INTERNATIONAL STANDARD

ISO 14934-3

Second edition
2012-05-15

Fire tests — Calibration and use of heat flux meters —

Part 3: **Secondary calibration method**

Essais au feu — Étalonnage et utilisation des appareils de mesure du flux thermique —

Partie 3: Méthode d'étalonnage secondaire

Reference number
ISO 14934-3:2012(E)

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 14934-3 was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 1, *Fire initiation and growth*.

This second edition cancels and replaces the first edition (ISO 14934-3:2006), which has been technically revised.

ISO 14934 consists of the following parts, under the general title *Fire tests — Calibration and use of heat flux meters*:

— *Part 1: General principles*

— *Part 2: Primary calibration methods*

— *Part 3: Secondary calibration method*

— *Part 4: Guidance on the use of heat-flux meters in fire tests* [Technical Specification]

Introduction

In many fire test methods, the radiation level is specified and, therefore, it is of great importance that the radiant heat flux is well defined and measured with sufficient accuracy. Radiant heat transfer is also the dominant mode of heat transfer in most real fires.

A number of fire tests described in International Standards published by ISO require test specimens to be exposed to specified levels of irradiance. It is, therefore, necessary for fire test laboratories to be able to maintain working-standard heat flux meters to measure irradiance.

This part of ISO 14934 describes methods for the calibration of heat flux meters used as working standards in fire testing and for measuring heat flux in fire testing. Two different approaches can be used, either calibration in one of the primary calibration apparatuses or by means of a transfer calibration. The transfer calibration is performed by comparison of the heat flux meter with a heat flux meter with known sensitivity referred to as a secondary standard. The latter will have been calibrated according to ISO 14934-2.

The calibration of heat flux meters for use as primary and secondary standards requires considerable expertise and equipment that is not covered by this part of ISO 14934. For information on the calibration of primary standards and for a detailed account of the principles of the measurement of thermal radiation, reference is also made to ISO 14934-1 and ISO 14934-2.

Information on the accuracy of calibration, care of heat flux meters and guidance notes for carrying out the calibration are given in Annexes A to C. Annex D outlines a suitable procedure for the maintenance of a secondary standard of irradiance at a test laboratory.

Fire tests — Calibration and use of heat flux meters —

Part 3: Secondary calibration method

1 Scope

This part of ISO 14934 specifies methods for the calibration of heat flux meters for use in fire testing.

The methods apply only to instruments having plane receivers. They do not apply to receivers in the form of wires, spheres, etc.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 13943, *Fire safety — Vocabulary*

ISO 14934-1, *Fire tests — Calibration and use of heat flux meters — Part 1: General principles*

ISO 14934-2, *Fire tests — Calibration and use of heat flux meters — Part 2: Primary calibration methods*

3 Terms and definitions

For the purposes of this part of ISO 14934, the terms and definitions given in ISO 14934-1 and ISO 13943 apply.

4 Principle

Two different approaches can be used, either calibration in one of the primary calibration apparatuses or by means of a transfer calibration.

5 Transfer calibration

5.1 General

Transfer calibration of heat flux meters (total hemispherical radiometers and total heat flux meters) for use as working standards is carried out by comparing the heat flux meter response at various levels of irradiance with the response of a secondary-standard heat flux meter of the same type at the same levels of irradiance. The measurements are made at different levels of irradiance, which are obtained by varying the distance between the radiant source and the heat flux meter or by varying the temperature of the radiant source. The transfer calibration is conducted at a minimum of 10 different levels of irradiance. The secondary-standard heat flux meter is calibrated according to one of the primary methods described in ISO 14934-2.

5.2 Apparatus

5.2.1 Radiant source

The radiant source can be spherical, flat or conical. It shall be an electrically powered heater. The irradiance from the radiant source shall be maintained at a preset level by controlling the temperature. This can be done as with the heater described in ISO 5660-1. The temperature shall be kept constant during the calibration. The source shall be larger than the measuring surface of the heat flux meters under calibration.

The radiant source shall be placed in such a way that the irradiance from the radiant source is given vertically downward to the heat flux meter to be calibrated, which is placed below the radiant source.

