Methodical process for risk IDENTIFICATION

It is not sufficient to decide to work live and then devise preventative or protection measures

MIKE FRAIN OF ELECTRICAL SAFETY UK, EXAMINES LIVE WORKING ON LOW VOLTAGE SYSTEMS IN INDUSTRIAL AND COMMERCIAL FACILITIES; DETAILING A METHODICAL PROCESS FOR IDENTIFYING THE RISKS ASSOCIATED WITH LIVE WORKING AND THE METHODS FOR CONTROLLING THEM.

FROM MY EXPERIENCE, I believe Regulation 14 from the Electricity at Work Regulations 1989, referring to live working, is often misunderstood and sometimes overlooked. The duty holder is asked to apply a rigorous test of reasonableness in allowing live work to proceed in the first place, and to prevent injury by taking suitable precautions. It must be stressed that Regulation 14 requirements are 'absolute' which means it must be met regardless of cost or any other consideration. With this in mind it makes it very important that any live operation must be subject to a suitable and sufficient risk assessment.

Regulation 14 - Work on or near live conductors

A person shall not be engaged in any work activity on or so near any live conductor (other than one suitably covered with insulating material so as to prevent danger) that danger may arise unless

(a) it is unreasonable in all circumstances for it to be dead; and

(b) it is reasonable in all circumstances for him to be at work on or near it while it is live; and

(c) suitable precautions (including where necessary the provision of suitable protective equipment) are taken to prevent injury.

Before we move on, let me highlight a few of the important words from Regulation 14.

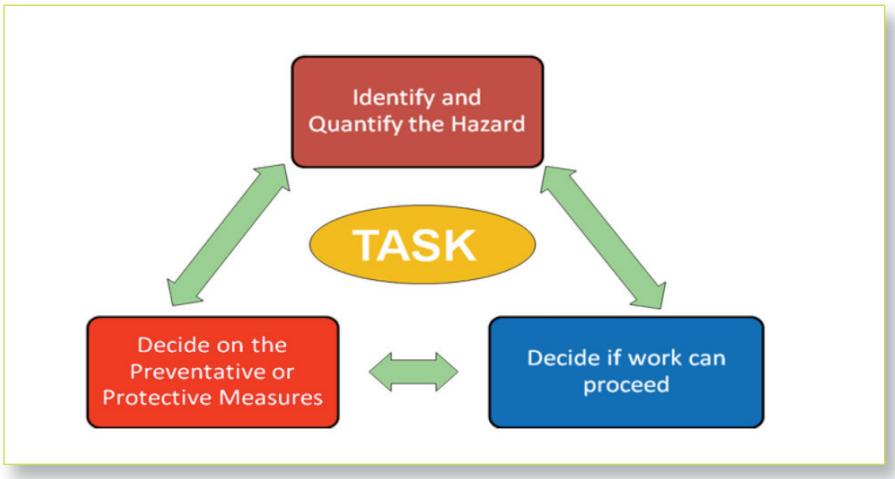
Near. This word debunks the myth live working only means those activities that require the manipulation or the removal/replacement of live conductors and components. Live work can also mean live testing and testing for dead. It can also mean the opening of control panel doors to undertake visual examinations or undertake non electrical work near energised equipment. I find that most live working in industrial and commercial facilities is confined to testing, inspections and running adjustments.

Suitably. This word completely changes the meaning of the opening sentence. I often hear when conductors are insulated through finger safe shrouding or cable insulation then live work can proceed with no further precautions necessary. I can name several examples of incidents in switchgear which was finger safe or of Form 4 construction. It is the task or activity near live conductors which will determine whether the insulation is suitable or not. An armoured and insulated underground cable may be suitably covered with insulation where its presence is known and careful location and hand dig techniques are adopted but would not be suitable using a jack hammer without safe dig techniques. Finger safe shrouding, providing it hasn't been removed, may be suitable insulation for routine testing but may not be suitable for the task of drawing in of cables into switchgear enclosures or other similar invasive tasks.

And. Parts a) b) and c) are separated by the word 'and' which means there is a legal requirement for all parts of the regulation to be satisfied before live work can be permitted.

Danger and Injury. Danger and injury are highlighted in bold and are specifically defined in the guidance documents referred to in this article. Briefly, danger means risk of injury, and injury means death or personal injury from electrical shock, burns or explosion and arcing. For live working, danger may be present but injury must be prevented.

As an electrical duty holder who may be vexed by the



Note the relationship between assessment and decisions is interdependent

questions posed in regulation 14 where do you look for help? Firstly there is the Memorandum of Guidance (HSR 25) published by the HSE. This is usually purchased instead of a separate copy of the actual regulations, to assist with the interpretation of each of the regulations in turn. In addition there is the guidance booklet HSG85 Electricity at Work – Safe Working Practices, also available from HSE Books. Further guidance can be obtained from the HSE website www.hse.gov.uk.

