

Guideline  
GD 40-2023



# **Guidelines for Approving Spraying and Foaming-in-place Process of Thermal Insulation Materials in Ship Refrigerated Compartment**

China Classification Society  
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Guidelines for Approving Spraying and Foaming-in-place Process of Thermal Insulation  
Materials in Ship Refrigerated Compartment

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## **Guidelines for Approving Spraying and Foaming-in-place Process of Thermal Insulation Materials in Ship Refrigerated Compartment**

### **1. Scope of Application**

1.1 This Guidelines is applicable to the approval of spraying and foaming-in-place process of thermal insulation materials in ship refrigerated compartments.

1.2 This Guidelines is inapplicable to the approval of spraying and foaming process of insulating layers of LNG tanks.

### **2. Normative References**

2.1 Chapter 3, Part 5 of China Classification Society Rules for Classification of Sea-Going Steel Ships 2023

2.2 Chapter 3, Part 4 of China Classification Society Rules for Construction of Ocean-going Steel Fishing Vessels 2021

2.3 GB/T 20219-2015 Rigid Cellular Plastics-spray-applied Polyurethane Foam for Thermal Insulation

2.4 GB 8624-2012 Classification for Burning Behavior of Building Materials and Products

2.5 SC/T 8059-2006 Operating Rule of Foaming for Insulating Layer on Fishing Vessel

### **3. Terms and Definitions**

3.1 Refrigerated compartment: refrigerated cargo holds, refrigerated fish holds and food cold storages in ship service spaces, with the general compartment temperature of above -60°C.

3.2 Spraying and foaming-in-place: the method of transporting raw materials, curing agents, foaming agents and other necessary materials and construction machinery to the construction site for raw material mixing and direct spraying and foaming construction.

3.3 Thermal insulation materials: the thermal insulation materials referred in this Guidelines are the sprayed rigid polyurethane foam composed of the following two raw materials:

(1) Premixed polyether (A mixture of polyether polyols and various additives, commonly known as white material, premixed material or material A, hereinafter referred to as material A)

(2) Isocyanate (commonly known as black material or material B, hereinafter referred to as material B)

Foaming agents shall be those that do not destroy the ozone layer and have low greenhouse effect. Alkane foaming agents with low boiling point shall not be used for site construction.

3.4 Construction contractor: the construction unit directly engaged in spraying and foaming-in-place, which can be raw material manufacturer or shipyard or third-party construction unit.

3.5 Spraying and foaming process plan: the technical document prepared by the construction unit before the spraying and foaming process approval test to guide the spraying and foaming process approval test. The spraying and foaming process plan shall include all technical parameters in the spraying and foaming process specification. In the approval test, relevant technical parameters can be modified and improved according to the test results.

3.6 Spraying and foaming process test report: the technical document that accurately describes and records the actually used and obtained technical parameters in the spraying and foaming process

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approval test, which can be used as the basis for the approval of the spraying and foaming process specification. Each test result involved in the report, including the retest result, shall be evaluated.

3.7 Spraying and foaming process specification: the spraying and foaming process plan modified and improved by the construction unit according to the qualified spraying and foaming process test report and formally approved by CCS to guide the product production and spraying construction.

### **4. Documents**

When applying for process approval to CCS, the applicant shall submit the following documents to CCS for review:

#### 4.1 Basic information of the construction unit

- (1) Overview of the construction unit: name, address, achievements, etc.
- (2) Enterprise registration certificate
- (3) Qualification certificate (if any)
- (4) List of management, technical and construction personnel

#### 4.2 List of construction equipment

- (1) Foaming equipment, including air compressor, spray gun, etc.
- (2) Ventilation equipment
- (3) Other necessary auxiliary equipment, such as heating equipment, lighting equipment, fire-fighting equipment, personnel protection equipment, etc.

#### 4.3 List of raw material suppliers

- (1) List of qualified raw material suppliers of thermal insulation materials and their works approval certificates.
- (2) Instructions for use of thermal insulation materials.
- (3) Raw material quality certificates and testing records of thermal insulation materials.

