CICIND

MODEL CODE FOR STEEL CHIMNEYS

THE CICIND CHIMNEY STANDARD

Revision 2 – September 2010

ISBN 1-902998-16-2

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Revision 1 – December 1999

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FOREWORD

When it was formed in 1973, the "Comité International des Cheminées Industrielles" (CICIND) adopted as a major goal the harmonization of national codes for the design of industrial chimneys. As a means to this end, a subcommittee was appointed in 1981, charged with drafting a proposal for a model code for steel chimneys which reflected the current "state-of-the-art" and a consensus of views, internationally. This document was published in 1988, with Commentaries being published the following year.

Since 1988, the science and technology of chimneys has advanced and in 1995, CIC1ND appointed a committee to revise the Model Code, recognizing current best international practice and knowledge.

The 2010 revision of the Model Code refers to the wind loads, both in along-wind and across-wind direction. The revision resulted from the findings, that the surface roughness of the chimney site and its surroundings should be taken into account. Corresponding amendment had been introduced in the revised Model Code.

The committee comprises:

J. Roberts	Great Britain — Chairman until Jan. 1998
B.N. Pritchard	Great Britain — Chairman after Jan. 1998
Max Beaumont	Great Britain
Michael Beaumont	Great Britain
G. Berger	Germany
J. Bouten	The Netherlands
R. Ghermandi	Italy
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Expert advice was received from:

B.J. Vickery (Canada)
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The 2010 revision was initiated and directed by:

H. van Koten	The Netherlands
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0. INTRODUCTION

0.1 General

Chimneys are required to carry vertically and discharge to the atmosphere, gaseous products of combustion, chemical waste gases, or exhaust air or for the combustion (flaring off) of industrial waste gases.

This Model Code contains guide-lines which reflect the current state of art in the design and construction of steel chimneys. Nevertheless, the design, fabrication and erection of steel chimneys require a thorough knowledge of these structures, the properties of the materials used, the actions occurring upon the structure and the recognized rules of the relevant technologies. The design of steel chimneys should therefore only be entrusted to appropriately qualified and experienced engineers. The construction and erection should be carried out by firms competent in this class of work. At all times the work should be under the direction of appropriately qualified supervisors.

CIC1ND will continue to try to improve the understanding of the behavior of chimneys. Further revisions of this Model Code will therefore be published from time to time.

0.2 Appendices and Commentaries

This Model Code is accompanied by extensive appendices and commentaries. The appendices provide information which the committee believes will be of use to a steel chimney designer, even though its inclusion in a chimney design code could not be justified. The commentaries have the following objectives:

a) Justification of the regulations of the Model Code.

b) Simplification of the use of the Model Code.

c) Understanding of the meaning of the regulations of the Model Code.

d) Documentation of the areas in the Model Code where the present knowledge is sparse so that the regulations are possibly or probably not optimal.

The following items are **not** objectives of the CICIND commentaries:

e) Change of the meaning of certain regulations of the Model Code where these are falsely expressed or obviously wrong.

f) Definition of the meaning of certain regulations of the Model Code which are so badly formulated that they could easily be misinterpreted even by experts.

Certain information from the Model Code is repeated in the commentaries when this simplifies the presentation of the ideas.

0.3 Philosophy

One of the main objectives of any code governing construction is the creation of a model which resembles as far as possible, the real situation. The model should be sufficiently “safe, simple and true”. It is very rarely that simplicity and truth are compatible, so a model must be used which provides an optimum compromise between truth, simplicity, safety and economy.

While the judgments of ‘sufficiently true’ and ‘sufficiently simple’ are subjective, ‘sufficiently safe’ is capable of rational judgment. This code interprets ‘sufficiently safe’ in terms of the social and economic consequences of failure. It does this by comparing the probabilities of failure for given safety factors during its design life with the failure probabilities required to satisfy accepted social and economic criteria. This leads to the development of safety factors which ensure that a chimney will have a probability of failure during its design lifetime between 10^{-3} and 10^{-4}, depending upon its reliability category.

CICIND has departed from generally accepted principles of steelwork design and construction only when this was required by the philosophy outlined above or by specific chimney requirements.

1. SCOPE

This Model Code relates to the structural design and construction of steel chimneys of circular cross-section, with a minimum height of 15m, with or without linings, and to the design and application of linings to such chimneys where required. It also relates to chimneys with a height less than 15m and a slenderness ratio more than 16. The Model Code does not deal with architectural or thermal aspects of steel chimneys nor with their foundations, except insofar as they affect the chimney’s structural design. The Model Code does not deal with those aspects of the design and construction of steelwork, refractories and insulation which are not peculiar to chimneys.

2. FIELD OF APPLICATION

The Model Code is valid for all steel chimneys of circular cross- section. However, the design rules have been formulated for self supporting chimneys taller than 15m. For other chimneys simplification may be acceptable. Additional information is given in the Appendices and Commentaries.

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4. NOTATIONS, UNITS AND DEFINITIONS

4.1 General

The following list shows only the principles by which the notations and their meanings are related. The actual notations are mostly explained in the text.

Local factors

γ load factor

Material properties

f yield strength (MPa)

E modulus of elasticity (GPa)

σ stress (MPa)

Loadings

T temperature in centigrade

V wind-speed (m/s)

w wind-force (N/m)

Cross-sectional forces

M bending moment (Nm)
e eccentricity (m)

Dimensions

h height (m)

z height above ground level (m)

d diameter (m)

t wall thickness (m)

4.2 Subscripts-Superscripts

y yield limit

k characteristic value

* stress multiplied by load factor

cr critical

4.3 Units

Generally, the units of the SI system are used.

Examples:

- m (meter) and mm (millimeter) for dimensions
- MN (Mega Newton) and N (Newton) for forces
- MPa for stresses

In those cases where other units are used, the relevant references are given.

4.4 Definitions

The common names of parts of a steel chimney are explained in commentary 1.

5. BASIS OF DESIGN AND SAFETY FACTORS

5.1 General

The design of sections subject to permanent load and wind loads in the wind direction is based upon ultimate limit state conditions, the safety of the chimney being ensured by partial safety factors for loads and material. The ultimate limit state considered is reached when any part of the section is at the limit stress. The limit stress is defined as either yield stress or critical buckling stress (whichever is least), divided by the material safety factor. The calculation of the stress distribution and the strength of the sections shall therefore be made in accordance with the theory of elasticity.

The use of this procedure, combined with the partial safety factors listed below will ensure that low cycle fatigue will not contribute to failure of the chimney. In the design of details such as flanges, ultimate limit state may take account of plastic stress distribution

Safety in the case of response to vortex shedding is ensured by the use in the fatigue calculations of a suitable Miner Number, a material factor and a modeling factor.

5.2 Reliability differentiation

Different levels of reliability shall be adopted for chimneys, depending on the possible economic and social consequences of their failure.

Two classes of reliability related to the consequences of structural failure are used — Normal and Critical, as defined below. The choice of reliability category shall be decided by the chimney owner and relevant statutory authorities. Most chimneys will, however, be regarded as of Normal reliability.

Critical chimneys: Chimneys erected in strategic locations, such as nuclear power plants or in densely populated urban locations. Major chimneys in industrial sites where the economic and/or social consequences of their failure would be very high.

Normal Chimneys: All normal chimneys at industrial sites or other locations. (Typically chimneys in industrial sites, power plants or chimneys less than 100m tall in urban locations, where any domestic dwelling is outside the falling radius of the chimney).

5.3 Partial Safety Factors

Material safety factor for steel	1.1
Load factors for:	
Normal Chimneys	
Permanent load	1.1
Guy rope pretension	1.2
Wind load in wind direction (temperate zones)	1.4
Wind load in wind direction (tropical storm zones)*	1.5
Critical Chimneys	
Permanent load	1.1
Guy rope pretension	1.2
Wind load in wind direction (temperate zone)	1.5
Wind load in wind direction (tropical storm zones)*	1.6

* See literature (e.g. ref.(3)).

5.4 Cross-wind Effects

Chimneys shall be designed to avoid movements across the wind direction sufficient to cause failure or fatigue damage or to alarm bystanders.

The code contains means of estimating the amplitude of movement and consequent stress range due to crosswind loading. Limiting stress ranges are given for various weld classifications and design lives. In addition to a material safety factor 1.1, applied to fatigue category, a modeling factor of 1.4 shall be applied to the Miner Number derived in fatigue calculations for temperatures up to 200°C and 1.5 for temperatures between 200°C and 400°C.

To avoid alarming personnel, the maximum permitted amplitude of oscillations due to cross-wind effects or aerodynamic interference shall be agreed between the owner and designer. This limit will be governed by the prominence and visibility of the chimney and the anticipated frequency of recurrence of excessive movements. Guidance is given in Commentary 3.

6. MATERIALS

6.1 General

The materials generally used for steel chimneys are described in the

CICIND METALLIC MATERIALS MANUAL.

Table 6.1 shown below is a copy of Table 8.1 of this manual.
Special steels can be used provided they are precisely specified and their characteristics, such as yield stress, tensile strength, ductility and weldability, enable the Model Code to be put into application.

6.2 Structural Steels

The mechanical properties and the chemical composition of structural steels shall comply with local national standards.

The limit stresses of steel are equal to the yield stress of the steel used, divided by the material factor 1.1: