Electrical

Guidelines

GUIDELINES

Risk Assessment of Work Equipment

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FOREWORD

The Provision and Use of Work Equipment Regulations 1998 (PUWER 98) does not have a specific regulation requiring risk assessment. It relies instead on the risk assessment requirements detailed within The Management of Health and Safety at Work Regulations 1999 (Management Regulations). Regulation 3 (1) of these regulations requires that every employer shall make a suitable and sufficient assessment of the risks to health and safety of their employees to which they are exposed at work for the purposes of identifying measures the employer needs to take to comply with relevant statutory provisions.

However, with respect to risk assessment of work equipment, the Approved Code of Practice and Guidance to PUWER 98 states that: "Risks to health and safety should be assessed taking into account matters such as the type of work equipment, substances and electrical or mechanical hazards to which people may be exposed." The risks imposed by work equipment must be evaluated by the employer (duty holder), or by an individual or organisation competent* to do so on the duty holder's behalf.

These Guidelines have been produced to assist in the assessment of the risks to health and safety of work equipment. They set out specific guidance on electrical issues and related matters that should be included in the assessment as to whether or not work equipment meets with the requirements of PUWER 98. Further general guidance is also given.

**** Because failures of electrical equipment may be sudden and have catastrophic results, the need for the use of a competent person and appropriate guidance for risk assessment is paramount.***

INTRODUCTION

The specific regulations within PUWER 98 which require particular attention in respect of electrical safety aspects are :

1.	Maintenance	-	Regulation 5
2.	Inspection	-	Regulation 6
3.	Controls	-	Regulation 14/15
4.	Emergency Stop Controls	-	Regulation 16
5.	Isolation from Sources of Energy	-	Regulation 19
6.	Lighting	-	Regulation 21
7.	Indirect Implications	-	General Guidance

GENERAL

All risk assessments carried out should align with the 5 steps to Risk Assessment outlined in HSE publication IND(G) 163L. These are:

1. Look for the hazards

2. Decide who may be harmed

3. Evaluate the risks and decide whether existing precautions are adequate , or that more should be done

4. Record your findings

5. Review your assessment from time to time and revise it if necessary

[Note: This risk assessment is concerned with avoiding harm to persons. It is not about keeping the plant or equipment running or operating.]

1 MAINTENANCE - REGULATION 5

This Regulation requires that work equipment be kept in an efficient state, in functional working order and in good repair. Any maintenance log that has been provided should be kept up to date at all times to reflect all maintenance, repair and modification activities. With regard to electrical equipment, Regulation 4 (2) of the Electricity at Work Regulations 1989 (EAW) requires all electrical equipment within a system to be maintained so as to prevent, so far as is reasonably practicable, danger.

Risk assessment of any electrical equipment should seek to identify both the likelihood and consequences of failure of that equipment to perform it's function as designed under both normal and fault conditions. It should also aim to identify circumstances where failure of the equipment's enclosure may create a potential for direct contact with live parts.

A feature of most electrical components is that, without maintenance, there is usually very little forewarning of malfunction given that deterioration can be so rapid that the component changes from normal working to failure mode very quickly. For example, contactors are quite complex electromechanical devices with many moving parts. A common problem is failure into the closed mode i.e. seized or welded in the 'on' position. The operating condition leading up to this situation may include some extra noise, but the contactor is likely to suddenly remain in the closed condition due to seized mechanical parts or welding of the electrical contacts. Observation of the contactor in use may give no clue to impending seizure and is further complicated by the fact that the contactor is electrically live and thus any close inspection or work on it is subject to Regulation 14 of the EAW, which governs working on or near live equipment. The consequences of a seized contactor therefore needs to be the subject of a risk assessment, and if likely to cause harm to persons, increased preventative maintenance would be required.

The risk assessment process for electrical equipment should, take account of the following: (the list is not exhaustive or in any order of priority)

- **Visual indicators** - evidence of inadequate standards of maintenance would include open or damaged enclosures exposing components, cables inadequately protected in positions where there is clear exposure to damage, components or enclosures running at high temperatures and components inadequately fixed or supported.

- **Records** - all electrical maintenance functions should be recorded in a maintenance log or report. Remedial work should be identified and recorded, showing dates and details of personnel involved. Absence of sufficient records or indications of periodically recurring similar faults would indicate inadequate preventative maintenance.

