


D9M Pressure Sensitive Safety Mat System Operation Manual


Produced July 2003


Notice:

OMRON products are manufactured for use according to proper procedures by a qualified operator and only for the purposes described in this manual.

The following conventions are used to indicate and classify precautions in this manual. Always heed the information provided with them. Failure to heed precautions can result in injury to people or damage to property.

 **DANGER** Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

 **WARNING** Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

 **Caution** Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury, or property damage.

OMRON Product References

All OMRON products are capitalized in this manual. The word “Unit” is also capitalized when it refers to an OMRON product, regardless of whether or not it appears in the proper name of the product.

Visual Aids

The following headings appear in the left column of the manual to help you locate different types of information.

Note Indicates information of particular interest for efficient and convenient operation of the product.

1,2,3... 1. Indicates lists of one sort or another, such as procedures, checklists, etc.

Precaution Indicates precautionary information that should be heeded in using the D9M.

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About this Manual:

The D9M pressure sensitive mat system is designed for use as a safety product in an industrial environment by professional personnel. It provides protection against risks which can be eliminated by the isolation of electrical power when an operator is in the vicinity of the hazard. This manual covers the installation and use of all parts of the D9M system. All installation procedures should be carried out by suitably trained and qualified personnel and should be in accordance with statutory requirements for safety.

READ THIS MANUAL IN FULL BEFORE INSTALLATION.

AFTER INSTALLATION THIS MANUAL SHOULD BE RETAINED IN A SAFE AND ACCESSIBLE PLACE.

For further assistance please contact OMRON.

Precautions provides general precautions for using the D9M, and related devices.

Section 1 describes the storage and handling of the D9M pressure sensitive mat system.

Section 2 provides an overview of the system, its uses, and rib patterns.

Section 3 describes the uses of the system and details the necessary points to consider in each application.

Section 4 lists the specifications and dimensions of the system.

Section 5 provides the information necessary to design the system.

Section 6 covers the steps involved in installing and wiring the system, and confirming its functional operation.

Section 7 describes the precautions to be taken before putting the system into service.

Section 8 provides instructions on cleaning, inspecting, disposing, troubleshooting, and repairing the system.



WARNING Failure to read and understand the information provided in this manual may result in personal injury or death, damage to the product, or product failure. Please read each section in its entirety and be sure you understand the information provided in the section and related sections before attempting any of the procedures or operations given.

SECTION 1

Storage and Handling

This section describes the storage and handling of the D9M pressure sensitive mat system.

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1-1 Storage

The D9M control unit and mat sensors should be stored within the temperature range of -40°C to $+70^{\circ}\text{C}$. The mat sensors should be stored vertically.

1-2 Handling & Transport

The D9M control unit and mat sensors should be transported within the temperature range of -40°C to $+70^{\circ}\text{C}$. The original packaging or something similar should be used, together with stiffening if necessary, to give protection from damage and flexing. Always unpack carefully and avoid damage by knives, etc.

When sensor mats are being moved into position, never pull or lift the sensors by their connecting wires.

For the larger sensor mats, two people are required for safe lifting and to prevent risk of damage to the sensor mats from excessive flexing.

SECTION 2

System Description

This section provides an overview of the system, its uses, and rib patterns.

The D9M system comprises one or more interconnected pressure sensitive mats and a control unit. There are no 'dead zones' within the detection zone. Individual sensor mat sections are available in standard rectangular sizes and also in specially cut shapes up to the size of the largest standard mat. All sensor mats have the same construction and operating principle.

Each mat has two conductive plates which are held apart by non-conductive compressible separators. The mats operate at 24 V DC and are connected together in series to form a floor level sensing system for hazard areas around machinery. The circuit through the mats is monitored by the D9M control unit which, when the area is clear, provides a signal to the machine control circuit. When any mat is stepped on, the conductive plates touch and the resistance in the circuit drops. This is monitored by the control unit, which shuts the machine down. Any single electrical fault in the mat, wiring or control unit will be detected and the control unit outputs will go to a safe (OFF) state. The molded vinyl sensor mats are sealed to IP 67.

Two operating modes are available: manual reset and auto reset.

In manual reset mode the output 'ON' signal can only be restored after the actuating force has been removed and after a reset. The manual reset is achieved by pushing and releasing the lid mounted control unit reset button or a remote mounted button. At power-on or following the loss and subsequent restoration of power, the outputs will be 'OFF' until a reset signal is received even if the mat is not actuated.

In auto reset mode the output 'ON' signal is achieved solely by removal of the actuating force. For both modes, the safety contacts will always be 'OFF' (open) after the mat is actuated.

Mode selection is covered in more detail in *SECTION 5*.

Individual sensor mats connect to each other and to the control unit via 4 wires. The control unit has cross monitored safety relays and it is possible to configure the unit so that an external contactor fault will be detected.

Compliance with the requirements of EN 954-1 category 3 is achieved for the control unit regarding electrical faults and can be met for the associated part of the machine control system. Compliance with the requirements of EN 954-1 category 1 is achieved for the mat sensors.

SECTION 5 deals with interfacing in detail. The operating principle of the mat is shown in Figure 1.

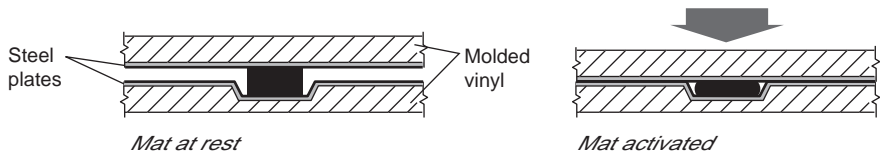


Figure 1

When the mat is activated the non conductive compressible separators (shown black) compress into their recess allowing the two plates to make contact, giving all-over sensitivity.

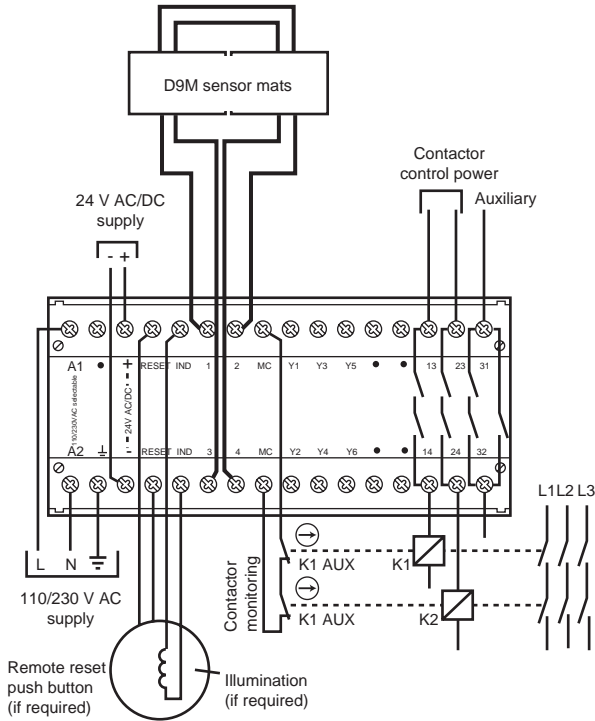
The D9M is intended for the detection of adult persons with a weight of 35 kg or more. It is suitable for the detection of adults using walking aids (walking sticks or frames).

The D9M is not suitable for the detection of children.

The D9M must not be used with any additional covering on the mat.

The vinyl outer surface of the mat is completely sealed to resist the ingress of liquids. It will resist bleaches, acids, salts and most industrial chemicals. Refer to SECTION 5-3-1 for detailed guidance on chemical resistance.

The system operates at 24 V DC with restricted fault current. Damage to the mats or interconnecting wiring will not therefore generate any electrical shock hazard in normal circumstances.



**Figure 2 Basic D9M system and connections (shown with two contactors).
D9M-CD1**

The D9M mat sensors have two different rib patterns as shown. Either pattern may be used as the upper surface. The checker pattern gives the best grip in all directions. The straight rib pattern is easier to hose/wash down and is more suitable for use in dirty or hygiene-sensitive applications.

