TAPESWITCH
SAFETY MATS-
CKP/S1 Sensors
with PSSU control units

TECHNICAL MANUAL 343181-07

English

WARNING

Tapeswitch safety mat systems are intended to protect operators working at or near dangerous machinery. They can only perform this function if they are correctly fitted and interfaced to a suitable machine. It is essential that the full contents of this manual and all the authoritative documents referred to herein are fully understood before any attempt at installation is made. If in doubt contact Tapeswitch or your Tapeswitch distributor.

IMPORTANT

This manual must accompany the product throughout its working life. Those persons responsible for the use of the product must ensure that all persons involved in the installation, commissioning, operation, maintenance and servicing of the product have access to all the information supplied by the manufacturers of the machine and its safety system.

CONTENTS

1. INTRODUCTION

1.1 PRODUCT DESCRIPTION

Tapeswitch safety mat systems are pressure sensitive safety devices designed to protect operators working at or near dangerous machinery. A system consists of a pressure sensitive sensor and a control unit. When correctly installed at and interfaced to a suitable machine the system will:

(a) detect a person present in the dangerous area and prevent dangerous motion from occurring.

(b) detect a person entering the dangerous area and cause dangerous motion to cease before the person can reach the dangerous parts.

(c) a combination of **(a)** and **(b)**.

Pressure sensitive sensors are fixed to the floor. The area covered by the sensor depends on which of the functions (a), (b) or (c) is to be performed. When a person steps onto a sensor a signal is transmitted to the control unit which will in turn transmit a stop signal to the machine control system.

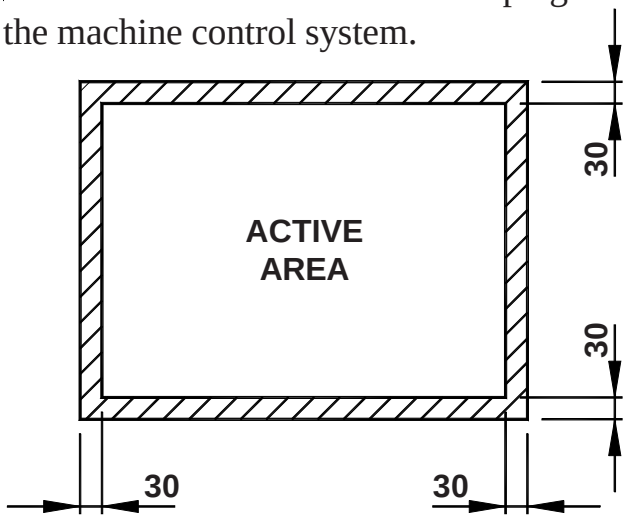


Figure 1 - Dimensions of the inactive area around outer edge of sensor

1.2 PRODUCT RANGE

1.2.1 SENSORS

1.2.1.1 SENSOR SHAPES AND SIZES

Mat sensors can be produced in any shape and size which meets the following restrictions:

- all corners, internal or external, should be 90 degrees.
- the maximum possible width of a mat is 1200 millimetres.
- the maximum possible length of a mat is 2400 millimetres.
- the maximum total area is 2.88m².

Rectangular shapes are preferred although any shape which meets the restrictions outlined above is possible.

The dimensions of sensors and their layout must be such access to the machine is not possible without stepping on a sensor. It should not be possible to move the sensors or bridge them using boards, plates etc. Further guidance is given in section 1.6.

NOTE: CKP/S1 sensors have an inactive area around the outer edges. This inactive area is 30 millimetres wide which means that the dimensions of the active area (i.e. the zone within which the application of pressure will actuate the sensor) is 60 millimetres less than the overall dimensions of the mat as shown in Figure 1. This should be borne in mind when specifying the size of mat for a particular application. See section 1.6 for further guidance on determining sensor dimensions.

1.2.1.2 SENSOR OPTIONS

CKP/S1 sensors can be supplied with two 2-core leads or a single 4-core lead. Where a single mat sensor is used a single 4-core lead is most practical. Where several mats are connected in series to form a larger sensor two 2-core leads should be specified.

1.2.2 CONTROL UNITS

Four versions of the control unit are available, PSSU/1, PSSU/2, PSSU/3 and PSSU/4. All units provide monitoring of a sensor (or a number of sensors connected in series), a reset input and two separate safety outputs. In addition, the PSSU/3 and PSSU/4 provide a non-safety monitor output. Apart from the provision of a monitor output, the units differ only in their type of enclosure and supply voltage.

The PSSU/1 control unit is housed in a DIN rail mounting enclosure with 16 integral terminals and operates from 110 or 240V a.c. supply. The PSSU/2 control unit uses the same enclosure but operates on 24Vdc supply. Both these units are intended to be fitted inside an existing electrical enclosure on the machine. This existing enclosure must be sealed to a minumum rating of IP54.

The PSSU/3 control unit uses a polycarbonate enclosure sealed to IP67 and operates from 110 or 240V a.c. supply. The PSSU/4 control unit uses the same IP67 enclosure as the PSSU/3 unit but operates from 24Vdc. The function of all four units is exactly the same and is described in section 2.

1.2.3 ACCESSORIES

Aluminium edging is available for fixing the sensors in position. This edging consists of two interlocking aluminium extrusions, a base and a cover. The edging can accommodate the mat wiring and provides a 20 degree ramp to prevent a tripping hazard at the mat edge.

1.3 PRODUCT FEATURES

1.3.1 SENSORS

* Tapeswitch internal switching elements.
* Sealed to IP65.
* 24 volt operation.
* Low pressure actuation.
* Heavy duty, abrasion and chemical resistant materials.
* Multiple sensors can be connected to one control unit.

1.3.2 CONTROL UNIT

* Two cross-monitored safety output relays with force guided contacts.
* Integral start and restart interlock.
* DIN rail mounting or IP67 enclosure.
* Simple, reliable, proven technology.
* One control unit capable of monitoring multiple sensors.
* Built in diagnostic indication.
* 24Vdc or 110/240V 50/60 Hz ac supply.

NOTE: For the PSSU/2 and PSSU/4, the external 24Vdc power supply must either be provided from a safety transformer meeting EN742 or from a battery. Cables feeding the supply should be run separately and should be protected against damage.

1.4 PRODUCT APPLICATION

1.4.1 GENERAL

Tapeswitch safety mat systems can be used either to provide primary guarding where other types of guarding are impractical or to provide secondary guarding where the primary guarding method cannot protect all danger areas. Safety mats are particularly useful for protecting operators who may be inside large machines and for awkwardly shaped machines. Applications include:

* Robot cells
* Tube bending machines
* Carton folding/gluing machines
* Punching machines

1.4.2 FACTORS AFFECTING SUITABILITY

1.4.2.1 PERSONS TO BE PROTECTED

CKP/S1 safety mats are not suitable for use where children are to be protected.

1.4.2.2 MACHINE CONTROL FACTORS

The machine control system must satisfy the following requirements:

(a) The dangerous motion of the machine must be electrically controllable.
(b) The machine response/stopping performance must be adequate and consistent.
(c) It must be possible to stop the dangerous motion of the machine at any point in its operation.
(d) The control system as a whole must be constructed to provide the level of safety integrity determined by a risk assessment as described in section 1.4.2.2.

1.4.2.3 RISK FACTORS

Every machine has its own unique hazards. In order to determine the level of risk in a particular application a risk assessment must be performed. In many countries methods have been developed and published, usually by the organisations responsible for industrial safety, to enable a systematic risk assessment to be carried out.

The guidance available in a particular country may take the form of national, European or international standards. Persons responsible for selecting safety devices should be familiar with the guidance available in his country before specifying particular safety devices. In most current guidance the factors considered in risk assessment are:

(a) the severity of possible injury.
(b) the frequency of exposure to the hazard.
(c) the possibility of avoiding the hazard.

CKP/S1 mat sensors are suitable for use in low to medium risk applications where the following conditions apply:

EITHER

- the severity of possible injury is slight.

OR

- the severity of possible injury could be serious and
- the frequency of exposure to the hazard is low and
- the possibility of avoiding the hazard is high.

1.4.2.4 ENVIRONMENT FACTORS

The existence of the following factors may preclude the use of safety mat systems in particular applications:

(a) risk of injury from thermal or other radiation.
(b) a tendency for the machine to eject materials or components.
(c) a need for heavy vehicles to frequently enter the dangerous area.
(d) continuous or repeated immersion in water or other fluids.
(e) exposure to damage due to droppage of heavy or sharp objects.
(f) exposure to spillage of hot and/or solidifying substances.
(g) exposure to spillage of aggressive chemicals.

Consult Tapeswitch or your Tapeswitch agent if in doubt.

1.5 STANDARDS AND SAFETY

1.5.1 GENERAL

Tapeswitch CKP/S1 safety mat systems have been designed to meet the requirements of the German national standard DIN V 31006 Part 1: 'Pressure Sensitive Mats and Floors'. This standard specifies three possible levels of safety integrity for mat systems numbered 1, 2 and 3, with 1 being the lowest level and 3 the highest.

Tapeswitch safety mat systems meet safety integrity level 2 as defined by this standard. This requires that any single fault in the system will not lead to the loss of the safety function.

NOTE: Sensors can only partially meet this requirement, as described in section 3.3 of DIN V 31006-1. This standard acknowledges the difficulty in predicting the probability and precise nature of faults which may arise in the sensors due to long term physical deterioration, mechanical damage or chemical attack. For any type of pressure sensitive sensor it is possible to envisage a particular set of conditions or a particular series of events which would prevent the sensor from performing its safety function. For this reason these types of faults are not considered by this standard. There is however a general requirement that every attempt should be made to minimise the risk of such faults occurring. Tapeswitch sensors have been designed to meet this requirement. Application and maintenance in accordance with this manual will further reduce the probability of such faults to an insignificant level.

1.5.2 SENSORS

For electrical faults, CKP/S1 sensors exceed the requirements of level 2, in that, not only does a single fault not lead to a loss of the safety function but the fault will be detected and further use of the machine will be prevented. These types of fault are:

(a) Open circuit of any internal or external conductor.
(b) Short circuit between wires in cables (two lead sensors).
(c) Short circuit between adjacent wires in cable (single lead sensors).
(d) Short circuit in any of the internal switching elements.

1.5.3 CONTROL UNITS

Tapeswitch safety mat control units exceed the requirements of safety integrity level 2. The control units are self-monitoring which means that any faults in safety critical components will be detected and will render the machine inoperative until the fault is rectified.

NOTE: For the PSSU/2 and PSSU/4, the external 24Vdc power supply must either be provided from a safety transformer meeting EN742 or from a battery. Cables feeding the supply should be run separately and should be protected against damage.

