SIPROTEC – Down in a Coalmine

Protection systems Deutsche Steinkohle AG can depend on

■ The company

Deutsche Steinkohle AG (DSK) resulted from the merger in 1998 of two mining companies, Ruhrkohle AG and Saarbergwerke AG. In 2003, the company sold 27 million metric tons of coal, most of it to German power supply companies.

■ The starting situation

Under-ground mining poses electric power requirements that differ from those in normal utilities' power systems. This is true with respect to protection systems. Protection relays must be able to respond to faults in a fail-safe manner, even in explosion-hazardous areas. Special requirements also pertain to communications in explosion-hazardous areas and to auxiliary power supply, since batteries are prohibited as a power source in underground mines . In upgrading the incoming supply to a 10 kV power system, DSK opted for a SIPROTEC 4-based design that meets these requirements completely.

■ The concept

The SIPROTEC 4 product range of protection relays is highly flexible and can be safely used in underground mines. The version used is the ATEX-compliant 7SJ62 relay for protection of explosion-protected motors with the elevated level "e" rating of explosion protection. When used in explosion-hazardous areas with methane gas and electrically conductive coal dust, devices must comply with the "explosion-proof enclosure" type of protection. To meet this requirement, they are installed in the BARTEC 8SN enclosed switchgear from Siemens.

■ The special advantages

Communication despite enclosure

The installation within the enclosed, explosion-proof switchgear means that it is not feasible to go online with the protection relay via a wire connection to the DIGSI computer. To communicate with the laptop through the sealed glass window, an infrared adapter is therefore connected to the front interface of the 7SJ62 and simulates a serial interface.

Fig. 1 Coal mine of DSK

Fig. 2 Siemens Bartec 8SN encapsulated switchgear

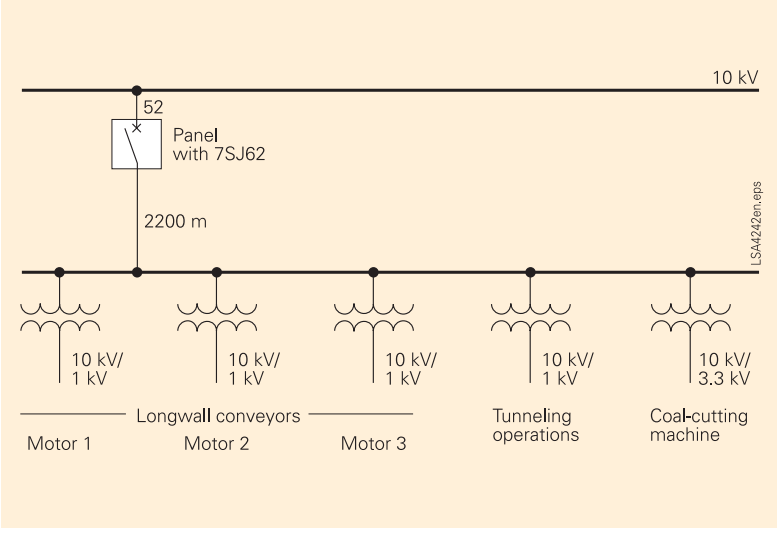

Fig. 3 Typical 10 kV power system in a coal mine

The protection relays are installed in a 10 kV switchgear panel. The motors for the belt conveyors, longwall conveyors, coal-cutting machine and tunneling operations in the longwall are located in the outgoing feeders. A characteristic feature is that these motors are constantly being relocated as the mining progresses. What's more, the long distances in the mine network to the coal face being cut pose special requirements that must be considered.

CFC logic detects short-circuits promptly

The basic rule of selecting a motor short-circuit setting above the highest starting current and below the 2-pole short-circuit level does not apply here. Due to the long distances, the short-circuit current may be lower than the starting current. The longwall conveyor motors are tuned to each other and start up sequentially within a short time interval, so that the total current continues to increase and exceeds the short-circuit level.

The use of CFC logic solved this problem: The pickup threshold is increased stepwise by detecting the motor start, so that no spurious tripping occurs yet a motor short-circuit can be detected promptly.

Communication with the world above

An intrinsically safe modem installed within the explosion-proof enclosure maintains communications to the outside world via the systems interface using PROFIBUS-FMS protocol. Actions such as readouts of operational information, switching events and protection settings can therefore be shifted above ground.

