Construction Plant-hire Association

Tower Crane Interest Group

TIN 036 **Tower Crane Electrical Supplies, Earthing Arrangements, Emergency Escape Lighting and Lightning Protection**

1.0 Introduction

This Technical Information Note provides guidance to tower crane hirers (users) about the provision of tower crane electrical supplies, emergency escape lighting and lightning protection. It includes guidance on inspection and testing following installation and whilst in service.

This guidance is not intended to extend to the electrical equipment and circuits on the crane that were provided by the crane manufacturer at time of first supply.

NOTE: *European Standard BS EN 14439 Crane- Safety tower cranes includes requirements for electrical equipment and circuits on tower cranes and EN60204-32:2008 Safety of machinery - Electrical equipment of machines - Requirements for lifting equipment.*

2.0 Regulatory Requirements, Guidance, and Information

The ***Electricity at Work Regulations 1989*** (EAWR) impose duties on employers to ensure that electrical equipment and systems are safe and without risk of injury to persons when purchased, installed, and put into use. Within the regulations, the term 'injury' means death or injury to any person from:

a) Electric shock;
b) Electric burn;
c) Fires of electrical origin;
d) Electric arcing;
e) Explosions initiated or caused by electricity.

Guidance on the application of EAWR is provided in HSE publication *HSR25 The Electricity at Work Regulations 1989 - Guidance on Regulations.*

Guidance on the safe working practices for people who carry out on or near electrical equipment is provided in HSE publication *HSG85 Electricity at Work - Safe working practices.*

British Standard BS 7671:2018+A2:2022 **-** *Requirements for Electrical Installations* (also known as the IET Wiring Regulations) are non-statutory regulations which provide guidance on the design, selection, erection, inspection and testing of electrical installations providing electrical power to the crane and emergency lighting systems.

Additional information is provided in:

- British Standard BS 7121-5:2019 Code of practice for safe use of cranes Part 5: Tower cranes;
- British Standard BS 7375:2010 Distribution of electricity on construction and demolition sites - Code of practice;
- British Standard BS 7430:2011+A1:2015 Code of practice for protective earthing of electrical installations;
- British Standard BS EN14439:2006+A2:2009 - Cranes -Safety -Tower cranes;
- British Standard BS EN IEC 62305-1:2011 Protection against lightning - Part 1: General principles;
- British Standard BS EN IEC 62305-2:2012 Protection against lightning - Part 2: Risk management;
- British Standard BS EN 62305-3:2011 Protection against lightning - Part 3: Physical damage to structures and life hazard;
- British Standard BS EN IEC 62305-4:2011 Protection against lightning - Part 4: Electrical and electronic systems within structures;

Technical Information Note

- British Standard BS 5266-1:2016 Emergency lighting. Code of practice for the emergency lighting of premises;
- Construction Plant-hire Association - Tower Crane Interest Group Technical Information Notes:
    - *TIN 011*: *Attachment of Floodlights, Illuminated signs and Christmas Decorations;*
    - *TIN 021: Maintenance Principles for Tower Cranes;*
    - *TIN 039: Guidance to Crane Users – Notification of Erection, Obstacle Lighting and Marking of Cranes.*

3.0 Electrical Supplies and Earthing

The tower crane hirer (user) should ensure that the electrical circuits to the crane are assessed, designed and installed in accordance with **BS 7671, BS 7375** and **BS 7340** by competent electrical persons.

3.1 Electrical Supplies

The tower crane hirer (user) should obtain from the tower crane supplier, details of the supply required by the crane. Most tower cranes require a 400V AC 3-phase supply (3-phase, neutral and earth). The current requirements of the crane will depend on the type, size and number of motors and control systems installed on the crane.

NOTE: *The use of variable-frequency drive-controlled motors on newer designs of crane reduces starting currents and, consequently, the required capacity of the power supply. However, BS7671 section 704: construction and demolition sites does not highlight the risks associated with inverter / frequency-controlled equipment connected to RCD circuits although the EAWR guidance to regulation 4(1) covers the risks broadly. Refer to point 64 in the guidance.*

3.1.1 Electrical Generators

If a suitable mains supply is not available on site, the alternative is to use an engine-driven generator, which must be adequately sized to cope with peak starting-current demands of the crane. The generator should be supplied with an appropriately sized circuit protection device.

If the generator and circuit protection devices provided are inappropriately selected to cope with peak current demands of the crane, nuisance trips may occur. These trips may cause damage to sensitive electronic items within the electrical control systems of the crane, shock loading on the crane and load swings as brakes are applied with loss of power.

3.1.2. Essential Supplies

A smaller power supply will be required for any obstacle lights that may be required on the crane. This power supply will be continuously required whilst the crane remains erected. The supply should be separate from the standard supply to the crane as power will be required when the main electrical supply to the crane is isolated, or the generator is switched off, when the crane is not in use. Guidance on fitment of obstacle lights is provided in *TIN 039: Guidance to Crane Users – Notification of Erection, Obstacle Lighting and Marking of Cranes.*

This smaller power supply can also be used to feed the control panel heaters, which should be left on continuously to ensure that a stable temperature and humidity is maintained in the control panel. This will prevent damage to sensitive expensive electronic equipment due to condensation.

3.2 Mechanical Protection

All cables supplying the crane should be protected from mechanical damage by one or more means, such as running in conduit, trunking or on trays, being clipped to a structure in a position where they are protected from mechanical damage and/or be of steel wire armour construction.

Cable connectors should be a suitably rated industrial type, with ingress protection.

3.3 Isolator Switches

The electrical installation should include suitable weatherproof isolator switches that can be locked in the off position for the main supply to the crane and any secondary supplies. The switches should be clearly marked to indicate both where supply originates from and the equipment it isolates. The switches should be positioned at or near to the base of the crane.

***NOTE**: Care should be taken to ensure that the tower crane power supply is not switched off without giving the crane team plenty of warning, as this may lead to uncontrolled movements of the crane.*

3.4 Electrical Protection

The electrical supply circuits supplying the crane should be provided with appropriate electrical protection against overload, short-circuit and earth fault current. The electrical protection should protect a human in the event of an indirect contact fault or where there is direct contact of a live component. Indirect contact faults could be protected by a device sensing a low-sensitivity differential of 300/1000mA, however where there is a risk of direct contact, then a high sensitivity breaker with a detection threshold of less than 30mA is required.

The type of protection shall conform to the type required by the OEM (Original Equipment Manufacturer) as identified in the user manual/instructions.

The protective devices should be capable of interrupting, without damage, any overcurrent that might occur. The characteristics of fuses and circuit-breakers used for protection of circuits should be coordinated to afford selectivity (discrimination) in operation to avoid dangers resulting from disconnection of other circuits.

If earth fault protection is provided by Residual Current Devices (RCDs), these may need to be set with an appropriate trip current and delay setting to ensure that there is discrimination between RCDs on the site distribution system and the crane, to prevent nuisance tripping.

Most tower cranes now use inverters to convert the incoming power supply from Alternating Current (AC) to Direct Current (DC) so that the speed of motors is controlled accurately using frequency converter(s). This allows energy saving, speed regulation and motor speed accuracy along with low-speed high torque and stepless changes. However, because the DC output from frequency converter is at such a high frequency, not all types of RCD will detect a fault. This is a factor in equipment with within the tower crane circuits as well as in resistor banks, regenerative braking, power storage and any other areas which also work in DC.

Certain RCDs cannot cope with the absence of the time-varying magnetisation in the summation of the current transformer required for the inductive energy transfer to trip the relay. In short there is insufficient time for the RCD to react and trip and so a fault may not trip the RCD.

This is compounded where an electrician adjusts an RCD to a higher tripping current where there has been a series of unexplainable nuisance trips. In such cases, the DC current leakage could be missed because the RCD is adjusted masking the first fault and not reacting to it. This is possible where circuits are vulnerable to dirt and/or moisture.

There are complications too with how the crane is switched on. Switches should be snap-action so that all phases / conductors energise without a stagger. This too can lead to earthing / earth leakage issues.

There are further factors like the length of the motor shielded supply power cables and also with the RCD test devices (clamp on probes) that may not be able to measure the problem as they measure in a limited band of frequencies. They need to be used with the correct frequency setting (>1kHz) to measure resistance value / current leakage in the circuit. Refer to the OEM user manual where advice is provided to the electrician so that they are undertaking a proper test. Always seek advice from the OEM if unsure.

Many tower crane OEMs are specifying type ‘B’ RCDs as these detect a fault that that has a high, smooth DC voltage content. However, the site temporary electrical supplies are often protected by type ‘A’ RCDs beyond (upstream) of the tower crane electrical panel.

This may cause nuisance tripping, which results in crane downtime whilst the fault is traced, except the fault is the incorrect selection of electrical components which will need to be replaced. The electrical layout and design of the construction site's power and residual / earth leakage protection should take into account what the power and RCD requirements are for each electrical device powered by it (e.g. construction hoists, tower cranes etc.)

To minimise nuisance tripping, provide the tower crane with its own dedicated output from the site supply. Provision of an appropriate type / design of type B RCD (30mA DC with 'MI design') may be able to eliminate the nuisance tripping of the downstream type A RCD (6mA DC). Seek advice from the RCD manufacturer during the planning of the electrical installation for the site. Sites may incorrectly believe that they are fixing the problem by adjusting the sensitivity of the type 'A' up to 300mA or even 1A, however this introduces an increased risk of a fatal electrocution should an electrical fault develop, which should have tripped the RCD at 30mA.