1.6 SPECIFICATION AND ORDERING INFORMATION

1.6.1 DETERMINING SENSOR DIMENSIONS

1.6.1.1 GENERAL

The dimensions of the dangerous area depend on the particular application. The parameters to be considered include:

- speed of walk or arm movement (typically 1,6m/s)
- arm length (typically 0,85m)
- length of stride (typically 0,7m)
- response time of system
- position of inactive areas
- overtravel of dangerous parts after stop signal is generated

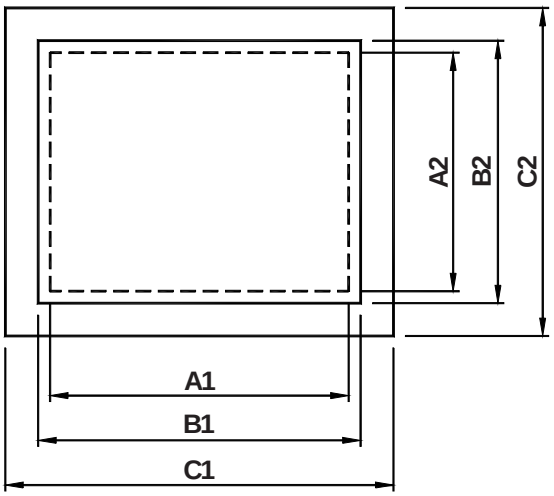
A Tapeswitch pressure sensitive safety mat system can be used as:

(a) a combined trip and presence sensing device - the device is positioned such that it will be activated when a person enters a dangerous area and remains activated whilst the person is inside the dangerous area.

(b) a presence sensing device - the sensor is positioned such that it will be actuated by a person who is inside a dangerous area.

(c) a trip device - the sensor is positioned such that it will detect a person entering a dangerous area.

NOTE: Tapeswitch CKP/S1 safety mats have an inactive area around the outer edges. This inactive area is 30 millimetres wide which means that the dimensions of the active area (i.e. the zone which must cover the dangerous area) will be 60 millimetres less than the overall dimensions of the mat, as shown in Figure 2. This should be borne in mind when specifying the size of mat for a particular application.



Active Area = A1 x A2
Overall Mat Dimensions = B1 x B2
Area Covered with Edging = C1 x C2

C1 = B1 + 126mm
C2 = B2 + 126mm
B1 = A1 + 60mm
B2 = A2 + 60mm

Figure 2 - Sensor dimensions

Where possible, the shape and size of the dangerous area should be designed such that a single rectangular sensor, preferably of a standard size, can be used. Where this is not possible, non-standard rectangular shapes, irregular shapes and combinations of sensors will be required. The range of standard sizes and the restrictions on size and shape for individual sensors are given in section 1.2.

Where a combination of sensors is required the following considerations apply:

(a) If possible all mat sensors in a combination should be the same shape and size. This makes it possible for the user organisation to hold spare sensors and simplifies the ordering of replacements.

(b) If possible the mat sensors should be arranged in a single row with joints perpendicular to the normal direction of approach of the operator as illustrated in Figure 3.

(c) When mats must be arranged in an array, one side of the array must not exceed two mats as shown in Figure 4.

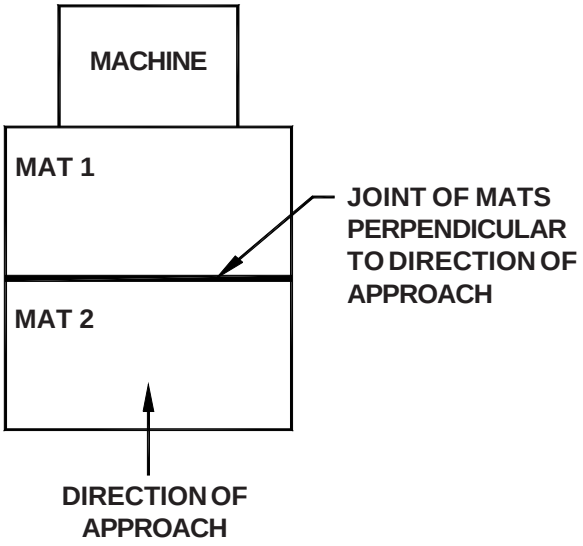


Figure 3 - Arrangement of mat joints

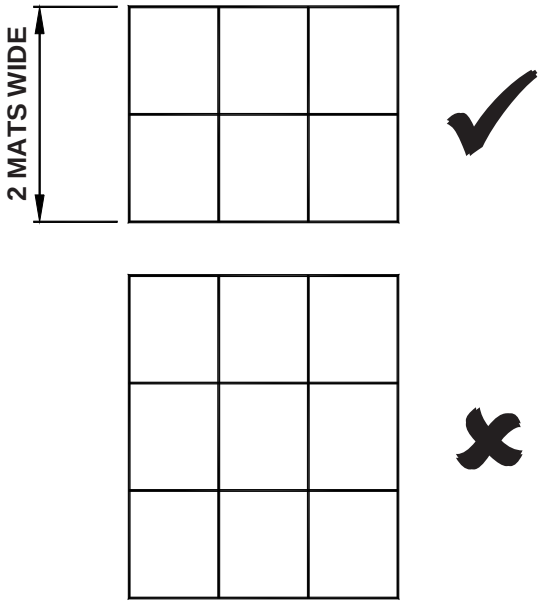


Figure 4 - Mat array requirements

1.6.1.2 USE AS A COMBINED TRIP AND PRESENCE SENSING DEVICE

When a system is used as a combined trip and presence sensing device it will normally be the sole means of guarding at that particular part of the machine. In this case it is necessary to ensure that the dimensions of the sensor(s) are such that the machine will be brought to rest before an approaching person can reach the dangerous parts and that the sensor covers all of the dangerous area. It should not be possible for a person to stand anywhere between the front edge of the active zone of the mat, and the machine without standing on the mat.

In order to determine the position of the front edge of the active zone it is necessary to consider the stopping performance of the machine.

Any machine, regardless of the efficiency of its braking system, will take a certain time to come to rest after a stop signal is generated.

From the instant that a persons foot touches the mat to the instant that dangerous motion actually ceases is called the overall system response time. The overall system response time, T, is given by the following calculation:

$$T = t1 + t2$$

where t1 = the maximum response time of the safety device between the actuation of the sensor and the generation of the stop signal = 30ms (Measured according to DIN V 31006-1).

and t2 = the response time of the machine between receiving a stop signal from the safety device and the dangerous parts coming to rest.

The dangerous parts will obviously continue to move during this time. The sensor must therefore be dimensioned such that the nearest point at which a person could first touch the mat is at a certain minimum distance from the dangerous parts, to prevent the person from reaching the dangerous parts before they have stopped.

This must take into account the worst case conditions illustrated in Figure 5 where a person could be a full stride onto the sensor before the sensor is actuated. This means that a certain distance from the front edge of the sensor and the nearest dangerous parts must be maintained.

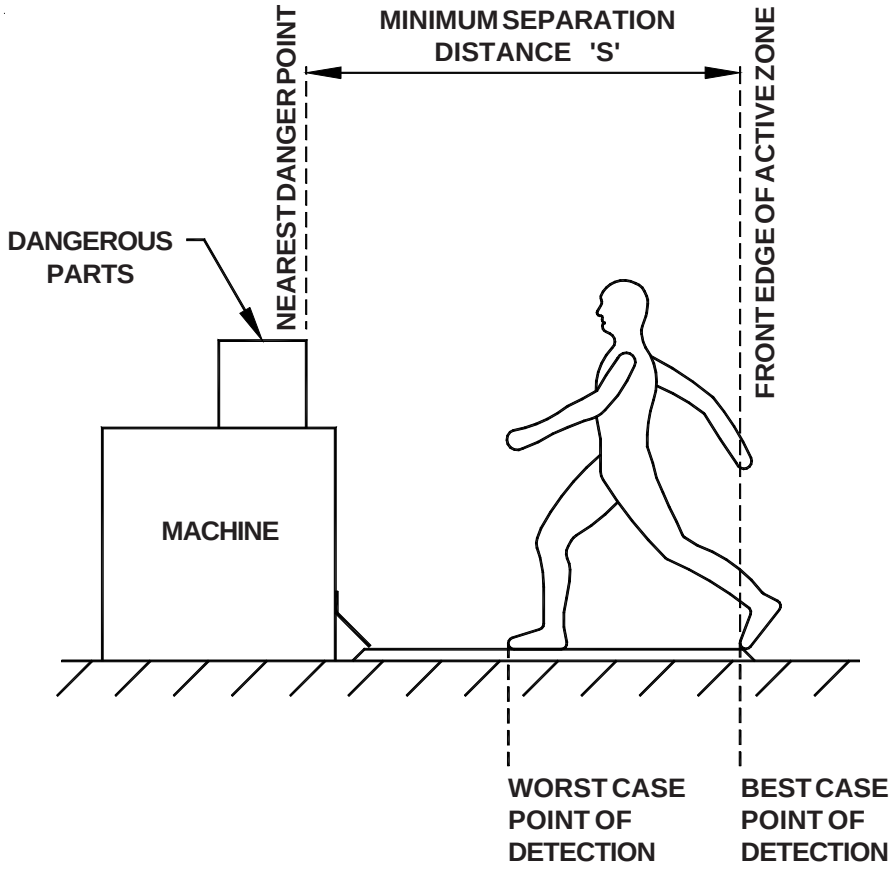


Figure 5 - Minimum separation distance

This distance is the minimum separation distance. All possible directions of approach must be considered. The minimum separation distance, S, can be calculated using the following formula:

$$S = (1600 \times T) + 1200$$

The overall system response time, T, should be measured several times and the highest value recorded, plus a suitable allowance for brake deterioration, should be used in the calculation of the minimum separation distance.

1.6.1.3 USE AS PRESENCE SENSING DEVICE

When the system is used solely as a presence sensing device it is normally used as a secondary guarding device in conjunction with a separate primary guarding device. The primary guarding device would normally, as a minimum, operate as a trip device. The position of the trip device should be determined according to the manufacturers instructions. The primary guarding device could be an interlocking fence, photo-electric curtain or similar device.

In this case it is necessary to ensure that the dangerous area, between the primary guarding device and the machine is completely covered by the active area of the sensor(s), such that it is impossible for a person to stand between the primary guarding device and the dangerous parts of the machine without standing on the active area of the mat(s).

1.6.1.4 USE AS A TRIP DEVICE

When the system is used solely as a trip device the minimum separation distance, i.e. the distance from the front edge of the active zone of the mat to the nearest dangerous parts should be calculated as described in section 1.6.1.2.

The minimum width of the active zone of the mat should be 750 mm (i.e 810 mm overall) to ensure that an operator cannot inadvertently step over the mat into the dangerous area without actuating the mat. See Figure 6.

