ACCIDENT INVESTIGATION REPORT

DOC NO. 3475/06/2013

Investigating team: Sakari Hatakka, Timo V. Pietilä, Ville Huurinainen

RAPORTTI

Fatal electrical accident at work in Savitaipale on 17 April 2013

Turvallisuus- ja kemikaalivirasto

tukes

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Summary of the investigation report

Accident case	Fatal accident at work at a transmission line site in Savitaipale
Time of accident	Wednesday 17 April 2013 at approximately 09.30 a.m.
Place of accident	Hyrkkälä, 54800 SAVITAIPALE
Summary of the accident and the investigation results	The transmission capacity of the high-voltage network of the Finnish electricity transmission grid was being increased, when in May 2013, a second 400 kilovolt (kV) power transmission connection from Huutokoski, Joroinen, to Yllikkälä, Lappeenranta, was taken into use. The open aerial line with an overall length of some 153 kilometres was erected along the same electric transmission corridor as the existing 400 kV power transmission line. In April 2013, during the last stages of the southern section of the connection, a 42-year-old electrician, employed by the Polish contractor, lost his life due to an electric shock while working on the power transmission line tower. The direct cause of the electric shock was a line terminal clamp of the temporary earthing device coming detached due to having been connected to the work object inadequately and against the given instructions. As a result of the clamp becoming detached, the isolated line being worked on was affected by induced voltage from the adjacent 400 kV power line that was being used for power transmission. The electrician became part of a circuit leading to the ground through his hands, receiving a fatal electric shock. Other indirect factors contributing to the course of events and the accident included: - differing notions concerning the monitoring of safety of electrical work within the consortium co-operation; - the short-circuit-proof temporary earthing not being electrically connected to the work object
Measures proposed by the investigation team to avoid similar accidents in the future	1. Those in charge must actually be involved in the assessment of work-related risks and be in close contact with the performance of the work under their responsibility. The supervisors must ensure that the instructions given are followed and that the agreed procedures are used. Supervision must be sufficient in all situations. 2. In electrical work carried out in Finland, standard EN 50110-1 can be applied only by observing both the basic requirements of the EN standard and the national requirements of standard SFS 6002. Numerous additions and references have been added to the national standard, and when combined with the original contents, they impair the comprehensibility and readability of the publication. 3. In recent years, several serious accidents and hazardous situations have occurred due to induced voltage during power line work. The working instructions for temporary earthing must be subjected to a risk assessment from the perspective of safety at work.

	4. There must be clear action plan, employee training and the required equipment for rescuing employees working on power line towers in the event of an accident. 5. Tukes restates the measures it proposed in the investigation report for the electrical accident that took place at the Alajärvi substation (Doc No. 13443/06/2010): Attention must be paid to induced voltage as a phenomenon, its dangers, and the correct working procedures. During networked operations, the exchange of information between the operators involved in electrical work and the coordination of supervision at a shared work site must be ensured. The same also applies to all other operations.
Grounds	(Finnish) Electrical Safety Act (STL 410/1996), Section 52 a
Date of the investigation report	xx December 2013
Signatures and printed names of the investigation team members	Sakari Hatakka Timo Pietilä Ville Huurinainen

1 Background

The Finnish main grid owner enhanced its capacity in its high-voltage electric power transmission network by having another 400 kilovolt (kV) power line constructed between Huutokoski, Joroinen, and Yllikkälä, Lappeenranta. A new, bare, high-voltage overhead line was laid alongside the 400 kV power line that already existed along the same transmission corridor or in place of it. A substantial section of the line is located on shared towers with 110 kV voltage lines. The total length of the completed link is 153 kilometres long.

The construction project consisted of two phases and two separate contracts. The northern section of the line, between the 400/110 kV substations in Huutokoski, Joroinen, and Visulahti, Mikkeli, was completed at the end of 2012. Construction work began on the southern section, between the 400/110 kV substations in Visulahti, Mikkeli, and Yllikkälä, Lappeenranta, in autumn 2010 with ground work and was completed in May 2013.

A French and a Polish company were jointly responsible for the construction contract relating to the southern section. They were both specialised in the construction of electric power distribution systems. In April 2013, a 42-year-old electrician, employed by the Polish contractor, lost his life due to an electric shock from the power line while working on the power line on the southern section of the connection.

The section of the line under construction was completed to the extent that parts of it had already been used as a temporary arrangement for the electrical supply. When the fatal electrical accident took place, the Polish team was repairing a high-voltage line on a tower after a deviation had been discovered during monitoring of the installation work.

The line under construction had been isolated from the supply voltage and its access to the section of line under construction was prevented by earthing insulators at the 400/110 kV * substations at Huutokoski and Yllikkälä, thus blocking the supply from both possible directions.

The **induced voltage from the 400 kV high voltage used for the conduction of electric power from a system adjacent to the connection being built was to be eliminated through additional temporary earthing at the site. The team was to install a single-phase temporary earthing device between the line on the crossarm above and the tower structure itself.

During the work, the temporary earthing device's line terminal clamp, which had been attached to the conductor contrary to instructions, came detached, and the line being worked on charged and became life-threatening. One of the electricians in the team who had been working on the line became part of the electric circuit travelling from the transmission line to the ground and received a fatal electric shock.

The transmission line transmitting power for 57 kilometres alongside the isolated line at the site had produced an induced voltage of some 10,000 volts (10 kilovolts) in the open end line being worked on, according to later calculations.

** Substations are junctions in the electrical network where power can be conducted along different lines and voltage levels can be changed. Switchgear, including circuit-breakers, disconnect switches and earthing switches, essential for the grid to operate properly, is kept within the fenced-off substations. A circuit-breaker can disconnect and connect load and fault currents in a circuit. Disconnect switches are used to establish a visible contact gap between dead open circuits in equipment, for the purposes of working safely. Earthing switches, like temporary earthing devices, prevent a site from becoming dangerously live, e.g. because of the mis-*

taken use or errors associated with equipment used for isolation, or for other reasons connected with unexpected voltage levels in equipment. Such situations can result from parallel or intersecting lines.

*** Any inductive or capacitive voltage caused to another line in the vicinity of a live (power) transmission line.*

2 Accident investigation

The accident took place on Wednesday 17 April 2013 at around 09.30 a.m. The victim's resuscitation commenced at the accident site after the accident. When the emergency services arrived, however, the victim was pronounced dead. The police examined the site immediately after the accident.

Tukes was informed of the accident that same day and an investigation team was appointed the following day.

The remit for the Tukes accident report was to discover:

- The course of events
- The circumstances at the time of the accident
- The company's work procedures related to the activity in question and whether they were observed
- Other factors affecting the accident
- Compliance with the legal requirements

In addition, the investigation team must propose actions to prevent similar accidents from occurring.

The Tukes accident investigation team visited the site of the accident on 18 April 2013, accompanied by the police (South Karelia Police Department) and an occupational health and safety inspector from the Regional State Administrative Agency for Southern Finland. The investigation continued on site on 19 April 2013.

The Tukes investigation team had the following materials at their disposal:

- descriptions received from the operators of the arrangements in place for monitoring the safety of electrical work, the electrical training of the staff involved, their experience, the occupational health and safety training that had been carried out in the field of electrical work, and the working instructions
- reports from the operators; details of the connection status, the state of the sections and parts of the grid under construction; temporary earthing arrangements
- documents relating to the construction of the installation and drawings and diagrams of the equipment
- an estimate by an expert of the induced voltage in the conductor at the time of the accident
- records of the accident (Police / Tukes)
- a report by the Finnish Meteorological Institute of weather conditions at the time of the accident

3 Description of the power line section, tower structure and accident site

The accident took place in Hyrkkälä in the municipality of Savitaipale, in South Karelia. The accident site is less than 10 kilometres from the town centre of Savitaipale. The rescue roads in the safety plan for the site and the other procedures in place for emergency situations and accidents had been reviewed with the construction operators' employees and the South Karelia emergency services. The Savitaipale fire station is located in the town centre of the municipality.

At Hyrkkälä, the main grid transmission lines are located in the transmission corridor in such a way that there are two parallel 400 kV transmission lines carried on guyed steel two-legged portal towers in the same right-of-way. Their distance from each other and from the centre line of the towers is approximately 33 metres. The transmission line area needed for the transmission lines consists of a right-of-way on the ground and border zones on each side of it. The right-of-way in the clearing generally extends about 18-21 metres either side of the central line of the tower structure. The border zone starts from the edge of the right-of-way and is an area where the height of trees is restricted.

The power line towers are marked and numbered for easy identification. The numbering system for the line in question starts in the south from the direction of Lappeenranta. At the site of the accident in Hyrkkälä, the number on the tower being worked on was 92.

The main parts of the tower structure and the line from the viewpoint of the accident and its investigation are:

- *The crossarm on the tower.* The crossarm on the tower where the accident took place is about 30 metres above the ground. The crossarm consists of an upper and lower flange and diagonal cross bracings to give the structure mechanical strength. The crossarm and the other main overground steel structures are connected to the tower earthing system installed on the ground.

- *Insulator string.* The phase wires on the tower at the accident site are supported from the crossarm by means of two insulator strings some four metres long. The string insulates the line from the tower structures that are connected to the ground.

- *Phase wire*, comprising three Finch subconductors. The diameter of one conductor is Ø32.9mm. The wires are installed in the shape of a triangle, so that the distance between the farthest wires in one phase is approximately 0.5m.

- *Clamps*, by means of which the subconductors are attached to the brackets on the insulator string, and to which the ***arcing horns that protect the wire are also fixed. There are protection pegs between the clamp and the conductor, preventing mechanical damage to the line at the fixing point.

***Arcing horns, or a spark gap, protect the line from climate-induced overvoltage, conducting any resulting electric arc to the spark gap in a controlled manner.

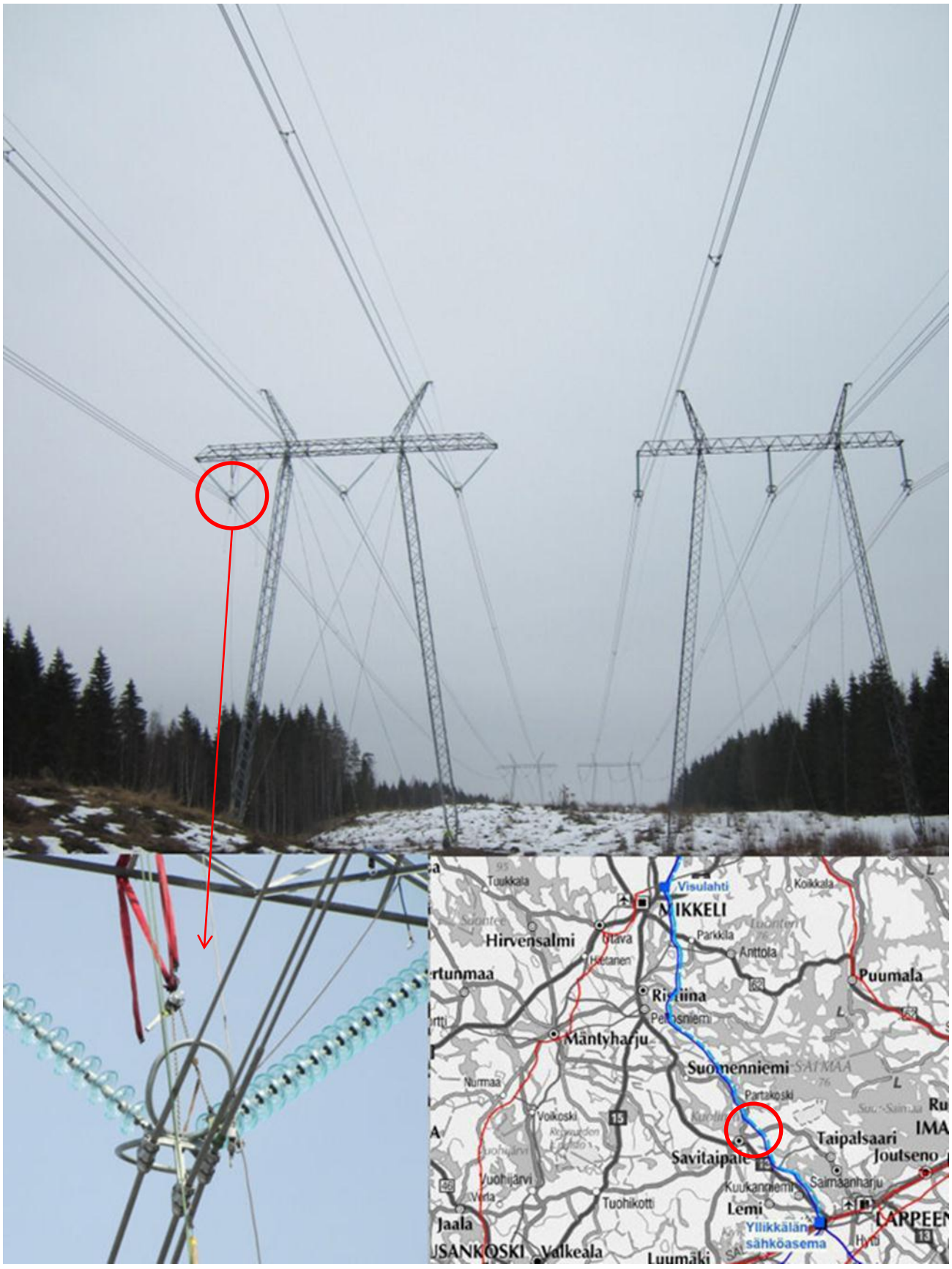


Figure 1. A general view of the accident site in Hyrkkälä, Savitaipale.

4 Chain of events – Events leading up to the accident and the accident itself

4.1 Work on the power line

The Polish contractor was to repair an installation deviation discovered during an investigation of the line. The task of the team, which was made up of four electricians (Linemen) and a Team Leader, was to move the line clamps on the underside of the insulator strings supporting the line so that the insulator string and the line would meet at right angles to one another. The task and the related arrangements had been discussed at an earlier on-site meeting between the customer and the supplier. The work was to be carried out on the upper crossbar of the tower and while working above the line. The instructions in place for working on towers and occupational health and safety in electrical work, and the procedures agreed with the customer were to be observed during the work.

4.2 Isolation of the site and temporary earthing

The norm publication SFS 6002 (Safety in electrical work) provides instructions for working on electrical equipment and in its vicinity, and defines the main fundamental measures for dead working procedures that ensure that the site is and remains dead whilst work is being carried out. After the respective electrical installations have been identified, the following actions shall be undertaken in the specified order unless there are essential reasons for doing otherwise:

- disconnect completely;
- secure against re-connection;
- verify that the installation is dead;
- carry out earthing and short-circuiting;

When the accident occurred, the section of the line at which the site on tower No. 92 was located had been isolated from the rest of the southern line under construction in both directions of electrical supply. Further away, the jumpers connecting the different phase subconductors had been removed from the anchor towers (Nos. 45 and 270) on both sides of the site. An air gap of approximately eight metres for all phases for the lines in the direction of the substations had formed at the points of isolation.

From power line tower No. 45 at the point of isolation in the direction of Lappeenranta, there was approximately ten kilometres of line under construction that was partly mounted on erected towers, and this was isolated from the Yllikkälä 400/110 kV substation using fixed short-circuit-proof earthing insulators. An earthing insulator would prevent supply voltage from getting from the substation to the line being built in the event of fault current. All phases of this section of the line under construction had been temporarily earthed using transportable short-circuit-proof temporary earthing devices to the ground-connected structures of tower No. 45.

The line section from tower No. 270 northward in the direction of Joroinen had been isolated and earthed using a short-circuit earthing insulator at the Huutokoski 400/110 kV substation.

In an instruction entitled Safety when working with High Voltage Installations (SÄTKY), which was added to the Standard on safety in electrical work, short-circuit-proof earthing is called main earthing.