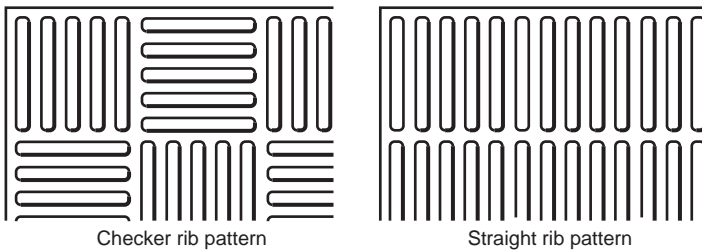


Figure 3 Alternative rib patterns.

SECTION 3

Applications

This section describes the uses of the system and details necessary points to consider.

It is important that the type of safeguarding system is suitable for the application for which it is intended. A documented process of risk assessment for the machinery or process will reveal the identity and nature of the hazards together with other relevant information. The characteristics of the safeguarding system should then be compared with the results of the risk assessment to determine whether the risk can be reduced to an acceptable level. On some applications the combined use of more than one type of safeguarding system may be necessary to achieve an acceptable level of risk.

- The D9M is designed for the protection of personnel by sensing their presence on floor areas around machinery and other similar hazards.
- The D9M must be used only within the specification limits given and be installed strictly in accordance with the information provided in this manual.
- The D9M alone does not provide protection against hazards arising from the ejection of materials, gases, and radiation. For these applications additional protective measures such as physical guards may be required.
- The D9M is not intended for use as a perimeter-only guard.
- The D9M is not intended for use as a machine initiation or re-initiation device. The machine control circuit must be configured such that closing of the D9M output contacts enables the starting circuit of the machine but does not directly cause the machine to start up. The starting or restarting of the machine should only be possible by a separate and deliberate action at the designated machine controls.
- The D9M is not suitable for use in explosive atmospheres.

Use as a combined trip and presence sensing system

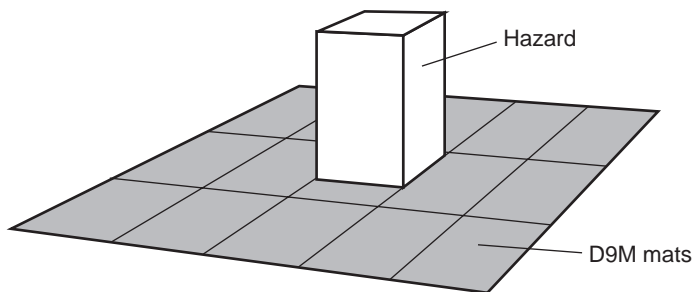


Figure 4 Use as a combined trip and presence sensing system.

The D9M allows a clear view of the process and unhindered access for operators and some types of vehicles.

- There must be sufficient space to allow the minimum distance from the hazard to the accessible mat perimeter to be in accordance with safety distance calculations given in *SECTION 5*.
- The entire floor area between the defined perimeter and the hazard must be covered by mat sensors so that it is not possible to approach or be in the vicinity of the hazard without actuating the D9M system.

Use as a presence sensing system within a guarded perimeter

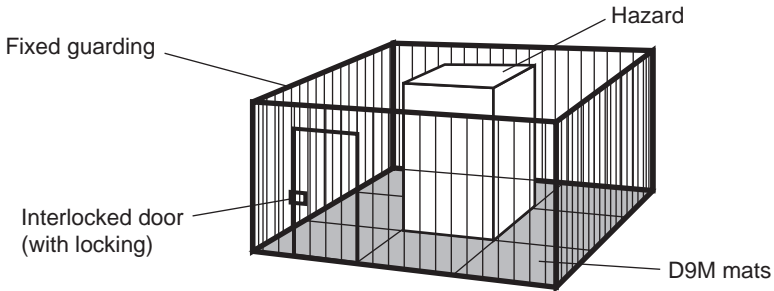


Figure 5 Use as a presence sensing system within a guarded perimeter.

The D9M provides presence sensing to prevent any possibility of the machine being started while personnel are inside the enclosed area.

- The safety distance calculations given in *SECTION 5-4-1* are not applicable when the D9M is used in this way as a secondary protective system. The perimeter guarding method should conform with all relevant requirements.
- The entire floor area between the enclosed perimeter and the hazard must be covered by mat sensors so that it is not possible for personnel to be in the enclosed area without actuating the D9M system.

SECTION 4

Specifications

This section lists the specifications and dimensions of the system.

Control Unit	D9M-CD1
Conformity	EN 1760-1, EN 60204-1, EN 954-1: Category 3, UL 508
Response time (mat pressed-safety contacts open)	35 ms
Environmental protection	Enclosure-IP40 DIN0470 Terminals-IP20 DIN0470
Impulse withstand voltage	2,500 V
Contamination level	III
Min. switched current/voltage	10 mA/10 V
Power supply - user select	110/230 V AC (50-60 Hz) and 24 V AC/DC +10%–15% (110-V setting also allows use at 100 V ±10%)
Power consumption	<9 VA 6 W
Relay outputs	2 × independent volt free N/O safety contacts 1 × volt free N/C auxiliary contact NB - Aux must not be used for safety circuit Fuse externally, 5 A max. (quick acting) for AC 2.5 A max. (quick acting) for DC
Utilization category	AC - 15; 4 A/250 V AC DC - 13; 2 A/30 V DC
Outputs: remote reset/indicator	24 V DC/0.24 W
Inputs	Remote reset switch (2 × N/O)
Safety inputs	4 wire mat
Indicator LEDs	LED 1 Power Green LED 2 Auto reset mode Green LED 3 Manual reset mode Green LED 4 Machine enabled Green
Internal controls	AC voltage selector, auto/manual reset selector
Internal supply fuses	500 mA replaceable
Operating temperature range	-10°C to +45°C
Humidity	Up to 90% RH at +50°C
Vibration	Tested in accordance with IEC 68-2-6, frequency range 10-55 Hz, displacement 0.15 mm 10 cycles per axis, sweep rate, 1 octave per minute
MC-MC contactor monitor loop	Normally closed contactor loop

Control Unit	D9M-CD1
Maximum conductor size	2 × 1.5 mm ² stranded with sleeves stripped 8 mm, 2 × 2.5 mm ² solid conductor
Terminals	Plus/minus captive terminal screws M3.5 with self lifting connection, washer terminal boards separately removable
Installation group	C in accordance with VDE 0110
Material	Polycarbonate
Fixing details	35 mm DIN-rail
Misc.	In the manual reset mode (M), a reset button must be connected
Housing	D = 120 mm H = 73 mm W = 152 mm 32 way DIN-rail
Weight	920 g

SENSOR MAT

Sensor mat conformity:	EN 1760-1, EN 954-1: Category 1, UL 508
Minimum weight of person with assured detection:	35 kg
Maximum detection zone:	100 m ²
Maximum number of individual mats:	No limit (up to max. 100 m ²)
Maximum total length of connection wires:	200 m
Mass/m ² (sensor mats):	24 kg
Environmental protection mats:	IP67
Mechanical life:	1 × 10 ⁶ operations
Humidity:	0-100% RH
Sensor mat outer covering material:	Vinyl
Standard color:	Yellow
Operating temperature range:	-10°C to +55°C
Storage temperature range	-40°C to +70°C

The system comprising of interconnecting sensor mats and control unit meets the requirements of EN 954-1 category 3.

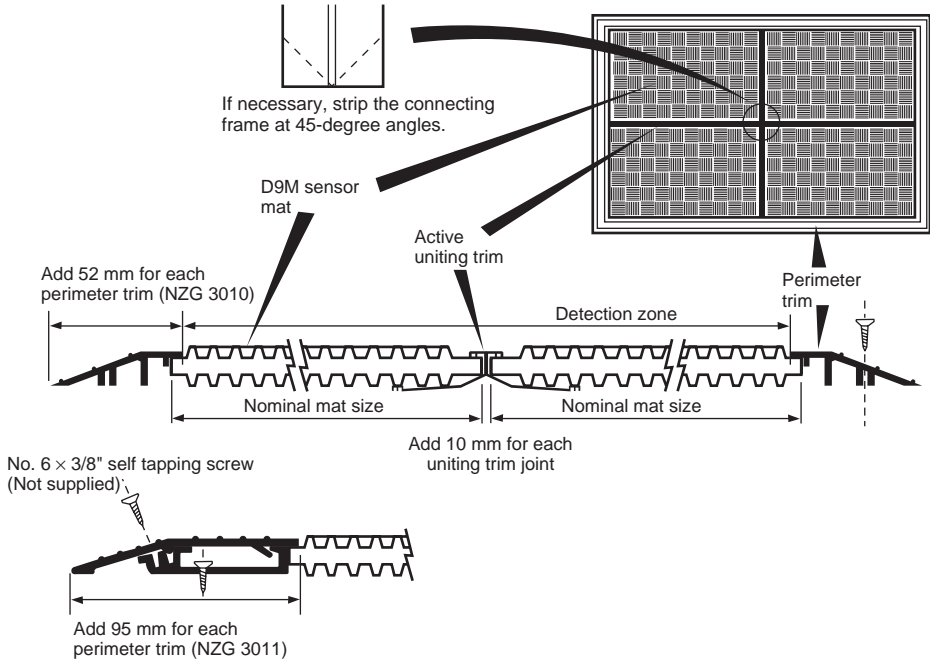


Figure 6 Details of perimeter trim and uniting trim showing detection zone.

