

Railway applications — Aerodynamics —

Part 2: Aerodynamics on open track

The European Standard EN 14067-2:2003 has the status of a
British Standard

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National foreword

This British Standard is the official English language version of EN 14067-2:2003.

The UK participation in its preparation was entrusted by Technical Committee RAE/1, Railway applications, to Subcommittee RAE/1/-/4, Aerodynamics, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

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This European Standard was approved by CEN on 2 January 2003.

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Foreword

This document EN 14067-2:2003 has been prepared by Technical Committee CEN /TC 256, "Railway applications", the secretariat of which is held by DIN.

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of an identical text or by endorsement, at the latest by October 2003, and conflicting national standards shall be withdrawn at the latest by October 2003.

This European Standard is part of the series "Railway applications — Aerodynamics" which consists of the following parts:

- Part 1: Symbols and units
- Part 2: Aerodynamics on open track
- Part 3: Aerodynamics in tunnels
- Part 4: Requirements and test procedures for aerodynamics on open track¹⁾
- Part 5: Requirements and test procedures for aerodynamics in tunnels¹⁾

This document includes a Bibliography.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard : Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard describes physical phenomena of railway-specific aerodynamics and gives recommendations for the documentation of tests.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 12663:2000, *Railway applications — Structural requirements of railway vehicle bodies*.

1) in preparation

3 Aerodynamic resistance

3.1 General

Locomotive manufacturers need to know the resistance to motion of trains to install the optimum power in their locomotives. Railway companies need it to calculate their time schedules and their energy needs, as well as to determine the type and/or number of locomotives that are necessary for a particular train consist, and to assist in equipment purchase decisions.

Although the drag of trains is normally the main component of their resistance to motion, it is difficult to dissociate from the other components, so that in this part non-aerodynamic terms will have to be considered too.

The resistance to motion is expressed in a standard formula which is applicable to all types of trains. Moreover, the methods of measurement used to obtain the resistance to motion of a train leading to a corresponding formula are defined and explained in prEN (WI 00256127).

3.2 Resistance to motion formula

For straight and level track, zero wind conditions, in open air and at constant speed, the running resistance is:

$$R = C_1 + C_2 v_{tr} + C_3 v_{tr}^2 \quad (1)$$

where C_1 , C_2 , C_3 are constants for a particular train, and the last two terms are the aerodynamic components. Although this formula only takes into account the first three terms of a mathematical series with which the total resistance should be represented, experience has shown that the higher terms may be neglected, while sound physical explanations can be given for these remaining terms.

C_1 is the rolling mechanical resistance. It is a linear function of the mass of the train.

$C_2 v_{tr}$ represents mainly the air momentum losses due to cooling air for the locomotives and the air conditioning of the trailer cars. $C_2 = Q_p$ where Q is the total air volume flow for forced ventilation.

The third term embodies train external pressure drag and skin friction drag.

$$C_3 = C_x S_{tr} \frac{\rho}{2} \quad (2)$$

C_x is divided into three terms:

$$C_x = C_{x1} + C_{x2} + C_{x3} \quad (3)$$

where C_{x1} is the drag coefficient of the leading vehicle, C_{x3} is the drag coefficient of the tail vehicle, and C_{x2} is the coefficient of the train drag without the leading and tail vehicle drag and depends on train length.

Ambient wind can substantially alter aerodynamic drag (see prEN (WI 00256127)). The influence of tunnels is dealt with in EN 14067-3 and prEN (WI 00256128).

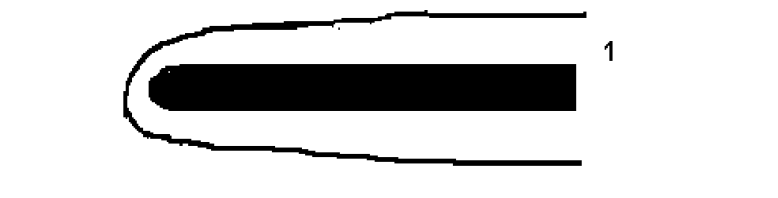
4 Aerodynamic effects of a train on persons and installations near the track

4.1 General

A moving train causes an unsteady flow field with varying pressures and flow velocities. These pressure and flow velocity transients have effects on persons, objects and buildings at the track side.

4.2 Flow field

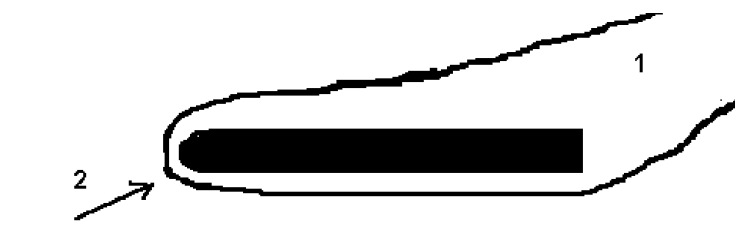
The extent of disturbed air alongside a train moving in the open-air depends on the wind conditions as shown in Figure 1 and Figure 2.



Key

1 Disturbed field

Figure 1 — Field disturbed by train in still air



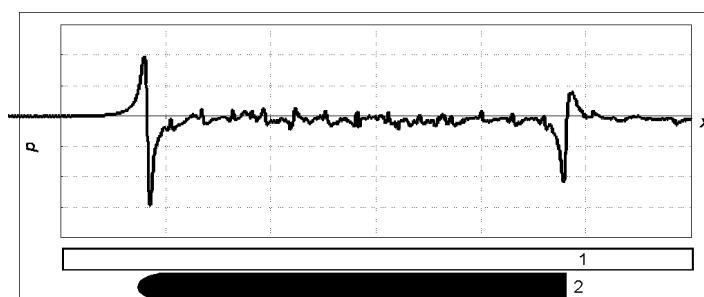
Key

1 Disturbed field
2 Ambient wind

Figure 2 — Field disturbed by train in cross-wind

4.3 Pressure changes on a wall

The pressure field on a wall parallel to the moving train in the open air is shown in Figure 3.



Key

1 Wall
2 Train

Figure 3 — Instantaneous pressure distribution on a vertical wall caused by train passing

The pressure field sweeps along with the train, and therefore at a stationary point at the side of the track, the pressure p will change with time as the train passes by in a similar way to the variation with position along the length of the train.