

# An automated system for indicating spray clearance times of MVR spray booths and rooms

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# An automated system for indicating spray clearance times of MVR spray booths and rooms

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This report describes the design and assembly of an automated device to warn of the presence of paint spray mist inside a spray booth/room during spraying and during the clearance time. A timer switch, programmed with the clearance time, is triggered by a sensor that detects when the spray gun is turned on and off.

Two types of sensor are evaluated and recommendations made for different operational setups.

The system is relatively inexpensive and can be retrofitted to existing spray booths/rooms.

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# EXECUTIVE SUMMARY

## Objectives

- 1) To develop an automated device that will alert sprayers of isocyanate based paints of the presence of spray mist inside paint spray booths /rooms used in the motor vehicle repair (MVR) and other industries.
- 2) The device should include a visible or audible warning that is triggered as soon as the paint sprayer starts spraying and remains on until the booth/room has completely cleared of spray mist. HSL was asked to investigate the practicalities of an automated device by HSE's MVR project team

## Main Findings

An automated device has been developed that will alert paint sprayers and others to the presence of paint spray mist inside a spray booth/room so that they know not to enter, or if they do, to wear respiratory protective equipment (RPE).

The device continues to indicate during spraying and for a period after spraying has ceased. This period is the *clearance time*, i.e. the time it takes for the booth/room to clear of paint mist. It can be determined beforehand using smoke. The method for measuring clearance time is described on HSE's MVR web page (<http://www.hse.gov.uk/mvr/priorities/isocyanates.htm>) and in HSE's guidance document Web36 ([www.hse.gov.uk/pubns/web36.pdf](http://www.hse.gov.uk/pubns/web36.pdf))

The device works by measuring a change in the line pressure or the airflow through the spray gun as the gun is turned on and off. This can be used to trigger a timer switch that is programmed with the clearance time.

## Recommendations

Ideally, a spray clearance indicator should be integrated into all new spray booths/rooms and retrofitted to existing booths/rooms. The type of switch used to trigger the device will depend on the set-up in any particular work place.

- Either a pressure or flow switch would be suitable in situations where a dedicated airline supplies the spray gun.
- A flow switch may be better if a single airline is used, in conjunction with a waist regulator, to supply both breathing air and spray air. This set up may lead to fluctuations in the line pressure, which could cause a pressure switch to falsely alarm.
- A flow switch may be better if the supply air is used to power several other pneumatic tools as well as the spray gun since once again this may lead to fluctuations in the line pressure, which could cause a pressure switch to falsely alarm.

If a flow switch is used then the supply air should be clean and dry since any contaminants in the air could eventually cause the switch to block. This should not present as great a problem with the pressure switch.



# 1 INTRODUCTION

Two-pack isocyanate paint, used extensively in the motor vehicle repair (MVR) and other industries, is known to cause occupational asthma. HSE statistics show that vehicle paint sprayers are approximately 80 times more likely to contract occupational asthma than the average for the UK working population.

Asthma is caused by inhalation of the fine paint mist that is generated when paint spraying two-pack isocyanate paint. This fine mist is invisible to the human eye in normal lighting conditions. One of the main controls is to ensure that spraying of two-pack isocyanate paint be carried out in a ventilated spray booth or a spray room. It takes time for spray booths and rooms to clear of the fine paint mist; this time is known as the *clearance time*. It is essential that personnel working in premises where paint spraying is carried out, know the clearance times of their booths/rooms. This is because entering a booth or room before it has become clear of paint spray will result in exposure to high concentrations of airborne isocyanates. Similarly, if sprayers remove their air-fed breathing apparatus or raise their visor to check paint coverage, before the fine mist has cleared, they will be again exposed to airborne isocyanates. One way MVR garages can determine booth/room clearance time is by filling the booth/room with smoke, which unlike paint mist is easily observed, and timing how long it takes to clear. This is reported by Saunders et al (2006) and described on HSE's MVR web page (<http://www.hse.gov.uk/mvr/priorities/isocyanates.htm>) and in HSE's guidance document Web36 ([www.hse.gov.uk/pubns/web36.pdf](http://www.hse.gov.uk/pubns/web36.pdf))

