SLOVENSKI PREDSTANDARD

SIST ENV 1999-2

prva izdaja
oktober 2002

Eurocode 9 - Projektiranje konstrukcij iz aluminijevih zlitin - 2. del: Konstrukcije, občutljive na utrujanje (prevzet ENV 1999-2:1998 z metodo platnice)

Eurocode 9 - Design of aluminium structures - Part 2: Structures suspectible to fatigue

Eurocode 9 - Conception et dimensionnement des structures en aluminium - Partie 2: Structures sensibles à la fatigue

Eurocode 9 - Bemessung und Konstruktion von Aluminiumbauten - Teil 2: Ermündungsfällige Tragwerke

Deskriptorji: gradbeništvo, jeklena konstrukcija, aluminij, aluminijasta konstrukcija, projektiranje, predpisi za gradnjo, računanje, mehanska trdnost

ICS 91.010.30; 91.080.10

Referenčna številka
SIST ENV 1999-2:2002 ((sl),en)

Nadaljevanje na straneh od II do IV in od 1 do 90

NACIONALNI UVOD

Predstandard SIST ENV 1999-2 ((sl),en), Eurocode 9 - Projektiranje konstrukcij iz aluminijevih zlitin - 2. del: Konstrukcije, občutljive na utrujanje, prva izdaja, 2002, ima status slovenskega predstandarda in je z metodo platnice prevzet evropski predstandard ENV 1999-2 (en), Eurocode 9 - Design of aluminium structures - Part 2: Structures suspectible to fatigue, May 1998.

NACIONALNI PREDGOVOR

Evropski predstandard ENV 1999-2:1998 je pripravil tehnični odbor Evropskega komiteja za standardizacijo CEN/TC 250 Konstrukcijski Evrokodi.

Odločitev za prevzem tega predstandarda po metodi platnice je sprejela delovna skupina WG 9 Aluminijaste konstrukcije, ki je pripravila tudi nacionalni dokument za uporabo v Sloveniji, potrdil pa tehnični odbor TC KON Konstrukcije.

Ta slovenski predstandard se lahko uporablja samo v skladu z nacionalnim dokumentom, ki je sestavni del SIST ENV 1999-2:2002.

Ta slovenski predstandard je dne 2002-09-02 odobrila direktorica SIST.

Rok veljavnosti tega predstandarda je do izdaje evropskega standarda EN 1999-2.

DELI EVROKODA 9 (EC 9 OZIROMA ENV 1999) SPREJETI V NACIONALNO STANDARDIZACIJO:

SIST ENV 1999-1-1:2002	((sl),en)	Eurocode 9 - Projektiranje konstrukcij iz aluminijevih zlitin - Del 1-1: Splošna pravila - Splošna pravila in pravila za stavbe
SIST ENV 1999-1-2:2002	((sl),en)	Eurocode 9 - Projektiranje konstrukcij iz aluminijevih zlitin - Del 1-2: Splošna pravila - Projektiranje požarnovarnih konstrukcij

OPOMBI

- Povsod, kjer se v besedilu predstandarda uporablja izraz “evropski predstandard”, v SIST ENV 1999-2:2002 to pomeni “slovenski predstandard”.
- Nacionalni uvod in nacionalni predgovor nista sestavni del predstandarda.

VSEBINA **Stran**

NACIONALNI DOKUMENT ZA UPORABO V SLOVENIJI

Ta predstandard se uporablja z naslednjimi parametri:

Za vrednosti parametrov, podanih v okvirju (večinoma delni varnostni faktorji odpornosti ali zunanjih vplivov), se v SIST ENV 1999-2:2002 privzamejo priporočene vrednosti, podane v ENV 1999-2:1998.

V tem predstandardu se za prevajanje uporabljajo naslednji enakovredni izrazi, skupni vsem Eurocode:

construction works	gradbeni objekt, zgradba
execution	izvedba
structure	nosilna konstrukcija
type of building or civil and structural engineering works	vrsta stavb in inženirskih objektov
form of structure	tip konstrukcije
construction material	gradbeni material
type of construction	vrsta gradnje
method of construction	postopek gradnje
structural system	sistem nosilne konstrukcije

EUROPEAN PRESTANDARD

PRÉNORME EUROPÉENNE

EUROPÄISCHE VORNORM

ENV 1999-2

May 1998

ICS 91.010.30; 91.080.10

Descriptors: civil engineering, steel construction, aluminium, design, building codes, computation, mechanical strength

English version

Eurocode 9: Design of aluminium structures - Part 2: Structures susceptible to fatigue

Eurocode 9: Conception et dimensionnement des structures en aliminium - Partie 2: Structures sensibles à la fatigue

Eurocode 9: Bemessung und Konstruktion von Aluminiumbauten - Teil 2: Ermüdungsanfällige Tragwerke

This European Prestandard (ENV) was approved by CEN on 26 October 1997 as a prospective standard for provisional application.

