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

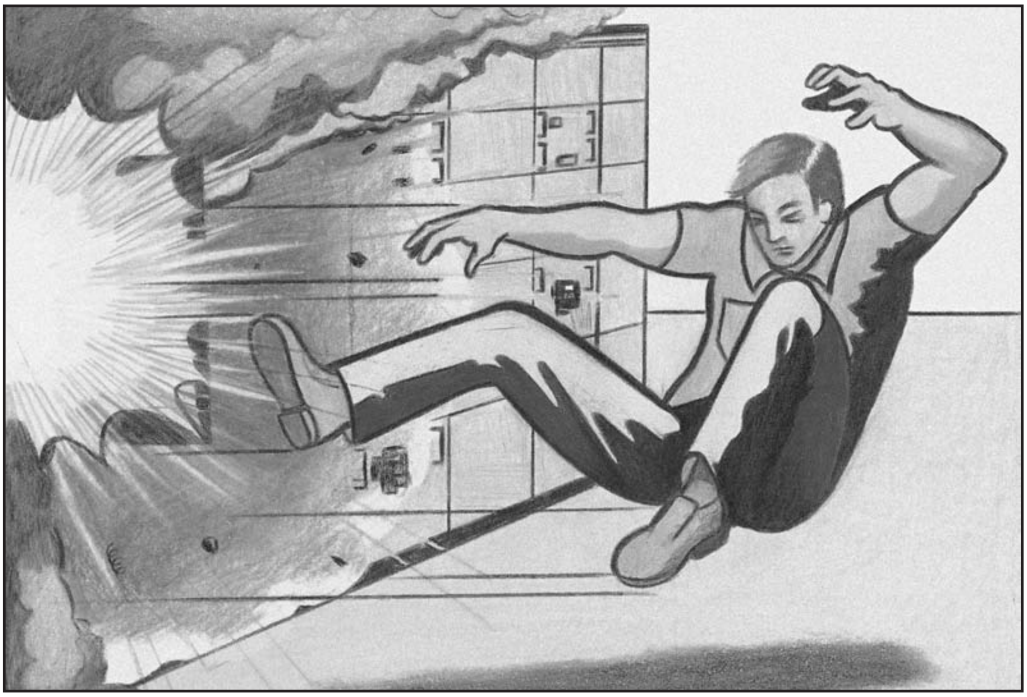
IN THIS ISSUE

The quality switchboard

The electrical switchboard is the heart of any industrial or commercial building. Failure of the switchboard can have dramatic consequences for the operation of an enterprise. Loss of business during the time it takes to rebuild the switchboard can exceed the cost of the switchboard many times over.

There has been an increasing trend for the type of switchboard installed to be governed by the amount of capital available and we are starting to see some dramatic results. While in the financial sense it may seem a waste to invest in a technically secure switchboard, a lack of foresight can prove very expensive. Extra money spent ensuring firstly the chance of failure is minimised and secondly that if a failure does occur the consequences are limited can be a worthwhile investment. It is often overlooked, as the financial objective is to provide the best returns. Extra money spent on the switchboard is unlikely to improve the rental return of a building investment.

The switchboard standards allow for switchboard designs to be either the absolute minimum or virtually indestructible. It is up to the purchaser to understand the implications of the various possibilities and specify a switchboard that is technically sound for the application.



Cost cutting on components and switchboard construction can prove expensive in the future.

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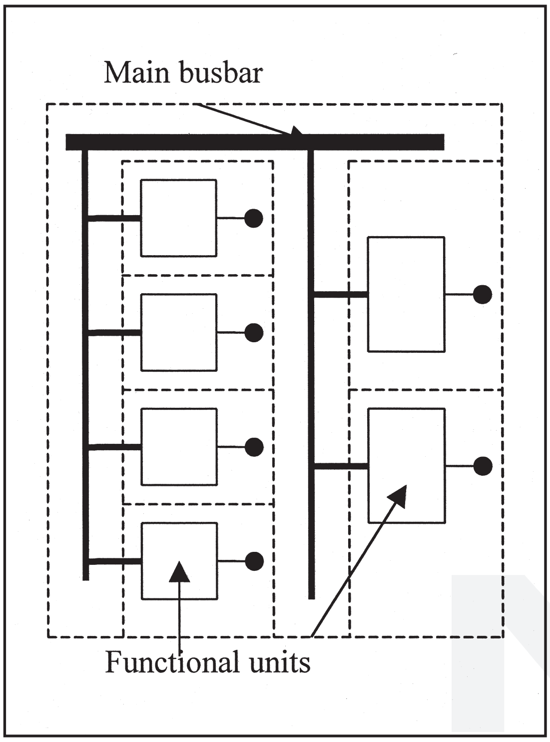

Form 4 construction may not provide quality.

