DOCUMENT CONTROL NUMBER /

S161 INFRA-RED FLAME DETECTOR

PRODUCT APPLICATION & DESIGN INFORMATION

1. INTRODUCTION

The S161 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 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 transmit infra-red between 4.2µm and 4.7µm [shown shaded in Fig. 1(a)]. The bandwidth chosen 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”.

Fig. 1(a) shows the spectrum of a typical fire of this type,

Fig. 1(b) the spectrum of the radiation of the sun and

Fig. 1(c) that of a tungsten filament lamp.

It can be seen that there is a large peak in the flame output at wavelengths in the region of 4.4µm. This peak is characteristic of carbonaceous flames and results from the formation of carbon dioxide in the flame. It can also be seen that radiation from the sun and from the filament lamp is relatively low in this region.

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

UK Patent No. 1550334

US Patent No. 4471221

Canadian Patent No. 1191229

European Patent Application No. 82301746.2

Japanese Patent Application No. 62667/82

The detector is electrically compatible with most conventional 2-wire fire detection systems. The circuit techniques used, together with the mechanical design, allows the detector to be certified for use in hazardous atmospheres.

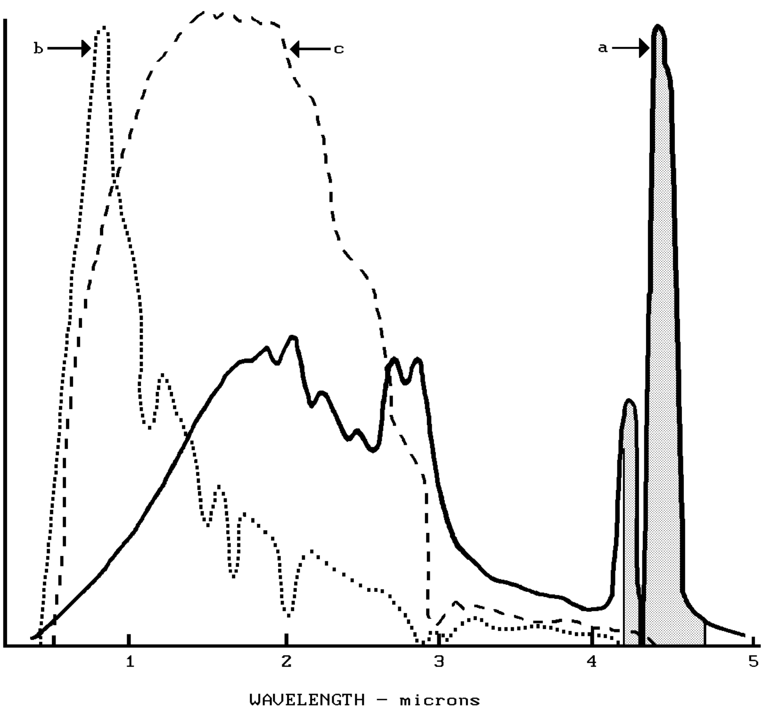

Fig. 1 Spectrums of a) Typical Carbonaceous Fire
b) Solar Radiation at Ground Level
c) Tungsten Filament Lamp

The hazardous area classification, together with the mechanical design, allows the detector to be used as a direct replacement for flameproof detectors such as the DETECTOR ELECTRONICS U7600 and U7698.

2. APPLICATION

2.1 GENERAL

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 of carbon dioxide. Typical materials in this type of risk are:-

a) Flammable liquids, including petroleum products, alcohol, and glycol etc.,

b) Flammable gases including methane,

c) Paper, wood and packing materials,

d) Coal,

e) 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, metals, and should not be used for such risks without satisfactory fire testing.

The S161, by virtue of its construction and rejection of spurious radiation, is suitable for use both indoors or outdoors in a wide range of applications.

2.2 USE IN HAZARDOUS ATMOSPHERES

The detector design uses the techniques of intrinsic safety, encapsulation and increased safety to achieve a classification of Ex e s ib IIC T5. This classification allows the detector to be used without a zener safety barrier as a direct replacement for detectors certified Ex d [flameproof]. However the circuit wiring must comply with Ex d or Ex e requirements.

