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Informal Note #3

PRELIMINARY SENSITIVITY ANALYSIS OF SYSTEM RESPONSE TO CONVENTIONAL RETARDER OPERATION

Introduction

This note documents a simple sensitivity analysis showing system response, as measured by distance headway, as a function of rolling resistance. Included in the response is the intervention effect of a typical conventional retarder logic system. The computer simulation runs required to perform this analysis were accomplished using the SRI-developed PROFILE simulation model*. These runs were made by Messrs. Jim Wetzel and Gerald Brubaker of Conrail, in consultation with William Stock of SRI.

Description of Runs

A series of computer simulation runs were made of the existing hump profile in Conrail's Elkhart, Indiana Yard. In each of these runs the roll of two cars following one another from the hump into the bowl was simulated using the PROFILE model. The rolling resistance of the lead car was held constant at 4 lbs per ton, while the rolling resistance of the following car was varied from run to run. The varying rolling resistances of the trailing car cause the simulated retarder system to respond to this car at the various rolling resistance levels tried. The effectiveness of

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*P.J. Wong, C.V. Elliott, R.L. Kiang, M.Sakasita, and W.A. Stock, Railroad Classification Yard Technology-Design Methodology Study Phase 1 Interim Report, September, 1978.

the system was measured in terms of the response of one variable: The coupler-to-coupler distance headway. These headways have been plotted as a function of trailing car rolling resistance at three critical points along the profile.

Retarder Logic

Because the retarder logic has such an important impact on system performance, it will be described here. The detailed retarder logic is, of course, the proprietary property of the vendor and is not available. However, the logic used in these series of runs, while simplified, is felt to be typical.

For both the master and group retarders, a target let out speed from the retarder is computed. This speed is based only upon the desired speed of the car at certain switches and other control points along the profile. The let out speed from the retarder can be computed directly from the profile data, the desired speed at the selected control points, and the car's rolling resistance. The control points used for the master retarder desired speed computation are the switches between this retarder and the group retarder. The control points used for the group retarder desired speed computation are the end of class track and the switches after this retarder. In each case, that control point requiring the slowest let out speed from the retarder is assumed to control. The desired speeds used for all switches is 15 mph; the desired speed used for the end of track is 6 mph.

The master retarder at Elkhart Yard consists of two adjacent retarders (designated M1 and M2). The total retardation computed from the let out speed must be divided between M1 and M2. This split is accomplished qualitatively as follows:

- For a very hard rolling car, M1 will not retard at all, since the car's let out speed from M1 will be less than the target let out speed from the overall master retarder pair. M2 may retard slightly if required to hold the car to the let out speed.

- For a normal rolling resistance car, M1 will retard such that the car's let out speed from M1 is equal to the let out speed from the master retarder pair. M2, then, only retards that amount required to hold the car to a constant speed (rather than allowing the car to accelerate on the grade).
- For a very easy rolling car, M1 will retard to its maximum capability, but this will not be sufficient to bring the car to the let out speed. Then M2 will have to retard an additional amount to decelerate the car further to the let out speed.

The above retarder logics are not actually incorporated within PROFILE. The retardation values, in feet of head, were therefore calculated manually using the above logics and input to the program.

Results

The results of these series of runs are given in Figures 1 and 2. Figure 1 shows the headways as the lead car leaves the master and group retarders. Figure 2 shows the headway as the lead car passes the clearance point. Figure 1 shows that the distance headway increases almost linearly with the trailing car rolling resistance at the exit of the master retarder. This result is in accordance with intuition. However, as headways are measured at points successively further downstream, the intervention of the retarders causes the headways to vary with the trailing car rolling resistance in a manner highly non-linear -- indeed, at the clearance point (Figure 2) the relation is also highly non-monotonic. While an explanation can be offered for the behavior observed at the clearance point, it is obvious that the headway behavior of car pairs, when the intervention of the retarder logic is considered, can be quite a complex phenomenon to analyze.

