

DIN EN 17997:2025-04 (E)

Railway applications - Braking - Definition of ETCS brake curve parameters for Gamma trains

Contents		Page
European foreword		6
Introduction		7
1	Scope	8
2	Normative references	8
3	Terms, definitions, symbols and abbreviated terms	8
3.1	Terms and definitions	8
3.2	Symbols and abbreviated terms	10
4	ETCS on-board brake model parameters	11
4.1	ETCS on-board emergency brake model parameters	11
4.1.1	Nominal emergency brake deceleration $A_{nominal}$	11
4.1.2	Correction factor $K_{dry}(C,V,EBCL)$	11
4.1.3	Correction factor $K_{wet}(C,V)$	12
4.1.4	Emergency brake response time	12
4.1.5	Traction cut-off time	12
4.2	ETCS on-board service brake model parameters	12
4.2.1	General	12
4.2.2	Nominal service brake deceleration $A_{nominalSB}$	12
4.2.3	Service brake response time	12
4.2.4	Normal service brake deceleration and correction factors K_n	12
5	Brake system architecture model	13
5.1	General	13
5.2	General procedure description for $K_{dry}(C,V,EBCL)$ determination	14
5.2.1	General	14
5.2.2	Step 1: Bottom-up functional analysis	14
5.2.3	Step 2: Top-down impact analysis	16
5.2.4	Step 3: Model simplification	17
5.3	Mathematical model building	18
6	Input data	20
6.1	General	20
6.2	Origin of input data	20
6.3	Validity of input data	21
7	Determination of ETCS emergency brake model parameters	22
7.1	Parameters	22
7.1.1	General	22
7.1.2	ETCS brake parameters set approaches	24
7.1.3	Approach dependency	25
7.1.4	Resolution of ETCS brake parameters	26
7.2	Nominal emergency brake deceleration	26
7.2.1	General	26
7.2.2	Determination by dynamic brake testing	27
7.2.3	Determination by calculation	33
7.2.4	Determination at degraded conditions	34
7.2.5	Determination for multiple unit operation	34

7.3	Correction factor $K_{dry}(C,V,EBCL)$	35
7.3.1	General	35
7.3.2	Determination of weighting factors $j(C,V)$	37
7.3.3	Determination of factors $j(i,C,V)$	37
7.3.4	Determination of factors $'k(C,V)$ and $'k(C,V)$	39
7.3.5	Determination of correction factor $K_{dry}(C,V,EBCL)$ with Monte Carlo method	40
7.4	Correction factor $K_{wet}(C,V)$	40
7.4.1	General method for determination of $K_{wet}(C,V)$	40
7.4.2	Determination of $K_{wet}(C,V)$ for wheel/rail adhesion independent brake units	41
7.5	Emergency brake time characteristic	42
7.5.1	General	42
7.5.2	Multiple units operation	42
7.6	Traction cut-off time	43
7.6.1	General	43
7.6.2	Multiple units operation	44
8	Determination of ETCS service brake model parameters	44
8.1	General	44
8.2	Nominal deceleration for service braking	44
8.3	Service brake response time	44
8.4	Normal service brake deceleration and correction factors K_n	44
9	Common set of parameters	45
10	Validation of the calculation tool	45
10.1	General	45
10.2	Verification using a simplified model	46
10.3	Validation by example calculations	46
11	Documentation	47
11.1	General	47
11.2	Brake system architecture model	47
11.3	Input data	47
11.4	Nominal values	47
11.5	Correction factors	48
11.6	Source list	48
Annex A (informative)	Basic formulae for the commonly used types of brake unit	49
A.1	General	49
A.2	Factor $j(i,C,V)$	49
A.2.1	Internal and external parameters for tread brake unit	49
A.2.2	Internal and external parameters for disc brake unit	51
A.2.3	Internal and external parameters for magnetic track brake unit	53
A.2.4	Internal and external parameters for eddy current brake unit	54
A.2.5	Internal and external parameters for electro-dynamic brake	57
A.3	Factor $j'(i,C,V)$	58
Annex B (informative)	Derivation of the formulae for $K_{dry}(C,V,EBCL)$	60
B.1	General	60
B.2	Linear and nonlinear input variables	60
B.3	Consideration of the complete train	62
B.4	Consideration of the structure of the train and subsystem	63
B.4.1	General	63
B.4.2	Higher level structure of the train and subsystem	63
B.4.3	Structure of the control units without redundancies	65
B.4.4	Consideration of redundancies	66
B.4.5	Cross system variables	68
Annex C (normative)	Application of $K_{dry}(C,V,EBCL)$ formulae	71

C.1	General	71
C.2	Example 1: 3-car EMU	72
C.2.1	Description of the train	72
C.2.2	Brake system architecture model	76
C.2.3	Weighting factors	76
C.2.4	Determination of factors $j(i,C,V)$	76
C.2.5	$K_i(C,V)$ formulae	80
C.2.6	Results	81
C.3	Example 2: architecture defined in EN 14531-1	82
C.3.1	Description of the train	82
C.3.2	Brake system architecture model	85
C.3.3	Weighting factors	86
C.3.4	Determination of factors $j(i,C,V)$	87
C.3.5	K_i formulae	88
C.3.6	Results	89
Annex D (informative) Determination of $K_{dry}(C,V,EBCL)$ using the Monte Carlo method depending on the number of Monte Carlo iterations		90
D.1	Definitions	90
D.2	Determination of $K_{dry}(C,V,EBCL)$ depending on the number of Monte Carlo iterations	90
D.3	Examples	92
Annex E (informative) Methods for simplifying the brake system architecture model		93
E.1	General	93
E.2	Structure grouping	94
E.2.1	Serial structure	94
E.2.2	Parallel redundant structure	95
E.2.3	Parallel branched structure	96
E.2.4	Double failure in parallel branched structure	97
E.3	Simplification example	97
E.3.1	Example system	97
E.3.2	Double failure check	98
E.3.3	Grouping of parallel branched structure	99
E.3.4	Grouping of parallel redundant structure	100
E.3.5	Grouping of serial structure	102
E.4	Extended description of the methods mentioned in 5.2.4	103
E.4.1	S-1 Grouping of components and technical functions	103
E.4.2	S-2 "Worst case consideration"	104
E.4.3	S-3 Neglecting of highly improbable event	105
E.4.4	S-4 Reduction of model levels	105
E.4.5	S-5 Assumption of permanently failed components	106
Annex F (informative) Determination of the failure probability by FIT rate analysis		107
F.1	General	107
F.2	Conversion of FIT rates into failure probability	107
Annex G (informative) Simplified model, used for the validation of a calculation tool		108
G.1	General	108
G.2	Train model	108
G.2.1	General	108
G.2.2	Statistical data for pneumatic brake	111
G.2.3	Statistical data for magnetic track brake	112
G.2.4	Statistical data for electro-dynamic brake	112
G.2.5	Statistical data for traction units	113
G.3	Examples of validation of the correct use of parameter information	113
G.3.1	Mass deviation	113
G.3.2	Wheel diameter deviation	113
G.3.3	MTB brake force deviation	114

G.3.4	ED brake force deviation	114
G.3.5	Failure probability of traction cut-off	115
G.4	Example of verification of the correct use of structural information	115
G.4.1	Failure probability on bogie level for pneumatic brake	115
G.4.2	Failure probability on vehicle type level for MTB	115
Bibliography	117