Learning resource

Demonstrate and apply knowledge of safe plant isolation, re-commissioning, and associated electrical testing procedures (level 3, credits 5)

Trainee Name: _____

Contents

Using this resource

The following information boxes may be found in this resource.

If there is an important note, or a key idea – they may be written into a box like this.

Definition

Word	Meaning of word

Introduction

Working on an industrial electrical installation, or anywhere “plant” (machinery and control systems) requires isolation comes with challenges.

Plant usually comes with local and or remote-control circuitry, equipment power supplies, extra low voltage, three phase and single-phase low voltage supplies, possible high voltage and often other sources of energy such as compressed air, gas, hydraulics, steam, and pressurised firefighting systems.

In this resource, we will take a look at how to safely isolate plant and get it going again.

Learning Objectives

At the end of this module, the trainee will be able to demonstrate and apply knowledge of safe plant isolation and re-commissioning, electrical testing for safety, and be able to describe the dangers and requirements when working on or near live electrical plant and equipment, which includes being able to:

- Identify and describe safety requirements in the workplace;
- Describe the dangers and requirements when working on live plant or equipment;
- Identify the requirements for isolation and the associated tagging required;
- Describe the required tests, and state the associated acceptable values;
- Carry out isolation tests;
- Describe and explain connecting plant and equipment to the supply;
- Describe and explain re-commissioning; and
- Develop a basic isolation and re-commissioning plan.

Isolation procedures

As sparkies, we usually think about isolation as removing the electrical supply from the gear we are working on, locking and tagging so that it can't inadvertently be turned on while we work - and that would be correct.

When you are working with plant though, there can be a variety of electrical supplies to the same equipment, and other energy sources or hazards as well, that could harm us.

Mechanical equipment like air operated rams, water jet cutters and hydraulic pumps, come onto the scene and the isolation ante goes up. You have to be on your game to make sure you are safe.

Full isolation of plant is not just removing the electrical supply, but includes isolating all forms of potentially hazardous energy to ensure that an accidental release of hazardous energy does not occur.

Photo by Graeme Jeffrey

Four important reasons for plant isolation are:

- To ensure that the equipment is de-energised while work is undertaken.
- To ensure that equipment cannot be re-energised while work is being undertaken.
- To ensure that all other potential energy sources are safely isolated.
- To keep all site-workers safe from all energy sources while working on the equipment.

Isolation and recommissioning plan

An isolation and recommissioning plan is a document used to ensure that all required plant and equipment is isolated in a safe and logical order.

It contains specific information regarding the:

- Work required, and who may undertake that task.
- Completion dates, times and any relevant time frame information.
- The sequence for recommissioning which may involve multiple people and trades.
- Manufacturers specifications / tests results / special testing procedures that may be used for compliance or reporting etc.

Shutting down

Before a plant can be isolated, it will need to be shut down.

Plant that has only one energy source can usually be shut down by the operation of a single control, such as a switch or valve.

More complex plant may have to be shut down in a certain sequence, such as, one conveyor before another, or by shutting down several energy sources e.g. electricity, petrol, diesel, oil, steam, pressurised air.

Shutting the plant down may require other potential hazards to be turned off and locked-out to prevent re-activation. For example, pipes and lines carrying gases, water, acids or alkalis.

Photo by Graeme Jeffrey

Identifying energy sources and other hazards

All energy sources and other hazards likely to place people at risk must be identified.

This is especially important for workers who may not be familiar with the complexities of processes associated with the plant, and sometimes the lack of reliable ‘as-built’ diagrams of plant installations at many workplaces.

Energy sources

Plant energy sources may include:

- Electricity (mains, solar, standby generator, ups, single phase, two phase three phase)
- Chemicals
- Fuels
- Heat
- Cold (extreme)
- Steam
- Compressed air
- Pneumatic pressure (gasses)
- Fluids under pressure, such as water or hydraulic oil
- Energy storing devices, such as batteries, springs, flywheels, accumulators and capacitors
- Pressurised firefighting systems
- Cleaning and wash down systems
- Gravity
- Radiation

