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(Supplement to IEEE C37.48-1987)

IEEE Guide for Application of Expulsion Fuses in Enclosures

Supplement to

IEEE Guide for Application, Operation, and Maintenance of High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories

Sponsor

**Switchgear Committee of the
IEEE Power Engineering Society**

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Abstract: Guidelines are provided for the application and maintenance of liquid-submerged and in-air expulsion fuses in enclosures. The operation of liquid-submerged fuses is also covered.
Keywords: in-air expulsion fuses, liquid-submerged expulsion fuses

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On page 7 of IEEE C37.48-1987, add to 1.1, Scope, an additional item as follows:

(9) Liquid-submerged expulsion fuses in switchgear

Update 1.2, References, as follows:

[7] IEEE C37.41-1988, IEEE Standard Design Tests for High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories (ANSI).

[10] ANSI C37.32-1990, American National Standard for Switchgear—High-Voltage Air Switches, Bus Supports, and Switch Accessories—Schedules of Preferred Ratings, Manufacturing Specifications, and Application Guide.

[11] IEEE C37.100-1981 (Reaff 1989), IEEE Standard Definitions for Power Switchgear (ANSI).[1]

On page 17, add Sections 7 and 8 as follows:

7. Application, Operation, and Maintenance of Liquid-Submerged Expulsion Fuses in Enclosures

7.1 General. This section applies to expulsion fuses that are immersed in liquid and used in switchgear (not directly associated with transformers) for alternating current distribution systems. It is intended to provide application, operation, and maintenance information necessary to correctly apply such fuses in an enclosure. It is not intended to apply to oil cutouts, which are devices covered by ANSI C37.44-1981 [2] and by other sections of this guide.

The switchgear manufacturer should ensure that the application of fuses in his switchgear meets the requirements of the fuse manufacturer and the applicable standards.

The fuse manufacturer should provide the design information necessary to properly apply the fuse.

The user should properly apply, operate, and maintain the devices covered by this section. Adequate safety rules and manufacturer's instructions should be followed.

7.2 Application

7.2.1 Usual Service Conditions. Usual service conditions are defined in 2.1 of IEEE C37.40-1981 [6]. Fuses in enclosures that conform to this standard shall be suitable for operation at their nameplate rating when the ambient air temperature surrounding the enclosure is not above 40 °C or below –30 °C.

7.2.2 Unusual Service Conditions That May Affect Design and Application. Where unusual service conditions exist, they should be brought to the attention of the fuse and switchgear manufacturer(s). Unusual service conditions are defined in 2.2 of IEEE C37.40-1981 [6]. Additional unusual service conditions may include

(1) Ambient temperatures outside stated range
(2) Enclosure dimensions and fuse clearances smaller than those specified by the fuse manufacturer

7.2.3 Clearance and Spacings. Three-phase assemblies should be capable of withstanding the transient and power frequency recovery voltages associated with the simultaneous operation of fuses in all three phases. Fuses in enclosures generate high-pressure gases that are expelled during the interruption process. Clearances between fuses of adjacent phases and from each fuse to ground should be sufficient to maintain adequate dielectric withstand at all times. Manufacturer's recommendations for proper clearances and spacings should be followed.

7.2.4 Ambient Temperature. The reference ambient temperature for a fuse in a liquid is that of the liquid immediately surrounding the fuse. (The reference ambient temperature for an enclosure is that of the air surrounding the enclosure.) The fuse manufacturer may specify a maximum reference ambient temperature for the fuse. Various derating factors may be applicable up to this temperature.

7.2.5 Derating Factors. Time-current characteristics (TCC) for most fuses are based on a 25 °C reference ambient temperature. Higher or lower ambient temperatures will cause some shift of the TCC and may also affect the current-carrying capability of the fuse.

[1]The references will be renumbered in the revision of the standard.

