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Rail Longitudinal Force Measurement Using the Track Loading Vehicle

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TD 92-016

__*Summary*__

Recent tests using the Track Loading Vehicle (TLV) show that rail longitudinal force and neutral temperature can be measured by a non-destructive method called "Rail Uplift". Revenue track test results confirmed the feasibility of conducting preventative buckling maintenance on track which experiences large temperature variations and heavy traffic.

The AAR modified the TLV using a new interchangeable rail-uplift bogie located at the center of the vehicle. The rail uplift bogie is equipped with feedback controlled actuator systems and rail hooks, and is capable of lifting both rails between the inboard axles of the TLV. The measurement technique is based on the correlation between the rail longitudinal force and the vertical force required to lift a segment of unrestrained rail.

Following the construction and initial checkout at the Chicago Technical Center, a series of feasibility/pilot tests was conducted in May, 1992 at the Transportation Test Center (TTC) in Pueblo, CO. These tests confirmed the viability of the rail uplift concept and demonstrated that the TLV measurement system met required accuracy and sensitivity limits.

Further tests were conducted on a major western railroad in August, 1992 to characterize the longitudinal force and temperature variation on "buckling sensitive" revenue service tracks. The test results from a recently maintained track correlated well with the expected rail-laying temperatures. The repeatability of the measurements was extremely good.

The results further confirmed the variable nature of CWR's neutral temperature distribution, hence the need for an accurate rail force measurement technique. Based on limited testing, longitudinal forces did not increase at bridge abutments or road crossings, nor did they increase near turnouts, where rails are expected to bunch.

Association of American Railroads
Research and Test Department

December 1992

INTRODUCTION AND CONCLUSIONS

Increased use of continuous welded rail (CWR) in North America has substantially improved rail safety performance. Although many types of safety concerns related to rail joints have been eliminated, it has also led to an increase in track buckling incidents, which can cause derailments. To further improve rail safety performance, the AAR, in conjunction with the Volpe National Transportation Systems Center (VNTSC) conducted a pilot study on Rail Neutral Temperature (RNT) variations.

The non-destructive measurement of rail longitudinal force has been one of the most important challenges in railroad research for more than a decade. Recent studies undertaken by the researchers at the Volpe National Transportation Systems Center has resulted in the development of analytical models and experimental techniques for the measurement of rail longitudinal force and track lateral resistance.

In conjunction with the joint AAR/FRA Vehicle Track Systems Project, the AAR modified the TLV for use in rail longitudinal force/rail uplift measurement on revenue trackage. The rail uplift technique, which has been developed by the VNTSC, is based on the correlation between the rail longitudinal force and the vertical force required to lift a segment of unrestrained rail.

The following conclusions were drawn from the analysis of the TLV test data:

- The TLV-rail uplift measurement system met required accuracy and sensitivity limits through verification tests.
- Based on pilot test data from both tangent and 5-degree curve tracks, excellent results were obtained in terms of measurement accuracy and sensitivity.
- The results generally confirmed what was expected by the railroad. Any track movement on curves, either inward or outward, corresponded to high and low neutral temperatures, respectively.
- Contrary to expectations, longitudinal forces did not increase at bridge abutments or road crossings, nor did they increase near turnouts, where the rails are expected to bunch.
- Test results further confirmed the variable nature of CWR's neutral temperature distribution, hence the need for accurate rail force measurement technique. Neutral temperatures ranged from a low of 60 degrees to a high of 113 degrees, where the maintenance RNT was targeted at 95 degrees.
- Overall, revenue rail uplift tests were extremely successful and repeatable. The TLV provides a non-destructive method of determining neutral temperature of CWR, and can be used to inspect the track for preventative buckling maintenance.

TLV RAIL UPLIFT TESTS

The principle of the rail uplift technique is based on the fundamental relationship between the longitudinal force level in the rail and the vertical lift force required to deflect a rail segment a given amount. The test procedure involves removal of the fasteners and rail anchors on both rails between the TLV inner wheels. Special hooks are clamped to the rail which is lifted to about 2 inches above the tie plates. The resulting uplift force measured by the TLV is later used to calculate the rail longitudinal force and the RNT at the pull point.

The new rail uplift bogie shown in Exhibit 1 was designed and constructed at the AAR's Chicago Technical Center. Two vertical and two lateral feedback controlled actuators are used to keep the bogie parallel to the track during lift and to center it over curves. The uplift bogie features two additional vertical actuators to lift the rails. The lift actuators are attached to a slide, mounted on linear bearings, which rides on a beam transverse to the track. The rail uplift bogie is equipped with an active feedback control system which is used to maintain the load frame position both parallel to the track and at a fixed height above it. A five piece hook mechanism is attached to the end of each lift actuator to clamp the rail head.

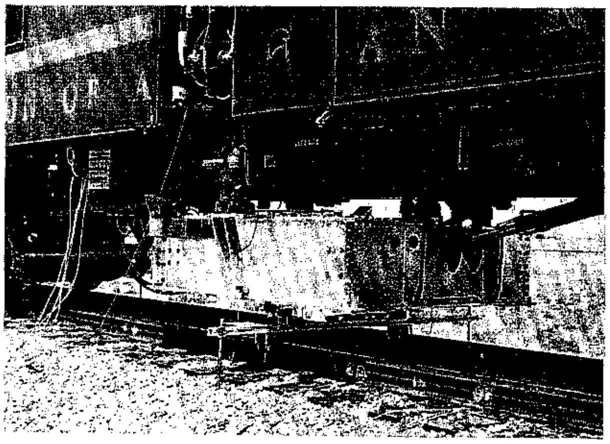

Exhibit 1. TLV Rail Uplift Measurement System.

