

## **Fire-resistive Performance Evaluation Manual for Principal Building Parts**

### Article 1: Scope of Application

This manual applies to the following types of performance evaluations.

- (1) Performance evaluations pertaining to approvals under Article 108-3 Paragraph 1 Item 2 of the Building Standard Law Enforcement Order (hereinafter referred to as the “Enforcement Order”).
- (2) Performance evaluations pertaining to approvals under Article 108-3 Paragraph 4 of the Enforcement Order

### Article 2: Documents to be Submitted for Performance Evaluations

The documents to be submitted for performance evaluations are as below. Formats and other requirements are as stipulated in application procedures defined elsewhere.

- (1) Performance evaluation application
- (2) Documents providing an outline of the building plan
- (3) Documents providing an outline of building facilities
- (4) Documents providing an outline of plans pertaining to fire-resistive performance
- (5) Building design documents (floor plans, elevations, cross-section drawings and detailed drawings of parts to be evaluated the fire-resistive performance)
- (6) Calculation reports and test reports used to verify fire-resistive performance  
In principal, these items should include test reports, survey reports or calculation reports pertaining to the items listed below.
  - 1) Calorific value of combustible items in the defined space
  - 2) Temperature distribution and heat flux distribution over time of a fire that could be expected to occur in the defined space
  - 3) Heating over time of parts to be evaluated
  - 4) Forces acting on parts to be evaluated
  - 5) Mechanical properties of materials used in parts to be evaluated
- (7) Documents containing other information required for fire-resistive performance evaluation

### Article 3: Evaluation Method

- (1) Implementation of evaluations

- 1) The evaluator(s) will conduct the following evaluations using the documents stipulated in Article 2 and in accordance with the evaluation method stated in (2). However, if it can be assumed that the effects of a fire that could be expected to occur in the part of the building concerned would not spread to other parts, and that the effects of a fire that could be expected to occur in other part of the building would not spread to the part concerned, judgments can be made according to whether or not the principal building parts in the part concerned conform with the technical standards stipulated in Article 107 of the Enforcement Order
  - ① The ability of frame members to withstand damage caused by an interior fire (resistance to deformation, melting, failure or other types of damage that would compromise the structural resistance of parts of principal building parts that support loads in the event of a fire that could be expected to occur inside the building) must be assessed using the method stipulated in (2-1).
  - ② The ability of principal building parts to prevent the spread of interior fires (the thermal insulation performance of walls, other than exterior walls, and floors by a fire that could be expected to occur inside) must be assessed using the method stipulated in (2-2). The flame blocking performance of fire preventive equipment fitted to openings in walls (excluding exterior walls) and floors must be assessed using the method stipulated in (2-3).
  - ③ The flame blocking performance of exterior walls and roofs must be assessed using the method stipulated in (2-3).
  - ④ The ability of exterior walls (only bearing walls) to withstand damage caused by an exterior fire (resistance to deformation, melting, failure or other types of damage that would compromise the structural strength of exterior walls that support loads in the event of a conventional fire occurring outside of the building) must be assessed using the method stipulated in (2-4).
  - ⑤ The ability of exterior walls to prevent the spread of exterior fires (the thermal insulation performance of walls, against a conventional fire occurring outside of the building) must be assessed using the method stipulated in (2-5).
- 2) If necessary for the purposes of the evaluation, the evaluator(s) will ask the applicant to explain the content of the documentation submitted for the performance evaluation, or to provide supplementary information.
- 3) If necessary for the purposes of the evaluation, the evaluator(s) may check the appropriateness of part or all of the methods described in the performance

evaluation application, such as by attending tests.

(2) Evaluation methods

(2-1) Evaluating the ability of frame members to withstand damage by an interior fire (a fire that could be expected to occur inside the building)

① Scope of evaluation

Evaluations cover principal building parts that would support loads in the event of a fire (bearing walls, columns, beams, floors, roofs, stairs and other parts through which loads acting on the building would be transmitted during and after a fire).

② Evaluation procedures

Evaluations must be carried out using the following procedures to confirm that the parts to be evaluated would not suffer deformation, melting, failure or other damage that would compromise structural resistance in the event of an interior fire.

1) Defining spaces in which an interior fire could occur

A space in which an interior fire could occur must be defined as stipulated below as the extent of possible combustion by a fire occurring at any point within a space adjoining the part to be evaluated.

A) If a space directly adjoining the part to be evaluated is enclosed in structures that would isolate it from combustion by a fire, such as buffer spaces (spaces in which the possibility that combustible materials that are present can be safely disregarded, such as cases in which the parts that form the space are made of non-combustible materials) permanently installed in a wall or floor, etc., it can be defined as a space directly adjoining the item to be evaluated. However, in such cases, there must be an evaluation as stipulated in 2-2 and 2-3 that simultaneous combustion will not occur in parts other than those defined, based on the structure of parts and other information shown in the design documents, etc.

B) In other cases, the evaluator(s) must confirm, on the basis of design documents, etc., that interior fires could occur in spaces directly adjoining the part to be evaluated and other surrounding spaces.

2) Identifying combustible materials that would contribute to an interior fire

The calorific value of combustible materials that would contribute to

combustion in an interior fire must be calculated according to the criteria stated below as the sum of the calorific values of combustibles stored inside a room and fixed combustible materials.

- A) Calorific value of combustibles stored inside a room: The calorific value of items stored in a space in which a fire could be expected to occur (hereinafter referred to as the “space concerned”) will be calculated using one of the methods stated below:
  - a) If the types, arrangements and storage patterns of combustible materials are known from information contained in the design documents (such as in the case of parking buildings, libraries or rack warehouses), the calorific value of combustibles stored inside a room which could contribute to combustion must be a value obtained by means of tests or calculations that reproduced the types, arrangements and storage patterns of the items. If the types of combustible materials are known but it is not possible to calculate the calorific value that they would contribute to combustion according to their arrangements and storage patterns, the calorific value must be the product of the weight of each type of stored combustible material and the unit calorific value of that material (calorific value per unit of weight). In this case, the evaluator(s) will check the information against the design documents to ensure that the tests or calculations were based on reasonable evidence and are applicable to the space concerned.
  - b) The calorific value is a figure calculated by adding a standard deviation to the average result of a survey of random samples of combustibles stored inside a room judged to be the same in terms of purpose, usage and size, etc. In this case, the evaluator(s) will assess the reliability of the survey and determine that the space used was similar to the space concerned.
  - c) If the room falls into a category in the table of combustibles stored inside a room as stipulated in Ministry of Construction Notification 1433 of 2000, the evaluator(s) will check that the value is as stipulated in that table.
- B) Calorific value of fixed combustible materials: The calorific value that would be contributed to combustion by fixed combustible materials, such as interior finishing materials and fixed fittings and other equipment, in a space in which a fire could be expected to occur will be calculated using one of the methods stated below:

- a) The values must be obtained through tests or calculations which reproduce the conditions stipulated in the design documents with regard to factors influencing the intensity, etc., of combustion, such as materials, arrangements and storage patterns. However, if it is not possible to calculate the calorific value that would be contributed to combustion according to arrangements and storage patterns, the calorific value must be the product of the weight of each constituent material and the unit calorific value of that material (calorific value per unit of weight). In this case, the evaluator(s) will check the information against the design documents to ensure that the tests or calculations were based on reasonable evidence and are applicable to the space concerned.
- b) The evaluator(s) will check that the calorific value of room finishing materials is a value obtained by multiplying calorific value per surface area per unit of thickness, as stipulated by Ministry of Construction Notification 1433 of 2000, by the surface area and thickness of the materials.

3) Estimating temperature distribution and heat flux distribution over time in by an interior fire

The spatial distribution of temperature and heat flux by an interior fire must be estimated according to the criteria below, with appropriate consideration for the burning rate of stored combustible materials in the space, as defined in 1), the ease with which air flows into the space, the degree of heat transfer from the space, and other factors.

- A) Temperature distribution within the space must be determined from rises in the average temperature and temperature rises in localized high-temperature areas within the space with the passage of time, taking into account the total quantity of combustible materials in the combustion area and the extent to which those materials are unevenly distributed.
- B) Rises in the average temperature within the space with the passage of time must be calculated according to the amount of heat within the space, as estimated from the balance between the rate of heat release (heat released by combustion per second) based on the distribution of combustible materials within the space, the volume of the space, and the inflow of air into the space per unit of time, and the rate of heat loss according to the positions and shapes of openings, the heat absorption properties of the members that make

up the space, and other factors, and the gas mass balance. If these values have been determined from tests, etc., involving the recreation of conditions representing the range of combustion established in 1), the evaluator(s) must check the appropriateness of the process.

