TECHNOLOGY DIGEST

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"DYNAMIC BUFF & DRAFT TESTING TECHNIQUES -- COUPLING OF THE 89-FOOT FLATCAR TO THE 2-AXLE FRONTRUNNER,"

by Magdy El-Sibaie

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Summary

The Federal Railroad Administration and the Association of American Railroads have jointly sponsored a program for developing cost-effective and rational techniques for evaluating the curving performance of any freight car under buff and draft conditions. The procedures are developed as possible inclusions to Chapter XI.

Under this program, an analytical method was developed for predicting coupler angles and forces for any given coupling arrangements and operating conditions. The method was validated in a series of full scale track tests. A test vehicle was also designed and constructed for the purpose of applying controlled levels of lateral coupler loads at the coupler pin of any adjacent candidate car.

The test car was used to evaluate the safe curving limits of two candidate cars, namely the Frontrunner and the 89-foot flatcar, under buff and draft loads of up to 250,000 pounds and for a 10-degree curve. The tests, supported by analysis, showed that coupling of the Frontrunner to the 89-foot flatcar reduces the flatcar's ability to negotiate curves safely for draft loads higher than 220,000 pounds and buff loads higher than 180,000 pounds.

Association of American Railroads
Research and Test Department

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INTRODUCTION AND CONCLUSIONS

The railroad industry still suffers derailments where in-train forces are the likely cause. In 1990, the Federal Railroad Administration (FRA) reported a total of approximately 200 derailments which were related to slack action or excessive drawbar forces at a direct cost of $11 million (estimated total cost of at least $25 million). The problem seems to be greatest for light or empty short/long car combinations.

To ensure the safety of operating the railroads under buff and draft conditions, and to minimize the cost to the industry from related accidents, an ad hoc committee was formed by the Association of American Railroads (AAR) and FRA to consider future methods for certification of new freight cars. The committee has identified the development of dynamic buff and draft testing techniques as an important requirement. Accordingly, the AAR and FRA have agreed to jointly fund the initial phase of a program for the development of cost-effective test procedures. The proposed techniques are to be submitted to the AAR's Car Engineering Committee for their consideration as potential inclusions to Chapter XI of the AAR's *Manual of Standards and Recommended Practices.*

Unlike the traditional method of utilizing the power of many locomotives to directly generate buff and draft forces, the new procedures utilize the power of a single locomotive and a special load application car, which was designed and fabricated at the Transportation Test Center, Pueblo, Colorado.

One particular car arrangement -- 89-foot flatcar coupled to the short 2-axle Frontrunner -- has been a suspected causal factor in a few recent derailments. Therefore, these two cars were the first candidate cars used in pilot testing of the new buff and draft test car. Both cars were tested in their empty configuration.

The following summarizes conclusions derived from these tests:

1. Testing established the feasibility of the load application car in imparting controlled levels of lateral load to the coupler pin of each of the two candidate cars.
2. Adopted procedures were successful in determining the limits of the lateral coupler load that can be safely applied to each of the two candidate cars while negotiating horizontal curves.
3. Testing showed that the maximum lateral coupler load that can be applied safely to the 2-axle Frontrunner car was 11,000 pounds. The limit for the 89-foot flatcar was 26,000 pounds. Both limits were determined based on the safe negotiation of a constant 10-degree curve according to the current Chapter XI criteria.
4. The Frontrunner's coupler load was limited by a drop in the average vertical load on the unloaded side below the minimum 10 percent static load level specified by Chapter XI. Occasional wheel lifts were measured and observed when the 11,000 pounds limit was exceeded.
5. The 89-foot flatcar's coupler load was limited by an increase in the single wheel lateral to vertical (L/V) load ratio on the loaded side above the maximum 1.0 value specified by Chapter XI.
6. Based on the established coupler load limits, analyses were conducted for the coupling of the two cars and the coupling of each to like cars under buff and draft loads of up to 250,000 pounds. The average steady state lateral coupler load experienced by the Frontrunner did not exceed the established test limit for both conditions of coupling. The 89-foot flatcar experienced lateral coupler loads that were within the established test limits *when coupled to a like car*. However, when coupled to the Frontrunner, the lateral coupler load experienced by the 89-foot flatcar exceeded the established test limit for draft loads in excess of 220,000 pounds and for buff loads in excess of 180,000 pounds.

