
**Railway applications — Railway
braking — Country specific
applications for ISO 20138-1**

*Applications ferroviaires — Freinage ferroviaire — Applications
spécifiques nationales de l'ISO 20138-1*

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Contents

Page

Foreword	iv
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Slowing or stopping distance calculation using a method implemented in France	1
4.1 General.....	1
4.2 Terms, symbols and abbreviations.....	1
4.3 Slowing or stopping distance calculation.....	2
4.3.1 French model for “G” position.....	2
4.3.2 Calculation using ISO 20138-1:2018, 5.7.5.1 (step model).....	3
4.4 Example of calculation.....	4
4.4.1 Test results.....	4
4.4.2 Comparison of calculation models with test results.....	4
5 Calculation of braking performance implemented in Japan	5
5.1 General.....	5
5.2 Brake ratio for a single vehicle.....	5
5.3 Example for brake ratio calculation.....	6
5.4 Equivalent response time.....	8
6 Stopping or slowing distance calculation methods for some particular rolling stock in China	9
6.1 General.....	9
6.2 Definitions, symbols and abbreviations.....	9
6.3 Train resistance retarding forces.....	11
6.3.1 Base running resistance.....	11
6.3.2 Curve resistance.....	12
6.4 Train brake block force.....	14
6.4.1 Total brake block force of train.....	14
6.4.2 Real friction coefficient.....	14
6.4.3 Conversion friction coefficient.....	15
6.4.4 Real brake block force.....	16
6.4.5 Nominal values of rigging efficiency.....	17
6.4.6 Emergency brake cylinder pressure.....	17
6.4.7 Conversion brake block force.....	17
6.4.8 Conversion braking ratio.....	19
6.4.9 Train unit brake retarding force.....	21
6.4.10 Dynamic brake force.....	21
6.4.11 Coefficient of adhesion.....	21
6.5 Brake calculation.....	22
6.5.1 Braking time.....	22
6.5.2 Free running time.....	22
6.5.3 Stopping/slowng distance.....	23
Bibliography	25

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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This document was prepared by Technical Committee ISO/TC 269, *Railway applications*, Subcommittee SC 2, *Rolling stock*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Railway applications — Railway braking — Country specific applications for ISO 20138-1

1 Scope

This document provides additional information to assist the understanding and the use of ISO 20138-1. The calculations in this document follow the same principles but they are slightly different.

This document contains country specific calculation approaches currently in use and represents the state of knowledge including for calculating:

- stopping and slowing distances;
- equivalent response time;
- brake performance;
- brake ratio.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

4 Slowing or stopping distance calculation using a method implemented in France

4.1 General

This calculation is based on the alternative method of equivalent response time calculation, as used in the French railway requirements, in particular for trains operating in “G” position.

4.2 Terms, symbols and abbreviations

For the purpose of Clause 4, the terms, symbols and abbreviations defined in [Table 1](#) apply.

Table 1 — Symbols, definitions and units

Term, symbol or abbreviation	Definition	Unit
1	Point when the brake force, deceleration or pressure has been substantially achieved, typically 95 %	—
a_e	Equivalent deceleration (on level track, without considering gradient effect)	m/s ²
g	Standard acceleration of gravity	m/s ²
“G” position	Distributor valve and distributor isolating devices (as defined in EN 15355[9])	
i	Gradient of the track (positive rising/negative falling)	—
s_{grad}	Stopping/slowing distance on a gradient	m
s_{tests}	Stopping distances measured during the tests	m
t_e	Equivalent response time	s
$2 \cdot t_e$	Equivalent response time multiplied by 2	s
v_0	Initial speed	m/s
v_{fin}	Final speed (= 0 in the case of a stopping distance)	m/s
X	Time	s
Y	Factor of nominal braking force, deceleration or pressure	—

4.3 Slowing or stopping distance calculation

4.3.1 French model for “G” position

This model provides a high level of accuracy for the calculation of stopping distances of trains with long build up time (e.g. “G” position). It is currently used by the infrastructure managers in order to evaluate the conformance of a train with the train control system and the length of the signalling sections.

For this French model of slowing or stopping distance calculation, [Figure 1](#) may be used for trains operating in “G” position for brake systems with retarding forces acting on rail contact point.

The model uses a linear development of the effort from 0 to 1 during a time of $2 \cdot t_e$.

The equivalent response time, t_e , can be calculated as set out in [Formula \(1\)](#):

$$t_e = t_a + \frac{t_{ab}}{2} \quad (1)$$

with t_a and t_{ab} in accordance with ISO 20138-1:2018, 5.5.2.

