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Implementing Improved Bulk Commodity Suspensions

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Summary

The railroad industry has begun to implement suspensions for 286,000-pound interchange cars designed to reduce forces imparted to the track, reduce wheel and rail wear, reduce loads in the car structure, and reduce fuel consumption. Controlled tests at the Transportation Technology Center (TTC) and monitoring of in-service performance have shown improvements are being realized.

The Association of American Railroads (AAR) Mechanical Research Committee directed work to improve bulk commodity suspension performance. The focus of the work was to mitigate increased car weights by better controlling vehicle performance. In July 2004, the railroad industry adopted a new Standard S-286 for interchange cars weighing 286,000 pounds on four axles. Standard S-286 requires suspension performance by specification M-976 of the *Manual of Standards and Recommended Practices*. Specification M-976 is based on the requirements set forth in the AAR program truck performance specification. Several new suspension designs have been approved.

The M-976 specification addresses the following performance issues:

- Wear and energy in wheel rail contact
- Maximum vertical forces from car dynamics
- Lateral forces in curving
- High-speed instability
- Derailment criteria

The prototype trucks tested in the research program reduced curve resistance and lateral forces by 50 percent or more as compared to conventional suspensions. In addition, the vertical body accelerations were kept below 1.0 g. This performance improvement should reduce wear and damage to the track structure while prolonging wheel life and reducing energy costs.

In 2006, tests at TTC of trucks modified to one S-286 design produced the following results:

- Vertical wheel force reduced from 98,500 pounds to 69,140 pounds in bounce mode at 55 mph
- Top chord stress reduced from 21,790 psi (near the buckling limit) to 13,162 psi
- Lateral curve forces reduced 50 percent in curves less than 10 degrees

To date, the approved suspensions rely on increased warp restraint, flexible primary pads, and tuned spring groups to achieve the desired result. Monitoring of S-286 equipment has included wayside measurement of curving forces, tests of worn suspensions to document adequate warp restraint, and observations from an earlier 286,000-pound car implementation by Tropicana Products Inc. In addition, testing was conducted at TTC and in a revenue service coal train to document the performance differences for a conventional truck and the same truck modified to S-286 standards.

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INTRODUCTION AND CONCLUSIONS

From 1999-2002, Transportation Technology Center, Inc. performed extensive testing of bulk commodity truck prototypes as part of the AAR Strategic Research Initiative (SRI) Program for advanced trucks. In general, a 50 percent improvement could be obtained for rolling resistance, lateral curve forces, vertical loads in pitch and bounce, and in derailment predictors such as ratio of lateral to vertical force (L/V) or minimum vertical load.

Adopted in 2004, a new industry standard S-286/M-976 requires the same type of performance improvements for new 286,000-pound interchange cars.

For the first time, analysis and testing to qualify new vehicles requires improvement in rolling resistance. In addition, a maximum vertical load criterion was introduced. These new criteria should predict reduced wheel and rail wear, reduced track damage, reduced derailment probability, reduced fuel consumption, and lower forces imparted to the car structure. Traditional safety criteria were also incorporated into specification M-976.

BACKGROUND

A SRI to solicit and evaluate improved bulk trucks was conducted from 1999-2002. Most successful prototypes relied on primary pads between the side frame and bearing adapter to reduce curving forces and rolling resistance. Figure 1 shows a primary pad in a truck with a Super Service Ride Control (SSRC) suspension.

Figure 1. Elastomeric Pedestal Pad in SSRC Suspension

In 2004, the AAR Equipment Engineering Committee adopted a new Truck Performance Specification for 286,000-pound gross rail load cars. This new specification requires performance not achievable with conventional suspensions.

Most prototypes offered to meet this new specification rely on friction wedges to generate warp restraint. These have good dynamic performance when the trucks are in nearly new condition. Two issues have been raised concerning the new designs: (1) Will the primary pads survive in railroad service, and (2) Will the warp restraint still be adequate after the friction wedges wear?

Canadian Pacific has experienced acceptable primary pad performance at 500,000 miles of service (to date) when the pads are in a Barber Frame Brace™ truck. TTX has reported that primary pads applied to conventional suspensions did not survive. Assuming the pads are strong enough to support the vehicle weight, the issues of pad life and warp strength seem to be intertwined.

Warp Restraint Testing

Without high warp restraint, the S-286 suspensions can become unstable. High-speed instability can destroy the primary pads eliminating any benefit. Three methods of increasing the warp restraint of conventional trucks have been tested (see Figures 2, 3, and 4).

