LASEROWE
SYSTEMY
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# Rail Head Profile Gauge

**Specification:**

Weight: 12 kg (gauge + datum beam + data logger)

Accuracy: +/- 0.02 mm

Operating temperature: 0 ÷ +40 °C

Measurement time: depending on rail head profile measured sector, usually < 30 sec + mounting time, entering the header data into the data logger

Calibration: once a year – may be carried out by the qualified and certified user staff, regular checkup using the provided master template is recommended every month

Reference list:

1. Huta Katowice Steel Plant (Poland), Dabrowa Gornicza (Poland)
2. Research and Technical Centre of Polish State Railways, Warsaw (Poland)
3. Diagnostic and Welding Centre of Polish State Railways, Warsaw (Poland)
4. ASMO – private company paying track and switch diagnostic and repair services to Polish State Railways Infrastructure, Gdynia (Poland)
5. Rail Welding and Reprofiling Plant, Bydgoszcz (Poland)

The gauge system consists of the mechanical measuring module, control and data logger module, as well as of the proprietary PC software. The key element of the gauge is a laser measurement probe travelling around the rail head taking readings of its transverse profile

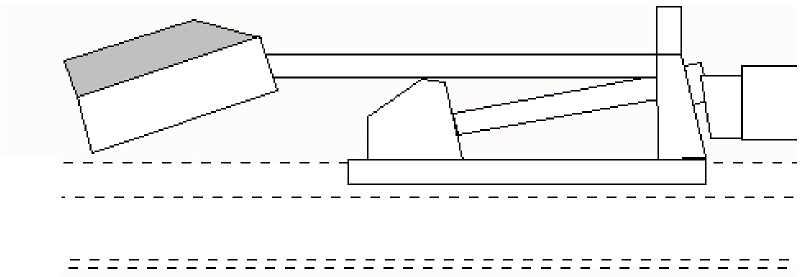

Figure 1: Rail head profile gauge – general view.

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The laser triangulation laser measurement probe made is mounted on the arm rocking around the rail head driven by an electric motor. This probe has very good stability of readings and performs well in harsh operating conditions. The measurement sector may be freely defined according to the actual needs - its range may incorporate full head shape starting from its fishing surface. When making measurements in the track, the gauge may be positioned precisely in respect to the other rail of the track using a beam, so that the rail head profile is analysed in regard to the track axis:

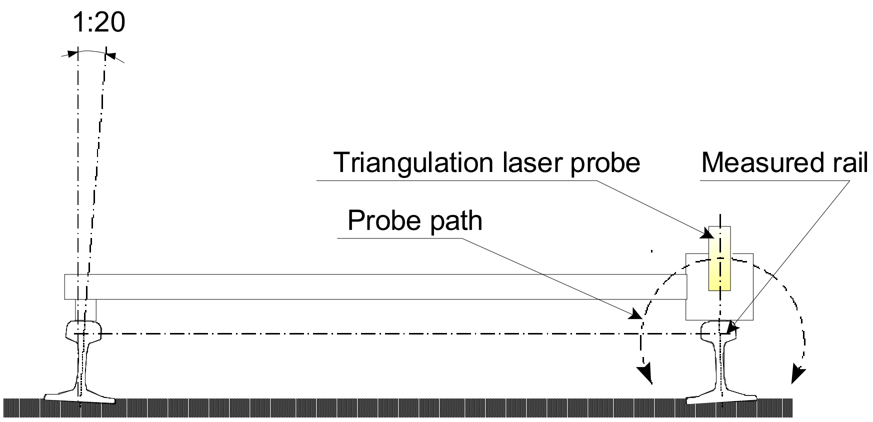


Figure 2: Measurement of the rail head profile in reference to the other rail

The gauge measurement sector is user programmablẹ̃ [43.2°÷216°], relevant resolution along the rail head profile is better than 0.5 mm while the radial resolution (perpendicular to the measured surface) is better than 0.01mm. The measurement cycle consists of two travels in the opposite directions of the laser probe along the rail surface.

