ESA Work

November 2015

1. Forword

ESA Work includes instructions for safe work at low-voltage and high-voltage installations.

Instructions for safe work concerning the three working procedures *Dead working*, *Working in the vicinity of live parts* and *Live working* are incorporated in the document. Instructions for work in connection with parallel lines are also included.

The document is a supplement to the *ESA Principles* and a prerequisite for using the *ESA Work* is to have access to both documents.

The following document discusses measures to ensure the personal safety of workers using one or more of the existing working procedures.

The document is structured in parts describing each action, that is applicable to the measures to be considered for every working procedure and every action. Information is given within marked squares on what must be specially considered for low-voltage and high-voltage.

In the text there are three titles that are not translated into English: elanläggningsansvarig[1], eldriftledare[2] and elsäkerhetsledare[3]. They are all explained in English at the bottom of every page where they occur.

1 person responsible for an electrical installation
2 nominated person in control of an electrical installation during work activities
3 nominated person in control of a work activity

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2. Work with electrical hazard

Work means work on an electrical installation where safety measures have been taken to ensure that work can be performed in an electrically safe way according to one of the working procedures *Dead working, Working in the vicinity of live parts* or *Live working*. In the following sections the work methodology for the different working procedures, used at work, are presented.

Planning

In order to achieve satisfactory safety at the work location, a careful planning of the electrical safety measures according to the *ESA Principles* is required.

At the employer's planning and risk management for *Dead working*, it is particularly important to consider the risks of nearby electrical installation parts, as well as to take into account the instructions, issued by elanläggningsansvarig[1], to prevent damage caused by electricity.

Risk management

Risk management means coordinated activities to direct and lead an organization with regard to risk.

Risk management must be carried out in writing.

The first risk management, Risk-Pl, is carried out already at the planning stage. It may cover the construction or reinvestment and maintenance of electrical installations, but also the safety culture of an organization, etcetera – see *ESA Principles*.

Risk-Pl for a work activity or operation measure must be performed by the employer or by the person this planning has been delegated to.

Risk-Pe must be performed by elsäkerhetsledare[3] at the work location before starting work and during the performance of the work activity.

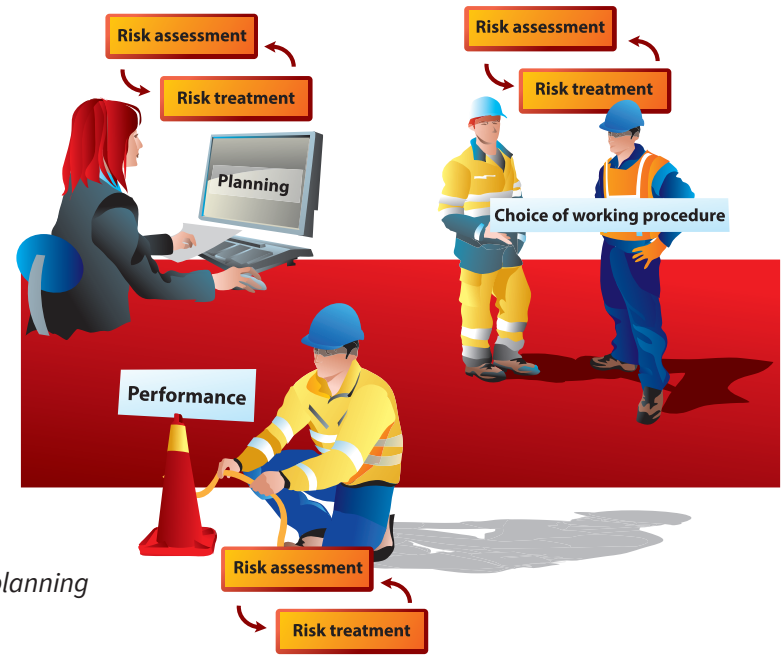

Figure 1. Risk management at planning and performance.

1 person responsible for an electrical installation
3 nominated person in control of a work activity

Risk management at planning (Risk-Pl)

Risk-Pl must be performed by the employer or by the person this planning has been delegated to.

Risk-Pl is the basis for the choice of working procedure and the planning of safety measures. The choice of working procedure must be made by the employer in consultation with elsäkerhetsledare[3]. See *figure 2*.

The working procedure must be adapted to the design of the installation, choice of tools, equipment and the skill of the workers and the resource requirements for the work activity.

Consideration must be given to all risks that may arise in connection with the work activity.

Personal protective equipment, such as clothing meeting the requirements for resistance to arcing, must also be taken into account when planning.

At Risk-Pl it must be ensured that the parts of the installation are clearly labeled and presented on maps, diagrams etcetera.

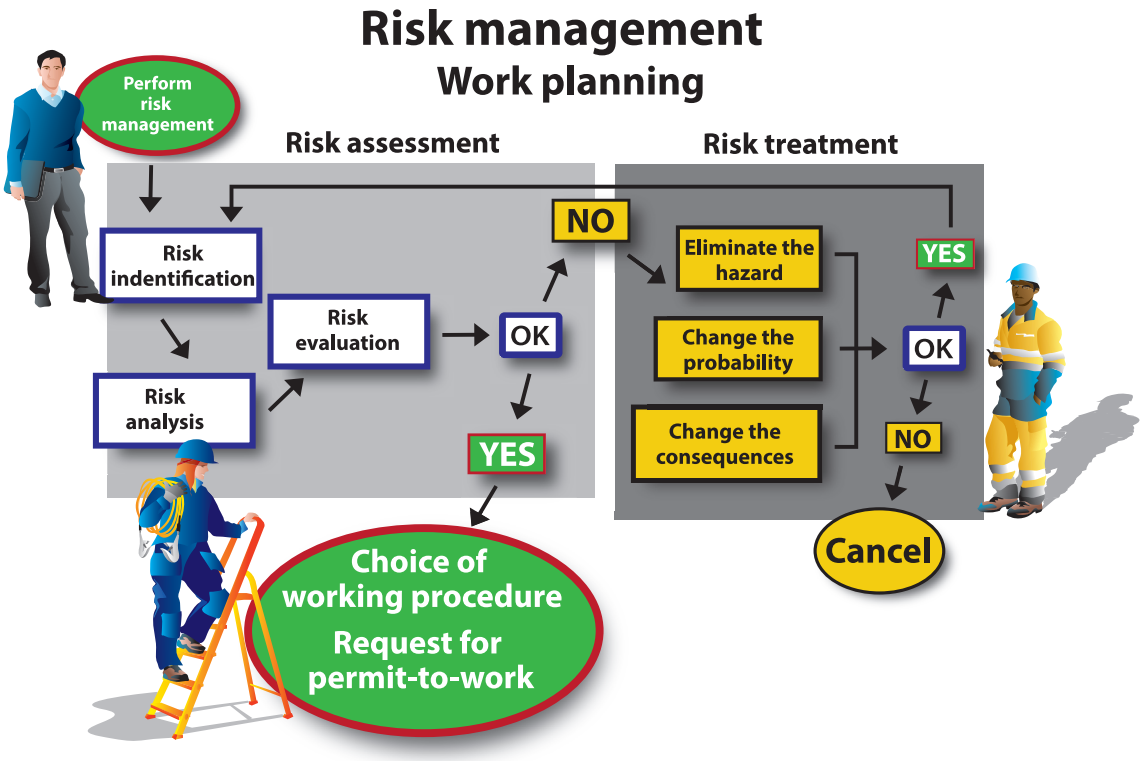

Figure 2. Risk management at work planning (Risk-Pl).

3 nominated person in control of a work activity

Risk management at performance (Risk-Pe)

Elsäkerhetsledare[3] is responsible for Risk-Pe to be performed at the work location before starting work.

Risk-Pe is performed to determine if work can be carried out with the safety measures that have been planned and with the proposed working procedure. Elsäkerhetsledare[3] sets the safety distance and determines whether further supplementary safety measures need to be taken.

Risk management must also take into account adjacent parts of the installation that are or may be energized.

A common review of Risk-Pe must always be carried out together with the workers who are going to carry out the work activity. Elsäkerhetsledare[3] must make sure that everyone has understood.

The risk management must state the risks that exist and how they must be handled. Risk management must be documented in writing and followed up.

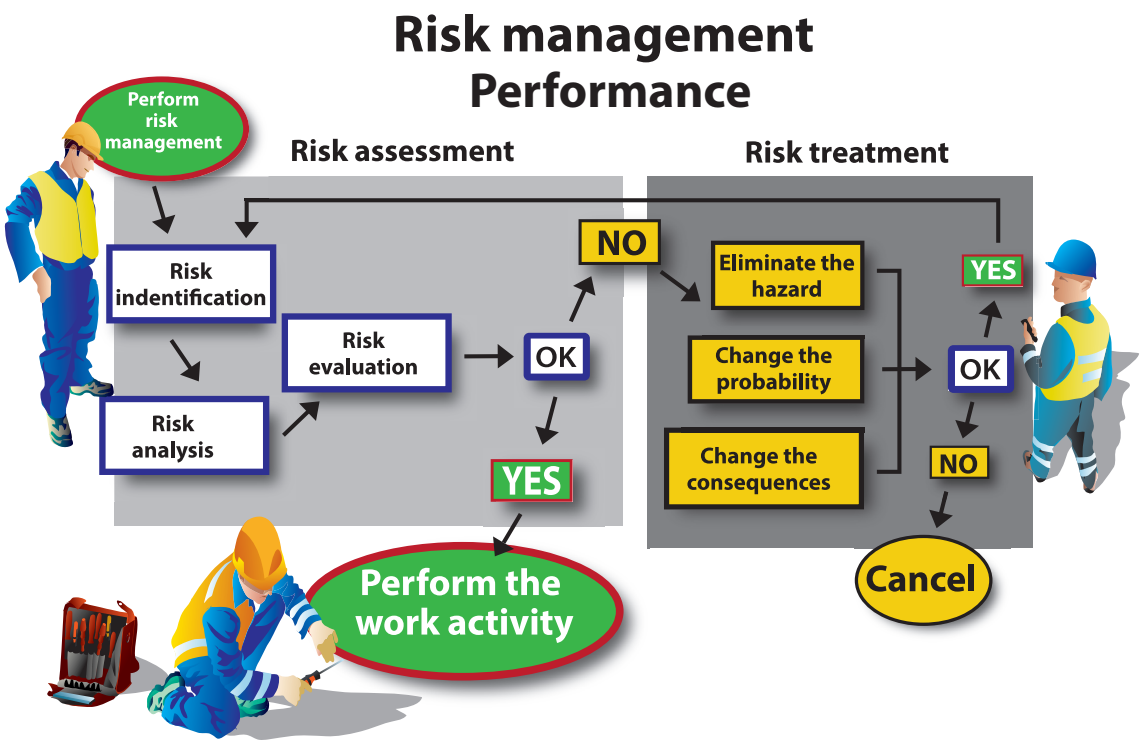

Figure 3. Risk management at performance (Risk-Pe).

3 nominated person in control of a work activity

Elsäkerhetsledare[3] must:

- before work begins, make a written assessment of how the risks can be minimized using the selected working procedure.
- go through the risk management together with workers and make sure that everyone has understood.
- if changed conditions, make a new risk management.

Everyone who participates in the work activity must:

- participate in carrying out the measures needed to achieve a good work environment.
- comply with the applicable requirements, instructions and directions from the authorities as well as from the employer and elsäkerhetsledare[3].
- be equipped with the appropriate personal protective equipment, other equipment and tools.
- use the safety devices and take other precautions needed to prevent ill-health and accidents.
- request clarification from elsäkerhetsledare[3] or the employer if anything is unclear or ambiguities exist.
- assist in risk management for the specific work activity.
- consider the suitability for work on parallel lines during lightning or damp weather.

3 nominated person in control of a work activity

3. Dead working – AUS

General

Dead working means work at an electrical installation where safety measures have been taken to ensure that the installation is disconnected and will remain de-energized as long as work is in progress.

This section describes the steps required. The sequence of the work activity is described in *figure 4.*

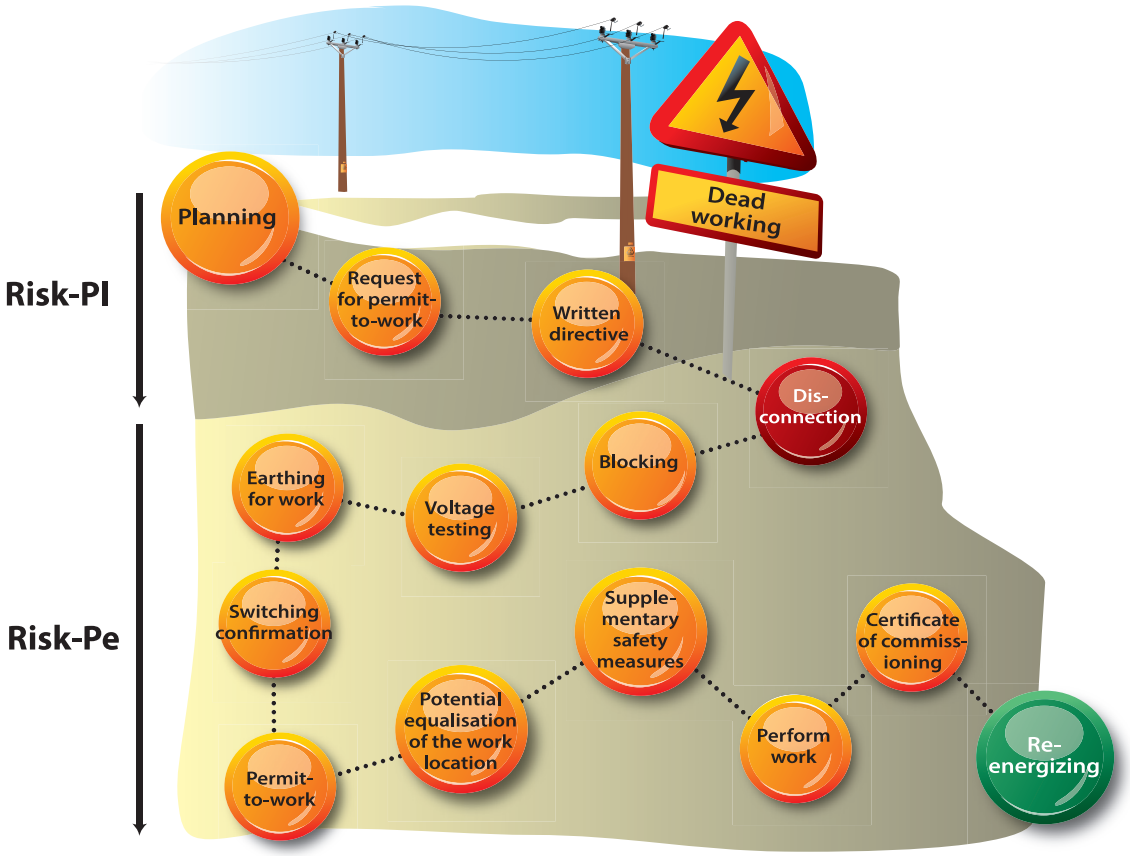

Figure 4. Example of workflow at Dead working.

