

Dedication for Safety-Related Fuses used in Class-1E Power System

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1. Introduction

The safety-related fuses used in class-1E power system provide overcurrent protection for electrical system and isolate the class 1E circuit from a fault or overload condition. These days, the number of nuclear grade suppliers has been reduced. Accordingly, commercial grade, instead of safety-related, fuses are procured and used in the utilities through the dedication process. Therefore, this paper introduces the commercial grade fuse dedication process/engineering and how to assure the quality requirements with this process and engineering.

2. Dedication Process

EPRI Report NP-5652 provides the general framework for implementing dedication program in the industry. Commercial grade item(CGI) dedication process for safety-related applications involves in technical evaluation and acceptance process as shown in Fig. 1. The technical evaluation is the key to effective dedication and shall be performed by engineering. The safety function of each item/service based on the approved safety analysis and supporting data is identified and documented through the technical evaluation. The acceptance process is a selection of one or more of acceptance methods for the given critical characteristics. In all cases, the dedication process must be conducted in accordance with the applicable provisions of quality assurance program for nuclear power plant. The process is considered completely when the item is designated for use as a basic component [1].

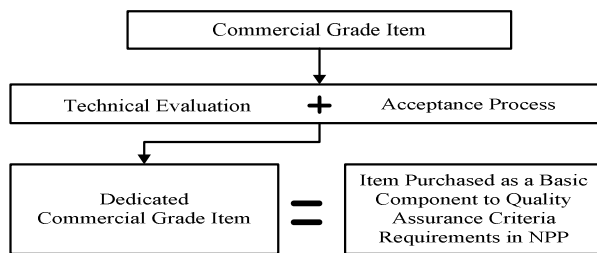


Fig. 1. Generic process for acceptance of commercial grade item used in safety-related applications [1]

3. Fuses Classification used in Class-1E Power System

3.1 Medium Voltage fuses

Power fuses used in class-1E power system that are rated at over 4000Vac are considered as medium voltage fuses and will be of either the current limiting

type or the expulsion type. The characteristics and requirement for high voltage power fuses can be found in ANSI C37.46. As described in the standard, current limiting type fuses will be either general purpose (E-rated or non E-rated) or R-rated [2].

3.2 Low Voltage fuses

Low voltage fuses based on Underwriters Laboratories (UL) and International Electrotechnical Commission (IEC) standards are less than 600V used in class-1E power system. The classification for these fuses is as described in Fig. 2

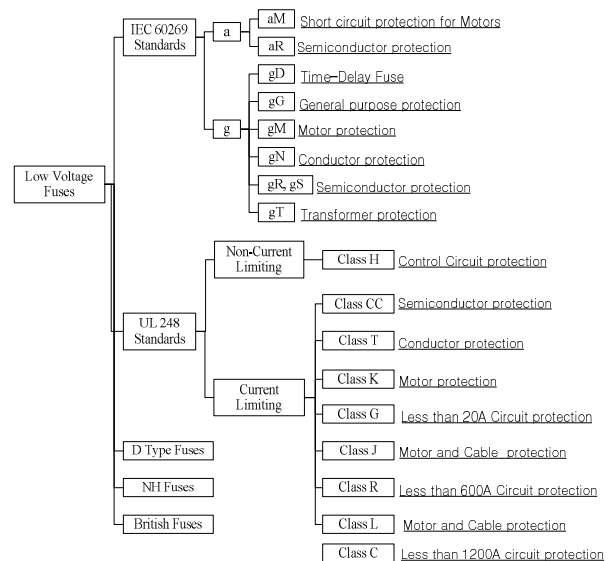


Fig. 2. Low Voltage Fuses Classification

4. Dedication for Safety-Related Fuses

4.1 Safety function

Fuses are typically designed to provide overcurrent protection for electrical system and equipment, and to carry normal load current without interruption. When fuses are installed for class 1E equipment, they must carry the designed basis load current without interruption. The Interruption of a current would adversely affect the function of any safety-related equipment downstream of the fuse. Additionally, the safety grade fuse may be required to isolate a fault or overload condition to prevent degradation of the class 1E circuit

4.2 Failure modes and effects for fuses

If adequate design information cannot be obtained at the level of detail necessary to determine critical

characteristics, determination of critical characteristics should be based on Table 1

Table 1. Failure modes and effects for fuses[2]

