TECHNOLOGY DIGEST

Timely Technology Transfer — 01-008

Performance Tests of Overloaded and Unbalanced Load Detection at Track Speeds

by John Tunna and Bill Sneed

Summary

The results from recent tests indicate it is possible to measure car weights to a reasonable degree of accuracy under normal operating conditions using a Wheel Impact Load Detector (WILD). The speed of the car over the test site was found to affect the measurement; therefore, a correction for this effect needs to be applied. There was more variation in the measurements in the northbound direction compared to the southbound direction. This may be due to the position of the car in the train and the resulting effect of buff and draft forces. Further analysis of the data and possibly more measurements are required before any conclusions can be drawn about the accuracy of the system in measuring front to back and side-to-side weight distributions.

As part of the Association of American Railroads' research program, Transportation Technology Center, Inc. (TTCI) conducted tests to determine if the system was capable of measuring car weights within suitable tolerances. Tests involved monitoring the response of the system to three scale monitor cars of known weights over a three-month period.

TTCI's field experiments were conducted with the help of CSXT and the Canadian National/Illinois Central (CN/IC) Railroads and Salient System, Inc. using a wayside system for measuring freight car loads. From June to November 2000 data was gathered on the CN/IC in Watson, Illinois. During this time, three scale monitor cars were marshaled into the trains that passed over the site. The scale cars had previously been weighed accurately on certified static scales. The scale monitor cars typically passed the site every other day in each direction.

Suggested Distribution:
- ❑ Maintenance of Way
- ❑ Planning & Analysis
- ❑ Transportation
- ❑ Mechanical
- ❑ Safety

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

Overloaded freight cars can increase the rate of degradation of track components, and unbalanced loads may increase the likelihood of derailment. For these two reasons, the North American railroad industry is interested in developing a wayside system for detecting overloaded and unbalanced cars.

Car weights can be accurately determined by static scales, and this accuracy is necessary for freight billing purposes. However, a wayside overloaded and unbalanced load detector need not be so accurate. TTCI and a Technical Advisory Group made up of AAR members produced a performance-based guidelines calling for:

- Accuracy of ±2 percent, 95 percent of the time.
- Accuracy of ±7 percent, 100 percent of the time

These accuracies were to be achieved for cars weighing between 200,000 and 500,000 pounds, at speeds up to 60 miles per hour.

The investigation of suitable wayside detectors for overloaded and unbalanced loads is part of a Strategic Research Initiative funded by the Asssociation of American Railroads in 2000. This Technology Digest describes experiments performed on the Wheel Impact Load Detector (WILD) system on the CP/IC at Watson, Illinois.

EXPERIMENTS

The experiment involved running scale monitor cars with known weights over the test site numerous times. The following three scale monitor cars were used in the experiments:

Car No.	On loan from	Weight (lb)
CR80072	CSXT	207,300
NYC80048	CSXT	167,300
NYC80081	CSXT	155,300

The weights of the scale monitor cars had been measured before the test runs started on a static scale with an accuracy believed to be ±0.1 percent.

The scale monitor cars were marshaled into local trains. They typically passed the test site once each day in either the northbound or southbound direction. Special software was written for the WILD system so that the following were recorded every time a scale car ran over the site:

- Car number
- Time
- Track
- Direction
- Number of cars in train
- Reference weight
- Date
- Location
- Speed
- Total train weight
- Position in train
- Measured weight
- Weight difference (measured less reference)
- Percent weight difference

Data was gathered from July 19 to October 30, 2000. Eighty-eight recordings were made for each scale car. A typical set of results is shown in Exhibit 1, where the percentage difference between the recorded and known car weight is plotted against the run number for scale car NYC80048.

The speed for Run 80 was only 6 miles per hour, which was considerably slower than that for the other runs. It is assumed that this is the reason why the measurement error was so large (-17 percent) for Run 80. It was also discovered that the WILD system was adjusted toward00s the end of July. For this reason, the results for the Runs 1 to 13 were ignored in the analysis that followed.

