Position Paper on IEEE Task Force on Insulator Icing Test Methods

Item # 5 Power Supply Requirements

By

Rudi F. Kremer

Vice President

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1. Abstract

- AC single phase power supplies utilized for alternating current insulator artificial icing tests shall have a defined impedance and the ability to provide an adjustable output voltage (which may change in the stated impedance range during operation) to an unknown and variable load impedance.

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- AC single phase power supplies may comprise (a) a transformer with an adjustable output voltage (recognized as variable ratio or variable transformer) or (b) may combine a variable ratio transformer and a fixed ratio transformer to step-up the output voltage, or (c) may combine a variable ratio transformer and a cascade-connected transformer arrangement to step up the output voltage to match the test requirements.

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- The variable transformer may be designed as a two winding transformer with one primary winding and one secondary winding or as an auto-transformer with one winding electrically and magnetically coupled.

- The variable transformer arrangement shall be rated for heavy duty application.
- The Fixed Ratio Transformer (recognized as step-up transformer) may be designed as (a) a two winding transformer or (b) a group of two or more step-up transformers connected in cascade.

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- The line frequency or the frequency of the test voltage shall be in the range of 45-65 Hz.

2. Scope

- Exclusively, the properties of Alternating Current Single Phase Power Supplies generating a variable output voltage to a test specimen are described below.
- NOTE: Moving-Coil Variable Transformers and Generators (Motor Generator Sets) do not fall into this category because of different electrical properties and will not be reviewed

3. Objectives

- To determine and specify the requirements and electrical properties of the power supplies utilized in AC high voltage Insulator Artificial Icing Tests.

- To develop methods and characteristic data which will permit the specification and verification of performance tests on power supplies employed in AC Insulator Artificial Icing Tests.

- An AC single phase power supply shall provide reproducible and reliable test data.

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4. Introduction

- An AC single phase power supply may be described as an electrical apparatus which provides an output voltage, output apparent power, with an output impedance (within a specified range) at constant frequency, to an unknown and variable load.

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- In the field of high voltage testing, a variable ratio transformer (or cascade transformer group) and a fixed ratio transformer are employed to provide the necessary output voltage to the test object.
- The resolution of the output parameters (voltage [V], apparent power [VA], and impedance [Ω]) may be infinitely variable or quasi-stepless depending on the variable transformer type.

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5. Electrical Properties of Variable Transformers:

- Today, toroidal variable transformers, column type variable transformers, and Thoma variable transformers are in practical operation.

- Toroidal variable transformers use current collector assemblies traveling circumferentially to the winding contrary to a column-type variable transformer having current collector assemblies traveling axially to the winding. Both types have the common feature of a low turn-to-turn voltage. The turn-to-turn voltage of $\leq$.7 V is necessary to yield uninterrupted output voltage and to limit losses during current flow.

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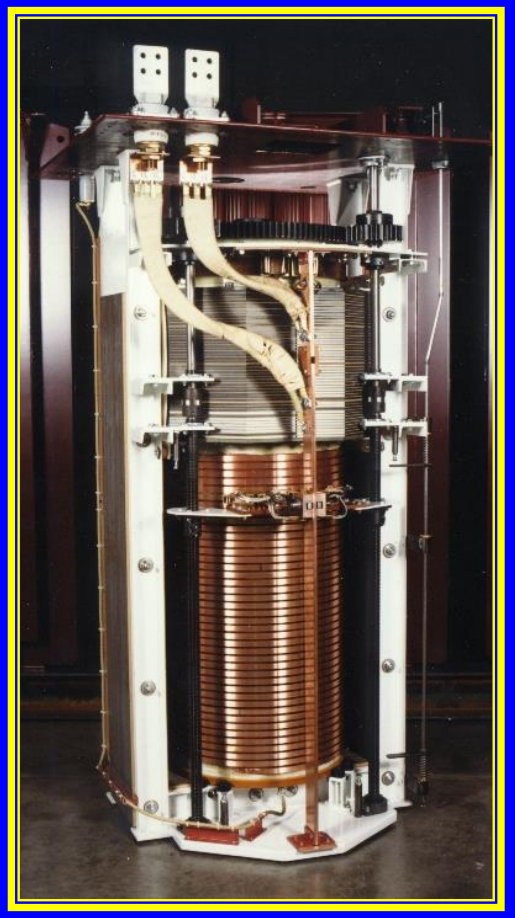
Column-Type Variable Transformer



Toroidal Variable Transformer

- The resolution of the output parameters (voltage [V], apparent power [VA]) is quasi-stepless.
- In general, variable transformers feature a single layer secondary winding on the magnetic core to allow a current collector to travel axially or circumferentially. This distinctive characteristic confines the shape and dimensions of the magnetic core and winding design. However, the magnetic core and winding layout does not permit the use of preventive measures to reduce the stray field caused by the current collector during current flow. Depending on the required output voltage, the current collector has to move on the winding. During current flow a stray field will be generated depending on the position of the current collector. Consequently, the impedance of toroidal and column type variable transformers are not constant. The impedance of toroidal and column type variable transformers depends on the current collector position during current flow.

