Patol Limited

5000 Series
Infra-red Fire Detection Equipment
Report On Conveyor Simulation Tests

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Test Location : Patol Facility - Padworth

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Issue	Change	Date	Remarks
1	Original	24/04/05	

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1.0 OVERVIEW

1.1 Equipment Under Test

The Patol Limited equipment tested comprised of:-

1.1.1 Series 5000 Sensor Head

The Sensor Head was a prototype 5011 unit similar to 5010 units, but with the “standard” size aperture fitted with a sealed window.
The inner module is slightly re-positioned such that it is closer to the aperture.
The unit was configured such that the effects of a reduced size outer case aperture could be examined.

1.1.2 Series 5000 Control Unit - Type 5020.

The control unit is a standard device.

The above were operated in conjunction with a 24V power supply.

1.2 Scope of Test

The purpose of the activity was to test the 5000 system when operated in a manner that was as close to an actual conveyor application as could be practically simulated.

The scope of the test was to examine unit performance in two specific areas :-

1.2.1 To obtain data on the response of the system as related to the speed of the hot target / anomaly.

This in order to gain an understanding of the practical limits of the equipment and confirm suitability of use with conveyor speeds up to 6 m/s.

1.2.2 To verify that the 5011 prototype provides an acceptable response and that there has been no unforeseen change in performance from that of 5010 sensor heads.

The sensor head was set up such that a “mask” could be introduced in order that the aperture size of the “final” configuration could be replicated.

Notes

A) Whilst the general test arrangements were preconceived, the actual detail of procedure was evolved during the tests.

B) The tests employ a relatively small “test target” capable of a maximum temperature of only 290°C.
In practice the temperature of an anomaly such as smouldering coal is many hundreds of degrees centigrade, and the amount of infra-red emission many orders of magnitude above that for the “target” operated in the 140-290°C range.
The purpose of the test was to confirm the lower temperature limits when replicating a conveyor application.
<u>Not to replicate a fire situation</u>.

2.0 CONVEYOR SIMULATION TEST SET UP

2.1 Requirement

The aim of the test set was to simulate a hot target (anomaly) travelling on a coal conveyor passing through the field of view of the 5000 Sensor Head. This arrangement to accommodate both different conveyor speeds, and locations of the hot target across the belt.

