DOCUMENT CONTROL NUMBER /

S111 INFRA-RED FLAME DETECTOR

PRODUCT APPLICATION & DESIGN INFORMATION

1. INTRODUCTION

The S111 is an infra-red flame detector designed to provide early warning of flaming fires involving carbonaceous materials. The detector makes use of "state of the art" infra-red sensors and optical filters to provide major improvements in the rejection of deceptive phenomena while retaining the inherent advantages of infra-red detectors

Special attention has been paid to the optimisation of the optical bandwidth. The detector uses optical filters which are made to THORN Security Limited's specification to restrict the response to a narrow band in the region of 4.4µm. The bandwidth chosen [see Fig. 1] gives high sensitivity to hydrocarbon fires while minimising the response to other sources of infra-red radiation. In particular the response to sunlight has been reduced to a level at which the detector can be considered completely "solar blind"

The principles, on which the detector is designed, are protected by the following patents:

US Patent No.	**4471221**
Canadian Patent No.	**1191229**
European Patent Application	
Publication No.	**64811**
Japanese Patent Application No.	**62667/82**

The use of micropower electronic circuits allows the detector to operate on a conventional 2-wire detection circuit, and to achieve intrinsic safety certification

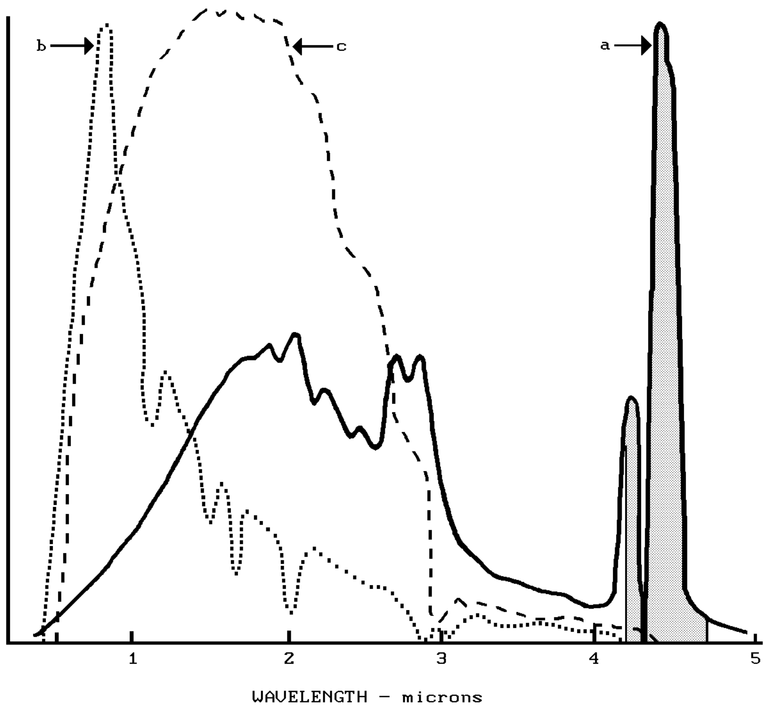

Fig. 1 Spectrums of a) Typical Carbonaceous Fire
b) Solar Radiation at Ground Level
c) Tungsten Filament Lamp

1.1 GENERAL CONSTRUCTION

The detector is of robust construction to allow its use in harsh environments.

The Infra-red sensor and all other circuit components are mounted on a single printed circuit board within a steel screening box. The box is filled with epoxy resin to form a rugged opto-electronic assembly

The encapsulated assembly is in turn contained within an impact-resistant moulded plastic housing designed to give a level of protection to IP65. The complete detector is mounted on a stainless steel bracket which allows a wide range of adjustment in two axes.

The detector has a MIL spec plug permanently sealed into the housing and the electrical connections are made via the mating socket which is supplied with 2 metres of 4 core PVC insulated, braid screened PVC sheathed cable to DEF Std 61-12: Pts 4 and 5

1.2 APPLICATION

The detector is intended for the protection of high-risk areas in which accidental fires are likely to result in flaming combustion with the production carbon dioxide. Typical materials in this type of risk are:

- Flammable liquids including petroleum products, alcohol, and glycol etc.
- Flammable gases including methane.
- Paper wood and packing materials.
- Coal.
- Plastics.

