The Committee for Conformity Assessment of Accreditation and Certification on Functional and Technical Textiles
Specified requirements for protective clothing for firefighting
Document No. FTTS-FP-108e
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## 1.Scope：

1.1 This standard specifies test methods and minimum requirements for clothing to be worn during structural firefighting operations. It does not cover special clothing for use in high risk situations, e.g. fire entry suits, or clothing for use in long term firefighting operations in high ambient temperatures, e.g. forest firefighting.

1.2 Firefighters' protective clothing is intended to protect the firefighter's upper and lower torso, neck, arms, and legs, but excluding the head, hands, and feet, from the effects of heat and flame. It does not cover protection against other hazards, e.g. chemical, biological, radiation and electrical hazards. It does not cover clothing design and complete garment testing for typical scenarios encountered by a firefighter.

## 2.Terminology：

2.1 hole: A break in the test specimen at least 5 mm×5 mm in size caused by melting, glowing or flaming. The hole may be discontinuous.

2.2 afterflame time: The time for which a material continues to flame after the ignition source has been removed.

2.3 afterglow time: The time for which a material continues to afterglow after cessation of flaming or after removal of the ignition source.

2.4 heat transfer index, $HTI_{24}$ and $HTI_{12}$: The time in seconds to achieve a temperature rise of (24.0±0.2)℃ and (12.0±0.1)℃ when testing by using a copper disc of mass (18.00±0.05) g and a starting temperature of (25±5)℃.

2.5 radiant heat transfer time, $t_{24}$ and $t_{12}$: The time in seconds to achieve a temperature rise of (24.0±0.2)℃ and (12.0±0.1)℃ when testing by using a copper plate of mass 35.9~36.0 g.

2.6 Index of penetration: the percentage of chemical flows through holes or essential openings in the material.

2.7 Index of repellency: the percentage of chemical runs off from the material.

2.8 water-vapour resistance, $R_{et}$: expressed in $m^2 \cdot Pa/W$, it is a quantity specific to textile materials or composites which determines the "latent" evaporative heat flux across a given area in response to a steady applied water-vapour pressure gradient.

## 3. Requirements：

3.1 Flame spread: The assembly shall be tested after the pretreatment and the following requirements shall be satisfied. The flame shall be applied to the outer surface of the garment, the innermost lining of the outer garment and/or the outer surface of the wristlet material.

3.1.1 No specimen shall give flaming to top or either side edge.

3.1.2 No specimen shall give hole formation in any layer, except for the outer layer of a multilayer assembly.

3.1.3 No specimen shall give flaming or molten debris.

3.1.4 The mean value of afterflame time shall be ≦ 2 s.

3.1.5 The mean value of afterglow time shall be ≦ 2 s.

3.2 Heat transfer (flame): The assembly shall be tested after the pretreatment and give a mean $HTI_{24}$≧13 and a mean ($HTI_{24}$- $HTI_{12}$) ≧4.

3.3 Heat transfer (radiation): The assembly shall be tested after the pretreatment and give a mean $t_{24}$≧22 s, a mean ($t_{24}$-$t_{12}$) ≧6 s, and a mean transmission factor≦60%.

3.4 Residual strength of material when exposed to radiant heat: The outer material shall be tested after being exposed to radiant heat and each specimen shall have a tensile strength ≧450 N.

3.5 Heat resistance: Each material shall not melt, drip or ignite, and shall not shrink more than 5%.

3.6 Tensile strength: The outer material shall give a breaking load in both length and width directions ≧450 N.

3.7 Tear strength: The outer material shall give a tear strength in both length and width directions ≧25 N.

3.8 Surface wetting: The outer material shall give a spray rating ≧4.

3.9 Dimensional change: Each material shall give a dimensional change ≦3% in both length and width directions.

3.10 Penetration by liquid chemicals: The assembly shall give ＞80% run off and no penetration to the innermost surface.

3.11 Hydrostatic pressure: The moisture barrier shall be classified according to the levels of performance given in Table.

| Class | Hydrostatic pressure（kPa） |
|---|---|
| A | ≧20 |
| B | ＜20 |

3.12 Water-vapour resistance: The assembly shall be classified according to the levels of performance given in Table.

| Class | Water-vapour resistance（$m^2$·Pa/W） |
|---|---|
| A | $R_{et} \leqq 30$ |
| B | $30 < R_{et} \leqq 45$ |

## 4. Test items

(1) Flame spread
(2) Heat transfer (flame)
(3) Heat transfer (radiation)
(4) Residual strength of material when exposed to radiant heat
(5) Heat resistance
(6) Tensile strength
(7) Tear strength
(8) Surface wetting
(9) Dimensional change
(10) Penetration by liquid chemicals
(11) Hydrostatic pressure
(12) Water-vapour resistance

## 5.Test method（Summary）：

5.1 Pretreatment

5.1.1 Apparatus and materials

(1) Washer of the front loading, horizontal drum type

Diameter of inner drum is (51.5±0.5) cm, depth of inner drum is (33.5±0.5) cm. Three lifting vanes, each (5.0±0.5) cm high, extending the depth of the inner drum and spaced 120° apart. Distance between inner and outer drums is (2.8±0.1) cm. Rotating action for normal is (12.0±0.1) s clockwise, (3.0±0.1) s stop, (12.0±0.1) s anticlockwise, (3.0±0.1) s stop; for gentle is (3.0±0.1) s clockwise, (12.0±0.1) s stop, (3.0±0.1) s anticlockwise, (12.0±0.1) s stop. Rotational frequency during washing is 52 $min^{-1}$, during hydroextraction (spin) is (500±20) $min^{-1}$.Water supply normal is (25±5) L/min。Filling time is less than 2 min when filled to 13 cm, draining time is less than 1 min when drained from 13 cm. Heater capacity is (5.40±0.11) kW.

