APTU Uniform Rules (Appendix F to COTIF 1999)

Uniform Technical Prescriptions (UTP) relating to the Subsystem Rolling Stock

FREIGHT WAGONS - ANNEX J

VEHICLE TRACK INTERACTION AND GAUGING
BOGIE AND RUNNING GEAR

Explanatory note:

The texts of this UTP which appear without columns are identical with corresponding texts of the European Union regulations. Texts which appear in two columns differ; left-hand column contains the UTP regulations, right-hand column shows the text in the corresponding EU regulations. The text in the right hand column is for information only and not part of the OTIF regulations.

OTIF UTP | *Corresponding text in EU regulations [1]* *EU ref. [2]*

J.1 STATIC TESTS WITH EXCEPTIONAL IN-SERVICE LOADS

Definitions of Applied Loads

The applied loads consist of:

- vertical and transverse loads,
- loads due to roll,
- loads due to braking,
- torsional loads.

Vertical and Transverse Loads

The vertical and transverse loads are calculated by reference to the nominal bogie load (for example: bogie for 20 t or 22,5 t on-rail axle load).

In order to take the maximum dynamic load into account:

- The vertical load to be applied to the pivot bearing shall be:
- $F_z \max = 1{,}5\ F_z$, with $F_z = 4\ Q_o - m^+g$ (for 2-axle bogies)
- $F_z \max = 1{,}5\ F_z$, with $F_z = 6\ Q_o - m^+g$ (for 3-axle bogies)

If only the vertical load due to bounce is to be simulated, a load of 2 F_z shall be applied to the pivot bearing only.

The transverse load to be applied to the bogie shall be:

- $F_y \max = 2\left(10 + \frac{2\,Q_o}{3}\right)$ kN (for two-axle bogies)
- $F_y \max = \frac{8}{3}\left(10 + \frac{2\,Q_o}{3}\right)$ kN (for three-axle bogies)

NB: The transverse loads for 3-axle bogies given are based on the load distribution recorded during running trials for the qualification of bogie type 714. For a different bogie type, the load distribution recorded during running trials with the bogie.

Loads due to roll

The roll coefficient α is taken to be equal to 0,3 for a spacing between the friction pads of 1700 mm (standard 2-axle bogies).

If the spacing between the friction pads ($2b_g$) differs from 1700 mm, the value for α should be:

$$\alpha = 0{,}3\left(\frac{1700}{2b_g}\right)$$

[1] TSI Freight Wagons – The Annex to the Commission Decision 2006/861/EC published in the EU Official Journal L344 on 08.12.2006 as amended by Commission Decision 2009/107/EC published in EU Official Journal L45 on 14.02.2009.

[2] If no EU reference is indicated, it means that the chapter/section number is the same as in the OTIF text.

Loads Due To Braking

The loads due to braking F_B correspond to 120 % of the forces resulting from emergency braking.

On the bogie under test, these loads due to braking F_B result in:

- deceleration loads,
- contact loads,
- loads applied to the brake linkages.

Torsional Loads

Loads on the bogie frame, when the bogie with its suspension is subjected to a maximum track twist of 10 ‰.

Test Procedure

Strain gauges and strain rosettes are attached to the bogie frame at all highly stressed points, in particular in zones of stress concentration. Positioning of the gauges shall be determined, for example, by means of strain indicating varnish.

The test shall be carried out in accordance with Figure 1 and Table J5 (for 2-axle bogies) or Figure 2 and Table J6 (for 3-axle bogies).

The test loads shall be applied in steps. Loads with values corresponding to 50 % and 75 % of the maximum values shall be applied before applying the full load configuration.

Results To Be Obtained

The elastic limit of the material shall not be exceeded for any load case.

After removal of the test load there shall not be any evidence of permanent deformation.

