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Quarterly Technical  
Newsletter of Australia's  
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and switchgear.

## CONTACTOR FAILURE

### Reasons for contactor failure

The failure of contactors is a common event, but often the reason for the failure is not understood. The modern contactor is the product of many years of refinement of basically the same technology. The performance of each contactor is well documented under test conditions. If the application only operates the contactor within its defined operating parameters, a life consistent with its published ratings can be expected. If the contactor is subject to a stress outside its ratings, rapid failure can sometimes be the result.

An understanding of the possible causes of early failure is helpful in

evaluating failure in service.

Problems with contactors manifest in three forms: (a) the contactor does not close, (b) it will not open, or (c) it flashes over.

### (a) failure to close

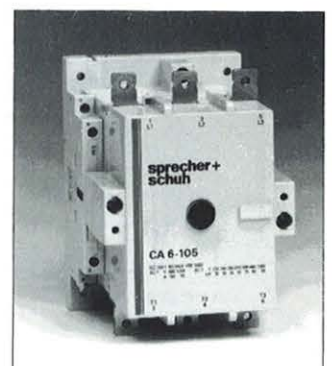
Open circuit coils are a regular culprit in contactor failures. While the coil may be considered a very simple device, it is subject to ageing. In A.C. applications the windings are subject to forces which can cause very slight movement of the windings. This movement is normally controlled by some form of bonding of the turns, which can be achieved by complete encapsulation, dipping in varnish, or by the use of a special coating on the wire which bonds the coils

together when heat is applied.

Over a long period of time any movement can result in sufficient damage to the coil to cause an insulation breakdown.

### Temperature

The insulation materials also have a life which is dependent on temperature. The normal expectation is that the life is halved for every 10°C increase in temperature.



**Fig. 1.**  
*The modern contactor is the product of many years of refinement.*

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#### Contactor failure

(a) failure to close

(b) failure to open

(c) flashover

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Coil temperature is directly influenced by the enclosure temperature and adjacent equipment. The frequency of operation can also cause the coil to overheat, as the pull in currents are much greater than the hold current. Failure of the magnet system to fully close can also cause thermal problems with the coil, as any air gap will cause the coil to draw a higher current.

### Coil windings

The cross section of wire used in most coils is very small (decreases as voltage increases). It is possible for a chemical attack to cut through the wire very quickly. The most vulnerable section is the attachment to the terminal. The copper wire can be exposed at this point, and if any soldering fluxes, or other contaminants are present, problems can arise. If the coil separates at the attachment point there will usually be no sign of overheating of the coil, as occurs with most other modes of coil failure.



**Fig. 2.**  
*Contactor coil with burnt out winding*

### Voltage stress

Voltage stress will also cause failure. The stress can be caused by transients on the voltage supply, or by the switching of the coil itself.

The actual construction of the coil is very important, as this determines the maximum voltage between turns. The position of the lead to the start of winding is usually the problem area. If this lead is allowed to come into contact with the top windings, maximum voltage stress is produced. A failure between turns first results in a shorted turn, or turns, which behaves like a short on a transformer. The current in the affected turns increases, and a burnt ring appears on the coil. The wire will eventually fuse and the coil becomes open circuit.

### Magnet system

If the applied voltage is too low for the magnet system to close, the coil can also burn out, as it is still possible for the coil current to be at a higher level than the normal closed state.

Mechanical interlocks fitted to operate between two contactors will also cause coil burnout if an attempt is made to operate against the interlock.

### Contacts

The magnet system may operate correctly, but not all contacts close. The simplest cause can be contamination of the contact surface preventing the contacts from touching. Lack of care during the construction of control gear assembly is the most common source of contamination. As most contactors do not have a fully sealed contact chamber they should never be exposed to such things as swarf or building rubble.

Contactors that have had an arduous electrical life can also

reach the point that the contact has been eroded so much it does not make contact any more.

## (b) failure to open

Problems are sometimes found with magnet systems failing to release. The pole faces become bonded and the opening springs fail to break this bond. Oil has been one of the culprits in this regard. The steel that forms the core of the magnet system may still have oil between the laminations, and this oil can weep onto the pole facing causing them to stick.

Contactors manufacturers try to ensure that any unwanted oils are removed after the laminations are punched, as the problem is well known. In the field, however, some maintenance staff have been found to use aerosol lubricants on contactors. While the label on the can might suggest the contents will cure just about any problem, these lubricants should never be sprayed into block type contactors.

### Contact welding

Welding of the contacts is the major cause of contactors failing to open. Welding is common, but at normal current levels the welds are very minor and the operating spring will break the weld. The contact materials used are mostly silver, in combination with another material, to reduce the silver's tendency to weld. A balance is required between several conflicting requirements. As the

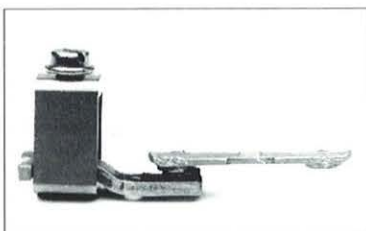
tendency to weld is reduced, the electrical resistance also increases. The contact must also be able to withstand the arc produced when opening. Most arc resistant materials, such as tungsten, are also poor electrical conductors.

