POWER TRANSFORMERS

TXpand™
A rupture resistant transformer solution
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Reduce risk to increase safety and protect the environment

Standard transformers are extremely rigid and strong structures, but when extreme pressure builds up due to internal failures, in rare cases transformers can rupture, creating severe safety and environmental hazards.

Like crumple zones in modern cars, which protect passengers by absorbing the energy during a crash for controlled damage, increased flexibility can provide the solution.

TXpand™ is a new power transformer solution for rupture resistance, enhancing safety for people and the environment. Transformers containing this technology can literally expand, absorbing energy from faults.

ABB has developed the TXpand™ solution through careful analysis and modeling to make the most rigid areas flexible, the weakest points stronger, and integrating strategic rupture points to take control of the most unpredictable failures.

Safety
In real-life testing, the TXpand™ solution has been demonstrated as capable of absorbing the expansion caused by gases generated during a 20 megajoule arc. Containing the energy safely and preventing a rupture, reducing risk and increasing safety for people in and around power substations.

Environment
Features of TXpand™ design mitigates the consequences of even catastrophic failures.

Further tests have been performed, intended to force the tank to rupture by simulating an extreme arc energy. The TXpand™ demonstrated that a rupture can be controlled; minimizing any oil spilled and predictably channeling what little oil escapes for more easy containment.

Economy
More control and easier containment not only protects people in the area but also protects other valuable assets in a substation.

By preventing damage to other substation equipment, maintenance or replacement of this equipment is minimized and the risk of unplanned and long outages are reduced.
The chance of failure

Although extremely rare, transformer tank rupture is a threat to safety of operators and can lead to major damages.

ABB strives to produce the world’s safest and most reliable transformers. These critical assets are perhaps the component in a power network that work the hardest and have to withstand the highest stresses. As such, when exposed to the most extreme and unexpected conditions in the network, sometimes even these very robust products have a risk to catastrophically fail.

Safety
The absolute top priority is safety. Although substations are normally remote and unmanned, personnel safety is critical.

Environmental concerns
A catastrophic rupture may result in oil spills, causing soil and water contamination and a potential fire hazard with a toxic smoke.

Loss of assets and commercial damage
In additional to the transformer itself, in the event of an especially severe failure there may be collateral damages to surrounding substation equipment.

Unfortunately, such an uncontrolled failure would inevitably result in a loss of revenue and costly cleanup.

Failure statistics
Transformers are extremely reliable, but they run 24 hours a day, 7 days a week for months or even years at a time, often in less than optimal conditions.

These transformers have a lifespan of 40 years, or longer, and a transmission system may have thousands of units. Therefore, failure risk is an important part of network management.

Even so, on average during a one year period, only 1% of transformers might experience a major failure.

Failure with a tank rupture and fire
Extremely severe failures are an even more rare occurrence, with 0.6% resulting in a major oil spill, and 0.1% resulting in a prolonged fire.

None the less, such a failure can have very serious consequences and must be avoided or, if that’s not possible, controlled.

The cause of fire
A fire requires three elements:
- Oxygen
- Heat
- Fuel

A transformer fault and rupture can introduce these element. However, by preventing a rupture, oxygen is eliminated and a fire will be avoided.

Design and simulation

The desired strength and flexibility combination is achieved by advanced engineering simulations, material selection and a precise manufacturing process.

**Design**
The TXpand™ solution comprises of multiple design features and components carefully selected in order to resist ruptures caused by specified failures.

A major element of the TXpand™ solution is the transformer tank design. Flexibility is introduced to absorb the expansion of gases produced during internal arcing. This concept has been developed and tested for core form transformers. However, the same principles can be used for other designs; shell type, specialty and industrial units, including our offshore wind transformers, plus instrument transformers.

To take control of the most serious failures that exceed even the TXpand™ safety-margins, rupture points are designed at the tank-to-cover weld. This makes a typically uncontrolled potential rupture predictable, safer and minimizes the potential oil leakage.

**Simulation**
This design and transformer specification is the result of sophisticated simulations based on decades of experience in transformer development.

Part of this simulation incorporated finite element analysis (FEA). Including nonlinear material properties, large deflection, proper element type and mesh size in the FEA ensured the reliability and accuracy of the results.

Additionally stress, strain and displacement results are carefully analyzed by an experienced expert engineer.

Of course, the FEA results have also been validated in multiple, real-world laboratory tests.
Testing and validation

TXpand™ has been developed and validated in a close collaboration with the global utility manager and power systems experts, Hydro-Québec.

This almost 5 meters long and over 4 meters tall test-transformer was injected with air pressurized to 20 MPa (~3000 pounds per square inch). The air simulated the gases that would be produced during a severe internal arc of 20 megajoules.

The results of these tests verified the numerical simulations and demonstrated that the TXpand™ solution was capable of resisting ruptures that, in a normal transformer could result in a catastrophic failure.

The cross-company team allowed the execution of this ambitious project in a short period of time and enabled these full-scale tests to be a complete success.

This collaborative research and development enabled the creation of a robust transformer specification that became TXpand™.

“Rupture resistant transformer tank is among the most important feature that Hydro-Québec implemented in the last 10 years.

The collaboration between Hydro-Québec and ABB facilitated the development of this specification.

The importance to have a manufacturer involved is to be sure that our specification is applicable and feasible.”

Claude Rajotte
Engineer, Chief - Studies and Normalization
Hydro-Québec-TransEnergie
References

Proven design and production experience with 50 designs and 90 units delivered.

Our rupture resistant transformer solutions, now known as TXpand™, have been in the field for over 6 years. Primarily in the North America region, driven by our partnership with Hydro-Québec, but also in Europe and Asia.