Technical Perspectives

ENVIROTEMP™ NATURAL ESTER FLUID

Potential benefits of Envirotemp™ FR3™ fluid filled transformers expanded capability for a MV substation design.

A hypothetical electrical public utility needs to establish a Medium Voltage (MV) substation to feed a city's center 100MVA load. Distribution will be from 13.8kV to 480V (LV networked) all fed from a 138kV (N-1) transformer network. Two of the system requirements are:

- The loss of a single HV-MV power transformer shall still allow the system to carry the entire 100MVAload without customer interruption. Hence the (N-1) design.
- The existing downstream 15kV distribution system has a short circuit withstand limit of 25kA, i.e., the 15kV substation shall not permit greater than 25kA to flow to downstream connected equipment.

Three (3) 30/50MVA mineral oil (MO) filled transformers were selected. Operational options:

A. With three 30/50MVA paralleledtransformers, having 15% impedance, the f ault availability is 25,100A (approx.). This exceeds requirement #2.

B. The impedance could be increased to16% reducing the fault availability to 23,533A, but voltage regulation could be an issue. This increases the exercising ofthe transformer's on-load tap changer and/or the need for 15kV VAR support via switched capacitor banks.

The planned 15kV network design is shown in Figure 1.

Option A was selected keeping TR3 as a hot standby spare (low side main breaker normally open) in case of the unplanned loss of either TR1 or TR2. TR3 can be placed into active service via fast breaker control logic. All main bus ties are operated normally closed (NC). With two paralleled transformers, the main bus fault availability is limited to 16,733kA (approx.) based on 15% impedance.

There are two weaknesses with this planned design:

1. During load fluctuations, the 15% impedance may cause premature maintenance costs for the transformer's OLTC trying to regulate the main bus voltage within desired tolerances.

2. The fast breaker control logic between sources will cause a temporary main bus voltage dip when a single transformer carries that 100MVA. This may be unacceptable.

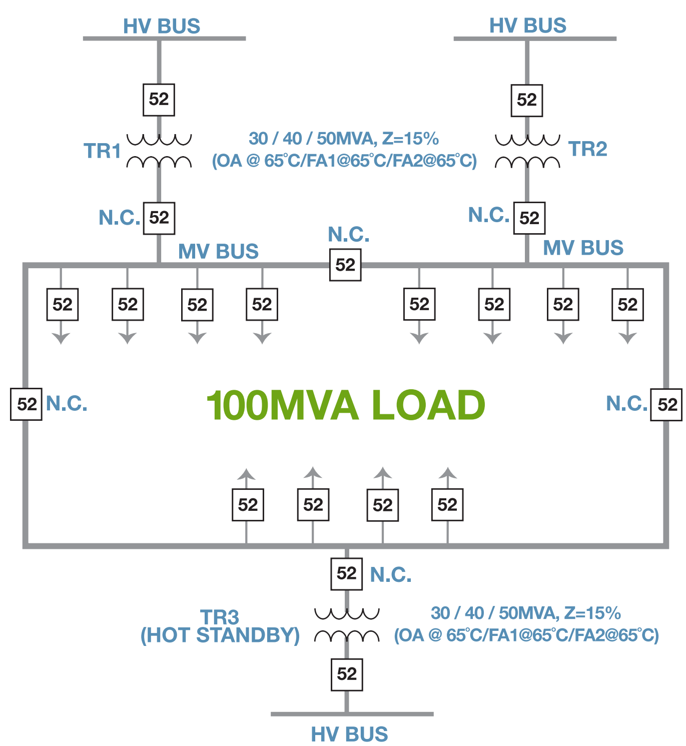

Figure 1 - Single-line diagram of a power system.

Alternate Design

An alternate solution should be considered, exploring the enhanced capability of FR3™ fluid filled transformers.

This is presented in Figure 2.

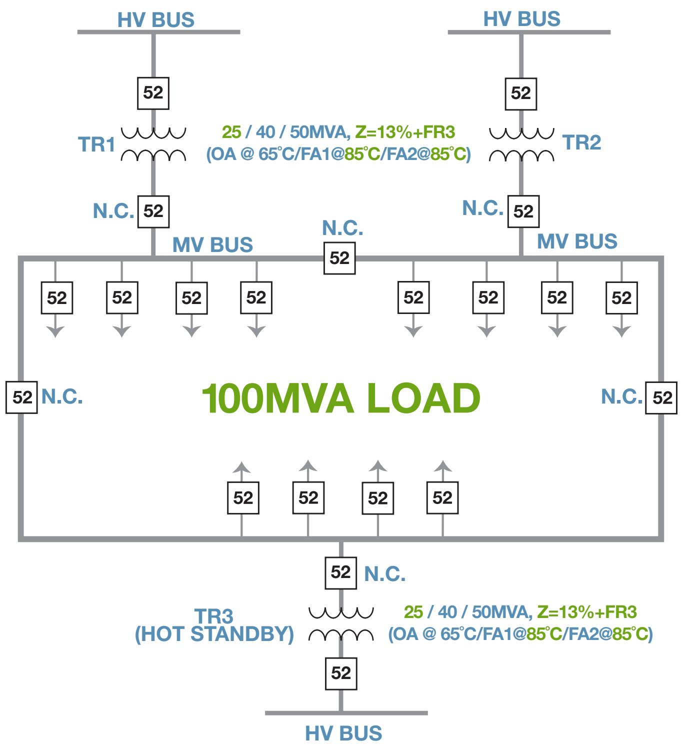

Figure 2 - Single-line diagram of a power system modified for exploring the additional capability of FR3™ fluid filled transformers. Note: 52 is a power circuit breaker

Alternative FR3™ fluid-filled units solution benefits

Apply three (3) 25/50MVA, FR3 filled transformers which may take advantage of the increased thermal class of the TUK paper immersed in natural ester liquids for the highest rated capacity. The base transformer capacity OA (which should be renamed to KNAN) has been reduced from 30MVA to 25MVA, rated at the conventional temperature rise limits.

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This also allows reducing transformers' impedance to 13%Z. With the reduction in impedance, it is now possible to operate all the MV breakers in a normally closed position without exceeding the 25kA limit of the downstream equipment.

This provides the following advantages.

- Operating with all mains and tiebreakers closed permits bounceless transfer between sources during an unplanned (N-1) event, resulting in improved customer reliability.
- Fast breaker control logic is not needed; engineering design hours can be saved.
- The smaller base core transformer keeps the fault availability limited to 24,137A (approx.) within the downstream fed equipment capability.
- Transformers may be physically smaller releasing substation real estate for other purposes. The cost of the transformers may also be reduced.
- No need for fire walls between transformers or fire suppression equipment further releasing substation real estate for other purposes.
- Simplified containment system, due to using a biodegradable k-class insulating liquid.
- The MV switchgear remains unchanged (main bus ampacity and kA I.C.) from initial proposed Figure 1.
- Potential reductions in the total occupied area and cost of the substation.

Considerations

The proposed alternative solution using Envirotemp FR3 is expected to bring effective advantages, while voltage regulation needs to be load flow analyzed and planned for.

Cargill's technical team is ready to help your company make the most of this advantage.