Genius Engineering & Service Co., Ltd.

CORRECTION OF TEST VALUE TO DESIRED TEMPERATURE

Insulation Resistance
RTD
Copper Winding Resistance

Information corrected by Kongsit

Purpose

To standardize the test value to be the same reference

Insulation Resistance Corrected Value to 40 DegC

IEEE Std 43 - 2013

The correction may be made by using Equation (2):

$$R_C = K_T R_T$$

where

R_C is insulation resistance (in megohms) corrected to 40 °C,
K_T is insulation resistance temperature coefficient at temperature T °C (from 6.3.2 or 6.3.3),
R_T is measured insulation resistance (in megohms) at temperature T °C.

For the range of 40 °C < T < 85 °C, is illustrated in Equation (4).

$$K_T(T) = \exp\left[-4230\left(\frac{1}{(T+273)} - \frac{1}{313}\right)\right]$$

where

T = Temperature in °C

Over the other range (10 °C < T < 40 °C), is illustrated in Equation (5).

$$K_T(T) = \exp\left[-1245\left(\frac{1}{(T+273)} - \frac{1}{313}\right)\right]$$

where

T = Temperature in °C

Example:

IR= 14 MOhms @ 33 DegC
Corrected to 40 DegC
= EXP(-1245((1/(33+273))-(1/313))x 14
= 10.28 Mohms

IR= 14 MOhms @ 45 DegC
Corrected to 40 DegC
= $K_T x R_T$
= EXP(-4230((1/(45+273))-(1/313))x 14
= 17.31 Mohms

IEEE Std 62.2 - 2004

Normally RTD for Stator Winding Temperature is PT100

Platinum RTDs: 100 ohms at 0 C

$$\text{Temperature C} = (R_e \times 2.523) - 252.3$$

Re = Element Resistance

Example:

วัดค่า Resistance ของ RTD (Re) ได้ 113 Ohms

Convert to temp C

= (113x2.523) – 252.3

= 33.099 DegC

Copper Winding Resistance

IEEE Std 62.2 - 2004

For copper conductors, this correction is done by using the temperature of the circuit under test (Tt), the temperature of the circuit at standard conditions, (usually 75 °C) and applying the following formula:

Corrected to 75 degC

$$R_t\,(234.5 + 75)/(234.5 + T_t) = R_{75}$$

Example:

R = 200 mOhms @ 33 DegC

Corrected to 75 DegC
= 200x(234.5+75)/(234.5+33)
= 231.4019 mOhms

Corrected to 20 DegC
= 200x(234.5+20)/(234.5+33)
= 190.2804 mOhms

INSULATION RESISTANCE REFERENCE STANDARD

IEEE Std 43 – 2013 (1/2)

IEEE Std 43™-2013
(Revision of
IEEE Std 43-2000)

IEEE Recommended Practice for Testing Insulation Resistance of Electric Machinery

6.3 Effect of temperature

6.3.1 General theory

The insulation resistance value for a given system, at any given point in time, varies inversely, on an exponential basis, with the winding temperature. There is a contrast between the temperature dependence of resistivity in metals and non-metallic materials, especially in good insulators. In metals, where there are numerous free electrons, higher temperature introduces greater thermal agitation, which reduces the mean free path of electron movement with a consequent reduction in electron mobility and an increase in resistivity. However, in insulators, an increase in temperature supplies thermal energy, which frees additional charge carriers and reduces resistivity. This temperature variation affects all of the current components identified in 5.1 except for the geometric capacitive current. The insulation resistance value of a winding depends upon the winding temperature and the time elapsed since the application of the voltage. For example, when the machine has just been stopped, and the operating temperature is of the order of 90 °C – 100 °C, the temperature can drop significantly during 10 min and this can affect the *P.I.* In order to avoid the effects of temperature in trend analysis, subsequent tests should be conducted when the winding is near the same temperature as the previous test. However, if the winding temperature cannot be controlled from one test time to another, it is recommended that all insulation test values be corrected to a common base temperature of 40 °C using Equation (2). Though the corrected value is an approximation, this permits a more meaningful comparison of insulation resistance values obtained at different temperatures.

The correction may be made by using Equation (2):

