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CONSIDERATIONS REGARDING THE TESTING OF ELECTRICAL APPARATUS WITH THE TYPE OF PROTECTION "INCREASED SAFETY"

Abstract:
Increased safety "e" represent a type of protection applied to electrical apparatus in which additional measures are applied so as to give increased security against the possibility of excessive temperatures and of the occurrence of arcs and sparks in normal service or under specified abnormal conditions.

Keywords:
type of protection, increased safety, type tests

GENERALITIES

Evaluation and testing of equipments that compose an explosion-proof system, in purpose of certification, is very important considering the existing explosion risk which has to be minimized to ensure peoples health and security, as well as to prevent goods damage and, not in the last instance, to protect the environment.

The type of protection increased safety "e" applies to electrical apparatus with a rated value of supply voltage not exceeding 11 kV r.m.s. a.c. or d.c. Additional measures are applied to ensure that the apparatus does not produce arcs, sparks, or excessive temperatures in normal operation or under specified abnormal conditions.

The principle for the type of protection increased safety is represented by carefully choose of the materials used for construction of such kind of apparatus, assurance of certain clearances and creepage distances in such manner that the probability of a failure to occur and to result an electric arc or spark to be reduced at an acceptable level; as well as to ensure an adequate degree of protection for the apparatus enclosure.

For the certification of electrical apparatus with type of protection increased safety, this should be submitted to type tests and routine tests.

In the type tests category are included the tests to determine the maximum surface temperature (to include the apparatus in a certain temperature class), tests for resistance to impact, dielectric strength test, tests for degree of protection (IP) and, if necessary, tests for thermal endurance to heat and cold, resistance to light, resistance to chemical agents and other tests which are specific for different types of apparatus.

The tests for thermal endurance to heat and cold, determination of surface temperature for luminaries and electric motors; and determination of time t_E for electrical rotating machines now can be done at INCD-INSEMEX. The apparatus needed to run these tests was in part acquired with funds from National

Authority for Scientific Research in the Nucleu Program.

TESTS FOR THERMAL ENDURANCE TO HEAT AND COLD

The thermal endurance to heat shall be determined by submitting the enclosures or parts of enclosures in non-metallic materials, on which the integrity of the type of protection depends, to continuous storage for four weeks at (90 ± 5) % relative humidity at a temperature of (20 ± 2) K above the maximum service temperature, but at least 80 °C.
In case of a maximum service temperature above 75 °C, the period of four weeks specified above shall be replaced by a period of two weeks at (95 ± 2) °C and (90 ± 5) % relative humidity followed by a period of two weeks in an air oven at a temperature of (20 ± 2) K higher than the maximum service temperature.
The thermal endurance to cold shall be determined by submitting the enclosures and parts of enclosures of non-metallic materials, on which the type of protection depends, to storage for 24 h in an ambient temperature corresponding to the minimum service temperature reduced by at least 5 K but at most 10 K.

Figure1. Control and monitoring panel for climatic chamber Vötsch, type VC 7060

The test rig designed for these tests consists in a climatic chamber Votsch type VC 7060, having a capacity of 0,6 m^3, and the temperature can be adjusted in the range -70 ÷ +180 °C. The result of test is considered positive if the exposed apparatus shows no deteriorations that affect the type of protection.

TEST OF ROTATING ELECTRICAL MACHINES. DETERMINATION OF TIME, t_E

Time t_E represents the time taken for an a.c. rotor or stator winding, when carrying the initial starting current I_A, to be heated up to the limiting temperature from the temperature reached in rated service at the maximum ambient temperature.
The diagram illustrating determination of time t_E is given in figure 2.

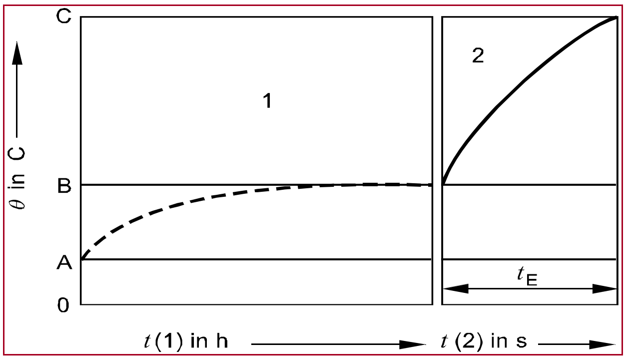

Figure 2 – Diagram illustrating the determination of time t_E

Key: *A Highest permissible ambient temperature B Temperature in rated service; C Limiting temperature; t Time; θ Temperature; 1 Temperature rise in rated service; 2 Temperature rise during stalled rotor test*

The temperature rise in stalled motors shall be determined experimentally as follows:

- *With the stalled motor initially at ambient temperature, rated voltage and rated frequency shall be applied.*
- *The stator current measured 5 s after switching on shall be considered to be the starting current I_A.*
- *The temperature rise in the rotor cage (bars and rings) shall be measured by thermocouples and measuring instruments having a small time constant compared with the rate of temperature rise, or by temperature detectors or other means. The highest of the temperatures obtained during these measurements is the one to be considered.*
- *The average temperature rise of the stator, determined from resistance measurements, is taken as the temperature rise of the winding.*

When the stalled motor test is made at a voltage less than rated voltage, the measured values shall be increased proportionally to the ratio of those voltages, directly for the starting current *and according to the square of the temperature rise. Saturation effects, if any, shall be taken into account.*

The block diagram for the test rig used to determine time t_E is given in figure 3. To fulfil the test rig the following apparatus was acquired: power analyzer Fluke 435, milliohmmeter Cropico DO5001, data acquisition system Agilent 34970A with thermocouples, laptop Dell Latitude D830.

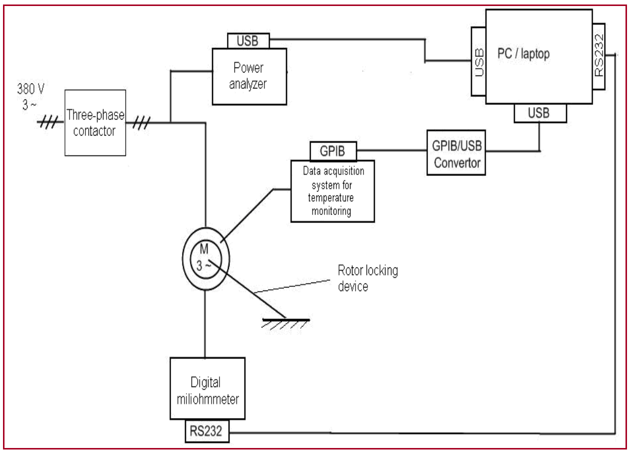

Figure 3. Block diagram of the test rig used to determine time t_E

The role of Fluke 435 power analyzer is to measure and record the important parameters (voltage, current, frequency, power factor, etc.) during the test.

The Cropico DO5001 milliommmeter measure and record the values for the stator winding resistance in cold state and after the test..

The data acquisition system Agilent 34970A with thermocouples is used to measure and monitor temperature during test.

DETERMINATION OF MAXIMUM SURFACE TEMPERATURE FOR ELECTRICAL ROTATING MACHINES

In order to determine the maximum surface temperature the following apparatus is used: power analyzer Fluke 435, milliohmmeter Cropico DO5001, data acquisition system Agilent 34970A with thermocouples, tachometer Lutron L1236L, laptop Dell Latitude D830.

To determine the maximum surface temperature the following steps should be covered:

- *build-up experimental mounting according block diagram from figure 4, and connect the electric motor to adjustable load test rig;*

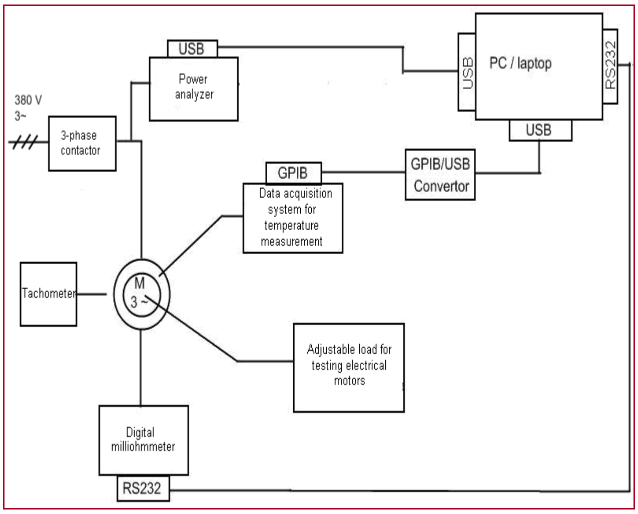

Figure 4. Test rig to determine maximum surface temperature for electrical rotating machines

- *the stator winding resistance is measured and recorded, in „cold" state, with the help of Cropico DO 5001 microohmmeter;*
- *the thermocouples connected to Agilent 34970A data acquisition system are placed in points considered to be the hottest points during motor running;*
- *the adjustable load test rig is powered-on and the electric motor is driven on low speed;*
- *the electric motor is powered-on through a 3-phase contactor;*
- *the load is adjusted until the motor speed reaches nominal speed (rotation speed is measured with the help of Lutron 1236L tachometer);*
- *in this configuration, the system will function until the maximum temperature in normal functioning is reached, according SR EN 60079-0 and SR EN 60079-7 (temperature rising is lower than 2 K/ hour);*
- *after reaching the maximum surface temperature, the motor is powered-off and the adjustable load rig is driven so as to give a quick stop of the motor.*
- *the stator winding resistance is measured and recorded, with the help of Cropico DO 5001 microohmmeter;*

The rotor temperature is measured with thermocouples placed on the rotor through some holes affected in the drive-part shield. Delay time after power-off to determine overtemperature in rated service is presented in table 1.

Table 1: Delay time after power-off required to determine temperature in rated service

Rated power, (kW)/(kVA)	*Delay time after power-off, (s)*
$P \le 50$	30
$50 < P \le 200$	90
$200 < P \le 5000$	120

Temperature and winding resistance recording is made for at least 2 minutes after motor power-off, in reason to set-up the cooling curve for rotor and stator winding.

Data referring to electrical parameters during test (voltage, current, frequency, power factor, etc.) are viewed and recorded through the power analyzer, and transferred to a PC after the test.

The maximum temperature reached in stator winding at rated service is determined with the following formula:

$$\theta_2 = \Delta\theta + \theta_a$$

where

$$\Delta\theta = \frac{R_2 - R_1}{R_1} \times (k + \theta_1) + \theta_1 - \theta_a$$

R_1 – winding resistance value in cold state, in Ω;
R_2 – winding resistance value in warm state, in Ω;
θ_1 – winding temperature value in cold state, in °C;
θ_2 – winding temperature value after heating test, in °C;
θ_a – temperature value for the cooling environment (ambient);
k – reciprocal temperature coefficient for resistance at 0 °C for conductive material; k = 235 – for copper; k = 225 for aluminium;
T_{amb} – maximum ambient temperature (generally 40°C);

The maximum surface temperature is determined as the temperature measured in the hottest point of the motor, with the following formula:

$$T_{max} = T_{amb} + \Delta\theta$$

in this case Δθ represents the highest rise of temperature (measured in points where the thermocouples were placed).

DETERMINATION OF MAXIMUM SURFACE TEMPERATURE FOR LUMINAIRES DESIGNED FOR MAIN SUPPLY

In order to determine the maximum surface temperature for luminaires the following apparatus is used: ac power source Kikusui type PCR 1000M, data acquisition system Agilent 34970A with thermocouples, laptop Dell Latitude D830.

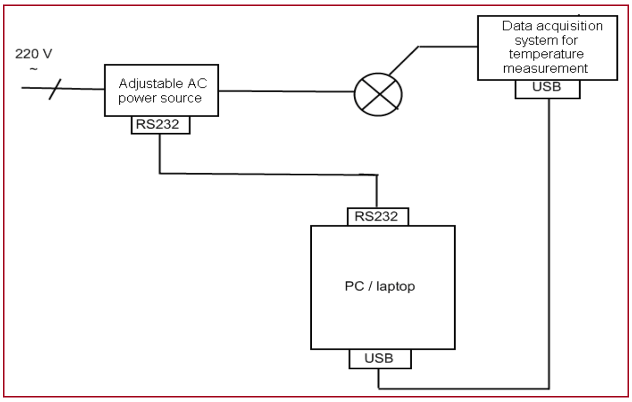

Figure 5. Test rig to determine maximum surface temperature for luminaires designed for main supply

To determine the maximum surface temperature of luminaires designed for main supply the following steps should be covered:

- *build-up experimental mounting according block diagram from figure 5;*
- *the thermocouples connected to Agilent 34970A data acquisition system are placed in points considered to be the hottest points during functioning.*
- *for tubular fluorescent lamps with main supply a diode will be connected in series with the lamp, and the luminaire supplied with a voltage equal to 110% of rated voltage;*
- *the luminaire is powered-on through Kikusui PCR 1000M ac power supply at voltage and frequency required by standard;*
- *in this configuration, the all system will function until the maximum temperature in normal functioning is reached (temperature rising is lower than 2 K/ hour). The temperature is monitored by data acquisition system Agilent 34970A with thermocouples;*
- *when thermal equilibrium is reached the ac power source output of powered-off, and the data corresponding to electrical parameters during test are saved on PC;*
- *after approximately 1 minute from power-off the ac power source output the temperature*

recording is stopped and the data is saved on computer;

- *the maximum surface temperature is determined with the following formula:*

$$t_{max} = t_{inc} + (t_{amb\ max} - t_{amb\ inc})$$

where:
t_{inc} *– temperature recorded during test (°C) in the hottest spot;*
$t_{amb\ max}$ *– maximum ambient temperature to which the equipment is designed to work;*
$t_{amb\ inc}$ *– ambient temperature during test;*

In the end of the test, the temperature should not exceed the temperature specified for the specific temperature class (80 °C for T6, 95°C for T5, 130°C for T4, 195°C for T3). The temperature at the rim of the lamp cap and at the soldering point of the lamp cap shall not exceed the limiting temperature.

CONCLUSIONS

The purpose of the paper is to underline the new test that can be done at INCD INSEMEX Petrosani for electrical apparatus with increased safety „e" type of protection. These tests are: thermal endurance to heat and cold, determination of surface temperature for luminaries and electric motors; and determination of time t_E *for electrical rotating machines. The apparatus needed to run these tests was in part acquired with funds from National Authority for Scientific Research in the Nucleu Program.*

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