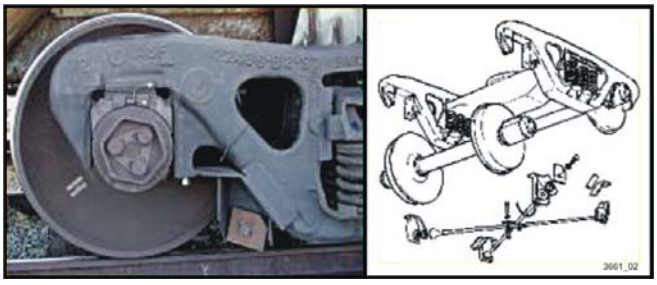

Figure 2. Barber Frame Brace™ Design

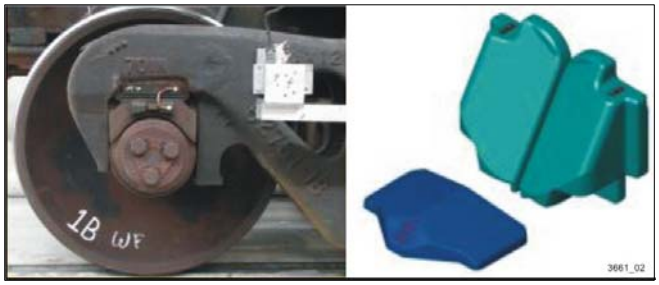

Figure 3. Split Wedge

Figure 4. Wide Wedge

High warp restraint for the suspensions accepted through the S-286 process has been achieved by various designs of friction wedges. These wedges will wear, reducing the warp restraint, over time.

The Barber Frame Brace design shown above has not been presented for S-286 approval; however, it is believed that this design has adequate warp damping thus providing a basis to compare warp damping results for worn wide-wedge or split-wedge designs.

Table 1 shows that moderately worn SSRM trucks still have adequate warp restraint. A truck shimmed to represent a worn out wedge still has 74 percent of the warp restraint of the Frame Brace.

Table 1. Vertical Wheel Force Performance

Truck	Wedge Rise in.	Stiffness in-kip per mrad	Damping in-kips	5 mrad Moment In-kip
S2HD Frame-Brace	N/A	119	387	981
SSRM (new)	N/A	227	702	1,838
SSRM	0.235	128	761	1,401
SSRM	0.375	104	924	1,444
SSRM (new)	1.0 (shim)	100	220	720

Controlled Testing Vertical

Any S-286 approved suspension has already demonstrated superior performance before introduction into 286,000-pound revenue service.

As part of an AAR SRI program, a test series was performed at TTC to document performance for a suspension upgraded to S-286 status. The suspension was an American Steel Foundries (ASF) SSRC design. This truck is a special case for 286,000-pound service. The SSRC has only been qualified for coal cars. The other designs have been approved for any 286,000-pound cars.

Table 2 shows the improvement in vertical force dynamics with the upgraded truck. Note that the top chord stress measured for the regular truck exceeds 90 percent of the calculated buckling limit.

Table 2. Vertical Wheel Force Performance

Test	Truck SSRC	Max. Vertical	Min. Vertical	Top Chord Stress
Bounce 55 mph	S-286	190%	50.5%	13,162
	Regular	272%	10.6%	21,790
Twist and Roll 20 mph	S-286	146%	58.0%	
	Regular	186%	7.0%	

Controlled Testing Lateral

Figure 5 shows the reduction in lateral force observed in controlled tests at TTC. Note that for this suspension, the benefit in lateral force reduction decreases in the sharpest curves.

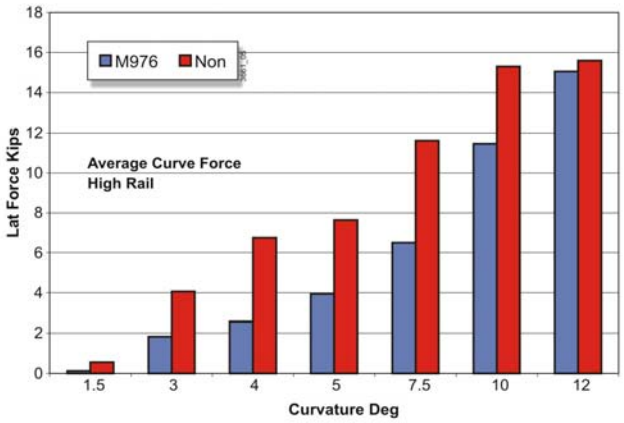

Figure 5. Lateral Curve Force Comparison

Wayside Lateral Force Monitoring

Figure 6 shows average force data for M-976 trucks and similar trucks with regular suspension elements at five wayside locations. Lateral force reduction has been achieved.

