

SINGAPORE STANDARD

# SS EN 1993-1-2 : 2009

EN 1993-1-2 : 2005, IDT

(ICS 13.220.50; 91.010.30; 91.080.10)

## Eurocode 3: Design of steel structures –

### *Part 1-2: General rules – Structural fire design*

---

This national standard is the identical implementation of EN 1993-1-2 : 2005 and is adopted with the permission of CEN, Rue de Stassart 36, B-1050 Brussels.

Published by  
SPRING Singapore  
2 Bukit Merah Central  
Singapore 159835  
SPRING Singapore Website: [www.spring.gov.sg](http://www.spring.gov.sg)  
Standards Website: [www.standards.org.sg](http://www.standards.org.sg)

SINGAPORE STANDARD

# SS EN 1993-1-2 : 2009

EN 1993-1-2 : 2005, IDT

(ICS 13.220.50; 91.010.30; 91.080.10)

## Eurocode 3: Design of steel structures –

### *Part 1-2: General rules – Structural fire design*

---

This national standard is the identical implementation of EN 1993-1-2 : 2005 and is adopted with the permission of CEN, Rue de Stassart 36, B-1050 Brussels

*All rights reserved. Unless otherwise specified, no part of this Singapore Standard may be reproduced or utilised in any form or by any means, electronic or mechanical, including photocopying and microfilming, without permission in writing from SPRING Singapore at the address below:*

Head  
Standardisation Department  
SPRING Singapore  
2 Bukit Merah Central  
Singapore 159835  
Telephone: 62786666 Telefax: 62786667  
Email: [stn@spring.gov.sg](mailto:stn@spring.gov.sg)

ISBN 978-981-4278-22-5

## **National Foreword**

This Singapore Standard was prepared by the Technical Committee on Building Structure and Sub-structure under the purview of the Building and Construction Standards Committee.

This SS EN is the identical implementation of EN 1993-1-2 : 2005 'Eurocode 3 : Design of steel structures – Part 1-2 : General rules – Structural fire design' including its Corrigendum EN 1993-1-2 : 2005 / AC : 2009 (incorporated after the main text) and is adopted with the permission of CEN, Rue de Stassart 36, B-1050 Brussels.

Attention is drawn to the following:

- The comma has been used throughout as a decimal marker whereas in Singapore Standards, it is a practice to use a full point on the baseline as the decimal marker.
- The Singapore Standards which implement international or European publications referred to in this document may be found in the SS Electronic Catalogue at:  
<http://www.singaporestandardseshop.sg>

The EN gives values with notes indicating where national choices may be made. Where a normative part of the EN allows for national choice to be made, the range and possible choice will be given in the normative text, and a note will qualify it as a Nationally Determined Parameter (NDP). NDPs can be a specific value for a factor, a specific level or class, a particular method or a particular application rule if several are proposed in the EN.

The requirements of this SS EN 1993-1-2 : 2009 are to be read in conjunction with the Singapore National Annex (NA) to SS EN 1993-1-2 : 2009 which contains information on the Singapore Nationally Determined Parameters and is published separately.

National choice is allowed in EN 1993-1-2 through the following clauses:

- 2.3 (1)
- 2.3 (2)
- 4.1 (2)
- 4.2.3.6 (1)
- 4.2.4 (2)

At the time of publication, this standard is expected to be used as a reference in the Building and Construction Authority's 'Approved Document – Acceptable Solutions'.

Attention is drawn to the possibility that some of the elements of this Singapore Standard may be the subject of patent rights. SPRING Singapore shall not be held responsible for identifying any or all of such patent rights.

