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PROBLEMS OF ENERGY SECTOR AND ENERGY-FUEL MANAGEMENT

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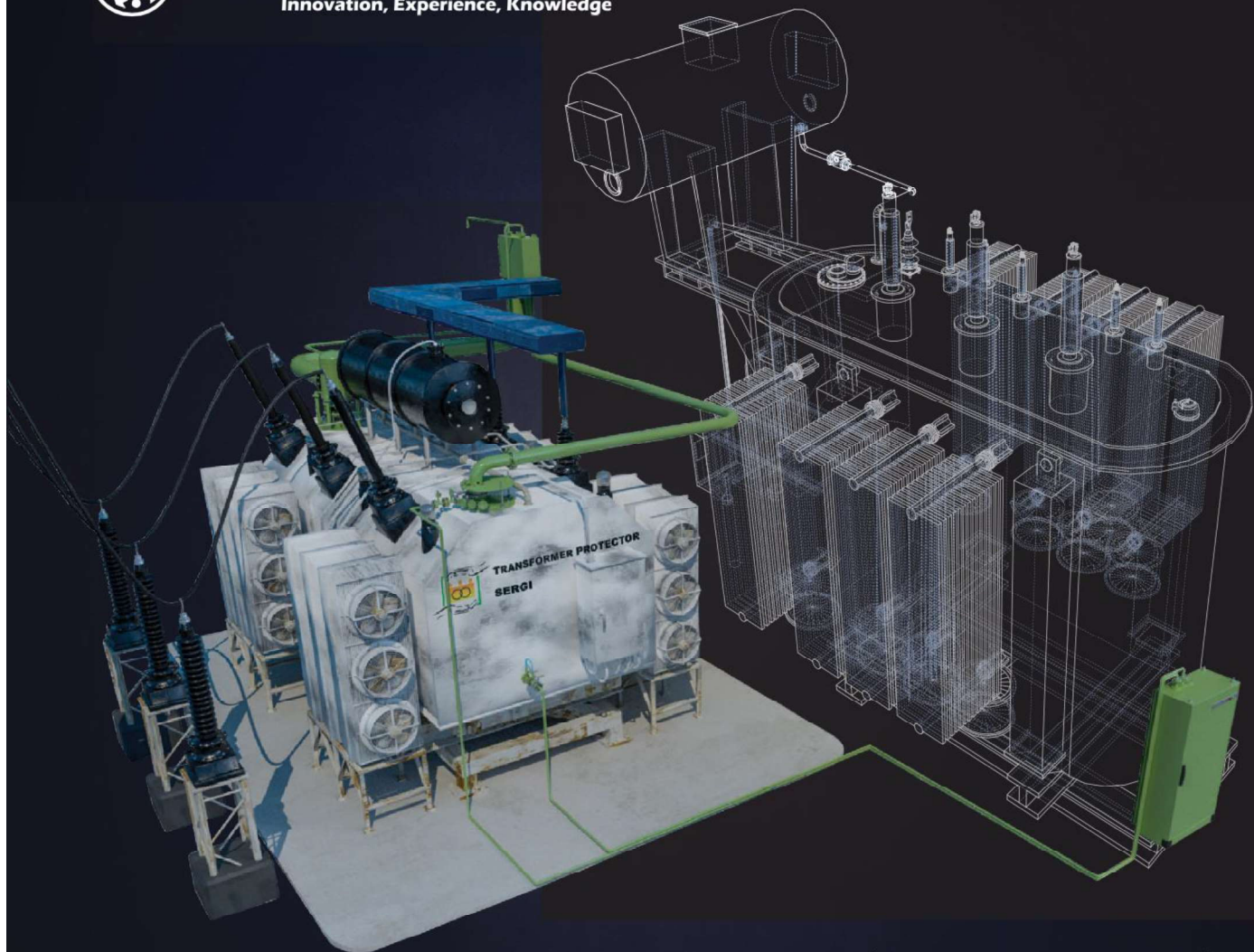
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Sergi Transformer Protector – State-of-the-art transformer safety system

Sergi Transformer Protector – the most modern system for safety of transformer operation

A transformer is one of the most expensive devices for the transmission and distribution of electricity at the desired voltage level. Its widespread use in power grid systems draws attention to the need to ensure failure-free operation. Failures that happen, however, can lead to significant technical, environmental and financial damage. The most dangerous are fires initiated by short circuits inside oil transformers, in extreme cases threatening to burst vats. To prevent this, it is worth using one of the most effective methods for specialized safety automation - Sergi Transformer Protector. It is the most modern system of safety of transformers on the market, which is increasingly popular in Poland.

