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Technical approval of monobloc wheels

Application document for standard EN 13979-1

Homologation technique des roues monobloc - Document d'application de la norme EN 13979-1
Technische Zulassung von Vollrädern - Anwendungsdokument für die EN 13979-1



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Summary

The purpose of this leaflet is to explain or complement the regulations set out in *EN 13979-1* for obtaining UIC technical approval for a wheel. For each chapter of the EN, the leaflet therefore gives explanations or additional material as necessary.

In relation to the EN, this leaflet defines the inspection procedure applied at UIC level to arrive at the decision to grant UIC technical approval.

UIC technical approval is granted to the wheel design. The approval can then be used by any manufacturer once all issues relating to ownership of the design have been dealt with.

1 - Scope

This leaflet also applies to the wheels of powered axles.

When making applications for the UIC technical approval of wheels made from grades ER8 and ER9 steel, regulations on the initiation and propagation of wheel tread defects shall be added to those contained in this document in order to obtain approval.

2 - Reference documents

(see Bibliography - page 66)

EN 13103, Railway applications - Wheelsets and bogies - Non-powered axles - Design method.

EN 13104, Railway applications - Wheelsets and bogies - Powered axles - Design method.

EN 13262, Railway applications - Wheelsets and bogies - Wheels - Product requirements.

EN 13979-1 Railway applications - Wheelsets and bogies - Monobloc wheels - Technical approval procedure - Part 1: Forged and rolled wheels

UIC Leaflet 510-2: Trailing stock - Wheels and wheelsets - Conditions concerning the use of wheels of various diameters.

ERRI B 126/DT 366: Braking problems - Brake control for freight trains on long gradients.

ERRI B 169/RP6: Standardization of wheelsets - Monitoring of solid wheels in service Non-destructive ultrasonic determination of the residual stresses in the rims of solid wheels.

ERRI B 169/RP 9: Standardization of wheelsets - Specification for wheels. Mechanical dimensions. Fatigue strength.

ERRI B 169/RP 10: Standardization of wheelsets - Definition of a specification for solid axisymmetrical wheels Verification of mechanical design: fatigue strength Towards a better shape for the wheel centre.

ERRI B 169/RP 12: Standardization of wheelsets - Production of a universal matrix representative of damage to a railway component with a view to performing fatigue tests.

UIC Leaflet 518: Testing and approval of railway vehicles from the point of view of their dynamic behaviour - Safety - Track fatigue - Ride qualit.

3 - Parameters for the definition

3.1 - Parameters for geometrical interchangeability

No further information. See prescriptions on *EN 13979-1, chapter 3.1* (see Bibliography - page 66).

3.2 - Parameters for thermomechanical assessment

NB : This chapter only looks at the thermomechanical design criteria for tread-braked wheels.
For the thermomechanical tests, a worn rim is defined as a rim with a minimum thickness of 25 +0/ +3 mm between the lathe jaw clamping diameter and the diameter of the wheel tread.

3.2.1 - Drag braking

Thermomechanical behaviour is defined by the maximum energy generated by friction between the brake blocks and the wheel tread that the wheel submitted for approval will be required to dissipate during drag braking.

3.2.1.1 - General

This energy is defined as:

- a power P_a^1 that is a function of time, where $P_a = m \cdot g \cdot v_a$ gradient where:
 - m: mass of the vehicle on rail per wheel [in kg];
 - g: acceleration exerted by gravity [in $m \cdot s^{-2}$];
 - gradient: average gradient of the line (gradient expressed in ‰) (see *ERRI B 126/DT 366* - see Bibliography - page 66).

It depends on:

- an application time t_a (in s) as defined in *ERRI B 126/DT 366*.
- the average running speed v_a [in $m \cdot s^{-1}$], as defined *ERRI B 126/DT 366*.

NB : When one of the application parameters of an already-approved wheel changes, tests should be carried out to check that the thermomechanical behaviour has not deteriorated.

1. In case of mixed braking, only that part of the braking power P_a , that is exerted on the wheels is considered.

3.2.1.2 - Special case of freight rolling stock braked with cast-iron blocks only¹

When monobloc wheels are fitted to wagons that are 100% tread-braked, the following parameters shall be taken into account:

Wheel diameter range in [mm] ^a	1 000 to 920 and 920 to 840	840 to 760	760 to 680
Standard power value	50 kW	42,5 kW	38 kW
Application time	45 min	45 min	45 min
Running speed	60 km/h	60 km/hj	60 km/h
N.B: The standard power values applied correspond to the maximum values resulting from a braking incident with cast-iron brake blocks			

a. These axle-load limit values are taken from UIC Leaflet 510-2 and are valid only for the thermomechanical assessment

NB : For specific types of freight traffic, the values for power and/or application time and/or running speed can be modified to check on the thermomechanical behaviour of these wheels in the context of a limited utilisation.

3.2.1.3 - Special case of freight rolling stock with composite/sintered brake blocks only

Thermomechanical behaviour shall be verified during drag braking, in accordance with point 3.2.1.2 with UIC-approved brake blocks.

3.2.1.4 - Other types of rolling stock (powered and passenger)

Pending the work currently in progress in Working Group B169.10, (see Bibliography - page 66) thermomechanical behaviour shall be verified during drag braking in accordance with point 3.2.1.1 - page 4.

1. P10 grey cast-iron brake block with two 320 mm blocks (1 block on each side of the wheel).

3.2.2 - Braking to a stop

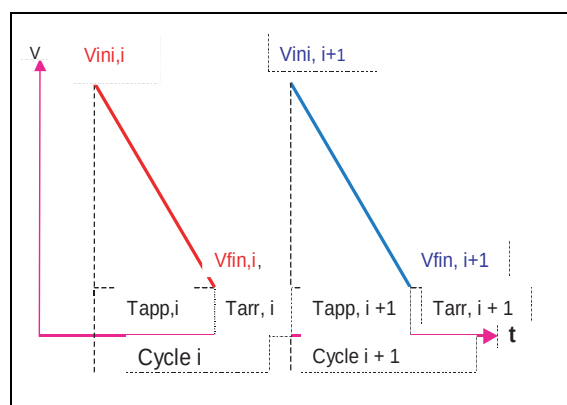
Thermomechanical behaviour is defined by the maximum energy generated by friction between the brake blocks and the wheel tread that the wheel submitted for approval will be required to dissipate when braking to a stop.

3.2.2.1 - General

The energy to be dissipated is defined by the cumulative effect of a succession of braking cycles (index i) with total power $P_a^1 = \sum P_i$. The power P_i is defined as follows:

$P_i = m \gamma_i (V_{ini,i} - V_{fin,i})$ where:

- speed at start of braking:
 $V_{ini,i} [m.s^{-1}]$
- speed at end of braking:
 $V_{fin,i} [m.s^{-1}]$
- train deceleration $\gamma_i [m.s^{-2}]$
- mass of the vehicle on rail per wheel
[in kg]



It depends on:

- an application time $T_{app,i}$
- the interval between two cycles $T_{arr,i}$

3.2.2.2 - Case of freight rolling stock with cast-iron brake blocks

The thermomechanical behaviour does not need to be verified when braking to a stop but only during drag braking (see point 3.2.1.2 - page 5).

3.2.2.3 - Case of freight rolling stock with composite/sintered brake blocks

The thermomechanical behaviour does not need to be verified when braking to a stop but only during drag braking (see point 3.2.1.2).

3.2.2.4 - Other rolling stock types (powered and passenger)

Pending the work currently in progress in Working Group B169.10, thermomechanical behaviour shall be verified during drag braking in accordance with point 3.2.2.1.

1. In case of mixed braking, only that part of the braking power P_a that is exerted on the wheels is considered

3.2.3 - Braking under exceptional load

Thermomechanical behaviour is defined by the maximum braking energy generated by friction between the brake blocks and the wheel tread that the wheel to be approved is required to dissipate under exceptional load.

3.2.3.1 - General

In order to ensure operating safety the wheels must, wherever possible, be able to withstand braking under exceptional load (braking incidents, etc.).

3.2.3.2 - Case of freight rolling stock with cast-iron brake blocks

Verification of thermomechanical behaviour under exceptional load - which corresponds to a braking incident, in other words the fusion of the cast-iron brake block - shall be carried out in accordance with point [3.2.1.2 - page 5](#).

NB : for specific types of traffic the exceptional load must be defined.

3.2.3.3 - Case of freight rolling stock with composite/sintered brake blocks

In abeyance.

3.2.3.4 - Case of suburban type passenger rolling stock

For braking with cast-iron brake blocks, verification of thermomechanical behaviour under exceptional load - which corresponds to a braking incident, in other words the fusion of the cast-iron block - shall be carried out in accordance with point [3.2.3.2](#).

NB : for specific types of traffic, the exceptional load must be defined.

3.2.3.5 - Case of powered axles

When specific measures are not taken (diagnostics, operating rules) a distinction should be made between the following cases:

1. Failure of the dynamic brake or trailing vehicle (without dynamic brake activated):

For drag braking:

- ◆ with cast-iron brake blocks, apply point [3.2.1.2 - page 5](#)
- ◆ with composite/sintered brake blocks, apply point [3.2.1.3 - page 5](#)

For braking to a stop:

- ◆ with cast-iron brake blocks, apply point [3.2.2.2 - page 6](#)
- ◆ with composite/sintered brake blocks, apply point [3.2.2.3 - page 6](#)

2. Braking incident:

- ◆ with cast-iron brake blocks, apply point [3.2.3.2 - page 7](#)
- ◆ with composite/sintered brake blocks, apply point [3.2.3.3 - page 7](#)

3. Wheel slip:

A check shall be carried out to ensure that the thermomechanical loading is not higher than that recorded in the other cases above.

If it is not, no particular action is necessary, otherwise, the design must take account of the loadings recorded.

3.2.3.6 - Case of passenger coaches

For braking with cast-iron brake blocks, verification of thermomechanical behaviour under exceptional load - which corresponds to a braking incident, in other words the fusion of the cast-iron block - shall be carried out in accordance with point **3.2.3.2 - page 7**.

NB : for specific types of traffic, the exceptional load must be defined.

4 - Description of the wheel to be approved

The designer of the wheel submitted for approval must provide full documentation as defined in Appendix **H** - page 41.

5 - Assessment of geometric interchangeability

Appendix F - page 37 to this leaflet gives a basic diagram for verifying interchangeability using the example of a standard ERRI wheel (axle-load of 22,5 tonnes).

6 - Assessment of thermomechanical behaviour

No further information. See prescriptions on *Norm EN 13979-1, chapter 6*.

7 - Assessment of mechanical behaviour

7.1 - General procedure

The assessment procedure to be followed is illustrated in point [B.1 - page 22](#). This leaflet requires a mechanical assessment procedure under exceptional load in addition to the provisions of *Norm EN 13979-1*.

7.2 - First stage - Calculation

For the mechanical design of wheels in accordance with this leaflet, no limit is set for the ratio between maximum axle-load and running tread diameter.

Unlike the thermomechanical assessment, mechanical behaviour can be assessed exclusively by calculation. It is for this reason that the designer of the wheel is asked to demonstrate that the calculation model being used will provide reliable results. The procedure to be followed for this demonstration is set out in [Appendix C - page 26](#) to this leaflet.

Appendix C to EN 13979-1 is considered as **normative**.

7.2.1 - Applied forces

7.2.1.1 - Exceptional loading

Exceptional loading of wheels for all types of rolling stock is defined in *UIC Leaflet 518, point 3.4* ([see Bibliography - page 66](#)) as follows:

- Vertical force $F_{z_{lim}} = 90 + Q$ where Q = load per wheel in kN, but also with a limitation linked to speed as indicated in the table below:

Speed in km/h	$F_{z_{lim}}$ in kN
$v < 160$	200
$160 \leq v < 200$	190
$200 \leq v < 250$	180
$250 \leq v < 300$	170
$300 < v$	160

- Lateral force $F_{y_{lim}} = \alpha (10 + P_0/3)$ where P_0 = axle-load in kN and $\alpha = 1$ for all rolling stock types.

7.2.1.2 - Service loadings for non-tilting rolling stock

1. Conventional forces

The assessment is carried out in accordance with *EN 13979-1, point 7.2.1.*

The forces to use are the conventional forces defined for axles in standards *EN 13103* and *EN 13104* (see Bibliography - page 66).

These forces shall apply when the proportion of line section comprising curves with a radius of ≤ 800 m is less than 24% of the total distance covered in one life cycle.

2. Non-conventional forces

If the proportion of sections consisting of curves with a radius ≤ 800 m is greater than 24% of the total distance covered in one life cycle, then the load spectrum shall be defined in accordance with *ERRI B 169/RP 12* (see Bibliography - page 66) or the simplified method in Appendix G - page 38.

7.2.1.3 - Service loading for tilting rolling stock: acceleration (a_q) $> 1 \text{ ms}^{-2}$

1. Conventional forces to be used for calculations

The following load cases shall be considered in cases where they are applicable:

Case 1: Straight track

$$F_{z1} = -1,25 \text{ Q.g}$$

$$F_{y1} = 0$$

Case 2: Curved track

$$F_{z2} = -1,25 \text{ Q.g}$$

$$F_{y2} = 0,8^a \text{ Q.g for non-guiding axles}$$

$$F_{y2} = 0,9^a \text{ Q.g for powered and guiding axles}$$

Case 3: Switches and crossings

$$F_{z3} = -1,25 \text{ Q.g}$$

$$F_{y3} = -0,6 \cdot F_{y1} = -0,6 \cdot 0,6 \text{ Q.g}$$

$$= -0,36 \text{ Q.g for non-guiding axles}$$

$$F_{y3} = -0,6 \cdot F_{y2} = -0,6 \cdot 0,7 \text{ Q.g}$$

$$= -0,42 \text{ Q.g for powered and guiding axles}$$

a. These values are consistent with standards *EN 13103* and *13104* for the design of axles for tilt-body rolling stock.

2. Non-conventional forces

If the proportion of line sections with curves of radius ≤ 800 m is greater than 24% of the total distance covered in one life cycle, the load spectrum shall be defined in accordance with *ERRI B169/RP12*.

7.2.2 - Calculation procedure

7.2.2.1 - Under exceptional loading

The assessment shall be carried out by calculating the principal stresses at all points of the mesh for the three load cases.

7.2.2.2 - Under service loading for non-tilting rolling stock

The assessment shall be carried out in accordance with *EN 13979-1, Point 7.2.2*.

7.2.2.3 - Under service loading for tilting rolling stock

The assessment shall be carried out in accordance with *EN 13979-1, Point 7.2.2*.

7.2.3 - Decision criteria

7.2.3.1 - Under exceptional loading

For each node, the VON MISES equivalent stress must remain less than or equal to the elasticity limit of the material.

7.2.3.2 - Under service loading for non-tilting rolling stock

1. Uniaxial fatigue criteria to be used for axisymmetrical wheels

The fatigue criteria to be used and the method and assumptions for determining these stresses are described in Appendix **B** - page 22.

2. Multiaxial fatigue criteria to be used for non-axisymmetrical wheels (with holes in the web for example)

If there exists a multiaxial stress during one wheel revolution, then a multiaxial fatigue criterion shall be used (currently under development in Committee B169).

7.2.3.3 - Under service loading for tilting rolling stock

1. Uniaxial fatigue criteria to be used for axisymmetrical wheels

The fatigue criteria to be used and the method and assumptions for determining these stresses are described in Appendix **B**.

2. Multiaxial fatigue criteria to be used for non-axisymmetrical wheels (with holes in the web for example)

If there exists a multiaxial stress during one wheel revolution, then a multiaxial fatigue criterion shall be used (currently under development in Committee B169).

7.2.4 - Assessment of uniawial mechanical design for special cases

Such cases can include for example wagons with a large overhang when propelled. Checks should be carried out to ensure that the conventional forces are applicable. If this is not the case, the assessment shall be carried out in accordance with *EN 13979-1* but with loadings determined using *ERRI B169/RP12* or the simplified method described in Appendix G - page 38.

7.3 - Second stage - Bench test

This assessment is carried out in accordance with *EN 13979-1, Appendix D*. This Appendix D is considered to be **normative** for this UIC leaflet.

The forces to be applied are obtained using a global matrix from which the test stresses should be defined.

Three cases are considered:

- The global matrix of stresses is known, since already determined for the same application in accordance with *ERRI B 169/ RP 12*. Where this is the case, there is no need to carry out new field tests.
- The global matrix of stresses is not known. Where this is the case, field tests must be carried out in accordance with *ERRI B 169/ RP 12* in order to determine the local stress matrix to be reproduced on the test bench.
- The global matrix of loading is unknown for the entire application. The global matrix is made up in this case of the superimposition of known elementary matrices and matrices determined additionally through field testing (*ERRI B 169/ RP 12*) taking account of weighting factors.

8 - Assessment of accoustical behaviour

No further information. See prescriptions on *EN 13979-1, Point 8*.

9 - Technical approval documents

The designer of the wheel to be approved must provide all the documents stipulated in Appendix H - page 41 (Procedure for the technical approval of wheels).

At the end of the conformity assessment procedure, if it is successful, UIC shall issue its approval and send to the supplier a conformity assessment certificate in accordance with Appendix I - page 64.

Appendix A - Assessment of thermomechanical behaviour

A.1 - Assessment flow chart

See Norm EN 13979-1, Appendix A1.

A.2 - Brake rig test procedure

A.2.1 - Definition of brake applications

The parameters for the brake applications are based on the stipulations of point 3.2 - page 4. When braking to a stop, the brake applications should generate if possible a crack depth of 9 ± 1 mm. However, if this depth is not obtained after a maximum of 270 applications, the test shall be halted.

In the case of tread-braked monobloc wheels with wheel tread diameters of 1 000 mm to 840 mm this gives:

- Type of brake blocks for drag braking:
 - block made from P10 grey cast-iron or composite material, depending on the intended use of the wheel,
 - brake configuration Bg 2 x 320
- Type of brake blocks for braking to a stop:
 - generally blocks made from composite materials, fitted so as to protrude by 5 mm

Table 1 : Wheel with new rim, $\varnothing$ 1 000 to 840 mm

Wheel	Type of brake application	Number of brake applications	Nominal brake power	Duration of braking	Speed
New wheel rim	Drag braking	3	30 kW	45 ± 1 min.	60 ± 1 km/h
	Braking to a stop	270 ^a	Initial braking speed: 150 ± 2 km/h Axle-load: 22,5 t Duration of braking: 55 ± 5 s Initial braking temperature: $\leq 50^\circ\text{C}$		
	Drag braking	1	40 kW	45 ± 1 min.	60 ± 1 km/h
	Drag braking	$1 + n$ ^b	50 kW	45 ± 1 min.	60 ± 1 km/h

a. or until one of the cracks is 9 ± 1 mm deep, starting from the notch.

b. number of drag braking applications at 45 ± 5 kW until fracture, or until a state close to fracture, or interrupt test if the residual stresses stabilise, but a maximum of 10.