Higher current drawing cranes, such as luffing jib cranes are prone to nuisance tripping as their RCDs are relay-based solutions which are sensitive to high frequency currents up to 2kHz, which corresponds to the switching frequency of the winches.

Any RCD and miniature circuit breaker (MCB) protecting the tower crane supply will need to be selected, configured and tested to avoid potential nuisance tripping. RCD's and MCB's used on systems which contain variable-frequency drives must be a type suitable for the service.

NOTE: *Nuisance tripping of a tower crane supply may also lead to uncontrolled movements of the crane.*

NOTE: *RCDs with a 30mA rated tripping current and 'instantaneous' operation are only required on final sub circuits, such as socket outlets, to protect users of portable appliances.*

NOTE: *The maximum load which may be applied to a Type 'A' RCD in the event of a fault is 6mA DC, regardless of their rated residual current, and hence can lead to nuisance tripping.*

3.5 Earth Bonding

The crane structure, motor frames and conducting cases of all electrical equipment, including metal conduit and cable guards, should be effectively and directly connected to earth.

4.0 Lightning Protection

4.1 Lightning Protection arrangements

Lightning protection should be designed, installed, tested and maintained by competent persons in accordance with both the *BS EN IEC 62305* series of standards and *BS 7430*.

The connection to the tower crane base should be carried out using the manufacturer's approved earthing points (see **Figure 1**). Earthing points should not be created by drilling or welding to structural elements of the crane, (see **Figure 2).**

Figure 1: Earthing point marked by manufacturer.

Figure 2: Earth incorrectly connected to a non-manufacturer approved point. The structural member should not have been drilled and tapped as this could weaken the member.

Reliance should not be placed on the earth conductor of any mains power supply. In most instances, the earth bonding can be connected to the lowest metallic part of the crane structure as the metal structure of a tower crane provides good continuity. Following installation of lightning protection, an earth continuity check should be made to ensure that the resistance between the bottom of the tower and earth is less than 10 ohms.

If the resistance to earth exceeds 10 ohms, the tower crane base should be bonded to a suitable earth network via a single core cable of not less than 70 mm2 cross sectional area, and the earth resistance measured again to ensure that it has been reduced to an acceptable value.

4.2 Action to be taken in the event of a thunderstorm

Lightning can induce significant voltages in the tower crane structure, which may lead to the electrocution of personnel in direct or indirect contact with the crane or load. In the event of a thunderstorm warning, the operator should put the crane out of service and leave the crane. Where the operator does not have time to leave the crane, as in the event of a sudden thunderstorm, he/she should stay in the operating cab and avoid touching any controls until the storm has passed.

It is important that personnel on the ground do not touch any part of the load, lifting accessories or the crane structure during a thunderstorm.

4.3 Action to be taken in the event of a lightning strike

In the event of a lightning strike, the crane supplier should be notified, and the crane should be thoroughly examined by a competent person before being returned to service. This is to ensure that damage has not occurred to the crane or any of its components, including the slew ring, safety and control systems. It is recommended that the slew ring is re-inspected after the crane is dismantled at the end of the hire period.

5.0 Emergency Escape Routes and Lighting

The organisation in charge of the site where the crane is erected, the principal contractor on a construction site, should prepare an emergency plan that considers emergency escape routes and lighting from the crane for the crane operator and maintenance personnel. This is especially important if the escape route is via a basement or enclosed area.

Tower cranes are not in general supplied with emergency and escape lighting and they should be provided and installed by the tower crane hirer (user) after consultation with the tower crane supplier.

It is essential that emergency and escape lighting and supply circuits are appropriately and securely fastened to the crane structure and do not interfere with the safe access and operation of the crane.

The emergency lighting system should be designed and installed in accordance with *BS 7671* and *BS 5266-1.*

The emergency and escape lighting should be inspected after first installation and thereafter at a maximum interval of three months. A record of inspections should be retained on site.

6.0 Floodlights, Illuminated Signs and Christmas Decorations on the crane

The tower crane hirer (user) should consult with the tower crane supplier in advance of installing any floodlights, illuminated signs and Christmas decorations on the crane. It is essential that the lighting fixtures and cables are securely attached to the crane and do not interfere with access to, and operation of, the crane.

Guidance on the installation of floodlights, illuminated signs and Christmas decorations to cranes is provided in *CPA TIN 011 - Attachment of Floodlights, Illuminated signs and Christmas Decorations*.

