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Quarterly Technical Newsletter of Australia's leading supplier of low-voltage motor control and switchgear.

IN THIS ISSUE

How does electrical equipment rate ?

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Electrical equipment is defined by a bewildering array of ratings. Few people fully understand these ratings as some of even the fundamental ratings have a history of international manipulation and compromise. This has resulted in obscure meanings that can leave the newcomer totally confused.

While the international playing field might be more level with Australia basically adopting IEC standards the placement of the goal posts is by no means fixed. The manufacturers and users of electrical equipment often find themselves aiming for different ends of the field.

The early Australian standards had a strong British influence and were full of practical approaches. In those days for instance the small wiring cables only had one current rating. Technical correctness had been put aside for the sake of simple understanding. This paper looks at a few of the ratings with some explanation of how we got where we are today.

Device rating needs to be understood to make correct selections.

Ratings based on current

Current influences the temperature rise, electromagnetic forces and the contact life of a device. There is a range of ratings based on current for normal and abnormal operating conditions.

Conventional free air thermal current (I_{th})

This is most fundamental of all the ratings as the $/amp is usually the first comparison made when selecting between products from different suppliers. Given its basic importance it is easy to see that if the Ith is increased so the price equation improves. It is not surprising therefore that when IEC principles were adopted, equipment

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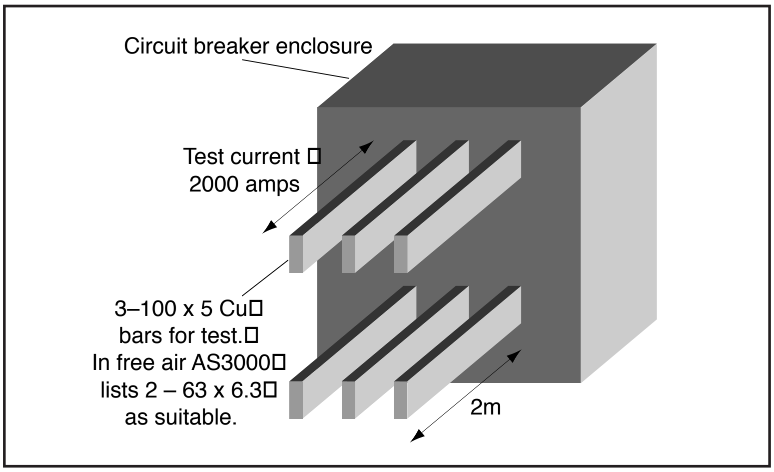
ratings increased. It would seem that the pressure groups at the time ensured that the test methods maximized the results that could be obtained in the standard tests. To achieve this the standard test conductors were made large and thus provided heat sinking of the device under test. The temperature restrictions were also increased to allow hotter running. The problem was compounded when the Australian Wiring Rules included tables for busbar ratings which implied busbar temperature rises of 70º C were acceptable. This is in stark contrast to the temperature rise of test conductors. These are proportioned to give a temperature rise of about 20º C in the test configuration.

Conventional enclosed thermal current (I_{the})

This is the value of current the device can carry when mounted in a defined enclosure. While most electrical switchgear is intended to be enclosed, I_{the} is not normally quoted. The variations caused to the actual temperature rise by the enclosure design and the heating caused by other equipment means that in most situations I_{the} will also vary.

Manufacturers can provide some guide to a suitable derating of enclosed equipment but the designer of the assembly must take responsibility for the final outcome.



Typical test arrangement for enclosed current rating.
Test busbars are of large cross section.

