

The Alkaline Aluminium Hydrogen Peroxide Semi-Fuel Cell for the Hugin 3000 Autonomous Underwater Vehicle

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HUGIN 3000 is an AUV for deep sea survey operations.

Displacement:	2.4m³
Velocity:	2.1 m/s (4 knots)
Max depth:	3000m (10000 feet)
Main sensor:	Multibeam echosounder
Typical operation:	120 feet above seabed, constant velocity.

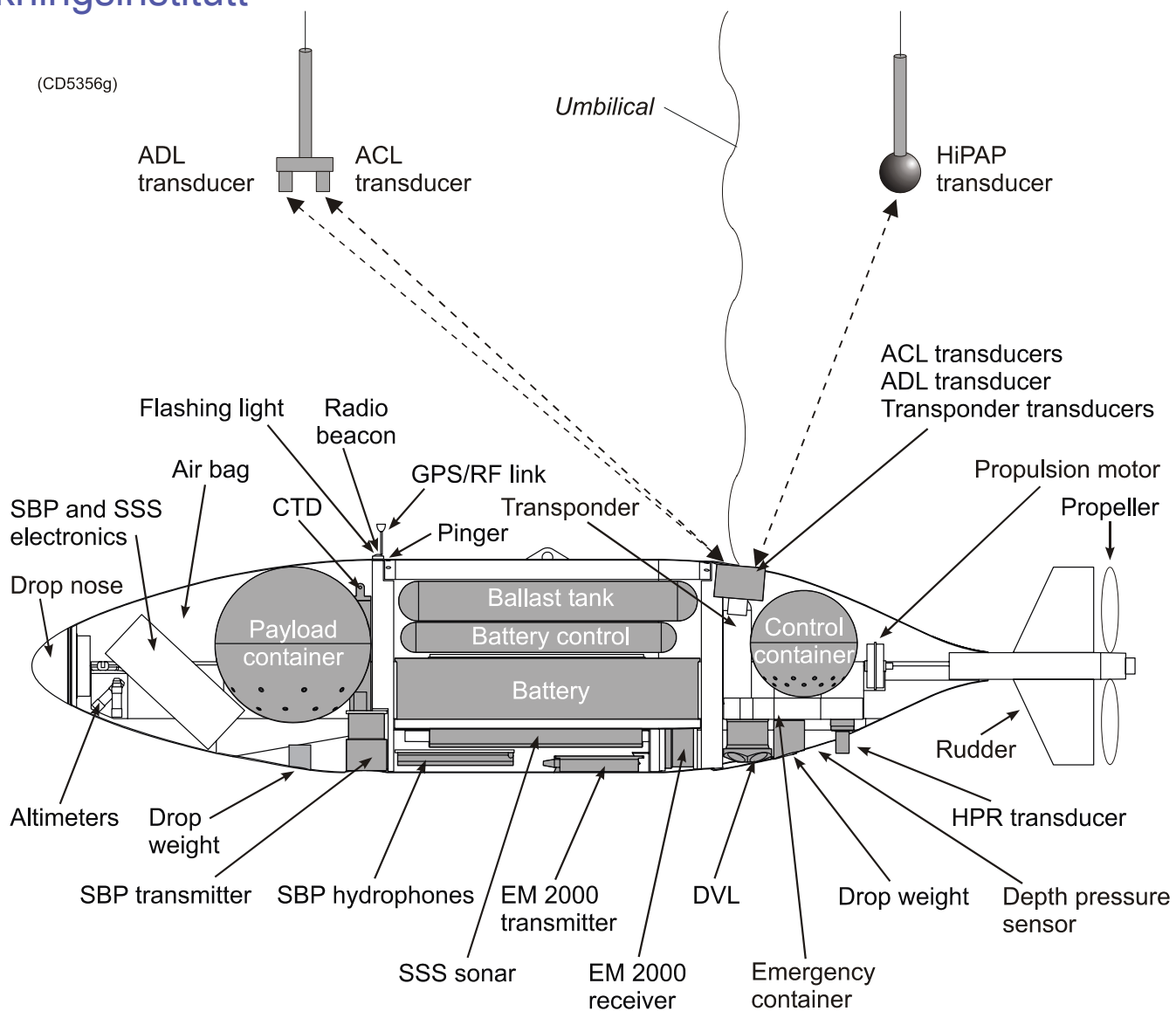


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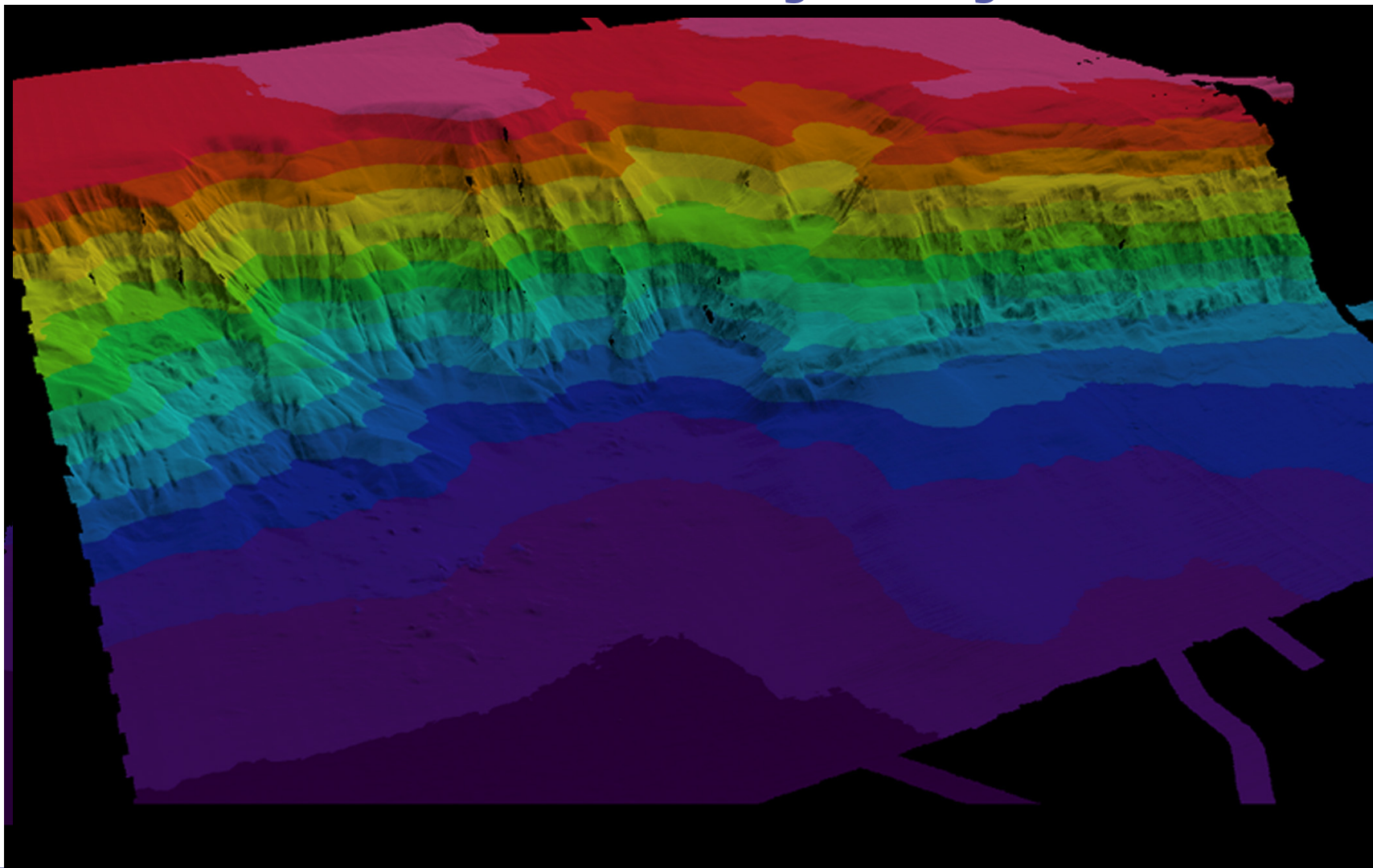
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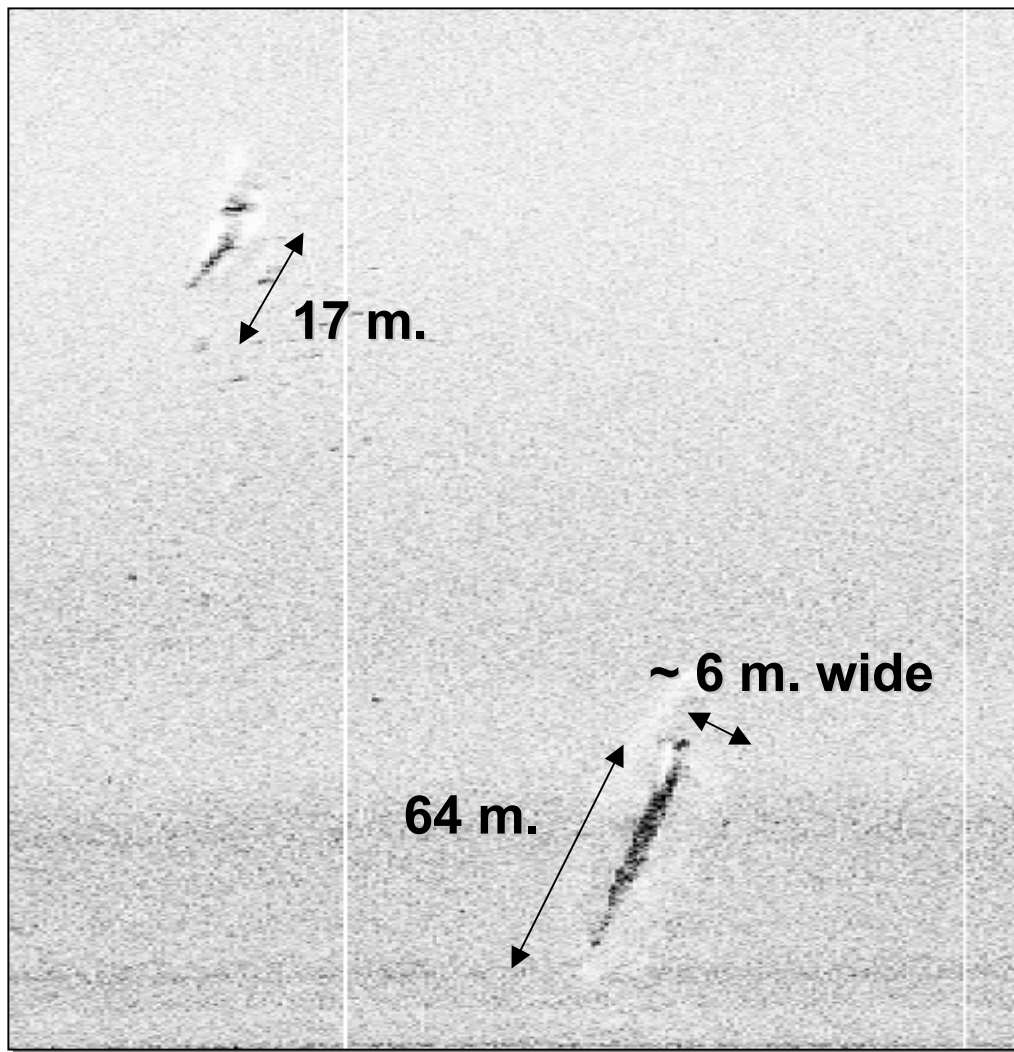
Sigsbee Escarpment - Swath Bathymetry





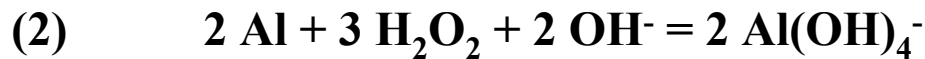
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Sonar Contacts Nos. 2 and 3 – a U-boat?