#### 4.4 Spraying and foaming process documents

- (1) Spraying and foaming process plan for thermal insulation materials (see Appendix 1 for details).
- (2) Approval test report for spraying and foaming process of thermal insulation materials (see Appendix 2 for details).
- (3) Specification for spraying and foaming process of thermal insulation materials (see Appendix 3 for details).

### **5. Approval**

5.1 The construction contractor shall be responsible for establishing a spraying and foaming process specification and demonstrating its applicability for a specific purpose. Before the spraying, the construction contractor shall prepare the summary table for product spraying and foaming process according to the personnel, equipment, process and other technical conditions and production experience, and submit it to CCS for approval. The summary table shall list the name and No. of the spraying and foaming process specification selected according to the spraying and foaming position and structural form.

5.2 If the construction contractor adopts new materials and processes, the process approval test shall be carried out to verify that the construction unit has the appropriate qualification to use the process for spraying and foaming operation. The construction contractor shall formulate a detailed spraying and foaming process plan. The spraying and foaming process plan submitted for approval shall include the following:

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- (1) Material and surface state requirements of the substrate to be sprayed (coating state, drying degree, surface cleanliness, etc.);
- (2) Raw material name, model, supplier name, approval certificate and instruction manual;
- (3) Model and main performance parameters of the spraying and foaming equipment;
- (4) Spraying and foaming position (horizontal, vertical, upward, etc.);
- (5) Schematic diagram of spray gun movement sequence;
- (6) Spraying and foaming parameters (raw material preheating temperature, material A/B flow rate, distance between spray gun and construction surface, angle between spray gun and construction surface, moving speed of spray gun, air compressor pressure and exhaust volume);
- (7) Maximum thickness of single spraying, and maximum allowable temperature of previous foaming layer during re-spraying;
- (8) Spraying and foaming environment: including the temperature, humidity, ventilation condition and cleanliness of the spraying and foaming-in-place environment;
- (9) Curing cycle after spraying and foaming;
- (10) Other relevant special requirements.

5.3 The test piece spraying and foaming and specimen cutting shall be witnessed by the Surveyor, and the test shall be witnessed by the Surveyor or conducted by the CCS-approved test agency.

5.4 During the test, the test parameters and results shall be recorded in the spraying and foaming process test report, and the Surveyor shall sign the test report.

5.5 The construction contractor shall prepare a complete spraying and foaming process specification according to the test results and submit it to CCS for approval together with the test report.

5.6 When the test results fail to meet the requirements, and the retest conducted according to the test requirements of this Guideline also fails, the construction contractor shall analyze the causes and adjust the spraying and foaming process plan, and repeat the spraying and foaming test according to the updated content.

5.7 When the construction contractor changes the personnel, equipment and process parameters involved in the approved spraying and foaming process specification, all changes shall be submitted to CCS. CCS shall determine whether to redo the approval test of the spraying and foaming process according to the specific change content.

5.8 The qualified spraying and foaming process specification obtained by a construction contractor is applicable to the construction site with the same technical and quality management conditions.

## 6. Approval Test

### 6.1 Spraying test plate

- (1) The spraying test plate surface shall be kept clean and dry, and the substrate surface shall be free of water, oil, dust and other pollutants.
- (2) The spraying test plate shall have a certain thickness and stiffness to prevent the specimen bending deformation caused by the stress generated after spraying and foaming.
- (3) The spraying test plate shall simulate the actual structure of the ship refrigerated compartment, such as laying stiffened plate, wooden frame and other structures.
- (4) The size of the spraying test plate shall ensure that a sufficient number of specimens can be taken, with the test plate area generally at least 1.5m<sup>2</sup>.

### 6.2 Specimen preparation

- (1) The construction contractor shall arrange the suitable personnel for the specimen spraying and foaming according to the submitted spraying and foaming process plan. Before the spraying, material A shall be fully mixed to ensure uniform composition.
- (2) During the spraying and foaming, the ambient temperature shall not be lower than 15°C.

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Otherwise, the environment, substrate and raw material shall be heated, with the pre-heating temperature of raw materials generally not lower than 30°C.

(3) During the spraying construction, the moisture content on the construction site must be strictly controlled, the construction surface and compressed air shall be free of water, and the air humidity on the construction site shall be controlled below 90%.

