8

C.D.U./U.D.C.: 621.316.53.024.027.512.064.3.001.4

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

(affiliée à l'Organisation Internationale de Normalisation — ISO)

NORME DE LA CEI

INTERNATIONAL ELECTROTECHNICAL COMMISSION

(affiliated to the International Organization for Standardization — ISO)

IEC STANDARD

Publication 158-1A

1975

Premier complément à la Publication 158-1 (1970)

Appareillage de commande à basse tension

Première partie: Contacteurs

First supplement to Publication 158-1 (1970)

Low-voltage controlgear

Part 1: Contactors

Bureau Central de la Commission Electrotechnique Internationale
1, rue de Varembé
Genève, Suisse

Prix Fr.s.
Price S.Fr. 23.—

INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIRST SUPPLEMENT TO PUBLICATION 158-1 (1970)

LOW-VOLTAGE CONTROLGEAR

Part 1: Contactors

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

The first draft, established in January 1971, was amended by the Chairman and the Secretary of SC 17B who took into account the comments received, and the second draft was discussed at the meeting held at Solna (Stockholm) in 1972. A third draft was examined in Paris in 1974. The final draft was submitted to the National Committees for approval under the Six Months' Rule in April 1974.

The following countries voted explicitly in favour of publication:

Austria
Belgium
Denmark
France
Germany
Israel
Italy
Japan
Netherlands
Poland
Portugal
Romania
South Africa (Republic of)
Spain
Sweden
Switzerland
Turkey
United Kingdom
United States of America

The present supplement reproduces, *inter alia*, the whole Appendix D (pages 70 to 77 inclusively) of IEC Publication 158-1 (1970) as well as the whole Amendment No. 1 of August 1971; this amendment is then cancelled.

FIRST SUPPLEMENT TO IEC PUBLICATION 158-1

LOW-VOLTAGE CONTROLGEAR

Part 1: Contactors

(Second edition — 1970)

APPENDIX D

D1 Conventional test circuits for the verification of rated making and breaking capacities of contactors in utilization categories AC-1 and AC-2

D1.1 *Test circuit for utilization category* AC-1

If a contactor has been tested for category AC-3 or category AC-4 with a rated operational current I_e, it needs no further test for making and breaking capacities in utilization category AC-1 provided its rated operational current for AC-1 does not exceed 2.5 times I_e.

In other cases, its making and breaking capacities shall be verified with a test circuit comprising:

- a substantially non-inductive load ($\cos \varphi = 0.95 \pm 0.05$);
- a low-impedance supply circuit with a prospective short-circuit current at least 30 times the rated operational current of the contactor (but not necessarily exceeding 30 kA).

D1.2 *Test circuit for utilization category* AC-2

If a contactor has been tested for category AC-3 or category AC-4 with a rated operational current I_e, it needs no further test for making and breaking capacities in utilization category AC-2 provided its rated operational current for AC-2 does not exceed 2 times I_e.

In other cases, its making and breaking capacities shall be verified with a test circuit similar to the one used for utilization categories AC-3 and AC-4 with the values for current, voltage and power-factor given for category AC-2 in Table II of Clause 4.3.6 of Publication 158-1, the values for transient recovery voltage natural frequency f and factor γ being those appearing in Clause D2.2 of this Supplement.

D2 Conventional test circuit for verification of rated making and breaking capacities of contactors in utilization categories AC-3 and AC-4

Note. — This test circuit shall also be utilized for the verification of electrical endurance in category AC-4 (see Clause 8.4.1 of Publication 158-1).

D2.1 *General*

The test circuit comprises the supply source, the contactor under test and the load circuit. The prospective short-circuit current at the point of connection to the supply terminals of the contactor shall be at least ten times the value of the test current, or at least 50 kA, whichever is the lower.

To ensure that tests made in different laboratories will be sufficiently comparable, it is necessary to specify in detail a conventional load circuit, composed of passive elements and representing as far as possible the conditions likely to be met by contactors when switching actual motors.

The load circuit shall consist of resistors in series with air-cored reactors, in parallel with resistors and capacitors. The values of these components shall be adjusted to obtain, at the specified voltage:

– the values of current and power-factor prescribed in Table II of Publication 158-1 (Clause 4.3.6);

– the specified oscillatory frequency of the transient recovery voltage and the specified value of factor γ.

Factor γ is the ratio of the value U_1 of the highest peak of the transient recovery voltage to the instantaneous value U_2, at the instant of current zero, of the component of the recovery voltage at the applied frequency (see Figure D1, page 12).

