BRITISH STANDARD

BS EN
50209:1999

Test of insulation of bars and coils of high-voltage machines

The European Standard EN 50209:1998 has the status of a British Standard

ICS 29.080.01; 29.160.10

National foreword

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Summary of pages

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English version

Test of insulation of bars and coils of high-voltage machines

Essai de l'isolation des barres et des bobines des machines à haute tension

Prüfung der Isolierung von Stäben und Spulen von Hochspannungsmaschinen

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CENELEC

European Committee For Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung
Central Secretariat: rue de Stassart 35, B-1050 Brussels

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Foreword

The Harmonization Document HD 345 S1, prepared by the Technical Committee CENELEC TC 2, Rotating machinery, was approved by CENELEC on 1976-03-30.

This Harmonization Document was submitted to the formal vote for conversion into a European Standard and was approved by CENELEC as EN 50209 on 1995-09-20.

The following date was fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1998-10-01

Introduction

The purpose of this standard is to assess the uniform quality of manufacturing and determine the dielectric behaviour of the insulation of machines having rated voltages from 5 kV to 24 kV. It applies to conductor bars and coils.

EN 60034-15 relates to impulse voltage withstand levels of rotating machines with form-wound stator coils and having rated voltages from 3 kV to 15 kV inclusive.

Scope

This specification applies to rotating electrical machines with rated voltages (U_N) from 5 kV to 24 kV inclusive and with rated output from 5 MVA upwards for generators and from 5 MW upwards for motors.

Requirements for machines with rated voltage above 24 kV should remain the subject of individual agreement.

This specification is also applicable to machines with rated outputs between 1 MVA (1 MW) and 5 MVA (5 MW) and with rated voltages of 5 kV and above, provided its use has been agreed beforehand.

In the case of machines whose windings are cured in the stator, tests on the separate winding elements are not possible; for these machines the requirements in Part B apply. The test of the conductor lamination insulation must however be carried out in accordance with 2.3 of Part A.

Part A – Tests on conductors bars and coils

1 Tests

As a manufacturer quality control of the insulation, bars and coils of high voltage windings shall undergo a routine test in accordance with clause 2, and, where it has been agreed, an additional random sample test in accordance with clause 3.

These tests serve to assess the uniformity of manufacture as well as to determine the dielectric behaviour of the insulation.

> NOTE: In the routine test, the uniformity of the manufacture is judged by measurement of the dielectric loss angle as a function of voltage. In the random sample test, the behaviour of the slot insulation under thermal stress is determined by measurement of the dielectric loss angle before and after heating.
> The random sample test also serves to determine by means of a.c. voltage tests, the dielectric strength of the insulation between the laminations of the conductor as well as the inter-turn insulation, the end winding insulation and the slot insulation. In the case of the last three insulations the breakdown voltage is also determined.

2 Routine test

2.1 The routine test shall be carried out on the number of bars or coil sides, including any spare bars or coils, as shown in Table 1.

Table 1

Number of poles	Rated output	Number of test samples
all polarities	< 5 MVA (MW)	10 % of bars or coil sides with a minimum of 20
two and four	≥ 50 MVA (MW)	all bars or coil sides
	< 50 MVA (MW) but not less than 5 MVA (MW)	at least 60 bars or 60 coil sides and, in addition, 10 % of all bars or coil sides
six and more	≥ 5 MVA (MW)	

2.2 The loss tangent shall be measured on the samples at room temperature in relation to voltage (see Figure 1) over the range of 0,2 U_N to 1,0 U_N at intervals of 0,2 U_N.

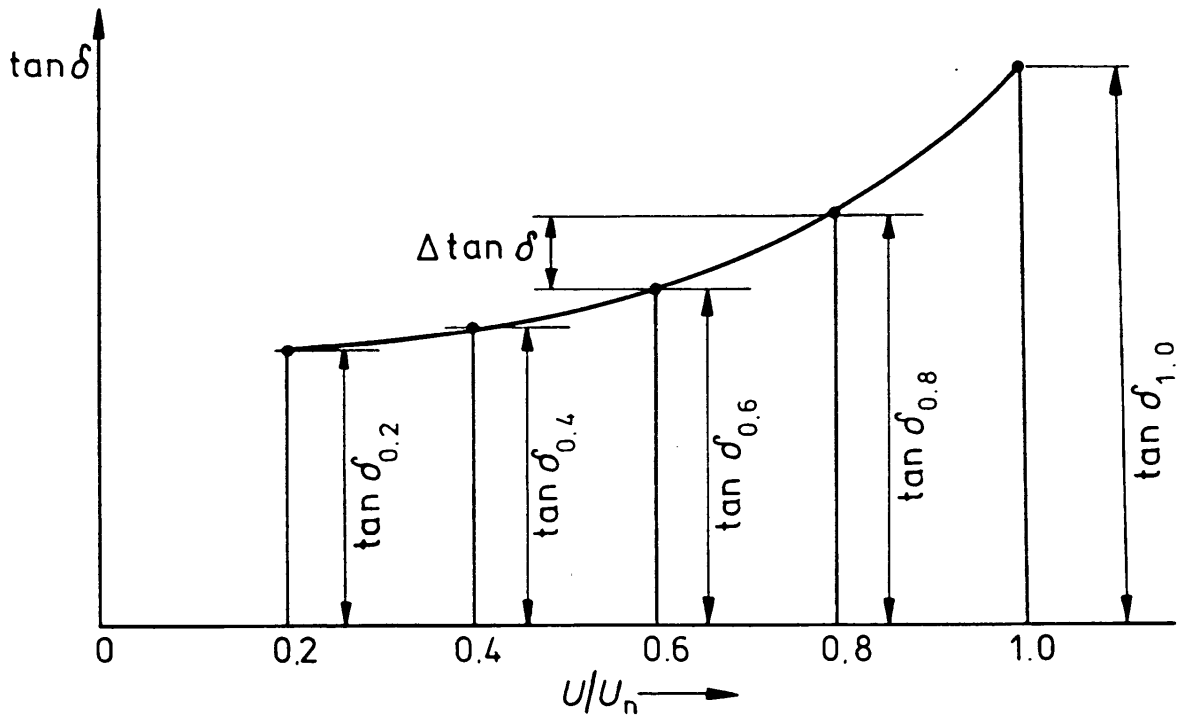

Figure 1: Curve of tan δ against the ratio U/U_N (example of a series of measurements)

The measurements shall be carried out by means of a Schering Bridge or an equivalent type of bridge, using a guard ring arrangement.
The length of the test foil shall be about equal to the axial length of the stator core.
The guard ring arrangement shall lie outside this zone.

The initial value of tan $\delta_{0,2}$, the increment ½ (tan $\delta_{0,6}$ - tan $\delta_{0,2}$) and the increment Δ tan δ per measuring step must not exceed the values in Table 2 for rated voltages up to 11 kV.

For rated voltages above 11 kV the values should be fixed by special agreement.

If more than 5% of the samples show test results in the ranges between columns 2 and 3 or between columns 4 and 5 of Table 2, or in a different range of agreed values, the testing shall be continued with an equal number of further samples, if necessary up to the total number of bars or coil sides. If during these tests the values of Table 2 or the agreed values are not exceeded, the test of insulation shall be regarded as satisfactory.

Table 2: Highest permissible values of loss tangent (rated voltage ≤ 11 kV)

1	2	3	4	5
tan $\delta_{0,2}$	½ (tan $\delta_{0,6}$ - tan $\delta_{0,2}$)		Δ tan δ per step of 0,2 U_N	
all samples	95 % samples	Remaining 5 %	95 % samples	remaining 5 %
30×10^{-3}	$2,5 \times 10^{-3}$	3×10^{-3}	5×10^{-3}	6×10^{-3}

2.3 The conductor lamination insulation of all bars of the machine shall be tested using a.c. 110 V, 50 Hz before applying the high voltage insulation. Interlaminar short-circuits must be eliminated.

3 Random test

3.1 *Sampling*

If a random sample test has been agreed it shall be carried out on two samples (two bars or two coil sides) chosen at random from the winding in the sequence shown below.

3.2 *General*

The loss tangent shall be measured as a function of the voltage (voltage range 0,2 U_N to 1,0 U_N, at steps of 0,2 U_N) at room temperature before and after heating to at least 90°C.

The test samples may be fitted into a model of the slot. The temperature of the insulation, which must be as uniform as possible, shall be measured at the surface of the insulation. After cooling the test samples to room temperature, the loss tangent shall be measured again in relation to voltage as described above.

For voltages equal to or below 11 kV, the maximum value of $\Delta \tan \delta$ per measuring interval of 0,2 U_N measured at room temperature after heating the sample, shall not exceed the maximum value measured before heating by more than 2×10^{-3} and shall not in any case exceed 7×10^{-3}.

In the case of rated voltages above 11 kV up to 24 kV the maximum values per measuring interval of 0,2 U_N shall not exceed values fixed by special agreement.

3.3 *Insulation of conductor laminations*

In the case of bars, the conductor lamination insulation shall be tested with a.c. 110 V, 50 Hz. In the case of transposed conductors, no short-circuits shall occur between the laminations within the slot portion.

3.4 *Insulation of turns*

3.4.1 To check the interturn insulation of coils, a test shall be carried out on the opened coil with a.c. at 0,3 U_N, applied between adjacent turns for a period of 1 min. During this test no breakdown shall occur. Immediately after this, the voltage shall be increased at the rate of 0,5 kV/s until breakdown of the interturn insulation occurs.

The breakdown voltage shall be recorded.

3.4.2 Alternatively, the following high-frequency method may be used.

A voltage with a peak value equal to the effective voltage of the machine, U_N, shall be applied for 15 seconds to the end of the coil from a high-frequency source (sinusoidal or non-sinusoidal).

3.5 *Insulation of straight parts*

3.5.1 The slot insulation shall be tested for 1 min with the test voltage prescribed for the rated voltage of the winding (EN 60034-1, 8.1). Immediately after this test, the voltage shall be increased at the rate of 1 kV/s if possible up to breakdown.

The breakdown voltage of the insulation shall be more than double the test voltage.

3.5.2 When the slot portions and the end windings are insulated in different ways, the insulation of both end windings shall be tested with a voltage of 2 U_N for 1 min. No breakdown shall occur. Immediately after this test, the voltage shall be increased at the rate of 1 kV/s up to breakdown.

The breakdown voltage shall be recorded.

3.6 *Result of the test*

If the random sample test in accordance with 3.2 to 3.5 on one of the samples is not successful, the unsuccessful part of the test shall be repeated on six further bars or three further coils. The random sample test shall be considered satisfactory if the part of the test repeated on the number of samples mentioned above fulfils the requirements.

Part B – Tests as a whole or composite tests

1 Test of the winding

The loss tangent of the complete winding, or if possible, of portions of the winding, shall be measured at room temperature as a function of the voltage over the range from 0,2 U_N to 1,0 U_N at steps of 0,2 U_N

Agreement should be reached on permissible limiting values.

2 Tests on corresponding single winding elements

If such a test has been agreed, at least two additional winding elements shall be manufactured at the same time and under the same conditions as the rest of the winding and accommodated in a slot model ; these shall be submitted to tests in accordance with clause 3 of Part A.

Agreement should be reached on permissible limiting values.

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