TECHNOLOGY DIGEST

Timely Technology Transfer

Evaluation of a Second Prototype High-Speed Tribometer

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TD 97-044

Summary

The second of two prototype tribometer (HST2) concepts designed to measure rail friction at speed has been demonstrated to be viable but in need of improvements in tests conducted by the Association of American Railroads (AAR). These evaluations were performed under closed-loop conditions at the Transportation Technology Center near Pueblo, Colorado. Data shows that prototype tribometer HST2 is capable of measuring rail friction at speeds up to 30 mph. The prototype evaluated is the second of three concepts being offered by various vendors for measuring rail friction at typical track-inspection speeds.

Rail friction was measured statically with a hand-operated tribometer and compared with data generated by the prototype tribometer at the same locations at speeds from 5 to 30 mph. Within these test speeds, the prototype was most consistent at speeds between 15 mph and 20 mph. Successive passes over the same sections of track indicated that repeatability of gage-face measurements was very high, while top-of-rail friction (μ) exhibited significant scatter. The hand-held tribometer exhibited scatter of greater than $\pm 0.1\mu$, thus accuracy of HST2 readings cannot be stated.

The prototype concept, as demonstrated, did not meet all guidelines established by the AAR and its steering committees. Prior to production, the deficiencies of this system for measuring rail friction should be addressed to ensure a safe, efficient, and user-friendly device.

AAR is sponsoring evaluations of technologies to measure rail friction at typical track-inspection speeds. These techniques could replace hand-held and hand-operated tribometers to assess lubrication effectiveness on the top and on the gage face of rail. Evaluation of the first prototype was covered in TD 97-014. Future work in this AAR-sponsored project will include evaluation of the third concept and monitoring revenue-service use of high-speed tribometers, providing that funding remains available.

Association of American Railroads
Railway Technology Department

November 1997

Suggested Distribution:

- ❑ Train Handling
- ❑ Maintenance of Way
- ❑ Planning and Analysis
- ❑ Track Maintenance

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INTRODUCTION AND CONCLUSIONS

A second concept for measuring rail friction at speed has proven viable but in need of improvements. This evaluation was performed at the Transportation Technology Center (TTC) near Pueblo, Colorado. The Association of American Railroads (AAR) is sponsoring evaluations of technologies that measure rail friction at track-inspection speeds. These technologies may eventually replace the hand-held tribometer, which is best used for spot measurements, but is too slow for in-service use over long lengths of track and requires separate adjustments for top-of-rail and gage-face measurements.

Lubrication of the wheel/rail interface has been shown to offer significant benefits in wheel and rail wear, along with reduced train energy consumption. However, improper lubrication, in the form of too much lubrication, can lead to train-braking concerns and increased track wear. High lubrication differentials between the top of each rail can lead to poor truck steering and increased lateral loads. A method to measure rail friction at high speeds has been proposed to give railroads a tool for managing lubrication over long lengths of track.

The AAR has coordinated an effort by the tribometer Technical Advisory Group (TAG) to create a set of operational guidelines to evaluate prototype high-speed tribometers (HST). In order to accelerate the introduction of an HST into revenue service, the AAR is testing and evaluating prototype devices and comparing performance to the TAG-generated guidelines.

More than 300 miles of testing on TTC tracks was conducted using the second prototype high-speed tribometer (HST2). Top-of-rail and gage-face friction data taken at speeds up to 30 mph showed reasonable correlation with hand-held tribometer data. However, scatter and resolution of the data varies with filtering and sample averaging.

PERFORMANCE GUIDELINES

The TAG-generated guidelines include basic safety, accuracy, reliability, and operating factors that would be considered by railroad users when selecting an HST technology for purchase or contract. These guidelines were sent to prospective vendors in the form of a specifications document describing the evaluation procedure to be used by the AAR. A high-speed tribometer would be evaluated against the following parameters:

- Safe operation over all track components, including switches, crossings, and guard rails
- Continuous friction data from top-of-rail and gage-face measurements
- Non-interference with routine track-inspection duties
- Friction-data accuracy comparable to a hand-held tribometer
- Inspection speed of 30 mph
- Immediate indication of rail-friction values
- Data storage for lubrication program planning
- Ease of installation, removal, and operation
- Successful mate to typical pickup hi-rail equipment

HST2 PROTOTYPE

The second prototype tested was provided by Diversified Metal Fabricators (DMF) of Atlanta, Georgia, with George Clem of GKC Consulting Company (GKC) as project manager. The prototype measurement system is supported by a four-wheel bogie that is pushed in front of the hi-rail vehicle. Individual measurement wheels are configured to measure top of rail and gage face.

For prototype testing, DMF equipped the HST2 with measurement wheels on the right side only. The measurement concept gradually increases rolling resistance of each measurement wheel. Friction is computed at the time of slippage by measuring the vertical and longitudinal forces. This sequence is repeated continuously. A running average of top-of-rail and gage-face friction is updated by showing a four-data-point running average, which is updated every two seconds. Control-system and data-collection is Windows®-based and proprietary.

