PUBLISHED DOCUMENT

PD IEC/TR 60787:2007

Application guide for the selection of high-voltage current-limiting fuse-links for transformer circuits

ICS 29.120.50

British Standards

National foreword

This Published Document was published by BSI. It is the UK implementation of IEC/TR 60787:2007. It supersedes BS 6553:1984 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PEL/32, Fuses.

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.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 May 2007

ISBN 978 0 580 50801 1

Amendments issued since publication

Amd. No.	Date	Comments

PD IEC/TR 60787:2007

TECHNICAL REPORT

IEC TR 60787

First edition
2007-03

Application guide for the selection of high-voltage current-limiting fuse-links for transformer circuits

Reference number
CEI/IEC/TR 60787:2007

CONTENTS

APPLICATION GUIDE FOR THE SELECTION OF HIGH-VOLTAGE CURRENT-LIMITING FUSE-LINKS FOR TRANSFORMER CIRCUITS

1 Scope and object

IEC/TR 60787, which is a technical report, serves as an application guide to the use, for distribution transformer circuit applications, of fuses complying with the requirements of IEC 60282-1: High-voltage fuses - Part 1: Current-limiting fuses. Therefore, this document is informative, not normative.

The object of this application guide is to specify criteria for coordination of high-voltage fuses with other circuit components in transformer applications and to give guidance for the selection of fuse-links with particular reference to their time-current characteristics and ratings.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60076-5: 2006, *Power transformers – Part 5: Ability to withstand short- circuit*

IEC 60076-7: *Power transformers – Part 7*: *Loading guide for oil-immersed power transformers*

IEC 60282-1: 2005, *High-voltage fuses – Part 1: Current-limiting fuses*

IEC 60470: 2000, *High-voltage alternating current contactors and contactor-based motor-starters*

IEC 60905: *Loading guide for dry-type power transformers*

IEC 62271-105: 2002, *High-voltage switchgear and controlgear – Part 105: Alternating current switch-fuse combinations*

IEC 62271-107: 2005, *High-voltage switchgear and controlgear – Part 107: Alternating current fused circuit-switchers for rated voltages above 1 kV up to and including 52 kV*

3 Features of current limitation

The use of high-voltage current-limiting fuses for the primary-side protection of distribution transformers provides significant advantages due to their current-limiting action. Under most short-circuit conditions, they are able to interrupt fault currents within a few milliseconds after fault initiation. Hence, the prospective peak of the fault current will not be reached and the resulting let-through current and energy will be significantly reduced. This feature makes current-limiting fuses particularly suited for distribution transformer protection since they are able to prevent or minimize any major consequences of internal transformer faults.

Figure 1 illustrates the operating I^2t versus prospective current for a non current-limiting device and a current-limiting fuse. In principle, the lowest current rating of current-limiting fuse that meets the coordination requirements of Clause 6 should be chosen. This is because a smaller fuse-link of a given design will generally have a lower operating I^2t. In the case of a low impedance internal transformer fault that produces a current-limiting action by the fuse-link, the I^2t limitation significantly reduces the likelihood of a disruptive failure, particularly with oil-filled transformers.

NOTE operating I^2t is proportional to energy dissipated at the site of the fault.

