AS 3851—1991

Australian Standard®

# The calculation of short-circuit currents in three-phase a.c. systems

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# PREFACE

This Standard was prepared by the Standards Australia Committee on Power Switchgear, in response to requests from the industry for standard methods suitable for both manual and computer calculation of prospective short-circuit currents.

It is based technically on the following IEC documents and acknowledgement is made of the assistance received from these documents:

73(Central Office)5: Draft—Short-circuit calculation in three-phase a.c. systems

73(Central Office)17: Draft—Application guide for the calculation of short-circuit currents in low-voltage radial systems neglecting the influence of motors

IEC 865: Calculation of the effects of short-circuit currents

The editorial presentation of this Standard does not follow these IEC documents but adopts a concise and systematic approach which should be more readily understood by non-specialist electrical engineers and students of electrical engineering.

The calculation procedure is divided into two basic steps—

(a) calculating the impedances of the circuit elements from their characteristics independent of the fault; and

(b) the calculation of fault currents from the fault voltage and impedances.

This Standard is concerned with the calculation of the current in the fault. The distribution of resulting currents in the network would need to be determined from detailed circuit analysis.

The major differences between this Standard and the above IEC documents are as follows:

(i) The IEC concept of a power station unit has been deleted, generators and transformers being treated independently. This results in a different treatment of faults around power station units.

(ii) The concept of $I^2t$ (joule integral) of the short-circuit has been substituted for the thermal equivalent short-circuit current in IEC 865, which permits a uniform presentation of results with regard to both fuse and circuit-breaker characteristics.

(iii) The reader is provided with data to be assumed in the absence of known data. This is particularly useful for calculations requiring zero-sequence data.

(iv) Values of the voltage factor *(c)* have been chosen to be representative of Australian practice.

(v) A more general equation has been provided for overhead line impedance.

(vi) Figure 8.2 for determination of the type of short-circuit producing the highest current when the phase angles of the sequence impedances are equal, has been redrawn to cover a wider range, allowing an improved appreciation of the relative significance of line-to-line-earth faults.

(vii) Appendix A has been included to cover standard calculations on a per unit basis.

(viii) Appendix C has been included showing equivalent circuits for the determination of zero-sequence short-circuit currents in transformers.

(ix) The Appendices D and E provide different examples for the calculation of short-circuit currents on ohmic and per unit bases respectively.

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# FOREWORD

The purpose of this Standard is to standardize a general, practicable and concise procedure for the calculation of short-circuit currents in electrical installations leading to conservative results with sufficient accuracy. For this purpose, the current is computed by considering an equivalent voltage source applied to the installation at the short-circuit location, with all other sources set to zero (see Clause 5). The procedure is suitable for computation by manual methods, analogue simulators (e.g. network analysers) or digital computers.

Other methods employing more complex models or those based on tests conducted on an existing installation are not excluded provided they give at least the same precision. For example, in existing, low voltage systems it is possible to determine the short-circuit and hence the prospective short-circuit current, on the basis of measurements at the prospective short-circuit location.

While the measurement methods are limited to existing installations, calculation methods based on the rated characteristics of electrical equipment and the topological arrangement of the system have application to both existing systems and to systems at the planning stage.

The standard procedure consists of a basic conservative method with variations to give higher accuracy when necessary, such as when the fault level is close to equipment ratings. The procedure is varied according to—

(a) whether or not the short-circuit current is significantly influenced by generators and motors; and

(b) the requirements for increased accuracy of short-circuit calculation.

Two different short-circuit currents are calculated which differ in their magnitude—

(i) the maximum short-circuit current which determines the necessary capacity or rating of electrical equipment; and

(ii) the minimum short-circuit current which can be a basis for assessing the adequacy of protection sensitivity and the application of fuses having minimum breaking current limitations.

STANDARDS AUSTRALIA

## Australian Standard

# The calculation of short-circuit currents in three-phase a.c. systems

## 1 SCOPE AND GENERAL

**1.1 Scope** This Standard specifies a standardized procedure for the calculation of prospective short-circuit currents in the fault for—

(a) low voltage a.c. systems; and

(b) high voltage three-phase a.c. systems, operating at a nominal frequency of 50 Hz.

The procedure is intended to be, as far as possible, in a form to facilitate its use by non-specialist engineers.

NOTE: The procedure is applicable generally to other frequencies close to 50 Hz; however, care should be exercised in the use of frequency-dependent factors.

Except in Appendix A, the basis of the calculation procedure in this Standard is ohmic. Appendix A converts this procedure to per-unit calculation.

NOTE: Worked examples are provided in Appendices D and E on ohmic and per unit basis respectively.

The current, calculated in this Standard forms the basis for the determination of the currents in the paths feeding the fault.

This Standard specifies a standardized method for the calculation of the joule integral $(I^2t)$ of a short-circuit current.

This Standard does not cover—

(i) short-circuits deliberately created under controlled conditions as in short-circuit testing stations;

(ii) short-circuits in the electrical installations of ships and aircraft;

(iii) non-simultaneous short-circuits, which can lead to higher aperiodic components of short-circuit current; or

(iv) methods for analysis of short-circuit currents in non-linear systems.

**1.2 Referenced documents** The following documents are referred to in this Standard:

| AS | |
|---|---|
| 1824 | Insulation coordination (phase-to-earth and phase-to-phase, above 1 kV) |
| 1824.1 | Part 1: Basic Principles, standard insulation levels and test procedures |
| 2374 | Power transformers |
| 2374.1 | Part 1: General requirements |
| 2926 | Standard voltages—Alternating (50 Hz) and direct |
| 3008 | Electrical installations—Selection of cables |
| 3008.1 | Part 1: Cables for alternating voltages up to and including 0.6/1 kV |

**1.3 Definitions** For the purpose of this Standard the definitions below apply:

**1.3.1** *Short-circuit*—accidental or intentional connection, by a relatively low resistance or impedance, of two or more points in a circuit which are normally at different voltages.

**1.3.2** *Short-circuit current*—current resulting from a short-circuit due to a fault or an incorrect connection in an electric circuit.

NOTE: It is necessary to distinguish between the short-circuit current in the fault and the currents in the network branches.

**1.3.3** *Prospective short-circuit current*—current that would flow if the short-circuit were replaced by an ideal connection of negligible impedance without any change of the supply.

NOTES:

1. The current in a multiphase short-circuit is assumed to be made simultaneously in all faulted phases.
2. ‘Without any change of the supply’ implies no operation of switchgear or current limiting switching devices such as current-limiting fuses or circuit-breakers.

**1.3.4** *Symmetrical short-circuit current*—r.m.s. value of the a.c. symmetrical component of a prospective short-circuit current (see Clause 1.3.3), the aperiodic component of current, if any, being neglected.

**1.3.5** *Initial symmetrical short-circuit current* $(I''_k)$—r.m.s. value of the a.c. symmetrical component of a prospective (available) short-circuit current (see Clause 1.3.3) applicable at the instant of short-circuit if the impedance remains at zero-time value (see Figure 3.1).

**1.3.6** *D.C. (aperiodic) component* $(i_{DC})$ *of short-circuit current*—mean value of the top and bottom of the envelope of a short-circuit current. This value decays from an initial value to zero as shown in Figure 3.1.