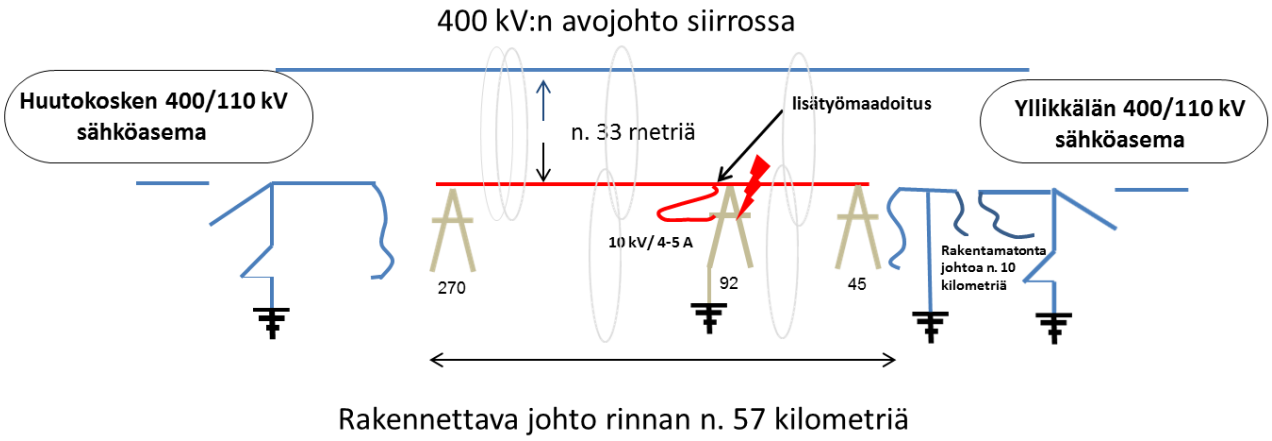


Figure 2. Principle diagram of the connection situation and temporary earthing.

4.3 Induced voltage

One requirement of the Standard on safety in electrical work is that, in addition to the requirements in place for working when circuits are dead, special steps have to be taken, especially when working on overhead lines, to enable a reduction in the potential (induced voltage) between the conductors and the earth caused by induction at the site to a safe level.

The dangerous levels of induced voltage caused by the adjacent power line transmitting electricity were to be eliminated by means of a transportable temporary earthing device installed at tower No. 92. While making preparations for working at the top of the tower, the team were to earth the line to be worked on to the steel structures providing a good connection between the tower crossarm and the ground.

The measure is called additional temporary earthing in the SÄTKY instruction.

4.4 Work on the power line tower

The following description is based on the information given by the members of the team at the site when the accident happened.

On the morning of Wednesday 17 April 2013, the team of the contractor engaged to lay the line set out from the Savitaipale base camp to carry out some pre-agreed tasks. At the work site, electricians A and B climbed the steps of transmission line tower No. 92 onto the crossarm and moved along it to above of the phase wire to be worked on. Electrician B lowered the other end of the rope he had taken with him to the team at ground level. A temporary earthing device and an insulating rod were attached to the rope and electrician B hoisted these up to the tower. In the same way, safety ropes for the electricians, a lever hoist for lightening the lines during work and two lifting lines for fastening were hoisted up to the tower crossarm.

As the work progressed, electrician B moved to the lower flange on the tower crossarm, where he prepared support for the hoist and examined and sorted out the safety ropes he had taken up with him. Meanwhile,

electrician A was fastening the temporary earthing device. According to his statement, electrician B did not see this precise activity taking place, as he had first been bent over while moving and then turned away from A while working. Electrician B lowered himself along the insulator string to the line underneath the crossarm and there received from electrician A the lever hoist and another lifting line. When the hoist had been suspended on the crossarm using the lifting line and the first subconductor in the power line phase had been attached to the lifting hook, using the other lifting line, electrician B sat down on the power line to work. Electrician B sat by the clamps in such a way that the temporary earthing clamp was behind his back. Once electrician A had also lowered himself to the line, the actual work of moving the suspension clamps began. Electrician A worked standing up on the line on the opposite side of the insulator string from electrician B (Figure 2). The work progressed, with the subconductors being marked with the necessary moving distance, after which the clamps on the conductor lightened with the hoist were detached one by one, moved and re-attached.

Two out of the three subconductors had already been moved, when the third conductor “crackled and flashed” to such extent that even the team and ground level noticed. Electrician B realised what was happening and noticed that electrician A had received an electric shock. Electrician A had one of his hands on the earthing device conductor and the other on the hoist.

Having realised what had happened, electrician B carefully attached the detached earthing device line terminal that was hanging loose to the line. When the current was discharged via the earthing device, electrician A was left hanging unconscious on his safety harness on the transmission line.

Once the situation became somewhat clearer, electrician B asked the team down below to call for help and send up another earthing device system. The team rang the work supervision, who in turn called the emergency services. At the same time, team members set out to fetch another earthing device system. The site was not earthed again, however; instead, the team started to help the victim (electrician A) down from the tower.

First, electrician B attached a rope to the chest strap on electrician A’s safety harness, and the unconscious victim was lowered down. Electrician B realised his situation on the line was life-threatening and asked to be lowered down himself on the rope. While two members of the work team lowered electrician B down to the ground level, Team Leader C applied first aid to the victim.

First aid was continued until the rescue services arrived. However, electrician A was pronounced dead at the accident site.

As the accident happened, electrician A had become part of an electric circuit through which the induced voltage in the line discharged through the electrician's arms and body to the metallic structures of the tower and the ground.

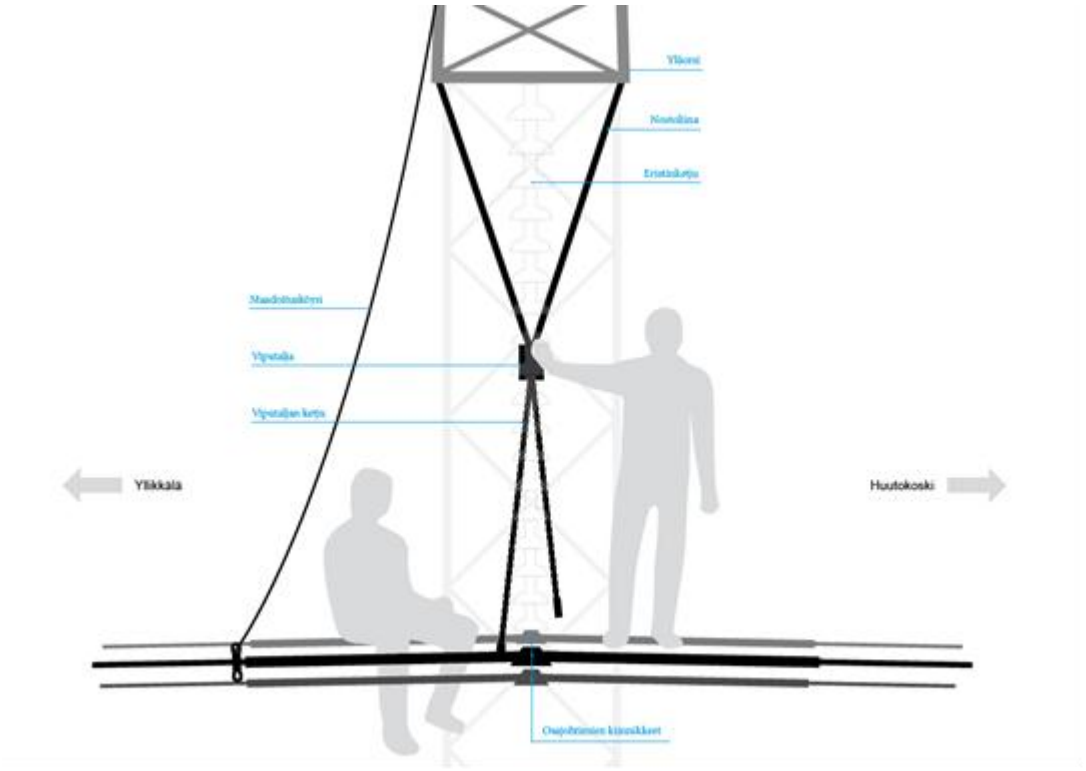


Figure 3. Illustration of electricians A and B working on the power line.

4.5 Induced voltage and the resulting electric shock

The work object had been isolated from any of its power supplies, as described above.

The dangerous level of induced voltage identified in the wire that was “in a floating state”, isolated from the supply voltage, was to be eliminated by means of an earthing device installed at tower No. 92 in the immediate vicinity of the work object (additional temporary earthing). The safety of work on the line relied solely on this additional earthing procedure. When the clamp on the earthing device line terminal came detached, the line being worked on became live and electricians A and B were in immediate danger of losing their lives.

The free end of the lifting chain of the hoist used to lighten the conductors was in contact with the arc horn of the same potential as the live wire, causing the metal frame of the hoist to become live. The chain hoist had been suspended on the tower crossarm with a lifting line that conducted electricity poorly, so that the induced voltage could not discharge via the lifting line to the tower structures and on to the ground.

The conductor on the earthing equipment that had the earth potential, which had come loose from the power line, and the phase terminal clamp at its end began to dangle freely at the work site.

Electrician A was working standing on the line wearing insulating rubber boots. Electrician A was gripping the hoist that had become live with one hand and the coated conductor of the additional earthing device at the same height with the other hand. As the insulating strength of the temporary earthing device's conductor coating failed, electrician A’s hands became part of the electric circuit from the power line to the tower earthing system. Due to a muscle spasm caused by the electric current, the victim remained part of the electric circuit (Figure 3).

When electrician B touched the charged power line with the additional temporary earthing device's phase terminal after noticing the accident, the induced voltage was momentarily discharged via the earthing device to the tower structures and on to ground, allowing the victim to be separated from the electric circuit. At the same time the line, acting as a working platform, became live again, and both electricians were in immediate danger of losing their lives until they were rescued and helped down from the tower.

According to calculations made by experts employed by the grid owner later on, at a time just prior to the accident, at about 09.40 a.m., the voltage induced by the Yllikkälä-Visulahti transmission line conducting power was around 10,000 volts (10 kV) and the current in effect at the accident site was around 4-5 amperes (A).

4.6 The accident site after the incident and its investigation

The police documented the site soon after the accident occurred. The site was kept as it was immediately after the rescue operation. The Tukes investigation team, a technical investigator employed by the police and an occupational health and safety inspector examined the site the next day, Thursday 18 April 2013. There were also staff employed by the main grid owner as well as the French and Polish companies at the site of the accident.

On arrival at the site, the equipment that had been used by the victim was observed on the ground: a helmet, a personal safety harness and gloves and rubber boots worn whilst at work. Burn marks were visible on the palm side of both of the victim's work gloves. There were no visible signs of damage to the rubber boots or signs of heat caused by an electric current. The insulating telescopic rod (closed) needed to attach the earthing device was close to the leg of the portal tower.

The tools and equipment that the team had used up on the crossbar and on the line could be seen: the lever hoist mounted in place to lighten the conductors, the auxiliary rope, the safety ropes and a sledgehammer required in the work. The earthing terminal used for the additional temporary earthing work arrangement had been attached to the upper flange of the crossarm. The earthing device conductor had been wound securely around the upper flange of the crossarm using a lifting line (Figure 4), and the line terminal clamp, which was meant to be attached to the power line at the other end, was hanging loose at the site.

Before the earthing device and other tools and equipment used on the tower crossbar and the line when the accident happened were detached/disconnected and lowered to the ground to be examined, the accident site was photographed from the crossarm above (Figure 5).

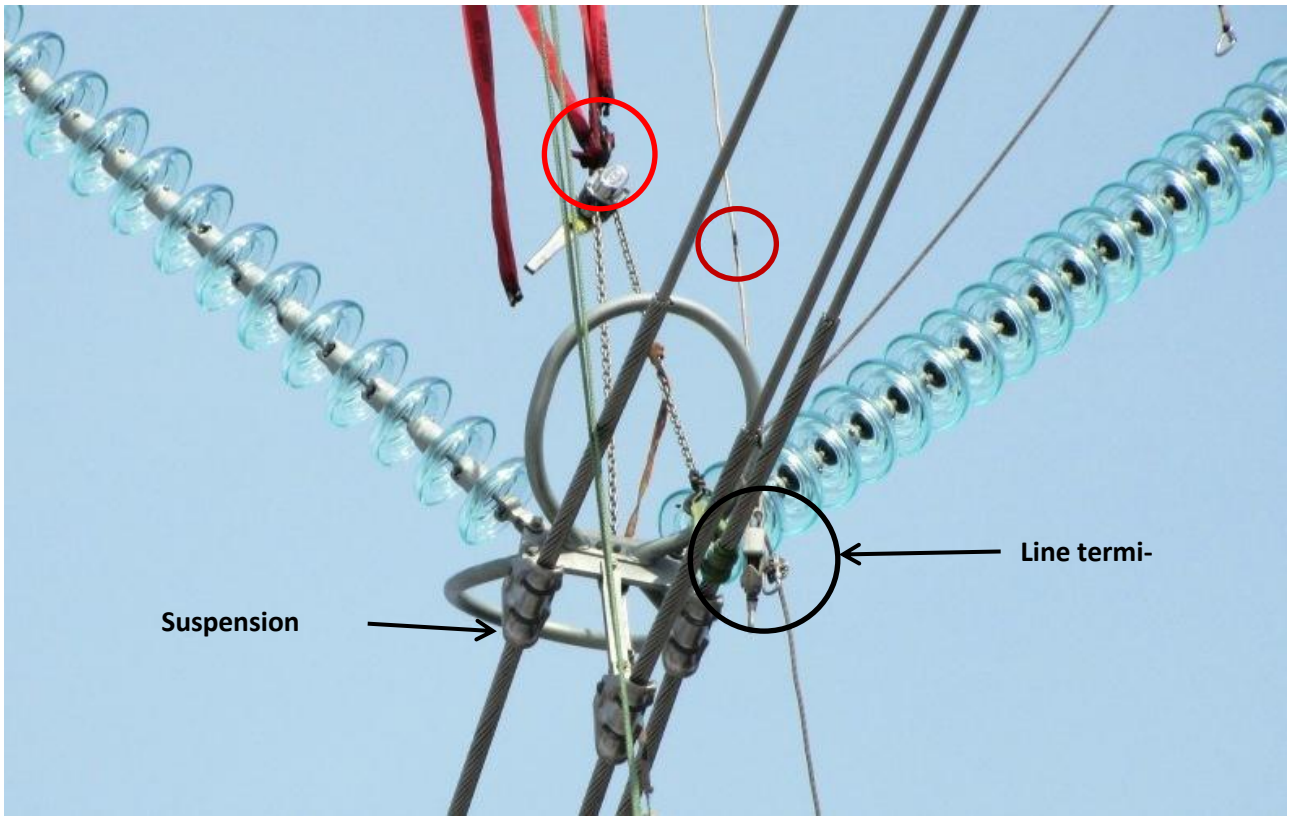


Figure 4. Work site. The red circles indicate the places where the electrician became part of the electric circuit.

An examination of the tools and equipment used at the site allowed the following observations essential to the investigation of the electrical accident to be made:

- the adjustable jaw on the line terminal clamp meant to be attached to the earthing device subconductor was open in its extreme position. Turning the clamp's mounting screw back from its extreme position required quite a lot of force.
- there was evidence of damage caused by heating due to the electric current in two places in the coating of the copper wire in the earthing device.
- the lifting line used to suspend the lever hoist showed a high degree of melting caused by a disruptive discharge.

It was observed that the clamp jaw to be attached to the object being earthed and the pitch of the mounting screw were structurally such that the equipment, if installed properly, could not accidentally open and become detached while work was going on.

Due to this observation, it was considered necessary to determine whether the line terminal clamp could have inadvertently been attached incorrectly. Some tests were conducted on the tower crossarm at the scene of the accident. In these, a telescopic rod and the appropriate procedures were employed to try to get the open clamp to stay on the conductor. The clamp could not be positioned on the line when the adjustable jaw was fully open and untightened. The investigation team was of the opinion that the clamp, which had been open, had remained in place suspended from the earthing rope that had been secured

tightly to the upper flange of the crossarm. When the conductor was lightened in order to move the clamp, the earthing rope became slack and the clamp came detached.

