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Three phase oil-immersed distribution transformers 50 Hz, from 50 to 2500 kVA with highest voltage for equipment not exceeding 36 kV - Part 4: Determination of the power rating of a transformer loaded with non-sinusoidal currents

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ENGLISH VERSION

Three phase oil-immersed distribution transformers 50 Hz, from 50 to 2500 kVA with highest voltage for equipment not exceeding 36 kV
Part 4: Determination of the power rating of a transformer loaded with non-sinusoidal currents

Transformateurs triphasés de distribution immergés dans l'huile, 50 Hz, de 50 à 2500 kVA, avec une tension la plus élevée pour le matériel ne dépassant pas 36 kV
Partie 4: Détermination de la caractéristique de puissance d'un transformateur avec des courants de charge non sinusoïdaux

Drehstrom-Öl-Verteilungstransformatoren 50 Hz von 50 bis 2500 kVA, mit einer höchsten Spannung für Betriebsmittel bis 36 kV
Teil 4: Bestimmung der Bemessungsleistung eines Transformators bei nichtsinusförmigen Lastströmen

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Up-to-date lists and bibliographical references concerning national implementation may be obtained on application to the Central Secretariat or to any CENELEC member.

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

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Foreword

This Part 4 of HD 428 was prepared by WG 7, Harmonics, of Technical Committee CENELEC TC 14, Power transformers.

The document was submitted to the Unique Acceptance Procedure (UAP) and was approved by CENELEC as HD 428.4 S1 on 1993-09-22.

The following dates were fixed:

- latest date of announcement of the HD at national level	(doa)	1994-03-01
- latest date of publication of a harmonized national standard	(dop)	1994-09-01
- latest date of withdrawal of conflicting national standards	(dow)	1994-09-01

1 Scope

This document gives to the user guidance to determine the loadability of an oil-immersed distribution transformer, as defined in and covered by HD 428, in the case of load current with harmonic factors exceeding the maximum values allowed.

NOTE: In general this document is also applicable to dry-type distribution transformers as defined in and covered by HD 538.

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.

(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.