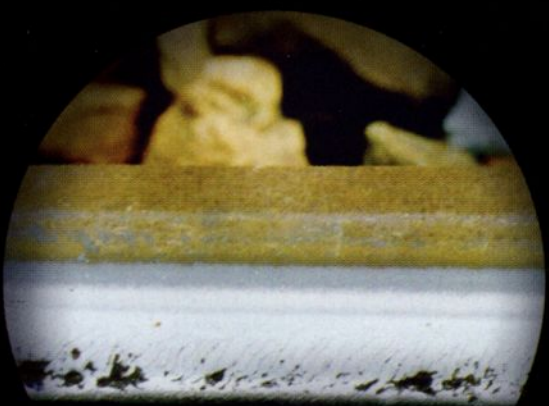


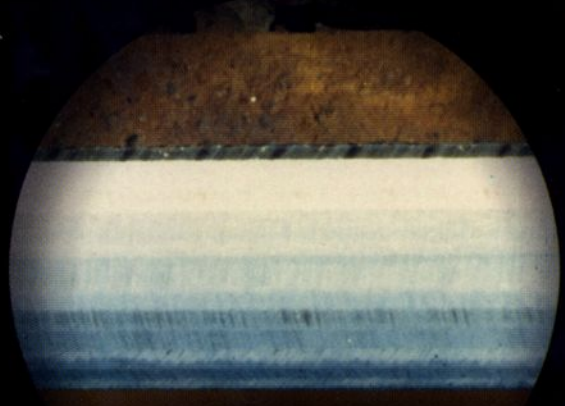
# RAIL ENGINEERING INTERNATIONAL



**Head checks !  
Headache !**



without **SPENO**



with **SPENO**



# Combating rail surface fatigue in Europe by head check grinding

Rail surface fatigue has become an issue of major importance, as railway companies are looking for ways to extend the service life of the rail and to reduce maintenance costs. By cyclically removing metal from the rail surface, which is subject to fatigue, a better matching of the transverse profile of the rail head with that of the wheel is effected. Thus, head checks develop at a slower pace, and no longer grow into severe cracks. Consequently, the service life of the rail is extended considerably.

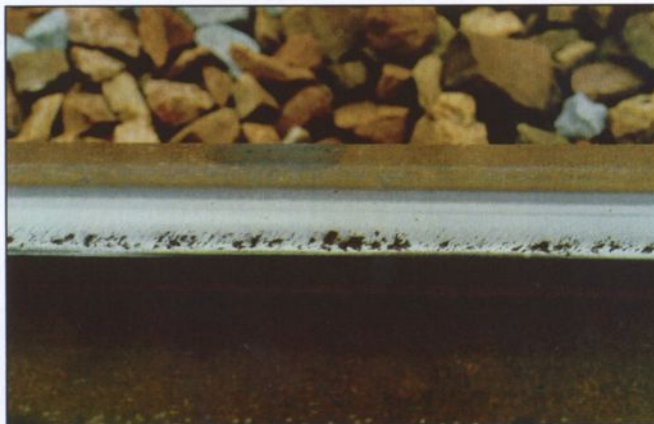
By: Dr. Wolfgang Schöch, External Affairs Manager, Speno International S.A., Geneva, Switzerland.

The transverse profile of the rail head mainly determines the contact and internal stresses, and wear, of the rail. When stress limits are exceeded, this results in the occurrence of surface fatigue defects which, according to their severity, can be classified as: head checking, flaking and spalling, ultimately resulting in cracking (Fig. 1).

Appropriate wheel/rail contact conditions ensure minimum contact stresses. Thus, as a preventive measure, rail grinding is applied to create special profiles by shaping the rails to a target transverse profile within specified tolerances.



*a: moderate head checking*



*b: severe head checking and flaking*

Regular cyclical grinding alleviates rail surface fatigue, extends the service life of the rail and, thus, results in cost savings. The extent of the cost savings depends on the applied grinding strategy and the expected extension of the service life of the rail.

## Rail surface fatigue in Europe

On heavy haul railway lines, rail surface fatigue has always been a major issue of concern. Resulting from the heavy axle loads carried, it is predominantly the steering factor for rail grinding.

In Europe there are, with a few exceptions, no heavy haul railway lines. The majority of railway lines carry mixed traffic, with passenger trains running at fairly high speeds and the maximum axle load of freight trains being 22.5 t. Here, a major issue of concern is to keep vibrations and, more importantly, noise at low levels.

In this respect, rail grinding is carried out to correct the longitudinal profile of the rail head by removing irregularities, such as short-pitch corrugation and short waves. Parallel to this, the transverse profile is shaped to meet a specified target profile which, in principle, is similar to the as-rolled profile. Tolerances are specified largely depending on prevailing line speeds.