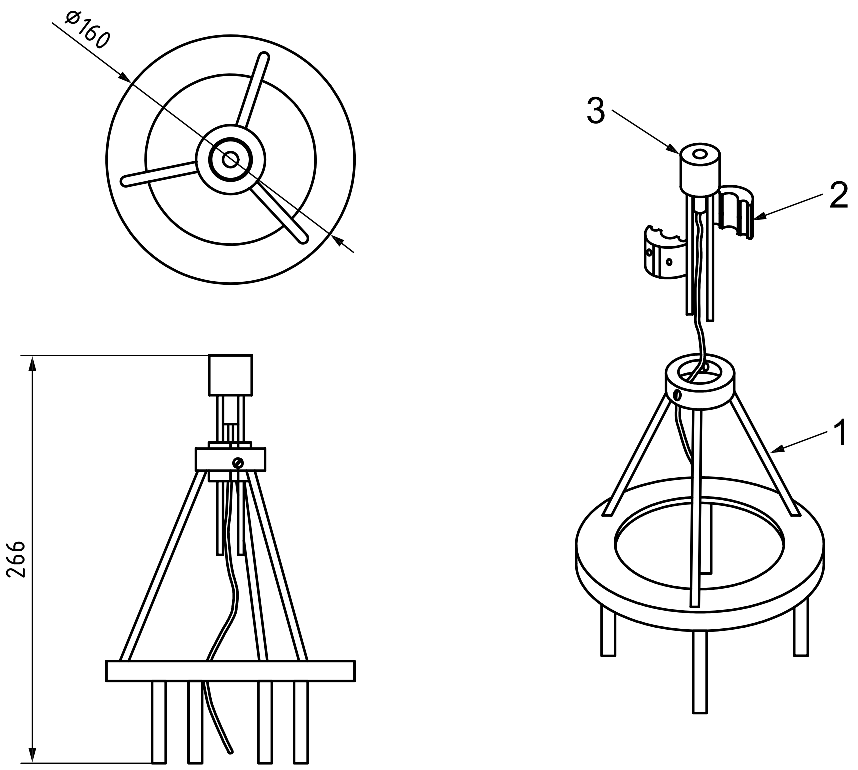
5.2.2 Mounting arrangements

5.2.2.1 Mounting arrangement for transfer calibration by varying the temperature of the heat source

The mounting apparatus shall be designed to bring the sensing surface of each heat flux meter (working-standard and secondary-standard) quickly in turn into a preset position beneath the centre of the radiant source in such a way that the irradiance to the heat flux meter can be varied. This can be achieved, for example, by a system where the position of a heat flux meter is fixed by adjusting the output from the radiant source (e.g. the conical heater of ISO 5660-1, ISO 13927 and ISO 17554).

For mounting the heat flux meters with water pipes parallel to the heat flux meter axis under the conical heater as in ISO 5660-1, ISO 13927 and ISO 17554, the arrangement shown in Figure 1 should be used. The heat flux meter calibration stand can also be used for mounting heat flux meters having the water pipes perpendicular to the heat flux meter axis as shown in Figure 2.

Dimensions in millimetres



Key

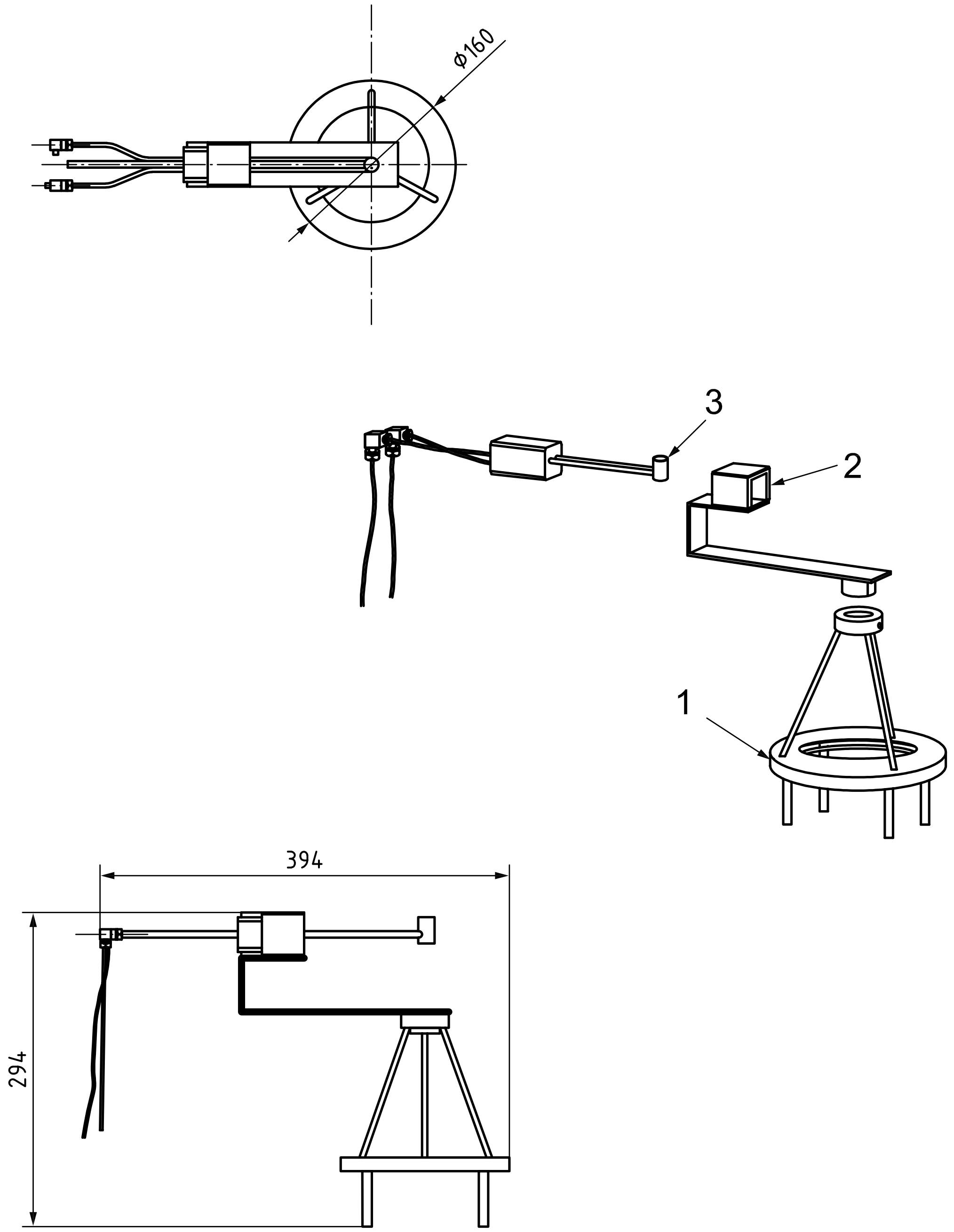
1 heat flux meter calibration stand

2 heat flux meter clamp

3 heat flux meter with water pipes parallel to the heat flux meter axis

Figure 1 — Calibration stand for heat flux meters with water pipes parallel to the heat flux meter axis under a conical heater

Dimensions in millimetres



Key

1 heat flux meter calibration stand

2 heat flux meter clamp

3 heat flux meter with water pipes perpendicular to the heat flux meter axis

Figure 2 — Calibration stand for heat flux meters with water pipes perpendicular to the heat flux meter axis under a conical heater

Irradiance to the heat flux meter can be altered by changing the power, i.e. temperature, of the radiant source.

The change in radiant source power shall be over a range which will provide an appropriate range of irradiance compatible with the working range of the heat flux meter to be calibrated. The heat flux meter shall not be placed in any convective air flow initiated by the radiant source. The means for locking the heat flux meter in position shall be rigid and such that the centre of the sensing surface is in the centre of the radiator.

The heat flux meter mounting apparatus shall be designed so that meters are not mounted directly over a substantial mass of material that will get hot and in such a way that it can be placed in position after the irradiance of the radiant source reaches a preset level.

NOTE It has been found suitable to have two calibration stands so that both the secondary-standard heat flux meter and the working-standard heat flux meter can be mounted prior to the start of calibration (see 5.5.6).

No part of the mounting apparatus shall project in front of the heat flux meters being calibrated.

All exposed surfaces of the heat flux meter mounting apparatus shall be coated with a heat-resisting, matte black finish.

5.2.2.2 Mounting arrangement for transfer calibration by varying the distance between the radiant source and the heat flux meter

The mounting apparatus shall be designed to bring the sensing surface of each heat flux meter (working-standard and secondary-standard) quickly in turn into a preset position beneath the centre of the radiant source in such a way that the irradiance to the heat flux meter can be varied. This can be achieved, for example, by a system where the position of the heat flux meter is varied by adjusting the distance between the radiant source and the heat flux meter.

The output from the radiant source remains constant throughout the whole procedure. The movement of the heat flux meter shall be such that it will provide an appropriate range of irradiance. The heat flux meter shall not be placed in any convective air flow initiated by the radiant source. The means for locking the heat flux meter in position shall be rigid and such that the centre of the sensing surface is in the centre of the radiator.

The heat flux meter mounting apparatus shall be designed so that meters are not mounted directly over a substantial mass of material that will get hot and in such a way that it can be placed in position after the irradiance of radiant source reaches a preset level.

5.2.3 Instrumentation

5.2.3.1 Secondary-standard heat flux meters

The secondary-standard heat flux meter shall have the water pipes parallel to the heat flux meter axis. It shall be of the same type as the working-standard heat flux meter, which is to be calibrated, except if the working-standard heat flux meter has the water pipes perpendicular to the heat flux meter axis. Thus, if the working-standard heat flux meter is a Schmidt-Boelter type, then the secondary-standard heat flux meter shall also be a Schmidt-Boelter type. The measuring range and the outer diameter of the heat flux meters shall also be identical.

If the secondary-standard heat flux meter and the working-standard heat flux meter have different diameters, then the uncertainty analysis is required.

The secondary-standard heat flux meter shall be calibrated at regular intervals according to one of the primary methods described in ISO 14934-2.

The scheme for inter-laboratory comparisons outlined in Annex D can be used in order to stabilize the sensitivity of the secondary-standard heat flux meter. In this case, three or more secondary-standard heat flux meters are required for these periodic inter-comparisons.

5.2.3.2 Working-standard heat flux meters

Working-standard heat flux meters used for the fire tests according to ISO 5660-1, ISO 5659-2, ISO 13927 and ISO 17554, have the water pipes perpendicular to the heat flux meter axis (see Figure 2). For the calibration, this working-standard heat flux meter is mounted in the normal cone heater assembly holder or in the holder shown in Figure 2.

Working-standard heat flux meters used for the fire tests according to ISO 5658-2, IMO Res A.653 and ISO 9239-1, have the water pipes parallel to the heat flux meter axis. For the transfer calibration, this working-standard heat flux meter is mounted as described in 5.2.2. This type of working-standard heat flux meter can also be directly calibrated in any of the primary calibration furnaces described in ISO 14934-2.

5.2.3.3 Recording instrumentation

Instrumentation shall be capable of assimilating the incoming data and producing a record, both permanent and immediately available to the operator, of the reading of each heat flux meter at intervals not longer than 5 s, having range settings appropriate to the outputs of the heat flux meters. It is recommended to use the same recording instrumentation for both secondary and working-standard heat flux meters.

5.2.4 Additional equipment

5.2.4.1 Protective clothing

Protective clothing, such as heat-resisting gloves and eye protection, should be worn, as necessary.

