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Järnvägar – Aerodynamik –
Del 5: Krav och provningsmetoder för aerodynamik i tunnlar

Railway applications – Aerodynamics –
Part 5: Requirements and test procedures for aerodynamics in tunnels

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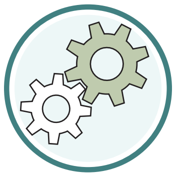

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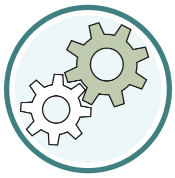

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Europastandarden EN 14067-5:2006+A1:2010 gäller som svensk standard. Detta dokument innehåller den officiella engelska versionen av EN 14067-5:2006+A1:2010.

Denna standard ersätter SS-EN 14067-5:2006, utgåva 1.

The European Standard EN 14067-5:2006+A1:2010 has the status of a Swedish Standard. This document contains the official version of EN 14067-5:2006+A1:2010.

This standard supersedes the Swedish Standard SS-EN 14067-5:2006, edition 1.

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Denna standard är framtagen av kommittén för Järnvägar, SIS/TK 254.

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 14067-5:2006+A1

November 2010

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English Version

Railway applications - Aerodynamics - Part 5: Requirements and test procedures for aerodynamics in tunnels

Applications ferroviaires - Aérodynamique - Partie 5: Exigences et procédures d'essai pour l'aérodynamique en tunnel

Bahnanwendungen - Aerodynamik - Teil 5: Anforderungen und Prüfverfahren für Aerodynamik im Tunnel

This European Standard was approved by CEN on 30 June 2006 and includes Amendment 1 approved by CEN on 28 September 2010.

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Foreword

This document (EN 14067-5:2006+A1:2010) 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of an identical text or by endorsement, at the latest by May 2011, and conflicting national standards shall be withdrawn at the latest by May 2011.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document includes Amendment 1, approved by CEN on 2010-09-28.

This document supersedes EN 14067-5:2006.

The start and finish of text introduced or altered by amendment is indicated in the text by tags [A1⟩ ⟨A1].

[A1⟩ This document has been prepared under a mandate given to CEN/CENELEC/ETSI by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive 2008/57/EC.

For relationship with EU Directive 2008/57/EC, see informative Annex ZA, which is an integral part of this document. ⟨A1]

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 track*

— *Part 5: Requirements and test procedures for aerodynamics in tunnels*

— *Part 6: Cross wind effects on railway operation*

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1 Scope

This European Standard applies to the aerodynamic loading caused by trains running in a tunnel.

2 Normative references

The following referenced document is indispensable for the application 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.

EN 14067-1:2003, *Railway applications — Aerodynamics — Part 1: Symbols and units*

3 Terms, definitions, symbols and abbreviations

For the purposes of this document, the terms, definitions, symbols and abbreviations given in EN 14067-1:2003 and the following apply.

NOTE Additional definitions, symbols and abbreviations are explained in the text.

3.1
tunnel
closed structure enveloping track(s) with a length of more than 20 m

4 Methodologies for quantifying the pressure changes in order to meet the medical health criterion

4.1 General

The relevant pressure changes caused by trains running in a tunnel may be measured at full-scale, estimated from approximating equations (see Annex A), predicted using validated numerical methods or measured using moving model tests. The determination of the pressure variations in order to meet the medical safety pressure limits may be undertaken in the same way.

Full-scale test data may be the basis for train and tunnel acceptance and homologation.

Each single train/tunnel combination is described by a train-tunnel-pressure signature.

4.2 Train-tunnel-pressure signature

4.2.1 General

The static pressure in the tunnel as shown in Figure 1 develops as follows when a train enters the tunnel:

— there is a sharp first increase in pressure Δp_{N} caused by the entry of the nose of the train into the tunnel;

— there is a second increase in pressure Δp_{fr} due to friction effects caused by the entry of the main part of the train into the tunnel;

— there is then a drop in pressure Δp_{T} caused by the entry of the tail of the train in the tunnel;

— there is a sharp drop in pressure Δp_{HP} caused by the passing of the train head at the measurement position in the tunnel.

Real measurements of pressure may differ from the idealised signature shown in Figure 1, for instance if the train cross sectional area varies along the train. In such a case special consideration shall be given to determining the individual Δp values.

All Δp values are to be considered as absolute values.

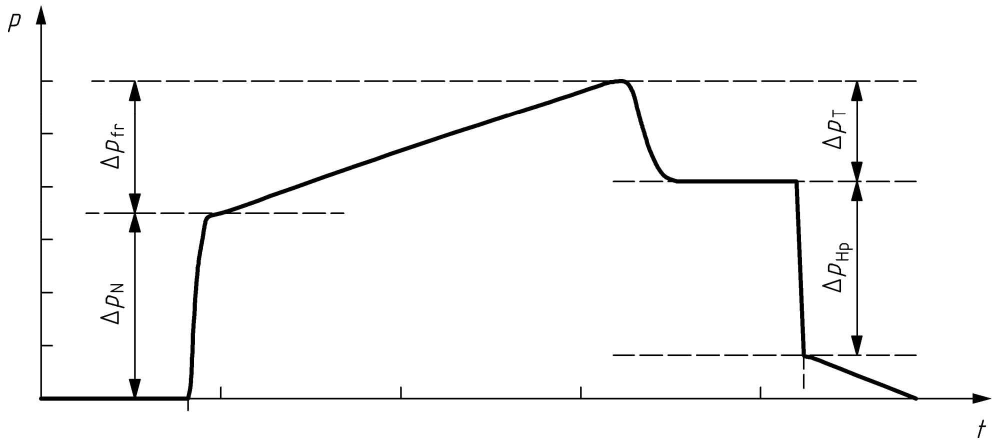

Figure 1 — Train-tunnel-pressure signature at a fixed position in a tunnel (detail)

The following methods are suitable for characterising the aerodynamic quality of a train in a tunnel.

