# SLOVENSKI STANDARD
# oSIST prEN ISO 80000-11:2017

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**Veličine in enote - 11. del: Značilna števila (ISO/DIS 80000-11:2017)**

Quantities and units - Part 11: Characteristic numbers (ISO/DIS 80000-11:2017)

Größen und Einheiten - Teil 11: Kenngrößen der Dimension Zahl (ISO/DIS 80000-11:2017)



Grandeurs et unités - Partie 11: Nombres caractéristiques (ISO/DIS 80000-11:2017)



**Ta slovenski standard je istoveten z:** **prEN ISO 80000-11**

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|---|---|---|
| 01.060 | Veličine in enote | Quantities and units |

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DRAFT INTERNATIONAL STANDARD

# ISO/DIS 80000-11

ISO/TC **12**

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# Quantities and units —

## Part 11:
## Characteristic numbers

*Grandeurs et unités —*

*Partie 11: Nombres caractéristiques*

ICS: 01.060



This document is circulated as received from the committee secretariat.

This draft is submitted to a parallel vote in ISO and in IEC.

**ISO/CEN PARALLEL PROCESSING**



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# Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.



The committee responsible for this document is ISO/TC 12, *Quantities and units*.



This second edition cancels and replaces the first edition (ISO 80000-11:2008).

ISO 80000 consists of the following parts, under the general title *Quantities and units*:

— *Part 1: General*

— *Part 2: Mathematics*

— *Part 3: Space and time*

— *Part 4: Mechanics*

— *Part 5: Thermodynamics*

— *Part 7: Light and Radiation*

— *Part 8: Acoustics*

— *Part 9: Physical chemistry and molecular physics*

— *Part 10: Atomic and nuclear physics*

— *Part 11: Characteristic numbers*

 

— *Part 12: Condensed matter physics*

IEC 80000 consists of the following parts (in collaboration with IEC/TC 25), under the general title *Quantities and units*:

— *Part 6: Electromagnetism*

— *Part 13: Information science and technology*

— *Part 14: Telebiometrics related to human physiology*

# Quantities and units — Part 11: Characteristic numbers

## 1 Scope

ISO 80000-11 gives the names, symbols and definitions for characteristic numbers used in the description of transport and transfer phenomena.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 80000-3:2006, *Quantities and units — Part 3: Space and time*

ISO 80000-4:2006, *Quantities and units — Part 4: Mechanics*

ISO 80000-5:2007, *Quantities and units — Part 5: Thermodynamics*

IEC 80000-6:2008, *Quantities and units — Part 6: Electromagnetism*

ISO 80000-8:2007, *Quantities and units — Part 8: Acoustics*

ISO 80000-9:2009, *Quantities and units — Part 9: Physical chemistry and molecular physics*

ISO 80000-9:2009, *Quantities and units — Part 12: Condensed matter physics*



## 3 Names, symbols, and definitions



The names, symbols, and definitions for characteristic numbers are given on the following pages.

Characteristic numbers are physical quantities of dimension number 1, although commonly and falsely called dimensionless quantities. They are used in the studies of natural and technical processes, and [may] present information about the behaviour of the process, or reveal similarities between different processes.

Characteristic numbers often are described as ratios of forces; in some cases however they are ratios of energy or work, although noted as forces in the literature; sometimes it is the ratio of characteristic times.

Characteristic numbers may be defined by the same equation, but carry different names if they are concerned with different kinds of processes.

Characteristic numbers may be expressed as products or fractions of other characteristic numbers if these are valid for the same kind of process. So the following tables are arranged according to some groups of processes.

As the amount of characteristic numbers is tremendous, and their use in technology and science is not uniform, only a small amount of them is given here. The choice largely was depending of their common use. Besides there was made a restriction on the kind of processes, which are displayed by the section headings. Nevertheless several characteristic numbers are found in different representations of the same physical information, e.g. multiplied by a numerical factor, as the square, the square root, or the inverse of other representation. Only one of these have been chosen, the other ones declared as deprecated or mentioned in the remarks column.

## 4 Momentum transfer



The transfer of momentum (ISO 80000-4:2006, item 4-8) basically occurs during a collision of 2 bodies, and is governed by the law of momentum conservation. Energy dissipation may occur. In a more generalized meaning momentum transfer occurs during the interaction of 2 subsystems moving with velocity $v$ relative to each other. Typically one of the subsystems is solid and possibly rigid, with a characteristic length, which may be a length, width, radi us, etc. of a solid object, often the effective length is given by the ratio of a body's volume to the area of its surface.



The other subsystem is a fluid, in general liquid or gaseous, with the following properties amongst others:

- mass density $\rho$ (ISO 80000-4:2006, item 4-2);
- dynamic viscosity $\eta$ (ISO 80000-4:2006, item 4-23);
- kinematic viscosity $\nu = \eta/\rho$ (ISO 80000-4:2006, item 4-24), or
- pressure drop $\Delta p$ (ISO 80000-4:2006, item 4-15.1).

The field of science is mainly fluid dynamics (mechanics). Characteristic numbers of this kind allow the comparison of objects of different sizes. It also may give some estimation about the change of laminar flow to turbulent flow.

| No. | Name | Symbol | Definition | Remarks |
|---|---|---|---|---|
| 11-4.1 (11-4.1) | Reynolds number | $Re$ | ratio of inertial forces to viscous forces in a fluid flow<br>$Re = \frac{\rho\, v\, l}{\eta} = \frac{v\, l}{\nu}$; where<br>$\rho$ is mass density (ISO 80000-4:2006, item 4-2),<br>$v$ is speed (ISO 80000-3:2006, item 3-8.1),<br>$l$ is a characteristic length (ISO 80000-3:2006, item 3-1.1),<br>$\eta$ is dynamic viscosity (ISO 80000-4:2006, item 4-23), and<br>$\nu$ is kinematic viscosity (ISO 80000-4:2006, item 4-24) | The value of the Reynolds number gives an estimate on the flow state: laminar flow or turbulent flow.<br>In rotating movement the speed $v$ is $l$, where $l$ is the distance from the rotation axis and $\omega$ *is* the angular velocity. |
| 11-4.2 (11-4.2) | Euler number | $Eu$ | relationship between pressure drop in a flow to kinetic energy per volume for flow of fluids in a pipe<br>$Eu = \frac{\Delta p}{\rho\, v^2}$; where | The Euler number is used to characterize losses in the flow.<br>A modification of the Euler number is considering the |

| No. | Name | Symbol | Definition | Remarks |
|---|---|---|---|---|
| | | | $\Delta p$ is drop of pressure (ISO 80000-4:2006, item 4-15.1),<br>$\rho$ is mass density (ISO 80000-4:2006, item 4-2), and<br>$v$ is speed (ISO 80000-3:2006, item 3-8.1) | dimensions of the containment (pipe):<br>$Eu' = \frac{\Delta p}{l}\frac{d}{\rho v^2} = \frac{d}{l}Eu$; where<br>$l$ is length (ISO 80000-3:2006, item 3-1.1),and<br>$d$ is inner diameter (ISO 80000-3:2006, item 3-1.7) of the pipe. |
| 11-4.3 (11-4.3) | Froude number | $Fr$ | ratio of a body's inertial forces to its gravitational forces for flow of fluids<br>$Fr = \frac{v}{\sqrt{l\,g}}$; where<br>$v$ is speed (ISO 80000-3:2006, item 3-8.1) of flow,<br>$l$ is a characteristic length (ISO 80000-3:2006, item 3-1.1), and<br>$g$ is acceleration of free fall (ISO 80000-3:2006, item 3-9.2) | The Froude number may be modified by buoyancy.<br>Sometimes the square and sometimes the inverse of the Froude number as defined here is called the Froude number.<br>The definition given here reflects that of the existing standard. However In the majority of references the squared value is used. |
| 11-4.4 (11-4.4) | Grashof number | $Gr$ | ratio of buoyancy forces due to thermal expansion which results in a change of mass density to viscous forces for free convection due to temperature differences<br>$Gr = l^3 g\,\alpha_V\,\Delta T/v^2$; where<br>$l$ is a characteristic length (ISO 80000-3:2006, item 3-1.1),<br>$g$ is acceleration of free fall (ISO 80000-3:2006, item 3-9.2),<br>$\alpha_V$ is thermal cubic expansion coefficient (ISO 80000-5:2007, item 5-3.2),<br>$\Delta T$ is difference of thermodynamic temperature $T$ (ISO 80000-5:2007, item 5-1) between surface of the body and the fluid far away from the body, and<br>$v$ is kinematic viscosity (ISO 80000-4:2006, item 4-24) | Heating can occur near hot vertical walls, in pipes, or by a bluff body.<br>The characteristic length can be the vertical height of a hot plate, the diameter of a pipe, or the effective length of a body.<br>See also Rayleigh number (item 11-5.3). |
| 11-4.5 (11-4.5) | Weber number | $We$ | relationship of inertial forces compared to capillary forces for bubbles or drops in a fluid<br>$We = \rho\,v^2 l/\gamma$; where<br>$\rho$ is mass density (ISO 80000-4:2006, item 4-2),<br>$v$ is speed (ISO 80000-3:2006, item 3-8.1), | The characteristic length is commonly the diameter of bubbles or drops.<br>The square root of the Weber number is called Rayleigh number. |

| No. | Name | Symbol | Definition | Remarks |
|---|---|---|---|---|
| | | | $l$ is a characteristic length (ISO 80000-3:2006, item 3-1.1), and<br>$\gamma$ is surface tension (ISO 80000-4:2006, item 4-25) | Sometimes the square root of the Weber number as defined here is called the Weber number. That definition is deprecated. |
| 11-4.6<br>(11-4.6) | Mach number | $Ma$ | ratio of the speed of flow to the speed of sound<br>$Ma = v/c$; where<br>$v$ is speed (ISO 80000-3:2006, item 3-8.1) of the body and<br>$c$ is speed of sound (ISO 80000-8:2007, item 8-14.1) of the fluid | The Mach number represents the relationship of inertial forces compared to compression forces.<br>For an ideal gas<br>$c = \sqrt{\gamma \frac{p}{\rho}} = \sqrt{\gamma \frac{RT}{M}} = \sqrt{\gamma \frac{kT}{m}}$; where $\gamma$ is ratio of the specific heat capacities (ISO 80000-5:2007, item 5-17.1). |
| 11-4.7<br>(11-4.7) | Knudsen number | $Kn$ | ratio of mean free path of a particle to characteristic length for gas flow<br>$Kn = \lambda/l$; where<br>$\lambda$ is mean free path (ISO 80000-9:2009, item 9-44), and<br>$l$ is length (ISO 80000-3:2006, item 3-1.1) | The Knudsen number is a measure to estimate whether the gas in flow behaves like a continuum.<br>The length $l$ can be a characteristic size of the gas flow region like a pipe diameter. |
| 11-4.8<br>(11-4.8) | Strouhal number<br>(Thomson number) | $Sr, Sh$ | ratio of characteristic frequency to characteristic speed for unsteady flow with periodic behaviour<br>$Sr = f\,l/v$; where<br>$f$ is frequency (ISO 80000-3:2006, item 3-15.1) of vortex shedding,<br>$l$ is a characteristic length (ISO 80000-3:2006, item 3-1.1), and<br>$v$ is speed (ISO 80000-3:2006, item 3-8.1) of flow | The characteristic length $l$ can be the diameter of an obstacle in the flow which can cause vortex shedding, or the length of it. |
| 11-4.9<br>- | drag coefficient | $c_D$ | ratio of the effective drag force to inertial forces for a body moving in a fluid<br>$c_D = \frac{2F_D}{\rho v^2 A}$; where:<br>$F_D$ is drag force (ISO 80000-4:2006, item 4-9.1) on the body,<br>$\rho$ is mass density (ISO 80000-4:2006, item 4-2) of the fluid,<br>$v$ is speed (ISO 80000-3:2006, item 3-8.1) of the body, and<br>$A$ is the cross sectional area (ISO 80000-3:2006, item 3-3) | The drag coefficient is strongly dependant on the shape of the body. |
| 11-4.10 | Bagnold | $Bg$ | ratio of drag force to gravitational force for a body moving in a fluid | The characteristic length $l$ is the body's volume divided by |