5.2.4.2 Low-pressure air and/or water supply

Low-pressure air and/or water supply for the heat flux meters should be supplied as required. An example is given in C.6.

5.3 Test environment

5.3.1 Room

The influence of the surroundings should be stable over time. The radiation from everything except for the radiant source should be limited by keeping all surrounding items including wall surfaces below 40 °C.

5.3.2 Draught

The calibration apparatus shall be contained in an essentially draught-free environment where the air flow does not exceed 0,2 m/s when the apparatus is cold. Particular care shall be taken to avoid draughts across the instruments under calibration. If necessary, screens shall be provided, but these shall be at least 1,5 m away from the heat flux meter under calibration.

5.4 Set-up procedure

5.4.1 General

Check that the apparatus is assembled correctly. If the sliding procedure is used then check that the mounting apparatus moves smoothly in relation to the face of the radiant source. Lubricate any sliding parts using a heat-resisting grease or graphite, if necessary.

Laboratories supplying instruments for calibration should be aware that with a new working-standard heat flux meter or one that has not been previously used, it is advisable to age the sensing surface artificially before a calibration is carried out to avoid or reduce initial drift in sensitivity. It is recommended that this should be done by exposing the sensing surface to radiation for 20 h to 25 h in a series of exposures of several hours' duration, at irradiance near the maximum at which it is likely to be used. With some types of heat flux meters, it is advisable to monitor sensitivity and continue ageing until the sensing surface has stabilized.

5.4.2 Mounting heat flux meters onto the calibration stand

5.4.2.1 Align the two parts of the clamp around the water pipes of the heat flux meter as shown in Figure 3 a), ensuring that the signal cable will run down the clearance provided in the middle.

5.4.2.2 Clamp down on the water pipes with two M3 grub screws on each clamp while holding the two parts of the clamp together, see Figure 3 b).

5.4.2.3 While holding the heat flux meter and the clamp, insert the meter into the ring of the tripod holder of the calibration stand, ensuring the ‘flats’ on the clamps are aligned with the holes for M5 grub screws on the ring. M3 grub screws on the clamp are still accessible when in the ring as shown in Figure 3 c). Tighten the M5 grub screws to secure the clamped heat flux meter.

The height of the heat flux meter can be adjusted to suit the position under the radiant heat source by loosening the M3 grub screws on one side of the clamp, just enough to slide it up or down into position and then re-tightening it to clamp. The distance between the heat flux meter sensing surface and the bottom of the conical heater shall be 25,4 mm.

5.4.2.4 The tripod holder is secured to the base plate with four M6 screws, and one is screwed into each leg, as shown in Figure 3 d). The base plate holding the prepared assembly is slid into position under the conical heater, using the same locating pin as on the load cell base plate (used in ISO 5660-1). This location ensures that the heat flux meter is concentrically located with the centre of the radiant heat source.

5.4.3 Mounting and alignment of heat flux meters

5.4.3.1 With the radiant source off, mount the secondary-standard heat flux meter and the working-standard heat flux meter, or heat flux meters that are being calibrated, onto the calibration stand. Ensure that all leads and tubes to heat flux meters are protected against radiation [wrapping with thin, shiny aluminium foil has been found suitable (see C.7), and that they do not become entangled in any mechanism when it moves. Connect the secondary-standard and working-standard heat flux meters independently to the recording instrumentation using appropriate leads.

