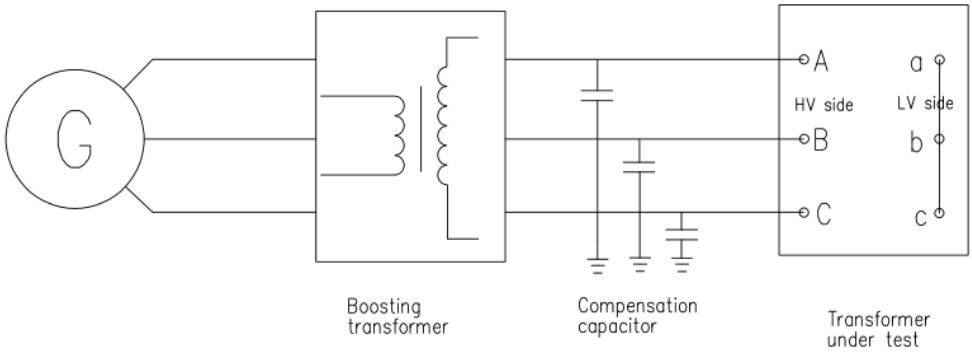
Dry Type Transformer Temperature Rise Test



| Main Points

Temperature rise is an important factor which decides transformer safe operation and useful life span under normal service condition.

Transformer temperature rise includes both increments $\Delta\theta$ which is caused by no-load losses and load losses. No-load losses do not vary with its loading. Load losses vary with the loading on the transformer.

Transformer temperature rise is power frequency test. A three-phase supply shall be used for the temperature rise test on three-phase transformers.

Transformer temperature rise is measured by their windings temperature increments, includes HV and LV windings; Windings temperature increments are conducted with a special three-phase transformer ohmmeter which is used to measure HV and LV resistances simultaneously;

Compared to oil transformers, dry-type transformer has low thermal conductivity. To get the most cost-effective dry transformer for their applications, now more and more purchasers require to put temperature rise test into their FAT list, especially for large capacity of dry-type transformers.

| Compliance with Standards:

IEC60076-11:2018, Power transformers-Part 11: Dry-type transformers

IEC60076-2: 2011, Power transformers-Part 2: Temperature rise for liquid-immerged transformers

| Test Methods

As per IEC 60076-11:2018 clause 14.3.2.2, three methods as below could be used for temperature rise test of dry-type transformers.

-Simulated load;

-Back-to- back;

-Direct loading;

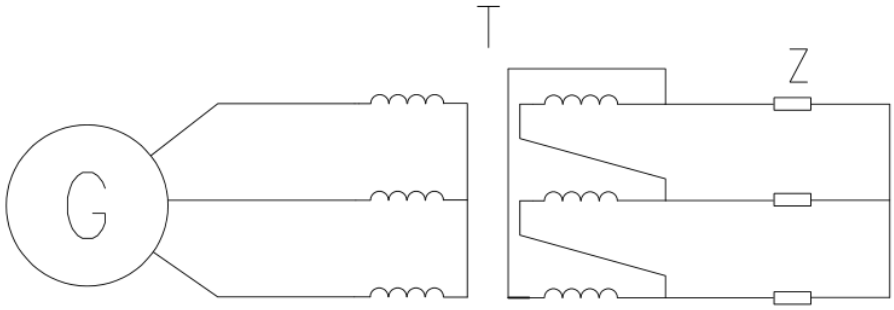
These methods are applicable for enclosed or non-enclosed or totally enclosed dry-type transformers with natural air or forced air cooling or water force cooling.

Since Back-to-back method and Direct loading method are not possible always. Actually,

Simulated load method is widely to executed temperature rise test around the world.

| Direct loading method

This method is only applicable for small transformers due to the limitation of the test laboratory power. Besides, direct loading method requires one appropriate load so that tested transformer could output its rated current. It is not easy also.



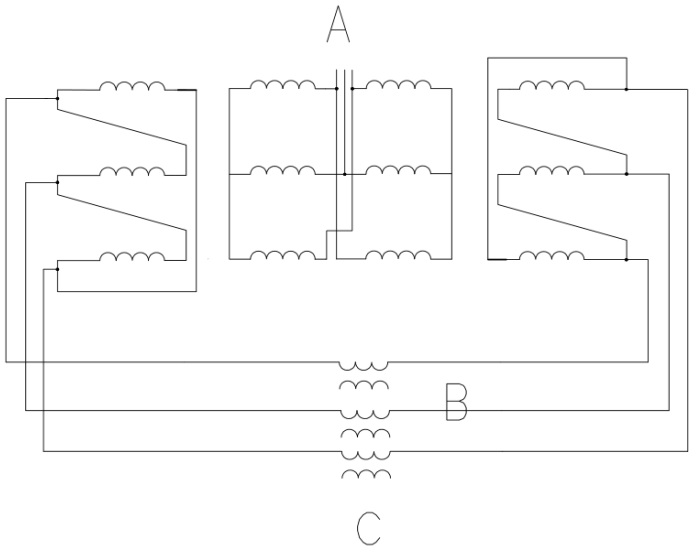
T: Transformer under test

Z: Direct load

Figure 1-Example of direct loading method-Three-phase

| Back-to-back method:

To conduct back-to back test when there are two suitable transformers and two necessary sources is available.



