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Research Results

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Improving the Wheel/Rail Performance on Amtrak's Northeast Corridor

SUMMARY

A collaborative program of study was initiated in 2001 by the Federal Railroad Administration (FRA) with a goal of migrating best practices from heavy-haul applications and other operations to U.S. commuter agencies. This program focused on field review of existing practices and the development and validation of improved practices on a working railroad, in this case the Amtrak Northeast Corridor. Improved wheel-rail profiles have been developed and tested, wayside lubrication practices improved, top-of-rail friction modification tested and validated, and a strategic rail grinding program developed and implemented.

BACKGROUND

Several low-speed wheel-climb derailments on Northeast commuter systems in the late 1990's, and the reaction of some railroads to those issues, convinced FRA that best practices for managing wheel-rail performance were not well disseminated through the U.S. commuter railroad industry. In 2001, the FRA initiated a collaborative study whose goal was to ensure that best practices being developed for heavy-haul systems and other operations were proven and available to U.S. commuter agencies. Amtrak, which was at the time working through vehicle –track performance issues with their recently acquired Acela high speed trainsets, has been a major partner in the program. Experts from the National Research Council Canada (NRCC), Volpe National Transportation Systems Center (Volpe), and ENSCO, Inc. rounded out the Amtrak/FRA team.

METHODS

This project focused on the 500-mile predominantly Amtrak owned and operated track between Washington, DC, and Boston, MA, known as the Northeast Corridor or NEC. Two teams were established to facilitate the work. A steering committee consisting of senior FRA, Amtrak and NRCC members took oversight responsibility for the efforts of the working group, which included members of all the participating agencies. Review meetings were held, typically, quarterly in Washington, DC or Philadelphia, Pennsylvania.

Field investigations of vehicle-track issues have played a large role in the program. A general overview of the Amtrak system identified a number of issues to be addressed including:

- Excessive wheel flange wear on the Acela vehicles (Figures 1 and 2),
- Vehicle stability issues on the Acela trains, especially on high speed tangent tracks and mild curves,
- Very poor (in many cases nonexistent) lubrication, especially on the Washington to New York section of the NEC, and
- Rail-grinding templates that had been adopted from another commuter agency with limited consideration to their compatibility with the Amtrak wheels. These templates were also only loosely being targeted in the rail-grinding program.

RESULTS

Each of the items in the previous section was the subject of further field work, experimentation and analysis. Each one is outlined over the following pages:

Reducing wheel flange wear

Analysis of the wheel/rail profile compatibility showed that the unworn wheel has a severe two-point contact with virtually all the rail – new or worn – on Amtrak's NEC (Figure 1).

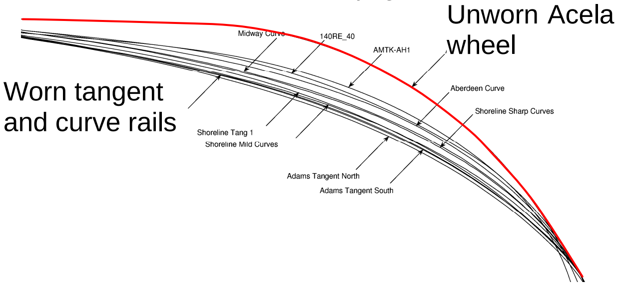

Figure 1. The unworn Acela wheel exhibits a severe 2-point contact against virtually all rails on the Amtrak NEC - curve or tangent.

In any curve sharper than about 0.25 degrees the 1:40 tapered wheel will flange. Examination of the worn wheels shows that the shapes change significantly with service. A new wheel profile was designed that mimics some features of the worn Amtrak wheels (Figure 2).

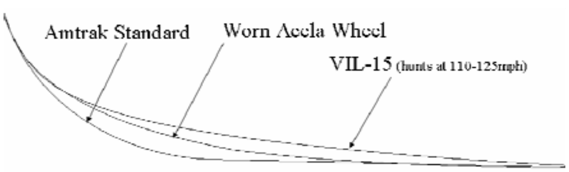

Figure 2. The worn Acela wheel has a very different shape in the flange-throat than the unworn wheel. Also shown is the VIL-15, a wheel shape that could reduce flange wear but led to truck instability when tested at high speeds.

In the absence of a working Acela model, the steering committee took the bold leap to place the new wheel in service on four axles of an Acela coach car, the first instance being on a train that served as part of a requalification test. Onboard ride quality instrumentation found no deterioration of dynamic performance when compared with the performance associated with standard profiles. An estimated increase in service miles of at least 80 percent was realized with Acela coach car wheels when employing the new wheel profile (Figure 3). Comparisons between well worn and newly trued wheels show that the new wheel profile is a geometrically stable profile throughout the service life observed during its evaluation. A document detailing the evaluation of the new profile has been prepared for FRA and Amtrak [1].

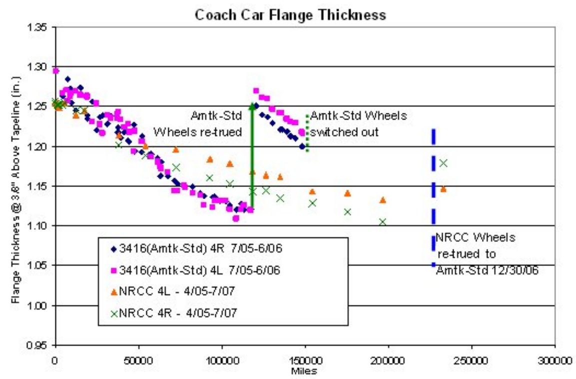

Figure 3. The new wheel profile (NRCC) exhibits a much lower flange thickness wear rate than the profile currently employed by Amtrak on its Acela fleet.

