Health and Safety Executive **Information Document**
HSE 668/23

SAFEGUARDING OF RESISTANCE WELDING MACHINES

INTRODUCTION

1 This document contains internal guidance which has been made available to the public. The guidance is considered good practice (rather than compulsory) but you may find it useful in deciding what you need to do to comply with the law. However, the guidance may not be applicable in all circumstances and any queries should be directed to the appropriate enforcing authority. The guidance is relevant to both suppliers and users of resistance welding machines.

RESISTANCE WELDING PROCESSES

2 Resistance welding makes use of the heating effect which occurs when an electric current flows through a resistance. Electrodes are used to squeeze together components to be welded. The electrical resistance is greatest where the components are in contact. If a large current at low voltage is passed between the electrodes and through the plates, heat is evolved at the interface. Localised melting takes place and a weld is produced. Pressure on the workpiece is maintained after the current is switched off until cooling allows re-solidification.

3 There are 7 resistance welding processes:

(1) spot;

(2) projection;

(3) seam;

(4) resistance butt;

(5) flash;

(6) percussion; and

(7) HF resistance.

RESISTANCE WELDING MACHINES

4 This document deals only with machines for spot, projection and seam welding. The common features of these resistance welding machines are that two electrodes are brought together by force, usually from a pneumatic cylinder and that the required electrical current is produced by a transformer. Apart from physical size and power, the main differences are in the design of the electrodes. Electrodes are made of copper or copper alloys and are usually water cooled.

5 Special purpose and multi-electrode machines are not dealt with in this document as they require individual assessment and consideration. However, effective safeguarding can be achieved by suitable selection from the safeguards described in paras 34 to 48.

Spot welding machines

6 Spot welding machines use electrodes which usually have a relatively small cross-section and which are located in holders in arms attached to the machine frame.

7 At fixed machines, it is usually the upper electrode which descends under power to generate the welding pressure. Arms may either pivot (known as rocker arm) or, more usually, operate vertically.

8 Portable machines either similarly close electrodes along a common axis (C-type) or may have both arms actuated like a pair of pliers or pincers. Some portable machines have separate transformers. They are usually suspended for ease of manipulation.

Projection welding machines

9 Projection welding is a form of resistance welding in which the welding force and current to produce the weld is localised to the required place either by the shape of the workpiece or by deliberate projections of a few millimetres on the surface of the workpieces. Projections collapse during welding. This allows several spot welds to be made simultaneously.

10 General purpose projection welding machines appear like presses and have flat platens with 'T' slots for the attachment of the electrodes. In projection welding, electrodes may be known as welding dies and they may be attached to the platens by holders which are often known as bolsters.

Seam welding machines

11 Seam welding machines have electrodes which are either rollers or wheels. Electrode wheels may be driven by a motor or moved by frictional contact with the work piece (idler wheels). Either or both wheels may be driven and the drive may be by knurled wheel or more usually by shaft. The upper wheel is normally used to exert the welding force and open the wheels to allow insertion of the work piece.

HAZARDS AND PRECAUTIONS IN THE USE OF RESISTANCE WELDING MACHINES

Electrical risks

12 The most significant electrical hazards that may occur are associated with the circuit which is used to supply a resistance welding machine's power source. For example, connections at a welding transformer's primary may operate at up to 300 volts between phase and earth for portable hand-held equipment (with built-in transformers) and 1000 volts between phases for fixed machinery.

13 The design of a resistance welding machine should incorporate protection against direct or indirect contact with parts at a dangerous voltage. This protection should be provided by earthing (Class 1) or double insulation (class II) at the electrical power source and the equipment's enclosure design should prevent finger contact with live parts, ie IP2X in accordance with BS EN 60529:1992 Specification for degrees of protection provided by enclosures (IP Code).

14 Electrical separation of the welding circuit including the workpiece (and all parts carrying the welding current) from the primary circuits is normally achieved by Class II transformer design.

15 However, for machines provided with Class I insulation it is essential that each welding circuit, including the winding, should be permanently connected to the protective earth conductor by either a direct fixing or via a suitably rated cable, resistor or saturable auto-impedance, where excessive circulation currents may occur. In this case the machine manufacturer or installer should provide either a current or voltage operated earth leakage circuit-breaker to detect electrical fault conditions and automatically isolate the welding circuit from the mains power source.

16 Resistance welding equipment which utilises direct current in the welding circuit should also incorporate these types of safeguard against electrical hazards.

17 Any difficulties encountered in dealing with electrical risks should be referred to a person competent in electrical matters.

Physical risks

18 Weld splash or splatter is less likely to occur if machines are correctly adjusted; welding force and current are the most significant factors. However, incorrect timing of the welding cycle, lack of electrode cooling water or presence of corrosion scale can cause molten metal to be ejected. Suitable eye protection is required by operators and other persons entering the welding area. Suitable protective clothing is also appropriate for those parts of the body assessed to be at risk. It may be possible to fit screens or shields at machines to partially contain splatter.