I find HSG85 Electricity at Work – Safe Working Practices is particularly helpful in the decision making process for working live or dead. Simple flowcharts are a feature of this document and one such flowchart is shown below.

It is not my intention to repeat verbatim the advice given in the existing guidance notes but to further expand on this decision making process and to emphasise a methodical process for identifying the risks and the methods for controlling them. I have used the following model many times with duty holders to explain the relationship between the live/dead working decision, task, identification and quantification of the hazard and preventative measures to be taken. As can be seen, this relationship is an interdependent one. It is not sufficient to decide firstly to work live and then devise preventative or protection measures.

To further clarify this relationship, a decision for work to proceed cannot be taken in isolation to other factors. The level of hazard and also the availability and effectiveness of preventative or protective measures will also need to be considered. This is all directly affected by the work task.

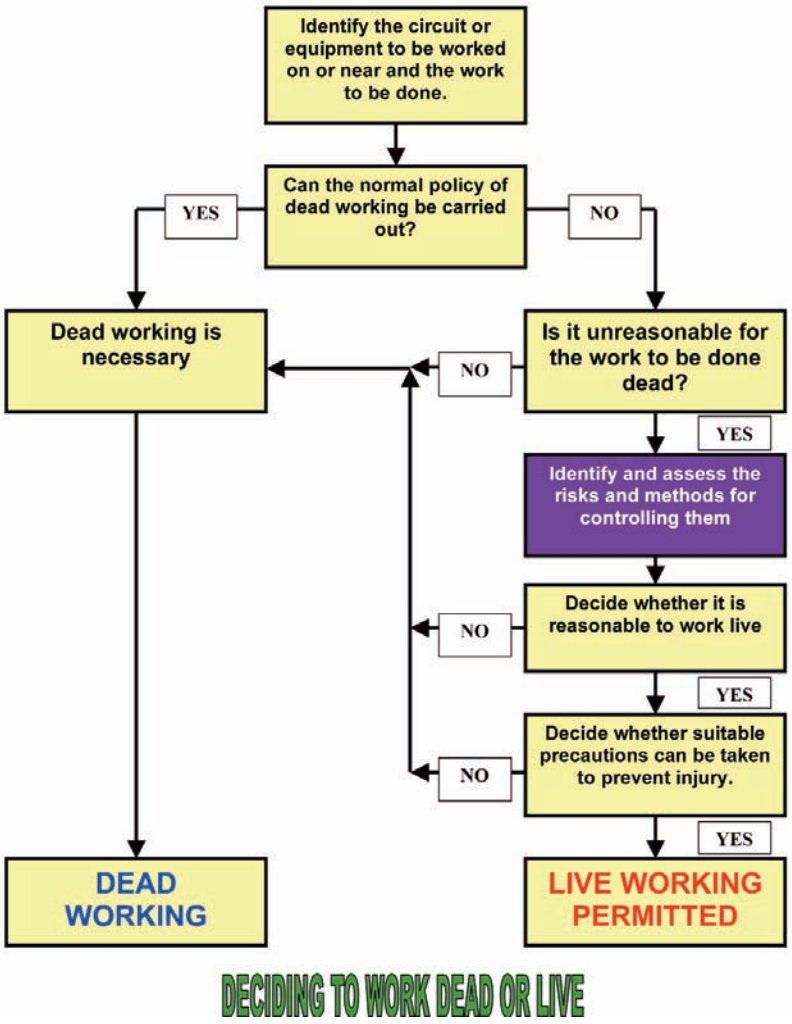


Fig 1. Diagram reproduced from HSG85 Electricity at Work - Safe Working Practices under PSI license no C2010000923

Steps to Identify and Assess the Risks and Methods for Controlling them.

The live working decision flow chart Figure 1 illustrates that a critical part of decision making is the identification of risks and the methods for controlling them. I find it useful to break this down into a four step process as follows.

STEP 1: Equipment and shock hazard
STEP 2: Electrical flashover
STEP 3: People and safe systems of work
STEP 4: Environment

STEP 1 – Equipment and shock hazard

Has the equipment been checked and is it in a safe condition? Check whether the equipment to be worked upon has been examined and in a safe condition for work. Live work should never be permitted where there are any doubts about the safety of cables and electrical equipment being worked upon or even adjacent to those being worked upon. The examination can be visual but also using other senses such as smell and hearing to detect burning or electrical discharge.