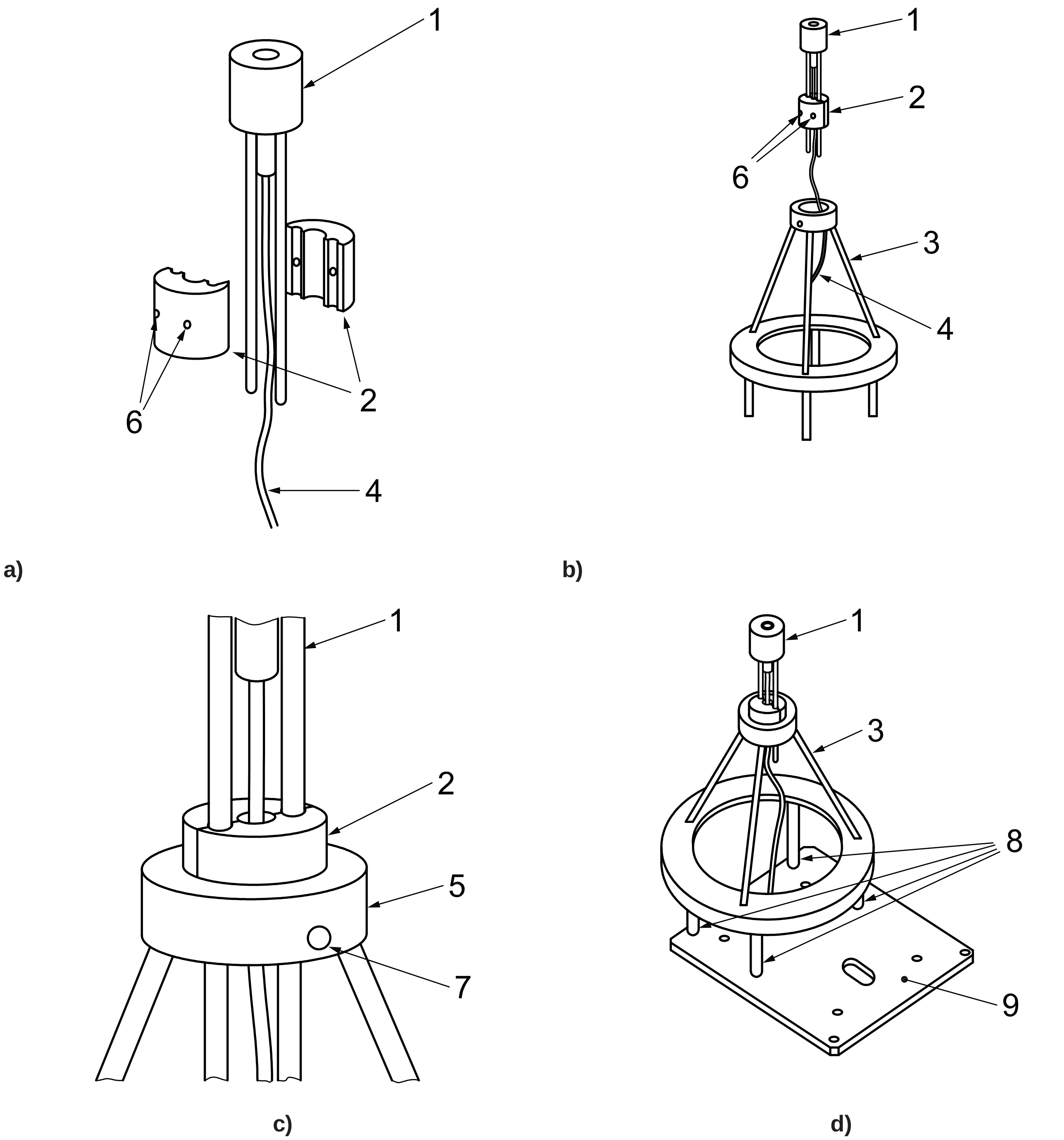
If a water-cooled heat flux meter is being calibrated, connect the appropriate supply and ensure that the flow rate is in accordance with the manufacturer’s recommendations. The temperature of the cooling water shall be ambient room temperature and shall not be below the dew point of the ambient temperature.

NOTE ISO/TS 14934-4 gives guidance on water cooling methods.

5.4.3.2 Place the mounting apparatus into position for calibration. Adjust the heat flux meters in turn horizontally, vertically and at an angle, so that when brought into the calibration position, their sensing surfaces lie in the same plane relative to the radiant source, with the centre of the sensing surfaces on the normal from the centre of the radiant source.

Ensure that the sensing surfaces of the heat flux meters are clean and that the line-of-sight between the sensing surfaces and the radiator is not obstructed when in the calibration position. Place small screens in front of the heat flux meters to shield them from the radiator.

As far as possible, the heat flux meters should be screened from radiation except during actual readings.



Key

1 heat flux meter

2 heat flux meter clamp

3 heat flux meter calibration stand

4 signal cable

5 ring of tripod holder of calibration stand

6 M3 grub screws

7 M5 grub screws

8 hollow legs fitted to M6 grub screws on base plate

9 base plate

Figure 3 — Mounting heat flux meters onto the calibration stand

5.5 Calibration procedure

5.5.1 Switch on the recording instrumentation, allowing any necessary time for warming up.

5.5.2 Place the calibration stand, with the secondary-standard heat flux meter mounted, under the conical heater.

5.5.3 With the radiation shield in place, switch on the radiant source and set the temperature to a preset level. The first level of irradiance shall be at 10 % or less of the highest irradiance level for the requested calibration.

5.5.4 Remove the radiation shield to expose the meter to the radiant source. Check with a spacer that the distance between the heat flux meter sensing surface and the bottom of the conical heater is 25,4 mm.

5.5.5 Continue the exposure in this position until the temperature of the radiant source reaches the preset level and the value recorded from the heat flux meter is essentially constant over a period of 1 min. Note the heat flux meter output reading (U_{S1}). Reinsert the radiation shield.

5.5.6 Remove the calibration stand with the secondary-standard heat flux meter. If the working-standard heat flux meter has the water pipes perpendicular to the heat flux meter axis, then the working-standard heat flux meter is mounted in the holder shown in Figure 2 or in the “cone holder”. If the working-standard heat flux meter has the water pipes parallel to the heat flux meter axis, then the working-standard heat flux meter is mounted in the holder shown in Figure 1.

The use of duplicate calibration stands will reduce the uncertainty contribution associated with this method.

5.5.7 Remove the radiation shield to expose the meter to the radiant source. Check that the distance between the heat flux meter sensing surface and the bottom of the conical heater is 25,4 mm.

5.5.8 Leave the stand with the heat flux meter under the heater until the value recorded from this heat flux meter is essentially constant over a period of 1 min. Note the heat flux meter output reading (U_W). Reinsert the radiation shield.

5.5.9 Return the calibration stand with the secondary-standard heat flux meter to its position and repeat 5.5.5, obtaining another output reading (U_{S2}).

5.5.10 Repeat 5.5.2 to 5.5.9 with the radiant source set at different power levels until at least 10 different levels of irradiance have been used (see Annex A). Ensure that the irradiance levels cover the required calibration range of the working-standard heat flux meter and that they are evenly spread over that range.