At present HSE requires that the clearance time be displayed on all doors to the spray booth/room. The painter has to note when he/she stopped spraying and note when the clearance time has passed. The same applies to anyone wanting to enter the booth/room safely. A more direct solution is to programme the clearance time into a simple timer switch connected to a visible warning such as a light or siren. On completion of spraying the paint sprayer would press the switch and the light would illuminate until the booth has cleared of paint mist. This would alert nearby workers, warning them not to enter the booth during this period. The main drawback of this method is that it relies on the paint spray operator remembering to activate the switch on completion of the job.

An improved and more reliable arrangement would be one that eliminates human intervention and automatically detects when spraying has ceased and triggers the timer switch.

This report describes an automated system that can use two different types of sensor/switch to detect when the spray gun is switched off. The system is relatively inexpensive and could easily be retrofitted to existing spray booths/rooms.

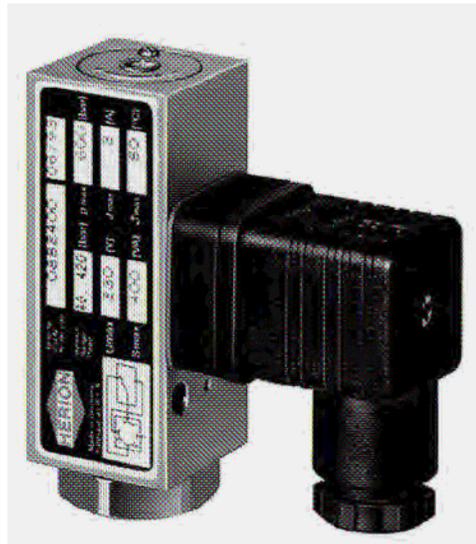
## 2 CLEARANCE TIME INDICATOR COMPONENTS

### 2.1 CHOICE OF SENSOR

A method of determining when the paint spray gun is switched on and off is required. Two obvious changes that occur when the spray gun is switched on are a drop in airline pressure, and an increase in airflow. Both of these changes can be detected and used to activate a switch. The spray gun used for the purpose of this work was the SATAjet RP, which has an air consumption of 280 l/min at an air pressure of approximately 2 bar. The pressure and flow switches were therefore chosen for use with this spray gun, but should also be suitable for most other pneumatic spray guns. There are many suppliers of pressure and flow switches and a non-exhaustive list is given in Appendix 5.1.

### 2.2 PRESSURE SWITCH

The pressure switch chosen was the Norgren/Herion Series 18D pneumatic pressure switch (part number 0880300), which has a single pole double throw electrical switching action and is shown in Figure 1. It is robust with a long life expectancy, and is compact and relatively inexpensive. Like most pressure switches of this type it works by applying the air pressure to a diaphragm. Movement of the diaphragm in turn pushes a piston, which operates a built-in microswitch. This model has a switching pressure range of 0.5 to 8 bar which is adjusted by loosening the locking screw on top of the switch and then adjusting the switching point using a hexagonal key. Clockwise rotation increases switching pressure and anti-clockwise rotation decreases switching pressure. The pressure switch is installed in the airline using a standard BSP T connector as shown in Figure 5. Care needs to be taken setting the switching pressure since the airline pressure with the spray gun on and off is not that great (approximately 1 - 2 bar). This is not an issue with a flow switch since it detects a change in flow conditions. The circuit used with the pressure switch is shown in Appendix 5.3.



