TECHNICAL NEWSLETTER

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- ☐ 4. Soft start for generator loads (Advantages of electronic soft starters)
- ☐ 5. Set the protection (MCCB breakers and application)
- ☐ 6. Contactor operating speed (Difference between AC and DC systems)
- ☐ 7. Quick guide to fault levels (Calculating the approximate fault levels)
- ☐ 8. IP ratings what do they mean? (IP Ratings, use and meaning)
- ☐ 9. Utilisation categories (Electrical life of switches)
- ☐ 10. AC variable frequency drives and breaking (Regenerative energy)
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- ☐ 17. Electrical surges can be expensive (Electrical surges)
- ☐ 18. Putting the PLC in control (advantages of the PLC)
- ☐ 19. The thinking contactor (The development of the contactor)
- ☐ 20. Some don't like it hot (Temperature rise in electrical switchgear)
- ☐ 21. Pollution of the airwaves (Unwanted signals and their effects on motor protection devices)
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- ☐ 27. The quality switchboard(Switchgear and protection devices for Switchboards)
- ☐ 28. How does electrical equipment rate (Understanding ratings of electrical equipment)
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TECHNICAL NEWS

INDUSTRIAL SWITCHGEAR & AUTOMATION SPECIALISTS

NHP

Will it turn you off?

Electrical switchgear, like all man made things can at times fail to operate correctly. One mode of failure is for the switching contacts to weld and prevent the device from turning off. Welding can be caused by a number of external influences and may not necessarily indicate a poor design but more a limitation of existing technologies. Prevention of welding requires a balance of different performance factors. These include temperature rise, energy let through and electrical switching life.

FEATURING

Electrical switchgear design is quite a complex task. The design engineer must allow for varying mechanical stresses involved across a range of conditions, from a short circuit situation through to continuous duty. It is also necessary to understand the application of a broad range of materials to achieve the desired result. This paper seeks to explain the nuances of product design and the practical considerations that affect product performance across a breadth of conditions.

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1.0 WHEN CONTACTS MEET

The surface of a contact is not completely flat. When the contacts close there will be a series of peaks touching and these form the electrical path. See fig 1. With the passage of current the tips of these peaks can melt and form micro welds, lowering the contact resistance. This effect is sometimes seen during temperature rise testing of the device. The temperature at the contact can rise rapidly and then drop back as the peaks melt and the contact resistance drops.

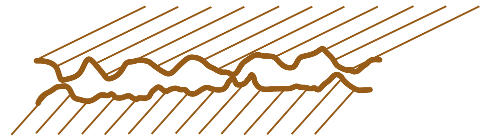
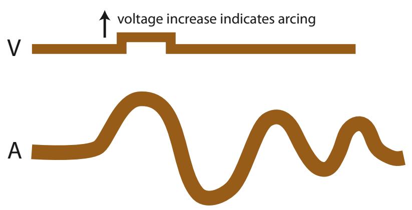


FIG. 1 MAGNIFIED VIEW OF CONTACTS

When contacts close there will be some lift caused by the impact rebound. This bounce draws an arc and then the contacts rapidly close. This creates the potential for molten metal to be created by the arc. The molten metal then solidifies when the contacts reclose and a weld is created. If the initial current is high, such as experienced when capacitors or motors are switched, there can also be a significant magnetic repulsion force created by the current. This repulsion can be high enough to force the contacts apart and also create an arc.



Current surges caused by a downstream fault can also cause contact welding. If the surge is of short duration it can be above the instantaneous trip level but fail to trip the circuit breaker mechanism. Any situation that causes contact lift and allows the contacts to reclose will create a weld and a latter attempt to turn off the device may fail. In marginal cases the weld can sometimes be broken by attempting to turn the device on and off several times.

2.0 MATERIAL SELECTION

Silver is a good material for electrical contacts and is found in most contact systems. It provides low resistance and is easy to work with. Its big disadvantage however is the tendency to weld and form strong bonds. To try and overcome this problem other materials are added to the silver to reduce the strength of any welds. Common additives are Tin, Nickel, Cadmium Oxide, Graphite and Tungsten. These are added in varying quantities to give the required contact properties but it is always a compromise. The problem with all additives is they all increase the contact resistance and this must be balanced with the contact's ability to resist welding and erosion due to arcing or mechanical movement.

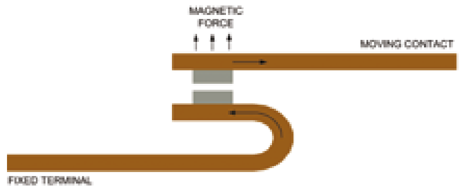
Contact resistance can be unstable and is influenced by the switching duty of the contacts. Atmospheric contamination also plays a part. Tarnish films form on the contact surface as the contact is switched and these can lead to higher resistance and influence the strength of any micro welds.

3.0 BREAKING THE BONDS

Welding at the contact surface will occur and for the designer of the switching mechanism the challenge is to ensure the welds can be broken by the opening action of the mechanism.

3.1 Repulsion contacts

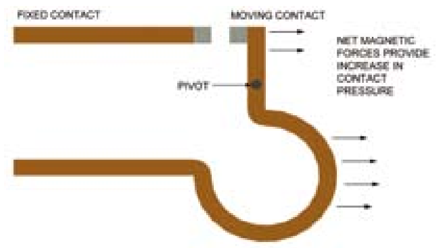
Moulded case circuit breakers are generally designed so that during a short circuit the magnetic forces lift the contacts while the current is still rising and start the interruption process as early as possible. This action allows the breaker to current limit and prevent the full prospective current being reached. A critical current level exists around the point the contacts lift and the pickup point the instantaneous trip mechanism releases. The ideal situation is if the contacts do lift the closing mechanism is tripped by the instantaneous trip and collapsed before the contacts can reclose. While some welding can occur at critical current levels the design of the mechanism should provide enough force to break the weld.



REPULSION CONTACT - TYPICAL MCCB

3.2 Self energizing contacts

For circuit breakers designed to carry high currents for short duration up to three seconds the contacts are usually arranged to have the contact pressure increased by the magnetic forces. The extra pressure helps the contact carry the high currents without lift or melting. Welding is possible as the heat produced by the current can cause surface melting of the contacts. Exceeding the short circuit time rating can result in this type of weld.



SELF ENERGISING CONTACT - TYPICAL ACB

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4.0 CONTACT CONDITION

There are large variations in the condition of the contact surface. In the new condition the surface may be silver rich giving cause to a weld situation. After switching current the contact surface can be pitted and tarnished giving rise to changes in contact resistance and susceptibility to welding. While designers try to cover all situations it is impossible to test for all combinations of contact condition and fault level. A new contact may have a 'silver rich' surface, but once it has been switched across a number of normal current cycles the surface may be less susceptible to welding. On the other hand a contact that has broken large currents may have large peaks formed on the mating surface and again be susceptible to welding.

5.0 STANDARDS

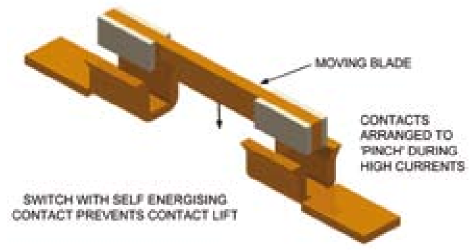
The performance standards for circuit breaker do provide for quite extensive testing over a range of currents to try and ensure that satisfactory performance is obtained. For the testing specified in the circuit breaker standard, AS60947.2 a welded contact would fail to comply. However the risk of contact welding in service is recognized and it is a requirement the circuit breaker mechanism design is such that it cannot indicate it is open when the contacts are welded.

6.0 OTHER DEVICES

6.1 Switches

To avoid contact welds in switches the rating must be coordinated with the fault level and the protection device. A conditional short circuit rating is normally provided for the switch by the manufacturer. This rating specifies the maximum short circuit level when used with a particular backup device.

Generally there are two types of switch contact arrangement. The simple butt contact arrangement that will lift during a fault and the blade type that is arranged to not lift. For critical applications the switch selection is important.



6.2 Contactors

Contactors are designed to switch normal load currents repeatedly. To achieve this, the closing mechanism is kept as simple as possible and forces are kept low to prolong mechanical life. This reduces the ability to withstand short circuits without contact welding. Under short circuit conditions it is normal to have contact lift and arcing, creating the ideal conditions for a weld. The opening operation may break the weld but it is common for the contactor to need servicing to break a weld.

7.0 AFTER A FAULT

As discussed above short circuit or pulse currents can cause welding. After any fault it is wise to check the operation of all switching components exposed to the fault. Contactors are the most vulnerable followed by switches. Load break switches and circuit breakers are generally quite okay but it is wise to check that they will turn off. In multi-pole devices it is possible to get one contact welded and this contact holds the other contacts just touching. This situation causes overheating and fairly rapid destruction.

8.0 CONCLUSION

While contact welding is quite rare it does occur. Manufacturers design to minimise the risk of welding but it is impossible to test for all conditions. Correct component selection and correct maintenance procedures after a fault can greatly reduce the undesirable consequences of a weld. A basic understanding of the problem allows better diagnosis.

Bill Mairs

The writer of this TNL, Mr. Bill Mairs, has been a significant contributor to NHP's technical and engineering department for 20 years. During his time at NHP, he managed a team responsible for the intricate electrical and mechanical designs of products that were specifically designed for the Australian market place. His extensive experience includes participation in Standards committees as well as detailed design of circuit breakers and control equipment. This knowledge underpins Bill's ability to speak with authority on the subject of switch gear design characteristics. With the decline of locally manufactured electrical switch gear and components, this level of detailed design knowledge is now a rarity in the Australian market place. So after a career spanning in excess of forty years, Bill has retired from active engineering duty and has relocated to Queensland to follow his passion and operate chartered yachts in the Whitsundays. We take this opportunity to thank Bill for his contribution to NHP and the broader engineering community, and wish him all the best in his new pursuit.

Alex Coslovich - General Manager Engineering and Quality - NHP