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# Evaluation of Cars Registering Salient Hunting Indices at or above 0.25

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*This Technology Digest (TD) is one of two TDs that will describe inspection, test, teardown, repair, and retest results of cars identified with specific performance characteristics when passing across Salient Systems' Hunting Truck Detectors. This TD will address those cars identified with absolute valued Hunting Indices (|HI|) generally in excess of 0.25. A subsequent TD will address results from cars identified with |HI| generally less than 0.25 but greater than 0.1, as well as cars with multi-platforms. It is anticipated that similar reports will address results from alternative hunting detectors once data from these systems becomes available in the North America vehicle health database, InteRRIS®.*

## Summary

The object of Hunting Detectors (HDs) is to identify cars having poor lateral dynamic performance. HDs detect this performance by sensing and quantifying the lateral oscillatory behavior of the wheelsets of a car while passing over a section of tangent track.

Salient Systems' HDs sense hunting by measuring the dynamic force patterns imparted by the wheelsets as the car passes over a length of tangent track. Other HDs sense hunting by measuring the attitude of the wheelsets when passing over a similar length of tangent track. Each detector type provides a measure of performance in some form of a hunting index (HI). HIs from different detector types may not be directly comparable.

Salient HD data has been analyzed from 36 sites. Single-unit (2-truck) cars were identified at different HI levels above 0.25. Thirty-three of these single-unit cars were brought to the Transportation Technology Center, Pueblo, Colorado, in 2005, for inspection, test and teardown. All were found, under test, to hunt between 35 and 50 mph. Twenty-two of these cars were found with condemnable wedge rise; 27 were fitted with roller side bearings, and 5 had less than one third of the prescribed constant contact side bearing (CCSB) preload. Seven cars were repaired to Association of American Railroads (AAR) Specification M-214 and fitted with long travel CCSBs. Their stability was improved in excess of 50 mph.

The conditions of cars with HIs below 0.25 or with multi-platforms will be reported in a future TD.

This work was tasked by the AAR as part of its Strategic Research Initiative Program and was conducted jointly with the Advanced Technology Safety Initiative Program, tasked to improve railroad safety and network efficiency by using innovative trackside technologies to provide freight car owners with advanced warning of degraded car performance.

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## Introduction

Transportation Technology Center, Inc. has been tasked by the AAR, as part of its Strategic Research Initiative Program, to:

- Analyze HD data
- Relate this data to car condition through inspections, tests, and teardowns of cars identified at different levels of performance
- Suggest repair procedures to improve condition
- Verify that these repair procedures improve dynamic performance

This work has been conducted jointly with the Advanced Technology Safety Initiative Program, which has been tasked to improve railroad safety and network efficiency by using innovative trackside technologies to provide freight car owners with advanced warning of degraded car performance.

Currently the predominant HD type used in North America is that supplied by Salient Systems, Inc. Consequently, Salient data has been analyzed and related to car condition. It is anticipated that other detector types will provide alternative data and that this will have to be either correlated with Salient data or the process described in this TD will have to be replicated.

Data was collected and analyzed from 36 detector sites over a period of 1 year. Cars were grouped according to their level of performance across these sites. Lists of cars in different groups were sent to railroads and car owners. Selected cars from each group were then sent to Transportation Technology Center (TTC) for inspection, test, teardown, repair, and retest. This TD reports on the results from these activities.

## Salient Systems' Hunting Truck Detector

The Salient Systems' Hunting Truck Detector comprises a series of instrumented cribs in close proximity on a section of tangent track. A crib is the section of track between adjacent crossties, as Figure 1 shows.

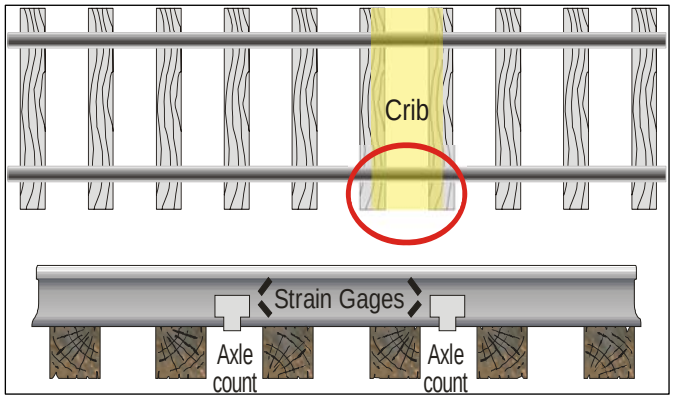


**Figure 1. Typical HD Crib**

Each instrumented crib is equipped with strain gages applied to each rail and oriented to measure the vertical and lateral forces of each passing wheel.

