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EMOS® - General Specifications (Sodium Chlorate)

EMOS®

Electrolyzer Management Optimization and Safety

General Specifications

(Sodium Chlorate)

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1. EXECUTIVE SUMMARY

The purpose of this document is to present R2's EMOS® product offering and provide customers with a comprehensive understanding of EMOS®' safety, maintenance and



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optimization capabilities. The document further describes details regarding the scope of work, supply and support for the successful deployment of the EMOS® System.

EMOS® (Electrolyzer **M**anagement, **O**ptimization and **S**afety) has a proven track record in many plants around the world with some of the World's largest electrochemical producers.

Significant operational and cost benefits can be achieved in production with the implementation of R2's EMOS® system and its associated utility and analysis tools, such as:

SAFETY:

- Maximized plant safety, prevention of incidents and incident related costs (explosions, fire, etc...) only possible through EMOS®' unique design giving an unparalleled ± 1.5 mV single element voltage measurement precision, and patented detection algorithms based on a complete HAZOP analysis of more than 30,000 elements worldwide.
- Single element security protection against element malfunctions or conditions causing irreversible damages through SIL-2 designed autonomous hardware trips and alarms.

MAINTENANCE:

- Early detection of potentially harmful process events to allow proactive maintenance and management procedures (feed blockage, short circuits, premature degradation of coating, etc...).
- Improved utilization rate through reduced occurrence of unplanned shutdowns (reduced downtime and production loss).



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OPTIMIZATION:

- Increased electrolyser component lifetime (electrode coating) and reduced energy costs.
- 3-5% energy savings can be achieved through optimization of influential process parameter set points.
- Reduce production costs when not at full load through performance based load distribution strategies.

The above benefits have been shown to have a significant impact on electrochemical operating costs. As an independent and neutral partner for the electrochemical industry, R2 is offering a complete suite of products and services to protect production equipment and significantly reduce operating costs, ultimately contributing to the company's profitability.



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2. EMOS® SAFETY PACKAGE

The EMOS® SAFETY package includes everything required to provide the plant with the highest level of safety available on the market. With stand-alone hardware (built to SIL-2 level as per IEC 61508 Functional safety of electrical/electronic/programmable electronic safety-related systems) and the EMOS® MONITORING software suite opening possibilities for maintenance management and process optimization, all the tools are there to care for present and future needs of the plant.

Through extensive research and development, R2 has integrated advanced detection algorithms into the stand alone SIL hardware to detect element malfunctions. There are no other systems providing equivalent functionality on the market.

The EMOS® SAFETY system is composed of three building blocks as described in the following sections.

2.1. MODA Assembly

The MODA assembly is composed of a MODA mother board along with a Terminal Fuse Plane (TFP). It is mounted directly on the electrolyzer inside a hermetic IP66 rated enclosure (optional ATEX enclosure available). By mounting the assembly as close as possible to the cells, voltage wire length and noise pickup is minimized for greater voltage measurement accuracy.

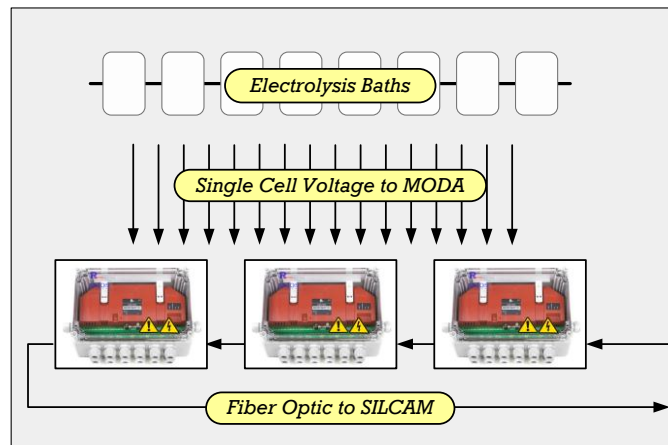


Figure 1 MODA to Electrolyzer

The TFP is used to connect individual cell voltage wires using standard terminal blocks. Each individual voltage input is protected by a fuse located on the TFP.



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Each MODA is composed of four isolated and independent analog modules, responsible for sampling eight individual cell voltages each, for a total of 32 inputs per MODA. Each analog module is equipped with special noise filtering algorithms that remove characteristic electrolyzer electrical noise in order to achieve the greatest possible accuracy.

The sampled data is sent to the SILCAM over an optical fiber link in order to preserve voltage isolation and noise immunity required in the harsh cell room environment.

The MODA is designed to SIL-2 and has built-in diagnostic capabilities to ensure that safety integrity is maintained during electrolyzer operation. The following are the general specifications for the MODA.

- $\pm 5\text{VDC}$ input range with a precision of $\pm 1.5\text{mV}$ over temperature range of -20°C to $+60^\circ\text{C}$.
- Designed expressly for the cell room environment.
- TÜV Certified to IEC 61010-1:2001 Safety requirements for electrical equipment for measurement, control and laboratory use: 600V CAT III, 1000V CAT II.
- Designed to SIL-2 as per IEC 61508 Functional safety of electrical/electronic/programmable electronic safety-related systems.
- ATEX compliant (Ex model) to IEC 60079-15:2007 non-sparking (nA), zone 2, class T1, explosion group IIC.

2.2. SILCAM Assembly

The SILCAM assembly is composed of the following elements, housed in a hermetic IP66 enclosure suitable for installation in the cell room or electrical room.

- Electrical Backplane
- One or more SFOCOM
- One IFOCOM



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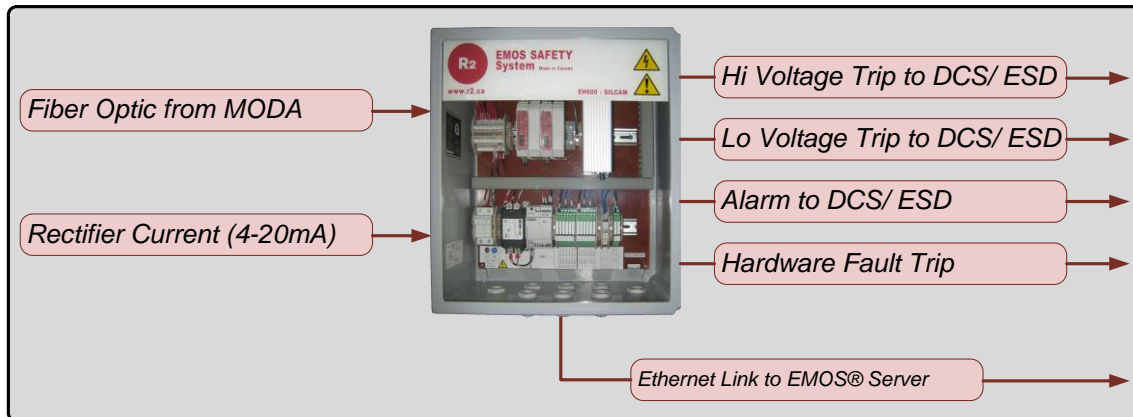


Figure 2 SILCAM Assembly

The Electrical Backplane is a standard DIN industrial control assembly that provides power supplies, interlock relays and electrical connections for the SFOCOM and IFOCOM.

The SFOCOM is the logic controller responsible for triggering the plant emergency shutdown system in case the electrolyzer or one of its cells is operated outside its safe operating area. It communicates with the MODA to gather the single cell voltage measurements. Designed to SIL-2 and using unique patented detection algorithms based on the analysis of more than 30,000 elements, the SFOCOM provides separate dry contacts to indicate if an abnormal low or high voltage condition is found in any of the electrolyzer cells, preventing irreversible cell damage and increasing overall plant safety.

The user has the flexibility to use these dry contacts in accordance with plant procedures. They can be connected to the plant Emergency Shutdown System (ESD) for immediate action or to the DCS where different alarm and trip management logic can be implemented.

The IFOCOM is used to establish the communication between the SIL part of the system (SFOCOM and MODA) and the EMOS® server. The IFOCOM communicates over Ethernet on standard copper or optical fiber networks.

- Configurable for one or two electrolyzers.
- 120/240VAC 50/60Hz input power supply.
- One 4-20mA input per electrolyzer for electrolyzer current acquisition.
- One HIHI, one LOLO, one ALARM and one HARDWARE FAULT dry contact per electrolyzer for emergency shutdown control.