The data-collection system displays a running-average friction for the rail (top-of-rail and gage-face). This system collects and stores continuous friction, speed, and operator-referenced location data. The prototype HST2 is shown in Exhibit 1.

DATA/EVALUATION PROCEDURE

After initial shakedown testing by the vendor, the prototype was shipped to TTC where it was attached to a hi-rail vehicle. The prototype HST2 was operated over various TTC tracks to determine operating safety and stability. In addition, the HST2 was tested for accuracy, repeatability, and reliability. Operations were conducted through turnouts (facing and trailing moves), curvature up to 12 degrees, dry and lubricated rail, road crossings, high guard rails, tight and wide gage, jointed and welded rail, and a variety of worn-rail profiles.

Data consisted of hand-held tribometer readings at selected locations, which were compared with friction levels indicated by the HST. Additional data includes

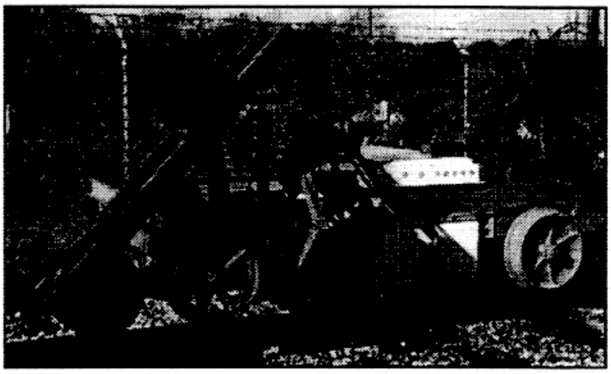

Exhibit 1. HST2 Prototype High-Speed Tribometer

notes on operations, adjustments, and repairs required by the operator and test staff during the evaluation program. No absolute, independent measurement of field rail friction was available. The existing hand-held tribometer was used as a comparison because it has proven to be very repeatable; however, during this test variations were noted with the hand-held unit.

RESULTS

During the TTC evaluation, some upgrades and changes to the prototype software and hardware were made by DMF and GKC personnel. Top-of-rail and gage-face data collected comparing HST2 and hand-held data is shown in Exhibits 2 and 3.

Results suggest that gage-face data scatter is significantly less than that of the top-of-rail, however resolution/sensitivity to changes in friction of the gage face is much less than that of the hand-held unit. Data displayed in Exhibit 2 shows a small change in HST2 gage-face readings of 0.12 (0.28 to 0.4) for a larger change in hand-held tribometer readings of 0.3 (0.2 to 0.5). The top-of-rail scatter (Exhibit 3) is much greater than the gage face, while the resolution/sensitivity to changes in friction is larger than the gage face. The HST2 tread data indicated a range of 0.32 (0.28 to 0.6), while the hand-held range for the same rails is 0.41 (0.19 to 0.6).

In both cases — top-of-rail and gage-face — scatter of the data makes an individual measurement somewhat unreliable. However, by creating a four-point running average both accuracy and repeatability increase. Exhibits 4 and 5 illustrate gage-face and top-of-rail results of repeated passes over a 1,500-foot length of non-lubricated tangent track, with Mile Post 12.545 being modified by coating 100 feet of rail with soap to reduce friction. The moving average utilizes four connective data points collected over a 200-foot distance, thus changes in friction over short distances tend to be filtered. For this test, as

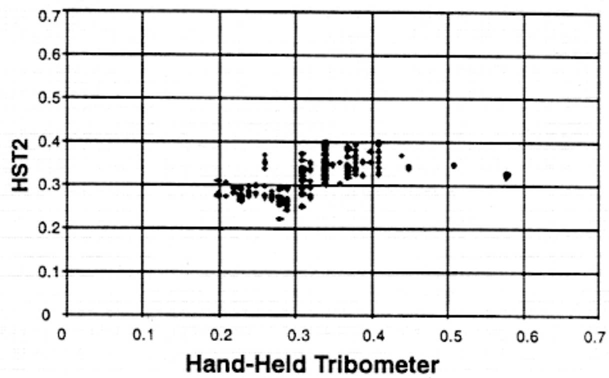

Exhibit 2. Gage-Face Friction — Hand-Held Tribometer vs. High-Speed Tribometer 2

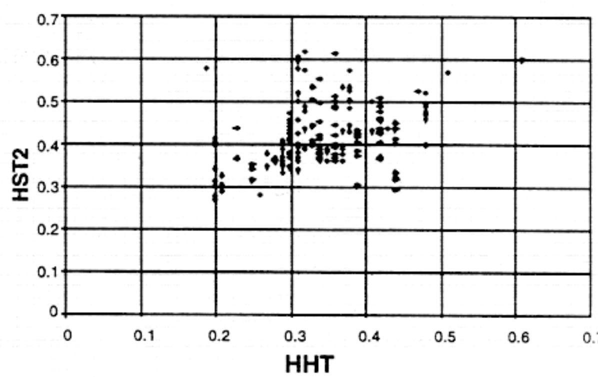

Exhibit 3. Top-of-Rail Friction — Hand-Held Tribometer vs. High-Speed Tribometer 2

friction was reduced by soap over 100 feet of rail only, the filtered data did not properly show friction values. The thicker dotted line in exhibits 4 and 5 shows actual unfiltered data instead of the four-sample moving average. This thicker dotted line is shown only for data in the immediate area in which localized lubrication was applied to the rail. This represents how data would be displayed if the rail had been lubricated for a longer segment. Note that the HST2 can collect and store raw data for post analysis while at the same time displaying filtered data, in this case a four-sample moving average, to reduce apparent scatter.