These substances ignite readily and burn rapidly, producing flame, often accompanied by large volumes of dark smoke.

Note: The detectors are not designed to respond to flames emanating from fuels which do not contain carbon, e.g hydrogen, ammonia, sulphur, metals, and should not be used for such risks without satisfactory fire testing.

The S111, by virtue of its construction and rejection of spurious radiation, is suitable for use both indoors and outdoors in a wide range of applications.

1.3 ADVANTAGES OF THE S111

Infra-red flame detectors offer certain advantages over detectors working in the visible or ultra-violet regions of the spectrum. For example, they are:

- Highly sensitive to flame.
- Not greatly affected by window contamination by dirt and oil deposits.
- Able to see flames through dense smoke.
- Able to see flames through high densities of solvent vapours.

The S111 has all the above advantages and additionally it is:

- Completely “solar-blind” in normal conditions.
- Insensitive to electric arcs.
- Insensitive to artificial light sources.
- Intrinsically safe.
- Sealed to IP65.

1.4 DETECTOR ENHANCEMENTS

Detectors from serial number 16000 upwards have the following enhancements:

1.4.1 RFI IMMUNITY

The RFI immunity of this detector has been considerably improved by the introduction of a stainless steel photochemically etched shield. The screen has been designed to provide immunity to high power cellular telephones operating in close proximity at up to 1GHz.

1.4.2 FAST RESET

In order to facilitate the use of this detector with control panels not manufactured by THORN security Limited, where the reset is short, a modification has been introduced which resets the detector within 0.5 seconds.

The fast reset facility is implemented as follows:

a) For fast reset to operate it is necessary for the supply to be removed for a minimum of 0.5 secs,

b) the supply must fall by greater than 5 Volts,

c) the detector [or Zone] must have an end-of-line resistor with a resistance of less than 100k,

d) the noise immunity on the line [ripple] is less than 3 Volts peak.

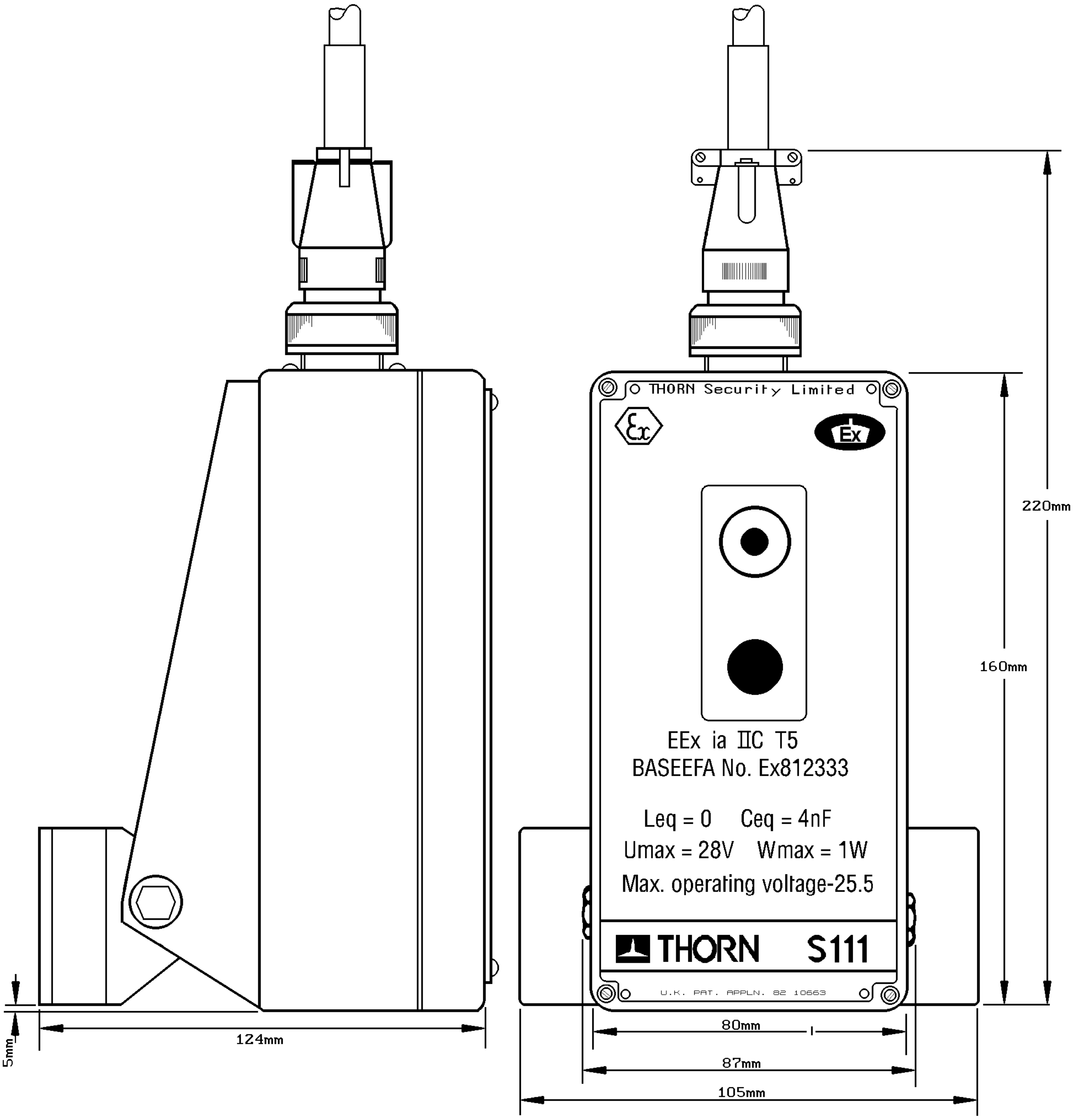

Fig. 2 S111 Overall Dimensions

2. TECHNICAL SPECIFICATION

2.1 MECHANICAL

The detector comprises a two-part moulded plastic enclosure as shown in Fig. 2. The rear section of the housing is attached to an adjustable mounting bracket.

The front section of the enclosure contains the encapsulated electro-optical assembly which is connected to the terminal block by a small cable form. Two windows are fitted in the front face of the housing. The upper window allows infra-red radiation to fall on the sensor and is made from sapphire. The LED alarm indicator is visible through the lower window which is made of red glass.

The front section of the enclosure is attached to the rear section by four captive screws. A seal provided between the front and rear sections ensures protection to IP65.

Dimensions:

The overall dimensions are shown in Fig. 2.

Weight: 1.7kg [with bracket and cable assembly].

Materials:

Enclosure:	Self coloured moulded plastic light grey.
Mounting Bracket:	Bright stainless steel to BS1449 Pt2 316 S16
Screws, etc., exposed to the elements:	Bright stainless steel to BS1449 Pt2 316 S16

2.2 ELECTRICAL CHARACTERISTICS

The S111 is a two-wire device which is designed to operate on any fire detection control equipment currently manufactured by THORN Security Limited. The quiescent current drain is very small and the alarm condition is signalled by a large increase in current demand. Resetting is achieved by removing the supply voltage for a period of at least three seconds [see para 1.4.2 for fast reset parameters].

Supply Voltage:	+15.5V to +25.5V d.c. [polarity conscious]

Note: The detector performance is not guaranteed below 15.5V and the output stage is inhibited at 15V and below.

Quiescent Current:	100uA max. at 20V.
Alarm Output Mode:	2-wire, latching. 330 ohm in series with 3V switched across supply.
Alarm Current:	60mA maximum.
Alarm Indication:	red LED visible from front of detector.
Reset Time:	3 seconds [typical]. 5 seconds [max.].
Reset Voltage:	supply must be reduced to less than 2V.
Stabilisation Time:	20 seconds [typical].
Equivalent Inductance:	0
Equivalent Capacitance:	4nF

2.3 ENVIRONMENTAL

Temperature

Operating temperature:	-30^{o}C to +70^{o}C. [-40^{o}C with reduced range]
Storage temperature:	-40^{o}C to +80^{o}C.

