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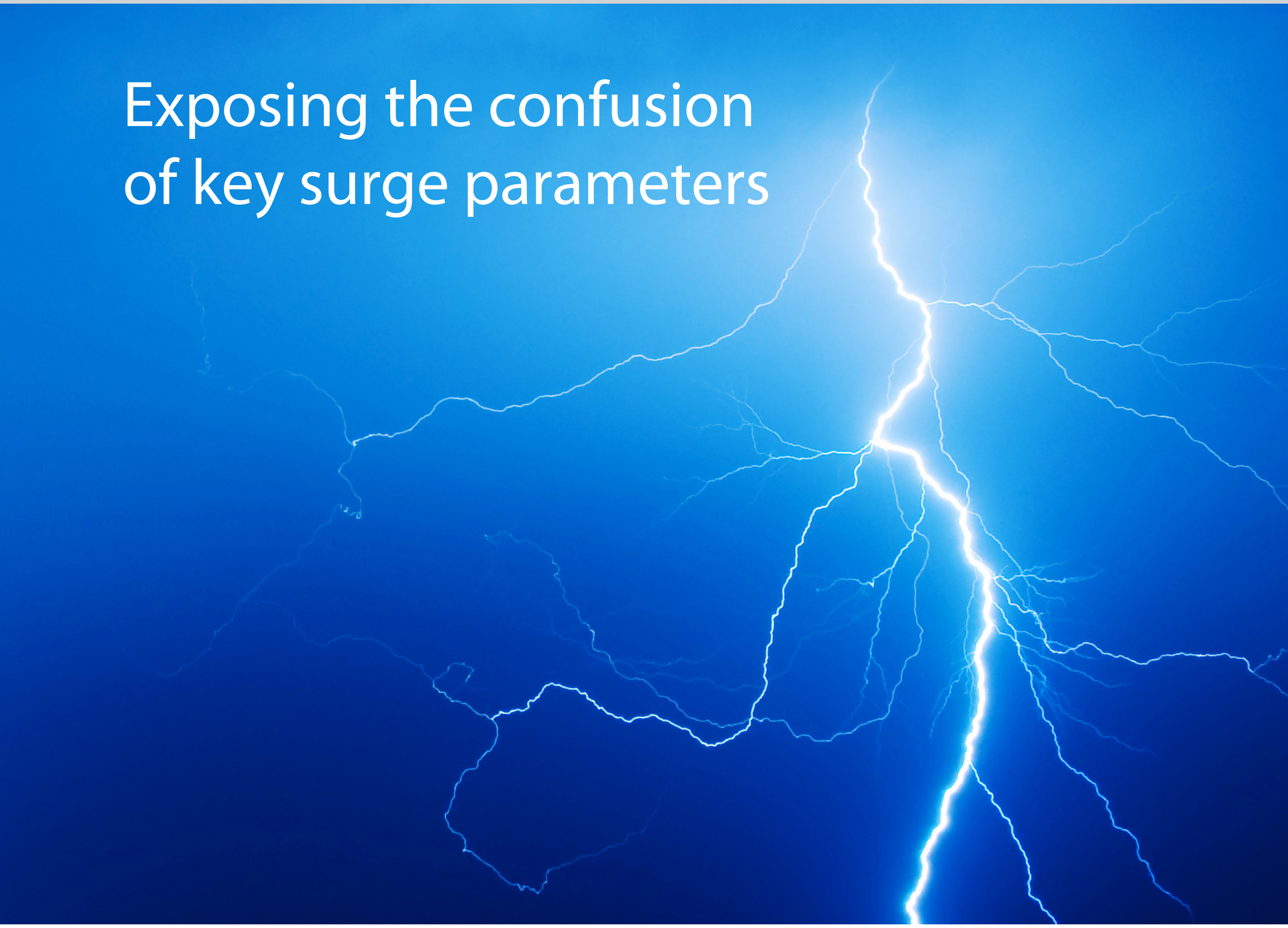
Technical News

INDUSTRIAL SWITCHGEAR & AUTOMATION SPECIALISTS

Exposing the confusion of key surge parameters



Written by Wes Stephenson
Product Manager - Power Quality

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Surge technology is highly developed and the benefits are well known, however, why can it be so difficult to choose the right surge diverter? Is the I_{max} rating (kA) the only measure for selection? What is the importance of all the other technical features of a Surge Protection Device (SPD)? The challenges of selecting the right SPD for the application are made all the more difficult with the differing local and international protection standards.

