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PUBLICATION

AFAP-2
(Edition 3)

NATO REACTION-TO-FIRE TESTS FOR MATERIALS

SMOKE GENERATION

AFAP - 2
(Edition 3)

JULY 2010

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NORTH ATLANTIC TREATY ORGANIZATION

NATO STANDARDISATION AGENCY (NSA)

NATO LETTER OF PROMULGATION

30 July 2010

1. AFAP-2(Edition 3) – NATO REACTION-TO-FIRE TESTS FOR MATERIALS - SMOKE GENERATION is a non classified NATO publication. The agreement of interested nations to use this publication is recorded in STANAG 4602.

2. AFAP-2(Edition 3) is effective on receipt. It supersedes AFAP-2(Edition 2) which shall be destroyed in accordance with the local procedure for the destruction of documents.

3. It is permissible to distribute copies of this publication to Contractors and Suppliers and such distribution is encouraged.

Cihangir AKSIT, TUR Civ
Director, NATO Standardization Agency

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Record of Changes

Change Date	Date Entered	Effective Date	By Whom Entered

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Preface

1. This Allied Publication forms part of a series as follows:

   AFAP-1 NATO reaction-to-fire tests for materials - POLICY FOR THE PRE-SELECTION OF MATERIALS FOR MILITARY APPLICATIONS.

   AFAP-2 NATO reaction-to-fire tests for materials - SMOKE GENERATION

   AFAP-3 NATO reaction-to-fire tests for materials - TOXICITY OF FIRE EFFLUENTS

   AFAP-4 NATO reaction-to-fire tests for materials - SURFACE SPREAD OF FLAME

   AFAP-5 NATO reaction-to-fire tests for materials - HEAT RELEASE RATE

2. The contribution to fire hazard from a particular material, depends on a number of interrelated factors. It is not only influenced by the reaction-to-fire properties of the material, but also by the way in which the material is used in practice and by the fire scenario to which it is exposed. These Allied Publications define methods for the assessment of reaction-to-fire properties of materials, valid under the specific conditions of each test. They provide comparisons between candidate materials, but do not predict the behaviour of the materials, or combinations of materials, in actual fire conditions. Together, they are intended to be used as part of the comparative screening process for the pre-selection of materials on the basis of their fire characteristics.

3. Any enquiries regarding this Allied Publication in relation to an invitation to tender or a contract in which it is incorporated are to be addressed to the Technical Authority.

NATO REACTION-TO-FIRE TESTS FOR MATERIALS

SMOKE GENERATION

Warning

This Allied Publication may call for the use of substances and/or procedures that may be injurious to health or damaging to the environment if adequate precautions are not taken. Test operators shall be responsible for implementation of such precautions, in order to ensure the safe operation of the test. The text of this Allied Publication refers only to technical requirements and in no way absolves the user from statutory or other legal obligations relating to health and safety or environmental legislation. Full account shall be taken of further health and safety advice/warnings that appear in the normative references and equipment manuals. Where attention is drawn to particular hazards, those quoted may not be exhaustive.

1. SCOPE

This Allied Publication defines a method for determination of smoke generation for a material, under three sets of specified laboratory conditions. The procedure is based on ISO 5659-2:2006 and as such describes an experimental method for measuring smoke production from specimens of the material, using a single chamber test. This is supplemented to include detailed requirements for specimen preparation for particular types of material, additional details for test and calibration procedures to enhance repeatability and reproducibility and data presentation, including an additional (optional) parameter, *VOF4* (see Sect 10.4) that provides a measure of the early smoke generation by the specimen.

2. NORMATIVE REFERENCES

2.1. The following documents are referred to in this Allied Publication:

ISO 291 Plastics - Standard atmospheres for conditioning and testing: 2008.

ISO 1514 Paints and varnishes - Standard panels for testing: 2004;

ISO 5659-2 Plastics - Smoke generation - Part 2: Determination of optical density by a single-chamber test: 2006;

NF X 10-702 Fire test methods. Determination of the opacity of the fumes in an atmosphere without air renewal: 1994/5;

STANAG 4602 Fire Assessment of Materials. 2004.

2.2. This Allied Publication has been prepared with reference to the particular versions of the standards specified above, which were current at the time of publication. From time to time, all standards are subject to revision and NATO will keep this prospect under review. Not withstanding this fact, the versions of the standards specified above shall

continue to be used, without amendment, until such time as NATO specifies the use of any amendments or revisions published by the relevant standards organisations.

2.3. National and international standards are available from the relevant national standards body for each nation or from ISO. NATO STANAGs and Allied Publications can be obtained from the NATO STANAG point of contact for each nation.

3. DEFINITIONS

3.1 Technical Authority

The relevant authority, responsible for providing regulations and guidance on reaction-to-fire properties of materials/products associated with procurement and in service support.

4. PRINCIPLES OF THE TEST

The procedure assesses the smoke generated by horizontal test specimens exposed to specified levels of irradiance under three of the four sets of experimental conditions given in ISO 5659-2, by measuring the attenuation of light as the combustion products accumulate in a test chamber. Specimens are tested in accordance with ISO 5659-2, using three sets of test conditions (i.e. 25 kW/m^2 with and without a pilot flame and at 50 kW/m^2 without a pilot flame) and this is supplemented and amended by the provisions of this Allied Publication, which include significant additions to the test procedure and calculation of an additional (optional) parameter.

5. GENERAL

5.1 Conduct of tests

Carry out the tests in accordance with ISO 5659-2 supplemented and amended by the provisions of this Allied Publication. Where the provisions of ISO 5659-2 conflict with the provisions of this Allied Publication, the provisions of this Allied Publication shall be applied. Where no information is given in this Allied Publication all of the provisions of ISO 5659-2 shall be applied.

5.2 Additional information

Only the information that is additional to ISO 5659-2 is included in this document. All remaining information appears in ISO 5659-2 and in order to carry out the test specified by this Allied Publication it must be read in conjunction with ISO 5659-2.

6. SUITABILITY OF A MATERIAL FOR TESTING *(ISO 5659-2 SECT 3,5 & 7)*

6.1 Physical characteristics *(ISO 5659-2 Sect 5.2)*

In the case where materials submitted for evaluation have faces which differ or contain laminations of different materials arranged in a different order in relation to the two faces, the Technical Authority shall determine whether either or both faces of the materials are required to be tested. The test results shall only be valid for the particular face tested.