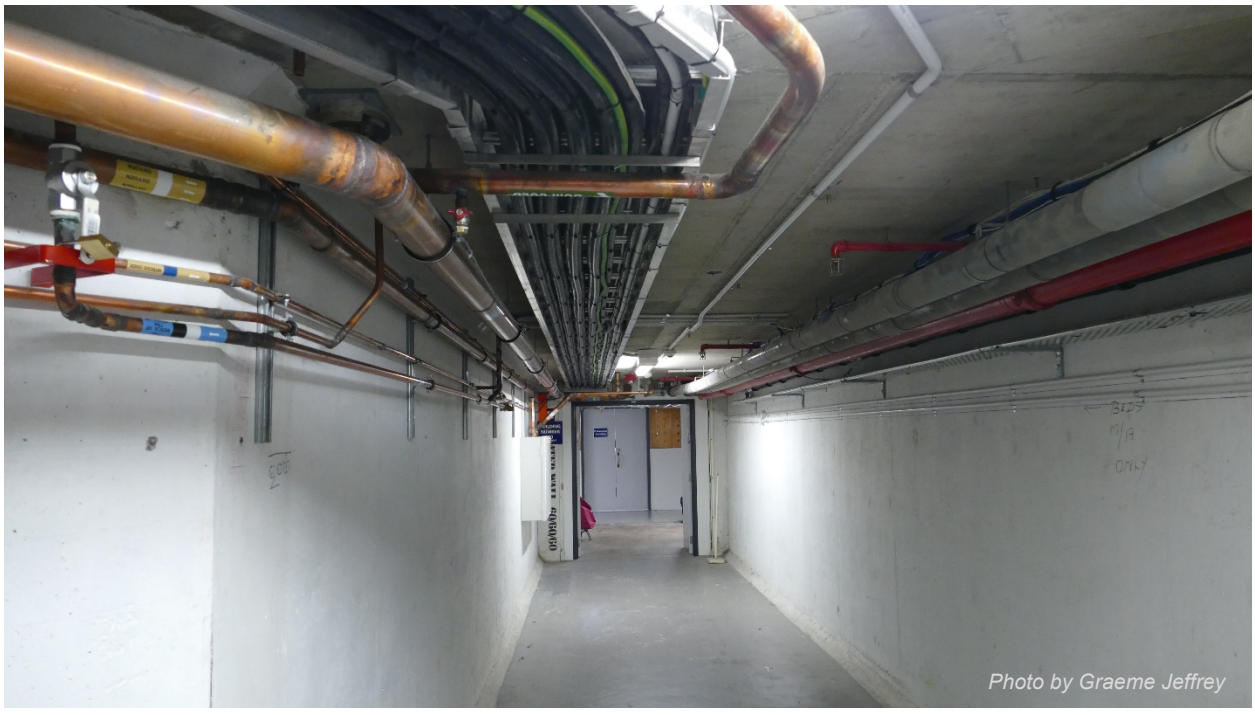


Photo by Graeme Jeffrey

Other hazards

Depending on the type of plant, other hazards may include:

- Hazardous substances, such as gases, acids, alkalis, solvents, glues or pooled liquids in which a person may drown
- Falls
- Falling (parts of machines)
- Burns
- Asphyxiation or engulfment
- Impact
- Mechanical – any form of rotating, crushing, grinding or mixing machinery

What is isolation?

Is there a difference between switching off and isolating? Yes. Switching off stops an electrical appliance or circuit from going or working. Isolation is the disconnection from a supply for safety reasons (AS/NZS 3000 1.4.62).

If isolation is for reasons of safety, part of that safety should include making sure that the equipment cannot be re-energised accidentally so that the equipment stays safe to work on.

Photo by Graeme Jeffrey

Note

An isolating switch has higher manufacturing specifications than a standard electrical switch. The contacts open further for example.

The symbol for an isolator is  and you can often see this as part of the manufacturers circuit symbol on devices that meet the requirements as an isolator.

The two-pole main switch shown above is an isolator and the extra circle on the symbol indicates it can break load current as well.

What is an isolation procedure?

An isolation procedure is a set of predetermined steps that must be followed to ensure that plant and related hazards is safe to work on.

There must be an isolation procedure for each item of plant, including the application of isolation devices, locks and tags.

While isolation procedures may vary in detail because of differences in plant power sources, hazards and processes, they should include the following steps.

Basic isolation procedure

1. Identify the plant involved and all corresponding energy sources.
2. Identify all other hazards.
3. Shut the plant down.
4. De-energise all energy sources.
5. Isolate, lock out and tag all energy sources.
6. Release or control other potential hazards.
7. Test by prove test prove, and ‘trying’ to re-activate the plant, without exposing the tester or others to risk, and any other suitable tests (depending on the energy sources involved).

Isolation procedures should be developed in consultation with:

- Safety and health representatives.
- People doing adjustments, cleaning, maintenance, repairs or inspections.
- Plant operators.
- If possible, plant manufacturers, suppliers and people who designed and installed the plant.

Electrical equipment

Definition	
Electrical equipment	Includes control gear, switch gear, appliances, fittings or luminaires. They are typically used for electrical energy storage, generation, conversation, transmission, distribution or utilisation.
Electrical appliance	A device that converts electricity into energy or is altered electrically. The energy is typically converted into heat or motion. Lamps are typically not included.

Electrical connections

Electrical equipment is connected to the supply in a variety of ways. The connection system is chosen for its suitability to the environment the electrical equipment is installed in.

Photo by Graeme Jeffrey

A good typical example that most of us can relate to is the humble heated towel rail in a bathroom. Heated towel rails are connected to the supply via a flexible and a permanent connection unit.

This type of connection is used as a precaution because a plug and socket would be dangerous in the moist bathroom. A permanent connection unit is much safer.

Generally electrical equipment and appliances are connected to the supply in parallel with other electrical equipment. You need to be aware that there are a few circumstances that equipment is connected in series though, such as some (LED) lighting systems and the components in plant control circuitry for example.

Electrical energy

Care must be taken to ensure all electricity sources are identified and isolated, as some equipment will have several control stations and sections which could have independent electricity sources.

Electrical components that operate other services, like switches and contactors, risk the other services being operated inadvertently while people are working on them.