- **Maintenance manuals** - evidence of relevant manuals and maintenance method statements will indicate a sound approach to maintenance requirements. Maintenance task periodicities should be recorded as applicable. Variations from periodicities recommended by Manufacturers should be explained.

2 INSPECTION - REGULATION 6

The EAW regulations refer to *maintenance* and does not specifically refer to *inspection* but Regulation 6 of PUWER 98 specifically relates to *inspection* and has been included to ensure there is no argument as to whether *inspection* is an integral part of *maintenance*

Inspection of work equipment is required after installation, or re-installation to verify that it is safe, whilst additionally it should be further inspected at suitable intervals if it is liable to deterioration to a dangerous condition. The equipment should also be inspected after any exceptional circumstances that are liable to jeopardise it's continued safety.

The scope of work equipment is very wide but PUWER 98 specifically includes "an installation" and defines it as a series of connected machines. It would be prudent to include all the electrical parts of any installation within this definition, although compliance with the more specific requirements of the EAW would almost certainly satisfy the requirements of PUWER 98 in respect of safety, as far as the electrical system was concerned.

The risk assessment for any work equipment should identify where there is significant risk that could result in injury. This could result from incorrect installation, deterioration, environment or as a result of exceptional circumstances. The purpose of periodic electrical inspections is to determine if there has been any deterioration or damage to the equipment, and whilst the normal expected rate of deterioration might be low, the consequence of electrical equipment failure can be death or extensive personal injury.

The risk assessment should verify that the operation and maintenance regime is sufficient to ensure continued safe operation of both the mechanical and electrical equipment, that suitable records are being maintained, and that a program of inspection and testing, by competent persons, is in place in accordance with guideline frequencies. It is important that the electrical equipment is included within this inspection process since, the electrical safety of the machinery is conditional upon the integrity of the electrical equipment; particularly the protective devices and the associated earthing system. The extent of fault identification in the inspection report will often give an indication as to the adequacy of inspection frequencies.

3 CONTROLS - REGULATIONS 14 & 15

3.1 CONTROLS[1] FOR STARTING OR MAKING A SIGNIFICANT CHANGE IN OPERATING CONDITIONS - REGULATION 14

It should only be possible to start any equipment by use of the appropriately identified start controls. Restarting the equipment after any stoppage should not rely solely on the re-setting of any protective device (e.g. emergency stop, interlock), but should require the separate operation of the start control.

It should only be possible to change the operating parameters of the equipment (e.g. speed, pressure, temperature and power), by using the appropriate control, unless the resulting change does not further endanger the operator or other people i.e. when on automatic control. However where automatically controlled machines are involved, it is necessary to have other suitable safeguards in place. (e.g. fixed enclosing guards round a robot, interlocked guards on an hydraulic press)

Emergency stop controls should not be combined with start or stop controls or controls for altering operating conditions, although regular operating controls may themselves be combined. The design and position of all controls should be such that unexpected, incorrect, or accidental operation is prevented or risk of inadvertent operation is reduced. e.g. Up and down controls should be physically located on any control panel or pendant in relation to their function.

[1] **PUWER 98** describes a **control** as the manual actuator that the operator touches, for example a button, foot pedal, knob, or lever. This is normally part of a control device such as a brake, clutch, switch or relay. The control and control device are parts of the control system.
Risks to be considered will include:

-functional irregularities (Malfunctioning of the machinery, unacceptable properties of the processed material, human errors)

-normal operation

3.2 STOP CONTROLS - REGULATION 15

Readily accessible controls should be provided, where appropriate to enable the operator to bring the equipment to a halt and/or safe condition without any increase in risk. A stop control does not necessarily need to result in an instantaneous stop, as it may be less dangerous to allow equipment to run down or come to the end of a process.

There may not be a need to positively stop parts of equipment that are, for instance, totally guarded and therefore do not present any risk to persons.

A stop control should also dissipate all sources of energy once the equipment has stopped, should this be necessary to prevent danger to persons. When stored energy is present, it can be a potential source of danger, (be this electrical, pneumatic, hydraulic, kinetic or otherwise) and should be either isolated or dissipated as necessary to ensure safety. If it is necessary to retain power, i.e. for an 'inch' control, this should be isolated and/or disconnected immediately in the event of any hazardous movement occurring.