6.2 Intumescent materials *(ISO 5659-2 Sect 3.12)*

For each test mode, if any of the specimens behave as an "intumescent material" as defined in ISO 5659-2 (Sect 3.12) with the cone heater 25 mm from the specimen, terminate the test and discard the results for that specimen. Test an additional substitute specimen in the same test mode, at the same separation and if this exhibits the same behaviour, discard all of the results for this mode at 25 mm separation and test three new specimens in this mode, at 50 mm separation, as described for "intumescent materials" in ISO 5659-2 (Sect 3.12).

Note: Results from tests at different separations may not be comparable.

7. SPECIMEN CONSTRUCTION AND PREPARATION *(ISO 5659 - 2 SECT 6)*

7.1 Form of sample to be tested *(ISO 5659-2 Sect 6.3)*

The test specimen form shall be determined in accordance with ISO 5659-2, with reference to Annexes 1 & 2 of this Allied Publication.

7.2 Conditioning

Condition the test specimens to constant mass as described in ISO 5659-2 Section 6.5, except using the conditions (23 ± 2) °C, (50 ± 10) % relative humidity (see ISO 291).

8. APPARATUS AND ANCILLARY EQUIPMENT

8.1 Heat flux meter (ISO 5659-2 Sect 9.8)

8.1.1 Calibration of the working heat flux meter

Calibration of the working heat flux meter used to set radiator cone at 25 kW/m^2 or 50 kW/m^2 at the start of each testing day (ISO 5659-2 Sect 9.8) shall be traceable by no more than 4 steps, to the primary standard maintained by LNE - France or SP - Sweden (see below). Details of how to obtain such a calibration may be obtained from the Technical Authority.

Note: Technical enquiries, on this subject, may also be directed to:

LNE Laboratoire National de Metrologie et d'Essais
Centre for Metrology and Instrumentation
Division for Optical Radiation Metrology
and Thermal Properties of Materials
29, Avenue Roger Hennequin
78197 Trappes Cedex
France
Tel : +33 (0)1 30 69 10 00
Fax : +33 (0)1 30 69 12 34
e-mail: info@lne.fr

SP Technical Research Institute of Sweden
Fire Technology
Box 857
SE-501 15 Boras
Sweden
Tel.: + 46 (0) 10 516 50 00
Fax : + 46 (0) 33 13 55 02
e-mail: info@sp.se

8.1.2 Transfer calibrations

Transfer calibrations shall be made using the radiator cone an ISO 5659-2 smoke chamber, according to the procedures described in Annex 3 of this Allied Publication. (Steps 2 and 3 in Figure 4 in Annex 3).

8.2 Specimen holder (ISO 5659-2 Sect 7.3.5)

8.2.1 The grid described in this part of ISO 5659-2 shall not be used unless specified by the Technical Authority, for example, in a materials specification.

Note: Where the grid is used, the apparatus may need to be adjusted to ensure that, with the grid and retainer frame in place, the lower rim of the radiator cone shade remains 25 ± 1 mm above the surface of the specimen (ISO 5659-2 Sect 7.3.2).

8.2.2 A schematic diagram of the specimen holder is shown in Figure 1. Means shall be provided to hold the retainer frame securely in position on the specimen holder and to prevent it moving as a result of distortion, swelling or intumescence of the specimen during the test. This may be achieved using retaining devices inserted through the side wall of the frame (screw, bar, etc.) or with a loop of wire wrapped around each edge of the frame and holder (see Figure 2). The wire shall not pass above the exposed face of the specimen.

8.3 Pilot burner (ISO 5659-2 Sect 7.3.6)

The nozzle of the pilot burner shall be positioned vertically above the centre of one of the edges of the exposed face of the specimen, with the flame extending horizontally towards a position above the centre of the specimen, as shown in Figure 1 & Figure 2 of this Allied Publication.

9. TEST PROCEDURE (ISO 5659-2 SECT 10)

Carry out the test procedure described in ISO 5659-2 Section 10 supplemented and amended as follows;

Note: The test procedure is significantly changed, particularly in relation to the time at which the test is terminated.

9.1 Preparation of test chamber

ISO 5659-2 Section 10.2 supplemented by the provisions Section 8 of this Allied Publication.

9.2 Tests with pilot flame

ISO 5659-2 Section 10.3 supplemented by the provisions of Section 8.3 of this Allied Publication.

9.3 Loading the specimen (ISO 5659-2 Section 10.5.)

Secure the edge frame as specified in Section 8.2.2 of this Allied Publication.

Note: Extinction of the pilot flame before the shield is removed (ISO 5659-2 Section 10.4 paragraph 2 refers) may also indicate a problem with the set up of the gas and/or the burner and not with the specimen. Such problems should be resolved before starting the test.

9.4 Observations

ISO 5659-2 Section 10.7. If the pilot flame is extinguished by gaseous effluent during a test (ISO 5659-2 Section 10.7 paragraph 3 refers) the results from that specimen shall be discarded and an extra specimen tested in its place.

9.5 Termination of test (replaces ISO 5659-2 Sect 10.8)

9.5.1 Carry out the initial test in each test mode for 20 minutes, regardless of the occurrence of any minimum in the light transmission curve (see Note). If the minimum transmittance value is shown by the initial test to occur within the first 10 minutes, then terminate subsequent tests for that test mode at 10 minutes. Otherwise, terminate the tests at 20 minutes.

Note: This is in order to verify the possible existence of a secondary minimum, for example as might occur when a layered material burns through from one layer to the next.

9.5.2 The exception to 9.5.1 is that it is permissible to terminate the test at a time when the specific optical density, D_s, reaches the upper limit defined in Section 10.2 of this Allied Publication, i.e. $D_s = 792$. The value of percentage light transmission, T_t, that corresponds to $D_s = 792$ may need to be determined by calculation, prior to the test, if this procedure is to be adopted (see Note below).

Note: The upper limit value is applied to D_s (not T_t). However, during the test run most types of smoke chamber display only an instantaneous value of T_t and Equation 1 below is used afterwards to calculate D_s (see Section 10.1 of this Allied Publication). This calculation includes a correction for the optical density of the ND-2 range extension filter, which is different for each smoke chamber. For the idealised case, where the optical density of this filter is exactly equal to 2.00, the correction factor, $C_f = 0$ and the value of percentage light transmission at which $D_s = 792$ is $T_t = 0.00010\%$. However, usually in practice, the optical density of the ND-2 filter is not exactly equal to 2.00, so that the transmission reading displayed on the instrument at the point where $D_s = 792$ will be higher or lower, depending on the sign of C_f. In such cases it is necessary to determine the value of T_t corresponding to $D_s = 792$, by calculation prior to testing, using the value of C_f that has been determined in accordance with ISO 5659-2 Section 9.5. The alternative is to continue the test at least until $T_t = 0.00005\%$ to ensure that the true point where $D_s = 792$ has been reached, before the test is terminated.