D2.2 *Characteristics of the load circuit*

The oscillatory frequency of the transient recovery voltage of the load circuit shall be adjusted to the value:

$$f = 2\,000 \cdot I_c^{\,0.2} \cdot U_e^{\,-0.8} \pm 10\%$$

where: f = oscillatory frequency, in kilohertz;

I_c = breaking (or making) current, in amperes;

U_e = rated operational voltage of the contactor (equal to the rated voltage of the motor), in volts.

Note. — This formula is based on tests carried out with motors for 50 Hz. The exact influence of the supply frequency is under consideration.

Factor γ shall be adjusted to the value:

$$\gamma = 1.1 \pm 0.05$$

The voltages, the currents and the power-factors shall be as mentioned in Table II of Publication 158-1 (Clause 4.3.6).

The value of reactance necessary for the test may be obtained by coupling several reactors in parallel under the condition that the transient recovery voltage can still be considered as having only one oscillatory frequency. This is generally the case when the reactors have practically the same time-constant.

For the breaking capacity test, the load side terminals of the contactor shall be connected as close as possible to the terminals of the adjusted load circuit, in order to make negligible the influence of the connecting leads: otherwise, the adjustment shall be carried out with these leads present.

Note. — It is not necessary to adjust factor γ or the oscillatory frequency for tests concerning only the making capacity.

D2.3 *Description of a method for the adjustment of the load circuit*

To adjust the load circuit to obtain the characteristics prescribed above, several methods may be applicable in practice. One of them is described below.

The principle is illustrated in Figure D2, page 13.

The oscillatory frequency f of the transient recovery voltage and the value of factor γ are essentially determined by the natural frequency and the damping of the load circuit. Since these values are independent of the voltage and frequency applied to the circuit, the adjustment can be made by energizing the load circuit from an a.c. power supply, the voltage and frequency of which may be different from those of the supply source utilized for the test of the contactor. The circuit is interrupted at a current zero by a diode, and the oscillations of the recovery voltage are observed on the screen of a cathode-ray oscilloscope the sweep of which is synchronized with the frequency of the power supply (see Figure D3, page 12).

To permit reliable measurements to be made, the load circuit is energized by means of a high-frequency generator G giving a voltage suitable for the diode. The frequency of the generator is chosen equal to:

2 kHz for test currents up to and including 1 000 A;
4 kHz for test currents higher than 1 000 A.

Connected in series with the generator are:

- a dropping resistor having a resistance value R_a high with respect to the load circuit impedance ($R_a \geq 10\ Z$, where $Z = \sqrt{R^2 + (\omega L)^2}$ and where ω is 2π . 2 000 s^{-1} or 2π . 4 000 s^{-1} respectively).
- an instantaneously blocking switching diode; switching diodes commonly used in computers such as diffused junction silicon switching diodes of not over 1 A forward rated current are suitable for this application.

Due to the value of frequency of the generator G, the load circuit is practically purely inductive and, at the instant of current zero, the applied voltage across the load circuit will be at its peak value. To ensure that the components of the load circuit are convenient, it must be checked on the screen that the curve of the transient voltage at its initiation (point A in Figure D3) has a practically horizontal tangent.

The actual factor γ is the ratio U_{11}/U_{12}: U_{11} is read on the screen, U_{12} is read between the ordinate of point A and the ordinate of the trace when the load circuit is no longer energized by the generator (see Figure D3).

When observing the transient voltage in the load circuit with no parallel resistor R_p or parallel capacitor C_p, one reads on the screen the natural oscillatory frequency of the load circuit. Care should be taken that the capacitance of the oscilloscope or of its connecting leads does not influence the resonant frequency of the load circuit.

If that natural frequency exceeds the upper limit of the required value f, the suitable values of frequency and factor γ can be obtained by connecting in parallel capacitors C_p and resistors R_p of appropriate values. The resistors R_p shall be practically non-inductive.

It is recommended that, as a first step, each of the three phases of the load circuit be adjusted separately. The adjustment is then completed by successively connecting, in each possible combination, the high-frequency generator to one phase in series with the other two in parallel as shown in Figure D2, page 13: the adjustment is refined if necessary so that the specified values of f and γ are obtained in each combination.

Notes 1. — A higher value of frequency obtained from the generator G makes the observation on the screen easier and improves the resolution.

2. — Other methods of determining frequency and factor γ (such as the impression of a square-wave current on the load circuit) may also be applicable.

D3 Conventional test circuit for verification of rated making and breaking capacities of contactors in utilization categories DC-1, DC-2, DC-3, DC-4 and DC-5

The supply source used for the verification of making and breaking capacities shall have sufficient power to permit the verification of the characteristics given in Table II of Publication 158-1.

