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Informal Note 57*

DRAFT FOR DESIGN MANUAL
CHAPTER 5: DECIDING ON FLAT VS. HUMP YARD

5.0 General

In this chapter we attempt to address the questions of whether a flat yard or hump yard should be built, or perhaps more importantly, whether an existing flat yard should be rehabilitated into a hump yard.

One can classify a flat yard as a labor-intensive facility, whereas a hump yard is a capital-intensive facility. For this reason, it has been traditional to build flat yards for low-volume terminals (i.e., less than 1,000 cars per day), and to build hump yards for high-volume terminals (i.e., greater than 1500 cars per day). However, the traditional rules of thumb need to be re-examined because of the rapid inflation of labor costs in the last decade and the innovation in the design of so-called "mini-hump" yards. In particular, Southern Pacific has pioneered the development of small mini-hump yards which it is claimed are economical for small- and medium-sized yards, i.e., those classifying from 500 to 1500 cars per day.

5.1 Alternatives for Small Yards

In this section we briefly describe the alternatives for small yards. These include the flat yard and three versions of the mini-hump yard.

*This is a working document written primarily for communicating preliminary results of research. It does not constitute an official report and it may be revised as further research results are obtained.

5.1.1 Flat Yard

A flat yard generally consists of a series of tracks connected by a ladder track and switching lead, as shown in Figure 1.* Most flat yards use the same tracks for receiving, classifying, and dispatching trains although many such yards do have separate receiving and/or departure tracks. The car-sorting process requires that a group of cars be pulled out to the switch lead where the switch engine will accelerate quickly toward the yard and then decelerate. Just prior to the deceleration, a car or group of cars will be uncoupled and the deceleration of the switch engine and the cars coupled to it will cause one or more of the uncoupled cars to separate from the rest. This procedure is called giving the cars a "kick." The switch engine generally continues kicking cars toward the classification tracks until reaching the ladder track, at which point it will pull the remaining cars back along the switch lead and resume the process. The cars and groups of cars that have been kicked will travel along the switch lead and ladder track until switched onto the appropriate classification track. Switches in most flat yards are generally manually thrown. To improve operations, the grades of flat yards are often somewhat saucer-shaped so that the cars will tend to accumulate in the center of the yard when switching from both ends of the yard. Such gradients also reduce the frequency of cars stopping short on the ladder track or classification track.

5.1.2 Hump Yards

5.1.2.1 General Hump Yard Description

Hump yards can classify a large volume of cars more efficiently than

*A large flat yard may have the "top" half of the yard configured as in Figure 1, with the "bottom" half a miror image.

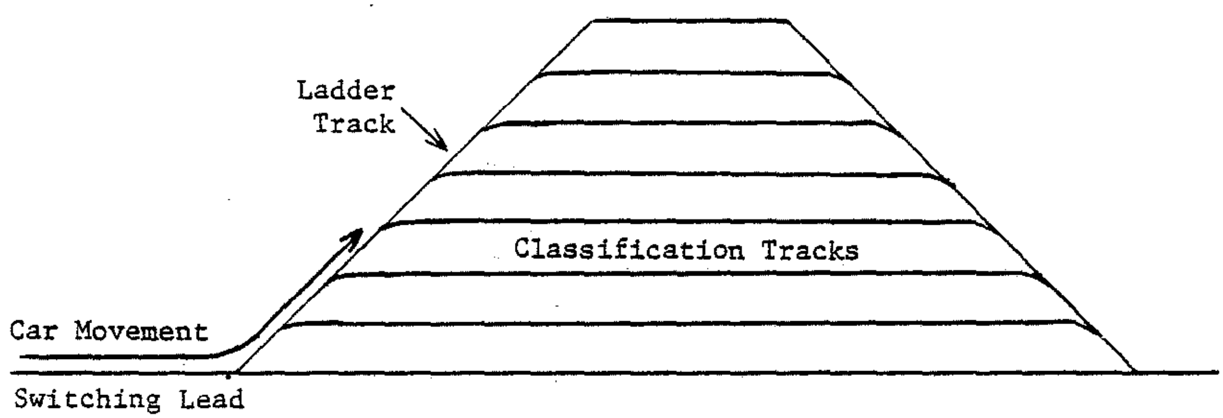


FIGURE 1 EXAMPLE FLAT YARD TRACK CONFIGURATION

a flat yard. To efficiently handle the large volume of cars, typically a hump yard has separate receiving, classification and departure subyards. The classification process requires that a yard engine take a group of cars from the receiving yard and push these cars over a raised portion of track called the hump. Cars are uncoupled at the hump crest and begin to accelerate down the hump grade, thereby separating from the yard engine and the remaining cars. Referring to Figure 2, as the cars roll down the hump grade, braking devices called retarders control the speed of the cars, and the appropriate switches are thrown to route the cars into the designated classification tracks.

