

Gage Restraint Measurement Systems (GRMS)

Overview and Status Report

December 2002

Before the first fixed axle steel wheel ran on a steel rail the track builder measured the distance between the rails.

Modern track geometry methods have been in use since the 1960's and are the basis of the track maintenance planner's work today. Ultrasonic rail flaw detection not only finds existing rail defects, but also allows the railroads to plan their rail requirements on the basis of fatigue life. Rail profile measurement is used to analyze wear characteristics and the trends for planning of rail purchases, and to plan and support rail-grinding programs.

Track strength measurement techniques, that is, measurement of the response of the crossties and fasteners to vertical and lateral loads, was first developed and demonstrated in the late 1970's.¹ Through the 80's and 90's, split-axle load/measurement systems have been analyzed and accepted by AAR and FRA as an effective means to assess and quantify track strength.²

In the past, track strength assessment has been subjective and dependent on the judgment of the track maintenance personnel. Although track geometry vehicles do measure gage under load, it is unlikely that they will locate all of the weak spots in track due to vehicle dynamics.³ Further, geometry cars do not have the ability to analyze the variability of track strength. Controlled, continuous measurement split-axle loading devices, known as GRMS vehicles, can effectively measure and quantify track strength, be an effective tool to find weak spots in track that need repair, and be used as a planning tool to maximize the effectiveness of capital tie programs. Objective, performance based assessment of track strength is a major development that can improve safety and assist railroads in the effective management of resources.

In April 2001, FRA amended the Track Safety Standards to allow the use of acceptable GRMS vehicles in the application for "Waiver Track", that apply performance based standards as the controlling method to determine if track meets tie and fastening standards.⁴

American Railway Engineering and Maintenance Association (AREMA) Committee 2 has developed standards of GRMS measurement in conjunction and association with the work of the AAR and FRA. Chapter 2 of AREMA outlines the testing equipment and parameters required to perform effective GRMS testing. Critical measurements include unloaded gage, loaded gage, and actual vertical and lateral loading, on a maximum one-foot incremental basis. Load severity index must be between 3000 and 8000 pounds, with a minimum of 10,000 pounds of vertical force on each rail. L/V ratios must range between approximately 0.55 and 0.85. Maximum testing speed of up to 35 mph is acceptable. PLG²⁴ (*see note at end of report) is calculated from the active gage and loading readings.

GRMS testing is effective for immediate repairs of weak track conditions, for meeting FRA requirements for “Waiver Track” and defined by the most recent Track Safety Standards, and for capital tie planning programs. GRMS provides the unique ability to test the strength to accepted performance based standards, which can lead to improved track safety and potentially improved economics related to tie and fastener installation and performance.

Holland’s TrackSTAR® is the only hi-rail GRMS vehicle in existence in the world. Developed over the last 10 years, the equipment was evaluated by FRA and found acceptable to perform GRMS testing. TrackSTAR® also provides full inertial based track geometry and laser optical rail profile measurement during the GRMS testing. Typical testing speeds of up to 30 mph delivers full testing days of up to 150 track miles. Available for short or long-term contracts, Holland now has four TrackSTAR® vehicles in testing service throughout North America. In total, Holland has tested over 30,000 miles of track for over 60 customers including Class 1’s, Regionals, Shortlines, and Transits.

Following is a summarized list of development work and significant readings and dates related to track strength measurement evaluation:

- 1978—AAR demonstrates the feasibility of automated, continuous and objective measurement of tie/fastener performance with test devise mounted on the trailing truck of a flatcar. ¹
- 1980—AAR with cooperation from Southern Railway and FRA build the prototype track strength measurement vehicle none as the Decaroter which demonstrated continuous track strength measurement up to 7 mph. ⁵
- 1980—Volpe National Transportation System Center (VNTSC), in cooperation with the AAR conducted track safety research tests, which led to the development of the Gage Restraint Measurement System (GRMS). This joint effort of FRA, VNTSC, AAR and AREA, used a spreading split axle as the lead axle on the trailing truck of a half-loaded 100-ton hopper car with test loading of 14L/17V kips. ⁶
- 1985—Under the auspices of the AAR’s Vehicle Track Systems Program and the joint AAR/FRA effort in the Track Train Interaction Derailment Analysis Project, several research programs were launched, including the quantification of lateral strength characteristics of track.
- 1989—The Track Loading Vehicle (TLV) is built by the FRA to measure track strength and investigate derailment mechanisms. The TLV demonstrated that by applying controlled lateral and vertical loads to the track and measuring the response of the rails to the loads, gage-widening resistance could be determined. ⁷
- 1991—In-motion TLV track gage widening tests were run under simulated 33 and 39 ton axle loads on the High Tonnage Loop at the AAR FAST track in Pueblo, Colorado. During this year the TLV was used on nine North American railroads to test lateral track strength. ⁷

