CONCERNED ABOUT SAFETY? WE R2

R2

MORE
THAN JUST
MONITORING

PERFORMANCE? YES, BUT WHAT ABOUT SAFETY?

Over the years, chlor-alkali cell operation has changed dramatically: plant capacities have increased significantly, current density has more than doubled and electrode gaps are down to zero. Meanwhile, intrinsic safety measures have seen no such dramatic improvements.

Protection against: explosions, chemical releases, and accidental performance losses in the cell room is still today mainly in the hands of the plant operators. The entire focus of new cell technologies has been placed on improved production and power consumption creating high performance but sensitive machines.

It is with this concern in mind, namely to minimize the growing gap between new production technologies and safety standards, that R2 is innovating once again with the introduction of the EMOS® SIL2 Safety System, the only electrolyser safety system available with a SIL2 rating.

The EMOS® SIL2 Safety System: The 3 building blocks

IT'S ALL ABOUT PRECISION

1 THE MODA

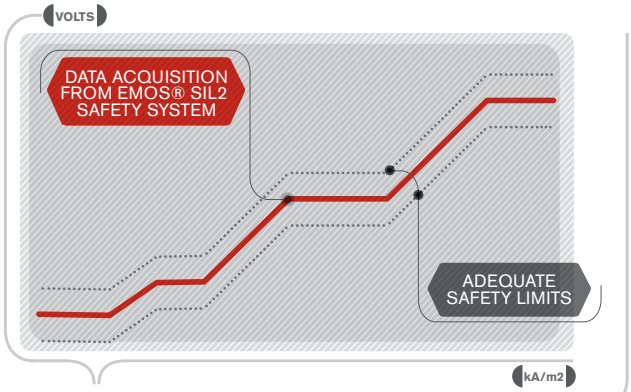
Intelligent data acquisition sensor

Designed expressly for the cell room environment, the MODA incorporates sampling algorithms that synchronize with the fundamental rectifier frequency, removing any unwanted noise. This synchronization provides faster data acquisition when compared to standard filtering and averaging techniques. Without this advanced filtering, overall precision would be reduced by several millivolts. The MODA is designed to be installed directly on the electrolyser, minimizing wire length, reducing noise pickup, and increasing precision. Most off-the-shelf data acquisition components advertise precision, omitting the temperature drift which can exceed ±20 mV. Our thermally compensated MODAs offer an unparalleled precision, within ±1.5 mV over the practical operating temperature range found in cell rooms.

No Compromise on Safety and No False Trips

Precision, accuracy, and speed of data acquisition are crucial elements in safeguarding your cell-house personnel and protecting your investment. In order to avoid costly production losses caused by false trips, buffers are usually added to trip limits in order to compensate for inaccurate readings. Fortunately, there is no need to compromise between safety and production anymore. R2's system provides reliable data, enabling you to set realistic limits with NO FALSE TRIPS. Why settle for imprecise measurements when the higher level of accuracy provided by R2 can help save lives, time, and money. R2 provides Safety and Uninterrupted Production.

EMOS® SIL2 Safety System



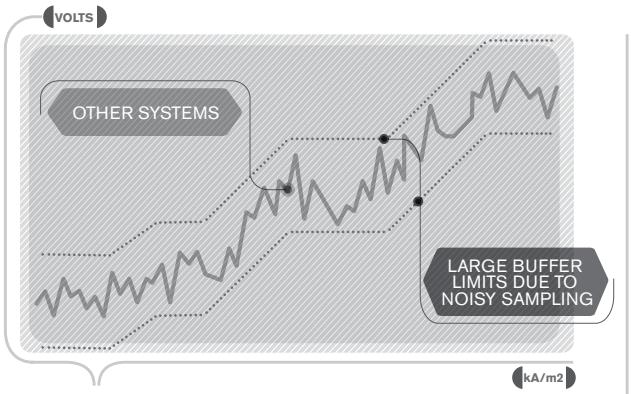
The necessity of precision

Increase Reaction Time: Early detection of certain hazards is only possible with a high level of precision. For example, early detection of injector blockage is observed in a change of cell behavior within a range of about 20mV. A precise reading provides time to perform corrective action before build-up accumulates to the point of no-return resulting in the emergency shutdown of an electrolyser.