19 Accidents occur at resistance welding machines mainly due to trapping by electrodes or due to injury from accessories such as workpiece feed systems. Safeguarding systems for prevention of accidents at electrodes are described at paras 34-49.

20 Accidents at the electrodes usually result in crushing injury to the fingers of operators. Fracture or partial amputation of fingers often occurs. Setters and other maintenance workers are also at risk, particularly where safeguards may be defeated temporarily to allow adjustment or where safeguards depend upon the use of jigs. In general, the welding force applied at the electrodes increases from spot to seam to projection welding.

21 Electrode tips require periodic dressing to size and shape. This may be done in situ using either a hand file or a special power tool or the tips may be removed. Machines should be isolated from power supplies before work requiring such close approach is attempted.

LEGAL REQUIREMENTS

22 Resistance welding machines come within the scope of the Electrical Equipment (Safety) Regulations 1994 (EESR), which implement the EC Low Voltage Directive. Manufacturers and suppliers (including of second-hand and hire machines) should comply with these Regulations.

23 EESR Regulation 5(1) requires that resistance welding machines should be safe and meet the safety objectives in Schedule 3. Schedule 3 makes clear that these objectives include protection against non-electrical dangers (see paras 18-21 above). Compliance with Regulation 5 is presumed if a machine meets the requirements of a harmonised standard (see paras 28-33). However, such standards may not address all of the hazards of a given machine and cannot be relied upon entirely. The overriding requirement is that the machine should be safe.

24 Except for machines placed on the market before 1 January 1997 and for machines supplied second-hand or hired, CE marking is required by EESR.

25 Manufacturers and suppliers will have satisfied the main requirements of the Health and Safety at Work etc Act 1974 (HSW Act) Section 6 by fulfilling their duties under EESR. However, Section 6 also requires that suppliers should provide adequate information about any conditions necessary to ensure safe use of the machine. Suppliers, including of second-hand machines, will need to enquire about the intended use of the machine in order to meet this duty.

26 Users of resistance welding equipment will need to comply with the Provision and Use of Work Equipment Regulations 1992 (PUWER). PUWER Regulation 11 sets out the requirements in relation to the guarding of the electrodes of resistance welding machines. PUWER Regulation 10 requires that users ensure that resistance welding machines first provided for use at their premises meet the requirements of EESR.

27 Users of spot and projection welding machines often order only a basic

machine without indicating to the supplier the type or range of work to be undertaken. In such circumstances, to comply with HSW Act Section 6, the supplier should specify the limitations for safe use. Users changing or extending the use of equipment should fit any appropriate additional safeguard which then becomes necessary in order to meet their duties under PUWER Regulation 11.

HARMONISED STANDARDS

28 BS5924:1989 (equivalent to EN 50063) Safety Requirements for the Construction and the Installation of Equipment for Resistance Welding and Allied Processes is a harmonised standard for the purposes of EESR (see para 23).

29 The requirements of BS 5924 intended to provide protection against electric shock are described in clause 5.1. The main features of these requirements are set out in paras 13-16.

30 The safeguarding requirements of BS 5924 intended to protect against the physical risks described in paras 18-21 are in clause 5.5. This sets out measures which are required when the workpieces to be welded cannot be introduced and retained throughout the operation without danger.

31 Where it is possible to weld without danger, the standard states that the following control devices are permitted:

(1) simple foot control;

(2) manual control using one hand only; and/or

(3) simple control by means of the pieces to be welded (normally associated with automatic workpiece feed systems).

32 BS 5924 does not clarify where it is possible to weld without danger. Assessment of the risks of all work to be carried out at the machine should be carried out. However, it can be accepted that there is minimal danger where:

(1) a machine is adjusted so that the gap between the electrodes does not exceed 6mm;

(2) where the machine is fitted with correctly adjusted low force approach safeguarding (see paras 38 and 39);

(3) suitable jigs are used (para 37);

(4) portable machines are used; or

(5) where at least one of the components to be welded is large and occupies both of the operators hands (para 35).

33 Where it is not possible to weld without danger, the standard indicates that at

least one of the following measures, together with suitable interlocks, is required:

(1) fixed and/or movable mechanical guards;

(2) protective devices that operate without contact, eg photoelectric devices;

(3) proximity or presence sensing devices that operate with contact; or

(4) 2-hand control (used only where other methods of safeguarding are not reasonably practicable).

SAFEGUARDING SYSTEMS FOR ELECTRODES

Limited gap between electrodes

34 This should not exceed 6mm measured between the electrodes. Adopting this safeguard will severely limit the range of work which can be undertaken at the machine.