3. BENEFITS OF THE S161

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

a) highly sensitive to flame thus increasing probability of early detection of hydrocarbon fires,

b) not greatly affected by window contamination by dirt and oil deposits thus decreasing maintenance frequency leading to operating cost reduction,

c) able to see flames through smoke, and able to see flames through high densities of solvent vapours thus increasing the probability of early detection of hydrocarbon fires over other [ultra-violet] detectors in the same conditions.

The S161 has all the above benefits and additionally it is

d) completely “solar-blind” in normal conditions thus eliminating false alarms due to direct or indirect sunlight,

e) insensitive to electric arcs thus eliminating false alarms from welding operations,

f) insensitive to artificial light sources,

g) suitable for use in hazardous atmospheres as a direct replacement for detectors certified Ex d [flameproof], and

h) sealed to IP67 [when suitable cable glands are used] ensuring long term reliability in harsh environments.

4. GENERAL CONSTRUCTION

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

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

The encapsulated assembly along with an encapsulated interface unit is in turn contained within a two-part impact-resistant glass reinforced moulded plastic housing, as shown in Figs. 2 and 3, designed to give a level of ingress protection to IP67. The complete detector may be mounted on an optional stainless steel bracket which allows a wide range of adjustment in two axes or the detector may be fitted directly to a suitable surface.

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

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 IP67.

Two 20mm cable entries are provided in one side of the housing and all electrical connections are made to two 4-way terminal blocks and an end of line terminal block inside the housing. A cable gland plate, secured inside the housing by metal Ex d [flameproof] cable glands [not provided], provides cable screen continuity.