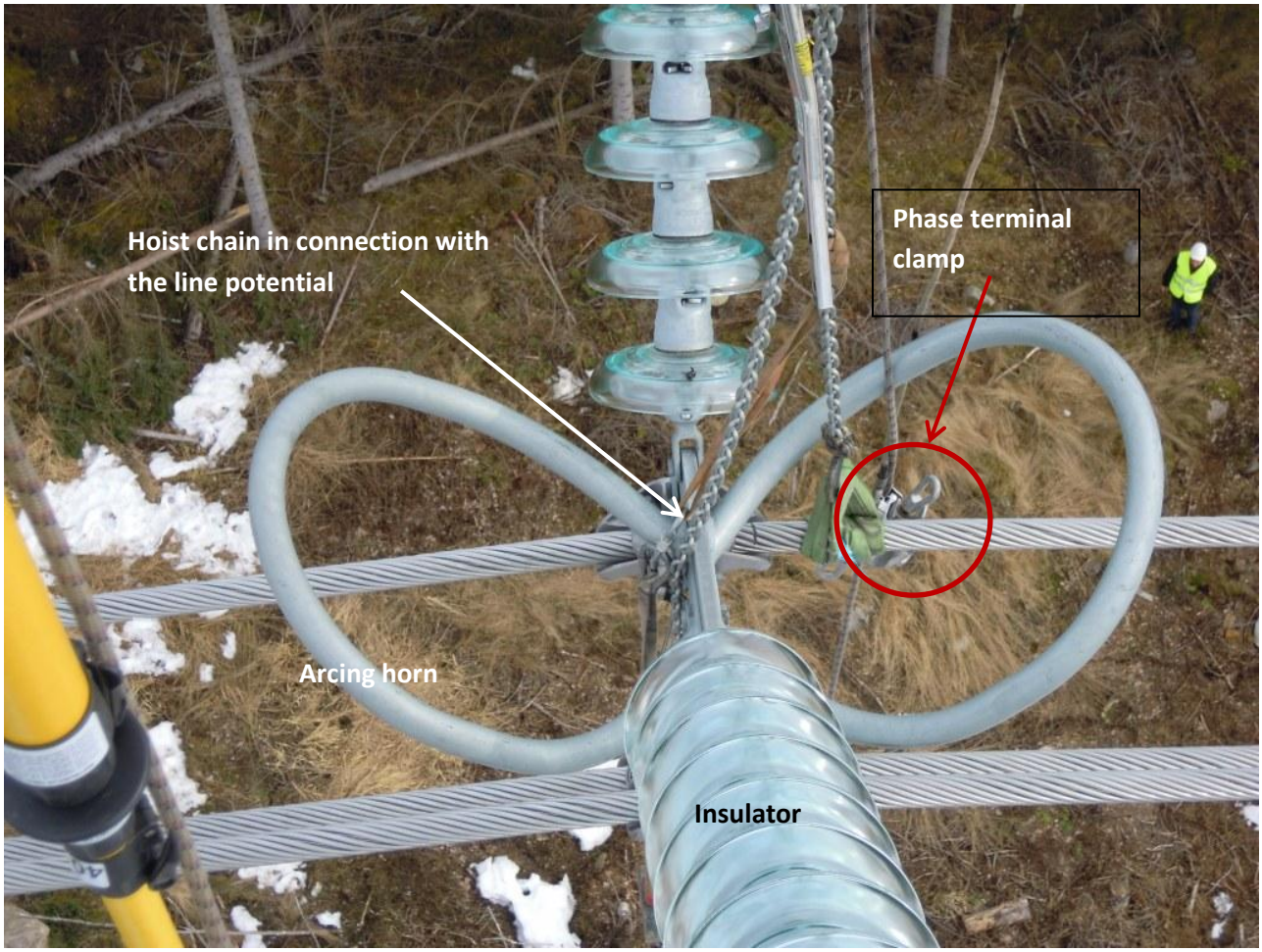


Figure 5. The site after the accident, 18 April 2013.

The grid connection situation and main earthing systems were as described above in Section 4.2.

After the accident, work on the line did not continue until the accident had been dealt with and the correct working procedures had been reviewed with the teams of the Polish company. Transportable short-circuit-proof temporary earthing devices were installed in towers No. 46 and 269 close to the line's isolation points.

4.7 Team debriefing session

A team debriefing session was held in connection with the investigation of the accident site on 18 April 2013. It was attended by the Tukes investigation team, staff of the consortium and the customer’s project manager. The members of the team wrote accounts in their own language of what they had seen at the time of the accident; these were later translated into Finnish. The team that had been at the site of the accident were also consulted in their mother tongue with the assistance of the Polish project manager, who spoke English.

Figure 6. Left: earthing device rope tied to the upper flange of the crossarm. Right: the gloves worn by the victim.

5 Requirements and instructions for temporary earthing related to the work

According to the amendment on safety at work (KTMp 1194/1999) to the Decision of the Ministry of Trade and Industry on Electrical Works (KTMp 516/1996), the structure of the electrical installation must be reliably established, the risk factors related to the work assessed and any necessary measures taken to ensure electrical safety before any electrical work is begun. Electrical work must be carried out using established work methods that have been found to be safe. The work requirements are considered fulfilled if the standards and publications approved by the electrical safety authorities are applied to the performance of the work. The standard approved for electrical work is SFS 6002 Sähkötyöturvallisuus (SFS 6002 Safety at Electrical Work). The standard contains the first part of EN 50110-1, which is the model for the standard, and the Finnish supplement to the requirements. If the method applied to the work is unusual or new, any risk factors related to the method must be assessed and taken into account.

5.1 Standard on safety at electrical work SFS 6002

Induction risk and temporary earthing according to the standard on safety at electrical work SFS 6002:

Section 6.1.1 of the standard deals with induction. According to the section, live conductors can cause charges in other conductors or conductive parts in their vicinity. In addition to the following requirements of 6.2 (Dead working) and 6.4 (Working in the vicinity of live parts), specific precautions shall be taken when working on electrical systems influenced by induction (this is particularly so for work on overhead lines): These special measures include:

- by earthing at adequate intervals in order to reduce the potential between conductors and earth at a safe level;
- by equipotential bonding at the work location in order to avoid the possibility of workers inserting themselves in an induction loop.

According to subsection 6.2.4.1, *General*, of section 6.2.4, Temporary earthing, of the standard, “all parts of any high-voltage installation or certain low-voltage installation (SFS 6002 6.2.4.2) where work is being carried out must be temporarily earthed (earthed and short-circuited). Earthing and short-circuiting equipment or devices shall be first connected to the earthing point and then to the components to be earthed. The earthing and short-circuiting equipment or devices shall be visible, whenever possible, from the work location. Otherwise, the earth connections shall be applied as close to the work location as is reasonably practical."

Section 6.2.4 of the standard, *Temporary earthing*, contains an additional national requirement: “Temporary earthing prevents the work location from becoming dangerously live because of incorrect use or malfunction of the switchgear used for isolation or because voltage is supplied to the installation for other reasons. These kinds of situations may be caused by generators or control voltages connected to the equipment or by adjacent or intersecting lines, for example. In such cases, the temporary earthing must be carried out separately for high voltage and low voltage.”

According to section 6.2.4.3 of the standard, *Requirements for high-voltage installations*, the temporary earthing of bare overhead lines and bare conductors must be carried out on all sides of the work location

for conductors entering the location. At least one piece of temporary earthing equipment or device must be visible from the work location.

These rules have the following exceptions:

- for specific jobs where conductors are not cut during the work, using a single piece of temporary earthing equipment or device is acceptable at the work location;
- if the temporary earthing equipment or devices are not visible from the work location, a local temporary earthing device must be installed at the work location or the temporarily earthed work location must be marked or otherwise indicated.

If work is performed on only one conductor of an overhead line, the short-circuiting of all phases is not required at the work location provided that the following conditions are met:

- all isolation points have been temporarily earthed in compliance with section 6.2.4.1 (see above);
- the conductor being worked on and all conducting parts at the work location have been connected and earthed with appropriate equipment or devices;
- the earthed conductor, the work location and the person performing the work are at least at a distance greater than *D*L (the shortest acceptable distance in air that defines the outer limit of the live working zone) away from the other conductors of that circuit.

The bare parts of insulated overhead lines, cables and other insulated conductors shall be temporarily earthed at the points of isolation of the installations or as close to these as possible on all supply sides of the work location.

Additional national requirement:

However, the temporary earthing does not have to be visible in the work location if no conductors are cut or will be cut during the work and the line is a single branch line or a line fed from two sides and the lines are easily identifiable to prevent any risk of mistake. In such a case, temporary earthing with short-circuit current capability in the vicinity of the isolation point(s) shall be sufficient. If the work location is more than 3 km away from the temporary earthing, additional temporary earthing must be carried out to ensure that the 3km distance is not exceeded.

5.2 SÄTKY instructions

The SFS 6002 standard on safety at electrical work has been supplemented by instructions on safety at electrical work on high-voltage installations. The purpose of these instructions is to clarify the requirements of the standard with regard to work on electrical installations of 1 kV or higher.

Temporary earthing complying with the electrical safety standard and special measures required in addition thereto, particularly in the case of overhead lines, are referred to as main earthing and additional temporary earthing in the SÄTKY instructions.

These earthing procedures are discussed in chapter 6 (Advance design of and planning for connections) of the SÄTKY instructions as follows:

“6.2.1 Design of main earthing

The installation separated for the work shall in all cases be provided with main earthing. The main earthing shall be provided even if the work is not done on the isolated installation itself but the work location extends to the installation's immediate vicinity.

The purpose of the main earthing is to prevent dangerously high supply voltage from entering the work location from any direction in the event of a fault, faulty switching or equipment damage. The main earthing shall be dimensioned to withstand any short-circuit currents or earth fault currents that may occur in such situations.

The person in charge of operating the electrical installation shall be responsible for designing the main earthing.

The main earthing must be provided in all supply directions. If, as at work on the main busbar of a switchgear, this is not reasonably possible, the person in charge of the operation must ensure that the main earthing is sufficient for electrical safety.

Main earthing shall primarily be carried out with an earthing switch. If there is not one available, the main earthing shall be done with transportable temporary earthing devices that withstand short-circuit current and earth-fault current.

"8.3 Additional temporary earthing

The main earthing will prevent operating voltage from entering the work location but cannot exclude dangerous induced voltage in all cases. Any dangerous induced voltage must therefore be eliminated with additional temporary earthing. It will also reduce climatic risk factors or risk factors related to conductors touching each other.

The work team shall be responsible for establishing any need for additional temporary earthing and for the connection, supervision and removal of the devices. The cross section of the conductors used for the temporary earthing must be at least Ø 16 mm².

Before the additional temporary earthing is connected, it must always be ensured that the work location is dead. Even though a tester may indicate that the work location is dead, the work location may be carrying a lethal induced voltage that can only be eliminated with temporary earthing.

The temporary earthing equipment must be visible from the work location wherever possible.

In addition to additional temporary earthing, auxiliary temporary earthing can be carried out at the work location; no requirements have been set for its current-carrying capacity."

The purpose of auxiliary temporary earthing is to equalise any differences in potential that might be unfavourable to the work. Auxiliary temporary earthing will not have a direct effect on the safety of electrical work.

5.3 Instructions issued by the grid owner

The main grid owner has issued its own instructions, "Safety at electrical operation and work on the main grid" ("Käyttö- ja sähkötyöturvallisuus kantaverkossa"), which are based on the standard on safety at electrical work (SFS 6002) and the SÄTKY instructions. The instructions contain clarifications to working on the

main grid or its vicinity that have been deemed necessary. With regard to temporary earthing, they have been updated with operating instructions issued in 2011.

6 Temporary earthing equipment and its installation

For the additional temporary earthing of work locations in the main grid, it is recommended that equipment with a cross section larger than that of the conductor and made of copper, with a diameter of at least Ø 25 mm² or 3.2 kA [1 s], and complying with the SÄTKY instructions be used as such equipment is mechanically superior and have a higher current-carrying capacity.

The additional temporary earthing shall be connected to and disconnected from the work location with an insulating rod. The insulating rod must be long enough to prevent the user having to enter the live working zone. It is absolutely vital that the temporary earthing device is attached in the right order, first reliably to a point connected to earth and only then to the work location.

In the work that led to the accident, the work team used an insulating rod (a telescopic rod with a strap) appropriate for attaching the temporary earthing device. The additional temporary earthing device used had a cross section of Ø 35mm², it was made of copper and had a current-carrying capacity of 9 kA [1 s]. The temporary earthing device is attached with adjustable clamps.

Exact product information on the temporary earthing device used in the accident was not available for the investigation. The thickness of the wall of the coating (TPE-O) of the conductor of a temporary earthing device commonly used for high-voltage work with a corresponding cross section is reported as 1.3 mm and its dielectric strength as about 10 kV/mm.

Figure 6. The temporary earthing device used in the work leading to the accident.

7 Working conditions

7.1 Weather, clothing and equipment

Weather

The Finnish Meteorological Institute observation stations closest to the site of the accident are the Lappeenranta airport and the Lepola weather station in Lappeenranta.

Weather observations at the stations on 17 April 2013:

Lappeenranta airport at 9.40 a.m.
- temperature: 6.3 ˚C
- relative humidity: 77 %
- visibility: good, 30 km
- average wind speed: 3.1 m/s

Cumulated precipitation at Lepola station between 9.00 a.m. and 10.00 a.m.
- there was no rain during the time period

Clothing
- work clothes, helmet

Equipment and tools
- Fall prevention equipment required for pole work, safety ropes and required hand tools. An insulating rod and a single-phase temporary earthing device, where the cross section (Ø) of the copper cable was 35 mm^2.

7.2 Activities of the organisations

The course of events and the contributing issues and circumstances have been determined during the accident investigation. A description of the course of events has been presented above. The following is an account of the activities with regard to the legal provisions valid at the time of the accident. The publications referred to are as follows (excerpts included in the Appendix):

1. Electrical Safety Act (410/1996), hereinafter (ESA 410/1996)
2. Decision of the Ministry of Trade and Industry on Electrical Works (KTMp 516/1996) and the amendment on safety at work (KTMp 1194/1999), hereinafter KTMp (516/1996)
3. Tukes instructions S7-2012, Notification of electrical work
4. Tukes instructions S10-2012, Standards on the safety of electrical installations and safety at electrical work
5. The binding force of standard SFS 6002 (2005), Safety at electrical work, is stated in KTMp 516/1996 and the Tukes instructions.

7.3 Contractor's procedures in the selection of partners

The main grid company maintains a list of approved suppliers, the purpose of which is to ensure in advance that the contractors and suppliers have the financial and technical capacity to carry out power line projects.

In order to be entered in the register, the suppliers are requested to provide the following details, for example:

- basic and financial information on the company, including documents required by the Act on the Contractor's Obligation and Liability when Work is Contracted Out;
- the company's references for similar projects;
- the company's personnel resources (project management, planning and installation personnel);
- a description of the company's quality assurance process.

Previous co-operation between the French and Polish companies

The French-owned company, which the main grid company has used in previous projects as well, has been operating in Finland since 2006, after which the name of the company has changed. The changes to the company name have been related to the internal reorganisation of the company's parent group. The French company has been the contractor in a number of projects launched by the Finnish main grid company where the Polish-owned company has been a partner of the French company, first as a subcontractor and later as a member of a consortium in the Yllikkälä-Visulahti power line project.

The two companies have worked in partnership in other countries as well, such as Poland and France.

Before signing the first contract, the client evaluated the functioning of the French-Polish partnership, for example by making a fact-finding visit to France, where the Polish company worked as the French company's subcontractor. The operations and resources of the Polish company were assessed on a fact-finding visit, which also included discussions with the company's most important Polish client. The Polish company's references were updated before the contract for the Yllikkälä-Visulahti line section was signed.