The remaining data points in Exhibit 1 show that there is a tendency for greater errors in the northbound direction. The scatter in error also appears to be greater in the northbound direction.

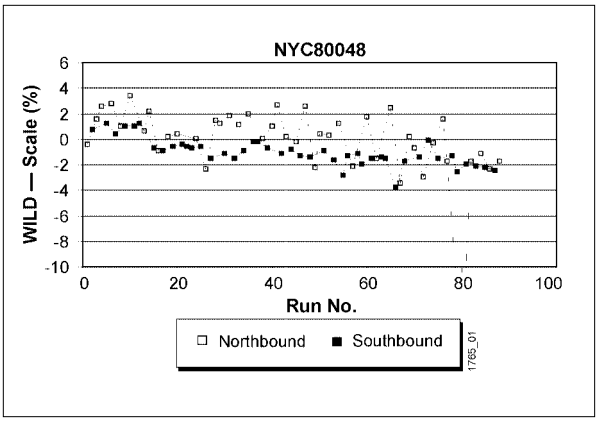

Exhibit 1. Accuracy Results for NYC80048

Exhibit 2 shows the measurement error plotted against the speed for car NYC80048. The northbound and southbound data points are shown as empty and solid squares respectively. It can be seen that there is a weak relationship between speed and measurement error. The northbound data was generally recorded at higher speeds than the southbound data. This could explain the difference in the average errors in the two directions and the greater variation in the northbound speeds.

Linear regression was performed on the speed/error data for all three scale monitor cars with the following results:

Car No.	Slope	Intercept (%)	R Square
CR80072	0.084	-4.74	0.36
NYC80048	0.096	-4.71	0.47
NYC80081	0.064	-2.71	0.25

Although the R-square values are small, these relationships were used to compensate the measurement error for the effect of speed. The resulting measurement errors for scale car NYC80048 in the northbound and southbound directions are shown in Exhibits 3 and 4. These exhibits show the guideline limits of ±2 percent and ±7 percent. It can be seen that, with the exception of the 80th data point in the northbound direction, all the data lies within the ±7 percent error bands. With the additional exception of the first six data points (before the system was adjusted) nearly all the data lies within the ±2 percent limits. Similar results were achieved for the other scale cars.

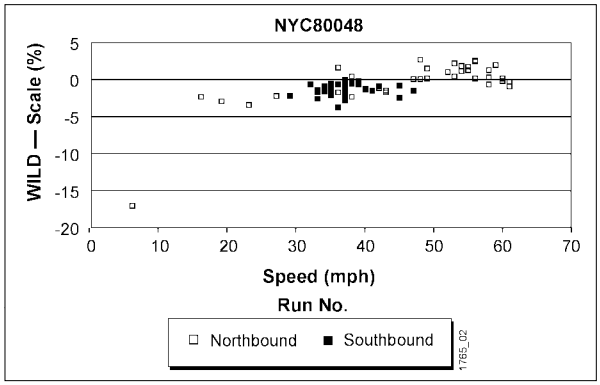

Exhibit 2. Effect of Speed on Accuracy for NYC80048

The following lists the standard deviations of the measurement errors and the percentage of values within the guidelines assuming that the errors are normally distributed random variables:

Car No.	Direction	Mean Meas, error (%)	Standard Dev. of Meas. error (%)	Within ±2%	Within ±7%
CR80072	North	-0.13	2.09	66%	99.92%
CR80072	South	-0.26	0.67	99.7%	>99.99%
NYC80048	North	-0.21	2.05	67%	99.93%
NYC80048	South	-0.14	0.65	99.8%	>99.99%
NYC80081	North	-0.24	1.51	81.5%	>99.99%
NYC80081	South	-0.26	0.67	99.7%	>99.99%

