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ORDER-OF-MAGNITUDE COMPARISONS OF VARIOUS ENERGY DISSIPATING MECHANISMS

This note compares the orders of magnitude of various energy dissipating mechanisms in a classification yard. To put the comparison on a common basis, a 100-ton car is selected. This comparison, despite its crudeness, reveals the relative importance of the various mechanisms.

1. Rolling resistance on a tangent track

Assuming R = 0.2%, the energy loss per foot of track

$$E_t/\ell = W \cdot R = 400 \frac{\text{ft-lbf}}{\text{ft}}$$

2. Rolling resistance on a curved track

Data in Ref. 1 indicate that, on a statistical basis, the rolling resistance on a curved track is approximately 0.3% above that on a tangent track. Hence, the energy loss per foot of curved track

$$E_c/\ell = W \cdot \left(R + \frac{0.3}{100}\right) = 1000 \frac{\text{ft-lbf}}{\text{ft}}$$

3. Wind resistance

The aerodynamic drag (D) on a moving body can be expressed in terms of its drag coefficient (C_D) as follows:

$$D = \frac{1}{2} \rho V^2 A C_D$$

For an 8' x 8' box car, we shall assume C_D to be 0.8. Then, for a relative wind velocity of 10 mph, the energy loss per foot of track

$$E_w/\ell = D = 13 \frac{\text{ft-lbf}}{\text{ft}}$$

4. Switch resistance

The velocity head loss across a switch is generally taken to be 0.025 ft. The energy loss for a 100-ton car

$$E_{sw} = W \cdot (0.025) = 5000 \text{ ft - lbf.}$$

Since the overall length of a switch is on the order of 60 ft,

$$E_{sw}/\ell = \frac{5000}{60} = 80 \frac{\text{ft-lbf}}{\text{ft}}$$

5. Energy absorbing capacities of conventional retarders

For a 100-ton car with 33' wheels, the capacity of a full-capability retarder is approximately 0.11 ft. V.H./ft. Energy absorption per foot of retarder is then equal to

$$W \cdot (0.11) = 22{,}000 \frac{\text{ft-lbf}}{\text{ft}}$$

In the case of a weight-responsive retarder, the energy absorption is about 1/2 of the above value. In the case of a spring loaded inert retarder (cheapest of all retarders), its energy absorption is about 1/4 of the above value.

6. Energy absorbing capacity of Dowty Retarder

$$E_{Dowty} \lesssim 0.5 \text{ ft-ton} = 1000 \text{ ft-lbf}$$

7. Energy absorbing capacity of ASEA spiral retarder

$$E_{ASEA} \lesssim 7{,}200 \text{ ft-lbf}$$

Conclusions

1. Compared with energy dissipated by rolling resistance, the energies dissipated by wind resistance and switch resistance are approximately one order of magnitude less.

2. It takes 22 Dowty retarders to equal to the energy capacity of one foot of full-capability retarders. For the ASEA retarders, the number is 3.

Ref. 1
G. H. deVries and C. N. Kerr, "Improvement of Coupling-up Performance in Automatic Marshalling Yards: a Simulation," ASME Publication, 77-RT-8.