The train-tunnel-pressure signature can be derived from calculations or measurements at a fixed position in a tunnel, i.e. the four pressure changes Δp_N, Δp_{fr}, Δp_T and Δp_{HP} at a given point in the tunnel (see 4.2.2).

4.2.2 Full scale measurement of Δp_N, Δp_{fr}, Δp_T and Δp_{HP} at a fixed location in the tunnel

The tunnel should have constant cross section, no airshafts and no residual pressures waves. Ideally there should be no initial air flow in the tunnel. However, if there is, its influence on the measurements should be checked.

Pressures are measured using transducers in the tunnel. These should be calibrated prior to use over the expected pressure range, typically ± 4 kPa. The measurement error should be less than 1 %.

The speed of the train shall be known within an accuracy of 1 % and should be constant during the entry into the tunnel within 1 %.

Data should be sampled at a rate of at least 5 v_{tr}/L_N Hz, with anti-aliasing filters with a cut-off frequency of one quarter of the sampling rate.

In order to obtain precise values of Δp_N, Δp_{fr}, Δp_T and Δp_{HP} for a fully developed wave pattern, it is necessary to ensure the following conditions when the train speed v_{tr} and the length of the train L_{tr} are given:

— the distance x_p between the entrance portal and the measuring position is

$$x_p = \frac{cL_{tr}}{c - v_{tr}} + \Delta x_1 \qquad (1)$$

where the additional distance Δx_1 ensures a good temporal separation of the individual pressure variations and ideally should be about 100 m. The measuring system should be installed at x_p to avoid wave damping effects;

— the minimum tunnel length is

$$L_{\text{tu,min}} = x_{\text{p}} + \frac{cL_{\text{tr}}}{2v_{\text{tr}}} + \Delta L_1 \qquad \text{if } \Delta p_{\text{HP}} \text{ is not needed} \qquad (2)$$

$$L_{\text{tu,min}} = \frac{x_{\text{p}}}{2}\left(1 + \frac{c}{v_{\text{tr}}}\right) + \Delta L_1 \qquad \text{if } \Delta p_{\text{HP}} \text{ is needed} \qquad (3)$$

where the additional length ΔL_1 ensures a good temporal separation of the individual pressure variations and ideally should be about 150 m.

4.2.3 Full scale measurements of $\Delta p_{\text{N,o}}$, $\Delta p_{\text{fr,o}}$ and $\Delta p_{\text{T,o}}$ on the exterior of the train

If it is not possible to carry out measurements at fixed locations in a tunnel, Δp_{N}, Δp_{tr} and Δp_{T} can be approximated by measurements of $\Delta p_{\text{N,o}}$, $\Delta p_{\text{fr,o}}$ and $\Delta p_{\text{T,o}}$ on the exterior of the train. If needed, Δp_{HP} can be derived either from predictive formulae or assumed to be equal to $\Delta p_{\text{N,o}}$.

The tunnel shall have constant cross section, no airshafts and no residual pressures waves. Ideally there should be no initial air flow in the tunnel. However, if there is, its influence on the measurements should be checked.

Pressures are measured using transducers on the exterior of the train. These should be calibrated prior to use over the expected pressure range, typically ± 4 kPa. The measurement error should be less than 1 %.

The speed of the train shall be known within an accuracy of 1 % and should be constant during the entry into the tunnel within 1 %.

Data should be sampled at a rate of at least 5 $v_{\text{tr}}/L_{\text{N}}$ Hz, with anti-aliasing filters with a cut-off frequency of one quarter of the sampling rate.

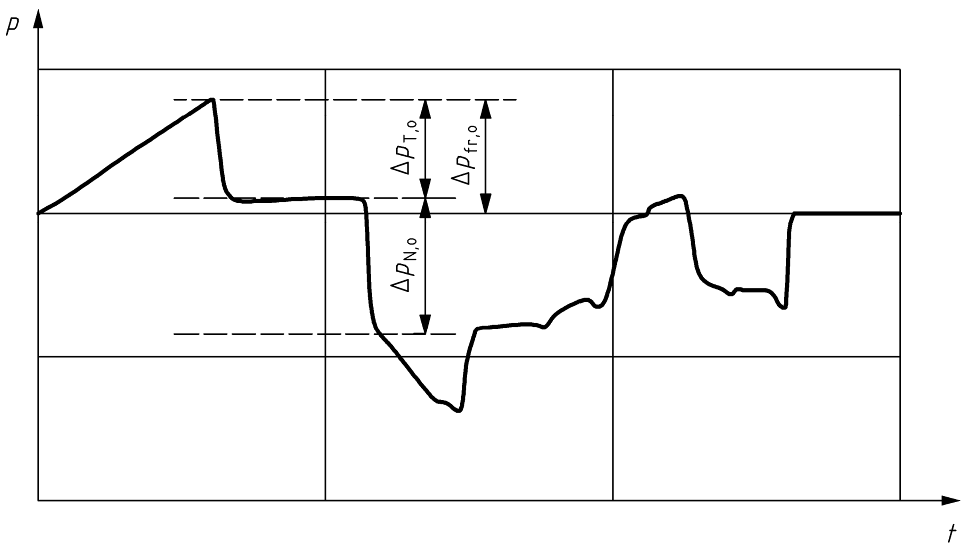

Figure 2 — Train-tunnel-pressure signature at an exterior position just behind the nose of the train

To get the whole friction pressure rise Δp_{fr} it is necessary to measure the pressures on the outside of the train just behind the nose at a position where the full cross section is reached.

The minimum tunnel length $L_{\text{tu,min}}$ is