(4) For the sample preparation by the layered spraying method on the spraying test plate, the spraying thickness of each layer shall be controlled below 40mm. In order to prevent delamination, cracking and core burning, heat accumulation due to chemical reaction shall be prevented, and after each layer of spraying, the next layer shall be sprayed until the reaction heat has dissipated. The total thickness of the specimen shall not be less than 60mm.

### 6.3 Sampling

The sampling must be witnessed by the Surveyor. Before the sample cutting, the test piece shall be cured at the temperature of  $23 \pm 2^\circ\text{C}$  and relative humidity of  $(50 \pm 5)\%$  for no less than 48h, and subject to the 100% visual inspection, to ensure the sample surface is not cracked, soft, brittle or powdery, and the sample cross section is uniformly dispersed with fine pores, without delamination and core burning. The insulating layer and the substrate shall be closely contacted and firmly bonded together.

The sample shall be cut from the center of the spraying and foaming test piece and the core sample shall be taken for testing, i.e., the outer surface and the surface on the substrate interface shall be removed. Generally speaking, the upper and lower surfaces shall be neatly cut by (3~5) mm respectively, with at least one or more inner surfaces on the continuous spraying interface in the core sample.

### 6.4 Spraying and foaming process test items

The spraying and foaming process specimen shall be cut from the sample described in Article 6.3 for the following tests, with the specimen size meeting Article 5.3~5.11 of GB / T 20219-2015 *Rigid Cellular Plastics-spray-applied Polyurethane Foam for Thermal Insulation*:

- (1) Apparent core density specimen, 3 pcs.
- (2) Compressive strength specimen, 5 pcs.
- (3) Dimensional stability specimen, 9 pcs.
- (4) Tensile strength specimen, 5 pcs.
- (5) Water absorption specimen, 3 pcs.
- (6) Water vapor permeability specimen, 5 pcs.
- (7) Closed porosity specimen, 2 pcs.
- (8) Thermal conductivity (23°C) specimen, 2 pcs.
- (9) Adhesive property specimen, 1 pcs.
- (10) Flame retardant property specimen (oxygen index specimen, 15 pcs., fire growth rate index specimen, 3 pcs., 60S flame tip height specimen, 6 pcs.).

### 6.5 Spraying and foaming process test result requirements

#### (1) Appearance

After the spraying and foaming of the insulating layer, the surface shall not be cracked, soft, brittle or powdery, and the cross section shall be uniformly dispersed with fine pores, without delamination and core burning. The insulating layer and the substrate shall be closely contacted and firmly bonded together. The visual defect of the insulating layer is allowed to be repaired.

#### (2) Flatness

The surface of the insulating layer shall be flat, with the convex no more than 2mm above the datum, and the concave no more than 5mm below the datum.

#### (3) Thickness

The thickness of the insulating layer formed by the spraying and foaming operation shall

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meet the design requirements.

(4) Apparent core density

The insulation material density requirements are shown in Table 6.5(1).

| <b>Material Density</b>          |  | <b>Table 6.5 (1)</b>       |
|----------------------------------|--|----------------------------|
| Compartment temperature $t$ , °C |  | Density, kg/m <sup>3</sup> |
| $t \geq -25$                     |  | $\geq 32$                  |
| $-50 < t < -25$                  |  | $\geq 38$                  |
| $-60 \leq t \leq -50$            |  | $\geq 45$                  |

(5) Other physical and chemical properties

The tensile strength, compressive strength, closed porosity, thermal conductivity, water absorption, water vapor permeability, dimensional stability shall meet the requirements of GB/T 20219-2015 *Rigid Cellular Plastics-spray-applied Polyurethane Foam for Thermal Insulation*, as shown in Table 6.5(2).