7.4 Consortium partnership

The building contract for the Yllikkälä-Visulahti line section was to be carried out by the ****consortium formed by the French and Polish companies. The main responsibility for achieving the consortium's objectives lay with the French consortium partner.

According to the contractual documents, each consortium partner was responsible for its own work.

According to the consortium agreement and the building contract, the Polish company was primarily responsible for preparing the work instructions for the project and for carrying out the work for building and installing the line.

The common work language of the client and the consortium members was English, which was also the language of the contractual documents.

***** In general, "consortium" is a term for a temporary association of companies for a specific business transaction.*

8 Supervision of the construction of the electrical installation and safety control of the work site

The supervision of the construction and the site had been defined at several levels in this extensive power line project. The client and the consortium companies had appointed specific persons to supervise the quality of the construction, general occupational safety, electrical safety and safety at electrical work, for example.

On the site, the safety was supervised by the project manager appointed by the grid owner, who was also the safety coordinator for the project. The client had also appointed a site supervisor, who also acted as a liaison officer for occupational safety, and a person responsible for electrical safety.

The client's representatives visit the site regularly, having a clear idea of the situation on the site all the time. The number of these visits depended on the current work stages, for example, and the progress of the project.

The project was also monitored by a steering group appointed from among the personnel of the client and the consortium, which visited the site several times. In addition to supervision carried out by the client itself, the project was supervised on the basis of the contract by a Finnish company specialising in construction, construction supervision and consulting.

8.1 Operating conditions under the Electrical Safety Act

In Finland, according to the Electrical Safety Act and the statutes based on the Act, electrical installations may be installed or repaired or electrical equipment repaired only by persons who meet the requirements set out in Section 8 of the Electrical Safety Act (410/1996).

One of the key requirements is that the operator must appoint an electrical works manager in charge of electrical safety from among its personnel and, in accordance with Section 4 of the Decision of the Ministry of Trade and Industry on Electrical Works (KTMp 516/1996), give the manager sufficient authorisation to manage and supervise the electrical work. In addition, the operator must notify Tukes in accordance with Section 12 of the Act before the work is begun.

According to the contract between the consortium and the client, the person responsible for electrical works referred to in Section 8 of the Electrical Safety Act, the manager of the electrical works, would be the French company's manager of electrical works during the contract. The electrical work of the French company was entered in Tukes's register of electrical work contractors in 2007 and the company's operations were considered to comply with the provisions in the Electrical Safety Act and the requirements based on the Act.

Tukes had made a control visit to the consortium's work site with regard to electrical contracting on 10 April 2013. During the control visit, it was discovered that Tukes had not been notified of the French company's change of name. It was also discovered that the Polish company's electrical works had not been entered in Tukes's register of electrical contractors. The minutes of the control visit raised the issue of whether the French company's manager of electrical works could realistically supervise the electrical works

from France. The Polish company was immediately requested to notify Tukes of its electrical contracting operations.

8.2 Definition of the supervision of electrical work safety

According to legislation on electrical work performed in Finland, the employer (or the employer's substitute) and the supervisor of electrical works appointed by the employer shall in general ensure that the Safety at Work Act, the Electrical Safety Act and any statutes and regulations issued by virtue of these Acts are complied with.

The responsibilities of a supervisor of electrical works include ensuring that the persons performing electrical work are competent and have received adequate instruction in their work. He shall also ensure that electrical safety during the work at each location is supervised by a person who is authorised to carry out electrical work independently within his own field of expertise (KTMp 516/1996, SFS 6002).

In the contract made with the client, the person appointed under Section 8 of the Electrical Safety Act as the supervisor for the work under the project was the site manager of the consortium's French member (A person in charge of electrical work).

Requirements for personnel and the organisation of safety of electrical work are set out in more detail in the nationally binding Annex X of the electrical safety standard SFS 6002. According to Annex X.4 of the standard, if the person appointed as the supervisor of electrical work cannot carry out all his responsibilities himself, he must ensure that there is a system in place for meeting the requirements. For each piece of work, there must be a person appointed responsible for the work or operation, such as a foreman, if the site manager is not directly supervising the work himself.

In the project contract agreement, the persons appointed by the consortium's French member to be responsible for the work were as follows:

- the person responsible for work in accordance with SFS 6002
- the person responsible for overseeing site safety

The Polish company building the line had a system based on the standard on electrical work safety in place, which described the organisation of supervising the company's safety at work in six levels by area of supervision and the supervising persons by job title (the team leader, the foreman, deputy supervising foreman, supervising foreman, the Site Manager-Resident, Deputy Project Manager and Project Manager).

According to Section 29c of the Decision of the Ministry of Trade and Industry (KTMp 516/1996, SFS 6002), a person who is authorised to carry out electrical work independently within his own field must be appointed to supervise the electrical safety during the work at each work location. In the nationally binding Appendix to the standard on electrical work safety, this person is called a supervisor of electrical safety during the work.

"The supervisor of electrical safety during the work is required to have both the formal skills and knowledge of

and experience in the installation methods, supplies and tools applied. Other important qualities include his attitude to safety and his reliability, carefulness and responsibility. It is essential that he is present at the work location and able to supervise the safety of the work. If there are several people working at the work location, it must be clear in all situations who is responsible for supervising electrical safety at work. Determining the supervision of electrical safety at work is particularly important at work locations where there are different people working simultaneously for different employers. In such cases, the supervision of electrical safety at work must generally be determined in writing. If the organisation of the work and the assignments are clear enough for oral determination of the supervision or for practice agreed on in advance, written determination is not necessary."/ SFS 6002

The person appointed to supervise the electrical safety of the work that led to the accident was the team leader of the Polish team.

8.3 Professional skills, training and instruction of the persons taking part in the work

There are several types of tasks involved at the various stages of power line construction that require professional skills and work experience related to construction, metalwork, and vehicle and machine operation, for example.

The employer of the Polish workers has submitted files regarding the training of the company's workers required in the course of the accident investigation. The members of the team involved in the accident were professionals with backgrounds in various fields who had been trained in transmission network construction. The team members had several years' experience in building transmission lines.

According to the information received, A, the deceased worker, had had professional training in electrical work.

The teams have had to attend annual health and safety training courses, which focus particularly on electrical safety, working in high places and first aid. Every five years, the workers have had to take a compulsory examination to prove their proficiency in the above safety issues. Those who pass the examination are granted the relevant Polish licence (qualification certificates D and E issued by the Polish Electricians' Association). The training in electrical safety at work is based on the European standard EN 50110-1 (Operation of electrical installations).

The three project and site managers of the consortium had received training in compliance with the electrical safety standard SFS 6002 in Finland, partly in order to impart the content of the standard to their own personnel. According to a report by the Polish company, six of its engineers have received such training.

On the line construction site, there were "Welcome meetings" for orientation, and the work teams were given more detailed instructions related to the standard before they began work. The employees also attended practical training for the correct preparation of the work location, which also included the installation of temporary earthing.

Every opportunity was taken to remind them of the risk of induction from the adjacent 400kV transmission line. The importance of maintaining a sufficient distance from the line during work was stressed to the teams. Any anchoring for pole erection, for example, had to be done on the opposite side of the line in operation.

8.4 Safe use of the electrical installation

In accordance with Section 3 of the Decision of the Ministry of Trade and Industry on Electrical Works, the main grid owner has appointed a person holding the required qualification certificate as supervisor of operational works. The supervisor of operational works must ensure that the operation and maintenance of the electrical installation comply with the Electrical Safety Act and any provisions and regulations issued thereunder and that all persons engaged in operational work have the professional skills and sufficient instructions for their duties. Accordingly, the responsibility for the operational safety of the electrical grid, identification and assessment of risks and instruction in the specific elements of electrical hazards related to the installation lie with the supervisor of operational works. The person responsible for coordinating and improving the work safety of the project was the supervisor of operational works appointed for the transmission network.

The above-mentioned instructions “Operating and electrical work safety in the main grid” and their supplementary instructions about temporary earthing in the main grid are documents that have been prepared by a group of experts and also translated into English, one purpose of which is to highlight and manage the risks caused by the special features of equipment. By observing the instructions, damage and accidents caused by identified hazards could be prevented.

In the Electrical Safety Act, from the perspective of the requirements placed on a constructor of electrical installations, the grid owner played the role of client in the power line project. In the project contract document and its appendices, there are many detailed requirements set by the client for consortia concerning electrical safety and the safety of electrical work, as well as requirements concerning the safety of using the grid, among other things. The documents draw attention to definitions of electrical safety monitoring and to different situations at the various stages of power line work, such as the dangers of induced voltage, earthing, intersections of different voltage levels in the area of the connection under construction, and incident management.

During the site safety monitoring performed by the client, attention was paid to site safety and it was deemed necessary to approach all contractors by letter in 2011 and 2012. The letters asked them to pay attention to ensuring occupational safety and developing a culture of occupational safety on sites.

8.5 The monitoring of occupational and electrical work safety on site

The contract agreement concerning the project and its appendices contained many mentions of site management and related procedures. The supplier, a consortium, appointed a site manager to the project, who had to be able to communicate in Finnish or English. The site manager had to be available during working hours. The document specified that at least one foreman had to be able to speak Finnish and English. The site also needed someone who could communicate in Finnish with the grid owner’s operating centre. The French company had appointed a Finnish professional, whom it employed and who was skilled in English, for supervision and practical site arrangements.

The construction personnel, team leaders and project management of the Polish company carrying out the practical work were mainly Polish and communication in the work teams took place in Polish.

On a shared construction site, the main contractor is responsible for the site’s general and common safety. The main contractor has the main responsibility for site safety management, planning and monitoring [Government Decree on the Safety of Construction Work (205/2009), Section 2, Sections 6−10].

In spite of the consortium formed, the different parties of the consortium were responsible for their own work and such matters as responsibilities set for employers in the Finnish Occupational Safety and Health Act remained within the companies themselves.

On site, guidance and monitoring of practical occupational safety and electrical work safety were handled by consortium site managers and the team leaders of the Polish work teams.

The client's practice is to require of contractors written reporting of accidents and hazardous situations and a presentation of remedial measures. The principle is that all negligence noticed will be intervened in. Accidents, hazardous situations and observed cases of negligence are dealt with at site meetings. If deficiencies are observed on site in, for example, the use of personal protective equipment, the client sends the main contractor a written complaint and gives a warning to the person who has breached the instructions given.

In the monitoring of safety on the client's site, attention was paid to the hazards of induced voltages. During a site visit by the steering group in March 2011, the client carried out a review of occupational safety, during which this issue was emphasised. In order to ensure safe working, in July 2011 the contractors were supplied with new written requirements for temporary earthing on the main grid, the introduction of which was confirmed by the contractors. These instructions paid particular attention to the generation of induced voltages and to the dangers caused by them.

8.6 Previous electrical accidents on site and remedial measures taken as a result of them

On the Yllikkälä-Visulahti site, an electrical accident resulting from induced voltage occurred in October 2012. At the time, Polish electricians were working in a lifting cage connecting conductor parts under construction at an anchor pole. One of the two electricians of the team had fixed the earth connector of the earthing conductor to the pole, and was holding the line terminal in his hands while the electricians used the lifting cage to move to the conductor end of the insulator chain. At that time, the electrician's work pair received an electric shock after grasping the steel tensioning piece between the subconductors. The electric shock was caused by induced voltage from the adjacent 400 kV power line and the failure to observe the instructions regarding temporary earthing.

As a result of the accident, an extraordinary meeting of the contract steering group was arranged, the content of which emphasised the need to improve occupational safety. As concrete measures agreed in the meeting, the French company sent a safety manager to the work site to review the work procedure and improve them. The Polish company constructing the power line increased the number of foremen by one, which enabled better monitoring of safety on site. When the management of the Polish company visited the site in November 2012, a meeting was held with all site personnel, reviewing the accident, its causes and how to avoid similar accidents in the future.

It was also agreed to lengthen the interruption periods of the remaining work phases requiring line transmission interruption (de-energising the line and isolating it from its power supply). The interruption periods were lengthened in order to reduce work pressure caused by urgency, thus improving safety.

In January 2013, the Polish company arranged annual occupational safety training for its electricians. The training focused on electrical safety. Separate safety training was also organised for electricians whose job is to climb towers and work at high places.

9 The results of the investigation

Reports received from the consortium members

In statements submitted for the accident investigation, the operators emphasise that, in line work, the above-mentioned instructions drawn up by the grid owner, “Operating and electrical work safety in the main grid,” and their supplementary operating instructions were abided by. The Polish employer of deceased electrician A draws attention to the fact that, according to the instructions, main earthing does not have to be in direct electrical contact with the object worked on.

In response to Tukes’ request for statements about safety monitoring of electrical work on site, the French company refers to the consortium agreement, and considers that both parties in the consortium were fully and separately responsible for their own work and employees. According to the consortium agreement, line construction work was the Polish company’s responsibility.

The Polish employer of the deceased employee states that, according to the contract agreement made with the client, the French company's site manager was responsible for the on-site safety monitoring. On behalf of the Polish company, on-site safety was monitored by: the team leader, the foreman, deputy supervising foreman, supervising foreman, the Site Manager-Resident, deputy Project Manager and Project Manager. A report was attached to the statement about the areas of responsibility for monitoring the safety of electrical work within the organisation. In its statement, the Polish company wishes to draw attention to the fact that the same work team and team leader had jointly carried out identical tasks previously during the project. The team leader had the responsibility of ensuring the prerequisites for safe working.

Work at the site and temporary earthing

The immediate cause of the accident was the detachment of a temporary earthing device line terminal clamp that had been fitted to a conductor at the site contrary to instructions, as a result of which a lethal voltage was discharged into the line being worked on. While working, the deceased electrician A became part of a circuit leading from the power line to the ground, receiving a fatal electric shock.

Based on discussions held during the accident scene investigation and reports received from operators, the work team should have been aware of the earthing instructions given and the correct way of attaching the additional temporary earthing device. The electric shock from induced voltage received by a Polish worker at the same site in autumn 2012 had been reviewed with the work teams constructing the line at the site. In order to ensure comprehension of the instructions given, the grid company’s earthing instructions were also translated into Polish. The working language of the consortium was English, but the work teams understood and spoke Polish almost exclusively. In the investigation, it was not discovered that language problems in communication would have arisen on the shared site which would have had a significant effect on occupational safety.

The correct attachment of the temporary earthing device and the work procedure are clear. It seems that the attachment of the temporary earthing device to the object worked on may have consciously been done contrary to instructions. The accident investigation was unable to establish a reason for the work team acting contrary to the given instructions with any certainty. The team should not have been under any work

pressure, and attaching the temporary earthing device by tying it from the conductor to the crossbeam did not provide significant benefit to the performance of the work. It is possible that, in spite of guidance and several warnings, the real mortal danger caused by induced voltage had not been properly understood.

Figure 7. The picture on the left shows the line terminal tightened by pulling it onto the conductor, suspended by the earthing rope. The picture on the right presents the correct method.

When the work began, the isolated line section that was worked on did not have any temporary earthing. Work was exclusively made possible by the additional temporary earthing set as the task of the work team. In discussions held with the work team, it emerged that members of the team had noticed the strength of the electrical phenomena caused by induced voltage varying at different stages of the line work when connecting the temporary earthing device. Among other things, this was caused by earthing done to the line by other work teams, which discharged the charge. Previous experiences of working on a line carrying a lower charge, earthed at many places, may have caused a dismissive attitude towards the safety impact of earthing.

The condition for beginning work was the authorisation given by the person in charge of operating the electrical installation. Permission to start can only be given to the workers by the person in charge of the work after the detailed measures required in the electrical work safety standard for de-energised work have been carried out. According to a national additional requirement of the standard, permission to start an individual task may be given by the supervisor of electrical safety at work.

A site meeting preceding the accident had dealt with inspection and finishing work to be done on the constructed line. At the meeting, a representative of the grid owner was present and it was stated that the work teams would install additional temporary earthing at the site before starting work.

