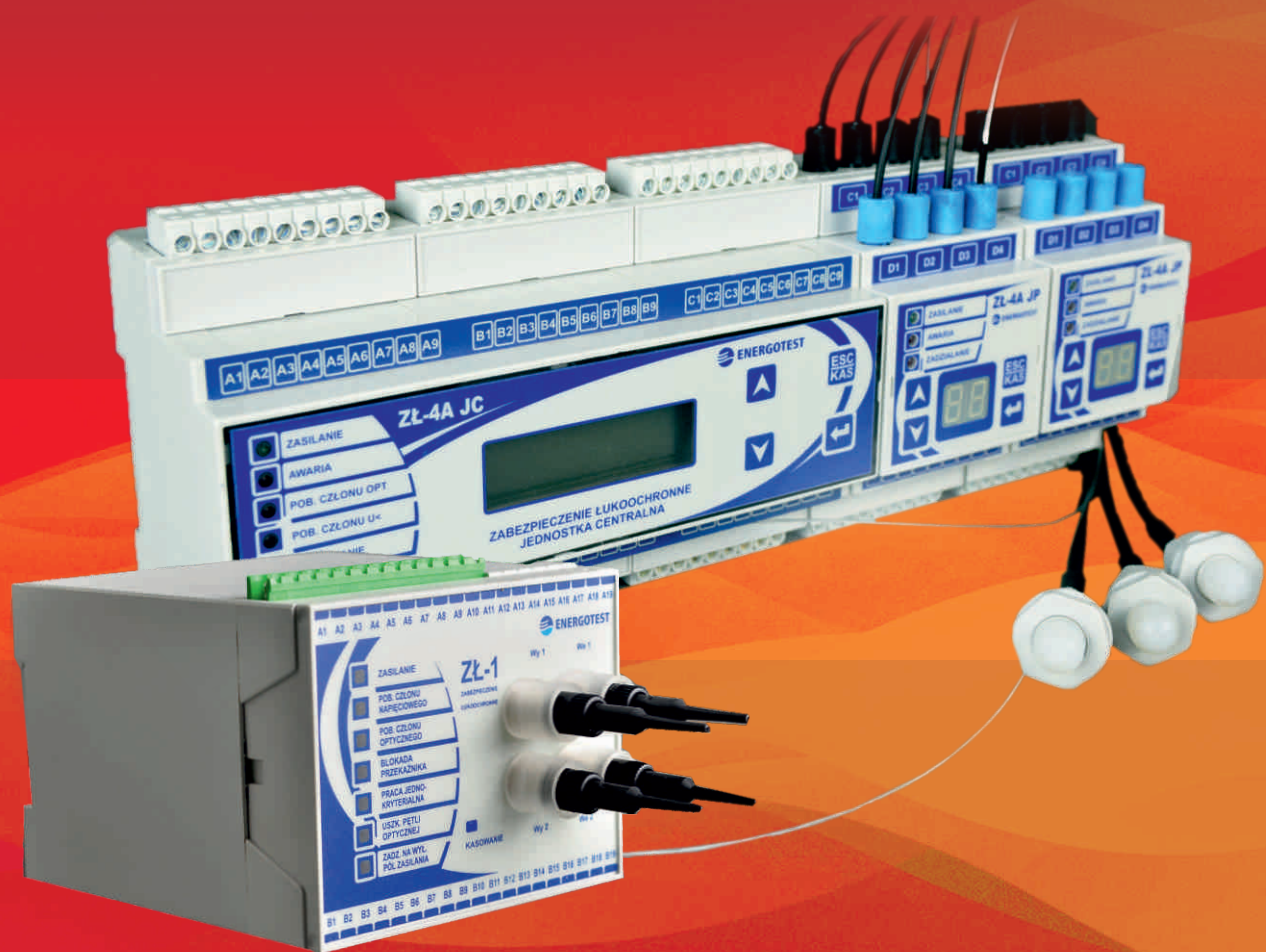


PROTECTION AGAINST EFFECTS OF ARC FAULTS

SPIE ENERGETEST



- ZŁ-1: for open switchgears
- ZŁ-2: for indoor transformers
- ZŁ-4A: for hooded switchgears

