IEC/TS 60034-18-42

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TECHNICAL SPECIFICATION

SPÉCIFICATION TECHNIQUE

Rotating electrical machines –
Part 18-42: Qualification and acceptance tests for partial discharge resistant electrical insulation systems (Type II) used in rotating electrical machines fed from voltage converters

Machines électriques tournantes –
Partie 18-42: Essais de qualification et d'acceptation des systèmes d'isolation électrique résistants aux décharges partielles (Type II) utilisés dans des machines électriques tournantes alimentées par convertisseurs de tension

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Part 18-42: Qualification and acceptance tests for partial discharge resistant electrical insulation systems (Type II) used in rotating electrical machines fed from voltage converters

FOREWORD

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Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC 60034-18-42, which is a Technical Specification, has been prepared by IEC technical committee 2: Rotating machinery.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
2/1482/DTS	2/1502/RVC

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

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 publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

The approval of electrical insulation systems for use in rotating electrical machines driven from voltage converters is set out in two Technical Specifications. They separate the systems into those which are **not** expected to experience partial discharge activity within specified conditions in their service lives (Type I) and those which **are** expected to withstand partial discharge activity in any part of the insulation system throughout their service lives (Type II). For both Type I and Type II insulation systems, the drive system integrator should inform the machine manufacturer what voltage will appear at the machine terminals in service. The machine manufacturer will then decide upon the severity of the tests appropriate for qualifying the insulation system. The severity is based on the impulse rise time, the peak to peak voltage and, in the case of Type II systems, the impulse repetition rate.

IEC/TS 60034-18-41

Type I insulation systems are dealt with in IEC/TS 60034-18-41. They are generally used in rotating machines rated at less than 700 V r.m.s. and tend to have random wound stators. In this Technical Specification, the necessary normative references and definitions are given together with a review of the effects arising from converter operation. Having established the technical foundation for the evaluation procedure, the conceptual approach is then described.

IEC/TS 60034-18-42

In this Technical Specification, the tests for qualification and acceptance of electrical insulation systems chosen for Type II rotating electrical machines are described. These insulation systems are generally used in rotating machines and tend to have form-wound coils, mostly rated above 700 V r.m.s. The qualification procedure is completely different from that used for Type I insulation systems and involves destructive ageing of insulated test objects under accelerated conditions. The manufacturer requires a life curve for the insulation system that can be interpreted to provide an estimate of life under the service conditions with converter drive. Great importance is attached to the qualification of any stress grading system that is used and testing here should be performed under repetitive impulse conditions. If the insulation system can be shown to provide an acceptable life under the appropriate ageing conditions, it is qualified for use. Acceptance testing is performed on coils made using this insulation system when subjected to a voltage endurance test.

This Technical Specification should be read in conjunction with IEC/TS 60034-18-41, which provides a background to the technology of converter drive/machine systems.

The winding insulation systems intended for converter-fed machines and converter technologies are evolving rapidly. In addition, there is on-going research into the best ways to test such insulation systems. It is expected therefore that there will be improvements in these Technical Specifications over the next few years.

ROTATING ELECTRICAL MACHINES –

Part 18-42: Qualification and acceptance tests for partial discharge resistant electrical insulation systems (Type II) used in rotating electrical machines fed from voltage converters

1 Scope

This Technical Specification defines criteria for assessing the insulation system of stator/rotor windings of single or polyphase AC machines which are subjected to repetitive impulse voltages, such as pulse width modulation (PWM) converters, and expected to withstand partial discharge activity during service. It specifies electrical qualification and acceptance tests on representative samples which verify fitness for operation with voltage-source converters.

This document does not apply to:

– Rotating machines which are fed by converters only for starting.

– Electrical equipment and systems for traction.

NOTE Although this Technical Specification deals with voltage-source converters, it is recognised that there are other types of converters that can create repetitive impulse voltages. For these converters, a similar approach to testing can be used if needed.

2 Normative references

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

IEC 60034-18-1, *Rotating electrical machines – Functional evaluation of insulation systems – Part 18-1: General guidelines*

IEC 60034-18-32, *Rotating electrical machines – Functional evaluation of insulation systems – Part 18-32: Test Procedures for form-wound windings – Electrical evaluation of insulation systems used in machines up to and including 50 MVA and 15 kV*

IEC/TS 60034-18-41, *Rotating electrical machines – Part 18-41: Qualification and type tests for Type I electrical insulation systems used in rotating electrical machines when fed from voltage converters*

IEC 60216-3, *Electrical insulating materials – Thermal endurance properties – Part 3: Instructions for calculating thermal endurance characteristics*

IEC/TS 61251, *Electrical insulating materials – A.C. voltage endurance evaluation – Introduction*

IEC 61800-4, *Adjustable speed electrical power drive systems – Part 4: General requirements – Rating specifications for a.c. power drive systems above 1 000 V a.c. and not exceeding 35 kV*

IEC 62068-1, *Electrical insulating systems – Electrical stresses produced by repetitive impulses – Part 1: General method of evaluation of electrical endurance*

IEC 62539, *Guide for the statistical analysis of electrical insulation breakdown data*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
voltage endurance coefficient
symbol: n
exponent of the inverse power model or exponential model on which the relationship between life and stressing voltage amplitude for a specific insulation system depends

3.2
life
time to failure

3.3
stress grading material
material generally having a non-linear resistivity characteristic, applied to the endwindings of stators to reduce the maximum surface electrical stress

3.4
corona protection material
material which is used to coat a stator bar within the slot portion of the stator core to avoid slot discharges

3.5
impulse rise time
symbol: t_r
time for the voltage impulse to go from 0 % to 100 % (See Figure 1)

NOTE Unless otherwise stated, it is estimated as 1,25 times the time for the voltage to rise from 10 % to 90 %.