Relative humidity: 95% [non-condensing] [100% intermittent].

Enclosure Protection: IP65 - IEC529, BS 5490.

Vibration:

The S111 is designed to operate within specification and without false operation when subjected to vibration on any axis at the following levels:

2 - 24Hz	±1.27mm
24 - 55Hz	2.50g
55 -100Hz	0.70g

When the detector is correctly mounted using the bracket supplied there are no significant resonances in the frequency range 2-100Hz.

Electromagnetic Compatibility

EMC: Equals or exceeds the requirements of BS EN 50081-1 and BS EN 50082-1

Note: The above standards fulfil the requirements of the European Directive for EMC (89/336/EEC).

Ionising Radiation:

The S111, like other infra-red detectors, is insensitive to X-rays and gamma radiation as used in non-destructive testing. The detector will operate normally and will not false alarm when exposed to this type of radiation although long term exposure at high radiation levels will ultimately lead to permanent damage.

3. PERFORMANCE CHARACTERISTICS

3.1 GENERAL

A large number of fire tests has been carried out to determine the response limits of the S111 detector. The results of these tests are summarised below. In order to appreciate their significance, an understanding of the mode of operation of the detector is necessary, and a brief explanation follows.

3.1.1 MODE OF OPERATION - BEHAVIOUR IN FIRE TESTS

Flaming fires involving carbonaceous materials produce large quantities of carbon dioxide. This part of the combustion process gives rise to a very high level of infra-red radiation in the wavelength region between 4.2µm and 4.7µm. The unique patented filtering system of the S111 Detector restricts the radiation reaching the sensing cell to a narrow band of infra-red radiation in the region of 4.4µm. The radiation from a fire flickers in a characteristic way and the detector uses this flicker signal to give extra discrimination against interfering infra-red sources.

The detector circuit analyses the signal within the flicker frequency region and, if the amplitude of the signal is above a preset threshold level for three seconds, then an alarm is signalled. If the signal is below this threshold level then the detector will not alarm even after a long period of time.

The level of the signal depends upon the size of the flame and its distance from the detector. For liquid fuels the level is roughly proportional to the surface area of the burning liquid. For any type of fire the signal level varies inversely with the square of the distance.

For convenience, fire tests are normally carried out using liquid fuels burning in pans of known area in still air. The sensitivity of a detector can then be conveniently expressed as the distance at which a particular ire size can be detected. It is important to think in terms of distance rather than time because of he different burning characteristics of different fuels. Fig. 3 shows the response to two different fuels which ultimately produce the same signal level.

The signal level given by petrol quickly reaches its maximum, and produces an alarm within about six seconds of ignition. Kerosene, on the other hand, being less volatile, takes about a minute to reach equilibrium and an alarm is given in about 55 seconds from ignition.

The time taken by the fire to reach equilibrium depends of course on the initial temperature of the fuel. If the kerosene were to be pre-heated to a temperature above its flash point then its behaviour would be equivalent to that of petrol at 25C.

The test data presented below refers to fires which have reached their equilibrium condition.

3.2 FIRE TEST DATA

3.2.1 PETROL

The most convenient fuel for fire tests is petrol [gasoline] since it is readily available and quickly reaches its equilibrium burning rate.

The graph in Fig. 4 shows the detection range as a function of pan area for petrol fires. It will be seen that this curve is approximately a square law; that is to say that to obtain detection at twice the distance the pan area must be multiplied by four.

