PROCEDURE FOR TESTING THE RESISTANCE OF METALCLAD SWITCHGEAR UNDER CONDITIONS OF ARCING DUE TO AN INTERNAL FAULT

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- To provide its members with ongoing programs directed at developing greater understanding on the part of the public, customers and governments of the contributions, concerns and problems of the Canadian electrical and electronic manufacturing industry;
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Procedure for Testing the Resistance of Metal Enclosed and Metalclad Switchgear Under Conditions of Arcing due to an Internal Fault

Scope: This procedure describes the method of testing the structural resistance to internal arcs for metal enclosed and metalclad switchgear assemblies as described in EEMAC Standard G8-2, 1972. The procedure applies to equipment rated 2.4 KV and above. The test is subject to an agreement between the manufacturer and the user and the test procedure represents the effects of an arc occurring entirely in atmospheric air within the enclosure when the doors and covers are closed. This test procedure does not provide for tests within components and/or insulating systems other than air. (See Note 4)

1.0 Foreword:

1.1 Failure within the switchgear enclosure due either to a defect, an exceptional service condition or maloperation may initiate an internal arc.

1.2 There is little probability of such an event occurring in equipment meeting the requirements of EEMAC Standard G8-2, but it cannot be completely disregarded.

1.3 Such an event may lead to the risk of injury, if persons are present, but with an even lower probability.

1.4 It is desirable that the highest possible degree of protection to persons should be provided. The principal objective is to avoid internal arcs or to limit their duration and consequences.

1.5 Experience has shown that faults are more likely to occur in some locations inside an enclosure than in others. Special attention should be paid to such areas.

1.6 For guidance, a list of such locations and causes is given in Columns 1 and 2 of Table I. Measures to decrease the probability of internal faults or to reduce the risk are recommended in column (3).

2.0 Test

2.1 If the measures described in paragraph 1.6 are considered to be insufficient, then, to cover the case of an arc occurring entirely in air within the switchgear enclosure, a test in accordance with this standard may be agreed between the manufacturer and user.

2.2 A test should be unnecessary on those parts of circuits protected by current limiting devices such as fuses. However, the line side of fuses, as in a potential transformer enclosure, are points where a fault may occur.

2.3 The occurrence of arcs inside switchgear is coupled with various physical phenomena. For example, the arc energy resulting from the arc developed in air at atmospheric pressure will cause an internal overpressure and local overheating, which will result in mechanical and thermal stressing of the equipment. Moreover, the materials involved may produce hot decomposition products, either gaseous or vaporous, which may be discharged to the outside of the enclosure.

2.4 This procedure makes allowance for internal overpressure acting on covers, doors, inspection windows, etc., and also takes into consideration the thermal effects of the arc or its roots on the enclosure and of ejected hot gases and glowing particles and damage to partitions which would endanger operating personnel doing maintenance inside adjacent compartments. It does not cover all effects which may constitute a risk, such as toxic gases (see Note 1) nor the location of the equipment within a building (see Note 4).

3.0 Types of Accessibility

3.1 A distinction is made between three types of accessibility to switchgear assemblies corresponding to the test conditions given in clauses 6.3.2, 6.3.3. and 6.3.4.

3.2 Accessibility Type A: Switchgear with arc resistant construction at the front only.

3.3 Accessibility Type B: Switchgear with arc resistant construction at the front, back and sides.

3.4 Accessibility Type C: Switchgear with arc resistant construction at the front, back and sides and between compartments within the same cell or adjacent cells.

Note to Type C: The only exception is that a fault in a bus bar compartment of a feeder cell is allowed to break into the bus bar compartment of an adjacent feeder cell.