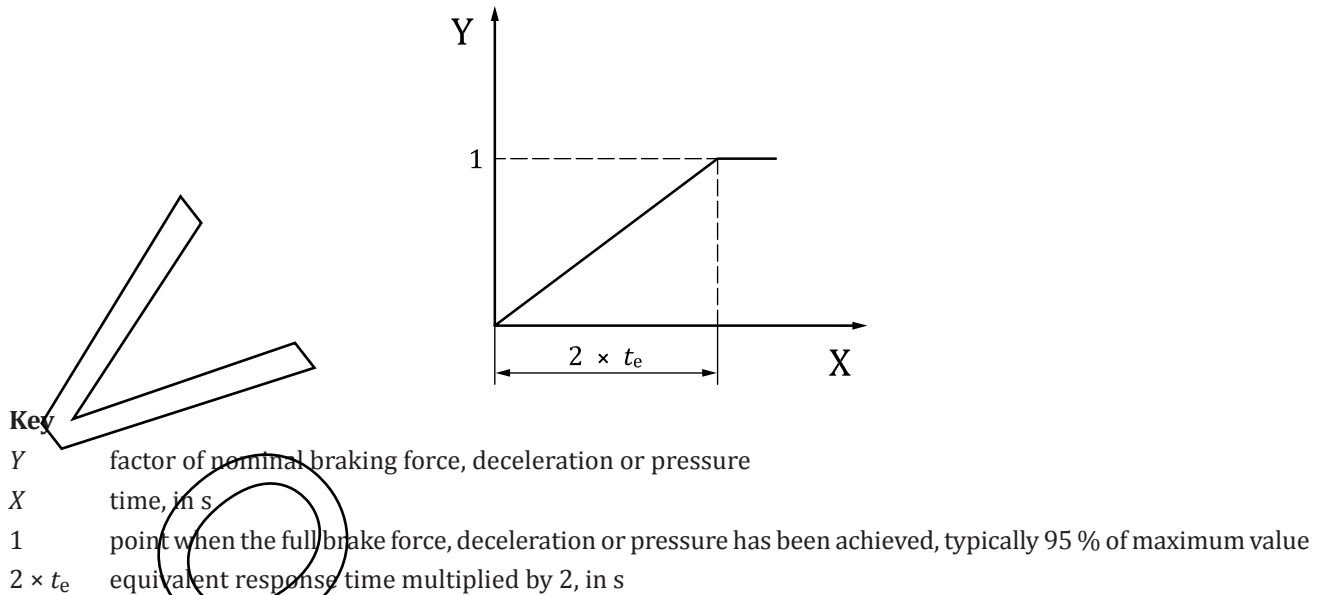


Figure 1 — Model based on a linear development of the effort from 0 to 1 during a time of $2 \cdot t_e$

The stopping ($v_{\text{fin}} = 0$) or slowing distance can be calculated as set out in [Formula \(2\)](#):

$$s_{\text{grad}} = v_0 \cdot t_e \cdot \frac{a_e}{a_e + g \cdot i} + \frac{v_0^2 - v_{\text{fin}}^2}{2 \cdot (a_e + g \cdot i)} \cdot \frac{a_e \cdot t_e^2 \cdot (a_e + 4 \cdot g \cdot i)}{6 \cdot (a_e + g \cdot i)} \quad (2)$$

NOTE 1 The equivalent deceleration, a_e , does not take the effect of the gradient into account.

[Formula \(3\)](#) is valid for stopping/slowing distance calculation with fully established braking forces. The following condition is fulfilled:

$$v_0 - v_{\text{fin}} \geq (a_e + 2 \cdot i) \cdot t_e \quad (3)$$

where

s_{grad} is the stopping/slowing distance on a gradient, in m;

v_0 is the initial speed, in m/s;

t_e is the equivalent response time, in s;

a_e is the equivalent deceleration (on level track, without considering gradient effect), in m/s^2 ;

g is the standard acceleration of gravity, in m/s^2 ;

i is the gradient of the track (positive rising/negative falling);

v_{fin} is the final speed (= 0 in the case of a stopping distance), in m/s.

NOTE 2 The stopping/slowing distance as calculated by applying [Formula \(3\)](#) will be shorter than calculated according to the method described in ISO 20138-1:2018, 5.7.4.

4.3.2 Calculation using ISO 20138-1:2018, 5.7.5.1 (step model)

ISO 20138-1:2018, 5.7.5.1, gives [Formula \(4\)](#) for calculations on level track ($i = 0$) or with gradient.