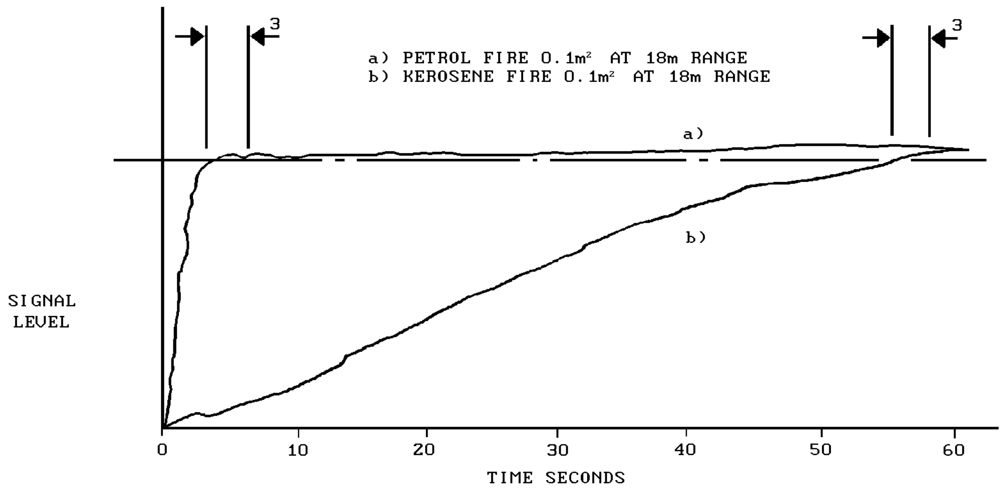

Fig. 3 Typical Response to Fires

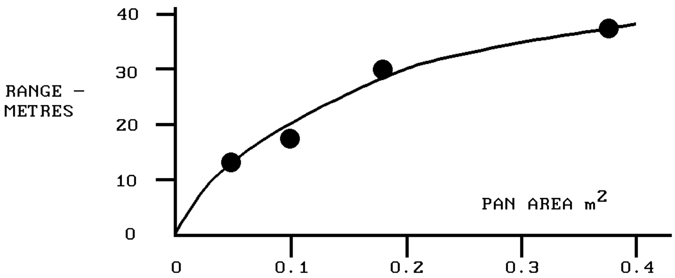

Fig. 4 Detector Range vs Pan Area - Petrol

3.2.2 OTHER LIQUID HYDROCARBONS

Ranges achieved with other fuels burning in 0.1m ^{2} pans are as follows:-

n-heptane	18m
Kerosene	18m
Alcohol (I.M.S.)	15m
Diesel oil	15m
Ethylene glycol	18m

The detection range for other pan areas may be calculated using the square law relationship given in para 3.2.1.

3.2.3 GAS FLAMES

Most flammable gases contain carbon, and the radiation produced when such gases burn is easily detected by the S111. Additionally tests have shown conclusively that “accidental” fires involving gases will produce sufficient flicker to give rapid alarm response from the detectors. This is equally true for fires resulting from low pressure [less than 0.5 lb/in^2 (0.035kg/cm ^{2})] or high pressure [greater than 300 lb/in ^{2} (21.092kg/cm ^{2})] leaks.

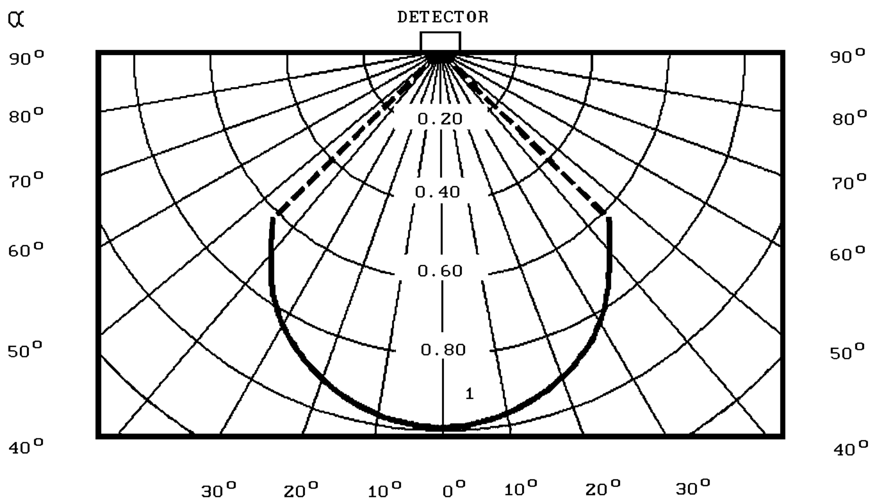

Fig. 5 Relative Range vs Angle of Incidence

Typical results obtained by burning natural gas [methane] from a 1 inch [25.4mm] diameter pipe are given below:

Gas Pressure [lb/in^2]	[kg/cm^2]	Detection Range [metres]
0.5	0.035	30
1.0	0.070	30
5.0	0.351	50
25.0	1.758	60

3.3 VOLTAGE DEPENDENCE

The sensitivity of the detector is constant over the voltage range +15.5V to +25.5V d.c. The performance outside this range is not guaranteed.