The essence of arc faults problems

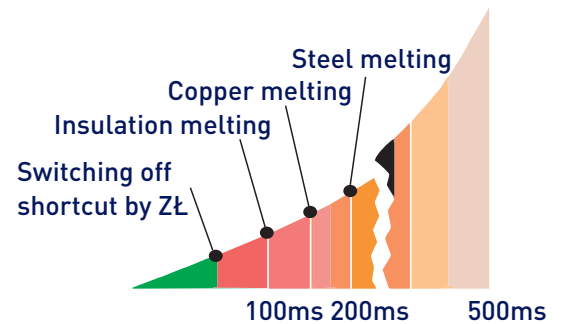
According to official statistics from the National Labour Inspectorate, several people are killed and dozens of people are seriously injured by arcs every year all over the country. Electrical equipment in which an arc fault has occurred is damaged to such an extent that it usually has to be replaced with new equipment. In specific cases, the losses including downtime costs amount to many millions of PLN.

The most common cause (60%) of arc faults are human errors: incorrect connections, poor organization of work. To protect people and equipment from the effects of short circuits in the technical standards PN-EN 62271 -200, PN-88/E-05150, PN-IEC 439-1 specifying the requirements for MV and LV switchgear and transformer stations, it is recommended, in addition to maintaining the relevant design features of equipment, to use additional measures to reduce the effects of arc faults. One of the recommended methods are protections reacting to arc light. Such a solution is the fastest and most effective way to minimize the effects of arc faults.

The key protection factor - short circuit duration

In ZŁ-type protections the switching-off signal is generated in less than ms_{10} . The arc is extinguished within 30-50 ms, depending on the type and condition of the breaker. Such a shutdown time guarantees full protection of human life and health and minimizes the damage to the device.

The arc fault identification is based on two criteria: detection of the arc light and voltage drop in the protected area. Application of the voltage drop criterion guarantees protection of the whole switchgear (there are no dead/unprotected zones). It enables simple and correct operation of protection in systems of supplying one section of switchgear from several different power supply sources. Protection based on current criterion does not have these features.



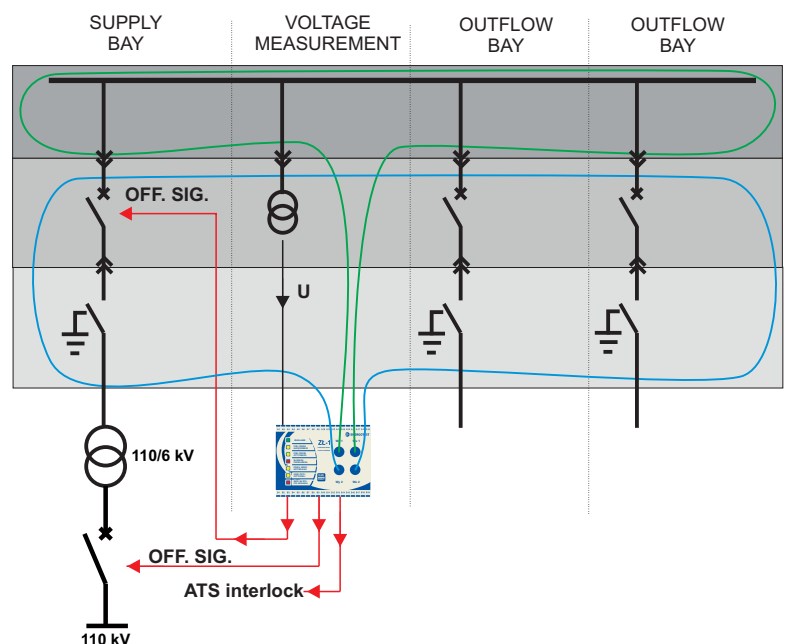
ZŁ-1 Protection relay

Protection of open switchgears

The ZŁ-1 protection is dedicated for protection of open MV switchgears, e.g. the GIPO type. Supplementing the switchgear with this protection is relatively simple. The unshielded optical fibre loop is installed in all bays. In two-storey switchgears, one loop protects the connection area, and the other protects the busbar and switchgear area. In case of simultaneous detection of electric arc and voltage drop to $0.7 U_n$, the protected section of switchgear is switched off.

