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Part 1: Circuit-breakers

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

First supplement to Publication 157-1 (1973)
LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR
Part 1: Circuit-breakers

FOREWORD

1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.

2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.

3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendation and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

PREFACE

This standard has been prepared by Sub-Committee 17B, Low-voltage Switchgear and Controlgear, of IEC Technical Committee No. 17, Switchgear and Controlgear.

Elaboration of Part A: "Appendix D: Co-ordination of circuit-breakers with separate fuses associated in the same circuit".

Pursuant to the decision taken in September 1972 during the Stockholm meeting, a first draft was established in July 1973 and examined in Paris in February-March 1974. The second draft was successively circulated under the accelerated procedure in September 1974 and under the Six Months' Rule in April 1975.

The following countries voted explicitly in favour of publication:

Australia
Belgium
Canada
Denmark
Finland
France
Israel
Japan
Netherlands
Poland
South Africa (Republic of)
Spain
Sweden
Switzerland
Turkey
United Kingdom
United States of America

Elaboration of Part B: "Amendments to be made to IEC Publication 157-1 (2nd edition, 1973)".

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Spain
Sweden
Switzerland
Turkey
Union of Soviet Socialist Republics
United Kingdom
United States of America
Yugoslavia

First supplement to Publication 157-1 (1973)
LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR
Part 1: Circuit-breakers

A — APPENDIX D

CO-ORDINATION OF CIRCUIT-BREAKERS WITH SEPARATE FUSES ASSOCIATED IN THE SAME CIRCUIT

Introduction

With integrally-fused circuit-breakers, the circuit-breaker manufacturer is responsible for ensuring the correct co-ordination of the circuit-breaker with its fuses. But circuit-breakers are frequently connected in series with separate fuses, for reasons such as the method of power distribution adopted for the installation, or because the breaking capacity of the circuit-breaker alone may be insufficient for the proposed application. In such instances the fuses may be mounted in locations remote from the circuit-breaker. Moreover, a single circuit-breaker may be backed up by one fuse (or a set of fuses in the case of a polyphase circuit), or the fuse or fuses may be protecting a main feeder supplying a number of circuit-breakers.

For such applications, the user or specifying authority may have to decide, on the basis of a desk study alone, how best the optimum level of co-ordination may be achieved. This appendix is therefore intended to give guidance on this decision, and also to give guidance on the type of information the circuit-breaker manufacturer should make available to the prospective user.

Guidance is also given on test requirements, should such tests be deemed essential for the proposed application. But for the vast majority of applications, expensive and complicated testing may not be considered necessary. This may be for a variety of practical considerations, such as the prospective short-circuit current being only marginally in excess of the breaking capacity of the circuit-breaker alone.

It is important to note that this appendix is intended to deal with the co-ordination of fuses with circuit-breakers which have break-times of the order of 10 ms or above. It does not deal with the co-ordination of fuses with current-limiting circuit-breakers which have break-times well below 10 ms at their breaking capacity limit, and thereby greatly restrict the short-circuit current Joule integral I^2t.

D1 Scope

This appendix deals with requirements for the co-ordination of circuit-breakers with separate fuses associated in the same circuit.

D2 Object

The object of this appendix is to state:

— the general requirements for the co-ordination of a circuit-breaker with its associated fuse or fuses;

— the methods and the tests intended to verify that the conditions for co-ordination have been met.

D3 General requirements for co-ordination of a circuit-breaker with its associated fuse or fuses

D3.1 *Take-over current*

The take-over current I_B (see Clause 9.5.1) shall be not greater than the breaking capacity of the circuit-breaker alone.

D3.2 *Behaviour of the circuit-breaker in association with its fuses*

For all values of over-current up to and including the breaking capacity assigned to the combination:

a) The making operation of the circuit-breaker as well as the breaking operation of the combination shall not give rise to external manifestations (such as emission of flames) projected beyond the limits stated by the manufacturer (see Clause 9.2.2 *a)*).

b) There shall be no flashover between poles or between poles and frame, nor welding of contacts (see Clause 9.2.2 *b)*).

Note. — See also Clauses D5.2 and D5.3.

D4 Type and characteristics of the associated fuses

On request, the manufacturer of the circuit-breaker shall state, in accordance with the relevant IEC publications (Publications 269-1 and 269-2 or 269-3), the type and the characteristics of the fuses to be used with the circuit-breaker, and the maximum prospective short-circuit current for which the combination is suitable at the stated rated operational voltage.

