energynetworks association

POWERING IMPROVEMENT

AUTUMN 2012 ENA SHE MANAGERS

REVIEW OF PAST ASSET RELATED INCIDENTS

VISION

The UK Electricity Industry will be a world leader in health and safety performance by 2015.

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SHE REVIEW – AUTUMN 2012

INTRODUCTION

This is a special edition of the SHE Review to support our Powering Improvement initiative. This year the Powering Improvement theme is safety related to assets. Assets are simply the plant, equipment, cables, lines, poles and towers that make up our networks. The focus of this review is therefore past incidents, most of them involving the plant and equipment in our industry.

Once again, these incidents give us a great opportunity to learn from the past, and more importantly, to prevent the same things happening again.

These types of incidents tend to be less common, unexpected and more serious when they occur, but like all incidents they are preventable. Some of you will remember these incidents. Please take some time to remind yourself of the important learning points and ensure that the messages in this review are passed on, especially to colleagues who may not remember them.

You will notice that the outcomes in these incidents vary considerably, some are fatalities, some are near misses, some are serious injuries. This highlights the fact that once an incident happens, the severity of the outcome is pure chance.

The photographs used in this review are typical examples of both failed and good assets. They are not always photographs of the incidents described.

Thankfully the type of incidents listed in this review are rare, and the failure rates of our industry's plant are very low. Our networks are generally well operated by skilled competent people, with few failures.

The aim of this review is to help to eliminate failures.

Please pass this on to one of your colleagues when you have read it.

INCIDENTS INVOLVING POLES

We have approximately 4 million poles in the UK. They are used to support the majority of our HV and LV overhead lines (OHL).

A large pole can weigh a quarter of a tonne, with a transformer or other equipment this will be considerably more.

The main risks from poles as assets are where they have been erected poorly, or where they have decayed in service. In this state they represent a real risk to our people and others working on or near them, since any activity on or near them may cause them to collapse.

POLE FALLS INTO CAR PARK

In one incident an 11kV terminal pole with a pole transformer mounted on it fell into a car park damaging eight vehicles and writing one of them off.

The direct cause of the collapse was found to be that the pole had not been installed to the correct depth.

Falling poles have killed our industry colleagues in the past.

Underlying and contributory causes included:

> Inadequate assessment of the site and soil conditions.

> Failure to install to correct depth, and use a baulk.

> Poor supervision, quality control and auditing of the installation process.

Learning points:

> It is important that anyone involved in the erection of poles is competent to assess site conditions and understands the importance of good installation.

> Always install poles to the correct depth.

> Robust supervision and quality control of the process is needed.

POLE FALLS PARTIALLY AS CONDUCTORS AND PLANT ARE TAKEN DOWN

In another incident a team was dismantling an OHL on sloping ground and removed the conductors on the uphill side of a pole mounted transformer. As the transformer was being removed from the pole, the pole started to fall down the slope until it was restrained by the stay wire which caught in a tree. Two linesmen were attached to the pole and one was slightly injured.

On investigation it was found that there was a void in the ground around the base of the pole, which was not visible prior to the work.

Direct and contributory causes:

> The pole was not firmly secured in the ground, either due to poor installation or subsequent erosion.

> The on-site risk assessment and subsequent method adopted did not identify this possible risk.

Learning points:

> If possible, complete other work on a pole before removing conductors.

> Inspect poles carefully before climbing them.

> If necessary, provide temporary support for the pole.

> Always ensure poles are installed correctly, and that backfill is properly consolidated and rammed.

DECAYED POLES

There have been a number of incidents where linesmen have climbed decayed poles which have then fallen while the linesmen were on the pole. Some of these have resulted in serious injuries or fatalities, both to linesmen on the poles and to others who have been hit by the falling poles.

Direct and contributory causes have included:

> Failure to test poles properly before climbing them.

> Climbing poles marked as defective.

> Not changing defective poles.

Learning points:

> Asset Management procedures need to ensure that decayed poles are effectively identified, recorded and removed in a timely manner.

> Always check poles first for any notices or signs indicating they have been marked as defective. Make sure you understand the system your company uses for this.