Given the apparent success of the outlined testing techniques, it is recommended that further effort be invested in developing the specific Chapter XI provisions.

TEST PROCEDURES AND RESULTS

Proposed certification techniques, consisting of testing aided by analysis, are based on the fact that when a car is subjected to buff or draft loads, only the lateral and vertical components of these loads affect the stability of its performance. Therefore, a proper assessment of the performance of a car may be made if the longitudinal forces are substituted with their effective lateral and vertical components. An advantage of this concept is that the required loads may be limited, based on the limits of coupler angles, to a more practical range of perhaps 10,000 pounds to 60,000 pounds.

Based on this concept, the AAR designed and constructed a special test car capable of applying controlled levels of lateral force at the coupler pin of any adjoining car. Shown schematically in Exhibit 1, the car, while in motion, can apply lateral coupler loads of up to 60,000 pounds through a pair of servo-controlled hydraulic actuators.

An additional requirement that this method presents is the need to determine the coupler angles and forces associated with each dynamic event in order to predict the corresponding lateral components. This is determined analytically by an IBM compatible computer program which was developed by the AAR for this purpose. The program named Coupler Angling Behavior Simulator or CABS was validated in a series of track tests in which measured coupler angles were compared to those predicted. The results of the validation showed that program correctly predicted the average coupler angles and forces produced under constant curving conditions.

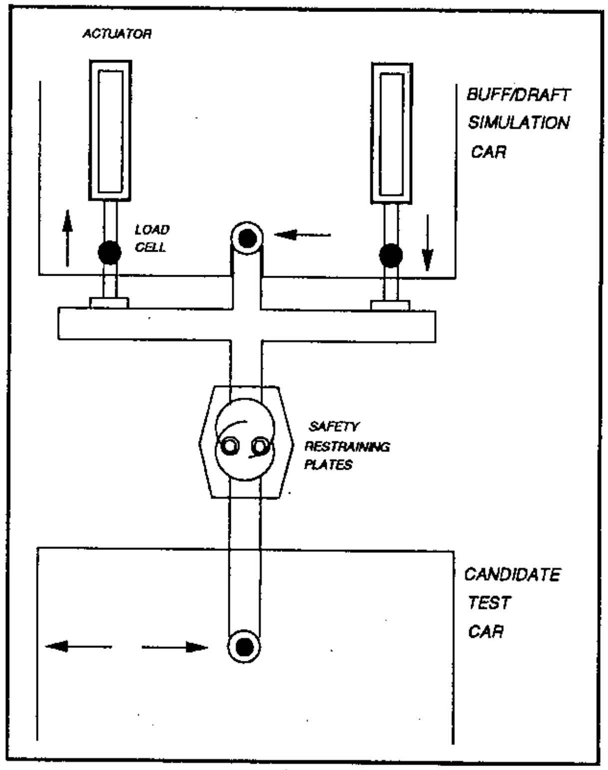

Exhibit 1. Schematic of Buff and Draft Test Car

Under the proposed program, two sample cars were selected for the initial phase of testing with the buff and draft car. These were the Frontrunner and the 89-foot flatcar. A few recently reported derailments, in which buff and draft forces were suspected, involved the coupling of the Frontrunner or some other short car to the 89-foot flatcar. Both cars were tested in only the empty configuration. Testing was conducted on the Wheel/Rail Mechanics loop on the 10-degree curve in the clockwise direction. The Frontrunner was tested at speeds of 12, 24, and 32 mph corresponding to -3,0, and +3 inches off the balance speed for this curve. The 89-foot flatcar was tested only at the 24 mph balance speed.

