FIRE SYSTEMS PRODUCTS

MR601TEx INTRINSICALLY SAFE ENHANCED OPTICAL SMOKE DETECTOR

PRODUCT APPLICATION AND DESIGN INFORMATION

1. INTRODUCTION

The MR601TEx Intrinsically Safe High Performance Optical Smoke Detector forms part of the M600Ex series of plug in detectors for ceiling mounting. The detector plugs into the Minerva MUBEx base and is intended for two-wire operation on the majority of the control equipment currently manufactured by the company. The Intrinsically Safe High Performance Optical detector is available in one sensitivity setting only.

2. INTRINSIC SAFETY

The detectors are designed to comply with EN 50 014 and EN50 020 for Intrinsically Safe apparatus. They are certified:

ATEX code: ⟨Ex⟩ II 1 G

Cenelec code: EEx ia IIC T5

under ATEX certificate number BAS01ATEX11134X.

These detectors are designed and manufactured to protect against other hazards as defined in paragraph 1.2.7 of Annex II of the ATEX Directive 94/9/EC.

2.1 DETECTOR USE

It is recommended that the detector is used in conjunction with a suitable isolator or shunt diode safety barrier in a certified Intrinsically Safe system, ie, System 601.

3. OPERATING PRINCIPLE

The MR601TEx operates by sensing the optical scatter from smoke particles generated in a fire. While the optical scatter detector can give good detection performance for the majority of fires, some fast burning fires produce little visible smoke and some produce very black smoke, neither of which are easily detected by the optical scatter detector. (Such fires are represented in EN 54 Part 9 by Wood Crib and Heptone type fires respectively). These fires do however, produce high heat outputs with an associated rise in air temperature.

The HPO detector has been designed to offer improved detection of such fires by detecting the rapid Rate-of-Rise of air temperature and under these conditions increasing the smoke detection sensitivity. This gives an earlier detection of such fires and a broader detection capability than a standard sensor.

The HPO detector has two sensing systems as follows:

- An optical chamber with associated electronics to measure the presence of smoke by light scatter.
- A thermistor bridge with its associated electronics to detect the presence of hot air currents.

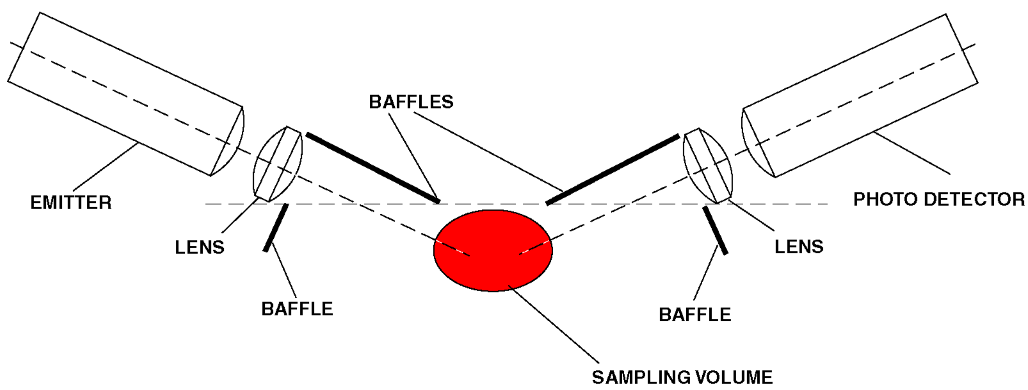


Fig. 1 Optical System Schematic

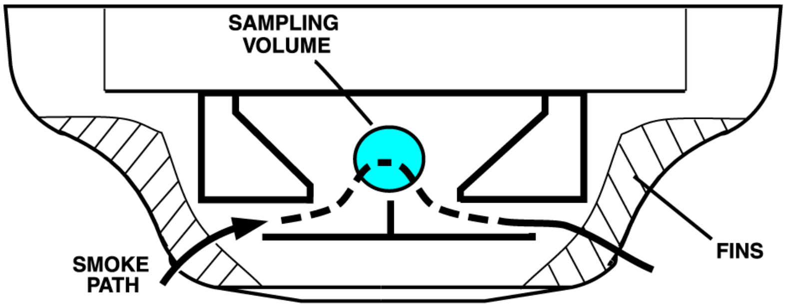


Fig. 2 Measuring Chamber Showing Smoke Flow Path

3.1 SMOKE DETECTION

The MR601TEx detects visible particles produced in fires by using the light scattering properties of the particles. Fig. 1 shows the chamber schematic.