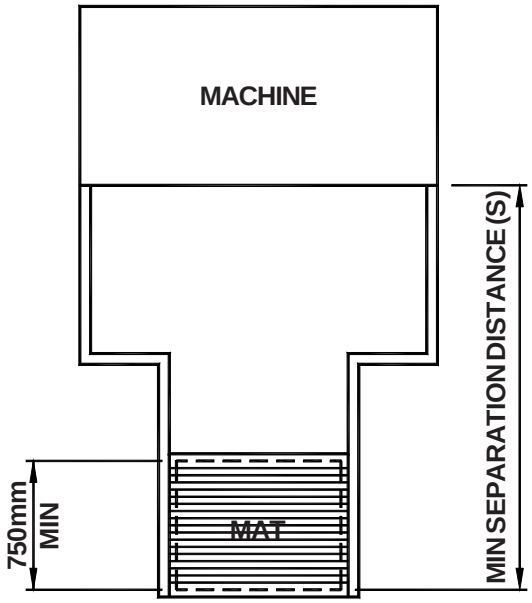


Figure 6 - Mat used solely as a trip device

1.6.2 ORDERING INFORMATION

1.6.2.1 MAT SENSORS

When ordering mat sensors the following order code should be used. See Figure 7 for lead position details:

ORDER CODE: CKP/S1 / XX / XX / XXXX / XXXX / XXXX

SENSOR TYPE

EDGE PREPARATION
SE - SQUARE EDGE

CABLE POSITION
LD - LONG EDGE, TWO 2-CORE LEADS
SD - SHORT EDGE, TWO 2-CORE LEADS
LLS - LONG EDGE, LEFT SIDE, ONE 4-CORE LEAD
LRS - LONG EDGE, RIGHT SIDE, ONE 4-CORE LEAD
SLS - SHORT EDGE, LEFT SIDE, ONE 4-CORE LEAD
SRS - SHORT EDGE, RIGHT SIDE, ONE 4-CORE LEAD

LONG EDGE LENGTH mm

SHORT EDGE LENGTH mm

CABLE LENGTH mm

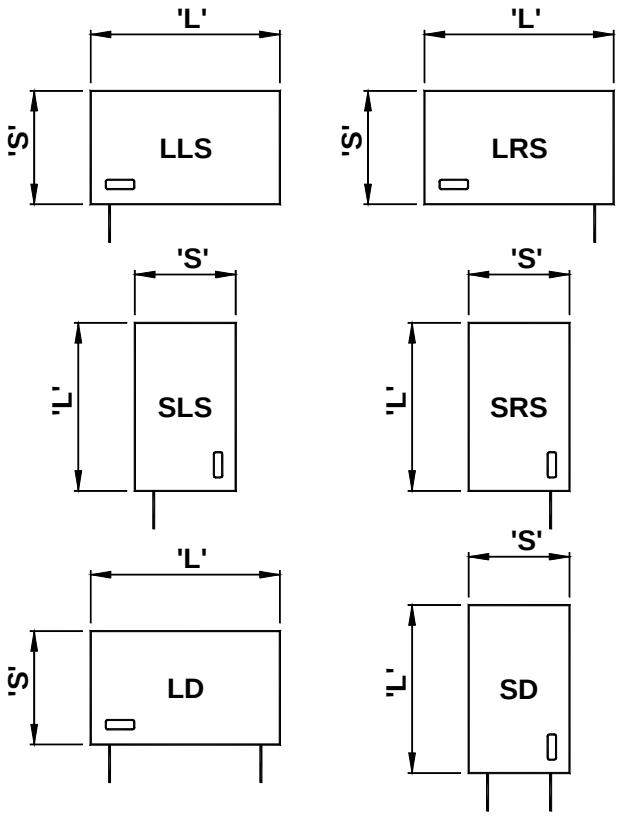


Figure 7 - Lead position options

1.6.2.2 CONTROL UNITS

When ordering control units simply use the control unit type designation i.e. PSSU/1, PSSU/2, PSSU/3 or PSSU/4.

1.6.2.3 AE-13 MAT EDGING

AE-13 Mat Edging is for use with the CKP/S1 Mats. The edging can be supplied in kit form already prepared, or in D-I-Y form for the edging to be prepared when the mat is being installed.

2. TECHNICAL DESCRIPTION

2.1 SYSTEM OVERVIEW

A Tapeswitch safety mat system consists of two elements: a sensor and a control unit. The sensor may consist of a single mat sensor or a combination of mat sensors. When a person stands on the sensor a stop signal is transmitted to the control unit. On receiving a stop signal from the sensor the control unit switches off its output relays causing dangerous motion to cease or be prevented.

The control unit contains the system power supply, the sensor monitoring circuit and the safety output relays. The safety output relay contacts must be connected into the machine control circuit such that when the output relays are switched off, power to the machine primary control element(s) is removed.

A machine primary control element or MPCE is defined as 'an electrically controlled element which directly controls the normal operating motion of a machine such that it is the last (in time) to operate when motion is initiated or arrested'.

NOTE: On low to medium risk machines a single MPCE is normally used. If two MPCE's are provided their function should be such that each of them is capable of stopping the machine, regardless of the state of the other.

2.2 SENSORS

2.2.1 MAT SENSORS

The construction of the CKP/S1 sensor is shown in Figure 8. A network of Tapeswitch ribbon switching elements is sandwiched between two thick sheets of PVC material. The switching elements are connected in series. The switch elements are glued to the bottom layer.

The top and bottom layers are sheets of ribbed, heavy duty matting material. This material is of laminated construction and is PVC based with special additives and fillers to increase its abrasion and chemical resistance. This material can withstand years of pedestrian traffic and is resistant to most chemicals commonly found in an industrial environment including water, coolant, oil and hydraulic fluid. The top sheet is 6.5 millimetres thick and the bottom sheet is 5 millimetres thick.

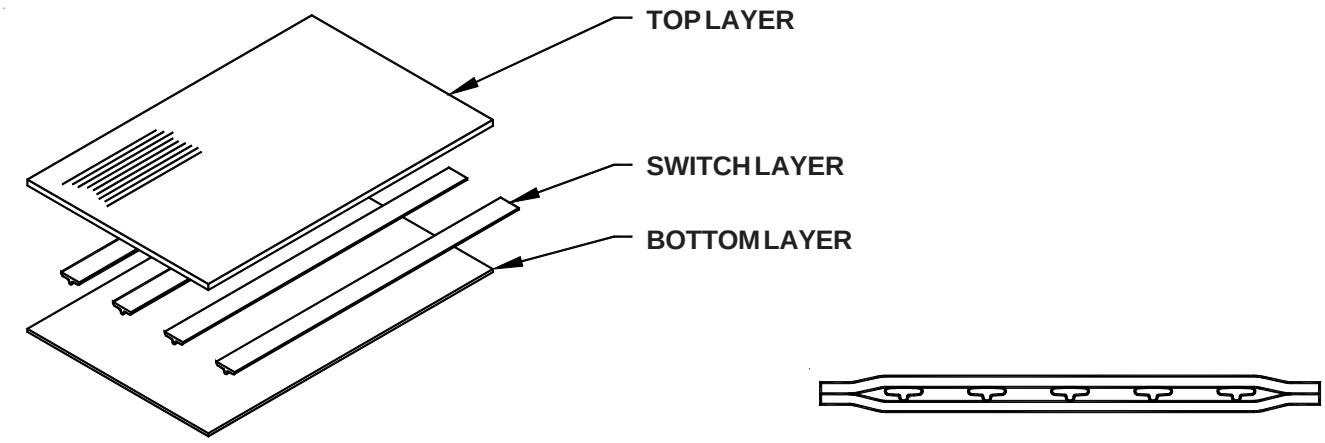


Figure 8 - Construction of CKP/S1 sensor

2.2.2 COMBINATION OF SENSORS

The construction of the Tapeswitch elements is shown in Figure 9. Each switching element is a long normally open switch. The switch consists of two copper plated steel conductors held apart at the sides by an insulator. When pressure is applied to the bead, the two conductors are forced together in the centre, closing the switch.

All the upper conductors of all the switch elements are connected together and all lower conductors are connected together, effectively creating a single normally open switch. Heavy gauge copper plated steel wire is used for all internal wiring and all connections to the switching elements are direct solder joints. The switches are self-bottoming and as a result they can withstand very high loads and repeated operation. Several million operations is typical.

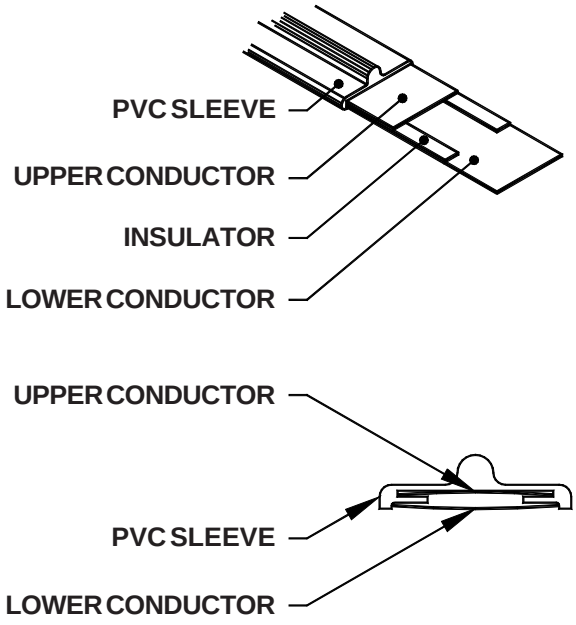


Figure 9 - Construction of Tapeswitch elements

When a number of mat sensors are used in combination, sensors with two 2-core leads should be used. The sensors should be connected in series such that the control unit 'sees' a single normally open switch. One of the 2-core cables can be considered to be the inlet cable and the other the outlet cable. When connecting a number of sensors together the outlet cable of the first sensor is connected to the inlet cable of the second sensor and so on. This leaves the inlet cable of the first sensor and the outlet cable of the last sensor to be connected to the control unit as illustrated in Figure 10.

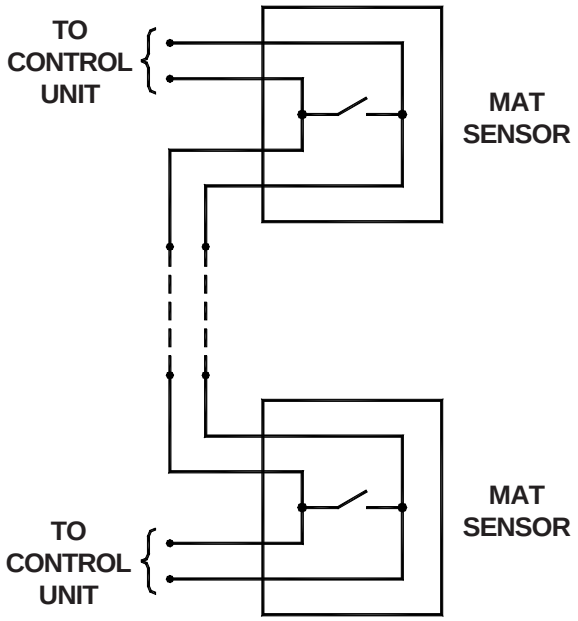


Figure 10 - Connection of sensors in series

2.3 CONTROL UNIT

The control unit contains the power supply for the system, the safety output relays and the reset circuit. Figure 11 shows the principle of operation.

A 24Vdc power supply is taken from the control unit to each of the switching elements in the sensor(s), +ve to the upper conductors, -ve to the lower conductors, and back to the control unit where it supplies power to the output relays. The output contacts of the safety relays are only closed when the output relays are energised. When the coils of the output relays are de-energised the output contacts are open. It can be seen that when a person stands on the mat, the 24Vdc power supply to the output relays is shorted out causing them to de-energise.

Furthermore, if the power supply to the output relays is interrupted or shorted out by a fault in the cabling, internal wiring or switch elements, power to the output relays will be lost, the relays will de-energise and the output contacts will open.

The reset circuit provides start and restart interlock functions as described:

START INTERLOCK - When power is applied to the machine/mat system the output relays cannot be energised until a reset signal has been applied and removed.

RESTART INTERLOCK - Once the mat has been actuated and the output relays have been de-energised, they cannot be energised again until a reset signal has been applied and removed.

Reset will be prevented while the mat is actuated, if there is a fault in the reset input circuit or if the two output relays are in disparity.

In addition, where the machine control system has two MPCE's, these devices can be cross-monitored by connecting normally closed auxiliary contacts from the MPCE's in series with the reset input. Disparity between the two MPCE's will prevent a reset.

The safety output contacts of the control unit are connected to the MPCE(s) in such a way that if either of the safety output relays is de-energised then the machine will be brought to rest regardless of the state of the other relay.

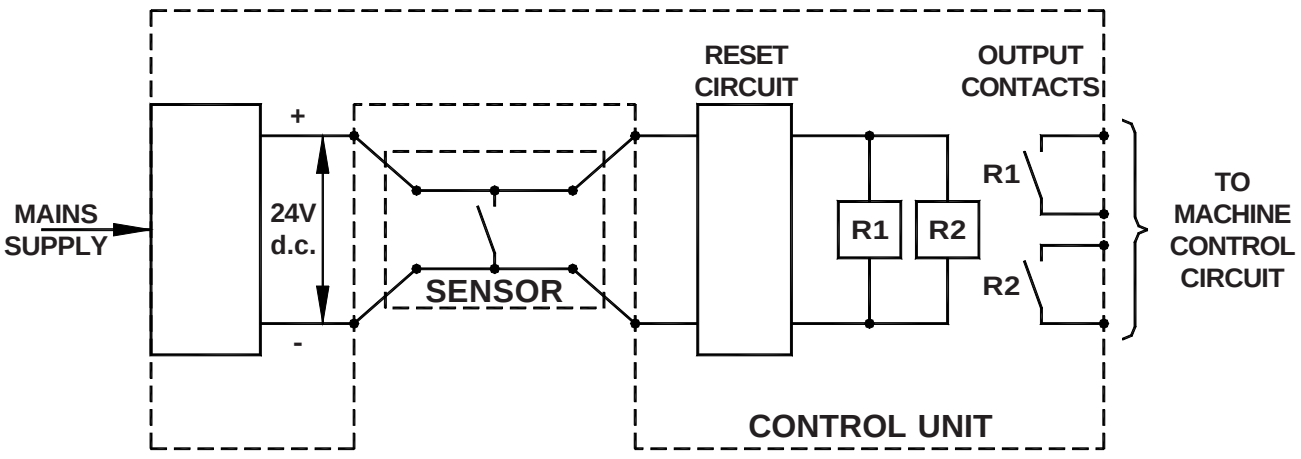


Figure 11 - Control unit principle of operation

3. INSTALLATION

WARNING

TAPESWITCH SAFETY MAT SYSTEMS ARE DESIGNED TO PROTECT OPERATORS WORKING AT OR NEAR DANGEROUS MACHINES. THEY CAN ONLY PERFORM THAT FUNCTION IF THEY ARE CORRECTLY FITTED AND INTERFACED TO A SUITABLE MACHINE. EVERY EFFORT HAS BEEN MADE IN THE PRODUCTION OF THIS MANUAL TO PROVIDE COMPREHENSIVE AND ACCURATE INFORMATION. IT IS THE RESPONSIBILITY OF THE USER TO ENSURE THAT ALL PERSONS INVOLVED IN THE INSTALLATION OF THE PRODUCT HAVE THE KNOWLEDGE, TRAINING AND EXPERIENCE NECESSARY AND THAT THEY ARE FULLY CONVERSANT WITH ALL LAWS, RULES, REGULATIONS AND CODES OF PRACTICE PERTAINING TO THEIR TASK.

3.1 GENERAL

The attention of the installer is drawn to following general requirements for the installation of a Tapeswitch safety mat system:

(a) The machine must be electrically controllable.

(b) It must be possible to stop the dangerous motion of the machine at any point in its operation, in any operating mode.

(c) The control system as a whole must be designed to provide the level of safety integrity determined by the risk assessment.

(d) Steps must be taken to prevent access to the dangerous parts of the machine from any direction not covered by the sensor. Such steps could include fixed or interlocking fences or screens, additional pressure sensitive mats or photo-electric devices.

(e) Steps must be taken to prevent a person standing in the dangerous area without standing on the sensor. The inner surfaces of fixed mechanical fencing should be designed such that there are no ledges or steps on which a person could stand and thereby avoid the sensor. It may be necessary to fit additional mechanical barriers, covers etc. to cover any surfaces within the dangerous area on which a person could stand, such as the feet of the machine. Particular attention should be paid to the edge of the mat nearest to the machine. Ensure that a person tip-toeing at the front of the machine will still be standing on the active area of the mat. See Figure 12.

(f) Wherever possible rectangular mats of standard sizes should be used. Where this is not possible, due to obstructions, mats with edge or corner cutouts and even with holes can be specified. This should only be done where the obstructions are permanent.

(g) Under no circumstances should a mat sensor be cut or drilled. It is not possible for the user to modify the size or shape of a mat sensor.

(h) Great care should be taken when handling mat sensors. Never pick the sensor up or drag it around using the cables. Never bend a mat at a radius less than 300 millimetres. Keep mat sensors flat whenever possible. Always store flat. Mat sensors with one edge longer than 1 metre should be handled by two people.

(i) No devices other than those specified in this manual should be connected to the internally generated power supply of the system.

(j) After installation the machine/mat system must be commissioned in accordance with section 4 of this manual.

(k) Any covers removed during installation must be replaced as soon as possible.

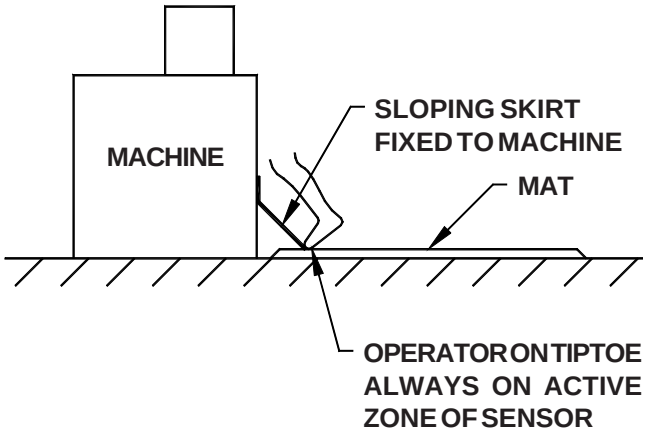


Figure 12 - Ensure operator is always standing on active area of sensor

3.2 SENSOR INSTALLATION

3.2.1 SENSOR MOUNTING SURFACE

The surface on which the sensor is mounted must be sound and reasonably flat. The sensor can tolerate minor irregularities but sharp edges or projections greater than 1mm may cause premature degradation. Where the surface is rough, cracked or breaking up, it should be treated using proprietary sealing and levelling compounds.

3.2.2 SENSOR FIXING

The sensor(s) must be fixed permanently in position. Tapeswitch aluminium edging should be used around the outer edge of the sensor. This specially designed edging comes in two parts, a base and a cover. The cover provides a 20 degree ramp to prevent a tripping hazard at the outer sensor edges. The base can accommodate sensor wiring which protects the cables from damage and acts as a conduit to route the cables to the control unit. Type AE-13 edging is illustrated in Figure 13 and AE-C corner pieces in Figure 14. At the junction of several mats, the mats should be fixed to the floor using double sided tape.

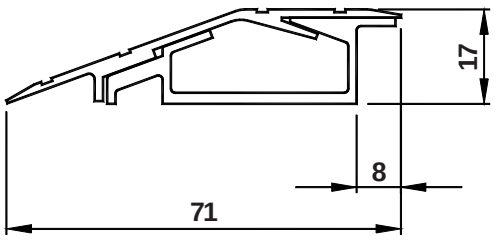


Figure 13 - AE-13 Sensor Edging

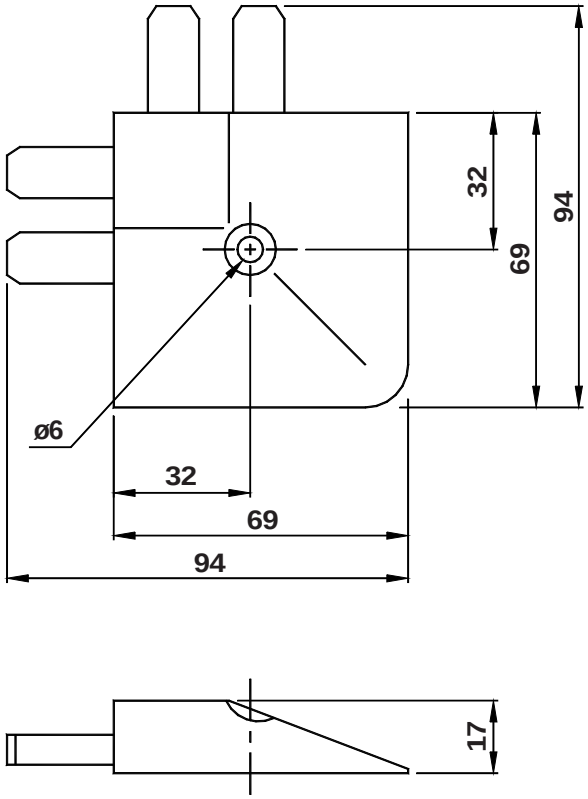


Figure 14 - AE-C Corner piece

3.2.3 INSTALLATION PROCEDURE

Step 1 - Plan the layout. Mark out on the floor the position and size of each sensor. Take care to use the overall dimensions of mat sensors.

Step 2 - Cut all edging to size. Remove any burrs and sharp edges with a file.

Note: If AE-C corner pieces are used then:

the cut length = mat dimension - 12mm of AE-13

Step 3 - Mark the positions of the sensor cables and cut slots in the inner face of the edging base extrusion to allow access for the sensor cables.

Step 4 - Position the base sections around the mat and fit AE-C corner pieces as shown in figure 15. Drill pilot holes through each corner piece and holes in the base sections if applicable. Remove base sections / corner pieces and drill and plug the floor. Refit base sections and corner pieces and secure in position with the screws provided, ensuring the cable exits neatly through the slot(s) in the base section.

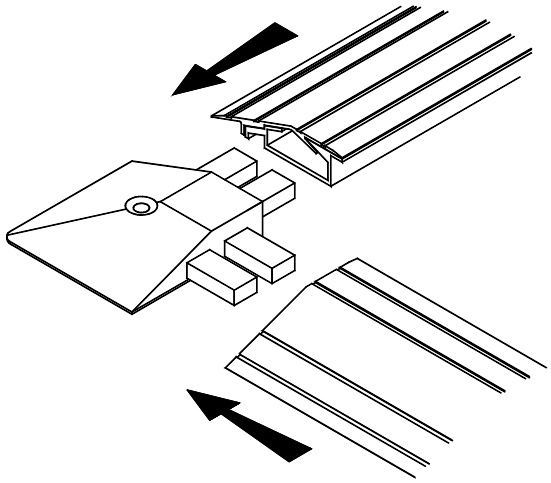


Figure 15 - AE-13 & AE-C Installation

Step 5 - In the case of a combination of sensors connect the sensors in series as shown in Figures 16 and 17. Special grease filled waterproof connectors are available from Tapeswitch Ltd. for this purpose. If necessary cut the cables to length. Always leave some slack in the cables in order that a sensor can be disconnected and reconnected at a later date. The connectors are fitted using a pair of pliers. Make sure that they are fully mated.