The period of validity of this ENV is limited initially to three years. After two years the members of CEN will be requested to submit their comments, particularly on the question whether the ENV can be converted into a European Standard.

CEN members are required to announce the existence of this ENV in the same way as for an EN and to make the ENV available promptly at national level in an appropriate form. It is permissible to keep conflicting national standards in force (in parallel to the ENV) until the final decision about the possible conversion of the ENV into an EN is reached.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

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

Central Secretariat: rue de Stassart, 36 B-1050 Brussels

Ref. No. ENV 1999-2:1998 E

Contents

Foreword

Objectives of the Eurocodes

The Structural Eurocodes comprise a group of standards for the structural and geotechnical design of buildings and civil engineering works.

They are intended to serve as reference documents for the following purposes:

a) As a means to prove compliance of building and civil engineering works with the essential requirements of the Construction Products Directive (CPD).

b) As a framework for drawing up harmonised technical specifications for construction products.

They cover execution and control only to the extent that is necessary to indicate the quality of the construction products, and the standard of the workmanship, needed to comply with the assumptions of the design rules.

Until the necessary set of harmonised technical specifications for products and for methods of testing their performance is available, some of the Structural Eurocodes cover some of these aspects in informative annexes.

Background to the Eurocode Programme

The Commission of the European Communities (CEC) initiated the work of establishing a set of harmonized technical rules for the design of building and civil engineering works which would initially serve as an alternative to the different rules in force in the various Member States and would ultimately replace them. These technical rules became known as the "Structural Eurocodes".

In 1990, after consulting their respective Member States, the CEC transferred the work of further development, issue and updates of the Structural Eurocodes to CEN, and the EFTA Secretariat agreed to support the CEN work.

CEN Technical Committee CEN/TC 250 is responsible for all Structural Eurocodes.

Eurocode programme

Work is in hand on the following Structural Eurocodes, each generally consisting of a number of parts:

EN 1991	Eurocode 1	Basis of design and 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

Separate sub-committees have been formed by CEN/TC 250 for the various Eurocodes listed above.

This part of the Structural Eurocode for Design of Aluminium Alloy Structures, which had been finalised and approved for publication under the direction of CEC, is being issued by CEN as a European Prestandard (ENV) with an initial life of three years.

This Prestandard is intended for experimental practical application in the design of the building and civil engineering works covered by the scope as given in 1.1 and for the submission of comments.

After approximately two years CEN members will be invited to submit formal comments to be taken into account in determining future action.

Meanwhile feedback and comments on this Prestandard should be sent to Secretariat of sub-committee CEN/TC 250/SC 9 at the following address:

Secretariat of CEN/TC 250/SC 9
c/o Norwegian Council for Building Standardization
Postboks 129 Blindern
N - 0314 OSLO

or to your national standards organisation.

National Applications Documents

In view of the responsibilities of authorities in member countries for the safety, health and other matters covered by the essential requirements of the CPD, certain safety elements in this ENV have been assigned indicative values which are identified by □. The authorities in each member country are expected to assign definitive values to these safety elements.

Some of the harmonised supporting prestandards, including the Eurocodes giving values of actions to be taken into account and measures required for fire protection, may not be available by the time this Prestandard is issued. It is therefore anticipated that a National Application Document (NAD) giving definitive values for safety elements, referencing compatible supporting standards and providing national guidance on the application of this Prestandard, will be issued by each member country or its Standards Organisation.

It is intended that this Prestandard is used in conjunction with the NAD valid in the country where the building or civil engineering works are located.

Matters specific to this Prestandard

General

The scope of Eurocode 9 is defined in Part 1.1 and the scope of this Part of Eurocode 9 is defined in 1.1.

In using this Prestandard in practice, particular regard should be paid to the underlying assumptions and conditions given in 1.4.

In developing this Prestandard, background documents have been prepared, which give commentaries on, and justifications for, some of the provisions in the Prestandard.

Use of annexes

The six chapters of this Prestandard are complemented by five Annexes, some normative and some informative.

The normative annexes have the same status as the chapters to which they relate. Most have been introduced by moving some of the more detailed Application Rules, which are needed only in particular cases, out of the main part of the text to aid its clarity.