- For guidance on machine interfacing see *SECTION 5*.
- For details of the fixing and interconnection arrangements see *SECTION 6*.

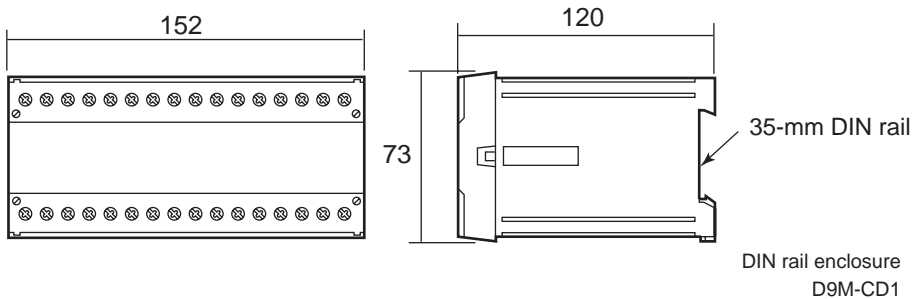


Figure 7 Dimensions (not to scale).

SECTION 5

Installation Design

This section provides the information necessary to design the system.

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This manual should be read in full before installation is commenced.

It is recommended that installations should only be designed by persons suitably competent in electrical and mechanical engineering and having experience in safety related control system design.

Many factors contribute to a safe and reliable installation. Working through the following steps will ensure that nothing is overlooked and that the installation can be planned and implemented with minimum fuss and maximum confidence. The details of the procedures which follow are based on best practice, and compliance with the EU Machinery Directive. Even if these requirements do not apply in your installation we recommend that you follow the same steps but modify the details to suit relevant statutory requirements or codes of practice (e.g. ANSI, OSHA).

5-1 Nature of Hazard

The D9M system provides protection against risks that can be eliminated by the isolation of electrical power when an operator is in the vicinity of the hazard.

Additional measures are required to deal with other hazards identified by a risk assessment (e.g. part ejection, hot surfaces, etc.). These measures may include fixed guards, interlocked guards, warning notices, etc. Contact your OMRON representative for further information if required.

Note Risk assessment is included in EN 291-1 and detailed in EN 1050.

5-2 Nature of Safeguarding

The system design must satisfy three main requirements:

- 1,2,3...**
1. The machine must be stopped if a person is in a position of being able to reach into the hazard zone.
 2. The machine must come to a stop before an approaching person can be in the position of being able to reach into the hazard zone.
 3. The system shall not be easily bypassed.

The recommended use of the D9M system gives presence sensing over the whole area where access is possible to the hazard (see the examples in *Figure 8*). Other uses of D9M, for example, solely as a perimeter access guard, or as a machine enabling device, are not recommended. If you are considering D9M for any application not covered by this manual, please contact OMRON.

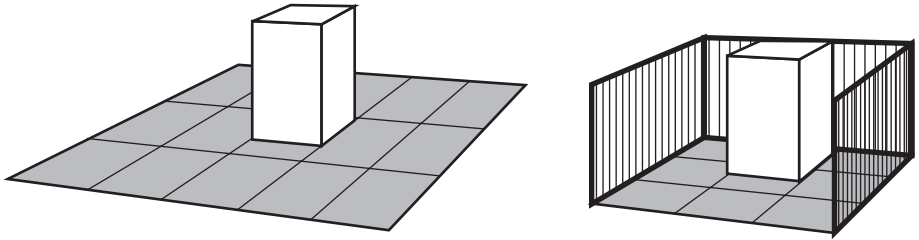


Figure 8

5-3 Environment and Operating Conditions

By reference to the specifications given in SECTION 4 and the information in this section, ensure that there are no adverse factors that could compromise the integrity of the system.

5-3-1 Chemical Resistance of Sensor Mat Vinyl Covering

Substance	Resistance of mat covering
Water	Excellent
Ethyl alcohol	Excellent
Sodium chloride	Excellent
Bleach	Excellent
Hydrochloric acid	Fair to excellent
Sulphuric acid	Fair to excellent
Nitric acid	Fair to excellent
Acetic acid	Fair
Gasoline	Fair
Trichlorethylene	Fair to poor
Benzene	Poor
Acetone	Poor

In general the covering has excellent resistance to acids, alkalis and salts.

Hot acids and alkalis, as well as concentrated and organic acids, have a deleterious effect on prolonged exposure. The covering has fair resistance to aliphatic solvents, fair to poor resistance to aromatic and chlorinated solvents and poor resistance to ketones and most esters.

Note Combinations of chemicals can have unpredictable effects.

5-3-2 Slipping/Tripping Hazards

Both D9M sensor mat patterns provide a non-slip surface under most conditions but should be kept free from large deposits of grease, soaps, or gels. If the straight rib side is uppermost, it is recommended that the ribs run across the hazard to give improved grip.

5-3-3 Wear and Damage

The mat outer surface can be damaged by impacts from sharp or heavy objects. After every such event the mat should be inspected for deformation or puncturing and replaced if necessary.

D9M mats have been designed and tested to withstand one million operations in any one spot. In use, this number of operations in any single location should not be exceeded.

Occasional heavy loads, (e.g., up to 3-ton trucks) are unlikely to damage the D9M mats but they should not be used on traffic through routes.

5-3-4 Explosive Atmospheres

The D9M is not suitable for use in explosive atmospheres.

5-3-5 E.M.C.

The D9M complies with the requirements of the European EMC Directive. Normal operation under interference conditions likely in industrial environments is assured and has been tested and certified.

Note Special measures may be required in the presence of abnormally high levels of E.M.I., e.g., near welding or induction heating equipment, near radio transmitters/transceivers, or when servo-motor or inverter noise is present.

5-3-6 Floor

The floor or mounting surface for the D9M sensor mats must be flat, smooth and rigid, i.e., show no perceptible distortion under the heaviest load anticipated. Undulations, protrusions, large gaps, or other irregularities will increase the sensitivity of the sensor mats and may result in intermittent unintended switching off (nuisance tripping).

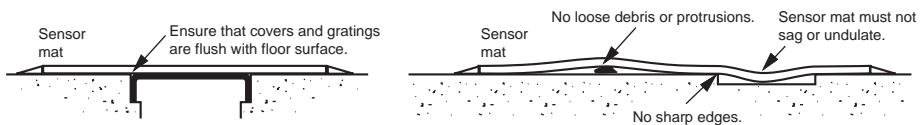


Figure 9 Floor condition for mats.

Small and regular protrusions such as checker plate pattern are acceptable. Skimmed concrete floors are ideal.

5-3-7 Control Unit Mounting (Refer to SECTION 4 Figure 7.)

The control unit MUST NOT be mounted within the detection zone. If access to the control unit is required for manual reset or routine indicator observation, it should be mounted at an accessible position outside the protection zone which provides a good view of the hazard and protection zone.

In other cases, the control unit may be mounted anywhere convenient outside the protection zone taking into account the access requirements for test and maintenance.

Note The D9M control unit is not suitable for direct exposure to high-pressure cleaning.

5-4 Mat Positioning

5-4-1 For Use as a Combined Trip and Presence Sensing Device

The positioning of the mat edges is calculated as a horizontal distance from the hazard zone. Define the hazard zone as a volume, taking into account all the possible modes of the machine and all variations in the size of the workpiece. It is essential to record the dimensions and position of the hazard zone and the assumptions used, so that the adequacy of the safeguarding can be checked.

If other safeguarding measures are used in conjunction with the D9M they may affect the requirements for the size and positioning of the mats as shown in Figure 10.

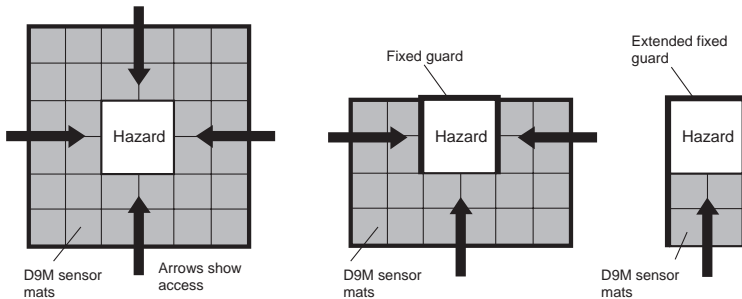


Figure 10 Note: Fixed guarding should meet the requirements of EN 953, EN 294, & EN 811.

First, ascertain the route(s) where unobstructed access to the hazard zone is required across the D9M. Take into account all the routine needs for access, such as product inspection, machine inspection and adjustment, tool changes, and clearing blockages. Consider also visual observation of the process. Take into account the space requirements of persons and ancillary equipment close to the machine during interventions.

Safety Distance Calculations

For applications using the D9M as a combined trip and presence sensing system these should be done in accordance with EN 999. The flow chart in *Figure 11* shows the essential steps.

Note If the machine is designed in conformity with an existing harmonized European “C”: type standard for that machine which gives specific formulae or minimum distances, then these should be used in preference to those given in EN 999.

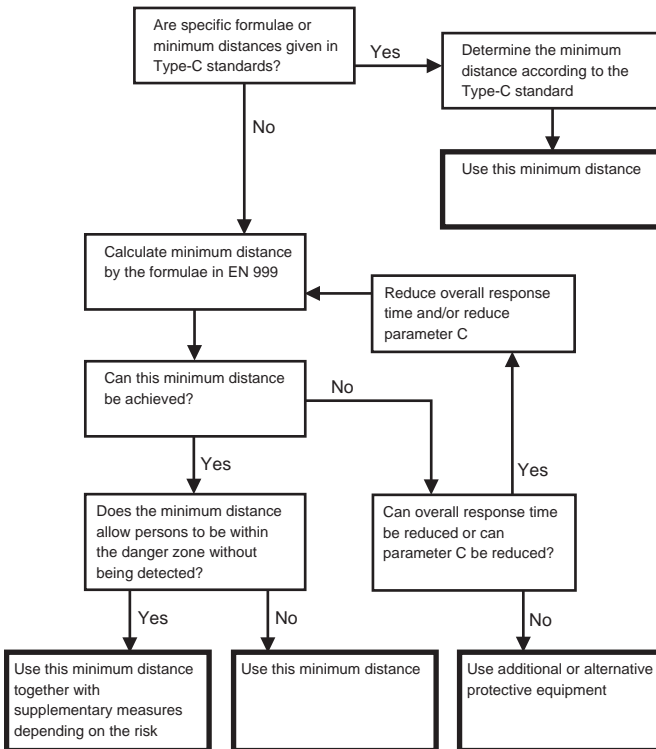


Figure 11 Flow Chart Showing Methodology

The minimum distance calculated is the minimum horizontal distance from the outer edge of the D9M sensor mat detection zone to the nearest part of the hazard.

The EN 999 formula for floor mounted safety mats is $S = (1,600 \times T) + 1,200$ mm

S is the minimum safety distance in millimeters

The factor of 1,600 is based on the standard assumption of 1,600 mm/s as the approach speed.

T is the overall stopping time in seconds

The added 1,200 mm is parameter C given in EN 999 and takes into account stride length and arm reach

The overall stopping time T is made up of two parts: $T = t_1 + t_2$

t₁ is the maximum time between actuation of the sensing function and the output signal switching devices being in the OFF state.

For the D9M, t₁ = 35 ms.

t₂ is the response time of the machine, i.e., the time required to stop the machine or remove the risks after receiving the output from the D9M.

The response time of the machine used in the calculation needs to be the worst case time. Some machines have inconsistent response times which are dependent upon the mode of operation, the nature of the workpiece and the point in the operating cycle at which stopping is initiated. An allowance should be made for wear in brakes, etc., if this can affect the response time. An allowance for further delays in the machine control system may be required in some circumstances.

Calculation example

In this example the D9M is being used with a machine whose worst case response time has been measured as 0.485 second.

Using the formula,

$$\begin{aligned} T &= T_1 + t_2 \\ &= 35 \text{ ms} = 485 \text{ ms} \\ &= 520 \text{ ms} = 0.520 \text{ s} \end{aligned}$$

$$\begin{aligned} S &= (1,600 \times 0.520) + 1,200 \text{ mm} \\ &= 832 + 1,200 \text{ mm} = 2,032 \text{ mm} \end{aligned}$$

Sensor mats will be required from 2,032 mm right up to the edge of the machine baseplate.

5-4-2 For Use as a Presence Sensing System within a Perimeter Guarded Area

If the area around the hazard is totally enclosed within a guarded perimeter, the requirements of EN 999 may not apply. In these applications the D9M system detects the presence of an operator to prevent the perimeter guarding system being reset and the machine restarted while the operator is inside the enclosure.



Figure 12 Note: Fixed guarding should meet the requirements of EN 953, EN 294, and EN 811.

A suitable perimeter guarding system would be a fixed guard with an access door fitted with an interlock switch with conditional guard unlocking (see EN 1088). A trip device, such as a safety light curtain, may also be suitable for some applications. It is important to note that the positioning of the light curtain must be calculated according to EN 999.

When using the D9M for these applications the entire enclosed floor area accessible to the operator should be covered by sensor mats.

5-5 Fixed Guards

The fixed guards should be designed so that access is not possible to the hazard zone other than via the D9M. Guard construction and positioning should be in accordance with EN 953, EN 294, and EN 811.

5-6 Good Installation Design and Measures against Bypass

It must not be possible to reach the hazard without standing on the D9M mats.

Access to the hazard zone from positions that do not involve standing on the D9M mats must be prevented. This will typically require additional angle plates and careful positioning of pipework and trunking. Good practice in this respect is illustrated in *Figure 13*.

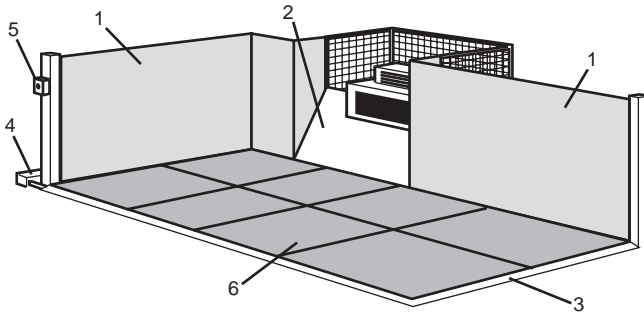


Figure 13

- 1,2,3...**
1. Fixed guards prevent access to the hazard zone in such a way that there is no access between the guard and sensors.
 2. A sloping cover plate prevents the operator from eluding the sensing area by standing on the machine base plate.
 3. The tripping hazard at the sensor edge is reduced by a ramp at the point of access. The ramp may also protect connecting cables. The D9M perimeter trim is a ramp section.
 4. Cable trunking is installed outside of the fixed guard. This prevents its misuse as access to the hazard zone.
 5. A reset button is located in a well protected location giving full visibility of the machine.
 6. Mats are properly installed.

5-7 Electrical Interfacing

The protection provided by the D9M depends on the correct interfacing between the D9M and the machine.

The safety output contacts from the D9M are arranged as two independent voltage free N/O contact pairs. The terminal positions are given in *SECTION 6-2* and ratings are given in *SECTION 4*.

The D9M control unit conforms to category 3 according to EN 954-1. In common with other safety mats and floors, category 3 performance for the sensor mat cannot be achieved for faults resulting from severe mechanical damage or long-term degradation. The sensor mats conform to category 1 according to EN 954-1.

The system comprising of interconnecting sensor mats and control unit meets the requirements of EN 954-1 category 3.

The D9M system may be used as the sole protective measure or in combination with other measures or devices (e.g., safety light curtain, system of work).

Where a harmonized European “C” standard is available for the machine type, it will contain requirements and guidance for the machine’s safety related control system. EN 954-1 also provides guidance. It is important that an adequate level of protection against foreseeable faults is provided to the appropriate category of EN 954-1 and for this reason it is recommended that a dual channel configuration with duplication and monitoring of the final switching elements (contactors) is used on all higher risk applications.

Examples of interconnections of the D9M system are given in *Figure 14* and *Figure 15*.

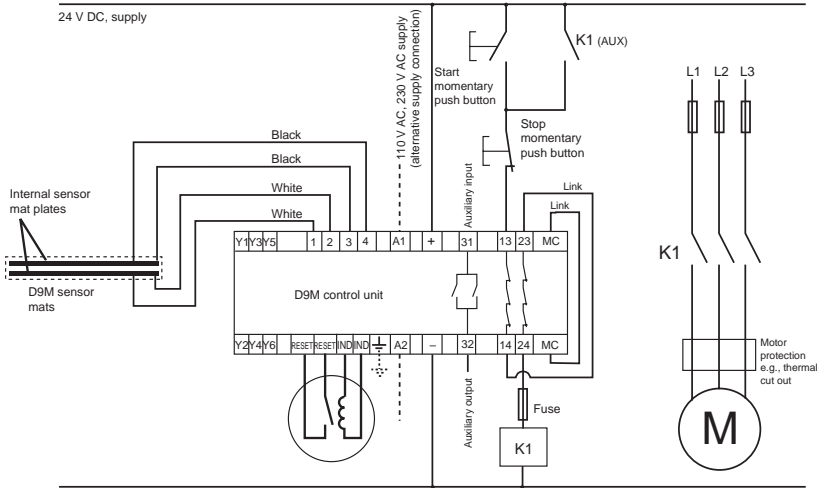


Figure 14 Example connection diagram showing application with single contactor (single channel), D9M-CD1. Circuit status - Supply power ON -No presence on sensor mat - Reset button operated (if in manual reset mode) - Machine start circuit enabled.

Note If the contactor sticks ON - the motor will not stop when the mat is stood on.

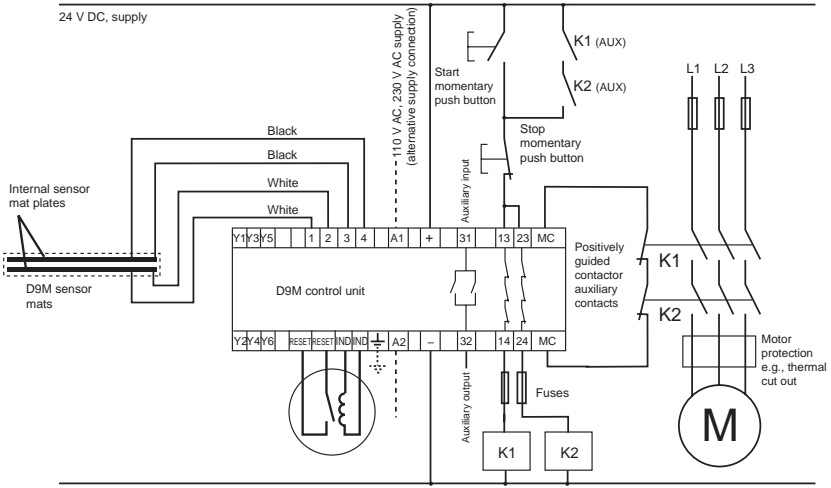


Figure 15 Example connection diagram showing application with two contactors and contactor monitoring (dual channel), D9M-CD1. Circuit status - Supply power ON - No presence on sensor mat - Reset button operated (if in manual reset mode) - Machine start circuit enabled.

Note If either of the contactors stick ON, the motor will stop when the mat is stood on and the fault will be detected.

After completion of the design of the safety related control system ensure that the response time assumed at 5-4-1 remains valid. If the value changes, it will be necessary to repeat the safety distance calculations.

Next consider the options for reset. The consequences of the reset scheme selected should be carefully considered for hazards caused by unexpected start up, etc., both under normal conditions and under fault condition. Timing diagrams are given below for both modes of the D9M.

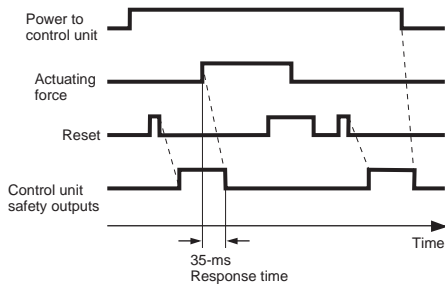


Figure 16 Manual reset mode
Relationship between actuation, reset, and output.

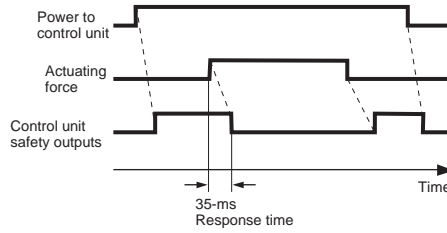


Figure 17 Auto reset mode
Relationship between actuation and output

Manual Reset Mode

The reset can be accomplished by the button on the control unit or by a remote pushbutton or by voltage free contacts within the machine safety related control system. The outputs of D9M will remain OFF until reset after the power is turned ON and may require master/slave reset circuits in complex systems where other power up interlocks (start interlocks) are present.

Auto Reset Mode

When used in the auto reset mode, the machine's control system will need a separate reset function to prevent machine start up when stepping off the mat or after a temporary power supply failure or dip.

Selecting the Power Supply

The D9M offers four possibilities for power supply and in virtually every case a suitable supply will be available from the machine. Check that the power supply parameters conform with the requirements of the D9M as given in the specifications. Where a 24-V AC or DC supply is used it must be isolated from the mains supply in accordance with international electrical safety practice (IEC 364-4-41). One pole should be grounded (negative to be grounded for DC supplies). If special arrangements have to be made, commercial units supplying 24 V DC to suit the D9M are readily available.

Auxiliary Output

This is a non-safety output provided as a status output. It is particularly useful in systems using PLC functional machine control in combination with hard wired safety circuits as a status import to the PLC. Other uses include diagnostics in protection schemes and/or driving status lamps or alarms. The safety function must not depend on this output.

Arc Suppression

Arc suppression networks or devices are recommended for all inductive loads. For safety circuits, suppressors should be fitted across the load and never across the contacts. The type and ratings of the suppressors will be determined by the supply and load characteristics. Note that suppressors can increase response time, particularly suppressor diodes across DC coils, and should be in place when measuring response times.

Contactors Monitoring

Contactors monitoring is provided via the two terminals marked MC. It should be used in all dual channel two contactor systems. If one of the contactors fails to isolate the power, the D9M control unit will lock out and prevent the re-energizing of the other contactor until the fault is rectified.

5-8 Final Sensor Mat Layout

Having considered these factors, the sensor mat layout can now be checked and finalized. Consider whether the machine response time has changed from the initial calculations.

Whenever possible, mats should be arranged with the wires at the outside edge of the detection zone. This simplifies installation and replacement if required and all wiring is protected by the perimeter trim.

5-9 Wiring

All D9M wiring must be protected from mechanical damage and suitably sealed for the operating environment. Waterproof butt connectors are supplied for mat to mat connections and are protected by the edge trim. Where wire runs are required across the floor, use conduit or cable trunking. The sealing integrity of the control unit must be maintained by the use of correctly sized and tightened conduit fittings or cable glands to IP65.

Note In order to ensure the isolation of the 110/230 V supply, the input power supply must be separately routed and enter the control unit via separate fittings or glands to those used for the output wiring. Wiring from the control unit to the mat may be buried in the floor using conduit, or pass via the edge trim. Flexible conduit is recommended for this type of installation. See *SECTION 6* for further details.

Determine the wiring method and determine the input and output connection points for the mat to control unit wiring.

5-10 Final Details

Prepare a work schedule and drawings of the installation layout and the electrical circuit. It is recommended that all measurements and calculations are recorded and retained in the technical file for the machine.

SECTION 6

Installation

This section covers the steps involved in installing and wiring the system, and confirming its functional operation.

6-1	Mat Installation	30
6-2	Control Unit Installation and Wiring	33
6-3	Checking the Mechanical Installation	35
6-4	Checking the Electrical Functions	36
6-5	Checking the Safety Functions.	37
	6-5-1 Single Channel Systems	37
	6-5-2 Dual Channel Systems	37
	6-5-3 All System Types	37
6-6	Functional Checkout	38

This manual should be read in full before commencing installation.

Study this section completely before starting work.

The installation should be supervised by the system designer. A mechanical technician and an electrician familiar with industrial wiring practices and experienced in safety installations will be required to undertake the installation.

The following special tools are required:

Crimp tool for pre-insulated butt splice connectors

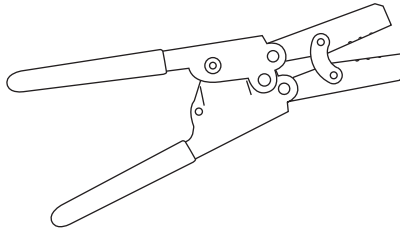


Figure 18

Hot air gun with reflector attachment for heat shrinking

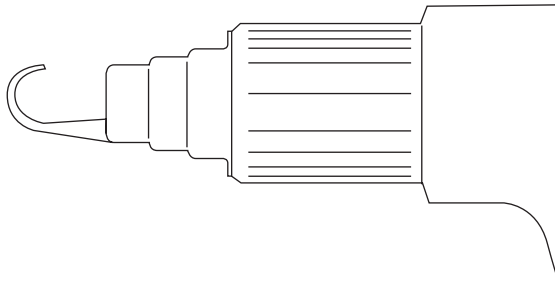


Figure 19

6-1 Mat Installation

Isolate and lock off the machine power supply at the source. Check that the floor is flat, smooth, clean and free of debris, and that any buried conduit or other wiring provision is correctly in place. Unpack the mats being careful to keep them flat and not to pull on the wires. Place the mats on the floor in the planned positions with the connecting wires at the periphery of the detection zone. Connect the mat sections together according to *Figure 20*.

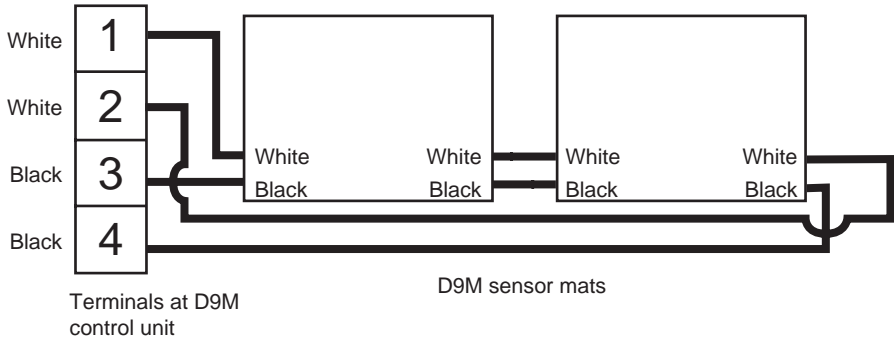


Figure 20

Note The mat wires have a black outer covering. Two have a black inner sheath and two have a white inner sheath (see *Figure 20* for positions).

Leave sufficient wire tail length to enable the connection to be remade if a mat is to be replaced, but ensure that the interconnecting wires will fit easily under the edge trim without crushing. Join the wires using butt connectors supplied as shown in *Figure 21* below. Where mat wires require extending, e.g. front mat to rear mat connections, use an extra pair of the butt connectors and a length of twin wire (see wiring specification - *SECTION 6-2*).

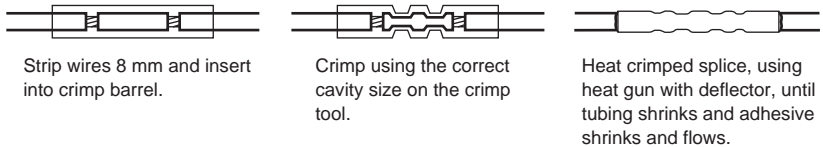


Figure 21

Trim Fixing

Where the wiring to the control unit is not buried, notch the perimeter trim at the wire entry and exit positions and cut the trim slope to suit the conduit system selected. Take care to notch completely so that any flexing of the perimeter trim will not trap the wiring. Ensure that there are no sharp edges or burrs that could damage the wires.

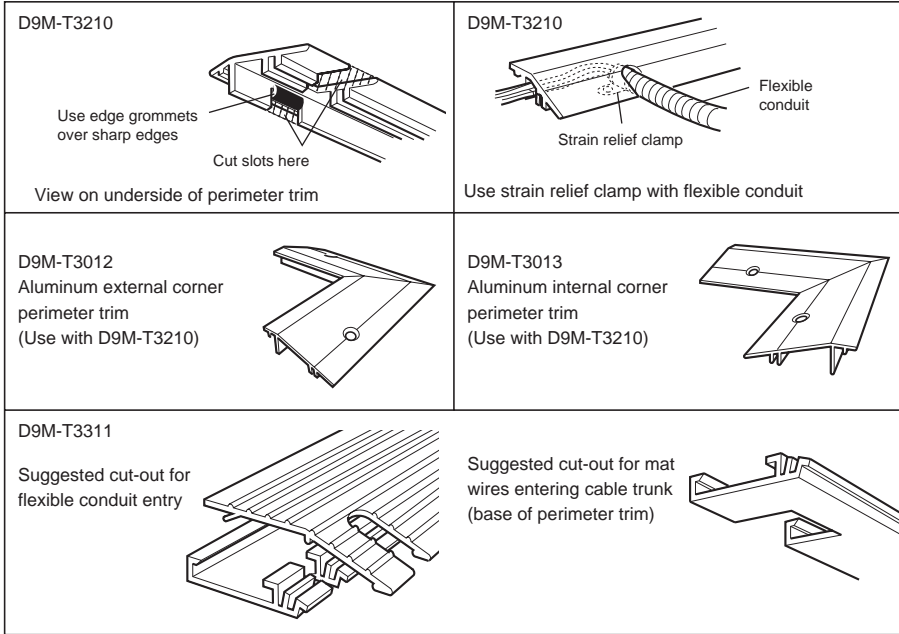


Figure 22 Details of trim fixings

Mark out the edge trim fixing positions on the floor allowing the trim to overlap the mat. Using the holes in the trim as a guide, mark out and drill the floor (fit plugs if required). Clean off the floor and fix the mats and edge trim in place using countersunk screws to suit the application.

As the perimeter trim is fitted ensure that none of the wiring is trapped or crushed between the trim and the floor or the top and bottom sections (depending on trim type).

If there is a possibility that the wires may be caught or pulled, a strain relief clamp should be used where the wiring exits the perimeter trim. All wiring should be protected in suitable conduit. If possible, the wiring/conduit should not cross a floor area where it will be a tripping hazard.

6-2 Control Unit Installation and Wiring

(Also refer to SECTION 4 Figure 6, SECTION 5-3-7 and SECTION 5-7.)

The control unit should be installed as supplied. It must not be modified or subjected to any procedures or connections other than those described in this manual.

Mount the control unit in its planned position. All wiring to the control unit terminals must use multistrand conduit cable/switch gear cable/equipment wire with 0.5- to 1.5-mm² conductors.

The insulated pin crimps supplied must be used. This wire and terminal combination avoids the possibility of shorts from loose strands or open circuits caused by overtightening or vibration.

Ensure that a suitable ratchet type crimp tool is used. Crimp onto both the conductor and the insulation. Do not connect more than one wire onto one crimp.

Ensure that the power supply remains isolated and locked off until SECTION 6-4.

The AC power supply must be externally fused at the point of supply by a 500-mA max. high rupture capacity (HRC) fuse. Unless the neutral side of the supply is referenced to ground, it must be fused to the same specification.

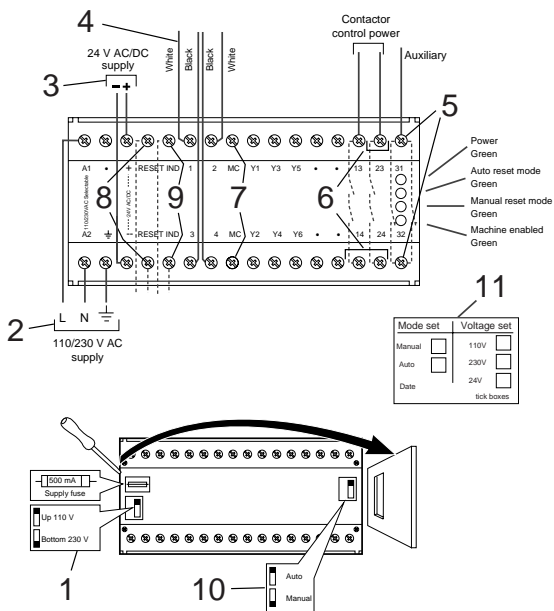


Figure 23 D9M-CD1 (Follow steps 1 to 12 for correct installation)

1,2,3...

1. When using a 110-V or 230-V AC supply, switch the voltage selector switch to 110 V or 230 V as appropriate.

Note The D9M is shipped from the factory with the selector set at 230 V AC.

2. If a 110-V or 230-V AC supply is being used, it should be wired, including a protective ground, to the terminals shown. Check setting on voltage selector switch, see step 1. Do not make any connections to the terminal shown at step 3. The size of the protective ground wire should be at least equal to that of the supply wire.
3. If a 24-V AC/DC supply is being used, it should be connected to the terminals shown, ensuring correct polarity. Do not make any connections to the terminals shown at step 2. With 24 V AC the grounded pole of the power supply should be connected to the -ve terminal.
4. Mat connections: Connect the leads from the mat to the terminals shown.
1 = WHITE, 2= WHITE, 3 = BLACK, 4 = BLACK
5. Auxiliary outputs: This terminal provides auxiliary N/C contacts (i.e., closed when the *MACHINE ENABLED* light is OFF) suitable for indication or alarm devices. They must not be connected to the safety circuit.
6. Safety outputs: These are volt free terminals for connection to the machine safety circuit. They are connected in series with the machine contactor control circuit (max. rating 250 V 4 A). They should be externally protected by a suitably rated fuse(s). For one contactor use terminals 14 & 25 with terminals 15 & 24 linked. For two contactors with two independent control circuits (i.e., a dual channel system), use 14 & 15 for connection to one contactor control circuit and 24 & 25 to the other.

See *Figure 14* and *Figure 15* in *SECTION 5* (page 24 & page 25) for examples of typical interfacing with the machine control circuit.

Note The safety outputs should be connected directly via hard wiring to the machine primary control elements (contactors). They must not be connected via any elements, e.g., ordinary relays, PLCs, etc., not suitably specified for safety related functions.

7. Contactor monitoring: The control unit is provided with these terminals linked. When the link is removed they can be connected to positively guided N/C auxiliary contacts on the machine contactors to provide monitoring of the contactors in dual channel control systems. If one contactor fails to isolate the power at de-energizing of its control coil the D9M unit will not allow the other contactor to be energized until the fault has been rectified.

8. Remote reset: N/O - These terminals are provided for the connection of a remote reset button. This **MUST** be an N/O momentary pushbutton device positioned at a location which gives a full view of the detection zone.
9. Remote reset indication: If this is used in conjunction with an illuminated pushbutton remote reset switch, it will show when the D9M needs to be reset. These terminals are for connection to the bulb (28 V).
10. Manual reset/Auto reset: M/A SWITCH. Set the M/A switch to the required setting.
M = Manual reset mode
A = Auto reset mode
11. Mark and sign the label according to the Voltage and Mode settings established.
12. Re-check the wiring connections including connections or modifications made to the machine control system wiring. Replace and secure the D9M control unit lid.

Disconnect the machine prime mover from the final contactor(s), so that no machine movement can take place.

6-3 Checking the Mechanical Installation

- 1,2,3...**
1. Check that the D9M sensor mats, perimeter trim and uniting trim are undamaged and correctly positioned and secured. Check that the designed safety distance has been achieved.
 2. Check that access to the hazard zone is not possible other than via the D9M mat and that any fixed guards, etc., are positioned according to the design and are secure.
 3. Check that the presence of a person between the hazard zone and the D9M is prevented.
 4. Check that the environmental conditions present or foreseeable correspond to those considered during the design stage.
 5. Check that the installation is free of hazards not foreseen at the design stage.
 6. Check that any warning notices are in place.
 7. Check that any other protective measures required have been installed.

6-4 Checking the Electrical Functions

1,2,3...

1. Ensure the mat is clear of persons and equipment. Temporarily disconnect any automatic reset function provided by the machine control system. Reinststate the machine power supply but ensure that the machine prime mover is still disconnected from the machine final contactor(s).

A. Manual Mode Only

2. Check on the control unit that:
 - the green LED - *POWER* is illuminated
 - the green LED - *MANUAL RESET* is illuminated
 - the reset lamp in the reset button is illuminated
 - the green LED - *MACHINE ENABLED* is OFF.
3. Press and release the reset button
 - check that the *MACHINE ENABLED LED* comes on and the reset lamp goes OFF
 - stand on the mat and check that the *MACHINE ENABLED LED* goes OFF.
4. Step off the mat, check that the *MACHINE ENABLED LED* remains OFF and the reset button is illuminated.
 - Press and release the reset button, check the *MACHINE ENABLED LED* comes ON and the reset button goes OFF.
5. Repeat the above tests to check the remote reset button(s) and lamp(s) if fitted.
6. Repeat the above to check the correct operation of any status monitoring connected to the D9M.

B. Auto Reset Mode Only

2. Check on the control unit that:
 - the green LED - *POWER* is illuminated
 - the green LED - *MACHINE ENABLED* is ON.
3. Stand on the mat, and check that the *MACHINE ENABLED LED* goes OFF.
4. Step off the mat, and check that the *MACHINE ENABLED LED* goes ON.
5. Repeat the above to check the correct operation of any status monitoring connected to the D9M.

6-5 Checking the Safety Functions

6-5-1 Single Channel Systems

(See Figure 14 SECTION 5.)

Simulate normal operation. Actuate the mat by standing on it and check that the main contactor drops out immediately. Check that any other safety related stop functions, e.g., brake, clutch contactors, are operating as intended.

6-5-2 Dual Channel Systems

(See Figure 15 SECTION 5.)

- 1,2,3...**
1. Simulate normal operation. Actuate the mat by standing on it and check that both final contactors drop out immediately. Check that any other safety related stop functions, e.g., brake/clutch contactors, are operating as intended.
 2. Isolate the power source and then install a temporary fault by short circuiting terminals 13 and 14 at terminal block 6 (Figure 23).
 3. Reinstate the power source and actuate the D9M sensor mat and check that one of the final contactors drops out immediately and any other stop functions associated with that channel operate as intended.
 4. Check that the D9M control unit will not reset
 5. Isolate the power source and remove the temporary fault. Reinstate the power source and check that the D9M operates normally. Taking the same electrical safety precautions, repeat the test with a temporary short circuit across terminals 23 and 24 at terminal block 6 (Figure 23).
 6. Again check that the D9M will not reset
 7. Remove the temporary fault, check that the D9M operates correctly.

6-5-3 All System Types

- 1,2,3...**
1. Carry out any other tests required to confirm that the safety related control system meets the requirements of its Category according to EN 954-1 and works as intended.
 2. Check any other safety functions associated with the machine circuits which have been affected by the installation of the D9M. There should be an existing procedure for these tests.
 3. **Isolate the machine power supply at the source.**

4. Reconnect any automatic reset function provided by the machine control system.
5. Reconnect the machine prime mover to the final contactors.
6. Secure all covers and doors.

6-6 Functional Checkout

Reinstate the machine electrical supply.

Check the following:

1,2,3...

1. Check that machine operation cannot commence until the D9M control unit has been reset. Perform the walking test described in *SECTION 8-2*.
2. Check that actuation of the mat stops hazardous movement.
3. Check that stepping off the mat does not start machine operation but does enable restart.
4. Check that when approaching the machine at walking pace, hazardous movement stops before the hazard zone can be reached. In critical applications, stop-time tests should be carried out.
5. If any type of muting system is installed, check that the D9M is muted only during non-hazardous parts of the operating cycle and that any mute indicators operate correctly.
6. Test the machine's emergency stop function.

SECTION 7

Use

This section describes the precautions to be taken before putting the system into service.

Prior to putting the machine into its normal service, ensure that operators and supervisors are aware of the nature and purpose of the D9M system and that they understand the functions of the controls and indicators.

Ensure that the technical specifications together with inspection, test and servicing instructions are available to the appropriate personnel and that a system for recording inspections is in place.