Failure Modes	Failure Effects
Open Spuriously	Loss of function of protected circuit
Open intermittently	Intermittent loss of function or trip of protected circuit
High Resistance	Increased ohmic heating within fuse Accelerated heat-related degradation mechanisms in fuse assembly
Fail to open	Loss of function of protected circuit

4.3 Selection of critical characteristics

The critical characteristics for acceptance shall be identifiable and measurable attributes based on the complexity, application, function, and performance of the fuse for its intended safety function. The critical characteristics for acceptance of fuses applied to UL 248 standards are as follows

- Critical characteristics #1 : Marking

The item's manufacturer, model number, voltage and current rating shall be verified visually and the appearance of the product state shall be inspected. Also, the lot/batch numbers of the received fuses for information only are recorded.

- Critical characteristics #2: Configuration

The all fuse shall be verified as per the configuration of the manufacturer's published data. This check shall examine whether the fuse is damaged or has poor workmanship or counterfeit·fraudulent·suspect items (CFSI).

- Critical characteristics #3 : Dimensions

The external dimensions shall be measured and compared with supplier's fabrication drawing or catalog

- Critical characteristics #4 : Fuse resistance

The cold resistance test of a fuse provides the primary indication of the fuse condition and, therefore, shall be checked and recorded. This test is to ensure no open fuses in the batch

- Critical characteristics #5 : Current-carrying capacity

The power supply shall be able to provide a 48~62Hz AC current and a DC test circuit may be used as per the fuse characteristics. The verification and criteria of temperature rise are applied differently as per the production standards of fuses. Therefore a dedicator should check the technical standards of fuses. The temperature of the UL fuse is measured by thermocouples that shall be placed on the center of the top or upper surface of the fuse. The below rated 600A of UL fuses shall carry 100% rating current until temperature stabilization that shall be considered to have occurred when no individual temperature rise reading of 4 consecutive reading taken at 5min intervals exceeds the average reading of these 4 reading by more than 2°C and no indication of increasing temperature rise is observed[3]. When temperature has stabilized, the current to 110% shall be applied to the fuse and continue to hold this current for an additional 15

minutes at below rated 200A or 30minutes at rated 201~600A. Acceptance criteria, the fuse shall not be opened during this test and the temperature rise shall not be exceeded as per the applicable standards

- Critical characteristics #6 : Current Clearing Time

The current as per the relevant standards requirement of fuses shall be supplied to the sample fuses selected as per instructions in the acceptance method. Acceptance criteria are as follows; non-time delay fuses below time shall not exceed the time specified for the fuse type, time delay fuses shall not below quicker than as specified and shall not exceed the time specified for the fuse type.

4.4 Selection of acceptance method to verify the given critical characteristics

The selection of the appropriate sampling plan to verify the critical characteristic provides the reasonable assurance of CGI conformance. Because of numerous qualitative procurement factors, it is normally not necessary to perform 100% and/or inspections to obtain reasonable assurance of item conformance to acceptance requirements. KHNP's dedication sampling plan in the CGI is applied in accordance with EPRI TR-017218-R1

KHNP performs all of the above critical characteristics testing as per EPRI NP-5652 guide with method 1, "Special Test and Inspections". Marking and Configuration of critical characteristics will be a visual verification on 100% of items received. Dimension and Current-carrying capacity of critical characteristics applied nondestructive test and inspection sampling plan in accordance with EPRI TR-017218-R1. Fuse resistance shall be required 100% verification with the calibrated equipment. Current clearing time should be verified based on destructive test sampling plan for lot formations in accordance with EPRI guide.

5. Conclusions

The fuses used in class-1E power system are to protect overcurrent and to isolate fault. Therefore the fuse for acceptance in order to improve the quality and reliability for commercial grade fuses shall be dedicated. The fuse resistance value may be useful as an indicator of acceptance. The current carrying capacity test can change the fuse performance properties. Therefore these critical characteristics are needed for additional review and analysis with fuse manufactures.

REFERENCES

- [1] EPRI NP-5652, Guideline for the utilization of commercial grade item in nuclear safety related application
- [2] NRC, NUREG-1760, Aging assessment of Safety-Rated Fuses Used in Low and Medium-Voltage Application in Nuclear Power Plants
- [3] UL-248-1, Low voltage fuses-Part1 General Requirements
- [4] EPRI TR-017218-R1, Guideline for sampling in the commercial grade item acceptance process