Remote controlled equipment may operate without warning because the controls may not be in the local area which may cause damage to property or people.

If programmable logic devices are used to control the equipment, then it is essential to use local isolating switches as the means to achieve secure and safe isolation.

Photo by Graeme Jeffrey

It is not acceptable to rely on the controls of the programmable logic devices for the isolation of equipment.

Emergency stop buttons are only acceptable for isolation if they are lockable, but they may only isolate the control equipment. Care must be taken as they may not be suitable for plant isolation.


Photo by Graeme Jeffrey

Push button switches are generally not acceptable for isolation, especially as they are usually not lockable, and they can be accidentally operated.

Some common electrical isolation methods are as follows:

Isolation method	Description
Lockable isolator	Switch off, lock and tag out.
Removal of fuses	Remove and replace these with blanks and a warning tag so no one re-connects it.
Removal of plug from socket	Remove this from the socket and place a lock-out cover over it to make sure no one puts it back in.
Turn off circuit breaker	Switch this off to isolate the circuit from point of supply. Must ensure a lockout is used to ensure continued isolation.
Disconnection of circuit conductors by a registered person	Disconnect conductors from the supply after isolation - for complete isolation.

Stored energy

Energy storage devices risk harm or damage to people or property if the stored energy is not isolated or removed.

While it is possible sometimes to isolate energy in storage devices, such as batteries, in other cases the energy must be dissipated before work begins on associated plant.

This is particularly important with electrical capacitors, springs and gases under pressure, such as in suspension systems. Static electricity can be dissipated via an earth to the ground.

Fluid, steam and pneumatic energy

Isolation of fluid, steam and pneumatic energy sources is usually achieved by closing a valve. Care needs to be taken as some valves may be automatic or remotely controlled by computers. Blanking or the use of spades may be the safest approach.

It may be necessary to drain pipes and lines leading to the plant to prevent workers being exposed to hazardous gases, liquids or covered by small solids e.g. mineral ore, sand or grain.

Compressed air held in lines connected to the plant needs to be released safely. Materials that are gravity fed should also be addressed, for example, grain in silos and other materials that may engulf the worker.

Other energy devices

Other energy storing devices that must be considered in developing an isolation procedure include:

- Those with rotational motion (kinetic energy), such as flywheels, saws, planers, mixers, pulleys and similar; and
- Those with potential energy due to their position. This type of energy source cannot simply be turned off. The energy must be dissipated or controlled.

When the potential energy is related to gravity, the plant must be allowed to ‘complete its stroke’ or ‘come to rest’ so that gravity has no further influence. If not possible, it may be necessary to prevent any possible movement by blocking, wedging or propping.

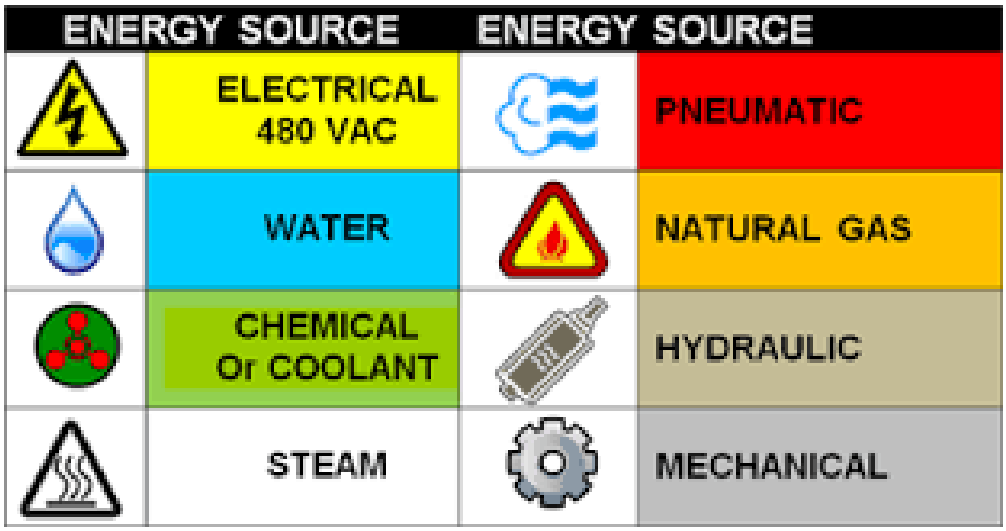
An ‘authorised person’ should ensure props, blocks or wedges are inserted, or chains and locks that are used to prevent rotation cannot inadvertently be removed.

This may be by securing them with some type of locking system, including the use of pins, shackles or chains, and tagging them.