Improving vehicle stability

From a wheel/rail perspective, there are two obvious approaches to improving vehicle stability:

A) Reduce the effective conicity of the wheel/rail pair in tangent track. The new tangent rail profiles designed for Amtrak (see below) were developed with effective conicity as one of the prime constraints. Additionally, newly laid rail is targeted for rapid grinding to remove metal from the gauge side to reduce conicity. The program did not specifically document ride quality improvements associated with improved profiles.

B) Friction Management. The dry rail surface at Amtrak was measured to be at levels of 0.5-0.6. By reducing those levels, the creep-force energy that contributes to hunting can be reduced. A trackside friction modifier dispenser was set up at a troublesome broad (0.75 degree) curve in New Jersey to dispense a friction control product to the top of the rail. But before the unit was even set up and functional, lateral acceleration exceptions on the six monitored Acela trains mysteriously disappeared and didn't resume over the period of the testing.

Improving rail lubrication

The results of a 1998 high speed tribometer run though the NEC New England Division (New York to Boston) prompted a significant upgrade in lubrication practices for that region, including the purchase and installation of nearly 100 electronic wayside grease dispensers. The southern end of the system, meanwhile, was effectively dry with few, if any, functioning lubricators.

A field review of lubricator performance was undertaken on the Shoreline of the NEC northern track. The key goals were to identify the best performing lubricant, decide on the best lubricator control settings, determine whether the long (55 in) grease dispensing bars were superior to the short (24 in) bars, and to establish a methodology for determining the best spacing between and placement of lubricators. The key findings were as follows:

- Improved rail curve grease was identified, which carried nearly three times the 1.9-midistance of the baseline grease then used by Amtrak. Grease that performed well in a heavy haul environment fared poorly on Amtrak.

- With improved lubricant and better location of the units, only 40 wayside units would be required to treat the two tracks of the 314 miles of northern track. This would make 60 or more units redundant and available for the southern region.

- Wheel sensors functioned erratically in Amtrak's electrified track system. Improved grounding of the sensors enabled them to perform as designed.

- The short bars outperformed the long bars at this location, which sees Amtrak trains exclusively. This is because the flange worn wheels of the Amtrak trains did not pick up the smaller grease beads of the longer bars. The larger beads that form with the short bars are more easily smeared by the passing Amtrak wheels.

- The electronic lubricators allow the user to separately set the time that the pump runs (duration, in seconds) and the frequency of application by number of wheel passes. For this Amtrak application, which is characterized by short commuter trains, the optimum settings were ¼ second every 16 wheels. This is longer and more frequent than is customary for a freight system.

A second lubrication study was carried out on the southern (Washington to New York) section of the NEC. In addition to Amtrak trains, these tracks see a mix of "foreign" commuter and freight trains. The southern track also is home to sharper track curvatures. Testing on the southern track included an evaluation of biodegradable soybean-based grease. The testing further supported the use of short bars but arrived at a higher setting for the digital control units, 0.2 seconds every eight wheels.

Top of rail friction management
Tests were conducted on a low speed, 8-degree curve at one end of the Baltimore Tunnel. Top of rail friction management proved very effective in reducing lateral forces on the rail (Figure 4).

Rail profiles and rail grinding
The rail grinding templates being applied at Amtrak before 2001 were quite different from the worn rail shapes and required metal removal in areas that would counter improvements to wheel-rail performance.

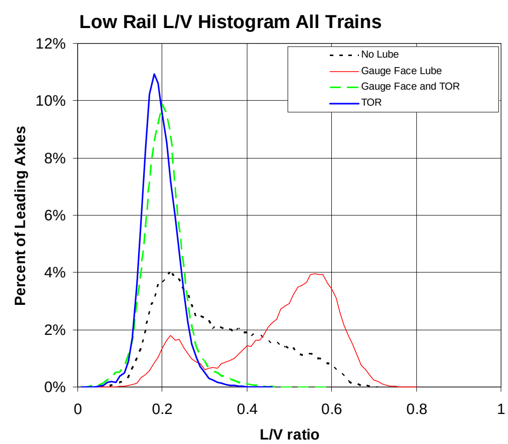

Figure 4. The application of top of rail friction management dramatically reduces the lateral/vertical (L/V) ratio on the low (and high) rail.

Figure 5. Even with significant gauge side contact, the 2001 Amtrak high-rail template suggests that the gauge side needs to be raised even higher. This would lead to severe 1-point contact and likely problems of rail fatigue.

A family of four templates has been developed for Amtrak including two tangent rail shapes, a mild curve high rail and a sharp curve high rail (Figure 5). These shapes are designed to match well with Amtrak's worn rail shapes and with the AMTK-NRCC wheel profile designed earlier in the program. Monitoring sites have been established, grinding patterns developed and a grinding program based largely on annual tonnage (rather than passage of time) has been established. A document outlining the best practices for rail grinding on Amtrak has been delivered [2].

Other work

Several other studies undertaken as part of this program are not detailed in this Research Results document. These include a review of the wheel-retruing limits [3], consideration of the wheel metallurgy, analysis of rail defect data, review of instrumented wheelset data to examine wheel-rail forces [4] and modeling of high speed Acela trains to understand vehicle stability issues.

CONCLUSIONS

An extensive program of field review, data collection, data analysis, field implementation and process validation has been undertaken on Amtrak's Northeast corridor. Improved wheel/rail profiles, lubrication and friction management practices have been established.

ACKNOWLEDGMENTS

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KEYWORDS

Wheel/rail profiles, lubrication, friction management, rail grinding, vehicle/track interaction.