- C) Temperature rises in localized high-temperature areas with the passage of time must be determined as a result of results from tests, etc., by the recognized engineering calculation formulae and the tests results that reproduced the conditions stipulated in the design documents, etc., for each part in which intense localized combustion occurs, according to the extent to which combustible materials are unevenly distributed. Proper consideration must have been given to the rate of heat release from unevenly distributed combustible materials, the extent of combustion spread to surrounding combustible materials, and the shape, etc., of flames and thermal flows formed by combustion.

4) Estimating heating applied to items to be evaluated

The heating applied to items to be evaluated must be determined as stated below for each specific part covered (hereinafter referred to as the “part concerned”) by the evaluation, using the temperature distribution of a fire with the passage of time, as estimated in 3) above.

- A) Both convective heat from smoke (including flames) around the item concerned and radiative heat to the item concerned must be taken into account with regard to the heating of the item concerned.
- B) The amount of convective heat to the item concerned must be determined through tests and calculations, etc., that reproduced the conditions stated in the design documents, based on the temperature, velocity and other factors of smoke around the part concerned.
- C) The radiative heat to the item concerned must be determined through tests and calculations, etc., that reproduced the conditions stated in the design documents, based on the shape of flames produced in the space, the temperature of smoke, the distribution of optical density and other factors.

5) Forces acting on items to be evaluated

The forces (axial force, bending moment, shear force, etc.) acting on parts to be evaluated when heat is applied as stipulated in 4) must be

determined according to the following criteria.

- A) Structural load: The structural load that must be transmitted to parts to be evaluated must be calculated according to the floor area supported by the items, in accordance with the provisions of Article 85 of the Enforcement Order. However, if part of a frame has been removed for evaluation, the load imposed by other parts must have been added to the value.
- B) Additional loads resulting from thermal expansion, etc.: Frame deformation and additional loads resulting from it caused by thermal expansion of the parts to be evaluated and other parts, when the temperature distribution patterns determined in 3) above are applied to the item to be evaluated and other principal building parts, must be determined according to the constituent materials, etc.
- C) Forces acting on the cross-section: Forces acting on the cross-section of the parts to be evaluated must be determined as the sum of the structural load effects described in A) and forced deformation effects caused by thermal expansion as described in B). However, if the structure has been made using extremely tough materials, such as steel, which redistribute forces acting on the cross-section within the frame, the those of each part to be evaluated must be estimated using elastic-plastic analysis, etc. In such cases, the evaluator(s) must ensure that the plastic deformation of the frame members is adequate, and that the redistribution of forces does not compromise the stability of parts other than those to be evaluated.

6) Strength of items to be evaluated

The cross-sectional strength of each part to be evaluated under the heating conditions described in 4) must be investigated according to the following criteria.

- A) Effective cross-section for structural strength: If there is a risk of cross-sectional failure (melting, carbonization, dropping, etc.) in the part concerned during heating as described in 4) above, the remaining cross-section must be designed to provide effective structural strength according to assumptions based on evidence from tests, etc.
- B) Cross-sectional strength (axial strength, bending strength, shear strength, etc.): The strength of the effective cross-section for

structural strength (effective cross-section) must be determined by means of tests using specimens configured to represent actual items, or by means of calculations that took into account changes in cross-sectional temperature distribution with the passage of time.

- a) If tests are used, the methods used must be capable of reproducing the heating described in 4), the assumed end restraint and load conditions. If the test data used are based on interpolation or extrapolation, the effects of the interpolated or extrapolated parameters (representative dimensions, etc.) must be reflected correctly on the basis of engineering evidence.
- b) If calculations are used, the cross-sectional strength must be estimated, after the temperature distribution within the effective cross-section must have been determined, and the mechanical properties of the constituent materials (modulus of elasticity, effective yield strength, breaking strength, etc.) must have been reduced accordingly. In the estimation, the following items must have been taken into account.
  - i) Temperature distribution within effective cross-section for structural strength: The method used to determine the temperature distribution within the effective cross-section for structural strength must be based on heat transfer calculations or tests that made appropriate allowance for heat penetration through partial cracking, etc.
  - ii) Mechanical properties of constituent materials: These must be set appropriately on the basis of evidence, such as specifications of standards or guaranteed specifications, etc., for the constituent materials. If special tests or measurements, etc., are used, the settings must provide a margin of safety to allow for unevenness in the properties of materials.
  - iii) Cross-sectional strength: Cross-sectional strength must have been estimated on the basis of the mechanical properties of the constituent materials, as defined in ii) above, according to the normal structural calculation methods used to determine the cross-sectional structural strength of the parts concerned. Appropriate allowance must be made for the degree of localized buckling, buckling of members that include the parts concerned, and the anticipated degree of deformation in joints and other weak spots (member angles, etc.).