It is advisable to start at a low irradiance and increase the power up to the maximum required, and then decrease the power (covering the same power levels) so that outputs are obtained from increasing irradiance and decreasing irradiance.

5.6 Calculation of results

5.6.1 General

The results shall be calculated according to the principles in ISO 14934-1. For the transfer calibrations, the total heat flux for calculating the calibration of the working-standard heat flux meter is taken as the heat flux reading from the secondary-standard heat flux meter. The mean value of the two series described in 5.5.10 is used.

The uncertainty of the calibration is caused by the uncertainty of the secondary-standard calibration, the uncertainty in the radiation source, the positioning of the heat flux meters, and the uncertainty from the regression.

5.6.2 Evaluation of results

The calibration results should be evaluated using a table with the columns as given in the table below.

Level no	Output reading from secondary-standard heat flux meter U_{S1}	Output reading from working-standard heat flux meter U_W	Output reading from secondary-standard heat flux meter U_{S2}	Average output reading from secondary-standard heat flux meter $U_{S\text{-}ave}$	Corresponding total heat flux, q_{tot} (kW/m^2)

5.6.3 Expression of results

The calibration results should be reported in a table with the contents as given in the list below:

— total heat flux, q_{tot} (kW/m^2);

— output voltage, U_W (mV).

A graph should be plotted of the total heat flux, q_{tot} (kW/m^2) versus output voltage U_W (mV) from the heat flux meter from the processed data. After this, a best fit should be calculated, using either a linear equation (resulting in A_1 only or in A_1 together with A_0) or a nonlinear approximation (A_0, A_1 and A_2).

In case the nonlinearity for a certain application is negligible, it can be stated that the nonlinearity during the calibration was negligible and that therefore a value for A_2 is not given.

Apart from the table and the end result expressed in the constants A_0, A_1 and A_2, the calibration certificate should mention the following:

— heat flux meter body temperature during calibration, in °C;

— field of view of the heat flux meter, expressed in degrees. In case of view-limiting apertures, specify field of view from the centre of the sensing surface to the edge of the view-limiting aperture. In case of flat receivers, specify 180°;

— absorptance of coatings;

— source temperature, in °C;

— spectral range. In case of window material, specify the 50 % transmission points in micrometers. These are the wavelengths at which the transmission is 50 % of the maximum transmission. In case of black coating without windows, specify 1 µm to 10 µm;

— transmission. In case of window materials, specify the average transmission of the window material if this is known. In case of absence of windows, specify not applicable;

— uncertainty for each level. The uncertainty estimation should include the uncertainty of the calibration method, the uncertainty emanating from the convective heat transfer, and the uncertainty from the calibration itself.

6 Secondary calibration in a primary furnace

6.1 General

When a working-standard heat flux meter is to be calibrated in any of the furnaces described in ISO 14934-2, the calibration shall be conducted at a minimum of three levels of irradiance. The levels should then be chosen to be as close as possible to the levels needed for the use of the working-standard heat flux meter.

Conduct the calibration according to any of the relevant procedures described in ISO 14934-2,7.2, 8.2, 9.2, Annex A, Annex D and Annex I, with the exception of number of levels.

6.2 Expression of results

The calibration results should be reported in a table with the contents as given in the list below:

— total heat flux, q_{tot} (kW/m^2) and/or incident radiation (kW/m^2);

— output voltage, U_W (mV) together with the uncertainty.

Apart from the table, the calibration certificate should mention the following:

— heat flux meter body temperature during calibration, in °C;

— field of view of the heat flux meter, expressed in degrees. In case of view-limiting apertures, specify field of view from the centre of the sensing surface to the edge of the view-limiting aperture. In case of flat receivers, specify 180°;

— absorptance of coatings;

— source temperature, in °C;

— spectral range. In case of window material, specify the 50 % transmission points in micrometers. These are the wavelengths at which the transmission is 50 % of the maximum transmission. In case of black coating without windows, specify 1 µm to 10 µm;

— transmission. In case of window materials, specify the average transmission of the window material if this is known. In case of absence of windows, specify not applicable.

7 Report

The calibration report should contain the following information in addition to the information listed in expression of results:

a) name and adress of the calibrating laboratory;

b) date and identification number of the report;

c) name and adress of the client;

d) name, type, serial number and manufacturer of the heat flux meter under calibration;

e) date of calibration;

f) calibration method;

g) identification of calibration equipment used (for transfer calibration, a reference to the source of calibration of the secondary-standard heat flux meter and the date of its last calibration should be included);

h) irradiance range employed (use the following statement: “This heat flux meter has been calibrated in the range from x to y kW/m^2”);

i) results as detailed in 5.6.3 or 6.2;

j) traceability of measurements;

k) any deviation from the calibration method;

l) date and signature.

Annex A
(informative)

Accuracy of calibration

The accuracy of calibration of the working-standard heat flux meter depends on the accuracy of calibration of the secondary-standard heat flux meter and also on the accuracy with which the inter-comparison can be made. The latter depends both on the accuracy of positioning of the working-standard heat flux meter in relation to the secondary-standard heat flux meter and on the statistical errors due to averaging, combining or comparing sets of data that, because of random processes such as physical perturbations and reading errors, exhibit some variation. In addition, the convection flow around the meter and the temperature of the heat source and the surrounding surfaces may vary during the calibration and thus add to the uncertainty.