Whenever possible, the fuses shall be located on the supply side of the circuit-breaker. If the fuses are located on the load side, it is essential that the connections between the circuit-breaker and the fuses be so designed as to minimize any risk of short-circuit.

D5 Methods for verification of the co-ordination

D5.1 *Determination of the take-over current*

Compliance with the requirements of Clause D3.1 shall be verified by comparing the characteristics of the circuit-breaker and of the fuse. If the circuit-breaker is fitted with adjustable over-current opening releases, the value of break-time to be used shall be that at the minimum current setting. If the circuit-breaker may be fitted with instantaneous over-current opening releases, the value of break-time to be used shall be that corresponding to the circuit-breaker fitted with such releases.

D5.2 *Verification of the behaviour of the circuit-breaker*

Compliance with the requirements of Clause D3.2 may be verified by one of the following methods:

a) By tests in accordance with Clause D5.3. In this case, all the conditions for the test shall be as specified in Clause 8.2 of this publication, with the adjustable resistors and inductors for the short-circuit test on the supply side of the association.

b) By comparing the characteristics of the circuit-breaker and of the fuse, special attention being paid to the following:

1) the Joule-integral values of the circuit-breaker and of the fuse during the total clearing time;

2) the effects on the circuit-breaker (e.g. by arc energy, by maximum peak current, etc.) at the peak value of the cut-off current of the fuse.

The suitability of the association can then be ascertained by considering the maximum total operating I^2t value of the fuse, over the range from the rated short-circuit capacity of the circuit-breaker to the prospective short-circuit current of the proposed application, but not exceeding the short-circuit capacity of the association. This value shall not exceed the maximum let-through I^2t of the circuit-breaker at its rated short-circuit breaking capacity.

The peak value of the cut-off current of the fuse shall not exceed the rated short-circuit making capacity of the circuit-breaker.

D5.3 *Current for verification of correct co-ordination*

The short-circuit test is made with the maximum prospective current I_A, for the proposed application. This shall not exceed the maximum prospective short-circuit current assigned by the manufacturer to the association.

If tests are made in accordance with Clause D5.2, the following procedure shall apply:

Order of tests	Test clauses applicable to circuit-breakers of short-circuit performance categories	
	P-1	P-2
Short-circuit test at current I_A	CO 8.2.4	CO 8.2.4
Calibration test (note 1)	8.2.8	8.2.8
Reduced voltage dielectric test (notes 1 and 2)	8.2.3	8.2.3
Temperature-rise test	8.2.4.10.1 *a)*	8.2.4.10.2 *a)*

1) This test is to be made on the circuit-breaker alone, not on the association.
2) The test is limited to the main circuit, the test-voltage value being twice the rated insulation voltage value.

D5.4 *Results to be obtained*

See Clause D3.2.

B — AMENDMENTS TO BE MADE TO PUBLICATION 157-1 (2nd EDITION, 1973)

1) *Amendment to Clause 8.2.4.5*

Replace the last sentence by: "The values of the resistances of the measuring circuits shall be at least 100 ohms per volt of the power-frequency recovery voltage. The values of the resistances shall be stated in the test report".

2) *Amendment to Clause 8.2.4.8.3*

Delete the last sentence ("The question is under consideration") of the note appearing at the end of paragraph *a)*.

3) *Amendments to Clause 8.2.8*

Add at the end of the clause:

"The test currents shall be applied as follows:

"*a) Verification of non-tripping*

"This verification is made under the conditions laid down in Clause 8.2.8.1 or in Clause 8.2.8.2.1 according to the releases; the current is maintained:

"— for 0.2 s in the case of instantaneous releases;

"— for an interval of time equal to twice the time delay stated by the manufacturer, in the case of definite time-delay releases.

"*b) Verification of tripping*

"This verification is made under the conditions laid down in Clause 8.2.8.1 or in Clause 8.2.8.2.1 according to the releases, but with a current value equal to 1.2 I_r or 1.1 I_r, depending on the type of the releases; the current may be maintained:

"— for 0.2 s in the case of instantaneous releases;

"— for an interval of time equal to twice the time delay stated by the manufacturer, in the case of definite time-delay releases."