Ensure that personnel understand that no additional coverings, boards, plates, or planks are to be on the D9M sensor mat during operation of the machine.

SECTION 8

Maintenance

This section provides instructions on cleaning, inspecting, disposing, troubleshooting, and repairing the system.

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8-6	Repair	45

This section should be read in full before any maintenance is attempted.

Attention is drawn to requirements for planned preventive maintenance.

During maintenance operations, disconnect the machine's prime mover before working on the D9M system. Observe electrical safety precautions.

8-1 Mat Cleaning

The sensor mats should be regularly swept to clear them of deposits such as filings and other materials. If it is necessary to wash or hose down the sensor mats to clean or remove grease, etc., it is permissible to use warm water and detergent. **DO NOT USE SOLVENTS.**

8-2 Routine Inspection and Test (Recommended Weekly)

Stop the machine. Clean the sensor mats and allow them to dry off. Inspect the top surface of the mat for damage. Minor nicks and abrasions of the vinyl cover are acceptable but any damage that exposes the metal plate must be dealt with immediately. Check that the perimeter trim and uniting trim are not cracked, broken or distorted and that the fixings are secure. Damaged parts must be replaced immediately.

Test the mat operation. Two persons are required, one to walk on the mat, the other to observe the control unit. On systems using manual reset mode the reset button must be continuously pressed and released. Check that the *MACHINE ENABLED LED* is ON prior to actuation of the mat and goes OFF as soon as the mat is stepped on. One person should walk over each section of the mat in turn and each joining section in turn (i.e., stand with both feet on the same uniting trim between two sections). The *MACHINE ENABLED LED* must remain OFF during the entire time. Step off the mat, operate the reset button. Check that the *MACHINE ENABLED LED* is illuminated. Start the machine, step onto the mat and check that the machine stops immediately.

Check that all fixed guards and angle plates, etc., are in place, undamaged and securely fixed.

If these checks reveal any problems, do not allow use of the machine until they are rectified. Record the inspection and test in a written log.

8-3 Thorough Examination and Test

(Recommended Twice Yearly or After Damage)

To be undertaken by a person competent in electrical and mechanical engineering.

- Carry out the test at 8-2 above.
- Isolate the power source to the machine and the D9M system. Observe electrical safety precautions.
- Inspect the mat components thoroughly for mechanical damage.
- Disconnect the wires to the mat at terminals 1, 2, 3, and 4 at the control unit.
- Connect the two white wires to one test input of an ohmmeter and connect the two black wires to the other input. One person should walk over each section of the mat in turn and each joining section in turn (i.e., stand with both feet on the same uniting trim between two sections) until all areas of the sensor mat have been covered. The maximum resistance with presence on the mat should not exceed 100 ohms.

If these checks reveal any problems, do not allow use of the machine until they are rectified.

Check that the stopping performance of the machine has not deteriorated from that used in the original safety distance calculations (see *SECTION 5*).

Record the inspection and test in a written log.

8-4 Dismantling and Disposal

Dismantling the D9M system is the reverse of the installation procedure and no extra hazards are presented.

Ensure that the machine and D9M power is isolated and locked off at the source before starting work.

If the system is to be reconfigured or relocated, observe the handling precautions given in *SECTION 1*.

The D9M system does not contain any hazardous materials that require special precautions for disposal.

8-5 Troubleshooting

Disconnect the prime mover prior to working on the D9M control system with power applied. Observe electrical safety precautions.

8-5-1 Symptom

With no presence on the mat and after the correct reset procedure has been followed, the machine cannot be started.

1,2,3...

1. If the *MACHINE ENABLED LED* on the D9M control unit is ON there is a probable fault on the machine or its control system external to the D9M. Check the external fuses in the control unit safety output wiring and replace if necessary. Ensure that the correct value of fuse is used (2 A max.) Record the replacement in the inspection log. If either fuse blows immediately or requires early replacement there is a probable fault in the machine control circuit between the safety output of the D9M control unit and the machine's final control element(s) (contactors).

2. If the *MACHINE ENABLED LED* on the D9M control unit is OFF, take the following actions:

Check that the *POWER LED* is illuminated.

If it is not, check the power supply to the D9M control unit.

Check that the power supply is connected to the appropriate terminals.

Check the primary and secondary fuses in the control unit and replace if necessary.

Ensure that the correct value of fuse is used (500 mA anti-surge) for both primary and secondary fuses. Record the replacement in the inspection log. If either fuse blows immediately or requires early replacement please contact your OMRON representative.

3. If the *MACHINE ENABLED LED* on the D9M control unit is OFF and the *POWER LED* is ON.

On dual channel systems with contactor monitoring, if the external safety output fuses have not blown, it is still probable that there is a fault external to the control unit. A single fault in either wiring channel will cause the D9M control unit to lock off the safety outputs until the fault is rectified and the control unit is reset. Check that all connecting wiring in the system is configured correctly and has not been damaged and that both contactors are functioning correctly.

Rectify any faults and if in manual reset mode press and release the control unit reset button.

4. If the problem is not resolved please contact your OMRON representative.

8-5-2 Symptom

Machine does not stop or can be started with presence on the mat.

Do not allow use of the machine.

- 1,2,3...
1. With presence on the mat, is the *MACHINE ENABLED LED* illuminated on the D9M control unit?
 2. If the *MACHINE ENABLED LED* is not illuminated there is a probable fault on the machine or its control system external to the D9M. **Do not allow use of the machine until the fault has been rectified and tested.**
 3. If the *MACHINE ENABLED LED* is illuminated. - **Do not allow use of the machine and contact your OMRON representative immediately.**

8-5-3 Symptom

Machine stops unexpectedly with no presence on the sensor mat but can be restarted after stepping on and off the mat (and resetting when in manual reset mode).

Check that all indicator lights are operating correctly. If they are, the problem is likely to be caused by a dip in supply power of a certain value and duration. This can cause one of the internal relays in the control unit to drop out, thus simulating a fault condition. This is a very unlikely occurrence and no remedial action is required. In the unusual event of the problem persisting, measures may be required to ensure a smoother power supply to the D9M system.

8-6 Repair

Prior to working on the D9M system or machine control system, isolate the power source to the machine and D9M system. Observe electrical safety precautions.

User repairs are limited to replacement by new D9M system parts.

Any repairs to the connecting wires should be made using the recommended butt splice connectors.

Tampering with component parts will invalidate warranty.

Warranty invalid if quality seal is broken on DIN rail (D9M-CD1) control unit.

Available Spares

	Standard sizes	Model No.
Sensor mat	500 mm × 500 mm	D9M-M1010
Sensor mat	750 mm × 500 mm	D9M-M1510
Sensor mat	1,000 mm × 500 mm	D9M-M2010
Sensor mat	500 mm × 1,500 mm	D9M-M1030
Sensor mat	750 mm × 750 mm	D9M-M1515
Sensor mat	1,000 mm × 750 mm	D9M-M2015
Sensor mat	750 mm × 1,500 mm	D9M-M1530
Sensor mat	1,000 mm × 1,000 mm	D9M-M2020
Sensor mat	1,000 mm × 1,250 mm	D9M-M2025
Sensor mat	1,000 mm × 1,500 mm	D9M-M2030

	Size	Model No.
Perimeter trim	2 m	D9M-T3210
Two-piece perimeter trim (with cable trunk)	3.5 m	D9M-T3311
Active uniting trim	4 m	D9M-T3420
Aluminum external corner perimeter trim		D9M-T3012
Aluminum internal corner perimeter trim		D9M-T3013
Aluminum external corner perimeter trim (with cable trunk)		D9M-T3014
Aluminum internal corner perimeter trim (with cable trunk)		D9M-T0315
D9M control unit		D9M-CD1

After replacing any parts the inspection and test shown at 8-2 must be carried out with special attention given to those parts replaced.

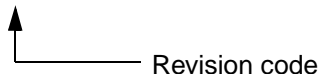


WARNING After maintenance or repair operations it is important that all edging trim, fastenings and cable protection are correctly refitted. Failure to do this or the use of non-approved parts or modifications may result in the D9M system failing to achieve its specified performance.

Revision History

A manual revision code appears as a suffix to the catalog number on the front cover of the manual.

Cat. No. Z186-E1-01



The following table outlines the changes made to the manual during each revision. Page numbers refer to the previous version.

Revision code	Date	Revised content
01	July 2003	Original production