Concept of reference standards

In order to use this Prestandard reference needs to be made to various CEN and ISO standards. These are used to define the product characteristics and processes which have been assumed to apply in formulating the design rules.

This Prestandard mentions certain "Reference Standards". Each Reference Standard makes reference to the whole or, part of, a number of CEN and/or ISO standards. Where any referenced CEN or ISO standard is not yet available, the National Application Document should be consulted for the standard to be used instead. It is assumed that only those grades and qualities given in normative Annex B of Part 1.1 will be used for buildings and civil engineering works designed to this Prestandard.

Partial safety factors

This Prestandard gives general rules for the design of aluminium structures which relate to the limit states of members and connections which involve structural failure due to fatigue.

Most of the rules have been calibrated against test results in order to obtain consistent values of the partial safety factors for resistance γ_{Mf}.

Guidance is given on appropriate partial factors γ_{Ff} for loading where the loading cannot be obtained from existing loading codes.

Fabrication and erection

Chapter 6 of this Prestandard is intended to indicate some minimum standards of workmanship and normal tolerances that have been assumed in deriving the design rules given in this Prestandard.

It also indicates the information relating to particular fatigue critical parts of a structure that the designer needs to supply in order to define the execution and maintenance requirements.

Design assisted by testing

Section 2.4 is not generally required in the course of routine design, but is provided, together with Annex C, for use in the special circumstances in which it may become appropriate.

1 General

1.1 Scope of Eurocode 9 Part 2

1.1.1 Application

(1) This Part 2 gives the basis for the design of aluminium alloy structures with respect to the limit state of fatigue induced fracture. Design for other limit states is covered in Part 1.

(2) This Part 2 gives rules for design by the following methods:

- Safe life
- Damage tolerance
- Design by testing

(3) This Part 2 contains the manufacturing quality requirements necessary to ensure that the design assumptions are met in practice.

1.1.2 Structural forms

(1) This Part 2 covers:

- Beams and braced and unbraced framed structures
- Latticed structures
- Stiffened plate structures of flat or shell construction
- Solid bodies

(2) This Part 2 does not cover pressurised containment vessels, or pipework.

1.1.3 Basic products

(1) This Part 2 covers:

- Rolled sections
- Extrusions
- Drawn Tubes
- Formed Profiles
- Forgings
- Castings

1.1.4 Member forms

(2) This Part 2 covers open and hollow sections, including members built up from combinations of these products.

1.1.5 Materials

(1) This Part 2 covers the wrought alloys listed with a tick in Table 1.1.1 and the cast alloys listed in Table 1.1.2.

Table 1.1.1: Wrought aluminium alloys for structures

Alloy designation	Process and form of product								
	Rolled (EN 485)			Extruded (EN 755)			Drawn (EN 754)	HF seam-welded (EN 1592)	Forged (EN 586)
	Sheet[1)]	Strip	Plate[2)]	Rod bar	Tube	Profile	Tube	Tube	Shapes
EN AW-3103	✓	✓	✓					✓	
EN AW-5083	✓	✓	✓	✓	✓	✓[3)]	✓		✓
EN AW-5052	✓	✓	✓						
EN AW-5454	✓	✓	✓						
EN AW-5754	✓	✓	✓						✓
EN AW-6060				✓	✓	✓	✓		
EN AW-6061	✓	✓	✓	✓	✓	✓	✓		
EN AW-6063				✓	✓	✓	✓		
EN AW-6005A						✓			
EN AW-6082	✓	✓	✓	✓	✓	✓	✓		✓
EN AW-7020	✓	✓	✓	✓	✓	✓	✓		

Note 1: thicknesses <6mm
Note 2: thicknesses ≥6mm
Note 3: simple profiles only

Table 1.1.2: Cast aluminium alloys for structures

Alloy designation (EN 1706)	Casting type	
	Sand	Permanent mould (chill)
EN AC-42100	✓	✓
EN AC-42200	✓	✓
EN AC-43200	✓	✓
EN AC-44100	✓	✓
EN AC-51300	✓[1)]	✓[1)]

Note 1: simple shapes only

1.1.6 Joining methods

(1) This Part covers the following joining methods:

- Arc welding (metal inert gas and tungsten inert gas)
- Fastening with threaded components
- Riveting
- Adhesive bonding

1.1.7 Environmental conditions

(1)P This Part covers structural applications exposed to normal atmospheric conditions and temperatures not exceeding +100°C (for fatigue purposes), including marine environments, except for adhesively bonded joints where the temperature limits apply to the range -20°C to 60°C. For aluminium alloy 5083 the data apply to maximum temperatures not exceeding 65°C. Fatigue strength data are not applicable to parts of the structure exposed to environments which are aggressively corrosive to the materials concerned.

