# Alouette aluminium producer increases efficiency with new control system

ABB

**Fig. 1: Alouette aluminium producer in Sept–Îles, Quebec**

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*Reliability, efficiency, availability and continuity are an aluminium producer's most important needs. "Running of the plant without power interruption: That's what we expect from our systems to provide," says Ms. Line Bérubé, Vice President Corporate Affairs at Alouette. Alouette Phase II in Canada, part of the biggest aluminium plant in North America, has increased its efficiency using ABB's new electric power control system AC 800PEC. The result: increased flexibility as well as efficiency.*

## Alouette phase II

Alouette, an aluminium producer in Sept-Îles, Quebec, Canada, currently has a capacity from its two potlines of 550,000 tonnes per year of primary metal. The three-year Phase II expansion was completed in 2005, ahead of schedule. The 161 kV Gas Insulated Switchgear (GIS) system is fed by Hydro Quebec. The potline nominal current is 350 kA at 1320 VDC.

As shown in fig. 2, ABB delivered the GIS, high voltage cables, five regulating transformers, five rectifier transformers, five 89 kA rectifier cubicles, 1320 VDC incl.

heat exchanger, five 48 MVar of harmonic filters and the whole rectifier control system with AC 800PEC. All products and installations meet CSA (Canadian Standard Association) standards. The AC 800PEC had to be integrated without any problems in order to quality for CSA approval.

## Technical description

### Redundancies

Five rectifiers, for N-1 operation, provide the potline current. Each 12-pulse rectifier also has N-1 re-
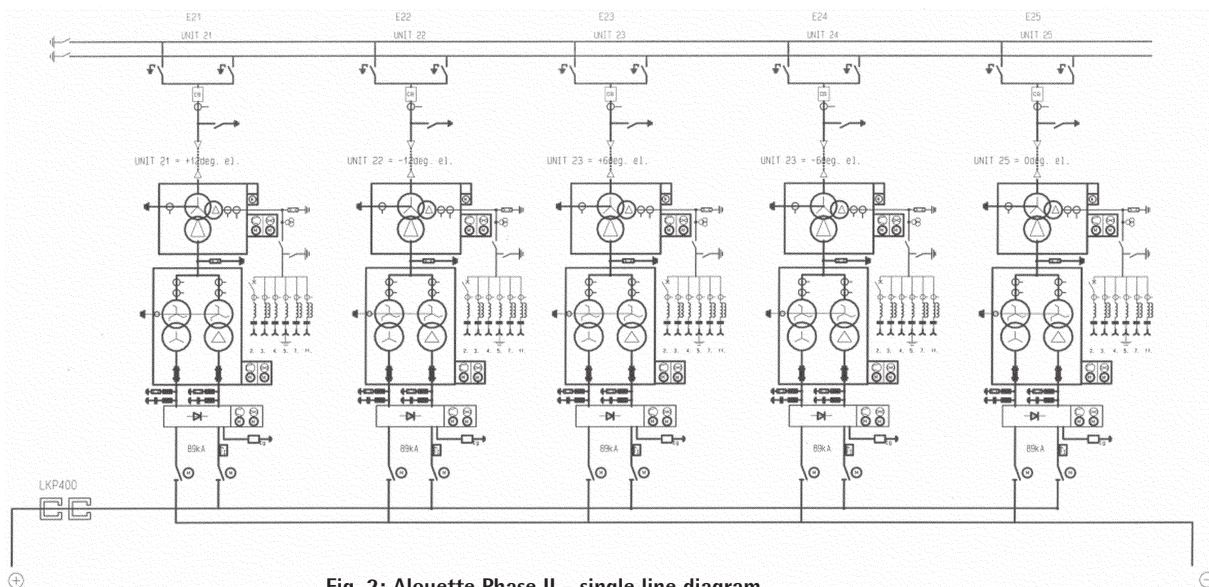


**Fig. 2: Alouette Phase II – single line diagram**
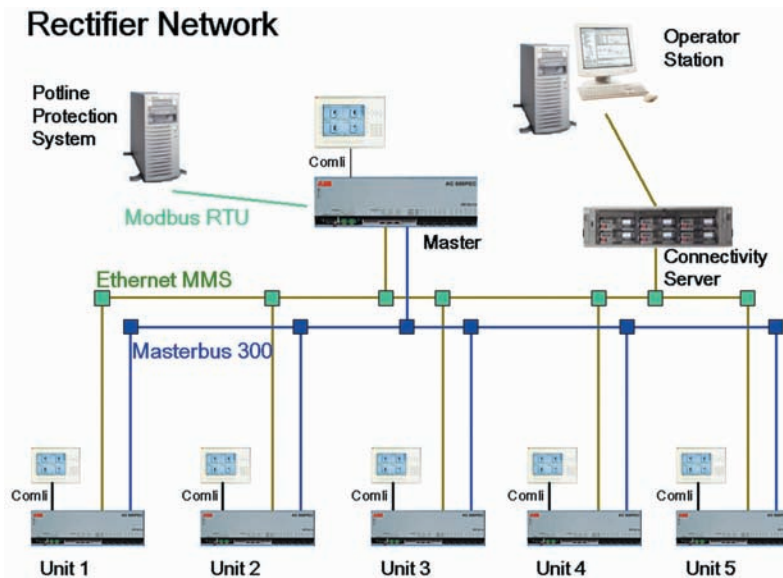
# Rectifier Network



**Fig. 3: Alouette Phase II – ethernet communication network**

dundancy per diode branch and a nominal current of 89 kA. In emergency situations the rectifier can operate without any controller up to 105 kA. All the required protection is assured by the hardwired backup trip, even during emergency operations.

## Flexibility, integration into different networks and systems

Two independent ethernet communication networks are installed as shown in fig. 3. One is dedicated to the data transfer between the master and the units. This link contains time critical data. The other one takes care of plant operation via HMI. The rectifier units and the master communicate via ethernet MMS to the connectivity server.

The CEX (Communication Extention Bus) plug-in enables the AC 800PEC to connect to the most used protocols worldwide, such as Modbus RTU, Profibus DP V2 etc.

In Alouette phase II this flexibility is used for the connection between the AC 800PEC of the master and the potline protection system via Modbus RTU.

Via the PEC-INT board, which is part of the AC 800PEC family, it is easy to integrate existing PSR II controllers or to integrate an AC 800PEC into an existing PSR II network.

A PowerLink connects the AC 800PEC Combi I/O boards, which are used for fast signal processing. Up to eight (distributed) Combi I/O's are connectable on one Controller, with the option of redundant FibreOpticLinks.

## Signal isolation

To ensure the rectifier system operates reliably, the signal isolation is built up over several stages. The first stage is the isolation provided by the device: the Combi I/O, binary inputs provide a high isolation level. The second stage is that all Combi I/O devices are connected via a fibre optical link to the AC 800PEC, which adds an extra isolation level. Other benefits of the fibre connection are its immunity to electromagnetic disturbances and the option to integrate a remote I/O concept.

## Digital signal processing

The Combi I/O meets the needs of aluminium smelters. One of the goals is to provide fast I/O handling for protection and control of the rectifier system.

