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# Measurement and Rectification of Carbody Twist

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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 carbody twist modes and the means to measure them. It also supports TD-07-010, which details conditions of the truck/carbody interface that might give rise to high truck to carbody rotational resistance. It will be, in turn, supported by a future TD suggesting tolerances for carbody twist as measured across the center plate.*

## Summary

Poorly performing cars detected by TPDs were sent to the Transportation Technology Center, Pueblo, CO for detailed inspection, test, and teardown.<sup>1</sup> High truck to carbody rotational resistance was specified as a cause for poor curving performance<sup>2</sup> and this, in turn, could result from carbody twist. Carbody twist is referred to here as any misalignment of center plate and body side bearing wear plate surfaces on either end of the platform to a common reference plane.

Measurement and repair procedures for carbody twist are described and are qualitative because of the variety of carbody constructions, modes of misalignment, and repair facilities available. Suggested tolerances for carbody twist and the rationale behind them are being developed and will be presented in a future TD.

Car owners should recognize carbody twist as an important component of car curving performance. Conscious efforts should be made to gain experience with degrees of carbody twist repair by executing graduated repairs to twisted cars and monitoring subsequent curving performance.

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



**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 has developed algorithms to identify poorly performing cars from TPDs.<sup>3,4</sup> The relationship between these algorithms and the physical condition of the equipment needs to be established for effective car identification and maintenance.

TTCI has 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 TTC for detailed inspection, test, and teardown.<sup>5,6</sup> Five more coal cars were inspected and partially torn down at another railroad maintenance facility.<sup>7</sup> Experience from these activities has been used to compile the information contained in this TD and other referenced reports.

TD-07-006 outlines inspection and maintenance procedures for identifying and rectifying causes for poor performance.<sup>1</sup> These procedures specify high truck to carbody rotational resistance as a prime, maintainable cause for poor performance at TPDs. A supporting TD, TD-07-010, outlines means to infer high rotational resistance and identifies carbody twist as a cause.<sup>2</sup>

This TD details means available to measure and repair carbody twist. Suggested tolerances for carbody twist and the rationale behind them are being developed and will be presented in a future TD.

**TRUCK AND CARBODY INTERFACE**

The vertical interface between trucks and carbody is traditionally across the:

- Two center plates/bowls and four truck side bearings
- Four body side bearing wear plates

Car design requires that these interfaces be parallel to some common reference plane (Figure 1).

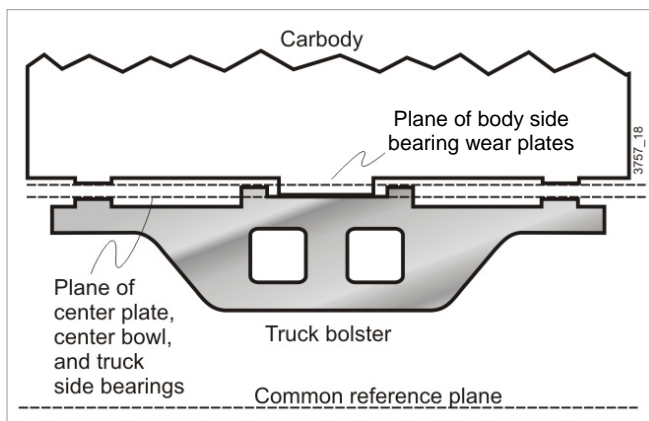


Figure 1

The center bowl and truck side bearing surfaces on the bolster are traditionally in one plane and machined in one operation. The rigidity of the bolster suggests that these surfaces should remain in one common plane. Consequently, the correct setup of the truck (wheelsets, adapters, springs, and friction wedges) should ensure that this common plane is horizontal for both trucks associated with a common carbody (platform) if the track is level.

The geometry of the underside of the carbody is more complex:

- Each platform end comprises an assembly of one or more cast and/or fabricated components locating body side bearing wear plates and center plate to each other. Each component in the assembly needs to be aligned parallel to a reference plane during manufacture and repaired to this plane, when necessary.
- One platform end needs to be parallel to the other, and hence to a common reference plane.