Planning at Dead working

In order to achieve a satisfactory level of safety at the work location, a careful planning of the electrical safety measures must be performed by the employer.

At the employer's planning and risk management for the work activity, it is particularly important to consider the risks of adjacent electrical installation parts.

Risk management at performance (Risk-Pe)

Risk management for *Dead working* must be performed by elsäkerhetsledare[3] at the work location before work begins.

3 nominated person in control of a work activity

Risk-Pe is performed to determine if work can be carried out with the safety measures that have been planned at Risk-Pl and with the proposed working procedure. Elsäkerhetsledare[3] sets the safety distance and determines if further supplementary safety measures need to be performed.

Risk-Pe must always be gone through together with, and be understood by, the workers who will carry out the work activity.

Risk management must also take into account adjacent parts of the installation that are or can be energized or that, by induction or influence, can energize the work location. In separately earthed systems, potential equalization of the work location must be carried out before work.

The risk management must indicate existing risks and whether they are serious or not. Risk management must be documented in writing and followed up. If the conditions change, a new risk management must be performed. See *figure 3 (page 7).*

Risk management at demolition, pulling down and dismantling of electrical installations

Example of questions:

- Is the installation disconnected from all energizing directions?
- Is there any electrical risk to the public in connection with the demolition, pulling down and dismantling?
- Is there a risk of induction or influence?
- Can the conductors reach another energized installation at demolition, pulling down or dismantling?

The safety precautions must remain until the installation is electrically safe.

If there is a permit-to-work, it must be returned after the completion of the demolition, pulling down or dismantling.

Conditions can change during the work and new situations arise. In these cases a new risk management must be performed.

For instructions on the demolition of an overhead line, see the EBR publication *Risks and methods for demolition of overhead line*s, HMS 1:07.

Request for permit-to-work

After planning a request for permit-to-work must be submitted to eldriftledare[2] according to the instructions in the *ESA Principles.*

Written directive

The holder of switching responsibility must issue a written directive as described in the *ESA Principles.*

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Disconnection

Disconnection for work must be carried out so that:

- energizing from all energizing directions is prevented.
- adequate isolating distance is obtained.
- isolation assured by visible break point or reliable position indication.
- withdrawable units placed in the disconnected position.
- control and signal circuits are disconnected.
- cables with the risk of residual voltage must be discharged and short-circuited.
- capacitors with risk of residual voltage must be discharged and short-circuited.

Disconnection of parts of the installation must be carried out in such a way that energizing is prevented from other parts of the installation (for example, when there are multiple switching devices). Example of such installations can be self-generated electricity, such as backup power, battery / UPS systems, solar cells or wind power.

Disconnection can be carried out for example by using

- a safety switch.
- a breaker.
- a miniature circuit breaker (MCB).
- fuses (melting cartridges).
- jumpers.

LOW-VOLTAGE

	Measures (The installation can be disconnected by)			
Items	Fuse	Miniature circuit breaker without a symbol for dis-connection for work.	Miniature circuit breaker with a symbol for disconnection for work.	Main switch Safety switch Circuit breaker
Isolate the part of the installation	Remove the fuse.	Switch off the main switch.	Switch off the miniature circuit breaker.	Open the breaker.
Protection against re-energizing / Apply a sign	Block the fuse.	Block the main switch with a padlock if possible and if it is accessible for unauthorized persons.	Block the miniature circuit breaker with a padlock if possible and if it is accessible for unauthorized persons.	Block the breaker with a padlock if possible and if it is accessible to unauthorized persons.
	Always apply a sign “Do not operate – Work in progress” with a name and phone number.			
Check that the installation is disconnected	Voltage test with reliable equipment			

Blocking (protection against re-energizing)

Blocking means an action to prevent unintentional operation. A blocking sign with a name and phone number must be used if the blocking is personal.

At blocking, the following actions must be taken:

- a sign, “Do not operate. Work in progress “, must always be applied.
- switching devices must be locked when accessible to unauthorized persons.
- control lever, fuse, connection piece, etcetera, must be removed. These must be kept inaccessible to unauthorized persons during the work activity.
- removed jumpers must be secured.
- a latch on switching devices. If the operating device on the switching device has an auxiliary power source it must be blocked or taken out of operation.

Note. A latch can be applied by remote operation of a mechanical blocking device fitted with a sign, which must prevent local operation of the switching device. There must be a reliable indication on the switching devices and in all the places where an operation can be performed.

Figure 5. Example of a personal blocking.

Voltage testing

Voltage tests must be performed to check and verify that the installation is not energized with operating voltage. When a part of the installation is disconnected and blocked, a voltage test must be performed using the intended and reliable equipment.

Voltage testing must be made on all phases, the carrier and the suspension components for overhead cable. It is not necessary to check the mounting brackets if it is obvious that they cannot be energized.

! Voltage testing is an important measure to take in order to reduce the risk of accidents and serious incidents.

Figure 6. Voltage testing in a low-voltage switchgear.

Voltage testing

At low-voltage installations, voltage testing must be carried out between all phases and between phases, neutral conductor and earth.

LOW-VOLTAGE

Voltage testing

Exemption from the demand for voltage testing applies to a part of an installation where the construction is of such design, that adequate safeguards exist even if earthing for work is performed to operating voltage. Voltage testing must always be performed if the voltage testing does not increase the risk.

A voltage detector has a lower performance limit. Therefore, the installation can be energized with a lower voltage even when the voltage detector indicates that the installation is de-energized.

At phase conductors which are heavily angled, there may be areas where the electrical fields cancel each other out. This means that the voltage detector indicates that the operating voltage is disconnected even though the installation is energized with operating voltage.

At certain types of installations with capacitive measuring points, the intended equipment must be used.

A voltage detector can only verify that the installation is not energized with operating voltage.

HIGH-VOLTAGE

If a cable must be cut and there is a risk of mix-up, the cable must be punctured or cut with a special tool (cable cannon, cable guillotine or similar). Contact must be established with the holder of switching responsibility.

Voltage detectors must be tested before and, if possible, after voltage testing.

Figure 7. Voltage testing in a high-voltage compartment.

Figure 8. Example of voltage detector for high-voltage.

Figure 9. Voltage testing of a battery installation.

Earthing for work and potential equalization of a work location

The purpose of earthing for work is to prevent that dangerous energizing occurs at the work location, for example by unintentional energizing by incorrect switching, feeding from local production, backup power, lightning, residual voltage, influence, induction and more.

Dangerous energizing by lightning cannot be completely prevented by earthing for work. Work on an electrical installation must therefore be stopped when there is lightning in the area.

A part of the installation may not normally be earthed for work before disconnection, blocking and voltage testing has been performed.

Earthing for work must normally be supplemented with potential equalization of the work location during work on overhead lines.

Earthing for work should withstand the maximum current that occurs – normally the short-circuit current.

There must not be any fuses between the earthing for work and the part of the installation where work will be performed. There can be switching devices between the earthing for work and the work location, if the switching devices are short-circuit proof and safely and mechanically blocked in the closed position.

Earthing for work must be connected to an earth electrode with such a low earth resistance that the installation will be switched off automatically if an unintended energizing should occur.

When working near contact wires for railways, the risks of potential differences must be particularly taken into account at risk management.

At Risk-Pe, there must be supplementary instructions for performing earthing for work and potential equalization of the work location.

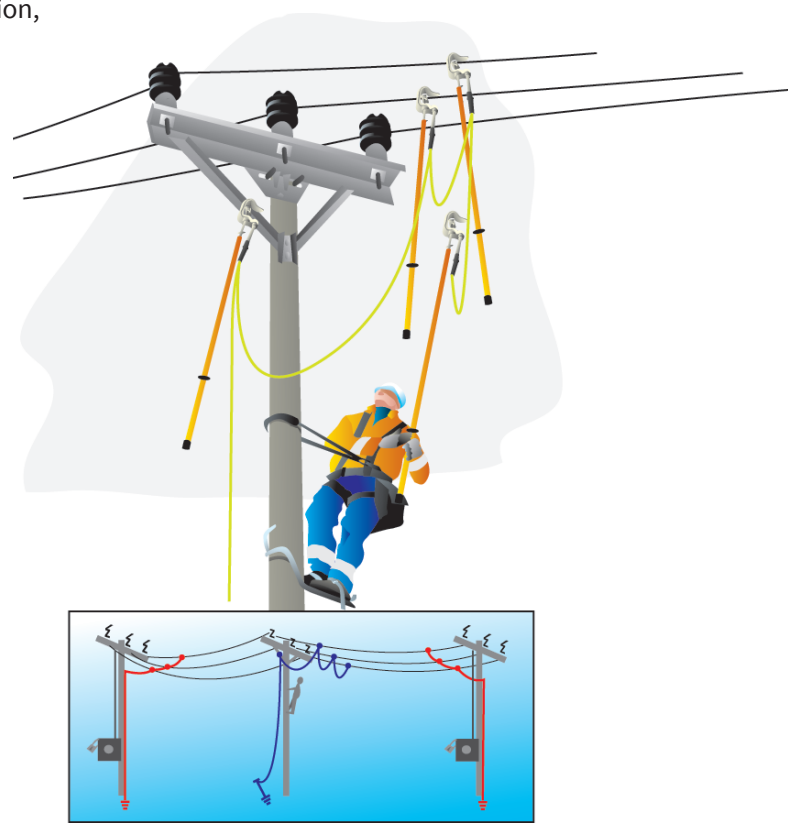

Figure 10. Earthing for work and supplementary potential equalization of a work location.

Earthing tools

Earthing tools must conform to current standards and, in addition, they must be checked according to the manufacturer's instructions.

Earthing tools that have been subjected to closing against voltage or damaged must not be used.

Earthing tools must be applied and removed with the intended equipment. The earthing tool must first be applied to the earth electrode and then to the conductors. When removing the earthing tool, it must first be removed from the conductors, and then from the earth electrode.

LOW-VOLTAGE

Dimensioning of earthing tools

Information about short-circuit power for selecting the correct dimension of earthing tools for low-voltage installations will be provided by elanläggningsansvarig[1].

HIGH-VOLTAGE

Dimensioning of earthing tools

Information about short-circuit power for selecting the correct dimension of earthing tools will be provided by elanläggningsansvarig[1].
The recommended minimum area is 25 mm^2 Cu.
The recommended minimum area for potential equalization is 16 mm^2 Cu.

Figure 11. Example of earthing tools for touch-protected adaptors.

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Earth electrode for earthing for work

Elanläggningsansvarig[1] must state the maximum value of resistance to earth, that is accepted for the installation.

Earthing for work, switching device

When working on low-voltage installations in buildings, cable cabinets, centrals or switchgears, earthing for work is normally not required.

If *Dead working i*s applied, there may be a risk that the system can be energized, for example, by backup power, micro production, customer facility or induction. Then earthing for work must be used.

LOW-VOLTAGE

Earthing for work, switching device

Earthing for work must be applied in direct connection with both sides of the switching device, or to parts of the installation directly connected to the switching device.

HIGH-VOLTAGE

Figure 12. Example of micro production in a low-voltage network.

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Overhead line

Earthing for work must be applied between the work location and the place from where energizing can take place. If possible, at least one point of earthing for work must be provided near the work location and preferably visible from there.

LOW-VOLTAGE

Earthing for work

Earthing for work on low-voltage cables is required when there is a bare overhead line in the system.

HIGH-VOLTAGE

Earthing for work, one phase conductor

If the system voltage is higher than 100 kV, and the work activity is limited to only one phase conductor, earthing for work can include only that conductor provided that:

- earthing for work is applied at all phases between the work location and disconnection points from which energizing can take place.
- the conductor, on which work will be performed, and all the conducting parts at the work location are potentially equalized.
- safety measures for *Working in the vicinity* of live parts are applied, if the risk management so requires.

Earthing for work

Coated overhead line

Earthing for work must be connected to the earth terminals at the prepared connection points. If necessary, penetrating clamps for potential equalization of the work location must be connected.

Overhead cable and bundle-assembled overhead cable

Earthing for work must be applied at the connection points of the cable where there normally is an earth terminal. Earthing for work must also include carrier cable, metallic sheath and screen.

Sheathed cable

Earthing for work must be applied at the cable connection points and at the transition between cable and overhead line.

HIGH-VOLTAGE

Cut or removed cable, must be fully insulated or earthed for work at the end.

Earthing for work, switchgear

Switchgear

Provided that all disconnection points are in the same room or in sight from the work location, a busbar only needs to be earthed for work at one point.