Static Tests With Exceptional In-Service Loads– two axle bogies

Figure J1

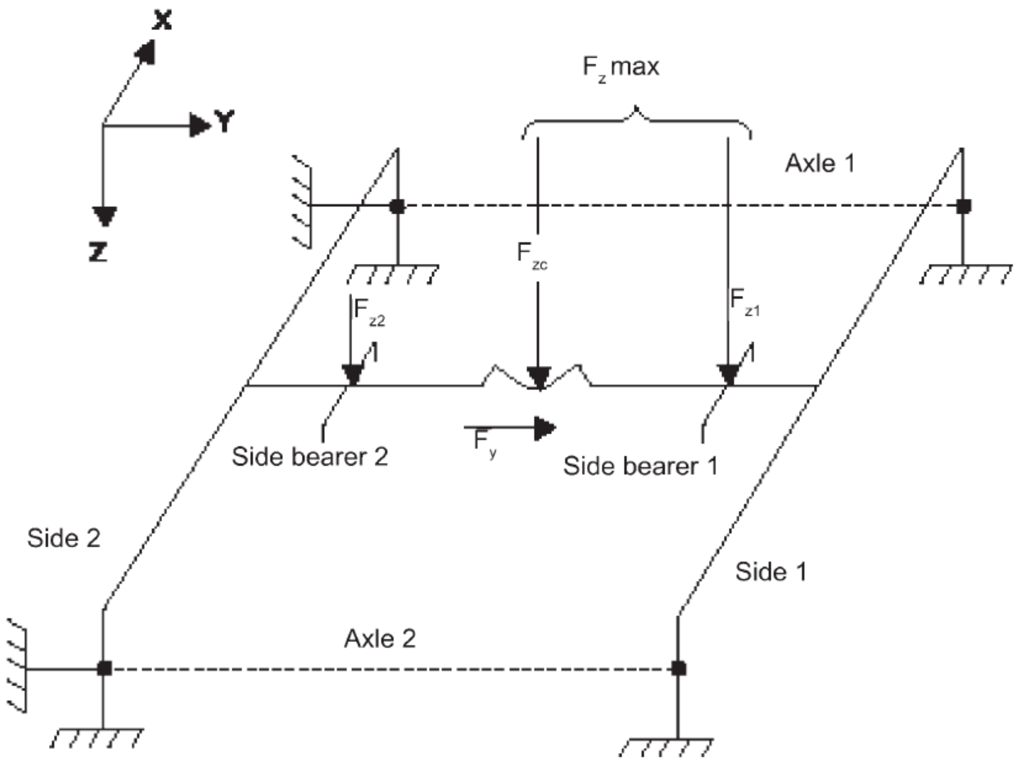


Table J5

Load case	Loads				Track twist g^+	Braking force
	Vertical			Transverse		
	Friction pad 2 F_{z2}	Pivot bearing F_{zc}	Friction pad 1 F_{z1}	F_y		
1		$2\ F_z$				
2	0	$(1-\alpha)\ F_z$ max	$\alpha\ F_z$ max		10 ‰	
3	0	$(1-\alpha)\ F_z$ max	$\alpha\ F_z$ max	F_y max		
4	$\alpha\ F_z$ max	$(1-\alpha)\ F_z$ max	0	$-\ F_y$ max		
5	0	$1{,}2\ F_z$	0			F_B

$F_z = 4\ Q_o - m^+g$

$F_y \max = 2\left(10 + \frac{2\ Q_o}{3}\right)$

$F_z \max = 1{,}5\ F_z$

F_B = Braking forces

$\alpha = 0{,}3\left(\frac{1700}{2b_g}\right)$

Static Tests With Exceptional In-Service Loads– Three Axle Bogies

Figure J2

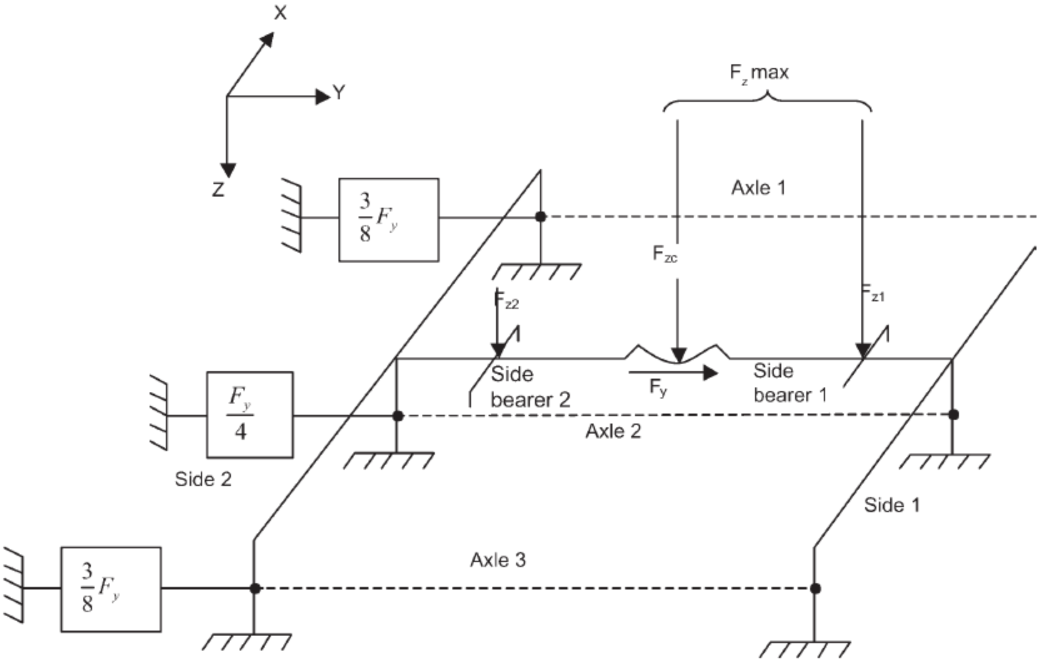


Table J6

Load case	Loads				Track twist g+	Braking force
	Vertical			Transverse		
	Friction pad 2 F_{z2}	Pivot bearing F_{zc}	Friction pad 1 F_{z1}	F_y		
1		$2\ F_z$				
2	0	$(1-\alpha)\ F_z$ max	$\alpha\ F_z$ max		10 ‰	
3	0	$(1-\alpha)\ F_z$ max	$\alpha\ F_z$ max	F_y max		
4	$\alpha\ F_z$ max	$(1-\alpha)\ F_z$ max	0	$-\ F_y$ max		
5	0	$1{,}2\ F_z$	0			F_B

