



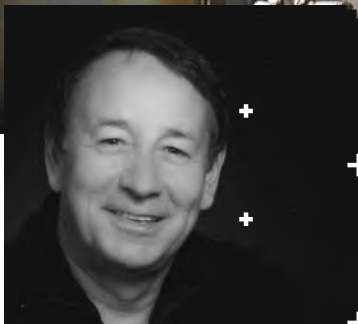
Electric Substation Large Power Equipment: Cost Effective Methods for Repairing Oil and Gas Leaks

by **Steven H. Wickman**

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To keep in tune with the theme of the last edition of *Transformer Technology*, a large, oil-filled power transformer is definitely the heart of the power system. Even with the advances in the technology of other insulating media, the large oil-filled transformer is still the tried-and-true major component of the transmission-type electric substation, as well as the sub-transmission and distribution substations. Many transformers still in service today were built in the slide-rule era designed by engineers with a built-to-last mentality. Thus, there are many older oil-filled transformers still out there throughout the world. Although they were built to last, they have their share of old age issues coming to bear. One of the greatest issues is oil leaks. Gaskets on bushings, radiator flanges, pumps, piping, etc. are deteriorating and leaking.

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Figure 1. Evidence of oil running down the sides of a large power transformer creates a negative perception of the utility's maintenance program.

According to literature, it is not uncommon for a transformer operating at higher temperatures to develop leaks from gasket failure after about 10 to 12 years in service. However, transformers are typically expected to remain in service much longer than this. Thus, sometime during the operating life of the transformer, the unit is going to experience deteriorated gaskets and subsequent oil leaks. If oil is leaking out, there is a risk of moisture and air being drawn in via capillary action, compromising the transformer oil insulating qualities.

The classic repair technique is to regasket the transformer, which entails taking the transformer out of service and draining the oil – usually thousands of gallons, removing radiators, removing bushings, and so on.

All these steps keeping your transformer out of service for weeks, and utilizing large substation crews, cranes, tankers, vacuum fill-oil processing trailers and similar can be a costly endeavor. Today's electric utility management is monitoring expenses closely. Transmission operations are wheeling power from

far-away generation sources to the local utility distribution load centers. Outages on transmission equipment are closely scheduled and lengthy outages are not granted on short notice for emergent repairs. The Operations people are coming to the Maintenance people asking for other solutions to address these oil leak repairs. The U.S. EPA Spill Prevention, Control, and Countermeasure (SPCC) Regulations (40CFR112) contains stringent requirements for electric utilities to monitor their equipment to prevent oil discharges off their substation properties. Even slight oil leaks, creating stains down the sides of transformers and oil circuit breakers, create a negative perception to the general public that the utility is not maintaining their equipment to a high standard of reliability (Figure 1).

There is a viable alternative solution to the oil leak correction problems on electric utility equipment. A technique for replacing failed and leaking gaskets in transformers is available through online leak seal technique.

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Consistency

Drill and Inject Technique

There are two techniques prevalent amongst the leak-sealing specialists. The first of these is a Drill and Inject technique whereby the leak seal technicians are able to drill access holes to the gasket groove and inject, under pressure, a sealant compound, essentially creating a new gasket without disassembly of the transformer to access the gasket groove (Figure 2).

Then pipe plugs are inserted to contain the sealant under pressure while it cures. The sealant is injected in a fluid, liquid state that has a consistency similar to honey or pancake syrup, to use an easily understood analogy.

The sealant cures into a flexible material that has durometric properties essentially identical to those of OEM nitrile rubber gaskets. The life cycle of the leak seal installed gasket material is essentially the same as OEM gaskets. Thus, with the leak seal repair technique you get the same result as regasketing without all the extra time, labor, and expense of a drain and regasket repair. Additionally, many Drill and Inject repairs, particularly if the leaks being addressed are on piping flanges at the lower end of radiators, away from

the energized components, can be performed with the transformer still in service carrying load (Figure 3).

Online leak seal techniques for replacing failed and leaking gaskets offer a viable alternative solution to regasketing, as they don't require taking the transformer out of service and draining the oil.