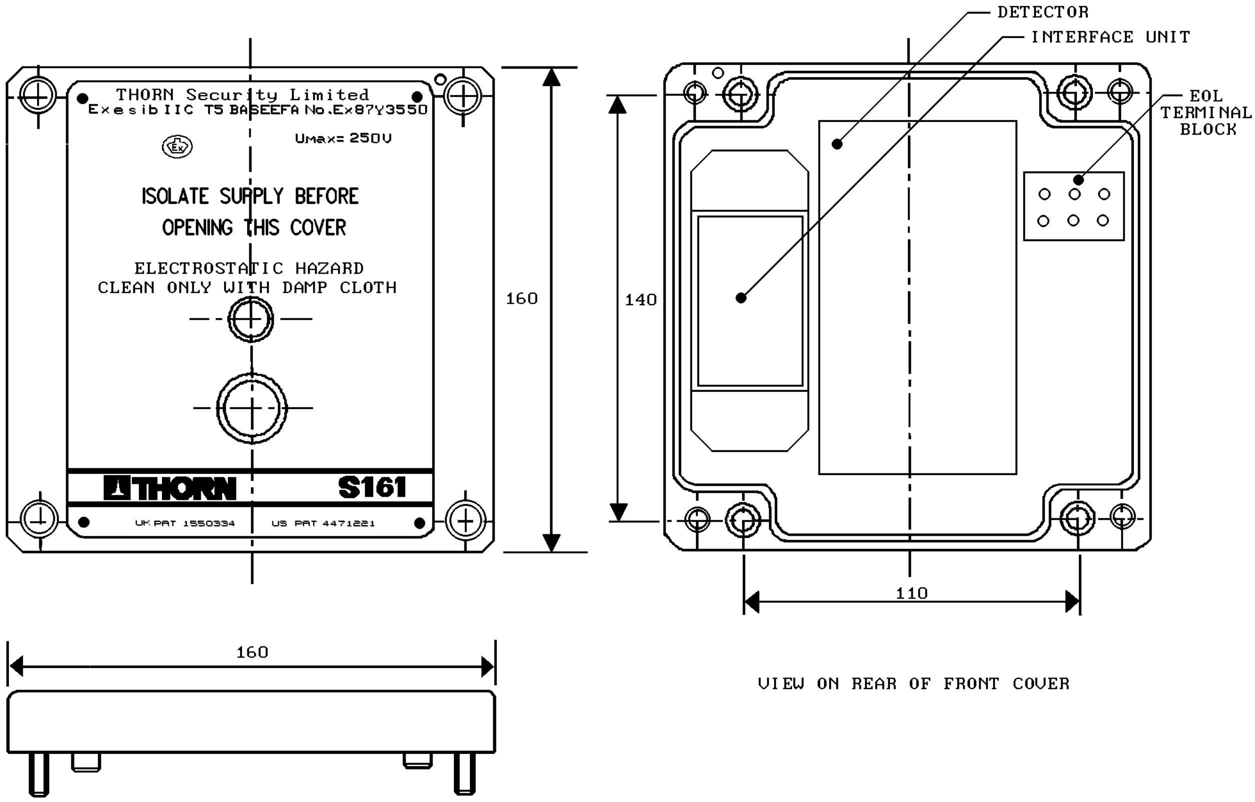

Fig. 2 S161 Cover

4.1 TECHNICAL DATA

Dimensions:	160mm x 160mm x 90mm without bracket [see Figs. 5 and 6].
Weight:	2.0kg [with optional bracket].
Enclosure:	Glass reinforced polyester plain grey
Mounting Brackets:	Bright Stainless steel to BS1449 Pt2 316 S16.
Screws, etc., exposed to the elements:	Bright Stainless steel to BS970 Pt1 316L.

5. ELECTRICAL CHARACTERISTICS

5.1 GENERAL

The S161 is a two-wire device which is designed to operate on any fire detection control equipment currently manufactured by THORN Security Limited or similar fire detection controllers. The quiescent current drain is very small and the alarm condition is latched in the detector and signalled by a large increase in current demand. Resetting is achieved by removing the supply voltage for a period of at least five seconds.

The Interface Unit is a device which limits the power transferred to the detector module to a safe level. The end to end resistance of the Interface Unit is nominally 373 ohms.