Annex B
(informative)

Care of heat flux meters

The accuracy of the calibration may be affected by the condition of the heat flux meters. Because of their delicate construction, some types of instruments can be easily damaged. When a heat flux meter is not in use, a cover, constructed in such a way that it does not touch the sensing surface, should be placed over the sensing surface to protect it from damage and dust. If dust is seen on the receiving surface, it should be removed by blowing gently. If the sensing surface is covered by a window, dust should be removed with a soft dry brush. Cleaning by rubbing or using solvents is not recommended. Mechanical shock and vibration can cause breakages in a thermopile circuit.

If the original surface coating of the sensor is damaged or contaminated even in the slightest, the sensitivity of the heat flux meter quoted by the manufacturer or the subsequent calibration may no longer be valid, since the absorptivity may have changed. If this occurs with a secondary standard, the secondary-standard heat flux meter should be retired or recalibrated against a primary standard.

A water-cooled type flux meter will be destroyed if the heat flux meter is exposed to radiant heat without cooling water running through the heat flux meter.

ISO/TS 14934-4 gives guidance on care of heat flux meters.

Annex C
(informative)

Guidance notes for carrying out calibration

C.1 Use of electrically powered radiant source

Because the convective contribution of a gas-fired radiant source is comparatively large and such a radiant source releases combustion gases and flame, an electrically powered radiant source should be used.

C.2 Limiting conditions for instrument calibrations

Even for heat flux meters (see C.4), where it can be thought that some convection transfer might be tolerated in calibration, it should be noted that in the same velocity/temperature field, the convection transfer depends on the geometry and temperature of the sensing surface, so that it can be different for different types of instruments. Bringing the heat flux meter close to the radiant source in an attempt to increase irradiance is of diminishing effectiveness, as the angle subtended at the heat flux meter by the panel becomes very large and, with some types of sensing surfaces, can give a calibration unrepresentative of the angle within which radiation is normally accepted in practice.

C.3 Heat flux meters

With heat flux meters whose sensing surfaces are flat and coincident with the front face of the enclosing protective body, radiation can be received from a solid angle of nearly 2π sr.

However, some heat flux meters have a more limited field of view, and for these it is very important that the radiant source should always be within the field of view of the instrument, i.e. all parts of the sensing surface can receive radiation directly from all parts of the radiating source. The comparison of two heat flux meters having different angles of view can result in a large error if the radiant source were larger than the field of view of one or both of them. Even for heat flux meters of the same type, having the same limited, nominal angle of view, the area of the radiant source viewed is unlikely to be identical in each case and errors can still result.

In calibrating a heat flux meter in terms of voltage output per unit of radiant energy incident on unit area per unit time (i.e. irradiance), it is not necessary for the absorptivity of the sensing-surface surface to be known, as long as the absorptivity does not change.

It is convenient for so-called total heat flux meters, i.e. instruments intended to measure radiative and convective heat-transfer rates, separately or combined, to be calibrated by the method described in this part of ISO 14934. However, several points should be especially borne in mind in applying a calibration in terms of irradiance to the measurement of a combined convective and radiative heat-transfer rate. The different nature of these heat-transfer processes should be kept in mind, especially that heat transfer by radiation depends on the absorptivity of the sensing-surface surface, while convection transfer does not. The calibration of a total heat flux meter by means of radiation is normally in terms of *incident* not *absorbed* radiant flux. If the heat flux meter, in practice, is exposed to a combined convective and radiative transfer and the convective transfer predominates over radiative, then it is more accurate to derive a calibration in terms of radiant energy actually absorbed by the sensing surface. If, for example, the sensitivity is S1 in terms of incident radiant flux then the sensitivity for absorbed radiant flux will be S1/a where a is the absorptance. Even for blackened surfaces, the difference between these sensitivities can exceed several percent.

C.4 Radiation and convection

It should also be noted that convection transfer depends on the local temperature and gas velocity and so is sensitive to the shape and position of the measuring instrument. Furthermore, measurements of the heat transfer rate to a cold (i.e. water-cooled) instrument generally requires adjustment to obtain the corresponding heat-transfer rate to a hot or warm body.

C.5 Instruments with windows

To reduce susceptibility to draught, or to reduce convection transfer to the sensing surface, some instruments have windows of radiation-transmitting material. Such materials can be relatively transparent to radiation in the near infrared region but are invariably opaque to radiation of longer wavelengths. Since the proportion of radiant energy in different parts of the spectrum varies with the temperature of the radiant source, the proportion of radiant energy absorbed by a window, and hence the sensitivity of the instrument, also varies with the source temperature. For example, a window that is transparent out to a wavelength of 5 μm and opaque to longer wavelengths will transmit 83 % of the radiation from a blackbody source at 1 200 °C, but only 68 % of the radiation at 800 °C, which would produce a large error if the calibration obtained for one source temperature were used to measure radiation from a source at the other temperature.