### **NOTE**

1. *Singapore Standards are subject to periodic review to keep abreast of technological changes and new technical developments. The changes in Singapore Standards are documented through the issue of either amendments or revisions.*
2. *Compliance with a Singapore Standard does not exempt users from legal obligations.*

EUROPEAN STANDARD

**EN 1993-1-2**

NORME EUROPÉENNE

EUROPÄISCHE NORM

April 2005

ICS 13.220.50; 91.010.30; 91.080.10

Supersedes ENV 1993-1-2:1995

English version

## Eurocode 3: Design of steel structures - Part 1-2: General rules - Structural fire design

Eurocode 3: Calcul des structures en acier - Partie 1-2:  
Règles générales - Calcul du comportement au feu

Eurocode 3: Bemessung und Konstruktion von Stahlbauten  
- Teil 1-2: Allgemeine Regeln - Tragwerksbemessung für  
den Brandfall

This European Standard was approved by CEN on 23 April 2004.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.



EUROPEAN COMMITTEE FOR STANDARDIZATION  
COMITÉ EUROPÉEN DE NORMALISATION  
EUROPÄISCHES KOMITEE FÜR NORMUNG

**Management Centre: rue de Stassart, 36 B-1050 Brussels**

| <b>Contents</b>   | <b>Page</b> |
|---|-------------|
| <b>Foreword .....</b>   | <b>4</b>    |
| <b>1. General .....</b>   | <b>9</b>    |
| 1.1 Scope .....   | 9           |
| 1.2 Normative references.....   | 10          |
| 1.3 Assumptions .....   | 11          |
| 1.4 Distinction between principles and application rules.....                             | 11          |
| 1.5 Terms and definitions .....   | 11          |
| 1.6 Symbols .....   | 12          |
| <b>2 Basis of design .....</b>  | <b>16</b>   |
| 2.1 Requirements .....  | 16          |
| 2.1.1 Basic requirements .....  | 16          |
| 2.1.2 Nominal fire exposure .....   | 16          |
| 2.1.3 Parametric fire exposure .....  | 16          |
| 2.2 Actions.....  | 17          |
| 2.3 Design values of material properties .....  | 17          |
| 2.4 Verification methods .....  | 17          |
| 2.4.1 General .....   | 17          |
| 2.4.2 Member analysis.....  | 18          |
| 2.4.3 Analysis of part of the structure .....   | 19          |
| 2.4.4 Global structural analysis .....  | 20          |
| <b>3 Material properties.....</b>   | <b>20</b>   |
| 3.1 General .....   | 20          |
| 3.2 Mechanical properties of carbon steels .....  | 20          |
| 3.2.1 Strength and deformation properties .....   | 20          |
| 3.2.2 Unit mass .....   | 20          |
| 3.3 Mechanical properties of stainless steels.....  | 23          |
| 3.4 Thermal properties.....   | 23          |
| 3.4.1 Carbon steels .....   | 23          |
| 3.4.2 Stainless steels .....  | 26          |
| 3.4.3 Fire protection materials .....   | 26          |
| <b>4 Structural fire design .....</b>   | <b>27</b>   |
| 4.1 General .....   | 27          |
| 4.2 Simple calculation models.....  | 27          |
| 4.2.1 General .....   | 27          |
| 4.2.2 Classification of cross-sections .....  | 28          |
| 4.2.3 Resistance .....  | 28          |
| 4.2.4 Critical temperature .....  | 36          |
| 4.2.5 Steel temperature development .....   | 37          |
| 4.3 Advanced calculation models.....  | 43          |
| 4.3.1 General .....   | 43          |
| 4.3.2 Thermal response.....   | 43          |
| 4.3.3 Mechanical response.....  | 43          |
| 4.3.4 Validation of advanced calculation models.....                                      | 44          |
| <b>Annex A [normative] Strain-hardening of carbon steel at elevated temperatures.....</b> | <b>45</b>   |
| <b>Annex B [normative] Heat transfer to external steelwork .....</b>                      | <b>47</b>   |
| <b>Annex C [informative] Stainless steel .....</b>  | <b>65</b>   |
| <b>Annex D [informative] Joints .....</b>   | <b>73</b>   |

**Annex E [informative] Class 4 cross-sections .....76**

## Foreword

This European Standard EN 1993, Eurocode 3: Design of steel structures, has been prepared by Technical Committee CEN/TC250 « Structural Eurocodes », the Secretariat of which is held by BSI. CEN/TC250 is responsible for all Structural Eurocodes.

