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RIDE QUALITY EVALUATION OF EXISTING TRI-LEVEL AUTORACKS

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Summary

Tests conducted by the AAR on tri-level autorack cars indicate that the ride quality performance of today's equipment can be improved, reducing the potential for damage to automobiles. These tests have resulted in a proposed specification for end-of-car cushioning devices that will reduce in-train forces due to slack action. Test results have also provided a preliminary set of data acquisition and analyses techniques that will be used in the development of an industry standard for the evaluation of ride quality.

Analysis of data from six separate revenue service test runs on tri-level autoracks covering a total of 15,000 miles provided information which can be used to quantify the environment associated with the use of typical three piece trucks and conventional no preload end-of-car cushions. Vertical, lateral and longitudinal accelerations were measured at one location each at the "A" and "C" deck levels.

In-train slack action with autorack cars can largely be attributed to the soft travel associated with slow speed closure of the end-of-car cushioning units. To prevent this accordion-like effect on cushioning units, it has been determined that preloads are desirable. However, a preload level must be chosen that performs as well as non-preload units under yard impact situations. Through a series of impact tests, an acceptable preload level was determined, and cushioning units tested to ensure that the desired benefits could be achieved. A new specification for end-of-car cushioning devices has been proposed for Mechanical Division Committee consideration.

The long term objective of this effort is the development of an industry standard for the evaluation of ride quality. These tests have produced a preliminary set of data acquisition and analyses techniques. These techniques will be used as a basis for discussions with railroad and shipper organizations to develop this standard.

Association of American Railroads
Research and Test Department

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INTRODUCTION AND CONCLUSIONS

Revenue from transportation of automobiles has been a very important part of the total commodity mix shipped by railroads in the past and is expected to rise considerably in the 1990's. The transportation of parts, finished automobiles and trucks, accounted for more than $2.6 billion in rail freight revenue during 1991. Based on preliminary estimates, the railroads moved about 65 percent of the new cars produced in 1992, an increase from 62.7 percent in 1990 and 43 percent in 1985. As the demand for rail transportation of autos has increased, the existing distribution system needs improvement in several areas. Some of the concerns of the auto manufacturers are: untimely deliveries, no guarantee of a 4 mph limit on rail yard impacts, irregular information systems, in-transit damage and paint contamination.

The AAR's Research and Test Department (R&T) has participated in previous autorack studies and tests, the main areas of participation being in the paint contamination and ride quality (in-train forces as well as yard impact) issues. In 1991 the Chicago Technical Center was asked to participate in a joint effort with member roads, to investigate data measurement and analyses techniques for the evaluation of ride quality of autorack railcars. This study was conducted in conjunction with the AAR Damage Prevention and Freight Claim Section. Their findings are covered in AAR Report: DP 1-93. In addition, in support of the Coupler and Draft Gear Committee, R&T participated in the preparation of a specification for preloaded end-of-car cushioning units specially designed for autorack railcars.

The major findings and conclusions of the testing effort are:

- The vertical environment in terms of accelerations measured due to pure vertical shock and vibration does not warrant concern. No proof of sustained vertical bounce and/or pitch motion was measured. Longitudinal action also results in vertical accelerations. Most of the accelerations measured (95%) were within -1.0 and +1.0 g, the maximum value being 2.2 g measured for a single count.
- Two of the six test operations experienced sustained hunting and the associated g values during hunting contributed to the maximums measured i.e. -1.4 and 1.5 g, and have the potential to cause damage. In the absence of hunting, the range of lateral accelerations measured were between -0.3 and +0.3 g, the bulk of the events (97%) resulting in values under +/- 0.5 g. Hunting is a direct result of worn wheel and rail profiles combined with a worn truck. At least one series of tests, where hunting occurred, was associated with a worn truck which indicated truck friction shoe rise of 1.25 inches. The limit recommended by truck manufacturers is 0.75 inches.
- Longitudinal accelerations measured reflected those due to in-train action as well as yard handling operations. The bulk of the data measured (99%) was within +/- 1.0 g while the maximum, occurring from yard impact, was over 4 g (two counts or samples). Railroads and the auto manufacturers have mutually agreed to maintain a maximum speed of 4 mph during yard impacts (approximately 1.2 to 1.5 g). The data suggests that in-train slack action may under certain circumstances generate longitudinal accelerations in excess of the 4 mph yard impact values.
- Through a series of impact tests an acceptable preload was determined. With the selected preload, between 50,000 and 60,000 pounds, it is expected that the coupler force and car accelerations will not exceed the 4 mph level considered by the auto manufacturers as the desirable limit of hump yard speeds.
- The need for limiting the analyses of data up to a maximum of 30 hertz should be stressed because the corruption due to localized high frequency structural vibrations can lead to very high acceleration values which do not cause any damage. It is fair to assume that all of the rigid body as well as the first flexible (fundamental) rail carbody modes are under 30 hertz. It is recommended that a low pass filter of 30 hertz