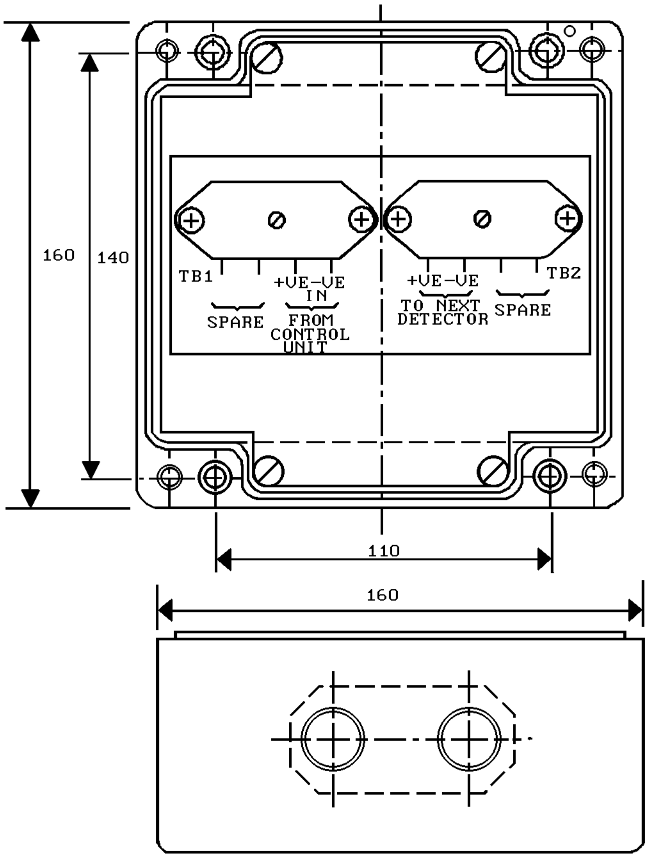

Fig. 3 S161 Housing showing Fixing Dimensions

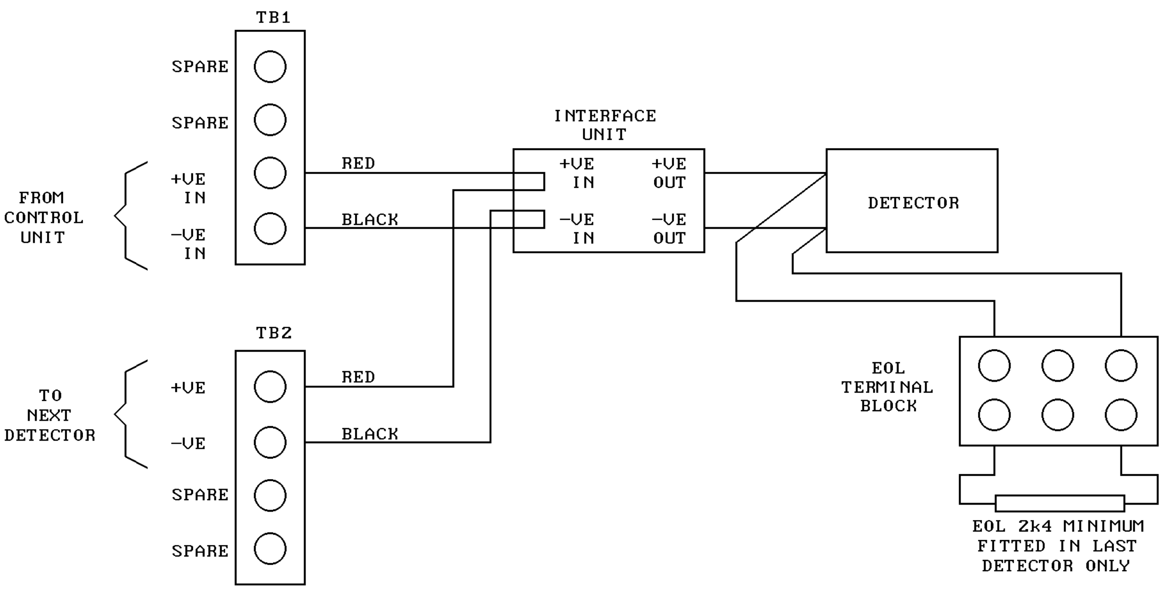

Fig. 4 S161 Connection and Internal Wiring Including EOL

5.1.1 DETECTOR ENHANCEMENTS

Detectors from serial number 16000 onwards have been modified to facilitate their use with control panels not manufactured by THORN Security Limited, where the reset is short, the detector will now reset within 0.5 secs.

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.

5.2 TECHNICAL DATA

Supply Voltage:	18.0V to 24.0V d.c. [polarity conscious]
Quiescent Current:	100µA max. at 20V d.c.
Alarm Output Mode:	2-wire, latching. 720 ohm in series with typically 4V switched across supply.
In-rush Current:	800µA peak decreasing with a time constant of 250ms to the quiescent current.
Alarm Indication:	red LED visible from front of detector.
Reset Time:	5 seconds [max.].
Reset Voltage:	supply must be reduced to less than 2V.
Stabilisation Time:	20 seconds [typical].
End of Line Resistors:	0.6Watt minimum, 2k4 minimum, metal film 5% not smaller than 2.5mm diameter and 10mm long, actual resistor value dependent on controller.