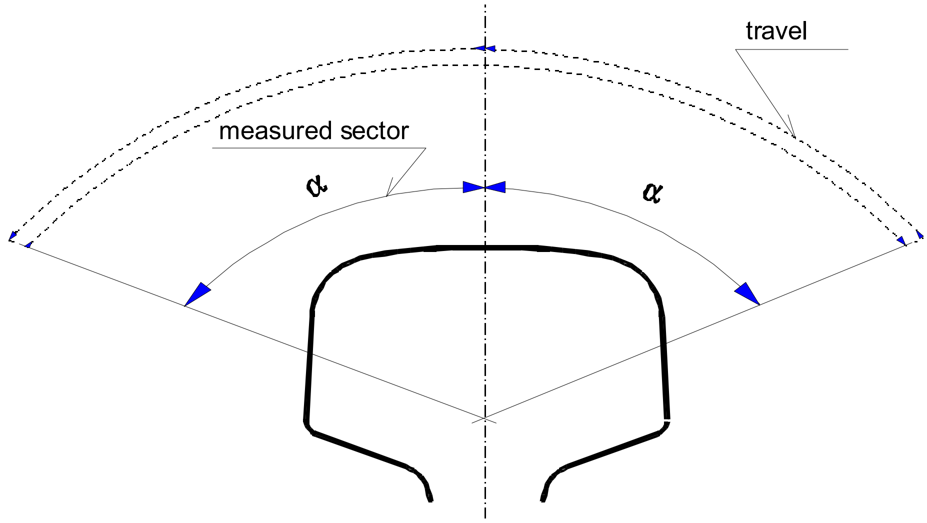


Figure 3: Illustration of the measurement cycle

Cycle time is about 20 sec depending on the measurement sector size. Measured values are evaluated during movement of the probe. All successive profiles are stored as separate files and are later transferred to a PC computer for analysis. Gauge memory capacity is sufficient to store more than 70 rail profiles. The gauge is capable of measuring entire rail head profile, e.g. the rail crown, its two shoulders, corners, and faces during one profile measurement, and - when necessary - one may check the head profile down to the fishing surface of the rail. The gauge was designed so that it is easy to use in the field conditions and the user qualifications do not influence the accuracy of readings.

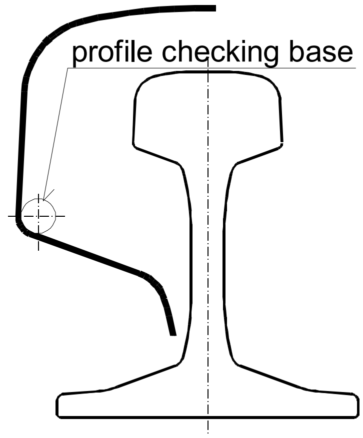


Figure 4: Fishing surface can be used as a datum for profile analysis and comparison

Data stored in the electronic memory of the control system data logger is transferred to the PC computer over the RS-232 link. The data having been transferred to the PC system, is matched to the rail head reference profile. Visualization and evaluation of results of measurements is carried out using the proprietary software supplied with the device. The user may then easily select the theoretical profile checking base or create a new one and employ it for the analysis, using the dedicated software.

Any gauge positioning errors are eliminated at this stage allowing user to take any measurements, perform zooming and annotating of the measured profile. The detailed analysis of the rail head profile may be made using the windowing capabilities of the software allowing the user to zoom in the minute details of the examined profiles - even the single measuring points, and track rolling, straightening, wear, and grinding effects.

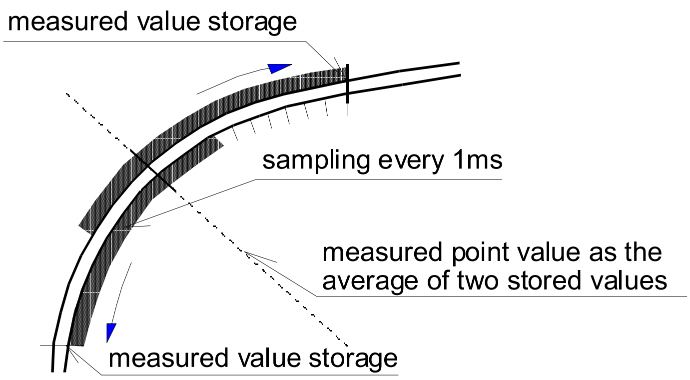


Figure 5: Illustration of surface sampling method

This versatility was obtained due to virtually continuous representation of the rail head, broad programmable angular measurement zone, and convenient defining of reference profiles. It is possible to measure and compare two or more profiles, profiles may also be compared with the theoretical and other measured ones, as well as with various user-predefined standard templates.