Construction

The set ZŁ-1 consists of a relay and two uncovered optical fibre loops. One set of ZŁ-1 can protect from up to 20 fields⁴⁰, which means that the unit cost of protection of one field is relatively low. The relay is installed in CN 100 AK (100x75x105 mm) casing with IP40 protection degree.



Basic functions of the relay:

- detection of voltage reduction on switchgear busbars,
- arc light detection,
- loop continuity check,
- generating shutdown signals,
- blocking the ATS automatic control,
- single-criteria operation signaling,
- device tripping indication,
- Indication of device malfunction,
- 4 or 5 switch-off contacts,
- 2 Signaling contacts at common potential.



Fiber optic loops

The loop material has an appropriate light absorption coefficient. The sensitivity is chosen so that the system does not react to sunlight or headlights used by the operator. The standard loop length is 60 m. In individual cases the loop length can be up to 100 m.

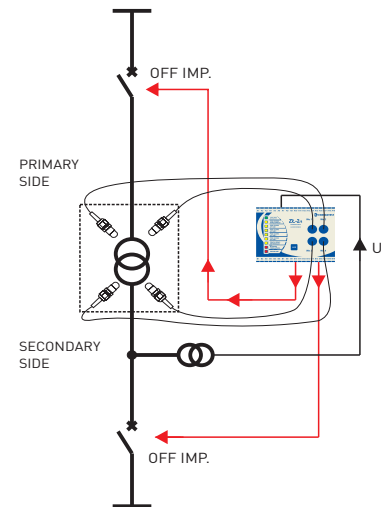
Dry-type indoor transformers and other equipment protection

ZŁ-2 Protection relay

ZŁ-2 protection is designed for the protection of indoor transformers and other electrical housing equipment in which the risk of arc fault occurs, such as converters, rectifiers, etc. Front optical sensors are installed in the transformer case or cabinet of protected equipment. The conditions of application of the protection device include an access to voltage measurement and possibility of remote power supply disconnection of equipment. In case of simultaneous detection of arc light and voltage drop to the level of below $0,7 U_n$ the power supply is disconnected

Construction

ZŁ-2 protection device consists of a relay and front sensors connected to it. The relay is installed in CN 100 AK (100x75x105 mm) housing with protection degree of IP40.



Basic functions of the relay:

- detection of voltage reduction on switchgear busbars,
- arc light detection,
- generating shutdown signals,
- blocking the ATS automatic control,
- single-criteria operation signaling,
- device tripping indication,
- 4 or 5 switch-off contacts,
- 2 signaling contacts at common potential.

Fiber optic sensors

The sensors have an appropriate light absorption coefficient. The sensitivity is chosen so that the system does not react to the light of the sun or headlights used by the staff. The standard length of fiber optic cable with sensors is 3, 5, 15 m. Security versions with three or four sensors are available.