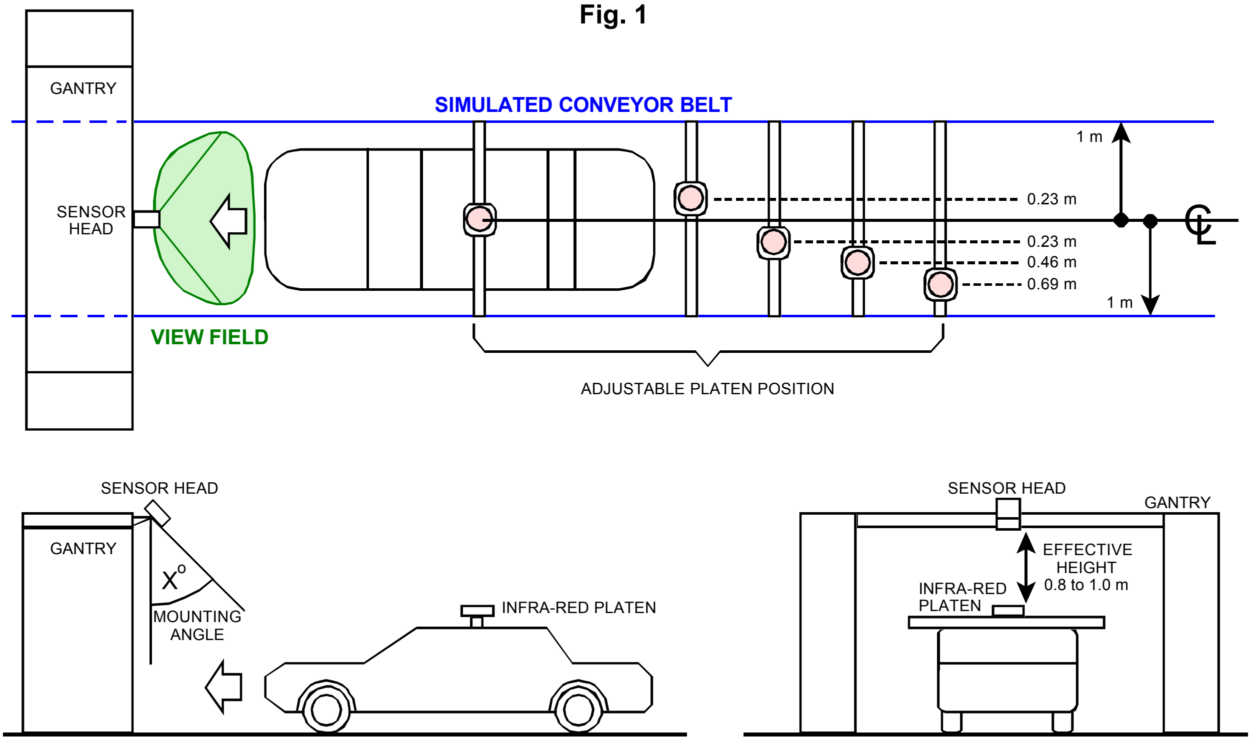
2.2 Test Arrangement

An Infra-red Test Platen (Type 5501) was mounted on the roof of a vehicle with an arrangement such the platen could be located at various positions across the roof thus simulating various locations across a conveyor belt. The Platen was mounted on a wooden beam attached to the vehicle's roof rack.
It was not possible to continuously power the platen; the device was therefore heated prior to each set of tests.
The platen had an associated digital thermometer which was also located on the vehicle. The vehicle was equipped with a digital speedometer.

A gantry was constructed, by means of two scaffolding towers, on which the sensor head was located.
The sensor head was mounted such that the vehicle could be driven beneath the sensor thus simulating a conveyor belt traversing the field of view.
Both the height of sensor above the "plane" of the platen, and the angle of the sensor were adjustable within ranges which replicate typical site parameters.

Note : Due to thermal gradients at the extremity, and similar discontinuity at the axial hub, the 5501 IR Platen is in effect a "thin" torus. The equivalent "flat" emissive area is equated to be approximately 200 sq cm at the monitored temperature.

Fig. 1



3.0 TESTS

3.1 Test 1

3.1.1 Conditions

Prior to heating the platen a number of transits were conducted at various vehicle speeds between 1 and 6 m/s. See 3.2.1 for sensor arrangement.

3.1.2 Results

No detection triggers registered.

3.2 Test 2

3.2.1 Conditions

Effective Height	Sensor Angle	Platen Location	Aperture
1.02 m	45 deg	Central	Circular / Standard

A number of runs were conducted with the temperature recorded just prior to transit start. The platen being returned to power after each transit.

3.2.2 Results

Temp at start Deg.C	Speed mph	Speed m/s	Detections
220	10	4.5	1-2-3
225	12	5.3	1-2-3-4
198	15	6.6	2-3
199	13	5.8	1-2

3.3 Test 3

3.3.1 Conditions

With the set up as per 3.2.1 a regime was evolved where the platen temperature was recorded at both transit start and end. The platen was not re-powered between transits and the natural thermal decay (cooling) allowed to prevail.

3.3.2 Results

Deg.C Start	Deg.C End	Speed mph	Speed m/s	Detections
275	263	20	8.9	2-3
248	238	14	6.2	1-2-3-4

3.4 Test 4

3.4.1 Conditions

Effective Height	Sensor Angle	Platen Location	Aperture
1.02 m	45 deg	Central	Reduced /Masked

With the test regime as evolved in 3.3.1 the aperture mask was introduced and the following results recorded.

3.4.2 Results

Deg.C Start	Deg.C End	Speed mph	Speed m/s	Detections
274	264	23	10.3	2-3
247	237	16	7.1	1-2-3-4
215	208	14	6.2	1-3
198	192	11	4.9	2-3
180	175	8	3.5	1-2-3-4
166	163	7	3.1	1-2-3
158	154	6	2.7	1-2-3-4
145	143	5	2.2	1-2-3-4
135	133	4.5	2	1-2-3-4

3.5 Test 5

3.5.1 Conditions

The sensor head angle was changed to 30 deg.

