Best Practice Guide

BENDER
The Power in Electrical Safety©

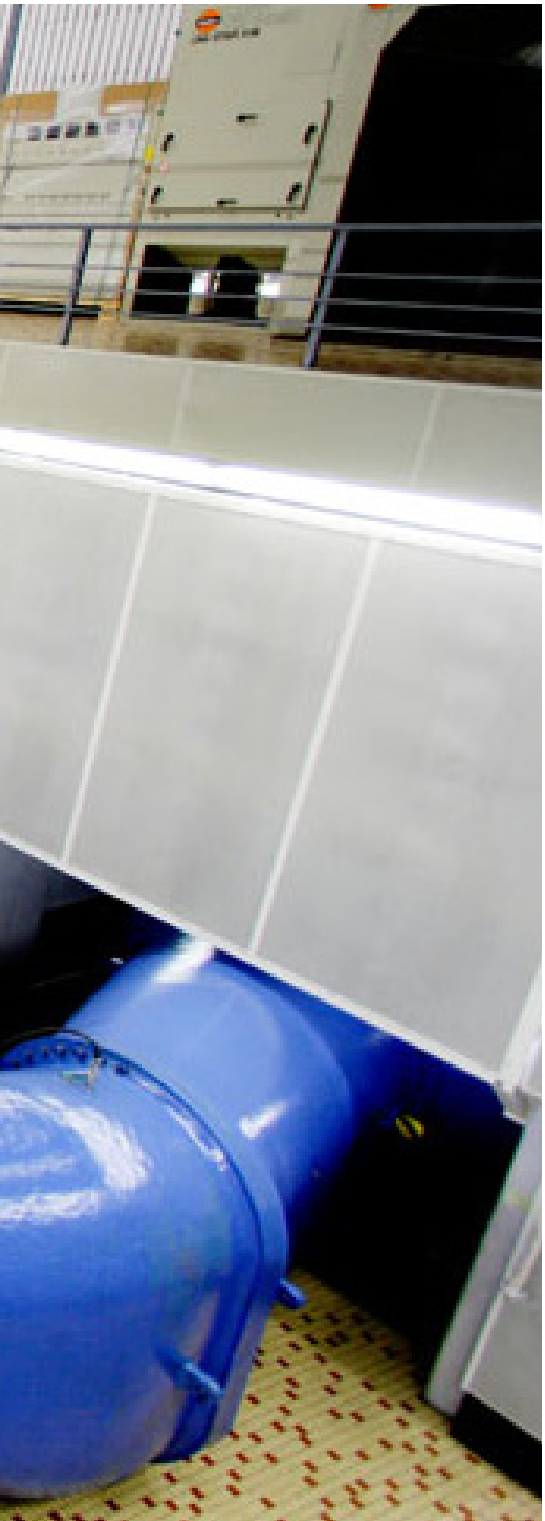
Schluchseewerk

High availability –
Pumped storage hydro power station Bad Säckingen

Pumped storage hydro power station for public power supply

In the field of energy supply, pumped storage hydro power stations are so far the only option from a technical point of view of storing an oversupply of electrical power. When required, the plant can make the excessive electrical power available within a few minutes and thereby contributes, together with other power plants, to a more regular utilisation of the power supply. Pumped storage hydro power stations are of particular importance in the event of large-scale power outages since, thanks to their black start capability, they can be used to start up other power plants, such as coal-fired power stations for example, which are not able to perform a black start.

Pumped storage hydro power stations also encourage the use of renewable energy since they balance out the inevitable fluctuations of these power generators.



Underground hydro power station Säckingen

General:	
Construction time	1961 to 1967
Average head	400 m
Turbine power output	360 MW (4 x 90 MW)
Pump capacity	300 MW (3 x 70 MW + 1 x 90 MW)

4 x Francis turbine	
Max. output	92.5 MW
Water flow rate	24,500 litres/sec.
Impeller diameter	2,072 mm

3 x storage pumps	
Max. output	70.7 MW
Pumping volume	16,150 litres/sec.
Impeller diameter	2,173 mm

1 x storage pump	
Max. output	89.3 MW
Pumping volume	21,300 liters/sec.
Impeller diameter	2,880 mm

4 x synchronous generator	
Nominal capacity	118 MVA
cos phi	0.76
Rotor weight	160 tonnes
Nominal speed	600 U/min
Number of pole pairs	5
Poles	10
Stators + rotors	air cooled

4 x generator transformer	
Nominal capacity	125 MVA
Nominal voltages	235 kV / 15.75 kV
Control range	+/-16 %
Total weight	183 tonnes

Buildings	
Machine cavern	161.5 m long, 23 m wide, 33.6 m high
Access tunnel	1,563 m long, 6.3 m wide, 5.5 m high
Pressure shaft	400 m high vertical, 4.3 m diameter
Tailrace gallery	2,000 m, 5.5 m diameter

Eggberg reservoir (upper reservoir)	
Normal water level	700 m +sea level
Lowest drawdown level	679 m +sea level
Approx. 18 % generation from natural inflows as an average over 10 years	

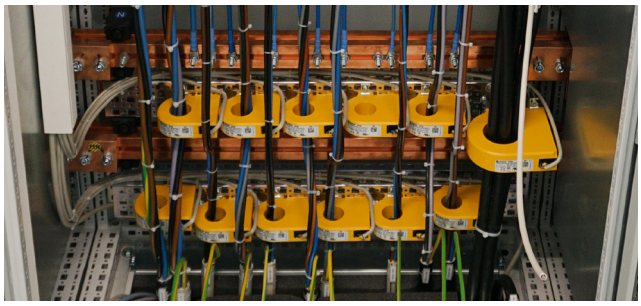
Installation monitoring in an earthed system (TN system)

Residual current monitoring system

For reliable operation of the electrical installation, periodic verification in accordance with IEC 60364-6 is required. The responsible electrically skilled person determines the test intervals during risk assessment. Recommendations can be extracted from the applicable regulations and standards. For example:

- IEC 60364-6
- EN 50110-1

When an installation is maintained by qualified personnel and continuously monitored during operation (e.g. insulation resistance monitoring with a residual current monitoring system), the requirements are fulfilled.



Residual current monitoring of final circuits and outgoing circuits

An insulation deterioration is detected and reported during operation. All other measurements and actions of the periodic verification can also be carried out during plant operation.

Advantage: No plant shutdown required thanks to periodic verification

CEP monitoring

For EMC-compliant operation of electrical systems, an installation in the TN-S system with a single central earthing point (CEP) is required (DIN VDE 0100-444). To maintain this status during the entire service life of the system (especially with expansions), the CEP must be continuously monitored.

The entire system leakage current flows exactly through this measuring point. Abrupt changes in the measured leakage current indicate a new PE-N bridge, a PE-N swapping or a low-resistance earth fault. The history memory of the monitoring devices shows the exact point in time when significant changes have occurred. Usually, the cause can also be detected (e.g. maintenance or conversion work) and the fault location can be determined.

Advantage: fast detection of unwanted additional PE-N bridges

Preventive fire protection

Partial (resistive) earth faults are a specific fire hazard if, at the position of the arc, relatively low resistances occur in the fault current circuit. Disconnection of the fault via upstream overcurrent protection devices, such as fuses or circuit breakers, is not given. With a heat capacity of > 60 W, the presence of oxygen can already lead to an ignition.

In this case, the residual current device (RCD) with a rated residual current I_N of 300 mA offers comprehensive protection. If, in specific application cases, a residual current device (RCD) cannot be used for technical reasons, the directives for damage prevention of property insurers (VdS) recommend the use of residual current monitors (RCMs) acc. to DIN EN 62020 (VDE 0663) with switching devices, e.g. circuit breakers, if their supply voltage is isolated from the supplying system (see: VdS2033). Since no low-resistance connection of an active conductor to earth exists in an unearthed system (IT system), no fire hazardous fault current can flow the first time an insulation fault occurs.