Any stop control should take priority over all operating or start controls and should be simple and easy to use.

BS EN 60204-1: 2006[2] gives further information on stop functions for individual and groups of machines

[2] BS EN 60204-1:2006 Safety of Machinery. Electrical Equipment of Machines, General Requirements

4 EMERGENCY STOP CONTROLS - REGULATION 16

This Regulation requires that an emergency stop(s) shall be provided based on the risk assessment, undertaken under the Management of Health and Safety at Work Regulations 1999, unless it is identified that either by nature of the hazards or speed of operation to bring the work equipment to a complete stop, such provision will produce no increased level of safety.

If an emergency stop control is fitted it should act in priority to any other stop control and should not introduce any additional hazards by its operation. It shall be available at all times irrespective of the particular operating mode. It must not impair the effectiveness of safety devices or of devices with safety related functions, or any facilities designed to release trapped persons.

Emergency stops are intended to effect a rapid response to potentially dangerous situations. They should not be used as a functional stop control or replace normal stop controls. The risk assessment should take account of the emergency stop function such that the operator does not require to consider the resultant effects of actuation as part of the operating process.

When undertaking a risk assessment the use of emergency stops should be considered as an integral part of the risk evaluation and precautions stage. They should not be considered as an alternative for other precautions such as preventing access to the hazard. However, if those alternative precautions are not adequate to prevent risk under abnormal circumstances an emergency stop should be considered. The risk assessment may require analysis of the consequences of actuation of the emergency stop function to fully evaluate its effectiveness.

When assessing the reduction of time to come to a complete stop it should be compared against the normal speed of operation of the normal stop control. For example a chemical process stop may allow close down and stopping of drives after a stop request when a given part of the process falls below a certain temperature. If this temperature fall is essential to the safe stopping and if not undertaken will introduce an additional hazard the emergency stop is unlikely to reduce the danger. However if an alternative stopping process can be identified, say, based on tank levels, which significantly reduces the drive stopping times and therefore reduces the danger, an emergency stop should be considered as part of the risk reduction section of the risk assessment.

If used, emergency stops should effect a rapid response either by using an alternative stopping process to the normal or by initiating the stopping process more quickly. PUWER 98 calls for readily accessible stop controls under regulation 15 and these will normally be located at the operating point. The initiating of the stop sequence can be achieved more quickly in certain circumstances by the location of emergency stops near to the work equipment that creates the risk. This is particularly relevant when geographically dispersed work equipment items are started or stopped as a group or the single work equipment or its work piece is large.

If emergency stops are fitted to work equipment, one should be located at each control point in addition to the locations identified as part of the risk assessment.

Emergency stop controls should be clearly visible, easily reached and be undemanding to operate. Functional stops may be shrouded as part of their compliance with Regulation 14.

Emergency stop controls should not employ shrouding if this would impair their operation. Common types of actuator mechanism are:- mushroom-head push buttons, bars, levers, kick-plates, and pull-cables. Further guidance on possible special features and arrangements of emergency stops is given in National, European, and International Standards. (For example:BS EN ISO 13850:2008[3]and BS EN 60204-1:2006)

- In particular BS 7671 commonly known as the "IEE Wiring Regulations", makes clear that a means of emergency switching shall be provided in every place where an electrically driven machine may give rise to danger. (Danger means in this case fire, electric shock, burns arising from use of electricity or mechanical movement
- of electrically controlled equipment or where electrical switching is employed as the means of making safe for maintenance of mechanical plant) The operating means of the device shall be clearly visible and preferably coloured red. The operating means of the device for emergency switching shall be of the latching type or capable of being restrained in the off or stop position. The release of the emergency switching device shall not re-energise the equipment concerned.

BS EN 60204-1:2006 amongst other requirements for emergency stop controls, calls for the emergency stop function to operate as a category "0" or "1" stop as determined by the risk assessment of the work equipment.

Where a category "0" stop is stopping by immediate removal of power to the machine actuators

- Where a category "1" stop is a controlled stop with power available to the work equipment actuators to achieve the stop and then removal of power when the stop is achieved

Devices for emergency stop should be readily accessible and located at each operator control station and at other locations where the initiation of an emergency stop can be required. Emergency stop devices can be push-button operated switch with a palm or mushroom head type, a pull-cord operated switch or a pedal-operated switch without a mechanical guard and all must have a direct opening operation. Actuators of emergency stop devices must be coloured RED and if a background exists immediately around the actuator it must be coloured YELLOW.