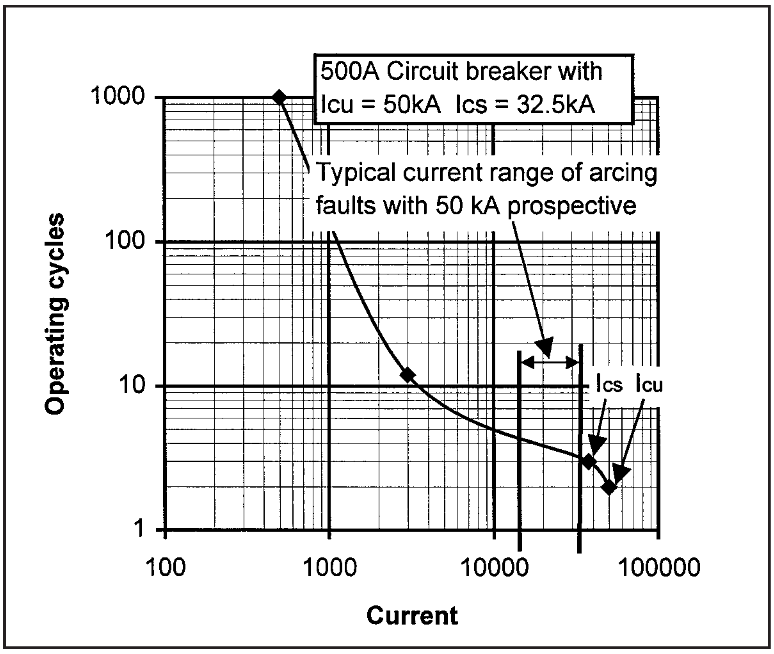
Rated operational current (I_e)

The operational current relates to the devices switching ability at its operational voltage. It is often less than the thermal current rating.

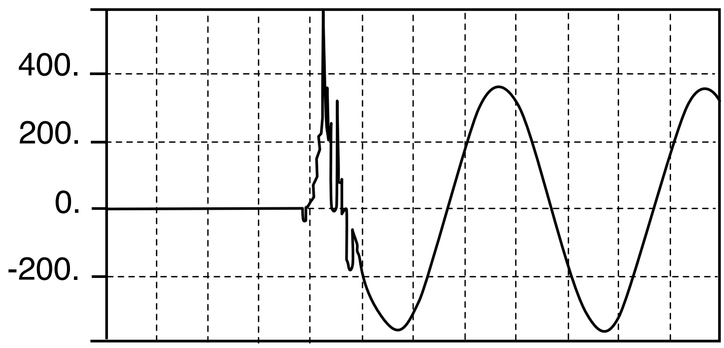
Rated service short-circuit breaking capacity (I_{cs}) and Rated ultimate short-circuit breaking capacity (I_{cu})

Before the adoption of IEC standards there were separate performance standards for Moulded Case Circuit Breakers (MCCB) and Air Circuit Breakers (ACB). The term Air Circuit Breaker referred to the fact that the breaking process was in air as against the old oil immersed style. A more accurate distinction between the two would have been metal clad as compared to moulded case.

While in principle the two



Circuit breakers can be selected on the basis of Icu.
Actual fault currents are normally less than the circuit prospective.



Transient voltage recorded during short circuit testing of a miniature circuit breaker. Actual peak is off scale.

styles of circuit breaker were much the same the ACB was considered more robust and had the ability to withstand short duration fault currents with the contacts remaining closed.

This ability allows time grading with down stream circuit breakers. The ACB was also expected to withstand an extra operation at maximum fault levels.

The ACB was generally applied at the main switchboard and MCCBs used for lower rated distribution circuits. As product ranges developed MCCBs increased in current rating and some ACBs used an increasing number of mouldings. These trends and the similar purpose of the two styles of circuit breakers resulted in a single standard being produced. The greatest difficulty in combining the two was the difference in the number of close open operations required at the rated short circuit level. For the MCCB, to increase the number of operations would have meant the short circuit rating would need to be reduced. For the ACB, to reduce the number would remove one of the main differences between the two styles of breaker. This issue was resolved by introducing the concept of Ultimate (I_{cu}) and Service (I_{cs}) short circuit ratings. The Ultimate rating requiring an open / close open test sequence while the Service rating an open / close open / close open sequence. Unfortunately this has resulted in confusion ever since. There is no guide given in the standard as to how to apply the two ratings.