## Head checks

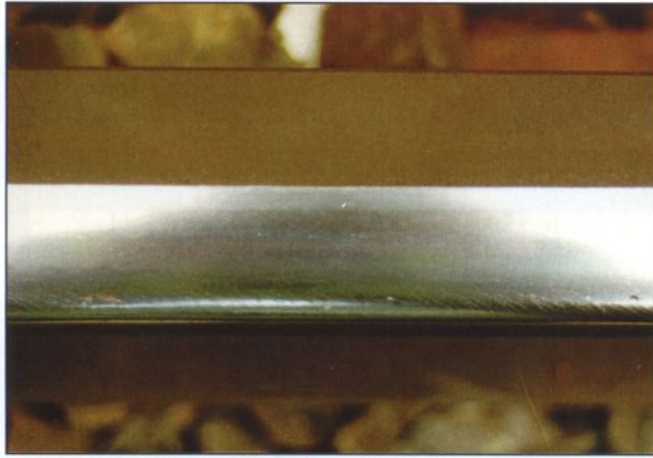
Until recently, rail surface fatigue was not regarded as a serious problem on conventional railway lines in Europe. Nowadays, however, it is receiving more attention and, also on high-speed lines, head checks are being detected more often, as well as gauge corner fatigue on high rails in curves, and severe defects, such as flaking, spalling and gauge corner collapse (see Figs. 1 and 2).



*c: final stage*

*Fig. 1: Different stages of rail surface fatigue*



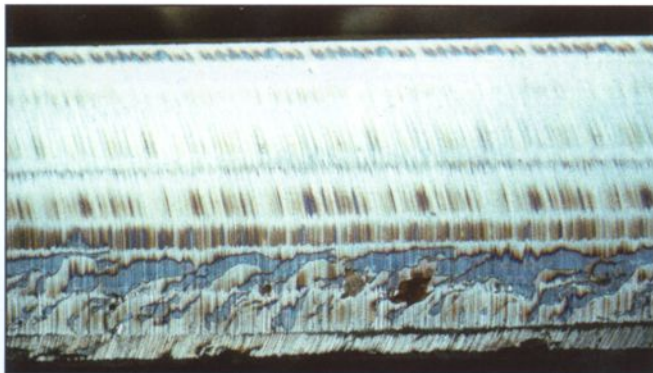


a: head checks



b: spalling

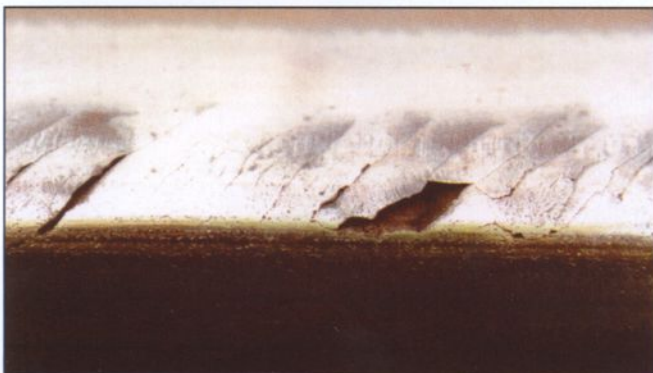
Fig. 2: Examples of gauge corner fatigue defects



a: partly removed head checks, immediately after grinding



b: partly removed head checks, over which traffic has passed



c: deep head checks/flaking

Fig. 3: If rail surface fatigue is not removed completely (a and b), deep head checks and flaking, as shown in c, may occur

#### Combating rail surface fatigue

In order to combat rail surface fatigue, several railways in Europe have defined specific target profiles for rail grinding. For instance:

- German Rail (DB AG) has defined a single target profile for all rail grinding work. This profile is derived from the UIC 60 profile laid at an angle of 1 in 40. Thus, the 300 mm centre radius extends over a smaller zone, the gauge corner radius is larger and, as a result, the target profile for grinding is more convex than for the original UIC 60 profile;
- Austrian Federal Railways (ÖBB) apply a specified target profile for rail grinding that is similar to the one used by DB AG;
- French National Railways (SNCF) have developed specific profiles that are characterised by the extent of gauge corner relief and which, depending on the degree of undercutting of the sensitive area at the gauge side, are called AHCC (Anti Head Check Corrective) or AHCP (Anti Head Check Preventive);
- in The Netherlands, the infrastructure company ProRail applies a strategy that is similar to the one used by SNCF. On high rails in large radius curves, it applies the UIC 54 profile with 1 mm gauge corner relief.

In general, it can be stated that, for combating rail surface fatigue, a target transverse profile should be specified that best suits the majority of passing wheel profiles. For producing such profiles by grinding, a target profile that is somewhat lower in the critical gauge corner area should be specified that remains within the usually applied production tolerances, i.e. in the order of  $\pm 0.3$  mm.

Various rail grinding strategies can be applied:

- the removal of a small amount of metal at a very early stage of the defect, at regular intervals (this practically avoids the occurrence of rail surface fatigue altogether);
- the cyclical removal of a certain depth of metal at a later stage of the defect, in order to control rail surface fatigue;
- a heavy intervention at an advanced stage of the defect, in order to repair, or at least minimise, the damage.