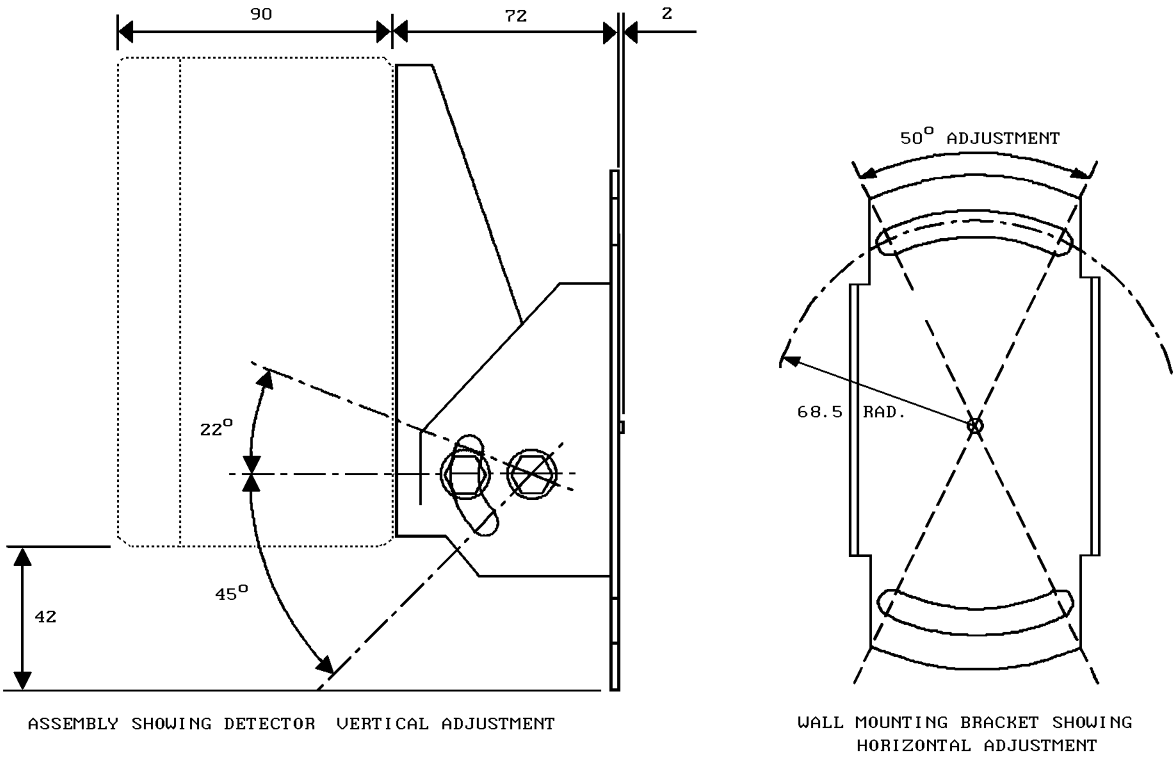

Fig. 5 Mounting Bracket [Type A Stockcode 517-001-184]