A wheelset on a hunting car executes a near sinusoidal motion, as Figure 2 shows. While executing this motion, it imparts a pattern of vertical and lateral forces to the rails. These forces are detected by the series of instrumented cribs.

An algorithm proprietary to Salient Systems is used to translate the pattern of forces from both wheelsets of each truck into a single HI associated with each truck in the car.

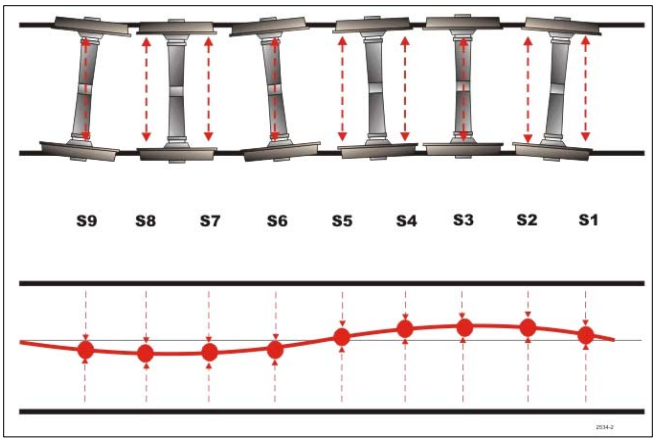


**Figure 2. Hunting Motion**

The Salient Systems' HI is generally positive, although some negative indices do occur. Consequently, the absolute value of this index, |HI|, has been used in this study.

## Data Analysis

Data was collected and analyzed from 36 detector sites over a period of 1 year.

Cars were grouped according to:

- Performance level of their worst performing trucks
- Number of passes at that level
- Number of cars identified in each group in a 1-year period (an indication of the maintenance capacity required by the industry if an alarm was set at the indicated criteria given current car and operating conditions)

Table 1 shows the groupings for the year analyzed.

**Table 1. Car Groupings According to Performance**

| Salient \|HI\| Level | Number of Passes at \|HI\| Level | Estimated No. of Cars Alarmed in 1 Year |
|---|---|---|
| $\|HI\| \geq 0.65$ | At least 1 | 300 |
| $\|HI\| \geq 0.45$ | At least 2 | 1,400 |
| $\|HI\| \geq 0.30$ | At least 3 | 4,100 |
| $\|HI\| \geq 0.25$ | At least 3 | 4,100 |

A total of 33 single-unit (2-truck) cars identified from the above groups were sent to TTC for inspection, test, teardown, repair, and subsequent test. Table 2 shows the single-unit car classifications.

**Table 2. Single-Unit Car Groupings Sent to TTC**

| Salient \|HI\| Level | Number of Passes at \|HI\| Level | Number of Cars Sent to TTC |
|---|---|---|
| $\|HI\| \geq 0.65$ | At least 1 | 4 |
| $\|HI\| \geq 0.45$ | At least 2 | 7 |
| $\|HI\| \geq 0.30$ | At least 3 | 15 |
| $\|HI\| \geq 0.25$ | At least 3 | 7 |

## Inspections at TTC

On arrival at TTC, the cars were inspected for:

- *Car type/truck type*
- *General indications of hunting:* worn uncoupling rods and coupler carriers, worn and/or broken pedestal roof liners, and worn door fittings
- *Low warp restraint:* high friction wedges and worn truck side frame column guide wear liners
- *Low truck/carbody rotational resistance:* roller or block side bearings, low CCSB preload (measured by jacking the carbody and inserting a load cell)
- *Wheel profiles:* Measured using MiniProf™

Tables 3 and 4 show the type of car identified and general condition of these cars.

