

Recognized as an
American National Standard (ANSI)

IEEE Std C57.18.10-1998(R2003)
(Revision and redesignation of
ANSI/IEEE C57.18-1964)

IEEE Standard Practices and Requirements for Semiconductor Power Rectifier Transformers

Sponsor

**Transformers Committee
of the
IEEE Power Engineering Society**

Approved 4 February 1999

American National Standards Institute

Reaffirmed 9 December 2003

Approved 19 March 1998

IEEE-SA Standards Board

Abstract: Practices and requirements for semiconductor power rectifier transformers for dedicated loads rated single-phase 300 kW and above and three-phase 500 kW and above are included. Static precipitators, high-voltage converters for dc power transmission, and other nonlinear loads are excluded. Service conditions, both usual and unusual, are specified, or other standards are referenced as appropriate. Routine tests are specified. An informative annex provides several examples of load loss calculations for transformers when subjected to nonsinusoidal currents, based on calculations provided in the standard.

Keywords: eddy current losses, harmonic load losses, single-phase transformers, three-phase transformers, three-winding transformers, transformer load losses, two-winding transformers

The Institute of Electrical and Electronics Engineers, Inc.
345 East 47th Street, New York, NY 10017-2394, USA

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ISBN 0-7381-0191-5

Second Printing 26 January 2006. To obtain errata information, please go to
<http://standards.ieee.org/reading/ieee/updates/errata/index.html>.

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Introduction

(This introduction is not part of IEEE Std C57.18.10-1998, IEEE Standard Practices and Requirements for Semiconductor Power Rectifier Transformers.)

Early editions of ANSI C57.18 were written for transformers used with pool cathode mercury arc rectifiers. The last revision date for ANSI C57.18 was 1964. That standard did not reflect the practices that have developed with the use of semiconductor rectifying or converting devices, nor did it reflect the latest transformer technology. As a result, much of it is inconsistent with current practices and with other related standards, such as ANSI C34.2^{*}, that deal with semiconductor converters. This new standard is the result of the decision to write a new rectifier transformer standard instead of revising the old standard. Suggestions for improvement of these practices will be welcomed.

Basic impulse level (BIL) ratings for windings connected to converters are not specified by this standard. There are many practical reasons why windings connected to converters need not have a BIL test or rating. These windings are often high-current, low-voltage windings that will not produce ANSI standard waveforms when tested. Interleaved windings cannot be impulse tested easily. Usually the converter and the transformer are close coupled in a throat connection and not subject to lightning strikes. The converter usually cannot withstand normal transformer BIL ratings for the winding voltages to which they are connected. These conditions aren't always true, however. If a user wishes to have a BIL rating or test, this may be arranged through commercial negotiations and technical specifications that may override this standard. This should also be acknowledged by the transformer manufacturer during the bidding process.

Hottest-spot winding temperatures are referred to in this standard. These are not tested values. Hottest-spot temperatures cannot be measured from a practical standpoint on production units. Therefore, average winding temperatures plus a hottest-spot increment may be used. There is continuing work in other standards groups on this matter.

The methods of rating the transformer kVA and currents in previous editions of ANSI C57.18 were based on the rms equivalent of a rectangular current wave shape based on the dc rated load commutated with zero commutating angle. This is the rms kVA and current method. All of the tables in Clause 10 are based on this traditional method. A new approach is to base the transformer kVA and currents on the rms value of the fundamental current and kVA. This is the fundamental kVA and current method. The fundamental kVA method is in use in IEC standards. This approach needs to be reflected in ANSI C34.2 and ANSI C34.3 as well as in this standard. The traditional tables are retained in Clause 10 to maintain its method. Both kVA values will be shown on the nameplate to accommodate either method. Specifying engineers should clearly define whether they are specifying the traditional rms kVA or the fundamental kVA so as to avoid confusion. RMS kVA is beneficial to users who utilize their primary metering on the transformer to monitor load. The fundamental kVA is related directly to the real power used by the rectifier or convertor. The rms kVA can be determined when the fundamental kVA is given along with the harmonic spectrum for the load. The specifying engineer is always obligated to supply the harmonic spectrum in order to properly rate and design the transformer. The specifying engineer has overall system responsibility; definition of the harmonic spectrum is not the transformer manufacturer's responsibility. The difference between the two methods should result in only a small percentage error in kVA sizing, but in some cases it may be determined to be critical. Future coordination with ANSI C34.2 and ANSI C34.3 working groups should give a final direction with regard to kVA rating method.

Two cautionary notes are in order regarding testing.

First, errors may result when measuring losses on transformers with low power factors. Care must be exercised in making the loss measurements for rectifier transformers with high reactance and low losses. Test tol-

^{*}A new working group has been formed to revise ANSI C34.2.

erances should be held to 3% throughout the ranges of reactance and losses so as to accurately measure stray losses for the harmonic calculations. There is ongoing work on this subject within the Loss Measurement Working Group of the Performance Characteristics Subcommittee.

Second, other errors regarding resistance readings for losses or temperature rise tests are possible on low-voltage, high-current windings having very low resistance, often with bolted joints. Connection losses may alter normal resistance measurements. Work on this topic should be undertaken in the future.

The exact methodology for temperature rise testing using service losses enhanced with harmonics needs to be more fully developed. After this standard has been in use, it is expected that manufacturers and users will develop more detailed preferred methods. Experience will also provide insight as to whether there are any serious shortcomings in these methods. It is hoped that they will be found to be safely conservative. It is believed that some development time is necessary with the new approach before exact methods are prescribed.

Work should be done on future revisions to this standard to develop more detailed methods of interphase transformer loss testing. More precise methods for determining losses for commercial guarantee purposes, as well as thermal and magnetic capability, are needed. These were not attempted in this standard revision due to lack of time.

This standard was developed by a Working Group of the Subcommittee on Performance Characteristics of the IEEE Transformer Committee. The Working Group had the following membership:

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1. Overview

1.1 Scope

This standard includes semiconductor power rectifier transformers for dedicated loads rated

- Single-phase 300 kW and above
- Three-phase 500 kW and above

The scope of this standard excludes

- Static precipitators
- High-voltage converters for dc power transmission
- Other nonlinear loads

1.2 Mandatory requirements

When this standard is used on a mandatory basis, the words “shall” and “must” indicate mandatory requirements, and the words “should” and “may” refer to matters that are recommended and permitted, respectively, but not mandatory.

2. References

When the following standards and guides referred to in this standard are superseded by an approved revision, the latest revision shall apply.

ANSI C34.3-1973 (IEEE Std 444-1973), IEEE Standard Practices and Requirements for Thyristor Converters for Motor Drives.¹

¹This standard has been withdrawn; however, copies can be obtained from Global Engineering, 15 Inverness Way East, Englewood, CO 80112-5704, USA, tel. (303) 792-2181.