BS ISO 20958:2013

BSI Standards Publication

Condition monitoring and diagnostics of machine systems — Electrical signature analysis of three-phase induction motors

bsi.

...making excellence a habit.™

Document Sharing Hub

National foreword

This British Standard is the UK implementation of ISO 20958:2013.

The UK participation in its preparation was entrusted to Technical Committee GME/21/7, Mechanical vibration, shock and condition monitoring - Condition monitoring.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2013.
Published by BSI Standards Limited 2013

ISBN 978 0 580 74790 8
ICS 17.160; 29.160.30

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 August 2013.

Amendments/corrigenda issued since publication

Date	Text affected

Documents
Document Sharing Hub

Full document details: BS ISO 20958:2013

INTERNATIONAL STANDARD

ISO 20958

First edition
2013-08-15

Condition monitoring and diagnostics of machine systems — Electrical signature analysis of three-phase induction motors

Surveillance et diagnostic des systèmes de machines — Analyse de la signature électrique des moteurs triphasés à induction

Reference number
ISO 20958:2013(E)

Documents
Document Sharing Hub

© ISO 2013

Full document details: BS ISO 20958:2013

COPYRIGHT PROTECTED DOCUMENT

© ISO 2013

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

© ISO 2013 – All rights reserved

Documents
Document Sharing Hub

Full document details: BS ISO 20958:2013

Contents

Page

Foreword ..... **iv**

Introduction ..... **v**

1 Scope **1**

2 Normative references **1**

3 Terms and definitions **1**

4 Electrical signature analysis of three-phase induction motors **2**

4.1 General 2
4.2 Stator current analysis 2
4.3 Electrical current, voltage, and power analysis 10
4.4 Magnetic flux analysis 12
4.5 Partial discharge analysis 13
4.6 Electromagnetic interference testing 18
4.7 Rotor current analysis 20
4.8 Shaft voltage analysis 20

Annex A (informative) **Park's vector approach** **21**

Bibliography **23**

© ISO 2013 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS ISO 20958:2013

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2, www.iso.org/directives.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received, www.iso.org/patents.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

The committee responsible for this document is ISO/TC 108, *Mechanical vibration, shock and condition monitoring*, Subcommittee SC 5, *Condition monitoring and diagnostics of machine systems*.

© ISO 2013 – All rights reserved
Documents
Document Sharing Hub
Full document details: BS ISO 20958:2013

Introduction

This International Standard provides guidance for online condition monitoring and diagnostics of machines in the field of electrical signature analysis of three-phase induction motors.

In order to clarify the situation and direct attention towards the latest developments in this field, this International Standard presents an overview of well-established condition monitoring techniques, together with an indication of some which are expected to be less well known.

© ISO 2013 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS ISO 20958:2013

Documents
Document Sharing Hub

Full document details: BS ISO 20958:2013

INTERNATIONAL STANDARD ISO 20958:2013(E)

Condition monitoring and diagnostics of machine systems — Electrical signature analysis of three-phase induction motors

1 Scope

This International Standard sets out guidelines for the online techniques recommended for the purposes of condition monitoring and diagnostics of machines, based on electrical signature analysis. This International Standard is applicable to three-phase induction motors.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 13372, *Condition monitoring and diagnostics of machines — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13372 and the following apply.

3.1
current analysis
analysis of the three supply currents to a motor for magnitude, balance, and harmonic content

3.2
current signature analysis
spectral analysis performed on the line current to the motor to determine if there are currents at specific frequencies that can indicate component defects

Note 1 to entry: Traditionally, this has been focused on a single phase, but newer techniques such as Park's vector and voltage and current systems that analyse all three phases simultaneously can provide additional information.

3.3
induction motor
asynchronous AC machine that comprises a magnetic circuit interlinked with two electric circuits or sets of circuits rotating with respect to each other and in which power is transferred from one circuit to another by electromagnetic induction

Note 1 to entry: There are two basic types: squirrel-cage (SCI) and wound-rotor induction motors.

3.4
squirrel-cage induction motor
induction motor in which the secondary circuit consists of usually un-insulated rotor bars in core slots shorted together by end rings connected to both ends of each bar

Note 1 to entry: The most common bar and end ring materials are copper, aluminium, or alloys of these materials.

© ISO 2013 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS ISO 20958:2013

3.5
wound-rotor motor
induction motor in which the secondary circuit consists of polyphase windings made from insulated multi-turn coils, with each winding phase connected to a slip ring

Note 1 to entry: Control of stator and rotor current during starting and motor torque and speed during running is achieved by connecting external resistances, or a solid-state converter to each rotor winding phase by means of slip rings and brushes.

Note 2 to entry: This type of motor is also known as a slip-ring induction motor.