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The percentage shift in the TCC is a function of the reference ambient temperature, the construction of the fusible element, and the preload current. Since fuses vary in their construction, common factors cannot be given. It is recommended that the manufacturer be consulted for information on rating changes necessary if the fuse is to be applied at a temperature that is different from that at which the ratings were established.

7.2.6 Selection of Fuse Voltage Rating. The guidelines for selecting the proper voltage ratings are the same as shown in 3.7.2.1, 3.7.2.2.1, and 3.7.3.

7.2.7 Selection of Interrupting Rating. The interrupting rating of the expulsion fuse, when used alone, should be equal to or greater than the maximum fault current available at the fuse. When used in conjunction with a backup device having a higher interrupting rating, the maximum interrupting rating of the expulsion fuse should be greater than the minimum interrupting rating of the backup device. The interrupting rating of the combination of the expulsion fuse and backup device is then equal to that of the backup device rating and should be equal to or greater than the maximum fault current available at the combination. The backup device should be chosen to have an energy let-through within the energy withstand capability of the expulsion fuse. Refer to NOTE 1 of 3.10 for proper expulsion fuse and backup device coordination. The interrupting rating of the fuse (if used alone) or the combination in symmetrical amperes may be directly compared to the calculated symmetrical fault current available. Fuses will interrupt asymmetrical fault currents associated with specified X/R ratios. These ratios are generally more severe than those experienced on actual power systems. For the rare cases where system X/R is greater than that specified for the fuse, reduction of the interrupting rating may be necessary. The fuse manufacturer should be consulted.

7.2.8 Selection of Fuse Continuous Current Rating. All of the criteria listed in 3.9.2.1, 3.9.2.3, 3.9.2.4, and 3.9.3.1 also apply to these fuse applications.

7.2.9 Fuse-Coordination Procedures. The fuse-coordination criteria listed in 3.10 also apply to these fuse applications.

7.2.10 Liquid in Which the Fuse Is Submerged. The liquid is an integral part of the equipment design and the fuse performance, and manufacturer's recommendations should be followed.

7.2.11 Fuse Information. The fuse manufacturer usually supplies the following information. The minimum information typically supplied on a fuse unit is indicated by an asterisk (*).

(1) Manufacturer's name, trademark, or monogram*
(2) Manufacturer's type or identification number*
(3) Rated continuous current
(4) Rated maximum voltage
(5) Rated maximum interrupting current

7.3 Removal and Replacement of Fuses

7.3.1 Pressure Relief. A sealed tank may have a pressure greater than atmospheric. This internal pressure should be returned to atmospheric pressure prior to removing fuses or performing maintenance.

7.3.2 Operating Speed. The successful operation of some devices used to disconnect or close an energized circuit is dependent on operating speed, and manufacturer's recommendations should be followed.

7.3.3 Locking or Latching of the Fuse. The fuse should be securely locked, latched, or held fast in the closed position as recommended by the manufacturer.

7.4 Maintenance

7.4.1 Frequency of Maintenance. All switchgear should be installed and maintained in accordance with the switchgear manufacturer's recommendations.

7.4.2 Liquid. The level and quality of the liquid in the equipment may affect the performance of the expulsion fuse. All gasketed joints and seals should be properly maintained.

Inspection should include checking the tank for liquid leakage and for indications of any external damage or deterioration. The level of the liquid should be checked to see that it is in accordance with the switchgear manufacturer's recommendation. Liquid should not be withdrawn from, or added to, the switchgear while it is energized unless there is a suitable means or procedure for this function.

7.4.3 Inspection of Fuse Components. Manufacturer's recommendations and require-

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ments for inspection and maintenance of fuse components should be followed. Replacement fuses should be those recommended by the switchgear manufacturer. Many users have established procedures to allow inspection and maintenance of energized equipment. In the absence of such procedures, the equipment should be de-energized before performing any inspection or maintenance.

The following are some general guidelines for inspecting and maintaining fuse components:

(1) All current-carrying components of the fuse carrier or bayonet assembly should be inspected. Any components showing indication of excessive heating or damage from arcing should be replaced. Excessive arc damage or heating of contact surfaces may indicate the need to inspect internal contacts. This generally requires removing the unit from service.