4.0 Test Arrangements

4.1 When deciding upon the choice of the test sample, the number of cells and their equipment, the following points shall be observed:

a) the test shall be carried out on a functional unit not previously subjected to arcing;
b) the mounting arrangements should be as close as possible to those of normal service.
c) the functional unit should be fully equipped. Mockups of internal components are permitted provided they have the same volume and be of similar material as the original items;
d) the test assembly shall be grounded at the normal grounding point or points;

5.0 Current and Voltage

5.1 General: The prospective short circuit current applied during the calibration is to be stated by the manufacturer and may be equal to or lower than the rated short time capability of the equipment. Subsequent arcing tests shall be done without any modification to the circuit. (see Note 2)

5.2 Voltage: The applied voltage of the test circuit should be equal to the rated voltage of the switchgear. A lower voltage may be chosen if the following conditions are met;

a) the current remains practically sinusoidal,
b) the arc is not extinguished prematurely.

5.3 Current:

5.3.1 A.C. component - The short-circuit current, for which the switchgear is specified with respect to arcing should be set to a -0% tolerance. The current should remain constant.

NOTE: If the test plant does not permit this, the test should be extended until the integral of the a.c. component of the current equals the value specified within a tolerance of +10% -0%. In this case, the current should be equal to the specified value at least during the first three half-cycles and should not be less than 50% of the specified value at the end of the test.

5.3.2 D.C. Component - The instant of closing should be chosen so that the prospective value of the peak current flowing in one of the outer phases is not less than 2.7 times the r.m.s. value of the a.c. component, specified in clause 5.1. If the voltage is lower than the rated voltage, the peak value of the short-circuit current should not drop below 90% of the prospective peak value.

5.4 Frequency: For a rated frequency of 50 Hz or 60 Hz, the frequency at the beginning of the test should be between 48 Hz and 62 Hz. For other frequencies it should not deviate from the rated value by more than ±10%.

5.5 Duration of the test:

5.5.1 Test 1: Duration of arcing to be 160ms. This test is performed to prove the resistance of switchgear against pressure .

5.5.2 Test 2: Duration of arcing to be 1 sec. This test is performed to prove the resistance of switchgear to burn through.

5.5.3 Tests 1 and 2 may be combined.

6.0 Test Procedure:

6.1 Supply Circuit:

6.1.1 The neutral of the supply system must be grounded unless the switchgear is to be used on an ungrounded system.

6.1.2 The connections must not alter the test conditions.

6.1.3 Generally, the arc inside an enclosure may be fed from two directions. The direction to be chosen is the one likely to result in the highest stress.

6.2 Arc initiation:

6.2 Arc Initiation

6.2.1 The arc shall be initiated by means of a metal wire of about 0.5mm diameter.

6.2.2 The arc shall be initiated between the three phases except where phase conductors are separated by grounded metal in a segregated phase system where the arc may be initiated between one phase and ground.

6.2.3 The point of arc initiation shall be chosen to produce the highest stress in a way that can be considered to simulate realistic service conditions.

6.2.4 The arc shall be initiated at joints or gaps in the insulation embedded parts and not by perforating solid insulation.

6.3 Indicators (for observing the thermal effects of gases)

6.3.1 General: Indicators are pieces of black cotton fabric arranged so that their cut edges do not point toward the test unit. Care shall be taken to see that they cannot ignite each other. This is achieved by fitting them, for example, in a mounting frame. The indicator dimensions are to be 150 mm x 150 mm.

6.3.2 Accessibility Type A: Indicators are to be fitted vertically only at the front.

6.3.3 Accessibility Type B: Indicators are to be fitted vertically at the front, back and at the sides of the switchgear to be tested.

6.3.4 Accessibility Type C: Indicators are to be fitted vertically at the front, back, at the sides of the switchgear and the interior compartments adjacent to the compartment in which the arc is initiated.

6.3.5 The indicators are to be located at a height of no more than 2 m from the floor and at a distance of about 10 cm from the switchgear facing all points where gas is likely to be emitted, (eg. joints, inspection windows, doors, etc.). Indicators are to be placed inside adjacent cells when testing for accessibility type C.

6.3.6 Black cotton fabric approximately 150 g/m2 is to be used for the indicators.

7.0 Assessment of the Test:

7.1 The following criteria allow for the arcing effects listed in Section 2.0. Whoever requests the tests to be performed must specify which of these criteria will be used to assess the tests or the manufacturer must state which criteria was used for a standard design.