The task of the work team’s supervisor of electrical safety at work was to ensure that, before starting work, additional temporary earthing of the object worked on had been done correctly and that work could begin safely.

Short-circuit-proof temporary earthing

According to the general earthing requirements of the electrical work safety standard concerning the work during which the accident happened, all parts of high-voltage equipment and specified low-voltage equipment being worked on shall be temporarily earthed (earthed and short-circuited). The temporary earthing equipment must be visible from the work location wherever possible. Otherwise, the temporary earthing must be installed as close to the work location as reasonably possible.

The temporary earthing requirements for high-voltage installations are supplemented in the standard so that the temporary earthing of bare overhead lines and bare conductors is to be done, in respect to the work location, in all directions for all incoming conductors, and at least one piece of temporary earthing equipment or device should be visible from the work location. These requirements can be deviated from if the conditions specified in the standard are met. As an exception to the general requirements, it is not required to short-circuit all phases in the work location, if the work only concerns one overhead line conductor. This exception requires that all isolation points be temporarily earthed in accordance with the general requirements of the standard, and the conductor that is worked on and all conducting parts in the work location are connected and earthed using suitable equipment or devices. The earthed conductor, work location and worker must also be at least a voltage work distance away from other conductors in the same circuit.

According to the additional national supplement to the standard, temporary earthing prevents the work location from becoming dangerously live because of incorrect use or malfunction of the switchgear used for isolation or because voltage is supplied to the installation for other reasons. Such situations can arise at a network construction site from parallel or intersecting lines.

When the object worked on may become charged due to induction, in addition to the requirements for de-energised work, special measures should be initiated, particularly with overhead lines, such as earthing at suitable intervals in order to reduce the potential between the conductors and the ground to a safe level. The preconditions of de-energised work are complete isolation, the prevention of connection of voltage, verifying the de-energised state of the equipment, and temporary earthing (report Section 4.2).

In all cases, it must be ensured that the temporary earthing equipment or devices, and the cables and connectors used to connect them, are fit for the purpose and suitable for the fault current values of the location of use. The reliable fastening of the temporary earthing equipment during the work must be ensured.

The grid owner is responsible for main earthing for the purpose of working. According to the SÄTKY guidelines, main earthing must be earthing that can withstand short circuits. In its statement, the main grid owner considers that the voltage supply possibilities for the planned work targets were prevented with earthing connectors connected on the ends of the power line under construction in accordance with the company's instructions. According to the statement, the requirement written in the grid owner’s instructions “Operating and electrical work safety in the main grid” concerning the connection of one main earthing device to a part separated for work refers to maintenance work. An operating procedure concerning earthing that supplements the grid owner’s instructions has interpreted the SÄTKY guideline to the effect that main earthing does not have to be in direct electrical contact with the object worked on.

When the accident occurred, deceased electrician A was holding the coating of the temporary earthing device’s conductor, which does not provide protection, and the purpose of which is not to protect, against

a high-voltage electric shock. When the induced voltage exceeded the voltage strength of the coating, a disruptive discharge took place and the induced voltage was discharged through the hands of electrician A that were protected with gloves, through his body to the tower structures leading to the ground.

The investigation remained open about how large the induced voltage would have been if the line had had temporary earthing that could withstand a short circuit.

The operations of the organisation

An operator carrying out electrical work in Finland must appoint one of its employees as the person in charge of electrical safety (electrical works manager), and must notify Tukes of the matter. The electrical works manager must have a Finnish certificate of qualification that is valid and adequately broad in scope.

The Polish company was acting as the electrical contractor for the power line project. An electrical works manager from the French company who possessed a Finnish certificate of proficiency had been appointed for the consortium in an agreement. The consortium was not, however, an operator (legal person) as referred to in the Electrical Safety Act, so the procedure was not in accordance with this Act.

According to the understanding of Tukes' investigation group, the electrical works manager contractually appointed to the consortium played little role in taking care of the key functions of an electrical works manager on a practical level, which include work supervision, guiding employees and taking care of external framework of the work.

The consortium's person responsible for the work appointed to supervise electrical safety had close contact with the performance of the work and communicated both with the client and the project management of the Polish company constructing the line. During the project, the person in charge of the work had drawn attention to the safety-related flaws that he had noticed. Similarly in its monitoring of site safety, the client had drawn the contractor's attention to safety issues and had demanded the remedial measures mentioned above. In spite of consortium co-operation, the Polish company as an independent operator and employer was responsible for such matters as the occupational safety of its employees and for monitoring it. However, the requirements to improve employee supervision and on-site occupational safety culture originated from outside the company's organisation that was in charge of safety.

European standard EN 50110-1 (Operation of electrical installations) does not specify the persons, the electrical works manager and the temporary safety supervisor, who occupy a key role in the monitoring of electrical work safety in Finland. The requirements of Finnish electrical work safety standard SFS 6002 concerning personnel and the organisation of electrical work safety are given in the standard's nationally binding Annex X. The electrical work safety monitoring arrangements in line with this standard are strongly based on the Finnish requirement under the Electrical Safety Act that work shall be managed by an electrical works manager employed by the operator. The employment relationship gives the electrical works manager, who acts as the employer's deputy, the right of direction to lead the work and to give work-related instruction and orders to the workers.

It is possible that the diversity of the Finnish requirements of special statutes concerning electrical safety and, for example, the different persons specified in the electrical work safety standard compared to the model European standard have to some extent caused challenges in the organisation and actual monitoring of networked electrical work safety supervision.

In electrical work carried out in Finland, however, standard EN 50110-1 can be applied only by observing both the basic requirements of the EN standard and the national requirements of standard SFS 6002. If the requirements differ from each other, national requirements take precedence.

10 Summary of the accident and the contributing factors

The immediate cause leading to the accident was a failure to attach the additional earthing device in accordance with the instructions and guidance given at the work location. The work at the location relied on the additional earthing alone. Once the attachment clamp of the line terminal of the additional earthing device became detached, the line that was being worked on became charged, which posed a mortal danger for those working on the line. Once the induced voltage exceeded the dielectric strength of the coated conductor of the earthing device, the person holding the conductor received a fatal electric shock. The dangerous situation was not over until the workers had been helped down from the tower. In addition to the risk of an electric shock, the workers were at risk of falling while they were being rescued with the work rope from the pole.

Judging by the reports obtained for the investigation and the interviews conducted, the team was aware of the correct way of carrying out the additional earthing. It is possible that one of the reasons why the instructions had been departed from was that the seriousness of the danger posed by the induced voltage had not been fully appreciated. The person appointed for the team to supervise electrical safety during the work should have ensured before the work started that the additional earthing at the location had been properly carried out and the work could be safely started.

During the project, it had been discovered on the site that the occupational safety culture needed to be improved and the employees' supervision needed to be increased. Although measures had been taken to remedy the matter, the investigation team did not feel these had resulted in any long-term commitment to maintaining and improving safety on the site.

It appears from the inquiries carried out during the accident investigation that the various parties to the project were not sufficiently aware of the operating conditions required in Finland under the Electrical Safety Act, for example. Supervision and responsibilities had been defined in great detail in the project contract, its appendices and the consortium agreement. However, at the project management level, the understanding of the supervision specifications was not uniform. Ultimately, ensuring that the workers' skills and the guidance and instructions given to the workers are sufficient is always their employer's responsibility. The employer should have made sure that the purpose of the instructions was understood and that the instructions were followed.

The investigation remained open about what the induced voltage and current would have been at the accident site, if the part being worked on had had temporary earthing that could withstand a short circuit. The instructions for the electrical safety of high-voltage installations (SÄTKY) define the earthing procedures for main and additional earthing referred to in the standard. The basic requirement for earthing at work set out in the nationally binding standard for safety at electrical work and in the European model for the standard is presented ambiguously enough to leave room for an interpretation that is less strict than the original requirement.

11 Actions recommended by the investigation team

1. Those in charge must actually be involved in the assessment of work-related risks and be in close contact with the performance of the work under their responsibility. The supervisory staff must make sure that the importance of the instructions given is understood. The supervisory staff must also ensure that any agreed procedures are followed. An operator coming to do electrical work in Finland must acquire a sufficient knowledge of the national special legislation.

2. According to the introduction to the Finnish standard on safety at electrical work, SFS 6002, the purpose of standardisation is to define over time a uniform European level of safety for operation of electrical installations and work at or in the vicinity of electrical installations. The current standard contains numerous national amendments and references to Finnish legislation, e.g. the Electrical Safety Act, which does not help make the requirements set out in the standard easier to understand or the publication itself easier to read. This is an issue that should be addressed in the standardisation work and the compilation of any instructions supplementing the standard. Companies coming to Finland to perform various electrical work assignments must be able to use the publication as the basis for organising their work in such a way that both the European standard and the Finnish requirements are complied with.

3. Construction of new high-voltage overhead lines usually takes place in existing power line corridors, in consideration of their environmental impact, and makes use of common support structures, for example. Adjacent or intersecting lines pose a challenge for grid construction sites and electrical work safety. Reliable isolation of specific parts of an installation from the supply voltage plays a key role in electrical work safety, as does temporary earthing. The standard on safety at electrical work includes provisions regarding transmission lines in the working zone requiring that special measures should be taken to eliminate the danger of induced voltage from work on electrical installations, for example. The potential between a charged connector and earth can be reduced by earthing the isolated line at appropriate intervals. This section of the standard contains no details on how the earthing should be carried out in the working zone or at the work site.

   The section regarding the temporary earthing of high-voltage installations contains a national additional requirement according to which additional temporary earthing must be carried out at the work site to keep the distance from the temporary earthing below three kilometres.

   However, in the operating instruction for the main grid, on the basis of expert calculations and experiences, it has been deemed necessary to reduce that distance to two kilometres in order to ensure that induced voltage and any current caused by it in the vicinity of power lines will not cause a dangerous electric shock to humans in the event of an accident.

   The danger posed by induced voltage is exceptionally great compared to working on the majority of isolated low- or high-voltage installations. One of the topics addressed during the accident investigation was the procedure for earthing where the safety of a worker depends on a single transportable earthing device.

   Once the grid owner has carried out the main earthing, the contractor will be responsible for carrying out safe additional temporary earthing. As the standards provide no details on how the earthing

should be carried out, the employer must establish reliably any risks involved in the work before the work is begun and take measures required for safe electrical work (see e.g. KTMp 516/1996).

It must be noted before any work is begun that high-voltage testers run on the supply voltage but do not detect induced voltages that are lower than the supply voltage but nevertheless measured in kilovolts.

During the work, the worker is often connected in parallel with an earthing device discharging the charge of the line to earth. If the earthing device becomes detached because of a poor conducting connection, a thoughtless or inadvertent action or an unforeseen event, the worker will be in immediate mortal danger. Because the on-site work conditions in the open air are demanding and the parts handled and the machinery operated are large and the power caused by them great, the possibility of the earthing device becoming detached or a mechanical failure taking place cannot be excluded. This risk is particularly significant if the person is working high on a tower.

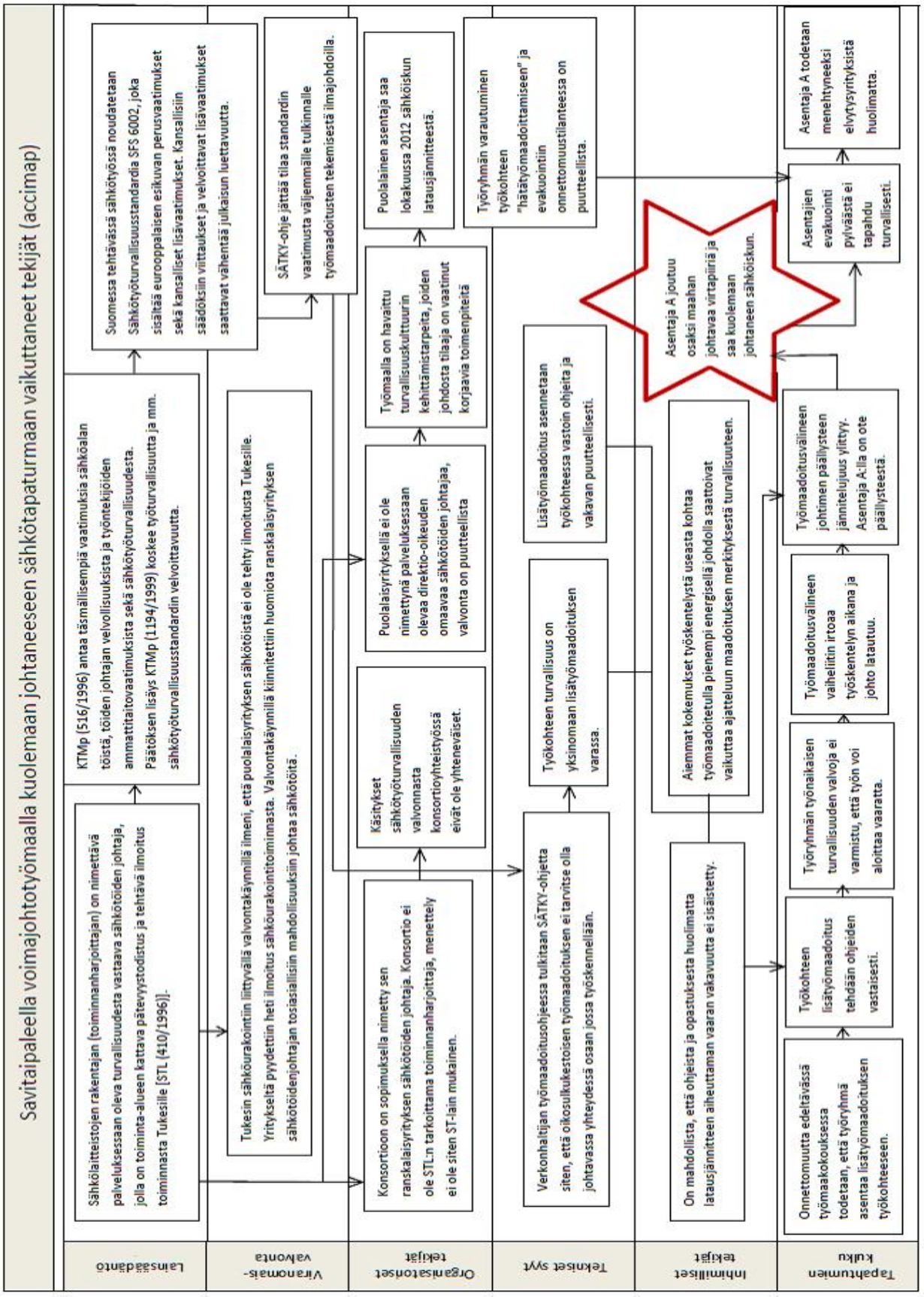
An electric shock from induced voltage will cause serious physiological injuries.

Several serious accidents and dangerous situations have been caused by induced voltage in recent years. In the investigation team's opinion, the instructions on temporary earthing on high-voltage overhead lines supplementing the standard should be subjected to a risk-based review, with the instructions issued by the occupational safety authorities on risk assessment taken into account if necessary.

4. Another issue focused on at the investigation was the team's preparedness for rescuing the workers on the tower at the site of the accident. The rescue operation as it unfolded involved several risk factors. The operators must ensure that there is a plan in place for mitigating the damage and the injuries, and that there will be skilled people and readily available tools for carrying out temporary earthing and rescuing workers from the tower. The client had required in the appendices to the project contract that the site organisation have clear procedures in place for prompt communication with the grid owner's operating centre and the emergency response centre in any emergencies. Rescuing the workers from the poles did not cause any further damage or injuries, and the team's call for help was promptly passed on to the emergency response centre by the Polish foreman and a Finnish employee.

In a statement made concerning the accident investigation report, the Polish employer states that the team had been trained in safe evacuation from a tower and that it had additional temporary earthing devices available. An emergency chart was prepared at the start of the project and used to demonstrate the procedure and phone numbers for calling help. The chart was familiar to all workers on the site.

Accimap


Savitaipaleella voimajohtotyömaalla kuolemaan johtaneeseen sähkötapaturmaan vaikuttaneet tekijät (accimap)
Lainsäädäntö
Viranomais-valvonta
Organisatoriset tekijät
Tekniset syyt
Inhimilliset tekijät
Tapahtumien kulku
Sähkölaitteistojen rakentajan (toiminnanharjoittajan) on nimettävä palveluksessaan oleva turvallisuudesta vastaava sähkötöiden johtaja, jolla on toiminta-alueen kattava pätevyystodistus ja tehtävä ilmoitus toiminnasta Tukesille [STL (410/1996)].
KTMp (516/1996) antaa täsmällisempiä vaatimuksia sähköalan töistä, töiden johtajan velvollisuuksista ja työntekijöiden ammattitaitovaatimuksista sekä sähkötyöturvallisuudesta. Päätöksen lisäys KTMp (1194/1999) koskee työturvallisuutta ja mm. sähkötyöturvallisuusstandardin velvoittavuutta.
Suomessa tehtävässä sähkötyössä noudatetaan Sähkötyöturvallisuusstandardia SFS 6002, joka sisältää eurooppalaisen esikuvan perusvaatimukset sekä kansalliset lisävaatimukset. Kansallisiin säädöksiin viittaukset ja velvoittavat lisävaatimukset saattavat vähentää julkaisun luettavuutta.
Tukesin sähkörakointiin liittyvällä valvontakäynnillä ilmeni, että puolalaisyrityksen sähkötöistä ei ole tehty ilmoitusta Tukesille. Yritykseltä pyydettiin heti ilmoitus sähkörakointitoiminnasta. Valvontakäynnillä kiinnitettiin huomiota ranskalaisyrityksen sähkötöidenjohtajan tosiasiallisiin mahdollisuuksiin johtaa sähkötöitä.
SÄTKY-ohje jättää tilaa standardin vaatimusta väljemmälle tulkinnalle työmaadoitusten tekemisestä ilmajohdoilla.
Konsortioon on sopimuksella nimetty sen ranskalaisyrityksen sähkötöiden johtaja. Konsortio ei ole STL:n tarkoittama toiminnanharjoittaja, menettely ei ole siten ST-lain mukainen.
Käsitykset sähkötyöturvallisuuden valvonnasta konsortioyhteistyössä eivät ole yhteneväiset.
Puolalaisyrityksellä ei ole nimettynä palveluksessaan olevaa direktio-oikeuden omaavaa sähkötöiden johtajaa, valvonta on puutteellista
Työmaalla on havaittu turvallisuuskulttuurin kehittämistarpeita, joiden johdosta tilaaja on vaatinut korjaavia toimenpiteitä
Puolalainen asentaja saa lokakuussa 2012 sähköiskun latausjännitteestä.
Työryhmän varautuminen työkohteen "hätätyömaadoittamiseen" ja evakuointiin onnettomuustilanteessa on puutteellista.
Verkonhaltijan työmaadoitusohjeessa tulkitaan SÄTKY-ohjetta siten, että oikosulkukestoisen työmaadoituksen ei tarvitse olla johtavassa yhteydessä osaan jossa työskennellään.
Työkohteen turvallisuus on yksinomaan lisätyömaadoituksen varassa.
Lisätyömaadoitus asennetaan työkohteessa vastoin ohjeita ja vakavan puutteellisesti.
Asentaja A joutuu osaksi maahan johtavaa virtapiiriä ja saa kuolemaan johtaneen sähköiskun.
On mahdollista, että ohjeista ja opastuksesta huolimatta latausjännitteen aiheuttaman vaaran vakavuutta ei sisäistetty.
Aiemmat kokemukset työskentelystä useasta kohtaa työmaadoitetulla pienempi energiselllä johdolla saattoivat vaikuttaa ajatteluun maadoituksen merkityksestä turvallisuuteen.
Työmaadoitusvälineen johtimen päällysteen jännitelujuus ylittyy. Asentaja A:lla on ote päällysteestä.
Asentajien evakuointi pylväästä ei tapahdu turvallisesti.
Asentaja A todetaan menehtyneeksi elvytysyrityksistä huolimatta.
Onnettomuutta edeltävässä työmaakokouksessa todetaan, että työryhmä asentaa lisätyömaadoituksen työkohteeseen.
Työkohteen lisätyömaadoitus tehdään ohjeiden vastaisesti.
Työryhmän työnaikaisen turvallisuuden valvoja ei varmistu, että työn voi aloittaa vaaratta.
Työmaadoitusvälineen vaihelitin irtoaa työskentelyn aikana ja johto latautuu.

Sources

Tukes' pictorial material from the site of the accident on 18 April 2013.

The police's pictorial material from the site of the accident on 18 April 2013.

Main grid owner's pictorial material

ESA (410/1996), KTMp (516/1996)

Tukes instructions S7-2012, Notification of electrical work

Tukes instructions S10-2012, Standards on the safety of electrical installations and safety at electrical work

Standard of safety at electrical work SFS 6002, second edition

Instructions for the electrical safety of high-voltage installations (SÄTKY)

Operating and electrical work safety in the main grid instructions, and the supplementary operating instructions concerning temporary earthing, prepared in 2011

Tukes inspection record 8/TVP/13

With regard to risk assessment, the occupational safety authority's website:

Appendix

Excerpts from legislation applying to the accident

Electrical Safety Act 14.6.1996/410

Chapter 3

Work in the electricity sector

Section 8

Work related to the repair and servicing of electrical equipment, and work related to the construction, repair, servicing and use of electrical installations shall be authorised on the following conditions:

(1) a sufficiently qualified natural person is appointed to direct the work (*supervisor*);

(2) a natural person independently carrying out and supervising work possesses sufficient qualifications or otherwise has sufficient professional skills; and

(3) premises and tools necessary for carrying out the work are used, and the provisions and regulations on electrical safety are observed.

No supervisor is required for one-time work, as laid down in more detail by the Ministry, or for work that may cause only a minor risk or interference referred to in Section 5. Furthermore, the Ministry may determine when no supervisor is required for work related to operation and servicing.

The Ministry shall issue further provisions on the conditions mentioned in paragraph (1).

Section 9

The supervisor shall ensure that the work referred to in Section 8(1) complies with the provisions of Section 5 and the provisions laid down pursuant to Section 6. The supervisor shall have an actual possibility of performing his duty. (21.12.2007/1465)

The supervisor referred to in Section 8(1) shall himself be the operator or shall be in the service of the operator, unless otherwise provided by the Ministry on work related to operation and servicing.

The same person may be appointed as the supervisor of the electrical or lift work of no more than three operators at the same time. (3.12.2010/1072)

The Ministry shall issue more detailed provisions concerning the tasks of the supervisor.

Section 10

The qualifications referred to above in Section 8(1)(1) shall be evaluated and a certificate of qualification issued by an evaluation body the appointment of which is made by application and revoked by the Electrical Safety Authority. (2.4.2004/220)

In addition to the qualifications referred to in paragraph (1), the evaluation body may also evaluate other qualifications based on this Act, as laid down in more detail by Decree or decision of the Ministry.

The evaluation body shall meet the requirements laid down by Decree and shall demonstrate that this is the case. The Electrical Safety Authority shall supervise the activities of the evaluation body and ensure that compliance with the stipulated requirements is verified regularly. (2.4.2004/220)

Section 11

The Electrical Safety Authority may decide that the qualifications of a natural person referred to in Section 8 may also be demonstrated by presenting a foreign certificate of qualification or an equivalent document. In this case, it is a prerequisite that the requirements laid down with respect to education and work experience correspond to the requirements laid down by virtue of Section 8(3), and that the provisions and regulations on electrical safety of the country in question correspond in essence to the provisions and regulations in force in Finland.

However, the appropriate Directive of the European Community is applied to the recognition of formal qualifications and professional competence acquired in another member state of the European Economic Area as laid down in more detail by a Decree of the Ministry. (8.11.2002/913)

Section 12

A person carrying out operations referred to above in Section 8(1), shall, for the purpose of surveillance, notify the Electrical Safety Authority thereof. Furthermore, the Electrical Safety Authority shall be notified of changes concerning the supervisor and of other significant changes affecting the operations.

The Ministry shall issue further provisions on the notifications mentioned in paragraph (1). Furthermore, the Ministry may provide that the notifications referred to in paragraph (1) need not be made on work related to operation and servicing, nor in the case where the operation can be considered non-recurring or otherwise limited.

Section 52 a(2.4.2004/220)

The police, rescue services and labour protection authority and the owner of the distribution grid in the distribution area must notify the Electrical Safety Authority of any electrical incident causing a serious accident. The definition of a serious accident is laid down in more detail in a Decree of the Government.

The Electrical Safety Authority must investigate the accident, if the Authority deems it necessary for the purpose of determining the cause of the accident or for preventing further accidents.

Decision of the Ministry of Trade and Industry on electrical works 5.7.1996/516

KTMp (516/1996, 1194/1999)

The Ministry of Trade and Industry has passed the following decree in accordance with the Electrical Safety Act of 14 June 1996 (410/96):

Chapter 1

Definitions

Section 1

Electrical work refers to the repair and servicing of electrical equipment and the construction, repair and servicing of electrical installations.

Electrical work is not considered to include the demolition of electrical equipment and installations if the equipment or installation in question has been reliably and duly de-energized.

Operational work refers to operational measures for electrical installations and the related repair and servicing work, as well as electrical installation inspections. (17.12.1999/1194)

Chapter 2

Work Supervisors

Section 2

The person or organisation engaged in electrical work shall appoint a *Supervisor for Electrical Works* for electrical work. However, a Supervisor for electrical works is not required for electrical work which does not require notification to the Electrical Safety Authority in accordance with the provisions laid down in Chapter 4.

The possessor of the Electrical installation shall appoint a *Supervisor for Operational Works* for operational work if:

(1) the electrical installation includes parts with a nominal voltage exceeding 1,000 volts, not including electrical equipment with a nominal supply voltage not exceeding 1,000 volts or comparable installations, or

(2) if the connection capacity of the electrical installation, i.e. the sum of the connection capacities of the connections installed in the building of the possessor of the electrical installation or in a corresponding group of buildings, exceeds 1,600 kilovoltamperes.

Section 3

The Supervisor for Operational Works must be either the possessor of the electrical installation or in the employ of the possessor. The Supervisor for Operational Works can also be a person in the employ of an organisation that has an electrical equipment maintenance agreement with the electrical installation possessor. In addition, a person who is not in the employ of the possessor of the electrical installation can serve as Operational Supervisor when the electrical installation includes no more than three (3) transformer substations each not exceeding 20 kilovolts nominal voltage, or separate power distribution stations comparable to a transformer substation of a nominal voltage of more than 1,000 volts.

The stipulations of the Electricity Market Decree (518/95) apply to the service relationship of the electrical network operator’s Supervisor for Operational Works.

Section 4

The person or organisation engaged in electrical work must grant the Supervisor for Electrical Works sufficient opportunities to manage and supervise the electrical work.

Likewise, the possessor of the electrical installation must grant the Supervisor for operational works sufficient opportunities to manage and supervise operational work. Furthermore, the possessor of the electrical installation must provide the Supervisor for operational works with the required information on electrical installation construction and repair work and the related inspections.

Section 5

The Supervisor for Electrical Works must ensure that:

(1) the Electrical Safety Act (410/96) and the statutes and regulations issued under it are followed in all electrical work;

(2) the condition of electrical equipment and installations meets the requirements of the Electrical Safety Act and the statutes and regulations issued thereof prior to commissioning, or handing over to another party; and

(3) the persons carrying out electrical work have adequate professional skills and are sufficiently instructed in their duties.

The Supervisor for Operational Works must ensure that:

(1) the Electrical Safety Act and the statutes and regulations issued thereof are followed in the use and maintenance of the electrical installation; and

(2) the persons carrying out operational work have adequate professional skills and are sufficiently instructed in their duties.

The Supervisor for Electrical Works and the Supervisor for Operational Works must be familiar with the currently valid electrical safety requirements and otherwise constantly maintain their professional skills. (6.5.2010/351)

Section 6

The Electrical Safety Authority can, if deemed necessary, demand an inquiry into the competency of the Supervisor for Electrical Works and the Supervisor for Operational Works to carry out their duties and other tasks mentioned in Sections 4 and 5.

Section 7

The person or organisation engaged in electrical work shall appoint a Supervisor for Electrical Works prior to commencement of the work.

The possessor of the electrical installation shall appoint a Supervisor for Operational Works within three months of the commissioning of the electrical installation.

A new Supervisor for Electrical Works and Supervisor for Operational Works shall be appointed within three months of the supervisor in question being changed or prevented from carrying out his/her duties for reasons other than a brief absence.

Section 8

If the Electrical Safety Authority finds that the duties of the Supervisor for Electrical Works or Supervisor for Operational Works are being executed incorrectly or inappropriately, the authority can, under Section 26 of the Electrical Safety Act, bar him/her from acting as the Supervisor either for a determined period or indefinitely, or restrict their existing right to act as a Supervisor.

In the event of the above, the Electrical Safety Authority must immediately notify the person or organisation engaged in electrical work of its suspension of, or restrictions imposed upon, the Supervisor for Electrical Works, and the possessor of the electrical installation of its suspension of, or restrictions imposed upon, the Supervisor for Operational Works.

Decision of the Ministry of Trade and Industry on electrical works

KTMp (516/1996, 1194/1999)

Section 1

Electrical work refers to the repair and servicing of electrical equipment and the construction, repair and servicing of electrical installations.

Operational work refers to operational measures for electrical installations and the related repair and servicing work, as well as electrical installation inspections.

Section 5

The Supervisor for Electrical Works must ensure that:

(1) the Electrical Safety Act (410/96) and the statutes and regulations issued under it are followed in all electrical work;

(2) the condition of electrical equipment and installations meets the requirements of the Electrical Safety Act and the statutes and regulations issued thereof prior to commissioning, or handing over to another party; and

(3) the persons carrying out electrical work have adequate professional skills and are sufficiently instructed in their duties.

The Supervisor for Operational Works must ensure that:

(1) the Electrical Safety Act and the statutes and regulations issued thereof are followed in the use and maintenance of the electrical installation; and

(2) the persons carrying out operational work have adequate professional skills and are sufficiently instructed in their duties.

Chapter 4 a

Electrical safety at work

Section 29 a

This Chapter is applicable to electricity sector work which poses a hazard for an electric shock or an electric arc.

However, the Chapter is applied to the electrical work specified in Section 10 only where applicable in order sufficiently to ensure safety.

In addition, the Chapter is applicable to other work in the vicinity of the electrical installation as stipulated in Sections 29 b and 29 h–29 k.

Section 29 b

Before electrical work or other work in the vicinity of the electrical installation is initiated,
the structure of the electrical installation must be reliably determined, a risk assessment regarding work related hazards must be carried out and all necessary measures taken in regard to electrical work safety.

Electrical work must be carried out using established work methods that have been found to be safe. If, however, the method applied to the work is unusual or new, any risk factors related to the method must be assessed and taken into account.

Section 29 c

For all work locations, a person as referred to in Section 11 must be appointed to supervise electrical work safety on site. The said person can him/herself participate in or execute in full the electrical work in question.

Section 29 d

If necessary for the purposes of electrical work, method-specific or work-specific written instructions which fulfil the requirements set out in this Chapter must be drawn up.

The currently valid standards and instructions applicable to the work in question must be kept readily available to the worker.

The worker must be provided with training and guidance that is relevant to the demands of the work in question. The worker's full understanding of the information provided must be verified through questioning or other suitable means.

Section 29 e

In electrical work, safe tools and equipment either specifically designed for or otherwise suitable for the work in question must be used, the safety of which must be verified as necessary both prior to commencement of the work and during the course of the work.

Section 29 f

Electrical installations undergoing electrical work must be isolated from the supply to a de-energised condition. However, operational work on an electrical installation may be carried out when the electrical installation is live if the work is done with sufficient care so as to avoid the hazard of electric shock or electric arc.

