

RESOLUTION A.516 (13)

*Adopted on 17 November 1983
Agenda item 10(b)*

**RECOMMENDATION ON FIRE TEST PROCEDURES FOR
SURFACE FLAMMABILITY OF BULKHEAD
AND DECK FINISH MATERIALS**

THE ASSEMBLY,

RECALLING Article 16(j) of the Convention on the International Maritime Organization concerning the functions of the Assembly in relation to regulations concerning maritime safety,

NOTING Assembly resolution A.166(ES.IV) entitled "guidelines on evaluation of fire hazard properties of materials" which, *inter alia*, contains guidelines for deciding the flame-spread characteristics of surface and finishing materials,

RECOGNIZING that "low flame spread" is defined in regulation 3.8 and referred to in regulations 34.3 and 49.1 of chapter II-2 of the 1981 SOLAS amendments,

DESIRING to ensure uniformity in the test procedures for measuring surface flammability of bulkhead and deck finish materials as a basis for characterizing their flammability and suitability for use in marine construction,

HAVING CONSIDERED the recommendation made by the Maritime Safety Committee at its forty-eighth session:

1. ADOPTS the Recommendation on Fire Test Procedures for Surface Flammability of Bulkhead and Deck Finish Materials, set out at Annex to the present resolution which supplements the guidelines of resolution A.166(ES.IV);
2. RECOMMENDS Governments concerned to apply the fire test procedure set out in the Annex in conjunction with the guidelines on the evaluation of fire hazard properties of materials set out in resolution A.166(ES.IV);
3. REQUESTS the Maritime Safety Committee to keep the Recommendation under review in the light of experience gained in its application and to report as necessary to the Assembly.

ANNEX

**RECOMMENDATION ON FIRE TEST PROCEDURES FOR SURFACE
FLAMMABILITY OF BULKHEAD AND DECK FINISH MATERIALS**

1 Scope

This Recommendation specifies a procedure for measuring fire characteristics of bulkhead and deck finish materials as a basis for characterizing their flammability and thus their suitability for use in marine construction.

2 Warning

2.1 Ignition hazards: The use of this test method involves the generation of very high heat flux levels which are capable of causing ignition of some materials such as clothing following even brief exposures. Precautions should be taken to avoid accidental ignitions of this type.

2.2 Toxic fume hazards: The attention of the user of this test is drawn to the fact that the fumes from burning materials often include carbon monoxide. Other more toxic products may in many instances be produced. Suitable precautions should be taken to avoid any extended exposure to these fumes.

3 Definitions

Certain terms used in this Recommendation require definition for clarity. Other fire characteristics terms are also used; these are defined hereunder but relate only to the results of measurements by this specific test method.

3.1 Compensating thermocouple: A thermocouple for the purpose of generating an electrical signal representing long term changes in stack metal temperatures. A fraction of the signal generated is subtracted from the signal developed by the stack gas thermocouples.

3.2 Critical flux at extinguishment: A flux level at the specimen surface corresponding to the distance of farthest advance and subsequent self extinguishment of the flame on the centreline of a burning specimen. The flux reported is based on calibration tests with a dummy specimen.

3.3 Dummy specimen: A specimen used for standardizing the operating condition of the equipment; it should be of roughly 20 mm thickness, $800 \pm 100 \text{ kg/m}^3$ density and should meet the requirements of resolution A.472(XII) as non-combustible.

3.4 Fume stack: A box-like duct with thermocouples and baffles through which flames and hot fumes from a burning specimen pass. Its purpose is to permit measurement of the heat release from the burning specimen.

3.5 Heat of ignition: The product of ignition delay time and the flux level at the 50 mm position on the specimen; this latter obtained in prior calibration of the apparatus.

3.6 Heat release of specimen: The observed heat release under the variable flux field imposed on the specimen and measured as defined by the test method.

3.7 Heat for sustained burning: The product of time from initial specimen exposure until arrival of the flame front and the incident flux level at that same location as measured with a dummy specimen during calibration.

3.8 Reverberatory wires: A wire mesh located in front but close to the radiating surface of the panel heat source. This serves to enhance the combustion efficiency and increase the radiance of the panel.

3.9 Viewing rakes: A set of bars with wires spaced at 50 mm intervals for the purpose of increasing the precision of timing flame front progress along the specimen.

4 Principle of the test

This test provides methods for evaluating flammability characteristics of 155 x 800 mm specimens in either a horizontal or vertical orientation. The specimens are exposed to a graded radiant flux field supplied by a gas fired radiant panel. Means are provided for observing the times to ignition, spread and extinguishment of flame along the length of the specimen as well as for measuring the compensated millivolt signal of the stack gas thermocouples as the burning progresses. Experimental results are reported in terms of: heat of ignition, heat of sustained burning, critical flux at extinguishment and heat release of the specimen during burning.

5 Facility and apparatus requirements

5.1 General: A detailed description of the facility and apparatus required for conduct of this test is included in the appendix. Compliance with the appendix forms an essential requirement of the test method. The equipment needed may be summarized as follows:

5.1.1 Special test room fitted with fume exhaust system as well as fresh air inlet.

5.1.2 Radiant panel frame fitted with blower or other source of combustion air, a methane or propane gas supply system with suitable safety controls, and a radiant panel heat source, with reverberatory wires, arranged for simple adjustment to radiate on either a vertical or horizontal specimen.

5.1.3 The specimen holder frame, three specimen holders, two pilot burners, specimen holder guides, viewing rakes and a viewing mirror.

5.1.4 A specimen fume stack with both stack gas and stack temperature compensating thermocouples together with a means for adjusting the magnitude of the compensation signal.

5.1.5 Instrumentation comprising a chronograph, digital or sweep second electric clock, a digital millivoltmeter, a two channel millivolt recorder gas flow meter, one or two heat flux meters, a wide angle total radiation pyrometer and a stopwatch.

6 Calibration

Mechanical, electrical and thermal calibrations should be performed as described in the appendix. These adjustments and calibrations should be performed following initial installation of the apparatus and at other times as the need arises.

6.1 Monthly verification: The calibration of the flux distribution on the specimen and the proper operation of the fume stack with its thermocouple system should be confirmed by monthly tests, or at more frequent intervals if this is found necessary. (See 4.6 in the appendix.)

6.2 Daily verification: As a means of assuring continued proper adjustment of the apparatus, the following tests should be performed on a daily basis, or more frequently if the nature of the specimens makes this necessary.

6.2.1 Adjustment of the pilot burner: The gas and air supply should be adjusted to provide a flame length of about 230 mm. When this has been done the flame length as viewed in a darkened laboratory will be seen to extend about 40 mm above the upper retaining flange of the specimen holder. The burner spacing from the specimen is adjusted with the use of soft wood splines of 3 mm thickness and of 10 and 12 mm width. When these splines are moved during a two seconds exposure along the flame length, between the pilot burner flame and a dummy specimen surface the 10 mm spline should not be charred but the 12 mm spline should show char. With the specimen in the vertical position the charring of the 12 mm spline should occur over a vertical distance of at least 40 mm from the upper exposed edge of the specimen. With the specimen in the horizontal position the charring distance should be at least 25 mm and be located about the midwidth of the specimen. (See figure 9 in the appendix.)

6.2.2 The stack gas thermocouples should be cleaned by light brushing at least daily. This cleaning may be required more frequently, even, in some instances, before each test when materials producing heavy soot clouds are tested. These thermocouples should also be individually checked for electrical continuity to ensure the existence of a useful thermojunction. Following daily cleaning of the parallel connected stack gas thermocouples both they and the compensating junction should be checked to verify that the resistance between them and the stack metal is in excess of 10^9 ohms.

6.3 Continuous monitoring of operation: A dummy specimen should remain mounted in the position normally occupied by a specimen whenever the equipment is in stand-by operation. This is a necessary condition of the continuous monitoring procedure which is accomplished by measuring:

- .1 the millivolt signal from the total radiation pyrometer mounted securely on the specimen holder frame to view the surface of the radiant panel;
- .2 the millivolt signal from a heat flux meter positioned at 50 mm from the exposed end of a dummy specimen.

Either of these measurement methods would be satisfactory for determining that an appropriate thermal operating level has been achieved. The use of the radiation pyrometer is preferable since it permits continuous monitoring of panel operating level even when tests are in progress. The measurement made by the method used should have remained essentially constant for a period of three minutes prior to the start of a test. This observed operating level should correspond within two per cent of the similar measured condition during the calibration procedure mentioned in 6.1 above.

7 Specimens

7.1 Number required: Three specimens should be tested for each different exposed surface and specimen orientation of the product evaluated.

7.2 Dimensions: The specimens should be 155 ± 0 mm wide by 800 ± 0 mm long, and should be representative of the product.

7.2.1 Specimen thickness: Materials and composites of normal thickness 50 mm or less should be tested using their full thickness. For materials and composites of normal thickness greater than 50 mm, the requisite specimens should be obtained by cutting away the unexposed face to reduce the thickness to 50 ± 3 mm.