NOTE: MAT SENSORS MUST BE FITTED WITH THE LABEL SIDE UP.

Step 6 -Route the cable(s) to the control unit. The cable(s) should exit from the edging as close to the control unit position as possible. The cables should be protected in suitable conduit between the edging and the control unit. Protect any edges over which the cables pass with grommet strip or similar.

Step 7 - Fit the cover extrusion of the edging using suitable self-tapping screws.

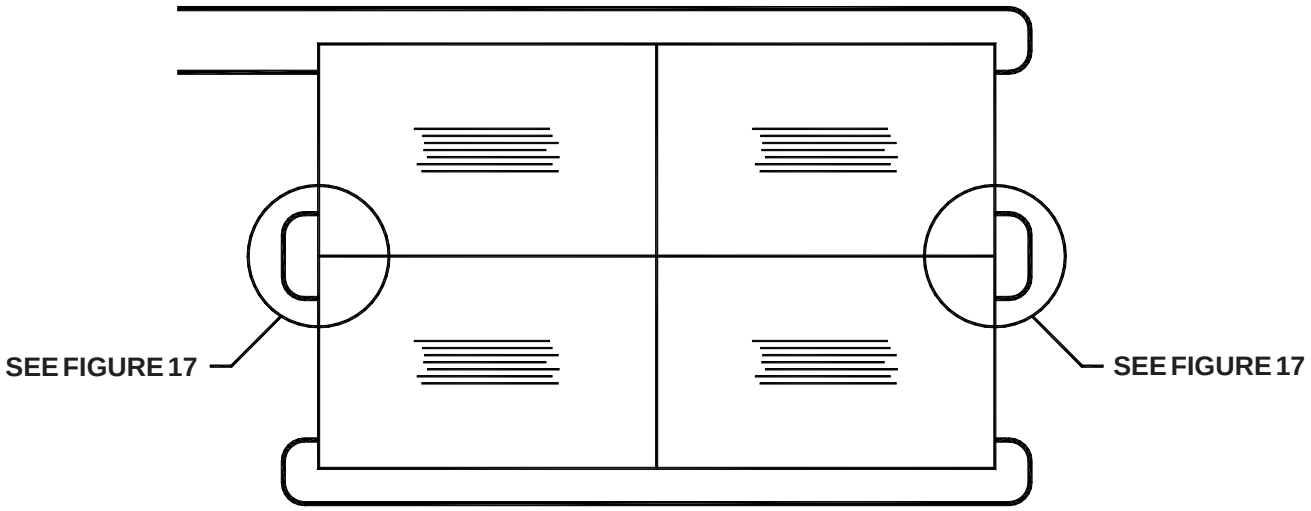


Figure 16 - Connection of sensors in series

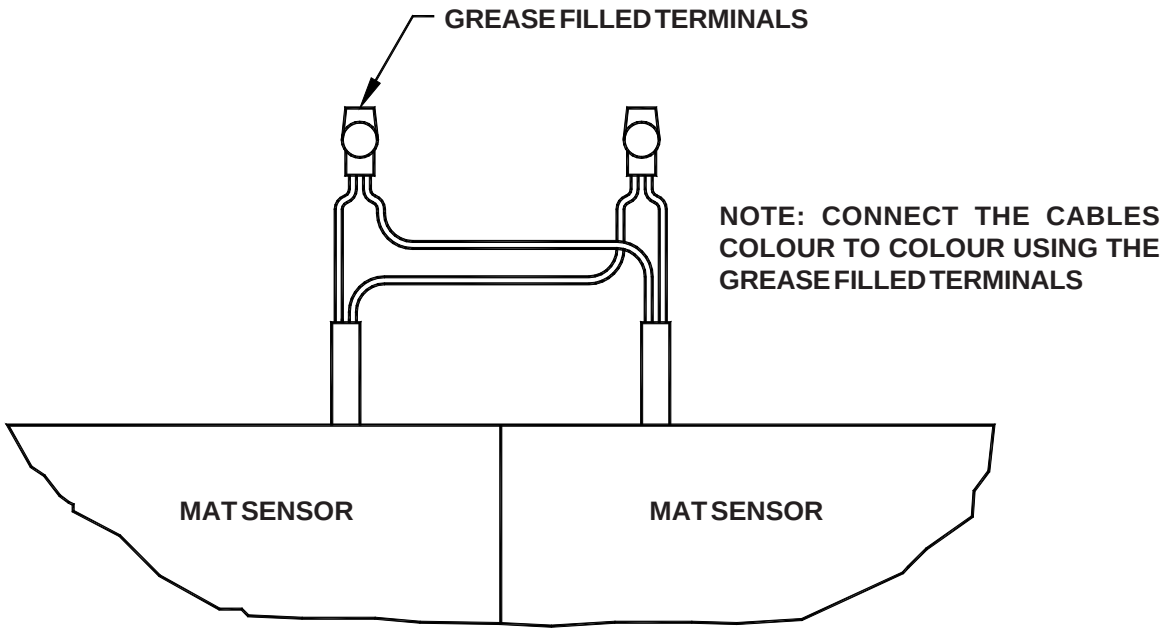


Figure 17 - Wiring of two mat sensors each with 2 x 2 core cables

3.3 CONTROL UNIT

3.3.1 MECHANICAL

3.3.1.1 PSSU/1 & PSSU/2 CONTROLUNITS

Control units of types PSSU/1 and PSSU/2 should be mounted in the machine control unit on standard 'top hat' terminal rail type DIN EN 50 022-35. The machine control unit must provide sealing to IP54 according to IEC 529. The dimensions of these two units are shown in Figure 18.

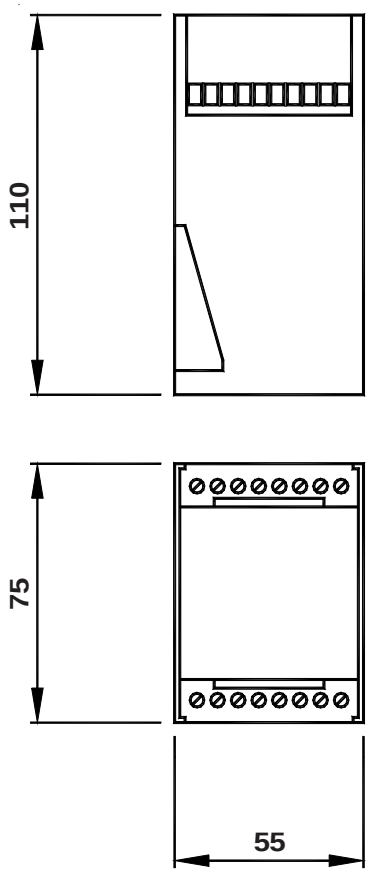


Figure 18 - Dimensions of PSSU/1 and PSSU/2 control units

3.3.1.2 PSSU/3 & PSSU/4 CONTROL UNITS

Control units of types PSSU/3 and PSSU/4 should be mounted on a permanent part of the machine in a position which keeps cabling to a minimum and provides sufficient protection from damage by passing traffic but allows adequate access for servicing. The dimensions of these units and the position of mounting holes are shown in Figure 19.

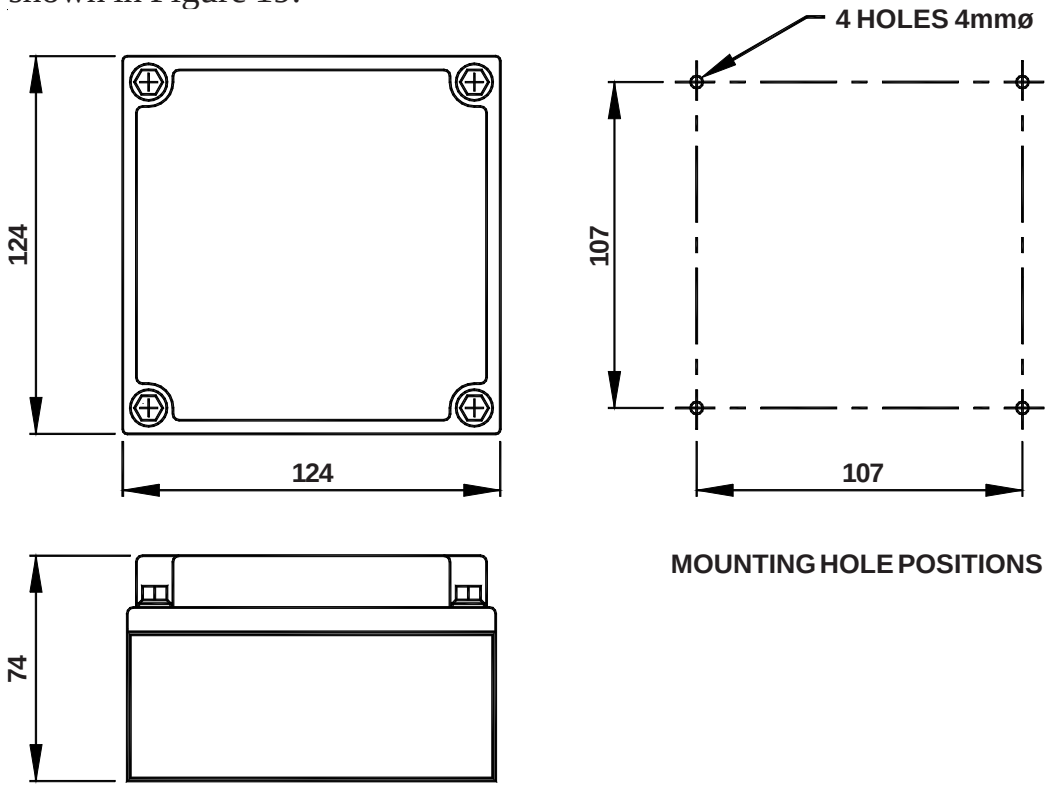


Figure 19 - Dimensions of PSSU/3 and PSSU/4 control units

It will be necessary to punch or drill cable entry holes in the enclosure. These holes should be made in the top and bottom surfaces of the enclosure. It is recommended that the printed circuit board (PCB) assembly is removed whilst these holes are made. Ensure that the PCB assembly is refitted in its original orientation.

For sensors with two 2-core cables six holes will be required. For a sensor with a single lead five holes will be required. See Figure 20 for hole positions. One hole should be used for (each of) the sensor cable(s), one for the mains supply cable, one for each of the safety output cables, one for the reset input cable and one for the monitor output cable. The holes should be 20mm diameter to accept PG13.5 cable glands. Six cable glands are supplied with the unit which will accept cables of 5 - 9 millimetre diameter. If other cable glands are used they must provide sealing to at least IP54 according to IEC529.