9.5.3 Extinguish the burner if the pilot flame has been used.

Note: The burner is extinguished in order to obviate the possibility of air mixing with combustion products present and causing an explosion.

9.5.4 Move the radiation shield below the cone.

9.5.5 Switch on the exhaust fan and when the water manometer indicates a small negative pressure, open the inlet vent and continue exhausting until a maximum value of percentage light transmission is reached, with the appropriate range selected and record this as the, “clear beam”, reading T_C (see ISO 5659-2 Sect 10.8.4).

9.6 Testing in different modes (ISO 5659-2 Sect 10.9)

Measure the percentage light transmission of three sets of three specimens in accordance with the following schedule:

Mode 1 (25NP): Irradiance 25 kW/m^2, no pilot flame 3 test specimens.

Mode 2 (25P): Irradiance 25 kW/m^2, pilot flame 3 test specimens.

Mode 3 (50NP): Irradiance 50 kW/m^2, no pilot flame 3 test specimens.

Note: Testing in Mode 4, with the pilot flame at 50 kW/m^2 as described in ISO 5659-2 is not required for the purposes of this Allied Publication.

9.7 Repeat tests (ISO 5659-2 Sect 10.9.2)

Follow the procedure specified in ISO 5659-2 Section 10.9.2 for repeat tests required if replicate results for any test mode are irreproducible.

10. EXPRESSION OF RESULTS *(ISO 5659-2 SECT 11)*

There are significant additional requirements for the expression of results. In addition to recording D_{s10} and D_C in accordance with ISO 5659-2 Section 11, calculate the values of $D_{s,max}$, t_{max}, and if required, *VOF4* according to the following procedure;

10.1 Specific optical density D_s (replaces ISO 5659-2 Sect 11.1)

10.1.1 For each valid specimen, record a continuous record of light transmission against time.

10.1.2 Use Equation 1 below to calculate the maximum specific optical density, $D_{s,max}$, from the minimum percentage light transmission recorded during the test (see Section 9.5 of this Allied Publication). Record the time (in minutes to 1 decimal place) at which $D_{s,max}$ occurred, as t_{max}. If the calculated value of $D_{s,max}$ exceeds the upper limit for D_s (see Section 10.2. of this Allied Publication), set $D_{s,max}$ equal to 792 and record t_{max} as the time at which this value was first reached.

$$D_{st} = \frac{V}{AL}\log_{10}\left(\frac{100}{T_t}\right) + C_f \qquad \textbf{Equation 1}$$

where,

T_t is the percentage light transmission (to two significant figures), taken from the continuous record, at time t;

D_{st} is the specific optical density at time t;

$\frac{V}{AL} = 132$ is a factor derived from the geometry of the test (see ISO 5659-2 Sect 11.1.1);

Note: *V* is the volume of the chamber, *A* is the exposed area of the specimen and *L* is the length of the light path.

C_f if the filter is present the calibration factor for the ND-2 range extension filter, as described in ISO 5659-2 Section 11.1.2.

Note: The clear beam correction is not used in this calculation.

10.2 Upper limit on specific optical density, D_s (ISO 5659-2 Section 10.6)

For the purposes of this Allied Publication, the values of specific optical density, D_s, reported or used in the calculations shall not exceed 792.

Laboratories shall ensure that any software package used to calculate test results for this Allied Publication complies with this requirement.

Note 1: When very high levels of smoke are produced and the percentage light transmission, T_t, approaches zero, the formula used to calculate the specific optical density, D_s, (see Sect 10.1 of this Allied Publication) results in a value that increases exponentially towards infinity. It is therefore necessary to choose a limiting value for reporting. It is also necessary to avoid the use of readings below the accurate measuring range of the photometric system.

Note 2: Before this provision was introduced in ISO 5659-2: 2006 Sect 10.6 it was known that the lowest value of T_t (or highest value of D_s) reported by equipment from different manufacturers varied because of the different data recording methods used, e.g. various computer software packages or pen chart recorders.

Note 3: The upper limit of $D_s = 792$ was been chosen because it corresponds to a percentage light transmission equal to 10% of the full scale deflection for the lowest measuring range (see Note 4). Measurements below approximately 10% of the full scale are not considered accurate with the type of photometric system used (see ISO 5659-2 Sect 10.6).

Note 4: This assumes an ND-2 range extension filter with optical density exactly equal to 2.00. Where this differs from 2.00 the corresponding value of T_t will differ to some extent, but the same upper limit of 792 is to be applied to D_s (see Sect 9.5.2 of this Allied Publication).

Note 5: ISO 5659-2 requires the provision of an ND-2 range extension filter to achieve a lowest measuring range with a full scale deflection of 0.001%. However, some older designs of smoke chamber are not equipped with this filter and as such are not capable of accurately measuring values of T_t below 0.01% (equivalent to

D_s = 528 if C_f = 0). This shall be recorded as a deviation from the test method in the test report when appropriate.

10.4 *VOF4*

If required by the Technical Authority, for each specimen calculate the parameter *VOF4* from the following equation:

$$VOF4 = D_{S1} + D_{S2} + D_{S3} + \frac{D_{S4}}{2} \qquad \textbf{Equation 2}$$

where,

D_{s1} , D_{s2} , D_{s3} , D_{s4} are the specific optical densities at 1.0, 2.0, 3.0 and 4.0 minutes respectively

Note 1: Values of D_s to be used are subject to an upper limit (see Sect. 10.2 of this Allied Publication)

Note 2: The clear beam correction is not used in this calculation.

Note 3: *VOF4* is a measure of the smoke generation by the specimen during the first four minutes of the test. It is not the optical density of the smoke present in the chamber after four minutes (which is given by D_{s4}). It is a parameter described in French standard NF F 10-702 Part 2-5, that depends on the area under a graph of D_s versus time between the start of the test and 4 minutes. It is designed to discriminate against materials which produce smoke early in the test. Because of the different conditions of test, the value of *VOF4* from NF X 10-702 does not correspond to the value determined in this test.

10.5 Clear-beam correction factor D_C *(ISO 5659-2 Section 11.2)*

For each specimen calculate D_C from T_C, recorded in 9.5.5 using the Equation 1. Do not record the correction factor D_C if it is less than 5% of the maximum specific optical density.

10.6 Specific optical density at 10 minutes D_s10 *(ISO 5659-2 Section 11)*

For each mode of exposure, calculate the mean value of D_s10 for the specimens tested.

Note: The value of D_s is subject to an upper limit (see Section 10.2 of this Allied Publication).

