Transformers

VOL 4 ISSUE 2 APRIL 2017 MAGAZINE

INTERVIEWS:

Bryan Sayler
Arnaud Magnier

TECHNICAL ARTICLES:

SFRA measurements
Heat recovery
Moisture-equilibrium charts
Cellulose water content

COLUMNS:

Tap-changer know-how
Market review
Condition monitoring
Transformer lifecycle

ISSN 1849-7268 (Digital)
9 771849 331006

iF DESIGN AWARD 2017

Shaping the future of transformers

▪ Winding machines ▪ Accuracy matters ▪ Bypassing a transformer ▪ Rugged fans ▪
▪ Smart maintenance ▪ Silent transformers ▪ CONNEX ▪ INSULutions® STRIP-Flex K ▪

ARNAUD MAGNIER

Vice President at SERGI TRANSFORMER PROTECTOR

The SERGI TRANSFORMER PROTECTOR company

SERGI has its headquarters in France, near Paris. As of today, it is a company of more than 100 employees worldwide, operating two entities in France, one in India, one in Brazil, USA of course, and Peru. SERGI has two manufacturing facilities, one in France and the other in the USA. The U.S. facility was established because of the large SERGI customer base in USA and Mexico. SERGI sells approximately 400 TRANSFORMER PROTECTOR (TP) units per year, averaged over the past three years.

A long journey to the ultimate safety

SERGI was created in the 1950s by Electricité de France (EDF), the French owned electricity generation, transmission and distribution company, which needed a solution for extinguishing fires caused by transformer explosions. At that time, SERGI used to design and manufacture a system called "Drain and Stir" to extinguish transformer fires.

In the beginning of the 1990s, the company decided to invest in preventive technologies to prevent transformer explosions, and thus avoid oil fires. SERGI was a small business of around ten employees then and only few people were dedicated to manufacturing the "Drain and Stir" fire extinguishing system, while the remaining staff were mainly researchers. This solely explains the strong, permanent, outstanding and up-to-date SERGI policy in R&D investments.

In line with this new approach, SERGI started conducting an intensive R&D program in 1995, which led to the first TRANSFORMER PROTECTOR patent application in 1999, and the first TP on-site installation was done in Italy one year later.

In France, EDF implemented the TP for the first time in 2007.

Abundance of simulations and prototyping

To first explain the phenomenon, transformers explode primarily because of internal electrical arcs resulting from failure of electrical insulation. When occurring, electrical arcs immediately generate a large gas volume in the sealed transformer tank. These gases produce a first dynamic pressure peak reflecting inside the tank, creating pressure waves. Within milliseconds, the pressure waves superimpose to create static pressure, meaning that pressures become uniformly applied on the entire tank leading to explosion and fire.

Since 1995 SERGI has been developing its own numerical solvers to simulate the behavior and properties of electrical arcs, the associated gas generation inside transformer oil, first dynamic pressure peak propagation, pressure wave creation and static pressure build-up inside transformer tanks. These investigations allowed SERGI to understand the transformer explosion phenomenon and design the TP to be activated, depending on arc location and transformer size, within 0.5 to 20 milliseconds by the first dynamic pressure peak to avoid transformer explosion before the static pressure increases.

Over time, the SERGI R&D knowledge on these phenomena has improved significantly, thanks to the information gathered during successful TP activations, enabling R&D solvers to steadily improve, resulting in increasingly accurate numerical simulations.

Once the R&D numerical solvers were operational, SERGI decided to perform TP validation tests. These were conducted in two different programs. A first series of 28 live tests was conducted in 2002 at the EDF High Voltage Laboratory, Les Renardières, three years after filing of the patent application.

These 28 live tests were performed on small transformers, but the main objective was to validate the concept only, proving that the

As a manufacturer of the former "Drain and Stir" fire extinguishing system, in the 1990s SERGI invested in R&D to develop an efficient solution to prevent transformer explosions, rather than extinguishing oil fires

With more than 2,800 installations worldwide, SERGI provides the TRANSFORMER PROTECTOR which prevents transformer explosions, and thus fire, accompanied with an additional 15 million euro liability insurance for the end user

TP was functional and depressurizing the transformer before static pressure build-up.

Having validated the concept, the next step was to seek a high voltage laboratory that would accept the ignition of powerful electricals arc inside transformers on live test conditions to observe the TRANSFORMER PROTECTOR behavior. CEPEL, the Brazilian High Voltage Laboratory, accepted the SERGI challenge with electrical arcs energies of up to 2.5 megajoules. Three different transformers were fitted with the TP and 34 live tests were performed, with several levels of arc energies in various transformer tank locations to make sure the TP would prevent transformer explosion without tank deformation.

These two successful test campaigns led to a worldwide recognition since no other company up to now has performed such an extensive program. These live tests became a trigger for utilities and transformer owners to fully protect their transformers and update their technical specifications to include the TP. Therefore, between 2002 and 2017, SERGI can claim that the TP is the sole proven solution to prevent transformer explosion and fire.

