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Short Circuit Performance of Metallic Shields and Sheaths on Insulated Cable

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Foreword

This publication discusses factors for consideration in approximating the operability of insulated and/or covered wire and cable under the influence of uninterrupted short circuit currents encountered as a result of cable or other equipment faults. The duration of such a fault is considered to be up to approximately 2 seconds. Calculation for single short circuits of longer durations will yield increasingly conservative results.

The following items must be considered in order to estimate the short circuit performance of a specific circuit:

1. The magnitude and duration of the fault current including any fault current division due to available conducting paths.

2. The capability of joints, terminations and other accessories in the affected circuit to withstand the thermal and mechanical stresses created by the fault.

3. The interaction between the faulting circuit and surrounding equipment, such as supports, ties and clamps.

4. The capability of the affected cable circuit, as installed, to withstand the electromagnetic forces created during the fault.

5. The maximum temperature that cable components can withstand without incurring damage due to heating caused by fault current flow.

6. Damage to adjacent equipment due to arcing at the site of the fault.

7. For limitations imposed on the short-circuit current in the cable phase conductor see ICEA Publication P-32-382, *Short Circuit Characteristics of Insulated Cable.*

An important simplifying assumption in the formula is the adiabatic nature of the heat generated, *i.e., the duration of the fault is so short that all the heat developed by the fault current during this time is assumed to be completely contained within the sheath or shield.* The amount of heat dissipated from the sheath or shield during continuous, single fault occurrences of relatively short duration is small. A significant amount of heat may be dissipated because of the relatively long cooling periods involved for faults interrupted and reestablished with automatic reclosing of circuit protective devices. A non-adiabatic calculation may be more suitable for these situations and for single, uninterrupted short circuits in excess of 2 seconds requiring close accuracy. Non-adiabatic calculation methods are described in several published works listed in Section 1.2 “References”.

The formula (1) described in this publication is based on the thermal capacity of the metallic sheath/shield material and the transient temperature limit of the adjacent cable component materials. The quantity of heat contained in the metallic sheath/shield is that created by the fault current and is also a function of the temperature rise in the metallic sheath/shield. The magnitude of the temperature rise is the difference between the upper temperature of the cable material in contact with the sheath/shield and the operating temperature of the sheath/shield immediately prior to the initiation of the fault.

The operating temperature of the sheath or shield depends on the temperature of the conductor and the insulation thickness which is determined by the cable voltage rating. See Section 3, Table 3 for suggested estimated values.

The maximum transient temperature limits of the cable component materials are those which cause no significant change in the materials. These limits were extrapolated from laboratory test data.

Suggestions for improvements in this publication are welcome, and should be sent to the ICEA website http://www.icea.net

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Section 1
GENERAL

1.1 SCOPE

Equations and parameters have been established for short circuit calculations for sheaths or shields made of aluminum, bronze, copper, lead, steel, zinc and cupronickel alloys. The types of sheaths or shields included are:

- Wires, applied either helically, as braid or serving; or longitudinally with corrugations.
- Helically applied flat tape, not overlapped.
- Helically applied, overlapped, flat tape.
- Corrugated tape, longitudinally applied.
- Tubular sheath.

The types of cable materials in contact with the sheath or shield are: crosslinked (thermoset), thermoplastic, impregnated paper, and varnished cloth.

The materials which determine the maximum allowable short circuit temperatures are: paper, varnished cloth and several thermoplastic and thermosetting materials presently appearing in ICEA standards. Temperature limits, considered safe, were established for the various coverings and insulation materials.

The equations may be used to determine:

- The maximum short circuit current permitted for a specific sheath/shield and short circuit duration.
- The sheath/shield size necessary to carry a specific short circuit current for a given duration.
- The maximum duration a specific sheath/shield can carry a specific short circuit current.

1.2 REFERENCES

The following references were reviewed in preparing this document.

The Transient Temperature Rise of Round Wire Shields of Extruded Dielectric Cables Under Short Circuit Conditions, M. A. Martin Jr., A.W. Reczek Jr., IEEE-ICC Open Forum at 57 Meeting Nov. 17-19, 1975.

Optimization of Design of Metallic Shield-Concentric Conductors of Extruded Dielectric Cables Under Fault Conditions, EPRI EL-3014, Project 1286-2, final Report 4/83.

Optimization of Metallic Shields for Extruded Dielectric Cables Under Fault Conditions, IEEE Paper 86 T&D 339-B.

Normal and Short Circuit Operating Characteristics of Metallic Shielded Solid Dielectric Power Cable. M.A. Martin Jr., D. A. Silver, R. G. Lukac, R. Suarez, IEEE Paper 973 495-9.