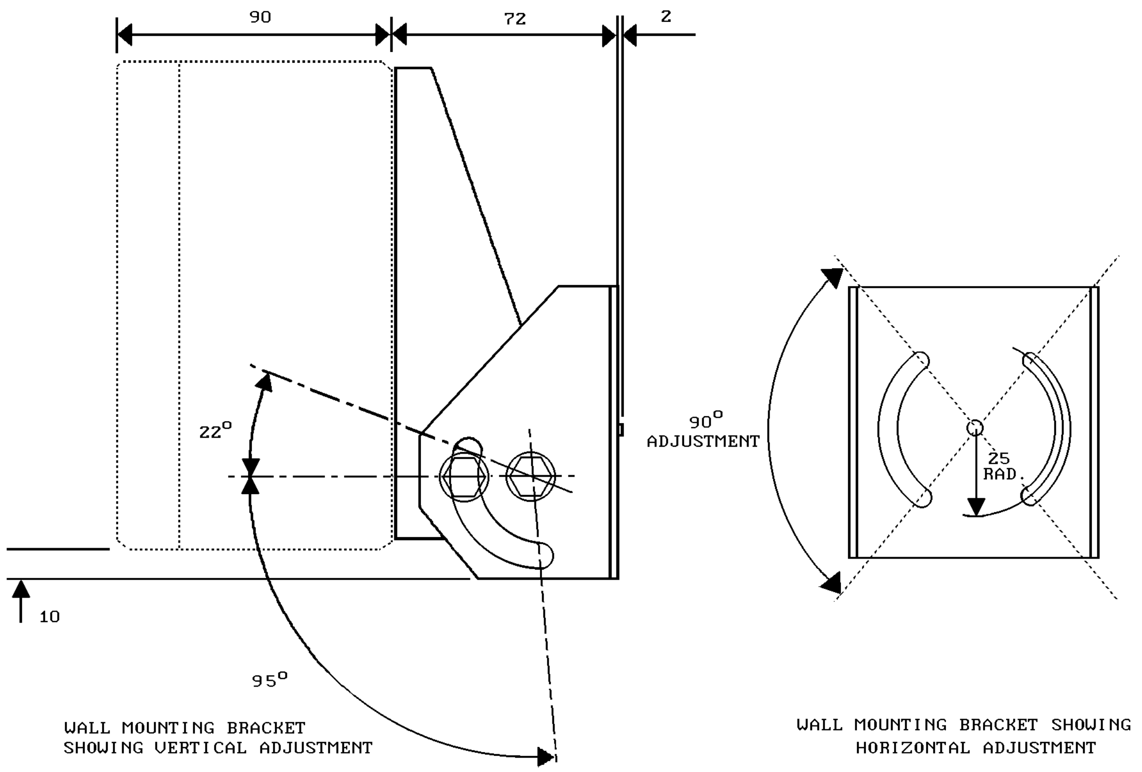

Fig. 6 Mounting Bracket [Type B Not Stockcoded]

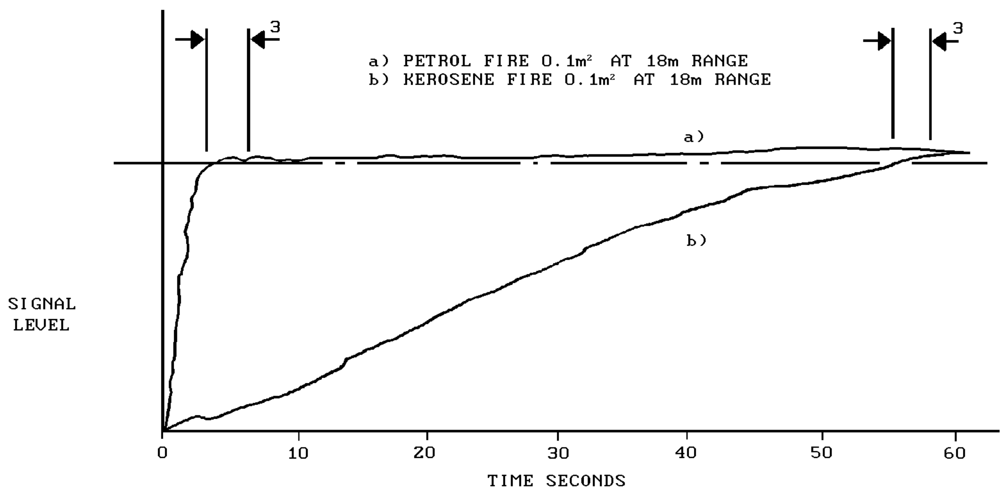

Fig. 7 Response to Fires

6. ENVIRONMENTAL

6.1 GENERAL

The design and construction of the S161 is such that it may safely be used over a wide range of environmental conditions. Relevant limits are given in Para. 6.2.

6.2 TECHNICAL DATA

6.2.1 TEMPERATURE AND HUMIDITY

Operating temperature range:	-20^{o}C to +70^{o}C [-40^{o}C with reduced range]
Storage temperature range:	-40^{o}C to +80^{o}C.
Relative humidity:	95% [100% intermittent]
Enclosure Protection:	IP67 - IEC529, BS5490.

6.2.2 VIBRATION

The S161 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	0.7g

6.2.3 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).

6.2.3.1 DETECTOR ENHANCEMENTS

Detectors from serial number 16000 onwards will be fitted with 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 approximately 1 GHz.

6.2.4 IONISING RADIATION

The S161, 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 to high radiation levels will ultimately lead to permanent damage.

7. PERFORMANCE CHARACTERISTICS

7.1 GENERAL

A large number of fire tests have been carried out to determine the response limits of the S161 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.

7.1.1 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 S161 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 fire size can be detected.

It is important to think in terms of distance rather than time because of the different burning characteristics of different fuels. Fig. 7 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 25^{o}C.

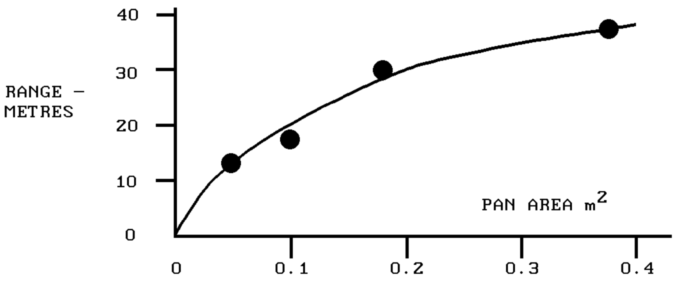

Fig. 8 Detection Range vs Pan Area - Petrol

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

7.2 FIRE TEST DATA

7.2.1 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. 8 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.

7.2.2 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 5.2.1.

7.2.3 GAS FLAMES

Most flammable gases contain carbon, and the radiation produced when such gases burn is easily detected by the S161. Additionally, tests have shown 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 (0.035 kg/cm^2)] or high pressure [greater than 300 lb/in^2(21.092 kg/cm^2)] leaks.

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

GAS PRESSURE		DETECTION RANGE
[lb/in^2]	[kg/cm^2]	[metres]
0.5	0.035	30
1.0	0.070	30
5.0	0.351	50
25.0	1.758	60

7.3 VOLTAGE DEPENDENCE

The sensitivity of the detector is constant over the voltage range +18.0V to +24.0V d.c. The performance outside this range is not guaranteed.

7.4 TEMPERATURE DEPENDENCE

The range of the detector will vary by less than ±10% over the range of -20°C to +70°C.

7.5 DIRECTIONAL SENSITIVITY

The sensitivity of the S161 is at a maximum on the detector axis. The variation of range with angle of incidence is shown in Fig. 9.

8. DESIGN OF SYSTEM

8.1 GENERAL

Using the information given in Paras 4 to 7 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 below.

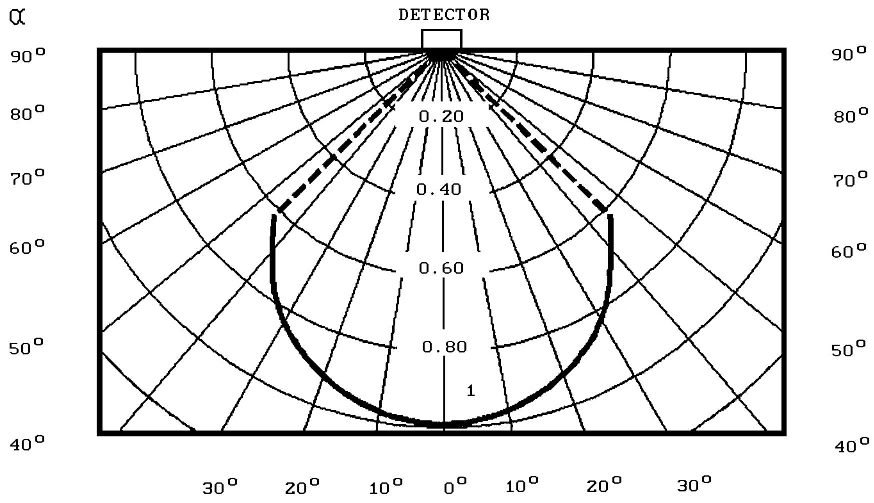

Fig. 9 Relative Range vs Angle of Incidence

8.2 USE OF FIRE TEST DATA

It has been explained in Para 7 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 S161 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 $0.4m^2$.

8.3 DETERMINING NUMBEROF 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 using a scaled plot based on Fig. 9 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 the detectors on the perimeter of the area and pointing into the area.

b) as the S161 is a line of sight detector 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 S161 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.

9. APPROVALS AND COMPLIANCE WITH STANDARDS

9.1 SAFETY

The S161 has been certified by BASEEFA for use in hazardous atmospheres under certificate number Ex 87Y3550. It is classified: Ex e s ib IIC T5, indicating a primary means of protection of Ex “e “[increased safety]. It is therefore suitable for use in zone 1 or zone 2 areas if installed to the requirements of BS5345 Parts 6 and 8.

9.2 OTHER STANDARDS

The S161 is a development from the S111 offering a more robust housing. 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^o.

9.3 OTHER APPROVALS

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

JM/jm

20th February 1997