Figure 1

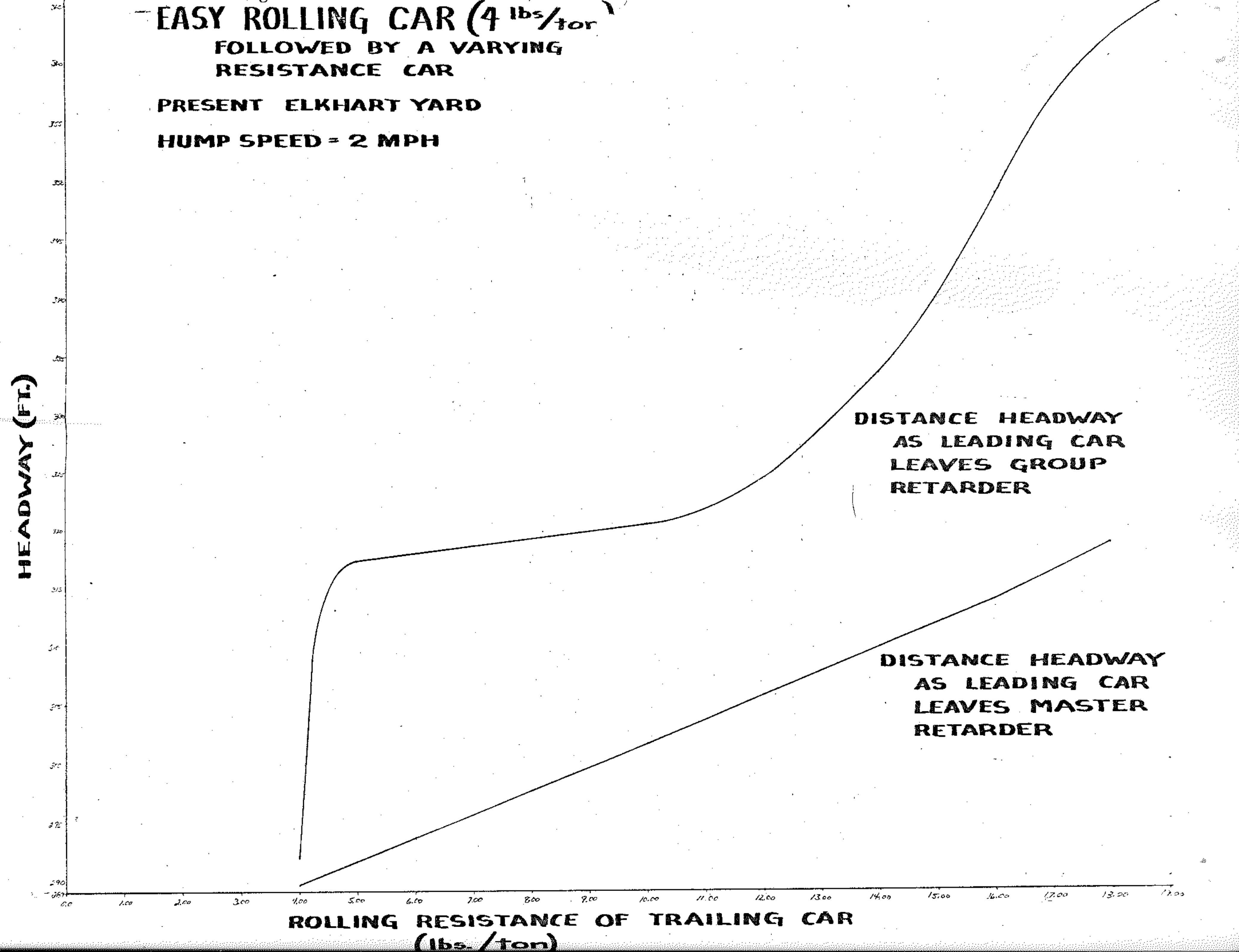
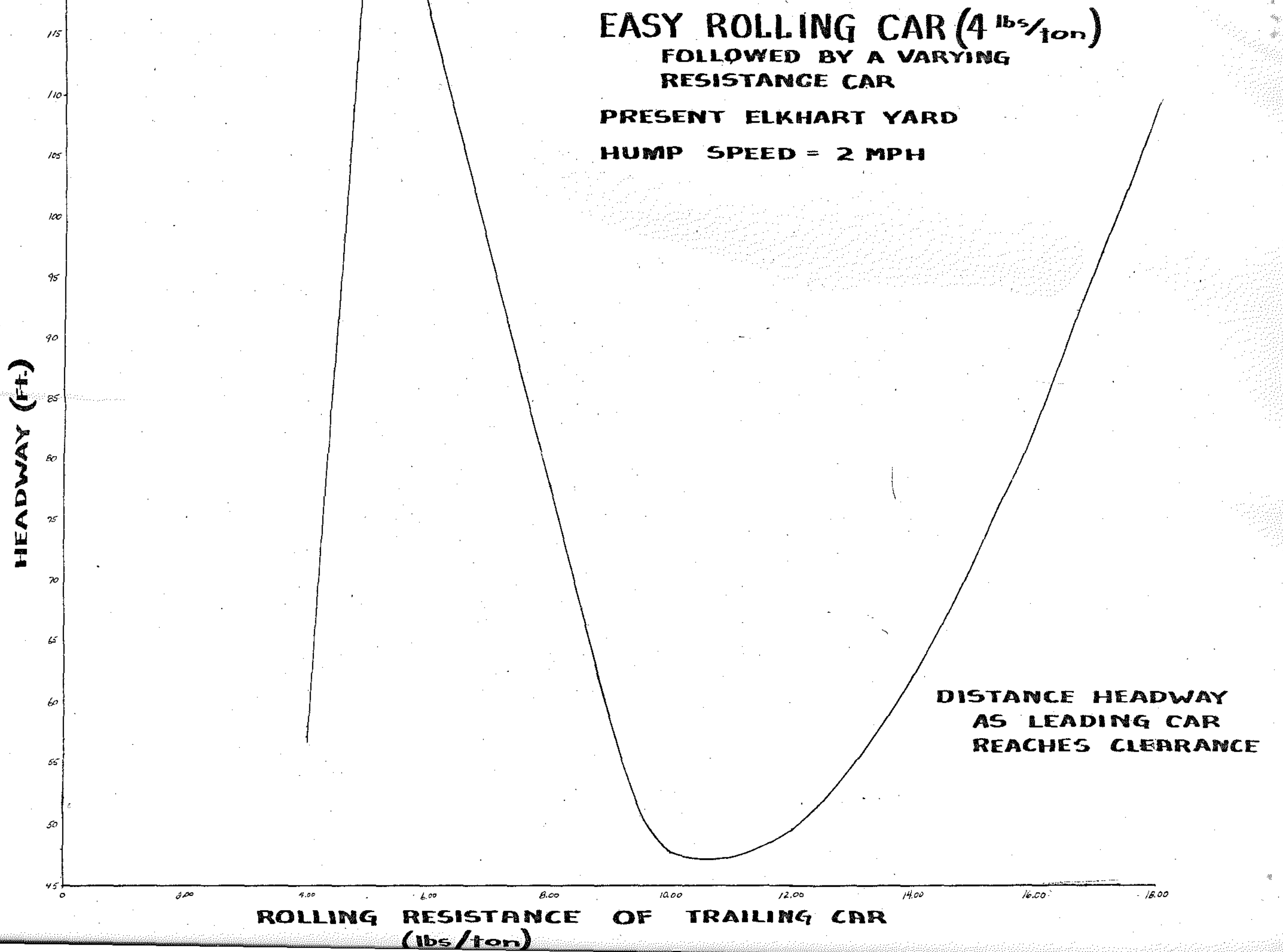

EASY ROLLING CAR (4 lbs/ton)
FOLLOWED BY A VARYING RESISTANCE CAR
PRESENT ELKHART YARD
HUMP SPEED = 2 MPH
DISTANCE HEADWAY AS LEADING CAR LEAVES GROUP RETARDER
DISTANCE HEADWAY AS LEADING CAR LEAVES MASTER RETARDER
HEADWAY (FT.)
ROLLING RESISTANCE OF TRAILING CAR (lbs./ton)

FIGURE 2


EASY ROLLING CAR (4 lbs/ton)
FOLLOWED BY A VARYING RESISTANCE CAR
PRESENT ELKHART YARD
HUMP SPEED = 2 MPH
DISTANCE HEADWAY AS LEADING CAR REACHES CLEARANCE
HEADWAY (Ft.)
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
0
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
ROLLING RESISTANCE OF TRAILING CAR (lbs/ton)