Exhibit 4 shows the gage-face measurement, where a reduction in friction at Mile Post 12.545 shows a larger change in value with the hand-held readings than the four-point running-average HST2 readings. Exhibit 5 shows top-of-rail readings for the same locations and rail conditions, and both the hand-held and HST2 show larger scatter and less repeatability. In both cases sensitivity to changes in friction of top and gage face is greater with

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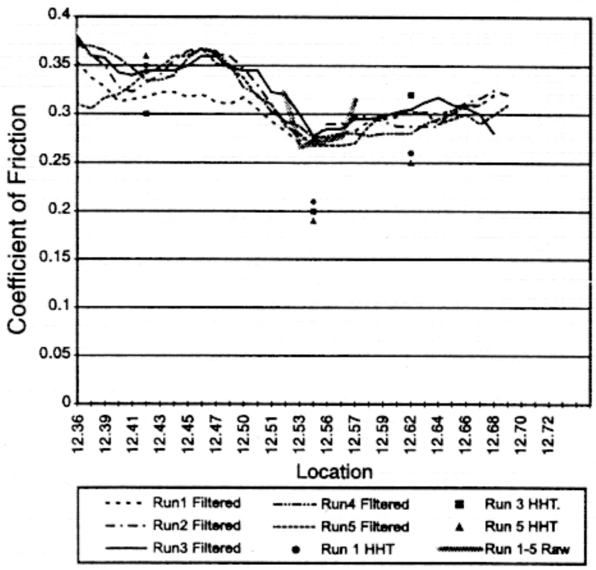

Exhibit 4. Repeatability and Resolution of Gage-Face Friction Measurements

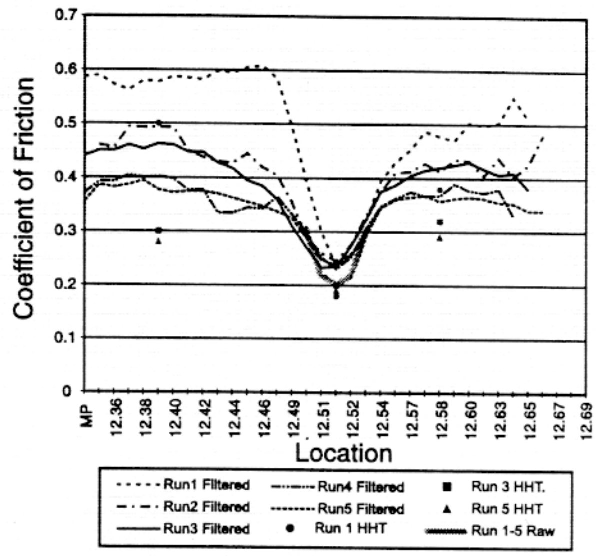

Exhibit 5. Repeatability and Resolution of Top-of-Rail Measurements

the hand-held tribometer than with the four-point running-average HST2. Repeated passes over this section appear to show that the soap was being picked up and transferred by both hi-rail truck wheels and HST wheels, and deposited on the rail away from the application site. This is seen as reduced friction during runs after the first pass.

RECOMMENDATIONS

Test results and observations indicate a number of the TAG guidelines were not met. The following issues should be addressed in a production HST2:

- Repeatability of top-of-rail data should be investigated.
- Measurement wheels tended to collect and retain excess lubricant which must be removed to prevent rail contamination.
- Filtering rate can affect apparent accuracy and ability to locate small lengths of contamination.
- The HST2 is difficult to maneuver due to its weight. An easy way to get the device off and onto the rail needs to be addressed.
- Single-person operation is difficult, as the operator must pay attention to the computer while watching for alarms and location marks.
- Enlarging the most important information on the computer monitor will assist the operator in viewing data at a glance.

CONCLUSION

A method of measuring rail friction at speed has been demonstrated by the DMF tribometer. If the above issues are adequately addressed in a production model, the ability to measure lubrication effectiveness over large distances will soon be available.

Because the HST2 is a prototype, statistical analysis of the data was not performed. A more rigorous evaluation of data repeatability and scatter will be conducted when a revised production design is available and has been tested.

Note: Contact Rich Reiff at (719) 584-0581 with questions or comments regarding this document.
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A MORE DETAILED REPORT, WHICH MAY CONTAIN REVISED INFORMATION, MAY BE AVAILABLE AT A LATER DATE THROUGH THE AAR, PUBLICATION ORDER PROCESSING, 50 F STREET, NW, 5TH FLOOR, COG, WASHINGTON D.C., 20001