Each analogue input can be processed through individual digital filters. Several digital filters can be selected and cascaded. This allows the optimal signal processing for every kind of signal. It is very easy to filter the AC or DC components of a signal. Provisions are also made to calculate the RMS or average values of a signal, for example of the line current. This set-up has improved the stability and the response time of the current controller at Alouette.
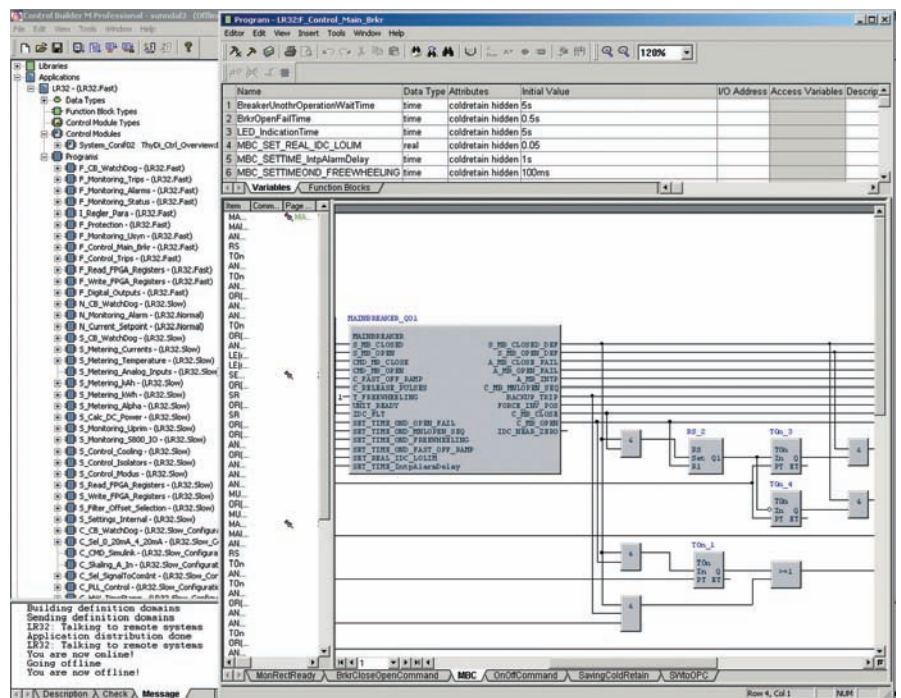


**Fig. 4: Control builder**

## Control Builder

The Control Builder programming tool is a modern and efficient software tool, based on the IEC 61131-3 standard. As required by the standard, the tool allows the AC 800PEC to be programmed in different programming languages. These programming languages are not dependent on a controller and can therefore be read and programmed by anybody knowing the standard languages. This is an advantage, as the maintenance staff does not need a great deal of training. In general, of the five possible languages, only function block diagram and structured text are used, as can be seen in fig. 4. These two are the most efficient to program, are the easiest to read and are the most commonly used.



**Fig. 5: AC 800PEC with the optical link connection to the Combi I/O**

The AC 800PEC combines slow and fast tasks on one controller. The slow tasks (typically >10ms) are programmed in the Control Builder. The fast tasks are predefined and have to be parameterized via Control Builder. The fast tasks contain the current control, the protection and the signal processing.

## Efficiency

The AC 800PEC controller family is designed for the harsh environment of rectifier applications such as substations of aluminium smelters. The extensive operating temperature range (-40°C to 70°C), rugged protection circuits, and lack of electrical connections between the controller and field all increase the efficiency of the system.

## AC 800PEC Combi I/O features

The combi I/O is specially developed to meet the needs of aluminium smelters. In addition to standard I/O features, the focus has been set on fast I/O handling, a software independent trip circuit, device supervision including a hardwired trip relay in case of a device error, a redundant power supply, and a redundant fibre optical communication link to the AC 800PEC. The combi I/O provides 32 binary inputs, 16 binary outputs, 12 fast analogue inputs and 4 fast analogue outputs.

The hardwired trip relays provide a controller and a communication link with an independent alarm circuit to provide a warning if any of the following failures occur:

❏ power,
❏ communication link,
❏ I/O module.

In addition to the internal board supervision mentioned above, the combi I/O has an integrated, independent software trip circuit with relay output. This allows an independent trip circuit to operate without a controller. This so-called backup trip circuit can be used for the following purposes:

1. Run the hardwired backup trip circuit with a controller in operation. This can operate two independent breaker coils, thereby increasing the reliability.
2. Run the rectifier in emergency operation mode without the

controller in operation, but still providing all necessary protection for the rectifier equipment. The combi I/O's 32 optically isolated binary inputs include a rugged protection circuit allowing safe operation even in a tough industrial environment. Each input can be selected individually to participate in the backup trip circuit by means of a dipswitch. All selected inputs are AND wired and force the trip relay to drop if one of the inputs drops. This solution minimizes the source of errors in comparison to the standard practice of doubling contacts via an interposing relay. This on-board solution eliminates errors due to defective wiring, the breaking of a wire during operation, the failure of a relay contact or of a relay.