HIGH-VOLTAGE

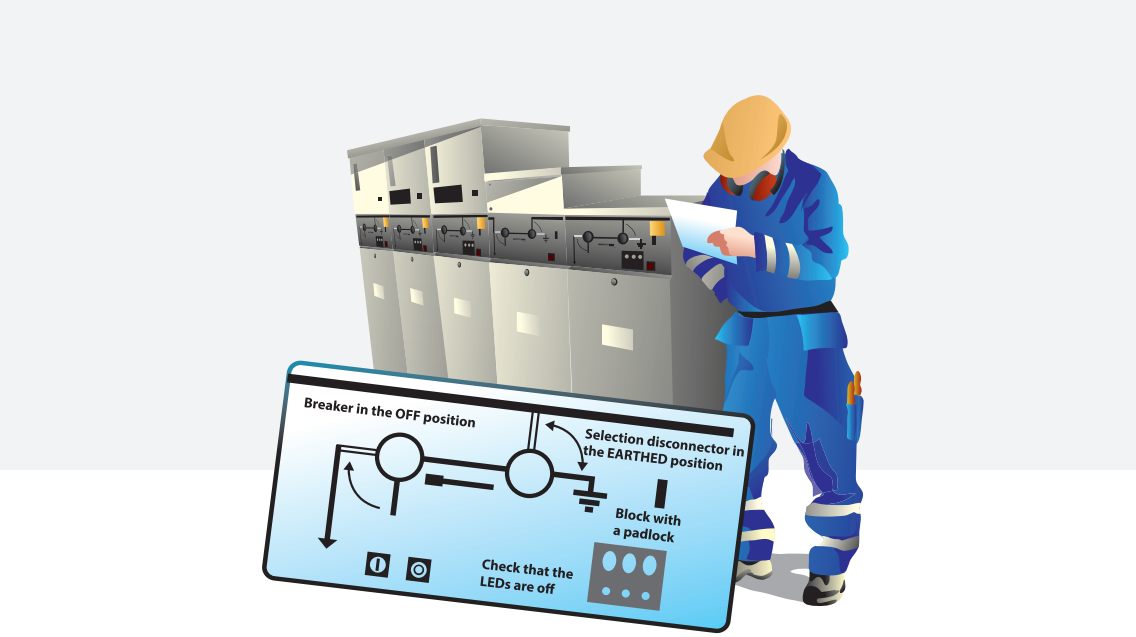

Figure 13. Example of a switchgear with a selection disconnector.

LOW-VOLTAGE

Earthing for work, switching device

When working in cable cabinets, distribution boards or enclosed switching device ("switchgear"), earthing for work is not required. Voltage tests must be performed before work.

HIGH-VOLTAGE

Earthing for work, switching device

Earthing for work must be applied in direct connection with both sides of the switching device, or to parts of the installation that are directly connected to the switching device.

Earthing for work, transformer

In substations with dual transformers that are connected to a shared neutral low-voltage busbar, the low-voltage winding of the transformer must be earthed for work.

LOW-VOLTAGE

Earthing for work, transformer

Earthing for work must be applied to all the windings of the transformer. This must also be performed even if work should be carried out at only one of the connections. Auxiliary winding in a transformer does not need to be earthed for work. The auxiliary winding must be disconnected and blocked.

Earthing for work must be within sight of the work location. If, for practical reasons, this is impossible, earthing for work can take place out of sight, but this requires a clear identification. This earthing for work must withstand occurring fault currents.

If the transformer shares the neutral point equipment with another transformer, the neutral point must be disconnected. Earthing for work must be applied to the neutral point of the transformer.

HIGH-VOLTAGE

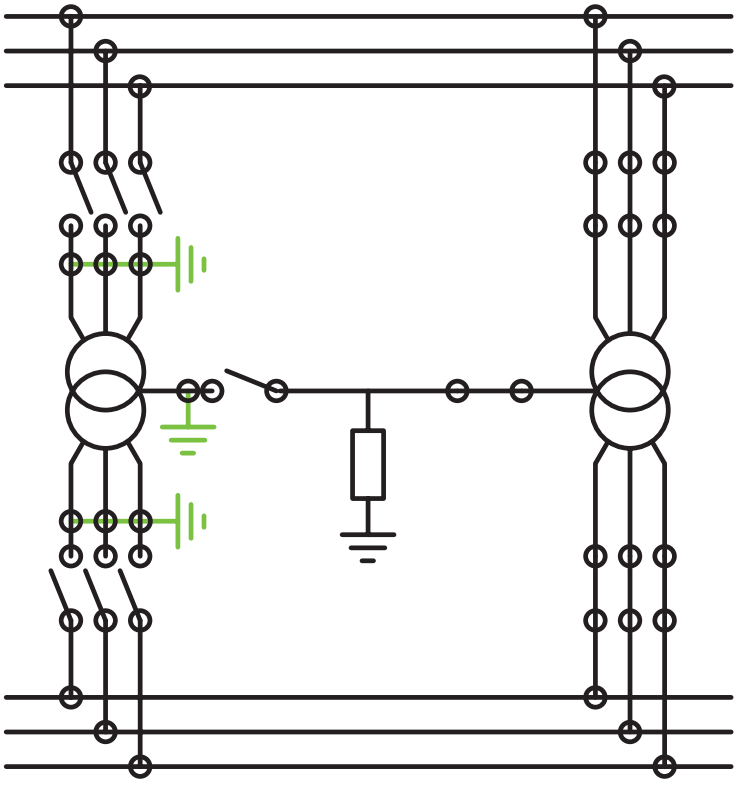

Figure 14. Earthing of a transformer with a shared neutral point.

LOW-VOLTAGE

Earthing for work, generator

Before earthing for work is applied, the rotor must not be rotating. Earthing for work must be applied as close to the phase output as possible.

HIGH-VOLTAGE

Earthing for work, generator

Before earthing for work is applied, the rotor must not be rotating. Earthing for work must be applied as close to the phase output terminal as possible.

Magnetization circuit must be disconnected and earthed for work, so that work can be performed. If the generator has a shared neutral point equipment with another generator, the neutral point must be disconnected. Earthing for work must be applied to the neutral point of the generator.

HIGH-VOLTAGE

Earthing for work, converters

Earthing for work must be applied both to the AC side and the DC side.

HIGH-VOLTAGE

Earthing for work, shunt capacitor bank

Earthing for work must be applied:

- after discharging.
- between the disconnecting point and the shunt capacitor.
- at the neutral point of the shunt capacitor unit, if any.
- on both sides of the capacitor units at which work is going to be performed.

The terminals on the removed capacitor unit must be short-circuited and connected to the casing.

HIGH-VOLTAGE

Earthing for work, capacitor voltage transformer

Earthing for work must be applied at the connection point of the capacitor. The danger of residual voltage must be taken into account in the same way as for a shunt capacitor.

When working only at the transformer part, it must be disconnected both on the upside and on the downside, and earthed for work on the upside.

Earthing for work, series capacitor bank

Earthing for work must be applied:

- at the part of the installation to which the series capacitor is connected.
- at both sides of the capacitor units on which work is going to be performed.

For work at a series capacitor equipped with a by-pass disconnector, the disconnector must be blocked in the closed position. Alternatively, earthing for work is applied on both sides of the disconnector.

For work at a capacitor unit and the handling of a replaced unit, the instructions are the same as for a shunt capacitor.

For work at a capacitor bank located on an isolated platform, the substructure can adopt a potential (voltage), therefore, special instruction from elanläggningsansvarig[1] is required regarding disconnection and earthing for work.

HIGH-VOLTAGE

Earthing for work, capacitor bank

When working, the capacitors must be discharged and earthed for work.

LOW-VOLTAGE

Earthing for work, series reactor

Earthing for work must be applied to the reactor.

HIGH-VOLTAGE

Earthing for work, Static Var Compensator (SVC)

Earthing for work must be applied to both sides of every:

- capacitor unit
- reactor
- converter

at which work is to be performed.

The shunt capacitor unit must also be earthed for work between the disconnecting point and the shunt capacitor, and at the neutral point, if any, of the shunt capacitor.

HIGH-VOLTAGE

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Earthing for work at testing

At certain tests on parts of an electrical installation, such as insulation testing and transformer ratio testing, the installation cannot be earthed for work. Nevertheless, in order to obtain adequate safety, the following must be observed:

Before the test:

- the part of the installation (at which the test will be performed) must be disconnected and earthed for work to the extent needed.
- if earthing for work, which is included in the permit-to-work for testing, needs to be removed, a permit must be submitted by the holder of switching responsibility.
- supplementary safety measures must be applied.
- measuring equipment must be connected.
- only one permit-to-work – the one for testing - must exist for each part of the installation, during testing.
- make sure that everyone is aware of the electrical hazards when the test will be performed.

During the test:

- the installation is considered energized.
- if the test equipment needs to be removed or shifted during the test, that part of the installation must be completely earthed for work.

After the test:

- removed earthing tools for work must be applied.
- test equipment must be removed.
- the installation must be restored to the same condition as before the test.

Potential equalization of a work location

Primarily, potential equalization of the work location is to be considered when working at overhead line installations. To prevent potential differences at the work location, all exposed parts and tools must be potentially equalized.

A potential equalization of the work location must normally be preceded by an earthing for work.

When there are multiple systems for earthing at the work location, the earthing systems must be joined to prevent potential differences (e.g. separately earthed pole substations).

When working near electrical installations for railways, potential equalization between the parts of the installation may pose a risk for potential differences. This must be especially considered at risk management.

The potential equalization must be carried out by using earthing tools that meet the applicable Swedish standards.

Potential equalization of the work location must prevent hazardous voltage differences occurring at the work location for example by:

- impact from other heavy-current installations through direct contact, influence, induction.
- residual voltage in previously energized installations such as cables and capacitors.

Potential equalization of the work location must include:

- phase conductors.
- overhead earth wires (continuous earth wires, if any).
- the carrier wire of the overhead cable.
- stays.
- short-circuiting of spark gaps.
- shunting of the conductor ends (binding) must be performed when removing jumpers or when cutting / joining conductors.
- earthed parts such as pole, cross arm or framework.
- bulky equipment that does not have adequate insulation.
- other conductive materials that can get a different voltage than that of the part of the installation, where the work activity is carried out (for example woodpecker netting, sky lift basket, winch, etcetera.)
- another nearby part of the installation that has been taken out of operation

Potential equalizing of the work location must be applied to the pole, where staff might risk contact with different potentials. Examples include continuous earth wires, earth electrode conductors, stays etcetera.

Potential equalizing of a work location to earth

Earth spike or earth screw can be used for potential equalization of the work location.

When working with bulky equipment, all conductive parts must be potentially equalized.

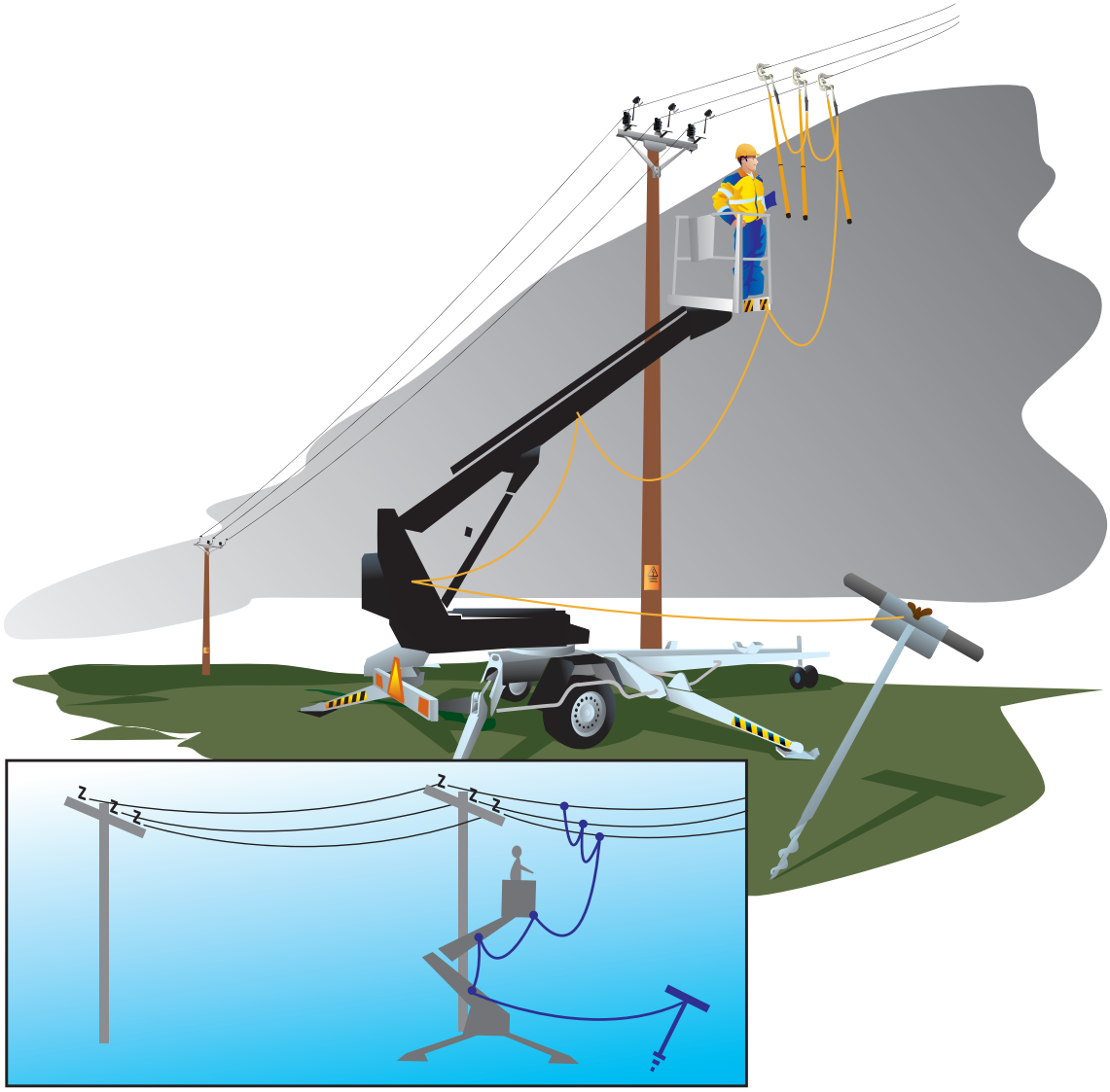

Figure 15. Example of a potentially equalized sky lift.