An electrical installation is considered de-energised if the following measures are carried out before commencing work:

(1) the work location has been reliably disconnected from the operating voltage at all points of supply;

(2) re-connection of the voltage to the work location during the work has been reliably prevented;

(3) the work location has been reliably verified as de-energised;

(4) the work location has been grounded using the appropriate tools if the nominal voltage of the electrical installation is more than 1,000 volts or if the work location consists of an open wire or high-current switchboard;

(5) the live parts of the electrical installation in the near vicinity of the work location have been reliably isolated from contact with the areas undergoing electrical work or from areas which can be entered or touched when performing the work, taking into consideration the tools and equipment used.

Supply may be re-connected to the electrical installation undergoing electrical work only when all work has terminated, the earthings have been removed and the installation has been verified in all respects as being safe to re-connect.

Section 29 g

As distinct from Section 29 f, electrical work may be carried out on unprotected live parts of an electrical installation if isolation of the electrical installation from its power source causes major drawbacks and the work is carried out in accordance with Paragraph 2, so that no electric shock or electric arc hazard is caused.

The work referred to in Paragraph 1 above must observe the following:

(1) the work is carried out by persons specified in Section 11 and who are specially trained and familiar with the work method in question;

(2) sufficient written instructions are provided for the work in question;

(3) tools and equipment used are designed for the work in question and are verified to be safe;

(4) the safety of the workers and others during the work project is ensured by implementing safety measures that meet the special requirements of the work location conditions; and

(5) the work does not increase the risk of explosion, fire or other such hazard.

Section 29 h

During electrical work and when entering or leaving the work location, the person carrying out the work must not either intentionally or unintentionally be able to come into contact with unprotected live parts or have close access to such parts In the definition of safety distances, the voltage level of the electrical installation and the tools and working method used must each be taken into consideration.

When necessary, the safe work zone must be marked with warning signs and cordoned off with reliable barriers or protective shields.

If a work space extends so close to non touch-protected live parts of the electricity installation that electrical work safety may be compromised, the parts must be reliably isolated from the working space or work carried out must observe the regulations stipulated in Sections 29 f and 29 g.

Section 29 i

The procedures observed in Finland, prevailing working conditions and structural properties of the electrical installations must be taken into consideration in all work included within the scope of application of this Chapter.

Work is considered to meet the safety requirements specified in this Chapter if the standards or publications applied in its implementation have been confirmed as corresponding with safety requirements in accordance with Section 29 j.

If necessary, the fulfilment of safety requirements can be demonstrated as distinct from Paragraph 2 if the requirements specified in Section 29 k are observed.

Section 29 j

The standards referred to in this Decree refer to publicly available technical specifications approved by an official standardisation body.

The Electrical Safety Authority, on the basis of the Electrical Safety Advisory Committee statement, maintains a register of safety requirement compliant standards approved by it and ensures the public availability of this register.

If no standards have been drawn up for certain work methods or electrical installations, publications comparable to existing standards and which correspond with safety requirements approved in accordance with Paragraph 2 may be applied.

The Electrical Safety Authority shall remove any reference to a standard or publication or part thereof from the register confirmed by it if application of the said standard or publication presents a significant hazard, and shall update the register of safety requirement compliant standards in accordance with Paragraph 2.

Section 29 k

If electrical work deviates from the existing standards or publications regarding safety requirements, a written report must be drawn up prior to commencement of electrical work regarding the fulfilment of safety requirements.

The written report regarding deviation from existing safety standards must include details of the following:

(1) alternative measures taken to fulfil safety requirements;

(2) a description of how these measures meet safety requirements; and

(3) the identification and signature of the author of the report.

The report can be supplemented with a statement by an authorised body or inspector as specified in Section 23 of the Electrical Safety Act appointed to inspect the electrical installation, to determine whether the electrical work method in question meets safety requirements.

Tukes instructions S10-2012

STANDARDS ON THE SAFETY OF ELECTRICAL INSTALLATIONS AND SAFETY AT ELECTRICAL WORK

1 General

Decision of the Ministry of Trade and Industry 1193/1999 (amended 517/2011) applies to the safety of electrical installations and Decision 1194/1999 applies to the safety at electrical work. The essential safety requirements stipulated in the decisions are considered to be fulfilled if certain safety standards or comparable publications are applied. The task of the Electrical Safety Authority, or the Finnish Safety and Chemicals Agency (Tukes), is to confirm such a list of standards and publications on the basis of a statement by the Electrical Safety Advisory Committee.

With these Tukes instructions, the Finnish Safety and Chemicals Agency confirms the lists of standards presented in Sections 2 and 3.

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3 STANDARDS APPLYING TO SAFETY AT ELECTRICAL WORK

The following standards correspond to the essential safety requirements presented in the Decision of the Ministry of Trade and Industry 1194/1999:

• SFS 6002 (2005) *Electrical safety at work*
The previous edition of the listed standard

According to Section 29 i of KTMp 516/1996 (amended 1194/1999) "The procedures observed in Finland, prevailing working conditions [...] must be taken into consideration". For this reason, the new 2005 edition of standard SFS 6002 should be adopted as soon as possible and, at the latest, when the personnel carrying out electrical work is next given training and instruction in accordance with Section 29 d of KTMp; according to the standard, this training and instruction must be repeated at intervals no longer than five years.

4 Entry into effect

These Tukes instructions will come into effect upon its publication and will be valid until further notice. The instructions are usually updated once per year due to updates to the standards. These Tukes instructions replace instructions S10-2011, 1.6.2011.

Excerpts from sections of the standard on safety at electrical work applying to the accident:

SFS standard 6002 (2005), Electrical Safety at Work (key excerpts of the standard with regard to the accident)

This Finnish standard SFS 6002:2005 includes a Finnish translation of the European standard EN 50110-1:2004, “Operation of electrical installations” and the Finnish national amendments in accordance with standard EN 50110-2:1996. The national amendments are marked with a sideline.

Standard EN 50110-1:2004 has been confirmed in English. In cases of conflict, the English text of standard EN 50110-1:2004 shall take precedence.

With regard to the national amendments, the Finnish text shall take precedence.

National foreword

The national amendments form a part of the actual content of the standard and are based on Finnish legislation, or stipulate the requirements to be followed in Finland in such parts of the standard where EN 50110-1 leaves stipulations to the national parts.

Binding regulations on safety at electrical work are stipulated in the Decision of the Ministry of Trade and Industry
on electrical works (516/1996) and its amendment
(1194/1999). This standard is a confirmed standard as per Section 29 i of the decision, and compliance with it
will fulfil the safety requirements.

3.2 Personnel, organisation and communication

3.2.1

fi työstä vastaava henkilö

***en* nominated person in control of a work activity**

Nominated person with ultimate responsibility for the work activity. Some of these duties can be relegated to
others as required.

Guiding information

The Supervisor for Electrical Works is a person appointed by the person or organisation engaged in electrical work defined in the Decision of the Ministry of Trade and Industry on electrical work (516/1996). In the decision, certain tasks have been appointed to him/her, and he/she has been appointed responsible for the electrical work. In this standard, the person appointed as the supervisor of electrical safety during work in accordance with Section 29 c of the Decision of the Ministry of Trade and Industry on electrical work (516/1996) is called the supervisor of electrical work safety. Said person can him/herself participate in or execute in full the electrical work in question. In accordance with Section 11 of the Decision, the supervisor of electrical safety during work must be a professional electrician capable of independent work.

3.2.2

fi käytöstä vastaava henkilö

***en* nominated person in control of an electrical installation**

Nominated person with ultimate responsibility for the operation of the electrical installation. Some of these duties can be delegated to others as required.

3.4.6

fi erottaminen

***en* isolate**

To disconnect completely a device or circuit from other devices and circuits by creating a physical separation able to withstand the anticipated voltage differences between the device or circuit and other circuits.

4.2 Personnel

Additional national requirement

With regard to the personnel and the organisation, the requirements valid in Finland must also be complied with in addition to the requirements of the EN standard. These requirements are presented in the binding Annex X and the Decrees referred to in it. Should there be a conflict between the requirements of the EN standard and the national requirements, the national requirements valid in Finland shall take precedence.

The responsibilities placed upon persons for the safety of those engaged in a work activity and those who are or may be affected by the work activity shall be in accordance with national legislation. All personnel involved in a work activity on, with, or near an electrical installation shall be instructed in the safety requirements, safety rules and company instructions applicable to their work. These instructions shall be repeated during the course of the work where the work activity is of long duration or is complex. The personnel involved shall be required to comply with these requirements, rules and instructions. Personnel shall wear clothing suitable for each work activity. This could include wearing protective clothing or personal protective equipment. Before any work activity is started and during the work activity, the nominated per-

son in control of that work activity shall ensure that all relevant requirements, rules and instructions are complied with. The nominated person in control of the work activity shall instruct all persons engaged upon the work activities of all reasonably foreseeable dangers that are not immediately apparent to them. No person shall undertake any work activity where technical knowledge or experience is needed to prevent electrical danger or injury, unless that person has such technical knowledge or experience, or is under such supervision as is necessary for the work undertaken. National legislation can set out the minimum age and the criteria for competence of persons. Where there are no national requirements for competence, the following criteria shall be used in assessing the competence of a person:

- knowledge of electricity;

- experience of electrical work;

- understanding of the installation to be worked on and practical experience of that work;

- understanding the hazards which can arise during the work and the precautions to be observed;

- ability to recognise in all situations whether it is safe to continue working.

The complexity of the work shall be assessed before the activity starts such that the appropriate choice of skilled, instructed or ordinary persons is made for carrying out the work activity.

4.3 Organisation

The nominated person in control of the work activity and the nominated person in control of the electrical installation shall agree both the arrangements of the electrical system to allow the work to take place and a description of the work activity on, with or near the electrical installation before any changes to the arrangements of the electrical installation are made
or work takes place

Each work activity shall be the responsibility of the nominated person in control of the work activity. Where the work activity is subdivided it may be necessary to nominate a person to be responsible for the safety of each subdivision, all under the responsibility of one coordinating person.

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6 Working procedures

6.1 General

Before starting any work it shall be planned.

According to the basic principles, either the nominated person in control of the electrical installation or the nominated person in control of the work activity shall ensure that specific and detailed instructions are given to the personnel carrying out the work before starting and on completion of the work.

Before starting work, the nominated person in control of the work activity shall give notification to the nominated person in control of the electrical installation, of the nature, place and consequences to the electrical installation of the intended work. It is preferable that this notification is given in writing, especially for complex work.

Only the nominated person in control of the electrical installation shall give permission for the work to be carried out. This procedure shall also be followed in the case of any interruption of the work activity and at the end of the work.

Additional national requirement

The person supervising electrical safety during the work can give permission to start, interrupt and end work in work activities that are easily manageable, work activities on installations that are easily manageable, or maintenance work activities carried out following agreed procedures, see Section 4.3 and Annex X. In such work activities, separate permissions from the nominated person in control of the work activity or the nominated person in control of the electrical installation are not required; the Supervisor for Electrical Works or the Supervisor for Operational Works can define the procedure, for example with standing written instructions. During live working, however, procedures in accordance with Annex Y shall be used.

Working procedures are divided into three different procedures: dead working (see 6.2), live working (see 6.3), and working in the vicinity of live parts (see 6.4). All these procedures are based on the use of protective measures against electric shock and/or the effects of short-circuits and arcing. If the requirements of 6.2 (dead working) or 6.4 (working in the vicinity of live parts) cannot be fully met then the requirements of 6.3 (live working) shall be observed. The insulation level for working shall be ensured by, for example interposing solid insulation material or the use of distance in air (see 6.3 and 6.4). The use of distance in air is explained in standard IEC 61472.

6.1.1 Induction

Conductors or conductive parts in the proximity of live conductors may be electrically influenced. In addition to the following requirements of 6.2 and 6.4, specific precautions shall be taken when working on electrical systems influenced by induction (this is particularly so for work on overhead lines):

- by earthing at adequate intervals in order to reduce the potential between conductors and earth at a safe level;
- by equipotential bonding at the work location in order to avoid the possibility of workers inserting themselves in an induction loop.

6.2 Dead working

This subclause deals with the essential requirements for ensuring that the electrical installation at the work location is dead and secure for the duration of the work. This shall require clear identification of the work location.

After the respective electrical installations have been identified the following five essential requirements shall be undertaken in the specified order unless there are essential reasons for doing otherwise:

- disconnect completely;
- secure against re-connection;
- verify that the installation is dead;
- carry out earthing and short-circuiting;
- provide protection against adjacent live parts.

Permission to start work shall be given by the nominated person in control of the electrical installation to the

nominated person or persons in control of any work activity. Any person engaged in this work activity shall be skilled or instructed or shall be supervised by such a person.

6.2.1 Disconnect completely

The part of the installation on which work is to be carried out shall be disconnected from all sources of supply. The disconnection shall take the form of an air gap or equally effective insulation which will ensure that the point of disconnection does not fail electrically.

If supply can be connected from more than one direction, or if the installation otherwise has multiple connection possibilities, the work location must be made dead with particular care in order to avoid mistakes.

6.2.2 Secure against re-connection

6.2.3 Verify that the installation is dead

The dead condition shall be verified on all poles of the electrical installation at or as near as practicable to the work location. This condition for parts of the installation which have been made dead shall be verified in accordance with the practice laid down in local instructions. These include, for example, the use of voltage detecting systems built into the equipment and/or the use of separately applied voltage detecting systems. These latter devices shall be proved immediately before and where possible after use. In the case of cable connected electrical installations, if the dead cables cannot be positively identified at the work location, other means of ensuring safety shall be adopted in accordance with established local practice. This may include the use of suitable cable cutting or piercing devices.

Where remotely controlled earthing switches are used to verify that an electrical installation is dead, the switch position of the earthing switch shall be reliably signalled by the remote control system.

Additional national requirement

The dead condition must always be verified before starting work on an electrical installation made dead. If work is interrupted and the personnel leave the work location in such a manner that the work location cannot be monitored by yourself or by the working team carrying out the work, the dead condition must be verified again before continuing the work. Verification of the dead condition is not required, however, when it has been ensured that the work location has been temporarily earthed.

6.2.4 Earthing and short-circuiting

6.2.4.1 General

At the work location for all high and some low voltage installations (see 6.2.4.2), all parts which are to be worked on shall be temporarily earthed (earthed and short-circuited). Earthing and short-circuiting equipment or devices shall be first connected to the earthing point and then to the components to be earthed. The earthing and short-circuiting equipment or devices shall be visible, whenever possible, from the work location. Otherwise, the earth connections shall be applied as close to the work location as is reasonably practical.

Where during the course of the work activity conductors are to be broken or joined and there is danger from potential differences on the installation, suitable measures such as bonding and/or earthing shall be taken at the work location before the conductors are broken or joined.

In all cases it shall be ensured that the earthing and short-circuiting equipment or devices and cables and connectors for bonding used for this purpose are suitable and adequately matched to the fault rating of the electrical installation where they are installed.

Precautions shall be taken to ensure that the earths remain secure during the time the work is in progress. If during measurement or testing the earth connections are removed additional or alternative special precautions to prevent danger shall be taken.

Where remotely controlled earthing switches are used to earth and short-circuit an electrical installation, the position of the earthing switch shall be reliably signalled by the remote control system.

Additional national requirement

Temporary earthing prevents the work location from becoming dangerously live because of incorrect use or malfunction of the switchgear used for isolation or because voltage is supplied to the installation for other reasons. These kinds of situations may be caused by generators or control voltages connected to the equipment or by adjacent or intersecting lines, for example. In such cases, the temporary earthing must be carried out separately for high voltage and low voltage.

Before temporary earthing, the dead condition of the part of the electrical installation to be temporarily earthed must be verified using a voltage detector or other similarly reliable method. If the temporary earthing is carried out using, for example, the earthing switch of an installation with an enclosed structure, or in some other manner where operation is safe even when the installation is live, the dead condition does not need to be verified with a voltage detector. In this case, as well, verification of the dead condition is recommended, for example using the installation's voltage indicators.