$F_z = 6\ Q_o - m^+g$

$F_y \max = \frac{8}{3}\left(10 + \frac{2\ Q_o}{3}\right)$

$F_z \max = 1{,}5\ F_z$

F_B = Braking forces

$$\alpha = 0{,}3\left(\frac{1700}{2b_g}\right)$$

J.2 STATIC TESTS WITH NORMAL IN-SERVICE LOADS

Definitions of applied loads

The applied loads consist of:

– vertical loads on the pivot bearing and friction pads,
– a transverse load,
– loads due to braking,

- torsional loads.

Vertical loads and loads due to roll

The vertical loads on the pivot bearing and friction pads shall be calculated by reference to the nominal bogie load. They depend on:

- F_z, the static load exerted by the wagon body on each bogie
- α, the roll coefficient
- β, the bounce coefficient

The roll coefficient α is taken to be equal to 0,2 for a spacing between the friction pads of 1700 mm (standard 2-axle bogies).

If the spacing between the friction pads ($2b_g$) differs from 1700 mm, the value for α should be:

$$\alpha = 0{,}2\left(\frac{1700}{2b_g}\right)$$

The bounce coefficient β that represents the vertical dynamic behaviour of the bogie shall be taken to be equal to 0,3 (the normal value for wagon bogies).

Transverse load

The transverse load shall be equal to:

- $F_y = 0{,}4 \times 0{,}5\,(F_z + m^+g)$ (for 2-axle bogies)
- $F_y = 0{,}53 \times 0{,}5\,(F_z + m^+g)$ (for 3-axle bogies)

Loads due to braking

The loads due to braking correspond to 100 % of the forces resulting from emergency braking.

On the bogie under test, these loads due to braking result in the following loads being applied:

- deceleration loads
- contact loads
- Loads applied to the brake linkages.

Torsional loads

Track twist, referenced to the bogie wheelbase, is taken to be equal to 5 ‰.

This twist g^+ shall be simulated either by moving the supports or by applying the corresponding calculated reaction forces.

Test procedure

Strain gauges and strain rosettes shall be attached to the bogie frame at all highly stressed points, in particular in zones of stress concentration.

The test consists of applying various load configurations to the bogie frame that simulate:

- running on straight track
- running in curves
- dynamic load variations due to roll and bounce
- braking
- track twist.

The various load cases to be applied are described in Figure 3 and Table 7 (for two-axle bogies) and Figure 4 and Table 8 (for three-axle bogies).

After application of the first seven load cases without simulation of track twist, four further tests shall be carried out by repeating load cases 4, 5, 6 and 7 with superposition of the track twist (value as specified for the bogie with its suspension).

For each of these four new load cases, the loads due to twist shall be applied first in one direction and then in the other.

The introduction of the track twist shall not modify the sum of the vertical forces.

Tests with application of loads corresponding to the loads due to braking shall be carried out if the results of the tests according to Appendix A show them to be necessary (elastic limit exceeded during those tests).

Results to be obtained

At each measuring point, the stresses $\sigma_1 \ldots \sigma_n$ shall be recorded for each of the load cases defined above.

From these n values, the minimum value $\sigma_{min.}$, and the maximum value $\sigma_{max.}$ are taken in order to determine:

$$\sigma_{mean} = \frac{\sigma_{max} + \sigma_{min}}{2} \quad \text{and} \quad \Delta\sigma = \frac{\sigma_{max} - \sigma_{min}}{2}$$

The behaviour of materials, including welded joints and other types of fastening, under fatigue loading should be based on current international or national standards, or alternative sources of equivalent standing such as the one based on ERRI B12 Committee report RPI7, wherever such sources are available.

Suitable data shall generally exhibit the following characteristics:

- a high probability of survival (i.e. preferably 97,5 %, but at least 95 %);
- classification of details according to the component or joint geometry (including stress concentration);
- derivation of the limiting values from small-scale samples using a test technique and previous experience to guarantee their applicability to full size components.

If the stress limits to be respected are those given in the fatigue strength diagrams in ERRI B12 Committee report RPI7, it will be permissible to exceed these stress limits by up to 20 % at a limited number of measurement points, which shall then be monitored with particular care during the fatigue testing. If no incipient cracks are found during testing, the stresses exceeding the limit recorded during static testing shall be accepted and the bogie shall be approved.