11. TEST REPORT

The test report shall include a reference to this Allied Publication together with the following information:

Note: Some of the following information may be required by the Technical Authority for the database described in AFAP-1.

a) the name and address of the laboratory undertaking the test;

b) the name and address of the supplier and where different, of the manufacturer (original source) of the material tested;

c) the date(s) of the test;

d) a full description of the material tested including, where applicable and/or known;

name

application

type of material (chemical composition)

type of product (form or shape e.g. sheet or tube etc.)

essential dimensions (including mass or density, sheet size/thickness, diameters and wall thickness of pipes/tubes, etc.)

colour (facing colour)

details of any coatings (including substrates, surface preparation techniques, no. of layers, colour, coverage rates, etc.)

details of upholstery construction (including number, type and thicknesses of each covering, interliner and padding layer, etc)

specifications

NATO Stock No.s or other Unique Identification No.s

details of any previous tests known

other relevant technical data

e) a full description of the specimen construction and preparation (e.g. including where relevant, substrate, use of grid, coating layers, tube or pipe, upholstery layers included in the specimen, etc.) ;

f) the specimen face(s) tested;

g) if calculated, the neutral density correction factor, C_f;

h) the thickness of each specimen tested; (if the material has been reduced in thickness in accordance with ISO 5659-2 Section 6.2.3, include both the thickness tested and the original thickness of the material as received);

i) for each valid specimen tested;

the mode of testing

the graph of light transmission against time

the graph of D_{st} against time (optional)

the maximum specific optical density, $D_{s,max}$ (if appropriate, report that D_s reached or exceeded the upper limit, see Section 10.2 of this Allied Publication)

the time to maximum specific optical density, t_{max}

the specific optical density at 10 minutes, D_s10 (if appropriate, report that at 10 minutes D_s had reached or exceeded the upper limit, see Section 10.2 of this Allied Publication)

the value of *VOF4* (optional)

the duration of the test

the clear beam correction factor, D_C

j) the mean values of $D_{s,max}$, t_{max}, *VOF4* (optional) and D_s10 for each of the three modes of testing;

k) observations of the specimens and the times from the start of the test at which the observations were made, together with details of any invalid tests and the reasons for these;

l) details of any repeat tests required in accordance with this Allied Publication;

m) the statement: "These results relate only to the behaviour of the specimens of the material under the particular conditions of test."

Note: The Materials Fire Characteristics Data Sheets from the STANAG 4602 database described in AFAP-1 may, optionally, be used for recording some of the test results. (Copies are shown in Annex 4 of this Allied Publication).

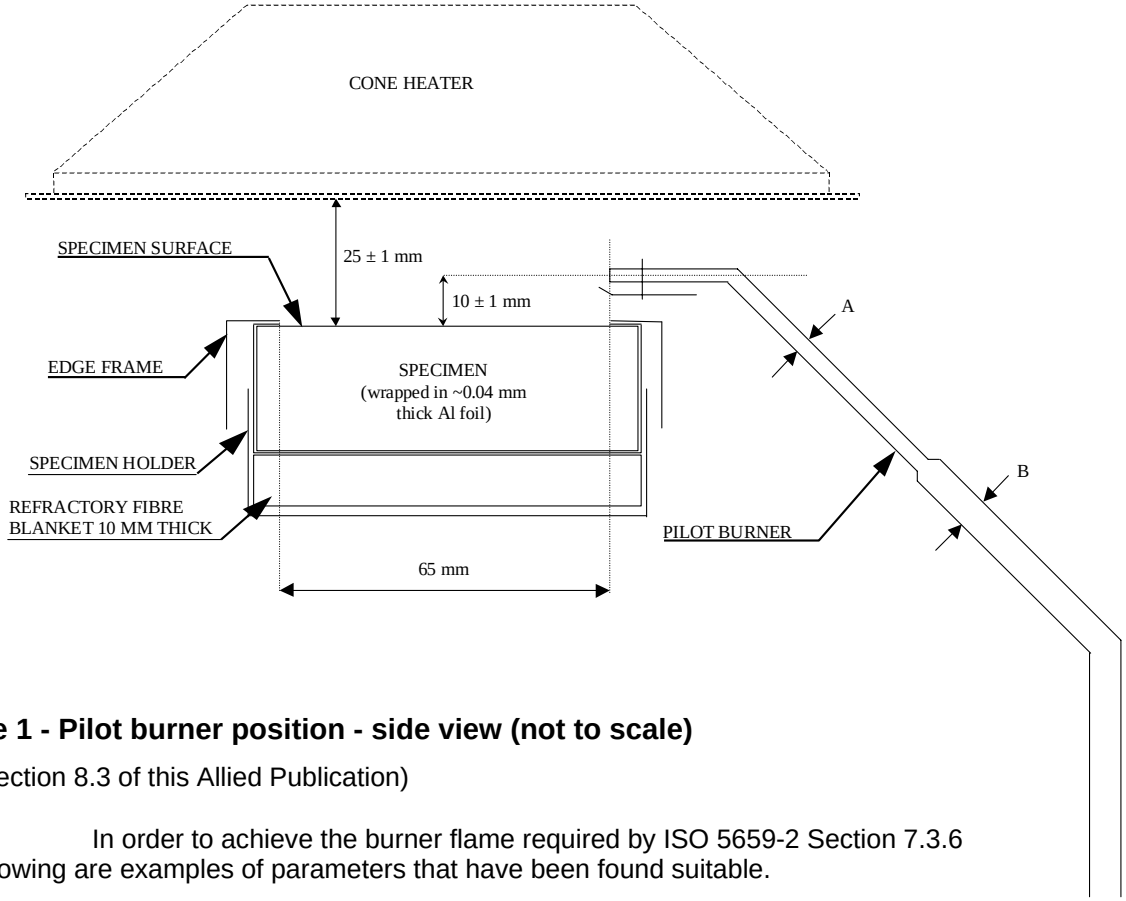

Figure 1 - Pilot burner position - side view (not to scale)

(see Section 8.3 of this Allied Publication)

Note: In order to achieve the burner flame required by ISO 5659-2 Section 7.3.6 the following are examples of parameters that have been found suitable.

