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Lightening Impulse Testing of Single Phase Combined Instrument Transformer

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Abstract - Combined Instrument transformers (CITs) are used for transformation of current or voltage from primary side (high values) in the transmission and distribution systems to the secondary side (low or measurable values) that can be used by low voltage metering and protection devices. There are three primary applications for which ITs are used: Tariff metering purpose, Protection purpose (over current & earth fault relay) and special protection purpose (Differential & bus bar protection relay). Depending on the requirements for those applications, the IT design and construction can be quite different.

The Combined current & voltage transformer offer the designer the skill of being able to house the CT & VT in one unit. This allow best possible use of substation space and also getting the cost savings by exclusion of one set of mounting pads and support structures. In addition, erection time is significantly reduced.

The crucial part of this equipment is to design the two bushing which are in opposite polarity and challenging task is to achieve uniform voltage and stress distribution along the surfaces of porcelain structure. Once bushing was design so its voltage and stress distribution can be evaluated by dielectric (High voltage) testing of combined instrument transformer. Dielectric testing includes lightening impulse, switching impulse ,wet power frequency test this all test are considered as a type test as per IEC 61869 [3]

This paper is more discuss about the lightening impulse test, different lightening impulse testing practices and their relevance to the procedures stipulated in the National and International standards**.**

Key Words: *oil impregnated paper bushing; Lightening impulse test ; Self –restoring & Non self-restoring insulation; High voltage techniques; combined instrument transformer.*

1. INTRODUCTION

All power system equipment use various kinds of insulation to provide isolation between live parts at different potentials as well as live parts and ground. Generally, the insulation is classified as self-restoring and non self restoring insulation. Self restoring insulation are those insulation which can recover its dielectric property after disruptive charges occurs and non self restoring are those insulation which do not recover its dielectric property after disruptive discharges occurs. External insulation (air, porcelain) is of self-restoring type and the internal insulation (solid/oil/gas) is of non self-restoring type. The standard test procedures adopted for lightning impulse withstand strength of these insulations are different based on their nature.

The lightning impulse test procedures are of two types:
1.Deterministic procedures

2. Statistical/Probabilistic procedures

The deterministic procedures are generally used to check the basic insulation level(BIL) of internal insulation (non self-restoring).

The statistical (probabilistic) procedures are generally used to check the BIL of external insulation (self-restoring). This paper discusses about the lightning impulse test practices and their effectiveness for combined instrument transformers [3], [4], [5] [6] & [8].

2. TEST PROCEDURE, TEST CONNECTIONS, APPLICATION OF LI TEST

There are three different impulse withstand test procedures stipulated in the IEC 60060-1 standard [2].

1) Withstand voltage test : Procedure A

Three impulses of the specified shape & polarity at the specified withstand voltage level are applied to the test object. This test is to be considered as pass if there is no any disruptive discharges or live part to ground flashover occurs. This procedure is recommended for test on degradable or non-self-restoring insulation.

Hence this procedure is also called as Deterministic procedure.

2) Withstand voltage test : Procedure B

Fifteen impulses of the specified shape & polarity at the specified withstand voltage level are applied to the test object. this test is to be considered as pass if there is not more than two disruptive discharges occurs in self- restoring part of insulation and if no indication of failure in non self - restoring insulation.

Hence this procedure is also called deterministic and probabilistic procedure.

3) Withstand voltage test : Procedure C

Three impulses of the specified shape & polarity at the specified withstand voltage level are applied to the test object.. If no disruptive discharge occurs the test object has passed the test. If more than one disruptive dis- charge occurs the test object has failed to pass the test. If one disruptive discharge occurs in the self-restoring part of the insulation, then nine additional impulses shall be applied and if no disruptive discharge occurs then the test object has passed the test. If any failure observed in non self -restoring insulation the test object is to be considered as failed.

Hence this procedure is also called deterministic and probabilistic procedure.

Generally, single phase combined instrument transformers possess both self-restoring and non self-restoring insulation so the procedure B of IEC 60060-1 is preferred.

As mention in procedure B there is two disruptive discharges are allowed as a result , the insulation exhibits 90% probability of withstand and 10% probability of failure [1][2]. Theoretically no test can finally prove that the insulation has a 10% probability of failure. To establish probabilistic BIL for self-restoring insulation tolerable number of flashovers is permissible. The equations of the curves based on the conditional probability [7] are:

S=q15+15pq14+105p2q13 - 2/15 test procedure B

Where,

S : probability of passing the test

p : probability of flashover

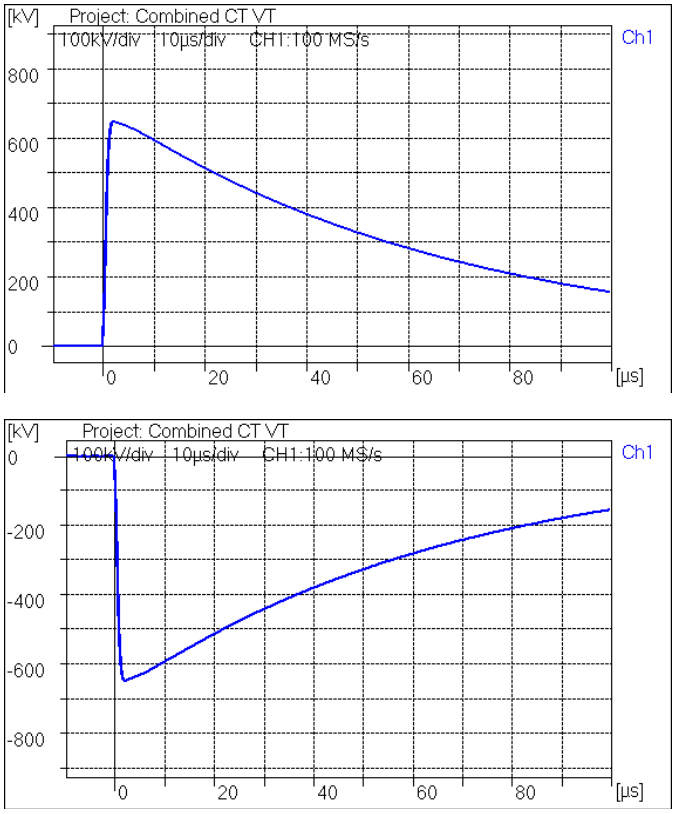
q = (1 - p)

Test Connections:

Impulse voltage source connected to primary terminal (HV terminal) of CT & IVT . all other secondary terminal of current transformer were shorted together and connected to earth along with base & capacitive terminal (Cx) connected to earth through shunt for current measurement. Similarly in case of inductive voltage transformer Terminals N (neutral end of HV winding) ,one end of each low voltage winding (1n,2n etc.) is connected to earth.

Application of LI test:

CG Aurangabad has developed 145 kV combined instrument transformer and evaluate the same by performing the lightening impulse voltage test. As discussed above we used procedure B for testing as it involves both self- restoring & non self - restoring insulation. Please find below positive & negative waveform for reference purpose.



Product withstand both 15 positive & 15 negative waveform.

3. CONCLUSIONS

From this paper we understand the various test procedures of lightening impulse voltage withstand test, probability of passing and failing the equipment. Based on this understanding we have evaluated 145 kV combined instrument transformer which was developed by CG Aurangabad as per Procedure B mentioned above. The product was successfully passed all the lightening impulses.

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