Reduce Risks: It is sometimes necessary to operate with higher voltage values until the next planned maintenance because of prematurely degraded elements. With a precise reading, a realistic trip limit can be set without putting the plant at risk.

Increase Savings: Precise individual voltage readings result in substancial savings by making selective maintenance possible. The individual voltage reading is the ONLY, on-line, direct indication of a cell's condition.

Other systems



WHY SIL2?

While monitoring over 35,000 elements in plants around the world, R2 was able to conduct an extensive Hazop Study. This study concluded that, in order to provide complete electrolyser protection with a very low possibility of failure, SIL2 is necessary.

The EMOS® SIL2 Safety System includes everything required to provide your plant with the highest level of safety available on the market.

Identifier	Undesired Event	Consequence	Frequency	Risk Class
UE-1	Anode loss of coating	S2	P2	C
UE-2	Cathode loss of coating	S2	P2	C
UE-3	Cathode poisoning			
UE-4	Electrode passivation			
UE-5	Membrane poisoning			
UE-6	Insufficient electrolyte feed			
UE-7	Cell temperature control fails			
UE-8	Electrolyte concentration control			
UE-9	Differential pressure out of range			
UE-10	Leaking cells			
UE-11	Membrane pinholes, tears and blisters	S2	P2	C
UE-12	Short circuit	S2	P2	C

Table 5 Risk Analysis

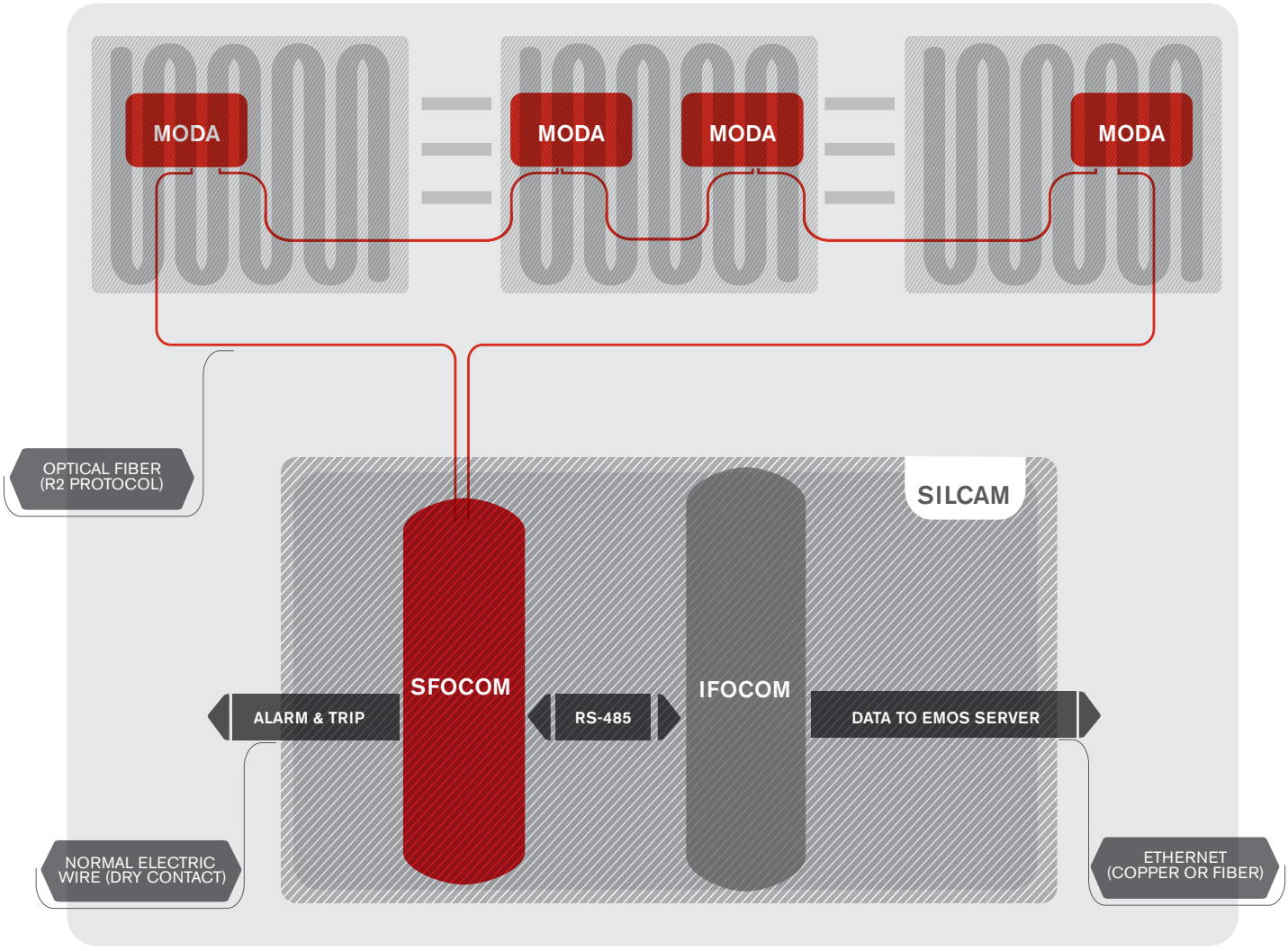
Frequency	Consequence S1
P0	A
P1	A/B
P2	B
P3	C
P4	E

Table 4 Risk Matrix

Category	Injury to personel Criteria
S1	Fatalities
S2	Serious injuries, irreversible
S3	Injuries, reversible
S4	Minor injuries, no lost time

Table 3 Consequences

EMOS® SIL2 Safety System Architecture



IT'S ALL ABOUT SAFETY AND INTELLIGENCE

2 THE SFOCOM
Logic solver

The SFOCOM is the logic controller responsible for triggering the plant emergency shutdown system in case an electrolyser or one of its cells is operating outside of its safe zone. It communicates with the MODA to gather the single cell voltage measurements. Designed according to SIL2 and using unique patented detection algorithms, the SFOCOM provides separate dry contacts to indicate if an abnormal low or high voltage condition is detected in any of the electrolyser cells, preventing irreversible cell damage and increasing overall plant safety. Additionally, through system self diagnostics, the SFOCOM features a third dry contact to signal the DCS that preventive maintenance is required in the SIL2 system. 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 control logics can be implemented.

3 THE EMOS® SIL2 SAFETY ALGORITHMS
Event detection

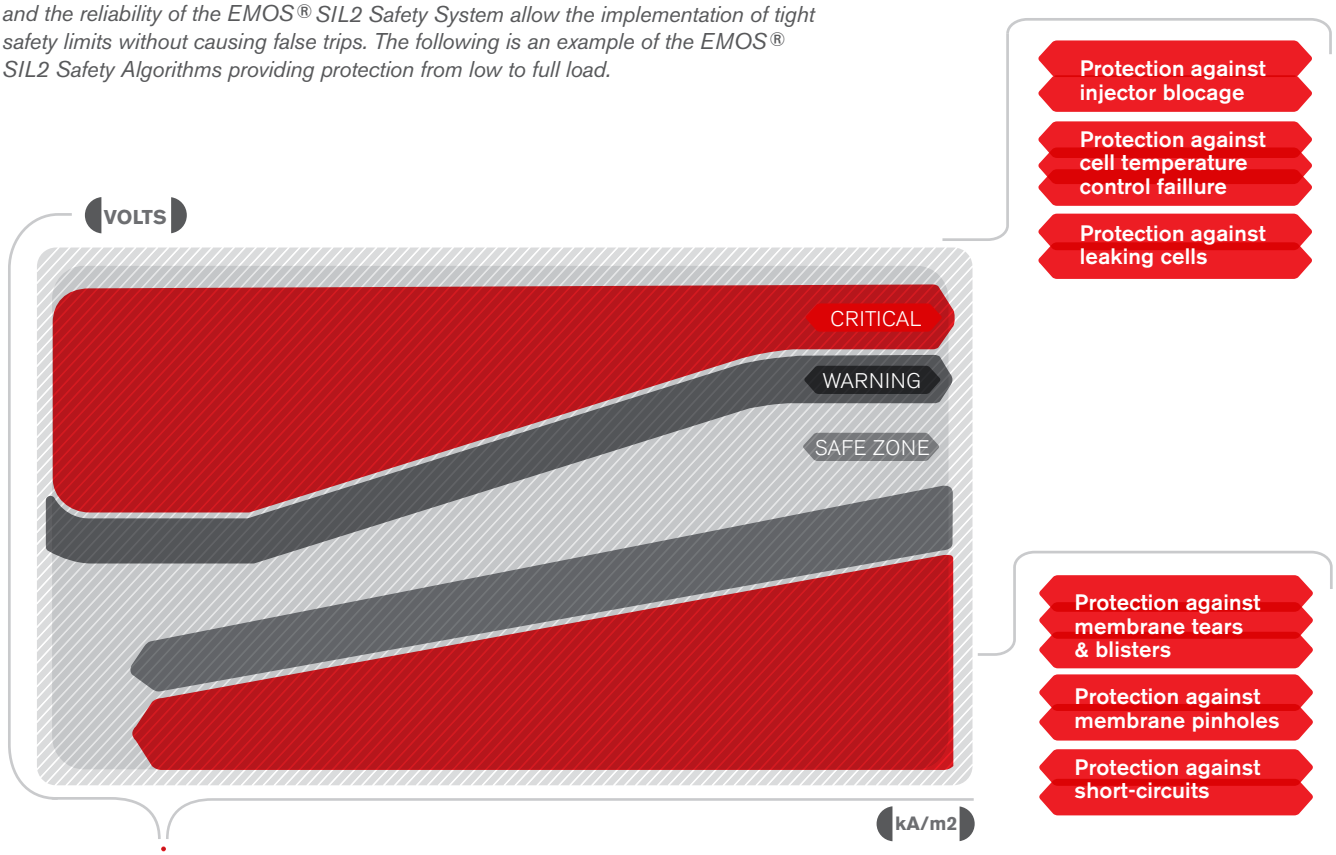
Through extensive research and development, learned from the monitoring of more than 35,000 cells over the course of several years, R2 has developed and integrated advanced detection algorithms into the stand-alone EMOS® SIL2 hardware to detect all known single element malfunctions or conditions causing irreversible damage such as:

- *Anode coating loss*
- *Cathode coating loss*
- *Electrode passivation*
- *Membrane poisoning*
- *Insufficient electrolyte feed*
- *Cell temperature control failure*
- *Electrolyte concentration control failure*
- *Differential pressure out of range*
- *Leaking cells*
- *Membrane pinholes, tears and blisters*
- *Short circuits*

UNIQUE KNOWLEDGE AND EXPERTISE

The Algorithms

With fixed alarm levels, the electrolyser is only adequately protected at full load. For all other cases, the difference between the cell voltage and the alarm level may result in cell damage before the electrolyser is shutdown. The precision of measurement and the reliability of the EMOS® SIL2 Safety System allow the implementation of tight safety limits without causing false trips. The following is an example of the EMOS® SIL2 Safety Algorithms providing protection from low to full load.



EMOS® SIL2 hardware LO or LOLO alarm

The calculation is disabled below a certain rectifier level. If one of the individual voltages is below the calculated Warning or Critical Level (LO or LOLO), an alarm or trip will be triggered. The detection level is modulated with the electrolyser load for increased protection.

EMOS® SIL2 hardware thermal HI or HIHI alarm

There is a maximum amount of heat a cell can withstand. The Thermal Individual HI Algorithm calculates a HI and HIHI thermal alarm for individual cell heat dissipation as a function of the electrolyser load. This provides adequate protection at any range of operation, not only at maximum load.

EMOS® SIL2 hardware absolute HI alarm

As a last line of protection, there is the traditional absolute HI alarm. If any of the cells go higher than the HI or HIHI level, an alarm or trip will be triggered to protect the cell.

EMOS® SIL2 hardware normalized global HI/HIHI alarm

The EMOS® SIL2 Safety System also provides protection in the following situation: what if all cell voltages increase simultaneously? This could be an indication of a major problem (i.e. membrane contamination, cathode poisoning, electrolyte concentration control failling, etc). To prevent such a situation, there is an alarm set on the Global HI voltage (normalized as a function of the current density).

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