TECHNOLOGY DIGEST

Timely Technology Transfer — 02-009

Reducing the Railroad Stress State with Improved Bulk-Commodity Suspensions

by Ken Rownd and Darrell Iler

Summary

Modest changes to familiar bulk commodity truck designs can result in significant economic benefits for typical railroad service. The Association of American Railroads (AAR) has sponsored the Advanced Freight Car Truck program, an ongoing effort to solicit improved suspensions for commodity specific freight services. Since 1999, this program has focused on better economic performance for bulk commodity service, and AAR subsidiary Transportation Technology Center, Inc, (TTCI) has developed performance requirements, provided design support, and performed the prototype tests and evaluation.

Recently railroad research issues have re-focused on reducing the stress state of the railroads. The same improvements that result in economic benefit for bulk commodity suspensions also reduce the energy put into the track structure. This is demonstrated by reduction in lateral and vertical forces input to the track and by reduction in energy absorbed in the wheel rail contact patch.

This *Technology Digest* compares the vehicle forces and energy input to track for four prototype bulk commodity trucks as compared to that measured for today's premium three-piece truck technology.

The bulk commodity initiative is focused on suspensions for very heavy cars. The maximum weight on rail for free interchange service is now 263,000 pounds carried by four axles. The concept of capping the railroad stress state becomes even more important as railroads implement 286,000-pound cars and envision 315,000-pound gross rail load service. At present, 286,000-pound cars are permitted in interchange if they meet AAR Standard S-259, but acceptance by railroads receiving such cars in interchange is not mandatory.

Suggested Distribution:

- ❑ Mechanical Dept.
- ❑ Planning & Analysis
- ❑ Track Maintenance
- ❑ Safety

Work performed by TTCI Transportation Technology Center, Inc.
a subsidiary of the Association of American Railroads

INTRODUCTION

The Association of American Railroads (AAR) has sponsored an ongoing program to solicit improved suspensions for commodity specific freight services. Since 1999, this program has focused on better performance for bulk commodity service.

The four prototype bulk commodity suspensions tested in this program can lower the stress state of the railroads by:

- Reducing lateral forces in curving by more than 50 percent,
- Reducing energy dissipated in the wheel rail interface by more than 50 percent, and
- Reducing vertical forces by controlling vehicle response to track deviations.

The stress state of the railroad must consider the strength of the infrastructure and the energy input by passing trains. If heavier vehicles are to be operated, the stress state can only be controlled by making the track stronger or by limiting the energy of the trains. Exhibit 1 represents the interaction between track strength and energy put into the track by passing trains.

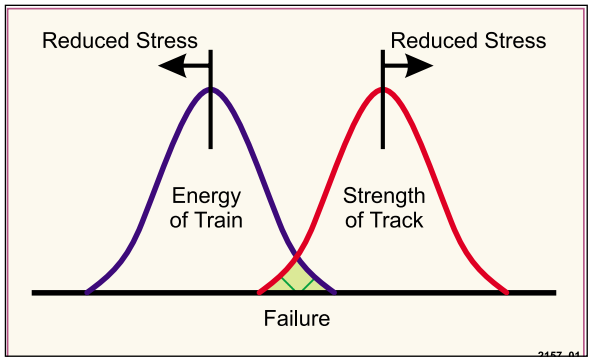

Exhibit 1. Stress State of the Railroad System

If existing suspension technology is applied at increased car weights, the railroad stress state will increase. Improved bulk car suspensions provide a method of increasing capacity without increasing the railroad stress state.

BACKGROUND

In 1998, a town hall meeting was conducted to announce the bulk commodity initiative. A technical specification handed out at this meeting described the test regimes a prototype would be subjected to and detailed the method for evaluation.

The success of these initiatives is dependent on participation by railroad suppliers. Five suppliers indicated intent to participate in this short program. Four were able to produce prototype equipment for test and evaluation. Exhibit 2 shows one of the base cars used for prototype evaluation. Union Pacific Railroad provided an empty and a loaded car. The loaded car weight was adjusted to meet the proponent's needs. Economic comparison to baseline was always within a loaded weight category.

Exhibit 2. Base Car

The baseline test data was taken at 315,000-pound weight on rail. A computer model was used to translate the lateral load data; which was reduced to a 286,000- or 263,000-pound equivalent service condition. It was then used in evaluating prototype trucks for those capacities. Train resistance and vertical loads are normalized by car weight, allowing direct performance comparisons.

Using a particular loaded car weight will affect the baseline cost. For instance, equal dynamic performance in 100,000 miles of 315,000-pound gross rail load service will generate more wheel wear, rail wear, and fuel consumption than the same mileage in 286,000-pound gross rail load service; but it will also move more commodity to market.

