Social- og Boligstyrelsen
Danish Authority of Social Services and Housing

# DS/EN 1991-1-2 DK NA:2014

National Annex to

# Eurocode 1: Actions on structures - Part 1-2: General actions - Actions on structures exposed to fire

## Foreword

This national annex (NA) is a revision of DS/EN 1991-1-2 DK NA:2011 and replaces the latter on 2014-12-15.

This NA lays down the conditions for the implementation in Denmark of EN 1991-1-2 for construction works in conformity with the Danish Building Act or the building legislation. Other parties can put this NA into effect by referring thereto.

A National Annex contains national provisions, viz. nationally applicable values or selected methods. The Annex may furthermore give complementary, non-contradictory information.

This NA includes:

- an overview of possible national choices and clauses containing complementary information;
- national choices;
- complementary, non-contradictory information.

# Overview of possible national choices and complementary information

The list below identifies the clauses where national choices are possible and the applicable/not applicable informative annexes. Furthermore, clauses giving complementary information are identified. Complementary information is given at the end of this National Annex.

| Clause | Subject | National choice[1] | Complementary information |
|---|---|---|---|
| 2.4(4) Note 1 | Temperature analysis - Nominal temperature-time curve | National choice | |
| 2.4(4) Note 2 | Temperature analysis – Parametric temperature-time curve | National choice | |
| 3.1(10) | Thermal actions for temperature analysis – General rules | National choice | |
| 3.2.2 | External fire curve | | Complementary information |
| 3.3.1.2(1) Note 1 | Simplified fire models - Compartment fires | See comments on Annex A | |
| 3.3.1.3(1) | Simplified fire models – Localised fires | No choice made | |
| 3.3.2(2) | Advanced fire models | National choice | |
| 4.2.2(2) | Simultaneity of actions – Additional actions | National choice | |
| 4.3.1(2) | Combination rules for actions – General rules | See DS/EN 1990 DK NA | See Annex H |
| Annex A (1) | Parametric temperature-time curves | National choice | |
| Annex A (2) | Parametric temperature-time curves | National choice | |
| Annex A (3) | Parametric temperature-time curves | National choice | |
| Annex A (5) | Parametric temperature-time curves | National choice | |
| Annex A (7) | Parametric temperature-time curves | National choice | |
| Annex A (8) | Parametric temperature-time curves | National choice | |
| Annex A (9) | Parametric temperature-time curves | National choice | |
| Annex A (10) | Parametric temperature-time curves | National choice | |
| Annex A (11) | Parametric temperature-time curves | National choice | |
| Annex B | Thermal actions for external members – Simplified calculation method | This Annex can be applied for the determination of the effects of temperature on external facades and structures | |

| Clause | Subject | National choice[1] | Complementary information |
|---|---|---|---|
| Annex C (1) | Localised fires | National choice | Complementary information |
| Annex E | Fire load densities | National choice | |
| Annex H | Fire resistance of external staircases or fire compartments used for traffic only | | Complementary information |

1)
*Unchanged:* The recommendation in the Eurocode is followed.
*No choice made:* The Eurocode does not recommend values or methods, but allows the option of determining national values or methods.
*Not applicable:* The Annex is not applicable.
*Applicable:* The Annex is applicable in Denmark and has the same status as specified in the Eurocode.
*National choice:* A national choice has been made.
*Not relevant for building structures:* See the National Annexes published by the Danish Road Directorate and Banedanmark.

# National choices

**2.4(4) Note 1 Temperature analysis - Nominal temperature-time curve**
Annex F is not applicable.

**2.4(4) Note 2 Temperature analysis - Parametric temperature-time curve**
With a fire model, the temperature analysis shall be made for the full duration of the fire.

**3.1(10) Thermal actions for temperature analysis – General rules**
Fire exposures as stated in 3.2.1 and 3.2.3 and 3.3 should be used. For flash-over fires, fire exposures according to Annex A, Annex B and Annex H may be applied. Localised fires that have not been subject to flash-over may be assessed to a limited extent, cf. Annex C.

**3.3.2(2) Advanced fire models**
Two-zone models are not applicable for determining the effects of temperature on structures. CFD models shall be validated for temperature-time curves for the fire exposure considered. For ventilation controlled fires, account shall be taken of the combustion of gases that are not completely burnt out in the fire. It is not sufficient that the model is validated for the determination of smoke movements.

**4.2.2(2) Simultaneity of actions - Additional actions**
Additional actions are determined as follows:

1. Where all members and joints have at least the required fire resistance and account is taken of forces due to restrained thermal expansion, the fire exposure can be determined either as a nominal fire or a parametric fire. The member will not be subject to further additional actions, and the fire resistance is determined according to DS/EN 1990, DS/EN 1991-1-1 and DS/EN 1992-1996.
2. Where parts of the structure are unable to resist the expected fire exposure but it is documented that the main structure retains its stability during the required time of exposure, the stability may be verified with respect to changes of the static model and other changes of the effect of actions due to the fire exposure.

