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Translation

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Maximum permissible wear profiles for switches

Profils d'usure maximum admissible pour les aiguilles
Maximal zulässige Abnutzungsprofile für Weichen



UNION INTERNATIONALE DES CHEMINS DE FER
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Contents

Summary	1
1 - Characteristics of new and worn wheels	2
2 - Review of theoretical concepts	3
2.1 - Safety against derailment	3
2.2 - Contact between tyre and rail	3
2.3 - Shear angle	4
3 - Contact between attacking wheel and track components	5
3.1 - Tangential contact	5
3.2 - Interference contact	5
4 - Construction of gauges	8
4.1 - Frontal attack with worn flange	8
4.2 - Side attack with new flange	10
4.3 - Value of γ_A	11
4.4 - Wheel uplift	12
5 - Conclusions	13
6 - Observations	14
Bibliography	18

Summary

The purpose of this leaflet is to recommend a method of producing templates for assessing what work needs to be carried out on switch and stock rails in service and, where necessary, on the moving point rails of crossings.

To enable the chain of reasoning to be followed, the leaflet first of all reviews:

- the characteristics of new and worn wheels;
- a certain number of theoretical concepts relating to safety against derailment and to tyre/rail contact.

1 - Characteristics of new and worn wheels

The tread profile of new wheels is given in *UIC Leaflet 510-2, Appendices A, B.1 and B.2*.

The shape of the worn flange is defined in *UIC Leaflet 510-2, point 1.5.1* and in the *RIV Agreement 2 000 point 24.5*, as q_R , i.e. the horizontal distance between two points of the profile characterising the angle of the active face of the flange; these points are:

- the point of the profile situated 10 mm radially outside the running circle (reference point); and
- the point situated 2 mm radially inside the tip of the flange defined statistically and not as the point of smallest permissible angle.

The minimum q_R is 6,5 mm.

There should moreover be no sharp edge or burr on the outer profile of the flange at a distance from the flange tip exceeding 2 mm.

2 - Review of theoretical concepts

2.1 - Safety against derailment

Safety against derailment may be considered as guaranteed when the ratio between guiding force Y and wheel load Q occurring simultaneously, i.e. $\frac{Y}{Q}$, is below a limiting value which is a function of the coefficient of friction μ between wheel and rail and of the angle of inclination γ_A of the tangential contact plane at contact point A between wheel and rail on level track.

The relationship between these three items established by BOEDECKER and also by NADAL and CHARTET, is written as follows:

$$\frac{Y}{Q} = \frac{\operatorname{tg} \gamma_A - \mu}{1 + \mu \operatorname{tg} \gamma_A} \quad (1)$$

or, in another form:

$$\gamma_A = \operatorname{arc} \operatorname{tg} \frac{Y}{Q} + \operatorname{arc} \operatorname{tg} \mu \quad (2)$$

Starting with a value $\frac{Y}{Q}$ which is considered admissible and an assumed value of μ based on experience and experiment, equation 2 determines the minimum permissible angle of inclination γ_A to the plane of contact having regard to safety against derailment.

In order to eliminate the risk of flange climbing as far as possible, it must be ensured that no point of the flange with a contour slope of less than $\operatorname{tg} \gamma_A$ can come into contact with track components.

2.2 - Contact between tyre and rail

This problem has been studied by HEUMANN and BOUTELOUP. For the information of the reader the fundamental concepts are outlined below.

The wheels do not remain constantly parallel to the rails, and the flanges may present a shear angle.

When the wheel in the track is actually parallel to the rails (axle perpendicular to the track), i.e. with an approach angle of $\alpha = 0$, the sections of the wheel through planes perpendicular to the axle, which are circles, project into the plane perpendicular to the track in a vertical direction.

When the wheel forms an approach angle in the track $\alpha \neq 0$, the sections of the wheel project along a narrow elliptical path. The projection of the wheel longitudinally to the track into a plane perpendicular to the track produces the "apparent tangential contour" which is formed by the envelope of the ellipses originating from different points of the tyre profile in a meridian section.

The points situated on this envelope are no longer in the vertical meridian plane of the axle.

2.3 - Shear angle

The largest shear angle which needs to be taken into account is determined using the formula $\text{tg } \alpha = \frac{a}{R} + \frac{\sigma}{a}$ in which:

- R is the smallest track radius,
- 2σ is the maximum play in track,
- $2 a$ is the maximum fixed wheelbase.

For example:

with $R = 190 \text{ m}$ $2 \sigma = 0,027 \text{ m}$ and $2 a = 4,50 \text{ m}$

we obtain:

$$\alpha = 1^\circ$$

In switch and crossing work, beyond the toe of the switch, the approach angle consists of:

- the angle of skew calculated previously, namely 1° and
- the switch entry angle, which is typically 1° .

3 - Contact between attacking wheel and track components

The two possible cases of contact between the attacking wheel of a wheelset and track components are:

- tangential contact,
- interference contact.

3.1 - Tangential contact

Tangential contact does not normally involve any risk of derailment.

The BOEDECKER, NADAL and CHARTET equation shows, moreover, that the larger the flange angle γ_A , the greater is the guiding force Y which the wheel can withstand for a given wheel-load Q .

Consequently, in the event of tangential contact between rail and worn flange, safety against derailment is generally improved through the increase in the flange angle.

3.2 - Interference contact

When a wheel is moving in tangential contact to the rail its apparent contour may encounter, in the switch and crossing work:

- switches not fully closed, with which it may make interference contact: this is frontal attack, and the worn flange is the greatest risk;
- switches whose running edge is damaged (ragged, side-cut) beyond the toe of the switch tongue, which may also result in interference contact: this is side attack, when the new flange is the greatest risk.

When contact between wheel and track components is of the interference type, safety against derailment will be guaranteed when such contact occurs at points where the angle of the wheel tread is greater than the minimum $\text{tg } \gamma_A$.