(2) If these limits are exceeded resort may need to be made to test data and certification of fabrication technology.

1.2 Normative References

(1) This European PreStandard incorporates by dated or undated reference, provisions from other standards. These normative references are cited at the appropriate places in the text.

EN 287-2	Approval testing of welders - Fusion welding - Part 2: Aluminium and its alloys
EN 288-4	Specification and approval of welding procedures for metallic materials - Part 4 Welding procedure tests for the arc welding of aluminium and its alloys.
EN 485	Aluminium and aluminium alloys - Sheet, strip and plate
EN 586	Aluminium and aluminium alloys - Forgings
EN 719	Welding coordination - Tasks and responsibilities
EN 729-2	Quality requirements for welding - Fusion welding of metallic parts - Part 2: Comprehensive quality requirements
EN 754	Aluminium and aluminium alloys - Cold drawn rod/bar and tube
EN 755	Aluminium and aluminium alloys - Extruded rod/bar, tube and profiles
EN 1011-4	Recommendation for arc welding - Part 4: Specific requirements for aluminium and its alloys
EN 1706	Aluminium and aluminium alloys - Castings
EN 30042	Arc welded joints in aluminium and its weldable alloys - Guidance on quality levels for imperfections
ENV 1991-3	Traffic loads on bridges
ENV 1991-5	Actions induced by cranes and machinery

1.3 Distinction Between Principles and Application Rules

(1) Depending on the character of the individual clauses, distinction is made in this Eurocode between Principles and Application Rules.

(2) The Principles comprise:

- general statements and definitions for which there is no alternative, as well as
- requirements and analytical models for which no alternative is permitted unless specifically stated.

(3) The Principles are identified by the letter P following the paragraph number.

(4) The Application Rules are generally recognised rules which follow the Principles and satisfy their requirements.

(5) It is permissible to use alternative design rules different from the Application Rules given in the Eurocode, provided that it is shown that the alternative rule accords with the relevant Principles and is at least equivalent with regard to the resistance, serviceability and durability achieved by the structure.

(6) In this part the Application rules are identified by a number in brackets, as in this paragraph.

1.4 Assumptions

(1)P The following assumptions shall apply:

- Structures are designed by appropriately qualified and experienced personnel.
- Adequate supervision and quality control is provided in factories, in plants and on site.
- Construction is carried out by personnel having the appropriate skill and experience.
- The construction materials and products are used as specified in this Eurocode or in the relevant material or product specifications.
- The structure will be adequately maintained.
- The structure will be used in accordance with the design brief.

(2)P The design procedures are valid only when the quality requirements for execution and workmanship given in Annex D are complied with, except where specific measures are taken to enable alternative quality standards to be validated by fracture mechanics or test.

(3) Numerical values identified by □ are given as indications. Other values may be specified by Member States.

1.5 Definitions

1.5.1 Terms common to all Eurocodes

(1)P Unless otherwise stated in Part 1 of Eurocode 9 the terminology used in International Standard ISO 8930 applies.

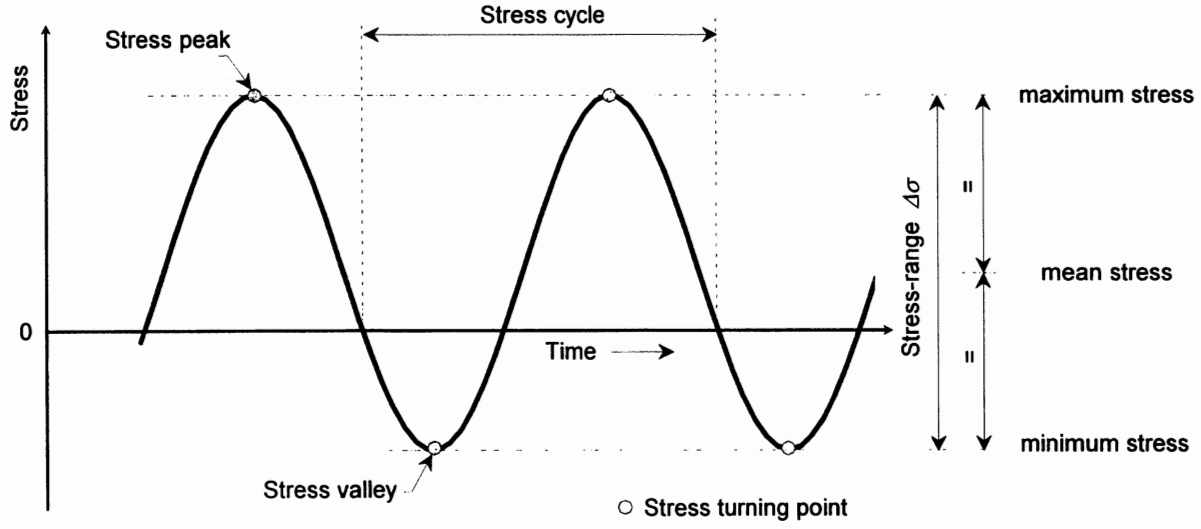
1.5.2 Special terms used in this Part 2 of Eurocode 9