Advantage: Minimisation of fire hazard

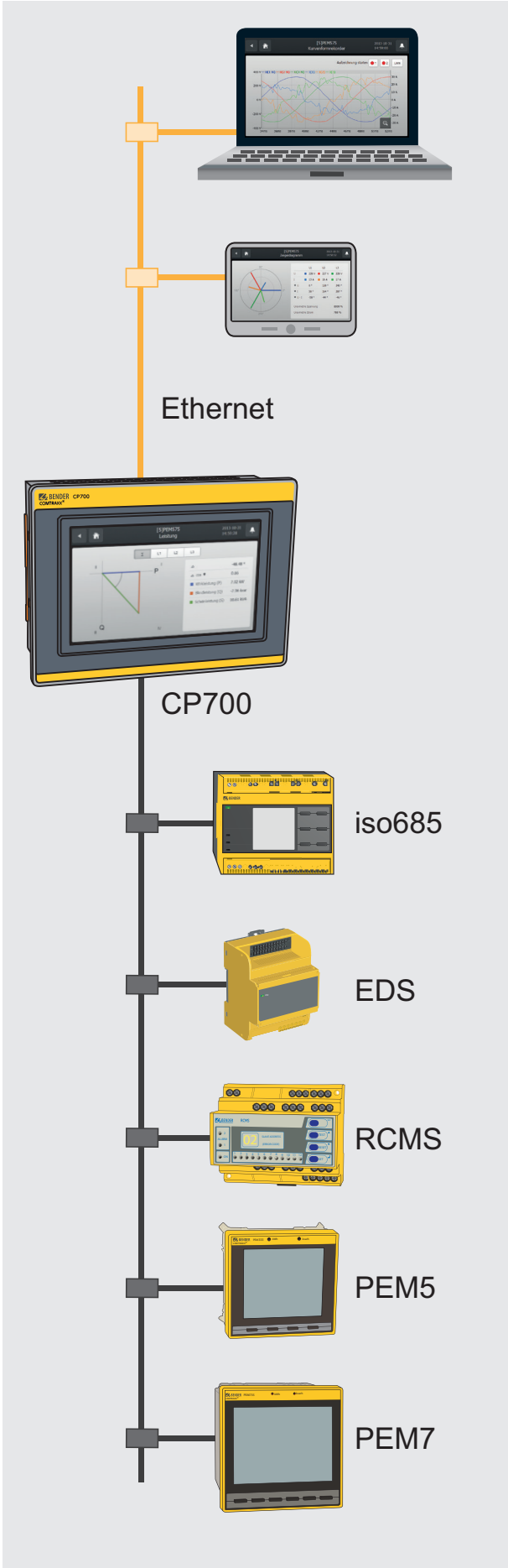
The system control centre as a portal

Due to rising energy costs, the subject of energy efficiency is becoming more important. However, useful measures for energy feed can only be determined when the energy flows in the system are known. Energy meters for DIN rail mounting and power meters for front panel mounting like the PEM333 can be used for this purpose.

In addition to the energy meter, a power meter provides information regarding harmonic content and can be involved in fault location in the event of a fault. A PEM735 is used to monitor the voltage quality. The ground A network analyser provides weekly reports for download via an integrated web interface. The system control centre (CP700) collects measuring values from recording devices via various bus systems (Modbus RTU, TCP, BMS) and makes information regarding energy consumption and power flow centrally available.

The system condition can be viewed on a PC or smartphone via a web server access. Installing specific software is not required.