Effective Height	Sensor Angle	Platen Location	Aperture
1.02 m	30 deg	Central	Reduced/Masked

3.5.2 Results

Deg.C Start	Deg.C End	Speed mph	Speed m/s	Detections
287	274	17	7.5	2-3-4
251	240	22	9.8	None
215	209	15	6.7	2-3
194	191	13	5.8	2-3
179	175	9	4	1-2-3
163	163	5	2.2	1-2-3

3.6 Test 6

3.6.1 Conditions

The sensor height was reduced to 0.8 m.

Effective Height	Sensor Angle	Platen Location	Aperture
0.8 m	30 deg	Central	Reduced/Masked

3.6.2 Results

Deg.C Start	Deg.C End	Speed mph	Speed m/s	Detections
280	271	12	5.3	2-3-4
248	242	12	5.3	1-2-3
230	221	13	5.8	2-3
205	201	13	5.8	2-3
193	188	12	5.3	2-3
177	173	11	4.9	2-3
164	161	13	5.8	3
153	150	13	5.8	None
144	140	8	3.6	1-2-3
134	132	12	5.3	None

3.7 Test 7

3.7.1 Conditions

The platen was offset from the centre line by 0.23 m to the right.

Effective Height	Sensor Angle	Platen Location	Aperture
0.8 m	30 deg	0.23 m Right	Reduced /Masked

3.7.2 Results

Deg.C Start	Deg.C End	Speed mph	Speed m/s	Detections
270	262	12	5.3	1-2-3
248	241	12	5.3	1-2-3
229	223	14	6.2	1-2-3
211	205	11	4.9	2
195	191	12	5.3	2
179	175	10	4.4	2
166	161	7	3.1	1-2
151	147	8	3.6	1-2

3.8 Test 8

3.8.1 Conditions

The platen was offset from the centre line by 0.23 m to the left.

Effective Height	Sensor Angle	Platen Location	Aperture
0.8 m	30 deg	0.23 m Left	Reduced/Masked

3.8.2 Results

Deg.C Start	Deg.C End	Speed mph	Speed m/s	Detections
291	280	9	4	2-3-4
268	259	11	4.9	1-2-3-4
246	240	12	5.3	2-3-4
207	204	13	5.8	3-4
191	186	13	5.8	None
178	172	10	4.4	3
163	160	9	4	3-4

3.9 Test 9

3.9.1 Conditions

The platen was offset from the centre line by 0.46 m to the left.

Effective Height	Sensor Angle	Platen Location	Aperture
0.8 m	30 deg	0.46 m Left	Reduced /Masked

3.9.2 Results

Deg.C Start	Deg.C End	Speed mph	Speed m/s	Detections
286	278	11	4.9	2-3-4
261	252	13	5.8	2-3
237	230	12	5.3	2-3-4
219	214	13	5.8	3-4
203	199	12	5.3	3-4
187	184	12	5.3	4
175	171	12	5.3	None
158	153	8	3.6	2-3-4

3.10 Test 10

3.10.1 Conditions

The platen was offset from the centre line by 0.69 m to the left.

Effective Height	Sensor Angle	Platen Location	Aperture
0.8 m	30 deg	0.69 m Left	Reduced/Masked

3.10.2 Results

Deg.C Start	Deg.C End	Speed mph	Speed m/s	Detections
292	284	11	4.9	3-4
270	262	11	4.9	4
250	243	13	5.8	3
227	222	9	4.0	3-4
212	205	8	3.6	4
196	191	6	2.7	2-3-4
183	179	8	3.6	None
169	166	6	2.7	3
160	157	4	1.8	3

3.11 Test 11

3.11.1 Conditions

A test was conducted, with the set up as per 3.10.1 , to confirm that the detector triggers were not dependant on any IR radiation contribution from the vehicle's engine compartment or radiator. Two runs were conducted with a “thermally insulating sheet” (low IR emissive barrier) draped over the car’s bonnet and radiator grill.