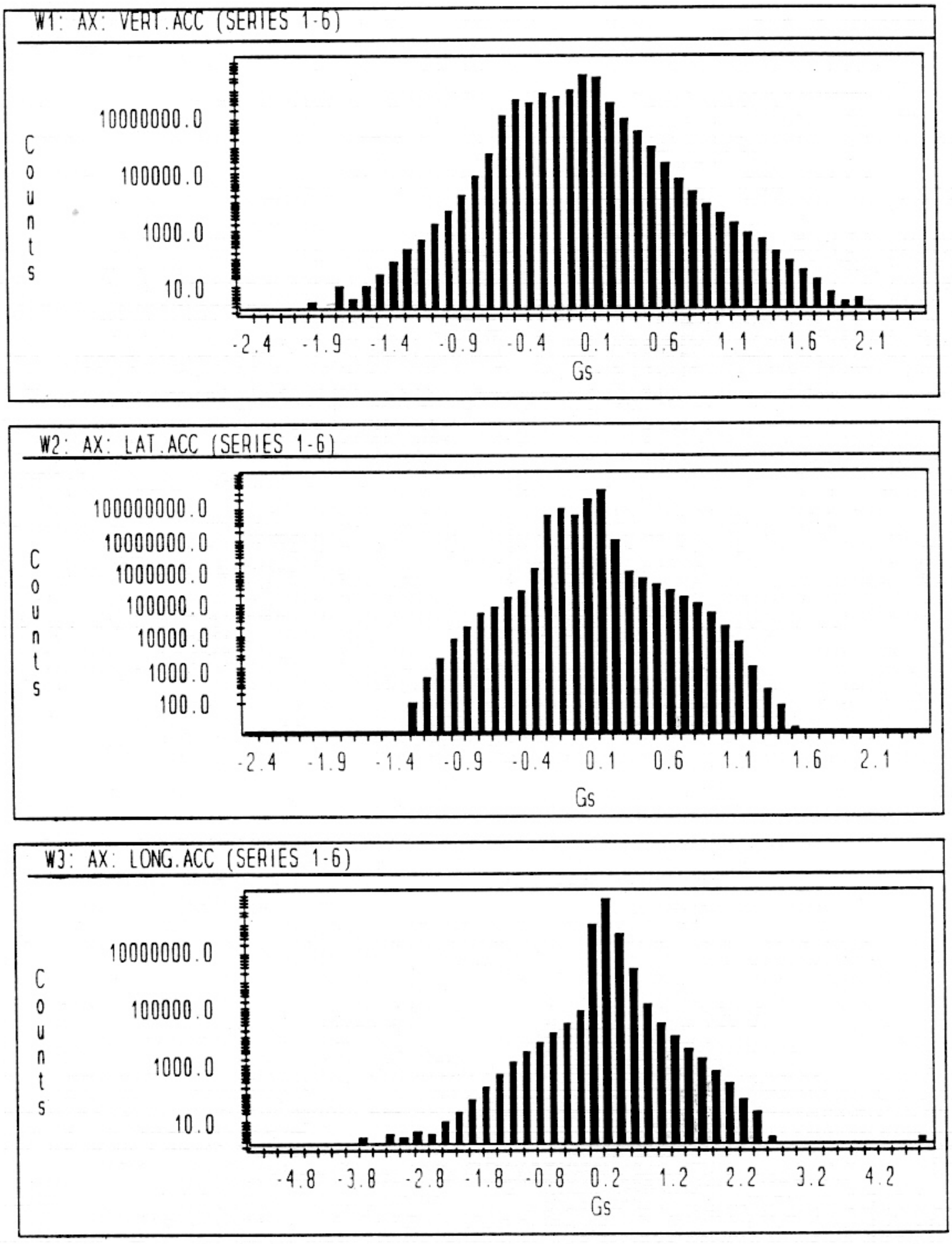

Exhibit 1. Total Cumulative Distribution - Series 1-6

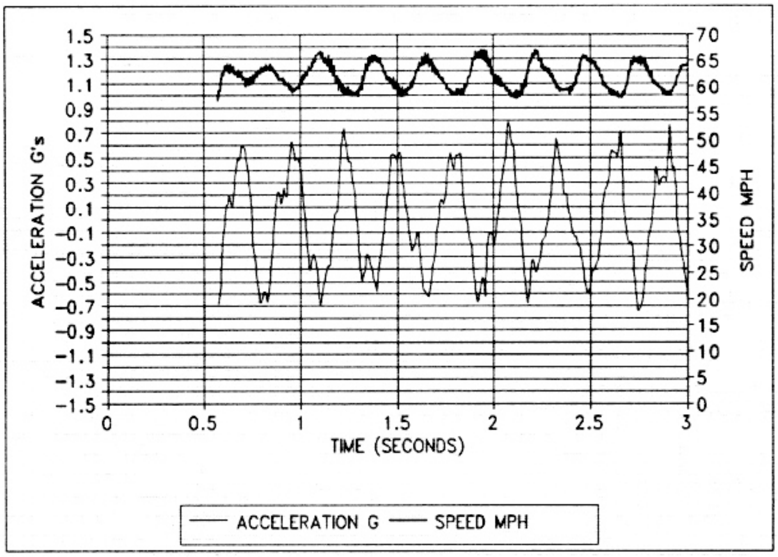

Exhibit 2. Typical Measured Lateral Acceleration During Hunting

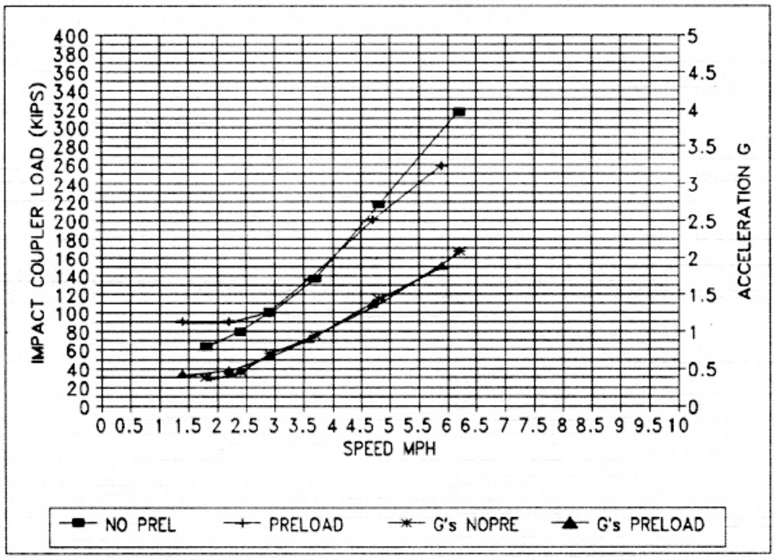

Exhibit 3. Effect of Pre-Loaded Cushion Units on Force and Acceleration.

(preferably 4-pole Bessel) be employed along with a sample rate of 300 samples/second to obtain a better than 98% accuracy limit on the maximum values measured. In addition, the length of track over which data is required should also be specified.

- The recommended analysis should include a histogram or similar type of presentation which provides the total distribution of the acceleration over a selected revenue route. In addition, the analysis should include instances of time history data, preferably of events when maximum accelerations are experienced. The time history data is useful in assessing the severity of the yard and in-train action accelerations/forces by providing the duration of the events.