Foot pedals

35 Foot pedals need to be shrouded to prevent accidental operation. The use of a foot pedal alone without additional safeguards is only acceptable at spot welding machines where either the gap between electrodes is 6mm or less or where the workpiece requires to be held by both of the operator's hands and that they are far enough away to avoid risk from the electrodes. Welding where a component occupies both hands is often associated with other components being small and either automatically fed and/or held by location devices. Such systems and devices need to be designed and maintained to avoid jamming or mislocation of components as operators can be tempted to take corrective action whilst 'riding' the foot pedal.

Control by workpiece

36 Control by workpiece is rarely adopted as it can create operational reliability problems. If it is employed in a way which does not engage both of the operators hands, additional safeguards are required.

Use of jigs

37 Jigs are regarded as devices which are held by both hands of the operator. They are to be differentiated from location devices which do not occupy the operator's hands. It is important that jigs are designed and maintained to ensure retention of the workpiece during the welding cycle as accidents often occur when operators attempt to relocate workpieces after initiating the welding cycle. It is recommended that jigs for use on high duty cycle operations be of non-magnetic material to avoid heat build up.

Low force approach

38 This may also be known as low pressure approach. This system allows the top electrode to descend at a low force or under gravity until it reaches a predetermined adjustable position above the bottom electrode. This should not exceed 6mm. Application is usually limited to spot welding machines due to the potential for injury of gravity descent by the heavier electrodes and associated equipment. Low force approach systems are available from several suppliers. Their cost and sophistication varies. Not all systems are capable of retro-fitting.

39 High lift is a similar system to low force. It is designed to allow a wider gap between the electrodes. Two foot pedals are normally employed. One is used to apply the welding force once a gap of not more than 6 mm is achieved and the other is used to open or close the electrodes from or to the pre-set 6mm gap.

Fixed guarding

40 A maximum use of fixed guards should always be considered. Totally enclosed fixed guarding may make the feeding of components difficult. The design needs to allow for dressing of electrodes.

Interlocked guards

41 Interlocked guards should ensure access is closed before initiation of the machine and that access is prevented until the electrodes are closed. Interlocked guards should reach the fully closed position before the electrodes can be closed.

Sensing devices

42 Non-contact sensing devices such as photoelectric safety devices are more popular as they do not slow production. Acceptable design and installation of non-contact safety systems, including photoelectric devices etc, will conform with the requirements of BS 6491:1984 Electro-sensitive safety systems for industrial machines, or equivalent standards. Additional fixed guarding will also be required to complete protection. Safeguards of this type are most usual at special purpose machines but need also to be considered for projection welding machines.

43 Contact sensing systems such as pressure sensitive mats are not often adopted at resistance welding machines

Single hand control

44 Single-hand control of resistance welding machines should necessarily perform in a hold-to-run mode which requires continuous actuation of the control device(s) to energise the welding circuit.

45 Single hand operation is not acceptable at machines other than spot welding machines and portable machines (these require the operators second hand to assist manipulation).

Two-hand control

46 Hand controls are usually buttons. Where the nature of the work ensures that the operator has one hand occupied away from the electrodes a single hand control is acceptable. Where this is not the case, 2-hand control is required, but should always be regarded as an option of last resort. Where production runs of significant length are to be undertaken, consideration needs to be given to additional or alternative safeguards.

47 Where it is reasonably foreseeable that other persons may approach or assist the operator and there is unprotected access to the electrodes, additional measures should be provided such as restriction of access by extended fixed side guards.

48 A minimum acceptable standard for 2-hand control of a resistance welding machine needs to incorporate 2 control actuating devices requiring concurrent operation by both hands, until welding current flow is started. At this point it is normal for the machine to 'lock on' until the weld part of the cycle is complete and therefore the operating devices can be released without effect. A type 1 or 2, two-hand control circuit may be provided for this purpose in accordance with BS EN 60204:1993 Safety of machinery. Electrical equipment of machines.

APPLICATION OF SAFEGUARDING SYSTEM

49 The safeguarding systems (paras 34-48) are not universally applicable to all types of resistance welding machines. The usual scope of application is:

(1)	Spot welders	- foot pedal (para 35); - low force/high lift (paras 38 and 39); - limited gap (para 34); - jigs (para 37); - fixed/interlock guards (paras 40 and 41); - non contact sensing devices (paras 42 and 43); - hand control (paras 44 to 48);
(2)	Projection welders	- two-hand control (paras 46 to 48); - fixed/interlock guards (paras 40 and 41); - jigs (para 37); - non contact sensing devices (paras 42 and 43);
(3)	Seam welders	- foot pedal (para 35); - high lift (para 39); - limited gap (para 34);
(4)	Portable welders	- single hand control (paras 44 and 45).

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