Understanding the purpose of the surge protector and its capabilities will ensure an educated selection of the surge protector is made. This Technical News aims to clarify the differences in the local and international surge protection standards, the significance of testing and the essential parameters of a surge unit.

INTRODUCTION

Like any other circuit protection device, surge protection is critical to an installation by maintaining disruption-free operation and protecting the equipment within. Why, then, is it so difficult to select the appropriate device for any given application?

Surge protection has long been considered a 'black art', the correct application all too complicated for the average consumer to grasp. But the problem extends beyond application misunderstandings to the very ratings that define the operation of these devices. With products readily available from overseas manufacturers, built to at least three different standards, the performance of these devices is difficult, if not impossible, to compare due to different rating definitions.

So, with many standards in common usage and the many different device ratings to consider, in addition to which type of device is appropriate for the application, how does a consumer make an informed decision about what to install?

FUNDAMENTAL PURPOSE OF SURGE PROTECTION

To help understand the correct application of surge protection it is useful to remind ourselves of the fundamental purpose of surge protection - prevention of hazardous potential differences. Many people get caught up with the industry buzz terms, or simply believe that the most important feature of a surge diverter is its ability to conduct current. However, what use is this feature if the surge diverter doesn't limit the voltage to a suitable level, a level which an installation's equipment can sustain?

To illustrate this point consider a general purpose outlet (GPO) with a sensitive load connected ***(Fig. 1)***. A GPO has a terminal-to-terminal insulation capable of withstanding 1000 V. If the surge diverter cannot limit the voltage to less than 1000 V then there is the possibility of a short circuit between terminals, thereby rendering the surge diverter ineffective (no matter how much current it is capable of conducting). If the connected equipment has a lower voltage withstand than what the surge diverter is able to limit the voltage to, then the connected equipment will likely be the source of the short circuit, damaging or destroying the equipment.

Of course, there are many ratings for a surge diverter, each having their own distinct definition and use. To understand what the ratings mean and how to apply them we refer to the standards. The problem in Australia is that there are at least three standards that are commonly cited, AS/NZS 1768, IEC 61643 and UL 1449. Which rating comes from which standard, and can these similar ratings be compared?

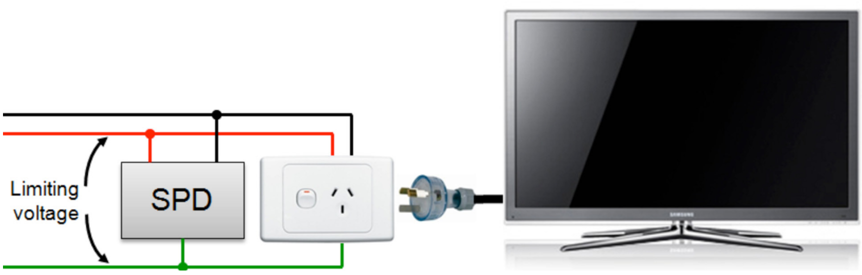

Fig. 1 - Sensitive load connected to a general purpose outlet

KEY RATINGS

Of all the different ratings definitions there are in the market, the following are the most crucial in terms of application and technical feature comparison: nominal current, I_n; maximum current, I_{max}; impulse current, I_{imp}; and voltage protection level / rating, U_p or VPR.

Nominal Current - this rating describes the longevity of a surge diverter, its ability to withstand multiple impulses of the 8/20 µs test current waveform ***(Fig. 2)***, with the number of impulses detailed in Table 1. The test waveforms are described by the time it takes the current to reach 90 % of the peak (8 µs), and the time it take for the current to subside to 50 % of the peak (20 µs).

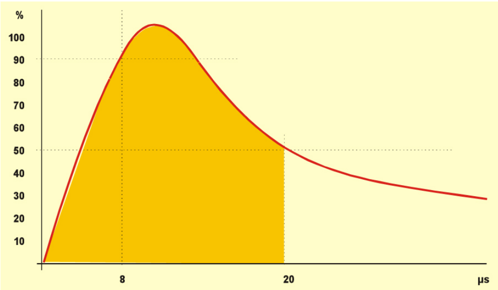

Fig. 2 - 8/20 µs test current waveform

The intention of this rating is common amongst all three standards, however notice that AS/NZS 1768 does not define a testing procedure to ensure the integrity of this rating.

IEC 61643.1 and UL 1449 Ed. 3 both define a very similar testing procedure, whereby the test current waveform is applied in three groups of five impulses. The test and rest periods are as follows, to give an indication as to the comprehensive nature of this test procedure:

1. Apply I_n impulse
2. Rest sample for 60 seconds
3. Repeat steps 1-3 a total of five times
4. Rest sample for 30 minutes
5. Repeat steps 1-4 a total of three times

The pass criteria for this test is that the sample must still function at the nominal system voltage after the test procedure.

Table 1- Nominal current ratings requirements

Standard	Symbol	Definition
AS/NZS 1768	I_n	15 impulses - test sequence not defined
IEC 61643.1	I_n	15 + 1 impulses, part of operating duty test procedure
UL 1449 Ed. 3	I_n	15 impulses, part of operating duty cycle test procedure

Maximum Current - a measure of the ability of the surge diverter to conduct a large amount of current. Again, this rating is defined using the 8/20 µs test current waveform, however the surge diverter is only intended to accommodate this current relatively few times.

According to AS/NZS 1768 a surge diverter must only withstand this current once, however there is no test procedure to validate this rating.

Conversely, IEC 61643.1 details a comprehensive test procedure to determine the Imax rating. The test is defined as the operating duty test, which includes both the I_n and I_{max} tests. A successful test result confirms both I_n and I_{max} ratings. The operating duty test includes the test procedure for I_n as a preconditioning test, after which the following impulses are applied to the device to determine the I_{max} rating:

1. 0.1 x I_{max}
2. 0.25 x I_{max}
3. 0.5 x I_{max}
4. 0.75 x I_{max}
5. 1.0 x I_{max}

To achieve both I_n and I_{max} ratings, one final impulse of I_n is applied. If the device still functions after these tests the device may be rated with these values.

Finally, the I_{max} rating is not defined by UL 1449 Ed. 3.

Table 2 - Maximum current ratings requirements

Standard	Symbol	Definition
AS/NZS 1768	I_{max}	1 impulse - test sequence not defined
IEC 61643.1	I_{max}	5 incremental impulses, part of operating duty test procedure
UL 1449 Ed. 3	N/A	Not defined

Impulse Current - a measure of the ability of the surge diverter to conduct an extreme magnitude of current. This rating is similar to maximum current in that a surge diverter is seldom expected to conduct this current, however a surge diverter carrying this rating is intended to be used in high exposure, high current applications, hence must be tested in a different way. A device is tested to show its ability to withstand impulses of the 10/350 µs test current waveform ***(Fig. 3a)***. For comparison the 8/20 µs and 10/350 µs test current waveforms are shown overlaid on the same graph in ***(Fig. 3b)***.

According to IEC 61643.1 impulse current is defined using the operating duty test as described above in the I_{max} section, however instead of using the 8/20 µs test current waveform the impulse current test utilises the 10/350 µs test current waveform ***(Fig. 3a)***.

AS/NZS 1768 does not define the rating I_{imp} however does acknowledge its existence in the IEC standard. Instead of defining the rating, AS/NZS explains a rough factor of 10 rule between I_{max} and I_{imp}.

Again, UL 1449 Ed. 3 does not define impulse current I_{imp}.

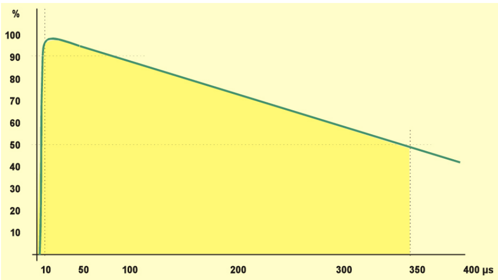

Fig. 3a - 10/350 µs test current waveform

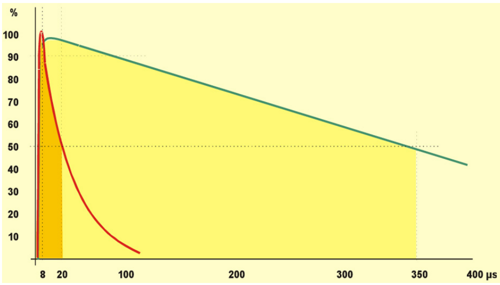

Fig. 3b - comparison between 8/20 µs and 10/350 µs test current waveforms

Table 3 - Impulse current ratings requirements

Standard	Symbol	Definition
AS/NZS 1768	N/A	Not defined, factor of 10 relationship with Imax
IEC 61643.1	I_{imp}	5 incremental impulses, part of operating duty test procedure
UL 1449 Ed. 3	N/A	Not defined

Voltage protection level/rating - is defined as the limiting voltage across the surge diverter's terminals. The voltage protection level is perhaps the most important rating for successful surge protection and this rating has a common intention across the three standards, but there are important differences to be aware of.

UL 1449 Ed. 3 is very clear and defines VPR with a complete test procedure based on a 3 kA current impulse.

AS/NZS 1768 and IEC 61643.1 in isolation are very clear also, however in the Australian market they are never considered in isolation. AS/NZS 1768 defines voltage protection level, U_p, with a 3 kA current impulse, whereas IEC 61643 defines voltage protection level, U_p, with an I_n current impulse. Due to the difference in the definitions these two ratings cannot be compared, even though they have the same symbol.

Table 4 - Limiting voltage ratings requirements

Standard	Symbol	Definition
AS/NZS 1768	U_p	Limiting voltage with 3 kA impulse (8/20 µs test current waveform)
IEC 61643.1	U_p	Limiting voltage with I_n impulse (8/20 µs test current waveform)
UL 1449 Ed. 3	VPR	Limiting voltage with 3 kA impulse (8/20 µs test current waveform)

SUMMARY OF RATINGS AND TESTING REQUIREMENTS

		AS/NZS 1768	IEC 61643.1	UL 1449 Ed. 3
Key Ratings	Nominal current	I_n	I_n	I_n
	Maximum current	I_{max}	I_{max}	N/A
	Impulse current	N/A	I_{imp}	N/A
	Voltage protection level / rating	U_p	U_p	VPR
Test Procedures	AS/NZS 1768 test procedures	No test procedures defined		
	UL 1449 Ed. 3 operating duty cycle test (I_n)?	✘	✘	✔
	UL 1449 Ed. 3 VPR test?	✘	✘	✔
	IEC 61643.1 operating duty test (I_n and I_{max})?	✘	✔	✘
	IEC 61643.1 U_p test?	✘	✔	✘

SUMMARY:

Surge protection is not trivial. There are many factors that must be considered to ensure an adequate protection system is realised. However, with the availability of international product and multiple standards in use, this task has become a lot more complicated and extremely confusing. We have seen that there are multiple concepts to consider. These concepts may have different definitions but could use the same symbol. How can anyone be sure that the lightning surge protection system they have designed will operate as intended?

In the short term, this situation poses an opportunity for lightning specialist companies to assist consumers. Only when all the facts are known can one design a lightning protection system that will perform as expected.

Another way to simplify the situation is to reference one standard only. Moreover, ensure any ratings are referenced back to a particular standard to ensure there is no confusion over which standard's rating should be used for product selection.

It is apparent that some standards are more specific with device ratings, particularly those that have structural testing regimes. To ensure consistency of performance and system design integrity, specifiers may benefit from applying the standard that is best suited to their application. Ultimately a correctly designed and implemented surge protection system provides many benefits and extends the life span of sensitive electrical and electronic equipment.

References

AS/NZS 1768:2007 - Lightning Protection

IEC 61643-1:2005-03 - Low-voltage surge protective devices - Part 1: Surge protective devices connected to low-voltage power distribution systems - Requirements and tests

IEC 61643-12:2008-11 - Low-voltage surge protective devices - Part 12: Surge protective devices connected to low-voltage power distribution systems - Selection and application principles

UL 1449 Third Edition - Surge Protective Devices

IEEE C62.41.1:2002 - Guide on the Surge Environment in Low-voltage (1000V and Less) Ac Power Circuits

IEC 62305-4 Ed. 2.0 - Protection against lightning - Part 4: Electrical and electronic systems within structures

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