

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Rotating electrical machines -

Part 26: Effects of unbalanced voltages on the performance of three-phase cage induction motors

Machines électriques tournantes -

Partie 26: Effets d'un système de tensions déséquilibrées sur les caractéristiques de fonctionnement des moteurs à induction à cage triphasés



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**Rotating electrical machines -
Part 26: Effects of unbalanced voltages on the performance of three-
phase cage induction motors**

FOREWORD

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IEC 60034-26 has been prepared by IEC technical committee 2: Rotating machinery. It is an International Standard.

This second edition cancels and replaces the first edition published in 2006. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) clarification that voltages are line-to-line voltages in Clause 4, Annex A and Annex B;
- b) addition of design NE according to IEC 60034-12 in Clause 4.

The text of this International Standard is based on the following documents:

Draft	Report on voting
2/2224/CDV	2/2251/RVC

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts of IEC 60034 series, under the general title *Rotating electrical machines* can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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INTRODUCTION

When the line voltages applied to a three-phase cage induction motor are not a balanced, symmetric three-phase system, the currents in the phases of the stator winding will also be unequal. A small percentage voltage unbalance will result in a much larger percentage current unbalance.

The application of unbalanced voltages to a three-phase induction motor introduces a negative sequence voltage, and this produces a flux in the air-gap rotating against the rotation of the rotor, thus having a slip of almost 200 %. For high values of the slip, the motor impedance is low, thus tending to produce a high negative sequence current in the stator winding and high currents in the rotor cage. A small negative sequence voltage can produce currents in the winding phases considerably in excess of those present under balanced voltage conditions. Consequently, the temperature rise of the motor operating at a particular load and a particular percentage of voltage unbalance will be higher than for the motor operating under the same conditions with balanced voltages.

The analytical and graphical methods used to calculate the symmetrical components from the voltage readings of the three phases are well-known and can be taken from textbooks. Thus, these calculation schemes are not incorporated in this document but shown in the informative Annex A. Besides, the evaluation of the symmetrical components can be done automatically by modern instrumentation.

An approximate evaluation of imbalance is given in the informative Annex B.

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1 Scope

This part of IEC 60034 describes the effects of unbalanced voltages on the performance of three-phase cage induction motors.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

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- ISO Online browsing platform: available at <https://www.iso.org/obp>

4 Effects of unbalanced voltages on performance

4.1 General

The effects of unbalanced voltages on motor performance are as described in 4.2 to 4.6.

4.2 Currents

The negative sequence component of the voltage produces a flux in the air-gap rotating against the rotation of the rotor. A small negative-sequence component of the voltage can produce currents in the winding phases considerably in excess of those present under balanced voltage conditions. The frequency of the current in the cage is almost twice the rated frequency. Thus, in the case of cages with current displacement, the increase of the rotor winding losses is substantially higher than the increase of the stator winding losses.

The currents at normal operating speed will be greatly unbalanced in the order of approximately 6 to 10 times the voltage unbalance.

The locked-rotor current will be unbalanced to the same degree that the voltages are unbalanced, but the locked-rotor apparent power will increase only slightly.

4.3 Heating

The temperature rise of the stator winding is always higher than in operation at balanced supply voltages due to the increase of the losses produced by the negative-sequence components of the currents and voltages.

The increase of the rotor losses is amplified by the current displacement (see 4.2).

In addition, unbalance of the voltages often is associated with a reduction of the positive-sequence component of the voltage, which causes, for a given load, an increase of the positive-sequence components of the currents in stator and rotor.

4.4 Torque

The locked-rotor, pull-up and breakdown torques are decreased when the voltages are unbalanced. Should the voltage unbalance be extremely severe, the torques will perhaps not be sufficient for the application.

Voltage unbalance is associated with the generation of an oscillating torque of twice the line frequency. Its amplitude increases linearly with the product of the negative and the positive sequence component of the voltages; at an unbalance factor of $f_u = 0,05$ (see Clause 5), its peak value is in the range of 25 % of the rated torque. Impermissible torsional vibrations of the complete shaft system can be excited, when its critical torsional speed is close to twice the line frequency.