C.6 Water cooling

For instruments intended to be water cooled, the body is usually cooled and stabilized by circulating water. Care should be taken that the flow rate of the cooling water is kept constant in accordance with the manufacturer's recomendations (see 5.4.3.1), that the water temperature remain as constant as possible, and that it remain above the local dew-point temperature. If the cooling-water temperature is below the dew-point of ambient air, water condenses on the exposed surface of the heat flux meter and gives an incorrect measurement. In case of a measurement of very low levels of heat flux, a change in temperature of the cooling water can affect the measurement considerably. Care also should be taken to ensure that the flow rate is in accordance with the manufacturer's recommendations.

C.7 Calibration procedure

In setting up the instruments and connecting up the wiring, care should be taken to avoid conditions giving rise to parasitic electromagnetic frequencies (EMFs) generated by temperature differences and/or electrical pick-up. Leads should be of copper with clean ends, should be electrically screened and should also be shielded from radiation. All electrical junctions should be in cool places, where the ambient temperature remains reasonably constant and screened from radiation.

Care should be taken to avoid radiation from the radiant source being reflected by nearby objects, e.g. polished metal surfaces, onto the instruments facing the radiant source. Only minimum quantities of aluminium foil should be used to protect electrical leads, and this should be crinkled to randomize reflections.

Avoid touching the sensing surfaces of the instruments. They should be kept free from dust by gently blowing across their surface. Durable black coatings may, if necessary, be gently cleaned with a very soft brush.

As mentioned in C.1, the instruments should not be placed so close to the radiant source that they are exposed to convection flow initiated directly by the radiant source.

The use of successive output values from the secondary-standard heat flux meter (F1 and F2) that are required to differ by less than 1 %, is intended to reduce the effects of variation with time of radiant-source irradiance. Under normal calibration conditions, it should not be necessary to take more than a few values for F before the required maximum 1 % difference is achieved.

Annex D
(informative)

Procedure recommended for maintenance of a secondary standard of irradiance at a test laboratory

D.1 This annex outlines the procedure by which a test laboratory can maintain reliable secondary and tertiary standards of irradiance. It is founded on the relative stability of sensitivity of heat flux meters which are reserved entirely for calibration and inter-comparison purposes and are never subjected to the rougher conditions of measurement in fire tests and experiments. Although the absolute determination of irradiance is a complex and time-consuming procedure, the maintenance of calibration of secondary and tertiary standard instruments is generally more straightforward.

D.2 The first step is to designate three heat flux meters (A, B, C), two of which will become tertiary-standard instruments, to be reserved henceforth solely for calibration of other instruments in the laboratory. These are usually commercially available Schmidt-Boelter measurement-type (thermopile) or Gardon measurement-type (foil) heat flux meters. These should ideally be new instruments purchased specially, or alternatively, instruments that have been used in the test laboratory but not been abused. In some cases, records of calibration can indicate certain instruments as having a stable sensitivity over a period of years and such instruments are especially suitable. The purchase of new instruments does not automatically ensure good stability of sensitivity, although on the whole new instruments are likely to be satisfactory.

D.3 One of the three heat flux meters, for example A, should be designated as the principal secondary standard.

D.4 This instrument (A) should then be calibrated at a standardizing laboratory maintaining a primary standard of irradiance, and the laboratory should be informed of the purpose of the calibration. The instrument should preferably be transported by hand, but if sent by post should be very well packed with resilient foam to cushion it against shocks in transit.

D.5 The test laboratory should now be in a position to make accurate calibrations of the two other heat flux meters, B and C using the procedure in Clause 5. Once completed, the principal secondary-standard instrument, A, should be wrapped for protection and stored away to be used to recalibrate instruments B and C on an annual basis (see D.6). Additionally, heat flux meter B should also be wrapped for protection and stored away.

D.6 At intervals, determined in part by the passage of time and in part by the volume of calibration work, C should be compared with B (using at least 20 data pairs). As a rough guide, it is suggested that the inter-comparison is required after 25 calibrations, or six months with fewer calibrations. However, if calibrations are very infrequent, the inter-comparison of B with C can be left until a calibration is required.

D.7 As an overall check on the validity of the procedure, it is recommended that the instruments B and C be recalibrated every year, using heat flux meter A. Furthermore, it is recommended that heat flux meter A be recalibrated every three years according to ISO 14934-2.

D.8 Continuity and a methodical approach are essential in long-term work of this kind. It is highly desirable that the work should be assigned to one reliable person, and it is essential that he or she should keep full, accurate and detailed records.

Bibliography

[1] ISO 5660-1, *Reaction-to-fire tests — Heat release, smoke production and mass loss rate — Part 1: Heat release rate (cone calorimeter method)*

[2] ISO 5658-2, *Reaction to fire tests — Spread of flame — Part 2: Lateral spread on building and transport products in vertical configuration*

[3] ISO 5659-2, *Plastics — Smoke generation — Part 2: Determination of optical density by a single-chamber test*

[4] ISO 9239-1, *Reaction to fire tests for floorings — Part 1: Determination of the burning behaviour using a radiant heat source*

[5] ISO 13927, *Plastics — Simple heat release test using a conical radiant heater and a thermopile detector*

[6] ISO/TS 14934-4, *Fire tests — Calibration of heat flux meters — Part 4: Guidance on the use of heat flux meters in fire tests*

[7] ISO 17554, *Reaction to fire tests — Mass loss measurement*

ICS 13.220.40, 13.220.50

Price based on 16 pages