Field Tests to Quantify Today's Environment

The data acquisition controller module is a sophisticated field computer which can be pre-programmed to collect various data modes unattended during revenue service tests.

Although the system can collect other information the following data modes were collected for the current autorack environment study:

- Time at Level
- Burst Time-history

The instrumentation included tri-axial accelerometer's, placed on the "A" (lowest) and "C" (highest) decks of a tri-level autorack car, in addition to a speed tachometer on one of the axles. The full scale range for the vertical and lateral accelerometers was set at +2.5 to -2.5 g while that for the longitudinal accelerometers was set at +5.0 to -5.0 g. The data mode of Time at Level was active for the entire journey. In this data mode the data is recorded in the form of number of counts of various levels of accelerations. The levels were specified in steps of 0.1 g over the appropriate full scale range.

Burst Time-history is collected for all channels after a specified level of acceleration is exceeded (trigger level). The Burst length was a function of the orientation i.e vertical, lateral or longitudinal acceleration being triggered. For each of the above there was a minimum of forty (40) Bursts collected.

The trigger levels for the vertical, lateral and longitudinal accelerometers were 0.5, 0.3 and 0.7 g respectively. A low pass filter cutoff of 30 hertz was selected for all the channels before they are digitized at a sample rate of 300 samples per second. As part of the experiment, whenever possible an inspection was made of the condition of the trucks and end-of-car cushioning, for each of the autoracks instrumented.

Vertical Ride Quality

Exhibit 1 (1st window) shows the total distribution of vertical acceleration counts for the six combined tests. If the bounce or pitch resonance of the suspension is excited, the vertical ride quality can degrade and cause damage to automobiles. This is especially true if the tie-down device is over-tightened such that it bottoms out the automobile suspension. Vertical response is also possible due to longitudinal shocks. No indications of a bounce/pitch mode of severe response were evident from the time history bursts measured.

The bulk of the data resulted in values below 1.0 g. The maximum measured value of 2.2 g was experienced once (counts or samples).

Lateral Ride Quality

Exhibit 2 shows a typical time history burst for the lateral accelerations measured along with the associated speed. Judging from the oscillatory nature of the motion measured, and the frequency of the motion of 3 to 4 cycles per second, it can be concluded that the vehicle was hunting. Exhibit 1 (2nd window) shows the cumulative total distribution in counts for the six runs. Lateral accelerations during the same six operations resulted in values between -1.3 and +1.5 g.

Longitudinal Ride Quality

Exhibit 1 (3rd window) shows the cumulative total distribution in counts for the longitudinal acceleration. The longitudinal acceleration data includes accelerations due to in-train action as well as yard handling operations. The bulk of the data measured was within +/- 1.0 g while the maximum, occurring from a yard impact, was over 4 g (two counts or samples).

Recent AAR Committee deliberations have prompted a new end-of-car specification for the lighter weight autoracks. The use of e-o-c units with a 100,000 pound preload raised some concerns during yard impacts. The concern is that at 4 mph the coupler force generated may exceed the force due to e-o-c units without preloads. In-train action simulations of run-in and run-out events for various train consist configurations have reaffirmed that a higher preload of 100,000 pound is clearly preferred, and even a 60,000 pound preload is better than no preload. Limited over-the-road data showed that the 60,000 pound and 100,000 pound force levels are routinely exceeded. However, the preload level should be chosen such that it does not effect the yard impact performance over that of a non-preload unit. Impact and limited over-the-road tests have produced data for current conventional units (10 inch units) and prototype units with different preload levels provided by manufacturers. The tests were conducted in Chapter VIII format. The test car, equipped with the test e-o-c units was impacted into a standing string of cars.

Data from the impact tests (Exhibit 3) show that a 50 to 60,000 pound preload unit will not adversely affect the impact performance. A 50,000 pound preload was selected as a "rock bottom" value. A full train test, with cars equipped with 50 to 60,000 pound preload cushioning units, is currently under consideration to evaluate the train action performance area.

Note: Contact F. D. Irani at (312) 808-5830 with questions or comments about this document.