A Voltage source at rated frequency for no-load losses

B Source for rated current at rated frequency for load losses

C Booster transformer

Figure 2-Example of back-to-back method-Three-phase

| Simulated load method

This method is established by combing the short-circuited test(load loss) and the open circuit test(no-load loss). Since no-load and load losses are performed separately, only one source is necessary. Simulated load method, is greatly simplified temperature rise test of dry-type transformers.

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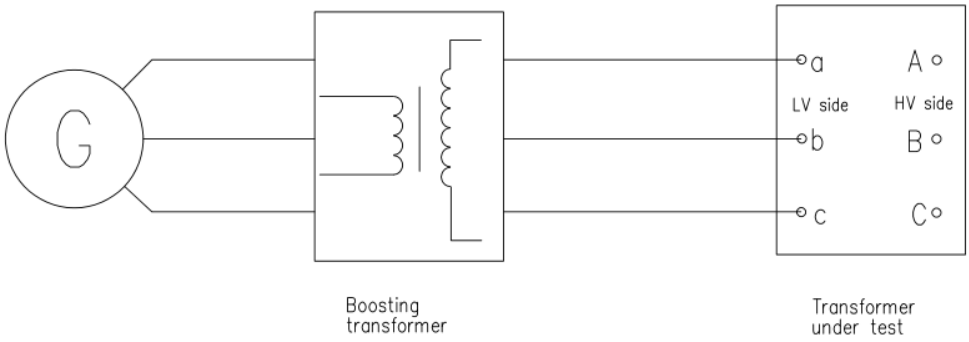


Figure 3-No-load example of simulated load method-Three-phase

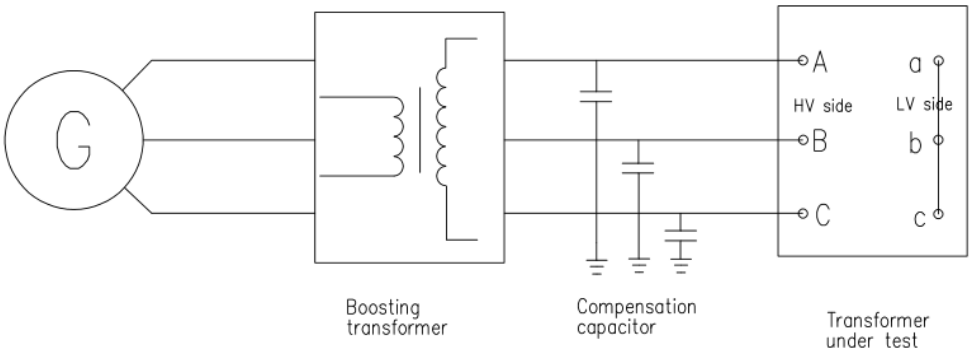


Figure 4- load losses example of simulated load method-Three-phase

The test procedure shall be performed in two steps in any sequence:

-the winding short-circuited test is carried out until stabilization of the core and the winding temperature;

-the open-circuit test is carried out until stabilization of the core and the winding temperature;

The test can be switched off when the transformer has reached a steady state condition". According to IEC 60076-11:2018 (clause 14.3.2.4) stabilization of the core and the winding temperature; means,does not exceed more than 1 K per hour.

The total winding temperature rise , Δ θ'c of each winding, with rated current in the winding and normal excitation of the core, is calculated by the following formula:

$$\Delta\theta'_c = \Delta\theta_c \left[1 + \left(\frac{\Delta\theta_e}{\Delta\theta_c} \right)^{1/K1} \right]^{K1}$$

where:

Δ θ'c is the total winding temperature rise;

Δ θc is the winding temperature rise at the short-circuited test;

Δ θe is the winding temperature rise at the open-circuited test

K1= 0.8 for natural air cooling and 0.9 for forced air cooling.

Insulation classes	A	E	B	F	H	N	C
Insulation system temperature ℃	105	120	130	155	180	200	220
Max. average winding temperature rise limits at rated current K	60	75	80	100	125	135	150

The temperature rise limits for different insulation classes of dry type transformers.

Tel:0086-29-88897866 Fax:0086-29-82526199
E-mail:sales@xaapt.com
www.xaapt.com
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