DIN EN 14067-5:2023-03 (E)

Railway applications - Aerodynamics - Part 5: Requirements and assessment procedures for aerodynamics in tunnels (includes Corrigendum :2023)

Contents

Page

European foreword 5

1 Scope 6

2 Normative references 6

3 Terms and definitions 6

4 Symbols and abbreviations 8

5 Requirements on locomotives and passenger rolling stock 14
5.1 Limitation of pressure variations inside tunnels 14
5.1.1 General 14
5.1.2 Requirements 14
5.1.3 Full conformity assessment 16
5.1.4 Simplified conformity assessment 16
5.2 Limitation of pressure gradient entering a tunnel (relative to micro-pressure wave generation) 18
5.2.1 General 18
5.2.2 Requirements 18
5.2.3 Simplified conformity assessment 20
5.3 Resistance to aerodynamic loading 20
5.3.1 General 20
5.3.2 Requirements 21
5.3.3 Exceptional load assessment 27
5.3.4 Fatigue load assessment 28
5.3.5 Assessment in case of modification 28

6 Requirements on infrastructure 29
6.1 Limitation of pressure variations inside tunnels to meet the medical health criterion 29
6.1.1 General 29
6.1.2 Requirements 29
6.1.3 Full conformity assessment 31
6.1.4 Simplified conformity assessment 31
6.2 Limitation of pressure gradient entering a tunnel (relative to micro-pressure wave generation) 32
6.2.1 General 32
6.2.2 Reference case 32
6.2.3 Requirements 32
6.2.4 Assessment 32
6.3 Further aspects of tunnel design 33
6.3.1 General 33
6.3.2 Aural pressure comfort 33
6.3.3 Pressure loading on installations 34
6.3.4 Induced airflows 35
6.3.5 Aerodynamic drag 35
6.3.6 Contact forces of pantograph to catenary 35
6.3.7 Ventilation 35
6.3.8 Workers' safety 35
6.3.9 Loads on vehicles in mixed traffic operation 36
6.4 Additional aspects for underground stations 36

DIN EN 14067-5:2023-03 EN 14067-5:2021 + AC:2023 (E) 6.4.1 Pressure changes 36
6.4.2 Induced airflows 36
6.4.3 Specific case for loads on platform barrier systems due to trains passing 37

7 Methods and test procedures 37
7.1 General 37
7.2 Methods to determine pressure variations in tunnels 39
7.2.1 General 39
7.2.2 Full-scale measurements at fixed locations in a tunnel 40
7.2.3 Instrumentation 41
7.2.4 Full-scale measurements on the exterior of the train 43
7.2.5 Predictive formulae 44
7.2.6 Assessment by numerical simulation 44
7.2.7 Reduced scale measurements at fixed locations in a tunnel 45
7.3 Assessment of maximum pressure changes (vehicle reference case) 46
7.3.1 General 46
7.3.2 Transformation of measurement values by a factor (approach 1) 46
7.3.3 Transformation of measurement values based on A.3.3 (approach 2) 47
7.3.4 Transformation by simulation (approach 3) 47
7.3.5 Assessment of the pressure time history 48
7.3.6 Assessment quantities and comparison 52
7.4 Assessment of maximum pressure changes (infrastructure reference case) 52
7.4.1 General 52
7.4.2 Assessment method 52
7.5 Assessment of the pressure gradient of a train entering a tunnel (vehicle reference case, with respect to micro-pressure wave generation) 54
7.5.1 General 54
7.5.2 Assessment by simulations 54
7.5.3 Assessment by moving model rig tests 55
7.6 Assessment of the micro-pressure wave (infrastructure reference case) 55
7.6.1 General 55
7.6.2 Assessment by numerical simulations 56
7.6.3 Assessment by moving model rig tests 58
7.7 Assessment of aerodynamic loads 59
7.7.1 Assessment of load due to strong wind 59
7.7.2 Assessment of open air passings for fatigue load assessments 60
7.7.3 Assessment of transient loads in tunnels 61
7.7.4 Assessment of fatigue loads 64
7.7.5 Determination of the damage-equivalent load amplitude for scenario 66
7.7.6 Documentation 67
7.7.7 Simplified load cases 68
7.8 Assessment of pressure sealing 69
7.8.1 General 69
7.8.2 Dynamic pressure tightness 70
7.8.3 Equivalent leakage area 70
7.8.4 Test methods 71
7.8.5 Dynamic tests 73

Annex A (informative) Predictive formulae 75

A.1 General 75
A.2 SNCF approach 75
A.2.1 Entry of the nose of the train 75

DIN EN 14067-5:2023-03 EN 14067-5:2021 + AC:2023 (E) A.2.2 Entry of the body of the train 75
A.2.3 Entry of the rear of the train 76
A.3 TU Vienna approach 76
A.3.1 General 76
A.3.2 Symbols 76
A.3.3 Calculation of pN 77
A.3.4 Calculation of pfr 78

A.3.5 Calculation of pT 79
A.3.6 Calculation of the drag coefficient Cx,tu 80
A.4 GB approach, ignoring changes in air density and the speed of sound 83
A.4.1 General 83
A.4.2 Calculation of pN 83
A.4.3 Calculation of pfr 84
A.4.4 Calculation of pT 84

Annex B (informative) Pressure comfort criteria 85

B.1 General 85
B.2 Unsealed trains (generally dyn < 0,5 s) 85
B.3 Sealed trains (generally dyn > 0,5 s) 85

Annex C (informative) Micro-pressure wave 86

C.1 General 86
C.2 Compression wave generation 86
C.3 Compression wave propagation 87
C.4 Micro-pressure wave radiation 87

Annex D (informative) Pressure loading on unsealed crossing trains 89

Annex E (informative) Validation cases for the assessment of aerodynamic loads 92

E.1 General 92
E.2 Validation procedure 92

Bibliography 94