Based on the history of the ratings there is no reason why MCCBs should not be chosen on the basis of the Ultimate rating. There are very few MCCB problems that have resulted from the MCCB being selected on the basis of the Ultimate rating instead of the Service rating.

Voltage ratings

The voltage ratings are critical to the performance of electrical switchgear. While the IEC standards show a consistent treatment of the voltage ratings, modifications introduced by Australia have distorted the concepts to some degree.

Rated operational voltage (U_e)

This is the voltage at which the operational tests are performed. Several ratings may be applied for use at different supply voltages. This rating is fairly straight forward.

Rated insulation voltage (U_i)

This rating is equal to or greater than Ue and relates to the voltage at which the dielectric and creepage distances are referred. Testing for this rating includes allowances for overvoltages. As the standards specify a particular test voltage as covering a range of Ui ratings it is normal to specify Ui as the highest value in the range. It should never be assumed that a device can be operated at Ui as it may be incapable of breaking any current at that voltage.

Rated impulse withstand voltage (U_{imp})

Relates to the peak value of

voltage that the equipment can withstand without flashover or damage.

The occurrence of transient overvoltages in electrical systems is a normal event. They are caused by switching transients and induced effects from lightning strikes. The voltage withstand of the equipment needs to be high enough to prevent flashover. If flashover does occur this can often provide the means for a continuing arc to be established, resulting in severe damage.

The IEC approach is to establish a coordinated insulation system. The transients need to be limited to a level below the impulse withstand levels of the associated equipment. The magnitude of possible transients is considered greatest at the service entrance level and decreases at the distribution circuit and equipment levels. Surge arresters are normally required for transient control.

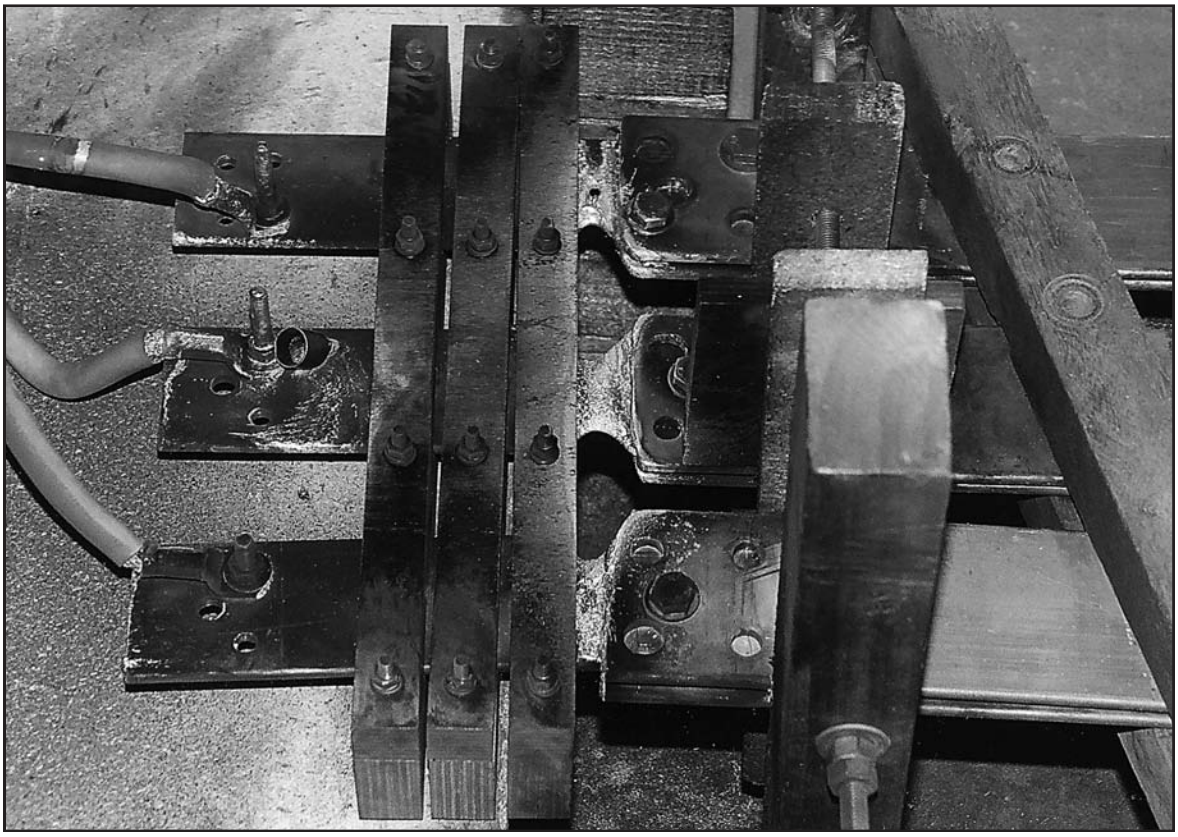
In Australia the use of surge arresters has not been common and there has been substantial resistance to adopting the IEC principles.

The Wiring Rules and the Australian versions of the switchboard standards have always specified quite large creepage and clearance distances. Based on experience the values specified have been sufficient to allow quite high transients to pass without flashovers. The basic switchgear standard AS3947 accepts the principles of insulation coordination and does not set specific requirements for Australia. On the other hand, AS3439, the switchboard standard, has been modified away from IEC requirements to require high withstand levels. The impulse level has been specified as 10kV and this effectively results in requiring the same creepage and clearance distances that have been used for many years. This difference makes flashover of busbars unlikely but failure of the equipment possible. This can be seen with sensitive electronic equipment as damage by electrical transients is common. The damage has reached a point were the domestic consumer is well aware of the problem and many surge arresters are being purchased to prevent loss of expensive equipment or data. In industrial applications failures are occurring with flashover of equipment inside switchboards. At this level

Surge diverters are being used to protect equipment

IEC preferred values of rated impulse withstand voltage when protected by surge-arresters. Overvoltage category			
I	II	III	IV
Specially protected level	Load (appliance equipment) level	Distribution circuit level	Origin of installation (service entrance) level
1.5kV	2.5KV	4kV	6kV
Minimum clearance required for inhomogeneous field conditions for above impulse levels.			
0.5mm	1.5mm	3mm	5.5mm
Impulse level as modified by AS4349 for the live conductors in Australian switchboards.			
	10kV	10kV	10kV
Minimum clearance required by AS3439			
	12mm	12mm	12mm

Australian requirements for switchboard surge ratings in not matched in Australian switchgear standards.



Flashover of test station terminals caused by a voltage transient. Test duration 0.2 seconds 50kA prospective current.

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however there seems to be a lower understanding of the problem than at the domestic level. There is of course a major difference in the consequences of the flashover. An electronic device that has been killed by a transient still looks the same but a fault in a switchboard usually results in extensive arcing damage even though the causes may have been identical.

What needs to happen

The thermal performance of equipment requires a balance between the device, the enclosure and the connecting conductors. The 1991 edition of the Wiring Rules was in conflict with the switchgear standards in regard to busbar selection but a better approach has been published in AS4388 -1996.

This standard details a method for switchboard temperature rise assessment and includes more realistic temperatures for the operation of busbars. Unfortunately, the busbar sizes are metric while imperial bar sizes are still common in Australia. This standard needs to be revised to include the imperial sizes.

The confusion between ultimate and service short circuit ratings needs to be clarified by perhaps a statement in the Wiring Rules. For normal distribution circuits the prospective short circuit level of the circuit needs only to be matched by the ultimate rating.

While those experienced in the electrical industry have a fair understanding of the problems of temperature rise the causes and remedies of electric flashover are very poorly understood. The destruction caused by the arc often hides the evidence but breakdown does occur even with quite large clearances as there is often no surge arrester in the system. As a flashover often involves substantial financial loss, litigation is often threatened but seldom undertaken because the issue quickly becomes quite technical. The presence and cause of a destructive transient is also very difficult to prove after the event. To overcome the situation Australian Standards need to remove the fuzzy approach to insulation coordination and accept that surge arresters should be required.

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