3.11.2 Results

Deg.C Start	Deg.C End	Speed mph	Speed m/s	Detections
285	278	10	4.4	3-4
261	255	11	4.9	4

4.0 CONCLUSIONS

4.1 General Response

4.1.1 Datum - Circular Aperture - 1m / 45 deg

The test of 3.1 shows that the detector does not respond to any IR emissions from the vehicle.
(This being confirmed with Test 11 - Ref. 3.11)

The result of 3.2.2 shows that with a belt speed of ~6 m/s the platen temperature to produce two detector triggers is less than 200°C. This is commensurate with the expectation of response from the unit specification.

The results of 3.3.2 (and 3.4.2) indicate that the unit will respond with belt speeds up to 10 m/s with a reduction in sensitivity requiring an increase in platen temperature in the order of 50°C to 70°C.

4.1.2 Reduced / Rectangular Aperture - 1m / 45 deg

A comparison of 3.3.2 to 3.4.2 indicates that changing the oversized circular aperture to a rectangular one of minimum required dimensions has little or no effect on response.

The results of 3.4.2 show the 6m/s two detector point to be less than ~210°C.

At ~5m/s two triggers occur at ~195°C.

The results also indicate that with belt speeds slower than 4 m/s the unit will provide detector triggers for platen temperatures as low as 130°C.

4.2 Response With 30° Mounting Angle

4.2.1 Mounting Height - 1 m

As expected there is some change to the *focal path profile* from that at 45°, however the result of 3.5.2 indicates that at least two detector triggers occur with a belt speed of 6m/s and a platen temperature in excess of ~190°C.

Belt speeds less than 4 m/s result in detection of platen temperatures of ~160°C or even less.

4.2.2 Mounting Height - 0.8 m

Reduction of mounting height to 0.8m with an angle of 30° provides a view field width of approximately 1.3m and is probably the optimum mounting configuration for the majority of coal conveyors that will be encountered.

The result of 3.6.2 indicates there may be a slight increase in sensitivity with one detector operating at ~6m/s with a platen temperature of ~163°C and two detectors operating at ~5m/s with a temperature of ~175°C.

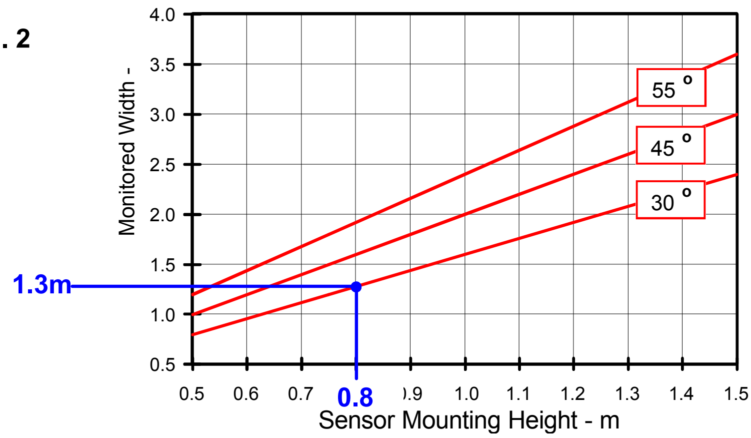
The two detector 6m/s point is less than ~200°C and may be interpolated to be as 4.2.1 at ~190°C (or even lower).

4.3 Monitored Width

4.3.1 Test Arrangement Clarification

The 30° Sensor Head angle / 0.8m height arrangement corelates to a maximum monitored belt width of 1.3m.
This is considered to be representative of a typical configuration for most coal conveyors that will be encountered.
Refer to Fig.2 (Extract from document D1101 - Technical Specification)

Fig. 2



The tests have been conducted with the Platen in five locations across the simulated "belt". Four of these positions are within the specified "field of view" for the mounting configuration. One is just outside the specified maximum "belt width". Refer to Fig.3