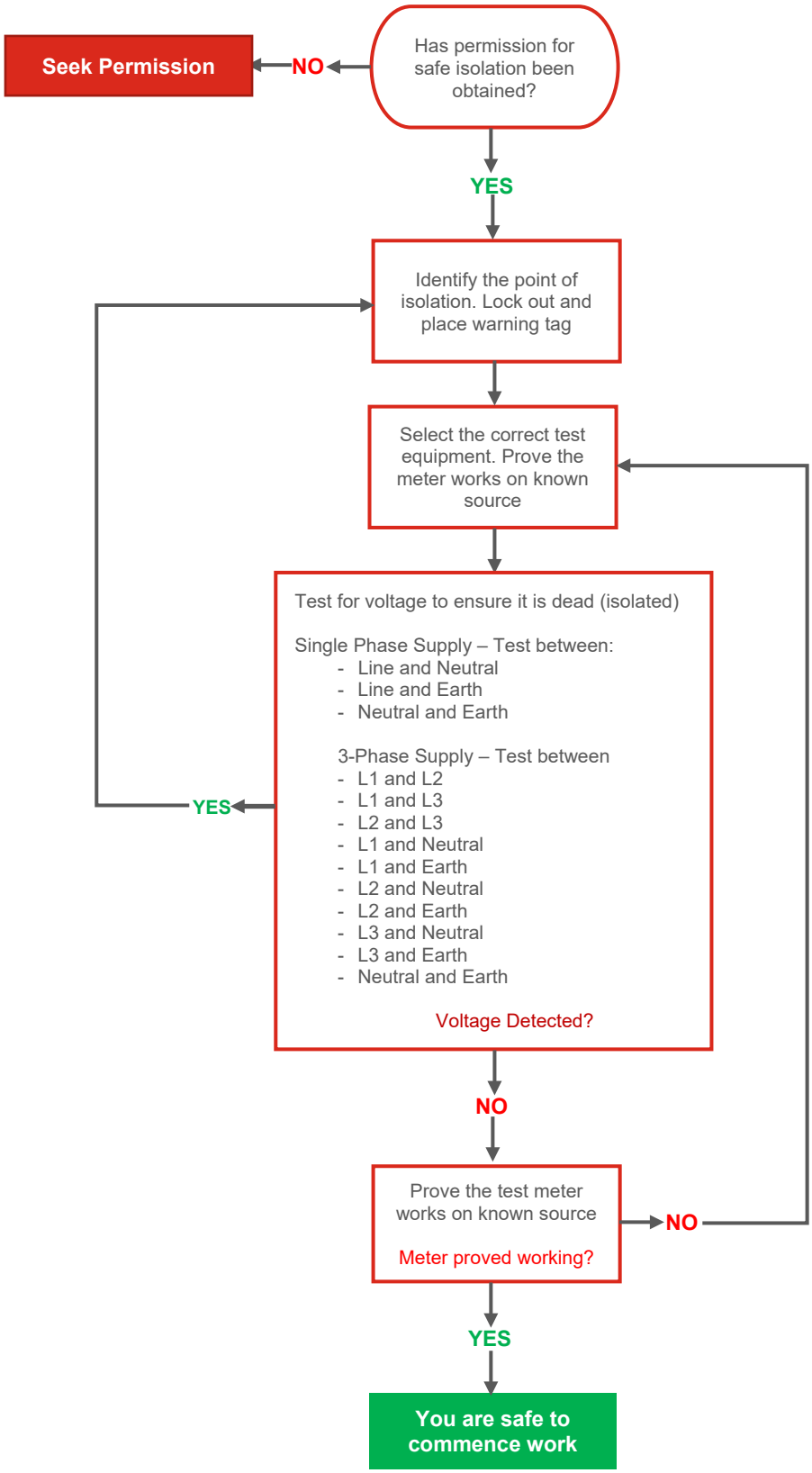
Negative pressure

Vacuum or negative pressure, while not strictly an energy source, may be used to activate the plant.

As part of the isolation procedure, any negative pressure needs to be equalised to avoid hazardous situations in the work area should the vacuum break while work is being undertaken.



Safe Isolation Procedure



Where isolation is not practicable

There may be workplaces where all the steps we have covered here for an isolation procedure cannot be carried out because of the way the plant is designed, installed or operated.

There may also be certain plant that can only be cleaned, maintained, repaired or adjusted by moving components under power. One solution is that the plant be fitted with controls that allow safe controlled movement and written safety procedures to be followed.

While to be avoided if possible, if there is no other alternative but to work on live equipment, then your company health and safety policy and risk management plan needs to be used to establish the local procedure and safety requirements for the work.

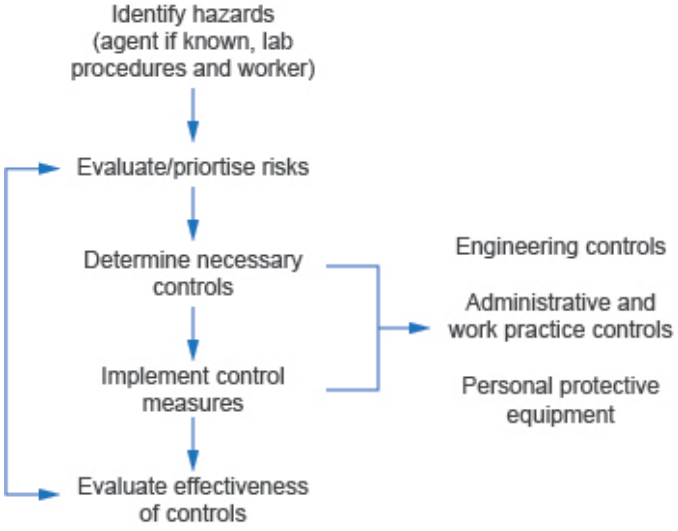
Risk management

Each company has to come up with its own risk analysis safety solution, and that plan may not be the same as another company's health and safety solution for the same situation. That is okay as long as it is appropriate for the situation and the risk.