Experience gained in Germany has indicated that early interventions, whereby a small amount of metal is removed, may be more beneficial. In this respect, it is important that rail surface fatigue is removed completely, as otherwise the cracks may grow deeper (Fig. 3), particularly when the next grinding intervention is scheduled after a long interval. This experience has also been confirmed by observations made by railways in other countries.



#### Technical and cost-efficiency considerations

Grinding rail profiles should always be seen from both a technical and a cost-efficiency point of view. Tight tolerances require the use of precisely controlled grinding machines and a very careful operation of equipment. This may result in higher production costs. However, if this results in longer grinding intervals, as the re-occurrence of rail surface fatigue develops more slowly, then the positive economic effect may be two-fold: — the higher grinding costs may be compensated by less frequent grinding interventions; and — the service life of the rail may be extended.

#### Head check grinding tests on DB AG

Currently, research work, discussions and tests with respect to combating rail surface fatigue in Europe are underway at various levels. For instance, DB AG and Speno International are carrying out research, in order to better understand the head check phenomenon. The aim of this ongoing research program is to determine the tolerances for the transverse profile of the rail head that delay, as long as possible, the re-occurrence of head checks after grinding (profile tolerances influence grinding time and costs considerably). In this respect, the development of rail surface fatigue after grinding is being monitored by means of a recording trolley featuring an eddy-current system, which allows the determination of the most appropriate target profile and permissible tolerances.

Recently, the second phase of this research program has started, which aims at finding a grinding strategy (i.e. metal removal rates and intervals) that ensures an efficient and cost-effective control of rail surface fatigue. For this, a number of rail sections will be ground at different intervals (1, 2 and 4 years), whereby a defined amount of metal will be removed.

#### Preliminary results

Data has been collected at regular intervals, both before and after grinding. Also, recordings of transverse profiles and visualisation of head checks, using magnetic powder under UV-light, have been made, and pictures taken at specific locations (Fig. 4).

The main conclusion that can be drawn so far is that positive deviations from the target profile increase the severity of head checks, whereas negative deviations from the target profile reduce the development of head checks (Fig. 5). Rail quality also plays an important role. With head-hardened rails, head check development is slower than with Standard 900A rails. Also, as lateral wear increases, high rails in sharp curves exhibit less head checking.

Further, the transverse profile recordings confirm that the originally different shapes of the rail profiles, after grinding, wear to a uniform shape close to the target profile, and then resemble the shape of the majority of passing wheels. This wheel/rail pairing ensures the lowest contact stresses and, hence, the lowest risk of rail surface fatigue development.

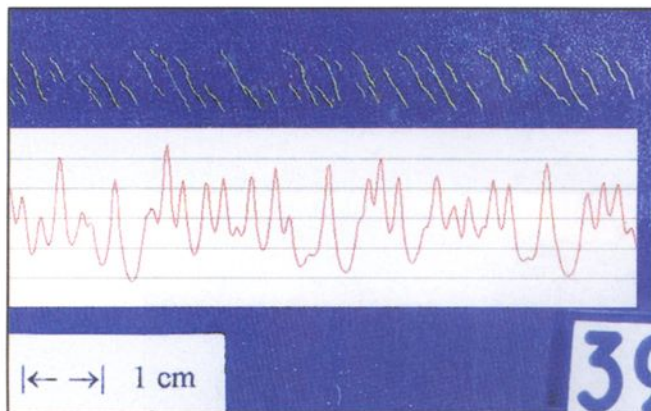


Fig. 4: Visualisation and corresponding eddy-current recording of head checks

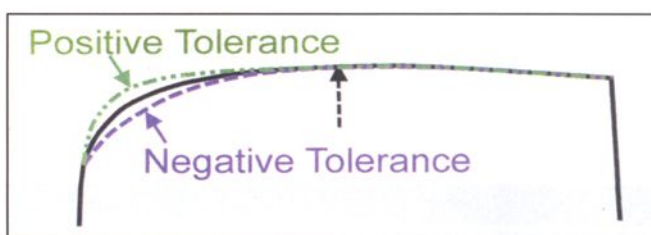


Fig. 5: Target profile featuring negative and positive tolerances

#### Outlook

Currently, the research program concentrates on determining the required amount of metal removal per intervention and the length of grinding intervals.

In the case of Standard 900A rails, grinding is carried out after 15 to 40 MGT borne, and in the case of head-hardened rails after 30 to 80 MGT (these figures relate to head special hardened (HSH) rails manufactured by Voest-Alpine Schienen GmbH). As these figures translate into grinding intervals of up to four years, it becomes clear that obtaining definite results will require some time.

As the research program continues, also the effect of wear will be taken into consideration. Both artificial wear due to grinding and natural wear caused by traffic will be monitored.

#### Conclusions

In Europe, the optimal grinding strategy for combating rail surface fatigue has not yet been found. However, research is under way to provide a better understanding of this phenomenon and the treatment thereof. Practical on-site tests provide insights which, when using the appropriate grinding technology, may contribute to extending the service life of the rail.

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