Technical note

N47-ASR: Controller and monitoring

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1. Alarm signals and display

The main control panel is placed at the bottom of the tower. From the control panel on line data and data stored in the controller can be accessed. Stored data needed is typically error messages and alarm signals.
With the possibility of adjusting selected parameters, authorized personnel can change operational limits of the turbine directly on the front panel.

A stationary or portable additional control panel can be mounted/connected to the top box in the nacelle for manual control of the turbine, when servicing.

A battery back up system supplies the emergency light.

Safety surveillance will monitor possible faults in the turbine and, if necessary, bring the turbine to a standstill.
Should the turbine come to a standstill due to some unacceptable conditions, it will start up automatically when proper conditions have been restored, e.g., after grid failure. When faults require service, the turbine will not be able to start up again until the fault has been corrected.

One of the special features of the turbine is that it has a number of back-up functions built in, and that the controller utilizes the possibility to operate the turbine even if a secondary system has broken down. This system increases the availability and makes it easier to schedule service of the turbine. If such an error appears a message will appear on the screen and eventually on a remote monitoring device.

The turbine is equipped with an external emergency system, working independently from the electronic control system supervising speed of rotor, nacelle vibrations and manual emergency push buttons. The detailed layout is explained in figure 1.
A circuit breaker is installed in the power section, disconnecting the turbine from the grid in case of overload current or short circuit current.

The WTG communicates with the surrounding world via modems, either via the normal telephone lines or via mobile phones or other wireless remote systems. The best solution is been chosen for the given turbine project (NORWIN or their representative will check to turbine during the warranty period).
The system is normally set up in a manner so that the turbine in case of a fault will call up one or more given telephone numbers, typically addressed at the turbine service company. The first approach from the service team normally then is to access the turbine from the monitoring system in the office

to get an overview of the situation, and eventually start up the turbine via monitoring program if the error is non critical or caused by external disturbances that has passed.

The monitoring system/program and the data that can be accessed in the turbine is described in the document 'N-MonitorPr.pdf', a clarification of the output possibilities are further outlined below in 2.

The turbine will only in principle only monitor the faults in the turbine itself. If the grid or the transformer causes the fault, the turbine will only react on it with some delay and after the limits of certain parameters has been exceeded.

<u>Important examples of faults that will make the turbine shut down (600 Volt 60 Hz system):</u>
Voltage low: If the voltage decreases below 540 V (-10%) for more than 0.5 seconds.
Voltage high: If the voltage exceeds 660 V (+10%) for more than 60 seconds
Voltage very high: If the voltage exceeds 690 V (+15%) for more than 0.5 seconds
Frequency low: If the frequency decreases below 56.5 Hz (-6%) for more than 0.5 seconds.
Frequency high: If the frequency exceeds 61 Hz (+2%) for more than 0.5 seconds.

The values can be adjusted if more narrow limits are desired.

In case of power loss, the turbine controller will store all data up to that point, and be ready to start up again when power is back. The controller UPS system will further make it possible to call up the turbine doing a grid loss, etc.

Important notes:

If grid loss occurs frequently i.e. due to lack of power where the utility shouts down portions of the grid, it would be a very big advantage if it is could be possible to get a warning a few seconds before, because it will make it possible to shut down the turbine in a controlled manner. Grid loss is a highly undesired situation for the turbine because it creates a high loading on the system during the event. Frequent grid losses will definitely decrease the lifetime of the turbine, especially the transmission system. The normal amount of grid losses considered in a turbine design is 2-3 per year.

The transformer shall be equipped with a circuit breaker in addition to the controller's circuit breaker. This will normally be an automatic breaker. Fuses could in principal be used, but is not advisable because we would like all three phases to be cut off if one of the phases trigs the event.

2. Measure output clarification

Measurements made by the turbine can be accessed either through the controller panel or from the monitoring system. From the monitoring system printout of various items can be made.

The following primary items are measured and shown:
- Wind speed
- Voltage 3 phases
- Amps 3 phases
- Cos fi
- Frequency
- Power output

- Rotor / generator rpm
- Nacelle wind speed
- Nacelle direction
- Temperature: Gearbox, generator, main bearing, ambient, controller, etc.
- System pressures in hydraulic system and gear lubrication
- Pitch position
- Brake position
- Generator small or large cut in
- Brake opened or closed.
- kWh produced
- Error code
- Turbine state (procedure)
- Warning code (warns of potential error)

Production figures are calculated for each day and shown for a month back, and for each year.