Burner pipe:			Approximate flow rates:	
A	3.18 mm OD	1.58 mm ID	Propane	50 cm^3/minute
B	6.35 mm OD	4.55 mm ID	Air	300 cm^3/minute

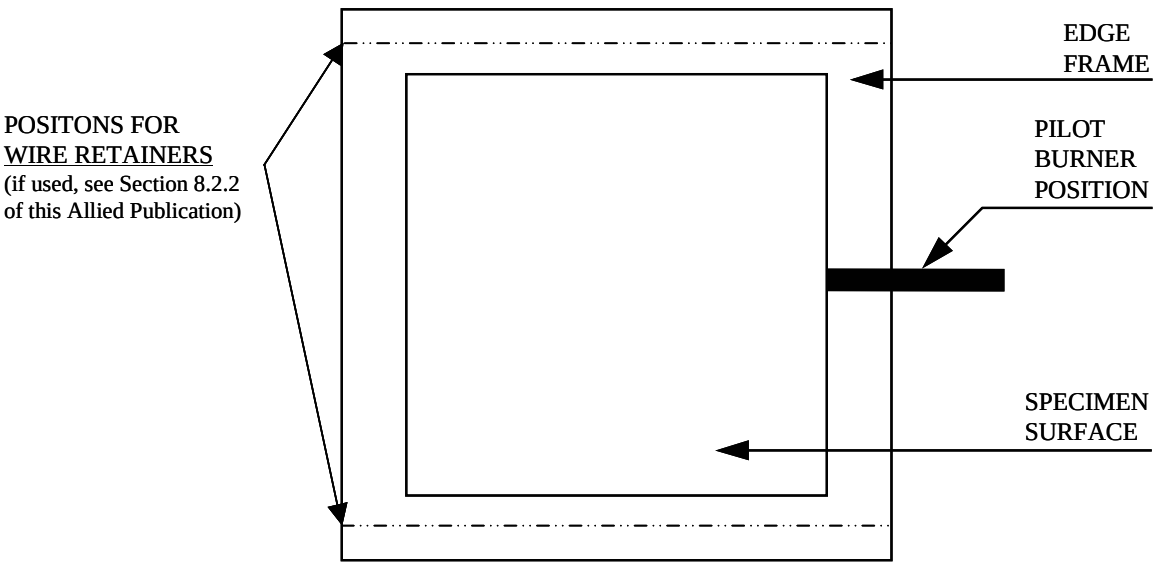

Figure 2 - Pilot burner position - Plan view (Not to scale)

ANNEX 1 - PREPARATION OF TEST SPECIMENS

A – Paint/coating

A.1 Paint/coating test specimens shall consist of mild steel panels[1], of nominal thickness 3 mm, coated on the upper (i.e. exposed) face with the paint system under test.

A.2 The dimensions of the test panels shall be 75 $^{+0}/_{-1}$ mm x 75 $^{+0}/_{-1}$ mm (as specified in ISO 5659-2 Section 6.2.1).

A.3 Prepare the surface of each test panel and apply the paint/coating system to the required thickness, according to the manufacturer's instructions that will be used in the end use application. The method of surface preparation shall be recorded in the test report. The back and edges of the panel shall not be coated.

A.4 In the absence of specific instructions on surface preparation from the manufacturer, the method of surface preparation shall be as specified by the Technical Authority.

Note: Examples of suitable surface preparation techniques can be found in ISO 1514.

A.5 Dry (or heat cure) each coated test panel for the manufacturers specified time under the specified conditions and then condition them at (23 ± 2) °C, (50 ± 10) % R.H. for 7 days, with free circulation of air and without exposing them to direct sunlight.

A.6 The smoke test procedure shall then be carried out within 7 days.

[1] Where the end use application of a paint/coating is on mild steel of less than 3 mm thickness, or on a different non-combustible substrate material, which has lower heat absorption, the smoke generation may be greater and/or more rapid. In such cases the Technical Authority may require that the material is tested on the end use substrate. If paint/coating is applied on a combustible substrate it shall be tested as part of the end use composite.

B - Tubes and pipes

Specimens shall be prepared as required in any relevant material/product specification as directed by the Technical Authority. In the absence of a material/product specification, specimens shall be prepared, without a substrate, as follows;

B.1 Flexible materials

If the material is sufficiently flexible, cut the tube or pipe lengthwise into strips and construct flat specimens, 75 $^{+0}/_{-1}$ mm x 75 $^{+0}/_{-1}$ mm.

B.2 Rigid materials

If the material is rigid, the test specimen shall be composed of strips cut from the tube/pipe 75 $^{+0}/_{-1}$ mm in length. A sufficient number of identical strips shall be provided to obtain a test specimen 75 $^{+0}/_{-1}$ mm wide. The combination of the number and the width of the strips shall be chosen such that a whole number of strips, when placed together as shown, fill the overall specimen width of 75 $^{+0}/_{-1}$ mm and the height under the curve is ≤ 5 mm[1]. All cuts shall be made normal to the wall of the tube/pipe. The spaces beneath the unexposed concave surfaces shall be left void.

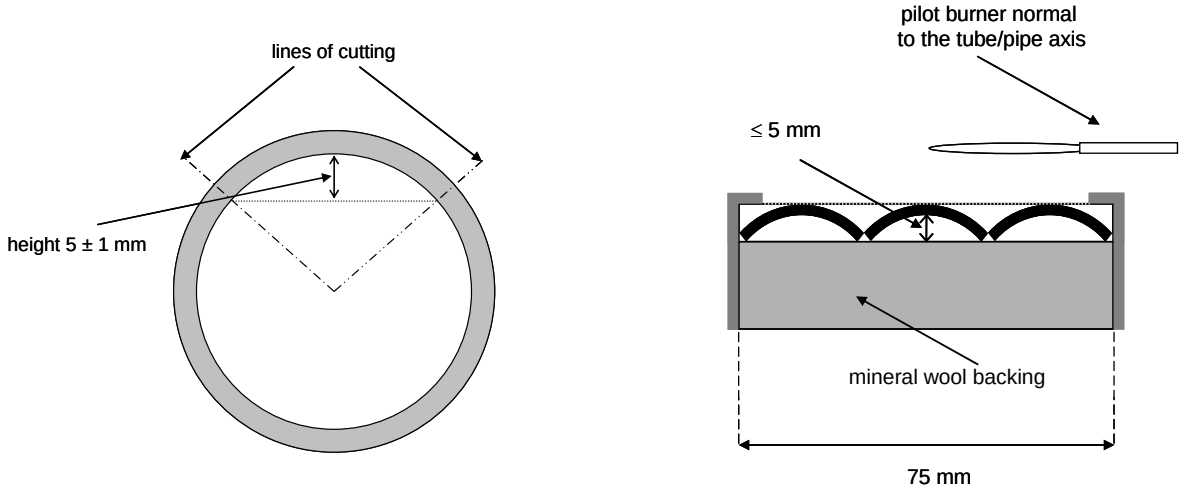

Figure 3 - Tube and pipe test specimens.

