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Track equipment for 25 tons (250 kN) axle loads on ballasted track

Armement pour voie ballastée chargée à 25 tonnes (250 kN) par essieu
Gleisbewehrung für 25 Tonnen (250 kN) auf Schotteroberbau

UNION INTERNATIONALE DES CHEMINS DE FER
INTERNATIONALER EISENBAHNVERBAND
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Contents

Summary

This leaflet sets out recommendations for track equipment to be used on the main lines of rail networks operating freight wagons loaded at 250 kN/axle for line categories E4 and E5, as understood by *UIC Leaflet 700* and running at maximum speeds of 100 km/h.

These recommendations are based on the results of previous work carried out in ORE (ERRI) and UIC Committees in connection with the increase in axle loads from 200 kN to 225 kN. They are only valid for ballasted tracks.

1 - Introduction

Increasing axle loads from 225 kN to 250 kN is primarily an economic issue. However the key remains a technical question for the track and for the vehicle.

There are complexities associated with dynamic loads/dynamic forces developed from track / vehicle interaction.

Each element of the track structure responds differently to changes in axle load, depending on its design and composition as well as on its interaction with other components.

When considering the phenomenon of track deterioration, some aspects of this deterioration must be clearly defined:

- fatigue (in general rail fatigue but also fatigue of fastenings, sleepers,…),
- wear (in general rail wear but also wear of fastenings, sleepers, ballast,…),
- deterioration of track geometry quality,
- deterioration of track components,

and their combined action results in deterioration of the track system.

This leaflet will not set out any fatigue limit, wear limit or destruction limit for the track or its individual components. Most of the track deterioration is strongly associated to the development of dynamic loads resulting from wheel/rail contact. These dynamic loads are influenced on the one hand by track geometry quality, track geometry layout, track-structure design,…. and on the other hand by the axle load, wheel quality, vehicle design, speed,…

Because of the complexities associated to dynamic forces it is difficult to set out any clear limits on the trackside.

Research, test results, railway literature, reports and experience have shown that the best way to decrease the deteriorating effects on track when operating with high axle loads is through reduction in dynamic wheel loads. Both the total wheel load, Q_{tot} (static + dynamic) and the dynamic part of it, have to be considered.

Preconditions for reducing dynamic loads include:

- good track geometry quality,
- adapted speed,
- good wheel quality,
- track-friendly vehicle design.

Empirical results have been obtained from extensive test runs during which wheel-rail forces were measured on a continuous basis. The results show that a higher static axle load does not necessarily lead to a higher dynamic load, if the vehicle from the outset is designed to exert reduced forces on the track.

On straight track in good condition, the increase in the dynamic part of the axle load of freight trains is small when the speed rises from 80 to 100 km/h. This increase is essentially due to the differences in track geometry quality.

The relationship between maximum axle load and track deterioration increases with speed, but this deterioration is all the higher when the track quality is poor.

Research has also shown that the proportion of differential settlement is amplified by disparities in axle load. A mixed traffic scenario with full trainloads of wagons loaded at 225 kN/axle and passenger trains running at 160 km/h will result in greater track settlement than a uniform pattern of full trainloads with high wagon axle loads but running at a lower speed.

These conclusions are based on different studies carried out by *ERRI, in ORE C 138, ORE D 117, ORE D 141, ORE D 161* (see Bibliography - page 8) and the experience of railways operating 250 kN traffic.

This leaflet only deals with track construction and focuses more specially on main track components.

2 - Maximum permissible forces

2.1 - Maximum vertical forces

The maximum permissible forces exerted on the track are defined:

- for wagons with an axle load ≤ 225 kN, in *UIC Leaflet 518* (see Bibliography - page 8).
  They are as follows, for speeds ≤ 160 km/h and cant deficiencies ≤ 130 mm:

  • $Q_{lim} = 200$ kN
  • $(Q_{qst})_{lim} = 145$ kN

  Vehicles accepted on the basis of *UIC Leaflet 518* comply with these limits.

- for wagons with an axle load > 225 kN and ≤ 250 kN, in *UIC Leaflet 518-2* (see Bibliography - page 8).
  They are as follows, for speeds ≤ 100 km/h and cant deficiencies ≤ 100 mm:

  • $Q_{lim} = 210$ kN
  • $(Q_{qst})_{lim} = 155$ kN

  Vehicles accepted on the basis of *UIC Leaflet 518-2* comply with these limits.

2.2 - Force levels and running conditions acceptable on a given line

The values as set out in *UIC Leaflet 518* are considered acceptable on most conventional lines which can thus accommodate, at their maximum speed, wagons accepted on the basis of this leaflet.

The values as set out in *UIC Leaflet 518-2* are acceptable on lines which comply with the requirements for track equipment defined in point 3 - page 5. Such lines can accommodate, at their maximum speed, wagons accepted on the basis of this leaflet. In terms of running these wagons on other lines, the Infrastructure Manager can decide:

- to accept the operation of these wagons at their maximum speed, if this solution is deemed acceptable considering the condition of the track and its state of maintenance,

- to accept the operation of these wagons with speed restrictions, in order to observe the limits set out in *UIC Leaflet 518*,

- to refuse the access of these wagons on such lines.

3 - Track equipment for new tracks or renewed tracks dedicated to 25 t axle loads

The recommendations below make reference to the following track components:

- sub-grade,
- ballast,
- sleepers,
- fastenings,
- rails,
- switches and crossings.

These recommendations apply to the construction of new track, existing track and/or major renewals of existing track, which comply with the requirements for track equipment.

Occasional and/or infrequent operations involving 250 kN axle loads on lighter track infrastructures are perfectly possible.

3.1 - Sub-grade

Most railway lines have already been built and the construction of a new track bed under existing track is a major task. Hence it is only when building a new line and/or completely rebuilding an existing line, that adaptations to the track bed will be possible.

The importance of a good quality of sub-grade and the necessity of repairing the sub-grade when the quality is not good, should be clearly stated.

Before track relaying, the formation should be investigated and if necessary improved on the basis of *UIC Leaflet 719* (see Bibliography - page 8).

In this case, the provisions of *UIC Leaflet 719* should be applied.

The thickness of the track bed used is determined in *UIC Leaflet 719, point 2.4* "Composition and thickness of the track-bed layers to give the desired bearing capacity", which provides for a theoretical calculated additional track-bed thickness of 7 cm for a line used by wagons loaded at 250 kN/axle as compared to 225 kN/axle.

3.2 - Ballast

As a recommendation the thickness of the ballast layer beneath the lowest rail seat should be 300 mm minimum.

It is recommended that the ballast used should be of high intrinsic quality. The conditions and test models are as described in *EN 13450:2002* (see Bibliography - page 8).

3.3 - Sleepers and sleeper spacing

3.3.1 - Sleeper types

The use of concrete sleepers has become almost the rule on European railways. These concrete sleepers should be designed to the rules set out in *UIC Leaflet 713* and *EN 13230* (see Bibliography - page 8).

Although wooden and steel sleepers are employed to a lesser extent during renewal operations in continental Europe, the experience of railways operating heavy axle loads elsewhere in the world indicates that these sleepers can also accommodate such loads. The type of traffic operated on these lines is however almost exclusively freight traffic. Passenger services are generally infrequent and operate at low speeds.

3.3.2 - Sleeper spacing

A sleeper spacing of 600 mm should be taken as the basic recommended value for operations at 250 kN/axle.

3.4 - Rail-fastening systems

Any elastic fastening system may be used, provided it complies with the provisions of *EN 13481, Parts 2 to 7* (see Bibliography - page 8).

However, when loads in excess of 250 kN are planned, it is recommended that the rail-fastening systems used comply with *EN 13481:2003, Part 8* (see Bibliography - page 8).

In sharp curves, new phenomena linked to the fastening system can occur. Reinforced fastening systems may therefore be needed in small-radius curves.

3.5 - Rails

Generally speaking, the use of continuous welded rails (CWR) should be considered as a standard. Experience shows that electric flash-butt welds have a longer service life than aluminothermic welds.

Use of profile 60 E1, grade 260 rails as per *EN 13674-1:2003* (see Bibliography - page 8) is the reference for tracks operated at 250 kN axle loads on straight track and large-radius curves.

Running on small-radius curves leads to greater lateral wear on the rails, and grades with a higher wear resistance are therefore recommended.

UIC Leaflet 721 (see Bibliography - page 8) gives indications for the use of rail steel grades on the basis of tonnage and curve radius.

Design of insulated joints must comply with the use of CWR.

Insulated joints remain a problem for maintenance and need special attention when operating at 250 kN axle loads.

3.6 - Switches and crossings

In general, switches and crossings are the costliest part of all track equipment in that they are subject to the highest dynamic loads and highest impact loads.

Special attention must therefore be paid both to good switch design and good bearing capacity of the formation.

3.6.1 - Turnout type 60 E1

Use of 60 E1 profile switches and crossings fully welded to the adjacent tracks is recommended.

Insulated joints should be installed in the less loaded branch of the turnout.

3.6.2 - Bearers

Wooden sleepers and bearers must comply with the provisions of *EN 13145:2001* (see Bibliography - page 8)

Prestressed bearers for switches and crossings must comply with the provisions of *EN 13230:2003, Part 4* (see Bibliography - page 8).

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Warning

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