Adjustment and calibration of Straightedges

Introduction

The guiding principle in the Dutch ProRail norm RLN00127 is that the measuring deviations from a straight edge should be less than 5% of the weld geometry standard. The official control (calibration) is done by a certified institute. However, the user is also obliged to check the straightedge regularly on a reference rail and to document these findings in relation to the official calibration results. On the reference rail the deviations from the norm should not exceed 4%. For larger deviations, it is required to either carry out an official calibration, or to be sent the straightedge to the supplier for adjustment. After an adjustment, the deviations should not exceed 2% of the standard.

Official caliber

For an official calibration of a straightedge a caliber is used with the following features:

1. A standard rail piece without a weld;
2. Length about 130 cm;
3. Vertical deviations in such a way that the QI lies around 1.0 (1.8 mrad), the norm at 140 km/h. This deviation can be created by milling a horizontal cut in the middle of the rail over a length of 50 cm, in the web, directly underneath the rail head. With 2 wedges the rail head is lifted relative to the web to create a deviation with a QI of about 1 for 140 km/h. For further details see Appendix.
4. The caliber is precision measured by a certified institute and the measurement results are stored in a file with the same format as a RAILPROF data file;
5. Through the RAILPROF desktop software the reference values are determined, being the maximum values according to this desktop software, referred to as:
   QIR, TOPmaxR, TOPminR, ZIJmaxR en ZIJminR.

Reference rail

For checking a straightedge by the user, a reference rail is used with the following features:

1. A standard rail piece without weld;
2. Length about 130 cm;
3. Deviations in such a way that the QI at 140 km/h is between 0.8 and 1.5, with a preference for a value around 1.0. This selection is performed with a RAILPROF;
4. Through the RAIPROF desktop software the reference values are determined, being the maximum values according to this desktop software, referred to as:
   QIR, TOPmaxR, TOPminR, ZIJmaxR en ZIJminR.
5. Immediately after an official calibration the deviations of the reference rail are measured with the straightedge. These values are scaled to the values of the official calibration, so that deviations of the reference rail have the same numerical value as at the official caliber. The correction factor based on this ‘zero’ measurement should be applied to all results of follow-up measurements at the reference rail.

Acceptance standard of straightedge

The acceptance test of a straightedge consists of a series of 5 measurements. After each measurement, the straightedge is lifted from the rail and then repositioned. For each measurement, per component, the difference is determined of the current value, indicated by ACT, and the reference (caliber) value REF, and this difference is divided by the admissible value for the geometry component, NORM, according to:

- Δ = | REF – ACT |/NORM;

To approve a straightedge the following limit values for Δ are applicable:

- Δ < 5% for calibration on precision caliber, otherwise adjustment;
- Δ < 4% for control on reference rail, otherwise precision calibration, or adjustment;
- Δ < 2% after adjustment, otherwise readjustment.

In the table below a NORM value for QI=1 (140 km/h, 1.8 mrad) and for QI=1 (300 km/h, 1 mrad) is presented. Although in vertical direction only a standard applies for QI, also a separate NORM for the deviations in vertical direction is attained of 0.3 mm. This leads to the following limit values.

Component	**NORM**	**0.05 * NORM**	**0.04 * NORM**	**0.02 * NORM**
QI 140 km/h	1.800 mrad	0.090 mrad	0.072 mrad	0.036 mrad
QI 300 km/h	1.000 mrad	0.050 mrad	0.040 mrad	0.020 mrad
Vertical displ.	±0.300 mm	±0.015 mm	±0.012 mm	±0.006 mm
Horizontal displ.	±0.500 mm	±0.025 mm	±0.020 mm	±0.010 mm

If up to 2 measuring values fall outside the norm, the whole series of 5 measurements may be repeated once.

Certificate

After calibration, a certificate is issued stating that the straightedge is approved, or rejected. Per component the largest deviation from the reference in absolute terms is presented, together with the percentage of the norm. If all deviations are smaller than the relevant standard, the device is approved for a period of 3, 6 or 12 months, depending on the maximum deviation established and the intensity of use.

At non-compliance with the standard (rejection) the straightedge need to be adjusted by the manufacturer. After the adjustment, a calibration report is issued by the supplier with the identified deviations as described above.

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Appendix

Description of simple reference rail for validating Railprof measurements:

Since it appears that grinding a correct Cosine in a railhead poses a problem with kinked lines we have the following practical solution:
1. Start with a new rail segment with length of 1.3m;

2. Make a horizontal cut in the middle of said rail segment with length of 0.5m underneath the rail head through the web;

3. Place a wedge from either side into the middle of the cut so they both lay on top of one another;

4. Tap the wedges alternating left and right until Railprof measures a QI of 1 at 140km/h. Repeat tapping and measurement until this QI of 1 is attained;

5. When the correct value has been attained, theoretically at +/- 125mm, the two wedges can be welded together to fixate position. Preferably weld on wedges only and not on the rail;

6. Cut off excess length of wedges;

7. Upon acceptance of the method the rail was measured on a precision measuring table with certified report.

Theoretical background:
1. Eddy current measurement will not measure full depth of head;

2. The lifting of the head trough use of wedges will generate a force that will deform the head in as a spline function (elastic line), that will practically have a cosine shape. Maximum slope is 3*A/L, while for a cosine it is π*A/L (A is depth or height = 2 times amplitude). A should be around 0.3 mm to attain an elevation of 3*.06 = 1.8 mrad;

3. There will be a natural line with continuity in the first, second and third derivative and thus no kinks;

4. The web is about 3 times as tall as the head and thus 27 times stiffer, resulting in about 0.01 mm of deformation in the web;

5. Care must be taken to avoid plastic deformation of the head.