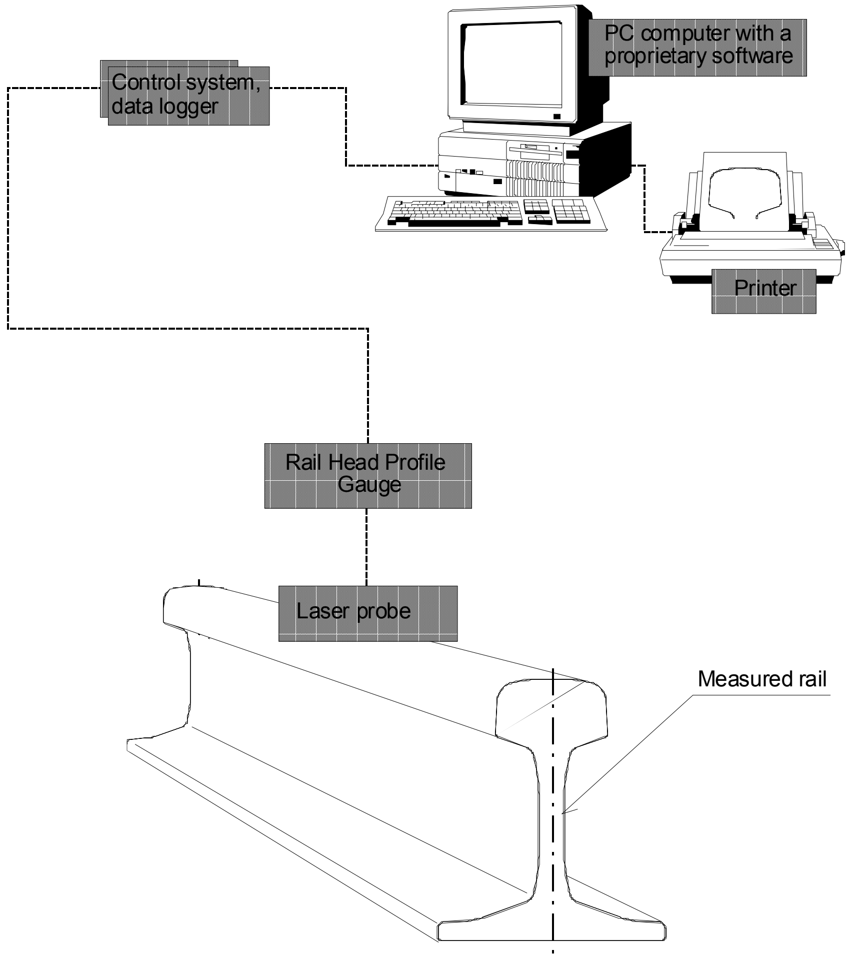


Figure 6: Schematic diagram of the measurement data flow and processing

## General considerations

The gauge has been designed for control of wear of rail heads in the track, control of accuracy of the rail head profile on welds, and for commissioning of the rail head profile after grinding. Railways treat correctness of the rail head profile as an ancillary criterion, next to their straightness, when deciding the necessity of their corrective grinding. This fault may be rectified by profile grinding, requiring sometimes as many as 6-7 passes of the grinding train, whereas on the average 4-6 passes are enough to repair minor track faults. To prove the necessity of scrupulous rail profile control, certain major faults - in extreme cases - require in some locations 10-12 grinding passes. The same holds true for the rail welds: the joints profile often differs from the theoretical profile thus deteriorating the overall track quality. The typical faults of the rail head profile occurring in the track are as follows:

- local deformations of the running surface of the rail, due most often to manufacturing errors,
- traces of the wheel spin, causing local quenching of the rail head that results in further chipping of the rail material and appearance of minute cracks,
- spalling of the running rail surface, as large as several millimetres sometimes, occurring most often in the heat treated rails,
- at high train speeds, crushed grains of the breakstone that got under the wheels cause micro-cracks of the rail head running surface.

It is well known that just the slightest unevenness of the rail head crown surface causes a serious increase of contact (Hertzian) stresses resulting in rail head wear, micro-crack propagation, and sometimes even structural changes of the rail head surface layer. The rail head geometry may be measured precisely and efficiently using dedicated equipment only. These measurements may be carried out manually, using special curve gauges, devices with a measuring arm driven by hand along the rail surface, or fully automatic ones, where readings are not affected by an individual's skill and accuracy.

Another taxonomy of rail head measurement methods is based on the way in which the rail surface shape is detected. There are two methods: contact and non-contact ones. The non-contact method makes it possible to avoid the inevitable shape errors of the measuring tip or roller affecting the contact methods.