7.3 Composites: Assemblies should be as specified in 7.2. However, where thin materials or composites are used in the fabrication of an assembly, the presence of an air gap and/or the nature of any underlying construction may significantly affect the flammability characteristics of the exposed surface. The influence of the underlying layers should be recognized and care taken to ensure that the test result obtained on any assembly is relevant to its use in practice.

7.4 Metallic facings: If a bright metallic faced specimen is to be tested it should be painted with a thin coat of flat black paint prior to conditioning for test.

7.5 Marking specimens: A line should be marked centrally down the length of the tested face of each specimen. Caution should be exercised to avoid the use of a line which would influence specimen performance.

7.6 Conditioning of specimens: Before test, the specimens should be conditioned to constant moisture content, at a temperature of $23 \pm 2^\circ\text{C}$, and a relative humidity of $50 \pm 10\%$. Constant moisture content is considered to be reached when, following two successive weighing operations, carried out at an interval of 24 hours, the measured masses do not differ by more than 0.1 per cent of the mass of the specimen.

8 Test procedures

8.1 General considerations: The test method involves mounting conditioned specimens in a well defined radiant flux field and measuring the time of ignition, spread of flame, its final extinguishment together with a stack thermocouple signal as an indication of heat release by the specimen during burning. Attention of operators is drawn to the presence of high radiation flux fields and the possible ignition of clothing together with the presence of toxic fumes that may result during operation of this equipment. Precautions should be taken to avoid these hazards.

8.1.1 The dummy specimen in a specimen holder should be mounted in position facing the radiant panel. The equipment fume exhaust system should be started.

8.1.2 The radiant panel is operated to realise the test conditions as specified in 6.3.

8.1.3 When the radiant panel has attained thermal equilibrium, after the preheat period, light the pilot flame. Thermal equilibrium should be monitored again.

8.1.4 Start the stack thermocouple millivolt recorder and wait at least 3 minutes to observe that a steady signal has been achieved.

8.1.5 Prepare a properly conditioned specimen for test in a cool holder away from the heat of the radiant panel. Prior to insertion in the specimen holder the back and edges of the specimen should be wrapped in a single sheet of aluminium foil of 0.02 mm thickness and dimensions of $(175 + a)$ mm x $(820 + a)$ mm where "a" is twice the specimen thickness. When inserted in the specimen holder each specimen should be backed by a cool 10 ± 2 mm sheet of non-combustible refractory insulating material with the same lateral dimensions and density as the dummy specimen.

8.1.6 Within a 10 second interval remove the dummy specimen holder and insert the specimen in the test position. Immediately start both the clock and chronograph.

8.1.7 Operate the event marker of the chronograph to indicate the time of ignition and arrival of the flame front during the initial rapid involvement of the specimen. The arrival at a given position should be observed as the time at which the flame front at the longitudinal centreline of the specimen is observed to coincide with the position of two corresponding wires of the viewing rakes. These times are recorded manually both from measurement on the chronograph chart and observations of the clock. As far as possible the arrival of the flame front at each 50 mm position along the specimen should be recorded. Record both the time and the position on the specimen at which the progress of flaming combustion ceases.

8.1.8 Throughout the conduct of the test no change should be made in the fuel supply rate to the radiant panel to compensate for variations in its operating level.

8.2 Duration of test: The test should be terminated, the specimen removed, and the dummy specimen in its holder reinserted when any one of the following is applicable:

- .1 The specimen fails to ignite after a 10 minute exposure.
- .2 Three minutes have passed since all flaming from the specimen ceased.
- .3 Flaming reaches the end of the specimen or self extinguishes and thus ceases progress along the specimen. This criterion should only be used when heat release measurements are not being made.

8.2.1 Operations 8.1.1 to 8.1.8 should be repeated for two additional specimens (see 8.3).

8.3 Conditions of retest: In the event that the first two of three specimens do not ignite following exposure for 10 minutes, at least one specimen should be tested with an impinging pilot flame. If this specimen ignites two additional tests should be run under this condition.

8.4 Observations: In addition to the recording of the experimental data, observations should be made and recorded on general behaviour of the specimen including: glowing, charring, melting, flaming drips, disintegration of the specimen, etc.

9 Derived fire characteristics

Experimental results should be reported in terms of the thermal measurements of incident flux measured with a dummy specimen in place. They should not be compensated for in changes in thermal output of the radiant panel during the conduct of the test. The following data should be derived from the test results.

9.1 Heat of ignition: the product of time to ignition and incident flux 50 mm from the hot end of the specimen.

9.2 Heat of sustained burning: the product of time for flame front arrival at each 50 mm interval along the specimen and the calibrated flux level corresponding to the station or position involved. An average value of this characteristic for the group of flame front positions observed following the initial ignition transient should also be secured.

9.3 Critical flux at extinguishment: the flux level, determined during calibration, at the location at which burning ceases at the centreline of the specimen.

9.4 Heat release of the specimen: Both a heat release-time curve and the area under this curve representing, on the basis of the calibration method used, the heat release of the specimen under the conditions of test. The data should be corrected for the non-linearity of the stack calibration curve.

9.5 Limitations on data from horizontal specimens: during tests of specimens in the horizontal position it is not practical to measure heat release by the method described in this test. As a result, data called for in 9.4 are not required.

10 Classification

11 Test report

The test report should include both the original data, observations made on each specimen tested and the derived fire characteristics. The following information should be supplied:

11.1 Name and address of testing laboratory.

11.2 Name and address of sponsor.

11.3 Name and address of manufacturer/supplier.

11.4 Full description of the product tested including trade name, together with its construction, orientation, thickness, density and where appropriate the face subjected to test. In the case of specimens which have been painted or varnished, the information recorded should include the quantity and number of coats applied as well as the nature of the supporting materials.

11.5 Data from the test including:

11.5.1 Number of specimens tested.

11.5.2 Orientation of each test and type of pilot flame used.

11.5.3 Duration of each test

11.5.4 Observations recorded in accordance with 8 above.

11.5.5 Other relevant observations from the test, such as flashing, unstable flame front, whether or not pieces of burning materials fall off, separations, fissures, sparks, fusion, changes in form.

11.5.6 Derived fire characteristics as described in 9 above.

11.6 A limiting use statement: The test results relate only to the behaviour of the test specimens of a product under the particular conditions of the test, they are not intended to be the sole criterion for assessing the potential fire hazard of the product in use.

APPENDIX

This appendix provides technical information intended to permit construction, erection, alignment and calibration of the physical equipment required for the conduct of tests by this procedure.

1 Test equipment fabrication

Figures 1 to 5 show photographs of the equipment as assembled ready for test. Detailed drawings and a parts list are available from the IMO Secretariat. These provide engineering information necessary for the fabrication of the main frame, specimen holders, stack and other necessary parts of the equipment.

1.1 Brief parts list for the test equipment assembly includes:

1.1.1 The main frame figure 1 comprises two separate sections, the burner frame and the specimen support frame. These two units are bolted together with threaded rods permitting flexibility in mechanical alignment.

1.1.2 Specimen holders which provide for support of the specimens during test. At least two of these are required. Three prevent delays resulting from required cooling of holders prior to mounting specimens.

1.1.3 A specimen fume stack complete with gas and stack metal compensating thermocouples.

1.1.4 The radiant panel has radiating surface dimensions of 280 x 483 mm. It has been specially fabricated for use with this equipment through use of commercially available porous refractory tiles.

1.1.5 The blower for combustion air supply, radiant panel, air flow metering device, gas control valves, pressure reducer and safety controls are all mounted on the burner frame figure 3. Requirements are summarized below:

- 1 Air supply of about 30m³/h at a pressure sufficient to overcome the friction losses through the line, metering device, and radiant panel. The radiant panel drop amounts to only a few millimetres of water.
- 2 The gas used may be either natural gas or propane. A pressure regulator should be provided to maintain a constant supply pressure. Gas is controlled by a manually adjusted needle valve. No venturi mixer is necessary. Safety devices include an electrically operated shutoff valve to prevent gas flow in the event of electric power failure, air pressure failure and loss of heat at the burner surface. The gas flow requirements are roughly 1.0 to 3.7 m³/h for natural gas or methane and about 0.4 of this flow rate for propane at a pressure to overcome line pressure losses.

1.1.6 The specimen holder, pilot flame holder, fume stack, flame front viewing rakes, radiation pyrometer and mirror are all assembled on the specimen support frame. The arrangement of parts on this frame is evident in figures 1 and 2. The mirror must be covered to prevent damage when specimens are tested in the horizontal position.

1.1.7 A dummy specimen approximately 20 mm thick made of non-combustible refractory board of 800 ± 100 kg/m³ density should be continuously mounted on the apparatus in the position of a specimen during operation of the equipment. This dummy specimen should only be removed when a test specimen is to be inserted.

