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Fire Testing of Furniture in the Cone Calorimeter

– The CBUF Test Protocol

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Abstract

A new method has been developed for testing upholstered furniture specimens according to ISO 5660 or ASTM E 1354 (Cone Calorimeter) standards. This method provides supplementary instructions for specimen preparation and other aspects of testing upholstered furniture composites which are not covered under the basic ISO 5660/ASTM E 1354 procedures. The new method provides for a significant improvement over the procedures described in the first edition of ASTM E 1474. Provisions are included for testing composites which include protective interliners and those which use loose-filling materials. The method also includes the testing of mattress composites.

Key words: Fire tests, small scale fire tests, heat release, upholstered furniture, cone calorimeter

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Introduction

This report presents a test protocol for testing upholstered furniture composites in the Cone Calorimeter. The protocol is tried out in the European fire research programme "CBUF - Combustion Behaviour of Upholstered Furniture". The programme was initiated by the Commission of the European Communities, DG XII, the Directorate General for Science, Research and Development. The work was managed and funded by SP, the Swedish National Testing and Research Institute.

The ISO standard on the Cone Calorimeter (ISO 5660 Part 1 [1]) contains the basic necessary instructions for specimen preparation and testing. This is supplemented, in the interim, by ASTM E 1354 [2] which also includes instructions for smoke measurements; the latter will be incorporated in ISO 5660 Part 2 when that part is published. The above standards are quite general and serve to provide guidance for testing a very wide variety of products. Upholstered furniture composites present some unique issues in specimen preparation. Recognising this, there has been an American standard addressed specifically towards providing additional guidance specific to upholstered furniture testing in the Cone Calorimeter. This standard was first promulgated by NFPA as NFPA 264A [3]; a substantively identical version was later also adopted by ASTM as ASTM E 1474 [4].

The ASTM E 1474 standard gives explicit instructions for preparing upholstered furniture specimens. The basis for it, however, goes back to work done at NIST in the mid-1980s. This was at the early time of studying furniture flammability with the Cone Calorimeter, thus, subsequent experience of laboratories working in this area was not incorporated. Also, the methods used in the ASTM E 1474 standard predate the availability of modern furniture interliners. It has been subsequently learnt that constructions using interliners need especial care in specimen preparation so that accurate results could be achieved.

For these reasons, in conjunction with CBUF research activities, it was realised that a protocol was needed which would be much more explicit and which would correctly treat interliners and other features which can be present in today's upholstered furniture constructions. The development work on this programme was laboratory-based. A number of modifications to the evolving protocol were progressively made until specimen behaviour was being obtained in the SP laboratories which was both correct and repeatable. This checking was accompanied by co-operative work with the other laboratories of the CBUF consortium doing Cone Calorimeter studies. Two objectives were sought for this: (1) that specimens prepared by an individual laboratory would perform nearly identically to specimens prepared at one laboratory and distributed to others for testing; and (2) that round robin repeatability and reproducibility would be satisfactory. Such successful results have been achieved and round robin results will be published giving details.

The instructions given in this document are based on the presumption that the user will perform all testing steps as specified in ISO 5660-1 (and the smoke as per ASTM E 1354) unless explicitly modified by the present instructions.

Acknowledgements

This report was prepared primarily by the authors. Stephen Grayson is acknowledged for his assistance with several aspects of protocol development. The participation of all of the laboratories of the CBUF consortium doing Cone Calorimeter studies was essential in achieving the objective.

1 Specimen preparation

This document describes the preparation of specimens from upholstered furniture (including mattresses) to make them ready for testing in the Cone Calorimeter. Basic specimen preparation instructions are presented, first, for the simplest case of upholstery systems comprising only a layer of fabric on top of a layer of foam. Given an understanding of the basic specimen preparation technique, details are then given for more specialised constructions. These include interliners, polyester fibre topper layers, and paddings with multiple materials (especially common in mattress construction). Also addressed are the preparation of specimens from furniture upholstered in leather, specimens from furniture using thinnner than 50 mm paddings, and loose fillings such as down and feathers. The preparation of upholstered furniture specimens requires a few special equipment and supplies not delineated in ISO 5660-1; these are described in the initial sections below.

1.1 Needed equipment and supplies for specimen preparation

1.1.1 Cutting equipment

Foams shall be cut with a band saw. A foam-cutting blade must be used. This blade has no teeth but, instead has a wavy scallop to the edge. Ensure that the blade is well sharpened. Make certain that no silicones or other oils are applied to lubricate the blade; lubrication must be solely with graphite or molybdenum compounds. The band saw blade must make a straight and true cut of the foam. Set the blade guide no higher than 12 mm above the stock to be cut.