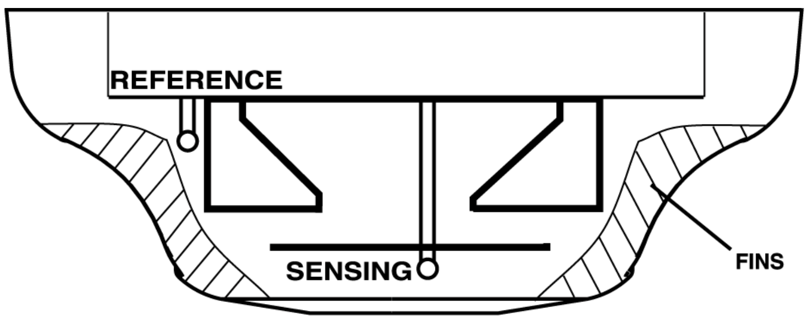
The optical system consists of an emitter and sensor, with a lens in front of each, so arranged that their optical axes cross in the sampling volume. The emitter, with its lens, produces a narrow beam of light which is prevented from reaching the sensor directly by the baffles. When smoke is present in the sampling volume, a proportion of the light is scattered, some of which reaches the sensor. For a given type of smoke, the light reaching the sensor is proportional to the smoke density. The amplified output from the sensor can be used to activate an alarm circuit at a predetermined threshold.

3.2 FEATURES OF MEASURING CHAMBER

The MR601TEx uses a unique measuring system shown in Fig. 2. Unlike most other optical scatter detectors the MR601TEx does not use vertical chevrons to exclude ambient light, but uses concentric baffles. This approach gives a better signal to noise ratio and allows the detector to be used in its high sensitivity enhanced mode. The chamber is the subject of a patent application.

The emitter (see Fig. 1) is a GaAlAs solid state type operating in the near infra-red at 880nm, while the sensor is a matched silicon photodiode. These devices together with their associated lenses are held in place by the labyrinth mouldings. The design of the labyrinth is such that the presence of small insects such as thrips should not cause false alarms.

The sampling volume is enclosed within a measuring chamber. The optical design of the chamber provides a very low background signal and is the subject of a patent application.



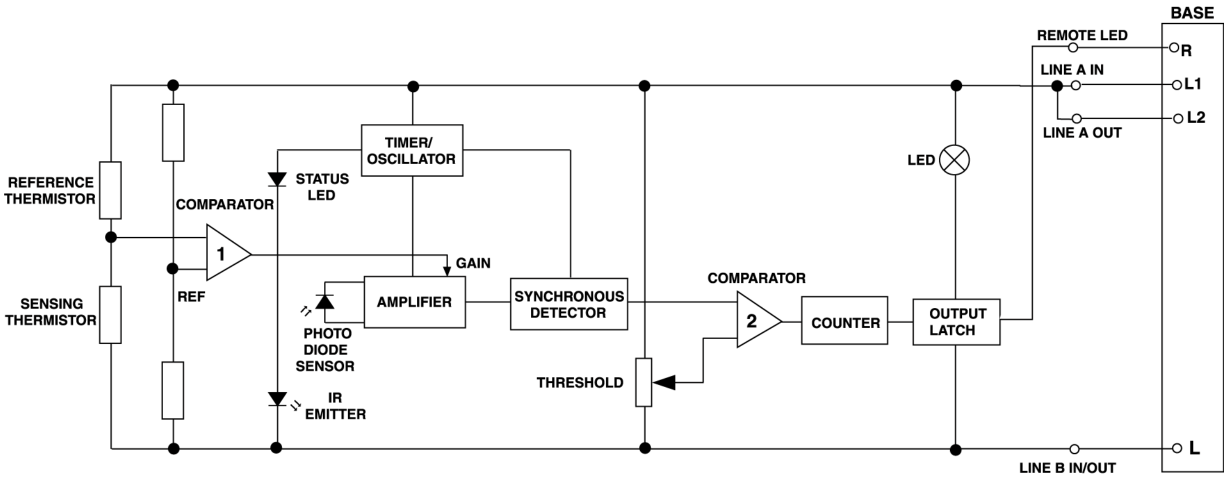


Fig. 4 Block Schematic of Detector

3.3 THERMAL MEASURING SYSTEM

Refer to Fig. 3.

This is designed to detect the presence of horizontally moving hot air draughts moving across the ceiling which occur in a fast burning fire.