This European Standard shall be given the status of a National Standard, either by publication of an identical text or by endorsement, at the latest by October 2005, and conflicting National Standards shall be withdrawn at latest by March 2010.

This Eurocode supersedes ENV 1993-1-2.

According to the CEN-CENELEC Internal Regulations, the National Standard Organizations of the following countries are bound to implement these European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

## Background to the Eurocode programme

In 1975, the Commission of the European Community decided on an action programme in the field of construction, based on article 95 of the Treaty. The objective of the programme was the elimination of technical obstacles to trade and the harmonization of technical specifications.

Within this action programme, the Commission took the initiative to establish a set of harmonized technical rules for the design of construction works which, in a first stage, would serve as an alternative to the national rules in force in the Member States and, ultimately, would replace them.

For fifteen years, the Commission, with the help of a Steering Committee with Representatives of Member States, conducted the development of the Eurocodes programme, which led to the first generation of European codes in the 1980s.

In 1989, the Commission and the Member States of the EU and EFTA decided, on the basis of an agreement<sup>1</sup> between the Commission and CEN, to transfer the preparation and the publication of the Eurocodes to CEN through a series of Mandates, in order to provide them with a future status of European Standard (EN). This links *de facto* the Eurocodes with the provisions of all the Council's Directives and/or Commission's Decisions dealing with European standards (*e.g.* the Council Directive 89/106/EEC on construction products - CPD - and Council Directives 93/37/EEC, 92/50/EEC and 89/440/EEC on public works and services and equivalent EFTA Directives initiated in pursuit of setting up the internal market).

The Structural Eurocode programme comprises the following standards generally consisting of a number of Parts:

|         |             |   |
|---------|-------------|---|
| EN 1990 | Eurocode 0: | Basis of Structural Design                        |
| EN 1991 | Eurocode 1: | Actions on structures                             |
| EN 1992 | Eurocode 2: | Design of concrete structures                     |
| EN 1993 | Eurocode 3: | Design of steel structures                        |
| EN 1994 | Eurocode 4: | Design of composite steel and concrete structures |
| EN 1995 | Eurocode 5: | Design of timber structures                       |
| EN 1996 | Eurocode 6: | Design of masonry structures                      |
| EN 1997 | Eurocode 7: | Geotechnical design                               |
| EN 1998 | Eurocode 8: | Design of structures for earthquake resistance    |
| EN 1999 | Eurocode 9: | Design of aluminium structures                    |

<sup>1</sup> Agreement between the Commission of the European Communities and the European Committee for Standardisation (CEN) concerning the work on EUROCODES for the design of building and civil engineering works (BC/CEN/03/89).

Eurocode standards recognize the responsibility of regulatory authorities in each Member State and have safeguarded their right to determine values related to regulatory safety matters at national level where these continue to vary from State to State.

### Status and field of application of eurocodes

The Member States of the EU and EFTA recognize that Eurocodes serve as reference documents for the following purposes :

- as a means to prove compliance of building and civil engineering works with the essential requirements of Council Directive 89/106/EEC, particularly Essential Requirement N°1 – Mechanical resistance and stability – and Essential Requirement N°2 – Safety in case of fire;
- as a basis for specifying contracts for construction works and related engineering services;
- as a framework for drawing up harmonized technical specifications for construction products (ENs and ETAs)

The Eurocodes, as far as they concern the construction works themselves, have a direct relationship with the Interpretative Documents<sup>2</sup> referred to in Article 12 of the CPD, although they are of a different nature from harmonized product standards<sup>3</sup>. Therefore, technical aspects arising from the Eurocodes work need to be adequately considered by CEN Technical Committees and/or EOTA Working Groups working on product standards with a view to achieving full compatibility of these technical specifications with the Eurocodes.

The Eurocode standards provide common structural design rules for everyday use for the design of whole structures and component products of both a traditional and an innovative nature. Unusual forms of construction or design conditions are not specifically covered and additional expert consideration will be required by the designer in such cases.

