from 5 to 3 (Figure 5), reducing unplanned shutdowns and diminishing human errors.

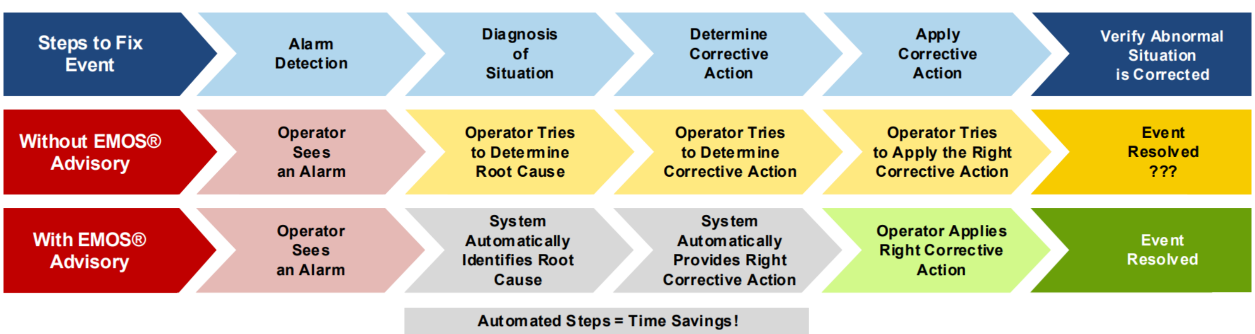

Figure 5: EMOS® Advisory Automatic Situation Diagnosis and Appropriate Corrective Action

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CONCLUSION

Though slightly different, Industry 4.0 and IIoT both relate to sweeping technological changes that affect chemical producers: digitalization, interconnectivity, automation, big data, machine learning, etc. The trends of Industry 4.0 and IIoT will bring significant business advantages to the chlor-alkali producers who successfully implement them: greater efficiency, better decision-making and greater plant safety. Chlor-alkali engineers and managers can map their cell-room evolution towards Industry 4.0 by using a convenient maturity index developed by acatech that outlines 6 maturity stages. R2 stands as a strong partner to accompany them in this transformation, as summarized in table 1.

Maturity stage	Stage description	How R2 can help
1. Computerization	Use digital interfaces to reduce repetitive manual interventions.	Automatic cell voltage monitoring with SIL2 safety system.
2. Connectivity	Transmit data to and from sensors, automatic systems, and servers.	SIL2 safety system transmits process data to the EMOS® server and receives data from DCS via OPC.
3. Visibility	Obtain complete end-to-end visibility of the process with real-time data.	EMOS® View displays real-time voltage data and alarms. EMOS® Asset Management Database (AMD) tracks asset locations.
4. Transparency	Analyze the collected data to explain behaviors.	EMOS® Advisory provides root causes of incidents. AMD helps diagnose if equipment types or locations require repairs more often.
5. Predictability	Use the observed behaviors to make predictions about the future.	EMOS® Advisory provides early detection of incidents. EMOS® Cell Performance Analyzer (CPA) offers predictive maintenance of membranes and electrodes.
6. Adaptability	Make automatic process adjustments based on modeled behaviors and predictions.	EMOS® Advisory partially automates response by recommending corrective action. SIL2 safety system automatically shuts down the electrolyzer in case of incidents.

Table 1: Industry 4.0 Maturity Index

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