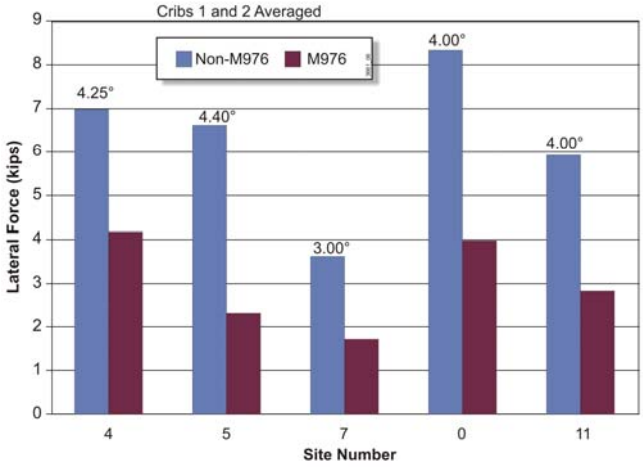

Figure 6. Wayside Lateral Force Comparison

Inspections at Tropicana Products Inc.

In 2002, Tropicana Products Inc. placed 10 improved trucks in its 286,000-pound service. These trucks were very similar to those now supplied by ASF as SSRM S-286 approved designs. Changes were made to the constant-contact side bearings (CCSB) when long-travel CCSB were required for new, rebuilt, extended service status, and increased gross rail load cars. In addition ASF changed the primary pad design to be the same as in its S-286 approved trucks.

Figure 7 shows the Tropicana car, and Figure 8 shows the original pad on the left and the replacement pad on the right.

Figure 7. Tropicana 286,000-pound Car

Figure 8. Original and Replacement Pad

After 280,000 miles of service, the wedges and pads in the 10 cars are in good condition. One car (original pads) had multiple pad failures in the first year. For this car, the trucks were put in service as retrofits using original wheels and castings. This truck had problems until the side frames were replaced. A 10,000 mile instrumented test was performed after the side frame replacement. Performance was stable and the pads remain in good condition. Figure 9 shows the failed pad.

Figure 9. Failed Primary Pad

CONCLUSIONS

Improved suspensions can lower the stress state of the railroad system by reducing component wear and loads imparted to the track. Benefits will be achieved from these suspensions if warp restraint devices and primary pads continue to perform at acceptable levels.

High mileage results for S-286 approved trucks are not yet available; however, TD-04-020 reports that life for wheels in standard three-piece trucks is 10-25 percent less than that obtained in modern designs. This is based on data supplied by two North American railroads and two private car owners for trucks similar to those now being implemented for 286,000-pound interchange service.

Several TDs have been published leading up to Standard S-286 and are listed here for reference:

TD-98-009: Economics of Improved-Suspension Trucks
TD-99-027: Improving the Economy of Bulk-Commodity Service through Improved Suspensions

TD-00-011: Improving the Economics of Bulk-Commodity Service: ASF Bulk Truck

TD-00-012: Improving Economics of Bulk-Commodity Service: S2E Standard Car Truck

TD-02-009: Reducing the Railroad Stress State with Improved Bulk-Commodity Suspensions

TD-03-023: Warp Characteristics of Bulk Commodity Suspension: Conventional and Frame Brace(TM) Truck Part 1 of 3

TD-03-024: Warp Characteristics of Bulk Commodity Suspensions: Standard Car Truck Company S2E Truck Part 2 of 3

TD-03-025: Warp Characteristics of Bulk Commodity Suspensions: American Steel Foundries SSRM Truck Part 3 of 3

TD-05-012: Warp Characteristics of Worn Bulk Commodity Suspensions: M-976-Type Trucks

TD-05-022: Overloaded Trucks Increase the Stress State of the Railroads

Limited inspection of sample improved truck components indicates that component life is satisfactory to maintain expected performance improvements.

Future investigation of improved truck performance will be obtained from wayside measurement and from in-service inspection.