1.1.2 Forming blocks

The specimen preparation rests crucially upon the proper use of forming blocks. These blocks are made in dimensions of 98 x 98 x 50 mm. Each of these dimensions is to be controlled to ± 0.5 mm. The material shall be maple or another dense wood minimally subject to dimensional changes when the humidity is changed. Pine shall not be used. Only fully kiln-dried timber shall be used for making the forming blocks. All surfaces shall be cut straight and true and shall be smooth. The edges shall not be rounded, but the corners shall be slightly rounded. It is preferable to lacquer the blocks with an acrylic lacquer to ensure a hard, smooth, stable surface.

A minimum of 12 blocks should be made up and available. This allows a reasonable number of specimens to be prepared at the same time.

1.1.3 Adhesive

The adhesive used shall be first tried with materials of the kind to be tested and shall show satisfactory holding power. Adhesives of neoprene or acrylic based types have been found suitable for many furniture materials. The adhesive shall be low in flammability. Normally it is to be used undiluted. To test an adhesive for effectiveness, prepare a piece of fabric and glue it together according to procedures given later in these instructions. After 24 h test the joints by tearing the fabric pieces one off the other manually. There is to be a substantial resistance seen from the adhesive; use a better adhesive if this test shows the holding power to be inadequate.

For applying the adhesive, a brush is used which is made of hog bristles or other stiff, coarse bristles. A flat, square-cut brush is required having a width of 7 to 8 mm.

For cleaning the brush a solvent that is compatible with the glue is used. A small container with the solvent is used to put away the brush while the gluing is done.

1.1.4 Masking tape

Masking tape is used to assist in assembling the test composites. Any type of tape which can adequately adhere to all fabrics and be easy to remove after completion of assembly is suitable for this.

Some interliners are damaged by direct application of masking tape to their surface, since removal results in tearing. For interliners susceptible to tearing, prepare bands of paper slightly wider than the width of the masking tape and long enough to reach all the way around the forming block.

1.1.5 Aluminium foil

The aluminium foil that is to be used must be 0.03 to 0.04 mm thick. No other foil thickness shall be used; especially, a thicker foil shall not be substituted.

1.2 Basic preparation of specimens

The basic instructions here pertain to specimens which comprise only a single layer of fabric over a single layer of foam padding. The same instructions apply to specimens where an interliner is laminated onto the back of the fabric; in the latter case, the fabric/interliner combination is simply treated as is a fabric alone. For specimens which use multiple padding layers, separate interliner layers, and other more specialised constructions, supplemental instructions are given in section 1.3.

1.2.1 Cutting of foam blocks

The thickness of the foam block will normally be 50 mm when a single layer of foam is the only padding material used in the composite. With a typical fabric thickness, this will result in a total specimen thickness of approximately 50.9 mm, which is acceptable.

Each foam block shall be cut square, with 90° corners and face dimensions of 102.5 ± 0.5 mm by 102.5 ± 0.5 mm. This size ensures that the foam will be compressed during composite assembly, leading to tight, well-formed specimens. Some foams have a tendency for high friction against the sawing table and the guide. To make a smooth cut by allowing the foam to slide easier, put a piece of paper between the foam and the table/guide. Push the assembly of foam and paper forward and allow the blade to cut through both the foam and the paper.

1.2.2 Weighing and accepting foam blocks

The Cone Calorimeter test results will not be repeatable if the test foam density is not very closely controlled. For this purpose, each batch of foam specimens that has been prepared shall be checked for mass. It is assumed here that 3 replicate tests will be performed for each specimen type. Therefore, once three foam blocks have been cut, they must be weighed. There shall be no block that has a mass of more than 105% of the mean of the three, nor any less than 95%. If such a difference occurs, additional blocks must be cut and weighed. The preparation of composites cannot start until three foam blocks have been obtained which conform to the above 5% deviation limit. The accepted blocks shall be marked to be traceable. The mass of each foam block shall be noted along with the identification marks of the blocks. The foam mass shall be reported in the test report along with other information about this test run.

1.2.3 Cutting and weighing of fabrics

First, cut a square of 200 mm by 200 mm. Do not cut 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.

For Cone Calorimeter results to be repeatable, fabric for the different replicates must show uniformity. When fabric material from a bolt of cloth is available, in cutting the specimens material closer than 25 cm to the selvedge (that is, the finished edge) shall not be used. (This is because sometimes there are weaving or coating variations that occur closer to the selvedge.)

To assist in verifying that uniform specimens have been cut, each set of fabric specimens that has been cut to the 200 mm by 200 mm size shall be checked for mass. When 3 replicate pieces have been cut, they shall be weighed. There shall be no piece that has a mass of more than 105% of the mean of the three, nor any less than 95%. If such a difference occurs, check to see if any of the pieces have been cut oversized; trim them if this is found to be the case. If the cause of variation was not due to oversized pieces, than additional fabric pieces shall be cut and weighed. Fabric acceptance will be complete once three pieces have been found which are within the 5% deviation limit.

Continue cutting the fabric for each specimen by cutting it to the shape indicated in Figure 1. All dimensions that are given shall be controlled according to tolerances given in the figure. Only essential dimensions are given in the figure. The 95 and 102 mm dimensions must be checked both before and after cutting.

When a fabric having thick threads is cut, stop cutting outside the "102 mm dimension" when a thread is reached. Do not cut through the thread if this will make the dimension smaller than 102 mm.

1.2.4 Preparing the fabric shell

Each shell shall be assembled upside-down upon a forming block. Place the fabric, top side down, on the table. Place the block on top, making sure that it is well-centred. Bend up the two short sides. Tape each of these sides on to the top of the forming block in the centre of the top edge. Bend up the long sides and also tape them to the top of the block. Make sure that the fabric does not slip sideways on the block by checking all four corners of the top face. The fabric shall be snug but not stretched.

For sensitive interliners, when paper bands are used, put two bands, forming a cross, under the fabric before placing the forming block on top of it. When the fabric is bent up, allow the bands to follow. Seal the paper band with masking tape to hold it on.

Using the suitable adhesive, glue down the 10 mm gluing area marked with stripes in Fig. 1 on each corner flap (i.e., which belongs to the "long" side) onto its mating short-side surface. Apply adhesive to both the underneath surface of the flap and to the surface against which it will mate. Use of a 7 to 8 mm wide brush will ensure that the glued area is approximately 10 mm wide. Press down immediately after applying the adhesive or after waiting to dry, as appropriate, according to the instructions of the adhesive manufacturer. The grey area is used for gripping and stretching the fabric around the corner of the forming block. Once the first two corners are glued up, turn the block so as to rest on this just-glued short side and glue up the two other corners. Put away the brush in the container with the solvent.

Turn the block once again, trim off the two flaps down to the indicated offset mark so that only the 10 mm glued-down portion is left. If necessary, apply a masking tape piece on top to hold the joint in place while it is drying or wrap the block with a paper band, sealed with masking tape. Repeat on the other side of the block. Leave the specimen to dry face down for 24 h (not stacked).

Wipe the solvent and any excess adhesive off the brush with a piece of cloth before gluing the next specimen.

After 24 h have elapsed, remove all the pieces of masking tape. If there is any fabric protruding below the bottom edge of the forming block, trim such excess off with scissors.

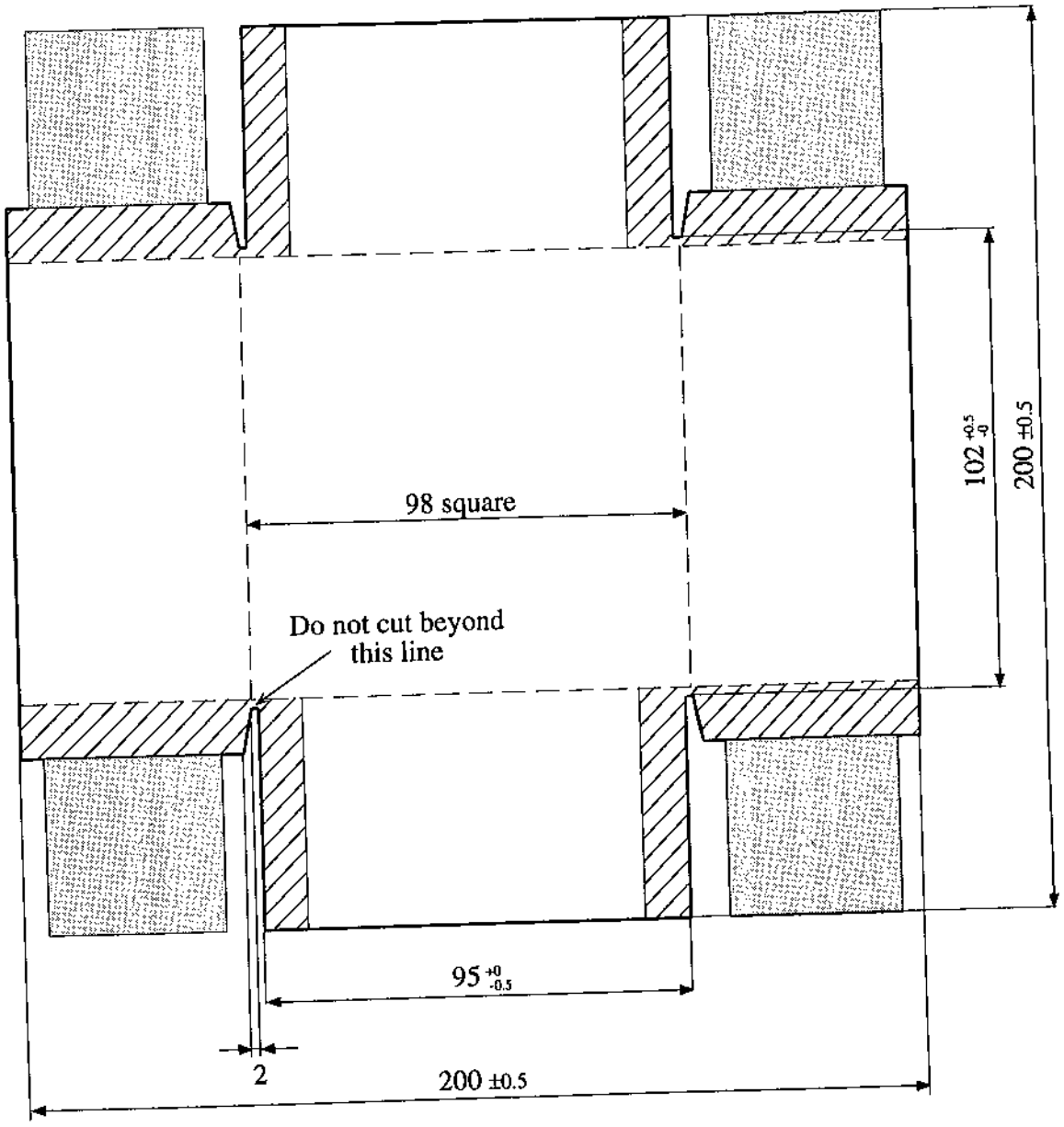

Figure 1 Fabric cutting shape

1.2.5 Preparing the aluminium foil

Now prepare the aluminium foil. Cut an over-sized piece of aluminium foil. If the foil has a shiny and a dull side, place the shiny side facing up. Place the forming block encased with the fabric shell top side up on the aluminium foil. Hold the block firmly in place and pull each side of the foil up to create the bottom folds. 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 the two sides of the specimen and pat all sides down flat against the specimen. Figure 2 illustrates the folds to be made. Make sure that the bottom edges and the corners are crisp, straight, and smooth. Remove the forming block and its encasing fabric shell from the foil cup.

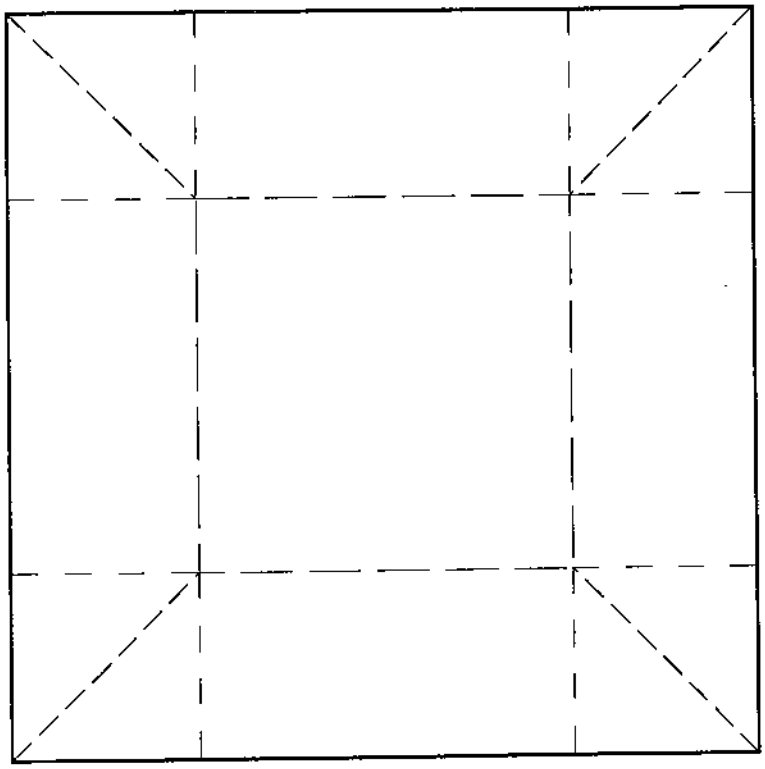

Figure 2 Folding of foil

1.2.6 Assembling the foam and the fabric shell

Remove the forming block from the fabric shell. If bits of adhesive stick to the block, use a chemist's spatula or a similar dull, knifelike device to loosen the corners. It is easiest to release the fabric by grabbing along the top edge of the fabric between the thumb and the index finger. Remove any adhesive which may remain stuck to the forming block.

Make certain that the foam blocks are identified and tracked according to their weights which have already been recorded. Compress the four corners of the selected foam block slightly with the fingers and insert the block into the fabric shell. Make sure that the foam is inserted straight. Check each of the foam block corners to see that they line up exactly at the corners of the fabric shell. Check the top face to see that the foam block is inserted fully into the shell and that there are no gaps. Also check that the bottom of the foam is neatly lined up with the bottom edge of the fabric. If the specimen construction involves additional padding layers or different padding layers, follow similar steps to ensure that a straight, taut assembly is made up. Carefully inspect the specimen. There shall be no buckles, warping, twisting, pulling, etc. The fabric must be taut and there must not be any air spaces between the fabric and the padding. If any such problems are discovered and cannot be corrected, discard the specimen.

Staple each of the four sides as shown in Figure 3.

Inspect the top face of the specimen. None of the four tabs are to overhang at the top of the specimen. If there is excess material there, trim it with scissors. Observe that a hole is not made in the specimen while doing the trimming.

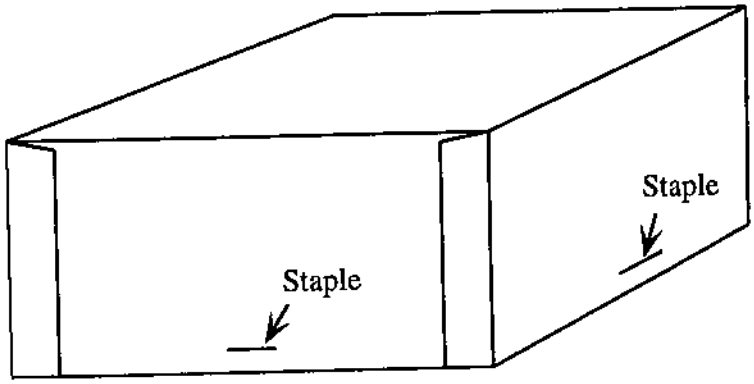

Figure 3 Assembled specimen

1.2.7 Assembling the specimen and the foil; conditioning the specimen

Put the assembled specimen in the foil cup. Pat the aluminium foil sides down flush against the specimen. Cut the top of the foil to be flush with the top of the specimen.

Open up slightly the corners of the aluminium foil and pull the foil top about 20 mm away from the specimen. This will allow good access of air in the conditioning chamber. Place the specimen in the conditioning chamber for 24 h.

1.2.8 Final preparation

Remove the specimen from the conditioning chamber. Check that the specimen is wrinkle-free, smooth and visually completely uniform and symmetrical. Fix or reject if defects are found. Weigh the specimen with and without the aluminium foil. Pat the aluminium foil sides again down flush against the specimen. Place the specimen on the sample holder. Gently push down on the top of the specimen, pushing against the ceramic fibre blanket. This ensures that the bottom conforms smoothly to the same bottom conditions as will be seen during the testing.

The specimen is now ready to be tested.

1.3 Preparation of specimens with multiple layers and specialised constructions

The instructions below give additional details for preparation of those constructions which involve more than a single fabric layer and a single foam padding layer. The instructions also provide for some materials which need specialised preparation techniques.

1.3.1 Specimens which use a separate interliner layer

Specimens which use a separate interliner layer are prepared according to the instructions above, but with the following special provisions.

For these composites, the forming block is covered twice, first with the interliner then with the fabric, using the following steps.

Some interliners are mechanically quite fragile. Avoid tearing them when the masking tape is stripped off. Test the tape to be used first to make sure that it can be smoothly pulled off the interliner without damage. Select an alternate tape if needed.

Cut the interliner using the same method as described for cutting fabrics (in 1.2.3). Glue up the interliner around the forming block using the same instructions as for fabrics (1.2.4). Leave the specimen to dry for 24 h. After 24 h have elapsed, remove all the pieces of masking tape. If there is any interliner protruding below the bottom edge of the forming block, trim such excess off with scissors. The forming block is now covered with a layer of interliner. Once this is done, follow the instructions above for cutting and preparing the fabric and continue on to 1.2.5 (Preparing the aluminium foil) and so on. To minimise thickness variations along the completed assembly, when placing the fabric on top of the interliner, turn its orientation by 90°. This will make the two sides where fabric flaps are glued **not** to be lined up with the similar flaps on the interliner, but rather so that 2 of the sides of the finished specimen will contain doubled-up areas of fabric flaps and the 2 other sides will contain doubled-up areas of interliner flaps.

1.3.2 Specimens which use a polyester fibre topper layer on top of the foam

The following instructions pertain to preparing the padding assembly if a polyester fibre batting layer is present over the top of the foam. If the un-compressed polyester fibre layer is 20 mm thick or less, it shall be compressed to ½ of that thickness in the final assembly. The foam block thickness is then to be = 50 mm minus ½ the un-compressed thickness of the polyester fibre layer. If the un-compressed polyester fibre layer is greater than 20 mm, the polyester fibre layer shall be cut back to give a 20 mm depth, and the preparation continued as above.

The polyester topper layer shall be placed on top of the foam block. This composite block shall be used wherever the general instructions refer to actions to be taken on the "foam block." During final assembly of the padding inside the fabric, the polyester plus foam composite block shall be compressed so as to have a total depth of 50 mm when the assembly is finished.

1.3.3 Specimens which use more than one padding layer (except polyester fibre)

Any padding layers thinner than 8 mm will be used in their natural thickness. The thickness of each remaining layer (those ≥ 8 mm in thickness) shall be so proportioned that its relative thickness in the remaining specimen depth (50 mm minus the thin layers) is in the same proportion as is found for those layers in the full-scale furniture article.

Once the appropriate layers are prepared according to this instruction, they are used in exactly the same way as is the single foam block which forms the basis of the general instructions above.

1.3.4 Specimens from furniture items of unusually thin construction

Some furniture items are manufactured where the total thickness of the entire padding layer is less than 50 mm. Examples include thinly padded chairs and innerspring mattresses. For such items, the padding layer is still tested in a 50 mm depth. To do this, it requires that 2 or more layers of padding be stacked together to achieve the required 50 mm depth. When testing Cone Calorimeter samples which represent known full-scale constructions, the test report shall clearly identify what the maximum thickness of padding found in the full-scale article was, when that thickness was less than 50 mm. For specimens where the padding comprises layers of several different materials, yet with a total thickness of less than 50 mm, each layer will be laid-up in an increased thickness so that the total padding thickness is 50 mm and maintaining the ratios of individual layer thickness in the same proportion as occurs in the full-scale article. The layers in the test specimen are to be laid-up in the same order as the layers of the furniture item.

1.3.5 Specimens upholstered in leather

Upholstered furniture specimens using leather shrink significantly during testing and need restraint against excessive movement. This requires the use of 4 tie wires. Copper wires of approximately 1 mm diameter and 350 mm long are used for this. The sample is prepared in the standard manner and placed in the sample holder. A tie wire is then looped around the sample and the holder such that it is parallel to, and 20 mm away from, one of the 4 edges of the sample holder as shown in Fig. 4. The wire is to run along the outside of the square locating frame that is welded to the underside of the sample holder. The ends of the wires are twisted together such that the wire is pulled firmly against the sample holder and the sample without distorting the latter. Excess wire is trimmed from the twisted section before testing. Fit the other remaining tie wires parallel to the other three sample holder edges.

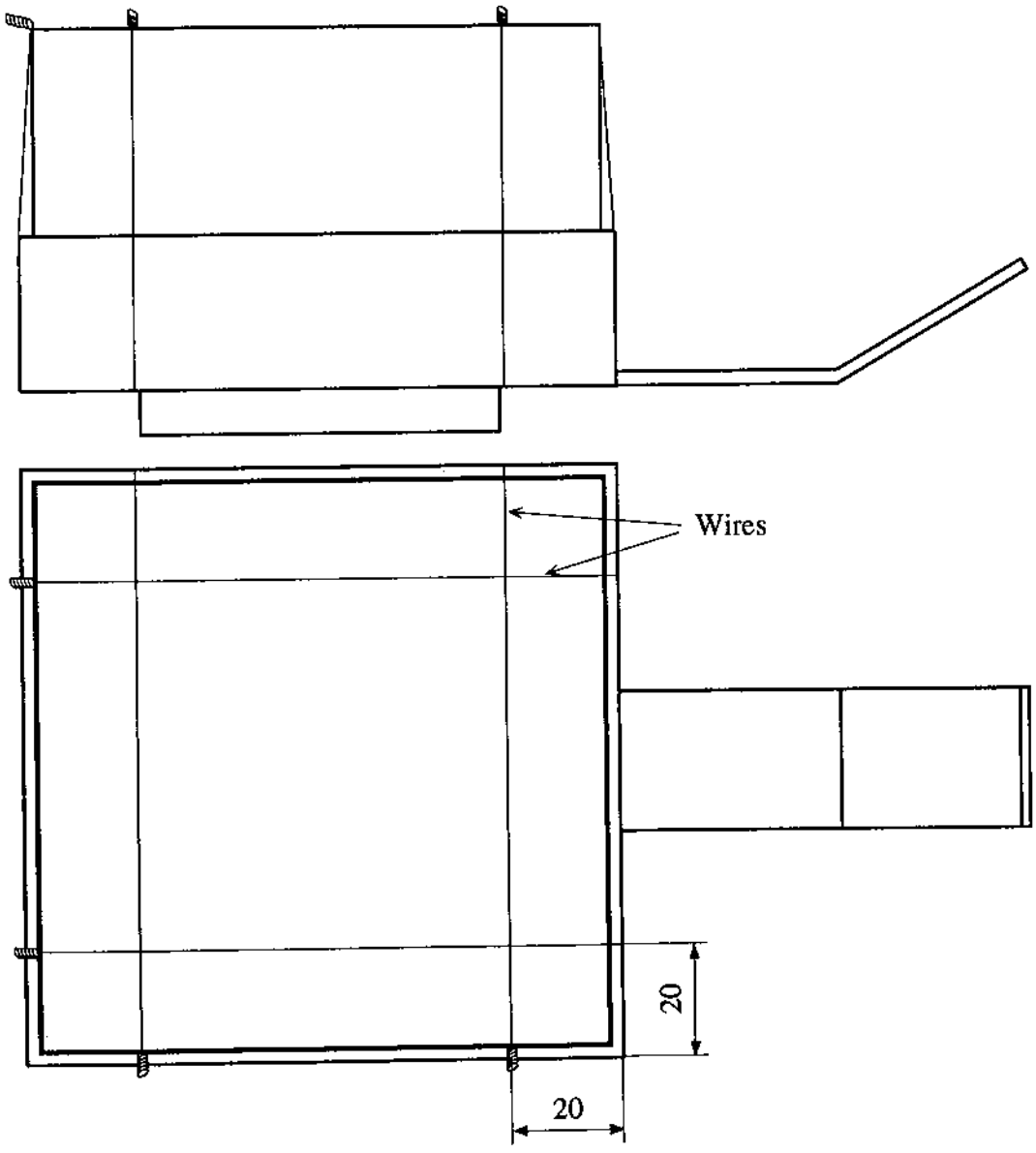

Figure 4 Assembling of specimen upholstered with leather

1.3.6 Specimens which use loose filling materials

Loose filling materials shall include feathers, down, shredded foams and any other fillings which are poured into place rather than cut to size. Cone Calorimeter samples for these shall be prepared by the manufacturer rather than by the testing laboratory. The manufacturer shall prepare a "square pillow" filled with the product. This will involve a fabric casing made from that fabric (not normally the outside upholstery fabric) which is used in the full-scale furniture article to hold together the loose filling material. The outside dimensions of this casing is to be 98 mm by 98 mm by 48 mm. The fabric casing must be prepared from two pieces. The top piece is to be cut slightly larger than 200 mm by 200 mm. The exact dimension will depend on the needs of the sewing technique. The casing top piece is now folded in a "waterfall" fold, see Fig. 5. The four corners are tucked inside. The blind opening left at each corner is then sewn shut. The second fabric piece (not shown in the figure) is used to form the bottom. Its size is slightly larger than 100 mm by 100 mm. The bottom piece is to be sewn to the bottom edge of the top piece by sewing around all the four sides. Before the bottom is completely sewn shut, fill the inside of the casing with the same density of material as will be used in the intended test article. Make sure that the corners are evenly filled and that any bulging of the top is minimised.

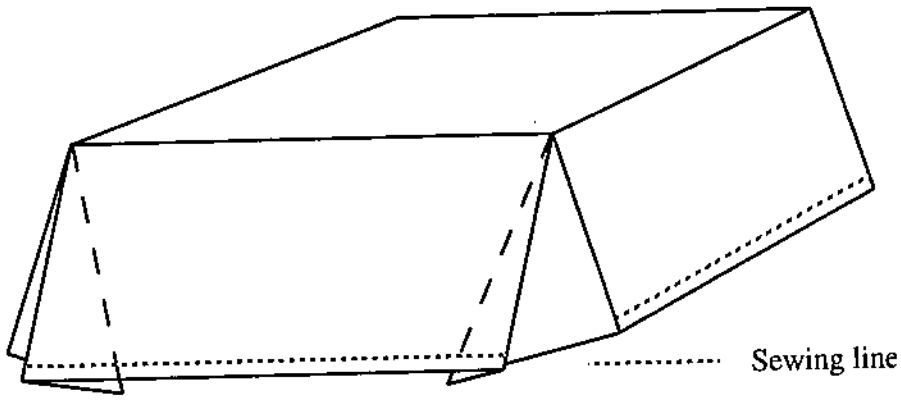

Figure 5 Folding of fabric for loose filling materials

It is also possible to have multi-layer constructions, where the loose fill material does not comprise the entire depth of construction, with the remaining depth comprising foam, battings, or other non-loose materials. In such cases, the fabric casing shall still be constructed to the dimensions specified above. For such multi-layer constructions, however, the casing shall be filled inside with proportionate depths of loose-fill and non-loose-fill material, proportioned in the needed depths.

2 Testing

2.1 General

Testing shall be according to ISO 5660-1; smoke aspects shall be according to ASTM E 1354-92. The following exceptions and special provisions, however, shall be observed.

2.2 Needed equipment and supplies for testing

2.2.1 Fibre blanket

A non-hygroscopic fibre blanket shall be used underneath the specimen. Kaowool or equivalent are acceptable. The thickness of the blanket shall be 12 mm.

2.2.2 Drying agent

Laboratories that are measuring CO_2 must use Drierite as the desiccant agent, as silica gel introduces errors into the CO_2 readings.

2.2.3 Edge frame and grid

No edge frame nor wire grid shall be used for normal testing.

2.2.4 Specimen shield

A specimen shield shall be used to start the test. The shield shall be metallic, of thickness no greater than 1.5 mm and of sufficient size so as to completely cover the heater opening in the heater base plate. The shield shall be covered with aluminium foil on the side towards the heater. Manual or powered means of retraction shall be provided so that the shield can be pulled out in no more than 0.5 s.

Check the adequacy of the temperature controller adjustments when using the specimen shield. This is to be done by use of the standard heat flux meter inserted into the normal position. Equilibrate the heater to the required 35 kW m^{-2} irradiance. Insert the specimen shield into position and keep it there for 10 s. Withdraw the specimen shield. The irradiance deviation after withdrawal shall not exceed 1 kW m^{-2}. The irradiance increase shall be reduced by 90% of the excursion within 10 s. Adjust the temperature controller parameter settings, if necessary, to obtain stability within the above limits.

2.3 Testing instructions

2.3.1 Irradiance, orientation, replicates

Tests shall, in all cases, be conducted at least at an irradiance of 35 kW m^{-2}, with 3 specimens being tested. Client's instructions may specify additional irradiances for testing. Only the horizontal specimen orientation shall be used.

2.3.2 Spark igniter

The spark igniter shall be removed after verifying 4 s of sustained ignition. If the specimen flames out early, leaving significant unburned material, the procedures given in ISO 5660-1 for repeating the test shall be observed. These specify that the test run shall be discarded and that a new test be run with increased time of sparking.

2.3.3 Insertion of specimen shield and specimen

Before each test, insert the shield into position, blocking the heater radiation. Place the specimen on the load cell. At 10 s after insertion of the shield, withdraw the shield. The moment of shield withdrawal shall constitute the start time (t = 0) for the test.

2.3.4 Observations during test

It is essential that the following events are observed if they occur during test and that the time for occurrence is noted:

- Raising, jumping, warping or any other movement of the foil cup
- Billowing or crowning of fabric
- Shrinkage of any part of the specimen
- Cracking of fabric
- Flashing
- Ignition
- Delamination of any part of the specimen
- Pieces of specimen falling down or being ejected
- Maximum flame height (if flames for instance reach top of cone or disappear into the hood)
- Especially large amounts of smoke or "smoky" flames (black edges of the flames)
- Explosive puffs
- Breakage of main flame into isolated flame areas
- End of flaming period
- Glowing after flame period
- Glowing at the end of test

2.3.5 End of test

The *end of test* shall be declared when the following conditions are met:

- 1. flaming has stopped **and** the mass loss rate dropped below 150 g m^{-2} per 1 minute.

or,

- 2. no ignition has occurred **and** 10 min have elapsed since the start of test.

Data shall be collected for a minimum of 2 minutes beyond the end of the test. This extra period ensures that analyser offset time subtraction can be validly performed and that there are enough data points to indicate a return to baseline.

2.3.6 Observations after test

- Note if there is any glowing at the end of test
- Appearance of the residue remaining, including if any of the original shape of the specimen remains.

2.4 Report of test

Time t = 0 shall be defined as the time at which the shield is removed, allowing the exposure to begin. All data, including heat release rate and ignition time are computed using this definition for t = 0.

Include tables of data at every scan interval for:

- heat release rate (kW m^{-2})
- total heat released (MJ m^{-2})
- smoke production rate ($m^2 s^{-1}$) (using e as the base of logarithmus)
- mass flow rate in duct (kg s^{-1})
- specimen mass (g)
- CO production rate (g s^{-1})
- CO_2 production rate (g s^{-1})

In addition to the instructions of ISO 5660-1, the following information must be reported:

- Average heat release rate from time of ignition to 60 s later ($\dot{q}''_{60}$).
- Average heat release rate from time of ignition to 120 s later ($\dot{q}''_{120}$).
- Average CO yield from ignition to the end of the test (g/g).

3 References

1 International Standard – Fire Tests – Reaction to Fire – Part 1: Rate of Heat Release from Building Products (Cone Calorimeter method). ISO 5660-1:1993(E). International Organisation for Standardisation, Geneva (1993).

2 Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products using an Oxygen Consumption Calorimeter (E 1354). American Society for Testing and Materials, Philadelphia.

3 Standard Method of Test for Heat Release Rates for Upholstered Furniture Components or Composites and Mattresses Using an Oxygen Consumption Calorimeter (NFPA 264A). National Fire Protection Assn., Quincy, MA (1990).

4 Standard Test Method for Determining the Heat Release Rate of Upholstered Furniture and Mattress Components or Composites Using a Bench-Scale Oxygen Consumption Calorimeter (E 1474). American Society for Testing and Materials, Philadelphia.

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