Potential equalizing of a work location when cutting or joining wires

Earthing for work must be applied to both sides of the joining point. To avoid potential differences at the work location the conducting parts must be potentially equalized.

If any conductor is intact over the joint, earthing for work is only needed to be applied on one side of the work location and potential equalization on the other.

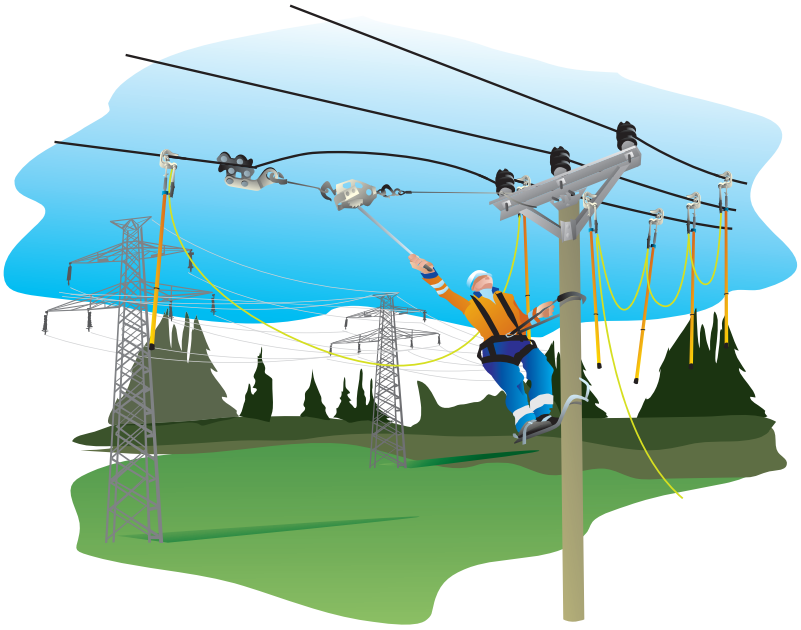

Figure 16. Example of shunting a line when cutting the wire.

Figure 17. Example of a potential equalization mat.

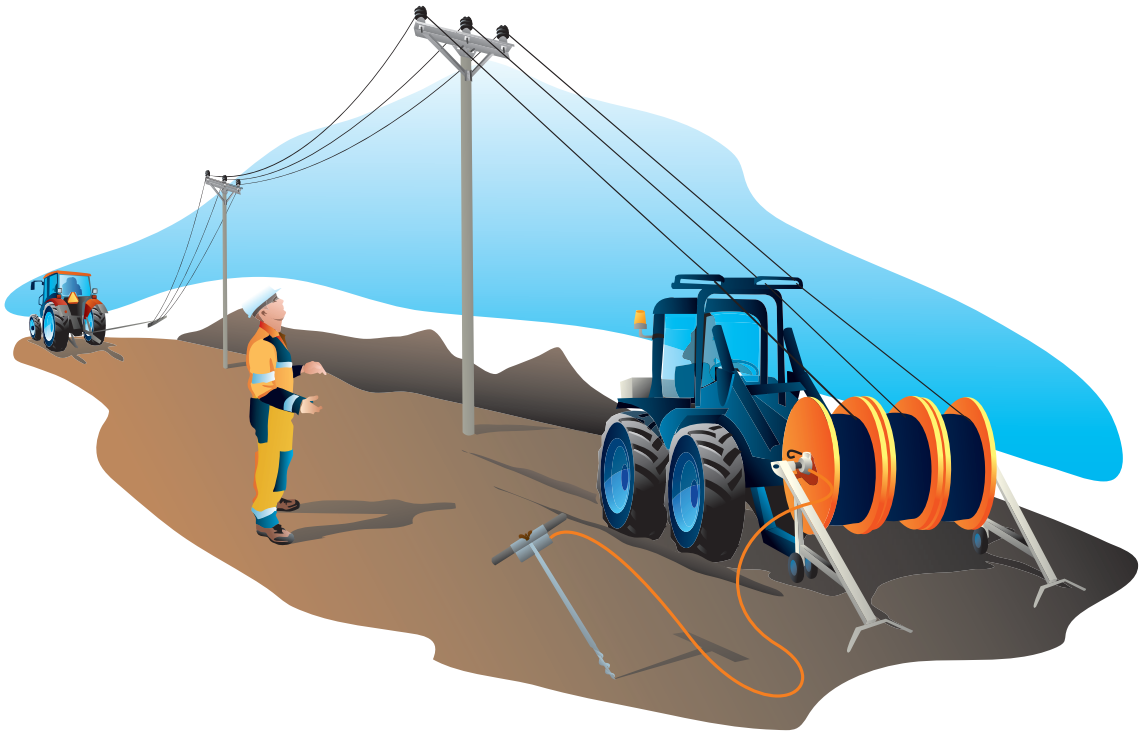

Figure 18. Example of potential equalization to earth when running out a line.

Potential equalizing of a work location when running out a bare conductor

When running out the conductors parallel to an overhead line, it is recommended to primarily disconnect the parallel overhead line. Earthing for work must be applied to both sides of the joining point. To avoid potential differences at the work location, the parts of the line must be bound together.

If disconnection is not possible, this must be handled in a local instruction.

As the conditions at these work activities can vary, for example, at risk of contact with adjacent energized overhead lines, measures for earthing for work / potential equalization of the work location must be adapted from case to case. At running out conductors, such potential equalization must be applied next to the winch site and drum site. The winch units and the brake units must also be potentially equalized.

HIGH-VOLTAGE

Potential equalizing of a work location when running out and securing a coated conductor

In addition to what is mentioned for bare conductors, a sliding earthing device must be applied to the gable of the drum. The sliding earthing device must have contact with the stripped end of the conductor. During work with securing and inserting the conductor the potential equalization must be connected to an arching horn in the nearest insulator protective fitting.

HIGH-VOLTAGE

Switching Confirmation

The switching operator is responsible for that the content of the switching confirmation corresponds to the actions performed, see *ESA Principles*.

Permit-to-work

The permit-to-work is a confirmation that safety measures have been taken for work on a part of the installation, to the extent stated in the permit. See *ESA Principles.*

Supplementary safety measures

Before work begins, elsäkerhetsledare[3] must supplement the safety measures with, for example, flagging, protection by safety barrier of the work location and transport routes.

Necessary safety measures must be assessed considering:

- the position of the work location and access roads.
- the duration of the work.
- the workers' experience and competence.
- the handling of equipment and tools that are going to be used.

Example of supplementary safety measures can be:

- supplementary earthing for work.
- potential equalization of the work location.
- to determine safety distances for devices and tools.
- to ensure good light conditions and more.
- to apply protection against nearby energized parts of the installation.

To enable *Dead working*, safety measures must sometimes be taken at, for example, protection by safety screen and / or protection by safety barriers at the work location and transport routes. See working procedure *Working in the vicinity of live parts (page 40).*

HIGH-VOLTAGE

Supplementary safety measures

When working in a high-voltage compartment, other energized compartments must be marked with safety barriers. This is especially important at new constructions.

3 nominated person in control of a work activity

Figure 19. Example of a barrier rope at an indoor switchgear.

Work

All workers at the work location must be informed and understand the range and the boundaries of the work location. After that, work can begin.

> **!** **If, during the working process, any unforeseen risk is found, leading to that the selected working procedure cannot be used, the work activity must be stopped and a new risk management must be performed.**

Before a certificate of commissioning is submitted, all workers at the work location must be informed that the work activities are ending and that the installation must be considered energized. If necessary, a new risk management must be performed and a safety barrier put up at parts of the installation that will be energized.

Certificate of commissioning

A certificate of commissioning must be submitted by the holder of the permit-to-work to the person that has submitted the permit-to-work according to the *ESA Principles.*

LOW-VOLTAGE

Measures before energizing

A part of the installation must not be re-energized and safety devices must not be removed until:

- it has been checked that all work has been completed.
- all concerned have been informed and elsäkerhetsledare[3] has given his or her approval.

When the safety devices have been removed, energizing can be made according to the written directive and in consultation with the holder of switching responsibility.

After the completion of the work activity, a feedback of the deviations in the safety planning must be carried out by the employer and elsäkerhetsledare[3] together.

If re-energizing of an installation cannot be performed with devices, tools or equipment designed to prevent hazard when properly used, the energizing must be planned, risk-assessed and carried out according to one of the working procedures.

If elsäkerhetsledare[3] and the person responsible for the test are different persons, elsäkerhetsledare[3] must inform all concerned about the coming energizing.

Reconnection

The holder of the switching responsibility must attend to that the automatic reclosing system is taken into operation after the return of all certificates of commissioning that correspond to the issued permits-to-work.

Work at especially exposed parts of electrical installations and parallel lines

When working at a part of an installation, which is exposed to induction or influence by other electrical installations, special measures must be taken.

Before work begins, eldriftledare[2] of the receiving line and the employer must consult on working out measures for earthing for work and potential equalization of the work location. For work on parallel lines, the distance to emitting lines, the level of the current and length of the parallel stretch, must be especially considered. Even parallel cable routes and bar systems can present a risk of induction.

2 nominated person in control of an electrical installation during work activities
3 nominated person in control of a work activity

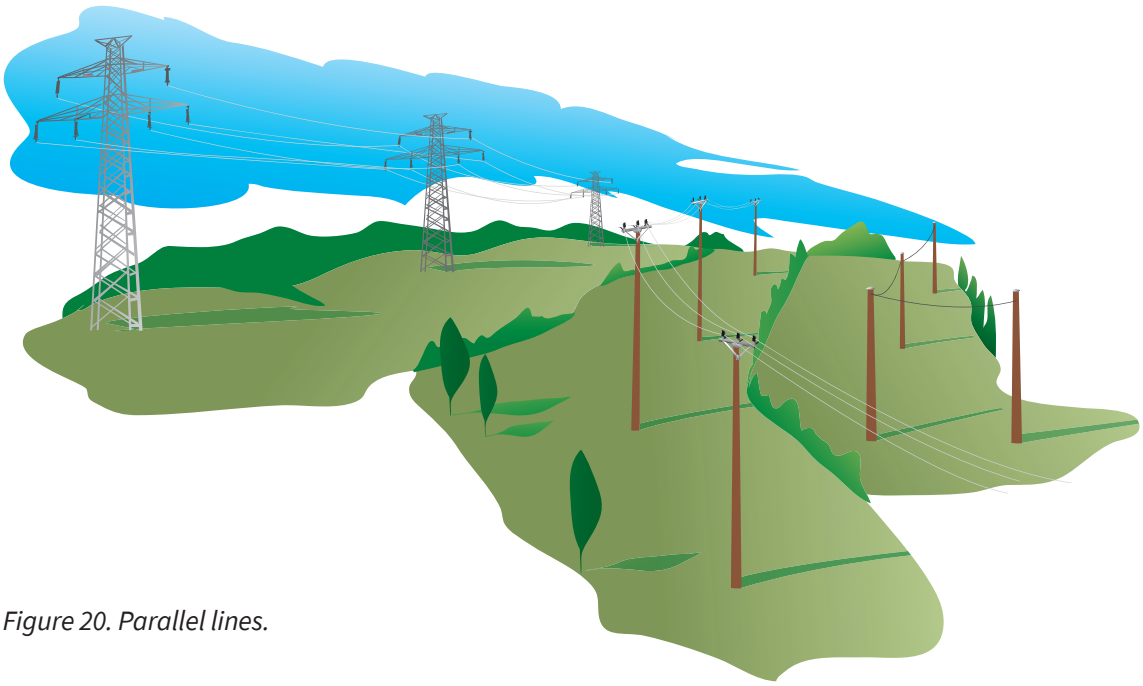

Figure 20. Parallel lines.

Definitions and concepts at parallel lines

- Emitting line
  Parallel transmission line which is energized and carrying current and its field affects the receiving line.
- Line with continuous overhead earth wire
  Line which in its entire length is provided with overhead earth wire.
- Line with insulated overhead earth wire
  Line with overhead earth wire which is electrically separated, wholly or partially, from the pole/pylon by insulators.
- Line without overhead earth wires
  Line which in its entire length is not provided with overhead earth wire.
- Receiving line
  A line which may reach dangerous voltage due to impact of an emitting line.

Measures due to impact of parallel lines

When working on a part of an installation, which is exposed to the dangerous effects from other electrical installations by induction or influence, special safety measures must be performed. Safety measures must consist of earthing for work and potential equalization of the work location.

Influence

Influence means charging of conductive objects which are isolated from earth.

Between two adjacent lines, of which one is energized (emitting line), charging and energizing will arise at the receiving line due to influence. The voltage can reach to several thousand volts, causing discharge currents which, if touched, in its turn can cause an accident.

To reduce the impact of the influence on the receiving line, the emitting line can be disconnected or a connection to earth can be applied on the receiving line to discharge it.