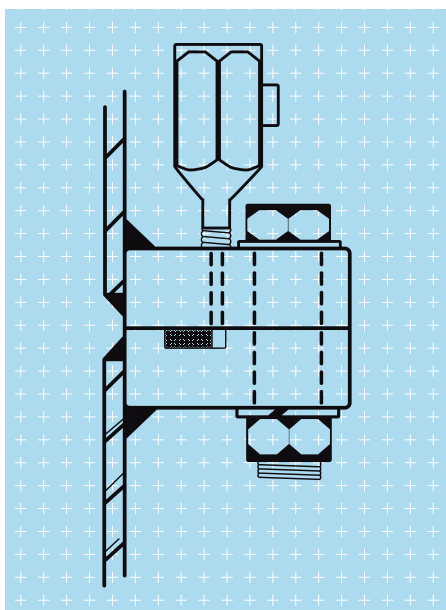


Figure 2. Drill and Inject technique. Left: A graphical sketch depicting how the injection valve is drilled into the gasket groove to inject the liquid sealant material and effectively replace the failed gasket material. Right: Injection valve with sealant injection hose.

Lastly, with this minimally invasive repair technique, it can be a viable option to only address the existing leaking components as opposed to doing a complete drain and regasket of the entire unit.

Some flanges on oil-filled apparatus cannot be repaired by the Drill and Inject technique. Open-faced flanges, where there is not a recessed gasket groove, require an alternative repair technique, which is to apply a custom fabricated aluminum clamp externally around the leaking flange. This clamp, measured and fabricated to the precise dimensions of the flange, is put in place and has an internal groove that is filled with the

same leak seal sealant to create, in essence, an external gasket around the leaking component. This leak repair technique works effectively on virtually any flange that cannot be drilled and injected (Figure 4).



Figure 4. Top left: Open face flange and butterfly valve. This configuration will not support the Drill and Inject technique. Top: A three-part clamp butterfly valve. Bottom: A three-part clamp butterfly valve installed.

In addition to open-faced flanges, this technique has been used on flanges on pumps, fault pressure relays, access hatches, bushing flanges and bushing turrets (Figure 5).

Again, no draining of oil, disassembly of components or outage are needed, unless it is required for safe work clearance for the technicians performing the work. Outages, if needed, will only be for the duration of the work, and for some cure time. Typically, the apparatus is returned to service the next day after the repair is performed.

If the leaking component is in close proximity to the energized conductors and the application of an aluminum clamp may compromise electrical clearances, an external clamp can be precision fabricated of PVC material

Figure 3. Drill and Inject technique: Online leak seal

with an internal cavity filled with the leak seal material. This repair has been commonly performed on CT lead through bushings into transformer main tanks as well as around low voltage bushings [480 V and below] on distribution transformers with limited clearance between the phases.

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Other Unique Repairs

In addition to the common piping flange leaks and those that have been mentioned above, there are other unique repairs that can be performed with this leak seal technique:

- Radiator fin leaks — application of an external clamp
- NLTC operating rod penetration; failure of the packing/bushing around this rod — external clamp
- Large open-faced flanges between sections of transformer tanks, such as the flange between the main tank and an LTC compartment
- Interface in bushings between porcelain and steel flange — often there is a gasket in a bushing between the porcelain insulating column and the bushing base. This gasket can fail and leak oil. The solution is to fabricate



Figure 5. Top left: Clamp installed on transformer oil pump. Top right: Clamp installed around a top-mounted sudden pressure relay leaking oil at its mounting flange. Bottom left: Clamp being installed on the flange of a transformer access hatch. Bottom right: Transformer bushing turret clamp.

a clamp filled with sealant to enclose on this interface surface.

This technique is also the most common solution for addressing leaks in SF6 filled CB bushings.

