BS EN 50541-2:2013

BSI Standards Publication

Three phase dry-type distribution transformers 50 Hz, from 100 kVA to 3 150 kVA, with highest voltage for equipment not exceeding 36 kV -

Part 2: Determination of loadability of a transformer loaded with non-sinusoidal current

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National foreword

This British Standard is the UK implementation of EN 50541-2:2013. It supersedes BS 7844-3:1998 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PEL/14, Power transformers.

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.

ISBN 978 0 580 78418 7

ICS 29.180

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

Amendments issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 50541-2

June 2013

ICS 29.180

Supersedes HD 538.3 S1:1997

English version

Three phase dry-type distribution transformers 50 Hz, from 100 kVA to 3 150 kVA, with highest voltage for equipment not exceeding 36 kV - Part 2: Determination of loadability of a transformer loaded with non-sinusoidal current

Transformateurs triphasés de distribution de type sec 50 Hz, de 100 kVA à 3 150 kVA, avec une tension la plus élevée pour le matériel ne dépassant pas 36 kV -
Partie 2: Détermination de la caractéristique de puissance d'un transformateur avec des courants de charge non-sinusoïdaux

Drehstrom-Trocken-Verteilungstransformatoren, 50 Hz, 100 kVA bis 3 150 kVA, mit einer höchsten Spannung für Betriebsmittel kleiner oder gleich 36 kV -
Teil 2: Bestimmung der Bemessungsleistung eines Transformators bei nicht sinusförmigen Lastströmen

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Ref. No. EN 50541-2:2013 E

Contents

Foreword

This document (EN 50541-2:2013) has been prepared by CLC/TC 14 "Power transformers".

The following dates are fixed:

• latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2014-04-15
• latest date by which the national standards conflicting with this document have to be withdrawn	(dow)	2016-04-15

The EN 50541 series consists of the following parts, under the general title: "*Three phase dry-type distribution transformers 50 Hz, from 100 kVA to 3 150 kVA, with highest voltage for equipment not exceeding 36 kV*":

- *Part 1: General requirements*
- *Part 2: Determination of loadability of a transformer loaded with non-sinusoidal current*

This document supersedes HD 538.3 S1:1997.

1 Scope

This European Standard gives to the user guidance to determine the loadability of dry type distribution transformers, as defined in and covered by EN 50541-1, 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 due to 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 r.m.s. value.

If the transformer is intended for converter operation or the harmonic factor is higher than 5 %, the matter is 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 r.m.s. 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.

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

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

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

where

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

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

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

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 r.m.s. value of the sinusoidal current, both at reference temperature;

n = harmonic order;

I = the r.m.s. 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 r.m.s. value);

I_1 = the fundamental current (amplitude or r.m.s. value);

q = an exponential constant[3)].

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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