Availability is specified in details i.e.:
- Hours OK
- Hours not OK
- Hours in service
- Production hours
- Total hours
- OK % (availability)
- Not OK %
- Service %
- Production time %
- Stop’s during operation
- Other statistics.

Error codes can be tracked up to a certain number back, so that it is possible to track an error event. This function makes it easier to find eventual faults, and to see how a fault initiated. The number of the different fault types is further counted and recorded.

The turbine power curve, measured with the nacelle anemometer is recorded and can be shown either as a graphical curve or as values. It is further possible to show the wind distribution as a graphical curve.

If a secondary surveillance system needs to be hooked onto the turbine, it will need to be done via communication with the PLC controller. Hooking up directly to measuring points is not acceptable because it can introduce spikes into the system and cause malfunction of the WTG.

NORWIN A/S
Wind Turbine Technologies

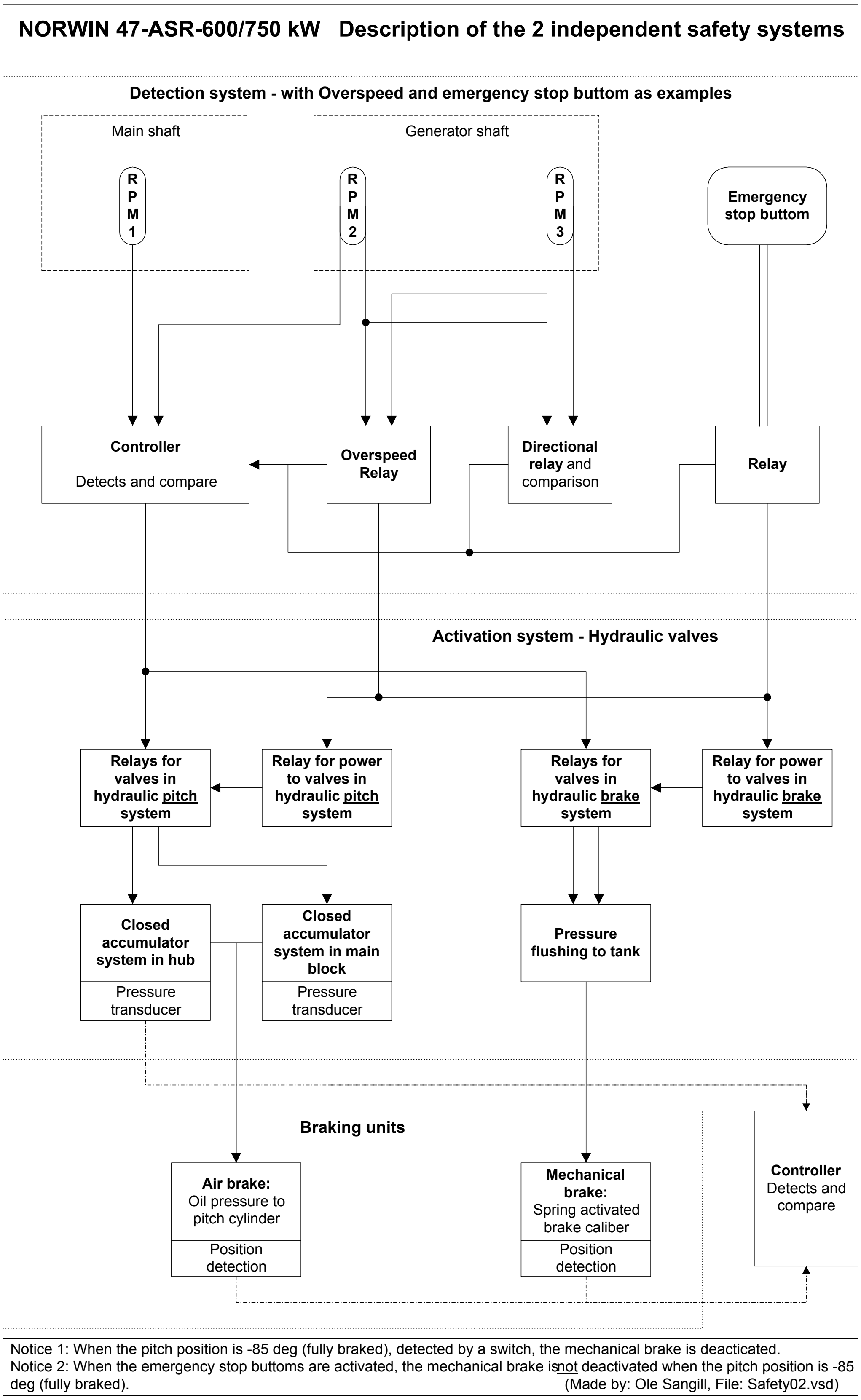
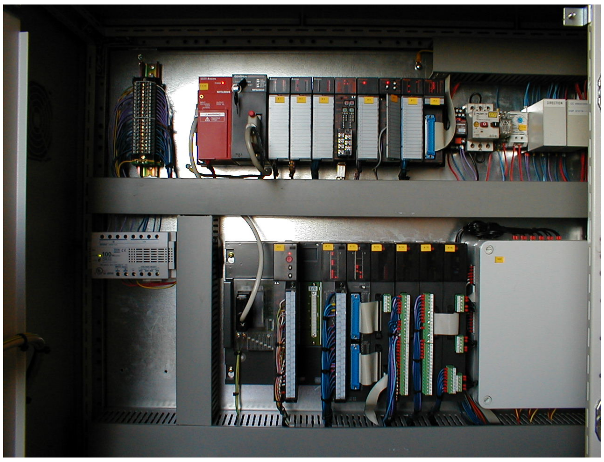