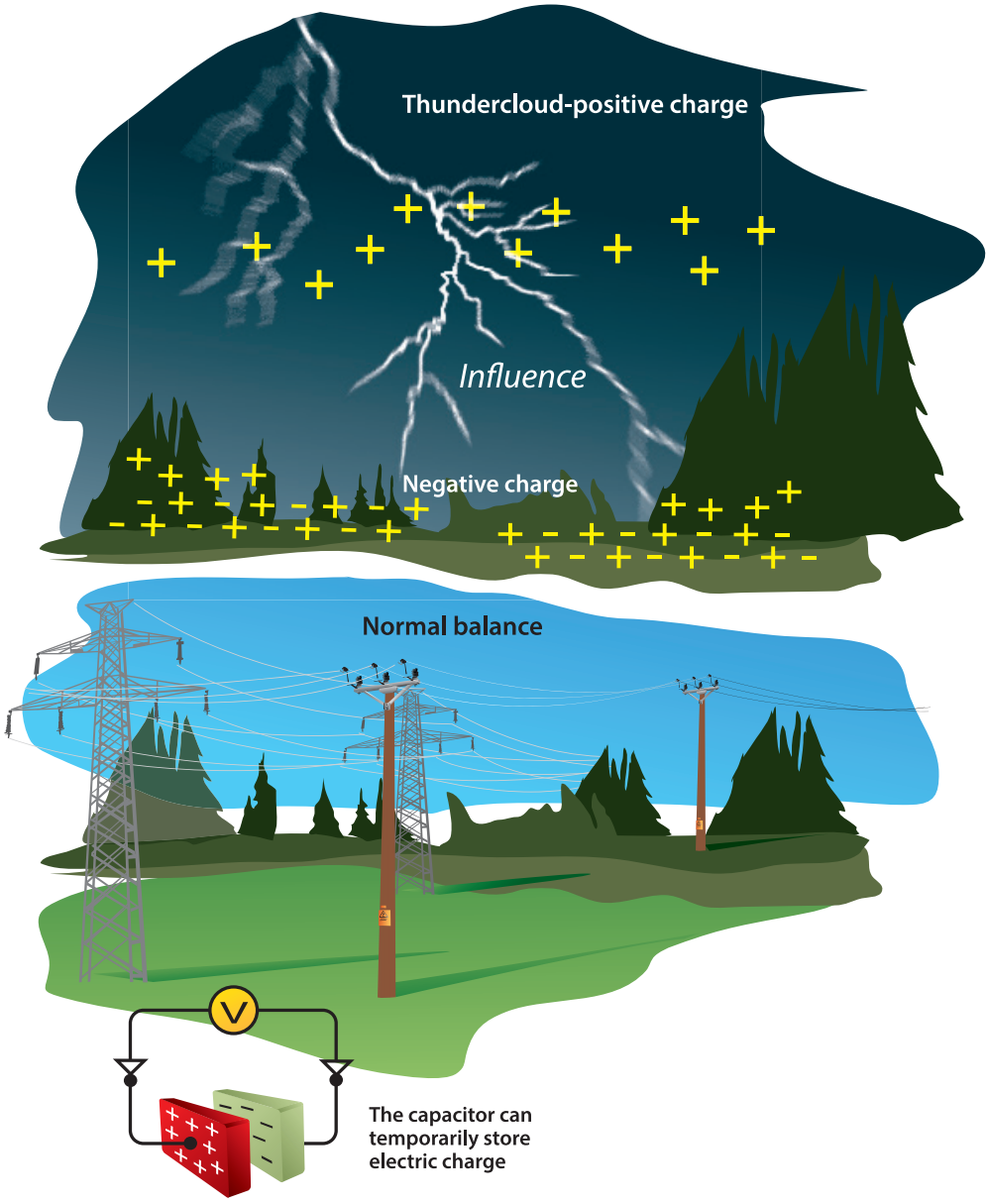

Figure 21. Influence can be found in different places.

Induction

Induction occurs when an electrical conductor passes through a varying magnetic field.

Around a current carrying conductor, a magnetic field is generated with the same frequency as the current. If another conductor passes through this magnetic field, a current is induced, which varies with the same frequency as the current of the emitting line.

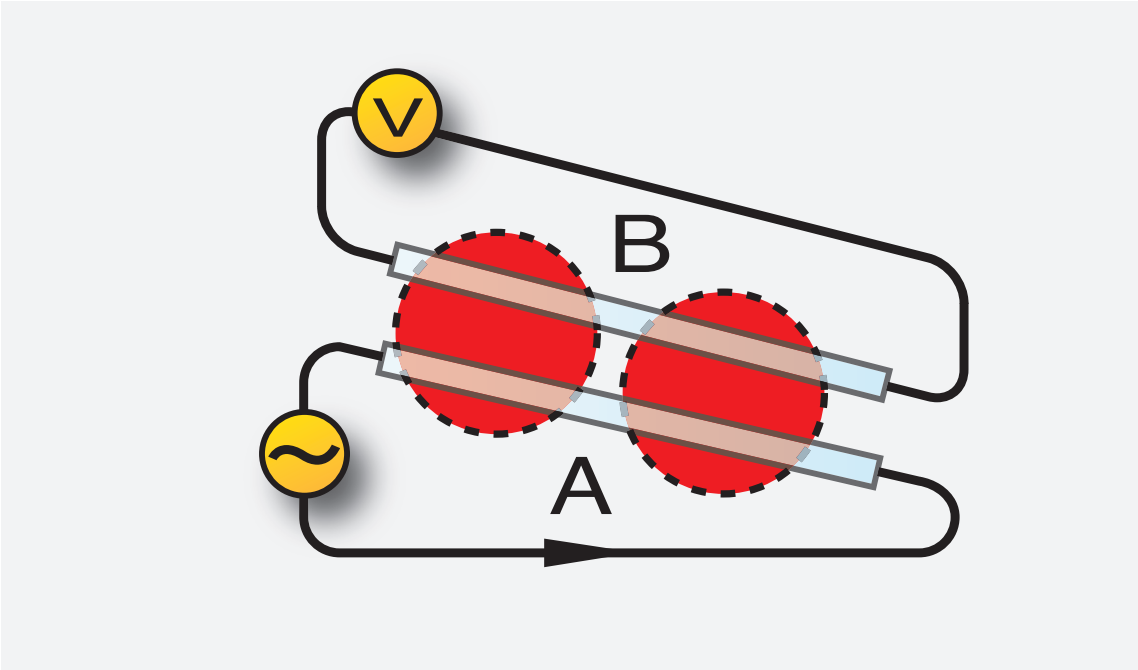

Figure 22. Field from conductor A (emitting line) generates a voltage in conductor B (receiving line) that can cause a dangerous current.

Around a power line, which is energized, a magnetic field is formed around each phase (emitting line). If a power line or another metallic conductor runs parallel to the emitting line, it (the receiving line) will be energized by induction.

How high this voltage will be, depends on the length of the parallel stretch, the distance between the receiving and the emitting line and how strong the magnetic field around the emitting line is. The power of the magnetic field is dependent on the current in the emitting line.

To reduce the induction to a safe level, the emitting line can be disconnected or the receiving line can be sectioned or earthed at the work location.

Planning for work at parallel lines

When planning for work, the basis must be good documentation and the following must be considered:

- at all parallel lines, there is a risk of induction.
- at risk of induction, a local instruction must be drawn up by elanläggningsansvarig[1].
- that this risk also includes the insulated overhead earth wires.
- that it in the operation order / switching schedule and permit-to-work is indicated if a conductor is exposed to dangerous induction.
- that, at several emitting lines with various elanläggningsansvarig[1], they must all be contacted to assess the risk of dangerous induction.
- that the load, and thus the induction, can vary.

Documentation of a line exposed to dangerous induction

Elanläggningsansvarig[1] of the receiving line must draw up a documentation, if the line is exposed to dangerous induction.

The documentation for the receiving line must include:

- emitting lines.
- calculated induction per line.
- elanläggningsansvarig[1] name and phone number.
- length of the parallel stretch.
- pole number at the beginning and at the end of the parallel stretch.
- presence of spark gaps and surge arresters in the overhead earth wire and the continuous earth wires on the receiving line.
- if the continuous earth wires serve multiple lines .
- a record of fixed earth electrodes.

The inducing voltage must be measured or calculated at the specified maximum load current at the emitting line.

Calculation

For the calculation of the effects of parallelism, both the distance to and the length of the parallel stretch must be taken into account. See instructions for the calculation in *appendix 1* and *2*.

1 person responsible for an electrical installation

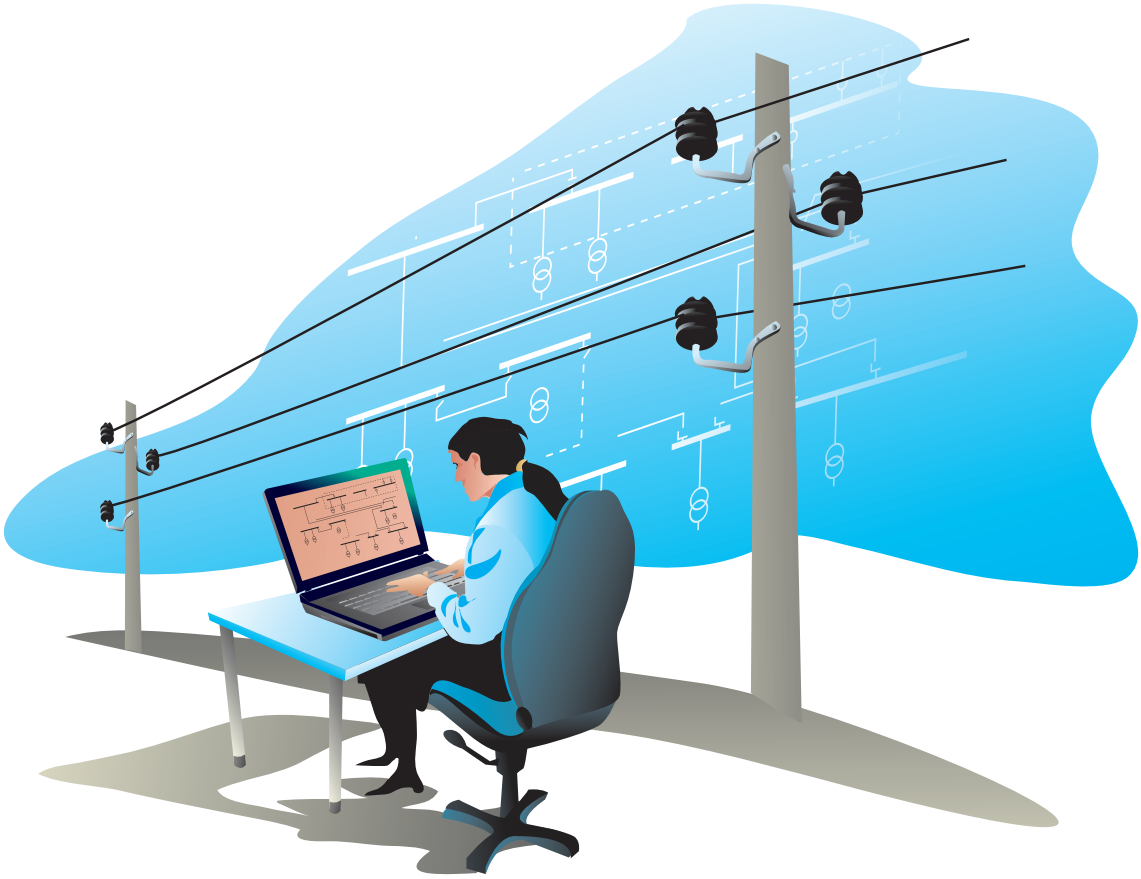

Figure 23. Documentation of the grid is important.

Protective measures when working at parallel lines

Earthing for work

Earthing for work must be performed according to the working procedure *Dead working*.

Potential equalization of the work location

Earthing for work must be supplemented with potential equalization at the work location. Potential equalization must be performed with earthing tools that meets the Swedish standard.

! Along the line there are dangerous potential differences, for example, at the removal of jumpers and when cutting / joining the conductors.

Safety measure:
Potential equalization to earth at the work location supplemented with shunting of conductor ends and similar conductive parts.

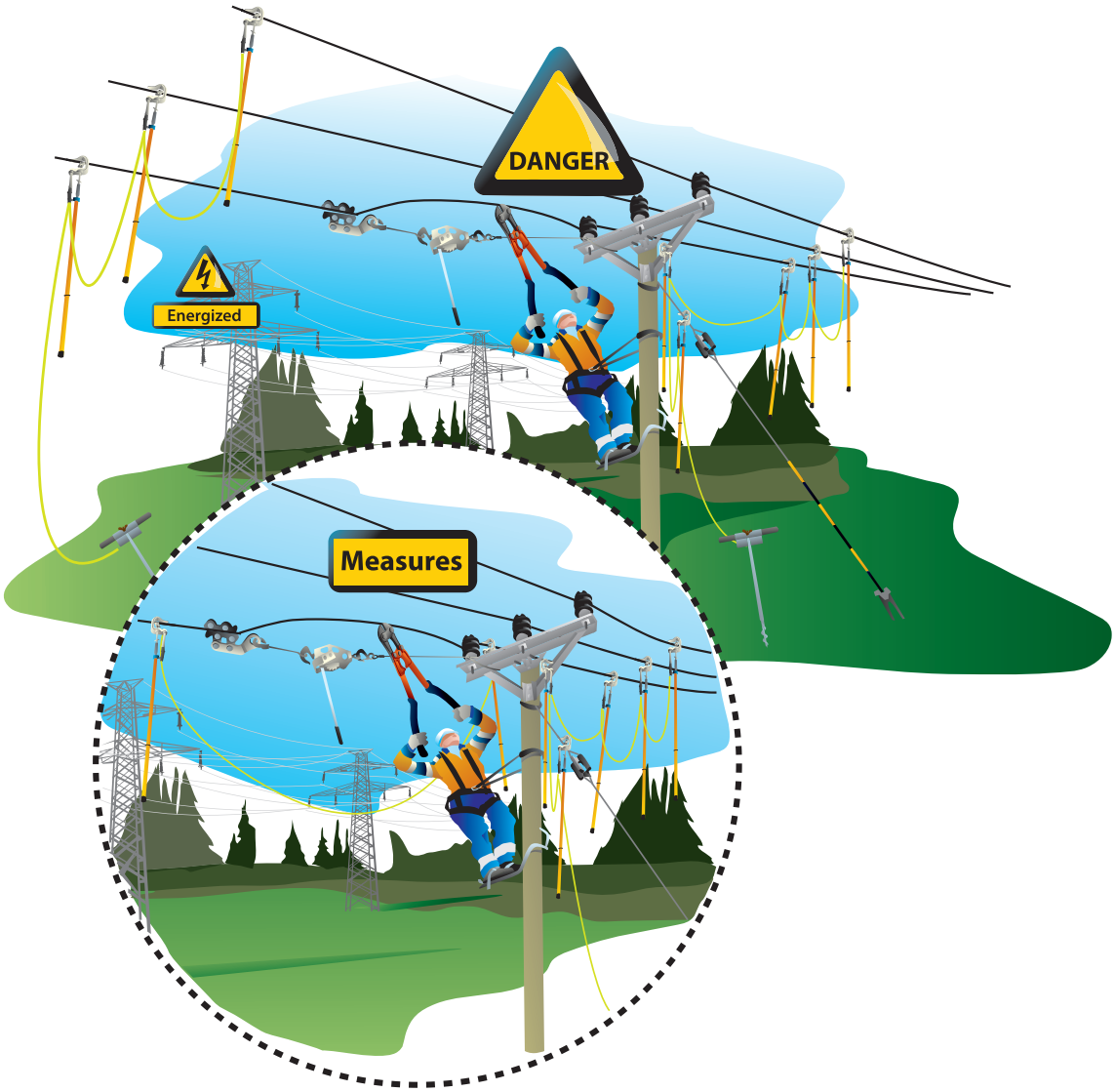

Figure 24. Example of shunting and potential equalization at the receiving conductor.