Note. — Attention is drawn to the influence of the source characteristics; preference is given to a d.c. generator or a battery source. Particular care is necessary in the case of rectifiers, inter alia to avoid excessive ripple; this requirement is practically achieved by the use of a three-phase bridge rectifier.

The test circuit comprises the supply source, the contactor under test and the load circuit. Pending better knowledge of the characteristics of actual d.c. loads, the load circuit shall consist of resistors in series with either air-cored reactors or reactors having laminated and essentially non-saturated iron cores; in both cases, the entire circuit is shunted by a parallel resistor taking 1% of the steady state current. The required inductance value shall be obtained by series coupling of individual reactors; parallel connecting of reactors is permitted when these reactors have practically the same time-constant.

Attention is drawn to the fact that, for a given value of stored energy before breaking, this conventional load circuit may produce more arc energy than a circuit in practical application. When the actual load is known, the verification of making and breaking capacities may be made on this load by agreement between manufacturer and user.

Note. — In order to facilitate application, the values J_c of stored energy in the conventional load have been referred to the power according to the rated values and therefore can be expressed (in joules) in multiples of U_e times I_e. The values of J_c corresponding to Table II of Publication 158-1 are approximately:

Utilization category	Stored energy J_c
DC-1	—
DC-2, DC-3	$0.0055 \times U_e \times I_e$
DC-4, DC-5	$0.033 \times U_e \times I_e$

The values of the constants 0.0055 and 0.033 result from applying formula:

$$J_c = \frac{1}{2} LI^2$$

where the time-constant has been replaced by 2.5×10^{-3}s (DC-2 and DC-3) or by 15×10^{-3}s (DC-4 and DC-5) and where: $U = 1.1\ U_e$ and $I = 4\ I_e$ (all these figures appearing in Table II of Publication 158-1).

A contactor, having passed this test, is assumed to be capable of closing and opening load circuits different from those mentioned above provided that:

— the voltage and current do not exceed the verified values of U_e and I_e;

— the energy J_a stored in the actual load be equal to or less than the energy J_c stored in the conventional load.

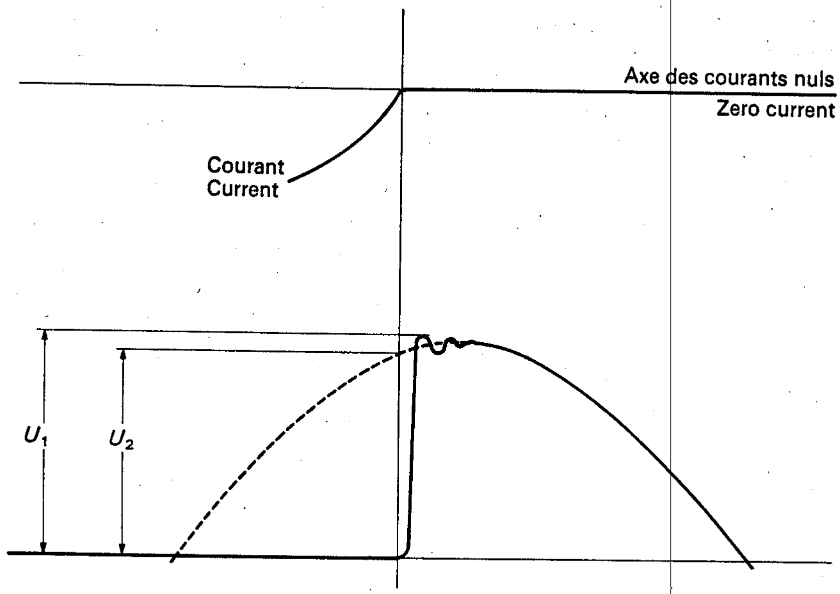


FIG. D1 — Représentation schématique de la tension de rétablissement entre les contacts de la première phase qui coupe.
Simplified illustration of the recovery voltage across contacts of the first phase to clear.