The switchboard

Large switchboards are usually custom built and may include major components that are purchased on an indent basis. Should a major fault occur, replacement or repair could take weeks. Careful consideration needs to be given to the possible modes of failure and how to eliminate or control any possible damage.

In some critical applications switchboards are duplicated so that failure of one will not cause loss of the facility. While many businesses will not go to the expense of duplication, the down time costs, should a failure occur, will often be found to be many times the cost of a duplicate switchboard.

Failure modes

External influence

The basic function of the switchboard is to divide the incoming electric supply into smaller rated sub circuits. The switchboard will provide protection of each outgoing circuit and this means a fault external to the switchboard will cause the protective device in the switchboard to operate. Depending on the actual fault level it is possible to “wear out” the protective device with repeated faults. The consequence can be failure of the protective device to interrupt the current resulting in an arcing fault within the switchboard.

The sum of the current ratings of the outgoing devices will normally exceed the rating of the incoming supply. This is called the diversity factor. If actual loading exceeds the diversity factor the switchboard can be overloaded without any of the outgoing protection operating. This can lead to a major failure due to overheating.

Internal problems

Despite careful attention to manufacture, defects sometimes go unnoticed. There can be loose connections, inadequate electrical clearances and other problems that can cause a breakdown within the switchboard. Rodents and other unwanted pests can also cause flashovers if they are allowed to penetrate the switchboard.

Form of construction

The Switchboard standards define different Forms of construction but give little guidance as to what they really mean. The different Forms relate to the levels of segregation between the busbars, terminals and functional units. The selection of a suitable Form can be quite complex. It is common for specifications to state a Form level but not to have this related to a desired performance level.

The questions that need to be resolved are, is the ability to connect or remove cables to an outgoing circuit while the switchboard is live important, is maintenance required to be performed on functional units while the switchboard is live and as a minimum, will maintenance only be performed while the main isolator is off? The Form of construction relates mainly to these issues and addresses accidental contact with live parts. It should be noted that the issue of accidental contact can also be addressed by insulation as against segregation.

A common mistake is to believe the Form of construction will provide extra protection if an internal fault does arise. The basic Forms are not required to be designed or tested for the effects of internal arcs. A higher Form will normally mean a more expensive switchboard but not necessarily a higher quality. By quality, it is meant, a reliable switchboard that even if an internal fault did arise would limit the damage and be quick and easy to repair.

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Protection

Overcurrent protection is the most common means of detecting trouble. For the switchboard itself overcurrent protection has some limitations which can cause excessive damage if the fault is within the switchboard. Time grading is normally used to ensure discrimination between each level of protection and this means that during a fault the level of damage will be greatest close to the point of supply as the time to trip will be greatest. With just overcurrent protection the switchboard is most vulnerable to damage from internal faults.

Earth fault detection

As most switchboards are of metal construction any internal fault will normally, quickly, involve currents to earth. This earth current can be detected by various means and operate the incoming circuit breaker faster than the normal overcurrent protection. The earth fault detection can be arranged to only respond to earth currents within the switchboard and therefore the operating time can be kept to a minimum.

Zone interlocking

By having circuit breaker protection relays linked, it is possible to speed up the tripping operation.
The operation time of the upstream protection is reduced if the downstream circuit breaker is not experiencing the fault current. This indicates the fault is internal to the switchboard and rapid clearance is required.

Camto optical arc detection.

Optical fault detection

Optical detection of arcing within a switchboard also allows rapid clearance of a internal fault. Optical sensors are placed within the switchboard and if an arc is detected can respond in only a few milliseconds to provide a trip signal to the main circuit breaker. This style of protection is simple but can be very effective in minimising damage.

Fault containment

It has been very common in Australia to specify fault containment or “Appendix E” style switchboards. This type of switchboard is intended to reduce the risk of injury to an operator in front of the board and to limit the spread of damage. While most switchboards built to containment standards do improve safety, the nature of the testing involved does not guarantee performance under all conditions. The assembly is considered to offer acceptable protection if the results meet the specified criteria. While it is not too hard to determine what is a good or bad result there are still many aspects of concern with these tests. In particular the tests are not very searching and in service faults that can arise may give different results. This is different to the operation of say an optical sensor which can be tested and maintained so that it will always give the expected result. Any arcing in the optical range will always cause operation of the circuit breaker in the minimum operating time.

Breakdown recovery

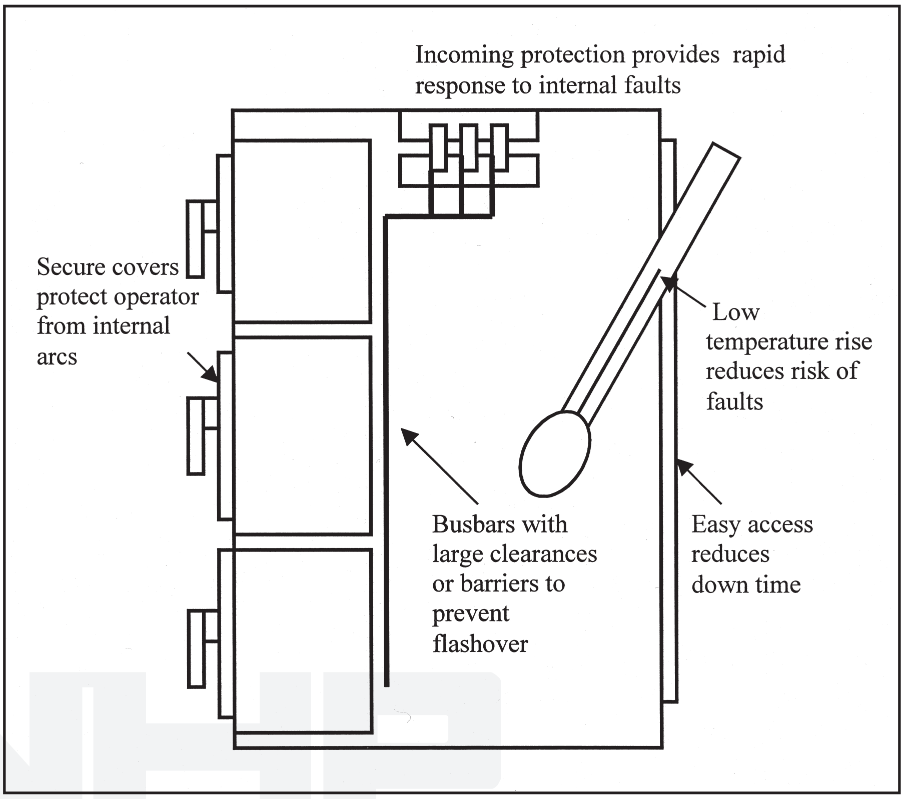
An arcing fault rapidly destroys all materials close by and contaminates a wide area with a black conductive soot deposit. Limited arc duration is the key to quick repair. A fault containment design does not necessarily make repair easy. A completely open design in which the arc may run freely can be much easier to repair.

Safety

Any electric arc represents extreme danger for anybody in close proximity. The heat produced and the explosive effect of the arc can cause severe injury in a very short time. Segregation of the operator from any possible fault area is important. Reduction of the duration of any fault will reduce the severity of injury should a person be exposed. With proper selection of the protection scheme and appropriate switchboard design reasonable safety levels can be achieved.

Design for quality

The traditional type tested switchboard is tested in accordance with the standards to withstand the effects of the passage of high currents for typically one or three seconds. This may prove the strength of the busbars and the supports but does little to prove the "quality" of the switchboard. The very concept of accepting one or three second delays before operation of the protective device can be a recipe for major damage within the switchboard.



The quality switchboard.

Quality in the performance sense is taken to mean:

1) the possibility of internal faults is kept to a minimum,

2) the ability to keep damage to a minimum if a fault does occur,

3) repair is quick and easy after a fault and

4) the operator is protected against internal faults.

(1) Internal fault minimisation

Excessive temperature rise is a major cause of electrical failures. The life of electrical insulation decreases rapidly as temperature is increased. Electrical connections are also temperature sensitive and at high temperatures can have their life reduced dramatically.

Careful selection of components, busbar sizes and the ventilation method is required. In a switchboard configuration most power components will require some derating to allow for them being enclosed and mounted adjacent to other devices producing heat. Typically a 10 - 20 percent derating is required to compensate for the differences between the test conditions used to rate the device and the actual installed conditions.