③ Judgment criteria

The strength of the parts concerned must not be less than the forces acting on each part to be evaluated.

(2-2) Evaluating thermal insulation performance by interior fires

① Scope of evaluation

The principal building parts to be evaluated are walls (excluding exterior walls), floors and other members of fire compartment.

② Evaluation procedures

Evaluations will be carried out using the following procedures to ensure that the items to be evaluated will not be affected by a loss of thermal insulation performance that would hinder their ability to prevent the spread of an interior fire.

1) Defining spaces in which an interior fire could occur

A space in which an interior fire could occur must be defined in accordance with the criteria in 2-1 1) as an area in which combustion could occur by a fire occurring at any location within a space adjoining the parts to be evaluated.

2) Identifying combustible materials that would contribute to an interior fire

The calorific value of combustible materials that would contribute to combustion in an interior fire must be calculated according to the criteria stated in 2-1 2).

3) Estimating temperature distribution and heat flux distribution over time by an interior fire

The spatial distribution of temperature and heat flux by an interior fire must be estimated according to the criteria in 2-1 3), with appropriate consideration for the burning rate of stored combustible materials in the space, as defined in 1), the ease with which air flows into the space, the degree of heat transfer from the space, and other factors.

4) Estimating heating applied to items to be evaluated

The heating applied to items to be evaluated must be estimated for each part concerned according to the criteria in 2-1 4), using the temperature distribution of the fire with the passage of time, as estimated in 3) above.

- 5) Estimating the temperatures of surfaces other than the heated surfaces  
Changes in the surface temperatures of evaluated items other than the heated surfaces with the passage of time, as estimated in 4) above, when heat is applied to surfaces adjoining the space defined in 1) (hereinafter referred to as the “heated surfaces”), must be estimated according to the following criteria.
  - A) Changes in the surface temperatures other than the heated surfaces with the passage of time must be determined through calculations or tests, taking into account the heat conduction within members (internal convective and radiative heat transfer in the case of items that include internal air cavities, etc.).
  - B) If there is a risk of excessive deformation of beams or other frame members supporting items to be evaluated, localized temperature rises resulting from cracking or other partial damage must be estimated by means of tests, etc.
  
- 6) Ignition temperatures of combustible materials  
The provisions of Ministry of Construction Notification No.1432 will apply, mutatis mutandis, with regard to the ignition temperatures of combustible materials.

③ Judgment criteria

The surface temperatures other than the heated surfaces as defined in 5) must not exceed the ignition temperatures of combustible materials as defined in 6).

(2-3) Evaluating flame blocking performance by interior fires

① Scope of evaluation

The principal building parts to be evaluated are exterior walls, roofs, and fire preventive equipment attached to openings (excluding those facing the outside). The evaluation relates to the flame blocking performance of these items by an interior fire.

② Evaluation procedures

Evaluations will be carried out using the following procedures to ensure that the items to be evaluated will not be affected by a loss of flame blocking performance that would hinder their ability to prevent the spread of an interior fire.

1) Defining spaces in which an interior fire could occur

A space in which an interior fire could occur must be defined in accordance with the criteria in 2-1 1) as the extent of possible combustion by a fire occurring at any location within a space adjoining the parts to be evaluated.

2) Identifying combustible materials that would contribute to an interior fire

The calorific value of combustible materials that would contribute to combustion in an interior fire must be calculated according to the criteria stated in 2-1 2).

3) Estimating temperature distribution and heat flux distribution over time by an interior fire

The spatial distribution of temperature and heat flux by an interior fire must be estimated according to the criteria in 2-1 3), with appropriate consideration for the burning rate of stored combustible materials in the space, as defined in 1), the ease with which air flows into the space, the degree of heat transfer from the space, and other factors.

