The Effect of L/V — ▪ — ▪ ▪ ━ ▪ ━ ▪ ━ ▪ ━

During the last several years, the subject of the dynamic interaction between railway vehicles and the track structure has grown in importance for both railway track and vehicle maintenance officers. Spreading interest in this area has been propelled by the extensive efforts of the recently concluded *Track Train Dynamics* program, in which vehicle-track interaction was studied extensively.

Of particular significance in examining this vehicle-track interaction is the combined effect of the lateral dynamic loadings (L) and the vertical dynamic loadings (V) imposed by the vehicle on the track. One relation frequently used involving these two parameters, and discussed here, is their quotient. This quotient is called the 'L/V ratio,' and is obtained from either measuring dynamic loading in the field or from theoretical analysis. The ratio can provide an indication of potential or 'incipient' failure of a vehicle-track system.

One such mode of 'failure' is *dynamic gage widening*, where the unloaded track gage undergoes a widening because of the outward movement of one rail under vehicle loading. Another failure mode is *wheel-climb,* in which the vehicle's wheel climbs over the rail without a preceding structural failure of the track. Both of these failure modes are related to and can be indicated by the L/V ratio.

In the case of dynamic gage widening — particularly that occurring on well-maintained track — the primary failure mechanism is the rotation of one of the rails outward from its original vertical axis.[1] This is usually the high rail in a curve, which experiences larger lateral loads. Rail overturning or rollover is the limit of this mechanism, where the rail actually turns over on its side. This differs from gage
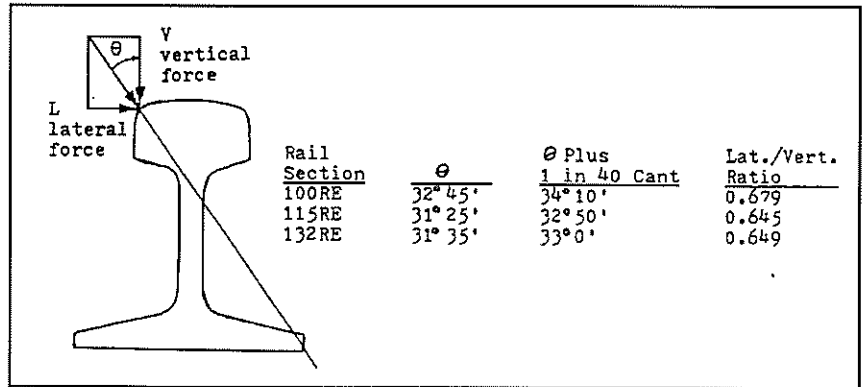

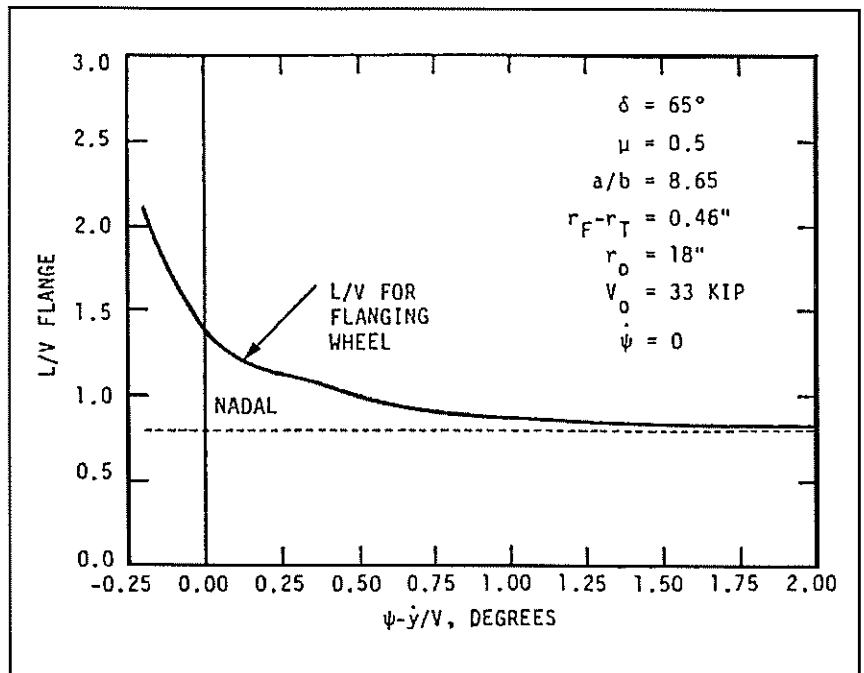Figure 1 — L/V ratio at potential instability for rail rotation

Rail Section	θ	θ Plus 1 in 40 Cant	Lat./Vert. Ratio
100RE	32° 45'	34° 10'	0.679
115RE	31° 25'	32° 50'	0.645
132RE	31° 35'	33° 0'	0.649

Figure 2 — L/V ratio of flanging wheel at incipient derailment for axle with zero yaw rate, vs. effective angle of attack.[3]

widening due to rail translation, which occurs when the rail base moves outward and can take place in track with poor tie conditions.

Tilting 'mechanism'

In examining the effect of the applied lateral and vertical loadings on the head of the rail, Figure 1 illustrates that a potentially unstable condition will exist when the vector resultant of the lateral and vertical forces falls outside the edge of the rail base. There then arises the potential for rail rotation about the outside edge of the rail base (A).

The L/V Ratio at which this potential instability occurs varies somewhat with rail section, and is in the general range of 0.64 to 0.68. Thus, for L/V ratios greater than 0.64, the *potential* for rail rotation, and consequently dynamic gage widening, exists. However, it should be noted that on good track, the rail is usually restrained against rotation by rail fasteners — particularly the rail hold-down fasteners on the gage side — along with the torsional stiffness of the rail section. Thus, the actual amount of rail rotation — and hence gage widening — is dependent not only on the L/V ratio, but on the magnitude of the lateral and vertical forces themselves[2] (see *Tracking R&D*, August 1986).

Wheel climb can of course result in a derailment of the vehicle, and has traditionally been associated with the L/V ratio. Therefore, L/V can be a surrogate measure of wheel climbing tendencies.[3] One such measure is given by the *Nadal Limit*. For typical wheel flange and coefficient of friction values, this limit corresponds to an L/V value of 0.8.[3]

The tendency for wheel climbing is also related to the angle of attack of the wheel with reference to the rail. The corresponding relationship between 'incipient' wheel climb, L/V ratio, and angle of attack for a flanging wheel is presented in Figure 2.[3] As can be seen from the figure, for high angles of attack the L/V ratio approaches the Nadal Limit defined earlier.

The L/V Ratio, then serves as a measure of the potential for failure in dynamic gage widening when it exceeds 0.64, and in dynamic wheel climb when it exceeds 0.8. Consequently, the ratio is a useful indication of potential problems in vehicle track systems.

References:
1. Zarembski, A. M., "Rail Rollover — The State of the Art": AREA Bulletin 664, Vol. 79, Sept. 1977.
2. Choros, I., "Laboratory Tests on Three Alternate Track Structures": AAR Report R 614, Sept. 1985.
3. Weinstock, H., "Wheel Climb Derailment Criteria for Evaluation of Rail Vehicle Safety": ASME, 84-WA/RT 1, 1984.