After Clause 8.2.8.2.2, add:

"8.2.8.3 *Verification of operation of definite time-delay releases*

"8.2.8.3.1 *Verification of time delay*

"This verification is made for a current value equal to 1.5 times the current setting:

"— with all the poles loaded, in the case of releases intended for protection against overloads;

"— with two poles in series carrying the test current, in the case of releases intended for protection against short-circuits.

"The value measured shall be between the limits stated by the manufacturer.

8.2.8.3.2 *Verification of non-tripping duration*

"This verification is made under the same conditions as for the verification of the time delay (see Clause 8.2.8.3.1).

"Firstly, the current is maintained for a time interval equal to the non-tripping duration stated by the manufacturer; then, the current is reduced to the rated thermal current and maintained at this value for twice the time delay stated by the manufacturer. The circuit-breaker shall not trip."

4) *Amendment to Clause 8.3.2*

The text of the present note shall become the last paragraph of the clause itself.

5) *Amendment to Clause 9.2.1*

Adopt the following title and text:

"9.2.1 *Behaviour of circuit-breaker alone*

"Any circuit-breaker incorporated into a composite unit, so forming an integrally-fused circuit-breaker, shall itself comply with this publication in all respects up to the rated breaking capacity assigned to it when operating alone.

"The circuit-breaker shall operate alone, without causing fuses to operate, at the occurrence of over-currents not exceeding a limiting value stated by the manufacturer."

6) *Amendment to Clause 9.2.2*

At the end of paragraph *a)*, add: "(see Clause 8.2.4.9)".

7) *Amendment to Clause 9.4*

Clarify the last sentence, so that the whole clause becomes:

"This type of composite unit shall be considered as a device different from the circuit-breaker it incorporates, with a set of characteristics which may differ from the characteristics of the circuit-breaker itself. The whole of this publication applies to that new device (i.e. the integrally-fused circuit-breaker), except for the short-circuit tests."

8) *Amendments to Clause 9.5*

Adopt the following text and figure:

9.5 *Verification of the requirements for co-ordination*

9.5.1 *Verification of the take-over current*

Compliance with the requirements of Clause 9.2.1 shall be verified by considering the characteristics of the circuit-breaker and of the fuses (see Figure A, page 18).

If the circuit-breaker is fitted with adjustable over-current releases, the total break-time shall be considered at the minimum setting current.

For fuses, the over-current curve of back-up type fuses, or the over-current ability of fuses for general purposes calculated from the pre-arcing curve, shall be considered (see IEC Publication 269-1, Low-voltage Fuses with High Breaking Capacity for Industrial and Similar Purposes. Part 1: General requirements).

I_B is the take-over current corresponding to the maximum break-time (operating time) of the fuse and to the minimum break-time of the circuit-breaker alone for the conditions of its minimum opening time. I_B is the lowest current value for which the fuses will with certainty interrupt the current before the circuit-breaker; I_B shall be less than the breaking capacity of the circuit-breaker alone.

Note. — Strictly speaking, the superposition of the time-current characteristic of one device, having the prospective current as abscissa, with the time-current characteristic of another device, having also the prospective current as abscissa, is not correct when reference has to be made to the behaviour of these two devices operating in series, since the impedance of the devices is not always negligible. It is recommended that this should be taken into account.
For high over-currents, it is recommended that reference should be made to Joule integrals instead of times.

9.5.2 *Verification of the behaviour of the composite unit*

Compliance with the requirements of Clause 9.2.2 shall be verified by short-circuit tests at different test currents, all the test conditions being as specified in Clause 8.2 of this publication, the adjustable resistors and inductors being:

— on the supply side of the integrally-fused circuit-breaker, only for the part corresponding to the rated short-circuit breaking capacity assigned to the unit under test;

— on either side for the remaining part, corresponding to reduced test currents.

Note. — It is assumed that the short-circuit breaking capacity of the circuit-breaker alone has already been tested.

9.5.3 *Test currents*

The following test currents are considered, in connexion with a stated operational voltage:

a) I_A: short-circuit breaking capacity assigned to the integrally-fused circuit-breaker.

b) The rated short-circuit breaking capacity of the circuit-breaker alone.