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- Furthermore, the core shape and winding design of toroidal/column type variable transformers limit the range of the output voltage. The input/output voltage ratio of both types typically does not exceed $\leq$1:15. However, to comply with heavy-duty application requirements the input/output voltage ratio of toroidal/column type variable transformers should be 1:1.
- The Thoma variable transformer is a type of variable transformer in which a single layer of wire is wound onto a rotating cylinder. The current collector assembly moves axially along the secondary winding.

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- Thoma type variable transformers generally are designed as two winding transformers and are oil immersed. The distinctive properties of the Thoma type variable transformers are infinitely variable resolution of the output parameters (voltage [V], apparent power [VA], constant impedance [Ω]) in 10-100% traveling range of the current collector position, line separation and providing an inductive compensation. The primary winding may be designed to accept an input voltage up to 50 kVAC, 50/60 Hz.
- The Thoma type variable transformer features a gapped core, which reduces the harmonic content of the output voltage. In addition, the gapped core represents an inductive load which compensates 8-10% of a rated capacitive load.
- Thoma type variable transformers comply with the heavy duty requirements.

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6. Electrical Properties of Step-Up Transformers:

- A step-up transformer shall feature a primary and secondary winding. The low voltage end of the secondary winding shall be grounded.
- The short circuit impedance or short circuit voltage shall be ≤6%. To match different load impedances, the secondary winding may be designed with additional taps.

7. Variable Transformer and Step-Up Transformer:

- If an AC single phase power supply comprises a variable transformer and a step-up transformer, the system short circuit impedance or system short circuit voltage shall be 15%-8% in the output voltage range of 65%-100%.

8. Duty Cycle and Application

- An AC single phase power supply shall be designed for heavy duty application.
- Example of heavy duty operation is:

  No movement of the current collector system for extended time or frequent ON and OFF under load.

9. System Parameters

- The impedance or short circuit voltage shall be indicated via a graph: Impedance/Short Circuit Voltage as function of the output voltage or traveling range.
- The waveshape of the output voltage should approximate a sinusoid with both half cycles alike, and it should have a ratio of peak-to-rms values equal to the square root of 2 within $\pm$5%.

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10. Excerpt

- An AC power supply shall provide an output voltage separated from the input line.
- An AC power supply shall provide an adjustable output voltage in the range from 0-100% to a variable load within a specified range.

- An AC power supply shall comprise a variable transformer and a step-up transformer (or cascade transformer arrangement) to match the voltage and load impedance of the test object.

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- The step-up transformer may be designed with additional taps.
- The short circuit impedance or short circuit voltage shall be 15%-8% in the output voltage range of 65%-100%.

- The short circuit impedance or short circuit voltage shall be indicated via a graph.
- An AC single phase power supply shall be designed for heavy duty application.

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Comments Regarding Power Supply Requirements

1. IEC Standard 507, Second Edition 1991-04, “Artificial pollution tests on high voltage insulators to be used on AC systems” and IEEE Standard 4-1995, Clause 15.3 does not determine and specify clearly and definitely the electrical properties of power supplies utilized in AC high voltage test apparatus. In addition, both standards do not provide methods and characteristic data for manufacturers and end-users to verify the quality standard of an AC high voltage power supply.

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- 2. I would like to suggest for discussion the following amendment and additions to Clause #5 of 3rd Draft of Position Paper:

- An AC power supply shall provide an output voltage separated from the input line.
- An AC power supply shall provide an adjustable output voltage in the range from 0-100% to a variable load within a specified range.

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- An AC power supply shall comprise a variable transformer and a step-up transformer (or cascade transformer arrangement) to match the voltage and load impedance of the test object.

- The step-up transformer may be designed with additional taps because useful tap operation range 30-100%.

- Utilizing the short circuit voltage and short circuit power factor to determine the electrical properties of an AC power supply. The short circuit impedance or short circuit voltage shall be indicated via a graph (would replace clause #5a).

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- The short circuit impedance or short circuit voltage shall be in a range of 15%-8% of the output voltage range of 65%-100%.
- Leakage current measurement capacity (would replace clause #5b).
- An AC single-phase power supply shall be designed for heavy-duty application.

Rudi F. Kremer,
Vice President

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