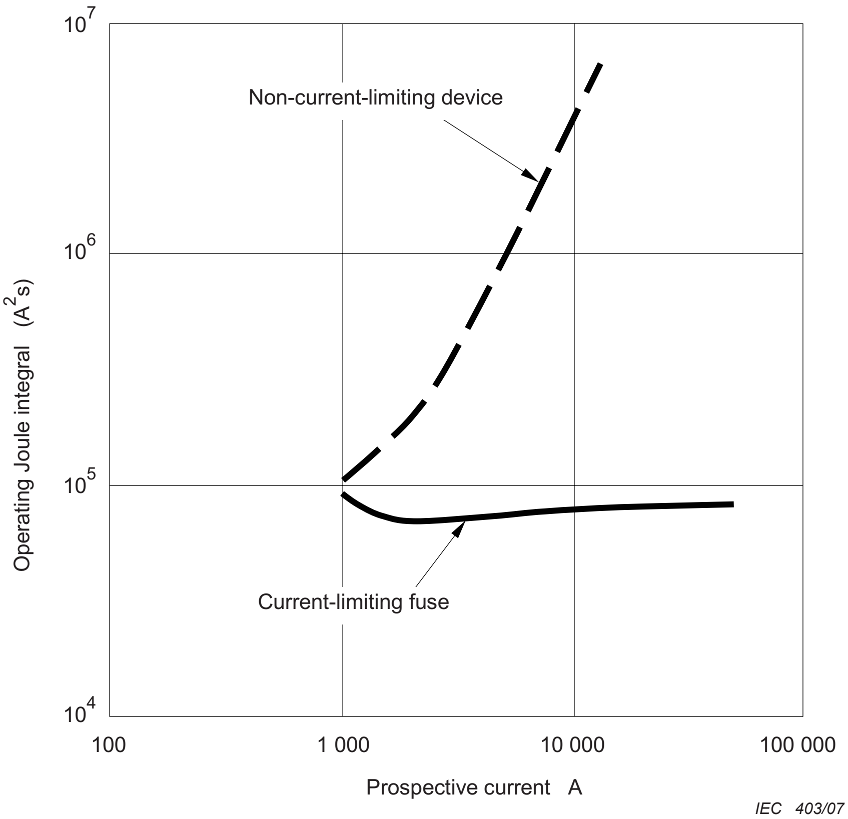

Figure 1 – Comparison of operating Joule integral (I^2t) for current-limiting fuses and non-current-limiting devices

Experience has shown that the I^2t associated with a current-limiting fuse interruption is often an order of magnitude less than that causing a disruptive transformer failure, hence the effectiveness of current-limiting fuses in reducing the likelihood of such serious incidents.

4 Fuse-link time-current characteristics

The time-current characteristics of high-voltage fuse-links for transformer circuit applications should have the following features:

a) Relatively high operating current in the 0,1 s region so as to withstand transformer inrush current and give good coordination with protection devices on the secondary side (where fitted).

b) Relatively low operating current in the 10 s region so as to:

   – ensure rapid clearance of transformer winding faults, secondary side faults (see Note below) and, if applicable, primary side earth faults;

   – give good coordination with overcurrent protective devices on the source side.

Therefore, the pre-arcing time-current characteristics of fuse-links for transformer circuit applications should preferably be within the following limits:

$$I_{f10} / I_{\mathrm{n}} \leq 6$$

$$I_{f0,1} / I_{\mathrm{n}} \geq 7\left(I_{\mathrm{n}} / 100\right)^{0,25}$$

where, all current values being expressed in amperes:

I_{n} is the rated current of the fuse-link;

I_{f10} and $I_{f0,1}$ is the pre-arcing currents corresponding to 10 s and 0,1 s respectively, expressed as mean values with the tolerances specified in 4.11 of IEC 60282-1.

The term $(I_{\mathrm{n}}/100)^{0,25}$ is introduced to take account of the fact that the pre-arcing time-current characteristics for a range of fuse-links diverge as they approach the short-time region.

NOTE Transformers are designed to withstand short-circuit currents caused by a solid short-circuit on the LV terminals for a specified short-circuit withstand duration. It is therefore important to verify that, at the resulting current on the HV side, the HV fuse maximum breaking time is equal to or less than the specified short-circuit withstand duration of the transformer (refer to IEC 60076-5, 4.1.3).

5 Coordination

Figure 2 illustrates a typical transformer application involving a high-voltage fuse-link (or fuse-links), a transformer and possible protective devices on both source and load sides.

The transformer will be chosen first for its particular duty. This establishes the value of the rated current of the transformer, the value of the permissible overload current (where applicable) and also by inference, the inrush current. The high-voltage fuse-link(s) are then chosen so as to give optimum protection to the circuit, bearing in mind the factors of Items a) to d) listed below.

With reference to Figure 2, the following should be noted:

a) The primary side high-voltage fuse-link minimum pre-arcing time-current characteristic should be to the right of point A defining the transformer inrush characteristic. For practical purposes this may be taken from 10 to 12 times the transformer rated current for a duration of 0,1 s.

b) The rated current of the primary side high-voltage fuse-link should exceed the rated current of the transformer:

   1) by an amount sufficient to allow for permissible overloading of the transformer under service conditions (refer to IEC 60076-7 and IEC 60905).

2) by a further amount where the fuse-link(s) are mounted in an enclosure so as to ensure that the specified temperature limits for fuse-links are not exceeded and so that excessive fuse element temperature does not lead to premature fuse operation. See Annex F of IEC 60282-1.

3) by a further amount where the ambient air temperature is likely to exceed that specified in Clause 2 of IEC 60282-1.

c) The pre-arcing current of the primary side high-voltage fuse-link should be as low as possible in the 10 s region of the fuse time-current characteristic in order to ensure the maximum protection of the transformer (see Clause 5 and Note 1 below).

d) For complete coordination between primary side and secondary side fuse-links or other protective devices on the load side, the intersection B of the primary side time-current characteristic (minimum pre-arcing) and the secondary side device characteristic (maximum total operating) (as referred to the primary side taking into account the appropriate ratio) should occur at a value of current greater than that of the maximum fault current on the load side of the secondary side protective device.