| <b>Technical Requirements</b> |   | <b>Table 6.5 (2)</b>    |
|-------------------------------|---|-------------------------|
|                               | Test parameter  | Technical requirement   |
|                               | Tensile strength  | $\geq 200$ kPa          |
|                               | Closed porosity   | $\geq 90\%$             |
|                               | Compressive strength  | $\geq 200$ k Pa         |
|                               | Thermal conductivity (23°C)   | $\leq 0.024$ W/(m.K)    |
|                               | Water absorption (volume ratio)   | $\leq 4\%$              |
|                               | Water vapor permeability (relative humidity / RH (0-50)%, 23°C)                             | $\leq 4.5$ ng/ (Pa·m·s) |
| Dimensional stability         | Low-temperature dimensional stability at -20°C (48h)  | $\pm 1\%$               |
|                               | Damp-heat dimensional stability at 80°C (48h)   | $\pm 2\%$               |
|                               | High-temperature dimensional stability at 70°C (relative humidity / RH 97% $\pm 3\%$ , 48h) | $\pm 4\%$               |

(6) Flame retardant property

The flame retardant property shall be tested according to the corresponding requirements of GB 8624-2012 *Classification for Burning Behavior of Building Materials and Products*, as shown in Table 6.5(3).

| <b>Requirements for Flame Retardant Property of Insulation Materials</b> |             |                                  | <b>Table 6.5(3)</b>  |
|--|-------------|----------------------------------|--|
| Fire retardant property grade  | Test method | Grading criteria                 |  |
| B2   | D           | GB/T 20284                       | Fire growth rate index $FIGRA_{0.4MJ} \leq 750$ W/s  |
|  |             | GB / T 8626<br>ignition time 30s | Flame tip height within 60s $F_s \leq 150$ mm;<br>There is no filter paper combustion caused by flaming droplet within 60s |
|  |             | GB/T 2406.2                      | Oxygen index value $OI \geq 26\%$  |

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**7. Issuance of Process Documents**

After the document review and process approval test according to chapter 4,5 and 6 of this Guidelines, the spraying and foaming process specification will be issued by CCS. The approved process document shall only be valid within the scope of the construction unit and construction personnel specified in the document. If the process specification is modified after approval and involves the main information such as the construction unit, construction personnel, raw materials, equipment, and process parameters, it shall be resubmitted to CCS for approval.

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**Appendix 1    Spraying and Foaming Process Plan for  
Thermal Insulation Materials**

Job Control Number:  
No. \_\_\_\_\_

**Basic Parameter**

|   |                                     |   |   |   |              |               |
|---|-------------------------------------|---|---|---|--------------|---------------|
| Name and serial number of spraying process                            |                                     |   |   |   |              |               |
| Name and address of construction contractor                           |                                     |   |   |   |              |               |
| Name and ID number of construction personnel                          |                                     |   |   |   |              |               |
| Spraying position:  |                                     | Spraying equipment model:                 |   | Spray gun model:                                  |              |               |
| Test plate material:  |                                     | Test plate structure drawing (sketch)     |   |   |              |               |
| Test plate surface state:   |                                     |   |   |   |              |               |
| Antirust primer on test plate surface:<br>Yes/No                      |                                     |   |   |   |              |               |
| Spraying parameters   |                                     |   |   |   |              |               |
| Raw material A/B flow rate  | Raw material preheating temperature | Distance between spray gun and test plate | Normal angle between spray gun and test plate | Spraying speed                                    | Gas pressure | Gas flow rate |
|   |                                     |   |   |   |              |               |
| Spray gun spraying sequence (sketch)                                  |                                     |   |   |   |              |               |
| Spraying environment parameters                                       |                                     |   |   |   |              |               |
| Ambient temperature   |                                     | Ambient humidity                          |   | Ventilation condition                             |              |               |
| Raw materials (material A/B model, specification, supplier name):     |                                     |   |   |   |              |               |
| Test plate temperature:   |                                     |   |   | Maximum thickness of single spraying and foaming: |              |               |
| Surface temperature before respraying:                                |                                     |   |   | Curing cycle after spraying:                      |              |               |
| Test plate preheating temperature and method before spraying (if any) |                                     |   |   | Other related special requirements:               |              |               |