The measuring system consists of two fast responding negative temperature thermistors. A sensing thermistor is located above the labyrinth under the cover in the airstream and will detect any sudden changes in the air temperature or draughts of hot air moving across the ceiling. The second thermistor is located out of the airflow within the smoke labyrinth and has a longer time constant and is used as a temperature reference to compare the sensing thermistor against. At a given temperature differential between the two thermistors, the comparator will switch and increase the gain of the amplifier, thereby increasing the sensitivity of the sensor. Fins located on the top of the labyrinth are designed to increase air turbulence and the efficiency of the sensing thermistor.

3.4 CIRCUIT OPERATIONS

A simplified block schematic of the detector is given in Fig. 4.

The emitter is subjected to a pulse stream only every 10s in order to reduce the quiescent current. The pulse signal received by the photodiode is fed to a high-gain amplifier. If smoke is present, the pulse signal received varies in proportion to the smoke density.

The amplifier output is fed via an integrator, the output of which is compared to a preset threshold level. Sophisticated synchronous detection techniques are used to reduce the effects of noise and spurious transients.

The gain of the front end amplifier is controlled by the thermistor bridge circuit. When the temperature differential between the two thermistors exceeds a certain value, the amplifier gain increases. Under these conditions the High Performance Optical detector is more sensitive to the presence of smoke and is said to be in ‘Enhanced Mode’.

When the detector is in the ‘Enhanced Mode’, the detector will only alarm if a smoke signal is present. The presence of rising temperature alone cannot cause an alarm.

If the signal amplitude exceeds a threshold level, then the emitter samples the smoke every two seconds. The sample period remains at two seconds if the signal is above the threshold. When the counter has counted three consecutive pulses above the threshold, the output stage is latched into the alarm condition. If however, the amplitude of the second or third pulse is below the threshold, then the pulse period reverts to 10 seconds and the counter resets. The switching of the output stage lights the alarm LED and provides drive for an remote LED indicator.

The critical front end of the circuit is run off a 12V regulator to make it independent of supply voltage.

The detector is polarity conscious.

3.5 WIRING

Loop cabling is connected to base terminals as follows:

L	-VE
L1	+VE IN
L2	+VE OUT
R	Remote LED Drive

4. MECHANICAL CONSTRUCTION

The major components of the detector are:

- Body Assembly
- Printed Circuit
- Optical Chamber

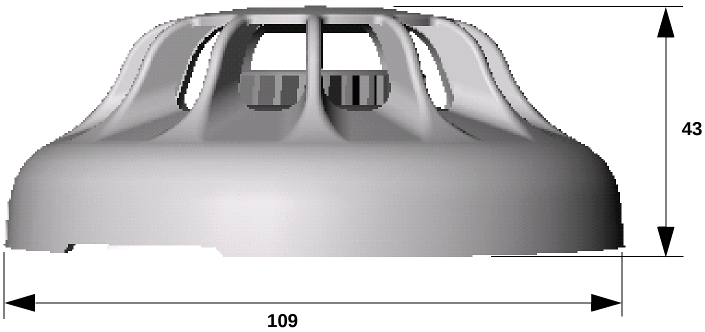


Fig. 5 Overall Dimensions of MR601TEx

- Optical Chamber Cover
- Thermistor
- Light Pipe
- Outer Cover

4.1 ASSEMBLY

The body assembly consists of a plastic moulding which has four embedded detector contacts aligning with contacts in the MB600Ex base. The moulding incorporates securing features to retain the detector in the base.

The PCB is soldered to the body contacts, then the underside of the PCB is epoxy encapsulated.

The chamber cover is clipped to the body over the optical chamber ensuring the thermistor protrudes through the cover. The light pipe is slotted into the chamber cover. Finally, the outer cover is clipped to the body.

4.2 PRINTED CIRCUIT/OPTICAL ARRAY ASSEMBLY

All electronic components are fitted to the PCB including the Alarm LED, the IR emitter, the photo-diode and the thermistors. The floor of the labyrinth clips into three holes on the PCB, the upper and lower labyrinth parts clip onto the labyrinth floor.

4.3 TEST AND FINAL ASSEMBLY

The detectors are fully functionally tested and their sensitivities set in a smoke tunnel to ensure correct calibration. The sealing ring and labels are then fitted to complete detector assembly.

5. TECHNICAL SPECIFICATION

5.1 MECHANICAL

Dimensions

The dimensions of the MR601TEx detector are shown in Fig. 5.