Finally, where it is seen that the desired degree of coordination has not been achieved, the selection or setting of the source side overcurrent protective device may be re-examined. Similarly, the maximum rating of the secondary side fuse-link(s) may need to be reduced for the same reasons.

NOTE Cold load pick-up: Some users have a requirement for the high-voltage fuse to withstand cold load pick-up conditions. These may arise due to the loss of load diversity following re-connection and to the higher current drawn by some system components when cold. No standardized values exist for such conditions and such withstand may well conflict with the requirements of Clause 5c). Such conflict of requirements may be resolved by discussion between user and fuse manufacturer.

6 Other ratings and requirements

6.1 Rated voltage

See 4.2 and 9.3.4 of IEC 60282-1.

6.2 Rated maximum breaking current

See 4.8.1 of IEC 60282-1.

6.3 Rated minimum breaking current and class:

See 4.8.2 of IEC 60282-1 and below:

Fuse-links should be selected so that the value of minimum breaking current is appropriate to the particular application concerned. It should be stressed that use of a fuse-link having too high a value of minimum breaking current could, under certain circumstances, result in disruptive failure of the fuse-link and consequent damage.

6.3.1 Fuse-links used in combination or association with other switching devices

Minimum breaking current need only be low enough to ensure correct coordination with the switching device of the combination. Back-Up fuses are generally used for this application.

a) use in striker-tripped combinations

In applications where operation of the fuse striker ensures instantaneous operation of the associated tripping mechanism, automatic transfer of breaking duty under low fault conditions from the fuse to the associated switchgear is assured. Back-Up fuses can be used for this application and it is only necessary to ensure that the fuse minimum breaking current is lower than the maximum breaking capacity of the associated switchgear.

b) use in relay-operated switchgear

In such applications Back-Up fuses may be used and it is only necessary to ensure that the time-current characteristics of fuse and associated switchgear relay intersect at a value of current above the minimum breaking current of the fuse.

Refer to IEC 62271-105, Alternating current switch-fuse combinations, to IEC 62271-107, Alternating current fused circuit-switchers for rated voltages above 1 kV up to and including 52 kV, and to IEC 60470, High-voltage alternating current contactors and contactor-based motor-starters, for standardized applications of a) and b) above.

In principle, the guidance of a) and b) applies also to fuses used in other forms of association or combination with switchgear.

6.3.2 Fuse-links used as the only protection on the HV side of the transformer

For applications where it can be shown by calculation or by service experience that low fault levels are unlikely to occur, then suitable Back-Up fuses may be used. In this case it is necessary to ascertain that the rated minimum breaking current of the fuse link is less than the smallest HV fault current likely to occur due to a fault located between the high-voltage fuses and the low-voltage protecting device(s).

For applications where experience or calculation indicates there is a possibility of very low values of overcurrents (i.e. below the minimum breaking current of Back-Up fuses) then General-Purpose or Full-Range fuses should be employed.

The latter class of fuse is especially recommended for applications where overcurrents can occur at values as low as the fuse minimum melting current or where the fuse has to be de-rated for use in an enclosure.

It should be checked that for a General Purpose fuse the 1 h-melting current (or the minimum breaking current if rated by the manufacturer), and for a Full Range fuse the minimum melting current, of the selected fuse is not above the value of the overcurrent to be considered.

6.3.3 Fuse-links used to provide short-circuit protection in combination with expulsion fuse-links

Minimum breaking current need only be lower than the cross-over current of the series combination. Values of minimum breaking current vary widely depending on the design of the combination. Back-Up fuses are normally used for this application.

7 Selection of rated currents of fuse-links for transformer circuit applications

The manufacturer of fuse-links intended for transformer circuit protection should make available recommendations for rated currents of fuse-links for given kVA ratings of transformers.

The information should preferably be given in tabular form. The transformer ratings quoted should be preferably selected from the R 10 series and should cover a range appropriate to the range of fuse-links concerned.

NOTE The R10 series comprises the numbers 1; 1,25; 1,6; 2; 2,5; 3,15; 4; 5; 6,3; 8 and their multiples of 10.

The rated currents of fuse-links chosen for each transformer rating should be governed by the criteria given in Clause 5.