(2) Any fuse carrier or cartridge showing signs of cracks, erosion, tracking, or excessive wear should be replaced.

(3) All seals and gaskets should be checked and any that are deteriorated or deformed should be replaced. Manufacturer-approved replacements should be used.

(4) Electrical connections should be checked to determine that they are clean and tightly secured.

(5) Satisfactory condition of the fuse should be verified, as recommended by the manufacturer.

7.4.4 Contamination. The operation of the fuse may cause carbon to form in the liquid. The degree to which this will affect the equipment characteristics depends upon the number of operations as well as their magnitude and duration. Operating experience will usually be the best basis for establishing a maintenance schedule.

8. Application and Maintenance of In-Air Expulsion Fuses in Enclosures

8.1 General. Many applications require the use of in-air expulsion fuses in enclosures (as defined in ANSI C37.100-1981 [11]) where the fuse and associated contacts may be subjected to air temperatures above 40 °C. This section applies to the use of fuses that are in conformance with applicable sections of ANSI C37.46-1981 [4] and ANSI C37.41-1988 [7].

When in-air expulsion fuses are applied in enclosures of any type, the performance characteristics of the total system should be evaluated. The following subsections reflect this basic requirement for system capability.

This section covers two types of in-air fuses that may be applied within enclosures. Both types require that the fuse be equipped with an exhaust-control device to modify and direct exhaust gases generated during fuse operation.

The first type is simply the fuse itself, mounted in the enclosure such that relatively free air circulation exists around the fuse. Reference ambient temperature is that of the air surrounding the fuse.

The second type is a combination of a fuse located inside a close-fitting container with restricted air flow surrounding the fuse. The fuse-and-container combination (hereafter termed F/C) is mounted in the enclosure such that relatively free air circulation exists around the container. Reference ambient temperature is that of the air surrounding the container.

The fuse, F/C (if present), and the enclosure produce a system with interacting effects. Each component may be supplied by a different manufacturer. Data should be available from the component manufacturers to permit proper application. Suitability of a specific application of a fuse inside a container should be the responsibility of the manufacturer of the F/C. Suitability of a specific application of a fuse or F/C in an enclosure should be the responsibility of the switchgear manufacturer. Proper application, operation, and maintenance of the switchgear, based on the recommendations of the switchgear manufacturer, should be the responsibility of the user.

8.2 Application

8.2.1 Usual Service Conditions. Usual service conditions are defined in 2.1 of IEEE C37.40-1981 [6]. Fuses in enclosures, which conform to this section, shall be suitable for operation at their nameplate rating when the ambient air temperature surrounding the enclosure is not above 40 °C or below –30 °C.

8.2.2 Unusual Service Conditions. Where unusual service conditions exist, they should

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be brought to the attention of the switchgear and fuse manufacturer(s). Unusual service conditions are defined in 2.2 of IEEE C37.40-1981 [6]. Additional unusual service conditions may include

(1) Ambient temperatures outside stated range.

(2) Enclosure dimensions and fuse clearances smaller than those specified by the fuse manufacturer. Normally the switchgear manufacturer is responsible for identifying and responding to this condition.

8.2.3 Clearances, Spacings, and Mounting. Certain designs of fuses may vent high-temperature exhaust gases from their exhaust-control devices. Such gases should not be deflected so as to adversely affect dielectric withstand between phases and from phases to ground. Exhaust-clearance recommendations of the fuse or F/C manufacturer should be followed.

Minimum clearances, metal-to-metal, as specified in ANSI C37.32-1990 [10], Table 7, for Indoor Air Switches, should be used as a guide in selecting phase-to-phase and phase-to-ground separations, although the use of adequate insulating barriers may permit reduced separations. Clearance and spacing recommendations of the fuse or F/C manufacturer should also be followed.