The temporary earthing must be carried out in such a manner that the triggering of an overcurrent protector or the opening of a switchgear

does not make the temporary earthing ineffective. Any overcurrent protectors between the work location and the temporary earthing must be bypassed, and all switchgear must be secured to the closed position.

Guiding information

Temporary earthing shall be carried out using temporary earthing devices with a fixed installation (earthing switches) when they are available. If fixed-installation devices are not available, the temporary earthing can be carried out using transportable temporary earthing devices, to which standard SFS-EN 61230 applies.

The transportable temporary earthing devices must be attached to earthing brackets complying with standard SFS 3742 on the electrical installation or other suitable fastening points, and the entire installation must withstand any fault currents present.

If two transportable temporary earthing devices must be connected in parallel due to current resistance reasons, the following requirements must be taken into consideration:

— both devices must have identical conductor cross section, length and connecting parts;

— the earthing brackets or fastening points on the same conductor may be at a maximum distance of 100 mm from each other; and

— the maximum allowed current is 1.6 times the current resistance of one device.

The written connection schedule shall present the number, location and the order of installation and removal of the temporary earthing devices.

Temporary earthing shall be carried out primarily using a fixed earthing electrode, a protective or PEN conductor, an underground anchor rod or similar. If a fixed electrode cannot be used, a temporary earthing electrode formed by a pipe or a bar reaching a minimum of 0.8 metres into the ground or other at least equivalent earthing device shall be used. No persons are allowed in the immediate vicinity of the temporary electrode during the connection to or disconnection from the conductors being earthed.

6.2.4.3 Requirements for high voltage installations

For bare overhead lines and bare conductors, earthing and short-circuiting shall be carried out on all sides of the work location on all conductors entering this location. At least one piece of temporary earthing equipment or device must be visible from the work location. These rules have the following exceptions:

— for a specific work activity, where there is no break in conductors during work, the installation of a single earthing and short-circuiting device at the work location is acceptable;

— where it is not possible to see earthing and short-circuiting equipment or devices at the limits of the work location, locally applied earthing equipment or device or additional signalling devices or any other equivalent identification shall be provided.

When working on only one conductor of an overhead line, no short-circuiting is required at the work location, provided all the following conditions are fulfilled:

— all points of separation are earthed and short-circuited in accordance with 6.2.4.1;

— the conductor upon which the work is being carried out and any conducting parts within the work location are bonded and earthed by suitable equipment or devices;

— the earthed conductor, the work location and the worker are at a distance greater than *D*L (see Figures 1 and 2) from the remaining conductors of the same electrical circuit.

For insulated overhead lines, cables or other insulated conductors, earthing and short-circuiting shall be carried out on the bare part of the points of separation of the installation or as close as possible to those points on all sides of the work location.

Additional national requirement

However, the temporary earthing does not have to be visible in the work location if no conductors are broken or will be cut during the work and the line is a single branch line or a line fed from two sides and the lines are easily identifiable to prevent any risk of mistake. In such a case, temporary earthing with short-circuit current capability in the vicinity of the isolation point(s) shall be sufficient. If the work location is more than 3 km away from the temporary earthing, additional temporary earthing must be carried out to ensure that the 3km distance is not exceeded.

6.2.6 Permission to start work

The authorisation of the nominated person in control of the electrical installation is a necessary condition. The permission to start work shall be given to the workers only by the nominated person in control of the work activity and only after the measures detailed in 6.2.1 to 6.2.5 have been carried out.

NOTE! Normally for HV work, formal written details of disconnections and earthing, where appropriate, should be used to avoid misunderstandings.

Additional national requirement

Permission to start an individual task may be given by the supervisor of electrical safety at work.

If there are several teams working in the same work location made dead, permission to start work can only be given by one nominated person in control of the electrical installation, supervising the entire work location.

Guiding information

Detailed instructions on making connections are particularly important in electrical installations with several operators, or the work location is connected to the electrical installations with several different owners.

Annex X

(national, binding)

Requirements on personnel and the organisation of safety at electrical work

X.1 Requirements in effect in Finland

General requirements on safety at work and the responsibilities of different people are set forth in, for example, the following statutes:

— Occupational Safety and Health Act (738/2002)

— Employment Contracts Act (55/2001)

— Government Decision on the Safety of Construction Work (629/1994)

— Government Decision concerning the acquisition, safe use and inspection of machinery used at work and other work equipment (856/1998)

— Decree of the Ministry of Social Affairs and Health concerning a register of examples of work that is considered particularly harmful and dangerous for young workers (128/2002)

— Government Decree on prevention of the danger caused by explosive atmospheres (576/2003).

Requirements particularly for the safety at electrical work are set forth in the following statutes.

— Electrical Safety Act (410/1996)

— Electrical Safety Decree (498/1996)

— Decision of the Ministry of Trade and Industry on electrical work (516/1996) and its amendment (1194/1999).

Only the original statute number is given in the above list. Most statutes have been amended later, and the amendments must also be taken into consideration. The above-mentioned statutes are binding, and they must be taken into consideration when applying the standard.

X.2 Personnel requirements

The qualification requirements for persons participating in electrical work are set forth in the Decision of the Ministry of Trade and Industry on Electrical Works (KTMp 516/1996).

In accordance with Section 9 of the Decision, all persons carrying out work in the electricity sector must be sufficiently oriented or instructed in the electrical work in question and the related electrical safety requirements. This general requirement applies to skilled, instructed and ordinary persons.

Section 10 presents the work tasks that are allowed for persons oriented or instructed in the task with no special qualifications. A professional electrician as per the standard is considered to be a person who is sufficiently skilled to execute and supervise the execution of of electrical and operational work independently and within his/her own field of expertise in accordance with Section 11 of KTMp (516/1996). The standard mostly refers to a professional, specifically referring to the professional electrician defined in the above statute.

An instructed person referred to in the standard can mean a person of two different types:

(a) a person who is acquiring the competence of a professional electrician in accordance with Section 11 of KTMp (516/1996) and who has training and/or work experience in the electrical sector, but who does not in all aspects fulfil the requirements of a skilled person capable of independent work; or

(b) a person with no training or work experience in the electrical sector, but who has been instructed to carry out a specific procedure, such as replacing a fuse or taking a measurement related to testing during equipment manufacturing.

The training and experience in the electrical sector of an instructed person defined in item (a) must be taken into consideration when determining what work tasks are allowed to him/her and what level of supervision is required. A person defined in item (a) may perform all work tasks allowed to instructed persons in

accordance with the employer's discretion and the training and experience the person has received thus far. A person defined in item (b) may

only perform the specific work tasks at the specific work locations for which he/she has been specifically instructed.

X.3 Instruction and guidance concerning work tasks

According to Section 14 of the Occupational Safety and Health Act (738/2002), the employer is responsible for the instruction and guidance provided to the employee.

According to Section 2 of KTMp (516/1996), the person or organisation engaging in electrical work shall appoint a Supervisor for Electrical Works, and the possessor of the electrical installation must, in certain cases, appoint a Supervisor for Operational Works for operational work. According to Section 5 of the Decision, the Supervisor for Electrical Works must ensure that the persons carrying out electrical work have adequate professional skills and are sufficiently instructed in their duties. The Supervisor for Operational Works must ensure that the persons carrying out operational work have adequate professional skills and are sufficiently instructed in their duties. In electrical sector work where a Supervisor for Electrical Works is not required, for example

at electrical schools and testing laboratories, the person responsible for the work must be separately appointed in writing.

The responsibility concerning training and instruction as set forth in Section 4.2 of the standard generally belongs to the employer according to Finnish law. With regard to electrical sector work, the Supervisor for Electrical Works and the Supervisor for Operational Works are also responsible. According to Section 16 of the Occupational Safety and Health Act, the employer may appoint another person to represent him or her (employer's substitute) to take care of the duties imposed on the employer.

General training on safety at electrical work must be given to all persons performing electrical sector work, including persons in supervisory, operating and expert tasks. Said training must include at least the following:

— dangers caused by electricity and accidents caused by electricity; and

— the contents of the key statutes on electrical work safety and this standard.

The contents of the training must take into consideration the tasks carried out by the persons participating in the training. For example, the training for persons working with high voltage installations is recommended to include the generally used common safety principles of operational works in use in the sector.

Full understanding of the information provided must be verified through questioning or other suitable means.

A certificate or a corresponding document must be issued for the training. The certificate can be issued, for example, in a card format. The employer is recommended to maintain a file containing information on the electrical work safety training received by his/her employees.

In order for the information to constantly meet the requirements of the work, the general electrical work safety training shall be repeated at a maximum interval of five years. The training is recommended to be

repeated at shorter intervals when essential changes take place in the employee's duties or requirements related to electrical work safety.

In addition to the general electrical work safety training, it is necessary to provide the employees with guidance, particularly when implementing new work methods or carrying out exceptional work.

The general electrical work safety training can only discuss the matters related to work tasks performed on a live part and live working issues only insofar as required to understand the special nature of live working. Training on the actual performance of live working is given separately in accordance with Section 6.3.2 and Annex Y.

When other work is performed on an electrical installation or in its vicinity, for example cleaning, transport, lifting or forestry, suitable guidance in electrical safety must be provided for the persons performing the work.

The general provision on preparedness to give first aid is set forth in the Occupational Safety and Health Act. In addition to this, special care must be taken in order to have the preparedness to give first aid in case of accidents caused by electricity. For this reason, all professional electricians participating in electrical work, including the supervision of works and supervision of operations, and the persons instructed in providing assistance in these tasks, need to be given first aid training; the training can be arranged, for example, as follows:

— A Finnish Red Cross emergency first aid course, particularly adapted to first aid for electrical accidents;

— a more extensive first aid course arranged by the Finnish Red Cross , for example the first aid basic course EA1

— other first aid training that covers at least the first aid given for burns, crushes and cuts, and the teaching of mouth-to-mouth resuscitation and related practical training.

First aid skills need to be constantly maintained. For this reason, first aid methods should be practised at least every three years. Tables giving first aid instructions should be placed in electrical repair shops and electrical laboratories

(cf. eg. SFS 6000 Chapter 803); additionally, these tables are recommended to be placed in equipment rooms and electrical staff lounges.

X.4 Supervision of the safety of electrical sector works

The employer (employer's substitute), the Supervisor for Electrical Works and the Supervisor for Operational Works will ensure on a general level that the Occupational Safety and Health Act, the Electrical Safety Act, and the statutes and regulations issued thereof are followed in electrical work and the operation and maintenance of electrical installations. The Supervisor of Electrical Works or the Supervisor of Operational Works can handle the related duties or ensure that there is a system in place that enables the requirements to be fulfilled as long as the system is followed. For each piece of work, there must be a person appointed responsible for the work or operation, such as a foreman, if the Supervisor for Electrical Works or the Supervisor of Operational Works is not directly supervising the work himself.

According to Section 29 c of KTMp (516/1996), a person who is authorised to carry out electrical work independently within his/her own field must be appointed to supervise

the electrical safety during the work at each work location. The said person can him/herself participate in or execute in full the electrical work in question. In this standard, this person is referred to as the supervisor of electrical safety during the work. In addition to formal professional skills, the supervisor of electrical safety during the work is required to have knowledge and experience in the installation methods, accessories and tools used. Other important qualities include his/her attitude to safety and his/her reliability, carefulness and responsibility. It is essential that he/she is present at the work location and able to supervise the safety of the work. If there are several people working at the work location, it must be clear in all situations who is responsible for supervising electrical safety at work. Determining the supervision of electrical safety at work is particularly important at work locations where there are different people working simultaneously for different employers. In such cases, the supervision of electrical safety at work must generally be determined in writing. If the organisation of the work and the assignments are clear enough for oral determination of the supervision or for practice agreed on in advance, written determination is not necessary.

Figure X.1 Persons supervising safety at electrical work and their areas of supervision

With regard to work that is not electrical, the general occupational safety regulations are followed, however taking into consideration the requirements set forth in Section 4.2 concerning the instruction of persons working in the vicinity of electrical installations. Even in work referred to in Section 4.3 of the standard, where a professional electrician is carrying out work in his/her own field and the risks are easy to identify and manage, the Finnish statutes must be complied with and a supervisor of electrical safety at work appointed, for example. If the professional electrician is performing the work alone, he/she will also act as the supervisor of electrical safety at work. In electrical sector work which poses a risk of electric shock or or an electric arc, a supervisor of electrical safety at work (cf. Section 29 a of KTMp (516/1999)). When building an electrical installation, the supervisor must be appointed at the latest when the installation reaches such state that a supply voltage can be connected to it. If voltage can be connected to the installation or a danger caused by electricity can be otherwise present at an earlier stage, for example when building overhead lines, or building installation parts that are connected to existing live equipment, the supervisor of electrical safety at work must be appointed already at that time.

Additional national requirement

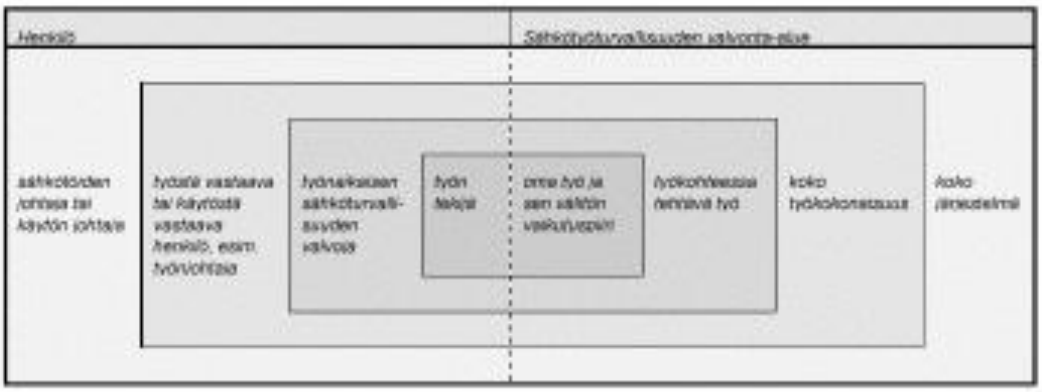
The Supervisor of Electrical Works or the Supervisor of Operational Works also acts as the nominated person in control of the work activity. If the Supervisor of Electrical Works or the Supervisor of Operational Works cannot act as the nominated person in control of the work activity at all work locations, he/she must ensure that the performance of the duties of the nominated person in control of the work activity is separately defined in writing. The duties of the nominated person in control of the work activity can be transferred as a whole only to a professional electrician capable of independent work, acting as the employer's representative. The supervision of electrical safety duties performed at an individual work location and related to the work in question can be assigned to a separately nominated supervisor of electrical safety. The supervisor of electrical safety must be a professional electrician capable of independent work, who personally supervises the electrical safety related to the performance of the work or executes in full the

electrical work in question. The supervisor of electrical safety must be a professional electrician capable of independent work, who personally supervises the electrical safety related to the performance of the work or executes in full the electrical work in question. If, for example, the work team includes several electricians without an actual supervisor, one of the team members must be appointed as the supervisor of electrical safety. In repeated tasks of a similar nature, the supervisor of electrical safety can be appointed with an unambiguous standing order. The duties of the nominated person in control of the work activity that can be transferred to the supervisor of electrical safety are specified below.

The nominated person in control of the work activity and the nominated person in control of the electrical installation shall agree both the arrangements of the electrical system to allow the work to take place and a description of the work activity on, with or near the electrical installation before any changes to the arrangements of the electrical installation are made
or work takes place

The same person can be in control of the work activity and the electrical installation.

If performing the work is demanding, planning must be done in writing.



Kuva X.1 Sähkötyöturvallisuutta valvovat henkilöt ja valvonta-alueet

tukes
Turvallisuus- ja kemikaalivirasto

HELSINKI PL 66 (Opastinsilta 12 B), 00521 Helsinki

TAMPERE Kalevantie 2, 33100 Tampere

ROVANIEMI Valtakatu 2, 96100 Rovaniemi

VAIHDE 029 5052 000 | www.tukes.fi