Properties of the Leak Seal Compound

For all leak seal repairs performed on electrical substation apparatus, only one type of leak seal compound is used, regardless if the device is a transformer, oil circuit breaker (OCB) or gas circuit breaker (GCB). The leak seal material will not adversely react with transformer oil, nitrogen gas used in a transformer blanket, nor OCB oil or SF6 gas. When fully cured, the leak seal compound is always soft and flexible, and it feels and behaves the same as OEM

nitrile rubber gasket material. The cured compound material does not adhere to the internal surfaces of a gasket groove, nor to the internal cavity of an external clamp. Thus, if the leak seal repaired flange requires disassembly for other repairs of the apparatus, the cured leak seal compound can be easily peeled away with a simple tool, even a pocket knife (Figure 6).

If it is necessary, sometime after the repair is completed, to disassemble the component, upon reassembly of the flange either a new OEM gasket can be put in place of the removed leak seal compound, or, in the case of a repair with an external clamp, the leak seal technicians can be called back to reinject the clamp with new leak seal compound, restoring the leak to its repaired state.

A skilled high-pressure leak seal technician is not necessarily best skilled for the low-pressure technique and is potentially not going to do the best repair.

Thus, a firm that specializes in the low-pressure electric equipment repair technique is most likely to perform a successful leak seal repair.

Oil Circuit Breakers

Oil Circuit Breakers (OCBs) have flanges, bushings and valves that are very similar to those found on large power transformers, thus, the same repair techniques can be applied to them. The most common repair is to address failed gaskets in HV OCB bushings at the interface between the porcelain and steel flange at the base of these bushings.

This leak is so common that the leak seal firms have made aluminum castings of this specific clamp that is fine-tuned by machining to tailor it to the specific bushing. This cast clamp is more economical to fabricate in multiple quantities than machining a unique clamp from a block of aluminum for each application.

SF6 Gas Circuit Breakers

Gas Circuit Breakers (GCBs) have multiple flanges on bushings and other components that are ideal candidates for leak seal repairs via the external clamp repair technique (Figure 7).



Figure 6. Left: Portion of clamp removed showing cured sealant. Top: Same repair, sealant cut away showing its flexibility.

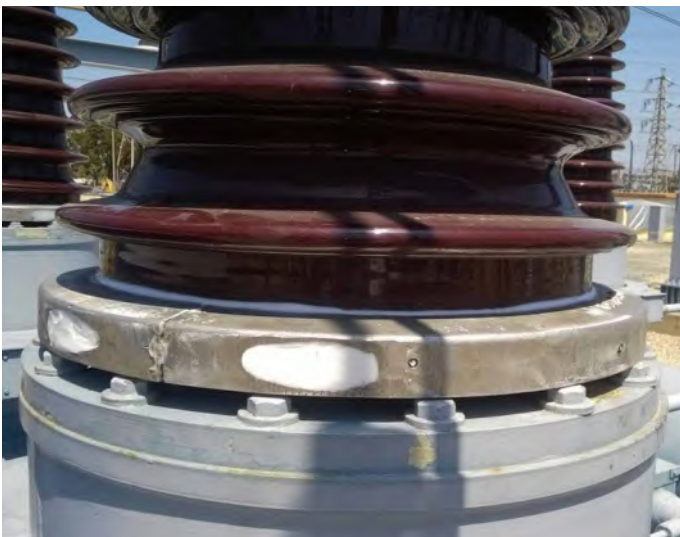


Figure 7. Left: Clamp on an EHV GCB bushing base. Right: Clamp enclosing on the end bell flange of an EHV GCB interrupter tank.



Additionally, leaks in instrument/ metering tubing, where threaded fittings are used, can be repaired with external clamps. As in the case with transformers, to perform complete regasket overhauls on large EHV GCBs, an extended outage with degassing of the GCB and opening up all components is required, as well as the testing and adjusting of the GCB mechanism upon completion of the leak repairs, all of which is time and labor intensive, and costly.

With these leak seal techniques, no disassembly or full gas removal is necessary. Outages are necessary only for the duration of the work and post repair leak testing the next day to assure all leaks have been corrected.