BULK COMMODITY OVERVIEW

Three proponents provided suspension designs based upon conventional truck equipment. Improvements were incorporated to reduce train resistance, lateral forces imparted to the track in curving, and the dynamic augment of vertical forces on rough track. One design in particular provided significant weight savings with substantial economic benefit. Combined, these three designs resulted in an economic benefit of between $1,100 and $1,300 per year per car in 50,000 miles of typical eastern operation. Benefits between $600 and $700 per year per car were calculated for typical western operation.

One proponent provided a unique design with significant weight savings and virtual elimination of incremental curving resistance. This design can be considered an engineering model, demonstrating achievement of most design goals. However, it is not yet ready for full economic analysis.

PROPONENTS

American Steel Foundries (ASF) Bulk Truck

The ASF bulk truck was designed for 315,000-pound service. Design goals included increased warp restraint and improvements to curve negotiation.

A dual rate suspension was designed to meet the challenge of controlling loaded car and light car dynamics. This truck provides a significant weight savings. The design includes the use of 36-inch wheels and special roller bearings. The wheel and bearing components are not considered in the bulk commodity program analysis.

Standard Car Truck (S2E) Bulk Truck

The 286,000-pound service Standard Car Truck Company bulk truck uses a split wedge design for increased warp restraint. Curving is improved by use of elastic pads applied between the axle and the side frame. The S2E truck has a dual rate spring design.

ABC-NACO Bulk Truck

The 315,000-pound service ABC-NACO bulk truck is based upon their Swing Motion™ design. It has been modified to provide additional vertical damping and to allow the axles to align themselves in curving by shearing an elastic pad above the axle bearing adapter.

Resco Engineering Bulk Truck

The 286,000-pound service Resco Engineering bulk truck is a fabricated bolster-less design that carries all of the body weight at four outboard locations. The dual rate load springs are angled slightly to provide dynamic roll control. Curve resistance is reduced by means of steering provided by a link between the inner axle of each truck and the car body. It is expected that this design will provide a substantial reduction in suspension weight.

GENERAL RESULTS

Compared to the premium three-piece truck technology (base truck), the three finished prototypes each had superior economic and safety performance. The engineering model prototype had superior tangent and curving performance. Control of vehicle rigid body modes has been partially tested only.

Dynamic performance of the four prototypes is compared to performance of a heavy duty, three-piece baseline truck. Baseline data is presented for 263,000-, 286,000-, and 315,000-pound service.This allows direct comparison within a service category and allows forces and energy for the heavier prototype designs to be compared to existing 263,000-pound service performance.

REDUCING THE ENERGY IN THE CONTACT PATCH

Improvement to incremental curving resistance is a direct measurement of reduction of energy consumed in the contact patch during curving. The result will be less wheel wear, reduced rail wear, and lower fuel consumption. Exhibit 3 compares the incremental curving resistance for the four prototypes to the base truck. All four prototypes provide substantial reduction of energy in the contact patch.

REDUCING LATERAL FORCES TO THE TRACK

Reducing the lateral curving forces will extend tie life, decrease track maintenance costs, and reduce derailment probability. Exhibit 4 compares the 286,000-pound prototype performance to a baseline synthesized from the 315,000-pound baseline test. Exhibit 5 compares the 315,000-pound prototype suspension performance to base truck performance.