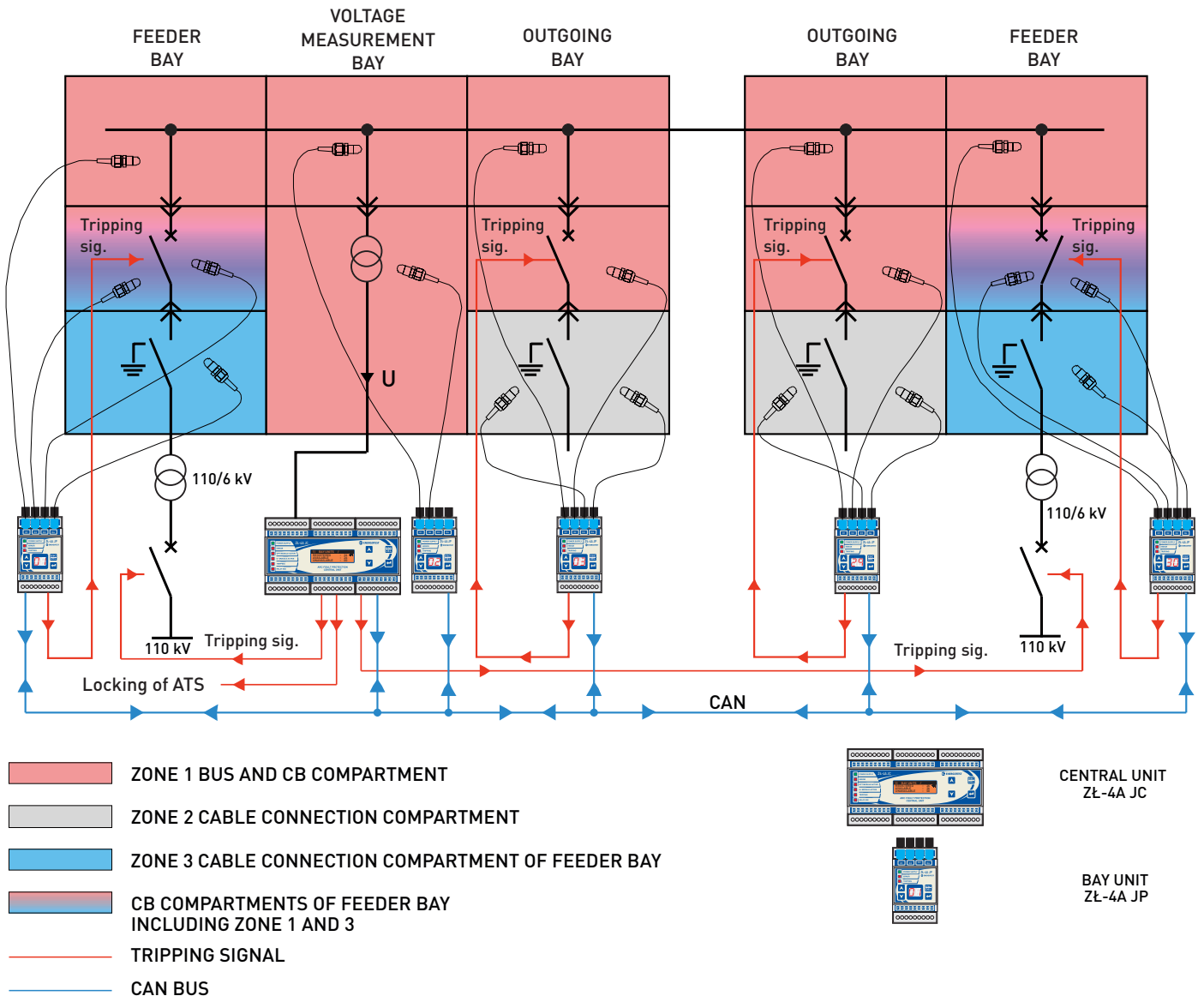


ZŁ-4A protection is dedicated to the protection of MV/nn hooded switchgears. It has dispersed construction. The central unit is usually installed in the voltage measurement bay, while the field units are installed in the switchgear fields. Optical frontal sensors (4 pieces) are placed in particular bay compartments.

In case of simultaneous detection of an electric arc and voltage drop of $0.7 U_n$, depending on the place of short circuit, it is switched off:

- the switch of a given bay - a short-circuit in zone 2 (connection compartment),
- switchgear power supply bay breaker - short circuit in zone 1 (breaker or busbar compartment),
- the nearest circuit breaker in the supply line of this switchgear - a short circuit in the supply bay.

The possibility of selective breaking down is a key feature of the protection ZŁ-4 very valuable from the operational and economic point of view.



Construction

ZŁ-4A protection consists of the central unit ZŁ-4A JC, power supply unit and field units ZŁ-4 JP. Each field unit is equipped with 4 optical sensors. Communication between the units takes place via the high-speed CAN bus. Parallel to the CAN bus, power supply circuits are distributed. The central and field units are installed directly on the TS bus. Dimensions of the central unit: 159 / 90 / 58 mm, field unit dimensions: 53 / 90 / 58 mm, protection degree of the central unit and field unit: Ip20. 99 field units can be connected to one central unit. Due to the use of a distributed design in the case of ZŁ-4, the unit cost of the enclosed switchgear field protection is relatively low.



Central unit ZŁ-4A JC



Basic functions of the central unit:

- Voltage drop detection on switchgear rails
- supervision of the correct operation of the systems
- security configuration
- sharing information on security status
- generation of cut-off pulses
- blocking ATS automatics
- single-criteria operation signalling
- Rs485 communication (Modbus RTU)
- signalling the activation of the device
- signalling of equipment malfunctions
- 6 programmable switch-off contacts
- 2 signal contacts on common potential

Bay unit ZŁ-4A JP

Podstawowe funkcje jednostek polowych:

- detekcja światła łuku w obrębie chronionej części rozdzielni,
- generowanie sygnału wyłączonego,
- generowanie sygnałów alarmowych do jednostki centralnej,
- raportowanie aktualnego stanu do jednostki centralnej.



