Buckled Rail

On warm days, rails in direct sunshine can be as much as 20 degrees centigrade above air temperature. As rails are made from steel, they expand as they heat up and are subject to strong compression. This expansion must be managed to reduce the risk of track buckling.

If the track does buckle, the line must be closed and the track repaired before services can resume, causing considerable disruption. Usually, these repairs cannot be done until the temperature of the rails has dropped.
If a section of track is judged to be at risk, local speed restrictions are introduced – slower trains exert lower forces on the track and reduce the chance of buckling.

Influencing factors

So, what is the critical value of buckling? Well, that is not so easy to say. The basic rule is that the destabilising forces (i.e., the normal forces in the rail) should be equal to the stabilising forces, such as the pressure from the ballast on the track, the stiffness of the rail etc. However, several factors are influencing both types of forces. Here are some aspects:

<u>a. The "Neutral Temperature"</u>

The "neutral temperature" is the temperature at which there are no normal forces in the rail. This temperature is of great importance. You could choose to have this temperature extremely high and thus prevent the lateral buckling of the track (because the temperature will never rise much above this value). The problem is that temperatures below this value will introduce tensile stresses in the rail. This increases the risk of rail breakage due to cracks since it is the same effect as if something is pulling the rail in both ends. As a compromise, you try to find a temperature which will not give to large compressive forces at the highest temperatures and not to large tensile stresses at the lowest temperature. In Sweden, this temperature is chosen at about 15-20 degrees (C) (local variations).

<u>b. Curves</u>

In curves, part of the normal forces will try to "push" the rail out of the curve (i.e. towards the convex side). This will give an increase in the destabilising forces acting on the track and thus increase the risk of lateral buckling of tracks.

<u>c. Ballast and Sleepers</u>

Some 60% – 70% of the stabilising forces are due to the influence of the ballast and sleepers. The influence of the ballast and sleepers is depending on the weight and the friction they can mobilise. Thus, on all welded tracks, concrete sleepers and rugged stones are used. Also, a ballast shoulder is placed outside the track, especially in curves. A good horizontal stabilisation (through ballast and sleepers) will also cause a possible lateral buckling to be a slower and less dramatic process. This increases the chance that the "sun curve" is spotted before it becomes so big that it may cause derailments.

d. The Stiffness of the Track

A rail with larger area will be more stable. However, an increased area will give rise to increased forces acting on the rail. The solution to this dilemma is to shape the area in an "intelligent way" so that you will get out a maximum of stability from the area used. This is one of the reasons why rails have the shape that they have. Also, good fastenings are increasing the stiffness of the track enabling the rail and the sleepers to form a stiff "frame".

e. Reconstructions of the Track

During track reconstruction, the stability of the track can be reduced, for instance due to removal of ballast. Also, lateral movements of the track, in order to alter the track geometry, has a great influence of the acting forces.

How the industry prevents rails buckling

a. If the track comprises short rails bolted together, small gaps are left between each length to allow for some expansion.

b. Most track is made up of long stretches of rail that are stretched and welded together, resulting in reduced compression – and a much lower risk of buckling – when they heat up.

c. The stability of the track is checked each winter and any weaknesses are strengthened before the summer arrives; typically, this includes replenishing the ballast that surrounds the sleepers, and re-tensing continuously welded rails.

d. Plan to avoid work that will disturb the stability of the track during the summer as this increases the chance of a track buckle, though sometimes it cannot be avoided.

e. Paint "at-risk" rails white so they absorb less heat, reducing rail temperatures. Typically, a painted rail will be five to ten degrees cooler than an unpainted rail.

f. Continually enhancing measures for calculating rail temperatures, including installing probes that give instant alerts when track temperatures rise.

g. On extremely hot days when high rail temperatures are widespread, speed restrictions are imposed at vulnerable locations; slower trains exert lower forces on the track, reducing the risk of buckling.

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