The measured wheel/rail forces were averaged for each run for the curve portion through which the applied actuator load was constant. This constituted a distance of roughly 600 feet for each run.

Exhibit 2 shows the average measured vertical wheel loads plotted versus the net applied lateral coupler load for the Frontrunner car and at the balance speed. Lateral coupler loads in excess of 11,000 pounds caused the unloaded side to drop below the minimum 10 percent static weight criteria set by Chapter XI. Testing beyond this limit in either direction produced occasional wheel lifts on the unloaded side as observed through a pair of video cameras set up to monitor the wheel/rail interface and as evident from the measured wheel/rail forces. A maximum L/V ratio of 0.8 was measured on the loaded side in either direction of load application.

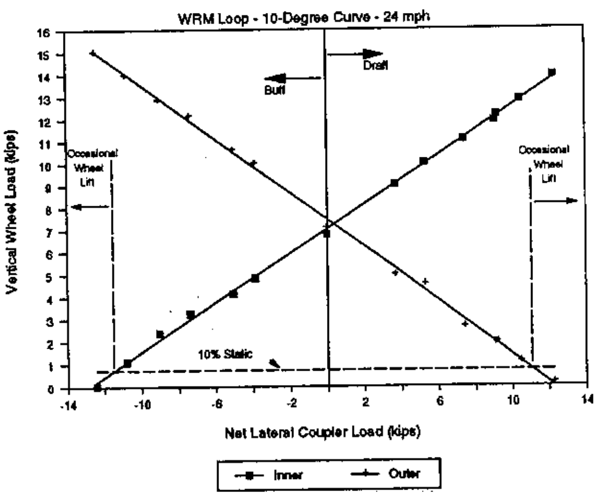

Exhibit 2. Average of Measured Vertical Wheel Loads

Similar testing of the 89-foot flatcar was conducted for coupler loads of up to 26,000 pounds in either direction. Testing was terminated at this load level due to the loaded side of the leading axle occasionally registering above 1.0 L/V ratio while averaging a near 1.0 L/V ratio.

To translate the limits of lateral coupler load established by the previous testing into limits on actual buff and draft forces, additional analysis was conducted using CABS.

Exhibits 3 shows the variation in the lateral coupler load as a function of the applied buff and draft load for the two cases of mixed and like coupling of the 89-foot flatcar. The two horizontal lines indicate the safe limits identified from the previous testing results.

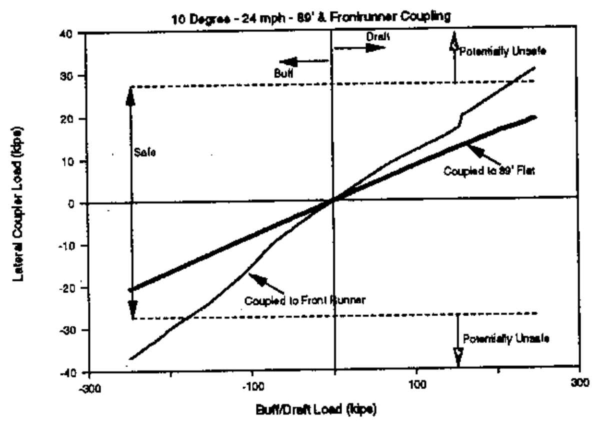

Exhibit 3. Buff/Draft forces Versus Lateral Coupler Load -- 89-foot Flatcar

For the flatcar, the results indicate a safe performance when coupled to a like car. However, coupling of the two cars reduced the ability of the flatcar to negotiate curves for draft loads in excess of 220,000 pounds and buff loads in excess of 180,000 pounds.

Contact Magdy El-Sibaie at (719)-584-0589 with questions or comments about this document.

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