Work at a line parallel to a live line

At the construction and maintenance of a line parallel to an energized line, the de-energized line is affected by magnetic and electric fields.

The degree of impact depends on several factors:

- distance between the lines.
- the length of the parallel stretch.
- voltage.
- the load current of the line.
- the resistivity of the ground.

The impact remains both before and after the parallel stretch, unless earthing measures are performed.

> **!** **Before work begins, elsäkerhetsledare[3] must measure the residual voltage of the conductors at the poles where work is to be carried out. If the residual voltage, in relation to earth, at the work location exceeds 50 V, which is the upper limit for extra low voltage, the lines must be provided with supplementary earthing for work.**

See *figure 33 (page 56)* and calculations in *appendix 1* and *2*.

3 nominated person in control of a work activity

4. Working in the vicinity of live parts – ANS

General

Working in the vicinity of live parts means work where a worker, a machine, equipment or tools enter, or risk coming into, the vicinity zone without reaching the live working zone. Protective measures for *Working in the vicinity of live parts* can be used as a supplement to the working procedure *Dead working*.

If the risk management shows that the work must be performed as *Working in the vicinity of live parts,* the following procedure must be followed and the precautions in the text below must be taken.

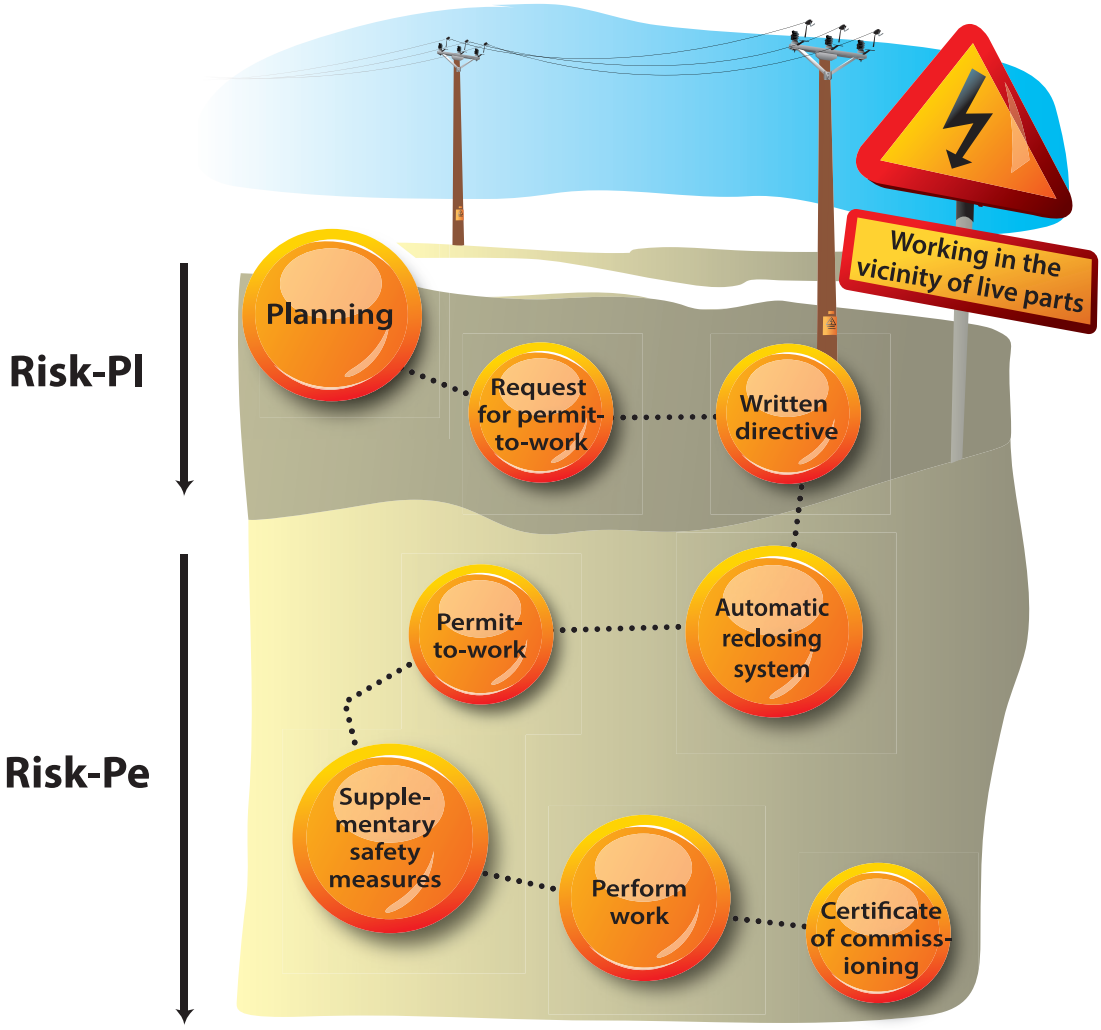

Figure 25. Example of workflow when Working in the vicinity of live parts.

Planning at Working in the vicinity of live parts

In order to reach satisfactory safety at the work location, a careful planning of the electrical safety measures must be performed by the employer.

When Working in the vicinity of live parts, the necessary measures must be assessed at Risk-Pl (see *ESA Principles*) with regard to:

- the position of the work location and access roads .
- the duration of the work.
- the workers' experience.

When working near a part of an installation with an automatic reclosing system (ar, far, dar or anr), the automatic reclosing system must always be out of operation during the time work is going on.

At the employer's planning and risk management before *Working in the vicinity of live parts*, it is particularly important to consider the risks of adjacent energized parts of the installation.

Risk management at performance (Risk-Pe)

Risk Management for *Working in the vicinity of live parts* must be performed by elsäkerhetsledare[3] at the work location before work begins.

Risk-Pe is performed to determine if work can be carried out with the safety measures that have been planned at Risk-Pl and with the proposed working procedure. Elsäkerhetsledare[3] sets the safety distance and determines if further supplementary safety measures need to be performed.

Risk-Pe must always be gone through together with and understood by the workers who will carry out the work activity.

The risk management must also take into account that induction can energize the work location. In separately earthed systems, potential equalization of the work location must be carried out before work.

The risk management must indicate existing risks and whether they are serious or not. Risk management must be documented in writing and followed up. If the conditions change, a new risk management must be performed.

Request for permit-to-work

After planning, a request for permit-to-work must be submitted to eldriftledare[2] according to the instructions in the *ESA Principles.*

Written directive

The holder of switching responsibility must issue a written directive as described in the *ESA Principles.*

2 nominated person in control of an electrical installation during work activities
3 nominated person in control of a work activity

Automatic reclosing system

Where an automatic reclosing system (ar, far, dar or anr) exists, this must be taken out of operation before work. If the automatic reclosing system is taken out of operation by a switching operator, a switching confirmation must be sent to the switching responsible person. See switching confirmation in the *ESA Principles.*

Marking

The points from which re-closing of a tripped circuit breaker can be performed, should be highlighted in eldriftledare[2] monitoring system, warning that *Working in the vicinity of live parts* is going on.

Permit-to-work

A permit-to-work is a confirmation that safety measures have been taken for work on a part of the installation to the extent stated in the permit. See *ESA Principles.*

Safety measures, such as the automatic reclosing system taken out of operation, must be specified in the permit-to-work.

Safety distance

Elsäkerhetsledare[3] must determine the safety distance for work according to the *ESA Principles.*

Supplementary safety measures

Before the work activity starts, elsäkerhetsledare[3] must perform supplementary safety measures.

One or a combination of the following supplementary safety measures must be taken before work.

Protection by safety screen

Protection by safety screen means a permanently or temporarily attached safety device that is insulated or not, and that is used to prevent approach to any equipment or part of electrical installation, which presents electrical danger. Protection by safety screen leads to that no one will be able to enter into the live working zone.

If the protection by safety screen fulfils the electrical insulation according to current standards, it may be placed closer to an energized part of the installation than the outer boundary of the live working zone D_L. It must not, however, be placed in direct contact with an energized part. Working with protection by safety screen is considered to be adequately safe if the location of the safety screen is equipped with a control device (for example, a guiding device) and if the person installing the safety screen has no part of his or her body closer to energized installation parts than the live working zone D_L in table 1 in the *ESA Principles*.

2 nominated person in control of an electrical installation during work activities
3 nominated person in control of a work activity

If the protection by safety screen is performed with unreliable electrical insulation or conductive material, the safety screen may only be applied in the vicinity zone (not in the live working zone). The installation of the screen must be performed as *Dead working*. Furthermore, a screen of conductive material must be earthed.

If a protection by safety screen needs to be removed during the ongoing work, it may only be carried out when elsäkerhetsledare[3] has given his or her consent. All workers must be informed of the action and supervision or close supervision arranged.

A temporary protection by safety screen must be removed as soon as its purpose is fulfilled.

A safety screen that is used as a platform during work, must be massive and designed for the mechanical load.

When it is not clear that a device represents protection by safety screen to an energized part of the installation, a warning sign must be applied.

Protection by safety barrier

Protection by safety barrier means a temporarily attached device intended to remind of danger and warn against entering a specific area.

The need for protection by safety barrier is formed by considering the risk of, for example, mix-up with an adjacent installation, selected working procedure, equipment and removal.

> **!** **When working at an installation with a risk of mix-up, all other energized compartments must be marked with a protection by safety barrier.**

Figure 26. Example of protection by safety barrier.

3 nominated person in control of a work activity

Supervision

Elsäkerhetsledare[3] can appoint, where necessary, a worker for supervision of the safety distance and that it is maintained throughout the work activity. The worker must be accounted for in the risk management.

The person conducting the supervision may participate in the work activity to the extent that the supervision assignment permits.

Elsäkerhetsledare[3] must give instruction on:

- the performance of the work activity.
- the boundaries of the work location to energized parts of the installation.
- the definition of the safety distance.
- how the installation can be disconnected.
- from where immediate help may be obtained if an accident should occur.

The supervisor must:

- have the knowledge and the skills that the task requires.
- ensure that the risk management / work instructions are followed.
- ensure that the communication with the holder of switching responsibility and with elsäkerhetsledare[3] works.
- stop the work activity and contact elsäkerhetsledare[3], if the work activity cannot be performed as planned.
- ensure that the workers' operations are coordinated and that the workers exchange information about their intentions.
- when necessary, warn the workers.

3 nominated person in control of a work activity

Close supervision

Elsäkerhetsledare[3] can appoint, where necessary, a person for close supervision of the safety distance and that it is maintained throughout the work activity.

The safety distance must be no less than the distance of the live working zone. The close supervisor must be accounted for in the risk management.

> **Close supervision is a safety measure of brief duration, maximum 5 minutes. Whoever keeps close supervision may not participate in the work and not supervise more than one worker.**

Elsäkerhetsledare[3] must give instructions on:

- the performance of the work activity.
- the boundaries of the work location to energized parts of the installation.
- the definition of the safety distance.
- how the installation can be disconnected.
- from where immediate help may be obtained if an accident should occur.

The close supervisor must:

- have the knowledge and skills that the task requires.
- ensure that risk management / working instructions are followed.
- ensure that the communication between the holder of switching responsibility and with elsäkerhetsledare[3] works.
- stop the work activity and contact elsäkerhetsledare[3] if the work activity cannot be performed as planned.
- when necessary, warn the workers.

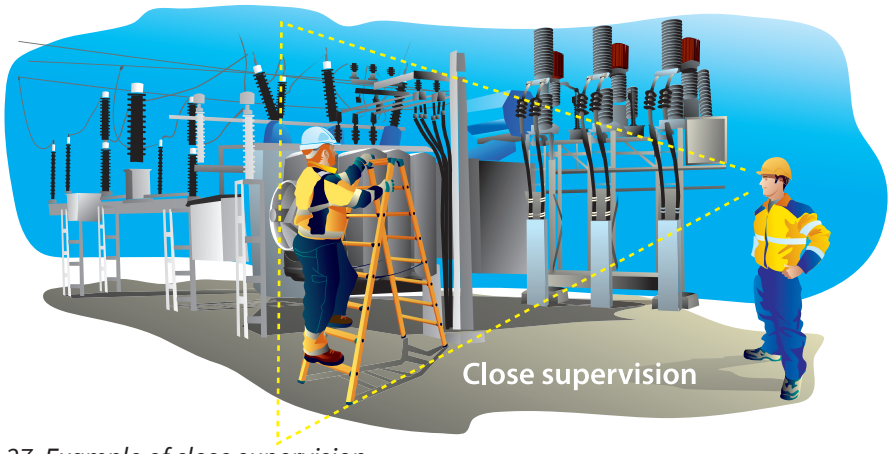

Figure 27. Example of close supervision.

3 nominated person in control of a work activity

Bulky equipment

Bulky equipment is equipment like lorry, mobile work platform, crane, forwarder, forestry mulcher, excavator, scaffolding, ladder etcetera.

For *Working in the vicinity of live parts* with bulky equipment, elsäkerhetsledare[3] must specify the safety distance with respect to:

- the size of the equipment.
- the maneuverability of the equipment.
- the material of the equipment.
- the risks of the equipment making unforeseen movements.
- the stability of the equipment while moving and in use.
- the temporary mechanical blocking of the equipment.
- the electronic control equipment that limits the maneuverability of the equipment.
- all parts of the equipment and that they are fitted with fixed terminals for earthing and potential equalization.

Risks to take into account:

- need for the removal of the equipment and the risks that may occur.
- with regard to the risk of energizing the equipment, it must be potentially equalized to earth.
- if the equipment must be removed and the earth connection cannot be maintained during the removal, the removal must be carried out under supervision or close supervision. It is important that communications are maintained between the operator of the equipment and the supervisor or close supervisor.
- if the equipment has rubber wheels, no-one must stay near the equipment unnecessarily before it is earthed.

> **!** **All parts of the equipment must also be potentially equalized, for example the support and the work basket of a sky lift.**

3 nominated person in control of a work activity

Bulky equipment nearby an electrical installation

For construction and building work, without applying any working procedure, or for the removal of machines and bulky loads, a stipulated safety distance must always be maintained. The distance must be determined from the closest unprotected live part or conductor.

Special attention should be taken when transporting machines with long arms on uneven ground, when a piece of equipment can swing out or when equipment is removed or lifted.

Figure 28. Important to determine the safety distance at various works.

Work

All workers at the work location must be informed by elsäkerhetsledare[3] about the range and the boundaries of the work location. Then work can begin.

> **!** **If, during the work process, any unforeseen risk is detected leading to that the selected working procedure cannot be used, the work activity must be stopped and a new risk management must be performed.**

Before a certificate of commissioning is submitted, all workers at the work location must be informed by elsäkerhetsledare[3] that the work activities are ending and that the installation is ready for operation.

Certificate of commissioning

A certificate of commissioning must be submitted by the holder of the permit-to-work to the person that has submitted the permit-to-work according to the *ESA Principles*.

Reconnection

The holder of switching responsibility must attend to that the automatic reclosing system (ar, far, dar or anr) is taken into operation after having received all certificates of commissioning that correspond to the issued permits-to-work.

3 nominated person in control of a work activity

5. Live working – AMS

General

Live working means work where a worker, a machine, equipment or tools enter the live working zone with some part.

Live working requires workers who have a specific training for the working procedure and the appropriate work instructions.

At *Live working*, safety measures must be taken to prevent electric shock and the effects of short circuiting and arcing. Consideration must be taken to the various potential differences that may occur at the work location.

LOW-VOLTAGE

Working at low-voltage installations with degree of protection at a minimum of IP20, may be conducted as lone working.

HIGH-VOLTAGE

For high-voltage installations, work must be performed by at least two live-working-trained workers.

Planning at Live working.

In order to reach satisfactory safety at the work location, a careful planning of the electrical safety measures must be performed by the employer.

When *Live working,* the necessary measures must be assessed at Risk-Pl (see *ESA Principles*) with regard to:

- the workers' education.
- the workers' experience.
- a safety observer, if necessary.
- the risk of switching over-voltage.
- the connecting or disconnecting of cables to an energized network, the capacitive currents must be taken into account.

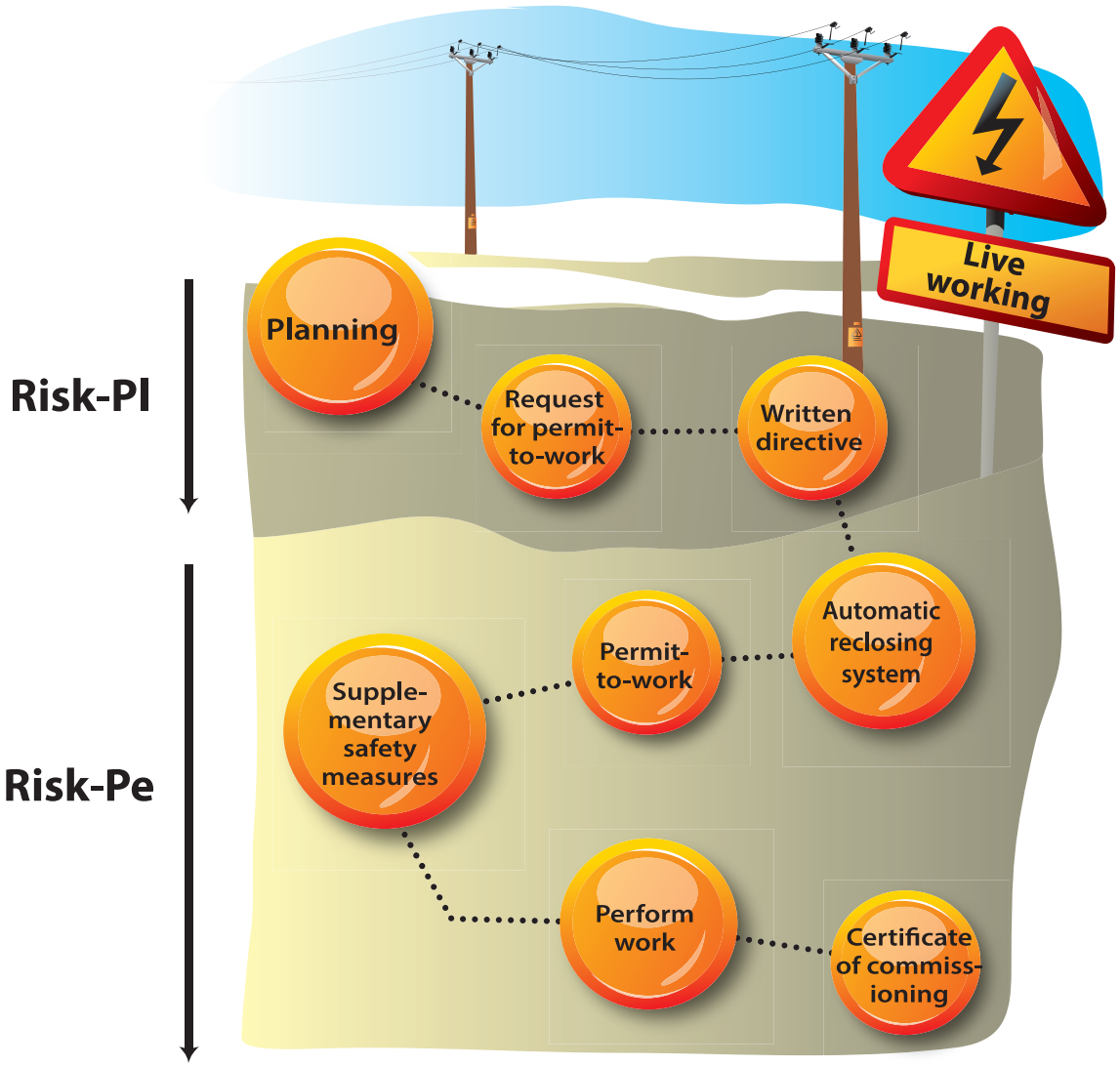

Figure 29. Example of workflow at Live working.

When working at a part of an installation with an automatic reclosing system, the automatic reclosing system must always be out of operation during the time work is in progress.

At the employer's planning and risk management before *Live working*, it is particularly important to consider the risks associated with adjacent parts of the installation with a different potential, for example earth.

Tools, equipment and devices must be manufactured for work at the voltage level in question. If insulating parts need cleaning, it must be specified how the cleaning procedure must be performed. Tools, equipment and devices must be inspected and checked according to the manufacturer's instructions.

Risk management at performance (Risk-Pe)

Risk management for *Live working* must be performed by elsäkerhetsledare[3] at the work location before work begins.

The risk management must indicate existing risks and whether they are serious or not. Risk management must be documented in writing and followed up. If the conditions change, a new risk management must be performed. The risk management must include a determination of the safety distance and more.

Risk-Pe is performed to determine if work can be carried out with the safety measures that have been planned in Risk-Pl and with the proposed working procedure.

Elsäkerhetsledare[3] must always go through the Risk-Pe and the produced work description together with the workers that are going to carry out work and ensure that everyone has understood.

Risk management must, among other things, include information on:

- suitable weather conditions.
- that a person's motor functions and mobility must not significantly be affected by cold weather.
- the consideration of the risks of fog, rain, and lightning with regard to insulation and flash-over.
- existing communication between the work location and the holder of switching responsibility.
- that the right tools and equipment are used.
- that the tools and the equipment are insulation tested, clean, dry and free from visible defects.

3 nominated person in control of a work activity

Request for permit-to-work

After planning, a request for permit-to-work must be submitted to eldriftledare[2] according to the instructions in the *ESA Principles.*

Written directive

The holder of switching responsibility must issue a written directive as described in the *ESA Principles.*

Work may only be performed at an installation with an automatic disconnection at an earth fault.

Automatic reclosing system

When working at an energized installation with an automatic reclosing system (ar, far, dar or anr), the automatic reclosing system must always be out of operation.

If the automatic reclosing system is taken out of operation by a switching operator, a switching confirmation must be sent to the switching responsible person. See Switching confirmation in the *ESA Principles.*

Marking

The points from which the reclosing of a tripped circuit breaker can be carried out, should be highlighted in eldriftledare[2] monitoring system, warning that *Live working* is going on.

Permit-to-work

The permit-to-work is a confirmation that safety measures have been taken for work on a part of the installation to the extent stated in the permit. See *ESA Principles.*

Safety measures, such as automatic reclosing system taken out of operation, must be specified in the permit-to-work.

Safety distance

Elsäkerhetsledare[3] must determine the safety distance for work according to the *ESA Principles.*

Supplementary safety measures

Elsäkerhetsledare[3] must ensure that the appropriate safety measures have been taken before work begins.

2 nominated person in control of an electrical installation during work activities
3 nominated person in control of a work activity

Safety observer

The safety observer must not take part in the work activity.

Elsäkerhetsledare[3] can hold the role of safety observer himself or herself.

The safety observer must have the knowledge and skills that the task requires, and:

- ensure that the risk management / work instructions are followed.
- ensure that the communication with the holder of switching responsibility and with elsäkerhetsledare[3] works.
- if the work cannot be conducted as planned the work activity must be stopped and elsäkerhetsledare[3] contacted.
- ensure that workers' operations are coordinated and that the workers exchange information about their intentions.
- when necessary, warn the workers.

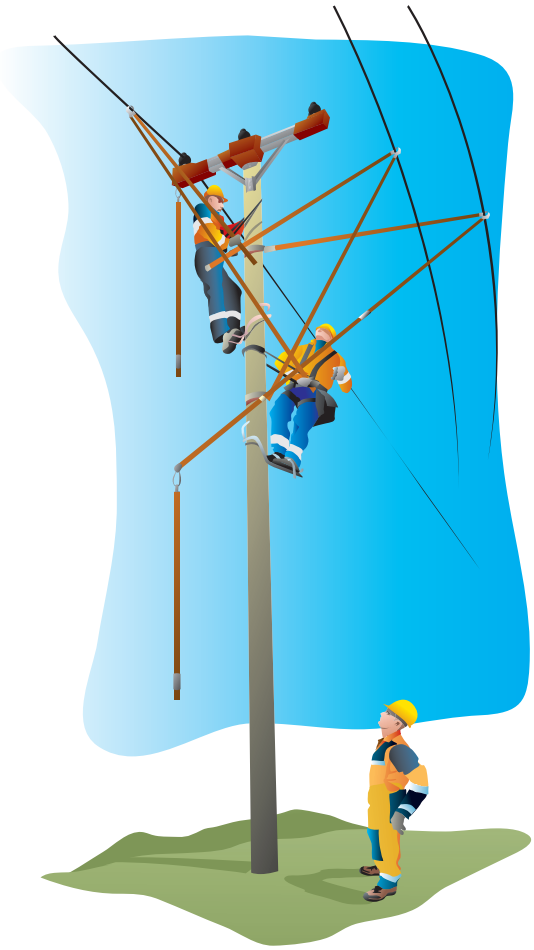

Figure 30. Safety observer at Live working.

If a work activity cannot be satisfactory closely supervised by the safety observer, the task can be handed back to elsäkerhetsledare[3], who appoints a new safety observer who has all the requirements for close supervision of the work activity.

If the safety observer and elsäkerhetsledare[3] have different views on the interpretation of the risk management / work description, a new risk management must be performed.

3 nominated person in control of a work activity

Work

At *Live working*, one or more methods can be used.

Technical cleaning of stations, for example of insulators, is to be considered as *Live working*.

Figure 31. Technical cleaning as Live working.

Insulating glove working

Working procedure in which the worker is in direct mechanical contact with energized parts of the installation and is electrically protected by insulating gloves and, if possible, insulating arm protectors.

Protection by safety screen must be carried out to prevent workers from coming into unintentional contact with live parts of the installation as well as to prevent from short-circuits.

Protection by safety screen must also be performed of earthed parts of the installation to prevent an earth fault.

Figure 32. Live working, AMS work with insulating glove.

LOW-VOLTAGE

Insulating glove working

Work on live parts, must be performed in such a way that the worker is protected with:

- isolating tools.
- insulating tools.
- insulating gloves.
- shield with insulating sheets.
- screens.

HIGH-VOLTAGE

Hot stick working

Working procedure where the worker is at a fixed distance from live parts (outside the live working zone) and performs work using insulating bars.

Bare-hand working

Working procedure where the worker is of the same potential as the live parts and in direct contact with them, and is suitably isolated from other potentials.

Note. Two or more of the above methods can be combined when carrying out work. These work activities must be planned and a work description must be drawn up separately for each method. During these work activities, the working methods must be performed separately and must not be combined at a single operation.