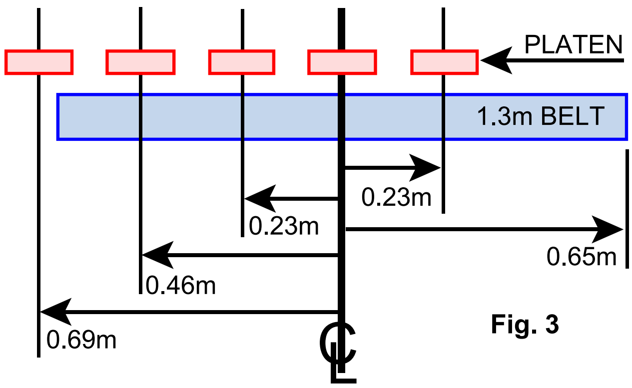


Fig. 3

4.3.2 Platen Central - Located On Centre Line (Test 6 - Ref. 3.6.2)

Three detectors triggered - 5.3m/s at ~245°C & 3.6m/s at ~142°C
Two detectors triggered - 5.8m/s at ~203°C & 4.9m/s at ~175°C
One detector triggered - 5.8m/s at ~162°C.

Two detector 6m/s point indicated at ~190°C by interpolation.

4.3.3 Platen Offset To Right - 0.23m (Test 7 - Ref. 3.7.2)

Three detectors triggered - 6.2m/s at ~226°C.
Two detectors triggered - 3.6m/s at ~149°C.
One detector triggered - 5.3m/s at ~193°C & 4.4m/s at ~177°C

Two detector 6m/s point indicated at ~210°C by interpolation.

4.3.4 Platen Offset To Left - 0.23m (Test 8 - Ref. 3.8.2)

Three detectors triggered - 5.3m/s at ~243°C & 3.6m/s at ~155°C
Two detectors triggered - 5.8m/s at ~205°C & 4.0m/s at ~160°C
One detector triggered - 4.4m/s at ~175°C

Two detector 6m/s point indicated at ~205°C or less.

4.3.5 Platen Offset To Left - 0.46m (Test 9 - Ref. 3.9.2)

Three detectors triggered - 5.3m/s at ~243°C & 3.6m/s at ~155°C
Two detectors triggered - 5.8m/s at ~216°C & 5.3m/s at ~201°C
One detector triggered - 5.3m/s at ~185°C

Two detector 6m/s point indicated at ~210°C by interpolation.

4.3.6 Platen Offset To Left - 0.69m (Test 10 - Ref. 3.10.2)

The results of 3.10.2 show a reduced sensitivity. This is as to be expected as the platen centre line is outside the recommended max belt width (1.3m) for the 30° / 0.8m configuration. Refer figs. 2 & 3 in section 4.3.1.

This result confirms the "geometry" of the published mounting information.

4.4 Summary

4.4.1 The tests indicate that there is some relationship between detector response and belt speed.

However, at least one detector channel will trigger over the full monitored belt width within a range of 140-200°C for a ~200 cm² anomaly travelling at speed up to 6m/s.

The tests generally confirm the published specification taking to account the variables of - speed - target size - mounting configuration (belt width).

Refer to Fig.4 (Extract from document D1101 - Technical Specification)

4.4.2 The tests indicate that the system will provide <u>two or more</u> detector triggers for a ~200 cm² 150-190°C anomaly at belt speeds of 1 to 4m/s.

4.4.3 The tests indicate that the system will provide <u>two or more</u> detector triggers for a ~200 cm² 190-220°C anomaly at belt speeds of 4 to 6m/s.