2 Instrumentation

2.1 Total radiation pyrometer: This should have a sensitivity substantially constant between the thermal wave lengths of 1 and 9 μm and should view a centrally-located area on the panel of about 150 x 300 mm. The instrument should be mounted on the specimen support frame in such a manner that it can view the panel surface oriented for specimens in both the bottom and side position.

2.2 Heat flux meter: It is desirable to have at least three flux meters for this test method, one with a range of 0 to 7 W/cm² and two with a range of 0 to 3 W/cm². One of the latter should be retained as a laboratory reference standard. These flux meters should have been calibrated to an accuracy of ± 5 per cent or better. The time constant should not be more than 3 seconds (corresponding to a time to reach 95 per cent of final output of not more than 10 seconds). The instrument calibration should not vary by more than 1 per cent for receiving surface plane in both vertical and horizontal positions. The target receiving radiation should be circular, flat and not more than 10 mm in diameter. The target should be contained within a water cooled body whose front should be flat and coincide with the plane of receiving face of the target. It should be symmetrical about the target permitting incident radiation from angles of up to $\pm 80^\circ$ from the normal to the plane of the target. The diameter of all parts of the body which can receive radiation from the panel should not exceed 50 mm. Radiation should not pass through any window before reaching the target. The instrument should be robust, simple to set up, and stable in calibration.

2.3 Timing devices: Both a chronograph and an electric clock with a sweep second hand or a digital clock should be provided to measure time of ignition and flame advance. The chronograph for timing ignition and initial flame advance may comprise a strip chart recorder with a paper speed of at least 5 mm per second and an event marker pen. Both the chronograph paper drive and the electric clock should be operated through a common switch to initiate simultaneous operation when the specimen is exposed. This may be either hand operated or actuated automatically as a result of complete specimen insertion.

2.4 Recording millivoltmeter: A two channel strip chart recording millivoltmeter of either potentiometric or at least one megohm input resistance should be used to record signals from both the fume stack thermocouples and the output from the radiation pyrometer. The signal from the fume stack will in most instances be less than 15 mV but in some cases this may be exceeded by a small amount. The sensitivity of the other channel should be selected to require less than full scale deflection with the total radiation pyrometer or fluxmeter chosen. The effective operating temperature of the radiant panel would not normally exceed 935°C.

2.5 Digital voltmeter: A small digital millivoltmeter will be found convenient for monitoring changes in operating conditions of the radiant panel. It should be capable of indicating signal changes of 10 μV or less.

3 Space for conducting tests

3.1 Special room: A special room should be provided for performance of this test. The dimensions of it are not critical but it may be of roughly 45 m³ volume with a ceiling height of not less than 2.5 m.

3.2 Fume exhaust system: An exhaust system should be installed above the ceiling with a capacity for moving air and combustion products at a rate of 30 m³/min. The ceiling grill opening to this exhaust system should be surrounded by a 1.3 x 1.3 m refractory fibre fabric skirt hanging from the ceiling down to 1.7 ± 0.1 m from the floor of the room. The specimen support frame and radiant panel should be located beneath this hood in such a way that all combustion fumes are withdrawn from the room.

3.3 The apparatus should be located with a clearance of at least one metre separation between it and the walls of the test room. No combustible finish material of ceiling, floor or walls should be located within 2 m of the radiant heat source.

3.4 Air supply: Access to an exterior supply of air, to replace that removed by the exhaust system, is required. This should be arranged in such a way that the ambient temperature remains reasonably stable. (For example: the air might be taken from an adjoining heated building.)

3.5 Room draughts: Measurements should be made of air speeds near a dummy specimen in the vertical position while the fume exhaust system is operating but the radiant panel and its air supply are turned off. At a distance of 100 mm the air flow perpendicular to the lower edge at midlength of the specimen should not exceed 0.2 m/s in any direction.

4 Assembly and adjustment

4.1 General: The test conditions are essentially defined in terms of the measured heat flux incident on a dummy specimen during calibration. Radiation transfer will predominate, but convection transfer will also play a part. The flux level incident at the specimen surface is a result of the geometrical configuration between the radiant panel and the specimen as well as the thermal output from the radiant panel.

4.1.1 Both in original adjustment of test operating conditions and periodic verification of this adjustment the measured heat flux at the surface of the specimen is the controlling criterion. This heat flux is measured by a flux meter (see 2.2) mounted in a dummy specimen.

4.1.2 Between consecutive tests the operating level should be monitored either by use of a flux meter mounted in a dummy specimen or by use of a radiation pyrometer which has been previously periodically calibrated on the basis of the readings of such a flux meter. This radiation pyrometer should be fixed to the specimen holder frame in such a manner that it continuously views the radiating panel surface (see 2.1).

4.2 Mechanical alignment: Most of the adjustments of the components of the test apparatus may be conducted in the cold condition. The position of the refractory surface of the radiant panel with respect to the specimen must correspond with the dimensions shown in figure 6. These relationships can be achieved by appropriate use of shims between the panel and its mounting bracket, adjustment of separation between the two main frames, and adjustment of the position of the specimen holder guides. These adjustments should be made for the specimen both in the horizontal and vertical positions. Detailed procedures for making these adjustments are suggested in paragraph 5.

4.2.1 The fume stack for heat release measurements should be mechanically mounted on the specimen support frame in the position shown in figure 7. The method of mounting should insure the relative positions shown but should allow easy stack removal for cleaning and/or repair. The compensating thermocouples should be mounted in such a manner that good thermal contact is achieved while insuring greater than one megohm electrical resistance from the stack metal wall.

4.3 Thermal adjustment of panel operating level: Thermal adjustment of the panel operating level is achieved by first setting an air flow of about 30 m³/h through the panel. Gas is then supplied and the panel ignited and allowed to come to thermal equilibrium with a dummy specimen mounted before it. At proper operating condition there should be no visible flaming from the panel surface except when viewed from one side parallel to the surface plane. From this direction a thin blue flame very close to the panel surface will be observed. An oblique view of the panel after a 15 minute warm up period should show a bright orange radiating surface.

4.3.1 With a water cooled* flux meter mounted in a dummy specimen the flux incident on the specimen should correspond to the values shown in table 1. Compliance with this requirement is achieved by adjustment of the gas flow. If necessary, small changes in air flow can be made to achieve the condition of no significant flaming from the panel surface. Duplication of the flux measurement with those shown in table 1 should be achieved at both the 50 mm and 350 mm positions; a tolerance of ± 10 per cent is permissible at other positions specified in this table. To meet these requirements, it may be necessary to make small changes in the specimen longitudinal position shown in figure 6. The measurement of the actual flux along the specimen length should be achieved as accurately as possible, preferably within less than 5 per cent; this of course will be limited by fluxmeter calibration. A plot and smooth curve should be developed on the basis of the eight flux measurements required. The shape of the curve should be similar to that defined by the typical data shown in table 1. These measurements are important, since the experimental results are reported on the basis of these flux measurements. If a total radiation pyrometer is to be used to monitor panel operation, records of its signal should be kept following successful completion of this calibration procedure. If a change in panel-specimen axial position is necessary to meet the requirements for flux at the 50 mm and 350 mm positions, this should be accomplished by adjusting the screws connecting the two frames. In this way, the pilot position with respect to the specimen will remain unchanged. However, with the specimen in the horizontal position no further change should be made in the spacing of the two frames. The specimen stop screw adjustment may be changed to meet the flux requirements in the standard and then the position of the pilot burner mount may require adjustment to maintain the 10 ± 2 mm pilot spacing.

4.3.2 Once these operating conditions have been achieved all future panel operation should take place with the established air flow with gas supply as the variable to achieve the specimen flux level as calibrated. This level should be monitored with use of either a radiation pyrometer fixed to view an area of the source surface or a flux meter mounted in the dummy specimen at the 350 mm position. If the latter method is used, the assembly of dummy specimen and flux meter should remain in place between tests.

4.4 The following adjustments and calibrations are to be achieved by burning propane gas from a line heat source located parallel to and in the same plane as the centreline of a dummy specimen located in the vertical position and without flux meters. This line burner comprises a 2 m length of pipe of 9.1 mm internal diameter. One end is closed off with a cap and a line of 15 holes of 2 to 2.4 mm is drilled at 16 mm spacing through the pipe wall. The gas burned as it flows through this line of vertically positioned holes flames up through the stack. The measured flow rate and the net heating value of the gas serve to produce a known heat release rate which can be observed as a compensated stack millivolt signal change. Prior to performing calibration tests, measurements must be conducted to verify that the stack thermocouple compensators are properly adjusted.