The combi I/O also provides a redundant 24 V power supply. This power supply generates all internal supplies and provides EMC protection.

## AC 800PEC CT module features

Like the combi I/O the CT (current transformer) module is specially developed for the needs of aluminium smelters, and converts the 1A or 5A CT current signal to an electronic level. The circuit provides galvanic isolation and decoupling. Another feature that has been built on board, consists of a replica of the rectifier circuit to provide a DC image of the AC currents. This signal can be used for indication during operation without the controller in operation.

## Emergency mode

It is vital for aluminium smelters to ensure a safe and reliable power supply to the potline. On the rare occasion of a total breakdown of the control system, the rectifiers can be operated independently of the control system. If this happens, it is important to ensure full protection of the rectifier system and easy handling for the operators. The emergency mode is built as follows:

- A key switch can be turned to bypass the controller.
- Main Breaker and DC Isolators can be operated by means of a control switch or manually.
- Regulating Transformer OLTC can be operated by means of a push button or manually.
- Saturable reactor current can be adjusted by means of potentiometers.
- All necessary indications are provided via hardwired circuits: OLTCposition; Saturable reactor currents; DC currents of star and delta system, rectifier ready; breaker and isolator positions.
- All devices independent of controllers like Buchholz, Temperature, over current, fuse monitoring etc. are in operation due to hardwired backup trip circuit.

The special features described in the previous chapters of the combi I/O and CT module ensure safe, reliable and easy to use operations during emergencies.

### Trip and alarm handling

All binary inputs provide the option of recording events SOE (sequence of events). This means that a changing signal at a binary input channel can be identified together with the time stamp when the change occurred. These events are transmitted via Ethernet/MMS to the rectifier common OPC connectivity server. As all AC 800PEC internal clocks are synchronized, an exact event list can be generated out of the OPC connectivity server data. This has the big advantage that if an incident occurs, the exact sequence of events is available for fast and efficient fault tracing.

### Potline current control

For a given number of pots, potline load is considered fairly stable. However, as all pots are not connected on the first day, the voltage increases progressively during start-up. After all pots have been connected, maintenance work will periodically take pots out of operation, thereby changing the potline voltage. Even with a consistent number of pots in operation, the potline voltage is disturbed due to a phenomenon called "anode effect". This affects the stability of the current. For these reasons the rectifier voltage/current needs to adapt to ever changing potline conditions.

As shown in fig. 6, the potline current during an anode effect remains stable. This was achieved by two cascaded current control loops. The inner one was implemented on the AC 800PEC of the unit, and maintains the current at setpoint given by the AC 800PEC of the master. The superimposed current controller on the master maintains the potline current at the given potline setpoint. The unit measures its AC current in the CT of the rectifier transformer and calculates the DC current. This method is very reliable and has an accuracy rate of more than Cl 0.5 at the operating point.

A LEM helps to carry out the potline DC current measurement. The signal is read by a third party system and sent over Modbus RTU to the master controller. The mas-
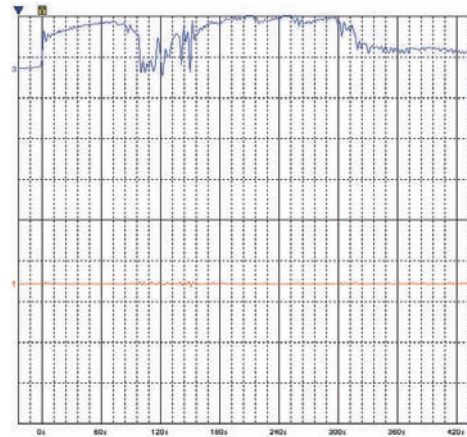


Fig. 6: Typical anode effect, red channel: potline current, blue channel: potline voltage

ter controller verifies continuously the values of the rectifier units and the LEM. If the LEM unit fails, it switches back to the values sent from the rectifier units. That means that no overshoot of the potline current occurs even if the feedback signal to the master PI controller is missing. All transfers of setpoints are made seamlessly. The result: the potline works continuously and is fully reliable.

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