Keywords: transformer, need to ensure failure-free operation, Sergi Transformer Protector – the most modern system for the safety of transformer operation

Transformers are devices that convert large amounts of energy. It is estimated that they can work for 40 years, or even longer, without any break. However, with such a long and intensive operation of the device, failures can occur. Most often, their direct cause is internal short circuits causing the formation of an electric arc, which evaporates the transformer oil within a few milliseconds. The gas generated in this way causes a dynamic increase in pressure inside the tank, which can cause an explosion. Sergi Transformer Protector (TP) [1-4] is the most effective protection against the explosion of transformer tanks.

It is worth noting that the regulatory gaps and the globalization of the market have caused a worrying decline in the quality of new transformers. Experts predict that their life span will decrease, and the failure rate over the years will increase.

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Transformer protected by Transformer Protector

Safety systems used so far

Experts agree that the basic measures to protect transformers are insufficient. Above all, they do not protect them against explosion. Currently, for example, the Buchholz relay is used, which, according to Polish regulations, should be used in all transformers with a capacity above 1 MVA.

Its main disadvantages include, first of all, the slow activation time - over 100 ms - and the lack of reaction to sharp pressure gradients.

A safety relief valve is also often used.

Unfortunately, it only functions at a low-pressure build-up and is not suitable for arc faults, as pressure relief valves are capable of slow pressure build-up, while the pressure gradients that occur during low-impedance faults are extremely rapid. This is confirmed by the explosions of transformers that were equipped with pressure relief valves.

To prevent the fire from spreading, entrepreneurs very often enclose the transformer stations with walls. However, this is not effective protection, as it only limits the spread of fire, not its occurrence at all. The same problem, in the context of high-power transformers, can be discussed in the case of common water or foam extinguishing installations.

In conclusion, the applied fire extinguishing systems and technical safety measures of transformers are insufficient. They are not able to stop the process of overpressure and its consequences - the bursting of the tank, fire, and spilling of transformer oil to the outside (despite the oil pans used).



A transformer explosion can have very serious consequences

Transformer Protector system A verified, reliable solution

Currently, the most effective device to protect the transformer's tank against bursting is the one made by SERGI Transformer Protector. The company was founded in 1955 in France, and its only representative in Poland is CORONA Serwis. On the Polish market, SERGI Transformer Protector is known primarily as a manufacturer of conservator valves commonly used in transformers. These valves are used to isolate the conservator tank when excessive oil flow is detected and to prevent it from escaping from the conservator when a fire occurs.

In cooperation with SERGI, the independent High Voltage Laboratory CEPEL has conducted experimental studies on the process of transformer explosion and developed a strategy to prevent it. As part of the research, tests and simulations with electric arcs (up to 5.3 m in length) were carried out on industrial transformers with a power of up to 200 MVA.

A protection system in the form of an expansion kit was installed, based on a direct mechanical response to the dynamic pressure inside the tank caused by a short circuit. The tests show that when an electric arc arises in the tank, the surrounding oil quickly evaporates, and the resulting gas is under pressure. The pressure difference created between the gas and the oil causes pressure waves to propagate through the oil. When the first dynamic pressure peak reaches the installed protection system, it activates by rupturing the bursting disc. The excess oil is immediately evacuated, which depressurizes the tank and prevents it from bursting.

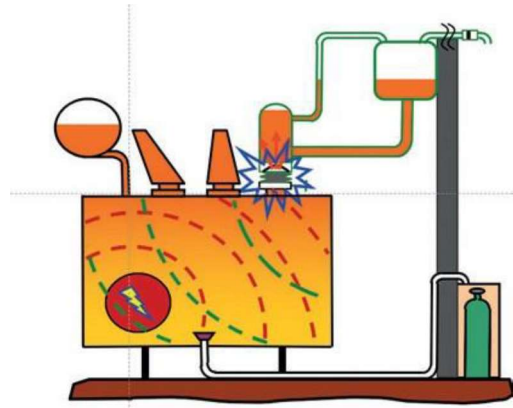


Diagram showing the moment the bursting disc is opened

Tests and simulations have shown that in the event of an electric arc in an unprotected transformer, dynamic pressure waves indirectly increase the static pressure in the tank, leading to its rupture. One simulation showed that in a transformer protected by the TP system, a rapid outflow of oil generates "waves" that cause the entire tank to expand and prevent static pressure from rising. This made the protection considered the most effective form of transformer protection against explosion.



Open rupture disc

SERGI Transformer Protector conducted simulations of the pressure increase in three-phase transformers with a capacity of 166.7 MVA and 363 MVA. On this basis, it was found that transformers that are not equipped with a rapid pressure reduction system during the formation of an electric arc show a sustained increase in the static pressure in the tank, well above the expected safety threshold of 1 bar. The pressure that builds up can cause the tank to break.