4.5 Compensation adjustment: The fraction of the signal from the compensator thermocouple which is subtracted from the stack thermocouple output should be adjusted with the potential divider shown in figure 10. The purpose of this adjustment is to eliminate, as far as practical from the stack signal, the long-term signal changes resulting from the relatively slow stack metal temperature variations. Figure 11 shows the curves resulting from low compensation, correct compensation, and overcompensation. These curves were obtained by abruptly placing the lighted gas calibration burner adjacent to the hot end of a dummy specimen and then extinguishing it. The compensator potential divider should be adjusted to yield curves that show a rapid rise to a steady state signal which is constant within 5 per cent over a 5 minute period following the first minute of transient signal rise. When the calibration burner is shut off the signal should rapidly decrease and reach a steady state value within 2 minutes. Following this, there should be no long-term rise or fall of the signal. When this adjustment has been achieved the potential divider should be locked in the selected position.

* Failure to supply water cooling may result in thermal damage to the thermal sensing surface and loss of calibration of the flux meter. In some cases, repairs and recalibration are possible.

4.6 Fume stack calibration: With the adjustment described in 4.5 completed, calibration of the stack millivolt signal should be made by introducing and removing the line burner as described in 4.3. The flow rate of propane gas of at least 95 per cent purity should be varied over the range of about 0.0015 to 0.020 m³/min in sufficient increments to permit plotting the data in a well defined curve of stack compensated millivolt signal against heat input rate. A similar calibration should be performed with the calibration burner located at the cool end of the specimen. The two curves should show agreement in indicated heat release rate within about 15 per cent. A typical curve is shown in figure 12. The curve for the calibration burner at the hot end of the specimen should be the one used for reporting all heat release measurements. This completes the calibration and the test equipment is ready for use following the test procedure.

5. Assembly and mechanical adjustment of the flammability apparatus

The following instructions assume that parts of the flammability test apparatus have been made according to the drawings. The radiant panel sub-assembly has been completed with the exception of the support brackets and reverberatory screen. The equipment can be assembled to permit test of specimens of thickness up to 50 or 75 mm. Unless there is a real need for test of thicker specimens, assembly for 50 mm specimens is preferable.

5.1 The panel frame should be placed upright on a level floor preferably in the location in which the equipment will be used.

5.2 The rotating ring should be mounted on its three guide bearings.

5.3 The panel mount frame should be bolted together and to the ring by four bolts.

5.4 A check should be made that the ring lies in a vertical plane. If the error is large, an adjustment of the upper ring support bearing location may be necessary. Prior to making such an adjustment, it should be determined whether the error is due to excessive clearance between the ring and bearing rollers. If this is the case, rollers of larger diameter may correct the problem.

5.5 The four panel support brackets should be fastened to the radiant panel at four corners. Do not use too much force in bolting these brackets in place. Prior to mounting these brackets, one 35 mm M9 cap screw is placed in the hole that will be farthest from the panel end. These screws provide a means for mounting the panel.

5.6 Four washers should be placed on each of the panel mounting screws and the panel assembled on the mount bracket.

5.7 The angularity of the radiant panel surface with the plane of the mounting ring should be checked. This can be accomplished by means of a carpenter's square and measurements to the refractory tile surface at both ends of the panel. Any deviation from the required 15 degree angle may be adjusted by adding or subtracting washers from the mounting screws.

5.8 The radiant panel should be rotated to face a specimen mounted in a vertical plane.

5.9 The panel surface should be checked with a level to ensure it also lies in a vertical plane.

5.10 The specimen frame with specimen support rails on side and bottom positions and pilot burner holders assembled in approximate position should be brought up to the burner frame and the two frames fastened together with two bolts and six nuts or two threaded rods and eight nuts. The spacing between the frames is roughly 100 mm.

5.11 The spacing of the two sides of the frames is adjusted to ensure that the specimen support frame longitudinal members is at an angle of 15 degrees to the radiant panel surface.

5.12 The single specimen holder side guide rail for vertical specimen orientation should be adjusted so that it is at the required 15 degree angle to the radiant panel surface.

5.13 An empty specimen holder should be slid into position on the rail and the position of the upper guide fork adjusted to ensure that when a specimen is inserted in the holder its surface will lie in a vertical plane.

5.14 The stop screw determining the axial position of the specimen holder should be adjusted to ensure that the axis of the pilot burner is 10 ± 2 mm from the closest exposed edge of the specimen. This adjustment should again be made by use of an empty specimen holder and substitution of a 6 mm steel rod of 250 mm length for the pilot burner ceramic tube. When viewed from the back of the specimen holder, the spacing between rod axis and the edge of the specimen retaining flange of the holder should be 10 ± 2 mm.

5.15 With the specimen holder still in place against the stop screw, the spacing between the panel and specimen support frames should be adjusted to make dimension B, figure 6, equal to about 125 mm. This adjustment is made by means of the two screws fastening the two frames together. In making this adjustment, it is important to make equal adjustments on each side to maintain the angular relationship called for in adjustments 5.11 and 5.12.

5.16 The nuts supporting the specimen holder side guide rail should be adjusted to ensure that dimension A, figure 6, is 125 ± 2 mm. Again, equal adjustments on the two mounting points are required. When doing this, a check should be made to ensure that the guide rail and edge of the specimen holder are in a horizontal plane. In making this adjustment it is important to ensure that the 45 mm stack position dimension shown in figure 7 is maintained. Another way of adjustment to dimension A is through changes in the number of washers mentioned in 5.6 above.

5.17 If necessary, procedure 5.13 should be repeated.

5.18 Similar procedures should be carried out for the specimen holder in the horizontal position. However, in this case, four screws on the side rail should be used to limit lateral movement of the specimen holder. The 15 degree angle between panel surface and specimen surface should be maintained by adjustment of the lower guide rail mounting screws even if the specimen is at a small angle to the horizontal.

5.19 The reverberatory screen should be mounted on the radiant panel. This must be done in such a manner that it is free to expand as it heats up during operation.

5.20 The viewing rake with 50 mm pins is mounted on an angle fastened to the specimen holder guide rail. Its position is adjusted so that pins are located at multiples of 50 mm distance from the closest end of the specimen exposed to the panel. It should be clamped in this position. The two viewing rakes for the horizontal specimen position should be similarly mounted on the specimen support guide rails.

TABLE 1
CALIBRATION OF FLUX TO THE SPECIMEN

This table indicates typical flux incident levels at the specimen and specimen positions at which the calibration measurements are to be made. The flux at 50 and 350 mm positions should be matched. Calibration data at other positions should agree with typical values within 10 per cent.

Distance from exposed end of the specimen	Typical flux levels at the specimen	Calibration position to be used
0 mm	4.95 W/cm ²	
50	5.05	5.05 W/cm ²
100	4.95	
150	4.64	X
200	4.16	
250	3.61	X
300	3.00	
350	2.39	2.39
400	1.82	
450	1.36	X
500	.99	
550	.714	X
600	.507	
650	.389	X
700	.285	
750	.216	X

