

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 p_T	79
A.3.6	Calculation of the drag coefficient $C_{x,tu}$	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 p_N	83
A.4.3	Calculation of p_{fr}	84
A.4.4	Calculation of p_T	84
Annex B (informative) Pressure comfort criteria		85
B.1	General	85
B.2	Unsealed trains (generally $\text{dyn} < 0,5 \text{ s}$)	85
B.3	Sealed trains (generally $\text{dyn} > 0,5 \text{ s}$)	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