[1] The exception to this is that if the internal diameter is ≤ 10 mm the tube/pipe strips shall be cut with a semi-circular cross section.

C – UPHOLSTERED FURNITURE

INCLUDING MATTRESSES

C.1 General

Where upholstered furniture items are to be evaluated by testing an assembled upholstered composite. The test specimen shall consist of layers of all of the covering(s), interliner(s) and padding material(s) (usually foam or other compliant material) arranged in the order that they occur in the finished item, assembled as described below.

Note: To ensure repeatability/reproducibility it is important that the masses of the blocks of padding material are consistent and the fabric pieces are uniform.

C.1.1 Overall thickness

Where the total thickness of the upholstery on the finished item of furniture [padding(s) + interlayer(s) + covering(s)] is less than or equal to 25 mm, all of the component layers shall be included in the test specimen at their original thickness.

Where the total thickness of the upholstery on the finished item of furniture [padding(s) + interlayer(s) + covering(s)] is greater than 25 mm, include any padding layers thinner than 8 mm in their original thicknesses. Include each of the remaining layers (i.e. those > 8 mm in thickness) at reduced thickness, so proportioned that their relative thickness in the remaining specimen depth (25 mm minus the thin layers) is in the same proportion as is found for those layers in the finished item of furniture.

C.2 CUTTING AND WEIGHING

C.2.1 Dimensions

Cut nine square pieces of each component material, $75\ ^{+0}/_{-1}$ mm x $75\ ^{+0}/_{-1}$ mm.

C.2.2 Fabrics

Do not cut fabrics on the bias.

If the fabric weave is such that the threads in the two directions do not lie at 90° to each other, do not cut the sample along threads in both directions, since a skew specimen would result.

Cut the fabric pieces from a position away from the edge of the supplied sample (if possible, at least 250 mm from any edge).

Material cut from the selvage (i.e. the finished edge of the fabric roll, which often has a different weave pattern and/or thickness) shall not be used.

C.2.2 Mass tolerance

Weigh each square and for each material, calculate the mean of the set of nine.

There shall be no piece that has a mass greater than 105%, nor any less than 95% of the mean. If necessary, check and adjust the dimensions of any over sized pieces and/or cut and weigh further pieces as necessary until the required tolerance is achieved.

Mark each accepted square for traceability and report the mass of each piece along with information about the corresponding test run.

C.3 PREPARATION OF THE TEST SPECIMEN

Weigh the combined components of each test specimen [padding(s) + interlayer(s) + covering(s)] and report the mass along with information about the corresponding test run.

Cut a square of aluminium foil, 145 mm x 145 mm.

With the dull side of the foil facing upwards (towards specimen), stack the components at the centre on the foil. Start with the material from unexposed side (usually padding), progressing in the order the layers occur in the finished furniture item, placing each layer oriented with the exposed side facing upwards.

Hold the block firmly in place and pull each side of the foil up to create the bottom foil. Form the corners by holding the foil firmly in contact with the corner of the specimen. Stretch the corner of the foil and make a 45° fold at each corner. Finally, pull the corners flat against two sides of the specimen and pat all sides down flat against the specimen.

Weigh each specimen with aluminium foil and report the mass along with information about the corresponding test run.

After mounting the test specimen in its holder, cut away excess aluminium foil. The central exposed specimen area is 65 mm by 65 mm.

NOTE If in the end use application the component layers are glued together over a substantial area, the Technical Authority may require that the component layers of the test specimen are glued using the appropriate adhesive. For test specimens with glued parts, it may be convenient for the producer to prepare the specimens.

ANNEX 2 - FORM OF TEST SPECIMENS

Material type	Form of test specimen
INTERIOR PAINT SYSTEMS, WET AND DRY SPACES	Full system including primer(s), undercoat(s) finish(s) etc. as recommended by the manufacturer for initial application. Applied in accordance with Annex 1 of this Allied Publication. Test with the painted face exposed to the cone heater.
INTERIOR DECK COVERING	End use thickness[1]. Test alone, with the upper face exposed to the cone heater. No application of adhesive, underlay or substrate.
THERMAL INSULATION (STRUCTURE)	Insulation at end use thickness[1], with glass cloth facing bonded with the adhesive used in manufacture of the final product. Test with the glass cloth side exposed to cone heater. No application of installation adhesive, vapour barrier coating or substrate, etc.
DECORATIVE LININGS	End use thickness[1]. Test alone, with the outer face exposed to the cone heater. No application of installation adhesive, coatings, fixings or substrate, etc.
UPHOLSTERED FURNITURE INCLUDING MATTRESSES	Assembled upholstered composite test specimens, prepared in accordance with Annex 1 of this Allied Publication.
UPHOLSTERY COMPONENT LAYERS	Some Technical Authorities may require tests on individual components, such as coverings, interliners or padding materials (e.g. core or barrier foams). In such cases the materials shall be tested in their end use thickness[1], without a substrate or facing.

[1] Materials with a thickness greater than 25 mm shall be cut to give a specimen thickness of 25 mm as described in ISO 5659-2 Section 6.2.

ANNEX 3 - HEAT FLUX METER CALIBRATIONS

Introduction

Most fire test laboratories operate a procedure for calibration of heat flux meters that requires a "transfer" or "secondary" method of calibration (e.g. see Figure 4). This is to reduce the cost burden of having all heat flux meters calibrated by a primary method.