Static Tests With Normal In Service Loads– Two Axle Bogies

Figure J3

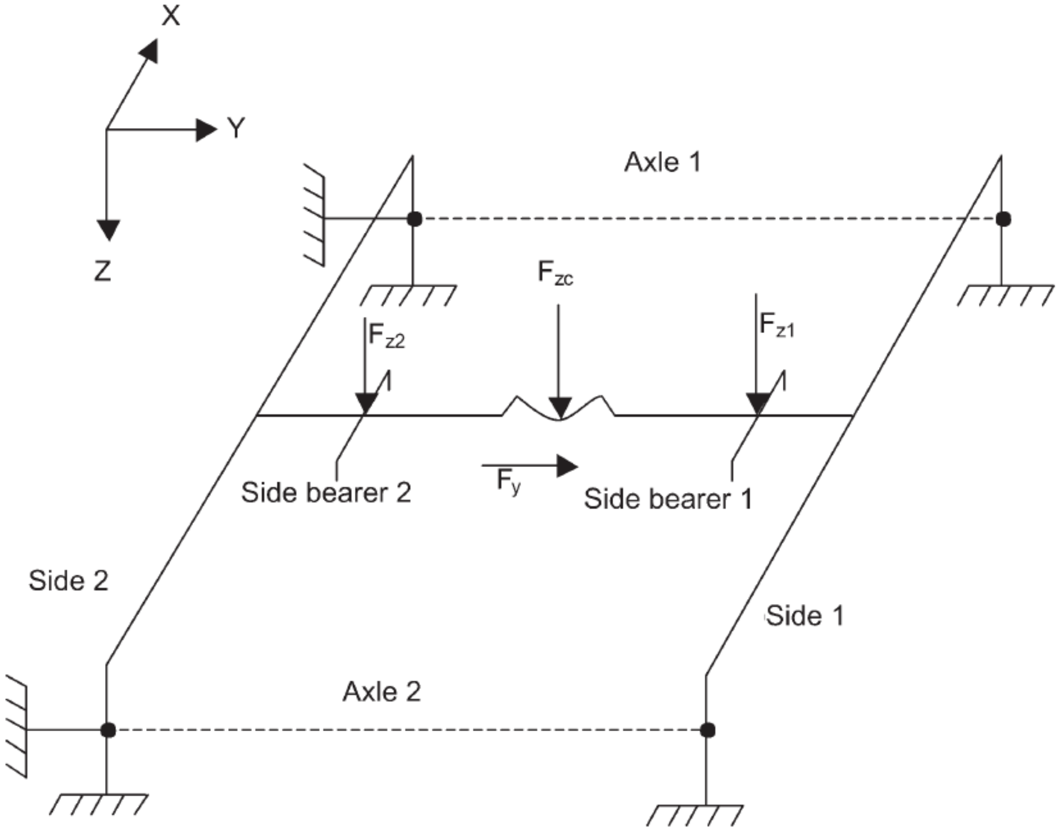


Table J7

Load Case	Loads				Braking Forces
	Vertical			Transverse	
	Friction pad 2 F_{z2}	Pivot Bearing F_{zc}	Friction pad 1 F_{z1}	F_y	
1	0	F_z	0		
2	0	$(1+\beta)\ F_z$	0		
3	0	$(1-\beta)\ F_z$	0		
4	0	$(1-\alpha)\ (1+\beta)\ F_z$	$\alpha\ (1+\beta)\ F_z$	F_y	
5	$\alpha\ (1+\beta)\ F_z$	$(1-\alpha)\ (1+\beta)\ F_z$	0	$-F_y$	
6	0	$(1-\alpha)\ (1-\beta)\ F_z$	$\alpha\ (1-\beta)\ F_z$	F_y	
7	$\alpha\ (1-\beta)\ F_z$	$(1-\alpha)\ (1-\beta)\ F_z$	0	$-F_y$	
8	0	F_z	0		F_B

$F_z = 4\ Q_o - m^+g$ $\qquad \beta = 0{,}3$

$\alpha = 0{,}2\left(\frac{1700}{2b_g}\right)$ $\qquad F_y = 0{,}4 \times 0{,}5\ (F_z + m^+g)$