Fibre sensors and loops



Sensors are characterised by a suitable light absorption coefficient. The sensitivity of the light detection path is set individually depending on the length of the sensors and the conditions in the object. The sensitivity must be selected so that the system does not react to sunlight or headlights used by the operator. The standard lengths of light guides with sensors are 3, 5 and 15 metres respectively.

Effects of arc short circuits in electrical systems not protected by fiber optic arc protection

Accidents in the category "electric shock" are 70 % caused by arc shorts. Arc shorts most often occur in medium voltage electrical systems, where this proportion reaches 90%. Short-circuit current in medium-voltage devices ranges from several to several tens of kA. The most common cause (60%) of arc shorts, apart from technical (construction, material, workmanship defects) and environmental (aging, corrosion, overvoltage, vibrations, rodents) are human errors: wrong connections, bad organization of works. During a long-term arcing short circuit the temperature reaches 20 000°C, a powerful bang is generated and a strong shock wave bursts out the equipment, a large amount of gases, often toxic with temperatures reaching several hundred degrees, are emitted. Under such conditions a person is exposed to loss of life or serious injury.

The thermal energy of a short circuit depends on two variables: its duration and the level of the short circuit current, according to the formula $Q=I^2 \times t$. We can only influence one of these factors - time. The operation of an electric arc in a period of less than 100 ms does not cause more serious damage, while with a short circuit longer than 500 ms irreversible damage occurs (melting of copper and steel) causing the need to replace the damaged equipment, which forces interruptions in business activity. Shortening the duration of a short-circuit is therefore the only effective way to reduce the adverse effects of arcing. It is worth remembering that in traditional overcurrent protections, operating sequentially, the setting times can reach even 2.5 seconds.

In Poland, each year there are several hundred accidents caused by a short circuit in which people are affected. There is no data on the number of short circuits in general. It is obvious that information about such events is not disseminated. It can be predicted that there are several thousand short circuits a year. Here are some examples to illustrate the destructive potential of short circuits.

Open switchgear 15kV, smelter



Short circuit duration: 1,7 seconds

Short circuit current: 10kA

Effects: Completely destroyed three fields. A significant area of a productive nature was without power for more than 24 hours.

Direct losses: Over half a milion PLN

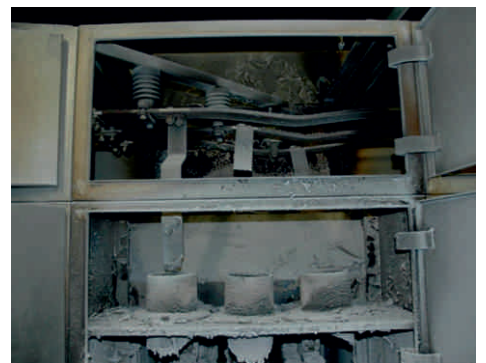
Short circuit duration: 1,4 seconds

Short circuit current: 15kA

Effects: Completely destroyed three fields. Total damage to secondary circuits and partially damaged primary apparatus in two adjacent fields.

Direct losses: Over 300k PLN

Hooded switchgear 6kV, CHP plant



Benefits resulting from application of fiber optic arc protection type ZŁ

ZŁ type protection has been used for 10 years. Over 1000 systems have already been installed. We know many cases in which they have protected devices and the lives of specific people. Wrong type protections identify a short circuit and generate disconnecting impulses to the circuit breakers in less than 10 ms, which with modern circuit breakers allows the power supply to be cut off a short circuit in even less than 30 ms. Thanks to this, the effects of arc shorts are reduced to a minimum, which significantly increases operating safety and reliability.

The requirement of simultaneous appearance of two criteria (light and voltage drop) ensures correct operation of the protection. The short-circuit identification algorithm is very reliable. We do not know of any cases of failure or faulty operation of protections. Below we present selected examples of positive effects of the protection ZŁ.