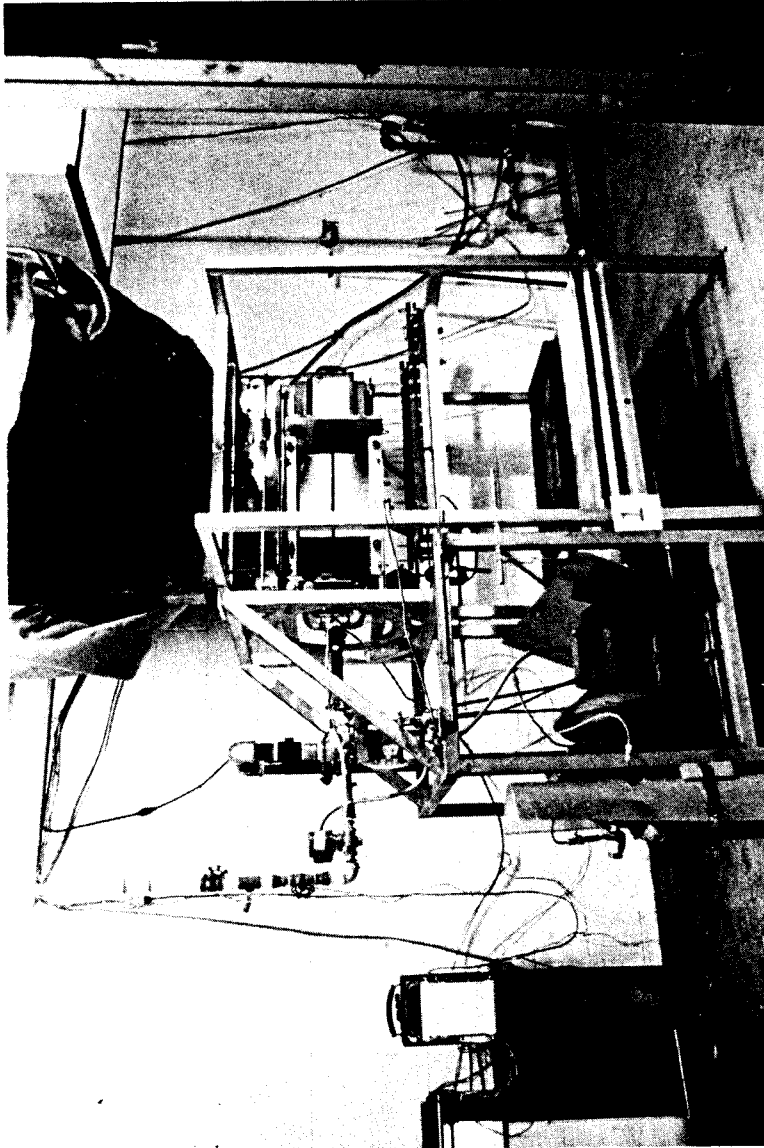


Figure 1 — General view of the apparatus

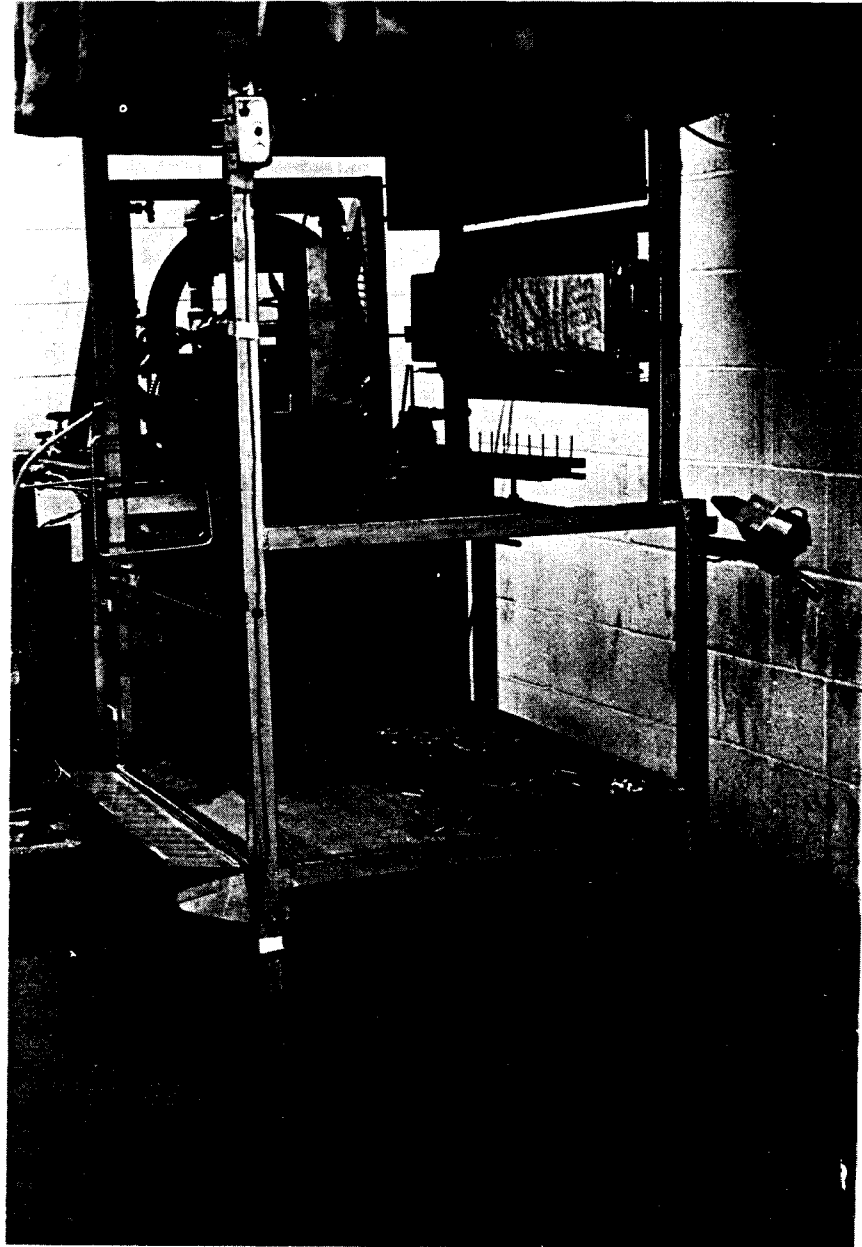


Figure 2 – View from specimen end

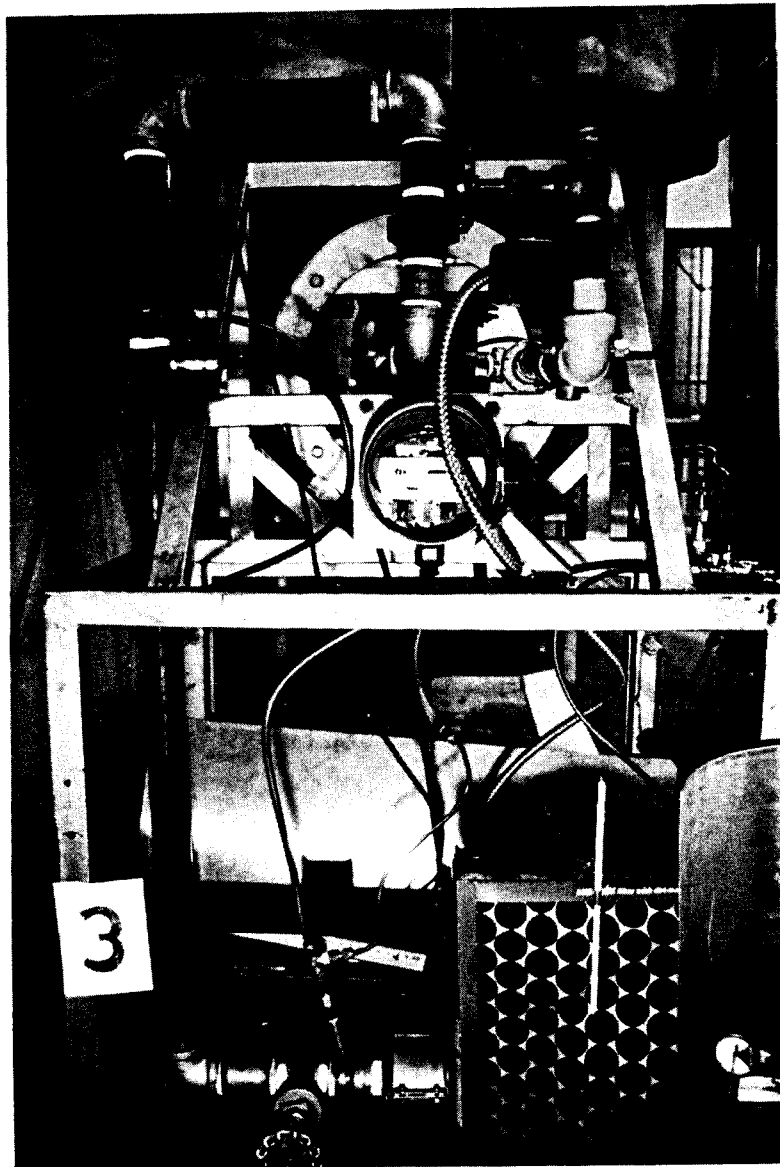


Figure 3 — View from radiant panel end

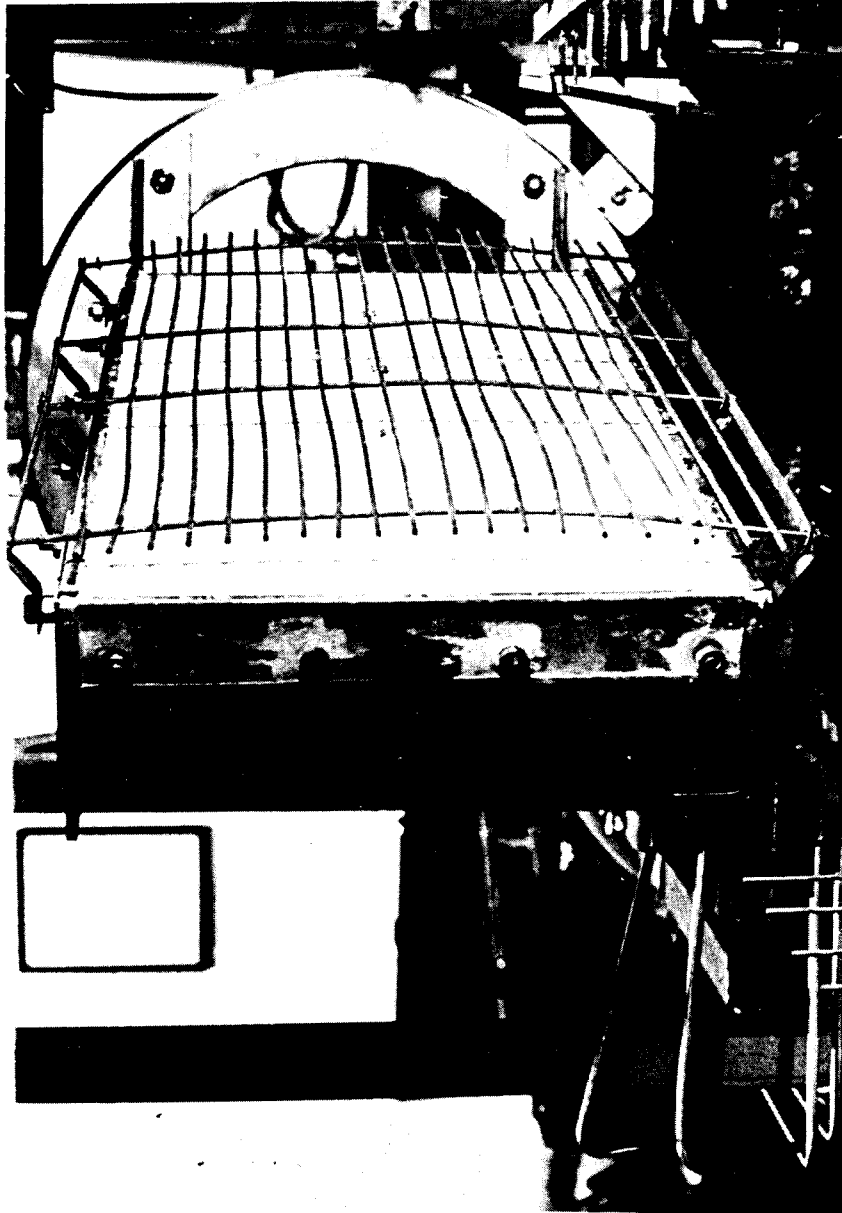


Figure 4 — Radiant panel with reverberatory wires viewed through specimen mount frame

