DIN EN 14067-6:2022-09 (E)

Railway applications - Aerodynamics - Part 6: Requirements and test procedures for cross wind assessment (includes Amendment A1:2022)

Contents

Page

European foreword 6

Introduction 7

1 Scope 8

2 Normative references 8

3 Terms and definitions 8

4 Symbols and abbreviations 9

5 Methods and requirements to assess cross wind stability of vehicles 22
5.1 General 22
5.2 Applicability of cross wind methodologies for rolling stock assessment purposes 23
5.3 Determination of aerodynamic coefficients 25
5.3.1 General 25
5.3.2 Predictive formula 25
5.3.3 Simulations by Computational Fluid Dynamics (CFD) 26
5.3.4 Reduced-scale wind tunnel measurements 29
5.4 Determination of wheel unloading due to cross winds 34
5.4.1 General 34
5.4.2 Simple method 34
5.4.3 Advanced quasi-static method 37
5.4.4 Time-dependent MBS method using a Chinese hat wind scenario 40
5.5 Presentation form of characteristic wind curves (CWCs) 47
5.5.1 General 47
5.5.2 CWC presentation form for passenger vehicles and locomotives 48
5.5.3 CWC presentation form for freight wagons 49
5.6 Requirements 50
5.6.1 Requirements for passenger vehicles and locomotives running at 250 km/h vmax 360 km/h 50
5.6.2 Requirements for passenger vehicles and locomotives running 140 km/h < vmax < 250 km/h 53
5.6.3 Requirements for freight wagons 53

6 Method to acquire the needed railway line data 54
6.1 General 54
6.2 Presentation form of railway line data 54
6.2.1 General 54
6.2.2 Plan profile 54
6.2.3 Vertical profile 55
6.2.4 Track design speed 56
6.2.5 Walls 57
6.2.6 Meteorological input data for line description 57
6.2.7 Integrated line database 58
6.2.8 Required minimum resolution/accuracy 60

7 Methods to assess the wind exposure of a railway line 60

8 Guidance for the analysis and assessment of the cross wind risk 61

8.1 General ... 61
8.2 Infrastructure with train speeds at or above 250 km/h ... 61
8.3 Infrastructure with train speeds below 250 km/h ... 61

9 Required documentation ... 62
9.1 General ... 62
9.2 Assessment of cross wind stability of passenger vehicles and locomotives ... 62
9.3 Assessment of cross wind stability of freight vehicles ... 62
9.4 Acquisition of railway line data ... 62

Annex A (informative) Application of methods to assess cross wind stability of vehicles within Europe ... 63

Annex B (informative) Blockage correction ... 67

B.1 Dynamic pressure method ... 67
B.2 German method ... 67
B.3 UK method ... 67
B.4 Slotted walls ... 68

Annex C (normative) Wind tunnel benchmark test data for standard ground configuration ... 69

C.1 General ... 69
C.2 ICE 3 leading vehicle wind tunnel model ... 69
C.3 TGV Duplex power car wind tunnel model ... 70
C.4 ETR 500 power car wind tunnel model ... 71

Annex D (informative) Other ground configurations for wind tunnel testing ... 73

D.1 Flat ground with gap (TSI HS RST) ... 73
D.2 Double track ballast and rails (TSI HS RST) ... 73
D.3 Standard embankment of 6 m height (TSI HS RST) ... 74
D.4 Flat ground without gap (Finnish method) ... 75
D.5 Double track ballast and rails (UK method) ... 75

Annex E (informative) Wind tunnel benchmark test data for other ground configurations ... 77

E.1 General ... 77
E.2 ICE 3 leading vehicle wind tunnel model ... 77
E.3 TGV Duplex power car wind tunnel model ... 81
E.4 ETR 500 power car wind tunnel model ... 86

Annex F (informative) Embankment overspeed effect ... 90

Annex G (informative) Atmospheric boundary layer wind tunnel testing ... 91

G.1 General ... 91
G.2 Benchmark tests ... 91
G.3 Wind simulation ... 92
G.3.1 Boundary layer profiles ... 92
G.3.2 Turbulence intensities ... 92
G.3.3 Turbulence integral length scale ... 93
G.4 Model scale and blockage requirements ... 93
G.5 Modelling accuracy ... 93
G.6 Instrumentation requirements ... 93
G.6.1 General ... 93
G.6.2 Speed measurement ... 93
G.6.3 Force and moment balance ... 94
G.7 Data acquisition requirements ... 94
G.7.1 General ... 94
G.7.2 Time scale, sampling frequency and acquisition duration ... 94
G.7.3 Measurement of temperature and atmospheric pressure ... 95

G.8 Calculation of mean values 95
G.9 Calculation of peak values 95
G.10 Calculation of air density 96
G.11 Calculation of the uncorrected rolling moment coefficient 96
G.12 Determination of the lee rail roll moment coefficient 97
G.13 Data interpolation 97

Annex H (informative) Five mass model 98

H.1 General 98
H.2 Derivation of formulae 100
H.3 Example calculations 104
H.3.1 General 104
H.3.2 Example vehicle 1 105
H.3.3 Example vehicle 2 108

Annex I (normative) Mathematical model for the Chinese hat 113

I.1 Mathematical model for Chinese hat 113
I.2 Example calculation for Chinese hat 116

Annex J (informative) Stochastic wind model 122

J.1 General 122
J.2 Assumptions 122
J.3 Application range 122
J.4 General Approach 122
J.4.1 General 122
J.4.2 First step: wind tunnel tests (aerodynamic properties determination) 123
J.4.3 Second step: calculation of turbulent wind speed 123
J.4.4 Third step: evaluation of aerodynamic forces 127
J.4.5 Fourth step: simulation of vehicle dynamics 128
J.4.6 Fifth step: evaluation of characteristic wind speed 128

Annex K (informative) Stability of passenger vehicles and locomotives against overturning according to national guidelines 130

K.1 General 130
K.2 According to DB Guideline 80704 (Germany) 130
K.3 According to Railway Group Standard GM/RT 2141 (Great Britain) 132

Annex L (informative) Information on methods to assess the wind exposure of a railway line 133

L.1 General 133
L.2 Wind map approaches 133
L.3 Transfer approaches 134

Annex M (informative) Extended CWCs 136

Bibliography 139