7.2 It is to be observed:

Criterion No. 1

That properly secured doors, covers, etc., do not open.
(Bowing or other distortion is acceptable.)

Criterion No. 2

That parts which may cause a hazard, do not fly off. This includes large parts or those with sharp edges, for example, inspection windows, doors, pressure relief flaps, cover plates. etc., made of metal or plastic.

Criterion No. 3

Accessibility Type A - That arcing does not cause holes to develop in the accessible front of the switchgear.

Accessibility Type B - That arcing does not cause holes in the freely accessible front, sides and rear of the enclosure.

Accessibility Type C - That arcing does not cause holes in the freely accessible front, sides and rear of the enclosure or in the walls separating the cells in an assembly (except for main bus bar barriers) or between compartments of a cell.

Criterion No. 4

That the indicators (clause 6.3) do not ignite. Indicators ignited as a result of the burning of paint, labels, etc. are excluded from this assessment.

Criterion No. 5

That all the grounding connections remain effective.

7.3 Test Report - The following information should be given in the test report. (see Note 3)

- Rating and description of the test unit with a drawing showing the main dimensions, details relevant to the mechanical strength, the arrangement of the pressure relief flaps and the method of fixing the switchgear to the floor and to the walls.

- Arrangement of the test connections and the point of initiation of the arc.

- Arrangement and material of indicators with respect to the type of accessibility.

- For the prospective or test current:
  a) r.m.s. value of the a.c. component during the first three half cycles;
  b) highest peak value;
  c) average value of the a.c. component over the actual duration of the test;
  d) test duration.

- Oscillogram(s) showing currents and voltages.

- Assessment of the test results and criteria chosen.

- Other relevant remarks.

Table 1

Locations, causes and examples of measures decreasing the probability of internal faults or reducing the risk

Locations where internal faults are more likely to occur 1	Possible causes of internal faults 2	Examples of Measures 3
Cable Termination Compartments	Inadequate design	Selection of adequate dimensions
	Faulty installation	Avoidance of crossed cable connections. Checking of workmanship on site.
	Failure of solid or liquid insulation (defective or missing).	Check of workmanship and/or dielectric test on site. Regular checking of liquid levels.
Disconnectors Switches Grounding switches.	Mal-operation	Interlocks. Delay reopening. Independent manual operation. Making capacity for switches and grounding switches. Instructions to personnel.
Bolted connections and contacts	Corrosion	Use of corrosion inhibiting coatings and/or greases. Encapsulation where possible
	Faulty assembly	Checking of workmanship by suitable means.
Instrument transformers	Ferroresonance	Avoidance of these electrical influences by suitable design of the circuit.
Circuit Breakers	Insufficient maintenance	Regular programmed maintenance. Instructions to personnel.
All locations	Error by personnel	Limitation of access by compartmentation. Insulation embedded live parts. Instructions to personnel.
	Ageing under electric stresses	Partial discharge routine tests.
	Pollution, moisture, dust, vermin etc.	Measures to ensure that the ingress specified service conditions are achieved.
	Overvoltages	Lightning protection. Adequate insulation co-ordination. Dielectric tests on site.

Note 1: Arc resistant construction reduces the risk to personnel working on live equipment but cannot eliminate all hazards. Operating procedures must take the danger into account. It is always preferable to de-energize equipment before working on it.

Note 2: The short circuit current is to be agreed by the purchaser and the vendor however nominal withstand ratings may apply to standard designs. Recommended symmetrical current ratings are 8, 12, 24 and 36 kiloamperes.

Note 3: Minor structural changes from a tested design to a standard design will not reduce the arc resistant characteristics of the switchgear assembly. The manufacturer may certify the design based on test results but must describe any important design modification such as size of the enclosure, equipment included, structural changes etc.

Note 4: The overpressure in the electrical room caused by arcing due to an internal fault in the switchgear and the effects of the ejection of gases from pressure relief devices should be taken into consideration in the design of the building.