Any measurement equipment's intermediate elements touching the rail head deteriorate accuracy of discerning details of its surface. The larger the stylus radius or roller diameter of the device, the less detailed the resulting measured profile is. Due to this inevitable disadvantage, all contact gauges are acceptable for rough measurements of the rail profile only, as they are not capable of reading the true rail head profile with the minute details necessary for its more sophisticated analysis.

Therefore, it is preferable to employ the non-contact method which is capable of revealing even the most minute surface details. Moreover, it is obvious that it is desirable to employ measurement equipment that may be used to check the rail quality both in the manufacturer's premises and on the track.

Rail manufacturers have to follow the recommended rail quality assurance procedures that include automatic inspection of rail dimensional tolerances which turn out to be more precise and reliable than manual measurements. The same holds true for the railways that have to carry out track maintenance as safety measures call for inspection of the railway tracks at carefully determined service time increments.

It is essential from the economic and safety of operation points of view that the decision to grind the track is made based on sound technological assessment of the track condition after analysis of the results of measurements of rails' straightness and deterioration of the rail head shape.

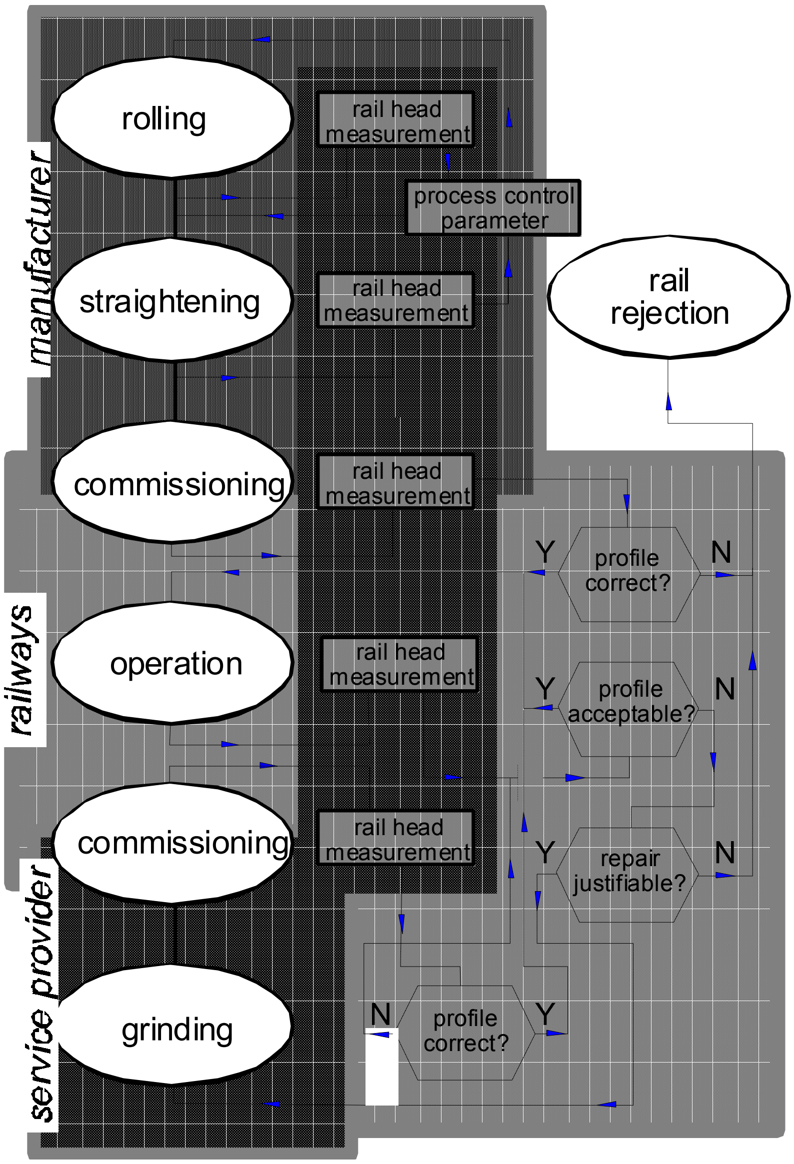


Figure 7: Where and why is the rail head profile control needed

It is possible to overlay a number of measured profiles to visualise any changes of rail head geometry, e.g. to control the rail head shape changes in certain locations in the operated track or – by the rail manufacturers - after mechanical adjustments of the rolling pass in the rolling plant. On the other hand the track condition and results of the maintenance work have to be checked very carefully regardless of who carried it out. It may be done by the railways' internal services or else by third party service providers, e.g. using leased grinding trains.