Developments in Small Dimension Fuse Technology and the Impact on a Third Party Independent Certification Organization

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1. Summary

A brief introduction to Underwriters Laboratories Inc. as a third party independent certification organization will be followed by a discussion of the historical evolution of the UL Standard for Supplementary Fuses, UL198G. The impact of technological advances on the Standard and UL will be noted, as will the UL involvement in the field of international harmonization of small fuse performance requirements.

2. Third Party Certification Organizations

2.1 In General

There is a definite need for organizations that can certify that the performance of a product complies with established norms. Such organizations serve to demonstrate that a particular product actually does comply with a formal set of requirements, without bias or a vested interest in the products ultimate profitability. The economic interests of the manufacturer or of a particular segment of industry thus do not influence the determination of product compliance.

Underwriters Laboratories Inc. fulfills the role of a third party certification organization because, as a not-for profit private corporation that does not have any stock holders, it does not market any products and thus has no direct financial reason to endorse or certify a product. Over the years UL has earned and maintained a reputation of fairness. UL has done so not only in the area of product certification, but also in the promulgation of the Standards to which products are evaluated.

2.2 UL as a Test Authority

One way that UL has earned a reputation for fairness is that UL Standards insure that the results obtained during a product evaluation are capable of being repeated with similar or identical results. This demonstrates the level of equality inherent in the test methods and test requirements, and also allows for additional verification of results should a dispute arise. The need for expensive and complicated tests and test equipment has been kept to a minimum, primarily so that smaller manufacturing organizations will have the same opportunity to design, research, and test a product as will the multi-national conglomerates.

2.3 UL as a Developer of Standards

A test authority can maintain a reputation for fairness only if the Standards used for product evaluations allow the determination of compliance to be made in a manner which is inherently unbiased . When UL undertook the responsibility to develop standards, the need for equanimity in standards became a basic part of the approach to accomplishing this task.

As a result, UL has made major efforts to write standards that do not demonstrate favoritism of any kind, and that are not biased in favor of a particular type of product or a particular manufacturer. In so doing, UL has sought input from as many interested sources as possible. The efforts to maintain impartiality do not cease when a standard has been initially published, but continue for any revisions of the standard as they may become necessary.

An additional consideration that has guided UL in the development of standards is that designers of products should be as free as practicable to incorporate technological advances and other factors into their product designs, in an atmosphere of non-restrictive trade.

2.4 UL as a Safety Organization

While fulfilling the roles of test authority and developer of standards, Underwriters Laboratories is also an organization whose prime concern is public safety. Accordingly, when a UL Standard is being developed or revised, the standard must serve to provide a level of safety that is commensurate with the product, the uses to which the product will be put, and the people who will use the product. The UL concern for safety means that any UL Standard is really a UL Standard for Safety, rather than merely a set of construction and performance requirements designed to test the products marketability.

A consequence of this concern for safety is that technological advances which may benefit a concerned industry may not always be incorporated into a UL Standard. Any proposed revision that dilutes the level of safety provided will not be considered.

However, in order to keep up with technical advances in a particular field as covered by the scope of the Standard, and

which can serve to improve the level of safety provided, UL constantly monitors the industry. And UL frequently provides updated revisions in order to satisfy the continuous feedback and response mechanisms.

Similarly, when a product is being evaluated and tested, if any feature of the product is observed that reduces the level of safety provided to a level which is less than that contemplated by the standard, the product may be deemed ineligible for third party certification by UL, even if it meets all the literal requirements of the standard.

Conversely, there is also a need to acknowledge that technological changes may yield a product that does not meet all the exact requirements of the standard, but that does not compromise the level of safety required. Such a product can be eligible for third party certification if the organization responsible for the certification is able to be flexible in its approach to the certification process. As we shall see, UL is such an organization.

3. The UL Safety Standard UL198G

3.1 Background

The requirements for what used to be called "Miscellaneous Cartridge Fuses" were originally added to the UL Standard for Fuses UL198. This standard was for what are now called Class H cartridge fuses and Plug fuses of the Edison base type and those designated Type S.

UL198 formed the nucleus of what later became the entire series of UL fuse standards, and served as the starting point for further fuse standards development. The levels of safety contemplated by UL198, in the form of required test parameters, influenced the development of all subsequent fuse standards.

In terms of test and performance parameters, the requirements for "Miscellaneous Cartridge Fuses" contained in UL198 were basically the same as those already existing for the regular type of cartridge fuses. An important difference in the construction requirements for the miscellaneous fuses was that the physical dimensions were not specified.

This was a direct response to the fuse industry and the various industries that used fuses. Leaving the dimensions unspecified provided the opportunity for third party certification of fuses that had many legitimate uses but which as a consequence of the application also needed to have unconventional shapes and sizes.

In 1972, UL undertook the development of a separate standard for miscellaneous fuses, and during the early discussions it was decided to include the additional classifications of "miniature" and "micro" fuses. This decision was based on the needs of the industry, which reflected the technological developments of the time.

3.2 The First Edition - UL198.6

Because the origins of the miscellaneous fuse requirements lay within UL198, certain performance values which had been applicable to the regular type of cartridge fuses were retained for the miscellaneous and miniature fuses when the First Edition of the Standard for Fuses For Supplementary Overcurrent Protection was published on August 24, 1974, with the designation UL198.6.

Performance requirements that were passed on to the miscellaneous and miniature fuses included the 10000A interrupting ability requirement, as well as the test values of 110%, 135%, and 200% of rated current for temperature, current carrying ability, and clearing time evaluation. Micro fuses were given a different set of test parameters in view of the differences in intended use and physical characteristics.

The test values noted above had been chosen years before as the values appropriate to demonstrate an acceptable level of overcurrent and short circuit protection for conductors, as well as for switching and utilization equipment, during the early stages of development of the electrical industry in the United States of America. By the time the first edition of the supplementary fuse standard was published, the need for fuses with a higher interrupting ability rating was apparent. For this reason miscellaneous fuses were able to be rated up to 100,000 amperes, but could not be rated any less than 10,000 amperes. The 10,000A level was kept for the miniature fuse for several reasons, including consistency with other fuse types, and the general agreement by the fuse industry that this value was within the capability of the extant fuse designs.

The micro fuse was assigned an interrupting rating of 50 A at 125 volts ac, based on its anticipated uses and physical characteristics, as previously mentioned. The micro fuse test levels for current carrying ability and temperature, and clearing time verification tests were chosen to be 100%, 150%, and 200% of rated current for the same reasons.

The first edition of the Standard UL198.6 formalized the definitions of what UL identifies as miscellaneous fuses, miniature fuses, and micro fuses, and also formalized the set of performance parameters for these types of fuses.

3.2.1 UL Supplementary Fuse Dimensions

In keeping with the flexible approach to dimensions for the miscellaneous fuses that had been found in UL198, the First Edition of UL198.6 gave the requirements for the dimensions[1] of the various fuse types in general terms, so that many shapes and sizes would fall under the scope of the Standard.

Miscellaneous fuses have specific dimensions if they are of the ferrule type, and if so, they shall be either 13/32 inch (10.3mm) or larger in diameter, or 1-1/2 inch (38.1mm) or longer in length. If the fuse is not of the ferrule type the dimensions and shape are not specified.

A miniature fuse has envelope dimensions of a) not larger than 9/32 inch (7.1mm) in diameter and 1-7/16 inch (36.1mm) long, and b) not less then 0.197 inch (5mm) in diameter if 0.787 inch (20mm) or longer, or 1/4 inch (6.3mm) in diameter if 5/8 inch (15.9mm) or longer.

A micro fuse also has envelope dimensions. They are a) if tubular shaped with terminals on each end they must fit within the outline 0.197 inch (5mm) in diameter and 0.394 (10mm) long, b) if cylindrical shaped with fuse terminals from base, they must fit within the outline 0.315 inch (8mm) in diameter and 0.394 inch (10mm) high, and c) if rectangular prism shaped with fuse terminals from base, they must fit within the outline 0.236 inch (6mm) wide, 0.394 inch (10mm) high, and 0.591 inch (15mm) long.

3.3 The Second Edition - UL198G

The Second Edition of the small dimension fuse Standard was published on October 23, 1981. By this time the old Standard UL198 had been retired, and replaced by a number of fuse standards, each dealing with a specific class or a group of classes of fuses. For administrative reasons, the designation of the second edition was changed to UL198G.

The second edition was basically a reissuing of the first edition, with very little change.

3.4 The Third Edition Of UL198G

The Third Edition was published on February 3, 1988. While the technical specifications including the dimensions have either not changed or not changed substantially from the original, many minor changes have been incorporated into the 3rd Edition in response to the input from concerned parties.

While it is true that the technical requirements of UL198G remain much the same as originally contained in earlier editions, technological advances in the fuse industry have not been ignored. Many needs of the industry have been met on an internal basis, and thus are not as visible as are revisions to a published UL Standard.

This includes the acquisition of a trained, experienced, and knowledgeable staff who can get the job done. And, because UL can be flexible in the approach to third party certification, and also because UL can offer more than one type of third party certification, (as will be discussed below), the job can often be done without the need for formal revision to the Standard.

One area in which UL has responded to the fuse industry is in the number of samples required for test purposes. Many years of test experience demonstrated that the level of safety provided by the original Standard would not be lessened if the number of samples used for testing was reduced. Accordingly, later versions of the Standard provided for reduced sample amounts. For example, the number of glass cartridge miniature fuses with press on ferrules needed for interrupting ability testing has been reduced from the original 10, to 5.

The third edition of the small dimension fuse standard remains in effect at this time. However, as previously mentioned, as a UL Standard UL198G is always under review and UL welcomes any input from interested parties with regard to revising the standard to accommodate technological advances which contribute to fuse performance without reducing the level of safety provided.

4. UL Listing and Component Recognition For Supplementary Fuses

A fuse which meets *all* of the performance requirements of UL198G is eligible for UL Listing. The UL Listing Mark identifies the fuse as one which has been fully evaluated to the Standard.

UL also offers a service to fuse manufacturers and fuse users which differentiates UL from most third party certification organizations. Under the Component Program, a fuse may be evaluated that does not meet one or more of the requirements of UL198G. A Component Recognition is conditional, that is, it delineates the known limitations of the fuse performance, including variations from the Standard, and requires that the particular application of the fuse in an end product be evaluated by UL to determine that the fuse is being used in accordance with the limitations of use.

Under the Component Program, many supplementary protection fuse types have been tested by UL and certified for use in applications where the suitability of the combination (fuse and end product) is to be determined by UL.

The flexibility of the Component Program serves two important functions. The first is that a UL Standard need not exist for a fuse to be third party certified. This means that testing can be performed to verify fuse operation to a wide variety of parameters, including those developed by other organizations.

The second is to allow for the manufacture of fuses which do not meet each and every requirement of the existing UL Standard, with the knowledge and understanding that such fuses serve legitimate needs in legitimate applications.

In such applications, particular or limited performance characteristics may be an asset rather than a liability, and the Component Program of Underwriters Laboratories specifically addresses the need for third party certification in this area.

The inherent flexibility of the Component Program contributes strongly to UL's ability to third party certify fuse performance without the need to constantly revise the fuse standard.

5. UL 198G and Fuse Technology Advances

The small dimension fuse industry has been directly influenced by the electronics industry. Electronic components have undergone a practically continuous reduction in size. Advances in miniaturization of electronic components have impacted on the fuse industry because it is still desirable to protect the miniaturized components and associated circuitry. The fuse intended for direct insertion in printed wiring boards was among the first responses to the evolution in electronic circuitry techniques.

UL accommodated this type of fuse in the First Edition of UL198.6, by including miniature fuses with "pig tail" leads and micro fuses with "terminals from base".

Now many components have been made small enough to be mounted directly on the surface of printed wiring boards, and the fuse industry has developed a number of types of surface mounted fuses (called SMT for surface mount type) as a direct response to the needs of those industries which use fuses.

UL198G, in its present form, does not address the SMT fuse. However, UL has been asked to provide third party certification of safety/performance by a number of manufacturers of SMT fuses.

The UL philosophy has always been that a product which has a form of construction differing from that described in a particular Standard may be examined and tested according to the *intent* of the Standard, and thus may be deemed eligible for UL Listing or UL Component Recognition, and Follow-Up-Service.

This position, which is formally stated in the Forward to every UL Standard, allows the SMT fuse to be tested by adapting the test methodology to fit the product.

In the past, UL has adapted many test methods, such as using a printed wiring board with samples soldered in place, to test the many different types of fuses being submitted for certification.

Working with fuse manufacturers to come up with suitable test methods and procedures has resulted in the desired third party certification of safety in many instances, even when the product being investigated is outside the literal scope of the Standard.

This is a further example of how technological advances have impacted on UL. While UL198G has not yet been revised to specify new ways to conduct fuse testing, UL has changed the way in which some fuses are tested because the changes in fuse designs have in some case rendered the old test methods inadequate. UL also acknowledges the need to change test methodology so that the test results more accurately reflect the fuse performance that will be observed in real world applications.

UL does not need to wait for the Standard to catch up to the industry before investigating a product.

6. The Universal Modular Fuse (UMF)

6.1 Background

The International Electrotechnical Commission has been attempting to develop requirements for a small dimension fuse that would have universal application and universal evaluation. If all third party certification organizations treat the fuse identically, then the UMF can be regarded as truly universal. Otherwise, the identifying mark of one organization may be judged in some cases and localities as being superior to the mark of another organization, and in other areas as inferior.

With the desired goal of agreeing to a policy that would ultimately yield a UMF that was internationally equivalent, a

meeting was held at the corporate headquarters of UL in April 1987. At the meeting were officials of UL as well as of the IEC. Also attending were a number of interested fuse manufacturers and users.

Agreement was reached on two important items. One was that UL would support the acceptance of a single international fuse standard with active participation in its development. The other was that the gates of 1.25 ("non-fusing") and 1.7 ("fusing") would be reserved by both UL and the IEC as applicable to the UMF and to no other fuse type.

6.2 UL participation

The writer has been involved with UL/IEC activities since 1984-1985, and is a member of the Working Group that has been charged with the responsibility to develop the UMF requirements. At many WG meetings, the question has been asked "What will UL do when the UMF documents are finalized, and what service will UL provide to manufacturers of UMFs?". The answers to these questions were given by Mr. Donald Mader, Vice President of UL, during the WG meetings at Orlando Florida, USA, in January 1989.

UL will use the UMF documents as a basis for a UL Standard, which will be developed via the UL standards development process. UL will then be in a position to offer Listing and Follow-Up-Service to manufacturers of UMFs.

6.2 Follow-Up Service for UMFs

UL differs from many third party certification organizations by conducting ongoing follow ups after an initial certification has been issued. The historical UL follow up for fuses has been comprised of two parts, working together.

Factory inspection is the mechanism by which the fuses being constructed at the manufacturer's factory are compared to a photographic and written description to see that the present construction is the same as that originally evaluated. This verifies continued compliance with the *construction* requirements of the Standard.

Samples are also selected by the UL Field Representative from production samples, and these sample are subjected to Follow-Up-Testing to verify continued compliance with the *performance* requirements of the Standard.

The IEC Working Groups are attempting to develop a scheme for reducing the number of samples tested during an initial submission to a test authority, based on the "homogeneous series" concept. This type of test approach has historically been used by UL when testing fuses. If an IEC scheme can be agreed to and adopted, the position of the WGs has been that a mandatory plan of follow-up testing must be implemented simultaneously. Accordingly, a follow-up plan has also been under discussion.

At this time, it appears likely that the technical work on the UMF will be finalized before agreement is reached on the reduced sample testing scheme and a follow-up testing plan. The first draft of the UL UMF Standard may therefore be developed with the understanding that, in the absence of an IEC reduced testing scheme and follow-up testing plan, the historical approach to fuse testing will be utilized and that the historical type of UL Follow-Up-Service for fuses will be applicable to the UMF.

In the event that the Working Groups need a substantial amount of additional time to agree on the reduced testing scheme and the follow-up plan, the First Edition of the UL UMF Standard may be published without the incorporation of these aspects of the IEC endeavors. However, it is hoped that while the UL UMF Standard is still going through the development process, the IEC will finalize the reduced sampling and follow-up concepts. They can then be introduced into the UL documents before publication.

In this way the UL and IEC requirements can be truly harmonized, and the culmination of years of efforts and years of technological advances will be a truly universal fuse.

7. Conclusions.

The UL Standard for Fuses for Supplementary overcurrent Protection UL198G has evolved, and continues to evolve, with due regard for public safety, the needs of the concerned industry, and technological advancements.

The methods used by UL to conduct small dimension fuse evaluations have changed in response to the design changes in the fuses being tested.

The UL Listing and Component Recognition Services for fuses fill the ever growing need for third party certification of fuse performance, and do so with a degree of flexibility that cannot be achieved by other organizations. UL can respond quickly to technological advances that are beyond the immediate scope of the written requirements.

UL has supported, and continues to support the international efforts for harmonization of standards, and will continue to participate in developing the Universal Modular Fuse requirements.

[1] Underwriters Laboratories Inc., Standard For Fuses For Supplementary Overcurrent Protection, UL198.6, 1974, Pages 6,7.