Contact welds that are of sufficient strength to prevent opening can usually be traced to an abnormal condition in the external circuits.

A contactor should never be returned to service after a weld without finding and correcting the external problem.

#### Short circuits

A short circuit on the system will cause the contacts to separate and produce an arc. The magnetic forces on the moving contact can, under fault conditions, exceed those of the contact springs. Some contact designs, such as those found in large circuit breakers, use the magnetic forces to increase the contact pressure



**Fig. 3.**  
*Welded contact caused  
caused by short circuit.*

and prevent lift. This, however, is not possible with the simple contact bridge used in most contactors. The heat produced by an arc under fault conditions is very high, and can result in a very strong weld. The device used for short circuit protection can help reduce the possibility of

welding if its characteristics can limit the peak fault currents.

#### Contact chatter

Problems with the control circuit sometimes produce a burst of rapid opening and closing of the contactor. This chattering will greatly reduce the contact life, and can cause a weld.

Electronic devices used in the control circuit are a common source of contactor chatter, as they can be sensitive to electrical interference. A failure to segregate the power wiring from the control wiring can be the cause.

#### Mechanical shock

Mechanical shock can also cause contacts to open and produce arcing and a weld. Control cabinets mounted directly on a machine may be the cause. A large contactor mounted next to a small one may also transfer sufficient shock to open the contacts of the small unit.

### (c) flashover

The compact design of the modern contactor means the phase separation is small. Flashover between phases does occur, but usually these can be traced to connection problems. A loose connection can produce an arc which can quickly transfer into a phase to phase fault. The resulting current can also cause internal damage to the contactor.

Internal flashovers are rare, but should never be found on a contactor operating within its design limits. Failure to

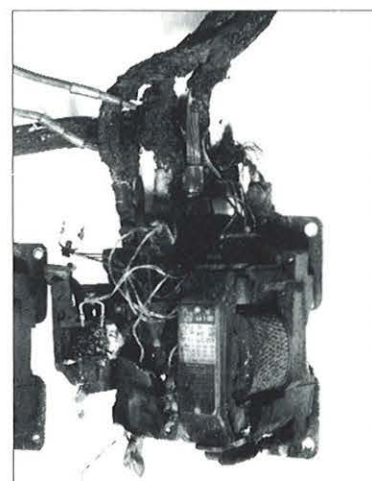
correctly assemble all parts after a field inspection can be a cause.

Some contactors that have reached the end of their life can have significant deterioration of the insulation between phases. In the extreme, a flashover may result.

## Conclusion

While the modern contactor is a fairly simple device, it represents many years of research and development. The performance has been refined to the point where confidence can be placed on the published ratings, but one should not expect a reserve outside of these ratings.

Contact failure as a result of manufacturing or design defects is a rare event. Careful examination of all the factors involved will usually find the cause of failure to be other than the contactor itself.



**Fig. 4.**  
*Flashovers can be very  
destructive*

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## Case histories

Often contactors are returned to the supplier with little detail relating to the actual installation, and what else happened at the time of failure. In these cases it sometimes takes a little detective work to determine the cause of failure.

### Heavy weld

In one case a contactor was returned with a welded contact, and the Building Manager was demanding an explanation of why the contactor should have failed. On removing the contacts the contactor was found to be in virtually new condition, except for a severe weld on one phase. The two undamaged phases indicated that the contactor was satisfactory for its normal switching, and there was no control circuit induced chattering. The heavy

weld must have been caused by a ground fault in the wiring to the motor, or the motor itself.

The Building Manager was advised of this conclusion, and fortunately had the motor checked before trying to restart it. At this stage he confessed that the application included a soft starter which had also been damaged, and that he had not considered the possibility that the motor itself was the actual cause of his problems.

### Retaining clip

In another case an irate customer was demanding to know why a contactor had flashed over between phases. The particular contactor had individually removable arc chutes and was returned in a partially disassembled state.

Careful examination revealed that for the fault to occur one of the arc chutes could not have been correctly fitted. This was confirmed when

no shadow from the retaining clip could be found in the soot markings on the side which had failed. This meant that the clip was not fitted, and the arc chute was only resting in the correct position.

The failure to refit the clip would not automatically cause a failure, as the clearance between phases was still quite high. The flashover must have occurred at the same time the contactor was switching a significant current, the hot gases from the resulting arc causing the flashover between phases.

When the customer was questioned he had revealed that the motor itself had failed. This would have caused the initial arcing at the contactor contacts. It also turned out that he knew that the retaining clip was not fitted, but thought it would be okay. ■

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