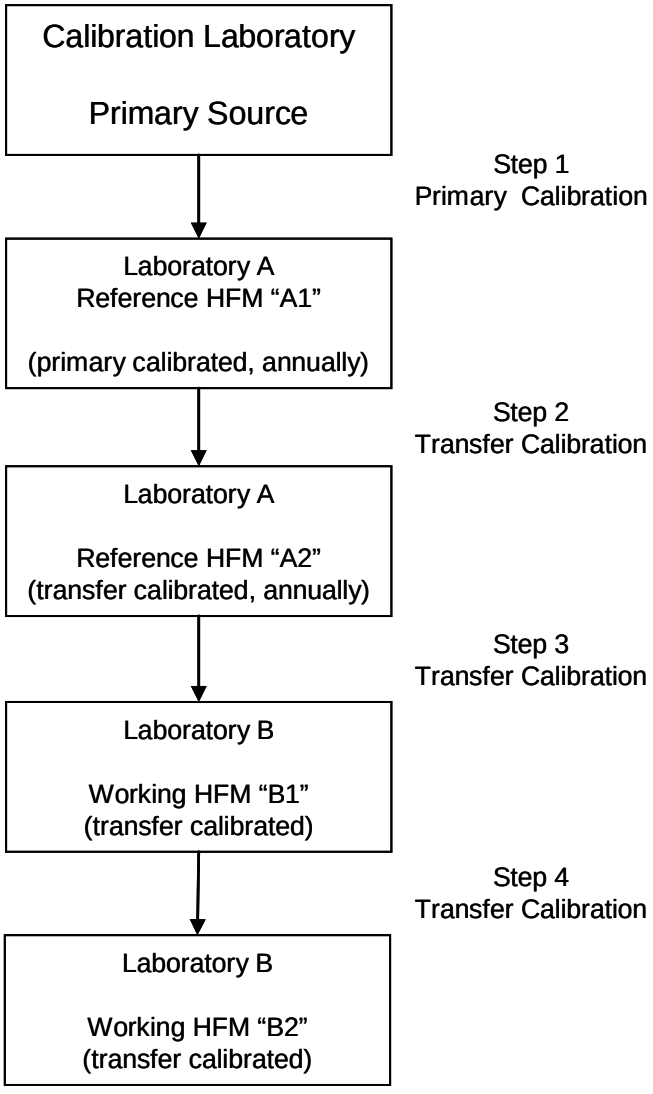

Figure 4 - Schematic illustration of possible 4 step heat flux meter calibration scheme.

Factors that should be considered when carrying out transfer calibrations include;

- Type of radiation source
- Geometry and uniformity of radiation source
- Temperature of radiation source
- View angle of heat flux meter in relation to the source
- Angular sensitivity of the heat flux meter in relation to the source.

Heat flux meters used to calibrate the cone heater in the smoke box are exposed to incident heat which is comprised of both radiation and convective components. The relative proportion of each component is dependent upon the orientation of the apparatus and the level of incident heat.

Setting up procedure

Using a suitable metal support stand (e.g. retort) with a boss and clamping arrangement, support the heat flux meter to be calibrated centrally under the cone heater as shown in Figure 5.

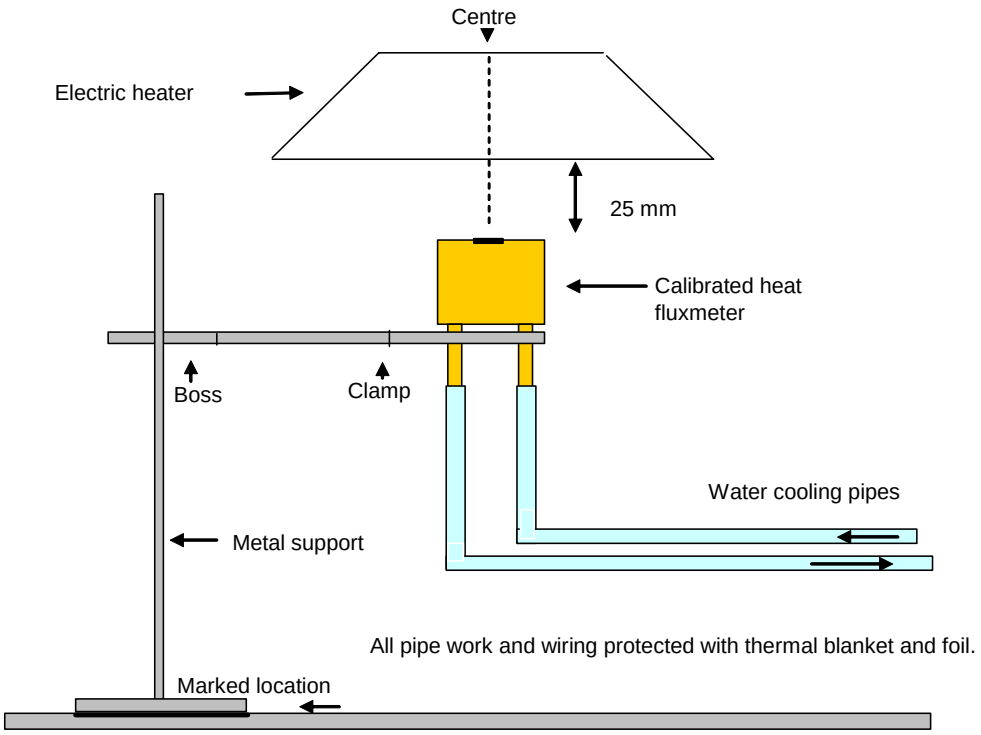

Figure 5 - Schematic diagram of heat flux meter calibration arrangement.

Ensure that the heat flux meter is clamped around the water cooling pipes under its cooling jacket as shown. The face of the heat flux meter should be located at the same distance from the cone heater as the surface of a specimen to be tested.

Attach a suitable length of plastic tubing securely to the water cooling pipes of the heat flux meter. Water can then be supplied to the water jacket of the heat flux meter by tap or a water tank and pump arrangement. The outlet pipe from the heat flux meter can be fed into a drain or returned back to the tank in the latter case.

Connect the output leads from the heat flux meter and thermocouples to a calibrated data logging device or PC, capable of measuring to a resolution of 0.001 mV, using the correct type of cable.

Protect exposed tubing, wires and other vulnerable surfaces including boss and clamp with thermal blanket and aluminium foil.

When in place, outline the base of the support stand and move the entire arrangement to one side.

Repeat the above procedure using the primary calibrated heat flux meter. Ensure that the support stand is identical to the previous one and that it is sitting exactly on the same marked area described earlier.

Procedure for Step 2 calibration

With the primary calibrated heat flux meter in place, locate a sheathed thermocouple approximately 20 mm into the entrance of water cooling outlet pipe. Also locate a bare wire thermocouple close to the apparatus, set up to monitor the ambient air temperature.

Attach the plastic tubing to a water supply and ensure that the water flow from the outlet pipe is continuous and free from air bubbles.

Close the door on the smoke box without latching it and taking care not to compress the water supply tubes. Adjust the power to the cone heater until the desired initial temperature is achieved on the smoke box monitor. Monitor the output of the primary calibrated heat flux meter on the data logger display until the output voltage readings have stabilised. Once in this stabilised condition, record the heat flux meter reading over a period of 5 minutes, using a scan interval of less than or equal to 5 seconds.

Then replace the primary calibrated heat flux meter and stand with the working heat flux meter and repeat the above procedure.

Repeat the above procedure with the primary calibrated heat flux meter, in order to check that the cone heater (thermal exposure) is stable.

Then adjust the power to the cone heater to a new temperature level and repeat the above procedure. Care should be taken when selecting the thermal exposure conditions to

ensure that the full range of the heat flux meter is covered by the calibrations, but that the maximum heat flux is not exceeded.