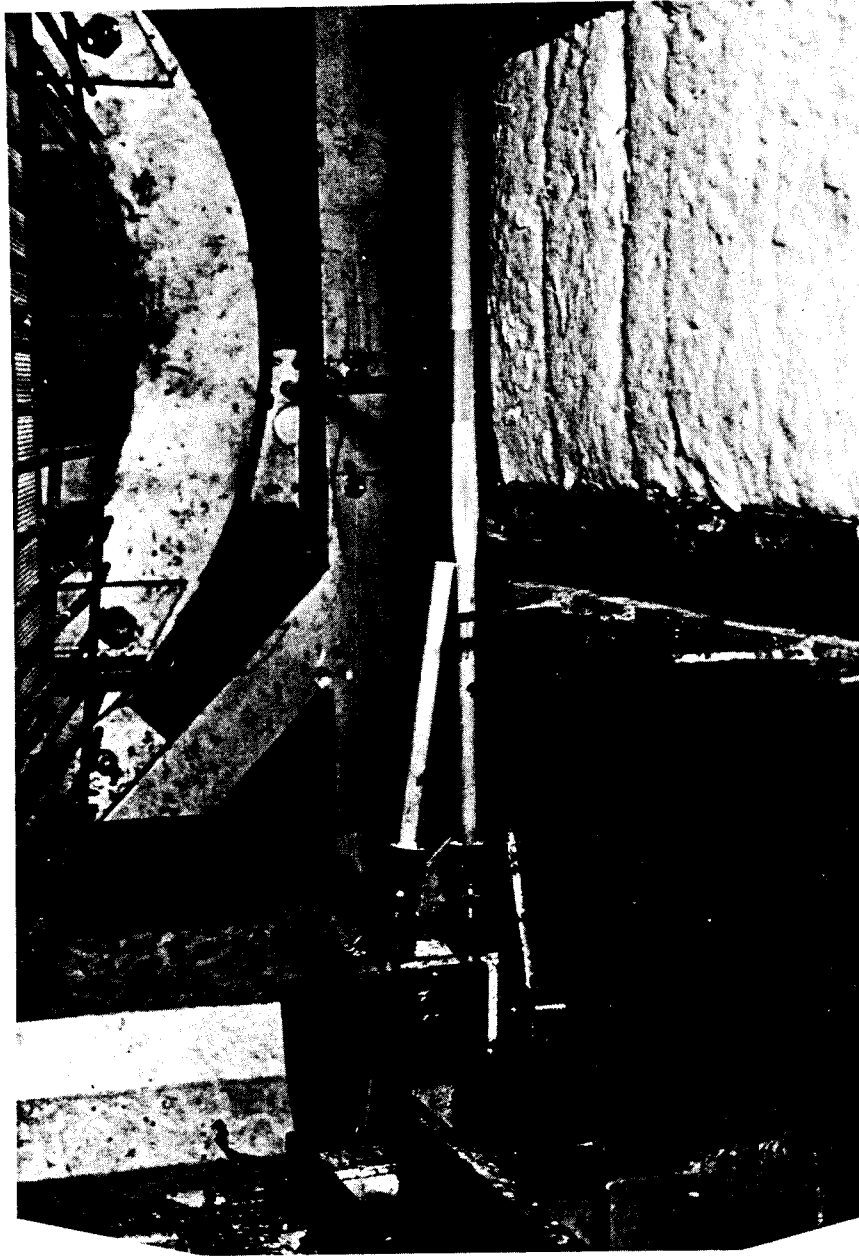


Figure 5 – Pilot burner and mount

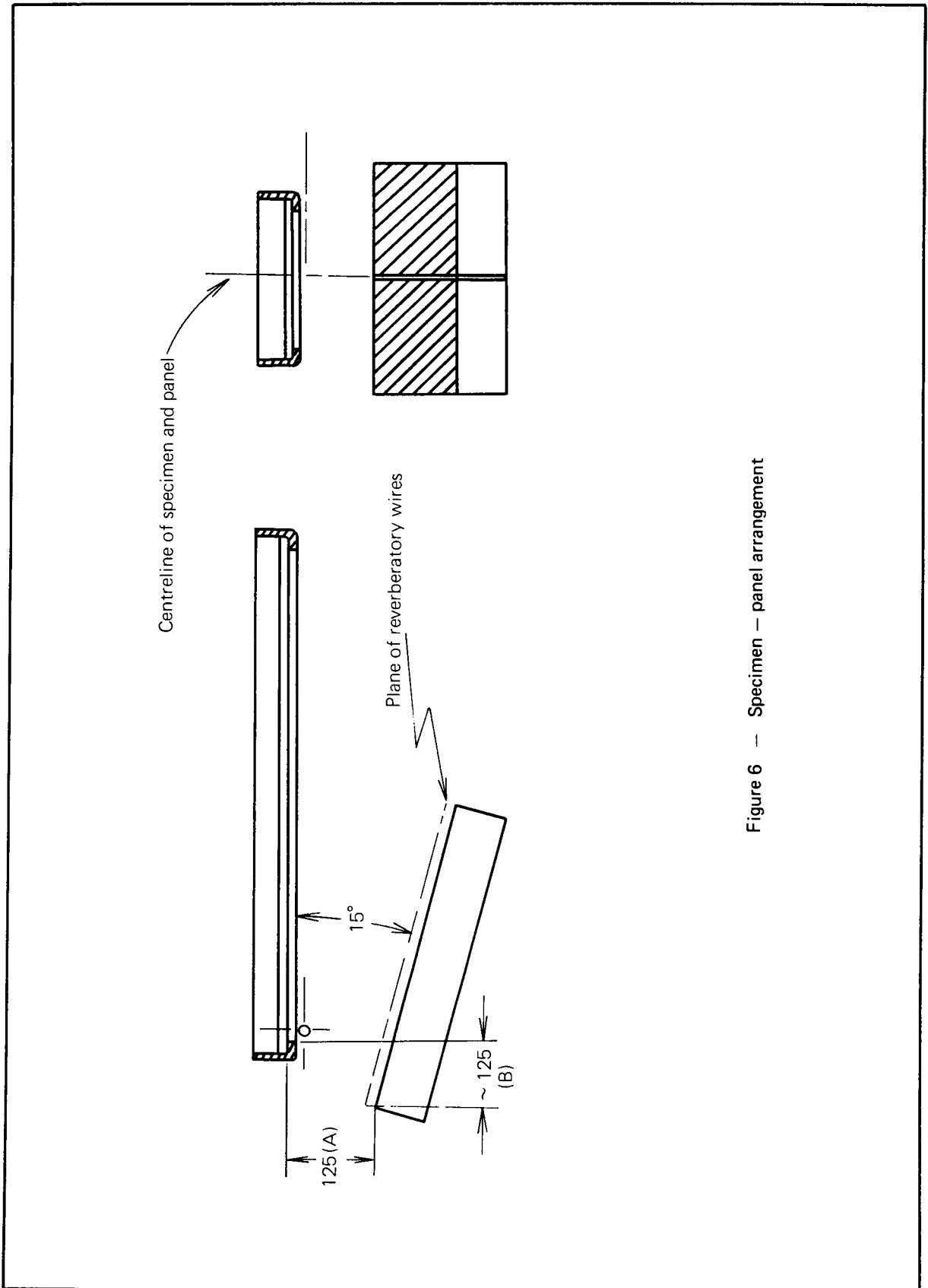


Figure 6 — Specimen — panel arrangement

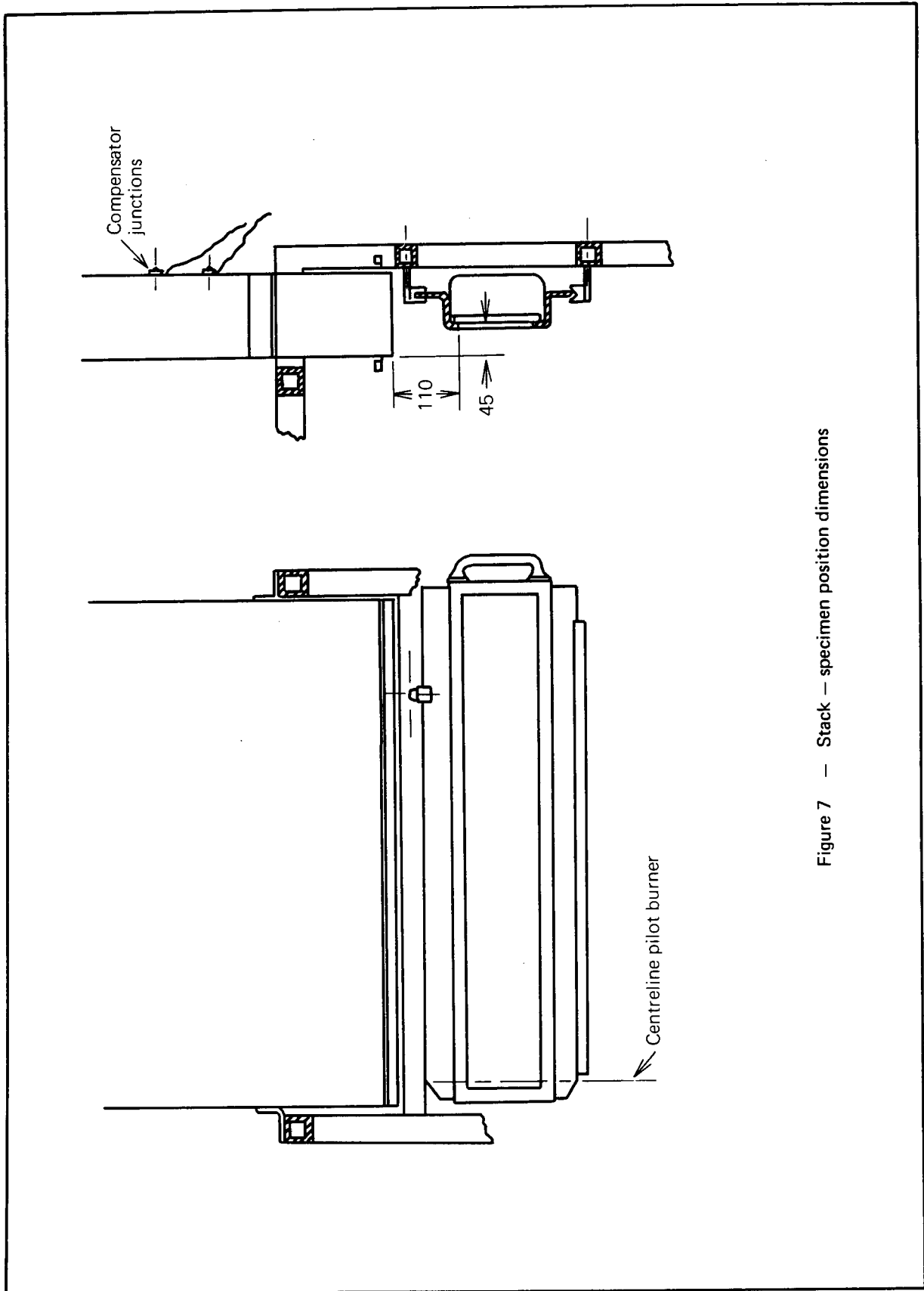


Figure 7 — Stack — specimen position dimensions

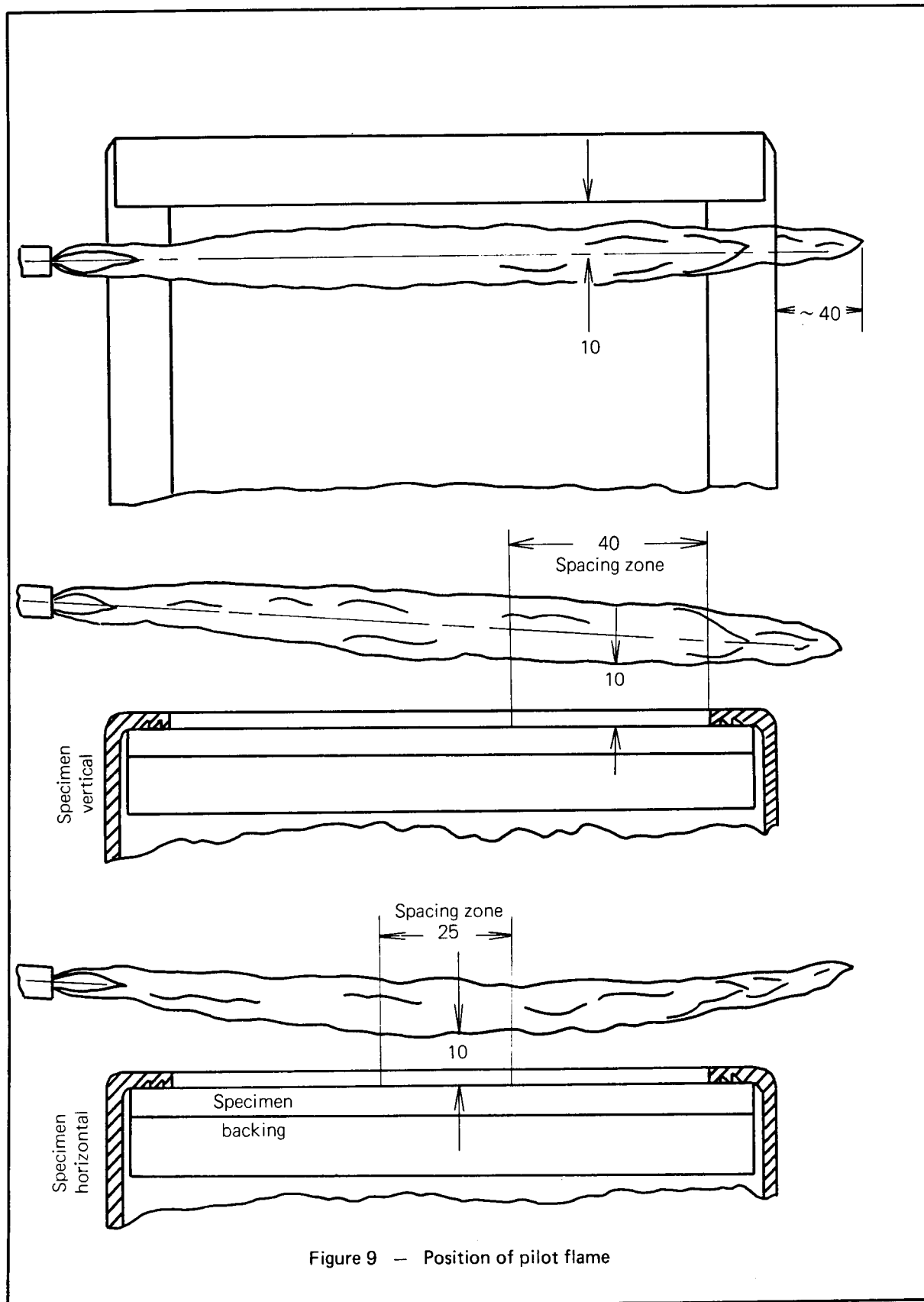


Figure 10 — Diagrammatic sketch of thermocouple circuit

Two sets of thermocouples and lead wires are required. The wire size and lengths within the fume T.C. group must be the same to ensure proper signal averaging. The parallel connection of the couples may be achieved at the mixing box by plug connection of the leads. This allows quick removal and checks for continuity and grounding problems with minimum delay. No cold junction should be used but the signal mixing box shall be shielded from panel radiation.

