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Ride Quality Evaluation of Doublestack Equipment

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Summary

Analysis of results from tests conducted on four revenue service trains show that the five-unit articulated doublestack car offers the best overall container and carbody load (lowest acceleration) environment. The three-unit drawbar connected doublestack train generates an acceleration environment which is comparable to the five-unit articulated doublestack. The reduced-slack coupling system (single-unit doublestack) offers an overall reduced load environment and smaller acceleration levels compared to the conventionally coupled single-unit double stack. Further, the results clearly establish that the level of large coupler forces and the carbody and container accelerations are directly controlled by the amount of total slack present in a train.

The four revenue service trains, equipped with articulated connectors, conventional couplers, drawbars, and the ASF Reduced-Slack Coupling System, respectively, were tested to evaluate the train action performance of the various types of doublestack cars available. Each train was made up of a total of 90 wells. Coupler force, carbody and container longitudinal, and container vertical accelerations were measured for each train under identical operation and service environments.

The above observations are based on comparisons of accelerations that are predominantly less than 1 g, and as such, may not be of significance to the lading of some shippers. However, the decision to opt for any of these four train configurations involves not only the ride environment but also operational flexibility, capital investment and maintenance considerations. To select the optimum train of the four test configurations requires that a complete economic analysis considering factors such as shippers' expectations, service corridor, purchase price, maintenance cost, and operational constraints.

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INTRODUCTION AND CONCLUSIONS

To investigate the ride quality of doublestack trains when equipped with various end of car coupling devices a series of revenue service tests were conducted. The tests included the use of five-unit articulated, three-unit drawbar connected and single-unit doublestack cars in the following four configurations:

- **Configuration 1** -- Ninety (90) single unit doublestack cars equipped with conventional couplers and draft gears.
- **Configuration 2** -- Eighteen (18) five-unit articulated doublestack cars equipped with conventional couplers and draft gears.
- **Configuration 3** -- Thirty (30) three-unit solid drawbar connected doublestack cars with a total of 90 wells equipped with conventional couplers and draft gears on the ends.
- **Configuration 4** -- Ninety (90) single unit doublestack cars equipped with a reduced slack coupling system.

An estimate of the total slack present in each of these trains is shown in Exhibit 1.

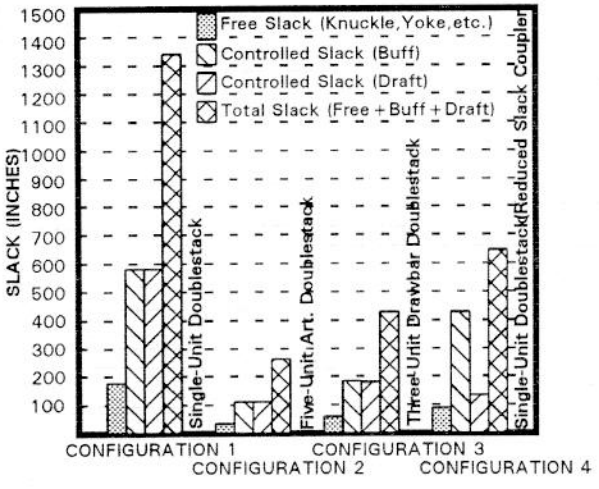

Exhibit 1. Estimate of total slack in four test configurations.

The physical quantities measured were:

- leading end coupler force
- carbody longitudinal acceleration
- top container longitudinal acceleration
- top container vertical acceleration on the leading end

The four test trains were made up and operated under identical train speed, handling, and schedule constraints to gather the data necessary for comparison. The test route was a total of 2200 miles consisting of heavy grades in one portion and fairly level territory for two-thirds of the route. The train operated near 60 mph.