> Test every pole first using the method approved by your company. Make sure you understand how to do this.

> Do not climb or work upon a suspect pole unless it is supported in an approved manner.

> Always use the hierarchy of access methods for working at height.

TAP CHANGER FATALITY

A fatal incident occurred when an engineer tried to manually operate a high voltage tap changer and the unit exploded, killing the engineer.

The direct cause of the incident was the failure of the mechanism in the tap changer leading to an electrical fault which caused the oil in the unit to ignite and explode.

Underlying and contributory causes included:

> A failure to carry out a modification to the tap changer which had been recommended some years before.

> The failure to understand the significance of repeated tap changer alarms and malfunctions.

Learning points:

> Alarms and defects on plant should be dealt with by staff who are trained and experienced in the maintenance of that type of plant.

> A robust asset management system is needed to ensure that recommended modifications are recorded, scheduled and carried out.

> Repeated alarms should be interpreted as an indication that there may be a more serious underlying problem which needs to be investigated.

> Manual live operation of tap changers should be reviewed and risk assessed, with appropriate controls applied.

> Where evidence exists that the internal mechanisms of either the divertor or selector are damaged, the unit should not be operated live.

> Ensure that staff dealing with alarms and defects on equipment have the knowledge, skills and competency to deal with that equipment.

METAL CLAD SWITCHGEAR

A number of fatal and serious incidents have involved work on metal clad switchgear.

FAILURE TO REMOVE TESTING CONNECTIONS

Several incidents in different companies have involved test or earthing connections and test prods (sometimes known as test plugs) being left in spouts by mistake, resulting in flashovers when the gear was re-energised, or worse still, when staff tried to remove them.

11KV INCIDENT

In one incident 11kV busbars were being extended to provide an additional transformer way on an indoor switchboard.

The section of busbar had been isolated and earthed via the bus section oil circuit breaker. It was also earthed by test sticks with flexible earths in an adjacent feeder way. Permits to Work had been issued for the busbar section. Once fitting work was complete, the restoration programme was started. Permits to Work were cancelled and a Sanction for Test issued to pressure test the busbars via test sticks in the adjacent feeder way.

On successful completion of the pressure test, the Sanction for Test was cancelled. The earth applied using test sticks was not replaced and was noted as an exception on the Sanction for Test. The restoration programme continued and the busbar was energised remotely by the control centre.

After the busbars were energised, permission was given by Control to restore the 11kV outgoing feeders connected to this section of busbar.

Shortly after the instruction was issued there was a flashover in one of the outgoing feeder cubicles.

The on-site Project Engineer was critically injured during the flashover and subsequently died from his injuries the next day. Investigations concluded that the engineer had made direct contact with live test sticks left inserted in the busbar spouts at the panel of one of the outgoing 11kV feeders. It is not known what his intentions were at that moment.

33KV INCIDENT

In a similar incident involving 33kV switchgear, a test lead was left on cable terminations and subsequently the covers were replaced with the test lead still connected, resulting in an explosion and extensive damage when the circuit was re-energised. No one was injured in this case.

Direct causes of these incidents:

> The engineer made contact with live test plugs which were left inserted in the busbar spouts at the time they were re-energised.

> The test lead was left inside the gear.

Underlying and contributory causes included:

> Failure to remove the test prods and test leads.

> Failure to check and confirm that the test plugs and test leads had been removed before the Sanctions for Test were cancelled.

Learning points:

> Wherever possible, re-energise from the point at which testing was done, and don't remove panels to enable testing unless there is no other option.

> Always check that test plugs, tools and any other items have been removed from busbar and circuit spouts that were under test and that the spouts have been locked shut before the Sanction for Test is cancelled.

> It is important to remain focussed throughout all switching and HV testing activities. Avoid distractions, exclude those not involved, and use a checklist if necessary to help correct restoration.

> Never touch or try to remove test plugs or connections from busbar or circuit spouts if the circuit concerned is not subject to a safety document which allows you to do so.