**Table 3. Car Types Sent to TTC**

| Car Type | Number of Cars | Percentage of 33 Cars Total |
|---|---|---|
| Box Car | 18 | 55 |
| Gondola Car | 11 | 33 |
| Hopper Car | 2 | 6 |
| Refrigerator | 2 | 6 |

**Table 4. General Condition of Cars Sent to TTC**

| General Condition of Car/Truck | Number of Cars with Condition | Total Number of Cars | Percentage of Cars with Condition |
|---|---|---|---|
| Condemnable Wedge Rise | 22 | 33 | 67 |
| Roller Side Bearings | 27 | 33 | 82 |
| Less than One-Third CCSB Preload | 5 | 6 | 83 |

All cars brought to TTC were equipped with old-style variable damped trucks. This may not be significant as the source of most of the cars sent to TTC is a railroad that operates this design of truck almost exclusively. Figure 3 shows the age distribution of these cars.

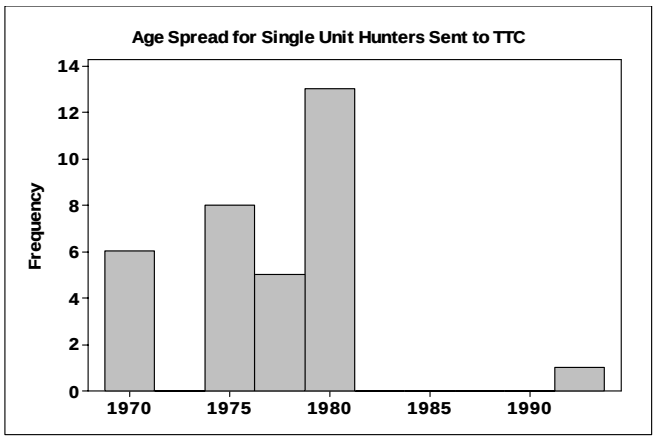


**Figure 3. Car Age Histogram for Single-Unit Cars Sent to TTC**

Many cars showed signs of hunting. Typically, components and fixtures that can slide relative to one another under a hunting motion showed signs of wear. This included worn coupler carriers, uncoupling rods, and door mechanisms.

It can be seen that 67 percent of cars had condemnable friction wedge rise and thus low warp restraint. Another 15 percent of cars had high, but not quite condemnable, friction wedges.

Almost 100 percent (32 of 33) of cars had low rotational resistance through either a lack of CCSBs or degraded or incorrectly adjusted CCSBs.

Most wheels were within wear limits and had less than 2 millimeters (mm) hollow wear. One wheel out of the 132 inspected wheelsets had condemnable flange height. Analysis of the conicities of their profiles when placed on TTC track revealed an average conicity of 0.30 for generally, ± 5 mm lateral deflections from the center position on the track (position where radius differential between the two wheels on a wheelset is zero). Some wheelsets had eccentrically worn wheel treads so that a lateral deflection of 5 mm implied flange contact. Under these conditions, the lateral deflection to flange contact was used to calculate conicity. Figure 4 shows a histogram of the calculated wheel conicities compared with those of a general sample of wheels in service having an average conicity of 0.24.

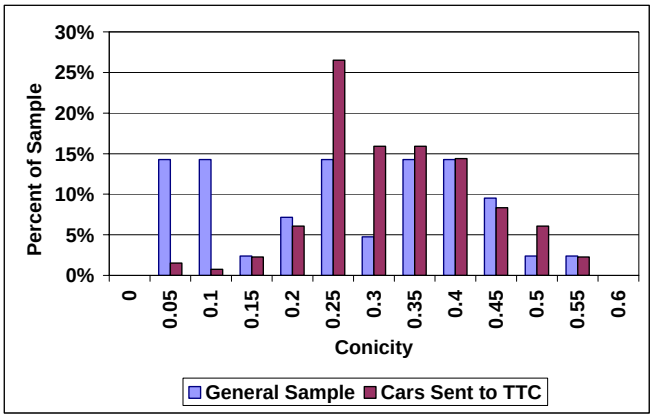


**Figure 4. Histogram of Calculated Wheel Conicities**

It is interesting to note that the sample of cars identified across HDs shows relatively few wheels with conicities below 0.25. This will account for the difference in average conicities between the two samples, which is not surprising because generally, wheelsets with higher conicities will be the ones to induce hunting. It must be emphasized, however, that the majority of wheels were within wear limits. Wheel replacement to improve hunting stability was not considered because:

- It is an expensive measure
- It is considered a temporary fix because the wheels will soon wear to similar profiles

## Results of Tests in Received Condition

Each car was tested individually in its received condition and in the direction (A- or B-end lead) in which it most often passed the detectors. The car was equipped with lateral accelerometers on the carbody above each truck and the speed of the car was recorded. The root mean square of the lateral accelerations was determined over sections of the track in accordance with the requirements of AAR Specification M-1001, Chapter XI.[1] The lowest tested speed at which the car met or exceeded Chapter XI hunting criteria was recorded. Figure 5 shows the results of the tests for all 33 cars.

