No 169

Safety NEWSLETTER

In this Issue
LIVE WIRES?

ICI
Imperial Chemical Industries PLC
Petrochemicals and Plastics Division

169/1

Lifting Stones: Uncovering Worms

Items in earlier Safety Newsletters (e.g. 133/7, 134/6, 136/2, 168/4) have described accidents which have concerned electrical installations. This edition describes some more accidents of that type.

Some electrical accidents have simple causes and immediate and slight effects. Some are much more complicated and could have been published in other editions dealing with construction, maintenance, operation, modifications or demolition. As usual the lessons to be learned have widespread applications. An inquiry into an apparently simple incident may reveal a series of errors of omission and commission with most unexpected consequences. So in most inquiries it is worth lifting a few stones. A surprising collection of worms may emerge!

169/2

Spare Connections

Sometimes spare connections on distribution boards are used for equipment which is added to the original plant. This can lead to all sorts of problems.

During the execution of a major project to provide natural gas to the boilers of an oil-fired Power Station, the power supplies for the gas import control system were taken from a spare way on the electrical distribution board on one of the several boilers. Some years later, some maintenance work was planned to be carried out on a transformer serving this particular distribution board when the associated boiler was down for major overhaul. The appropriate electrical diagrams were checked showing that no power supplies were in use, so the transformer was taken off-line. This resulted in the total loss of natural gas to the Station and a total site power failure, the problems being compounded by the failure of back-up systems to function as designed.

The basic cause of the incident was the connection of equipment serving all the boilers to a distribution board serving only one of them. Such an arrangement is bound to cause problems when maintenance has to be done on only part of the system. In this case there had also been a failure to amend the appropriate diagrams when the modification was made. The modification concerned the instrument and electrical sections and each had thought that the other had responsibility.

169/3

Long-Term Electrical Isolations

Occasionally, when a piece of electrical equipment has been taken out of service under

One Works has overcome this problem by the use of dummy fuse-holders made of wood and painted red for use when abnormal delays occur. A “Holding Clearance Register” is used and a cross-reference tag is attached to the dummy fuse.

the usual 'Clearance' procedure and the fuses have been removed, there are unexpected delays in completing the work involved. The equipment may then be out-of-service for several weeks. A number of potentially dangerous incidents have occurred where an electrician or switch-man has inadvertently replaced a fuse under such circumstances.

169/4

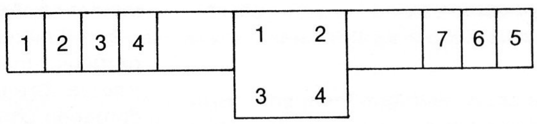
Odd Numbers

Numbering systems continue to cause problems, particularly in older plants which have been modified or extended.

Mistaken identity of a fan motor, due to an illogical and poorly marked numbering system led to the wrong motor being isolated. The mistake was not discovered until the fitter who had accepted the Permit to Work on the fan decided to check that the motor really was isolated.

The electrician thought he had isolated the correct motor and the supervisor signed the Permit to Work without checking (by pressing the motor start button). If the start button had been tried the mistake could have been uncovered before the fitter was exposed to the danger. This clearly shows how necessary it is to check the isolation before starting work. Do you? Always check that motors (and valves etc.) are isolated before starting work on dangerous equipment.

The second message is that numbering of equipment should always be logical. In this case a series of motors were numbered as shown with the motors from another unit sandwiched between them. The wrong No 2 motor was isolated.



This problem has been highlighted so often that checks should have eliminated this type of hazard. Yet accidents still occur. Have you an inconsistent numbering system on your plant?

169/5

Change of Speed Caused Change Direction

A large plant had several large Identical vessels each fitted with a two-speed motor to drive its agitator. One day all the motors were running at slow speed and a fitter noticed that one agitator was turning in the opposite direction to the others. A few moments later, as part of a planned start-up procedure, a control room operator changed to high speed operation. The changeover was accompanied by a loud screaming noise and the agitator began to turn In the opposite direction. All the other motor drivers were found to be correct and did not change direction when the speeds were changed

For many years the motors had been removed from the plant during total shut-downs. After overhaul and inspection each motor had been returned to its original position. Only occasionally, following a breakdown, had it been necessary to substitute a spare motor. Recently the shut-down time had been shortened and spare motors had been substituted for those removed, which were then overhauled later. Usually the work involved only the replacement of bearings and no interference with motor windings.

Such a substitution had recently taken place on the vessel involved in this incident but on checking the newly installed motor it was found to be standard in every respect. However it was found that the motor which had been removed was a rogue. It had been in the same position for many years and when it was originally installed the supply cables must have been rearranged at the switchgear in order to make it rotate correctly at both speeds. This adaptation had not been noticed when a standard motor was put in its place.

169/6

A Special Case

A special 12V battery pack had been purchased with an intrascope for vessel inspections. A special charger was also supplied which regulates the maximum charge current to less than one amp and has a timer to control the charging period. A carrying case, packed with foam rubber, had been made for the battery.

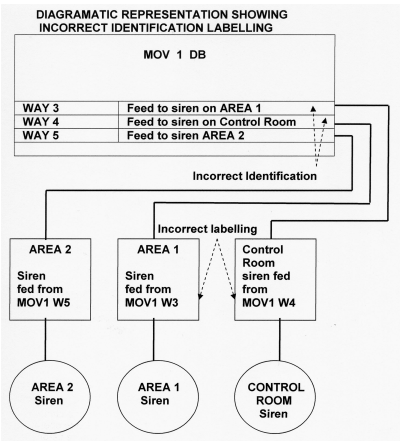
After some use on the plant, the battery was returned to the workshop to be recharged. Not knowing of the existence of the special charger and unable to see any manufacturer’s information on the battery as it was fitted in a special case, the electrician connected it up to the standard battery charger set at its lowest charging rate giving an indicated three amp charge. Some time later the battery exploded. Fortunately nobody was injured.

According to the manufacturer, overcharging leads to overheating, cell breakdown and internal short circuiting. It was advised that this type of battery containing nickel cadmium cells should be charged at a constant current dependent upon the Ampere-hour rating.

169/7

Fuses Withdrawn: Equipment Still Live

It was noticed that one of the three fire alarms on the plant was not working following the daily alarm test. A clearance certificate was issued and after Isolating the power supply by removing the fuses, the electrician and his supervisor proceeded to open the starter in order to find the fault. With the door of the starter open they checked the incoming supply with a test meter and the supply was found to be live.



What had happened was soon revealed. All three starters are fed from the same fused distribution board (See Figure 1) and marked with pen on green PVC tape showing its source of supply. The label on the front of the distribution board was marked in felt pen indicating which siren was fed from each way (3, 4 and 5). The electrician, wishing to isolate the power to the Area 1 siren removed the fuses from way 3, but, as can be seen from Figure 1, the labels are incorrect and the fuses were actually removed from the Control room siren.

This incident emphasises the need to test electrical isolations by an approved test instrument before electrical work is commenced. Before mechanical work is carried out, the start-button should be pressed to check that the supply is truly isolated. Temporary labels should be replaced (these can fall off, fade or get obliterated) by permanent labels, rechecking the source of supply before fitting.

A further point emerged from this incident. It was possible to open the door of the starter with the isolator selected to the 'ON' position due to an inadequate interlock mechanism.

169/8

Sparks Reveal Unsuspected Modifications

Sparks were seen to be coming from a pump which was surrounded by flames. The fire was extinguished and the pump motor was found to

It was found that there was a hole in the PVC outer sheath, the steel wire armour sheath inside it and in the PVC innermost sheath. It seemed most likely that the sheaths had been damaged much earlier as the armour was corroded for several inches on either side of the hole, under the PVC outer sheath. There is no doubt that there would have been sparking from the cable fault to the body of the motor nearby.

The pump had a mechanical seal flushed with plant condensate. Failure of the mechanical seal allows the flammable process fluid to be discharged with the

be in good order. However one main fuse had blown, there was a short to earth and more investigation was needed.

condensate to a nearby drain. On this occasion it had been known for some time that process fluid had been escaping from a faulty seal so there was no doubt about what fuelled the fire.

Why was such a pump allowed to stay on line? It was necessary to keep it on line because there had been several seal failures in quick succession on the spare pump.

Why the sudden series of failures? The plant engineer found that there had been a change in one of the materials used to make the mechanical seals. The manufacturer had made this change without any notification!

An Engineer's Case Book
No 69
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Epoxy Insulation Problems in High Voltage Electric Motors

In the late 50's and early 60's manufacturers of high voltage (HV) electric motors and generators introduced epoxy based insulating systems on stator windings in place of older bitumen based systems. The epoxy systems were heralded as the answer to the electrical engineers prayer offering significant advantages in areas such as higher allowable operating temperatures for machine windings; reductions in the thickness of coil insulation thereby leading to a reduction in machine size or allowing an increase in output from a given frame size; a very stable insulation which does not develop voids even after prolonged periods of operation; and as epoxy insulation does not absorb moisture it is tolerant to unpleasant conditions.

These improvements are all achievable by the use of epoxy based insulation, but as is so often the case the Law of Murphy eventually operates to reveal unexpected weakness in an otherwise perfect system.

Epoxy based systems have one unpleasant attribute which in the last few years has caused many problems in 11kV and higher voltage machines. Epoxy insulated coils are dimensionally stable and do not swell (as in the case of bitumen insulation) in operation to conform to the contours of their slots. Hence any initial slackness of the coil in its slot will remain throughout the life of the machine. Even a small amount of slackness will permit slight vibration of the coil in its slot, and eventually destruction of areas of the corona shielding (11kV and above) on the outside of the coil occurs. Small discharges then take place between the coil side and the slot resulting in erosion damage to the coil insulation until after a number of years (5 in the case of one large motor) an earth fault develops requiring the machine to be shut down until repairs can be effected.

It should be remembered that although 3.3kV machines do not require corona protection it is still possible for coil insulation to be damaged by vibration in the way described above.

One manufacturer studied the effect of loosely wedged coils under laboratory conditions, and as a result some few years ago instituted detailed improvements in coil design and installation, all aimed at minimising the risk of coil vibration. It is therefore important when ordering high voltage machines to discuss with the manufacturer what steps he takes to ensure absence of vibration of coils in their slots.

What can be done in the case of existing machines? The answer is to rely on visual inspections at annual shut downs, and on the use of accepted non-destructive testing techniques at two to three year intervals. During annual shut-downs inspect the machine internally and look for signs of coil movement – this may show itself as loose wedges, slackness in the bracing of the end windings, or very often by the presence of white dust from damaged insulation. Any evidence of these should be taken as the need to call in the original manufacturer to discuss remedial action. Non-destructive testing, in particular the use of a discharge loss analyser (DLA), can reveal impending trouble. Break up of the DLA trace at about 40% line voltage can indicate damaged corona shielding caused by coil vibration.

For further information see Electrical Review, Volume 207, Number 18.14 November 1980, “Recent developments in diagnostic testing of HV machine insulation” by J S Simons of GEC.

July 1983