THE IMPORTANCE OF REPORTING

SIGNS OF DAMAGE, VANDALISM AND TRESPASS

Two small boys trespassed into a substation and were killed when 11kV switchgear faulted while they were playing in the substation.

The fault occurred on a busbar joint chamber which joined the busbars of two items of switchgear in the substation.

The investigation concluded that the equipment had probably been damaged by a previous event which had left the cover fractured, allowing the ingress of moisture.

Learning points:

> Reporting damage to equipment before it faults can save lives.

> Once defects or damage are reported, they must be appropriately prioritised and rectified in a reasonable timescale.

> Always check for and report any signs of damage, trespass and vandalism.

> If a predominantly underground circuit trips but no fault is found, give consideration to further inspection of sites on the circuit.

> Use the ENA booklet on substation security or your company's own guidance on substation security.

TEST PRODS AND HV RING MAIN UNITS

Some of the worst incidents the industry has experienced have involved problems with the test prods used to test cables connected to HV Ring Main Units (sometimes known as test plugs).

Background:

These incidents can be very severe because the insulating oil can be ignited by any flashover, leading to a fireball. These prods are designed to be used safely in tanks which may have live conductors in them. They rely on a correct fit to guide them, so correct use of the right prods, in good condition, is critical.

FATALITIES DUE TO GUIDE ROD FALLING FROM TEST PRODS

Two engineers were killed and a fitter was seriously injured when a metal guide rod became detached from a set of test prods on a Reyrolle ROKSS ring main unit and fell onto the live HV metalwork at the bottom of the tank, causing a flashover and explosion which ignited the oil.

SERIOUS INJURY DUE TO USE OF WRONG PRODS

In a separate incident, an engineer used the wrong set of test prods to make test connections. Because they were the wrong test prods they were not guided when they entered the tank and they made contact with the live busbar bushing on the other side of the tank. This resulted in serious burns to the engineer.

Learning points:

> All test prods must be subject to a robust system of inspection, identification, and labelling.

> They must be kept in dry and secure storage.

> They must be protected from damage when transported, ideally in a box.

> Test prods must have no removeable parts.

> Staff must have training in the use and care of test prods, including awareness of the hazards involved.

> Test prods must be clearly identified and marked with the type of switchgear on which they are to be used, if there is any doubt, do not use them.

> Never attempt to modify or dismantle test prods during use.

> Consider testing from a location that does not involve test prods.

> Inspect test plugs every time before use, never use test plugs that are in a poor condition or with any parts that are loose.

CABLES ASSUMED TO BE DEAD

A repeated cause of injuries has been the assumption by staff that cables are dead.

ENGINEER KILLED AFTER TOUCHING HV CABLE WITH SEVERE DAMAGE

In one incident an HV cable was severely damaged by a mechanical excavator, leaving the cable with a severed end pointing upwards with the cores splayed apart. Two engineers attended the site and because the damage to the cable was so severe, they assumed the cable must be dead. It was not. One of the engineers was fatally injured when he approached the damaged end.

JOINTER BADLY BURNT AFTER ASSUMING A CAPPED LV CABLE WAS DEAD

A jointer was carrying out some LV mains jointing in a new housing development. It was not clear from his work instruction whether the cables involved were live, but because one of them had a capped end, he assumed it must be dead. He did not test the cable and did not work using live techniques. A flashover occurred, and the jointer suffered serious burns to his hands and legs.

ENGINEER BURNT AFTER CUTTING LV CABLE ASSUMED TO BE DEAD

An engineer suffered burns after he cut an LV cable he assumed to be dead. The cable was one of two LV cables which appeared to be running parallel together through two excavations with a short length of both cables being buried between the two excavations. One cable was proved dead and the engineer assumed the two cables maintained the same positions in both excavations, but they crossed in the ground that had been left unexcavated.

Cause:

The cause in every case here was the failure to identify and prove the cable was dead.

Learning points:

- Never assume any HV or LV cable is dead unless you have proved it dead by an approved method.
- A simple capped end can sometimes be energised without faulting.
- It is impossible to assess whether a cable is dead by looking at it.
- Always use live working techniques when working at LV if a live working technique exists for that task.
- Never energise a capped end.
- Ensure task instructions clearly explain the status of cables on a project.
- Never use relative position of cables, ducts, etc as a means of positively identifying a cable.