| No. | Name | Symbol | Definition | Remarks |
|---|---|---|---|---|
| - | number | | $Bg = \frac{c_\mathrm{d}\rho v^2}{lg\rho_\mathrm{b}}$<br>$c_\mathrm{d}$ is drag coefficient (item 11-4.9) on the body,<br>$\rho$ is mass density (ISO 80000-4:2006, item 4-2), of fluid,<br>$v$ is speed (ISO 80000-3:2006, item 3-8.1) of the body,<br>$\rho_\mathrm{b}$ is mass density (ISO 80000-4:2006, item 4-2), of the body,<br>$g$ is acceleration of free fall (ISO 80000-3:2006, item 3-9.2), and<br>$l$ is a characteristic length (ISO 80000-3:2006, item 3-1.1) | its cross sectional area. |
| 11-4.11<br>- | Bagnold number <for solid particles> | $Ba_2$ | ratio of drag force to viscous force in a fluid transporting solid particles<br>$Ba_2 = \frac{\rho_\mathrm{s} d^2\dot{\gamma}}{\eta}\sqrt{1/\left(f_\mathrm{s}^{1/2} - 1\right)}$; where<br>$\rho_\mathrm{s}$ is mass density (ISO 80000-4:2006, item 4-2) of particles,<br>$d$ is diameter (ISO 80000-3:2006, item 3-1.7) of particles,<br>$\dot{\gamma} = v/d$ is shear rate, time derivative of shear strain (ISO 80000-4:2006, item 4-16.2),<br>$\eta$ is dynamic viscosity (ISO 80000-4:2006, item 4-23) of fluid, and<br>$f_\mathrm{s}$ is volumic fraction of solid particles | |
| 11-4.12<br>- | lift coefficient | $c_\mathrm{l}$, $c_\mathrm{A}$ | ratio of the lift force available from a wing at a given angle of attack to the inertial force for a wing shaped body moving in a fluid<br>$c_l = \frac{2F_l}{\rho v^2 S} = \frac{F_l}{qS}$; where<br>$F_l$ is lift force (ISO 80000-4:2006, item 4-9.1) on the wing,<br>$\rho$ is mass density (ISO 80000-4:2006, item 4-2) of the fluid,<br>$v$ is speed (ISO 80000-3:2006, item 3-8.1) of the body,<br>$q = \rho v^2/2$ is dynamic pressure, and<br>$S = A\cos\alpha$ is effective area (ISO 80000-3:2006, item 3-3) when $\alpha$ is the angle of attack and A is area of the wing | The lift coefficient is dependent on the shape of the wing. |
| 11-4.13<br>- | thrust coefficient | $c_\mathrm{t}$ | ratio of the effective thrust force available from a propeller to the inertial force in a fluid<br>$c_\mathrm{t} = F_\mathrm{T}/(\rho n^2 d^4)$; where<br>$F_\mathrm{T}$ is thrust force (ISO 80000-4:2006, item 4-9.1) of the propeller; | The thrust coefficient is dependent on the shape of the propeller. |