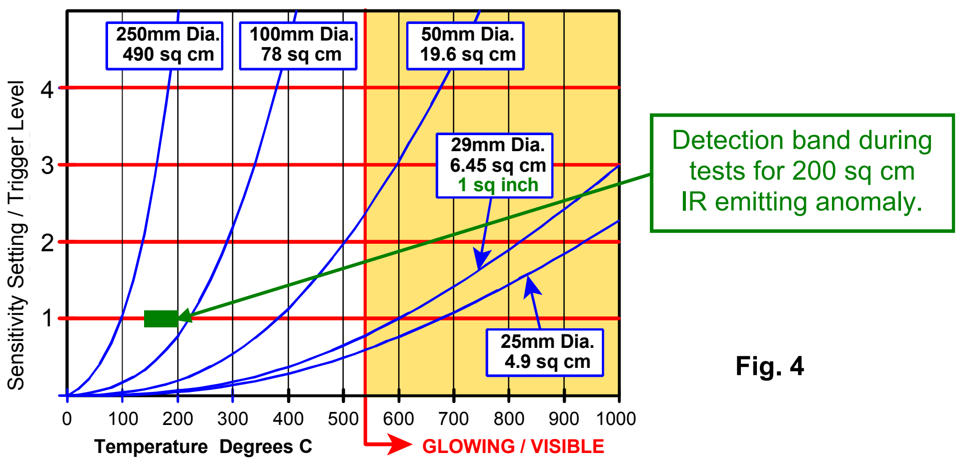
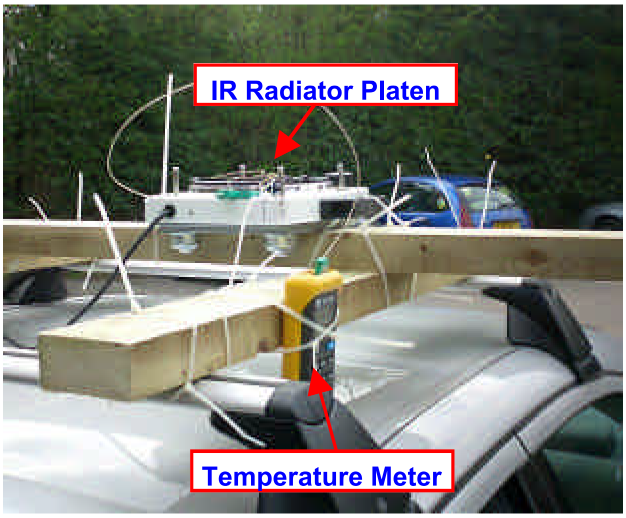
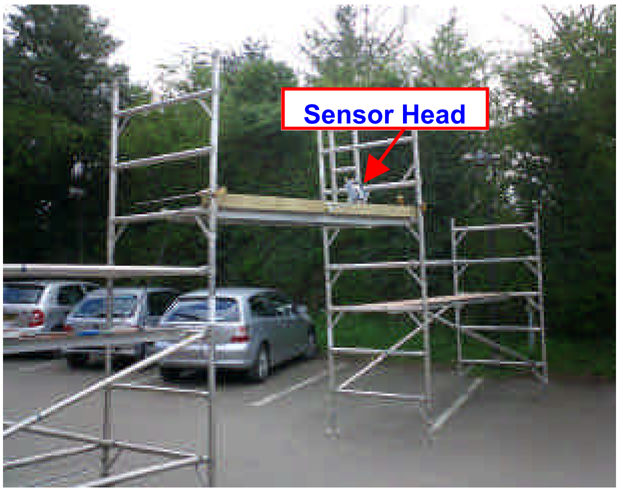