Materials

Body and cover:	FR110 ‘BAYBLEND’ Fire Resistant

Weight

Detector:	0.128kg
Detector + base:	0.174kg

5.2 ENVIRONMENTAL

Operating Temperature:	-20^{o}C to +70^{o}C (please see note below).
Storage Temperature:	-25^{o}C to +80^{o}C

Note:

1) ***The operating temperatures quoted exceed the ATEX Certification limits.***
2) *Operation below 0^{o}C is not recommended unless steps are taken to eliminate condensation and hence ice formation on the detector.*

Relative Humidity:	95% non-condensing

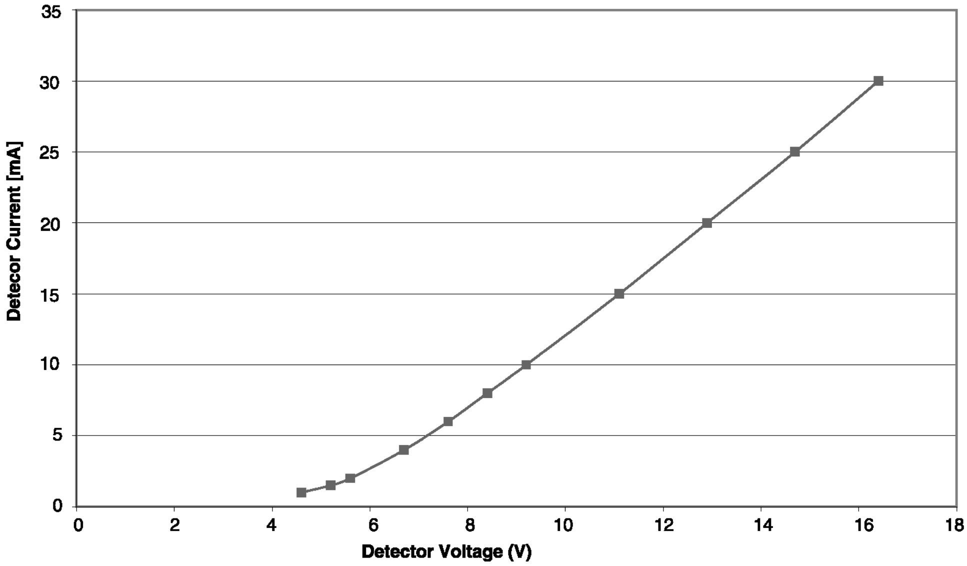


Fig. 6 Alarm Load Presented to the Controller

Shock:)
Vibration:)
Impact:) To EN54-7
Corrosion:)

5.3 ELECTROMAGNETIC COMPATIBILITY

The detector complies with the following:

Product family standard EN50130-4 in respect of Conducted Disturbances, Radiated Immunity, Electrostatic Discharge, Fast Transients and Slow High Energy

EN50081-1 for Emissions

5.4 ELECTRICAL CHARACTERISTICS

The alarm load presented to the controller is shown in Fig. 6.

The following characteristics shown in Table 1 are taken at 25°C with a supply voltage of 20V unless otherwise specified.

Characteristics	Min.	Typ.	Max.	Unit
Operating Voltage (d.c.)	16	20	28	V
Average Quiescent Current	90		110	µA
Switch-on-Surge			130	µA
Stabilisation Time			60	sec
Alarm Current	See Fig. 6			mA
Holding Voltage			5	V
Holding Current			1	mA
Reset Time		2	5	sec
Remote LED drive	Remote LED via 3.4k			

Table. 1 Electrical Characteristics

Intrinsic Safety Rating:

Maximum Voltage for safety (U_i):	28V
Maximum Current for Safety (I_i):	93mA
Maximum Power Input (P_i):	650mW
Equivalent Inductance (L_i):	0
Equivalent Capacitance (C_i):	0

5.5 PERFORMANCE CHARACTERISTICS

The fundamental parameter used to define the sensitivity of an optical smoke detector is the level of smoke which will just produce an alarm under ‘ideal’ conditions. This parameter, known as the response threshold value, is normally measured in a smoke tunnel and is defined in terms of the obscuration produced by the smoke over a one metre path. The response threshold value is normally given in dB/m, (or % per m).

Interpretation of response threshold value is somewhat complicated by the fact that the measurement is given in terms of obscuration, whereas the detector works by scattering from the smoke particles. The response threshold (m) value will therefore, depend on the colour of the smoke. Black smokes give less scattering than light smokes for given values of obscuration as shown in Fig. 7.