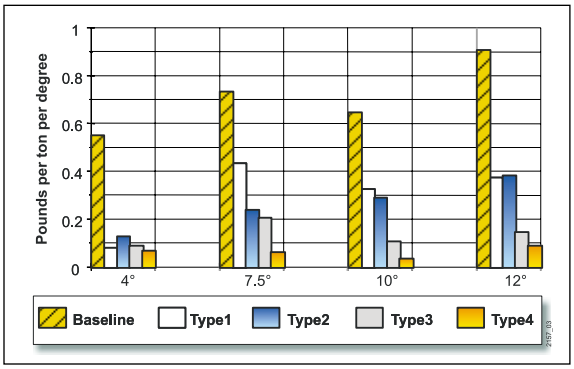

Exhibit 3. Incremental Curve Resistance Prototype Suspensions Compared to Base

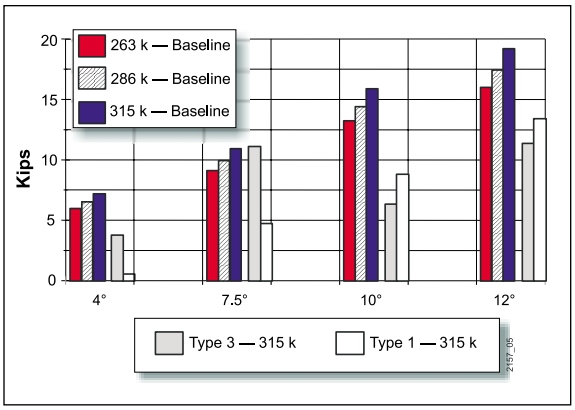

Exhibit 4. Lateral Forces in Curving 315,000-pound Prototypes Compared to Base

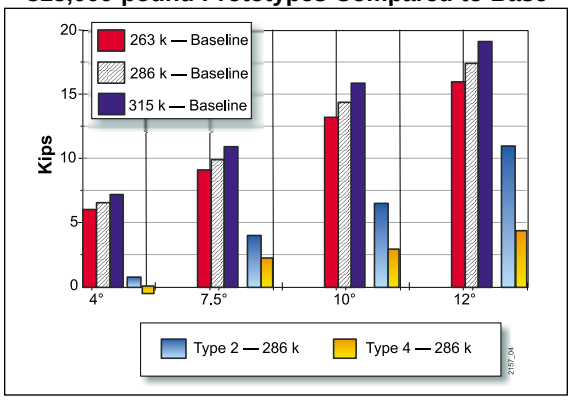

Figure 5. Lateral Forces in Curving 286,000-pound Prototypes Compared to Base Truck Performance

TTC = Transportation Technology Center; FAST = Facility for Accelerated Service Testing

All four prototype suspensions significantly reduce the lateral forces even when compared to 263,000-pound service performance.

REDUCING VERTICAL FORCES TO THE TRACK

Large vertical forces are imparted to the track when suspensions cannot control vehicle rigid body modes. These modes are primarily initiated by track irregularities such as road crossings or track geometry deviations.

The goal for this program was to reduce the vertical force dynamic augment and to eliminate suspension bottoming. Rigid body modes of twist, roll, pitch, or bounce can result in large vertical force input to the track. Limiting the dynamic augment will reduce track maintenance and decrease derailment probability

Exhibit 6 compares the vertical forces in twist and roll testing for the prototype suspensions to the base truck performance. Results are expressed as a percentage of static weight. Three of the four prototypes were effective in limiting vertical forces input to the track. The fourth unique design prototype was not tested in this regime due to component problems.

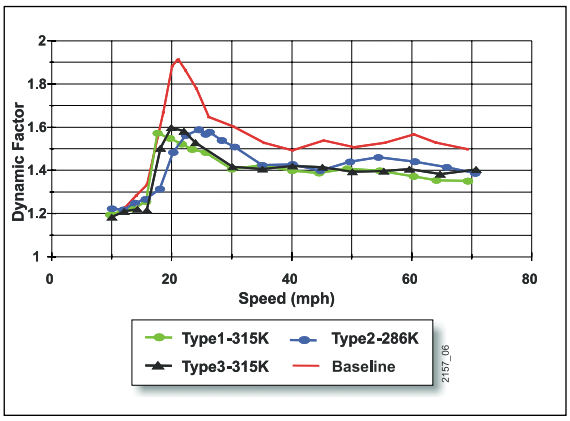

Exhibit 6. Vertical Load Augment in Twist and Roll Testing Prototype and Base Trucks

HIGH SPEED STABILITY

Controlled high-speed stability performance will improve suspension life and reduce high-speed derailment probability. All of the prototype trucks were stable to 70 mph. The base truck was unstable at speed higher than 55 mph.

SUSPENSION WEIGHT REDUCTION BENEFITS

Substantial savings can be realized from removing a few hundred pounds from the freight car suspension. Lighter suspensions will allow more commodity to be moved with the same gross weight on rail or it can allow the same amount of commodity to be moved with reduced wheel wear, rail wear, and fuel consumption.

CONCLUSION

It is in the best interest of the railroads and their customers to lower the overall cost of railroading. To accomplish this, railroads need a strategy to implement new technologies to match the efficiency gains of competitors and meet changing market trends. Purchasing decisions should reflect the true cost of railroad service including market retention, reliability, and long-term damage to the infrastructure.

The bulk truck program and the AAR's Heavy Axle Load (HAL) Program have demonstrated that significant benefits can be obtained from modest improvement to conventional freight car trucks. An equitable method to reward investment and lower the overall cost of railroading could help ensure that investment in new suspension technology is possible.

ACKNOWLEDGMENT

The authors would like to recognize the contributions of the railway suppliers in taking the performance specification and translating that into hardware for evaluation.

Note: Please contact Ken Rownd at (719) 584-0552 with questions or comments about this document.
E-mail: ken_rownd@ttci.aar.com
Web site: www.ttci.aar.com