TECHNOLOGY DIGEST
TD-07-010
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Evaluation of Rotational Resistance between Truck and Carbody

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This Technology Digest (TD) supports TD-07-006, which describes inspection and maintenance procedures for poorly performing cars identified by truck performance detectors (TPDs). It details conditions of the truck/carbody interface that might give rise to high truck/carbody rotational resistance — an identified cause of poor curving performance. It also refers to TD-07-007, which details inspection and maintenance procedures for carbody twist. Excessive carbody twist is one reason for high truck/carbody rotational resistance.

Summary

Poorly performing cars detected by TPDs were sent to the Transportation Technology Center, Pueblo, CO for detailed inspection, test, and teardown (TD-07-006). One cause of poor curving performance was identified as high rotational resistance between the truck and the carbody. This TD details inspection procedures associated with identifying high truck/carbody rotational resistance and supports TD-07-006 and TD-06-009, which outline overall inspection and maintenance procedures and detailed issues associated with the truck/carbody interface.

Experience gained from this process has enabled the development of procedures to guide inspectors in the identification of car subsystems and components requiring maintenance. Component suppliers' and Association of American Railroads' (AAR) performance limits are used where applicable. Where limits do not exist, but are desirable, suggestions are made. Inspection and maintenance experience in response to TPD identification is, to date, limited. In addition, poor performance has been observed to result from a combination of subsystem and component condition and functionality as well as car type. Consequently, recommended condition limits and maintenance actions are often qualitative. It is envisioned that individual car owners will use these recommendations as guidelines for developing inspection and maintenance processes most appropriate for their fleets and operating conditions.

This work was sponsored by the AAR as part of its Strategic Research Initiatives Program.

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BACKGROUND AND INTRODUCTION

As part of AAR's Strategic Research Initiatives Program, Transportation Technology Center, Inc. (TTCI) was tasked to develop inspection and maintenance procedures for cars identified as poor performers by TPDs.

TTCI developed algorithms to identify poorly performing cars using TPDs.[1,2] The relationship between these algorithms and the physical condition of the equipment needs to be established for effective car identification and maintenance.

TTCI conducted 23 inspections and teardowns of identified cars. Of these, 16 cars were initially inspected and partially torn down at railroad maintenance facilities. Two coal cars were brought to the Transportation Technology Center for detailed inspection, test, and teardown.[3,4] Another five coal cars were inspected and partially torn down at another railroad maintenance facility.[5] Experience from these activities has been used to compile this and other reports listed under references.

TD-07-006 outlines overall inspection and maintenance procedures for identifying and rectifying causes of poor curving performance.[6] This TD details inspection procedures that identify high truck/carbody rotational resistance. It refers to TD-07-007, which details inspection and maintenance procedures for carbody twist.[7] Carbody twist is one reason for high truck/carbody rotational resistance.

GENERAL CAUSES FOR HIGH TRUCK/ CARBODY ROTATIONAL RESISTANCE

General causes for high truck/carbody rotational resistance have been found to be:

- High center plate friction[3] as a consequence of insufficient or ineffective lubrication
- Eccentric truck rotation causing center bowl side wall contact with the center plate and increased rotational friction.[3,4,8] This is a consequence of one or a combination of:
  - Eccentric vertical loading across the center plate
  - Carbody twist[7] and/or off-center loading of the carbody
  - Incorrect or asymmetric side bearing clearances or setup heights
- High vertical contact loads at side bearings[3,4] as a consequence of:
  - Incorrect (generally tight) side bearing clearances or setup heights
  - Carbody twist[7]
- Poor center plate / center bowl geometry:[4,5]
  - Sharp edge on center plate chamfer
  - Concave center plates or bowls
  - Excessive roughness of center plates, bowls, and/or center plate liners
  - Vertical contact between the wall of the center bowl and the center plate or carbody

Many of the causes listed above are difficult to measure even when using sophisticated test equipment. Consequently they are difficult to quantify. Much of this report suggests means to infer poor performance from observed symptoms of high rotational resistance rather than through measurement. Consequently, many measures are qualitative and based on "best practice."

The structure of this TD follows the order of a typical inspection procedure carried out in the field. This order does not necessarily accord with a systematic approach for addressing individual causes listed above. Consequently, reference is made to these general causes in the description of each inspection step.

Repairs that reduce truck/carbody rotational resistance should be made with particular reference to TD-07-005, which discusses inspection and maintenance procedures for cars identified as poor performers by truck hunting detectors (HDs).[9] Rotational resistance should not be lowered to the extent that the car alarms at HDs.

INSPECTION PROCEDURE

It is assumed that an identified car will generally be inspected in the empty condition since:

- Railroads will not want to delay delivery of the lading
- Lifting of loaded carbodies without proper precautions is undesirable for reasons of safety and lifting equipment capacity

Inspection is made with the carbody on the trucks as well as with the carbody lifted. These processes are discussed separately. The inspection routine with the carbody on the trucks can obviously be used for inspecting a loaded car.

Inspection with Carbody in Place on the Trucks

An inspection should be made with the car standing on tangent and level track *before* lifting the carbody. Vertically uneven track makes any assessment of carbody twist difficult.[7] It may be necessary to place the car on a section of especially vertically aligned track to ease this measurement.