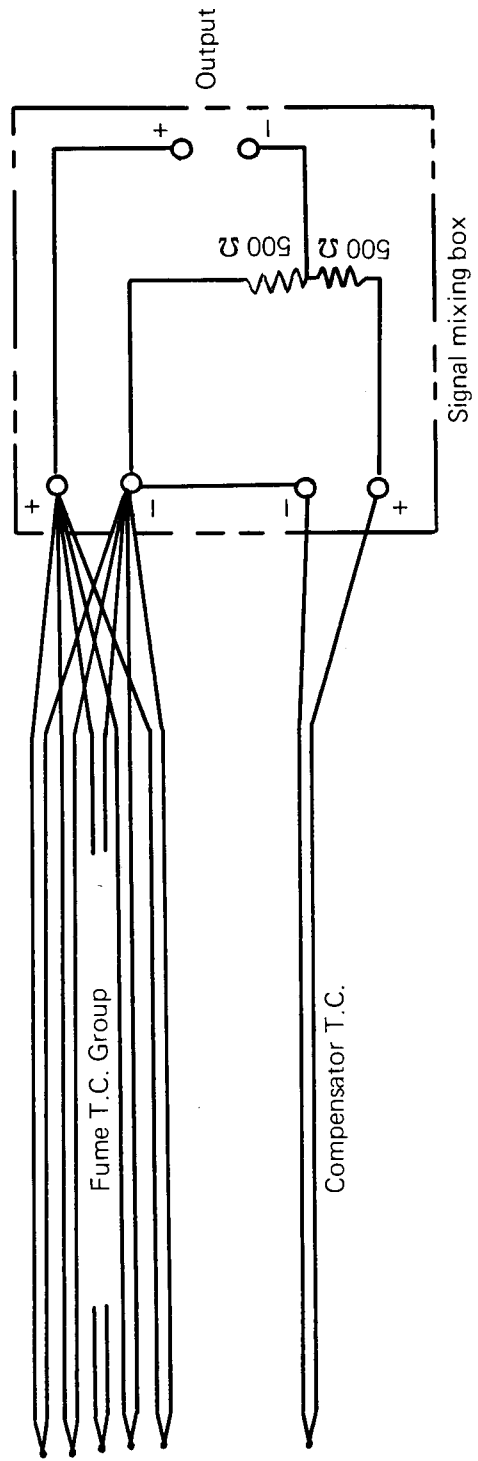
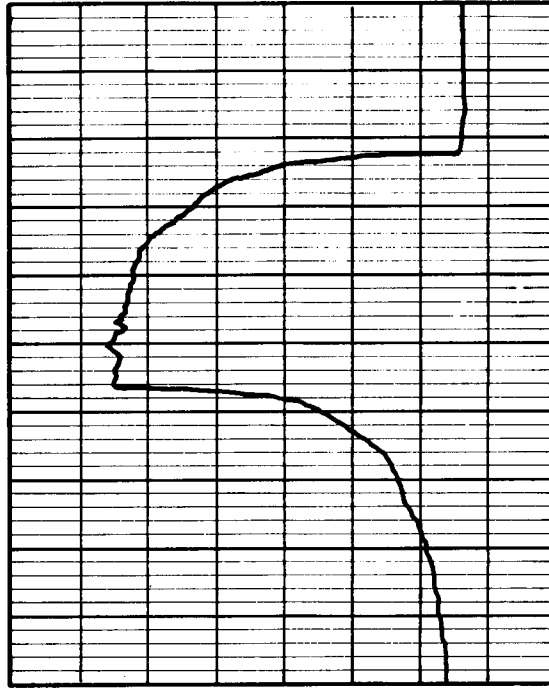
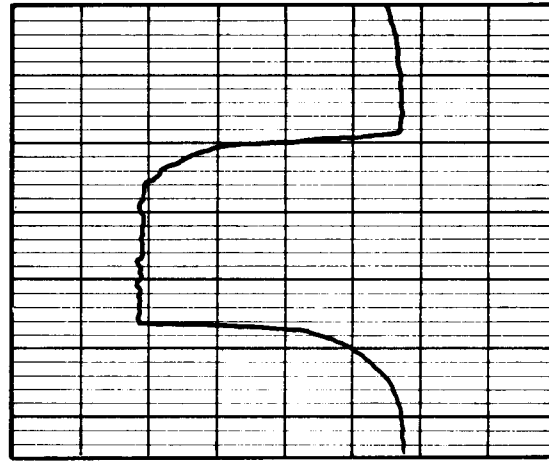


Figure 11 — Response-behaviour of heat release signal to a square wave thermal pulse

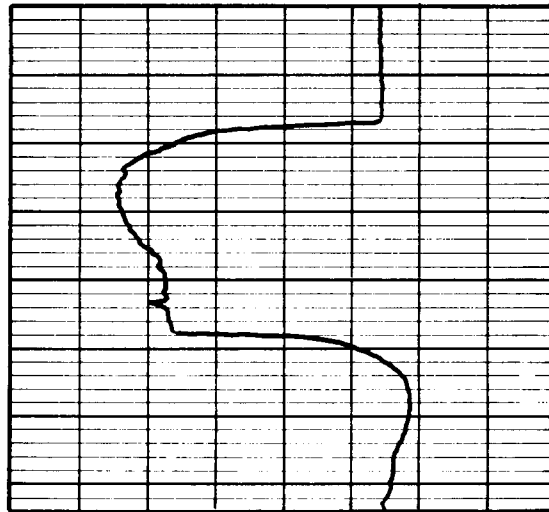
The three curves shown illustrate changes in the indicated signal for three different levels of inverse feedback or compensation signal.



Compensation too low



Correct compensation



Compensation too high

Time increases from right to left one large division about $\frac{3}{4}$ in. corresponds to two minutes.

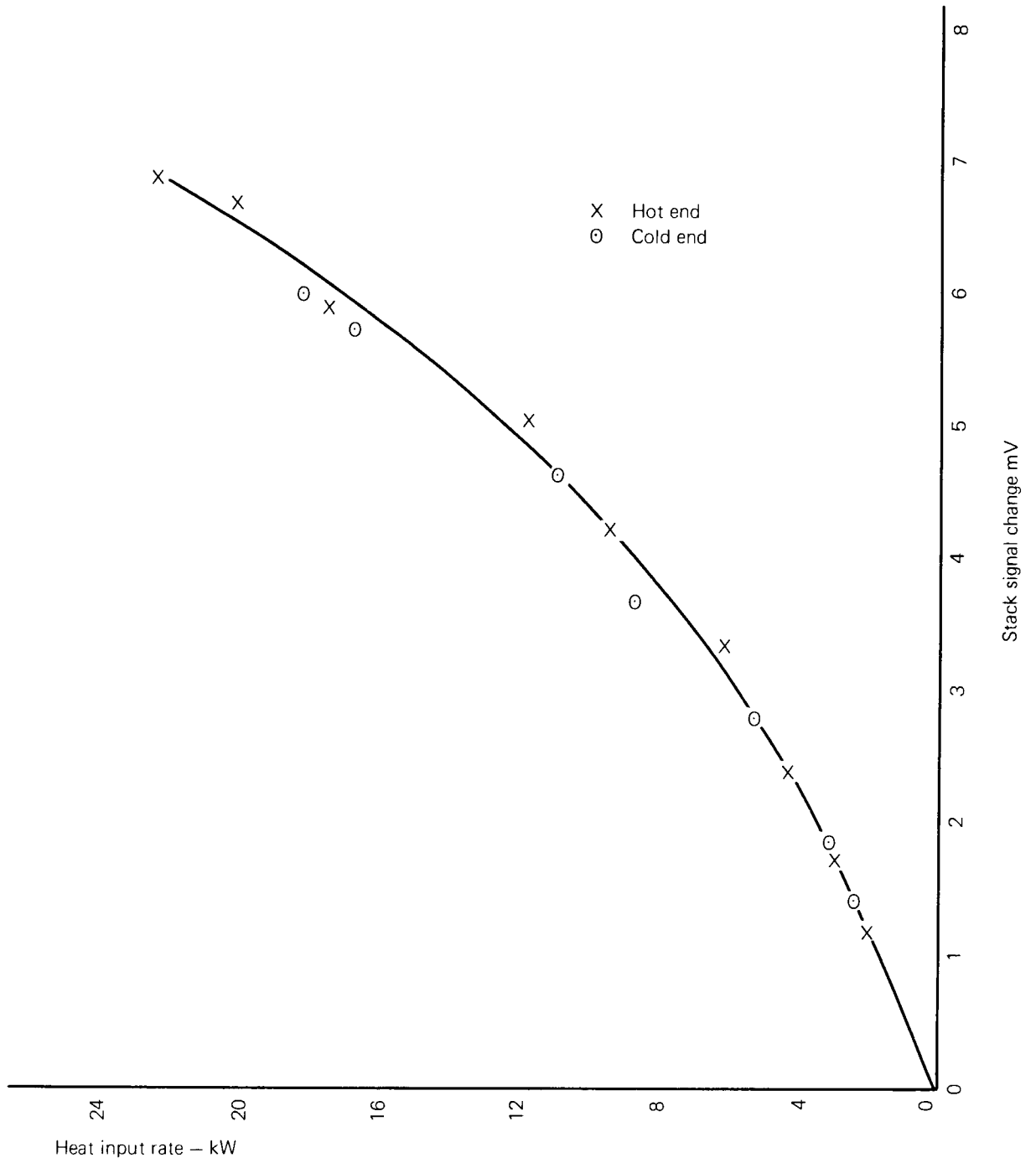


Figure 12 — Typical stack calibration