The supply disconnecting device may be locally operated to serve the function of emergency stop when it is readily accessible to the operator and it is of the type below

- switch-disconnector, with or without fuses, in accordance with IEC 60947-3, utilization category AC-23B or DC-23B;
- disconnector, with or without fuses, in accordance with IEC 60947-3, that has an auxiliary contact that in all cases causes switching devices to break the load circuit before the opening of the main contacts of the disconnector;
- any other switching device in accordance with an IEC product standard for that device and which meets the isolation requirements of IEC 60947-1 as well as a utilization category defined in the product standard as appropriate for on-load switching of motors or other inductive loads

[3] BS EN 13850:2008 Safety of Machinery. Emergency stop. Principles for design.
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5 ISOLATION FROM SOURCES OF ENERGY – REGULATION 19

This Regulation requires that all work equipment should be equipped with a suitable, effective and efficient means of isolation from all sources of energy. This specific requirement is to allow work equipment to be made safe under a variety of particular circumstances, e.g. to allow the performance of maintenance functions or when an unsafe condition develops, and in particular where reconnection of the energy source would put the operator or other persons at risk. There are many forms of energy as described in the guidance to the Regulations but referral is made to the EAW, and in particular Regulation 12, in respect of isolation (disconnection) of electrical supply.

To assist risk assessment personnel, physical separation of the equipment from the fixed wiring installation is a form of isolation, however, there follows guidance as to the principle aspects of suitable electrical switch-disconnectors (i.e. isolation devices) and also the problems associated with unsatisfactory forms of switching which do not provide a suitable means of isolation as required by the EAW.

Guidance Note 2 of BS7671 gives clarification as to what a device is required to have in order to comply with the legal aspects of suitable electrical isolation. The definition of isolation in the International Electrotechnical Vocabulary is: "A function intended to cut off for reasons of safety the supply from all, or a discrete section of, the installation by separating the installation or section from every source of electrical energy". This definition omits any reference to securing the isolation device. Information concerning securing is, however, necessary and is contained in BS7671 and the Memorandum of Guidance on the EAW Regulations.

Risk assessments should therefore include the following aspects in order to decide whether or not any work equipment is provided with suitable means of isolation by way of Switch-disconnector/Isolator to comply with PUWER 98:

- Switch-disconnectors/Isolators should be clearly marked and sited so as to ensure that they are easily identifiable and not difficult or awkward to operate. (i.e. not obscured, within normal reach).

- Switch-disconnectors/Isolators should be able to be secured (i.e. locked off) in a manner which cannot be overridden.

- Switch-disconnectors/Isolators should give a visual indication that all contacts/blades, etc. are separated. This requires that the means of indication must be directly linked to the operating mechanism and not just rely on markings on the face of a switch.

- Where a single Switch-disconnector/Isolator does not remove all sources of electrical supply to the equipment, suitable warning notices must be provided.

It should also be noted that Switch-disconnectors/Isolators can be 'off-load' or 'on-load' type and enquiries as to shut off procedures should be made to ensure that the 'Main Switch-disconnector/Isolator' is not being used as a convenient means of stopping the equipment

when operators are ceasing work. Particular attention should be given to equipment containing electrical heaters or motors, because in the case of the former, the power levels in these circuits causes damage to Switch-disconnector/Isolator contact points and in the case of the latter, danger may arise should the no-volt device not be working.

If the person undertaking the risk assessment is in any doubt as to the integrity or effectiveness of any means of isolation, then a note should be made in the risk assessment report to the effect that the means of isolation should be checked and confirmed as complying with the requirements of the EAW.

6 LIGHTING - REGULATION 21 (See also Regulation 15 of EAW)

This Regulation requires that suitable and sufficient lighting be provided for the use of work equipment, also that this use will include the maintainer and inspector as well as the operator.

Where the need for well lit access is reasonably foreseeable, as will be the case with control panels for example, the provision of fixed lighting should be considered, especially where live diagnostic testing is a recognised procedure. However, the use of temporary, or hand held lighting is not prohibited by this Regulation.

