NORTH AMERICAN STANDARDS FOR LOW-VOLTAGE FUSES

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1 General

1.1 Abstract

The ability of fuse manufacturers to access larger markets is significantly influenced by the standards used in specific countries. The North American fuse manufacturers, together with the primary North American safety certification agencies, recognized and responded to this situation by updating and harmonizing the low-voltage fuse standards to reduce the time and costs associated with multi-national market access. These new North American fuse standards are now available as the "248 Series".

1.2 History

Several years ago, Canadian and U.S.fuse manufacturers began discussing the possibility of harmonizing the low-voltage fuse standards for their two countries. Canadian manufacturers were represented by the Electrical Equipment Manufacturers Association of Canada (EEMAC), and the U.S. manufacturers were represented by the National Electrical Manufacturers Association (NEMA). At that time, the U.S. standards, published by Underwriters Laboratories Inc. (UL), and the Canadian standards, published by the Canadian Standards Association (CSA), were similar but not identical. The dissimilarities caused difficulties for manufacturers and added expense when testing for both UL and CSA product certification.

In addition to recognizing the added expense of dissimilar test requirements, U.S. and Canadian fuse manufacturers understood that trade treaties between the U.S. and Canada stipulated that standards should not be used to inhibit trade.

At the same time, UL and CSA began to work together in cooperative ventures, including working with certain industry groups to publish binational standards.

These initiatives came together to drive the Canadian manufacturers, the U.S. manufacturers, UL, and CSA to rewrite the low-voltage fuse standards to harmonize the requirements. A substantial majority of this work is now complete.

1.3 Mexican Participation

Concurrent with the standards-development work on the 248 Series, the Canadian, Mexican, and U.S. governments were developing the North American Free Trade Agreement (NAFTA). Like the earlier free trade agreement between Canada and the U.S., NAFTA specifies that standards be harmonized to eliminate as far as possible all technical barriers to free trade. The fuse harmonization committee invited Mexican participation into the effort in order to proactively harmonize all North American fuse standards.

1.4 Maintaining Fuse Performance

The fuse committee's objective was to update the requirements in order to harmonize national requirements, reflect present technology, provide consistent testing, and make the standards more compatible with international standards. Since there were no safety problems which motivated the update of the standards, changes were carefully monitored to ensure that they did not impact current fuse designs, nor change the application of fuses in accordance with national installation codes such as the U.S. National Electrical Code and Canadian Electrical Code.

Similarly, there was no intent to relax any requirements which are needed to maintain the excellent performance and safety record of low-voltage fuses.

1.5 Publication of Standards

Following a thorough review by the fuse manufacturers and all other interested organizations, the first phase of the binational Standard for Low-Voltage Fuses was published by UL and CSA on October 1, 1994. This phase includes 248-1, -4, -8, -10, -12, -14, and -15. The remaining Parts will be published in late 1995.

Part 1 of the 248 Series has been translated into Spanish by the Mexican participants and accepted as a voluntary standard for Mexico. The Mexican designation is NMX-J-009/248/1-1994-ANCE. Other parts are expected to be translated and published in 1995.

1.6 CANENA

Trinational committees, such as the fuse technical committee responsible for the 248 Series, have been established to harmonize many product standards. These harmonization efforts are overseen by a trinational organization known as Consejo de Armonizacion de Normalizacion Electrotecnicas de Norte America (CANENA) [Translation: Council for Harmonization of Electrotechnical Standardization of North America]. The committee responsible for the fuse trinational harmonization effort is now accepted as the CANENA Fuse Technical Committee.

2 Format

2.1 IEC Standards Style

In order to make these standards more accessible to an international market, the 248 Series uses a style very similar to IEC 269 standards. They utilize a multi-part approach, with 248-1 describing the general requirements, and the subsequent parts giving specific construction and test requirements for the various North American fuse Classes as shown in **Table 1**.

2.2 Definitions

The numbering of the definitions in 248-1 correlates with the numbering of similar items in IEC 269-1. This assists in clarifying the differences in existing terminology between North American and IEC fuses.