On the basis of an overall trend analysis of the coupler force, longitudinal carbody acceleration, and longitudinal and vertical container acceleration the following conclusions can be drawn:

- For a given number of wells, the five-unit articulated doublestack train generated the best overall (lowest) container and carbody load environment.
- The three-unit drawbar connected doublestack configuration generated an overall load environment superior to single unit cars with conventional draft systems and comparable to the articulated configuration.
- The single-unit doublestack car with reduced slack coupling system provided an overall load environment intermediate to the single unit conventional coupling configuration and the multi-unit configurations.
- The level of carbody longitudinal acceleration and container longitudinal acceleration correlate well with the total slack present in a train. Correlation of coupler force with total slack is less clear and is probably influenced by the total train weight.
- The above conclusions are based on comparisons of accelerations that are predominantly less than 1 g, and as such, may not be of significance to the lading of some shippers. Selection of one car configuration over another should be based on the interrelation between shippers requirements, operational flexibility, initial capital costs and maintenance considerations.

DATA ANALYSIS

The data for the four measured parameters (coupler force and three accelerations) were collected at four stations (1st car, and 1/4, 1/2, 3/4 down the train length) in the following modes:

- time-at-level data
- peak-valley matrix counts
- a limited number of time history bursts

The peak-valley matrix counts were found to be most significant for data interpretation and will be discussed here. The number and range of the cycles in the acceleration and coupler force data channels provide a measure of the load environment. The counts of the peak occurrences were analyzed to calculate the exceedance, which gives the total number of times a particular peak value was exceeded. As an example, in Exhibit 2 draft force peaks greater than 200 kips were measured 1000 times for test Configuration 4 (single well w/reduced slack coupling system).

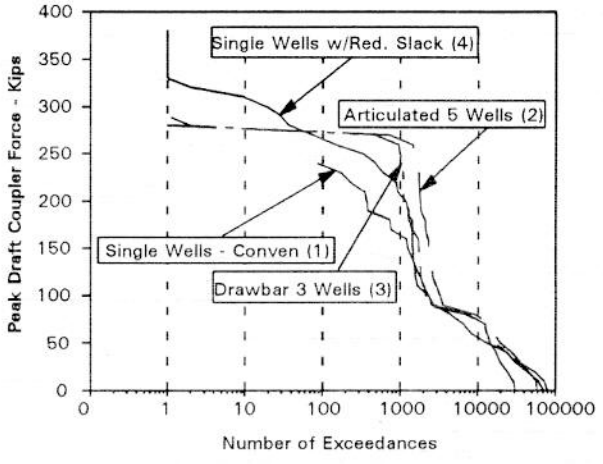

Exhibit 2. Number of exceedances vs. peak draft coupler force.

It should be noted that all high amplitude peaks due to train make-up at the origination yard were removed from the data, if it was deemed to be part of unusual handling required for assembly of the test cars with the train. The justification for this removal is that the test cars were treated differently from the rest of the train until the train was made up. These peaks were determined from the time history burst data.

Coupler Force Comparison

The peak-valley counts for the draft coupler force versus the number of exceedances are shown in Exhibit 2. Configuration 4 exhibits the highest peak coupler force. Configurations 2 and 3 show the next highest peak coupler forces. Configuration 3 has one count at a slightly higher force level than the highest peak on Configuration 2. This is followed by Configuration 1 with the next highest force level. Configuration 1 was the lightest of the four trains, hence the lower maximum draft coupler force seems reasonable.

The peak buff coupler force versus the number of exceedances is shown in Exhibit 3. Configuration 1 has the highest peak force, followed by Configuration 2. Configuration 3 has the third highest peak force, followed by Configuration 4. Below the level of 175,000 pounds, the four trains show a much closer response in buff than in draft.

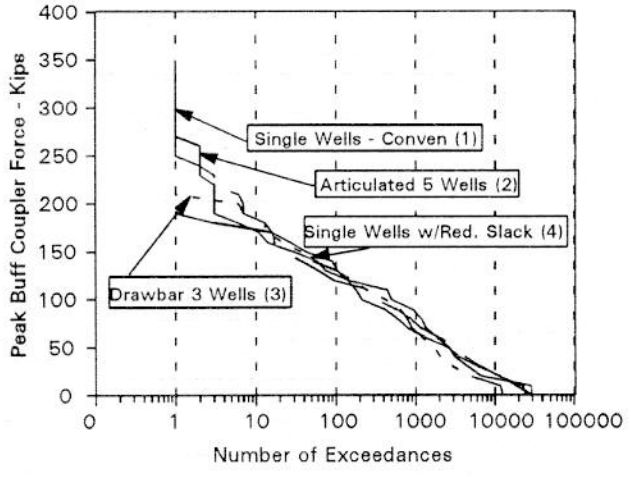

Exhibit 3. Number of exceedances vs. peak buff coupler forces.

Carbody Longitudinal Acceleration Comparison

Exhibit 4 shows the number of exceedances versus peak carbody longitudinal acceleration. In general, Configurations 2 and 3 (articulated and drawbar) tend to have one set of similar characteristics, while Configurations 1 and 4 (single conventional and single reduced slack) have characteristics similar to each other but quite different from Configurations 2 and 3. However, at high accelerations (above 1.2g) Configuration 4 does show an improvement over Configuration 1.

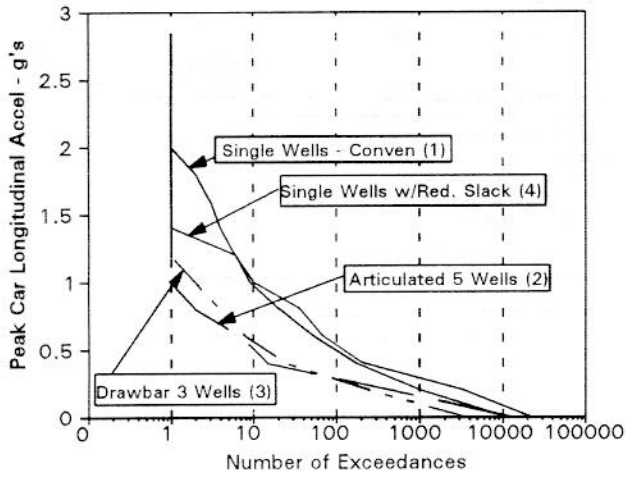

Exhibit 4. Number of exceedances vs. peak carbody longitudinal acceleration.

Configurations 2 and 3 generally show a lower acceleration environment than Configurations 1 and 4.

Container Longitudinal Acceleration Comparison

Exhibit 5 shows the peak container longitudinal acceleration versus the number of exceedances.

The order of the configurations in terms of highest peaks and overall load environment shown for the carbody longitudinal acceleration holds for the container longitudinal acceleration as well. One exception is Configuration 4, which tends to follow the drawbar and articulated configuration characteristics, but at a somewhat higher level. These overall relations are expected, since the container longitudinal acceleration depends primarily on the carbody longitudinal acceleration. Of course, pitching of the car, and shifting of the container would tend to increase the magnitude of the container acceleration above the carbody acceleration.

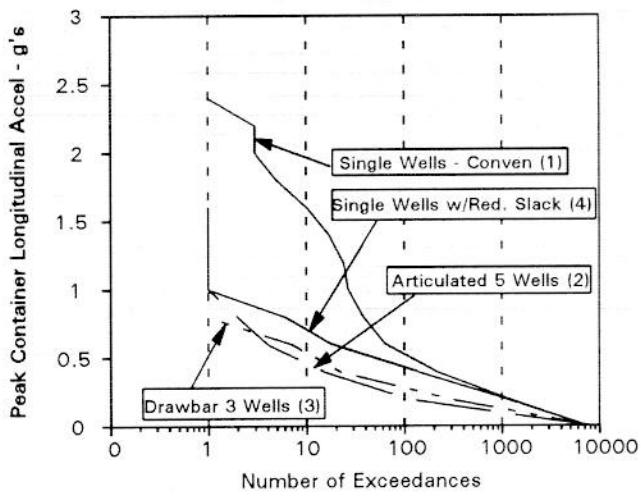

Exhibit 5. Number of exceedances vs. peak container longitudinal acceleration.

Container Vertical Acceleration Comparison

The vertical accelerations did not exceed 1 g for any of the configurations tested. The comparison of the vertical accelerations may be found in the report "Ride Quality Evaluation of Doublestack Equipment," which is in preparation.

NOTE: Contact D. R. Andersen at (312) 808-5828 with questions or comments about this document.