- 1992—Holland Company begins development of the TZAR track strength testing vehicle for the BN Railroad. This work is followed by the development and eventual patenting of the TrackSTAR® track strength hi-rail system. 8
- 1994—AAR completed additional track strength data collection and analysis using the TLV to propose a new methodology to assess critical gage conditions. AAR also examined the gage widening index called Projected Loaded Gage (PLG) which was developed by VNTSC. PLG was determined by AAR to be an effective predictor of the maximum dynamic gage expected under extreme loads based on extrapolation of the load/deflection curve. This work of the FRA, AAR and VNTSC gave strong indication that the concept of in-motion measurement of track gage strength using split axle devices to be one of the most promising alternatives to traditional visual inspection of crossties and fasteners for maintenance planning. 9
- 2001—FRA amends the Track Safety Standards to provide GRMS alternative to tie and fastening standards through the selection of “Waiver Track” territories that use accepted GRMS vehicles for the performance based testing of track strength. 4
- 2002—Holland Company completes the development of TrackSTAR® GRMS hi-rail vehicle to FRA standards. Vehicle is demonstrated to FRA in comparison to FRA T-6 car. Holland TrackSTAR® is approved by FRA as suitable for GRMS testing. 10

References:

- 2,3 Singh, S.P., “Revenue Track Gage Widening Tests Using the Track Loading Vehicle”, AAR Research Report No. R-886, Pueblo, CO, August, 1995.
- 1 Zarembski, A.M., “Measurement of Gage Restraint Rail Spreader Tests”, AAR Research Report R-347, Chicago, IL, December, 1978.
- 4 RT&S Magazine, February, 2001, page 29, “FRA amends Track Safety Standards...”.
- 5,9 O’Donnell, W.P., Hazel, A.B., Kalay, S., “Fundamental Track Gage Widening Tests Using the Track Loading Vehicle”, AAR Research Report R-862, Chicago, IL, June, 1994.
- 6 Kish, A., et al., “Experimental Investigation of Gage Widening and Rail Restraint Characteristics”, Volpe National Transportations Systems Center, FRA Research Report ORD-83-15, DOT-TSC-FRA-84-5, November, 1984.
- 7 Kalay, S.F., O’Donnell, W.P., “Demonstration Testing of the Track Loading Vehicle,” AAR Research Report R-782, Chicago, IL, June, 1992.
- 8 Railway Track & Structures Magazine, September, 1993, pages 54-59, “Testing track strength and wood-tie condition”.
- 10 FRA Draft Report, December, 2002, Washington, D.C., “Evaluation of Holland TrackSTAR® hi-rail GRMS compared to FRA T-6 car on Maryland Midland Railway”.

Numerous other reference reading is available. Suggested readings include AAR Research Reports R-862, R-782, R-347, R-395, R-427, and R-815. These reports

make additional reference to over 50 other papers, studies and evaluations performed by railroads, AAR, FRA, and numerous industry engineering and manufacturing companies.

*Projected Loaded Gage (PLG). One of the measurements that the GRMS utilizes to characterized track strength is PLG. The PLG predicts the maximum potential gage widening that would occur under extreme loading conditions. The PLG uses unloaded track gage (UTG), loaded track gage (LTG), and an extrapolation factor (A). The formula is as follows:

$$PLG = UTG + A \times (LTG - UTG)$$

Where “A” is the extrapolation factor used to convert the measured loaded gage to expected loaded gage under a 24,000 pound lateral load and a 33,000 pound vertical load.

Attachments:

- RT&S article, April 2001
- AREMA Committee 2-Recommended Practice Conditions for Gage Restraint Measurement
- FRA Track Safety Standards, Section 213.110 Gage Restraint Measurement Systems