$$R_c = K_T \; R_T \qquad (2)$$

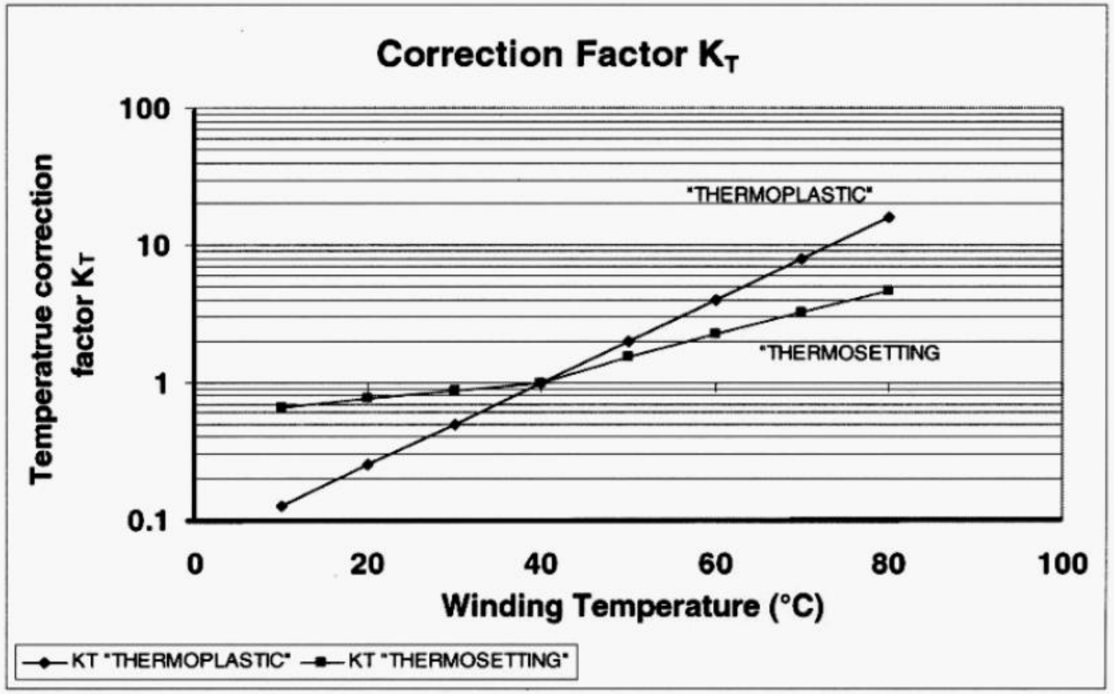
where

R_c is insulation resistance (in megohms) corrected to 40 °C,
K_T is insulation resistance temperature coefficient at temperature T °C (from 6.3.2or 6.3.3),
R_T is measured insulation resistance (in megohms) at temperature T °C.

IEEE Std 43 – 2013 (2/2)

6.3.3 Approximating K_T

The correction factors (K_T) are presented here for two different families of insulation systems labeled respectively "THERMOPLASTIC" and "THERMOSETTING". "THERMOPLASTIC" applies, for example, to asphaltic systems and other systems that were in use prior to the early 1960s. "THERMOSETTING" applies to newer insulations that appeared around the early 1960s. They include epoxy and polyester based systems. Both are presented on Figure 5.



6.3.3.1 Equation for "THERMOPLASTIC" insulation systems

For the THERMOPLASTIC family, K_T can be approximated by Equation (3).

$$K_T = (0.5)^{(40-T)/10} \tag{3}$$

where

T = Temperature in °C

For example, if the winding temperature at test time was 35 °C, then the K_T for correction to 40 °C would be derived in the following way:

$$K_T = (0.5)^{(40-35)/10} = (0.5)^{5/10} = (0.5)^{1/2} = 0.707$$

6.3.3.2 Equation for "THERMOSETTING" insulation systems [B8]

For thermosetting insulation, the correction factor equations for temperatures above 40 °C differ from those below 40 °C.

For the range of 40 °C < T < 85 °C, is illustrated in Equation (4).

$$K_T(T) = \exp\left[-4230\left(\frac{1}{(T+273)} - \frac{1}{313}\right)\right] \tag{4}$$

where

T = Temperature in °C

Over the other range (10 °C < T < 40 °C), is illustrated in Equation (5).

$$K_T(T) = \exp\left[-1245\left(\frac{1}{(T+273)} - \frac{1}{313}\right)\right] \tag{5}$$

where

T = Temperature in °C

DC WINDING REFERENCE STANDARD

IEEE Std 62.2 – 2004

IEEE Std 62.2™-2004

Standards

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(T_t), the temperature of the circuit at standard conditions, (usually 75 °C) and applying the following formula:

$$R_t (234.5 + 75)/(234.5 + T_t) = R_{75}$$

This corrected resistance value can now be compared with previous values that were corrected to the same standard conditions.

7.1.10.4 Interpretation

The interpretation of results is dependent on the type of conductor being measured. For example, some conductors consist of several parallel paths of stranded conductors and detecting a problem with only small percentage of strands may be beyond the resolution of the bridge or micro-ohmmeter. If several strands are broken or there is an inadequate internal connection, the Kelvin bridge or micro-ohmmeter may detect the resulting higher resistance circuit. A 2% variance from expected is usually an indication of an abnormal stator winding circuit. It should be noted that with only a 2% deviation from expected being a significant indication, the proper calibration of the instrument and proper measurement techniques are critical.

7.1.11 Stator winding temperature detector (RTD/TC) insulation test

7.1.11.1 Discussion

Many types of temperature detectors are used throughout the machine and exciter assembly. The two most common types of detectors are Resistance Temperature Detectors (RTDs) and thermocouples (TCs). These devices are typically grounded in their measuring instrumentation; however, there are cases where temperature measuring devices are intentionally grounded at the sensor or at the terminal board. Consult the original equipment manufacturer and instruction documents prior to measuring detector insulation resistance to determine if detectors are intentionally grounded. If the detector is intentionally grounded, the insulation resistance may not be testable unless the ground can be disconnected.

RTD REFERENCE STANDARD

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IEEE Std 62.2 – 2004

IEEE Std 62.2™-2004

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a) Copper RTDs; 10 ohms at 25 C

Temperature C = $[(R_e \times 259.5)/10] - 234.5$

b) Platinum RTDs: 100 ohms at 0 C

Temperature C = $(R_e \times 2.523) - 252.3$

7.1.12.6 Procedure for reading thermocouples

The easiest way to read the temperature indicated by a thermocouple is to connect to a proper direct reading device. The device should be calibrated for reading the type of thermocouple being measured. Thermocouple types commonly used in machines and exciters are shown in Table 3.

Table 3—Common types of thermocouples

ANSI Code	(+) Lead	(-) Lead	Thermocouple	Magnetic Lead
J	Iron Fe	Constantan Cu-Ni	(+) White (-) Brown (Red)	Iron (+)
K	Chromel Ni-Al	Alumel Ni-Al	(+) Yellow (-) Brown (Red)	Alumel (-)
T	Copper Cu	Constantan Cu-Ni	(+) Blue (-) Brown (Red)	—

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