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- 10/100BASE-T or 100BASE-FX Ethernet communication to the EMOS® PC Server.
- TÜV Certified to IEC 61010-1:2001 Safety requirements for electrical equipment for measurement, control and laboratory use: 600V CAT III, 1000V CAT II (pending).
- SFOCOM Designed to SIL-2 as per IEC 61508 Functional safety of electrical/electronic/programmable electronic safety-related systems.

2.3. EMOS® MONITORING

EMOS® MONITORING is a software package designed for the monitoring and management of process data obtained from the EMOS® voltage monitoring system, or any other OPC compliant application equipment. It offers a completely configurable user interface for customized monitoring of plant operations, reporting tools for alarms and cell voltages, and includes a graphical interface for trending and easy analysis of individual or grouped elements.

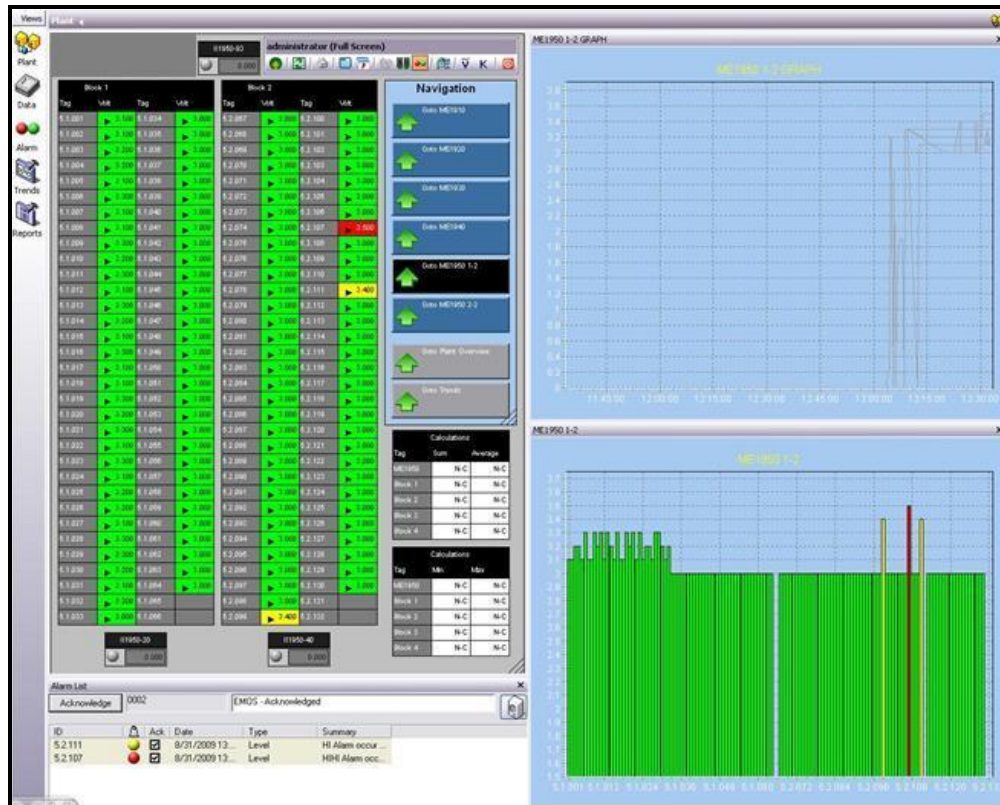


Figure 3 EMOS® MONITORING Screenshot



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The EMOS® MONITORING basic package provides license for one server workstation and one remote workstation for the plant operators. The software package comes equipped with the following:

- Data access server.
- Alarm and event server.
- Historian data access server.
- Operator view with licences to operate on the server and on one remote workstation.
- Pre-processing capability to provide calculated tags such as normalized voltages, k-factor, average, and sum calculation for each electrolyser.
- Dynamic Gateway tool for OPC connectivity (see Sec. 2.3.1)