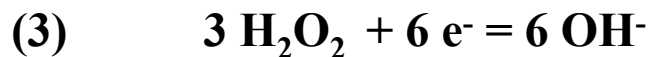


Cell Chemistry

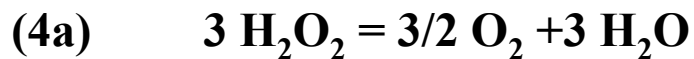
The overall cell reaction in the alkaline Al/HP cell is:



Whether HP is reduced directly at the cathode according to:



or is decomposed at the cathode surface or in the electrolyte according to



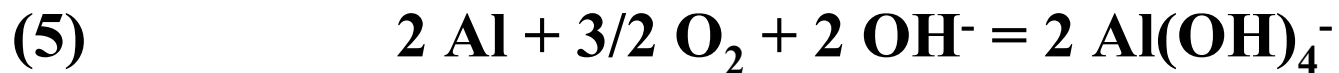
followed by reduction of oxygen:



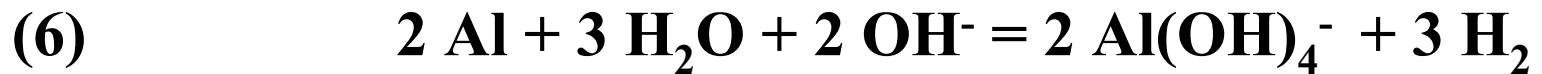
does not affect the overall cell reaction.

Corrosion:

Loss of reactants through the direct reaction with oxidant



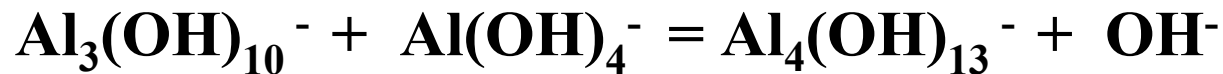
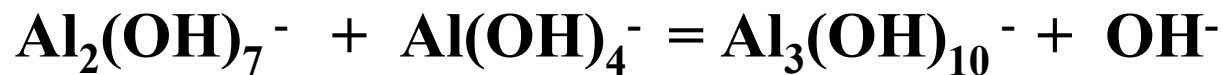
Loss of aluminium through reaction with water:



Precipitation of aluminiumhydroxide:



is a multi-step process:



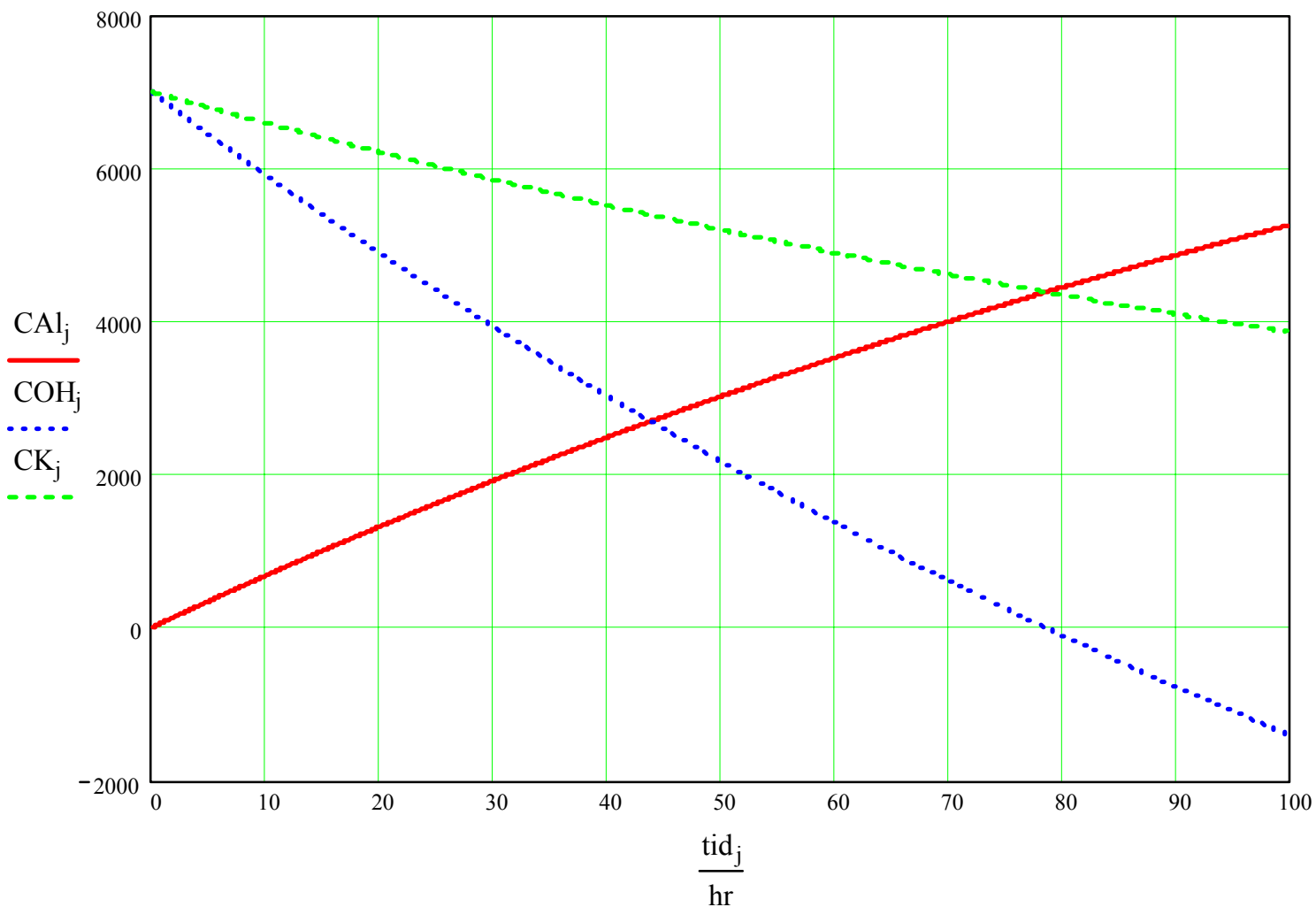
etc.

HUGIN 3000 operates with clear electrolyte, the discharge is terminated when $[\text{Al}^{+++}]$ exceeds ca 3M .