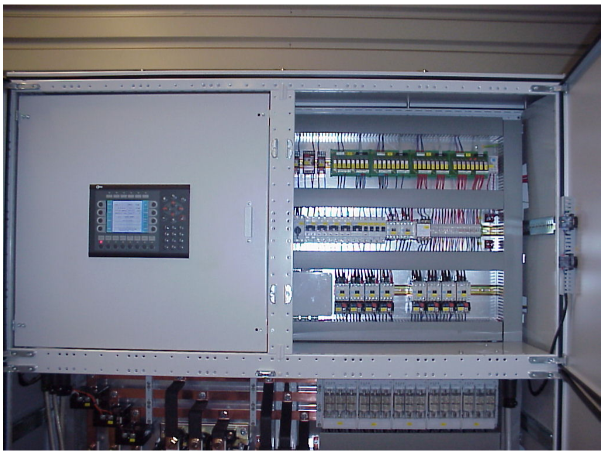
Figure 1. Safety systems.

Picture section:

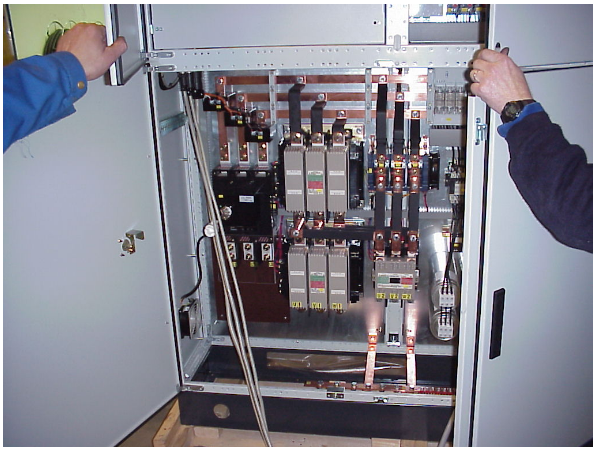
Portable unit for control of the turbine in nacelle.



PLC part of main controller.

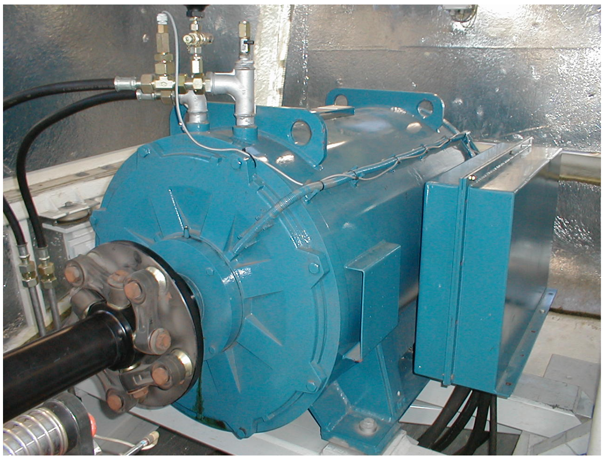


Relay, switch and display part in main controller.



High voltage part of main controller.

Doubled wind vane and anemometer for reliable operation.



750 kW water-cooled generator