- The only safe way of physically tracing a cable from a point of work to an earth (or other point at which it has already been proved dead) is if you could pull a running noose along the cable continuously over the whole route, without any interruption.
- Ensure changes are recorded on cable records and network diagrams in a timely manner.

MOVEMENT OF PLANT CAN BE FATAL

There have been many incidents involving the movement of heavy plant, some of these have resulted in fatalities or serious injuries.

TRANSFORMER TOPPLES TRAPPING MEMBER OF STAFF AGAINST WALL

A ground mounted transformer toppled whilst being moved. One corner of the transformer was left unsupported while another corner was jacked up.

Luckily the person in question received only minor injuries. Similar incidents in the past have resulted in the death of those involved.

Direct cause:

- Failure to support the plant fully during the move.

Learning points:

- Try to avoid substation locations that make the installation of plant difficult. If possible eliminate or design out the risk at the purchase and work planning stages.

- Moving heavy plant must be planned. If it involves lifting, this is a legal requirement.
- Appoint one person to lead the move.
- Use mechanical plant and aids for lifting where possible.
- Ensure that adequate numbers of the team involved have training and experience in the movement of heavy plant.
- Wherever possible avoid placing people under plant being lifted and in locations where plant might fall over.
- Keep plant level and well supported whilst being moved.

BATTERIES ARE IMPORTANT

We rely on batteries to operate many of our protective relays and also to trip many of our circuit breakers. A number of incidents have highlighted the importance of maintaining and checking batteries correctly.

Failure to disconnect faults quickly can lead to increased damage and risk to people and plant, as well as more extensive losses of supply.

COMPLETE BATTERY STOLEN

All the cells from a number of primary substation batteries were stolen, but this was not noticed immediately because the battery charger was connected across the battery terminals.

FAULTY BATTERY CELLS LEAD TO FAILURE OF BATTERY

When an 11kV feeder circuit breaker failed to trip for a cable fault, two members of the public were slightly injured. The long clearance time involved for the back up protection to operate led to more energy being released at the point of fault.

It was subsequently discovered that a number of cells in the battery were faulty, and the battery was unable to provide adequate current to trip the circuit breaker.

The defect was not picked up by a routine battery check carried out using a push button test.

Direct and indirect causes:

> Theft of batteries.

> Inadequate checking and monitoring procedures and techniques.

Learning points:

> We all need to be vigilant for signs of intrusion and theft.

> Effective control of access to substations and keys must be ensured.

> The design and maintenance processes should ensure that the routine inspection and testing of batteries reliably indicates cell and battery condition.

> A robust regime of battery testing and monitoring should be implemented.

CUT-OUTS AND SERVICE TERMINATIONS

This equipment is important because it is on our customers' premises. Over the years there have been a number of serious incidents, some of the issues have been:

> Damage or interference.

> Cross polarity.

> Overheating of connections.

> Old or damaged equipment no longer fit for purpose.

Learning points:

> Always check service termination equipment when visiting customers' intake positions.

> Report any damage, interference, defects or substandard equipment found.

> Follow your company procedure for checking polarity when installing, replacing or repairing termination equipment and connections to customers.

EXCAVATIONS AROUND CABLES

EXCAVATOR SUFFERS BURNS WHEN DIGGING ON LV FAULT

During LV fault location, the team dug a hole at the service joint of the last customer still on supply, they tested the cable and found it was still live at that point.

They then dug a hole at the service joint of the first customer off supply and found the cable to be dead.

They then proceeded to excavate along the cable towards the first hole.

The cable was in a duct and when they reached a section where the duct was found to be broken, a flashover occurred.

Direct and contributory causes:

> Digging too close to the fault.

> The method adopted was unsafe.

Learning points:

> Don't adopt an approach that will definitely excavate onto a live fault, follow your company LV fault finding procedure.

> Ensure staff who excavate on faults are trained for this work.