Side bearing clearances or setup heights must be measured and recorded. They should be measured and compared using procedures and standards recommended by their manufacturers. Tight side bearing clearances or incorrect setup heights may be an indication of high rotational resistance.

Inspection with Carbody Lifted off the Trucks

The carbody should then be slowly and carefully lifted from the trucks. This action may cause the friction wedges to slip relative to side frames and bolsters. This may be:

- Indicative of truck warp misalignment[10]
- A consequence of a rotational binding action between the truck and the carbody, which in turn is a consequence of high rotational resistance

Friction wedge slip upon lifting the carbody should thus be noted and this information used in conjunction with other

observations and measurements to draw conclusions regarding the state of the truck/carbody interface.[8]

The truck/carbody interface should then be inspected for evidence of high truck/carbody rotational resistance. This evidence may be:

- Galling of side bearing surfaces (Figure 1)

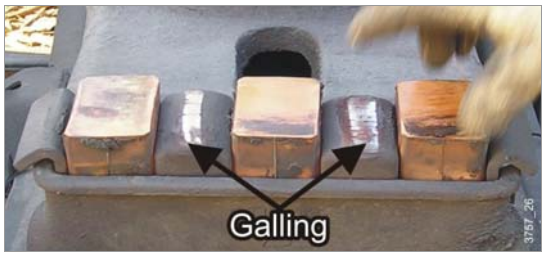

Figure 1. Galling of Side Bearing Surfaces

Galling is evidence of continuous solid contact across the side bearing as a consequence of tight side bearing clearances or incorrect setup heights that may be a consequence of carbody twist[7] or material flow of nonmetallic center plate liners. By their nature, short-travel constant-contact side bearings (CCSBs) are more susceptible to solid contact and hence galling.

- Tilted body side bearing wear plates (Figure 2) or worn wear plates (Figure 3) in cars fitted with CCSBs. These can cause rotational resistance to be higher in one rotational sense than the other because the side bearings have to lift or drop the carbody as the truck rotates underneath.

Figure 2. Tilted Body Side Bearing Wear Plate

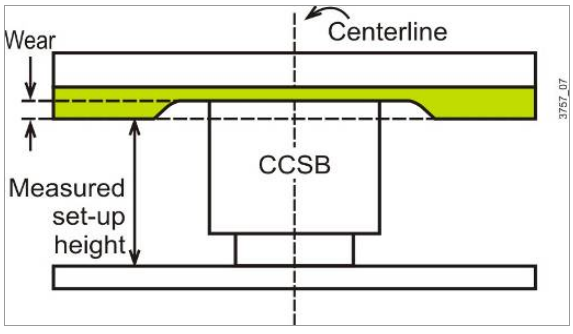

Figure 3. Worn Body Side Bearing Wear Plate

- Heavy galling of the center plate (Figure 4)

Figure 4. Galling of Center Plate

- Chatter on the side wall of the center plate (Figure 5). This is a sign of intermittent eccentric rotation of the center plate in the center bowl, a consequence of relative longitudinal motion and binding of the center plate against the wall of the center bowl.

Figure 5. Chatter on Side Wall of Center Plate

- Line contact between the chamfered edge of the center plate and the center plate liner. This is further evidenced by material flow on the chamfered edge of the center plate (Figure 6), which should have a 3/8-inch radius.[11]

Figure 6. Material Flow on Chamfered Edge of Center Plate

- Material flow or extrusion of polymer center plate liners (Figure 7)

Center plate galling, side wall chatter, line contact on the center plate liner, and extruded polymer center plate liners may all be indications of tight side bearing clearances or incorrect setup heights, poor center plate geometry, or carbody twist.[7]

Figure 7. Flow or Extrusion of Polymer Center Plate Liner

- Vertical contact between the side wall of the center bowl and the center plate.[5] This may occur as a result of incorrect setup (Figure 8a) or excessive center plate side wall or liner wear or deformation (Figure 8b).

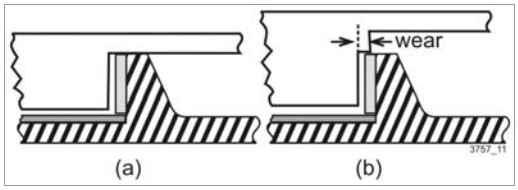

Figure 8. Vertical Contact Between Side Wall of Center Bowl and Center Plate

- Concave center plates and bowls. These are evidenced by shiny perimeters of both center plate and bowl (Figure 9) and can be measured using a straight edge.

Figure 9. Concave Center Plate Showing Edge Contact and Rust in Center

A correlation between concave center plates/bowls and higher rotational resistance has not been definitively made. Engineering judgment, however, does suggest that higher rotational resistance might occur as a result of a higher resistive moment arm and eccentric rotation as carbody roll occurs and the center plate load is transferred to the edges of the plate and bowl assembly. Concave surfaces could also result in higher sensitivity of the truck/carbody interface to tolerances in carbody twist.[7]

CONCLUSIONS

Inspection procedures were presented for identifying indications of high truck/carbody rotational resistance.

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