This is a deliberate function of the health and safety act, to allow flexibility for individual companies. They can come up with their own good effective local health and safety risk controls - that suit the local situation rather than limiting them by trying to impose a standard one size does not fit all government health and safety solution.

A risk management approach to the adjustment, inspection, cleaning, maintenance or repair of plant, and the isolation procedure itself, requires:

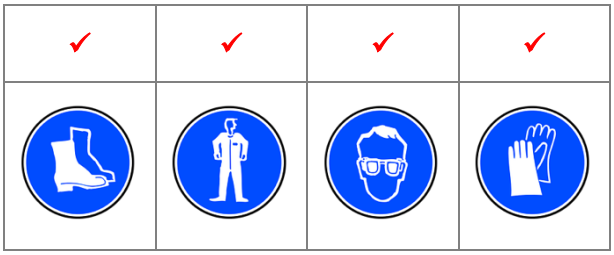
1) Hazards to be identified.
2) Associated risks to be assessed.
3) Risks to be eliminated or controlled.
4) The controls to be reviewed from time to time to ensure they remain effective.



PPE while isolating live equipment

The personal protective equipment (PPE) that is most likely to be required for isolating live equipment in an industrial setting may be as follows.

- Safety footwear.
- Protective clothing (may be required to be CAL rated).
- Eye protection (may be required to be tinted).
- Gloves (may be required to be insulating and arc protective)



Depending on the situation and the risk analysis, some companies may require less, some companies may require more PPE.

There is some guidance that can be followed in Table 9.2 from AS/NZS 4836 for such situations.

Testing for isolation

After isolation and before starting work, the electrical supply must be tested to confirm isolation.

Note: Remember the two “Golden Rules”

1. Test before Touch – always test electrical connections to plant before commencing work.
2. Prove-Test-Prove

(a) Prove the test instrument against a known source.
(b) Test for Isolation.
(c) Prove the test instrument against the known source again, to ensure that the test instrument or leads have not gone faulty while carrying out the test.

To test for voltage, the appropriate instruments must be used.

Non-contact neon type testers are great for finding circuits, indicating that a conductor is live and they should be part of any electrician’s instrument set.

Photo by Graeme Jeffrey

But… they are prone to not indicating occasionally, batteries going flat without you knowing and are not suitable to *ensure* a circuit is isolated.

By all accounts use one to your advantage, but don't rely on it to ensure isolation, don't forget, the stakes are high, you may pay with your life.

The following instruments can be used to test for isolation:

- Solenoid type voltmeter.
- Voltmeter.
- Multimeter set to volts.

Photo by Graeme Jeffrey

The tests for isolation include:

(a) Test each phase to neutral (if a neutral wire is present).

(b) Test each phase to earth.

(c) Test between each phase (if there is more than one phase).

(d) Test earth to neutral.

Electric shock, injury from machinery starting up, damaged tools and equipment and fires are all consequences for electrical circuits that are still alive.

If the isolation test shows the circuit to be live, then check for one of the following errors or factors:

(a) The wrong isolating switch has been operated.

(b) The wrong fuses or circuit breakers have been operated.

(c) The wiring is damaged, faulty or wrongly installed.

(d) The circuit is being fed from two or more different sources, or there are live conductors present from the control circuits such as –

- Thermostat switches
- Control sensors
- 3 plate ceiling roses
- Limit switches, and many more

(e) The isolating switch is not in the phase conductor

(f) It may be a combination of two or more of the above.

Locking out

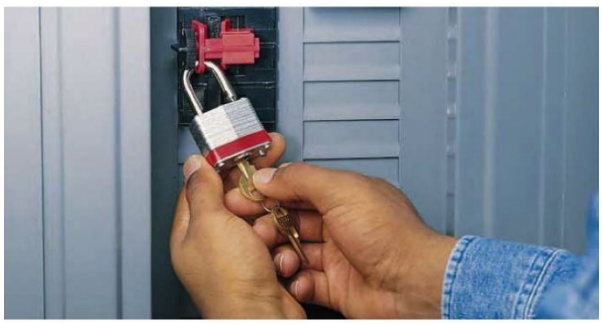
Locking out a circuit using one of many available lockout mechanisms is an effective and convenient method of ensuring a circuit stays isolated.

They give peace of mind that someone can't either accidentally or deliberately re-liven the equipment you are working on.

A wide range of devices are available for locking out energy sources. These include switches with a built-in lock, lockouts for circuit breakers, isolator switches, fuses and various types of valves.

Miniature Circuit Breaker Lockout

Main Breaker/Isolator Lockout



Circuit Breaker Lockout

A safe lockout procedure ensures each person working on the plant has their own lock, key and tag.

If more than one person is working on the same plant, a suitable multiple lockout device must be used and each person attach their own lock.

This prevents the isolation being removed until all the locks have been removed when everybody working on the plant has finished.