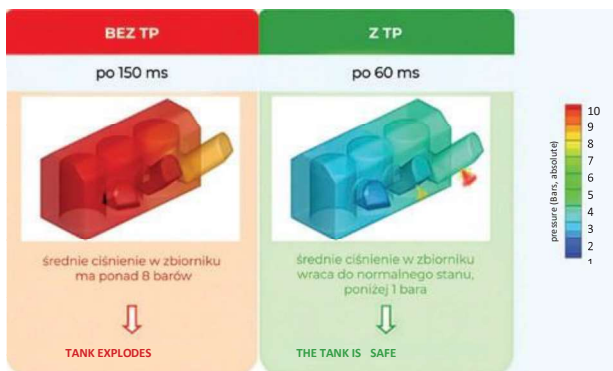


Diagram showing the pressure level in the tank with and without the TP system installed

For the same arc parameters, transformer tanks protected with a quick decompression system showed that the pressure reduction sets were already activated before the full development of the electric arc. Thanks to this, there was no possibility of the tank breaking.

Thus, the transformer's rapid pressure relief system of the Transformer Protector allows for the maximum reduction of the risk of the tank exploding and causing a fire.



TP system installed on transformer

Transformer Protector features

The basis of the Transformer Protector system is the mechanical reaction of the expansion set in relation to the dynamic pressure inside the tank, caused by the resulting electric arc. The system is activated by the first pressure peak before the high static pressure builds up causing the rupture disc to burst. Rapid depressurization of the pressure in the transformer tank by TP is achieved thanks to the use of a safety diaphragm in the decompression chamber. It enables the rapid drainage of oil from the protected transformer through the free cross-section resulting from the deliberate breaking of the bursting disc.

Depending on the position of the arc and the size of the transformer, the TP is activated during the first dynamic pressure peak by a shock wave within 0.5 to 20 milliseconds. The TP is a passive, mechanically activated solution without any actuator.

Moreover, the control panel, after receiving two independent signals from the system, initiates nitrogen injection into the tank. The flow of inert nitrogen disperses the explosive gases, preventing them from coming into contact with oxygen while cooling the transformer. Once the explosive gases are removed, the transformer is safe and ready to hand over for repair.



TP system installed on a wind farm

The Transformer Protector system and the protection of the environment

During many years of transformer operation, the oil inside it is subject to electrical and mechanical stress. It is gradually contaminated as a result of chemical processes due to contact with the windings and its permanent insulations. The chemical composition of such oil is complex and highly toxic. Leaving it outside is therefore very dangerous for the environment (ecosystem, hydrosphere). Transformer Protector effectively protects the transformer against explosion, so there is no question of oil leaking outside.

Additionally, when selecting the appropriate protection for the transformer, its operating costs should also be taken into account. Although the price of the Transformer Protector system itself is higher compared to traditional systems, the operating costs over 40 years (average transformer life) are several times lower. Using the TP system is much more economical. The manufacturer of the device guarantees liability insurance in the amount of EUR 15 million!

Already in 1999, Transformer Protector was registered in the patent office. In 2002, it received a positive assessment from the Électricité de France (EDF), and in 2004 - a certificate from the renowned high-voltage laboratory CEPEL. In 2015, the US Fire Protection Association (NFPA) published standards recommending strict fire protection in power plants and high-voltage substations. The TP is a device that meets the requirements of this standard. The device was also positively assessed in 2020 by the Chamber of Experts of the Coal Basin Division of the Association of Polish Electrical Engineers based in Katowice, as protection recommended for use in oil transformers [6].

Applications and effectiveness of the TP system

There are over three thousand TP systems in operation worldwide, manufactured by 175 different transformer manufacturers. Since 2005, the TP quick decompression system has been covered by the technical specification of 234 companies in 81 countries, almost on all continents.

The effectiveness of the Transformer Protector system was confirmed by the Russian Boguchanskaya power plant (2.997 MW). The protection concerned a three-phase transformer manufactured in 2008 with a rated power of 400 MVA. In 2013, the TP system successfully prevented the dangerous effects of the failure.



Boguchanskaya hydroelectric power plant in Russia

After careful analysis, it was found that the fault was caused by a high-energy arc discharge. The short-circuit energy was approximately 6,586 MJ. A thorough analysis of this incident showed that the first dynamic pressure peak caused by the arc quickly activated the TP. The prepared report showed that switching on the TP allowed the tank to be depressurized very quickly, protecting both the transformer and the power plant against a powerful explosion.

The effectiveness of the system was also confirmed in 2013 at the Salto Santiago power plant in Brazil (250 MVA transformer), in 2016 in Kazakhstan at the Aeroport-Novaya substation (63 MVA transformer), and in the same year in Zambia on one from a substation with a 315 MVA transformer.

In Poland, the Transformer Protector system functions, among others, in the Porąbka Żar pumped storage power plant, using transformers with a rated power of 156 MVA.

Applications of the TP system more and more often include offshore wind farms [5]. An example is the British GWYNT Y MOR farm, consisting of 160 wind turbines with a total capacity of 576 MW, with two transformer units with a capacity of 160 MVA each on two platforms.



The TP system secures more and more transformers, also in Poland

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AUTORYZOWANY PRZEDSTAWICIEL SERGI TP - SYSTEMU
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