Carbody twist is referred to here as any misalignment of center plate and body side bearing wear plate surfaces on either end of the platform to a common reference plane.

**MEASUREMENT OF CARBODY TWIST**

The measurement of carbody twist is complex. It depends on the facilities available at the measurement site. These facilities vary from:

- What may be termed as an ideal facility; e.g., where the:
  - Carbody is either placed on a common horizontal reference plane or on surfaces representing this plane.
  - Car is jacked into a position where three points on the carbody are aligned to, or parallel to, a common reference plane.
- What may be termed as a non-ideal facility; e.g. where the:
  - Floor is uneven
  - Capacity only allows for one body end at a time to be lifted

**Ideal Measurement of Carbody Twist**

- The carbody should be in the light car condition so that loads do not elastically deform the car structure.
- The carbody is then set down, preferably using the center plates, on two pedestals. The upper surfaces of the pedestals must be horizontal and parallel to each other and to any surrounding reference surfaces that might be used (Figure 2). Contact will typically be made at two points, one on each center plate, if the carbody is not perfectly straight. The body will rock on these two points and may require support by carefully inserting a wedge under one

center plate to form a 3-point suspension of the carbody. This method ensures that minimum elastic twist is introduced to the carbody.

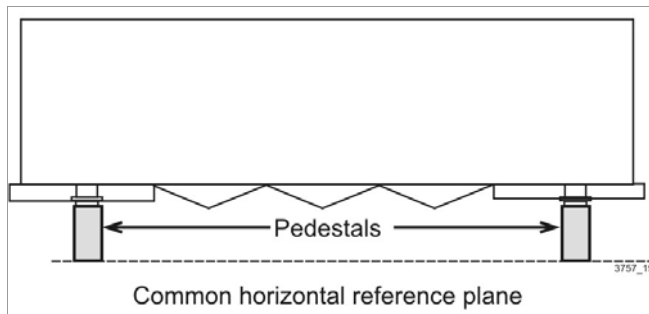


Figure 2

- The parallelism of the center plates and the body side bearing wear plates to a common plane can then be measured (Figure 3). This measurement can include the heights of all surfaces relative to the common plane, as indicated, as well as measuring laterally and longitudinally across each surface to determine its parallelism to the common plane.

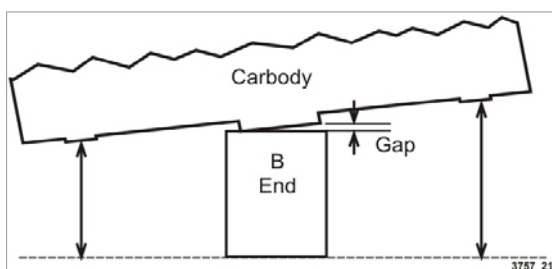
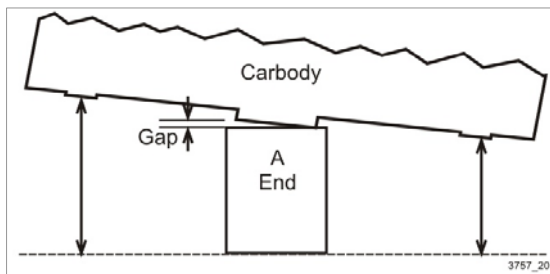


Figure 3

An alternative ideal method would be to jack the car at 4 (ideally 3) points until one lateral and one longitudinal reference are aligned to the horizontal, using, for example, a level. The relative heights and levels of all surfaces may then be referenced to horizontal planes, also setup using, for example, levels (Figure 4).

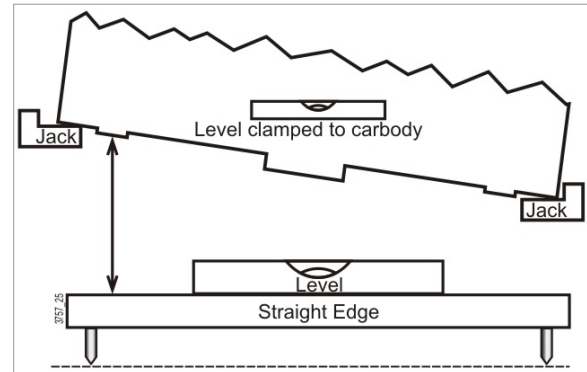


Figure 4

### Non-ideal Measurement of Carbody Twist

This method is typically used when there is only one set of jacks available.

