

Leaflet 23

High Voltage Electrical Equipment

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Scope

1 This Leaflet details the requirements for protection of persons from ionising radiations emitted by high voltage (HV) equipment. The scope of the Leaflet does not extend to the requirements for protection against non-ionising radiofrequency radiation. Nor does the scope extend to other items such as radioactive electronic valves, gaseous tritium light sources or smoke detectors which may also be associated with the electrical equipment. Such items are addressed in separate leaflets.

2 Under certain circumstances, ionising radiation in the form of X-rays may be emitted by HV electrical equipments not specifically designed to produce such radiation. Charged particles (electrons) acquire high energy when accelerated under the influence of HV – the energy lost by these electrons on striking a target material may be emitted in the form of X-rays known as adventitious or parasitic X-rays. Where the HV involved exceeds 5 kV, the Ionising Radiations Regulations 1999 (IRR99) apply to work involving the equipment. This Leaflet describes the resulting ionising radiation safety requirements for work with such equipment.

3 The most commonly found components producing parasitic X-rays are klystrons, magnetrons, high voltage valves, travelling-wave tubes and cathode ray tubes, although there are many other components capable of producing them in equipment such as high voltage rectifiers, display units and radar/electronic warfare equipment. Parasitic X-ray emissions should not be confused with radiofrequency emissions (non-ionising radiations) that may also be present and provide an additional hazard (see Leaflet 35).

4 High voltage equipment (>5 kV) containing a cathode ray tube or a visual display unit which, under normal operating conditions, does not produce a dose rate of more than 1 $\mu\text{Sv/hr}$ at a distance of 0.1 m from any accessible surface, benefits from some relaxations on the application of IRR99 (see Table 2).

Statutory Requirements

5 In addition to the general requirements of the Health and Safety at Work etc Act 1974 and the Management of Health and Safety at Work Regulations 1999, the following specific legislation applies directly:

- Ionising Radiations Regulations 1999 (IRR99).

Duties

Commanding Officer and Head of Establishment (CO/HoE)

6 The CO/HoE has a duty to the Secretary of State, and a personal responsibility, to protect the environment and secure the health, safety and welfare of their staff at work. The CO/HoE is also required to protect persons not in MOD employment (e.g. members of the public) against risks to their health and safety arising from the MOD work activities. This includes radiation safety. The CO/HoE's authority (but not responsibility) for radiation safety management arrangements may be delegated to appropriate personnel, such as a Radiation Safety Officer (RSO).

Radiation Safety Officer (RSO)

7 The Radiation Safety Officer (RSO) is to ensure that:

- They are familiar with the specific radiation hazards at their unit or establishment and that an appropriate risk assessment has been carried out;
- Local orders include the requirements for high voltage equipment covered by this Leaflet;
- Staff are appointed, instructed and trained in their duties relating to equipment covered this Leaflet;
- The requirements stemming from this Leaflet are subject to audit.

Radiation Protection Supervisor (RPS)

8 An RPS must be appointed in respect of any area designated as controlled or supervised. Where an RPS is appointed, they are to ensure that work is carried out in accordance with the local orders for radiation safety which are to include the requirements of this Leaflet. Further information on the requirements for designated areas and the appointment of an RPS is given in Table 2.

Workplace Supervisor (X-ray) (WPS-X-ray)

9 In units operating or maintaining high voltage equipment capable of emitting parasitic X-rays but where it is not necessary to appoint an RPS, a WPS (X-ray) is to be appointed with duties to ensure that work is carried out in accordance with the local orders which are to include the requirements of this Leaflet.

Employees

10 It is the responsibility of all employees to ensure that they are familiar with the relevant parts of local orders to ensure that their exposure to parasitic X-rays is restricted as far as is reasonably practicable. Any incident is to be reported to the appropriate supervisor or line manager.

Hazards

Table 1 Ionising radiation hazards associated with high voltage equipment

Radiation type		Emitted	Comments
Alpha		✗	
Beta	Direct	✗	
	Bremsstrahlung	✗	
Gamma		✗	
X-rays		✓	Parasitic X-rays are a by-product arising from many types of high voltage equipment (>5 kV). They may be emitted from klystrons, magnetrons, high voltage valves, travelling-wave tubes, cathode ray tubes and many other components such as high voltage rectifiers, display units and radar/electronic warfare equipment.
Neutrons		✗	

Risk Assessments for High Voltage Equipment

Risk assessment at procurement

11 In the acquisition of equipment which may emit ionising radiation, safety and environmental management is to begin at the *requirements definition* stage of procurement and is to be carried forward through service to disposal. All aspects of maintenance and operation (including military service) are to be taken into account. Those managing the procurement process and specification development of the equipment which may emit ionising radiation are to assess the risk areas and recommend solutions to reduce the risks to as low as reasonably practicable (ALARP) (see Leaflet 1 and Leaflet 2). Where it is possible to produce a generic risk assessment, this is to be carried out and made available to users.