3.6
electrical insulation system
insulating structure containing one or more electrical insulating materials together with associated conducting parts employed in an electrotechnical device

[IEC 62068-1]

3.7
(electric) stress
electric field in V/mm

3.8
rated voltage
symbol: U_N
voltage assigned, generally by the manufacturer, for a specified operating condition of a machine

3.9
fundamental frequency
first frequency, in the spectrum obtained from a Fourier transform of a periodic time function, to which all the frequencies of the spectrum are referred

NOTE For the purposes of this Technical Specification, the fundamental frequency of the machine terminal voltage is the one defining the speed of the converter-fed machine.

3.10
steady state voltage impulse magnitude
symbol: U_a
final magnitude of the voltage impulse (see Figure 1)

3.11
peak (impulse) voltage
symbol: U_p
maximum numerical value of voltage reached during a unipolar voltage impulse (e.g. U_p in Figure 1)

NOTE 1 For bi-polar voltage impulses, it is half the peak to peak voltage (See Figure 2).

NOTE 2 The peak to peak voltage, $U_{pk/pk}$ is shown in Figure 2.

3.12
voltage overshoot
symbol: U_b
magnitude of the peak voltage in excess of the steady state impulse voltage (see Figure 1)

3.13
impulse repetition frequency
average number of voltage impulses per unit time generated by the converter (switching frequency)

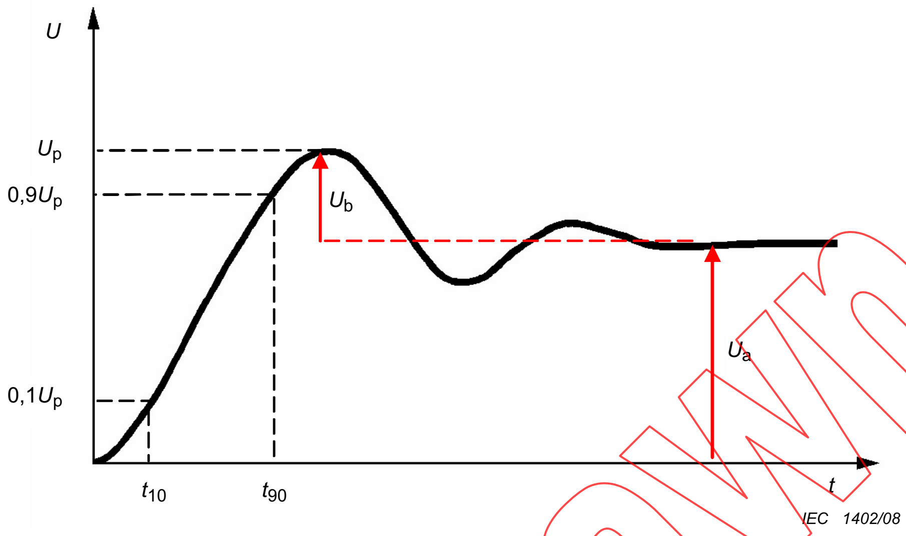
3.14
jump voltage
symbol : U_j
change in voltage at the terminals of the machine occurring at the start of each impulse when fed from a converter (see Figure 3)

3.15
peak to peak impulse voltage
symbol : $U'_{pk/pk}$
peak to peak voltage at the impulse frequency (See Figure 2)

3.16
peak to peak voltage
symbol : $U_{pk/pk}$
peak to peak voltage at the fundamental frequency (See Figure 2)

3.17
partial discharge
electrical discharge that only partially bridges the insulation between conductors

NOTE It may occur inside the insulation or adjacent to a conductor.



Key

U voltage *t* time

Figure 1 – Voltage impulse waveshape parameters

4 Voltage effects from converter operation

4.1 Voltages at the terminals of the converter-fed machine

Modern converter output voltage rise times may be in the 50 ns to 2 000 ns range due to power semiconductor switching characteristics. The voltage appearing at the terminals of a converter-driven machine depends upon several characteristics of the power drive system (see IEC 61800-4), such as

- operating line voltage of the converter
- architecture and control regime of the converter
- filters between the converter and machine
- length and characteristics of the cable between them
- design of the machine winding
- grounding system

In order to apply this Technical Specification to the qualification and testing of the insulation system of a winding, it is necessary to specify the required parameters of the voltage appearing at the machine terminals (Clause 6). In the case of 2-level or other U converters, depending on the rise time of the voltage impulse at the converter output and on the cable length and machine impedance, the impulses generate voltage overshoots at the machine terminals. This voltage overshoot is created by reflected waves at the interface between cable and machine or converter terminals due to impedance mismatch. The voltage appearing at the machine terminals when fed from a 3-level converter is shown in Figure 2. The figure shows one cycle at the fundamental frequency.

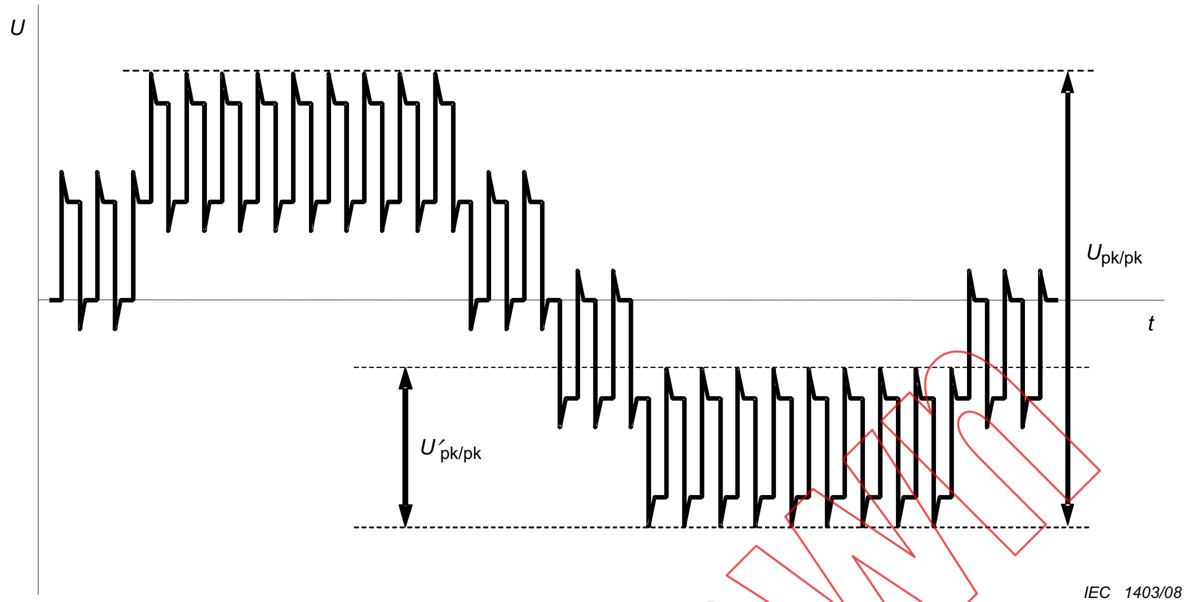


Figure 2 – Phase/phase voltage at the terminals of a machine fed by a 3-level converter

Two examples of the maximum change in voltage at the impulse frequency, U_j, are shown in Figure 3. This parameter is important in defining the voltage enhancement that can occur across the first or last coil in the stator. Although the smaller U_j in Figure 3 is the most common instantaneous voltage change occurring at the machine terminals, there is a possibility that on rare occasions this jump in voltage may occur at the moment of switching between stages, in which case the larger of the two voltages shown in Figure 3 can occur.

Examples of the enhancements that are produced for various rise times and cable lengths in the case of a 2-level converter are given in Figure 4, where the worst case is shown, arising from an infinite impedance load. In this case, the enhancement to the voltage for an impulse rise time of 1 000 ns is insignificant below about 15 m and only exceeds a factor of 1,2 when the cable length is greater than 50 m.

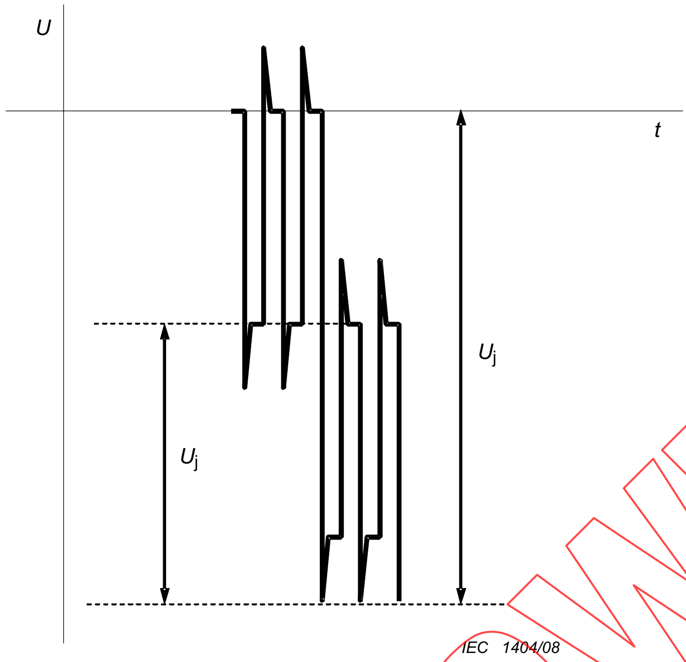


Figure 3 – Possible jump voltages (U_j) at the machine terminals associated with a converter drive