It uses the model for theoretical response time $t_e = t_a + \frac{t_{ab}}{2}$ as “step” model.

$$s_{grad} = v_0 \cdot t_e - \frac{1}{2} \frac{m_{st}}{m_{dyn}} \cdot g \cdot i \cdot t_e^2 + \frac{\left(v_0 - \frac{m_{st}}{m_{dyn}} \cdot g \cdot i \cdot t_e \right)^2}{2a_e} - v_{fin}^2 \quad (4)$$

With train resistance and dynamic mass which compensate each other and $v_{fin} = 0$, the formula is simplified as [Formula \(5\)](#):

$$s_{grad} = v_0 \cdot t_e - \frac{g \cdot i \cdot t_e^2}{2} + \frac{(v_0 - g \cdot i \cdot t_e)^2}{2a_e} \quad (5)$$

where

- s_{grad} is the stopping/slowing distance on a gradient, in m;
- v_0 is the initial speed, in m/s;
- t_e is the equivalent response time, in s;
- m_{st} is the static mass, in kg;
- m_{dyn} is the dynamic mass, in kg;
- g is the standard acceleration of gravity, in m/s^2 ;
- i is the gradient of the track (positive rising/negative falling);
- a_e is the equivalent deceleration (on level track, without considering gradient effect), in m/s^2 ;
- v_{fin} is the final speed (= 0 in the case of a stopping distance), in m/s.

4.4 Example of calculation

4.4.1 Test results

This example is based on a long train of 1 000 m in “G” position.

As a reference for further comparison, the tests realized on the tracks have provided the following results for the stopping distances s_{tests} :

Stopping distance on level track	824 m
Stopping distance on a down gradient of 5 ‰	885 m
Stopping distance on an up gradient of 5 ‰	776 m

The equivalent response time, t_e (delay time + 1/2 brake build-up time), derived from the results of the tests is 15,5 s.

The equivalent deceleration without including the effect of the gradient, a_e , derived from the results of the tests is 0,89 m/s^2 .

4.4.2 Comparison of calculation models with test results

The stopping distances, s_{tests} , calculated using [Formula \(5\)](#) (simplified ISO 20138-1 “step model”) are given in [Table 2](#):

Table 2 — Stopping distances calculated using step model

	v_0 km/h	g m/s ²	i mm/m	t_e s	a_e m/s ²	S_{grad} m	S_{tests} m	Difference S_{grad} VS S_{tests} %
Level track	100	9,81	0	15,5	0,89	864,0	824	5 %
Up gradient	100	9,81	5	15,5	0,89	834,7	776	8 %
Down gradient	100	9,81	-5	15,5	0,89	894,0	885	1 %

The stopping distances, S_{tests} , calculated using [Formula \(2\)](#) (French alternative method) are given in [Table 3](#).

Table 3 — Stopping distances calculated using French alternative method

	v_0 km/h	g m/s ²	i mm/m	t_e s	a_e m/s ²	Condition		S_{grad} m	S_{tests} m	Difference S_{grad} VS S_{tests} %
						$v_0 \geq (a_e + 2g \cdot i) t_e$				
						v_0 m/s	$(a_e + 2g \cdot i) t_e$ m/s			
Level track	100	9,81	0	15,5	0,89	27,8	>13,8	828,4	824	<1 %
Up gradient	100	9,81	5	15,5	0,89	27,8	>15,3	777,7	776	0 %
Down gradient	100	9,81	-5	15,5	0,89	27,8	>12,3	885,0	885	0 %

The values in the table demonstrate the following:

- The stopping distances calculated with the French alternative method are shorter than the ones of the simplified “step model” of ISO 20138-1.
- The stopping distances calculated with the French alternative method are more accurate and closer to the test results on the track.

5 Calculation of braking performance implemented in Japan

5.1 General

In Japan, the fundamental law is the Railway Operation Act^[3]. In addition, the Technical Regulatory Standards on Japanese Railway are published by the Ministry of Land, Infrastructure and Transport and Tourism (MLIT). The technical regulation consists of ministerial ordinances and approved model specifications. Explanatory documents which complement the ministerial ordinances and approved model specifications and help users to interpret these correctly have also been published. These documents are generally used as standards as well as Japanese Industrial Standards (JIS)^{[4][7][8]} and Japan Association of Rolling Stock Industries standards (JRSI)^{[5][6]}, etc. in Japan.

5.2 Brake ratio for a single vehicle

The brake ratio is used to compare the capability of single vehicles and is used for design assessment.

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