### National Standards implementing Eurocodes

The National Standards implementing Eurocodes will comprise the full text of the Eurocode (including any annexes), as published by CEN, which may be preceded by a National title page and National foreword, and may be followed by a National annex.

The National annex may only contain information on those parameters which are left open in the Eurocode for national choice, known as Nationally Determined Parameters, to be used for the design of buildings and civil engineering works to be constructed in the country concerned, *i.e.* :

- values and/or classes where alternatives are given in the Eurocode,
- values to be used where a symbol only is given in the Eurocode,
- country specific data (geographical, climatic, etc.), *e.g.* snow map,
- the procedure to be used where alternative procedures are given in the Eurocode.

It may contain

- decisions on the application of informative annexes,
- references to non-contradictory complementary information to assist the user to apply the Eurocode.

<sup>2</sup> According to Art. 3.3 of the CPD, the essential requirements (ERs) shall be given concrete form in interpretative documents for the creation of the necessary links between the essential requirements and the mandates for harmonized ENs and ETAGs/ETAs.

<sup>3</sup> According to Art. 12 of the CPD the interpretative documents shall :

- a) give concrete form to the essential requirements by harmonizing the terminology and the technical bases and indicating classes or levels for each requirement where necessary ;
- b) indicate methods of correlating these classes or levels of requirement with the technical specifications, *e.g.* methods of calculation and of proof, technical rules for project design, etc. ;
- c) serve as a reference for the establishment of harmonized standards and guidelines for European technical approvals.

The Eurocodes, *de facto*, play a similar role in the field of the ER 1 and a part of ER 2.

## EN 1993-1-2 : 2005 (E)

### Links between Eurocodes and harmonized technical specifications (ENs and ETAs) for products

There is a need for consistency between the harmonized technical specifications for construction products and the technical rules for works<sup>4</sup>. Furthermore, all the information accompanying the CE Marking of the construction products which refer to Eurocodes should clearly mention which Nationally Determined Parameters have been taken into account.

### Additional information specific to EN 1993-1-2

EN 1993-1-2 describes the principles, requirements and rules for the structural design of steel buildings exposed to fire, including the following aspects.

#### *Safety requirements*

EN 1993-1-2 is intended for clients (e.g. for the formulation of their specific requirements), designers, contractors and relevant authorities.

The general objectives of fire protection are to limit risks with respect to the individual and society, neighbouring property, and where required, environment or directly exposed property, in the case of fire.

Construction Products Directive 89/106/EEC gives the following essential requirement for the limitation of fire risks:

"The construction works must be designed and build in such a way, that in the event of an outbreak of fire

- the load bearing resistance of the construction can be assumed for a specified period of time
- the generation and spread of fire and smoke within the works are limited
- the spread of fire to neighbouring construction works is limited
- the occupants can leave the works or can be rescued by other means
- the safety of rescue teams is taken into consideration".

According to the Interpretative Document N° 2 "Safety in case of fire" the essential requirement may be observed by following various possibilities for fire safety strategies prevailing in the Member States like conventional fire scenarios (nominal fires) or "natural" (parametric) fire scenarios, including passive and/or active fire protection measures.

The fire parts of Structural Eurocodes deal with specific aspects of passive fire protection in terms of designing structures and parts thereof for adequate load bearing resistance and for limiting fire spread as relevant.

Required functions and levels of performance can be specified either in terms of nominal (standard) fire resistance rating, generally given in national fire regulations or by referring to fire safety engineering for assessing passive and active measures.

Supplementary requirements concerning, for example

- the possible installation and maintenance of sprinkler systems,
- conditions on occupancy of building or fire compartment,
- the use of approved insulation and coating materials, including their maintenance,

are not given in this document, because they are subject to specification by the competent authority.

Numerical values for partial factors and other reliability elements are given as recommended values that provide an acceptable level of reliability. They have been selected assuming that an appropriate level of workmanship and of quality management applies.

---

<sup>4</sup> see Art.3.3 and Art.12 of the CPD, as well as clauses 4.2, 4.3.1, 4.3.2 and 5.2 of ID 1.