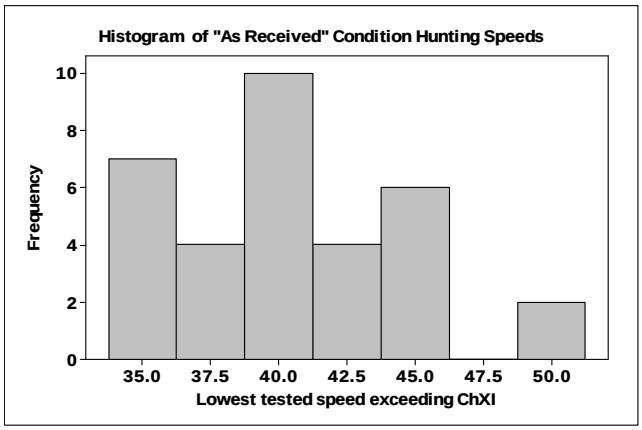


**Figure 5. Histogram of Tested Hunting Thresholds**

It can be seen that all the cars had a hunting threshold at or below 50 mph. This speed was the designated target speed for acceptable performance.

## Repairs and Upgrades

Selected cars were systematically repaired or upgraded.

Cars with trucks with high friction wedges were repaired by:

- Replacing friction wedges and column guide wear liners
- AAR Specification M-214 rebuild to standard wedge design and replacement of friction wedges[2]
- AAR Specification M-214 rebuild to a split wedge design

Cars were fitted with long travel, metal capped CCSBs, or existing CCSBs were correctly adjusted, or CCSB elements were replaced.

## Post-Repair and Upgrade Performance

Cars were then tested for hunting stability at various stages of repair/rebuild with the following results:

- Replacement of friction wedges and column guide wear liners made little significant improvement to initial performance. It should be noted, however, that the tested cars were not run to permit bedding-in of wear surfaces. This process is known to improve stability.
- AAR Specification M-214 rebuild to a standard wedge design and replacement of friction wedges increased the hunting threshold by a minimum of 15 mph.
- AAR Specification M-214 rebuild to a split wedge design increased the hunting threshold by a minimum of 15 mph.
- Fitting of CCSBs increased the hunting threshold by a minimum of 15 mph.
- Rebuilding the truck to a standard or split wedge design plus fitting of CCSBs increased the hunting threshold by at least 2 times 15 mph and generally in excess of this speed up to speeds of 80 mph.

## Conclusions

- Hunting detectors can identify cars with poor lateral dynamic characteristics.
- Cars passing Salient Systems' Hunting Truck Detectors and registering:
  - $|HI| \geq 0.65$ at least once, or
  - $|HI| \geq 0.45$ at least twice, or
  - $|HI| \geq 0.30$ at least three times, or
  - $|HI| \geq 0.25$ at least three times

  are very likely to have a hunting stability threshold between 35 and 50 mph.
- Cars thus identified are very likely to show signs of component wear as a result of hunting.
- Cars thus identified are very likely to have:
  - Reduced warp restraint (high, worn friction wedges, worn column guide wear liners, worn bolster pocket wear plates), or
  - Low truck/carbody rotational resistance (roller or block side bearings, degraded CCSBs), or
  - A combination of both.
- Poorly performing cars can be rectified by a combination of:
  - Inspection and verification that trucks and their components meet AAR Specification M-214 minimum standards or repair accordingly and:
    - Fitting of long travel CCSBs preferably with metal caps, or
    - Refurbishing existing CCSBs.

## Future Work

The condition and performance of cars with |HIs| below 0.25 or with multi-platforms will be reported in a future TD. This work and that associated with truck performance detectors (TPDs) will be consolidated into a single report to include inspection decision trees and maintenance guidelines for cars detected at HDs and TPDs.

## References

1. Association of American Railroads, *Manual of Standards and Recommended Practices*. 1997. AAR Specification M-1001, Chapter XI, Service-Worthiness Tests and Analyses for New Freight Cars.

2. Association of American Railroads, *Manual of Standards and Recommended Practices*. 1997. AAR Specification M-214, Rebuild and Repair of Truck Castings.