The most notable difference is the definition of *Fuse*. IEC 269-1 Par. 2.1.1 includes both the *Fuse-holder* and *Fuse-link*, while the North American definition is 248-1 Par. 2.1.3, correlating to the IEC definition of *Fuse-link* only. A North American *Fuse* is an IEC *Fuse-link*. An IEC *Fuse* is a North American *Fuse* with a fuseholder.

Some terms used in the IEC are not used in the 248 Series, therefore some clause numbers are intentionally deleted from 248-1. Conversely, some definitions have been added to the 248 Series, and these need to be considered when IEC 269-1 is revised.

Table 1

Standard	Fuse Class	Comments
248-1	General Requirements	
248-2	C	Primarily a Canadian fuse
248-3	CA and CB	Primarily a Canadian fuse
248-4	CC	
248-5	G	
248-6	H Non-renewable	Known as "Code" fuse in Canada
248-7	H Renewable	
248-8	J	At DIS stage for IEC 269
248-9	K	
248-10	L	At DIS stage for IEC 269
248-11	Plug Fuse	
248-12	R	
248-13	Semiconductor	Similar to IEC 127-4
248-14	Supplemental	Similar to IEC 127-2
248-15	T	
248-16	Test Limiters	

3 Technical Issues

3.1 Marking

To reduce the amount of translation needed for required fuse markings, several symbols were added to 248-1 as acceptable markings. This also makes the North American markings similar to IEC markings. Preferred symbols are shown in **Table 2**:

3.2 Types of Tests

A major benefit from the harmonization of standards is in ascribing common test requirements for all manufacturers and certification agencies. This provides a consistent approach which results in fair competition, benefitting the manufacturers, the certification agencies, and most importantly, the users.

The test requirements in the 248 Series are subdivided into four general groups. The highest current rating of each homogeneous series of fuses is subjected to:

1) verification of temperature rise and current-carrying capacity (I_{nf}),
2) verification of overload operation (for example: t_{max} at 1.35 I_n),
3) verification of operation at rated voltage, and
4) verification of peak let-through current and clearing I^2t.

Table 2

Unit of Measurement	Preferred Symbol
volts	V
amperes	A
kiloamperes	kA
milliamperes	mA
interrupting rating	IR or I_I
alternating current	∼ (IEC 417 No. 5032-a)
direct current	⎓ (IEC 417 No. 5031-a)
alternating & direct current	≂ (IEC 417 No. 5033-a)
cycles per second	Hz

3.3 Number of Samples and Circuit Constraints

The previous North American fuse standards were inconsistent in the number of samples required for testing various Classes of fuses. The standards also had some subtle differences in circuit constraints for short-circuit tests. When these inconsistencies were reviewed carefully, the fuse committee noted that they were not motivated by any safety concern, so 248-1 was written to remove these differences. As a result, sampling and circuit set-ups are much easier to apply to any fuse test.

3.4 Testing

3.4.1 Verification of Temperature Rise and Current Carrying Capacity

The existing U.S. fuse standards required temperatures to be measured by thermometers placed on the fuse contacts and body. This was a questionable method to measure temperatures on a fuse, but was linked to the temperature limits and the current during the test. The fuse committee revised the approach to temperature testing by implementing the following changes:

1. Replacing thermometers with thermocouples.
2. Reducing the current during the test from 110% to 100%.
3. Revising temperature limits to account for the above changes, and to account for new body materials.
4. Adding a 110% (I_{nf}) test after the 100% temperature stabilization in order to assure users that the fuse's non-fusing characteristics had not changed.

Under this new approach, the tests are more consistent, more repeatable, and relate better to actual use. However, no changes to the actual construction or field-performance of the fuses are anticipated as a result of the test changes.

3.4.2 Verification of Overload Operation

North American power fuses rated 600A and less have fusing gates at 1.35 I_n and 2.0 I_n, but the existing standards had different opening times for time-delay and non-time delay fuses at 2.0 I_n. For example, a time-delay 30A fuse had a t_{max} of 4 minutes at 2.0 I_n while the non-time delay had a t_{max} of 2 minutes. Both had a t_{max} of 1 hour at 1.35 I_n. Also, the time-delay and non-time-delay fuses are physically interchangeable, so many instances of cross substitution had occurred in actual use. The issue was whether the distinction was needed since there were no field reports of difficulties from users.

Research on wire temperature rises showed that the distinction at 2.0 I_n was unnecessary. Temperature tests on wires, conducted with the maximum current for the maximum allowable time, showed that the wire achieved higher temperatures during the 1 hour 1.35 I_n test than during the 4 minute 2.0 I_n test. The 248 Series has been revised to eliminate the difference in t_{max} for time-delay and non-time-delay fuses.

3.4.3 Testing at Rated Voltage

The 248 Series has clarified the testing of fuses at full voltage. However, no significant changes were made to the major elements of these tests, which include the following:

1. Full voltage testing at 2.0 I_n or 3.0 I_n
2. Verification of interrupting rating (I_1)
3. Maximum energy
4. Verification of current-limiting threshold
5. Verification of peak let-through current and clearing I^2t

3.5 Follow-Up Testing

The fuse committee is considering many items for future work, including the possibility of 248-1 including requirements for the regular follow-up testing of fuses in production. Follow-up testing is needed in order to assure continued compliance with the requirements of the 248 Series, but follow-up test sampling and frequency are currently determined by the various certification agencies. Placing the follow-up requirements in the 248 standards will provide many of the same benefits that harmonizing the existing standards has, including consistent test programs for all manufacturers and certification agencies, and increased user confidence, since users will be well aware of the substantial effort the fuse manufacturers put into consistent quality and compliance.

4 New Standards

In addition to the parts of the 248 Series which replace previous fuse standards, two new Parts have been added to cover fuses which previously had no published requirements. These are 248-13 and 248-16.

4.1 Semiconductor Fuses

248-13 covers semiconductor fuses. These fuses are presently certified in North America using requirements not published in a formal standard. The new 248-13 standard allows a very broad range of product, essentially verifying the manufacturer's claims and ratings. This standard is very similar to IEC 269-4.

Fuses will be distinguished by a gR rating for full-range fuses, or an aR rating for short-circuit protection only fuses.

4.2 Test Limiters

248-16 covers test limiters. Test limiters are special fuse-like products used during short-circuit testing on end-use equipment, such as during the testing of a fused switch. The test limiter allows greater peak current and clearing I^2t than is specified for the designated fuse, thus exposing the end-use product to a "worst-case" short circuit.

Test limiters are evaluated only for short circuit and must have larger I_p and I^2t than the maximum allowed for the represented fuse. Test limiters are presently certified in North America, using requirements not published in a formal standard.

4.3 DC Testing

248-1 includes general information on DC testing, and the subsequent Parts provide the specific details for each fuse Class. Thus, the current standards for DC testing are no longer needed.

5 National Deviations

The 248 Series is very successful at limiting National deviations to an absolute minimum. Only three such deviations remain, as follows.

5.1 Plug fuses in Mexico

Plug fuses (used in residential circuits) in Mexico must be tested and marked for use at 127 V, in order to correlate to past requirements and the predominant voltage delivered to residences. Canadian and U.S. plug fuses are marked and tested for use at 125 V. The fuse committee is planning to eliminate this deviation.

5.2 "P" and "D" fuses in Canada

Certain Canadian fuses for residential use in Canada must be tested for their ability to open the circuit when subjected to elevated ambient temperature conditions. These fuses are marked "P" or "D". The 248 Series allows the "P" and "D" marking only for these fuses in order to keep this marking restricted.

5.3 Language Markings

Fuses for use in Mexico will be marked in Spanish. Fuses for use in Canada and in the U.S. will be marked in English. In Quebec, fuses for residential use are required to be marked in French.

6 Summary

The 248 Series Standards are accepted by Canadian, Mexican, and U.S. fuse manufacturers, CSA, ANCE, and UL. 248-1 has been adopted as an NMX standard for Mexico. These standards are also expected to be adopted as Canadian National Standards (CAN), and American National Standards (ANSI).

The 248 Series of low voltage fuse standards provide complete coverage of North American fuse types, while allowing flexibility for future fuse technology. They provide a framework which could be used in any country, for any type of fuse. In addition, by unifying the requirements for Canada, Mexico, and the U.S., they demonstrate the proactive approach of the fuse manufacturers and product certifiers in North America.

MATHEMATICAL

MODELLING