(2) Dryer of the rotary tumble type

Controlled exhaust temperature is maximum 80℃. Drum volume is 80 L

to 120 L. Drum diameter is minimum 55 cm. Drum reversal. Lifting vanes shall be at least three in number, regularly spaced within the drum. Each 4 cm to 8 cm high. Heating input is maximum 3.5 kW. Cool-down period is minimum 5 min.

(3) IEC Reference Detergent (with optical brightener)。

(4) Ballast: The pieces shall be square and measure (30±3) cm×(30±3) cm, and shall consist of two thicknesses of 100% knitted polyester fabric, overlocked together on all four sides.

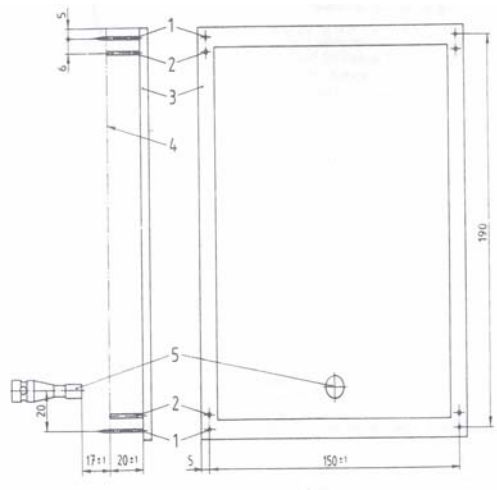
5.1.2 Procedure: The test specimens shall be washed five times in a front loading washer using 1g/L IEC reference detergent and finally dried in accordance with the procedures of ISO 6330. Washing shall be carried out by procedure 2A (at(60±3)℃) and drying by procedure E(tumble drying) unless otherwise specified in the care labeling. Materials which are labeled as dry cleanable only shall be dry cleaned five times in accordance with ISO 3175.

5.2 Flame spread

5.2.1 Apparatus and materials

(1) Mounting frame (see figure 1)

(2) Gas burner (see figure 2-5)

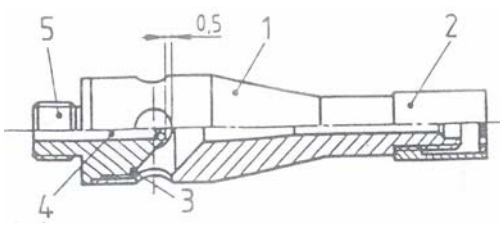



Dimensions in mm

1. Pin
2. Spacer stub
3. Specimen holder
4. Specimen
5. Burner

Figure 1. Mounting frame

Dimensions in mm




1. Burner tube 2. Flame stabilizer
3. Notch 4.Choke tube
5. Gas jet

Figure 2. Gas burner

Dimensions in mm

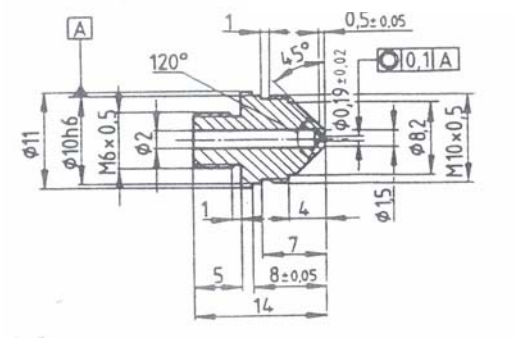
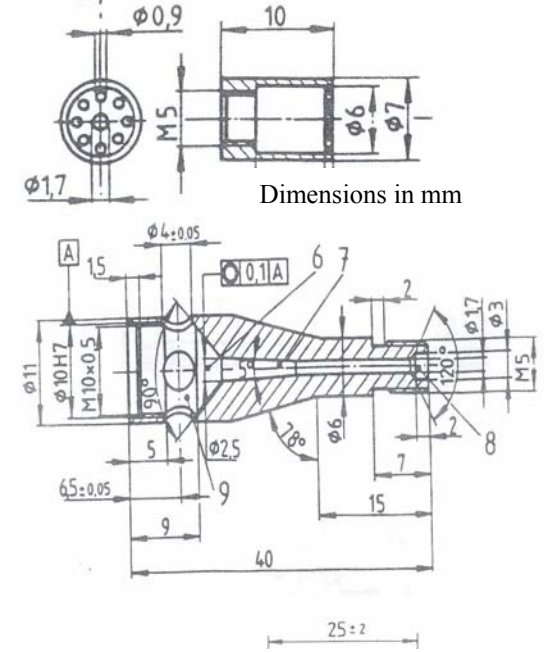



Figure 3. Gas jet




6. Gas mixing zone 7.Diffusion zone
8. Outlet 9.Air chamber

Figure 5. Burner tube

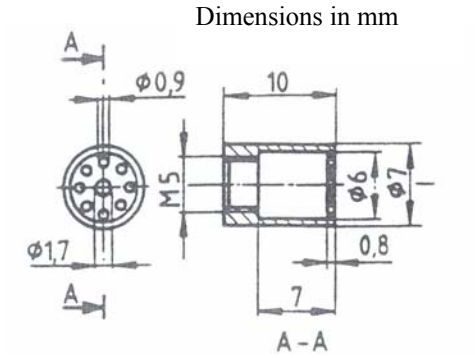
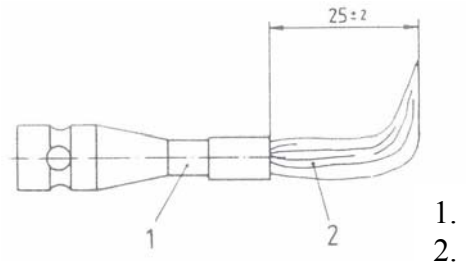



Figure 4. Flame stabilizer




1. Burner
2. Flame

Figure 6. Horizontal reach

5.2.2 Test specimens and condition: Cut each assembly after the pretreatment (the outer surface of the garment, the innermost lining of the outer garment and/or the outer surface of the wristlet material) a set of six test specimens (200±1) mm×(160±1) mm, three with the longer dimension in the length direction of the material and three with the longer dimension in the width direction. If there is the innermost lining of the outer garment, six in both directions. Each test specimen shall arrange in the order as used. An extra test specimen is required for the setting up procedure. Condition each specimen for at least 24 h in an atmosphere of (20±2)℃ and (65±5)% R.H.

5.2.3 Procedure

(1) If testing is not carried out immediately after conditioning, place the conditioned test specimens in a sealed container. Begin testing each specimen within 2 min of removing it from either the conditioning atmosphere or the sealed container.

(2) Place the extra test specimen on the specimen holder and each layer shall be arranged in the order as used. Fit the specimen holder to the mounting frame. Move the burner into the horizontal standby position and adjust

the horizontal reach of the flame (propane gas) to (25±2) mm (see figure 6). Move the burner from the standby position to the horizontal operating position. Confirm that the flame impinges on the test specimen in the correct location.

(3) Position a test specimen on the specimen holder and each layer shall be arranged in the order as used. Fit the specimen holder to the mounting frame. Move the burner from the standby position to the horizontal operating position. Apply the igniting flame for 10 s to the surface. Repeat on the remaining test specimens. The surfaces for applying the igniting flame are the outer surface of the outer garment, the innermost lining of the outer garment, the outer surface of the inner garment and/or the outer surface of the wristlet material.

5.2.4 Report: Record whether flaming to top or either side edge; whether a hole formation in any layer (except for the outer layer of a multilayer assembly); whether the occurrence flaming or molten debris; the mean value of afterflame time; the mean value of afterglow time.

5.3 Heat transfer (flame)

5.3.1 Apparatus and materials

(1) Gas burner: A Meker burner with a perforated top area of (38±2) mm diameter and a jet suitable for propane gas shall be used.

(2) Copper disc calorimeter: Copper disc has a diameter of (40±1) mm, thickness (1.6±0.1) mm, and a weight of (18.00±0.05) g. Be located in a mounting block which shall be non combustible, heat insulating board(see figure 7). A copper-constantan thermocouple is used.5.3 Heat transfer (flame)

(3) Calorimeter location plate: The plate shall weigh (264±13) g (see figure 8).

(4) Specimen support frame: The specimen support frame consists of a piece of copper (see figure 9).

(5) Support stand (see figure 10).

Dimensions in mm

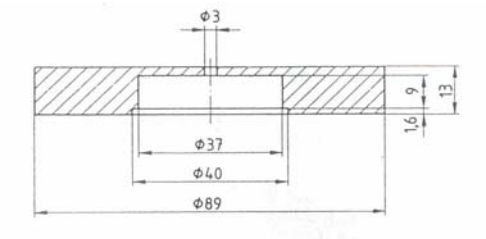



Figure 7. Calorimeter mounting block

Dimensions in mm

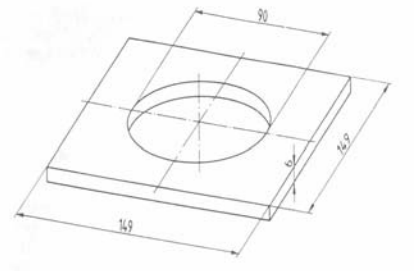



Figure 8. Calorimeter location plate

Dimensions in mm

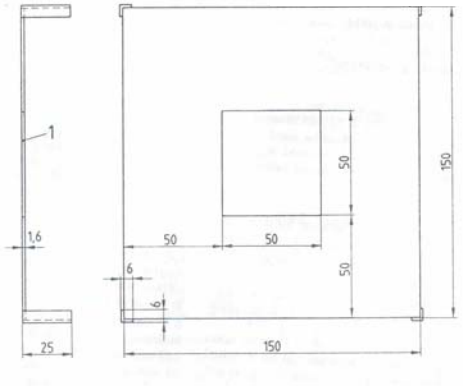
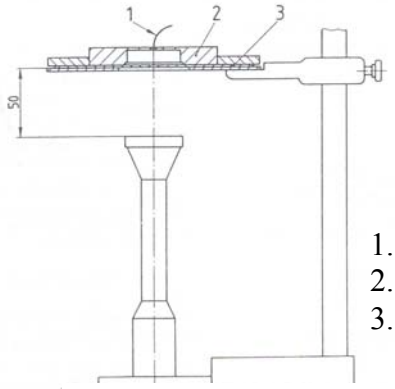



Figure 9. Specimen support frame

Dimensions in mm




1. Thermocouple
2. Calorimeter block
3. Specimen

Figure 10. Support stand

5.3.2 Test specimens and condition: A minimum of three specimens 140 mmx140 mm shall be cut for assembly after the pretreatment. Each test specimen shall arrange in the order as used. Condition each specimen for at least 24 h in an atmosphere of (20±2)℃ and (65±2)% R.H.

5.3.3 Procedure

(1) If testing is not carried out immediately after conditioning, place the conditioned test specimens in a sealed container. Begin testing each specimen within 3 min of removing it from either the conditioning atmosphere or the sealed container.

(2) Light the gas burner and wait until the flame (propane gas) is stable. Adjust the heat flux density. Allow the burner to remain in position without specimen for about 10 s. Determine the rate of rise of temperature in linear region. The heat flux density is calculated from the following equation:

$$Q = \frac{M \times Cp \times R}{A}$$

Q is heat flux density (kW/㎡)

M is the mass of the copper disc (kg)

Cp is the specific heat of the copper (0.385 kJ/kg℃)

R is the rate of rise of temperature in linear region (℃/s)

A is the disc area (㎡)

Adjust the gas flow rate until the heat flux density is (80±4) kW/㎡. Repeat until three consecutive values are obtained which fall within the required limits.

(3) Place the specimen face downwards on the specimen support frame. Allow the test to continue until a temperature rise of (24.0±0.2)℃ is observed.

5.3.4 Report: Measure the time in seconds for a temperature rise (24.0±0.2)℃ and (12.0±0.1)℃ , calculate the mean as the $HTI_{24}$ and $HTI_{12}$, and the mean of ($HTI_{24}$- $HTI_{12}$) to the nearest whole number.

5.4 Heat transfer (radiation)

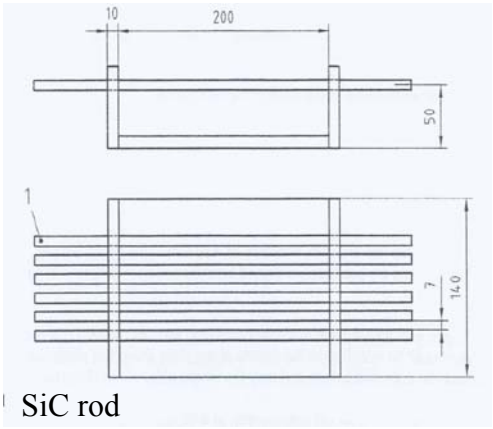
5.4.1 Apparatus and materials

(1) Source of radiation: Consist of six SiC heating rods, with diameter (7.9± 0.1) mm and electrical resistance (3.60±0.36)Ω at 1070℃ (see figure 11)。

(2) Calorimeter: The copper sheet shall be 50.0 mm×50.3 mm, 1.6 mm thick and have a mass of 35.9~36.0 g. This copper plate is bent in the longer direction into an arc with a radius of 130 mm, a chord of 50 mm. The calorimeter is located in a mounting block which is non-combustible and heat insulation board (see figure 12). A copper constantan thermocouple is used.

(3) Specimen holder (see figure 13)

Dimensions in mm




1. SiC rod

Figure 11. Source of radiation

Dimensions in mm

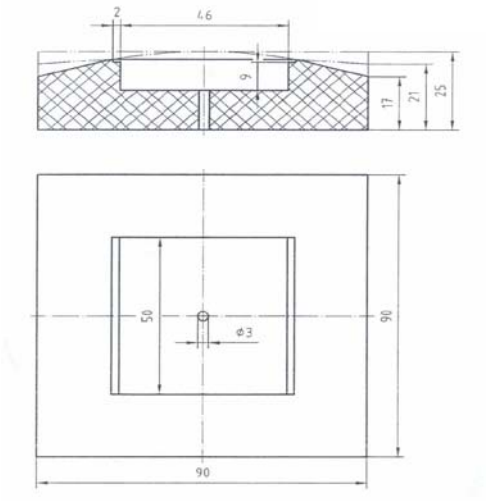



Figure 12. Calorimeter mounting block

Dimensions in mm

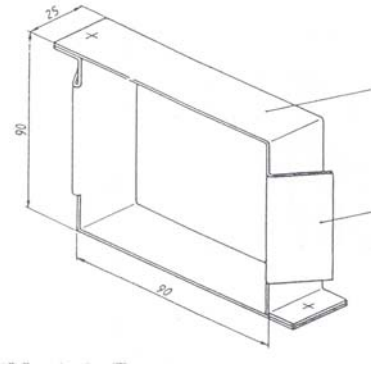



Figure 13. Specimen holder

5.4.2 Test specimens and condition: A minimum of three specimens 230 mm×80 mm shall be cut for assembly after the pretreatment. Each test specimen shall arrange in the order as used. Condition each specimen for at least 24 h in an atmosphere of (20±2)℃ and (65±2)% R.H.

5.4.3 Procedure

(1) Begin testing each specimen within 3 min of removing it from the conditioning atmosphere.

(2) Light the source of radiation and wait until to be stable. Adjust the heat flux density. The calorimeter without test specimen is fixed in its position in the opening of the vertical plate of the test frame. After the measuring device has been switched on, the movable screen is withdrawn and again returned to its position when a temperature rise of about 30℃ has been reached. Determine the rate of rise of temperature in linear region. The heat flux density is calculated from the following equation:

$$Q = \frac{M \times Cp \times R}{A \times \alpha}$$

Q is heat flux density (kW/㎡)

M is the mass of the copper plate (kg)

Cp is the specific heat of copper (0.385 kJ/kg℃)

R is the rate of rise of temperature in linear region (℃/s)

A is the area of the copper plate (㎡)

α is the absorption coefficient of the painted surface of the

calorimeter (greater than 0.9)

Before the start of every measurement the temperature of the calorimeter should be within ±2℃ of ambient temperature. Adjust the distance between the radiant source and the calorimeter until the heat flux density is (40.0±0.4) kW/$m^2$.

(3) The test specimen is fastened to specimen holder and held in contact with the face of the calorimeter, applying a force of 2 N. The calorimeter with test specimen is fixed in its position in the opening of the vertical plate of the test frame. The distance is same as 5.4.3(2). After the measuring device has been switched on, the movable screen is withdrawn, the starting point of the irradiation is recorded, and again returned to its position when a temperature rise of about 30℃ has been reached. The measurement may be stopped earlier if the specimen is obviously destroyed by the radiation.

5.4.4 Report: Measure the time in seconds for a temperature rise (24.0±0.2)℃ and (12.0±0.1)℃, calculate the mean as the $t_{24}$ and $t_{12}$, and the mean of ($t_{24}$- $t_{12}$) in 0.1 seconds. The transmission factor (TF) is calculated from the following equation:

$$Qc = \frac{M \times Cp \times 12}{A \times (t_{24} - t_{12})}$$

5.5 Residual strength of material when exposed to radiant heat

5.5.1 Apparatus and materials

(1) Source of radiation: As specified in 5.4.1(1).

(2) Calorimeter: As specified in 5.4.1(2).

(3) Specimen holder: As specified in 5.4.1(3).

(4) Tensile testing machine: As specified in 6.12 of CNS 12915.

5.5.2 Test specimens and condition: One length and one width specimen 300 mm×80 mm shall be cut for assembly. Each test specimen shall arrange in the order as used. Condition each specimen for at least 24 h in an atmosphere of (20±2)℃ and (65±2)% R.H.

5.5.3 Procedure

(1) Begin testing each specimen within 3 min of removing it from the conditioning atmosphere.

(2) As specified in 5.4.3(2), Adjust the distance between the radiant source and the calorimeter until the heat flux density is 10 $kW/m^2$.

(3) The test specimen is fastened to specimen holder and held in contact with the face of the calorimeter, applying a force of 2 N. The calorimeter with test specimen is fixed in its position in the opening of the vertical plate of the test frame. The distance is same as 5.5.3(2). After the measuring device has been switched on, the movable screen is withdrawn, and again returned to its position when the specimen is exposed to the heat flux for 3 min. The measurement may be stopped earlier if the specimen is obviously destroyed by the radiation.

(4) Raveled strip test or cut strip test procedures for determining the breaking force. For raveled strip test, take the outer material of the assembly after exposing to radiant heat to cut each specimen 300 mm×60 mm, ravel to give a testing width of 50 mm by removing an approximately equal number of yarns from each side of 60 mm. For cut strip test, take the outer material of the assembly after exposing to radiant heat to cut each specimen 300 mm×50 mm. Condition each specimen for at least 24 h in an atmosphere of (20±2)℃ and (65±2)% R.H.

(5) Set the distance between the clamps at (200±10) mm, mount the specimen in the clamp of the testing machine, and apply a applicable pretension to the bottom end of the specimen before gripping the specimen in the lower clamp. Operate the machine and break the specimen in the applicable average time-to-break of (20±3) s or (30±5) s.

5.5.4 Report: Record the breaking strength in 0.1 N.

5.6 Heat resistance

5.6.1 Apparatus and materials

(1) Forced air circulating oven: Capable of sufficient internal volume to allow the test specimen to be suspended, and is not less than 50 mm from any inner surface of the oven. The oven shall have an airflow rate of 0.5~1.5 m/s (20℃、1 atm), measured at the centre-point of the oven.

(2) Rule marked in mm.

5.6.2 Test specimens and condition: A minimum of three specimens 150 mm×150

mm shall be cut for each material used in the assembly. Condition each specimen for at least 24 h in a standard atmosphere of (20±2)℃ and (65±5)% R.H.

5.6.3 Procedure

(1) Lay the specimen flat on the smooth, flat surface without stretching the specimen. Make at least three pairs of marks on it in both length and width directions. No mark is less than 5 mm from the edges of the specimen and that the measuring points are regularly spaced across the specimen.

(2) Hang the specimens in the oven of 180~190℃ for 5 min.

(3) After the specified exposure, remove the specimen without stretching the specimen.

(4) Examine it for evidence of melting, dripping or ignition, and measure the specimens of dimensional changes.

5.6.4 Report: Record the evidence of melting, dripping or ignition, and calculate the mean changes in dimensions in both the length and width directions(%).

5.7 Tensile strength

5.7.1 Apparatus and materials: As specified in 6.12 of CNS 12915.

5.7.2 Test specimens and condition: Raveled strip test or cut strip test procedures for determining the breaking force. For raveled strip test, take the outer material of the assembly to cut each specimen 300 mm×60 mm, ravel to give a testing width of 50 mm by removing an approximately equal number of yarns from each side of 60 mm. For cut strip test, take the outer material of the assembly to cut each specimen 300 mm×50 mm. A minimum of five specimens in both length and width directions shall be cut. Condition each specimen for at least 24 h in an atmosphere of (20±2)℃ and (65±2)% R.H.

5.7.3 Procedure: Set the distance between the clamps at (200±10) mm, mount the specimen in the clamp of the testing machine, and apply a applicable pretension to the bottom end of the specimen before gripping the specimen in the lower clamp. Operate the machine and break the specimen in the applicable average time-to-break of (20±3) s or (30±5) s.

5.7.4 Report: Record the breaking strength (N). Calculate the mean in both length and

width directions to 0.1 N.

5.8 Tear strength

5.8.1 Apparatus and materials: As specified in 6.15.1 of CNS 12915.

5.8.2 Test specimens and condition: Take the outer material of the assembly to cut each specimen (225±0.5) mm×(75.0±0.5) mm. A minimum of five specimens in both length and width directions shall be cut. Make a slit longitudinally in each test specimen, beginning from the middle of the width, 80 mm in length. Condition each specimen for at least 24 h in an atmosphere of (20±2)℃ and (65±2)% R.H.

5.8.3 Procedure: Set the distance between the clamps at (100±10) mm , mount the specimen in the clamp of the testing machine. Operate the machine and tear the specimen in the rate of (100±10) mm/min until the test specimen is torn to break.

5.8.4 Report: For each test specimen, record the median of the five highest peaks of the middle section of 50%. And express the result with the median of the five test specimen in both length and width directions to 0.1 N.

5.9 Surface wetting: As specified in CNS 10461 to test the outer material of the assembly.

5.10 Dimensional change

5.10.1 Apparatus and materials

(1) Washer of the front loading, horizontal drum type: As specified in 5.1.1(1)

(2) Dryer of the rotary tumble type: As specified in 5.1.1(2)

(3) Reference Detergent: As specified in 5.1.1(3)

(4) Ballast: As specified in 5.1.1(4)

(5) Rule marked in mm.

5.10.2 Test specimens and condition: Cut three specimens for each material used in the assembly, each measuring at least 500 mm×500 mm. For materials less than 500 mm×500 mm, full material may be used. Condition each specimen for at least 24 h in an atmosphere of (20±2)℃ and (65±5)% R.H.

5.10.3 Procedure

(1) Lay the specimen flat on the smooth, flat surface without stretching. Make at least three pairs of marks on it in both length and width directions. Ensure that the distance between marks of each pair is at least 350 mm. No mark is less than 50 mm from the edges of the specimen and that the measuring points are regularly spaced across the specimen.

(2) Wash and dry the specimens according to the procedure specified in 5.1.2.

(3) After drying, condition each specimen for at least 24 h in an atmosphere of (20±2)℃ and (65±5)% R.H. Measure the specimens.

5.10.4 Report: Calculate the mean changes in dimensions in both length and width directions. State whether the dimension has decreased (shrinkage) by means of a minus sign (−) or increased (extension) by means of a plus sign (+). Express the average dimensional changes to the nearest 0.5%.

$$DC = \frac{L' - L}{L} \times 100$$

DC = Percentage change in dimensions (%)

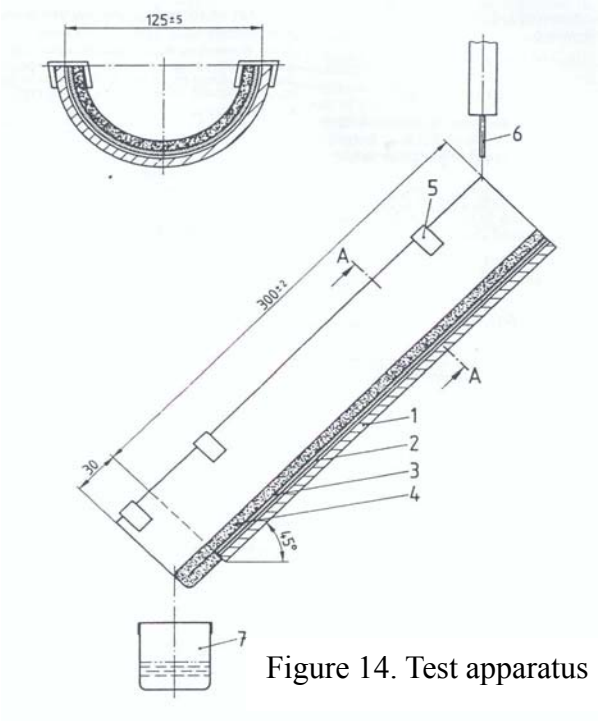
L= Original (mm)

L' = Final (mm)

5.11 Penetration by liquid chemicals

5.11.1 Apparatus and materials

(1) Test apparatus: Rigid transparent gutter of semi-cylindrical shape with internal diameter (125±5) mm, length (300±2) mm, and inclination 45°. Hypodermic needle with bore (0.80±0.02) mm and the end ground flat. The frame of Rigid transparent gutter, hypodermic needle and beaker see figure 14. To deliver the volume of test liquid (10.0±0.5) mL in unbroken stream via the needle within (10±1) s. Rigid cover of semi-cylindrical shape with external diameter (105±5) mm and weight (140±7) g.




Dimensions in mm

1. Rigid transparent gutter
2. Transparent film
3. Absorbent paper (e.g. filter paper)
4. Test specimen
5. Clips
6. Hypodermic needle
7. Beaker

Figure 14. Test apparatus

(2) Balance: accurate to 0.01 g.

(3) Stopwatch: accurate to 0.1 s.

(4) Beaker

(5) Transparent film: resistant to the test liquid, (300±2) mm×(235±5) mm.

(6) Absorbent paper (e.g. filter paper): 0.15~0.20 mm thick, (300±2) mm×(235±5) mm。

(7) 40% NaOH (20℃)

(8) 36% HCl (20℃)

(9) 30% $H_2SO_4$ (20℃)

(10) o-Xylene

5.11.2 Test specimens and condition: A minimum of three specimens (360±2) mm×(235±5) mm shall be cut for assembly. Each test specimen shall arrange in the order as used. Condition each specimen for at least 24 h in an atmosphere of (20±2)℃ and (65±2)% R.H.

5.11.3 Procedure

(1) Weigh the transparent film and absorbent paper, the beaker.

(2) Place the transparent film and absorbent paper, and test specimen (in that order) in the gutter. Ensure that their top edges align with the top edge of the gutter and that the folded edge of the test specimen is face down and protruding 30 mm from the lower edge. Ensure that all surfaces are in close contact. Secure with clips.

(3) Ensure the ground tip of the needle is (100±2) mm from the inclined surface of the gutter, place the weighed beaker under the folded edge of the test specimen for collection of test liquid running off the surface.

(4) Simultaneously start the stopwatch and discharge the test liquid (10.0±0.5) mL within (10±1) s. Then rest the semi-cylindrical cover centrally on top of the test specimen and ensure that the lower edges of the cover and the gutter are in line. After 60 s (from the start of the discharge of the test liquid), tap the gutter to dislodge any drops hanging from the folded edge of the test specimen.

(5) Remove the cover and the test specimen carefully, Weigh the transparent film and absorbent paper, the beaker.

(6) Repeat (1)~(5) with remaining test specimens.

(7) Weigh the test liquid of (10.0±0.5) mL of three repeat, calculate the mean.

5.11.4 Report: Calculate the mass of test liquid collected in the beaker and test liquid deposited on the absorbent paper/film combination. And calculate the indices of repellency and penetration as follows.

| | | |
|---|---|---|
| R = | $\frac{Mr}{Mt}$ | ×100 |
| | | |
| P = | $\frac{Mp}{Mt}$ | ×100 |

R =Index of repellency (%)

P = Index of penetration (%)

Mr= mass of test liquid collected in the beaker (g)

Mt = mass of test liquid discharged on to the test specimen (g)

Mp= mass of test liquid deposited on the absorbent paper/film combination (g)

5.12 Hydrostatic pressure

5.12.1 Apparatus and materials

(1) Test apparatus: The rate of increase of water pressure shall be (10±0.5) or (60±3) $cmH_2O$/min. A manometer should allow pressure to be read to an accuracy of 0.5 $cmH_2O$. It should be possible to clamp the specimen of fabric in such a way that it is horizontal and is not bulging, an area of the fabric of 100 $cm^2$ is subjected to steadily increasing water pressure, no leakage of water takes place at the clamps during the test period, the specimen does not slip in the clamps, any tendency for penetration to occur at the clamped edge of the specimen is minimized.

(2) Distilled or fully deionized water maintained at either (20±2)℃ or (27±2)℃.

5.12.2 Test specimens and condition: Take five test specimens from different places in the moisture barrier so that they represent the material as fully as possible. May be tested without cutting specimens. Areas with deep creases or fold marks shall not be tested. Condition each specimen for at least 24 h in an atmosphere of (20±2)℃ and (65±2)% R.H.

5.12.3 Procedure

(1) Wipe all water from the clamping surfaces. Clamp the conditioned

specimen in the test head so that the face of the fabric will be in contact with the water. Provide freshly distilled water for each specimen tested. The clamping shall be carried out in such a way that water will not be forced through the specimen prior to the start of the test.

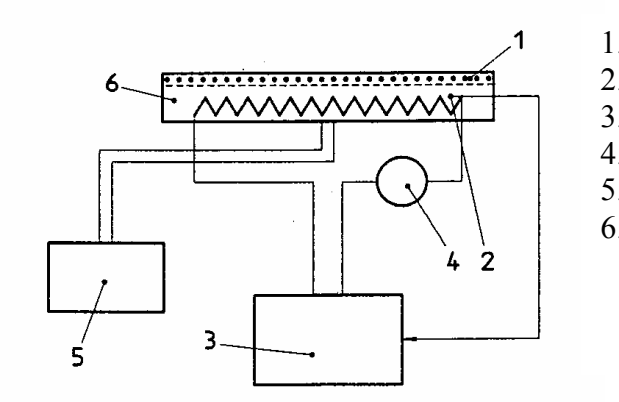
(2) Subject the specimen immediately to increasing water pressure. Watch continuously for evidence of penetration by water. Record the pressure at which water first appears at the third place in the specimen.

5.12.4 Report: The accuracy for recording the pressure shall be the following: until 1 $mH_2O$: 0.5 cm; more than 1 $mH_2O$ and until 2 $mH_2O$: 1 cm; more than 2 $mH_2O$: 2 cm. Calculate the mean of the pressures recorded for the specimens, the accuracy is the same. Report the mean result. (Exchange: 1 $cmH_2O$＝0.0981 kPa)

5.13 Water-vapour resistance

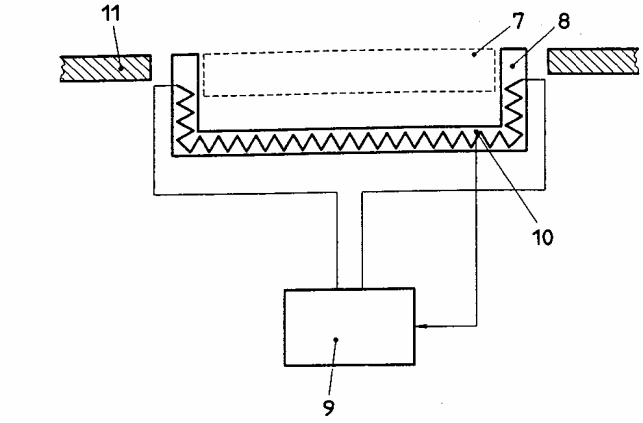
5.13.1 Apparatus and materials

(1) Measuring unit: with temperature and water supply control, consisting of a metal plate approximately 3 mm thick with a minimum area of 0.04 $m^2$ (e.g. a square with each side 200 mm in length) fixed to a conductive metal block containing an electrical heating element. The metal plate must be porous. The coefficient of radiant emissivity of the plate surface shall be greater than 0.35 (see figure 15). It is surrounded by a thermal guard (see figure 16). The temperature controller shall maintain the temperature of the measuring unit constant to within ±0.1 K. The heating power shall be measurable by means of a suitable device to within ±2% over the whole of its usable range. Water is supplied to the surface of the porous metal plate by a dosing device such as a motor-driven burette. The dosing device is activated by a switch which senses when the level of water in the plate falls more than approximately 1.0 mm below the plate surface, in order to maintain a constant rate of evaporation.




1. Metal plate
2. Temperature sensor
3. Temperature controller
4. Heating-power measuring device
5. Water-dosing device
6. Metal block with heating element

Figure 15. Measuring unit




7. Measuring unit
8. Thermal guard
9. Temperature controller
10. Temperature-measuring device
11. Measuring table

Figure 16. Thermal guard

(2) Thermal guard: consisting of a material with high thermal conductivity, typically metal, and containing electrical heating elements. Its purpose is to prevent heat leakage from the sides and bottom of the measuring unit. The gap between the upper surface of the thermal guard and the metal plate of the measuring unit shall not exceed 1.5 mm. The temperature shall be maintained at the same temperature as the measuring unit to within ±0.1 K by means of the controller.

(3) Test enclosure: into which is built the measuring unit and thermal guard, and in which the ambient air temperature and humidity are controlled. The conditioned air shall be ducted so that it flows across and parallel to the upper surface of the measuring unit and thermal guard. The height of the duct above the measuring table shall not be less than 50 mm. The drift of the temperature of this air flow shall not exceed ±0.1

K for the duration of a test. For the measurement of values below 100 $m^2$·Pa/W, an accuracy of ±0.5 K is sufficient. The drift of the relative humidity R.H. of this air flow shall not exceed ±3% R.H. for the duration of a test. This air flow is measured at a point 15 mm above the measuring table over the centre of the uncovered measuring unit and at an air temperature of 20℃. The air speed measured at this point shall have a mean value of 1 m/s, with the drift not exceeding ±0.05 m/s for the duration of a test. The air flow shall have a certain degree of turbulence of between 0.05 and 0.1, measured at approximately 6 s intervals over a time period of at least 10 min.

(4) Cellophone membrane: 10 μm-50 μm thick, water-vapour permeable but liquid-water impermeable.

5.13.2 Test specimens and condition: Test specimens shall completely cover the surfaces of the measuring unit and thermal guard. From each material to be tested, a minimum of three test specimens shall be cut and tested. For materials ≦5 mm thick, condition each specimen for at least 12 h in an atmosphere of (35±0.5) ℃ and (40±3)% R.H. For materials ＞5 mm thick, condition each specimen for at least 24 h in an atmosphere of (35±0.5) ℃ and (40±3)% R.H.

5.13.3 Procedure

(1) The surface of the porous plate is kept constantly moist by means of a water-dosing device. The cellophone membrane shall be fitted over the porous plate, and shall be moistened with distilled water and fixed to the measuring plate by appropriate means so that it remains completely free of wrinkles. The water supplied to the measuring plate shall be distilled.

(2) Test of bare plate: set the temperature of both the measuring unit and the air temperature at (35±0.5)℃. Set the air speed to (1±0.05) m/s. The relative humidity of the air shall be kept constant at (40±3)%R.H., corresponding to a water-vapour partial pressure of 2250 Pa. The water-vapour partial pressure directly at the surface of the measuring unit can be assumed equal to the saturation vapour pressure at the temperature

of this surface, i.e. 5620 Pa. Wait until the measured quantities reach steady-state before recording their values.

(3) Test of test specimen: set the temperature of both the measuring unit and the air temperature at (35±0.5)℃. Set the air speed to (1±0.05) m/s. The relative humidity of the air shall be kept constant at (40±3)%R.H. These isothermal conditions prevent water-vapour condensation within the test specimen. Place the test specimen on the cellophone membrane so that the inner will be in contact with the membrane. Each test specimen shall arrange in the order as used. Wait until the measured quantities reach steady-state before recording their values.

5.13.4 Report

(1) Calculate the bare plate resistance $R_{eto}$ as follows.

$$R_{eto} = \frac{(p_m - p_a) \times A}{H - \Delta H_e}$$

$R_{eto}$ = "bare plate" value（$m^2 \cdot Pa/W$）

$p_m$ = The saturation water-vapour partial pressure, 5620 Pa

$p_a$ = The water-vapour partial pressure（Pa）

A = The area of the measuring unit（$m^2$）

H = The heating power supplied to the measuring unit（W）

$\Delta H_e$ = The correction term for heating power（W）

Note: The temperature of the measuring unit and the thermal guard are set to the same value. However, the tolerances in practice may cause slight differences in temperature between measuring unit and the thermal guard. In such cases the heating power supplied to the measuring unit does not equal the heat flux through the test specimen. This shall be taken into account by the application of correction term ΔHe, $\Delta He=\beta(Tm-Ts)$. The measuring unit is covered by a water-vapour permeable membrane and supplied with water by the dosing device. The measuring unit and thermal guard are covered by a water-vapour impermeable material (e.g. PET film)

and a material of high thermal insulation (e.g. foam with a thickness of 4 cm min.). The air temperature is set to 35℃ with a relative humidity of (40±3)% R.H., and the temperature of the thermal guard (Ts) is set to 35℃. The temperature of the measuring unit (Tm) is raised relative to the thermal guard in steps of 0.2 K. The regression line of this heating power versus the difference in temperature between measuring unit and thermal guard gives the slope β。

(2) Calculate the water-vapour resistance $R_{et}$ as follows.

$$R_{et} = \frac{(p_m - p_a) \times A}{H - \Delta H_e} - R_{eto}$$

$R_{et}$ = the water-vapour resistance（$m^2$·Pa/W）

$p_m$ = The saturation water-vapour partial pressure, 5620 Pa

$p_a$ = The water-vapour partial pressure（Pa）

A = The area of the measuring unit（$m^2$）

H = The heating power supplied to the measuring unit（W）

$\Delta H_e$ = The correction term for heating power（W）

(3) Report the mean result.

## 6.Reference standard：

6.1 EN 469：1995 Protective clothing for firefighters – Requirements and test methods for protective clothing for firefighting

6.2 EN 367：1992 Protective clothing - Protection against heat and fire – Method of determining heat transmission on exposure to flame

6.3 EN 368：1992 Protective clothing - Protection against liquid chemicals – Test method: Resistance of materials to penetration by liquids

6.4 EN 532：1994 Protective clothing – Protection against heat and flame – Test method for limited flame spread

6.5 EN 24920：1992 Determination of resistance to surface wetting of textiles fabrics (spray test) (ISO 4920：1981)

6.6 ISO 3175：1995 Textiles – Evaluation of stability to machine dry-cleaning

6.7 ISO 4674：1977 Fabrics coated with rubber or plastics – Determination of tear

resistance

6.8 ISO 5077：1984 Textiles – Determination of dimensional change in washing and drying

6.9 ISO 5081：1977 Textiles – Woven fabrics – Determination of breaking strength and elongation (Strip method)

6.10 ISO 6330：1984 Textiles – Domestic washing and drying procedures for textile testing

6.11 ISO 6942：2002 Protective clothing - Protection against heat and fire – Method of test: Evaluation of materials and material assemblies when exposed to a source of radiant heat

6.12 CNS 12915 L3233：1991 Method of Test for Fabrics

6.13 CNS 10461 L3202：1983 Method of Test for Water Resistance of Clothes-Spray Test

6.14 EN 20811:1992 Determination of resistance of textile fabrics to water penetration – Hydrostatic pressure test

6.15 EN 31092:1993 Textiles – Physiological effects – Measurement of thermal and water-vapour resistance under steady-state conditions (sweating guarded – hotplate test)