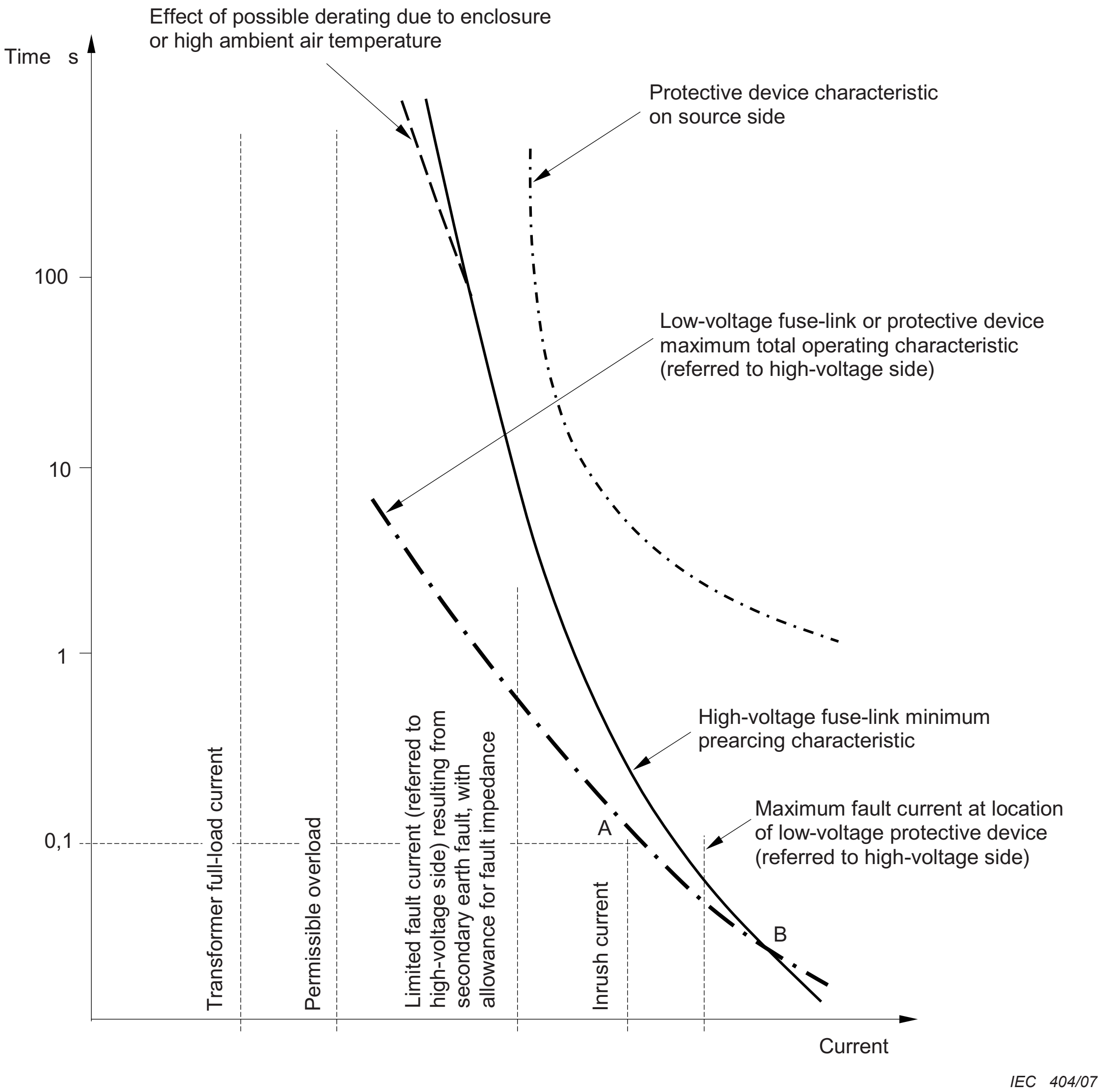

Figure 2 – Characteristics relating to the protection of the HV/LV transformer circuit

Manufacturing tolerances and variations between cold and hot characteristics of the various components of the circuit should be taken into considerations.

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: +44 (0)20 8996 9000. Fax: +44 (0)20 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: +44 (0)20 8996 9001. Fax: +44 (0)20 8996 7001. Email: orders@bsi-global.com. Standards are also available from the BSI website at http://www.bsi-global.com.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: +44 (0)20 8996 7111. Fax: +44 (0)20 8996 7048. Email: info@bsi-global.com.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: +44 (0)20 8996 7002. Fax: +44 (0)20 8996 7001. Email: membership@bsi-global.com.

Information regarding online access to British Standards via British Standards Online can be found at http://www.bsi-global.com/bsonline.

Further information about BSI is available on the BSI website at http://www.bsi-global.com.

Copyright

BSI
389 Chiswick High Road
London
W4 4AL