9.5.4 *Test procedure*

a) The following order of tests shall apply:

Order of tests	Test clauses applicable to circuit-breakers of short-circuit performance categories	
	P-1	P-2
Short-circuit test at current I_A (note 1)	O - *t* (*) - CO 8.2.4	O - *t* (*) - CO - *t* (*) - CO 8.2.4
Calibration test (note 2)	8.2.8	8.2.8
Reduced voltage dielectric test (note 3)	8.2.3	8.2.3
Temperature-rise test	8.2.4.10.1 *a)*	8.2.4.10.2 *a)*

1) After each test, all the fuse-links shall be replaced.
2) With new fuse-links.
3) The test is limited to the main circuit, the test-voltage value being twice the rated insulation voltage value.

*) The time interval *t* may be greater than the limit specified in Clause 8.2.4.3 in order to permit replacement of the fuse-links. The actual time interval shall be recorded in the test report.

b) A test shall be made on the composite unit at the rated short-circuit breaking capacity of the circuit-breaker alone; it shall be made with a circuit-breaker in a new condition, unless otherwise agreed by the manufacturer. It consists of a single CO operating cycle; during the test, at least one fuse shall operate.

9.5.5 *Results to be obtained*

See Clause 8.2.4.9.

After each short-circuit test, it shall be verified that the circuit-breaker has been tripped open and remains in the open position.

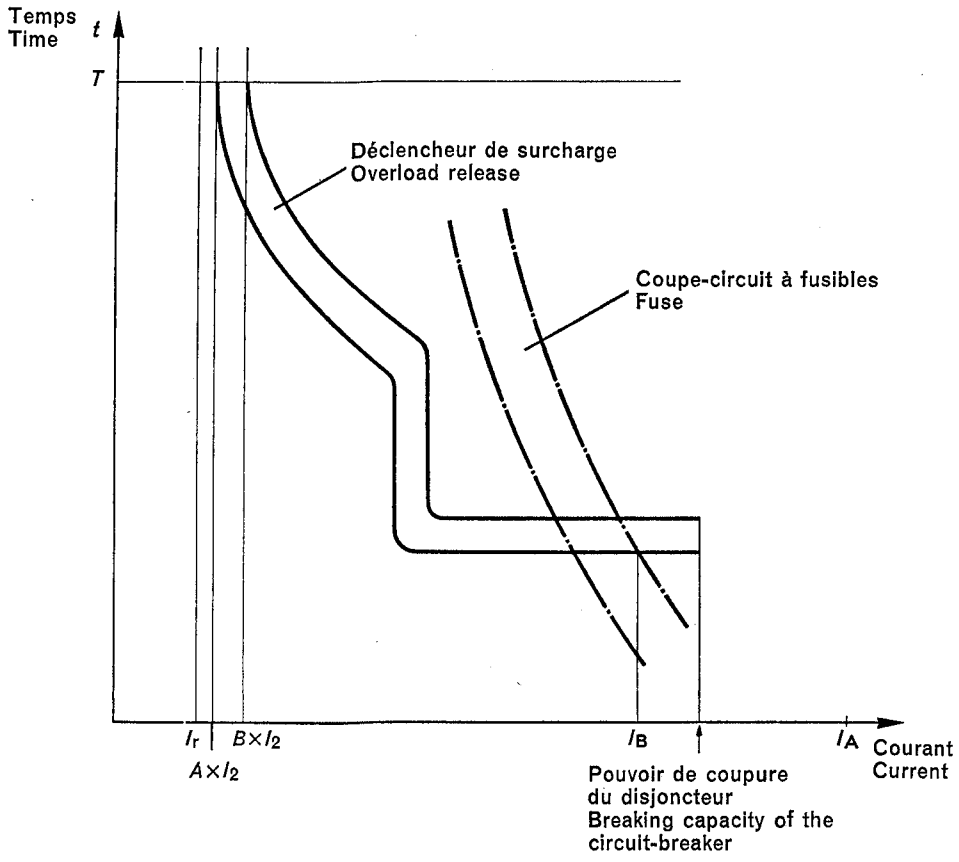
Temps
Time
t
T
Déclencheur de surcharge
Overload release
Coupe-circuit à fusibles
Fuse
I_r
$A \times I_2$
$B \times I_2$
I_B
I_A
Courant
Current
Pouvoir de coupure
du disjoncteur
Breaking capacity of the
circuit-breaker

FIGURE A