When carrying out work you should always keep the person in charge informed regularly with information such as, what work is being done, estimated duration of the work and when the work may be re- energised.

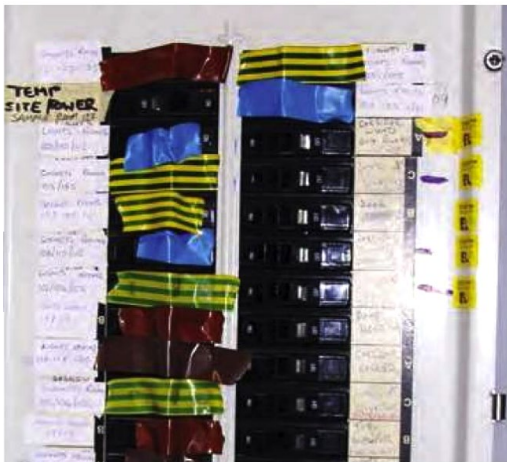
This is because the person in charge is responsible for safe and timely completion of the work. It also helps the person in charge organise other work that may be being done at the time.

Once your work is completed and safe to re-energise, you will take your lock off the isolation.

Photo by Graeme Jeffrey

The practice of placing insulating tape over a circuit-breaker to prevent inadvertent switch-on is not an adequate means of securing the device in the OFF position.

Such unsafe practice will not achieve compliance with the Electrical Safety Regulations



Locking out circuits protected by fuses

Where fuses are used, the removal of the fuse is an acceptable means of isolating the circuit. The problem is, they are difficult to lock or ensure the isolation remains as it is easy for someone to put a fuse back in.

To prevent the fuse being replaced by others, you should take the fuse bridge away with you and use a lockable fuse insert to achieve secure isolation. A warning notice should be attached at the point of isolation.

Where lockable fuse inserts are not available, or don't fit, the following must be considered:

- Where removal of the fuse exposes live terminals that can be touched, a dummy fuse (that is a fuse carrier which is not fitted with a fuse link) should be inserted in the fuse base to cover live parts. When this is not possible, the incoming supply to the fuse will need to be isolated.
- A warning notice should be attached to deter inadvertent replacement of a spare fuse;
- In addition, if possible, the fuse board door or cover should be locked to prevent access as long as that does not cause an unsafe situation where someone needs to turn the power off but can't.

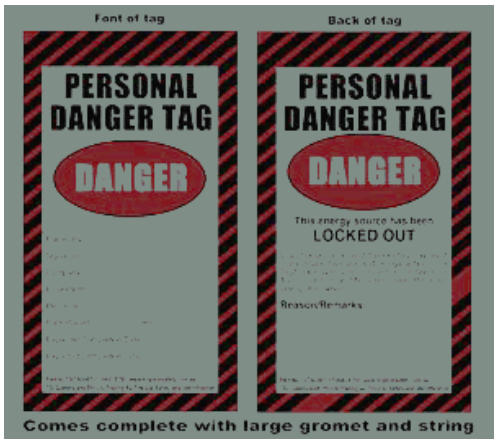
A solution of some sort needs to be put in place to keep you and your workmates safe from electrocution.

Tagging

A personal danger tag should accompany each lock used on an isolation. The tag identifies the person who put the tag and lock in place.

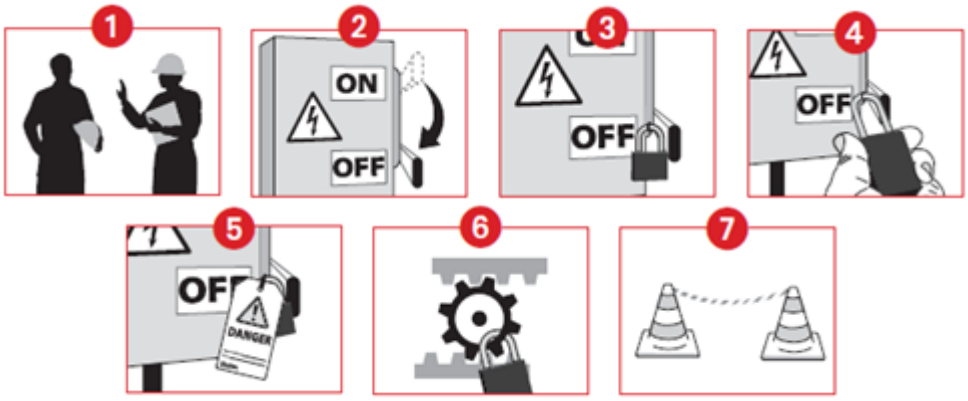
No one should interfere with, or operate any tagged equipment such as a main switch, push button or other electrical device until the item has been cleared for safe operation and the attached tag has been removed.

The tag must only be removed by the person who attached it, or by an 'authorised person' in accordance with an approved procedure. The 'authorised person' is responsible for ensuring procedures affecting the use of tags are followed.



LOTO

Put together, everything we have discussed is called LOTO – Lock Out, Tag Out.



LOTO is simple

While this may appear to be complicated, we will reduce it to a simple step-by-step procedure and flow chart below.

Before starting

Before starting the Safe Isolation Procedure, remember to seek permission from a relevant responsible person, because there might be certain vital services that must not be interrupted at any time. There might be a permit to work system in place to which you will need to comply.

Step 1

- Identify the point of isolation for the system or circuit.
- Lock off
- Place warning label
- keep the key to the lock with yourself.

Step 2

- Select the correct and mains approved test equipment
- Ensure that it works correctly by testing on the proving unit.

Step 3 A

- Single Phase installations test to confirm that there is no voltage between:
  - Line and Neutral
  - Line and Earth
  - Neutral and Earth.

Step 3 B

- 3 Phase installations test to confirm that there is no voltage between:

- L1 and L2	- L2 and Neutral
- L1 and L3	- L2 and Earth
- L1 and Neutral	- L3 and Neutral
- L1 and Earth	- L3 and Earth
- L2 and L3	- Neutral and Earth

Step 4

- Re-test the test equipment on the proving unit.

Recommissioning

Now that you have completed the repairs or maintenance, it is time to recommission the plant. Before recommissioning, you must first carry out electrical tests to ensure that the plant or equipment is safe to re-liven.

Electrical appliance and plant testing

When recommissioning plant and machinery, test procedures from the manufacturer's instructions should be followed to ensure that the plant or machinery operates as designed.

Additionally, the plant or machinery also needs to comply with current legislation such as electrical work done under part 2 of AS/NZS 3000 and AS/NZS 3760 for appliances. Testing should comply with the testing procedures and expected test results outlined in the standards.

Tests

- Visual / mechanical testing
- Earth continuity testing
- Insulation resistance testing
- Polarity and connections testing

The Visual/Mechanical Test

Test instruments cannot always show physical defects or unsafe conditions in electrical equipment. A careful visual and mechanical check should be made for the following:

- The general mechanical condition of the plant or appliance.
- Earth continuity conductors are connected to the earth bar and neutral conductors are connected to the neutral bar.
- Earth bonding has been done for all extraneous metal parts. AS/NZS 3000 specifies the earthing and bonding requirements.
- Broken components and conductor supports.
- Loose terminations of conductors.
- Stray conductor strands protruding from terminations.
- Burnt or damaged conductor insulation.
- Effectiveness of flexible cord or cable anchorage.
- Switches and protective devices are labelled as to the type of circuit they control or protect.
- Condition and rating of internal fuses, overload devices, overheating devices, internal switches and indicator lamps.
- Correct fitting of protective screens and guards.


Photo by Graeme Jeffrey

The Earth Continuity Test

The earth continuity test is carried out between exposed metal parts of the electrical plant and the earth pin of its plug or the earth bar.

The purpose is to prove an unbroken, low resistance path to earth from any exposed metal or earth termination.

This test is carried out with an ohmmeter set to the low ohm scale to register the very low resistance values.

The resistance value of an earth continuity conductor connecting exposed metalwork of an electrical appliance, or electrical equipment supplied by a flexible cord, to the earth pin of its three-pin plug, must not exceed 1 ohm.

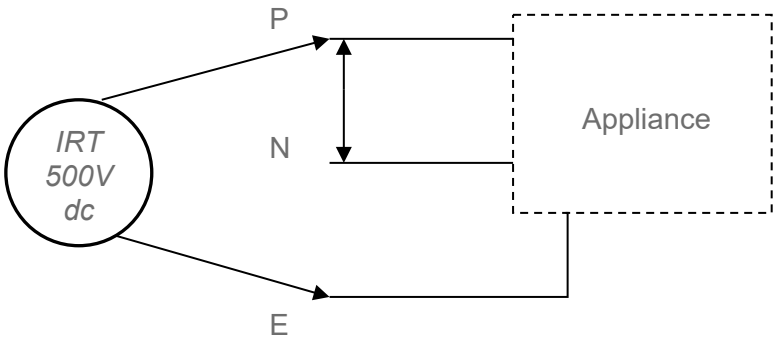
The resistance value of a fixed wired earth continuity conductor should be low enough to trip the protective device in the correct time.

Photo by Graeme Jeffrey

The Insulation Resistance Test

Insulation resistance tests are very important as a means of determining whether an electrical appliance or circuit is electrically safe to use.

The insulation resistance must not be less than 1 megohm (1,000,000 ohms) for plant or circuit.



It is very important to first ensure that the earthing is satisfactory before undertaking the insulation resistance tests.

CAUTION: Electrical appliances and circuits in which semi-conductor components are used require special consideration.

Many semi-conductor components will not withstand the higher voltage of an insulation resistance tester and will irreparably break down. When testing such electrical appliances observe the following precautions:

(a) Disconnect semi-conductor components before making an insulation resistance test between phase and neutral; or, if impractical,

(b) Join together both the phase and neutral and test between this pair and the electrical appliance framework when making an insulation resistance test to earth.

The Polarity and Connections Test

The polarity and connections testing is necessary to ensure that no shock hazard arises from the incorrect connection of the conductors.

The tests must check for, and prevent:

- Combinations of incorrect phase, neutral and earthing conductors.
- Connections resulting in the exposed conductive parts of the electrical installation becoming livened.
- Switches or protective devices incorrectly connected in neutral conductors, resulting in parts of appliances, such as heating elements and lampholders, remaining energised when the switches are in the OFF position.
- Multi-phase equipment, such as multi-phase motors, and semiconductor-controlled equipment operating in an unpredictable manner.
- Protective earthing conductors normally carrying current.
- Any short circuits.