Static Tests With Normal In-Service Loads– Three Axle Bogies

Figure J4

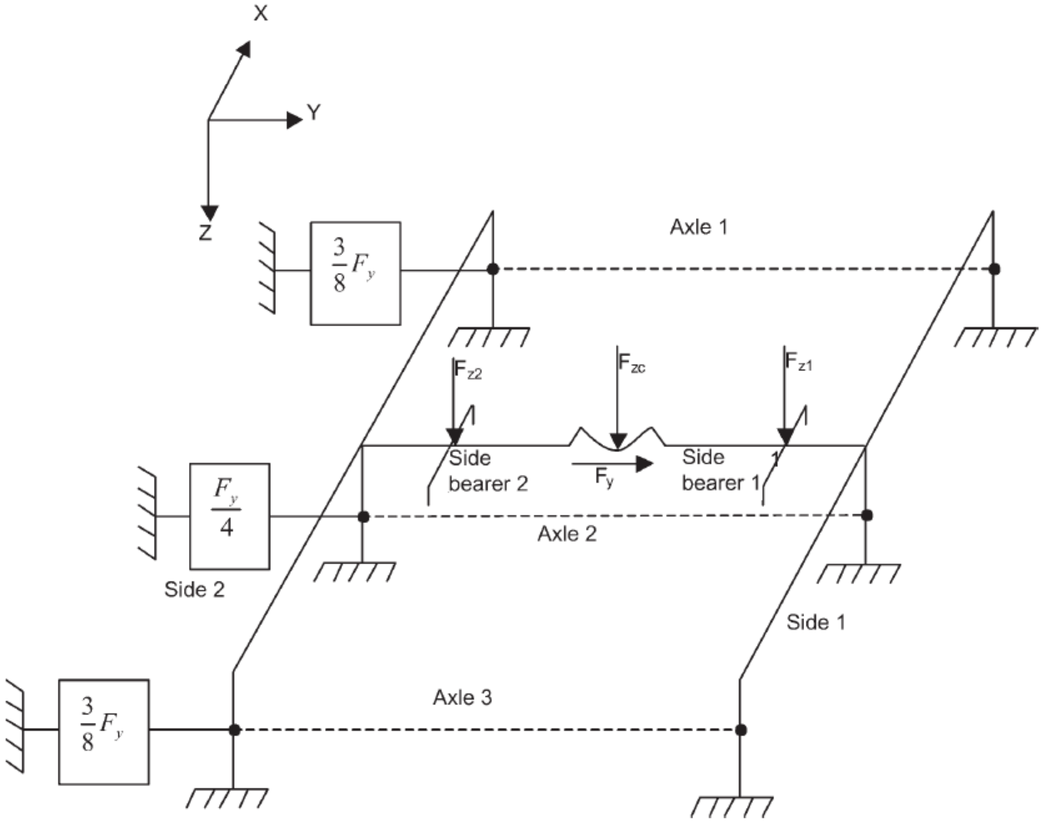


Table J8

Load Case	Loads				Braking Forces
	Vertical			Transverse	
	Friction pad 2 F_{z2}	Pivot Bearing F_{zc}	Friction pad 1 F_{z1}	F_y	
1	0	F_z	0		
2	0	$(1+\beta)\ F_z$	0		
3	0	$(1-\beta)\ F_z$	0		
4	0	$(1-\alpha)\ (1+\beta)\ F_z$	$\alpha\ (1+\beta)\ F_z$	F_y	
5	$\alpha\ (1+\beta)\ F_z$	$(1-\alpha)\ (1+\beta)\ F_z$	0	$-F_y$	
6	0	$(1-\alpha)\ (1-\beta)\ F_z$	$\alpha\ (1-\beta)\ F_z$	F_y	
7	$\alpha\ (1-\beta)\ F_z$	$(1-\alpha)\ (1-\beta)\ F_z$	0	$-F_y$	
8	0	F_z	0		F_B

$F_z = 6\ Q_o - m^+g$ $\beta = 0,3$

$\alpha = 0,2\left(\frac{1700}{2b_g}\right)$ $F_y = 0,53 \times 0,5\ (F_z + m^+g)$

J.3 FATIGUE TESTS

Definitions of applied loads

The applied loads consist of:

- vertical loads on the pivot bearing and friction pads
- a transverse load
- loads due to braking

- torsional loads

Vertical loads and loads due to roll

- The vertical loads on the pivot bearing and friction pads shall be calculated by reference to the nominal bogie load.

  They depend on:
- F_z, the static load exerted by the wagon body on each bogie
- α, the roll coefficient = 0,2
- β, the bounce coefficient = 0,3

F_z is a static load. The loads due to the coefficient α are considered to be 'quasi static'. The loads due to the coefficient β are considered to be 'dynamic'.

The roll coefficient α is taken to be equal to 0,2 for a spacing between the friction pads of 1700 mm (standard two-axle bogies). If the spacing between the friction pads ($2b_g$) differs from 1700 mm, the value for α shall be:

$$\alpha = 0{,}2\left(\frac{1700}{2b_g}\right)$$

Transverse loads

The transverse loads consist of two components:

- Two-axle bogies:
  - quasi-static load: $F_{yq} = 0{,}1\ (F_z+m^+g)$
  - dynamic load: $F_{yd} = 0{,}1\ (F_z+m^+g)$
- Three-axle bogies:
  - quasi-static load: $F_{yq} = 0{,}133\ (F_z+m^+g)$
  - dynamic load: $F_{yd} = 0{,}133\ (F_z+m^+g)$

Loads due to braking

The loads due to braking correspond to 100 % of the forces resulting from emergency braking.