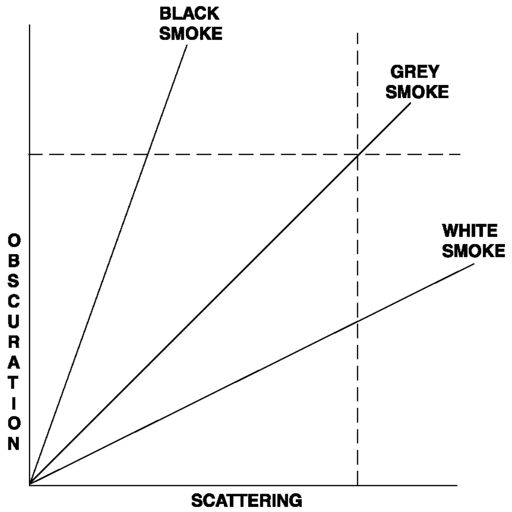


Fig. 7 Response Threshold vs Smoke Colour

Sensitivities are invariably specified for 'grey' smokes as produced by typical smouldering fires. Values for the MR601TEx are given below.

5.5.1 RESPONSE TO RATE OF CHANGE OF TEMPERATURE

The detector will not be enhanced by slow rates of change of temperature, or by cold air draughts moving across the ceiling creating negative rates of change of temperature. The detector is designed to detect sudden horizontal draughts of hot air produced by fast burning fires. The enhancement switching point has been set to allow the detection of TF1 type fires.

Normal response threshold = 0.12 dB/m, 2.7%/m typical.

Enhanced mode threshold = 0.05 dB/m, 1.1%/m typical.

5.6 RESPONSE TO FIRE TESTS

The response of an optical scatter detector to a fire will depend to a large extent on the colour of the smoke produced in the fire. However, other factors such as the detector smoke entry characteristics, the development of the fire and the thermal lift produced by the fire are important. In order to evaluate the response under realistic conditions, detectors are subjected to test fires which cover a range of fire types. These tests are defined in BS 5445: Pt 9 (EN54 Pt 9). The MR601TEx passes the following Fire Tests:

TF1	open cellulosic (wood-flaming)
TF2	smouldering pyrolysis
TF3	glowing smouldering (cotton)
TF4	open plastics (polyurethane foam)
TF5	liquid (n-heptane)

Table 2: Response to Fire Tests

Note: TF2 to TF5 are mandatory test fires required to

The MR601TEx is designed to respond to the mandatory tests TF2 to TF5 as required by BS5445 Pt 7. The MR601TEx gives an earlier response to TF5 fires than the MR601 due to its thermal circuit detecting the heat generated by this test of fire and the MR601TEx being 'enhanced'. For the same reason the MR601TEx will detect test fire TF1 (open wood cellulosic flaming fire) which is not normally detected by optical smoke detectors - demonstrating the detectors broader detection capability.

The MR601TEx does not respond to TF6 liquid (methylated spirit) which although having a rapidly rising temperature, does not generate any optical scattering. This shows that the High Performance Optical detector will not respond to hot air draughts without the presence of smoke.

6. INSTALLATION RECOMMENDATIONS

It is not recommended that the MR601TEx be installed in areas where it is likely to be regularly enhanced, since in this condition the detector is extra sensitive and there is a possibility of unwanted alarms from low ambient smoke levels.

The MR601TEx is designed to become enhanced by detecting a rapid temperature rise (>10°C) in air moving horizontally across the ceiling. Siting sensors in positions where air is being blown through the detector should therefore, be particularly avoided, eg, close to ceiling ducts or ceiling mounted industrial heaters; or areas of forced ventilation, such as ducts and under floor voids of computer suites.

Also, not recommended are areas open to the outdoors, such as cargo handling bays, or areas where the detector may become contaminated.

The MR601TEx is not recommended for use in applications where a heater jacket is required.

The MR601TEx is primarily aimed at benign environments.

7. DETECTOR IDENTIFICATION

The detector is identified by the logo label, as shown in Fig. 8.

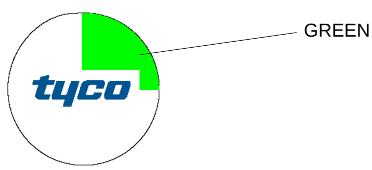


Fig. 8 Detector identification

8. ORDERING INFORMATION

MR601TEx Intrinsically Safe Enhanced Optical Smoke Detector:	516.054.011.Y
MUBEx Base for use with Ex Detectors:	517.050.610