Risks of transformer explosion

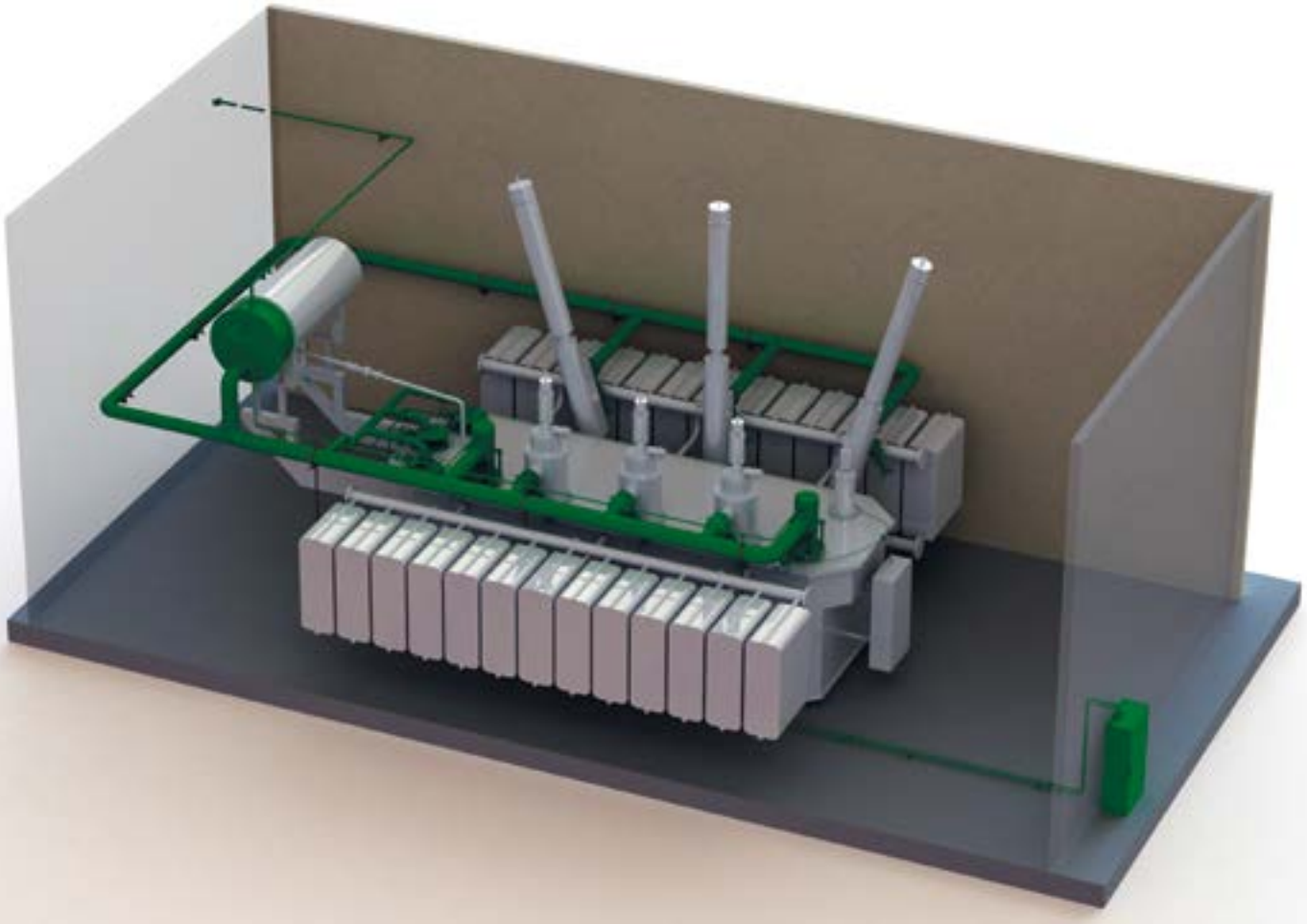
Currently, transformer explosions and fires are common occurrences. An article published by the German Federal Ministry for Nuclear Safety and Nature Conservation states there are two main transformer explosions a day in USA only, (refer to H.P. Berg, N. Fritze, Reliability of Main Transformers, *RT&A* # 01 (20), (Vol.2) March 2011).

There are many negative factors and consequences related to transformer explosions. Some of the main risks are the power outage, complete plant destruction, human injuries and lethal consequences. Recently, there was a case in Nepal where two people died because of a transformer explosion. In another case, ten people died and nearly 200 were injured in Saudi Arabia due to the fire caused by a short circuit involving a transformer. There are hundreds of similar cases.

Environmental issues are another important risk and efforts to avoid pollution caused by the spreading of oil. For example, in USA, a utility was fined several hundred million dollars because of the oil spillage into an adjacent river. Finally, the question of reputation for the utilities is also important; obviously, companies would like to avoid publicity linked to explosions, oil fire and pollution.