Today, there are only a few leak-sealing contractors still performing the low-pressure repair technique in the North American continent, and only one firm that specializes in only low-pressure leak-sealing technique exclusively on electric substation equipment.

History of Online Leak Seal Repairs

This repair technique is something that was derived from the traditional high pressure leak sealing that has been performed for many years on high pressure piping in power

generation plants, refineries, and other chemical processing plants. In 1988 one of the established high pressure leak-sealing specialists was approached by a U.S. electric utility's senior equipment specialist in their Substation Services Group and asked if it was possible to apply the high-pressure leak seal techniques to repairing transformer oil leaks. The utility equipment engineer worked with the leak seal specialist to develop the low-pressure leak seal technique and the Substation Leak Seal Services, as we know it today, was born. This low-pressure technique was further developed and performed by several leak-sealing contractors around the country. Today, there are only a few leak-sealing contractors still performing this repair technique in the North American continent, and only one firm that specializes in only low-pressure leak-sealing technique exclusively on electric substation equipment. A skilled high-pressure leak seal technician is not necessarily best skilled for this low-pressure technique and is potentially not going to do the best repair. Thus, a firm that specializes in the low-pressure electric equipment repair technique is most likely to perform a successful leak seal repair.

The ability to address maintenance issues such as oil and SF6 leaks in a quick and short outage manner will always be a major benefit, so the online leak sealing repair technique will most likely be a popular option.

Future of Online Leak Sealing

Large power transformers and EHV circuit breakers are going to continue to be the heart of the electric utility grid. As sources of generation evolve perhaps away from large central power plants to more widely distributed wind and solar farms, the need for a reliable transmission grid will be as important as ever. Plus, the ability to get extended outages for major overhaul of the apparatus will be ever challenged. The ability to address maintenance issues such as oil and SF6 leaks in a quick and short outage manner will be of major benefit. This author predicts that this repair technique will be a popular option. In addition, the leak-sealing specialists are embracing new technologies such as modeling clamp design on 3D printers to test-fit a new clamp prior to fabrication in aluminum to assure proper fit. Also, these technicians are exploring the use of portable scanning devices to measure leaking flanges and fittings from a safe distance for clamps, without getting an electrical outage for the measurement phase of the repair. These new technologies will be beneficial in adding to the success of this leak repair technique.

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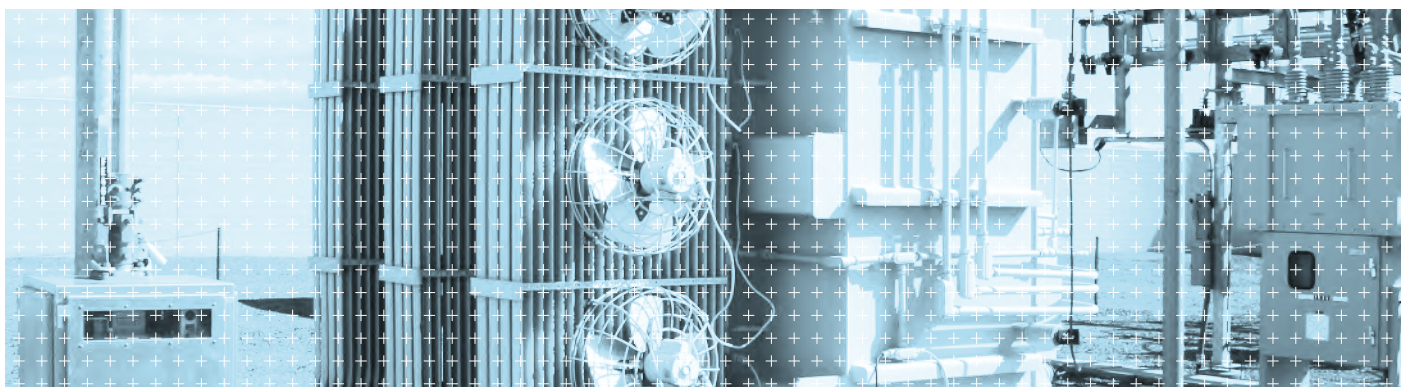


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