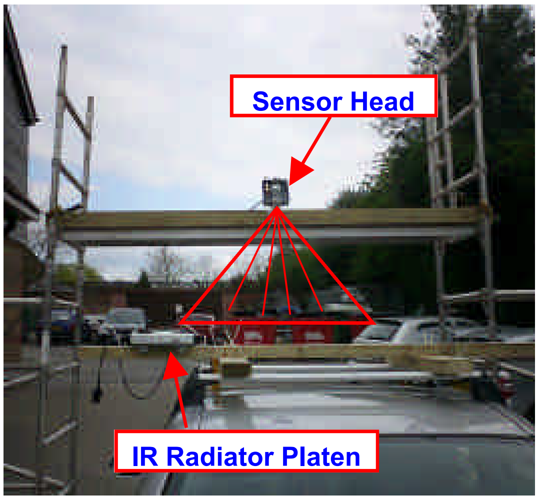
Fig. 4

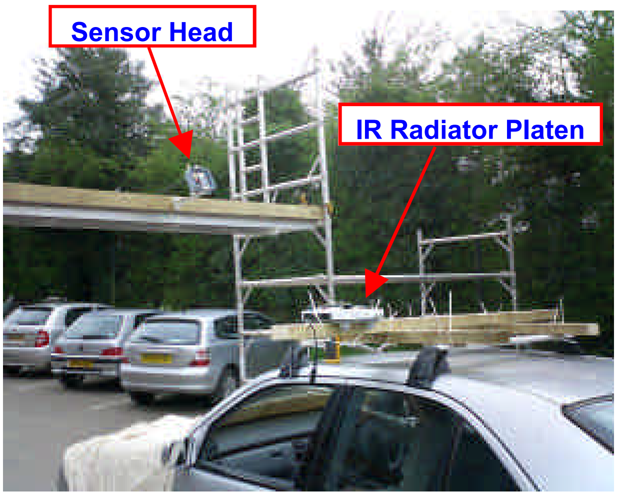
Section 5

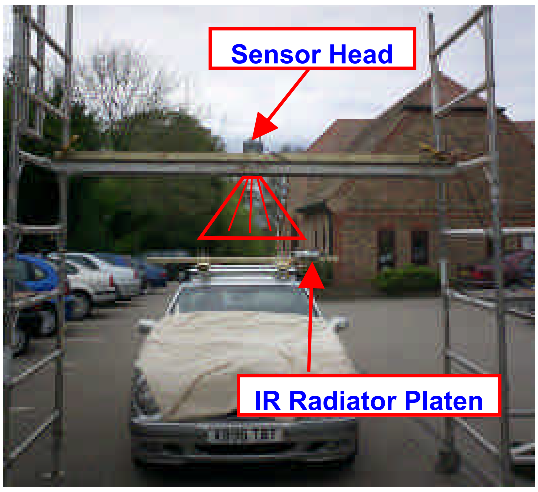
Photographs of test set-up.











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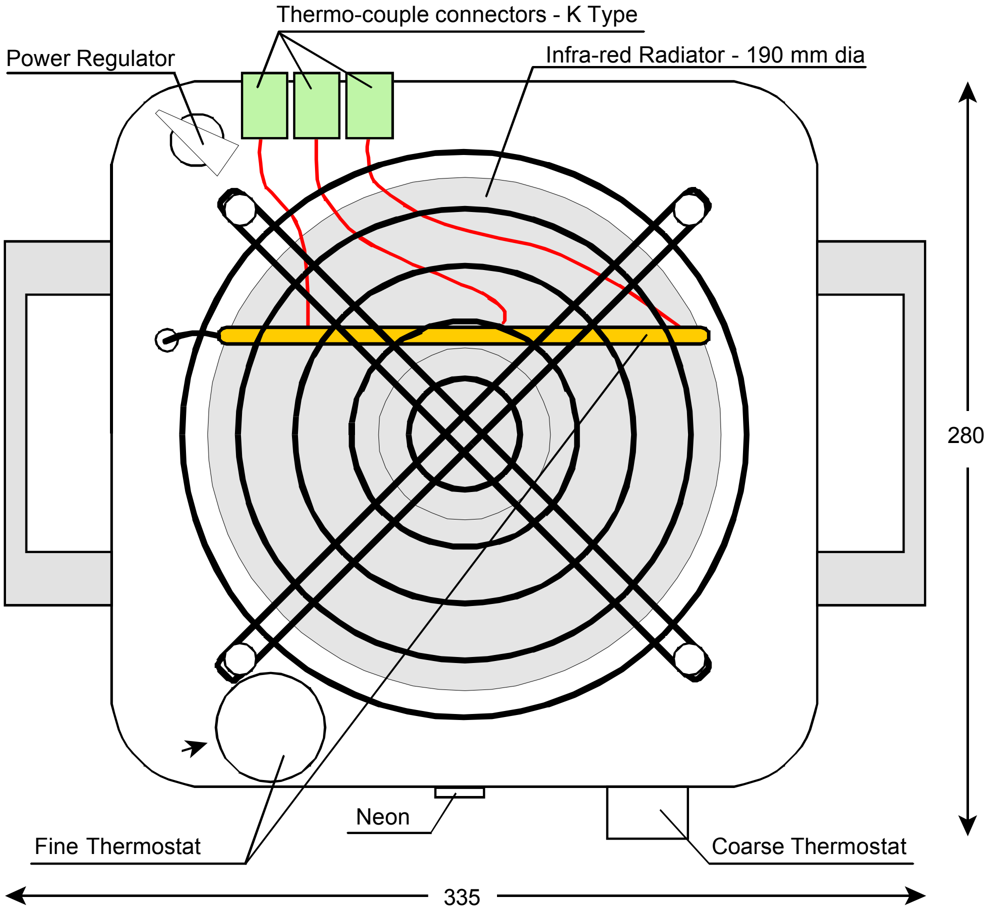
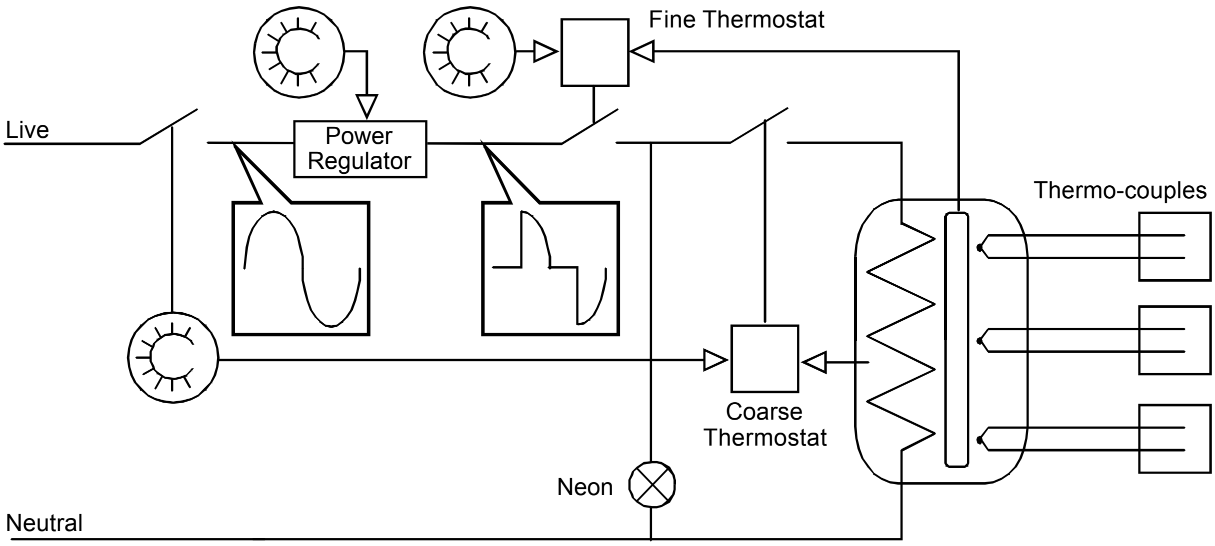
TYPE 5501 INFRA-RED RADIATOR