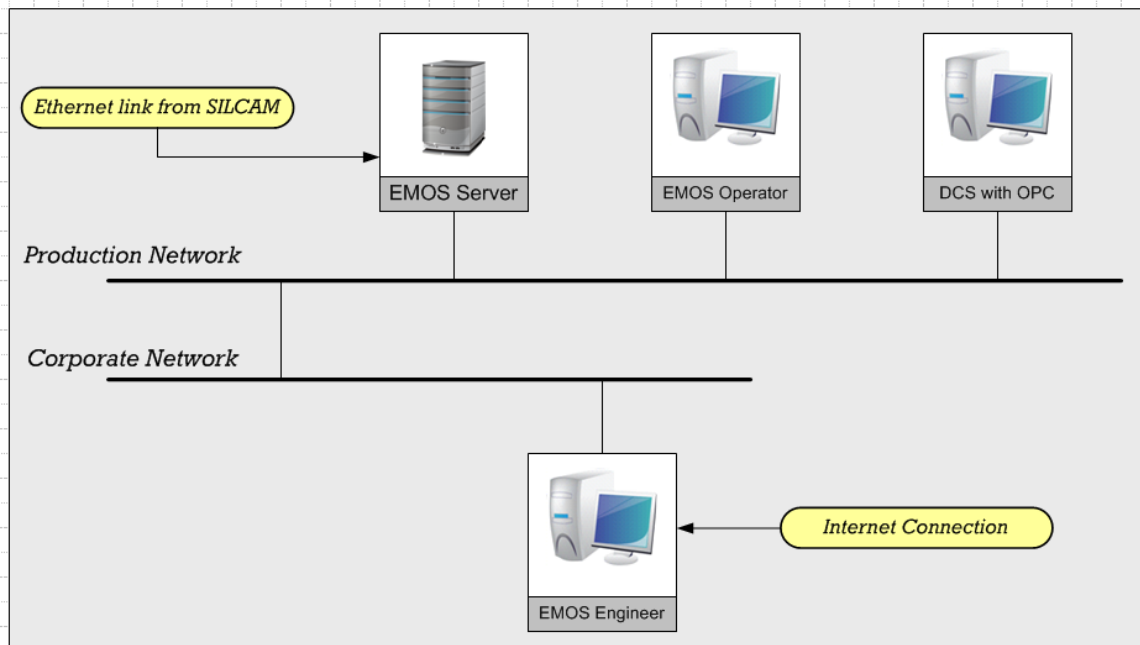


Figure 4 Typical Plant Network Configuration

In addition, together with the voltage monitoring hardware, EMOS® MONITORING provides the user with all the required tools to operate the plant electrolyzers safely while reducing operational costs. As mentioned above, the following unique functionalities are included in the EMOS® MONITORING software package.



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2.3.1. Dynamic Gateway for OPC Connectivity

The Dynamic Gateway enables the transfer of relevant process data between the DCS and EMOS® MONITORING via OPC standard. By providing access of peripheral process parameters to EMOS® MONITORING, additional performance analyses can be performed in order to improve maintenance planning and optimize energy consumption.



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3. ADDITIONAL PACKAGES

3.1. Operator Workstation Package

The Operator Workstation Package provides the plant with a supplementary remote client licence for full access to EMOS® MONITORING (see Sec.2.3) from another PC within the network. Multiple floating licenses can be purchased to provide simultaneous access rights through multiple machines within the network.

3.2. Engineering Workstation Package

The Engineering Workstation is a supplementary remote client licence for full access to EMOS® MONITORING (see Sec 2.3) as well as the addition of the EMOS® VISUAL EXTRACTOR software. VISUAL EXTRACTOR enables the user to easily access data from the EMOS® database for further analysis within three (3) graphical interfaces provided, or to export specified data sets in other industry standard output formats.



Figure 5 VISUAL EXTRACTOR screenshot



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3.3. EMOS® Asset Management Database

This specialized software is designed to store, track, and manage all relevant cell component information (coating type, batches, location in plant, service history, etc). It allows the user to build, commission, and decommission cell assemblies with an easy drag-and-drop functionality. It can also collect, store, and correlate cell specific lab data analysis and maintenance information, and is fully configurable.

