FR3™ ENVIROTEMP™ NATURAL ESTER FLUID

Technical Perspectives

Potential benefits of Envirotemp™ FR3™ fluid filled transformers expanded capability for a LV system design.

Typical low voltage (LV) systems in the USA (Canada) apply transformers having a 480V (600V) secondary voltage. For those systems, equipment utilizations are at 460V (575V) respectively. Typical industrial or commercial facilities at 480V (600V) apply 4000A - ANSI (3200A - IEC) main bus LV switchgear. These main bus capacities are a perfect match for mineral oil filled transformers rated 2500kVA (OA)/3125k-VA (FA). When the insulating liquid is Envirotemp™ FR3™ some new possibilities are created.

An important facility will have two transformers feeding into a main-tie-main (MTM) switchgear, a typical (N-1) configuration. Figure 1 is an example. With both transformers in operation, they will be 50% loaded. The loss of a single MV-LV power transformer will still carry the entire facility after tie-breaker closing.

Design Considerations

- Employee safety. Arc flash calculation based on IEEE's 1584-2018 standard will show substantial risk levels at the LV main bus.
- Even though the transformers are operated at 50% loading, the no-load losses (NLL) are unchanged. The NLL are based on excitation and are independent of actual kVA loading.

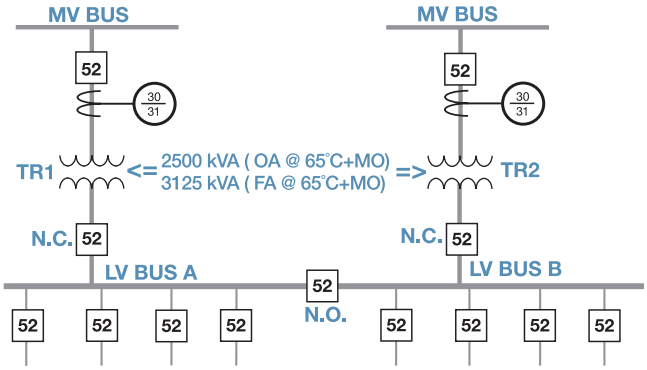

Figure 1 - Single-line diagram of a LV power system.
Note: 52 is a power circuit breaker and 50/51 are protective relays

Alternate Design

The 3125kVA top rating in the above example is a 25% increase over the base rating through the use of one stage of fans for traditional mineral oil units having conductors insulated with thermally upgraded kraft (TUK) paper.

An alternate solution that could be considered is as follows. A transformer filled with FR3 fluid and using TUK paper solid insulation may operate at 20°C higher temperature without reducing the transformer life expectancy. This is estimated to allow 20% additional kVA capacity, reaching 3750kVA. Instead, let's apply a 2000kVA base FR3 fluid filled unit, reaching 2000 kVA * 1.25 * 1.2 = 3000 kVA, (3600A@480V; 2887A@600V), as in Figure 2.

The 3000kVA capacity is reached with the same number of fans, but increasing the average winding rise to 85°C, as per the thermal class of 140 for TUK paper in FR3 fluid.

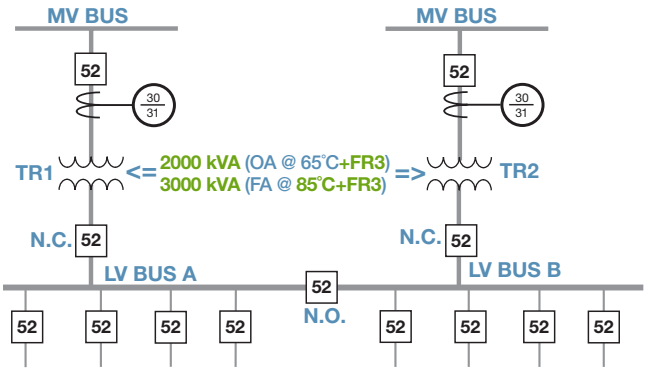

Figure 2 - Single-line diagram of a LV power system modified for exploring the additional capability of FR3 filled transformers

Safety and operational improvements

• Arc flash energy calculations are a linear function based on the short circuit levels on the transformer base rating. Since kVA base rating is 20% lower, the short circuit current will also be reduced. Therefore, the arc flash energy levels will decrease by 20% when assuming the same transformer base %Z.

• The no-load losses (NLL) may decrease by up to 20% resulting in operational energy savings.

• The reduction of the base rated capacity of the transformers may lead to more compact units and bring economic savings.

• Those 50/51 protective relays are microprocessor types (50, instantaneous; 51, time overcurrent). With both transformers active there would be no need to have the 51 function's amp pickup setting at the full 3000kVA rating. It can be set at a lower value closer to normal loading of 1500kVA (approx.). **This improves the system in two ways:** lowers the arc flash energy levels; improves system stability by faster response to faults due to the tighter protection. Upon a N-1 transformer event, the relay can switch to its alternate settings group at the 3000kVA loading level. This relay philosophy may also be applied to the LV protective relays on the main breakers.

• Depending upon impedance (%Z) and motor contribution, the LV switchgear's capital cost may be lower.

• There may be no need for fire walls between transformers or fire suppression equipment releasing station real estate for other purposes. These transformers may also now be placed closer to a commercial building's outside walls.

• Envirotemp™ FR3™ fluid represents 56x less carbon emissions than mineral oil.

• FR3 fluid has a fire point of 360°C compared to mineral oil at 160°C. By being a K-class, FM Approved liquid, Envirotemp FR3 helps mitigate the risk of fire, with a history of zero fires after 20+ years in commercial operation and filling more than 2 million transformers in service around the globe.

Considerations

The transformer primary may be protected by medium voltage Current Limiting Fuses (CLF) and not power circuit breakers with microprocessor relays. Figure 3 shows this alternate configuration.

Those "E" CLFs may not be able to simultaneously: protect the transformer from mechanical damage (per ANSI C57.109); not melt on transformer energization inrush; and also carry that 3000kVA loading without premature melting. Discuss your particular application with the CLF's OEM. CLF style and/or TCC (fuse performance curve) may have to change.

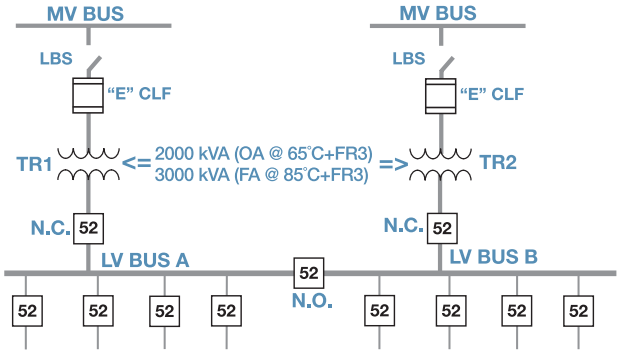

Figure 3 - Single-line diagram of a LV power system modified for exploring the additional capability of FR3 fluid-filled transformers including the "E" CLF.

Since the per unit impedance is higher, voltage regulation needs to be load flow analyzed and planned for. If voltage regulation is determined to be an issue, one possible solution is to specify a lower %Z during the transformer procurement phase. But this change could negate some of the above listed operational improvements. Users and engineering firms would have to come to common agreement.

Cargill's technical team is ready to tailor this concept to your installation and make the most of this advantage.

Contact us - envirotempfluids.com

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