Lighting must be adequate, especially where switchgear is being inspected or maintained, particularly if the local machine lighting will be isolated along with the switchgear or panel being worked on.

The need for adequate lighting is also covered by Regulation 15 of the EAW and lighting circuits should be inspected and tested periodically as part of the electrical installation.

In dirty environments, periodic cleaning of lamps, shades and diffusers can be a very cost effective benefit.

Expert advice may be necessary regarding the level of lighting required for any particular application.

Further guidance is contained in HSE guidance HS(G) 38 “Lighting at Work”.

7. GENERAL GUIDANCE

Other Regulations within PUWER 98 which have indirect electrical safety implications include such aspects as Suitability of Work Equipment (Regulation 4) and Guarding Protection Systems (Regulation 12). The following is offered as general advice to the person undertaking the risk assessment.

7.1 SUITABLE ELECTRICAL EQUIPMENT (See Also Regulation 6 of EAW)

- Electrical equipment must be suitable for the environment and conditions of use to which it may reasonably be expected to be exposed in order that any danger arising from such exposure may be prevented as far as reasonably practical.

- Particular attention should be paid to the protection of equipment against ingress of liquids, moisture, dusts and solid objects, and the protection against direct contact with live parts.

- The environmental conditions to consider include the effects of weather, natural hazards, temperature and pressure, and the consequences arising from humidity, condensation, flooding, hosing down and solvents. The suitability for conditions also includes consideration of dirty and corrosive conditions, flammable and explosive gases, vapours and dusts, together with protection from mechanical damage such as impact, strain, wear and vibration.

7.2 GUARDING PROTECTION (ELECTRICAL ISSUES)

- PUWER 98 Regulation 11 - Dangerous Parts of Machinery, requires, where fixed guards are not practicable, 'protection devices' or 'protection appliances' to prevent access to any dangerous part of machinery or rotating stock-bar. Such devices or appliances may be electrically operated and functional testing may be necessary as part of an inspection regime. Some work equipment comes within Regulations that require periodic thorough examination, but the intervening inspections under PUWER 98 may require more than a visual assessment e.g. functional testing.

- Functional testing would include (as appropriate)

  - timing of the device or appliance against known criteria
  - proving the effectiveness of any electrical and photoelectric protection devices as necessary
  - the physical operation of the device or appliance

- The need for such devices or appliances may be a requirement of a published Standard (e.g. BS or BS EN) for the equipment/machine requiring protection, and the suitability of such devices or appliances selected would need to be verified against that particular Standard.

- The protection device or appliance itself may also be subject to the requirements of a Standard and would need to be verified against that Standard.

7.3 HIGH VOLTAGE SYSTEMS (Electrostatic Precipitators)

- High voltage electrostatics are most commonly found as electrostatic precipitators used in air filtration systems and the following applies:

- A high potential electric field is established between the discharge & collecting electrodes of opposite electrical charge. The gas to be cleaned passes through the electric field that develops between the electrodes, The particles are ionised, and are attracted to the collecting plate. The collecting plate is automatically rapped, causing the particles to be deposited and collected

- Depending on the size and application, the ionising voltage can be between 10,000 and 70,000 volts DC.

- The standard method of protection is to totally enclose the discharge and collection electrodes and to bond to earth any enclosure metalwork.

- Any access panels, hatches or doors must be interlocked (preferably with a figure key locking system) to ensure that access to high voltage parts cannot be gained unless the supply is disconnected and earthed.

- Provision should be available to securely isolate or de-isolate the electrical supply. Where internal access is required and where necessary to ensure safety, written safety rules together with a written Permit to Work system should be adopted.

- Manufacturer's instructions should be available as to any requirement for electrical discharge equipment/procedures.

7.4 MAINTENANCE LOCKS

- Any system or device that has been operated to isolate and disconnect electrical supplies for maintenance purposes must be provided with a suitable means of locking to prevent re-energisation.

- The locking function may be provided by mechanical or electrical means. (Electrical interlocking would need to be sophisticated to reach an acceptable standard).

- Mechanical locks should take the form of a physical barrier or locking device that prevents access to or operation of any switching device capable of re-energising the system.

- Administrative methods should take the form of appropriate written safety rules, the issuing and signing of Permits-to-Work and records of authority for persons competent to safely perform certain operations on plant.