(1)P The following terms are used in Part 2 of Eurocode 9 with the following meanings:

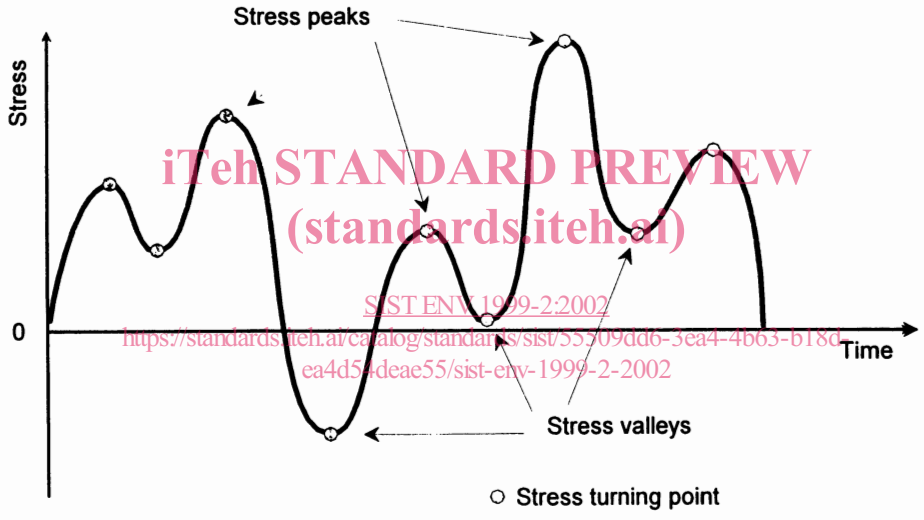
- **Fatigue:** Weakening of a structural part, through gradual crack propagation caused by repeated stress fluctuations.
- **Fatigue loading:** A set of typical load events described by the positions or movements of loads, their variation in intensity and their frequency and sequence of occurrence.
- **Loading event:** A defined loading sequence applied to the structure, which, for design purposes, is assumed to repeat at a given frequency.
- **Nominal stress:** A stress in the parent material adjacent to a potential crack location, calculated in accordance with simple elastic strength of materials theory, i.e. assuming that plane sections remain plane and that all stress concentration effects are ignored.
- **Modified nominal stress:** A nominal stress increased by an appropriate geometrical stress concentration factor K_{gt}, to allow only for geometric changes of cross section which have not been taken into account in the classification of a particular constructional detail.
- **Structural stress (also known as 'geometric stress'):** The elastic stress at a point, taking into account all geometrical discontinuities, but ignoring any local singularities where the transition radius tends to zero, such as notches due to small discontinuities, e.g. weld toes, cracks, cracklike features,

normal machining marks etc. The structural stress is in principle the same stress parameter as the modified nominal stress, but generally evaluated by a different method.

- **Geometrical stress concentration factor K_{gt}:** The ratio between the structural stress evaluated with the assumption of linear elastic behaviour of the material and the nominal stress.
- **Hot spot stress:** The structural stress at a specified initiation site in a particular type of geometry, such as a weld toe in an angle hollow section joint, for which the fatigue strength, expressed in terms of the hot spot stress range, is usually known.
- **Local stress concentration factor of a classified detail K_{cd}:** The ratio between the peak stress evaluated with a particular finite element method (FEM) analysis at the hot spot of a classified detail and the nominal stress.
- **Stress history:** A continuous chronological record, either measured or calculated, of the stress variation at a particular point in a structure, (usually for the duration of a loading event) (see Fig.1.5.1).
- **Stress turning point:** The value of stress in a stress history where the rate of change of stress changes sign (see Fig.1.5.1).



a) Constant amplitude



b) Variable amplitude

Fig.1.5.1 Terminology relating to stress histories and cycles