*Design procedures*

A full analytical procedure for structural fire design would take into account the behaviour of the structural system at elevated temperatures, the potential heat exposure and the beneficial effects of active and passive fire protection systems, together with the uncertainties associated with these three features and the importance of the structure (consequences of failure).

At the present time it is possible to undertake a procedure for determining adequate performance which incorporates some, if not all, of these parameters and to demonstrate that the structure, or its components, will give adequate performance in a real building fire. However, where the procedure is based on a nominal (standard) fire the classification system, which calls for specific periods of fire resistance, takes into account (though not explicitly), the features and uncertainties described above.

Application of this Part 1-2 is illustrated in Figure 1. The prescriptive approach and the performance-based approach are identified. The prescriptive approach uses nominal fires to generate thermal actions. The performance-based approach, using fire safety engineering, refers to thermal actions based on physical and chemical parameters.

For design according to this part, EN 1991-1-2 is required for the determination of thermal and mechanical actions to the structure.

*Design aids*

Where simple calculation models are not available, the Eurocode fire parts give design solutions in terms of tabulated data (based on tests or advanced calculation models), which may be used within the specified limits of validity.

It is expected, that design aids based on the calculation models given in EN 1993-1-2, will be prepared by interested external organizations.

The main text of EN 1993-1-2 together with normative Annexes includes most of the principal concepts and rules necessary for structural fire design of steel structures.

**National Annex for EN 1993-1-2**

This standard gives alternative procedures, values and recommendations for classes with notes indicating where national choices may have to be made. Therefore the National Standard implementing EN 1993-1-2 should have a National annex containing all Nationally Determined Parameters to be used for the design of steel structures to be constructed in the relevant country.

National choice is allowed in EN 1993-1-2 through paragraphs:

- 2.3 (1)
- 2.3 (2)
- 4.1 (2)
- 4.2.3.6 (1)
- 4.2.4 (2)

## 1. General

### 1.1 Scope

#### 1.1.1 Scope of EN 1993

(1) EN 1993 applies to the design of buildings and civil engineering works in steel. It complies with the principles and requirements for the safety and serviceability of structures, the basis of their design and verification that are given in EN 1990 – Basis of structural design.

(2) EN 1993 is only concerned with requirements for resistance, serviceability, durability and fire resistance of steel structures. Other requirements, e.g concerning thermal or sound insulation, are not considered.

(3) EN 1993 is intended to be used in conjunction with:

- EN 1990 “Basis of structural design”
- EN 1991 “Actions on structures”
- hEN’s for construction products relevant for steel structures
- EN 1090 “Execution of steel structures”
- EN 1998 “Design of structures for earthquake resistance”, where steel structures are built in seismic regions

(4) EN 1993 is subdivided in six parts:

- EN 1993-1 Design of Steel Structures : Generic rules.
- EN 1993-2 Design of Steel Structures : Steel bridges.
- EN 1993-3 Design of Steel Structures : Towers, masts and chimneys.
- EN 1993-4 Design of Steel Structures : Silos, tanks and pipelines.
- EN 1993-5 Design of Steel Structures : Piling.
- EN 1993-6 Design of Steel Structures : Crane supporting structures.

#### 1.1.2 Scope of EN 1993-1-2

(1) EN 1993-1-2 deals with the design of steel structures for the accidental situation of fire exposure and is intended to be used in conjunction with EN 1993-1-1 and EN 1991-1-2. EN 1993-1-2 only identifies differences from, or supplements to, normal temperature design.

(2) EN 1993-1-2 deals only with passive methods of fire protection.

(3) EN 1993-1-2 applies to steel structures that are required to fulfil this load bearing function if exposed to fire, in terms of avoiding premature collapse of the structure.

**NOTE:** This part does not include rules for separating elements.

(4) EN 1993-1-2 gives principles and application rules for designing structures for specified requirements in respect of the load bearing function and the levels of performance.

(5) EN 1993-1-2 applies to structures, or parts of structures, that are within the scope of EN 1993-1 and are designed accordingly.