Signs of vermin or birds inside switchgear or water ingress is a definite prompt to stop and investigate only when the switchgear is dead and isolated. Approaches should never be made to cables damaged by site traffic or excavation.

Is the equipment finger safe? If the equipment is in a safe condition the next step is to consider whether the equipment is finger safe. If the equipment is not finger safe, can measures such as temporary shrouding be used to prevent contact with live parts? The term 'finger safe' is defined as no exposed live parts that can be accessed by solid objects greater than 12.5mm as given by IP rating IP2X.

Do not rely purely on the original specification of the equipment. Insulation is often removed and not replaced. If it is not finger safe, or other measures cannot be introduced to prevent contact with live parts then carry out the work dead.

Are tools, instruments and leads checked fit for purpose? If measures to prevent contact with live parts can be implemented, are tools, instruments and leads checked fit for purpose? Tools and instruments must be of the correct duty rating and their condition must be checked especially test leads. It is important correct instruments and leads should be selected and in particular the correct over voltage installation category in accordance with EN61010-1. The wrong meter and leads can increase the chances of electric shock or the initiation of an electrical flashover due to transient over voltage. Most instrument manufacturers publish guidance about overvoltage on their websites.

Are you sure the equipment is designed for live operation? There seems to be some opinion that because electrical components 'plug in' then this operation can be carried out live. Examples of such components are plug in circuit breakers or bus bar trunking tap off units. Always contact the equipment manufacturer if such a live operation is contemplated. You may find the equipment has been designed for flexibility rather than for live operation and the manufacturer may discourage such activities.

STEP 2 – Electrical flashover or arc flash

Is there a significant risk of burns from electrical flashover? I have authored several articles on the subject of electrical flashover in *Electrical Review* and they can be accessed at www.electricalreview.co.uk. In brief, the severity of the thermal effects of an electrical arcing event is usually expressed in units of calories per square centimetre at the working distance from a potential arc source and the head and torso of the worker. This is called incident energy and a level of 1.2 cal/cm2 is sufficient to predict a 50% chance of the onset of a second degree burn.

Incident energy has an approximate linear relationship firstly; to the amount of current that can flow in the arc and secondly to the time that it can flow before the upstream protective device clears the fault. Note that arcing current does not equal prospective fault current (PFC) and at 400 volts is likely to be less than 50% of PFC. It follows the upstream device may take longer to operate with resulting higher levels of incident energy. Keep in mind also, protective devices need to be maintained to ensure they will operate according to their time current characteristic.

When undertaking arc flash studies for industrial and commercial facilities, I have found, where the upstream protective device is a conventional fuse or fast acting fixed pattern circuit breaker at a rating less than 100 amperes and the voltage is at 400 volts 3 phase and below, then the incident energy levels will be limited. A rule of thumb is to use the good old BS88 Industrial fuse as a model. If the entire time/current characteristic curve of the upstream device can sit below a BS88 100 ampere characteristic curve, the incident energy at a working distance of 450mm is unlikely to exceed 1.2cal/cm2. This does not mean flash burn injury can be totally discounted and severe burns can still be experienced particularly at the hands which will usually be closer any arc initiated when testing live circuits. For comparison, a BS88 400 ampere fuse could present a predicted *20 cal/cm2 at certain fault levels and an 800 ampere fuse could be in excess of *60cal/cm2.
*Note these figures are for indicative purposes only, not to be used in a risk assessment.

Suitable risk control measures must be employed and as a last resort PPE should always be used. In the case of the 800 ampere fuse, PPE is unlikely to fully protect the worker because of the possible ballistic and other effects of a flashover. Regardless of tasks, I recommend electrical workers should not carry out work in high power environments in clothing that can ignite or melt.

If the incident energy at the equipment to be worked on is over 1.2 cal/cm2, then can it be reduced to below 1.2 cal/cm2? As an alternative, can risk controls be put in place to prevent or mitigate arc flash effects and are they adequate? Please refer to my recent articles, available on the Electrical Review web site. If the answer is no to both questions then proceed no further until advice is sought or carry out the work dead.

STEP 3 – People and safe systems of work

Are the workers competent for the task? Regulation 16 from the EAW Regulations 1989 states: "A person shall not be engaged in any work activity where technical knowledge or experience is necessary to prevent danger or, where appropriate, injury, unless he possesses such knowledge or experience, or is under such degree of supervision as may be appropriate for that purpose having regard to the nature of the work."

Do not rely purely on the original specification of the equipment. Insulation is often removed and not replaced

In the context of live work, technical knowledge or experience means the person should be properly trained and assessed in the techniques being employed but the person must also understand the hazards from the electrical system and be able to recognise whether it is safe for the work to continue at all times including whilst the work is being carried out.