4 Electrical signature analysis of three-phase induction motors

4.1 General

The vast majority of motors used in industry are induction machines.

Reliability surveys show that the most vulnerable parts of an induction motor are the bearings, the stator winding and core pack, and the rotor cage winding.

There is a lot of published material about a group of monitoring and diagnostic techniques, collectively referred to as electrical signature analysis, that can be used for condition monitoring of induction motors. In general, these techniques are based on the analysis either of signals available at the motor terminals or obtained through appropriate transducers fitted to the structure. Several of these techniques are presented in 4.2 to 4.8.

The purpose of condition monitoring applied to three-phase induction motors is to assess the integrity of the motor and to provide early warning of possible faults. As an aid to this end, it is possible to obtain information about the health and integrity of an induction motor through analysis of its electrical signature. The variations in electric current, voltage, and power can equally be caused by the driven equipment, not just the motor; hence, the requirements of this International Standard, and electrical signature analysis, also apply to assessing the mechanical condition of the driven equipment.

If a motor is supplied from a variable voltage and frequency converter, care must be taken to account for current and voltage components in the output of such devices that could be misdiagnosed as resulting from motor defects. For techniques such as stator current analysis (4.2) and partial discharge (PD) analysis (4.5), it is advisable to lock the converter frequency and voltage while performing these tests.

4.2 Stator current analysis

4.2.1 General

Stator current analysis refers to measurements of the stator current. However, as the stator current is also affected by air gap fluxes and the rotor current, stator current analysis is capable of detecting problems in the rotor and the driven equipment.

4.2.2 Spectral analysis

Current signature analysis (CSA) has the capability of detecting the following problems in squirrel-cage and wound-rotor induction motors, where applicable:

— cracked rotor bars;

— cast rotor windings with large internal voids;

— broken bar-to-short circuit ring connections;

— cracked short circuit rings;

© ISO 2013 – All rights reserved
Documents
Document Sharing Hub
Full document details: BS ISO 20958:2013

— excessive air gap eccentricity;

— rolling element bearing defects;

— coupling misalignment;

— stator winding shorted turns;

— problems in the driven equipment.

From this list, the most significant and damaging of these are rotor cage winding problems, eccentric air gaps, and rolling element bearing defects. Rolling element bearing defects are included since CSA can identify these defects that may also be identified by vibration monitoring.

Conventional CSA is done online at or close to normal full load. The current on one motor phase is analysed for its current frequency content by measuring it with a clip-on current transformer around a motor supply cable (see Figure 1) or around the secondary side of a current transformer (CT) (see Figure 2). Newer approaches can analyse all three phases and also look at the relation between current and voltage.

Care should be taken when interpreting the results of stator spectral analysis when the motor is driving a time-varying mechanical load since different phenomena can lead to similar characteristic frequencies showing up in the stator current. Some additional means of discriminating between the possible different causes may be required.

4.2.3 Rotor cage defects

CSA monitoring has revolutionized the detection of broken rotor bars and cracked short circuit rings in squirrel-cage induction (SCI) motor rotors. Specific frequencies in the current indicate the presence of defective rotor windings during normal operation of the motor. The detection of broken rotor bars by CSA can sometimes also be confirmed by bearing vibration analysis. References [19] and [27] independently pioneered current signature analysis in the late 1970s.

In simple terms, the current flowing in the stator winding not only depends on the power supply and the impedance of the stator winding, but also includes current induced in the stator winding by the magnetic field from the rotor. That is, the stator winding is a probe or “transducer” for problems in the rotor. The key issue is separating currents that flow through the stator to drive the rotor from the currents that the rotor induces back into the stator if there is a problem. This separation is accomplished by measuring current components at frequencies other than power frequency, using a high-resolution frequency spectrum analyser.

The additional frequency components, due to rotor defects, are seen as sidebands to the fundamental frequency component at frequencies given by Formula (1):

$$f = (1 \pm 2ks) f_1 \tag{1}$$

where

s is the per unit rotor slip;

f_1 is the fundamental supply frequency;

k is 1, 2, 3, etc.

The rotor currents in a cage winding produce an effective three-phase magnetic field, which has the same number of poles as the stator field, but is rotating at slip frequency with respect to the rotating rotor. If rotor current asymmetry occurs, then there is a resultant backward (i.e. slower) rotating field at slip frequency with respect to the forward rotating rotor. Asymmetry results if one or more of the rotor bars is broken or there are breaks in a short circuit ring preventing current from flowing through them. It can be shown that this backward rotating field is actually rotating forwards at (1 – 2s) times synchronous speed with respect to the stationary stator winding. This induces currents in the stator

© ISO 2013 – All rights reserved

AVA Documents
Document Sharing Hub
Full document details: BS ISO 20958:2013