5.1.2.2 Mini-Hump Design Alternatives

The performance of a mini-hump design should be specified in terms of a given humping rate (without misswitches and stalling) and a range of coupling impact speeds on the classification tracks for all cars between design-specified hardest and easiest rolling resistance cars (specified in pounds/ton or equivalent percent grade).

For small yards (i.e., 8 to 16 class tracks), Figure 3 shows three alternatives for a mini-hump yard design. The alternatives shown are:

1) Master-retarder-only design
2) Group-retarder-only design
3) Tangent-point-retarder-only design.

Conventional hump yard designs for medium yards or larger normally contain a master and group retarders, and if a high hump rate is desired, may have in addition tangent point retarders (e.g., Southern Pacific's West Colton Yard).

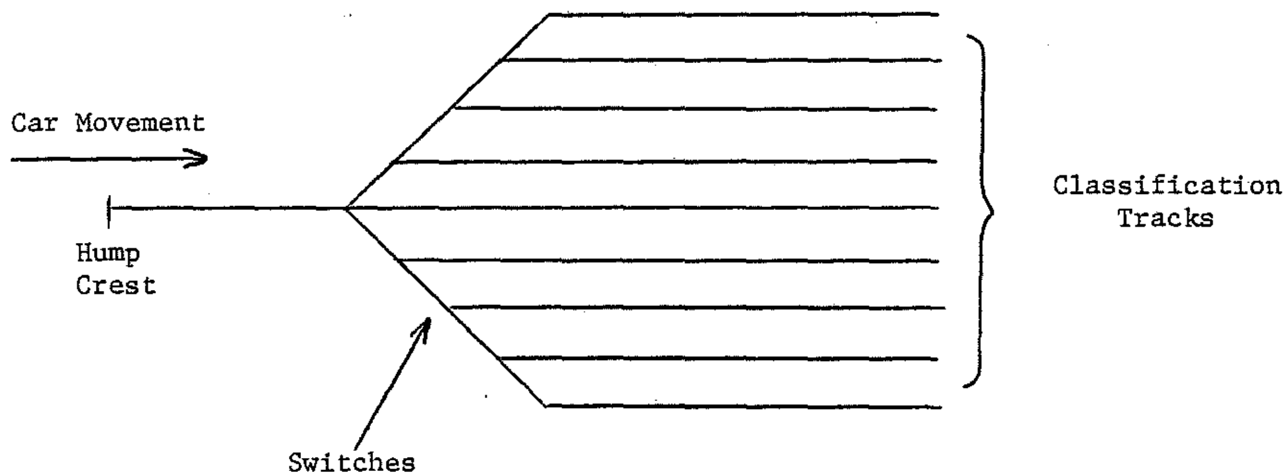
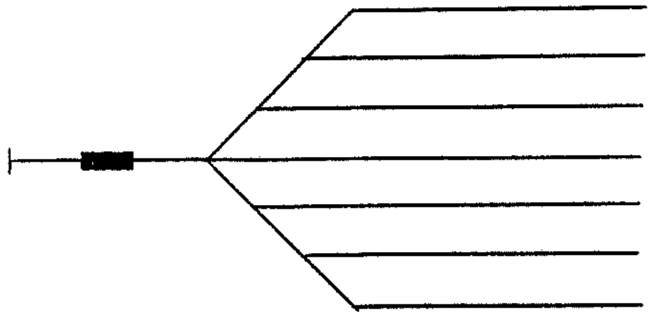
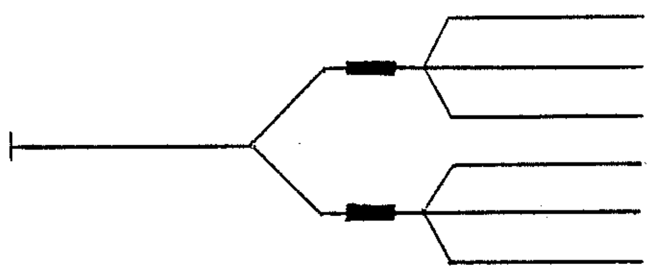