Risk assessment for users

12 A prior risk assessment (PRA) is to be carried out by the unit or establishment in consultation with the radiation protection adviser (RPA) before undertaking any new activity involving high voltage equipment that may generate parasitic X-rays. This risk assessment is to take into account the generic risk assessment carried out at the procurement stage (if available) and the recommended solutions to reduce risk provided by the acquisition process and the local conditions of use. Details of the form of the risk assessment and the actions to be taken arising from it are described in Leaflet 2. Risk assessments are to be reviewed as detailed in Leaflet 2.

13 The following are key inputs into the risk assessment:

13.1 Advice from the manufacturer and information from the Project Team;

13.2 RPA information and advice – the Dstl Environmental Sciences Radiation Protection Group (Dstl ESD) may be able to provide detailed hazard and risk assessment information on the equipment;

13.3 Radiation survey information – estimated dose rates when operating and during maintenance (if carried out);

13.4 Planned systems of work and routine operation profile e.g. continuous, intermittent, 1 hour per day etc. Routine maintenance profile e.g. 8 hour per week at operating voltage;

13.5 Personnel access and occupancy of areas subject to levels of ionising radiation;

13.6 Assessment of reasonably foreseeable fault conditions and resultant dose rates;

13.7 Assessment of the impact of reasonably foreseeable accidents/incidents/occurrences.

Design of Equipment

14 All high voltage electrical equipment is to be provided, where reasonably practicable, with shielding to ensure that beams or fields of radiation do not produce accessible dose rates in excess of 1 $\mu\text{Sv/hr}$ in the working area. If this is not reasonably practicable, other control measures may be necessary and are to be determined in consultation with the RPA.

15 The equipment is to, by design, or by the provision of safety devices prevent anyone reaching inside to an area where the dose rate exceeds 7.5 $\mu\text{Sv/hr}$. Where practicable, the safety devices are to be fail-safe.

16 Where access to the inside of any equipment is permitted, protective covers providing shielding to components producing parasitic X-rays are to be incorporated into the design.

Installation

17 The installer of equipment operating at more than 5kV and where ionising radiation could be emitted has a number of duties imposed by IRR99, in particular:

17.1 They must carry out a critical examination of the way in which the equipment has been installed ensuring that safety features and warning devices operate correctly and that there is sufficient protection for persons from exposure to ionising radiation.

17.2 They must consult with their RPA or with the operator's RPA with regard to the extent of the critical examination and in regard to the results of that examination

17.3 They must provide the radiation employer (the radiation employer being the operator of the equipment e.g. the CO, Head of Establishment) with adequate information about proper use, testing and maintenance of the equipment.

18 The radiation employer must consult their RPA regarding the plans for installing the equipment in relation to engineering controls, design features, safety features and warning devices. They are also to consult the RPA regarding the acceptability of the test results of the critical examination and the requirements and results of any further commissioning tests or radiation surveys.

19 The radiation employer is to ensure that they understand the information provided by the manufacturer and installer and that a radiation survey is carried out prior to first use.

20 The equipment is not to be operated until any deficiencies identified in the initial inspection have been repaired by a suitably qualified person, and the equipment has been re-inspected and monitored.

Protection against Parasitic X-Ray Emissions

21 X-ray emissions identified by a unit or establishment that are not referred to in the equipment handbook are to be reported to the equipment sponsor, the appropriate TLB safety authority and the RPA (Dstl ESD).

22 Sponsors of equipments producing parasitic X-ray emissions are, where reasonably practicable, to introduce modifications to minimise the hazard to personnel. This may be by the provision of shielding around the equipment or part of the equipment which generates the parasitic X-rays.

23 Where removable radiation shielding is provided, it is to be used as directed in the equipment handbook. Such shielding is to be marked to indicate the presence of an increased radiation hazard if it is removed. Equipments with removable shielding are to, whenever practicable, be fitted with engineered controls e.g. interlocks to prevent the equipment from operating when the shielding is removed.

Increased Ionising Radiation Hazard during Maintenance

24 Where users carry out maintenance or inspection tasks which require the equipment to be powered up, account must be taken of the increased hazard faced by maintainers. The increased hazard may be due to the need for access to components which are normally shielded or due to the need for a maintainer to be positioned closer to the source of ionising radiation than is necessary during normal operation. These issues must be carefully considered in the risk assessment and appropriate measures to restrict exposure introduced. Such measures must be described in local orders for radiation safety (see Leaflet 16) and must also be included in the training of maintainers.

Legal and MoD Mandatory Requirements

25 Table 2 summarises the legal and MOD mandatory ionising radiation requirements for high voltage equipment. In cases of doubt, the RPA is to be consulted for advice.