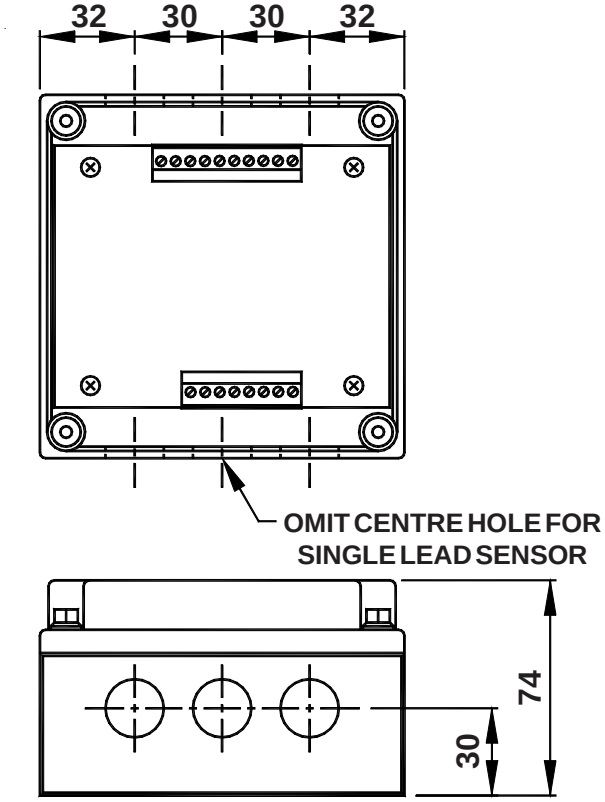


Figure 20 - Cable entry hole positions

The exact cabling requirements are at the discretion of the installer and depend on the siting of the various control system elements and whether the monitor output is used. Generally it is recommended that high voltage cables are routed away from low voltage cables.

3.3.1.3 RESET INPUT DEVICE

A momentary action, normally open switch, preferably a 22mm industrial pushbutton, should be used to provide the reset input. The switch should be housed in a suitable enclosure and should be mounted in such a position that it is safe from damage by passing traffic and such that the person operating the switch can see all of the dangerous area.

3.3.2 ELECTRICAL

3.3.2.1 GENERAL

The connections for each of the control units are shown in Figures 21, 22, 23 and 24. Crimped ferrules should be fitted on all stranded wires. It is recommended that electrical installation is performed in the order described below.

3.3.2.2 SENSOR CONNECTION

Connect the sensor cables to the control unit taking particular care that there are no stray strands which could cause a short between adjacent terminals.

3.3.2.3 POWER CONNECTION

Connect mains power to the control unit. For ac operation on the PSSU/1 and the PSSU/3 units links will need to be fitted as shown in Figures 21 and 23 to select the required voltage.

SENSOR TYPE	SENSOR CONNECTION			
	A	B	C	D
Tapeswitch Safety Mat (single lead 4 wire)	Brown or Black	Green or Red	Yellow	White
Tapeswitch Safety Mat (dual lead 4 wire)	Brown 1 or Black 1	White 1	Brown 2 or Black 2	White 2

Table 1

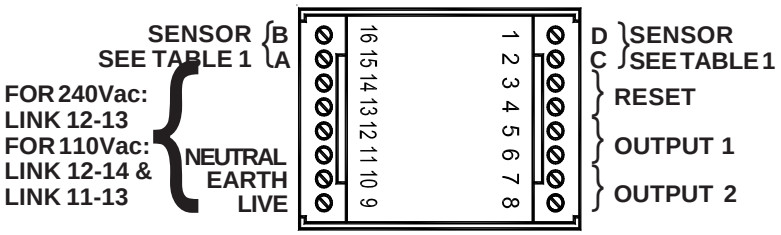


Figure 21 - PSSU/1 connection details

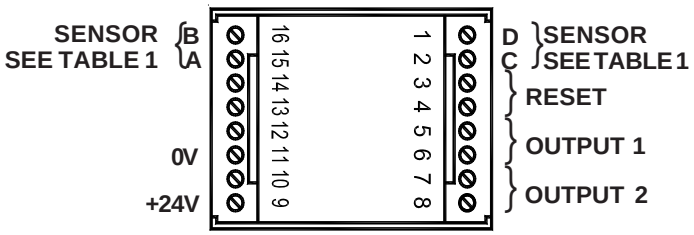


Figure 22 - PSSU/2 connection details

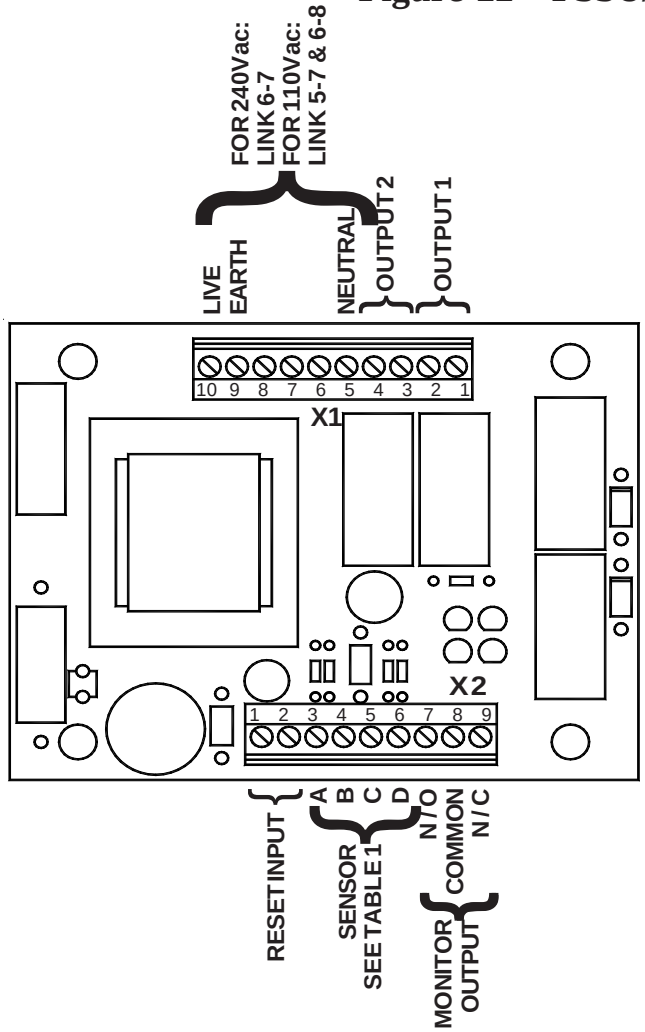


Figure 23 - PSSU/3 connection details

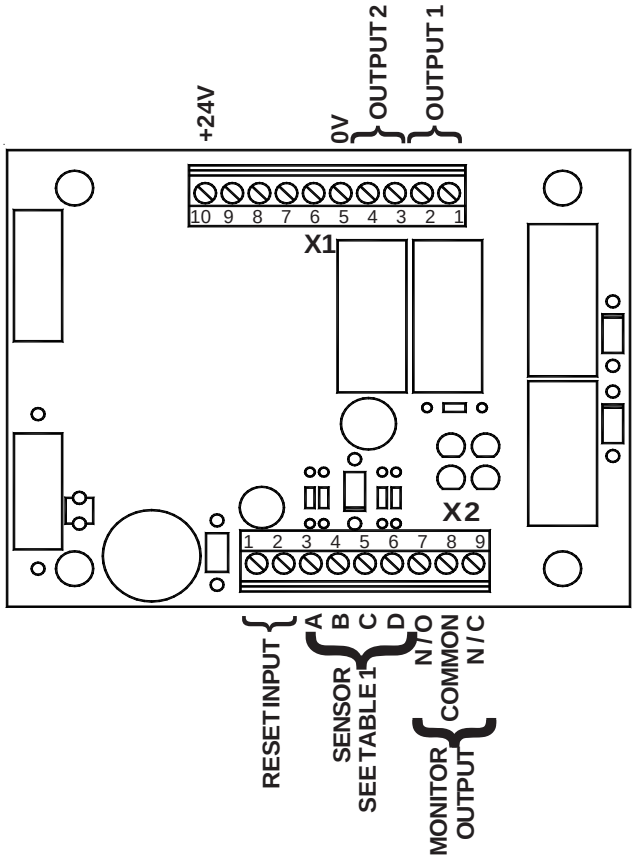


Figure 24 - PSSU/4 connection details

3.3.2.4 RESET INPUT CONNECTION

Connect the reset input to the control unit. If the machine has two MPCE's, a pair of normally closed auxiliary contacts from each MPCE can be connected in series with the reset input as shown in Figure 25. This provides cross-monitoring of the MPCE's such that if they are in disparity due to a fault, reset will be prevented until the fault is rectified.

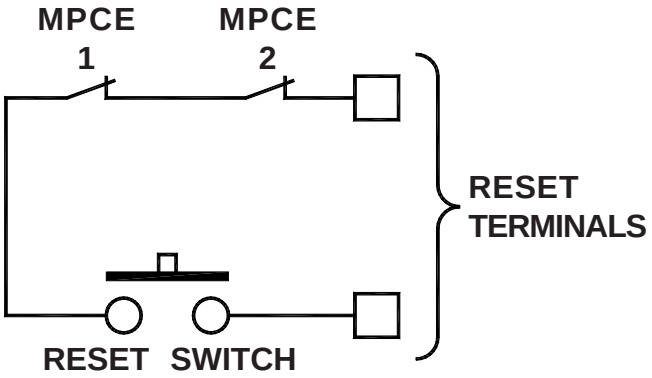


Figure 25 - Cross-monitoring of MPCE's

The reset input can also be used to provide a test input. This is often used in higher risk applications where the actuation of the safety device is simulated every machine cycle to reveal faults in the machine interface. This test input can be provided by connecting a normally open contact in parallel with the reset switch as shown in Figure 26.

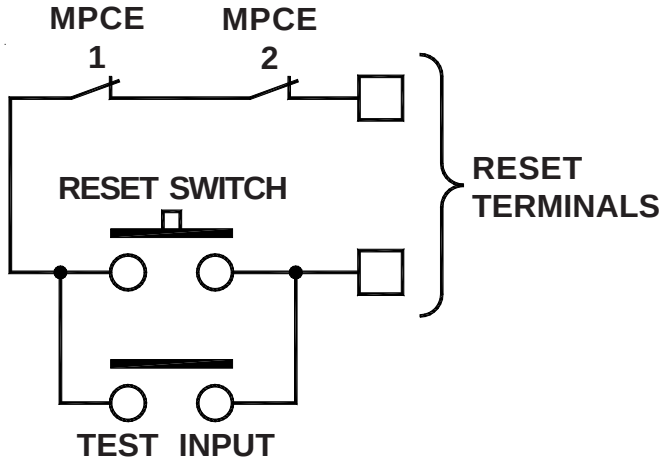


Figure 26 - Connection of test input

3.3.2.5 SAFETY OUTPUT CONNECTION

3.3.2.5.1 SAFETY OUTPUT CONTACTS

Two normally open safety outputs are provided. In low to medium risk applications the machine is normally provided with a single MPCE. In such cases both safety outputs should be connected in series with the MPCE coil as shown in Figure 27.

If the machine is fitted with two MPCE's one safety output should be connected in series with each MPCE coil as shown in Figures 28 and 29.

3.3.2.5.2 ARC SUPPRESSION

To protect the contacts of the safety output relays from the effects of switching inductive loads, arc suppressors are supplied with the control units which should be fitted in parallel with the MPCE coils as shown in Figures 27, 28 and 29. Arc suppressors must not be fitted across the safety relay contacts.

3.3.2.5.3 SAFETY FUSES

To protect against the possibility of both safety outputs welding in, due to an overcurrent fault in the machine circuit, 2A fuses should be fitted in series with the MPCE coils as shown in Figures 27, 28 and 29. This limits the current through the safety output contacts to well below that which could cause the contacts to weld.

3.3.2.6 MONITOR OUTPUT (PSSU/3 & PSSU/4)

The monitor output is a volt-free changeover relay output. The monitor relay follows the output relays, i.e when the output relays are energised, the monitor relay is energised. The monitor output can be used as an input to a machine control device such as a programmable logic controller (PLC) to signal that the sensor has been actuated.

NOTE: The monitor output is not a safety output and must not be used in the machine stop circuit.

3.4 INITIAL CHECKING

The system can be checked at this point as follows:

(a) Check that the sensor is clear.

(b) Apply power to the control unit. DO NOT APPLY POWER TO THE MPCE'S. The POWER ON and SENSOR CLEAR indicators should be lit, the RESET ON and OUTPUT ON indicators should be off.

(c) Press and hold the reset button. The RESET ON indicator should illuminate.

(d) Release the reset button. The RESET ON indicator should go off and the OUTPUT ON indicator should illuminate.

(e) Actuate the sensor. The SENSOR CLEAR and the OUTPUT ON indicators should go off.

If the system operates as described above the installation can be completed. Before putting the machine into use the complete system should be commissioned by qualified personnel and as a minimum the commissioning checks described in section 4.2 of this manual should be performed.

If the safety system does not operate as described above refer to section 5.3.1 of this manual for fault finding procedure. When the fault has been rectified return to this section and complete the preliminary check again.

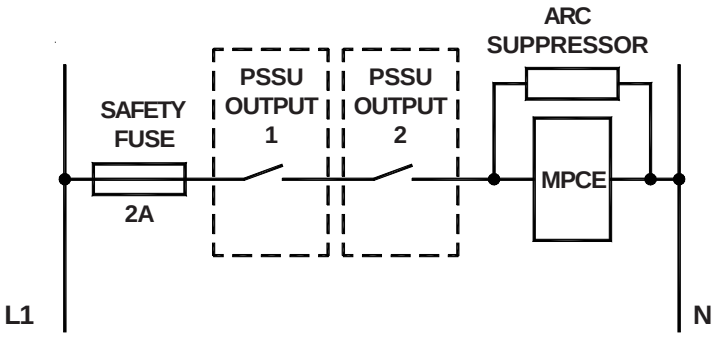


Figure 27 - Connection of the safety outputs to the MPCE's where the connecting cables are run within an IP54 enclosure. A single 4-core cable can be used.

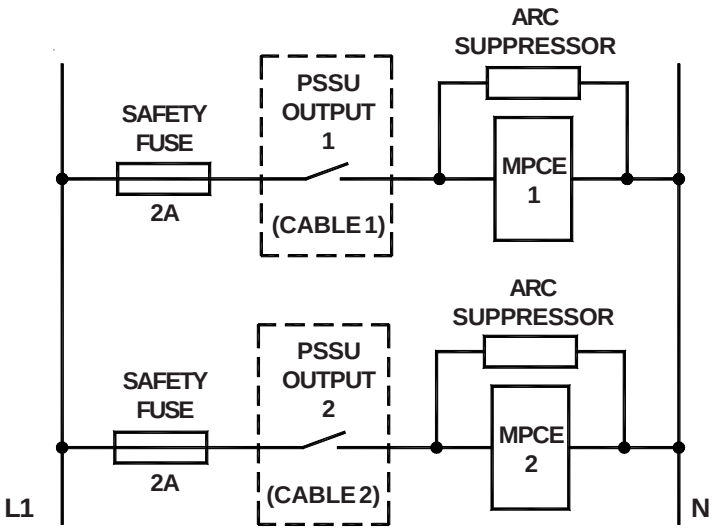


Figure 28 - Connection of the safety outputs to the MPCE's where the connecting cables are run outside an IP54 enclosure. Two 2-core cables should be used and should be protected against mechanical damage.

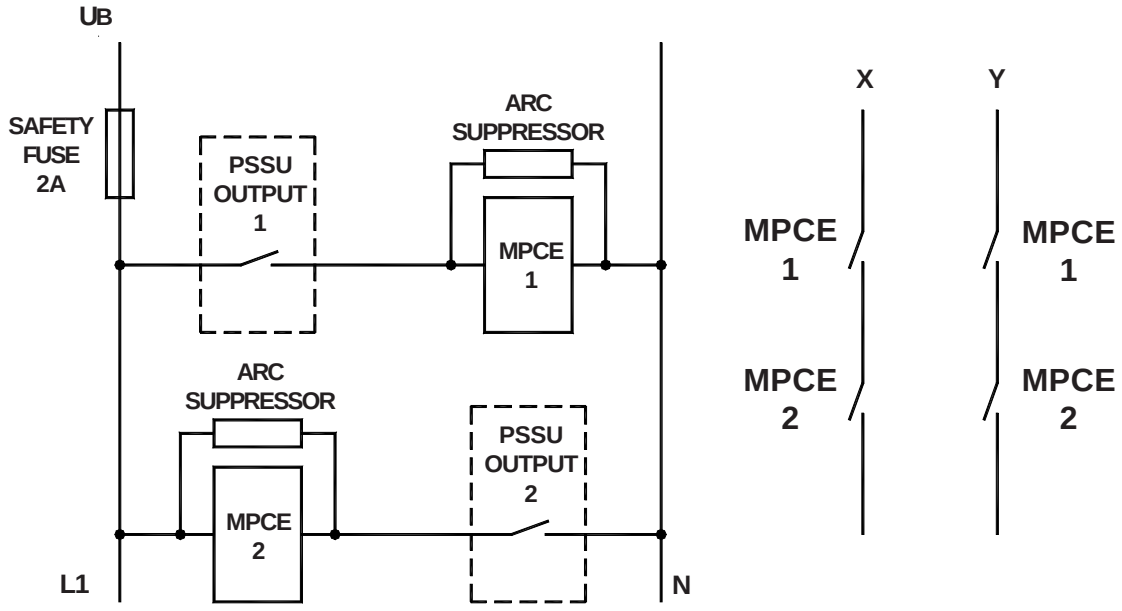


Figure 29 - Connection of the safety outputs using the principle of opposite coils. A single 4-core cable can be used. The MPCE's must have force guided contacts and their pull-in voltage should be greater than ½UB. Redundant connections X-Y should be made to the MPCE's.

4. PERIODIC CHECKING

4.1 GENERAL

The following sections describe the periodic checks to be performed on a machine fitted with a Tapeswitch safety mat system. If the machine is fitted with additional safety devices the periodic checks prescribed by the manufacturer of these devices should be incorporated into the periodic checking regime described below.

If the machine fails any of the prescribed checks the machine must be isolated and must not be used until the fault has been identified and rectified.

4.2 COMMISSIONING CHECKS

The commissioning checks should be carried out by persons who are competent and who have access to all the information supplied with the machine and its safety equipment. The results of the examination should be recorded and copies of this record should be kept by the user and the employer of the person performing the examination.

The person carrying out the examination should, as a minimum, perform the following checks:

(a) Check that the Tapeswitch safety mat system is suitable for use in the application in question using the guidance provided in section 1.4 of this manual. In particular:

(i) Check that the machine control system meets the general requirements of section 1.4.2.1 of this manual.

(ii) Check that the level of safety integrity provided by the safety mat system is suitable for the level of risk presented by the machine as described in section 1.4.2.2 of this manual.

(iii) Check that the environment is suitable for the use of the device taking into account the factors described in section 1.4.2.3 of this manual.

(b) Check that the dimensions and position of the sensor(s) are correct taking into account the operating mode as described in section 1.6.2 of this manual. For this purpose it will be necessary to check the overall system response time using a device designed for this purpose.

(c) Check that adequate measures have been taken to prevent access to the dangerous parts of the machine from any direction not covered by the sensor(s).

(d) Examine the machine controls and connections to the Tapeswitch safety mat system to ensure that the requirements described in this manual and in the machine manual have been met.

(e) Check that the sensor(s) are fixed in position and that no trip hazards are present within the dangerous area.

(f) Except where the device is used solely as a trip device, check that it is not possible for a person to stand in the dangerous area without actuating the sensor(s).

(g) Check that it is not possible for the dangerous parts of the machine to be set in motion while the sensor is actuated.

(h) Check that actuation of the sensor during a dangerous phase of operation of the machine results in the dangerous parts being arrested, or where appropriate, assuming an otherwise safe condition, before any part of a person could reach them.

(i) Check that, after the machine has been stopped by the actuation of the safety mat system, it is not possible for the dangerous parts to be set in motion until the sensor has been cleared, the reset button has been operated and released, and the machine start control has been re-operated.

(j) Check that the removal of power from the safety mat system prevents further operation of the machine. It should not be possible for the dangerous parts of the machine to set in motion until power has been restored, the reset button has been actuated and released, and the machine start control has been actuated.

(k) Check that the sensor(s) operate over the whole active area by walking, 'heel to toe', over the whole area in two directions, as shown in Figure 30. Actuation can be checked by observing the SENSOR CLEAR indicator which is lit when the sensor is clear and off when the sensor is actuated.

(l) Examine the stopping performance monitor (if fitted) to ensure that it is fitted and functioning correctly. Ensure that the means by which the the stopping performance can be assessed by the operator is indicating correctly.

(m) Test the muting arrangements (if fitted). Ensure that the muting is only possible during non-dangerous operation and ensure that the safety level of the muting device is at or above that of the safety mat but never below.

(n) Examine brakes and clutches (if fitted) as recommended.

NOTE: No stopping performance monitor or muting facilities are provided with the Tapeswitch safety mat system and there is no means provided for the connection of such devices to the system. These devices may however have been provided elsewhere in the machine control system.

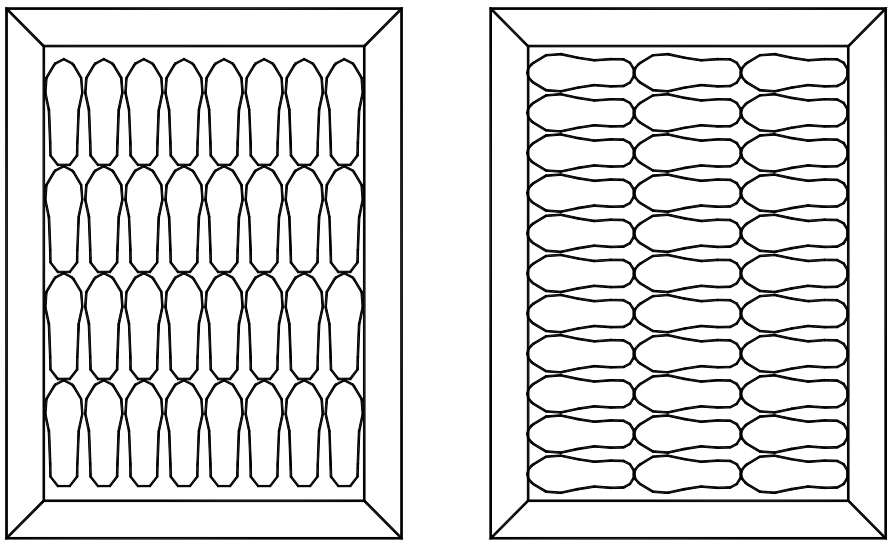


Figure 30 - Checking operation of sensor

4.3 SIX MONTHLY CHECKS

These examinations should be carried out by competent persons. The results should be recorded and a copy kept by the user.