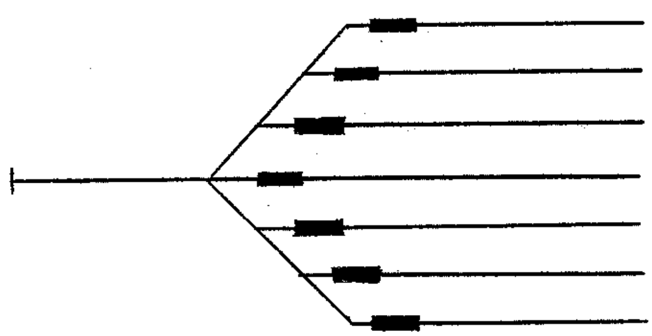
FIGURE 2 EXAMPLE TRACK CONFIGURATION FROM HUMP CREST TO CLASSIFICATION TRACKS



a. Master-Retarder-Only Design



b. Group-Retarder-Only Design



c. Tangent-Point-Retarder-Only Design

FIGURE 3 MINI-HUMP DESIGN ALTERNATIVES

The design of low-cost mini-hump yards was made feasible by the development of relatively inexpensive weight-responsive hydraulic retarders and low-cost speed measuring devices (i.e., doppler radar and sonic-notched-rail devices). Conventional hump yards traditionally use pneumatic, electric, or electro-hydraulic heavy duty retarders, which are considerably more expensive than weight-responsive hydraulic retarders.

The master-retarder-only design presented in Figure 3a shows a single weight-responsive hydraulic master retarder. Because the distance to couple and the curves negotiated enroute to the various classification tracks vary, additional sensors and computer logic to calculate rolling resistances, track fullness, and variable retarder release speeds based on distance to couple should be incorporated in order to achieve a high humping rate while maintaining proper coupling speeds. The need for this additional sophistication to maintain a high humping rate and proper coupling speeds becomes more acute as the number of classification tracks controlled by the single master retarder increases. As the number of classification tracks increases, the uncontrolled distance for a car's roll from the master retarder to the classification tracks increases, thus making it more difficult to achieve a high humping rate while maintaining sufficient headway between cars to throw switches; the extra distances and curvature to the outside tracks makes accurate coupling on the classification tracks difficult. In this design it is critical to bring all the clear points as close to the master retarder as possible to minimize the uncontrolled distance. However, a master retarder which is too close to the hump crest will constrain the humping rate, since not enough distance is allowed for cars to gain sufficient separation to avoid two cars being in the retarder simultaneously; normally the master retarder is placed at least 70 feet from the crest and preferably slightly farther.* The hump height for this design is approximately 7 feet for a 12 classification track yard; the actual height varies depending on the hardest rolling resistance for the design and the number of classification tracks.

To keep the uncontrolled distance of a car's roll from the retarder to the outside classification tracks within a reasonable limit so as not to let performance suffer, it is obvious that one solution is to limit the number of classification tracks being controlled by a given retarder. This philosophy gives rise to the group-retarder-only design shown in Figure 3b, in which two or more weight-responsive hydraulic retarders are used to control two or more groups of classification tracks. Thus, the group-retarder-only design can be considered as an evolution of the master-retarder-only design when one wants to achieve higher performance by limiting the number of classification tracks under the control of a single retarder. In this design it is not only critical to minimize the uncontrolled distance from the group retarder to the clear point of the outside tracks, but it is also imperative to minimize the uncontrolled distance of a car's roll from the hump crest to each group retarder. The group retarders should be sufficiently close to the hump crest to avoid the need for a master retarder ahead of the group retarders since this adds to the cost. In an attempt to place the group retarders as close to the hump crest as possible, the first-divide switch should not be so close as to constrain the humping rate. In particular, if the

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*As a function of distance from the hump crest, the separation between cars increases to a maximum before decreasing.

first-divide switch is too close to the hump crest, the humping rate will be limited because not enough distance is allowed for cars to gain sufficient separation to throw the switch; normally the first-divide switch is placed at least 70 feet from the crest and preferably slightly farther (see footnote on page 8). Again, the performance of this design can be enhanced by additional sensors and computer logic to calculate rolling resistances, track fullness, and variable retarder release speeds based on distance to couple.

The Southern Pacific (SP) has pioneered the development of the tangent-point-retarder-only design; they currently have six of these types of yards on their property.* Figure 3c shows the design favored by SP in which weight-responsive hydraulic retarders are placed at each tangent point. The initial grades are designed to deliver the hardest rolling car to the tangent point at approximately 4.0 mph; the tangent point retarders are designed to slow and release easier rolling cars at a preset release speed of approximately 4.0 mph. The yards can achieve 3 cars per minute over the hump. The key to the design (as claimed by SP) is that the tangent point retarders squeeze the wheels and straighten out the trucks, thus narrowing down the "band" of rolling resistances on the class tracks and giving superior coupling performance. The classification track grade is a "maintaining" grade for the easiest rolling car; therefore, no coupling impact speeds are greater than 4.0 mph. The hardest rolling car generally goes about a third of the way into the class track; because their wheels have been straightened they easily get "bumped" further into the class track by succeeding cars. An important factor for a successful operation

*Mr. Barney Gallacher of the SP is designer of this type of yard.

is a "tight" design in which the uncontrolled distance of a car's roll from the hump crest to clear point on the outside track is kept to a minimum. However, again the first-divide switch should not be so close as to constrain the humping rate (see earlier discussion and the footnote on page 6). SP claims that a 24 class track yard could be designed as long as the maximum distance from crest to clear can be kept at less than 550 feet. The hump for this design is approximately 6 feet high for a 12 classification track yard; the actual height varies depending on the hardest rolling resistance assumed for the design and the number of classification tracks. Because the tangent point retarders have a simple preset release philosophy, no sophisticated sensors or computers are needed to calculate rolling resistance, track fullness, ~~and~~ or variable retarder release speeds ~~are required~~ to maintain high performance. Thus, even though there are more "feet" of retarders involved in this design as compared to the master-retarder-only or group-retarder-only designs, the costs of this design may not be substantially greater, especially if coupling performance is considered.

Which of the above mini-hump designs is best for a given mini-hump performance specification depends on the assumptions of rolling resistance and the local operational environment. In any event, the detailed hump grade and retarder placement design procedures discussed in Chapter 11 should be used to analyze and evaluate the various design alternatives.

5.2 Deciding on Flat vs. Hump Yard

The decision to construct either a new flat yard or hump yard, or to rehabilitate an existing flat yard into a hump yard should not be based on a simple car volume count, but rather on an economic evaluation of the alternatives. In the case of a flat yard versus a hump yard the economic analysis involves a tradeoff of the higher operating expenses of a flat yard versus the higher capital expenses of a hump yard; assumptions on the interest rates for capital and the inflation rate of wage scales can be critical to the evaluation. The detailed economic analysis procedures discussed in Chapter 7 should be used where Alternative 1 is a flat yard and Alternative 2 is the most cost-effective mini-hump design.

The economic evaluation procedure discussed in Chapter 7 can be a very involved process if carefully performed. Before embarking on such an analysis it may be desired to have a rough-cut procedure to determine whether or not one should proceed with the more detailed economic analysis. One rule of thumb used by a particular railroad is that a mini-hump yard is attractive if it can eliminate one yard engine and crew per trick. An alternative approximate procedure is based on the simple worksheet shown in Figure 4. This worksheet attempts to calculate the economic savings for a mini-hump yard; if the annual savings look attractive as a percentage of the additional capital investment required for a mini-hump yard, then one should proceed with the more detailed economic analysis. The desired percentage of dollar savings to additional capital investment in order for the mini-hump yard to look attractive is a function of the desired rate of return, interest rate for capital, and the amortized life of the investment. In any event, a simple threshold percentage in conjunction with the worksheet shown in Figure 4 can be used as a rough-cut procedure to determine whether a more detailed economic analysis is justified.

Item Expense	Flat Yard	Hump Yard	Hump Yard Eliminates	Dollar Savings Per Unit	Annual Savings
Number of Locomotives Per 24 Hours					
Number of Locomotive Crews Per 24 Hours					
Number of Supervisory Personnel Per 24 Hours					
Per Diem				Note 1	
				TOTAL SAVINGS	

Note 1: Estimated per diem car savings per day = (Estimate of reduced yard time per car)
X (Estimate of average hourly per diem rate per car)
X (Average number of cars processed per day)

FIGURE 4 SIMPLIFIED WORKSHEET TO CALCULATE SAVINGS OF MINI-HUMP YARD VERSUS FLAT YARD