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Original

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Recommendations for the use of rail steel grades

Recommandations pour l'emploi de différentes nuances d'aciers à rails

Empfehlungen für die Verwendung unterschiedlicher Schienenstahlsorten



INTERNATIONAL UNION
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1st edition, January 1980	First issue
2nd edition, March 2005	Overhaul of leaflet for conformity with CEN standards
3rd edition, January 2015	Overhaul of leaflet with new knowledge from e.g. EU-project INNOTRACK

The person responsible for this leaflet is indicated in the UIC Code

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Summary

During recent years significant research and development aimed at RCF of rails has been conducted, motivated by the more frequent occurrence of RCF experienced by railways.

Further, the way in which the *UIC Leaflet 721, 2nd edition* has been employed varies between Infrastructure Managers across Europe.

This new knowledge also included a systematic approach to combine the experience from the current operational situation and respective degradation models.

Due to the new findings steels with a hardness ≥ 350 HBW may be installed also in curves with larger radii than previously recommended.

This leaflet gives an overview on the topic of rail grade selection. For more detailed information on specific topics, please refer to the bibliography.

1 - Introduction

Increases in railway traffic, heavier axle loads, higher speeds and the introduction of new generations of rolling stock have increased loads and degradation rates of rails. In particular, the occurrence of rolling contact fatigue in many larger radii curves has increased.

In the EU-project INNOTRACK the influence of the steel grades on the degradation behaviour of the rails was a main research topic. The knowledge generated in *INNOTRACK Concluding Technical Report*, gave some important impulse for the current revision of the *UIC Leaflet 721* (see [Bibliography - page 14](#)). This leaflet reflects a common understanding between UIC and UNIFE experts.

One conclusion of the INNOTRACK project which is considered in this leaflet is that steels with a hardness ≥ 350 HBW (see [List of abbreviations - page 13](#)) may be installed also in curves with larger radii than previously recommended.

The aim of the current *UIC Leaflet 721* is to provide assistance in the selection of rail steel grades so that the most suitable rail is chosen based on the specific railway operating conditions in a case-by-case analysis.

The presented recommendations do not apply for heavy haul conditions (over 25 tons/axle). Further, rail grades under trial are excluded, in particular bainitic grades are only referred to in a future perspective.

Timely execution of maintenance measures (tamping, grinding/milling, and lubrication of the rail-wheel-interface) has a decisive impact on the service life of rails in curves.

Often, a combination of the two measures - a proper choice of rail steel grade and related maintenance procedures - is necessary in order to achieve a cost-effective service life for rails.

The decision to select the appropriate rail grade can only be taken considering the historical occurrence of the specific rail defects as well as prevailing specific operating conditions (speed, traffic type, track geometry and permanent-way design, lubrication, weather conditions etc.).

In addition to the issue of rail grade selection, the *UIC Leaflet 721* also covers recommendations to assure quality when installing and maintaining rails.

2 - Rail defects influencing steel grade selection

There are several potential defects that influence the steel grade selection. These defects may arise on the head, web and foot of the rail, or can be limited to the rail ends or welds. Different alloys and heat treatments influence the mechanical properties of the rails - such as the residual stresses and not least the weldability of rail steels - and thus the degradation under traffic. Improvements in steel production, the increasing hardness of standard rail grades and the changes in traffic have led to a change in the occurrence of the most relevant rail defects.

In recent years the dominating rail defects leading to the highest maintenance costs arise on the rail head and will be summarized in the following.

The numbering follows the classification in *UIC Leaflet 712* (see [Bibliography - page 14](#)).

2.1 - Wear (UIC-defect code 220)

The wear mechanism depends on the relationship between (dynamic) contact stresses, slip conditions and material properties.

2.1.1 - Lateral wear (UIC-defect code 2203)

In tight curves with (unlubricated) wheel flange contact the highest contact stresses occur on the gage face of the rail head. The highest wear rates occur due to the adhesive wear mechanism and is commonly accompanied by plastic deformation.

From today's perspective high strength pearlitic steels withstand these operational demands best.

An increase in hardness from 260 HBW to 350 HBW reduces the wear rate approximately by a factor of three.

2.1.2 - Corrugation (UIC-defect code 2201 and 2202)

Corrugation is a periodic type of wear. Usually there is a division into short pitch and long pitch corrugation depending on the peak-to-peak distance.

The degradation rate (depths of the troughs) can be reduced by a choice of high strength pearlitic steels. Occurrence cannot usually be prevented, however the amplitude and the wavelength will be reduced by such a choice (see *Testing of hsh rails Report in high-speed tracks to minimise rail damage* in [Bibliography](#)).

2.2 - Plastic deformation (UIC-defect code 223 and 224)

Defect 223 crushing and/or 224 local batter of the running surface may occur if the plastic limit of the rail steel is repeatedly reached not only at the surface but also at depths of a few millimetres.

A harder rail grade (i.e. a rail material with a higher yield limit) is beneficial to prevent plastic deformation.