The person should perform all the checks detailed in section 4.2. In addition the person should:

(a) Examine and test the machine primary control element(s) to ensure that they are functioning correctly and are not in need of maintenance or replacement.

(b) Inspect the machine to ensure that there are no mechanical or structural aspects which could prevent the machine from stopping or assuming an otherwise safe condition when called upon to do so.

(c) Check that no modifications have been made to the machine control system, the safety mat system or the interface between them, which could adversely affect the system and that any suitable modifications have been correctly performed and suitably recorded.

4.4 DAILY/SETTING CHECKS

The following tests should be carried out daily and after setting by a designated person appointed by the machine user. The results should be recorded and a copy should be kept on or near the machine. Specific statutory requirements may apply to certain types of machine.

The designated person should:

(a) Inspect the top surface of the mat sensor(s) for mechanical damage to ensure that the top surface has not been penetrated or chemically damaged.

(b) Check the operation of the sensor in several locations by operating the reset and stepping on the sensor. Check at different locations each day such that the entire active area of the mat is periodically checked.

(c) Check that access to the dangerous parts of the machine is not possible from any direction not covered by the sensor.

(d) Check that it is not possible for a person to stand in the dangerous area without actuating the sensor.

(e) Check that when the muting facility (if fitted) is operative the moving parts are no longer dangerous.

(f) Check that the stopping performance monitor (if fitted) is in use and is set up and functioning correctly.

(g) Check that all electrical enclosures are closed and locked and that any keys have been removed for retention by a designated person.

(h) Check for signs of damage to cables and connections.

5. OPERATION, MAINTENANCE AND SERVICING

5.1 OPERATION

5.1.1 GENERAL

Operation of the system is straightforward. The only control device associated with the system is the reset button which must be actuated when the system is powered up and after each actuation of the mat.

5.1.2 SENSOR SURFACE LOADING

Daily work on the mat by one or several persons will not lead to any deterioration of the sensor. In addition, the sensors can withstand heavy loads from the wheels of vehicles provided that these wheels have pneumatic tyres with a diameter of 300mm or more. The maximum allowed wheel load for CKP/S1 type sensors is 1.5 tonnes although for these loads damage may occur if the floor is not flat.

NOTE: THE VEHICLE MUST NOT BE STEERED WHILST ON THE SENSOR. THE VEHICLE SHOULD BE DRIVEN STRAIGHT ON AND STRAIGHT OFF.

Heavy or heavily laden vehicles with small wheels or with wheels made of hard material must not be driven over the sensor(s). Where there is a temporary need to drive such a vehicle onto or over the mat a temporary protecting surface of wood or metal should be placed on top of the sensor.

NOTE: WHILST ANY TEMPORARY PROTECTIVE SURFACE IS PLACED ON THE SENSOR THE MACHINE MUST BE SWITCHED OFF. THE PROTECTIVE SURFACE MUST BE REMOVED BEFORE THE MACHINE IS USED.

5.2 MAINTENANCE

5.2.1 SENOSRS

The sensors do not need any maintenance, however the life of the sensor will be considerably increased if a basic cleaning routine is observed. NOTE: The requirements of this section are in addition to those required in the periodic checking regime described in section 4.

The surface of the mat should be cleaned daily. Dust and swarf should be swept off the mat.Grease and oil spillages can cause the surface to be made slippery and should be removed immediately or covered with sawdust and removed at the next daily cleaning. Mineral oils can be removed from the mat by using a cold de-greasing compound and rinsing with water. No solvents of any kind should be used as a cleaning agent.

Sharp objects such as sheet metal offcuts, should be removed from the mat immediately.

The frequency of cleaning depends on the nature of the environment. In relatively clean environments where water or other fluids rarely come into contact with the sensors monthly cleaning is sufficient. In dirtier environments weekly cleaning may be necessary.

5.2.2 CONTROL UNITS

The control units require no maintenance. Provided that the system has been installed in accordance with this manual, and is operated within the performance parameters described herein, the periodic examination in section 4 and the self-monitoring features of these devices are sufficient to ensure their safe operation.

5.3 SERVICING

WARNING

SERVICING OF SAFETY EQUIPMENT SHOULD ONLY BE CARRIED OUT BY QUALIFIED PERSONNEL. SERVICING INVOLVES THE EXPOSURE OF TERMINALS AND DEVICES CARRYING POTENTIALLY LETHAL VOLTAGES. ONLY THOSE PERSONS WITH THE APPROPRIATE TRAINING AND EXPERIENCE SHOULD UNDERTAKE THIS WORK. IF IN ANY DOUBT CALL TAPESWITCH OR YOUR TAPESWITCH DISTRIBUTOR.

IMPORTANT

AFTER ANY PART OF THE SYSTEM HAS BEEN REPLACED THE INSTALLATION SHOULD BE CONSIDERED AS NEW AND AS SUCH SHOULD BE COMMISSIONED IN ACCORDANCE WITH SECTION 4 OF THIS MANUAL.

5.3.1 FAULT FINDING

Faults in the system can be diagnosed by observing the control unit indicators. The function of these indicators is described below.

The RESET ON indicator is lit whenever the reset button is pressed. If this indicator is permanently lit there is a short circuit fault on the reset input. If this indicator does not illuminate when the reset button is pressed and the system will not reset, there is an open circuit fault on the reset input. If this indicator does not illuminate when the reset button is pressed but the system does reset, then the indicator has failed.

The POWER ON indicator is lit when power is applied to the unit. If the system power is on and this LED is not lit check fuse F1. If F1 is intact there is a fault in the power supply circuit of the control unit. If the fuse has blown check the system for short circuit faults and then replace the fuse.
The fuse is a 20 x 5mm 1A anti-surge type.

The SENSOR CLEAR indicator is lit when the sensor is clear, and goes off when the sensor is actuated. If this indicator is not lit when the sensor is clear there is an open or short circuit fault either at the sensor connections to the control unit, in the sensor cabling or in the sensor itself. Check in this order.

The OUTPUT ON indicator is lit when the output relays are energised i.e. when the machine is enabled. If the OUTPUT ON indicator does not illuminate when the POWER ON and the SENSOR CLEAR indicators are lit, and after a successful reset (i.e. the reset button has been pressed and released and the RESET ON indicator has been lit and gone off), there is a fault in one of the output relays.

5.3.2 SENSOR REPAIR / REPLACEMENT

It is not possible for the user to repair malfunctioning or damaged sensors. It is sometimes possible for repairs to be made by Tapeswitch or your Tapeswitch distributor. Consult your Tapeswitch distributor in the first instance for an assessment of the feasibility of a repair and the procedure for return of the defective sensor.

When ordering a replacement sensor use the part number shown on the mat label or use the full order code as as described in section 1.6 of this manual.

5.3.3 CONTROL UNIT REPAIR / REPLACEMENT

In the case of control units type PSSU/1 and PSSU/2 there are no user serviceable parts within the device. The complete device must be returned for repair or replacement.

In the case of control unit types PSSU/3 and PSSU/4 it is possible to replace just the printed circuit board assembly. Order part number 232085 for PSSU/3 and part number 232086 for PSSU/4, stating the serial number of the control unit.

6. TECHNICAL SPECIFICATION

6.1 SYSTEM

Safety Requirement Grade		2 (DIN V 31006-1, see note 3.3 with regard to the sensor)
Power Consumption		6VA
Response Time		30ms (DIN 31006-1)
Number of Operations		3 million typical (tested by BG for 1 million total over 5 places)
Actuating / Test Force		< 300N with an 80mm diameter test piece
Temperature Range	Operating	0...50ºC
	Storage	- 20...70ºC
Reset Function		Provided as Standard

6.2 SENSORS

Actuating Force	11mm diameter test piece	300N Maximum
	40mm diameter test piece	150N Maximum
	80mm diameter test piece	300N Maximum
	200mm diameter test piece	600N Maximum
Protection Rating		IP65
Inactive Area		30mm wide around outer edge of single sensor or combination of sensors
Operating Voltage		24V d.c.
Weight (approx.)		16Kg / m²
Static Load		75Kg / cm²
Vehicle Traffic		See section 5.1.2
Top Surface Material		Koroseal

6.3 CONTROL UNITS

Type of Unit		PSSU/1	PSSU/2	PSSU/3	PSSU/4
Supply Voltage (+10%, -15%)		110/240Va.c. 50/60Hz	24Vd.c.	110/240Va.c. 50/60Hz	24Vd.c.
Safety Output Devices	Device Type	Safety Relay with Force Operated Contacts			
	Contact Type / Quantity	2 x Normally Open, Voltage Free			
	Contact Rating a.c.	2A @ 240V			
	Contact Rating d.c.	2A @ 24V, 0.75A @ 50V, Resistive Load			
		1A @ 24V, 0.35A @ 50V, Inductive Load			
	Switching Frequency	5Hz Maximum			
Monitor Output Device	Device Type	Not Fitted		Standard Relay	
	Contact Type / Quantity			1 x Changeover	
	Contact Rating			5A @ 240V a.c.	
Enclosure	Protection Rating	IP20		IP67	
	Terminal Capacity	2.5mm²			
	Material	Polycarbonate			

6.4 MATERIAL SPECIFICATION

The material used for the outer surfaces of CKP/S1 sensors is Koroseal. Koroseal is a PVC based, heavy duty matting material which has been specially formulated for use in industrial environments. The following specifications are those of the manufacturer and have not been verified by BG.

6.4.1 MECHANICAL

CHARACTERISTIC	PERFORMANCE	TEST METHOD
Tensile Strength	1200lbs / in²	ASTM-D-412
Elongation	150% minimum	ASTM-D-412
Abrasion	0.09 grams lost maximum	Taber, 1000grams on CS-17 wheel for 1000 revolutions
Flammability	Self-extinguishing - A	Motor Vehicle Safety Standard #302
Aging and weathering	168hrs, 10 x magnification No change observed	ASTM-D-518
Hardness	88 +/- 5 points	ASTM-D-2240

6.4.2 CHEMICAL

A = Little or no effect, **B** = Minor to moderate effect, **C** = Moderate to severe effect, **D** = Not recommended

Chemical name	Rating
Acetic Acid - concentrated	C
Acetic Acid - dilute	B
Acetone	C
Ammonium Hydroxide	A
Amyl Acetate	C
Benzene	B
Butyl Alcohol	B
Carbon Tetrachloride	C
Chloroform	C
Creosote	C
Cresol	C
Ethyl Acetate	C
Ethyl Alcohol	B
Ethyl Ether	B
Formaldehyde	B
Gasoline	B
Hydrochloric Acid - concentrated	B
Hydrofluoric Acid - concentrated	B
Iodine	A
Methyl Alcohol	B
Methyl Ethyl Ketone	D
Mineral Oil	B
Nitric Acid - concentrated	C
Nitric Acid - dilute	B
Phenol	B
Silver Nitrate	A
Sodium Hydroxide (up to 30%)	A
Sulphuric Acid - concentrated	B
Sulphuric Acid - dilute	A
Trichlorethylene	B
Xylene	B

7. CONTACTS

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