On the bogie under test, these loads due to braking result in the following loads being applied:

- deceleration loads,
- contact loads,
- loads applied to the brake linkages.

Torsional loads

Track twist, referenced to the bogie wheelbase, shall be 5 ‰.

Test procedure

The fatigue tests consist of alternating quasi-static and dynamic load sequences that represent running through right and left-hand curves.

If the static tests defined in Appendix B have shown that the track twist induced stresses only in limited zones of the bogie frame, where the stresses caused by the vertical and transverse loads are minor, the fatigue test, as a first stage, shall be performed with only vertical and transverse loads.

In this case, the vertical and transverse quasi-static and dynamic loads shall vary with time as shown in the diagrams in Figures 3, 5, 6 and 7 (for two-axle bogies) or in Figures 5, 6, 7 and 8 (for three-axle bogies).

In each sequence corresponding to a curve to the right or to the left, the number of dynamic cycles, vertically and transversely, shall be 20.

The dynamic variations of the vertical and transverse loads shall be of the same frequency and shall be in phase, as shown in the diagrams. The number of sequences simulating right hand curves and left hand curves in the test shall be the same.

In this first test stage, the number of cycles of dynamic load variations shall be 6×10^6.

The second test stage shall consist of 2×10^6 cycles, with the static forces unchanged and the quasi-static and dynamic forces multiplied by 1,2.

The third test stage shall also consist of 2×10^6 cycles and is performed as the second stage, but with the factor 1,2 replaced by 1,4.

Tests with application of loads corresponding to the loads due to braking shall be carried out if the results of the tests according to section J.2 show them to be necessary (elastic limit exceeded during those tests).

Torsional loads

A total of 10^6 alternating torsional load cycles shall be applied in all:

– 6×10^5 during the first test stage
– 2×10^5 during each of the other two stages

When specifying the torsional tests, the results of the static tests and the capabilities of the existing test facilities shall be taken into account.

If the static tests have shown that the bogie frame is not affected by track twist, it shall not be taken into account.

If the static tests in Appendix B show that the effects of the track twist loads are clearly different from those resulting from the vertical and transverse forces (e.g. because the stresses occur in different zones), the 6×10^5 plus twice 2×10^5 cycles of torsional loading can be applied separately from the vertical and transverse loads. Otherwise, the test setup shall be adapted in order to apply the vertical, transverse and track twist loads simultaneously.

The loads that simulate the effect of track twist shall correspond to those that occur when the suspension is functioning with damping.

Results to be obtained

No cracks shall be found after application of the 6×10^6 cycles of the first test stage. This shall be confirmed by nondestructive inspection (magnetic particle or dye penetration test) after every 1×10^6 cycles.

At the end of the second test stage, only the occurrence of small cracks, that would not require immediate repairs if they occurred in service, shall be acceptable.

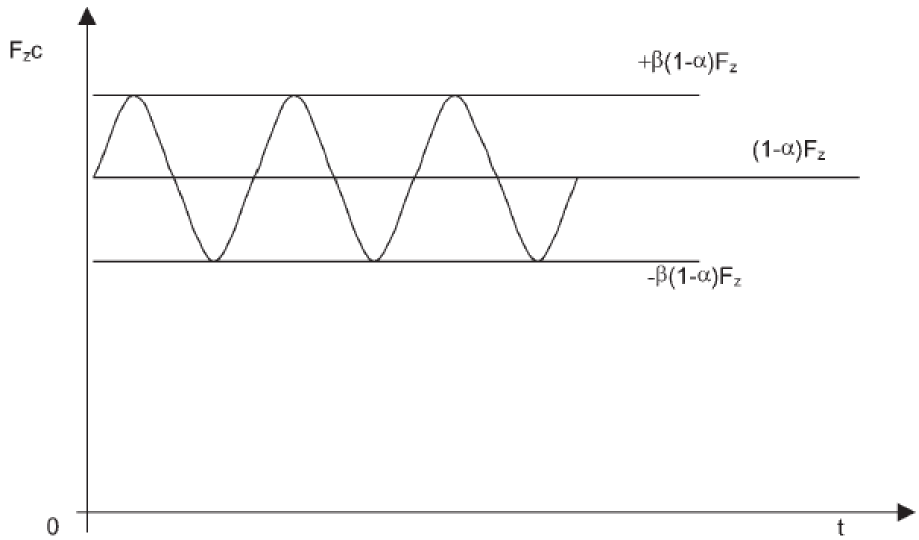
The evolution of the stresses at the locations of highest stress found during the static test (paragraph 6.1.1.2.1.3) shall be monitored by means of strain gauges during the fatigue test, and in particular where stresses exceeding the stress limit have been tolerated in accordance with paragraph 6.1.1.2.1.3

Fatigue tests — two-axle bogies

Refer to figure J3.

