# Rail Fastener Performance: What About Strength?

The recent trend towards increasing axle load and train weight has led to questions regarding the adequacy of traditional fastener systems, specifically the cut spike. More directly, there are requirements for effective fastener systems suited to different track (and tie) configuration and operating conditions.

These *performance* criteria have been the subject of numerous analyses, investigations, and tests. Two recent papers have attempted to consolidate varied research activities into specific performance characteristics for wood[1] and concrete[2] tie track.

### *Three basic categories:*

Fastener performance characteristics can be divided into three basic categories:

1. Track Strength Properties (including related fastener strength).
2. Operations and Maintenance Requirements.
3. Cost/Benefit Issues.

This *Tracking R&D* will address the first of these issues, Track (and Fastener) Strength, leaving the remaining two for subsequent coverage.

Consideration of Track Strength can be divided into four classifications. Each represents a basic mode of performance of track under traffic loading. These areas are:

a) *Longitudinal Restraint* — the ability of the track to withstand longitudinally applied loads, that is, loads in the direction of the track. Such loads include mechanical loading from train braking and acceleration, and thermal loading from changes in ambient and rail temperatures. For fastening systems, the requirement for longitudinal restraint translates into preventing the rails from moving with respect to the ties.

Among the specific longitudinal performance requirements is the capability of the fastening system to limit the size of the rail gap, in the event of a rail pull-apart. Table 1 presents a set of relationships between maximum allowable rail break or "gap" and fastener longitudinal restraint, for a temperature change of 75-degrees F.

A second fastener performance requirement is related to the force necessary to "plow" the tie in the ballast. Specifically, the fastener does not need significantly greater longitudinal holding power than this force, at which point the tie is already moving.

**TABLE 1**

**MINIMUM FASTENER RESTRAINT FOR DIFFERENT RAIL BREAK "GAPS" DUE TO MAXIMUM TEMPERATURE CHANGE of 75°F FOR 132 RE RAIL**

| RAIL BREAK "GAP" (INCHES) | FASTENER RESTRAINT PER UNIT LENGTH OF RAIL REQUIRED TO LIMIT THE RAIL BREAK GAP (lbs./inch) | LENGTH OF RAIL ON EACH SIDE OF GAP WHICH MUST BE ANCHORED TO LIMIT THE GAP (ft.) | FASTENER SPACING (inches) | FASTENER RESTRAINT PER FASTENER ASSEMBLY REQUIRED TO LIMIT THE GAP (lbs.) |
|---|---|---|---|---|
| 0.5 | 184 | 86 | 24 | 4416 |
| 0.75 | 122 | 129 | 24 | 2928 |
| 1.0 | 92 | 172 | 24 | 2208 |
| 1.5 | 61 | 258 | 24 | 1464 |
| 2.0 | 46 | 344 | 24 | 1104 |

*Table 1 — Rail Break Gaps*

b) *Gage Widening/Rail Rollover* — the ability of the track, and specifically the fastener system to maintain gage, that is, to keep the rails 56 1/2 inches apart at the gage points. Gage widening, in turn, is a combination of three factors: rail wear, translation, and rotation. The latter two are most directly affected by the fastening system. Under conditions of high lateral load and high L/V ratios (lateral to vertical wheel loads), it is critical that the fasteners limit the rotation of the rail, to prevent dynamic gage widening, and the possibility of a wheel dropping in between the rails.

c) *Lateral Shifting Track Buckling* — the ability of the track to withstand lateral loading without the lateral movement of the track as a whole, as opposed to gage widening where only the rail moves laterally. In this mode, the performance of the fastening system is secondary to those of the tie and ballast systems. However, the fasteners do act to strengthen the track "frame" in the lateral direction, and to reduce the lateral movement along curves as temperature changes. It is also a phenomenon related to characteristics of longitudinal restraint.

d) *Vertical Loading* — the ability of the track structure to withstand vertical loadings, both static and dynamic. The fastener system transmits vertical loads, applied at the railhead to the cross-tie. The tie in turn distributes the load into the ballast and ultimately the subgrade. In the presence of dynamic loading, such as particularly high impacts from wheel flats or rail surface defects, the fastener system must also help distribute, and in the case of concrete ties, attenuate these. This requirement for attenuation is related to the need for the fastener system to introduce resiliency into the concrete tie structure. Usually, this resiliency is associated with the pad portion of the system.

In the case of elastic fasteners, the performance of the fastener during rail uplift under traffic must also be taken into account. Here, the fastener system must support the weight of the tie and rail section without excessive deformation. (Next month in *Tracking R&D*, 'The Intangible Aspects of Fastener Performance.')


1. Zarembski, A. M., "Performance Characteristics for Wood Tie Fasteners", Bulletin of the AREA, Bulletin 697, October 1984.
2. Zarembski, A. M., "Performance Characteristics for Concrete Tie Fasteners", **Concrete Tie Systems for the 1980's,** Proceedings of the Prestressed Concrete Tie Workshop, November 1983.