Table 2 Legal and MOD mandatory requirements for work with high voltage equipment

Requirement	Applicable	Comments	Related Leaflet*
HSE authorisation	✘	Not required for electrical equipment emitting parasitic X-rays.	
HSE notification	✓ (but see comment)	In general, work involving high voltage equipment (> 5kV) is to be notified to HSE in accordance with Leaflet 3. The following work need not be notified: <ul style="list-style-type: none"> • Operation of any cathode ray tube for the display of visual images provided that the dose rate at a distance of 0.1m from any accessible surface does not exceed 1µSv/hr. • Operation of other electrical apparatus (>5kV and ≤ 30kV), provided that the dose rate at a distance of 0.1m from any accessible surface does not exceed 1µSv/hr. • Operation of any other electrical equipment (>5kV), if of a type approved by HSE, provided that the dose rate at a distance of 0.1m from any accessible surface does not exceed 1 µSv/hr. 	3
Environmental agencies notification**	✘	Not required for electrical equipment.	
Risk assessment	✓	A risk assessment is required to identify radiation dose rates and control measures at accessible positions during operation and maintenance. Reasonably foreseeable fault conditions are also to be considered.	2
Critical Examination	✓	A critical examination of the equipment prior to use should be undertaken.	

Restriction of exposure	✓	Observe manufacturer/equipment instruction and guidance. Ensure exposure of all personnel is as low as reasonably practicable (ALARP). Set dose investigation levels.	4
PPE	✗	Not required unless advised by the RPA for specific maintenance tasks.	
Maintenance of radiation engineering controls	✓ (but see comment)	Where design features include safety devices to restrict exposure by shielding or preventing access to areas of high dose rate, these devices are to be properly inspected, tested and maintained at suitable intervals.	4
Contingency plans	✓ (but see comment)	Required where the risk assessment identifies any immediate measures to be taken in the event of reasonably foreseeable faults, accidents or incidents leading to enhanced exposure levels.	40
Designated areas	✗ (but see comment)	Equipment is normally to be designed such that dose rates in the working area are ALARP and area designation is unnecessary. Designated areas may be required for some equipment during certain maintenance tasks. Normally, a controlled area will be necessary where the dose rate in the area exceeds 7.5µSv/hr and a supervised area if any person could receive more than 1 mSv in a year - the RPA is always to be consulted regarding area designation and the associated control measures.	4
Designation of personnel	✗ (but see comment)	Not normally required. However, where personnel could receive annual dose levels in excess of 6 mSv whole body (or other levels specified in Annex E to Leaflet 4) then they are to be made a classified person.	4, 38
Monitoring	✓	Local orders are to specify radiation surveys to be conducted, at regular intervals, around equipment that may produce dose rates exceeding 1 µSv/hr. The orders are also to specify dose rate action levels and the action to be taken. Instruments used for surveys are not to be susceptible to interference by radiofrequency radiation where this may be present. RPA advice must be sought on the suitability and calibration requirements for survey instruments and regarding action to be taken if radiation levels exceed the action levels.	4, 8
Training for users	✓	Information and instruction required so that users are aware of the measures to be taken for restriction of exposure and the content of local orders relevant to their duties.	15, 16
Local orders	✓	See Leaflet 16 for guidance.	16

Appointed person	✓	RPS not required except for areas required to be designated as controlled or supervised. Where an RPS is not required, a WPS (X-ray) needs to be appointed to ensure that local orders for radiation safety are followed.	39
Storage	✗	Not applicable.	
Accounting	✗	Not applicable.	
Leak testing	✗	Not applicable.	
Personal dosimetry	✗ (but see comment)	Not normally required unless an area is designated as controlled or supervised or as advised by the RPA (e.g. for personnel working in 909 radar compartments).	6
Reporting procedures	✓	An unusual radiation event or overexposure is to be reported in accordance with the procedures in Leaflet 14.	14
Transport	✗ (but see comment)	Radiological controls are not applicable to electrical equipment – but may be applicable to radioactive items within the equipment (see relevant leaflet for that item).	
Marking	✓	High voltage equipment that produces dose rates in excess of 1 µSv/hr at the surface of the equipment is to be marked on the outside with a radiation warning sign. Where internal access to the equipment is permitted, protective covers shielding components emitting parasitic X-rays are also to be marked with a radiation warning sign.	4
Sale/Transfer	✓	See Leaflet 11	11
Disposal of redundant items	✗ (but see comment)	Radiological controls are not applicable to electrical equipment but may be applicable to radioactive items within the equipment (see relevant leaflet for that item). Radiation warning signs are to be removed if the equipment earmarked for disposal has been permanently disabled.	

*JSP 392, unless otherwise stated

**Environment Agency (EA) for England and Wales, Scottish Environment Protection Agency (SEPA) for Scotland and Environment and Heritage Service for Northern Ireland (EHSNI).