4) Estimating heating applied to items to be evaluated

The heating applied to items to be evaluated must be estimated for each part concerned according to the criteria in 2-1 4), using the temperature distribution of fire with the passage of time, as estimated in 3) above.

5) Evaluating the flame blocking limits of members to be evaluated

The flame blocking limits of items to be evaluated must be evaluated by means of tests or calculations, according to the following criteria.

- A) If tests are used, these must be conducted using specimens representing the members to be evaluated, and the heating applied must be greater than that estimated in 4).

B) If calculations are used, the estimation must be made whether or not gaps would be formed that could allow flames to penetrate, based on deformation caused by thermal stress or other factors, according to the types of constituent materials used and the construction method, etc., and physical phenomena that could result in destruction. Appropriate allowance must be made for the extent of the predictions with safety margins, based on comparisons of multiple test results.

③ Judgment criteria

Flames must not penetrate to surfaces other than the heated surfaces.

(2-4) Evaluating the ability of exterior walls to withstand damage by an exterior fire

① Scope of evaluation

Evaluations cover the ability of exterior walls (only bearing walls) to withstand damage by an exterior fire.

② Evaluation procedures

Evaluations must be carried out using the following procedures to confirm that the items to be evaluated will not suffer deformation, melting, destruction or other types of damage that would compromise their structural strength, in an event of external fire.

1) Estimating heating applied to items to be evaluated

The heating applied to items to be evaluated must be determined for each part, according to the criteria below, on the basis of 60 minutes of continuous heating for the parts liable to catch fires, and 30 minutes of continuous heating for other parts, using the standard heating temperature curve defined in ISO834.

- a) Convective heat transfer from the air at temperatures on the standard heating temperature curve and radiative heat transfer from a body emitting at temperatures equivalent to the standard heating temperature curve must both be taken into account in estimates of the heating applied to the part concerned.
- b) Convective heat must be estimated using a method based on recognized engineering principles, such as thermal convection theory, and taking into account the temperature of smoke near the parts concerned, and

velocities.

- c) Radiative heat must be estimated using a method based on recognized engineering principles, such as thermal radiation theory, and taking into account the shape of flames formed in the space, the temperature of smoke, and the distribution of optical density.

- 2) Forces acting on items to be evaluated

The forces acting on items to be evaluated must be determined according to the criteria in 2-1 5).

- 3) Strength of items evaluated

The strength of items to be evaluated must be estimated according to the criteria in 2-1 6).

- ③ Judgment criteria

The strength of the parts concerned must not be less than the forces acting on each part covered by the evaluation.

#### (2-5) Evaluating flame blocking performance of exterior walls by exterior fires

- ① Scope of evaluation

Evaluations cover the performance of exterior walls by exterior fires.

- ② Evaluation procedures

Evaluations must be carried out using the following procedures to ensure that the thermal insulation performance of parts to be evaluated will not be affected by a loss of thermal insulation performance that would hinder their ability to prevent the spread of an exterior fire.

- 1) Estimating heating applied to items to be evaluated

The heating applied to items to be evaluated must be estimated according to the criteria in (2-4) 1).

- 2) Estimating the temperatures of surfaces other than those to which heat is applied

The criteria stated in (2-2) 5) must be applied, mutatis mutandis, to changes in the temperatures of surfaces other than the heated surfaces with the passage of time, when heat is applied to the outside of items to

be evaluated, as estimated in 1) above.

3) Ignition temperatures of combustible materials

The provisions of Ministry of Construction Notification No.1432 of 2000 will be applied, mutatis mutandis, with regard to the ignition temperatures of combustible materials.

③ Judgment criteria

The temperatures of surfaces other than heated surfaces as defined in 2) must not exceed the ignition temperatures of combustible materials, as defined in 3).

#### Article 4: Performance Evaluation Report

The evaluation report will include the following items.

- (1) Evaluation number and evaluation completion date
- (2) Name of applicant (company, representative, address)
- (3) Project name
- (4) Scope of evaluation
- (5) Summary of evaluation contents
- (6) Evaluation results
- (7) Other items identified during the evaluation process as necessary for inclusion in the report.