If supplied by a flexible cord, the polarity of the cord and plug pins must be tested to confirm that they are correct.

Removal of lock and tags

Once all tests have been completed, and the plant, equipment or appliance is known to be safe, the next step is to complete a functional test of the plant, equipment or appliance to ensure that it is operating correctly.

As each worker is finished and clear of the plant, they remove their locks and tags until all the locks are off and then the plant can be restored.

Restore power and test function

The final steps are as follows:

1. Check that tools, spares and anything not part of the machine has been removed
2. Restore power
3. Pre-commission if required:
    - Open valves
    - Restore pressures
    - Restore vacuum
    - Prime pumps
    - Ensure that people are clear
4. Power up the plant
5. Verify operation of components under various conditions
6. Verify interaction between systems and subsystems
7. Document performance of systems against design criteria

Certification

The final point to remember is that the plant or appliances must be certified.

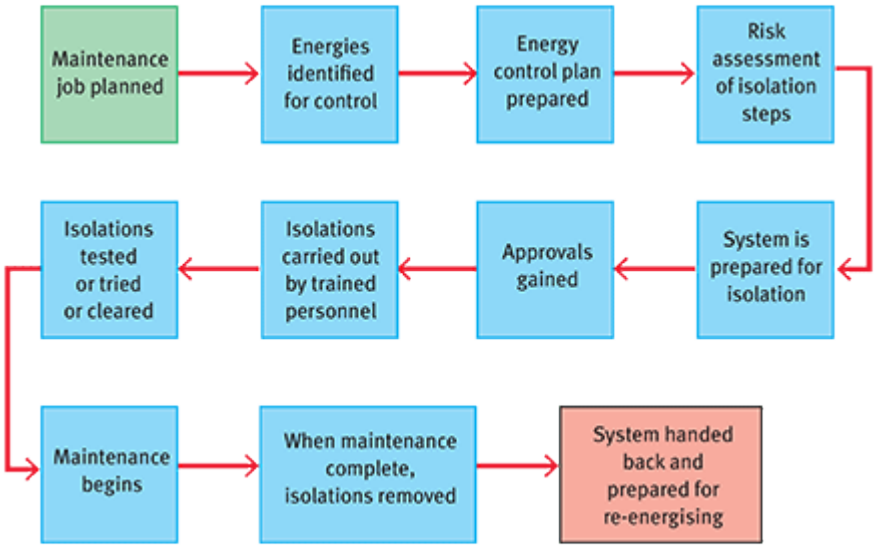
1. Appliances must be certified as safe in accordance with AS/NZS 5762. The electrical tests must have met the requirements of AS/NZS 3760 and other requirements specified in AS/NZS 5762.
2. Plant that is hardwired must be tested in accordance with AS/NZS 3000, and a Certificate of Compliance and or an Electrical Safety Certificate issued as necessary.

Isolation and re-commissioning plan

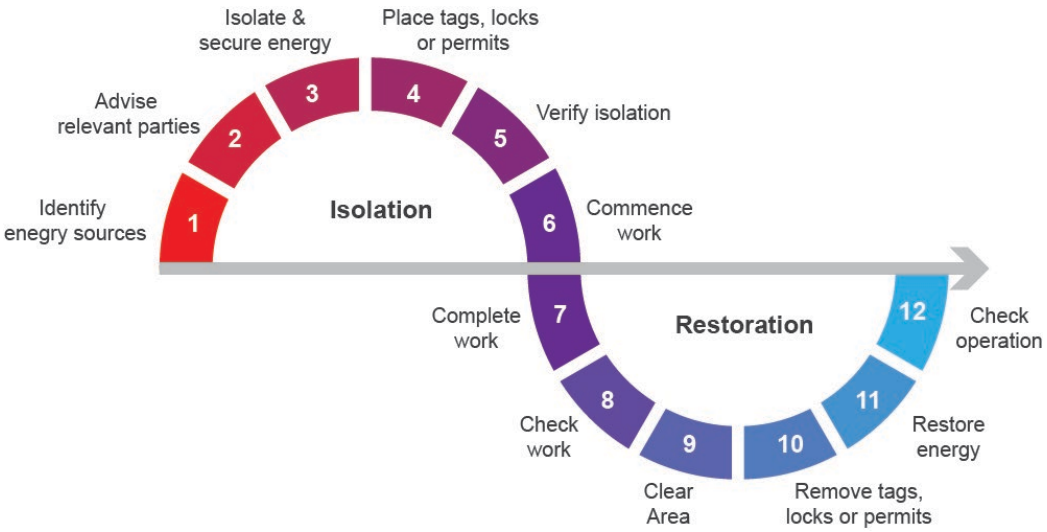
Now that you have learnt about isolation and recommissioning, you no doubt understand that there are many steps involved. With complicated equipment, it is important to create a plan before starting to make sure you remember all the steps required.

Some Samples

Block diagram



Snake diagram



skills.
Grow by growing others

The Skills Organisation
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