Is the work to be carried out at height? Working on live equipment at height is always a special case for consideration for two reasons:

1. Electric shock or arc flash to a worker at height can bring about a fall with obvious consequences.
2. An arc flash incident whilst working at height may mean that the worker cannot move out of the way because of the limited working space on access equipment. This may be the work platform of a scaffold or a mobile elevated work platform.

If the work has to be carried out at height, can risk control measures to prevent shock, burns and falls be put in place?

Is Accompaniment Required? Anyone undertaking work on or near energised electrical conductors will nearly always require some form of accompaniment by someone who can give assistance in an emergency. This implies a degree of competence such that the accompanying person can assist without danger to themselves or others. A requirement for a second person is to ensure safe working procedures e.g. preventing encroachment of non-authorised personnel into the working area.

STEP 4 – Environment

Is access and space adequate? Establish whether the access and space in front of the equipment is adequate to allow the worker to pull back from the conductors without hazard. HSG85 mentions a minimum 915mm measured from a live part or 1375mm when there are live parts exposed on both sides of the worker. The working space may need to be greater than these minimum distances as a result of the electrical flashover assessment in Step 2.

The work area should be clearly defined, with no tripping and slipping hazards and with good means of escape and illumination. Simple barriers and signs can often be erected for the demarcation of work areas to keep non-authorised staff away and also to protect electrical workers from interruptions at times when they need concentration.

Is lighting adequate? It is also important to check whether lighting levels are adequate for work as well as another requirement in Regulation 15. Use of additional lighting is essential where ambient lighting levels are poor.

Are hazardous conditions present? Check to ensure the immediate environment is free from water or dust. A hostile or wet environment will significantly increase the risk and severity of electric shock and should therefore be subject of special consideration to control the risks. Ensuring there is no possibility of an ignition hazard due to sparks is crucial. If there is a possibility of an ignition hazard, take precautions to remove the hazard before proceeding. There may other local environmental hazards that may need to be taken into account such as automatic fire fighting equipment.

Recommended Further Reading

HSR25 Memorandum of Guidance on the Electricity at Work Regulations 1989 *(HSE books)*

HSG85 Electricity at Work - Safe Working Practices *(HSE books)*

INDG163REV2 Five Steps to Risk Assessment *(HSE books)*

INDG 354 Safety in Electrical Testing at Work *(HSE books)*

GS38 Electrical Test Equipment for use by Electricians *(HSE books)*

Guidance on Safe Isolation Procedures for Low Voltage Installations *(Electrical Safety Council)*

HSG230 Keeping Electrical Switchgear Safe *(HSE Books)*

Proceeding with work

After all 4 steps are satisfied, then revisit the flowchart in Figure 1 and confirm the work is justified relative to the precautions, implement safe working and ensure adequate monitoring and supervision. Make sure any special equipment and PPE is properly used and maintained and always keep the duration of any live work to a minimum.

spec
Specialist Power Engineering Contracts

WWW.SPEC-LTD.COM

Address:
Unit 5 Eagle Point, Telford Way,
Wakefield 41 Industrial Estate, Wakefield, WF2 0XW
Tel: +44 (0) 1924 871 558
Fax: +44 (0) 1924 871559
Mobile: 0777 55 64 384 (24hours)
Email: craigwright@spec-ltd.com

Southern office:
Unit 13, Pegasus Court, North Lane, Aldershot,
Hampshire, GU12 7QH
Tel: 01252 375785
Fax: 01252 375786

Oxford office:
Unit 15 Tower Road Industrial Estate
Tower Road, Berinsfield, Wallingford
Oxfordshire OX10 7LN
Email: enquiries@spec-ltd.com

SPEC Ltd has recently expanded its services to meet the individual needs and demands of the customer.

Communication and a customer-focused approach are at the heart of our service, with staff that are able to talk your language and help you achieve your requirements effectively and safely to your timescales and specifications.

They have a proven track record of successfully working with many service users from small businesses to large Blue chip multinationals both UK and overseas.

The company has become known as a total service provider providing the role of control, installation, operation and maintenance of mains 415/11000/33000 V power networks.

To date **SPEC Ltd** operate and maintain circa 350 HV connected sites nationwide

- *Supply, installation, cabling, testing & commissioning of transformer and switchgear up to & including 33000 V.*
- *Specialists in the movement and erection inc the de-commissioning, removal and disposal of transformers and switchgears up to & including 33000 V.*
- *Full measured term contract maintenance of 415 / 11000 / 33000 V power networks.*
- *Dedicated specialist HV & LV jointing services up to & inc 33000 V.*
- *Specialists in transformers and switchgear up to & inc 33000 V.*
- *All backed up with a 24/7/365 dedicated call out service.*