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**Test items**

|  |                          |                          |                          |                          |                          |           |                          |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|-----------|--------------------------|
| 1. Appearance and size   |                          |                          |                          |                          |                          |           |                          |
| Surface inspection   | <input type="checkbox"/> | Cross section inspection | <input type="checkbox"/> | Flatness                 | <input type="checkbox"/> | Thickness | <input type="checkbox"/> |
| 2. Physical and chemical properties and flame retardant property |                          |                          |                          |                          |                          |           |                          |
| Apparent core density  | <input type="checkbox"/> | Tensile strength         | <input type="checkbox"/> | Compressive strength     | <input type="checkbox"/> |           |                          |
| Thermal conductivity (23°C)                                      | <input type="checkbox"/> | Water absorption         | <input type="checkbox"/> | Water vapor permeability | <input type="checkbox"/> |           |                          |
| Closed porosity  | <input type="checkbox"/> | Dimensional stability    | <input type="checkbox"/> | Flame retardant property | <input type="checkbox"/> |           |                          |

Note:  Applicable                       Not applicable

**Signature:**

Representative of construction contractor

Date

\_\_\_\_\_

\_\_\_\_\_

**The following is to be filled in by the Surveyor::**

.

The above-mentioned spraying and foaming process plan has been reviewed and the implementation of spraying process test in accordance with this plan is approved. ....

The above-mentioned spraying and foaming process plan has been reviewed with comments as follows: (Please reply and contact the attending Surveyor as soon as possible) .....

**Signature:**

CCS Surveyor

Date

\_\_\_\_\_ (                      )

\_\_\_\_\_

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**Appendix 2 Approval Test Report for Spraying and Foaming Process of Thermal  
Insulation Materials**

Job Control Number:  
No. \_\_\_\_\_

**Basic Parameter**

|   |                                     |   |   |                       |              |               |
|---|-------------------------------------|---|---|-----------------------|--------------|---------------|
| Name and serial number of spraying process                            |                                     |   |   |                       |              |               |
| Name and address of construction contractor                           |                                     |   |   |                       |              |               |
| Name and ID number of construction personnel                          |                                     |   |   |                       |              |               |
| Spraying position:  |                                     | Spraying equipment model:                 |   | Spray gun model:      |              |               |
| Test plate material:  |                                     | Test plate structure drawing (sketch)     |   |                       |              |               |
| Test plate surface state:   |                                     |   |   |                       |              |               |
| Antirust primer on test plate surface: Yes / No                       |                                     |   |   |                       |              |               |
| Spraying parameters   |                                     |   |   |                       |              |               |
| Raw material A/B flow rate  | Raw material preheating temperature | Distance between spray gun and test plate | Normal angle between spray gun and test plate     | Spraying speed        | Gas pressure | Gas flow rate |
|   |                                     |   |   |                       |              |               |
| Spray gun spraying sequence (sketch)                                  |                                     |   |   |                       |              |               |
| Spraying environment parameters                                       |                                     |   |   |                       |              |               |
| Ambient temperature   |                                     | Ambient humidity                          |   | Ventilation condition |              |               |
| Raw materials (material A/B model, specification, supplier name):     |                                     |   |   |                       |              |               |
| Test plate temperature:   |                                     |   | Maximum thickness of single spraying and foaming: |                       |              |               |
| Surface temperature before respraying:                                |                                     |   | Curing cycle after spraying:                      |                       |              |               |
| Test plate preheating temperature and method before spraying (if any) |                                     |   | Other related special requirements:               |                       |              |               |
| Other instructions:   |                                     |   |   |                       |              |               |