- All truck side bearing elements must be removed from the car.
- The carbody should be jacked to roll-out the truck at one end — termed the free end (the other end resting on the center bowl of its truck).
- The free end should then be lowered, still with the other end resting on the center bowl of its truck, until both center plates are substantially at the same height.
- The free end should be leveled using either center plate or body side bearing wear plates as reference.
- The surfaces on the free end can then be measured with reference to a horizontal surface.
- A level should be clamped, laterally and horizontally, to the carbody on the end resting on the center bowl of its truck (see Step 9).
- The free end can then be raised and its truck replaced.
- Steps 2 and 3 should then be repeated for the other end of the car.
- Step 4 must now be substituted. The jacks under the new free end should be adjusted so that the level that was clamped to that end (Step 6) indicates level (Figure 4).
- Step 5 can now be taken to measure the relative heights of the surfaces on the new free end.

### TOLERANCES FOR CARBODY TWIST

There are no known and accepted tolerances for carbody twist across center plates (Figure 3). Tolerances would, among others, be a function of the torsional stiffness of the car body, the vertical suspension of the car and the preload characteristics of its constant-contact side bearing elements. Generally, it may be stated that the stiffer these items are, the tighter the carbody twist tolerances should be. Suggested tolerances for carbody twist and the rationale behind them are being developed and will be presented in a future TD.

## REPAIR OF CARBODY TWIST

### Realignment of Body Side Bearing Wear Plates using Shims

The easiest and most common repair is the realignment of body side bearing wear plates. This is done by placing shims under the wear plates so that the two plates on one car end are level with a common plane (Figure 5).

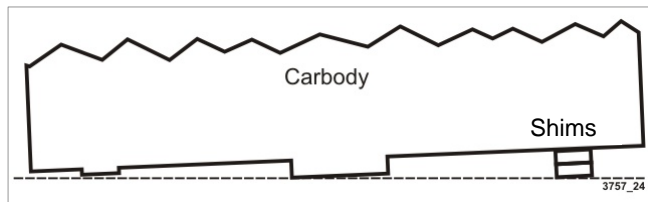


Figure 5

There are, however, two problems associated with this method:

- The determination of this common plane. If the common plane is not common to most of the carbody structure, carbody lean might be introduced.
- Although Figure 5 is exaggerated, it may be seen that excessive packing to counter excessive underframe twist from incorrect manufacture and/or damage can cause the center plate surface to become misaligned to the common reference plane. In the extreme, extensive realignment of the underframe may be required.

### Realignment of Tilted Body Side Bearing Wear Plates

Tilted body side bearing wear plates<sup>2</sup> will inevitably require removal, repair by welding, and replacement.

### Realignment of Tilted Center Plates

Tilted center plates (Figure 5) will inevitably require removal, repair by welding, and replacement if not part of an integral casting. Integral center plate castings may, in the extreme, require removal and straightening or replacement. This involves extensive work and serious consideration should be given before their use.

## CONCLUSIONS

Measurement and repair procedures for carbody twist are qualitative because of the variety of carbody constructions, modes of misalignment, and repair facilities available.

Suggested tolerances for carbody twist and the rationale behind them are being developed and will be presented in a future TD.

Car owners should recognize carbody twist as an important component of car curving performance. Conscious efforts should be made to gain experience with degrees of carbody twist repair by executing graduated repairs to twisted cars and monitoring subsequent curving performance.

Further analytical work of modeling carbody twist and center plate contact is recommended.

## REFERENCES

1. Tournay, Harry, et. al. April 2007. "Inspection and Maintenance of Poorly Performing Cars Identified by Truck Performance Detectors." *Technology Digest* TD-07-006, Association of American Railroads, Transportation Technology Center, Inc., Pueblo, CO.
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