The manufacturer of the fuse or F/C should be consulted for the direction and magnitude of the force exerted by the assembly when it operates at its maximum interrupting rating.

8.2.4 Ambient Temperature. The fuse or F/C application may be at an elevated operating temperature due to its confinement within the enclosure. Also, an elevated ambient temperature may surround the enclosure. The manufacturer of the fuse or F/C should specify the maximum reference ambient temperature. (See 8.1 for a description of reference ambient temperature.)

8.2.5 Time-Current Characteristics (TCC) Shift. When the fuse or F/C is installed in an enclosure, the resultant higher-than-normal ambient temperatures surrounding the assembly will cause some shift of the fuse TCC. Most fuse manufacturers publish information on such TCC shift when the ambient is other than 25 °C, and such available information should be utilized to obtain optimum coordination with other protective devices.

8.2.6 Reduction of Allowable Continuous Current Capability. Applications that subject the fuse to high ambient temperatures will likely result in a reduction of the allowable continuous current that the fuse or F/C is capable of carrying, since the capabilities are usually related to a lower ambient temperature.

Allowable continuous current is the highest current that the fuse is capable of carrying in a specified ambient without exceeding the maximum total temperature limits permitted by the device design.

The manufacturer of the fuse or F/C should provide the allowable continuous current for each fuse applied. Usually, these capabilities are available based upon a 25 °C ± 5 °C reference ambient. Factors normally published by the fuse manufacturer give the percent reduction of the allowable continuous current capability for ambient temperatures above 25 °C.

An additional factor will be needed if a fuse normally intended to be used alone is placed in a close-fitting container, thus producing an F/C. This factor adjusts for the condition that the temperature of air surrounding the fuse inside the container will be higher than the reference ambient temperature of the air surrounding the F/C.

8.2.7 Selection of Fuse Voltage Rating. The guidelines for selecting the proper voltage ratings are the same as given in 3.7.1 and 3.7.3.

8.2.8 Selection of Interrupting Rating. The interrupting rating of the expulsion fuse, when used alone, should be equal to or greater than the maximum fault current available at the fuse. When used in conjunction with a backup device having a higher interrupting rating, the maximum interrupting rating of the expulsion fuse should be greater than the minimum interrupting rating of the backup device. The interrupting rating of the combination of the expulsion fuse and backup device is then equal to that of the backup device rating and should be equal to or greater than the maximum fault current available at the combination. The backup device should be chosen to have an energy let-through within the energy withstand capability of the expulsion fuse. Refer to NOTE 1 of 3.10 for proper expulsion fuse and backup device coordination. The interrupting rating of the fuse (if used alone) or the combination in symmetrical amperes, may be directly compared to the calculated symmetrical fault current available. Fuses will

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interrupt asymmetrical fault currents associated with specified X/R ratios. These ratios are generally more severe than those experienced on actual power systems. For the rare cases where system X/R is greater than that specified for the fuse, reduction of the interrupting rating may be necessary. The fuse manufacturer should be consulted.

8.2.9 Selection of Continuous Current Rating. All of the criteria listed in 3.9 also apply to these fuse applications.

8.2.10 Fuse-Coordination Procedures. The fuse-coordination criteria listed in 3.10 also apply to these fuse applications.

8.3 Maintenance

8.3.1 Frequency of Maintenance. All switchgear should be installed and maintained in accordance with the switchgear manufacturer's recommendations.

8.3.2 Inspection of Fuse Components. Manufacturer's recommendations and requirements for inspection and maintenance of fuse components should be followed. Replacement fuses should be those recommended by the switchgear manufacturer.

Some general guidelines for inspecting and maintaining fuse components are listed in 5.2.

The exhaust-control device on the fuse is usually suitable for reuse after a fuse operation. This is dependent upon the fault magnitudes, and numbers, of fault-current interruptions it has experienced. It is advisable, after the operation of a fuse, to inspect the exhaust-control device and follow carefully the manufacturer's instructions for determining the suitability of the device for further service.

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