# DIN EN 14067-6:2020-06 (E)

## Railway applications - Aerodynamics - Part 6: Requirements and test procedures for cross wind assessment

## Contents

Page


European foreword ....5

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 ....58
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 ... 61
9.1 General ... 61
9.2 Assessment of cross wind stability of passenger vehicles and locomotives ... 61
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 ... 87

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 ..... 96
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) ..... 131

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

Annex ZA (informative) Relationship between this European Standard and the Essential Requirements of EU Directive 2008/57/EC aimed to be covered ..... 139

Bibliography ..... 142