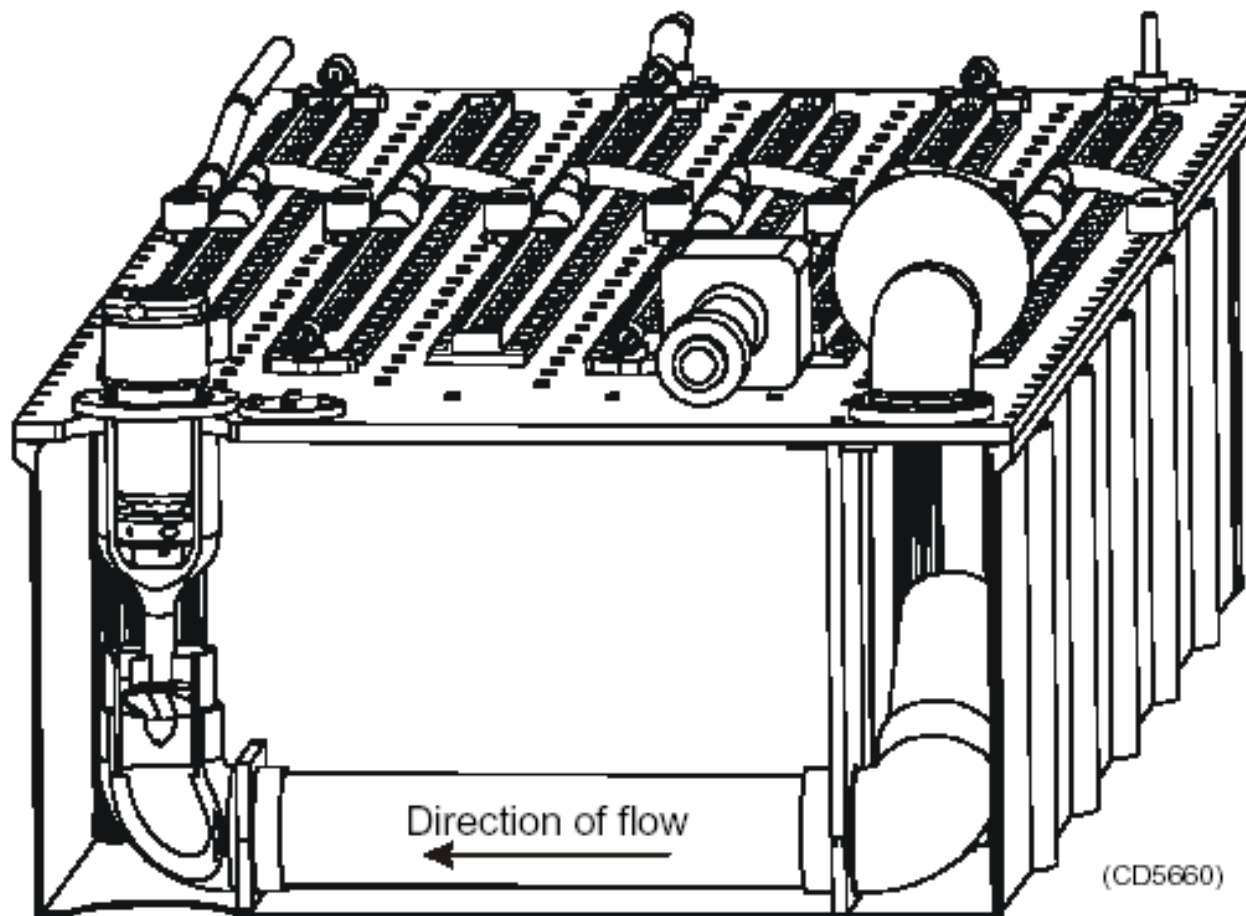
HUGIN 3000, system load 1.0 kW

Concentration (mol/m³) of aluminium, hydroxyl and potassium versus time in hours



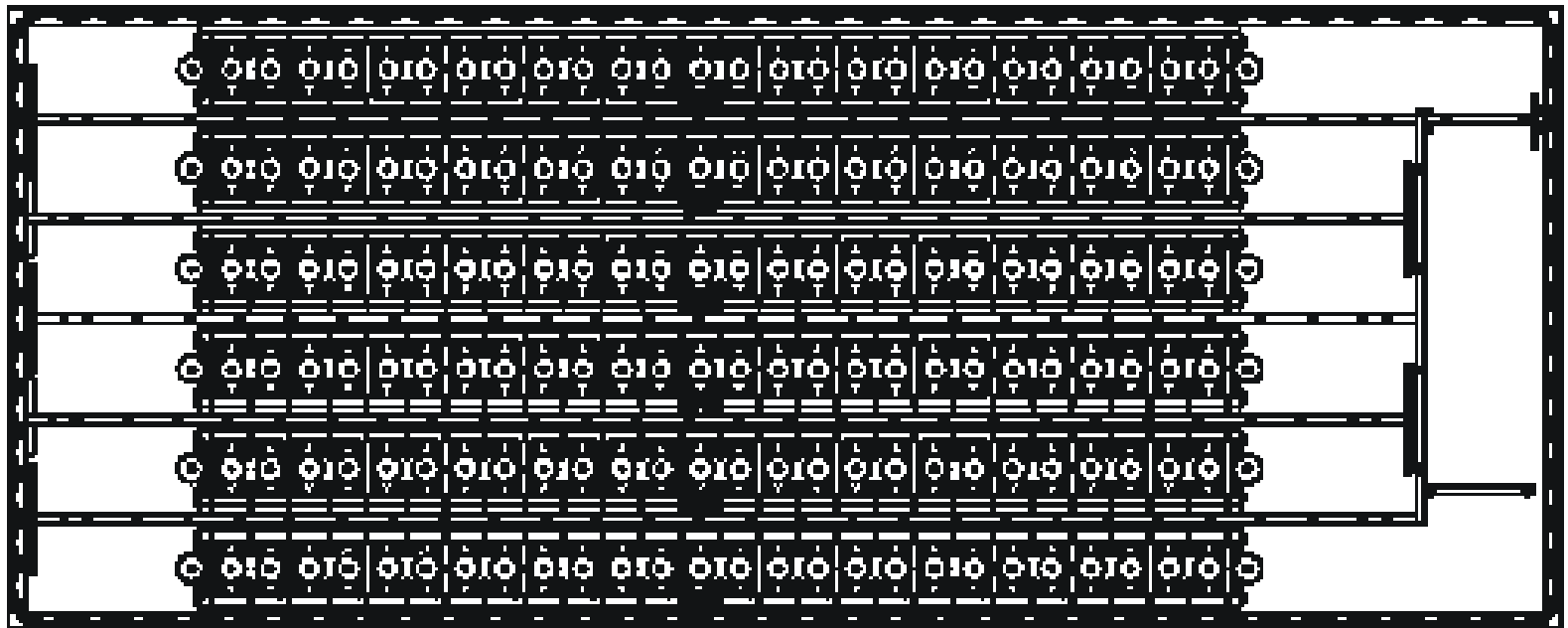
The Al –HP power source is composed of:

- Battery box with 6 serially connected cells
- Gas ventilation system
- Electrolyte circulation system (serial flow)
- Two HP storage bags
- HP dosing pumps
- Battery control electronics
- DC/DC converter
- NiCd buffer battery (21 F-cells NiCd of 7Ah)

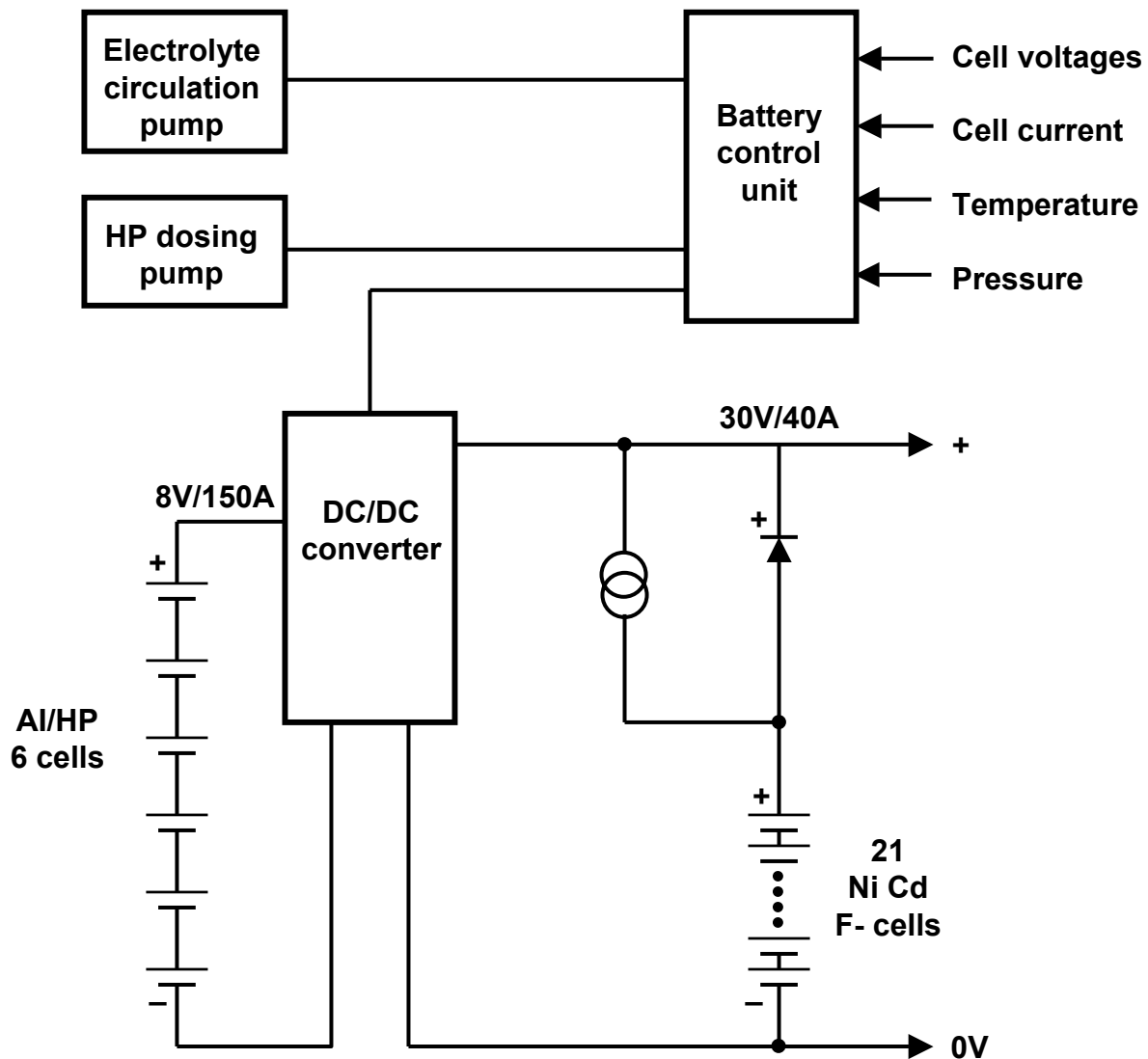




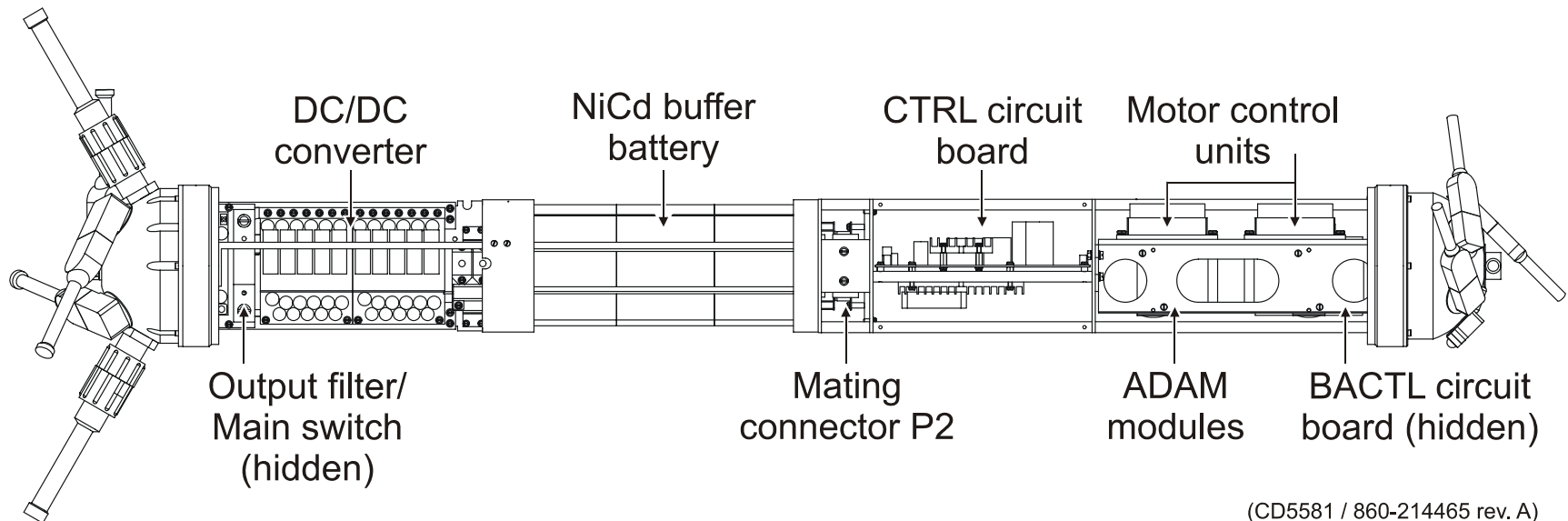
Top view of battery case.
(Serial flow and serial connection of cells)



(CD5656)



Battery control and buffer battery container



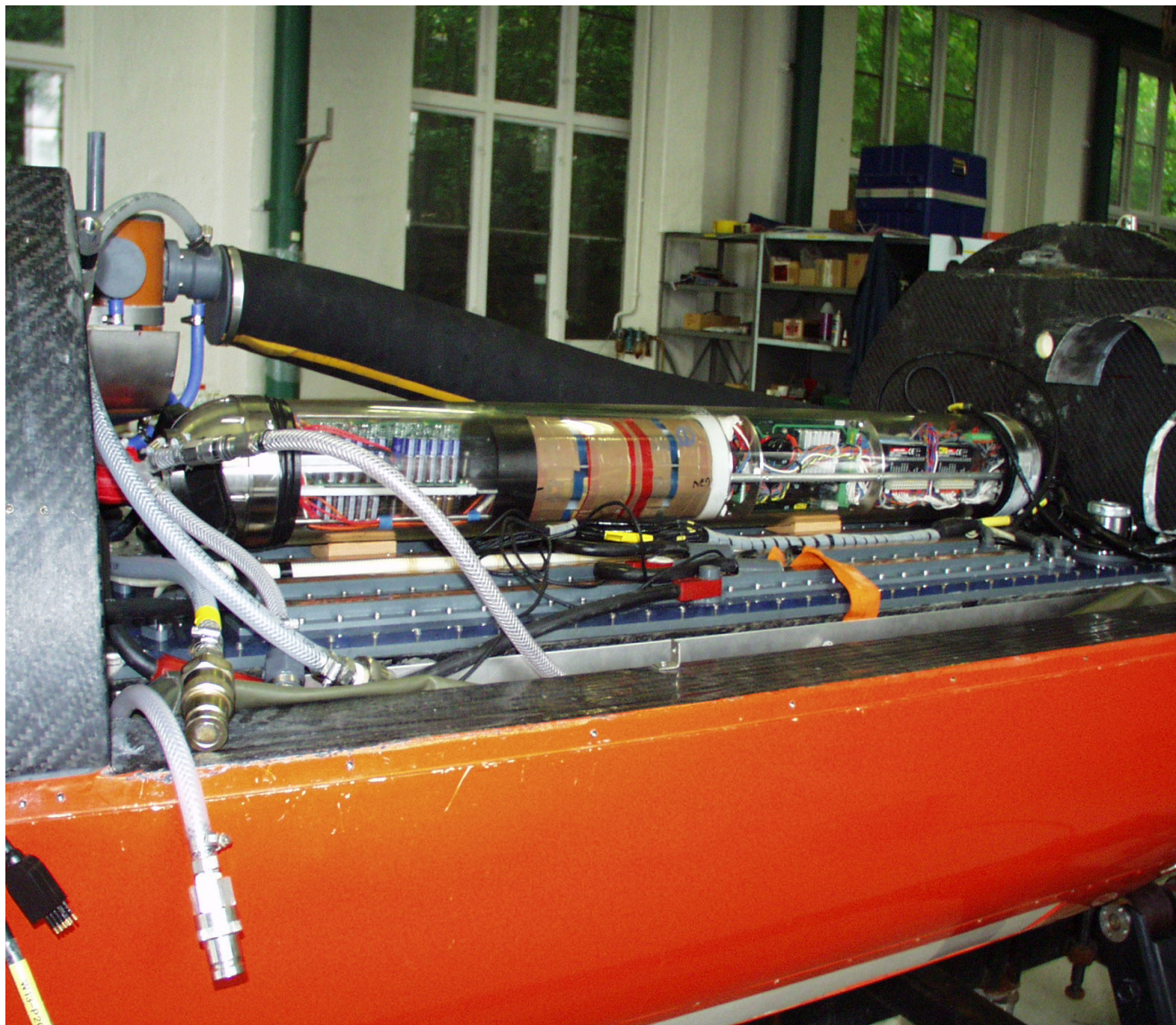


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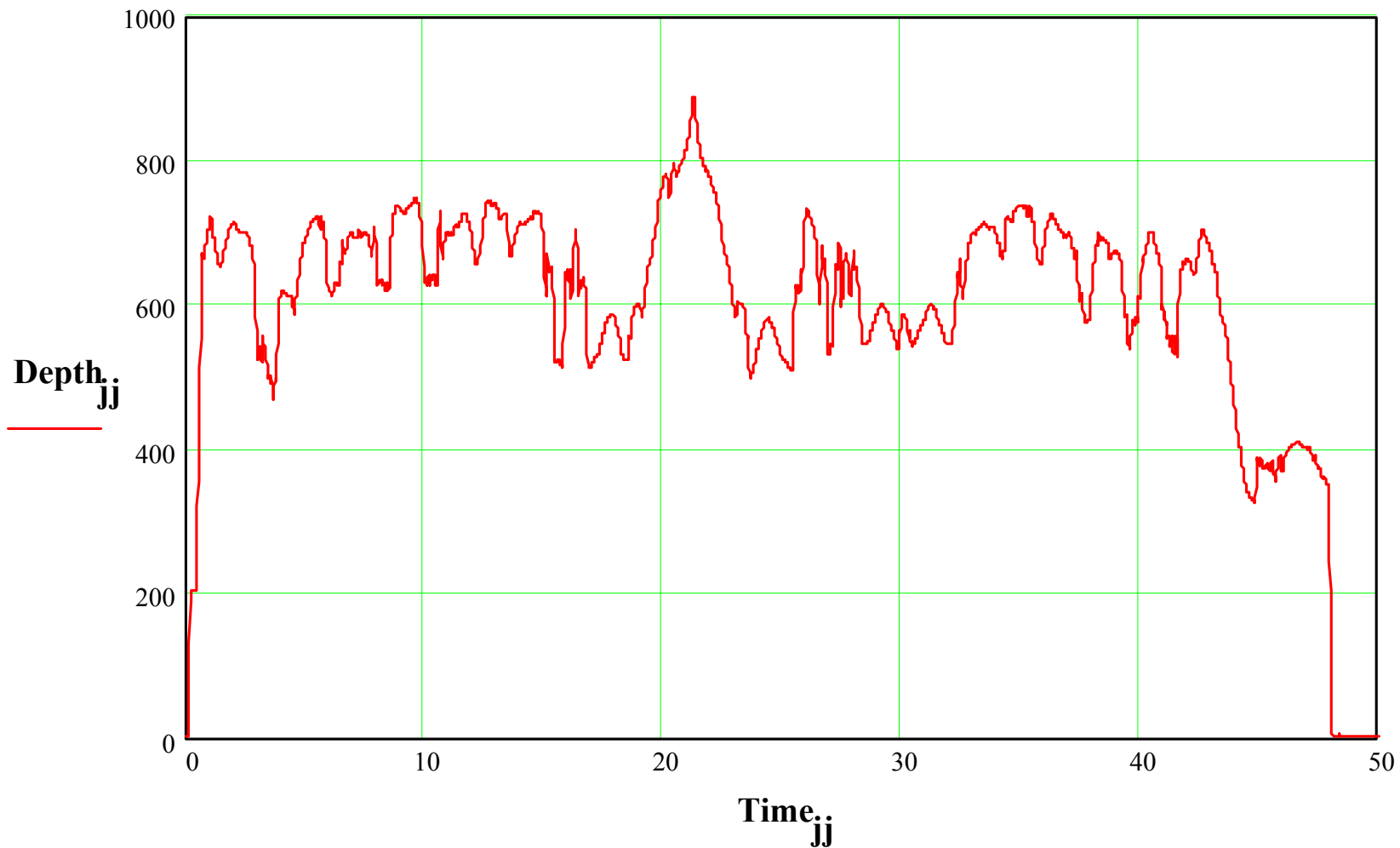




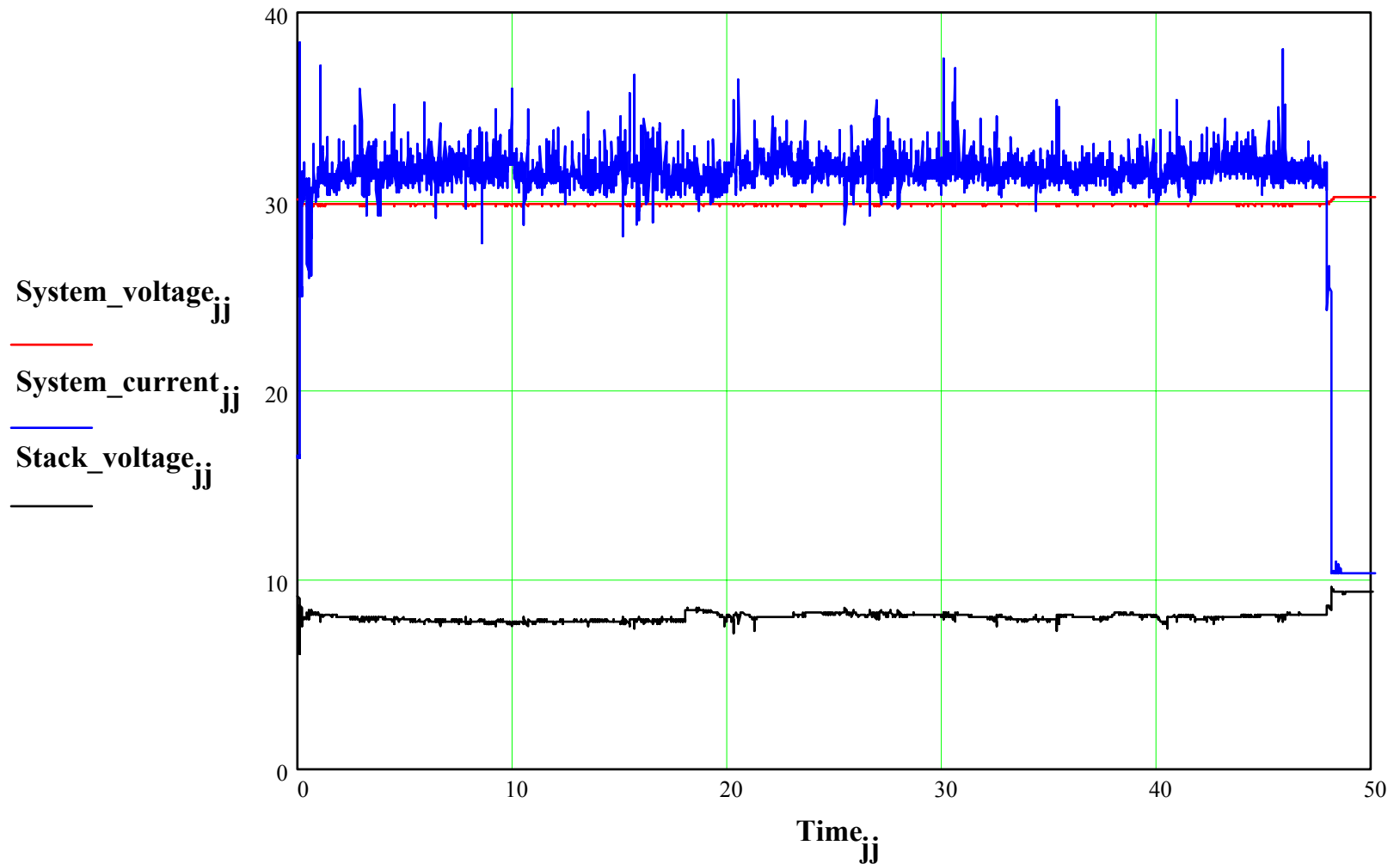
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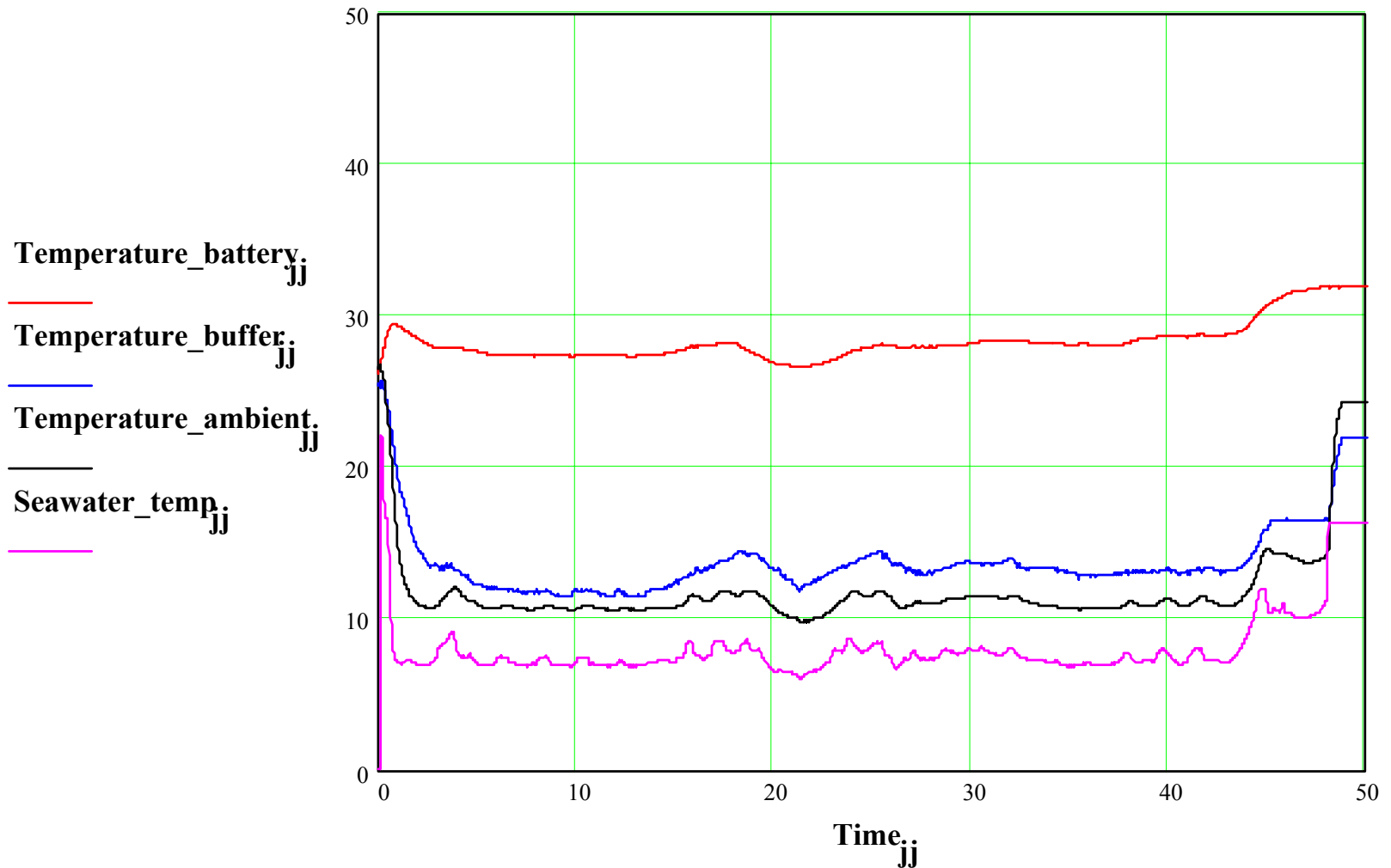
Depth / m versus time / hr. Mission date 02 04 14:



System voltage, stack voltage / V and system current / A versus time / hr :



Temperatures / C versus time / hr. Mission date 02 04 14:





Weight and performance of the Kongsberg Simrad Al/HP semi-fuel cell:

Aluminium anodes for 6 cells	60.8 kg
185 liter 7M KOH ($\rho = 1290 \cdot \text{kg/m}^3$)	238.7 kg
70 liter 50% HP ($\rho = 1200 \cdot \text{kg/m}^3$)	84 kg
Sum active components	383.5 kg
Battery box complete with cathodes	82.4 kg
HP system	6 kg
Sum battery weight	472 kg
Battery weight in water	148 kg
Nominal system voltage	30V
Nominal system energy	50 kWh
Maximum continuous system power *	1200 W

Conclusion:

The HUGIN 3000 AUV is now a proven deepwater survey concept.

During the last 12 month, more than 12000 line-km down to 2400 meters depth were successfully surveyed.

The development of the Al/HP semi-fuel cell has been an important contribution to this success.