**Figure 1.** Norgren/Herion Series 18D pneumatic pressure switch

## 2.3 FLOW SWITCH

There are two main types of flow switch. The first uses a reed switch, which is actuated by a magnet-equipped piston driven by the pressure differential produced by the flow of air through the switch. The second uses a vane/paddle placed in the airflow, which is displaced by the air movement to activate a microswitch. The vane type tends to be used inside large diameter pipework for measurement of high airflow rates. The reed switch variety can operate at lower flows and was considered to be the most suitable for this work. The flow switch chosen was the FS-3 (part number 166701-A-RS) from GEMS Sensors Ltd. and shown in Figure 2. It has a set point maximum flow of 12 l/min and has a normally open single pole single throw switching action. An additional relay is required in the circuit to convert to a single pole double throw switch. The double throw mechanism is essential since the warning light needs to be powered either directly (when the spray gun is on) or through the timer switch (when the spray gun is switched off). The circuit for the flow switch is shown in Appendix 5.4.



**Figure 2.** The GEMS FS-3 flow switch

## 2.4 TIMER SWITCH

The timer switch used to set the clearance time was the Omron H3CR-A8 (shown below in Figure 3), which can be configured to operate in 4 different modes. For our purposes it was set to operate in “on-delay” mode (mode A) by adjusting the operating mode selector in the top right corner of the timer until A was displayed. The time unit (sec, min, hrs, or 10 h) can be selected by turning the time unit selector located at the lower right corner of the front panel. The time range can be adjusted using the time range selector at the lower left corner of the front panel. This therefore comfortably covers the wide range of clearance times encountered.



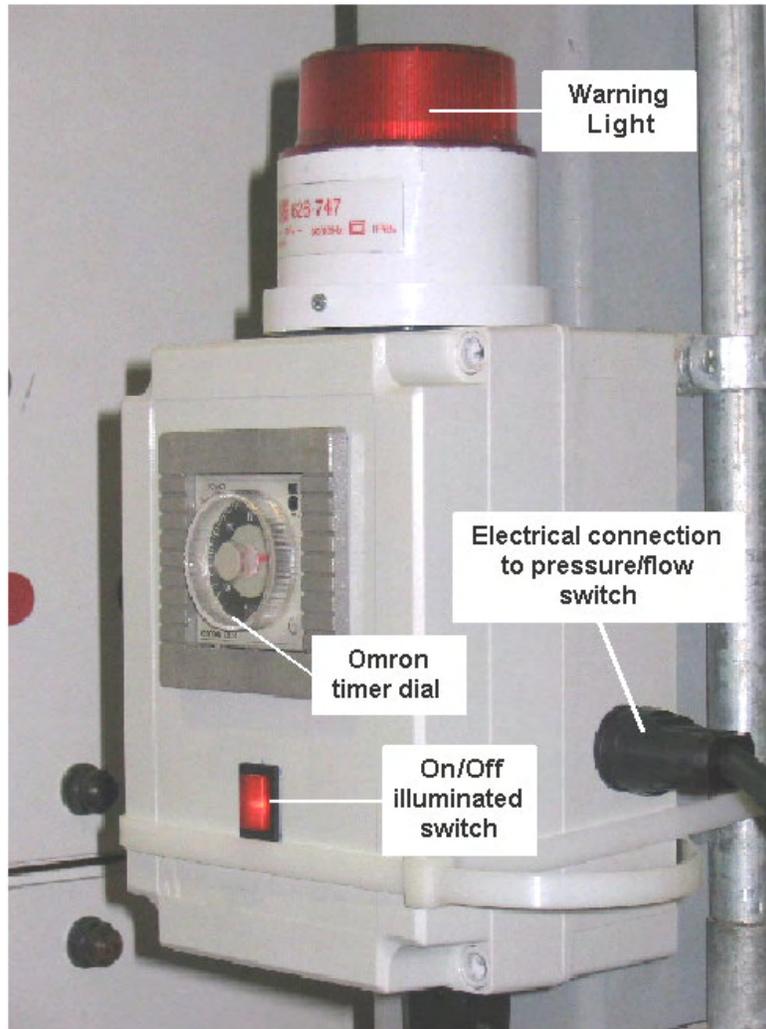
**Figure 3.** The Omron H3CR-A8 timer switch

Both pressure and flow switches perform essentially the same task i.e. when the spray gun is switched on, the timing circuit is by-passed and the warning light remains on. When the spray gun is switched off the timer switch is initiated and the warning light will remain on for the programmed time i.e. the spray clearance time. If the spray gun is switched back on before the clearance time has elapsed, the timer is reset to zero. This ensures that when the spray gun is switched off again the warning light will remain on for the full clearance time.