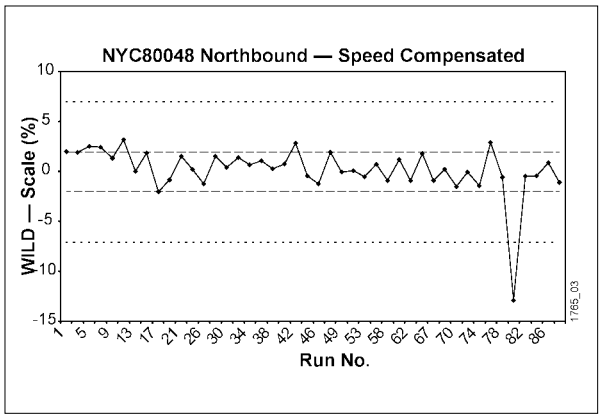

Exhibit 3. Speed Compensated Accuracy for NYC80048 – Northbound

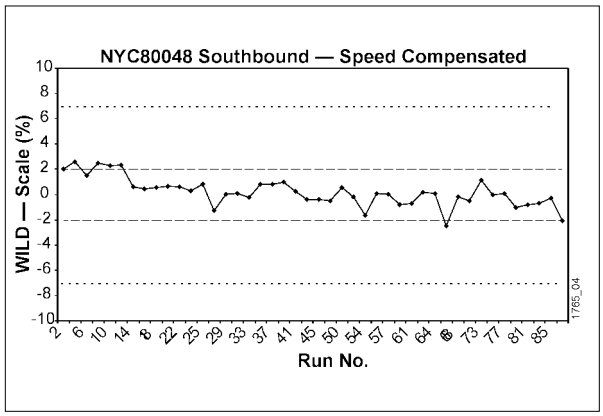

Exhibit 4. Speed Compensated Accuracy for NYC80048 – Southbound

These results show that the measurement error is within the guidelines in all cases except the northbound direction where less than 95 percent of the points lie within ±2 percent.

The reason for the standard deviation of measurement error being greater in the northbound direction may be due to the position of the scale car in the train. Exhibit 5 shows the measurement error for scale car NYC80048 plotted against the position of the car in the train (position 1 means the first car after the locomotives at the head of the train). The empty and solid squares represent northbound and southbound data respectively. The exhibit shows that the scale car was generally located towards the front of the train when it was running in the northbound direction and in the middle or towards the rear of the train when running in the opposite direction. A reasonable hypothesis would be that the WILD system is less accurate at measuring car weights when the car is towards the front of the train.

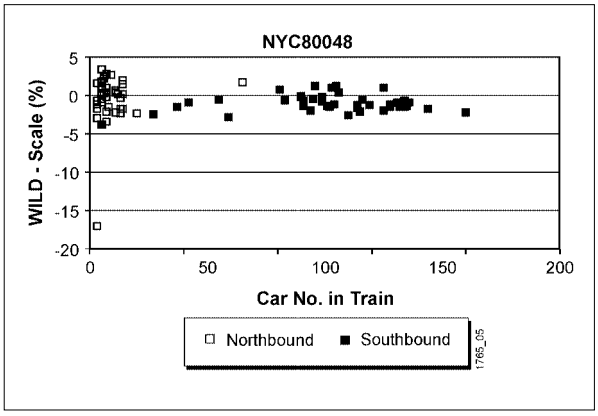

Exhibit 5. Effect of Car Position on Accuracy for NYC80048

An alternative explanation for the difference in accuracy between the two directions could be the grade of the line at the site. Traveling from the north, the grade is downhill before the site, level through the site, and downhill again after the site.

CONCLUSIONS

The results from these tests have shown it is possible to measure car weights to a reasonable degree of accuracy under normal operating conditions. The speed of the car over the site was found to affect the measurement; therefore, a correction for this effect needs to be applied. There was more variation in the measurements in the northbound direction compared to the southbound direction. This may be due to the position of the car in the train.

Further analysis of the data and possibly more measurements are required before any conclusions can be drawn about the accuracy of the system in measuring front to back and side-to-side weight distributions.

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A MORE DETAILED REPORT, WHICH MAY CONTAIN REVISED INFORMATION, MAY BE AVAILABLE AT A LATER DATE THROUGH AAR/TTCI, PUBLICATIONS, P.O. Box 79780, BALTIMORE, MD, 21279-0780.