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**Test items and results**

|  |   |                             |  |
|--|---|-----------------------------|--|
| 1. Appearance and size   |   |                             |  |
| Surface inspection:  |   | Cross section inspection:   |  |
| Flatness:  |   | Thickness:                  |  |
| 2. Physical and chemical properties                                |   |                             |  |
| Test item  |   | Test result                 |  |
| Apparent core density  |   |                             |  |
| Tensile strength   |   |                             |  |
| Closed porosity  |   |                             |  |
| Compressive strength   |   |                             |  |
| Thermal conductivity (23°C)  |   |                             |  |
| Water absorption (volume ratio)                                    |   |                             |  |
| Water vapor permeability<br>(relative humidity / RH 0 ~ 50%, 23°C) |   |                             |  |
| Dimensional<br>stability   | Low-temperature dimensional stability at -20°C (48h)                            |                             |  |
|  | Damp-heat dimensional stability at 80°C (48h)                                   |                             |  |
|  | High-temperature dimensional stability at 70°C (97% relative humidity/ RH, 48h) |                             |  |
| Flame retardant property   |   |                             |  |
| Flame retardant property grade                                     | Test method   | Grading criteria            | Test result  |
| B2   | D   | GB/T 20284                  | Fire growth rate index<br>FIGRA0.4MJ≤750W/s  |
|  |   | GB/T 8626 ignition time 30s | Flame tip height within 60s<br>$F_s \leq 150\text{mm}$ ;<br>There is no filter paper combustion caused by flaming droplet within 60s |
|  |   | GB/T 2406.2                 | Oxygen index value/ OI ≥26%  |

Note:  Applicable

Not applicable

**Signature:**

Representative of  
construction contractor:

Date:

CCS Surveyor:

( )

Date:

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**Appendix 3 Specification for Spraying and Foaming Process of Thermal Insulation  
Materials**

Job Control Number:  
No. \_\_\_\_\_

**Basic Parameter**

|   |                                     |   |   |   |              |               |
|---|-------------------------------------|---|---|---|--------------|---------------|
| Name and serial number of spraying process                            |                                     |   |   |   |              |               |
| Name and address of construction contractor                           |                                     |   |   |   |              |               |
| Name and ID number of construction personnel                          |                                     |   |   |   |              |               |
| Spraying position:  |                                     | Spraying equipment model:                 |   | Spray gun model:                                  |              |               |
| Test plate material:  |                                     | Test plate structure drawing (sketch)     |   |   |              |               |
| Test plate surface state:   |                                     |   |   |   |              |               |
| Antirust primer on test plate surface:<br>Yes / No                    |                                     |   |   |   |              |               |
| Spraying parameters   |                                     |   |   |   |              |               |
| Raw material A/B flow rate  | Raw material preheating temperature | Distance between spray gun and test plate | Normal angle between spray gun and test plate | Spraying speed                                    | Gas pressure | Gas flow rate |
|   |                                     |   |   |   |              |               |
| Spray gun spraying sequence (sketch)                                  |                                     |   |   |   |              |               |
| Spraying environment parameters                                       |                                     |   |   |   |              |               |
| Ambient temperature   |                                     | Ambient humidity                          |   | Ventilation condition                             |              |               |
| Raw materials (material A/B model, specification, supplier name):     |                                     |   |   |   |              |               |
| Test plate temperature:   |                                     |   |   | Maximum thickness of single spraying and foaming: |              |               |
| Surface temperature before respraying:                                |                                     |   |   | Curing cycle after spraying:                      |              |               |
| Test plate preheating temperature and method before spraying (if any) |                                     |   |   | Other related special requirements:               |              |               |
| Other instructions:   |                                     |   |   |   |              |               |

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**Test items**

|  |                          |                          |                          |                          |                          |           |                          |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|-----------|--------------------------|
| 1. Appearance and size   |                          |                          |                          |                          |                          |           |                          |
| Surface inspection   | <input type="checkbox"/> | Cross section inspection | <input type="checkbox"/> | Flatness                 | <input type="checkbox"/> | Thickness | <input type="checkbox"/> |
| 2. Physical and chemical properties and flame retardant property |                          |                          |                          |                          |                          |           |                          |
| Apparent core density  | <input type="checkbox"/> | Tensile strength         | <input type="checkbox"/> | Compressive strength     | <input type="checkbox"/> |           |                          |
| Thermal conductivity (23°C)                                      | <input type="checkbox"/> | Water absorption         | <input type="checkbox"/> | Water vapor permeability | <input type="checkbox"/> |           |                          |
| Closed porosity  | <input type="checkbox"/> | Dimensional stability    | <input type="checkbox"/> | Flame retardant property | <input type="checkbox"/> |           |                          |

Note:  Applicable

Not applicable

**Signature:**

Representative of  
construction contractor:

Date:

CCS Surveyor:

( )

Date: