2/1515/INF

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

TECHNICAL COMMITTEE NO.2: ROTATING MACHINERY

DETERMINATION OF EFFICIENCY OF INDUCTION MOTORS FROM TESTS – PARTICIPATION IN ROUND- ROBIN TEST – INTERMEDIARY REPORT

Further to 2/1475/INF this intermediary report informs IEC national committees and other stakeholders in the motor manufacturer and motor user community on the ongoing IEC TC 2 project to improve accuracy and repeatability in testing electric motors. So far a collection of 21 laboratories in 9 countries participate. The first results are coming in and final results will be published by IEC in 2009.

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1. Background

It has long been a concern that there is a considerable variation in energy efficiency as reported by different motor manufacturers and testing laboratories. This uncertainty must be reduced to a minimum before there can be a meaningful world-wide standard for efficiency limits. The eventual goal is to have a reliable and harmonized efficiency classification for motors[1] produced and traded in all parts of the world.

During the latter part of the year 2007, IEC Technical Committee 2 (TC2) initiated a project to test electric motors to determine the uncertainty of reported energy efficiency as determined from tests. TC2 Working Group 28 (WG 28) mandated Robert Bartheld as Project Manager. The project should be completed in early 2009. The scope of the project was distributed to all member countries of IEC TC2 with a request to inform TC2 those laboratories and motor manufacturers agreeing to participate.

The initial requirement before embarking on this project was to have a standardized test procedure. This was accomplished when IEC published IEC 60034-2-12 in 2007 which includes a variety of testing methods. Each method is classified for its level of uncertainty as low, medium or high. Uncertainty, as used in this project, is the deviation from a “true” efficiency that best represents a specific motor design. Two methods were of special interest:

- Summation of losses with load test: Additional stray load losses determined from residual loss
  (IEC 6034-2-1: 8.2.2.5.1)
- Summation of losses without load test: Additional stray load losses from Eh-star test
  (IEC 60034-2-1: 8.2.2.5.4)

As there should eventually only be one harmonized test procedure for the determination of additional losses, it is necessary to either prove them equal or select the method with the lower uncertainty.

2. Scope

The aim of TC2 WG28 plans to start a round-robin test is:

- to collect further experience with the test methods,
- to obtain sets of test data allowing to assess measurement deviations between laboratories,
- to eventually improve and optimize test procedures standardized in IEC 60034-2-1,
- to provide a basis for reviewing the tolerance limits in IEC 60034-1[3].

The program is not intended to gain knowledge on available and necessary testing lab qualifications and capacity. There will be no reference to any specific testing laboratory which will

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[1] IEC 60034-30 (FDIS, 2008): Rotating electrical machines: Efficiency classes of single-speed, three-phase, cage induction motors (IE-code)

2 IEC 60034-2-1 (Edition 1.0, 2007): Rotating electrical machines: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)

[3] IEC 60034-1 (Edition 11, 2004): Rotating electrical machines: Rating and performance

only be known to the PM except for those participating in Part 3 as these labs will have to know where to send sample motors.

- All costs associated with in-house testing will be the responsibility of the testing laboratory which will also be responsible for shipping the round-robin motor to the next laboratory.
- This program is intended to better define “uncertainty” of motor testing and not with meeting any specific efficiency level or category.
- By testing per IEC 60034-2-1 questions of instrumentation accuracy are established.
- This test program is planned to be completed by the end of 2008. It will take a few more months to prepare a summary report and make recommendations to TC2 for the revision tolerances and test procedures.

The parameters having to do with testing error can be subdivided into 5 categories:

- The accuracy and interpretation of the testing procedure;
- Instrumentation uncertainty;
- Manufacturing/material deviations;
- Operator errors;
- Laboratory variations.

3. Testing program

It was to provide a degree of reliability as to the uncertainty in the above categories that IEC TC2 elected to define an efficiency testing project. To address the above categories a 3 part program was developed.

- **Part 1: A series of tests in the same laboratory on a single motor.**
  These test results will assist in determining operator errors and the accuracy of the test procedure. Each test was to be performed using the 2 different methods for determining additional-load losses.
  It is proposed that all possible manufacturers/laboratories provide a minimum of 5 test results each (for the same motor) using both the load-test method and the Eh-star method. Perform no more than one test per week and use different test stands and testers whenever possible. After each test the results should be analyzed for potential improvement of uncertainty. Each following test should then use a modified test procedure that is different (but still within the limits of the standard), to verify the source of uncertainty. This series of test results will help to quantify the difference between test methods and also help to establish the influence of testing tolerances.

- **Part 2: A series of tests in the same laboratory on motors of the same design, from different manufacturing cycles, using the same test method.**
  These test results will help assign an uncertainty due to variations caused by materials and manufacturing processes.
  It is proposed that all possible manufacturers provide a minimum of 5 test results (for the same motor design of 5 different manufacturing cycles) using either the load-test method or the Eh-star method. This series of test results will identify the uncertainty introduced by variations in materials and manufacturing procedures.

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- **Part 3: A series of tests by different laboratories on the same motor, usually referred to as a "round-robin" test.**
  These results will help assign an uncertainty due to different interpretations of the test procedure, instrument uncertainty and laboratory equipment and personnel variations. It is proposed that a minimum of 3 motors (one from each of the 3 lower power ranges) with one each being sent to 5 laboratories (15 laboratories total) for testing using both the load-test method, the Eh-star method, and a comparison of 50 Hz versus 60 Hz performance. This series of test results will help to quantify the difference between test methods and also help to establish the influence of test facilities on uncertainty.

4. Motors tested

To cover efficiency variations due to motor size, 4 motor output power ranges were defined:

- 1 - 10 kW
- 11 - 50 kW
- 51 - 200 kW
- > 200 kW

The test motors will include 50 Hz and 60 Hz motors, without reference to any efficiency class.

The test reports will contain:

- Efficiency, xx.xx [%]
- The 5 losses, in [W]
  - Windage and friction loss
  - Iron loss
  - Rotor winding loss
  - Stator winding loss
  - Additional load loss (stray-load loss)
- Measured values used for calculations
- Resistor size (Eh-star); correlation factor & intercept
- Analysis of variances (why does this test differ from other tests in this series)

An electronic test report form was distributed to participating labs. The test reports will be assembled and analyzed by persons not affiliated with a motor manufacturer and the publication will be in anonymous form.

5. Countries responding

Nine countries responded by identifying a total 21 laboratories (see list in Annex). Most of the laboratories are affiliated with a motor manufacturer which permitted them to participate in all three parts. Several of the non-manufacturing labs only offered to test the round-robin motors. The round-robin testing was divided into 3 regions so as to reduce cost of shipping.

- Europe 9 laboratories
- North and South America 9 laboratories
- Asia and Australia 3 laboratories

6. Present stage of work

So far only 2 regions are currently testing the round-robin motors as there were not enough labs in the one region to obtain meaningful results. There was also insufficient participation for round-robin testing in the range > 200 kW.

For various reasons there are currently only 13 labs actively participating. Results are starting to arrive for Parts 1 & 2 and the first 2 round-robin motors will ship to a second lab in June 2008. New interested parties to contribute in all or one of the 3 Parts are still welcome. Please contact the project manager at rbartheld@aol.com.

Annex: List of participating laboratories

1	Brazil	WEG Equipamentos Elétricos S.A.-Motors, Jaragua do Sul
2	Brazil	Laboratories:Instituto de Eletrotécnica e Energia da Universidade de São Paulo - IEE-USP, São Paulo
3	Canada	Chercheur - Utilisation de l'énergie, Laboratoire des Technologies de l'Énergie Institut de Recherche, Hydro-Québec
4	China	SEARI, Shanghai
5	Czech Republic	Siemens Elektromotory s.r.o., závod Frenštát pod Radhostěm
6	Czech Republic	VUES Brno s.r.o., Brno
7	Germany	Schorch Elektrische Maschinen und Antriebe GmbH, Mönchengladbach
8	Germany	SEW Eurodrive GmbH & CO KG, Bruchsal
9	Germany	Siemens AG Automation and Drives, Bad Neustadt
10	Germany	PTB Physikalisch-Technische Bundesanstalt, Braunschweig
11	Finland	ABB, Vaasa
12	Japan	(Participation pending)
13	Poland	Fabryka Maszyn Elektrycznych INDUKTA S.A., Bielsko-Biala
14	Poland	Maszyny Elektryczne CELMA 16 S.A.,Cieszyn
15	USA	Baldor-Dodge-Reliance - Fort Smith, AR
16	USA	Baldor-Dodge-Reliance - Greenville, SC
17	USA	GE Industrial Systems – Fort Wayne, IN
18	USA	Regal-Beloit Corporation – Wausau, WI
19	USA	Siemens Energy & Automation – Norwood, OH
20	USA	TECO-Westinghouse – Taiwan
21	USA	Emerson Motor – St. Louis, MO