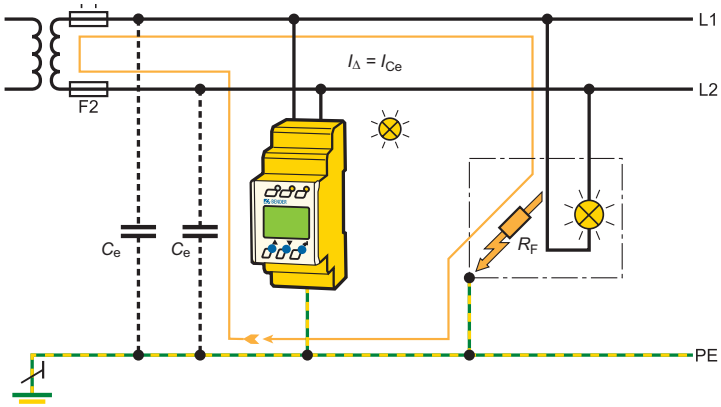
Advantage: Central system overview



Installation monitoring in an unearthed system (IT system)

In order to ensure a continuous and highly available power supply to the 20 kV switchgear, the voltage supply has been set up as an isolated DC 110 V control voltage supply system. The DC 110 V system is made available via a rectifier and buffered via a battery. A loss of the switchgear control voltage must be avoided under all circumstances.

The advantage of an IT system is that it does not have to be disconnected after the first insulation fault. This results in high operational safety and high economic efficiency.



By using an insulation monitoring device the system is continuously monitored and maintenance work can always be planned depending on the insulation level. The insulation monitoring device continuously records the measured insulation resistance and represents the sequence on a graph. During periodic verification, an R_{iso} measurement is not required since the insulation monitoring device continuously monitors the system and signals any deterioration of the insulation resistance.

Advantage: High availability since the system must not be disconnected. In addition, no periodic verification is required.

If an insulation fault occurs in the control voltage supply system of the 20 kV switchgear, the fault has to be located and eliminated as fast as possible. Continuous operation of the plant is absolutely necessary. This is ensured by the installed insulation fault location system, which can automatically start the fault location if an insulation fault occurs. The insulation monitoring device with an integrated locating current injector introduces a limited locating current in the system that can be detected by an insulation fault locator with connected current transformers in the faulty outgoing circuits. After the insulation fault has been detected the corresponding customer-specific text is indicated on the display of the insulation monitoring device.

Advantage: Cost reduction by avoiding downtimes.

Ready for the future and always connected

Robert Schäuble

Bernd Hierholzer

The underground hydro power station in Bad Säckingen is being prepared for the future. The first step was a partial renewal of the electrical system and the control system. The almost 50-year-old 20 kV/400 V switchgear was completely renewed without interrupting the power supply.

"We were connected at all times." This was a very important aspect for all responsible employees working in the maintenance department and something to be proud of.

From now on, an uninterruptible power supply should also be guaranteed during operation. For Robert Schäuble, Asset Management Electrical Engineering (responsible for all auxiliary installations and supply systems of the Schluchseewerk AG power plants), the advantages of Bender's LINETRAXX regarding the monitoring of a reliable power supply was a decisive factor.

Mr. Schäuble, how did you find out about the possibilities of continuous monitoring with Bender LINETRAXX?

The Schluchseewerk AG is already using residual current monitoring for the operational safety of the machines in the pumped storage hydro power station Waldshut. To date, the experiences of the senior maintenance engineer, Wolfgang Kiefer, have been very positive.

The advantages of Bender technology were presented and explained to us on site. My colleague Bernd Hierholzer and I were quickly convinced that Bender would provide us with the best support on our way to achieving high availability and a reliable power supply.

Bender LINETRAXX is used in all plant parts for fault location and power quality analysis. Which aspects were most important to you?

In the event of a fault in our 20 kV switchgear a huge effort would be required to locate the fault. A reliable supply could not be guaranteed if the fault had to be located via time-consuming shutdowns.

What was important to us was ensuring the highest possible plant availability and electrical safety. Bender LINETRAXX offers us continuous monitoring and a general overview of all relevant measurement points of the earthed and unearthed power supply.

Were you satisfied with the support from Bender?

Yes. Bender field service and product management/development were permanently involved in the project. In close cooperation, the plant components were tested, optimised and put into operation.

In order to realise a project of such complexity, on-site support is required – the support by Bender was always prompt and helpful. In the process, we became familiar with the systems and as a result we have obtained an ideal tool for continuous maintenance. During commissioning we received support from competent Bender employees and we know that they will also be available to us in the future.

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