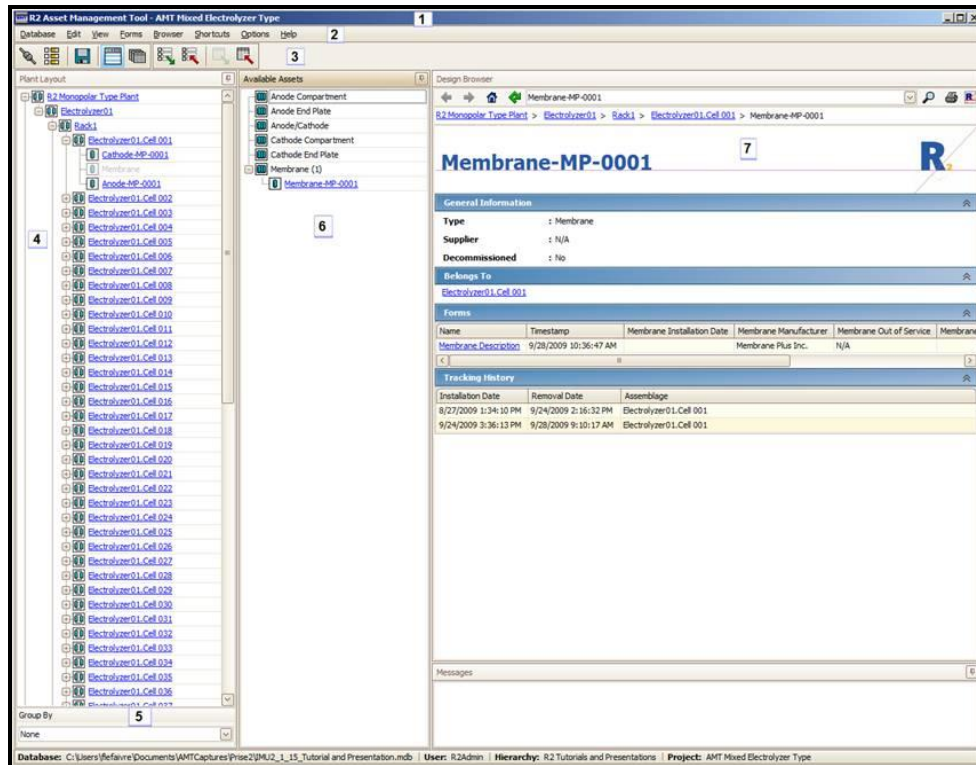


Figure 6 AMT Component Database screenshot



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4. SCOPE OF WORK AND SUPPLY

R2's scope of work and supply is flexible in order to accommodate each customer's standard work procedure. Upon demand, R2 can provide turnkey system installation.

4.1. Scope of Supply

The standard scope of supply is as follows.

#	Items	Description	R2	Customer
1	Integrated MODA assembly	Data Acquisition unit (32 readings) complete with enclosure	X	
2	SILCAM assembly	Electrolyzer Communication and Alarm Module with enclosure	X	
3	Emergency shutdown	Trip/Interlock dry contact (integrated within the SILCAM)	X	
4	EMOS® MONITORING	Basic Software Package	X	
5	4-20mA current signal	From rectifier shunt to the SILCAM		TBD
6	R2 Bus / Ethernet optical network	Fiber optic cable (62.5/125)		
7	R2 Bus / Ethernet optical network	Fiber optic connectors (ST type)		
8	EMOS® Server computer	Standard PC Server		
9	EMOS® Server computer	Operating system		
10	EMOS® Client computer	Standard PC Client		
11	EMOS® Client computer	Operating system		
12	Ethernet optical switch	100BASE-FX (100Mb)		
13	Voltage wires	NSGAFOU		
14	Wire identification markers			
15	Wire lugs			

Table 1: Scope of Supply



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4.2. Scope of Work

The standard scope of work is as follows.

Step	Description	R2	Customer
1	Installation of all enclosures (MODA & SILCAM)		X
2	Installation and identification of voltage wires and lugs		X
3	Installation and testing of fiber optic cables/network		X
4	Installation of server and clients, including OS configuration		X
5	LAN configuration		X
6	Configuration of OPC link on DCS side		X
7	Supply of secure remote access to EMOS® Server via internet		X
8	Installation of MODA mother boards	X	
9	EMOS® Software installation and configuration	X	
10	MODA – SILCAM – Server communication tests	X	
11	System start-up and data integrity check	X	
12	Configuration adjustments (if applicable)	X	
13	Configuration of OPC link on EMOS® side	X	
14	Supply of WebEx access	X	
15	Basic EMOS® training	X	
16	Advanced EMOS® training	X	

Table 2: Scope of Work



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5. ENGINEERING

5.1. Project Management

Project management is included as part of any R2 product package. This includes project plans, schedules and milestones. To simplify communications between the customer and R2, a unique point of contact is assigned for the duration of the project.