In this regard, it is worth mentioning that all TRANSFORMER PROTECTOR units commissioned by SERGI come with a TP lifetime liability insurance of

We help our customers avoid severe consequences relating to transformer explosions, such as a loss of production, human injuries and lethal consequences, environmental pollution, etc.



It is very common that customers approach us following a recommendation from their insurance company

15 million euros. From 500,000 euros when first set, the TP lifetime liability coverage has been multiplied by a factor of 30 over the last ten years because the TP lifetime coverage has never been activated, meaning the TRANSFORMER PROTECTOR has never failed.

As of today, twenty-three TP activations have been reported, which means that these transformers were prevented from explosion and even more critical consequences. Ten cases have occurred over the last three years, and two are very recent, one in Namibia (to be disclosed soon), and the other in Kazakhstan. NamPower, the Namibian utility, has already provided SERGI with a Certificate of Successful Activation. For Kazakhstan, we are yet to receive an official certificate from the end user.

We emphasize that up to now all transformers have been put back to service after a TP activation.

The TRANSFORMER PROTECTOR has a lifetime at least as long as the transformer it is protecting. The requirements for maintenance are based on transformer shut down with the replacement of critical parts scheduled at the same time.

Why do customers come to us?

There are three typical channels for customers to get in touch with SERGI. The most common is following a recommendation from the client's insurance broker. An interesting case is an on-going project in France in the nuclear sector.

Another common case is when SERGI is approached by companies willing to reduce the risk of transformer explosions. For example, we have installed several units at ArcelorMittal's steelworks. According to ArcelorMittal, a transformer explosion leads to a subsequent loss of production, which results in losses of millions of dollars per day. Compared to the TP cost investment, it is obvious that protecting the transformers with the TP is cost-effective.

The third channel appears to be a direct contact with utilities for inclusion of the TP in their technical specifications. In this case, companies usually perform a risk assessment and the most critical transformers are protected first. Obviously, utilities which have experienced transformer explosions are more willing to learn about transformer protection because they are fully aware of all consequences. Customers with such experiences are very interested in learning more about the SERGI research and the TP technology.

What else can SERGI provide?

The SERGI core business philosophy is to continuously develop our understanding and quantification of all phenomena pertaining to electrical arcs inside transformer oil and their consequences on transformer tank rupture. As customers are increasingly aware of SERGI's experience in this domain, the SERGI Research Department (RD) is often called for investigations, mainly by companies which have experienced transformer explosions or own transformer fleets vulnerable to failure. In this case, the SERGI RD simulates the transformer faults and proposes solutions based on Fluid Structure Interaction simulations. Often, these simulations lead to customer technical specification modifications for transformer design and related equipment.

The subsequent SERGI activity is the TRANSFORMER PROTECTOR design and manufacturing. SERGI can also provide supervision and maintenance

SERGI is developing new products similar to the TRANSFORMER PROTECTOR for small transformers

services and, upon client's request, extend to turn-key projects, but SERGI is mainly a research, engineering and manufacturing company.

In a variety of countries around the world, end users susceptible to transformer failures request SERGI to approve the TP position and configuration on their transformers because of the safety the TP provides. Therefore, SERGI uses its R&D numerical solvers to ensure that the provided protection is correctly sized and positioned for each transformer.

The TP positioning and location is decided on a case-to-case basis. When installing the TP on a new transformer, SERGI works directly with transformer manufacturers to select the best sizing and locations. On existing transformers, the configuration is adapted based on the available manholes or openings. For example, in some cases it is not possible to adapt the ideal TP configuration, so this may require installation of additional depressurization sets on transformer to make sure that we can achieve the most reliable solution to ensure that the TP will depressurize the transformer before static pressure increases.

Whenever SERGI deals with configurations never simulated in the past, the Research Department uses "in-house" simulation software to calculate and identify an ideal sizing and configuration for the TP installation. However, having protected more than 2,800 transformers so far, the need for such simulations is much less frequent than before, leading to reduced delivery time.

Future prospects

Currently, the SERGI Research and Development Departments are developing new products similar to the TRANSFORMER PROTECTOR, which are intended for smaller transformers. The current TP design is not very suitable for small transformers. This new product has already been installed in some end user sites and is planned to be launched at a global scale shortly.

In the medium-term, SERGI is looking at expanding and increasing its worldwide network by establishing branches in different countries – for example, in Africa, Middle East, and some Asian countries. Another key of success is to pass the FM Global Certification started by SERGI several years ago. This is a long process due to the lack of standards for transformer protection. Well-known insurance companies can also perform product accreditation.

It is also important to highlight that the TRANSFORMER PROTECTOR concept has been recognized by the National Fire Protection Association and included in the NFPA editions since 2005 as part of their 850 civil codes. This was an important achievement in the last decade.

Biography

Arnaud Magnier joined SERGI in 2006. Previous to joining Sergi, he worked for EADS (the European Aerospace and Defense Group, nowadays Airbus) and AREVA subsidiaries. His background is in engineering.