Load on pivot bearing

Figure J5



$F_z = 4\ Q_o - m^+g$

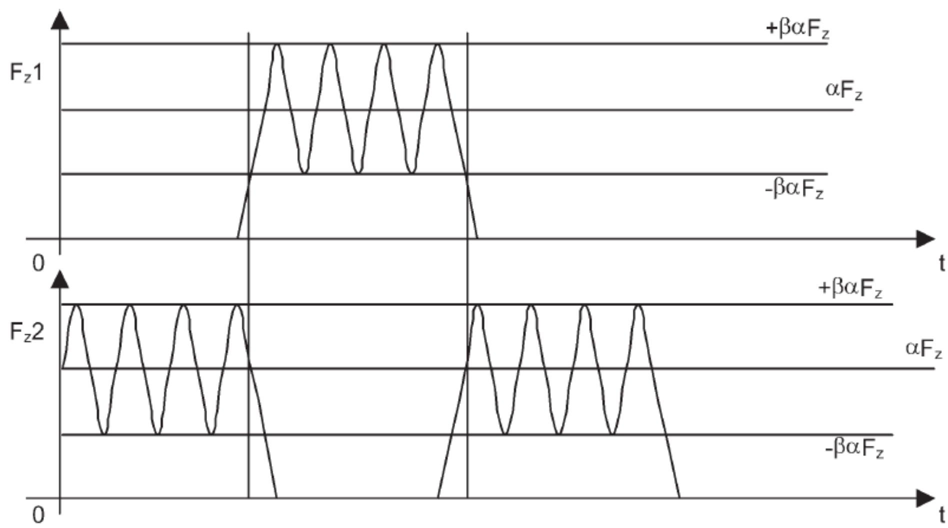
$\alpha = 0{,}2\left(\frac{1700}{2b_g}\right)$

$\beta = 0{,}3$

$F_zc = (1-\alpha)\ F \pm \beta(1-\alpha)\ F_z$

Loads on friction pads

Figure J6

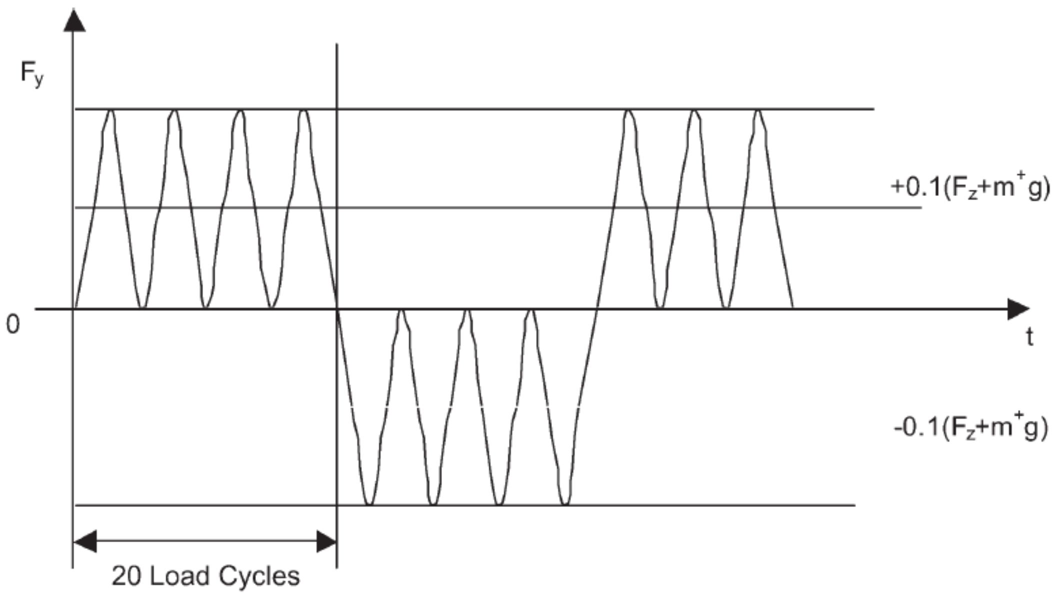


$\{F_{z1} = \alpha F_z \pm \beta\alpha F_z$

$\{F_{z2} = \alpha F_z \pm \beta\alpha F_z$

Transverse load acting on the pivot bearing

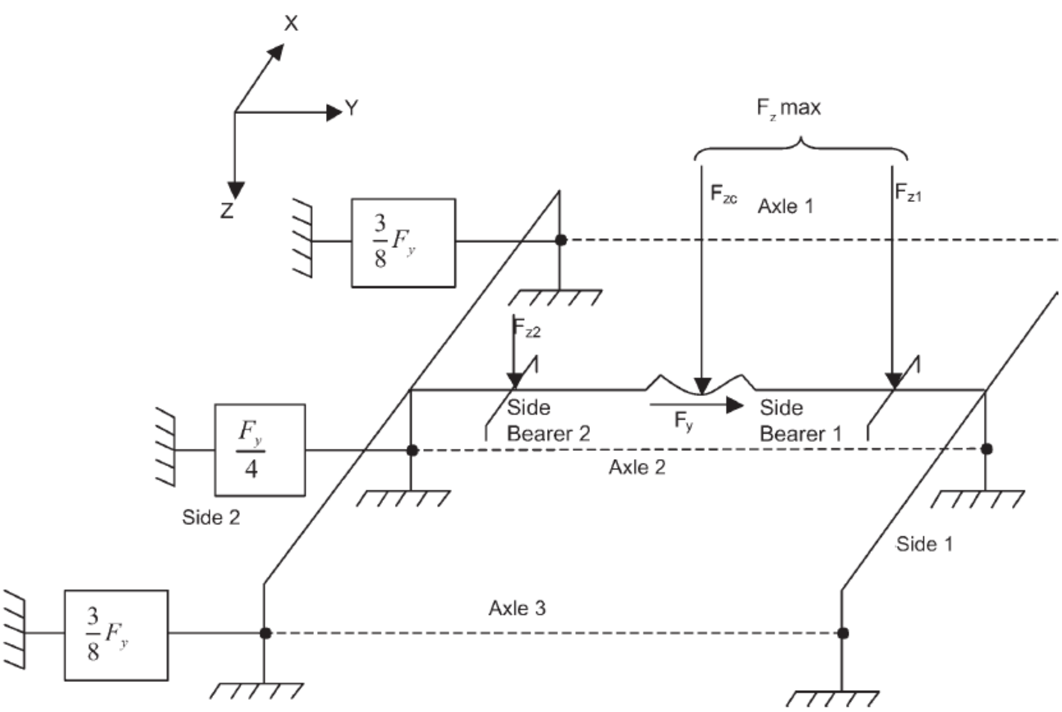
Figure J7



$\{F_y = \pm [0{,}1(F_z \pm m^+g) \pm 0{,}1(F_z+m^+g)]$

Fatigue Tests — Three Axle Bogies

Figure J8



$F_z = 6\ Q_o - m^+g$

$\alpha = 0{,}2\left(\frac{1700}{2b_g}\right)$

$\beta = 0{,}3$

$F_zc = (1-\alpha)\ F \pm \beta(1-\alpha)\ F_z$

Loads on friction pads

Refer to figure J6.

$\{F_{z1} = \alpha F_z \pm \beta\alpha F_z$

$\{F_{z2} = \alpha F_z \pm \beta\alpha F_z$

Transverse load acting on the pivot bearing

Refer to figure J7.

$F_y = \pm [0{,}133(F_z+m^+g) + 0{,}1(F_z+m^+g)]$

J.4 NOTATION

Q_o = Static vertical force at the level of the wheel for a loaded wagon (kN)

m^+ = Bogie mass (t)

F_z = Static vertical force acting on a bogie for a loaded wagon (kN)

$F_z = 4\ Q_o - m^+g$ (for 2-axle bogies)

$F_z = 6\ Q_o - m^+g$ (for 3-axle bogies)

g = Acceleration due to gravity (9,8 m/s^2)

F_y = Transverse force (kN)

F_B = Braking forces (kN)

g^+ = Track twist to be applied to the bogie axles (‰)

α = Coefficient corresponding to the effect of roll

The coefficient is a function of the spacing $2b_g$

β = Coefficient corresponding to the effect of bounce

$2b_g$ = Friction pad spacing (mm)

J.5 OVERVIEW/GUIDELINES

The tests can be divided into three groups:

- Static tests with exceptional in-service loads

  These tests verify that there is no risk of permanent and visible deformation of the bogie frame due to the superposition of the maximum loads that can occur in service.

- Static tests to simulate normal in-service dynamic loads

  These tests verify that there is no risk of fatigue cracks occurring due to the superposition of in-service loads.

- Fatigue tests

  The purpose of these tests is to determine the service life of the bogie frame, to detect potential hidden weak spots - in particular at locations where it is not possible to attach strain gauges - and to assess the safety margin.

Common conditions for Rig Tests

The tests shall be performed using a test set-up that allows the application and distribution of the loads exactly at the same locations where they occur in service, while at the same time correctly simulating the play and the degrees of freedom associated with the suspension and the elements connecting the bogie to the body.

The tests can be performed with or without the suspension.

The suspension damping devices shall be de-activated so as to prevent friction.

The constructional characteristics of the bogie shall be taken into account when determining the manner in which the loads and the resulting reaction forces are applied to the bogie frame. The sketch below shows an example of the application of the loads on 2-axle bogies.

The loads to be applied are detailed in Appendices A, B and C.