! **If, during the working process, any unforeseen risk is detected leading to that the selected working method cannot be used, the work activity must be stopped and a new risk management performed.**

Special Live working (sAMS)

Every person performing special *Live working* must be skilled or instructed.
For each work, there must be an instruction.

Some examples of special *Live working* are:

- Removal of trees with Safe-T-Cut.
- Removal of branches or leaning trees from lines.
- Cut-and-grapple method from a helicopter.
- De-icing overhead lines from the ground.
- De-icing overhead lines from a helicopter.
- Removal of trees with a throw-saw.
- Edge cutting with saw blades under a helicopter.
- Testing of insulators.

Skilled person

After a risk management and an exchange of permit has been performed, a skilled person can perform work such as washing and removal of dust, salt or ice on insulators, testing insulators, de-icing conductors, removing trees using a throw-saw, explosive clamping (Safe-T-Cut), removing branches or leaning trees from the live conductors and other similar work.

Instructed person

After having performed a risk management and an exchange of permit, an instructed person can carry out work in a non-tree-safe right-of-way with an insulated pole saw, which is approved for the voltage level in question.

Workers must be specifically instructed in accordance with the requirements stated in the work description for the work activity.

Certificate of commissioning

A certificate of commissioning must be submitted by the holder of the permit-to-work to the person who has submitted the permit-to-work according to the *ESA Principles*.

Reconnection

The holder of the switching responsibility must attend to that the automatic reclosing system (ar, far, dar or anr), is taken into operation after having received all certificates of commissioning that correspond to the issued permits to work.

6. Appendices

Appendix 1

Calculation example for induction (E) with one emitting line

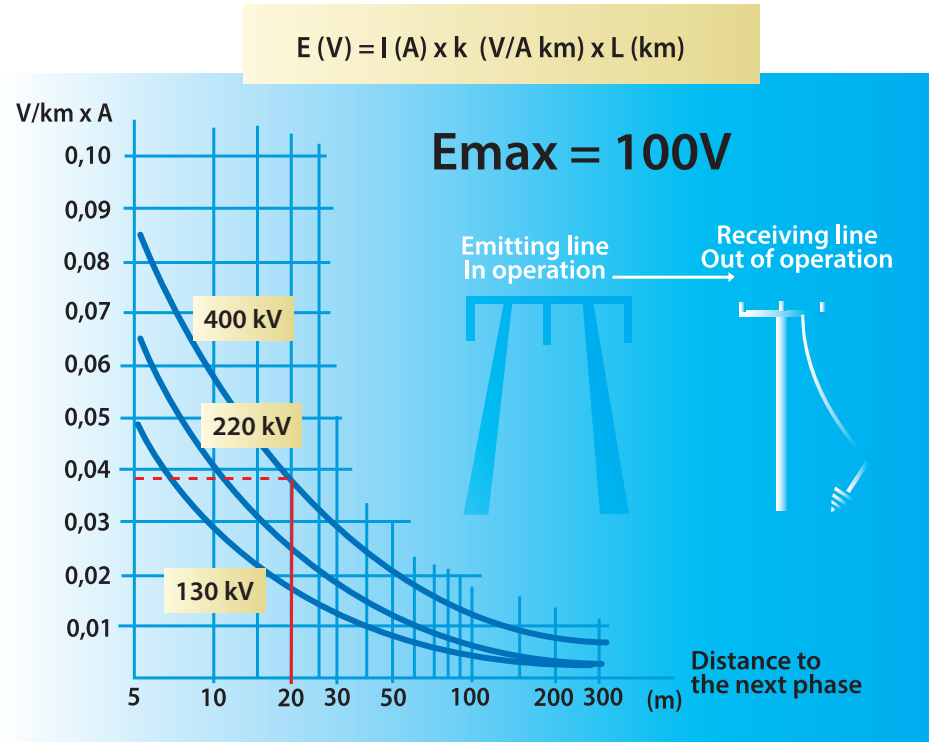

Figure 33.

The example below describes how, at planning, a rough estimate is made to see if measures against dangerous induction need to be taken. Thus, if E in the calculation exceeds 100 V (E max = 100 V). Note that the measuring must be made to earth at the work location and the value must not exceed 50 V without applying supplementary earthing for work, see *page 39*.

The transmission lines at the working area are parallel for 5 km (L). Distance to the nearest phase of the emitting lines is 20 m to the 400 kV transmission line. Maximum load current (I b) is 800 A for the 400 kV line.

Example

Emitting line: 400 kV, 800 A
Distance: 20 m
Parallel stretch: 5 km

E = 800 * 0.04 * 5 = 160 V

The value is higher than E-max which means that safety measures against induction must be taken.

Appendix 2

Calculation example for induction (E) with several emitting lines

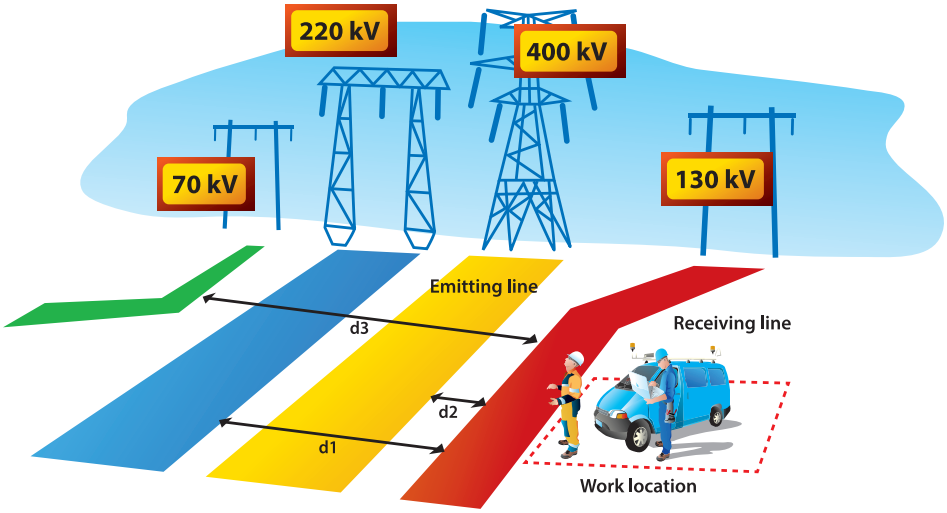

Figure 34. Four parallel lines in a line corridor.

The example below describes how, at planning, a rough estimate is made to see if measures against dangerous induction need to be taken when there are several parallel lines. Thus, if E in the calculation exceeds 100 V (E max = 100 V). Note that the measuring must be made to earth at the work location and the value must not exceed 50 V without applying supplementary earthing for work, see *page 39*.

The transmission lines at the working area are parallel for 6 km (L). Distance to the nearest phase of the emitting lines is 10 m to the 400 kV line and 40 m to the 220 kV line. The 70 kV line is outside the working area limited by the earthings for work and gives no contribution.

Maximum load current (I b) is 1400 A for the 400 kV line and 800 A for the 220 kV line. The contribution to the induction from each emitting line, can be calculated according to the correlation
E (V / km) = Ib (A) x k (V / km A)

where k is a factor that depends on the design of the line and the distance between the emitting line and the receiving line. This factor should be taken from available diagrams.

The diagram in *appendix 1* gives for the 220 kV line k220 = 0.015 V / km A and for the 400 kV line k400 = 0.060 V / km A.

The contribution from the 220 kV line is:
E220 = 800 x 0.015 = 12 V / km

The contribution from the 400 kV line is:
E400 = 1400 x 0.060 = 84 V / km

The sum of the induced voltage per km is E = 96 V / km. With a parallel stretch of 6 km for the two emitting lines, the voltage at the open end of the line will be Etot = 96 x 6 = 576 V.

The value is well above the permitted value of induced voltage. Thus, safety measures must be taken.

Appendix 3

Examples of instruction for special Live working

3.1 Removal of trees with explosive clamp as special Live working (sAMS)

General information:

Explosive clamp is a system developed for cutting and removing trees that have fallen over power lines. At a, for the purpose, insulated rod, an explosive clamp is placed at the point where the cut of the tree is wanted. The explosive clamp is then detonated from a safe distance using a non-electric ignition system that is completely insensitive to induction and therefore can be used near high-voltage power lines. In addition to increased safety compared to traditional clearing with chainsaw, this makes work faster and minimizes the outage time.

The working procedure that is normally applied is special *Live workin*g (sAMS). If sAMS cannot be carried out in a safe way, the working procedure *Dead working* (AUS) must be applied.
An electrically skilled person must be present at the work location.

Instruction for eldriftledare[2] in CC:

Where appropriate, receive request for permit-to-work for emergency clearing of the right-of-way.

Take the automatic reclosing system (ar, far, dar or anr) out of operation for the line in question. The automatic reclosing system must remain in that position throughout the work activity.

The marking sign "ANS / sAMS" must be applied on all switches in the control center, where the energizing of the tripped part of the installation normally occurs.

Uninsulated overhead lines (bare wire, BLL / BLX) must be disconnected / tripped (breaker in the off position) for operational safety reasons to protect the installation (not to be mixed up with measures to increase personal safety).

Detonation can normally be performed with the insulated line in operation. If an insulated overhead line (overhead cable) must be de-energized during the work activity, must be considered from case to case and must not to be confused with measures to increase personal safety. Any disconnection is purely an operating safety measure (risk of damage to the overhead line or causing customer impact). Eldriftledare[2] and elsäkerhetsledare[3] will determine in consultation how the work should be conducted, for example, if trees have fallen on an overhead line at a road crossing (class A constructions) or when trees have lent on the line for a long time with risk of insulation damage.

A permit-to-work / certificate of commissioning for ANS / sAMS must be exchanged for one or more lines with elsäkerhetsledare[3].

2 nominated person in control of an electrical installation during work activities
3 nominated person in control of a work activity

Instruction for elsäkerhetsledare[3]:

- Perform risk management (the risk management must clearly indicate which description of method that is being used).
- Receive a permit-to-work for special Live working, sAMS, or Dead working, AUS, before the work activity.
- Check that the work activity is carried out at the right line.
- Submit a certificate of commissioning after the completion of the work activity.

3 nominated person in control of a work activity

3.2 Removal of trees with the help of a throw-saw as special Live working (sAMS)

General information.

Throw-saw is a system developed for cutting and removing trees that have fallen over power lines. With a saw chain, which is attached to two, for the purpose produced, insulated ”special ropes”, trees that have fallen over the overhead lines can be removed in a way that does not require heavy equipment.

The working procedure normally applied is *special Live working* (sAMS). If the work activity cannot be carried out safely, the working procedure *Dead working* (AUS) and its regulations must be applied. An electrically skilled person must be present at the work location.

Instruction for eldriftledare[2]:

- Where appropriate, receive request for permit-to-work for emergency clearing of a right-of-way.
- Take the automatic reclosing system (ar, far, dar or anr) out of operation for the line in question. The automatic reclosing systems must remain in that position throughout the work activity.
- The marking sign ”sAMS” must be applied on all switches in the control center, where the energizing of the tripped part of the electrical installation normally occurs.
- Un-insulated overhead lines (bare wire, BLL / BLX) must be disconnected (breaker in the off position) due to operational safety reasons to protect the installation (not to be mixed up with measures to increase personal safety).
- Cutting with a throw-saw should normally be able to perform with an insulated line in operation.
- If an insulated overhead line (overhead cable) must be de-energized during work, should be considered from case to case, and must not be mixed up with measures to increase personal safety. Any disconnection is purely an operating safety measure (risk of damage to the overhead line or causing customer impact).
- The holder of switching responsibility and elsäkerhetsledare[3] determine in consultation how the work must be carried out, for example, if trees have fallen on an overhead line at a road crossing (class A constructions), or when trees have lent on the line for a long time with risk of insulation damage.
- A permit-to-work / certificate of commissioning for sAMS must be exchanged for one or more lines with elsäkerhetsledare[3].

Instructions for elsäkerhetsledare[3]:

- Perform risk management (the risk management must clearly indicate which description of method is used).
- Receive a permit-to-work for special Live working, sAMS, or Dead working, AUS, before the work activity.
- Check that the work activity is carried out at the right line.
- Submit a certificate of commissioning after the completion of the work activity.

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3.3 De-icing (snow rapping) overhead lines from the ground Insulator testing as special Live working (sAMS)

When working with snow rapping / de-icing conductors with an insulated rod with accessories, or polythene lines / ropes, each person performing special *Live working* must be a skilled person.

Measures before work:

- The employer plans the work activity and appoints elsäkerhetsledare[3] who is totally familiar with both the work activity and the work location and with the applicable regulations, standards and guidelines.
- A prerequisite for all work, is that personal protective equipment and, the for work necessary insulated tools and equipment for *Live working,* must be able to use.
- A request for permit-to-work must be made in writing to eldriftledare[2].
- When working on an energized installation with an automatic reclosing system (ar, far, dar, anr, or automatic system for neutral point resistance) the automatic system must always be out of operation.
- The marking sign "ANS / sAMS" must be applied on all switches in the control center where the energizing of the tripped part of the electrical installation is normally carried out.
- A permit-to-work must be submitted in writing by the holder of switching responsibility to elsäkerhetsledare[3].
- When the work activity is completed, the permit-to-work is returned in form of a certificate of commissioning.
- A risk management for the work activity must be performed and documented.
- Make sure that the equipment is intact and clean (insulated rods, polythene ropes).
- Always stand by the side of the phase wires and rap off snow / ice from the phase wires from the top to avoid down falling conductor / snow / ice at snow-rapping / de-icing.

2 nominated person in control of an electrical installation during work activities
3 nominated person in control of a work activity

7. References

EBR Publications

SS-EN 50110-1

SS-EN 50110-2

The Electricity Act

The Heavy-Current Ordinance

The Regulations of the Swedish National Electrical Safety Board

The Work Environment Act

Provisions from the Swedish Work Environment Authority

SS-ISO 31000