Open switchgear 15kV, power company



Short circuit duration: 0,04 seconds

Short circuit current: 8kA

Effects: No arcing damage.

Need to replace a broken support insulator.

Direct losses: Several hundred PLN

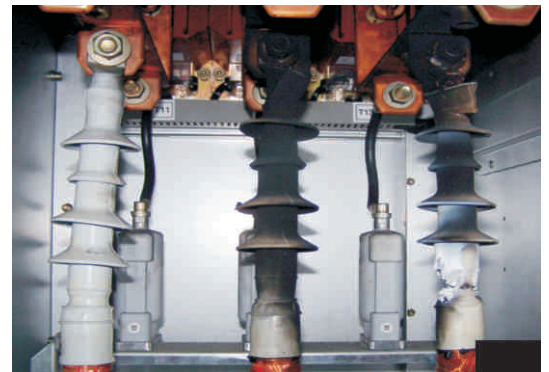
Short circuit duration: 0,05 seconds

Short circuit current: 15kA

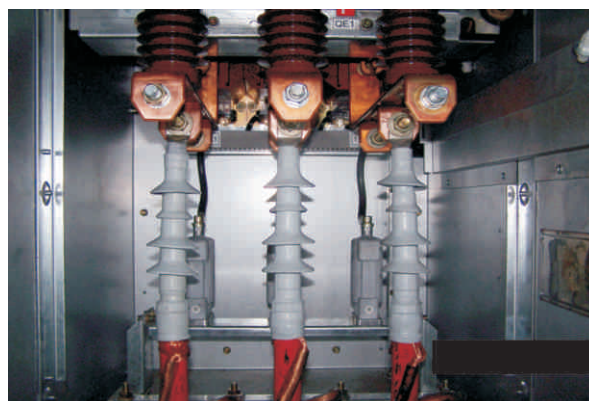
Effects: Damaged cable head on the connection. The walls of the compartment were not even dug in.

Direct losses: Several hundred PLN

Hooded switchgear 6kV, CHP plant



The same switchgear after a repair lasting only a few hours





Standard in arc fault short-circuit protection

Use of independent, dedicated fiber optic Arc protections protect lives and health of operators, increase safety of MV and LV equipment and contribute to reduction of downtime caused by short circuits. Such a solution is becoming a standard in power plants and combined heat and power plants, electric power engineering and industry, wherever human safety, equipment reliability and power supply reliability have the highest priority.

Advantages of ZŁ type protections:

- very short time to generate a shutdown signal (below 10 ms), which determines fast disconnection of a short circuit with time within 30-50 ms,
- selectivity of switching off particular outlets,
- lack of dead/unprotected zones characteristic of current criterion solutions,
- possibility of correct operation of protection in systems of supplying one section of switchgear from several different power supply sources,
- wide range of applications: open and closed switchgears, dry transformers, other electrical equipment such as converters, rectifiers, etc.
- the ability to use bare fiber loops or frontal optical sensors as needed,
- easy installation in old open switchboards,
- the light detection signal reaches the relay via fiber optic cable - no electrical interference,
- low unit cost of protection per field.

The use of ZŁ-type protections provides the opportunity to reduce the amount of the insured premium.

ZŁ safety devices have been tested for compliance with the requirements of relevant standards in certified laboratories.

REFERENCES

Switchgears

The ZŁ protections protect over medium and low voltage 20000 fields in Poland and abroad.

Power plants and CHP plants:

EDF, ENEA Wytwarzanie, ENERGA Wytwarzanie, PGE - Górnictwo i Energetyka Konwencjonalna, PGNIG Termika, Tauron Wytwarzanie

Distribution facilities:

ENEA-Operator, ENERGA-Operator, PGE Dystrybucja, Tauron Dystrybucja

Industry:

Cement,
Chemicals,
Mining,
Steel,
Coke,
Paper,
Petrochemicals.

Foreign:

Russia - Jukos, Lukoil, Salym Petroleum
Ukraine - Refineries and Energy Company
Belarus: Mozyr Refinery
Kazakhstan: Neftgaz
Nigeria: stacje Umuahia and Aloji

Transformers

ZŁ-type protections are used to protect transformers of the following manufacturers: Areva, Żychlin, Tesar Italy, ABB

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