Checkout tests in Chicago were followed by a series of track demonstration tests at TTC in May, 1992. The primary purpose of these tests was to determine the measurement system's accuracy and sensitivity limits, calibration requirements, and its suitability as a revenue service rail uplift device. During these tests, various tangent and curved track segments were destressed, strain gaged for longitudinal force measurement, and artificially heated to generate compressive rail force levels up to 50,000 pounds. The test results showed that the system met all the accuracy and sensitivity limits required to map the longitudinal force and the RNT variation on mainline quality track. The data obtained from these tests were used to develop a general "rail longitudinal force predictor" for use in revenue service applications. The relationship between the rail longitudinal force and the rail uplift force for a 5-degree curve is shown in Exhibit 2.

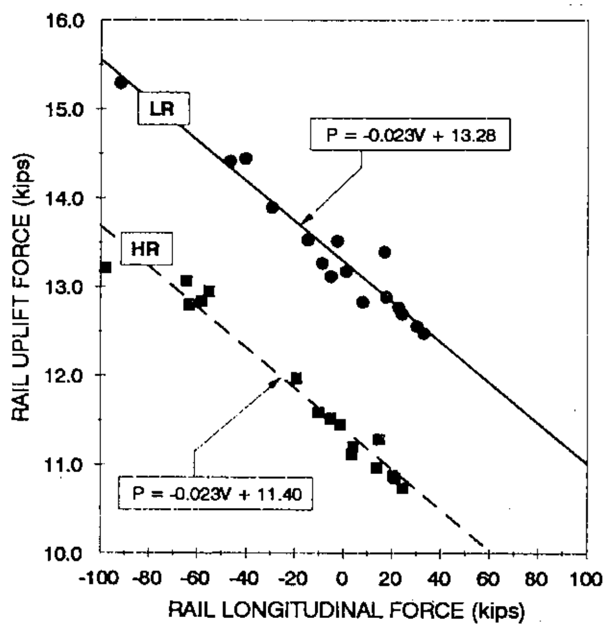

Exhibit 2. Effect of Rail Uplift on Rail Longitudinal Force, 5-degree Curve.

Following the initial calibration tests at TTC, a series of comprehensive tests were conducted on revenue trackage in August, 1992. The purpose of these tests was to characterize CWR rail force and neutral temperature variation on "typical" and "buckling sensitive" revenue service tracks and conditions. Track sites were chosen on the basis of a history of track buckling and alignment problems and to meet the various criteria set for the test program.

The track on this line sees about 45 million gross tons (MGT) of unit-train coal traffic per year. Approximately four miles of track were tested in 300-foot intervals, in about seven working days.

Exhibit 3 shows the variation of the RNT along the track in one of the test sections, which was laid with 132 pound (low rail) and 136 pound (high rail) CWR on concrete ties with Safelock fasteners. This track featured a 6-degree left hand curve and a short tangent on a 1 percent ascending grade. A ballasted-deck bridge was located at the center of the 6-degree curve.

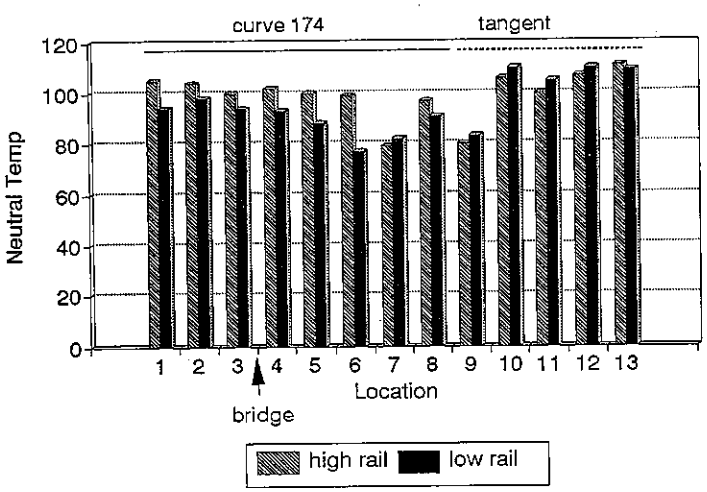

Exhibit 3. Neutral Temperature Variation on Newly Maintained Mainline Track on Concrete Ties.

The test track had been maintained three months prior to the TLV tests: near test locations numbered 4 and 12 the rails were de-stressed in 1000-foot sections using superjacks, and rewelded to produce a 95-degree laying-temperature. Except for a few locations, the TLV test results showed that the RNT remained between 90 to 100 degrees. The highest compressive force of 80,000 pounds was measured in the low rail at test location 6, where the rail temperature during testing was 109 degrees. At some of the test locations (not shown here) a considerable amount of variation in the RNT was found along the track and between the two rails. Areas that had large variations in the results were generally at the beginning and end of spirals. Based on limited testing, the test results showed that longitudinal forces did not increase at bridge abutments or road crossings, nor did they increase near turnouts, where the rails are expected to bunch. Moreover, high forces were not apparent at the bottom or top of the heavy grades.

The rail was de-stressed and rewelded at 95 degrees at one of the test locations where the RNT was measured at 60 degrees. This location was retested, and it was found that it had increased to 91 degrees after maintenance. In order to quantify the repeatability of the tests, several locations were retested at different times of the day. Overall, the uplift tests showed excellent repeatability.

It was shown that the rail uplift method is a viable technique to map the rail longitudinal force variation in revenue service. It is feasible that a production version of a vehicle like the TLV can help facilitate automated inspection of track for preventative buckling maintenance.

Note: Contact S. Kalay at (312) 808-5842 with questions or comments about this document.

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