CABLES IN CONCRETE

A contractor was injured when breaking out concrete above an LV cable using a compressor power tool.

The initial on-site risk assessment had correctly identified that the power tool should not be used to break the concrete directly above the cable, but this was not conveyed to a new team that took over the job.

As the job progressed, the concrete became thicker and closer to the cable.

Learning points:

> Power tools should never be used directly above a cable.

> If the cable is completely embedded in hard concrete it should be made dead.

PLANT FAILURES INVOLVING INJURY

FAILURE OF ISOLATOR LEADS TO FATALITY

A linesman was electrocuted whilst installing a set of OHL isolators under a Permit to Work.

The isolators were being installed on a section of network with three high voltage points of isolation. The only Circuit Main Earth being applied via a portable OHL earth.

A ground mounted earthing switch was available but this was subject to an operational restriction.

One of the points of isolation was a set of OHL isolators which had failed to operate correctly, and only two out of three phases had opened. The Senior Authorised Person did not confirm that all three phases had opened due to the isolator pole being covered with vegetation. An auto re-closer had operated during the opening of these isolators but this was dismissed by the control engineer as a spurious operation.

Following the issue of the Permit to Work, and some hours later, the control engineer closed the auto re-closer, believing he was energising up to the open isolators only. This resulted in one phase of the section of network covered by the permit to work being energised.

The OHL portable earth was ineffective and the linesman at work was electrocuted.

Direct and contributory causes:

> Failure of the isolator.

> Failure to confirm operation of the isolator.

> Poor vegetation management.

> Failure to rectify the defect on the earth switch.

> Wrong assessment of reason for protective device operation.

> Poor application of manual earth.

Learning points:

> Where possible always check visually to confirm that isolators have operated fully.

> Wherever possible apply CMEs via earth switches.

> When using portable earths, ensure that they are applied effectively in accordance with your company procedures.

> Always follow operational procedures.

> Investigate any operation of protective devices that coincides with activity on the network.

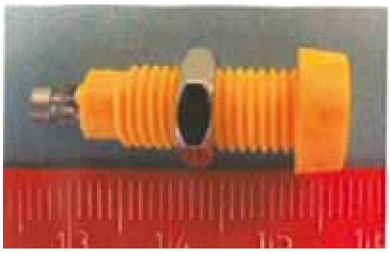
FAILURES OF TEST CONNECTIONS ON LV BOARDS

An engineer was using un-fused test leads to measure voltage by plugging into the 4mm un-fused test sockets on an LV Board.

A flashover occurred and the engineer received burns to his hands. It is believed that the insulated body of the test socket failed and the conducting part of the broken socket made contact with the earthed metal of the LV Board.

Similar failures had occurred previously and in other companies. A modification had been recommended to prevent the problem.

Other incidents had also involved test leads with terminations that were not 4mm plugs being forced into the sockets.



Direct and contributory causes:

> Poor design.

> Use of wrong plugs.

> Lack of care when using sockets.

Learning points:

> Always use test leads with fuses when taking measurements on live equipment.

> Known defects should be effectively followed up promptly to avoid similar incidents on the same type of equipment or plant.

> Consider reporting any defects to the ENA NEDERs scheme through your company contact.

> Consider banning the use of components that have a generic fault which can lead to dangerous incidents.

PLANT FAILURES, DEFECTS AND MODIFICATIONS

VT FAILURE

A voltage transformer (VT) failed catastrophically. The porcelain bushing exploded resulting in fire and ejection of debris over a 30-metre radius. This resulted in severe damage to an adjacent circuit breaker, current transformers, busbar supports and disconnecting equipment within the associated equipment bay.

As a result, staff were put at risk of injury and some 81,000 customers had their electricity supplies interrupted.

The subsequent investigation determined that the catastrophic failure had been caused by a flashover in the condenser core of the voltage transformer, due to moisture ingress. This failure mode was a known failure mode, and this particular voltage transformer had exhibited high readings during previous loss angle tests. These tests were not followed up on.

33 KV CIRCUIT BREAKER FAILURE

A fault occurred on a 33kV circuit but the circuit breaker failed to trip, and the fault was then cleared by the 33kV Stand-By Earth fault protection on the transformer incomers. This led to the loss of supply to all 30,000 customers fed from the 33kV substation.

The guide rod running through the centre of the trip coil spring had become detached and thus prevented the circuit breaker from tripping.

This failure mode was known, and a decision was taken that the issue could be dealt with during maintenance, but the maintenance procedures were not updated accordingly.

FAILURE OF MODIFIED 33KV SWITCH RESULTS IN LOSS OF SUPPLY

A fault on the yellow phase of a 33kV switch at an outdoor substation resulted in the loss of the whole site. The site was fed by two infeeds but one was out for maintenance at the time. 51,000 customers were left without supply.

The subsequent investigation determined that the faulted switchgear had been modified incorrectly, in an attempt to increase nominal rating from 800A to 1200A. The red and blue phase switch units had been replaced with switch units rated at 1200A. but the yellow phase unit was modified; additional flexible leads were added, and were connected by bolted lugs onto a connection not designed for this rating. This connection eventually burned out.

Direct and contributory causes:

> Failure to follow up on poor test results.

> Failure to manage required modifications effectively.

> Use of non-standard unapproved modifications.

> Failure to carry out full commissioning checks.

Learning points:

> Don't modify plant and equipment unless you are sure about the technical adequacy of what you are proposing.

> Make sure poor test results that might warn of failure are acted upon.

> Ensure defects and modifications are recorded and effectively closed out.

> Ensure full commissioning checks are carried out.

11KV OIL FILLED RING MAIN UNIT FOUND IN SERVICE WITH NO INSULATING OIL

During routine maintenance an11kV oil filled ring main unit was found in service with no oil in the ring switches.

This was probably due to the practice of transporting ring main units without oil in the switches.

OVERALL LESSONS

The incidents in this review show that failure to get it right at any stage in the life of an asset can lead to injury or worse. Key issues include:

> Good asset management starts at the planning and design stage of a project or programme. Huge amounts of risk can be removed or reduced at this stage.

> Select the right equipment, which is suitable for the purpose intended.

> Install it correctly, carry out all necessary testing, commissioning and recording.

> Operate it correctly, use it for what it was intended for, use it within its rating.

> Inspect it carefully and ensure warning indicators are acted upon.

> Follow maintenance procedures.

> Don't modify equipment unless you know what you are doing. All modifications must be approved by technically competent staff.

> Ensure robust procedures are implemented for reporting defects. Programme modifications and defects to ensure their timely completion, monitor progress to ensure risks are kept low.

> Always follow the safety rules and your company procedures.

> Where appropriate share details with other companies through the ENA.

If you are involved with any of these stages, make sure you are familiar with the requirements, if in doubt, ASK. If your team is responsible for any of these tasks, make sure they have the right training, experience and technical knowledge.

FINALLY...
KEEP CALM AND CARRY ON!

Reading this review you might think our networks and assets are very dangerous.

This is not the case. The incidents described have occurred over many years.

Thankfully the type of incidents listed in this review are rare, and the failure rates of our industry's plant are very low. Our networks are generally well operated by skilled competent people, with few failures.

The aim of this review is to help to eliminate failures.

POWERING IMPROVEMENT

For further information see
www.poweringimprovement.org

PARTNERS

Energy Networks Association (ENA) is the industry body for the UK electricity transmission and distribution companies.

Energy UK is the trade association for the UK electricity generation companies.

TRADE UNIONS:

GMB
Prospect
Unison
Unite

GOVERNANCE

Powering Improvement is managed and directed by National Health and Safety Advisory Committee (HESAC) comprising representatives from Energy UK and ENA member companies, the industry trade unions (GMB, Prospect, Unison and Unite) and HSE.

Executive decisions on behalf of ENA member companies rest with the ENA SHE Committee and ultimately the ENA Board.

Executive decisions on behalf of Energy UK companies rest with theEnergy UK Health and Safety Forum and ultimately the Energy UK Board.

Energy UK

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