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BRITISH STANDARD

BS 7844-3 : 1998

Three phase dry-type distribution transformers 50 Hz, from 100 to 2500 kVA, with highest voltage for equipment not exceeding 36 kV

Part 3. Determination of the power rating of a transformer loaded with non-sinusoidal current

ICS 29.180

National foreword

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The UK participation in its preparation was entrusted to Technical Committee PEL/14, Power transformers, which has the responsibility to:

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- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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Summary of pages

This document comprises a front cover, an inside front cover, the Harmonized Document title page, pages 2 to 4, an inside back cover and a back cover.

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May 1997

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English version

Three-phase dry-type distribution transformers 50 Hz, from 100 to 2500 kVA, with highest voltage for equipment not exceeding 36 kV Part 3: Determination of the power rating of a transformer loaded with non-sinusoidal current

Transformateurs triphasés de distribution de type sec, 50 Hz, de 100 à 2500 kVA, avec une tension la plus élevée pour le matériel ne dépassant pas 36 kV
Partie 3: Détermination de la caractéristique de puissance d'un transformateur avec des courants de charge non sinusoïdaux

Drehstrom-Trocken-Verteilungstransformatoren 50 Hz, 100 - 2500 kVA mit höchster Spannung für Betriebsmittel bis 36 kV
Teil 3: Bestimmung der Bemessungsleistung eines Transformators bei nicht sinusförmigen Lastströmen

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This Harmonization Document exists in three official versions (English, French, German).

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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

Ref. No. HD 538.3 S1:1997 E

Foreword

This Harmonization Document was prepared by the Technical Committee CENELEC TC 14, Power transformers.

The text of the draft was submitted to the Unique Acceptance Procedure and was approved by CENELEC as HD 538.3 S1 on 1996-10-01.

The following dates were fixed:

- latest date by which the existence of the HD has to be announced at national level (doa) 1997-06-01
- latest date by which the HD has to be implemented at national level by publication of a harmonized national standard or by endorsement (dop) 1997-12-01
- latest date by which the national standards conflicting with the HD have to be withdrawn (dow) 1997-12-01

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Introduction

In a study of the loadability of standard transformers in the presence of non-sinusoidal wave forms, constructional features such as the arrangement and type of windings have a strong influence on performance.

The formulae used in this document are intended to give guidance in selecting the most suitable unit from a range of transformers in order to provide sufficient reliability in service.

In the case that an accurate evaluation is required, assistance should be requested from the manufacturer.

1 Scope

This document gives to the user guidance to determine the loadability of a dry-type distribution transformer, as defined in and covered by HD 538 in the case of load current with harmonic factors exceeding the maximum values allowed.

2 Application

For normal electrical energy distribution, the allowable total harmonic factor[1)] and even harmonic factor of the load current are assumed to be limited to 5 % and 1 % respectively.

For electrical distribution with higher harmonic factors, it has to be taken into account that the load loss increases and, by consequence, the temperature rises in the transformer exceed those corresponding to sinusoidal currents having the same RMS value.

NOTE: If the transformer is intended for converter operation, the matter should be discussed between purchaser and manufacturer.

3 Equivalent power rating

The equivalent power rating is related to sinusoidal current which causes the same losses as those occurring with the non-sinusoidal current imposed.

The equivalent power rating is equal to the power based on the RMS value of the non-sinusoidal current multiplied by the factor K.

The rated power of the transformer to be used shall be equal to or higher than the equivalent power rating.

In case a transformer in service is subsequently loaded with harmonic currents, a derating factor $1/K$ shall be applied to the rated power.

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1) The harmonic factor H, in percentage, is defined by:

$$H\% = 100 \left[\sum_{n=2}^{n=N} \left(\frac{I_n}{I_1} \right)^2 \right]^{\frac{1}{2}}$$

4 Calculation of the factor *K* to obtain the equivalent power rating

The factor *K* is given by the following formula[2]:

$$K = \left[1 + \frac{e}{1+e}\left(\frac{I_1}{I}\right)^2 \sum_{n=2}^{n=N}\left(n^q\left(\frac{I_n}{I_1}\right)^2\right)\right]^{\frac{1}{2}}$$

In the above formula the following symbols and definitions apply:

- e = the eddy current loss due to sinusoidal current at fundamental frequency (e.g. 50 Hz), divided by the loss due to a d.c. current equal to the RMS value of the sinusoidal current, both at reference temperature
- n = harmonic order
- I = the RMS value of the sinusoidal current and, in the other case, of non-sinusoidal current containing all harmonics, given by:

$$I = \left(\sum_{n=1}^{n=N} I_n^2\right)^{\frac{1}{2}} = I_1\left[\sum_{n=1}^{n=N}\left(\frac{I_n}{I_1}\right)^2\right]^{\frac{1}{2}}$$

- I_n = the n_{th} harmonic current (amplitude or RMS value)
- I_1 = the fundamental current (amplitude or RMS value)
- q = an exponential constant[3]

2) In the formula it is assumed that both power ratings are based on the same RMS value of the load current.

3) The exponent *q* is dependent on the type of windings and on the frequency. However, as an approximation and as a guidance, the following constant values may be used:
- 1,7 for transformers with round or rectangular wire in both the low and high voltage windings,
- 1,5 for transformers having low voltage foil windings.

Other values, based on measurements and possibly frequency dependent, may be applied by agreement between purchaser and manufacturer.

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