7.0 Responsibility for supply, installation, testing and in-service maintenance

Clear lines of responsibility for supply, installation, testing and in-service maintenance should be established, ensuring that those appointed and responsible have sufficient knowledge and experience to carry out their duties in a way which will ensure that risks are properly controlled

NOTE: *Once a tower crane has been erected on a site, the user of the crane has a duty to ensure that it is adequately inspected and maintained. The actual undertaking of the maintenance and inspection is often delegated to the crane owner by the user. The user however retains the responsibility for ensuring that the maintenance and inspection is carried out. Further Guidance is provided in TIN 021: Maintenance Principles for Tower Cranes.*

The tower crane hirer (user) is normally responsible for supply, installation and testing of:

- The electrical switched isolator at or near to the base of the crane;
- The electrical supply circuits from the site distribution board or generator to the switched isolator;
- The lightning protection arrangements;
- Emergency escape lighting and any site lighting placed on the crane.

The tower crane supplier is normally responsible for supply, installation, and testing of:

- The electrical circuits from the electrical switched isolator to the control cabinets on the crane;
- The connection of electrical components and circuits on the crane during installation;
- Any obstacle navigation lights.

Records of inspections and tests should be retained by the tower crane hirer (user). Guidance on test reports is provided in *BS 7671*. A sample form for the acceptance of the electrical supply forms part of this TIN.

EXAMPLE: Crane Electrical Supply Acceptance form

Please Note: A separate approval / completion certificate is required for each tower crane

Project Details			
Client:			
Site Details:			
Tower crane No / Location:		Make / Model:	
Tower Height:		Jib Length:	
Base Type:			

Tower Crane Electrical Requirements *(Figures are based on information supplied by Wolffkran)*						
Crane model	Starting Current (Amps)	Design Running Current (Amps)	Rated (kVA)	Maximum fuse/Overload protection (standard tower heights)	Minimum generator size (kVA)	Method of starting

Note: *Power requirements are given for cranes at standard heights. When Cranes are erected at significantly greater heights, then mains cable size and supply requirements need to be changed. Mains power should be the preferred choice.*

Site Electrical Supply *(Please tick)*					
Generator	Yes		Mains supply	Yes	

Note*: The Power Supply - 240v (out of service operation for aircraft warning light) is required if the crane is on a generator and the Aircraft Warning Lights are to remain illuminated when the generator is switched off. A separate feed at the base of the crane will be required. (Please note; this may incur extra cost-as per contract).*

NB: Mandatory Requirement - Connection to the building site mains cabinet

Building site mains cabinets must conform to currently valid local regulations such as: DIN EN 60439-4 (2004) Low-voltage and switchgear combinations, part 4: Special requirements of building site mains cabinets.

The slewing tower crane is equipped with frequency-controlled drives. In accordance with VDE 0160, the crane may not be connected to building site mains cabinets which contain safety equipment that is sensitive pulse-shaped current.

In the event of malfunctions, high-frequency residual currents or smoothed DC fault currents could block the protective equipment.

The following types of connection are approved according to information from the Employer's Liability Insurance Association (BGI 608- Selection and operation of electrical systems and operating equipment at construction sites):

- *The crane may be connected to a building site mains cabinet that is equipped with an AC/DC sensitive residual current operated device (type B);*
- *A crane that is hooked up to mains by means of plug-in connector (rated power greater than 32 A to 63 A) must be operated in combination with an AC/DC-sensitive residual current circuit breaker (type B) at a ground fault current less than/ equal to 30 mA, or in combination with an isolating transformer;*
- *A crane that is hooked up to mains by means of plug-in connector (rated power greater than 63 A) must be operated in combination with an AC/DC-sensitive residual current circuit breaker (type B), or in combination with an isolating transformer;*
- *The crane can also be connected directly to power upstream of the fault current breaking device in the building site mains cabinet. In accordance with DIN VDE 0100- 410, such an application requires one or several protective measures to be taken.*

Protective devices which are sensitive to pulse-shaped current must not be connected in series to AC/DC-sensitive residual current breaking devices. The secondary coil of isolating transformers must be safely protected against indirect contact (insulation monitoring).

Tower cranes should be on a separate supply circuit on site power supply network to avoid nuisance tripping often caused by interference from supply side type A RCDs.

Client Declaration

I confirm the electric supply is in accordance with the Mandatory Requirements – Connection to the building site mains cabinet detailed on page 1 of this document and the chosen power supply, whether from mains power or generator is of sufficient capacity to the figures above to power this tower crane and will be supplied, in position and ready for use at least 24hrs prior to the erection or dismantle operation taking place. If not, I understand that this may delay the erection or dismantle process and agree to any additional charges that may apply.

Name:		Signature:		Date:	
Position:		Company:			

THE TOWER CRANE CANNOT BE ERECTED UNTILTHE COMPLETED FORM IS RETURNED. PLEASE RETURN AT LEAST 24 HOURS PRIOR TO THE OPERATION