It is recommended that a minimum of 5 data points be collected for a transfer calibration.

Procedure for Steps 3 & 4

For Step 3 & 4 calibrations, the primary calibrated heat flux meter is replaced with the reference heat flux meter (transfer calibrated) and the remainder of the procedure as outlined above should then be followed.

Data presentation and results

Determine the average voltage output for each heat flux meter each of the different thermal exposure conditions. Convert the measured voltage output from the primary calibrated heat flux meter to a heat flux using the appropriate calibration equation. Tabulate the data as shown below in Table 1.

	Calibrated heat flux meter		Heat flux meter to be calibrated		
Heater temperature (Deg C)	Average voltage (mv)	Average heat flux (kW/m^2)	Average voltage (mv)	Water coolant temperature (Deg C)	Ambient air temperture (Deg C)
490	1.40	17.06	2.70	23.23	23.69
544	1.91	23.11	3.74	24.15	24.86
613	2.69	32.22	5.07	24.96	25.62
639	3.04	36.25	5.65	23.54	23.60
658	3.33	39.67	6.21	23.69	23.91
688	3.86	45.60	7.35	23.19	23.47
698	4.05	47.69	7.72	24.61	25.42
			Average =	**23.91**	**24.37**

Table 1. Example of tabulated data.

Plot the primary calibrated heat fluxes against the voltage output of the working heat flux meter, as shown in Figure 6. The calibration equation for the working heat flux meter is determined from the slope and intercept of the straight line relationship.

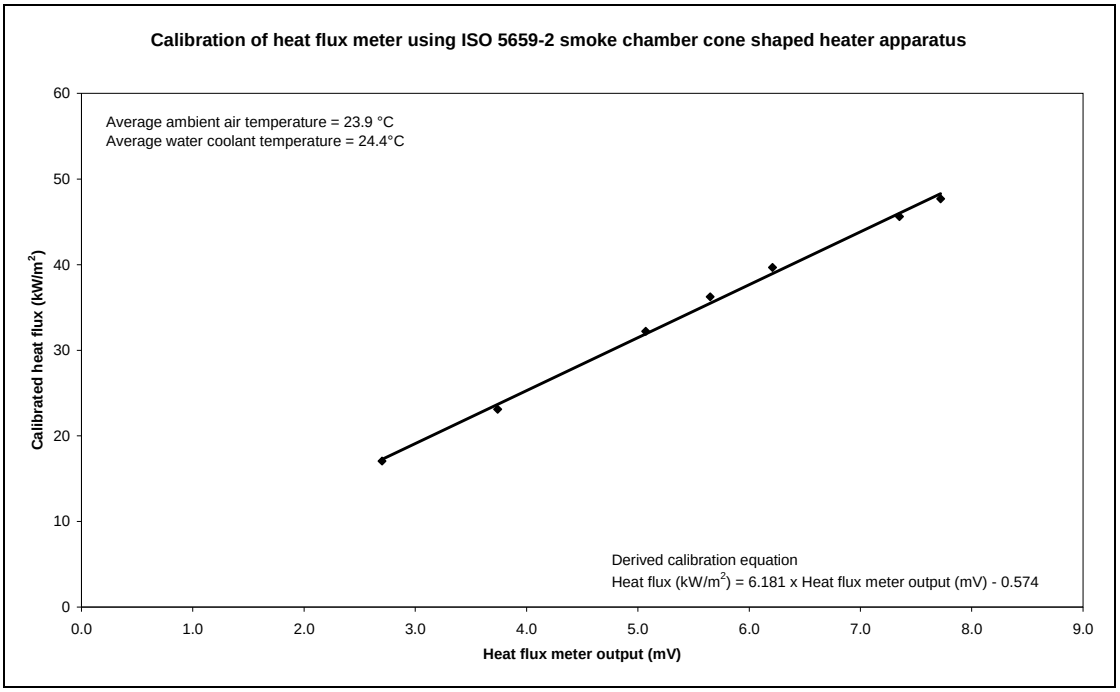

Figure 6 - Example of plotted data for heat flux meter calibration.

Note: It is recommended that a historical log of the calibrations for each heat flux meter is retained by the laboratory. This is useful information that can be used to identify any problems associated with the heat flux meter that can occur from time to time. As a general rule, the calibration of an individual heat flux meter should be fairly stable provided that it is kept free from occurrences that could result in damage, e.g. shock, impact, etc.

ANNEX 4 - DATASHEETS (OPTIONAL)

SMOKE GENERATION **SECURITY MARKING** **STANAG 4602**

AFAP-2 (ISO 5659-2 modified) Edition No. **Item Ref.**

Report No.	**Report Date**
Report Title	
Laboratory Address	**Supplier address**
Material	

Test specimen

(I) Thickness mm or μm:

(II) Specimen construction and preparation:

(III) Coatings:

(IV) Faced tested:

Repeat Tests:

(Details of any repeat tests required in accordance with AFAP-2)

Observations:

(Observations of the specimens and times from the start of the test at which the observations were made, together with details of any invalid tests and the reasons for these)

This document contains commercial Information – See conditions of release. These results relate only to the behaviour of the specimens of the material under the particular conditions of test (See appropriate Standard)

SECURITY MARKING

SMOKE GENERATION **SECURITY MARKING** **STANAG 4602**

AFAP-2 (ISO 5659-2 modified) Edition No. **Item Ref.**

Material:

Mode 1 25 kWm^2 no pilot flame				
Parameter	**Test 1**	**Test 2**	**Test 3**	**Mean of Tests**
$D_{s,max}$				
Time to $D_{s,max}$ (seconds) t_{max}				
VOF4 (= $Ds_1 + Ds_2 + Ds_3 + Ds_4/2$) (optional)				
D_s10				
Clear beam correction factor D_c				

Mode 2 25 kWm^2 + pilot flame				
Parameter	**Test 1**	**Test 2**	**Test 3**	**Mean of Tests**
$D_{s,max}$				
Time to $D_{s,max}$ (seconds) t_{max}				
VOF4 (= $Ds_1 + Ds_2 + Ds_3 + Ds_4/2$) (optional)				
D_s10				
Clear beam correction factor D_c				

Mode 3 50 kWm^2 no pilot flame				
Parameter	**Test 1**	**Test 2**	**Test 3**	**Mean of Tests**
$D_{s,max}$				
Time to $D_{s,max}$ (seconds) t_{max}				
VOF4 (= $Ds_1 + Ds_2 + Ds_3 + Ds_4/2$) (optional)				
D_s10				
Clear beam correction factor D_c				