When determining additional actions, account is taken of the simultaneous occurrences of:

- effects of temperature;
- changed geometry;
- changed stiffness parameters;
- changed cross-sectional forces due to deformations and restrained thermal expansion;
- changed cross-sectional forces due to redistribution of actions;
- dynamic effects due to complete or partial falling down of structural members.

These conditions are determined by a global analysis of the entire frame. It will then be possible to determine the fire resistance of each member and joint in the frame using the changed cross-sectional forces according to DS/EN 1990, DS/EN 1991-1-1 and DS/EN 1992-1996.

**Annex A Parametric temperature-time curves**

**(1)** The following is added:

There shall be no intermediate storeys or equivalent in the fire compartment, unless special documentation is provided.

**(2)** The following is added:

The model can be used for a fire load consisting of minimum 80% (by weight) wood/cellulose and maximum 20% (by weight) plastics or similar materials.

**(3)** The first line is replaced by:

The temperature-time curve for the full duration of the fire is determined as:
Expression (A.1) is replaced by:

$$\Theta_g = 20 + \frac{345\log_{10}(8\Gamma t + 1)}{1 + 0{,}04\left(\frac{t}{t_{max}}\right)^{3,5}}$$

$h_{eq}$ is the weighted mean height of vertical openings
$t$ is the time in minutes.

The following is added after the note:
NOTE 2 - The opening factor may conservatively be determined as the opening factor resulting in critical heating of the member. For structures built of concrete, wood and fire insulated steel, an opening factor of 0,02 $m^{1/2}$ may be used.

**(5)** Expression (A.4) is replaced by:

$$s_{lim} = \sqrt{\frac{60 \cdot t_{max} \cdot \lambda_1}{c_1 \cdot \rho_1}}$$

$t_{max}$ being given in seconds.

**(7)** Expression (A.7) is replaced by:

$$t_{max} = 7{,}8 \cdot 10^{-3} \cdot q_{t,d}/O$$

where $t_{max}$ is given in minutes.

**(8)** Is deleted.

**(9)** Is deleted.

**(10)** Is deleted.

**(11)** Is deleted.

**Annex C Localised fires**

See also the complementary information.

**(1)** The following is added:

Furthermore, the fire shall be arranged so that it has an unfavourable effect on the structure.

**Annex E**

Annex E is not applicable and is replaced by:

(1) The fire load is determined as the sum of the permanent fire load and the variable fire load. The permanent fire load consists of combustible materials that do not vary significantly during the service life of the structure and the variable fire load is the remaining part of the fire load in the compartment.

All construction products such as structures, insulation materials, technical installations, etc. may be taken as permanent loads. The permanent fire load is determined on the basis of the net calorific value for the individual product. Account may be taken of the fraction of the combustible objects that will be burnt during the prescribed fire exposure.

The variable fire load will typically be all furniture and equipment in the space. The fire load is determined as the 80% fractile. The variable fire load should, however, be taken as 50 MJ/m$^2$ surrounding surfaces.

Where documentation cannot be provided that other values are more correct, the design fire load $q_{t,d}$ related to the surface area $A_t$ enclosing the fire compartment is taken as:

| **Use** | $q_{t,d}$ |
|---|---|
| Dwellings and offices | 200 MJ/m$^2$ |
| Hospitals, classrooms, cinemas and hotels | 150 MJ/m$^2$ |

# Complementary, non-contradictory information

### 3.2.2 External fire curve

The Danish system does not apply this method. Where the Danish system describes the fire resistance time, the standard temperature-time curve specified in 3.2.1 is used, irrespective of whether the element is outside or inside the building.

### Annex C Localised fires

Attention is drawn to the fact that the models given in Annex C do not in themselves allow an adequate determination to be made of the effects of temperatures in structures for a fire not subject to flash-over.

### Annex H

(informative)

**Fire resistance of external staircases or fire compartments used for traffic only**

(1) For enclosed staircases where the stairwell is used for traffic only, the resistance may be determined using reduced actions provided that documentation is available to prove that the staircase can maintain its resistance throughout fire exposure.

(2) The temperature-time curve may be determined as a parametric fire curve with a fire load density corresponding to the occupancy of the building or as a nominal fire curve according to expression (3.4), where $\Theta_g$ after $t_{fi,req}$ is assumed to decrease by 10 °C/minute.

(3) For the design of staircases it is allowed to disregard the imposed load for that part of the temperature-time curve where the temperature of the stairwell exceeds 100 °C provided that it is verified by supplementary design that the structural resistance is adequate for the subsequent part of the temperature-time curve according to DS/EN 1990.