Note:The detector alarm circuit is inhibited for supply voltages of 15V or less.

3.4 TEMPERATURE DEPENDENCE

The range of the detector will vary by less than ±10% over the range -30C^o to +70C^o.

3.5 DIRECTIONAL SENSITIVITY

The sensitivity of the S111 is at a maximum on the detector axis. The variation of range with angle of incidence is shown in Fig. 5.

4. DESIGN OF SYSTEM

4.1 GENERAL

Using the information given in para 3 above it is possible to design a flame detection system having a predictable performance. Guidance on the application of the above data and on siting of detectors is given in the following paras.

4.2 USE OF FIRE TEST DATA

It has been explained in para 3 that the sensitivity of the detector is most easily specified in terms of its response to well-defined test fires.

Tests are conveniently carried out using a 0.1m^2 pan. Sensitivity to other pan areas is calculated from the square law relationship.

Accidental fires are by their very nature rarely of a well-defined size. It is still possible however to judge the response to a “real” fire using the fire test data.

For example, a spillage fire involving a highly volatile liquid such as petrol will spread very quickly from the point of ignition to cover the complete surface of the pool. Such a spillage would normally cover 2m^2 or so. Using the data for petrol fires and extrapolating to an area of 2m^2 we would expect the S111 to respond within 10 seconds at a distance of about 80 metres. At a distance of 10 metres the response time would only be a few seconds less and in any event can never be less than 3 seconds.

If on the other hand the spillage involved a less volatile material such as kerosene, the spread of flame from the ignition point would be much slower. The detector would then respond in a time dependent on the distance from the fire. At 18 metres, for example, an alarm would be given when the fire had reached 0.1m^2 and at 36 metres when the fire had grown to 0.4m^2.

4.3 DETERMINING NUMBER OF DETECTORS

It will be clear that the number of detectors required for a particular risk will depend on the area involved and the fire size at which detection is required. Large areas or small fires require large numbers of detectors.

There are as yet no agreed “rules” for the application of flame detectors and the overall system sensitivity must therefore be agreed between the installer and the end user. Once this agreement has been reached the system designer can determine the area covered by each detector by using a scaled plot based on Fig. 5 and the fire test data. This plot is best drawn to the same scale as the site plan so that direct superposition can be used to determine detector coverage.

In carrying out the design, certain factors should be kept in mind:

a) For area rather than spot protection, the best coverage will normally be obtained by mounting detectors on the perimeter of the area and pointing into the area,

b) any object within the detector’s field of view will cause a “shadow” in the protected area. Even small objects close to the detector can cause large shadows,

c) the S111 may be used to look vertically downwards on to a risk area since smoke blocking is minimal,

d) the detectors are passive devices and will not react with one another. They may therefore be positioned with their fields of view overlapping if required.

5. INTRINSIC SAFETY

The S111 complies with the harmonised European Standards:

BS 5501: Part 1: 1977 EN50 014

BS 5501: Part 7: 1977 EN50 020.

The detector has been certified by BASEEFA under certificate number Ex812333. The detector is classified:

EEx ia IIC T5.

6. OTHER STANDARDS & APPROVALS

6.1 STANDARDS

The S111 has been submitted to independent tests which show that it meets all the requirements of the C.E.A. Test Methods for Point Infra-red Flame Detectors up to its designed angle of vision of 90.

6.2 APPROVALS

S111 SERIES OF INFRA RED FLAME DETECTOR

The complete list of approvals for ALL equipment is given in Publication 05A-01-G1 which is updated at regular intervals.

7. ORDERING INFORMATION

The S111 is supplied with a socket/cable assembly having 2 metres of cable. Other lengths may be supplied to special order. The S111 is supplied complete with mounting bracket

The Stockcode is 516-009-006

JM/jm

20th February 1997