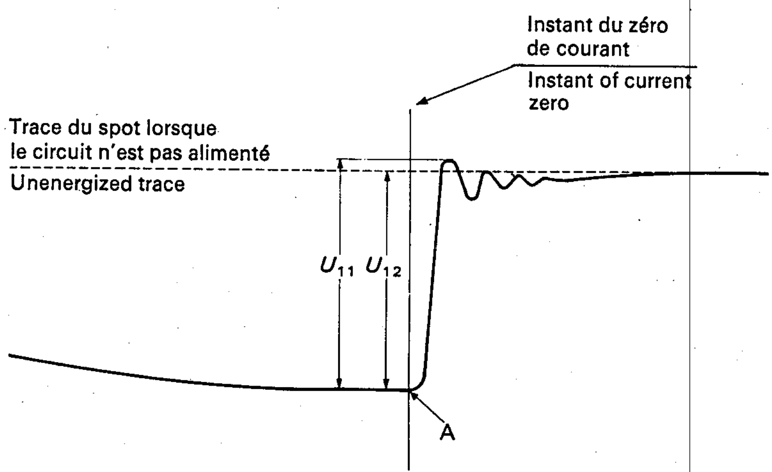
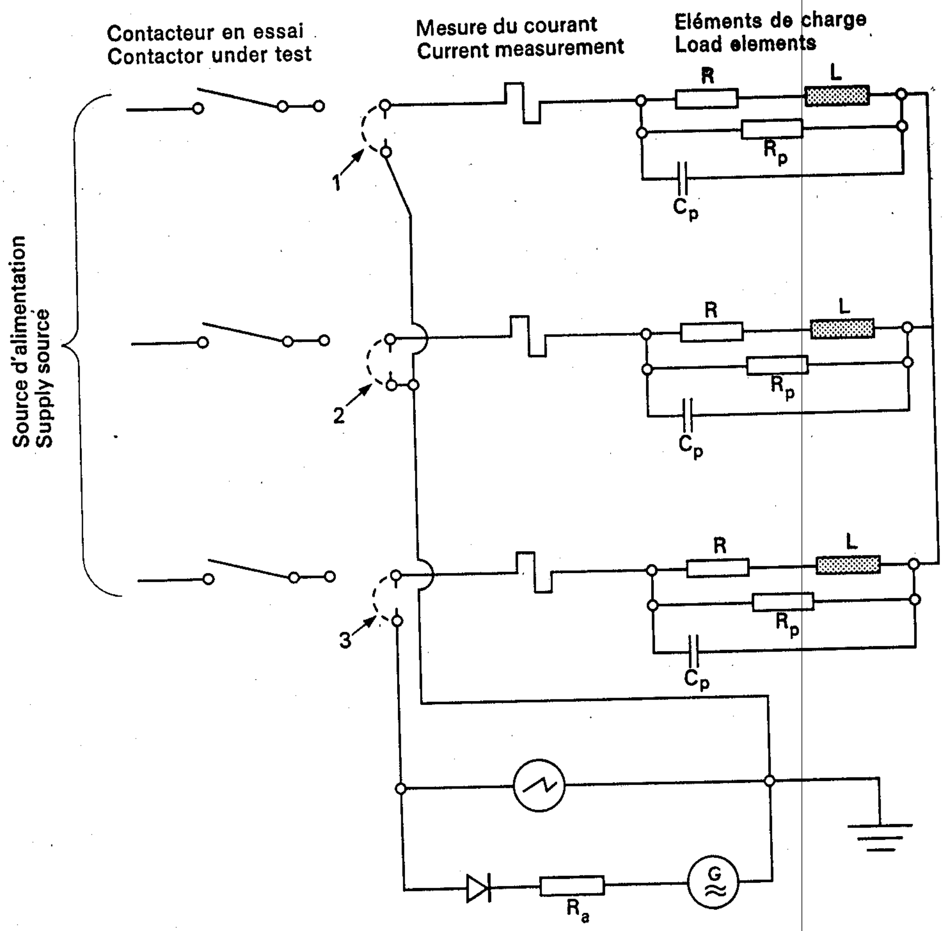


FIGURE D3.



R & L = résistance et réactance du circuit de charge
resistor and reactor of the load circuit

R_p = résistance en parallèle
resistor in parallel

C_p = condensateur en parallèle
capacitor in parallel

R_a = résistance
resistor

(diode symbol) = diode

(G) = générateur à haute fréquence
high-frequency generator

(oscilloscope symbol) = oscilloscope cathodique
cathode-ray oscilloscope

Notes 1. — Les positions relatives du générateur à haute fréquence G et de la diode doivent être celles indiquées sur la figure.

The relation of the high-frequency generator G and the diode shall be as shown.

2. — On ne devra mettre à la terre aucun autre point du circuit que celui indiqué sur la figure.

No other point of the circuit than the one indicated on the figure shall be earthed.

3. — A titre d'exemple, on a représenté sur cette figure des connexions en pointillé 1, 2 et 3 dans la position correspondant au réglage de la phase 3 en série avec les phases 1 et 2 montées en parallèle.

In this figure, as an example, dotted leads 1, 2 and 3 are represented in the position corresponding to the adjustment of phase 3 in series with phases 1 and 2 connected in parallel.

FIG. D2 — Schéma d'une méthode de réglage du circuit de charge.
Scheme of a method of adjustment of the load circuit.