5.2. Customized Plant View

Custom software display tailored to the plant topology is included with all software packages in order to provide the operators and engineers with an intuitive user interface.

5.3. Documents & Drawings

The Basic Safety Package includes the following documentation and drawings. System electrical drawings are drafted using customer naming convention.

- System block diagram.
- Cell room equipment layout.
- Wiring diagrams, MODA to electrolyzer.
- SILCAM wiring diagrams.
- MODA and SILCAM user manuals.
- Software CD, user and reference manuals.



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6. ON-SITE WORK AND SYSTEM COMMISSIONING

6.1. Activities

For the initial commissioning activities, R2 will send two field specialists onsite to verify the pre-commissioning work completed by the customer and execute the following specialized tasks:

- Install and configure the software.
- Establish communication between EMOS® Server and Client(s).
- Test the configuration.
- Establish communication with DCS through the OPC link.
- Activate the licenses.
- Calibration and test of all electronic units (MODA, IFOCOM, SFOCOM);
- Test of hardwired signals to DCS / ESD;

Once all these tasks are completed, R2 will be ready for electrolyzer polarization current. When the initial polarisation current is applied, R2's field specialist will do final verifications to the MODA terminals. After these verifications, he will install the MODA in its enclosure and give the go ahead to switch to the main rectifier to bring the electrolyzer under load.

6.2. Start-up Expertise

Once the first electrolyser has been powered and appropriate training has been given (see section 6.3), only one field specialist is required to stay onsite for the remaining of the start-up (until all electrolysers have reached at least 50% of the full load). During that time, the field specialist will start-up remaining electrolyser lines, verify system integrity and stability.



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6.3. Training

As part of the basic package, R2 offers training sessions on system maintenance, operation and administration. These trainings should be given only after EMOS® and at least one electrolyser have been started so that the personnel can learn on a live system.

6.3.1. Maintenance Training

- Usually given to plant electrical & instrumentation personnel.
- Contains information on troubleshooting the system in case of failure.
- Up to 5 or 6 people can be trained in one class.
- Class duration is about 4h (2h in class and 2h in field).

6.3.2. Operator Training

- Usually given to plant operators and system administrators.
- Contains information on how to operate the EMOS® MONITORING software.
- Up to 4 or 5 people can be trained in one class.
- Class duration is about 2h.

6.3.3. Administrator Training

- Usually given to the person(s) responsible for the EMOS® system (electrochemist, process engineer).
- Contains information on advanced features such as data back-ups, alarm set-points, plant view modifications.
- 1 or 2 people can be trained in one class.
- Class duration is about 3h.



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7. SUPPORT

R2 provides its customers with different support options so they can choose the level that suits their needs.

7.1. Software Support Contract

After the initial warranty period following installation, if an annual EMOS® Support & Maintenance Agreement is purchased, it will entitle the customer to receive free software updates and the support from our technical help desk. Prior to the termination of the standard warranty and support period, an R2 representative will contact the end user in order to discuss the desired agreement.

7.2. Hardware Support Contract

For customers who desire to maintain the hardware integrity to SIL specifications R2 offers a Hardware Support Contract. This contract will specify the yearly inspection work to be done on-site along with a fixed, pre-determined rate. R2 will give priority to the customer in order to be on-site during their annual shutdown.



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8. OPTIMIZATION PRODUCTS & SERVICES

R2 also offers a wide range of products and services to help customers operate their process as efficiently as possible. The following are some of the products and services currently available; however, the customer is invited to contact R2 for more information on these as well as new product developments or to arrange a technical presentation.

8.1. EMOS® Early Detection Engine

The Early Detection Engine (EDE) will detect any and all possible events that can occur within an electrolyser cell. It offers protection against economic risks to avoid dramatic irreversible damage to cell components.

Using previously recorded process data as well as CPR performance data, R2 will generate individual models for every cell within the plant. These models will then be deployed within EMOS® MONITORING in real-time to compare the real voltages against the predicted values; anomalies can then be detected as early as possible. Operators are informed of detected abnormal behaviour through notification alarms in EMOS® MONITORING so that appropriate action can be taken to avoid irreversible damage cell components.