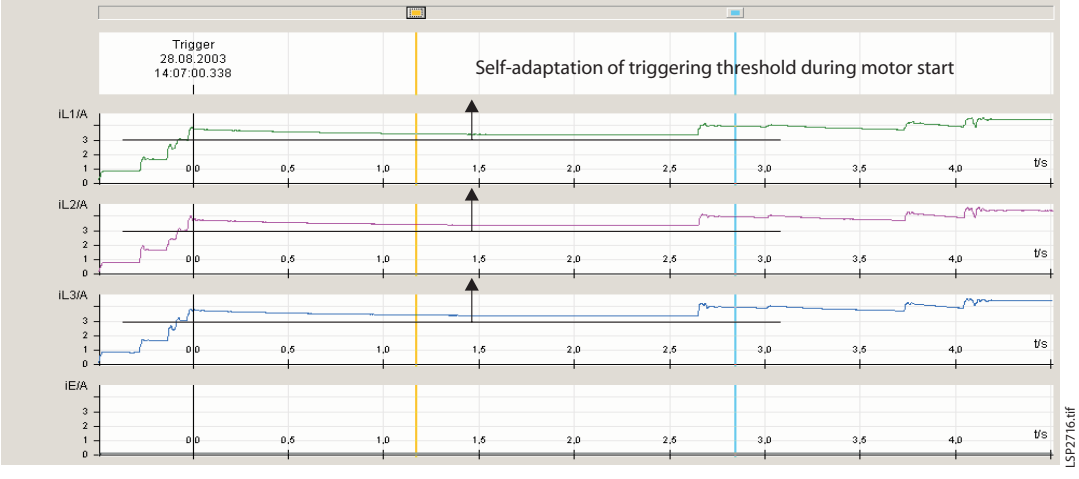

Fig. 4
Self-adaptation of triggering threshold during motor start

Visual display of information

The personnel on site should be able to obtain as much information as possible in visual form – without having to access operational messages or system fault messages by operating keys. To achieve this, SIPROTEC 4 relays can be additionally programmed by means of CFC logic blocks to cause optical indicator lights (LEDs) on the front plate to either blink or illuminate continuously, as desired. This means: In a 7SJ62 relay with 7 LEDs it is possible to display 14 different status indications.

Auxiliary power via voltage transformer

Another special aspect of underground mining is that batteries cannot be used for auxiliary power due to the explosion hazard. Protection relays are supplied through the voltage transformer (frequently only a single phase-to-phase voltage is available). However, tripping must be prompt if the voltage falls below the minimum level (<70%) to ensure that there is sufficient voltage to actuate the undervoltage coil.

Tripping assured to the n^{th} degree

With these factors in mind, a breaker-failure protection is also provided, in the event that the first undervoltage tripping signal fails to open the circuit-breaker.

If the first TRIP command is ineffective, the breaker-failure protection attempts to use a stored signal (lockout) to issue a TRIP signal to the same circuit-breaker. Reasons for the voltage dip may include:

- a voltage failure due to the incoming supply being shut off
- a voltage drop due to the starting of large motors
- a voltage dip due to a short-circuit

As a last resort, if the breaker-failure protection also fails or the supply voltage is already too low, the live-contact status of the protection relay trips via the undervoltage coil.

PE conductors provide fault detection

Since the supply cables are accessibly located along the longwall, there is always a possibility that they may suffer some minor impact damage. To detect such faults promptly before any critical damage is suffered by the phase cables, PE conductors are provided underneath the outer cable sheath. In the event of a fault, these conductors trigger alarms in the protection relay via the binary inputs, similar to the trip circuit supervision function.

No information loss

Supplying auxiliary power to the protection relays via voltage transformers rather than by battery voltage causes more frequent switching off of the SIPROTEC relays during operation. It is therefore all the more important that all essential process information remain stored in the protection relay, to be available to the operator for analysis once normal power is restored. Because even simple signals via the binary inputs can cause the circuit-breaker to trip, for instance if the environmental monitor issues a methane gas alarm.

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Fig. 5 Power supply in a coal mine

Automatic reconnect

When the protection relay is operational again and no further interlocks or messages requiring acknowledgment are outstanding, reconnections are established automatically. To prevent all loads from being reconnected to the supply simultaneously, which could cause large line voltage fluctuations even above ground, each 7SJ62 has stored its individual reconnect time in the CFC scheme and reconnects the respective circuit-breaker separately after a time delay of several seconds.

■ *Conclusion*

SIPROTEC relays have been used at DSK to implement a protection system that is more than adequate to meet the special requirements of coal mining.

Special underground requirements such as

- application in explosion-hazardous areas
- readout of fault records via infrared interface
- auxiliary supply of the relays by voltage transformers
- recording of fault-related data after supply voltage failure

were successfully met and solved optimally with SIPROTEC protection relays.

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Fig. 6 Tunneling operation

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Fig. 7 Coal-cutting machine at work