A cool running switchboard with live conductors insulated or provided with large clearances is the starting point for a quality design.

(2) Damage limitation

Any fault within a switch-board is likely to be an arcing fault. The actual current levels will typically be between 30

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and 70 percent of the maximum short circuit prospective at the point of the fault. With an arcing fault the energy release at the site of the arc rapidly causes severe damage. If an internal arc was allowed by the protection to be maintained for say three seconds, most switchboards would not be suitable for repair. With an arcing fault, it is desirable that it is cleared in a time close to the minimum operating time of the protecting circuit breaker. In assessing the likely times the failure of any of the components in the switch-board should be considered. Ideally the switchboard should be fitted with a main incoming circuit breaker. This will be the ultimate protective device for most of the switchboard.

The incoming breaker should be fitted with relays that will detect an internal arcing fault either by current measurement or optical means so that fault clearance is achieved in less than say 50 mSec.

(3) Quick repair

Given that any fault has been limited to a very short time, repair should be considered in two stages. The first stage is to be able to remove the damaged component and restore the dielectric strength of the switchboard. A Form 1 style of construction with rear access offers the best possibility in this regard. The fault and the repairs required will be obvious to repair personnel.

(4) Operator protection

As fault levels increase the risk to an operator standing in front of a switchboard also increases. The aim should be to provide a barrier between the operator and the area of possible fault. The "Appendix EE" tests are intended to provide a means of assessing risk and in most cases do result in a design which improves safety. The tests however only simulate a limited range of faults and do not test, all parts of the switchboard. To provide safety, the first step is to ensure all internal faults will be detected in the minimum possible time. The second is to provide remote operation of all power switching devices.

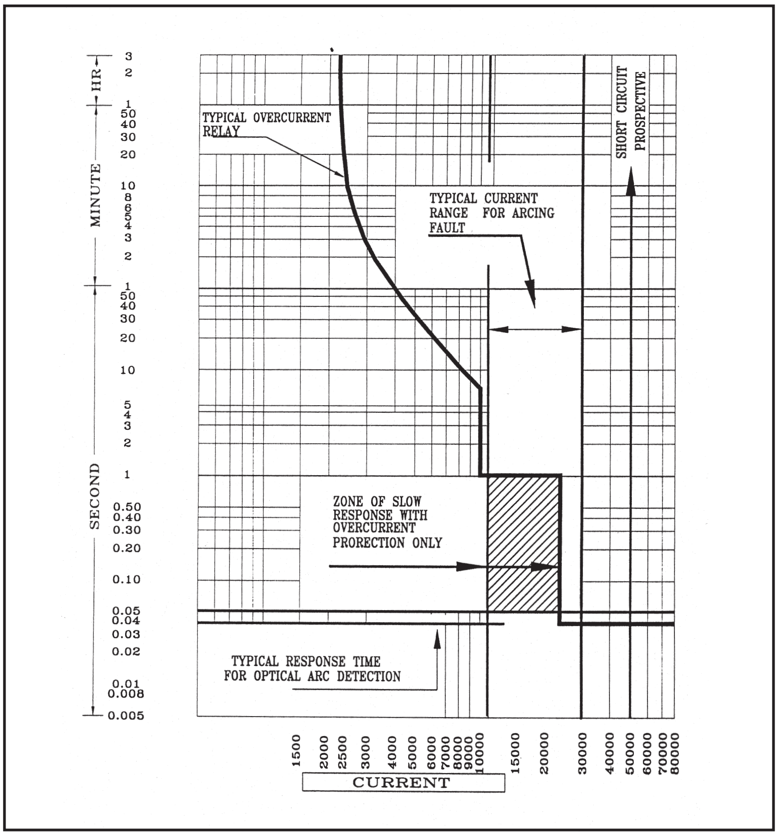
Large circuit breakers can be motor driven while the moulded case circuit breakers can be fitted with rotary extension operators. All covers on the switchboard need to be securely attached.

If the switchboard is Form 4 style with equipment mounted in small compartments, the pressure build up can be much higher than a design with more open style mounting of equipment.

Conclusions

The electrical switchboard is a vital component and is worthy of careful design in relation to the protection scheme, safety and speed of repair should a fault arise. The use of conventional overcurrent protection alone may not be sufficient for safety and damage minimisation. The addition of schemes such as optical arc detection can provide significant benefits. Tested fault containment style switchboards may not provide the performance expected.

Optical arc fault detection can be fast.



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