### 3 CLEARANCE INDICATOR CONTROL UNIT

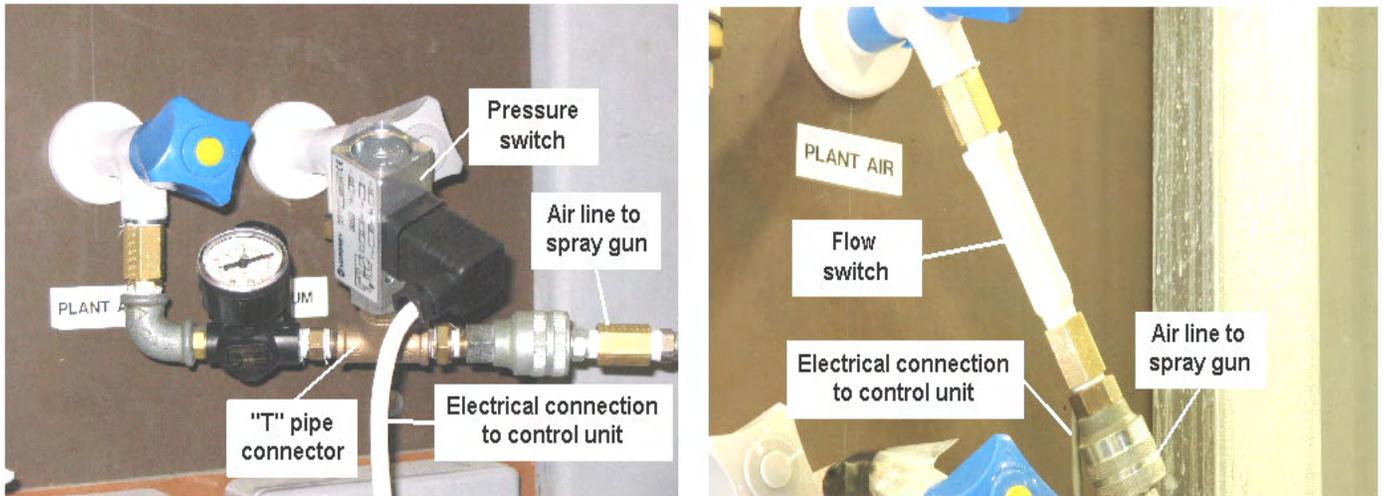
#### 3.1 CONTROL UNIT

The timer switch, relays and warning light were fitted inside a small box, referred to here as “the control unit” which is shown in Figure 4. This could be easily mounted outside the spray booth.



**Figure 4.** The control unit for setting the clearance time

A lead from a socket in the side of the control unit is connected to the electrical contacts of the flow or pressure switch. The pressure and flow switches are connected directly to the compressed air supply using suitable pipe fittings as shown in Figure 5. The control unit was powered by 240V ac, and plugged into a standard 13A wall socket. The control unit is shown fitted with a beacon as the warning indicator although this could be replaced with a smaller and less expensive light. If required, a buzzer or siren could also be fitted to the control unit to give an audible alert. An illuminated neon switch was used to switch on the power to the control unit and indicate when the unit was on.



**Figure 5.** Connection of pressure and flow switches to compressed air supply

### 3.2 OPERATION OF THE CLEARANCE TIME INDICATOR

Operation of the clearance time indicator is straight forward and should be carried out in the following sequence:

- Connect the pressure or flow switch to the supply air using suitable BSP pipefittings.
- Connect the spray gun airline to the pressure/flow switch as shown in Figure 5, preferably using quick-fit pressure connectors.
- Set the air pressure to the required value for the spray gun being used.
- Connect from the switch contacts to the control unit.
- Set the timer to zero by rotating the dial fully anticlockwise.
- Power up the control unit.
- Set the clearance time on the timer.

Once set, as long as the power to the control unit is left on and the compressed air is on, no further adjustment is needed. If a different clearance time is required, the above sequence should be repeated. The above sequence should be displayed close to the control unit for the paint sprayer to refer to at any time.

## **4 WHICH SWITCH TO USE?**

The choice of switch will probably depend on the circumstances under which it is used. For example, if a dedicated airline supplies the spray gun, a pressure switch or a flow switch would be suitable. If a single airline is used, in conjunction with a waist regulator, to supply both breathing air and spray air, then a flow switch may be a better option. If there are other tools connected to the same compressed air line as the spray gun, then these may affect the line pressure, which could cause the pressure switch to falsely activate even when the spray gun is not being used. In these circumstances, the flow switch is probably again the better option. If the supply air is dirty and/or contains water, then the flow switch may become contaminated quicker than the pressure switch, thereby causing a malfunction. In this case, the pressure switch might be the best option.

## 5 APPENDICES

### 5.1 LIST OF SOME SUPPLIERS/MANUFACTURERS FOR PRESSURE AND FLOW SWITCHES (NON INCLUSIVE)

<b>Manufacturer</b>	<b>Address</b>	<b>Telephone</b>	<b>Web address</b>
Norgren	Obtained from RS Components Birchington Road, Corby Northants NN17 9RS	08457201201	www.rsw.com
PVL Ltd	Unit 9, Lexden Lodge Ind Estate Crowborough TN6 2NQ e-mail: info@pvl.co.uk	01892664499	www.pvl.co.uk
Herga Electric Ltd	Northern Way Bury St Edmunds IP32 6NN e-mail: info@herga.com	01284701422	www.herga.com
Fluidic Ltd	4-8 Lochend Street Motherwell ML1 1RX e-mail: sales@fluidic-ltd.co.uk	01295 572401	www.fluidic-ltd.co.uk
Dwyer Instruments	Unit 16, The Wye Est London Road Bucks HP11 1LH e-mail: sales@dwyer-inst.co.uk	01494461707	www.dwyer-inst.co.uk
Gentech Int Ltd	Grangestone Ind Est Ayrshire KA26 9PS e-mail: sales@gentechsensors.com	01465 716999	www.gentechsensors.com
Gems Sensors Ltd	Lennox Road Hampshire RG22 4AW e-mail: sales@gems-sensors.co.uk	01256320244	www.gems-sensors.co.uk

Many of the switches from the above manufacturers can be purchased from RS components

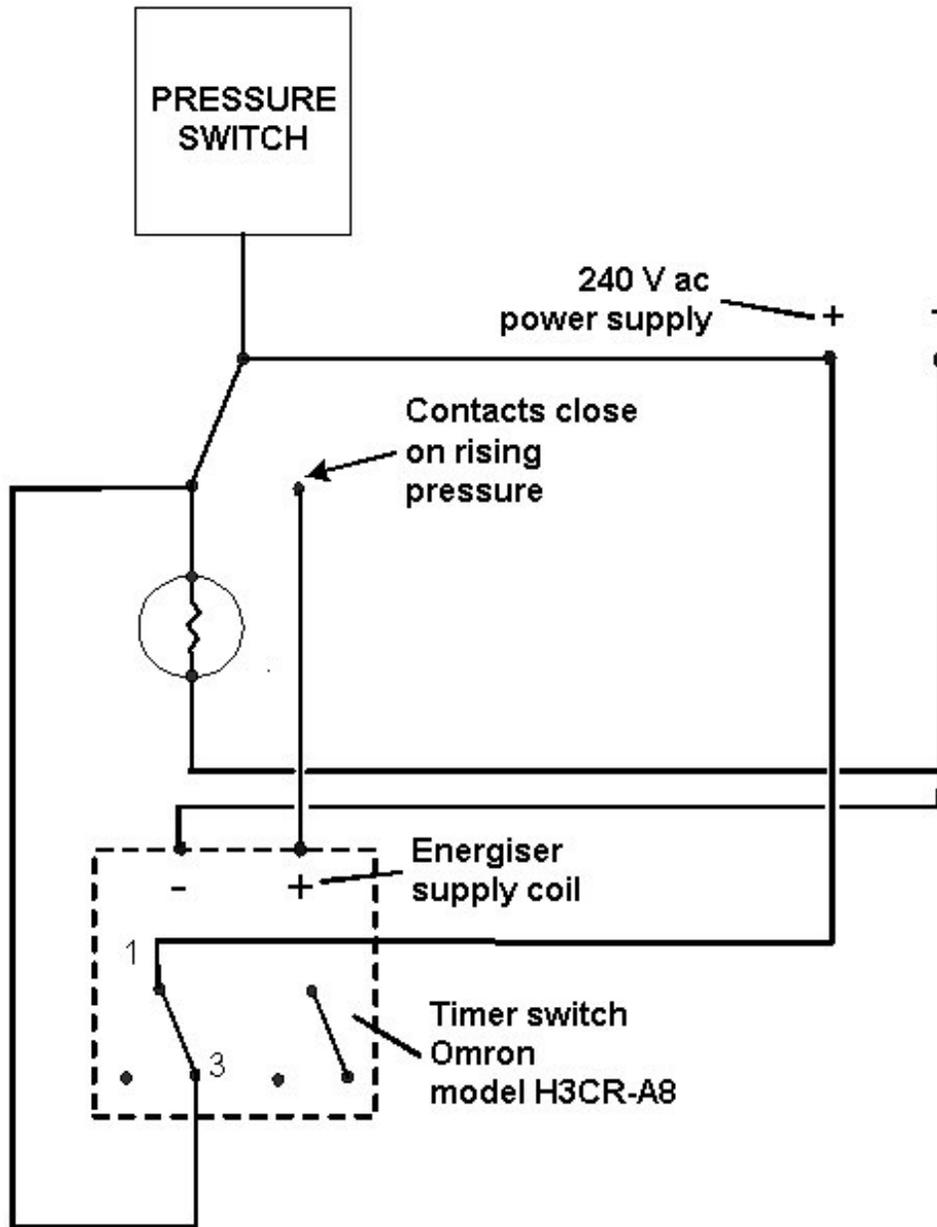
### 5.2 COST OF MAKING A CLEARANCE TIME INDICATOR

For convenience, all of the components were sourced from RS Components Ltd (prices correct of 09/06/2009). Cheaper alternatives may be available. Sourcing cheaper alternatives will reduce costs, possibly by as much as 50%

<b>Component</b>	<b>RS number</b>	<b>Price</b>
Norgren 0880300 pressure switch	366-3985	£65.49
Gems Flow Switch (12 l/min)	395-6990	£24.00
Omron DPDT 3 function timer switch	328-358	£40.15
Beacon	311-8946	£17.91
MNX enclosure 180x130x100mm	289-6320	£13.55
Omron SPDT relay switch	211-1304	£6.83
Other – plugs sockets etc		~£10.00
	<b>Total price (pressure switch)</b>	<b>£147</b>
	<b>Total price (flow switch)</b>	<b>£112</b>

5.3

WIRING DIAGRAM FOR THE PRESSURE SWITCH





## 6 REFERENCES

MVR Website. "Health and safety in the motor vehicle repair (MVR) industry". The address for this website is: <http://www.hse.gov.uk/mvr/>

Saunders C.J., Clarke S. and Pocock D. (2006) "Review of commercially available party fog machines suitable for determining the clearance time of paint spray booths and rooms". HSL internal report ECO/06/01.

Web36, (HSE guidance document). "Controlling isocyanate exposure in spray booths and spray rooms". This document is available at: [www.hse.gov.uk/pubns/web36.pdf](http://www.hse.gov.uk/pubns/web36.pdf)





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