Test and Commissioning Platen





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Description

The unit is designed for testing the operation of Infra-red detecting equipment by simulating abnormal temperature targets entering the field of view, and is fitted with four ball type castors in order that it may be readily moved on a “Test Bed”.

Various controls are fitted to the device as follows :-

Coarse thermostat with combined on/off switch (+/- 20 deg.C control about set point)

Fine thermostat (+/- 5 deg.C control about set point)

Power regulator - Used to negate “Over Shoot” due to thermal mass of platen

Thermo-couples and associated connectors - K Type - 3 off

Operating Procedure (From Cold)

A) Arrange to monitor the Thermo-couples with an appropriate instrument.

B) Set the *Fine Thermostat* to the required temperature.

C) Set the *Power Regulator* to the “Boost” position.

D) Apply mains supply and move the *Coarse Thermostat* from the “Off” position to the required temperature.

E) When the *Fine Thermostat* first operates (Neon extinguishes) set the *Power Regulator* to the “Idle” position

F) Allow the unit to stabilise for 30 mins.

G) Observe the Infra-red Radiator temperature by means of the thermo-couples. If necessary make minor adjustments to the *Fine Thermostat* and *Power Regulator* to achieve the required “mean” temperature taking into account surface distribution variations and control hysteresis cycle. Also see note.

Note:

In theory it is possible to reduce the *Power Regulator* setting such that the Infra-red Platen stabilises at a constant temperature within the *Fine Thermostat* control hysteresis band. This is dependant on both the regulation of the mains supply voltage and the stability of the ambient temperature. (The energy input equals the thermal dissipation.)

Either way, the closer that the input to output is balanced, the more uniform will be the surface temperature during the heating portion of the control cycle.

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