ON-BOARD TRUCK WEIGH SCALES

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ABSTRACT

Although on-board truck weigh scales have been available for more than 20 years, B.C. log haulers have experienced poor performance with most of the popular systems. In response to increased weight monitoring enforcement by the B.C. Ministry of Transportation and Highways, FERIC was asked to evaluate the accuracy and reliability of a number of the more common systems being marketed for highway log hauling. The study began in 1984 in the B.C. Cariboo with two test systems, and finished in 1988 after evaluating 22 different weigh-scale options.

The objective of the FERIC scale-evaluation project was to observe and document the accuracy and reliability of commercially available on-board truck weigh-scale systems operating under B.C. Interior log-hauling conditions. A secondary objective was to initiate scale-design improvements where possible.

Field evaluations were done on log-truck scale systems through all operating seasons.

INTRODUCTION

In B.C., 2500 highway log trucks deliver approximately 40 million cubic meters (or 32 million tonnes) of logs annually over the public road system. Highway log hauling is the most costly phase of fibre supply to the converting plants, often accounting for more than 50% of the total delivered log costs (or $9.00/m^3).

The forest industry recession of the early 1980s intensified competition between both forest companies and contractors of companies, but especially among truckers. Weights and dimension regulations were continually being tested, to the point that the B.C. Ministry of Transportation and Highways threatened to remove the reporting concessions for log haulers at the highway scale stations. This threat of increased enforcement initiated FERIC's member companies to request a study of on-board weigh scales for logging trucks. If truckers could consistently monitor bunk weights at the loading site, legal axle loading could be achieved regardless of log density.

On-board truck scales were not new to B.C. log haulers. Some U.S.-manufactured bunk scale systems have been available for over 20 years. However, they were never designed to withstand the rigors of the B.C. application where operating conditions include rough forest roads, low operating temperatures (to -40 degrees Celsius), liberal use of road salt, and heavy load weights. After trying most of the available scale systems, many truckers found it more economical to pay overload fines or reduce productivity than to incur the investment and repair costs of on-board scales.

The objective of the FERIC scale study was to evaluate the accuracy and reliability of on-board truck weigh-scale systems working under typical B.C. Interior conditions. A secondary objective was to initiate scale-system improvements through suggestions to manufacturers.

The FERIC scale-evaluation project began in the summer of 1984 with the purchase and installation of two electronic load-cell systems. By the termination of the project in the spring of 1988, observations were collected on 22 different scale systems.

STUDY METHODOLOGY

a) Installation

Because scale manufacturers commonly attribute the poor scale performance to installation shortcuts, FERIC placed considerable emphasis on correct installation procedures. Installations were performed by either a manufacturer's representative or by FERIC personnel and others under direct advice from the manufacturer.

b) Calibration

Following installation, the scale systems required calibration to ensure that the displayed weights were accurate. Calibration was performed through an iterative process of referencing the on-board truck-scale display to the printout from a mill-yard platform scale of a cooperating member company (Weldwood of Canada Limited). The test scale systems were periodically recalibrated over the evaluation period.

c) Data Collection

The drivers of each of the test trucks monitored over the study were provided with a log book for recording truck- and trailer-weight readings at the loading point. They were also asked to enter the platform-scale gross and tare weights for each trip. In addition, Weldwood provided a monthly report summary of all the truck weights across their mill-yard scale. FERIC used the monthly summary to verify the drivers' logs and to compare payload performance of trucks with scales to those without scales.

d) Maintenance and Repair

FERIC researchers performed all the repair and maintenance activities required on the test systems operating in the Williams Lake area. A maintenance journal was kept for each test truck under observation in which work descriptions and repair times were recorded. In some cases, repair times were longer than would have been expected from a commercial shop because extra effort was taken to identify the failure cause rather than to simply complete the repair. Routine maintenance services were also conducted monthly that included a thorough cleaning of all scale components and an inspection for potential problems.

e) Data Analysis

As a measure of accuracy for each system tested, a micro-computer spreadsheet was developed to analyze driver-recorded truck-scale data with the platform scale summaries received from Weldwood. Accuracy is defined as the deviation of the truck-scale data from a best-fit mill-scale/truck-scale regression line. Results were compiled for both the summer and winter hauling seasons.

SCALE SYSTEM DESCRIPTIONS

The truck scale systems evaluated were classified into four different categories based on their load-bearing characteristics.

a) Temporary Load-Bearing Scales

This category of scale includes the lift-pad units that support the load only during weighing, and that are retracted for travelling. The FERIC study monitored Smieja hydraulic scales and Williams Air scales in this category.

b) Non-Load-Bearing Scales

Strain gauges or transducers are used to sense load-induced deflection in a structural member of the tractor or trailer. This project studied Structural Instrumentation (S.I.) aluminum and steel transducers mounted on walking-beam suspension members and a steel transducer mounted on a trailer trunnion shaft.

c) Load-Bearing Scales

The electronic load-cell scale systems are installed as structural members of the log-bunk rigging. These systems utilize a steel bar, instrumented with strain gauges, that mounts between the vehicle frame and the bunk bolster to measure the load weight. FERIC studied Lodec, S.I., and Vulcan standard and heavy-duty electronic scales, as well as S.I. fifth-wheel scales.

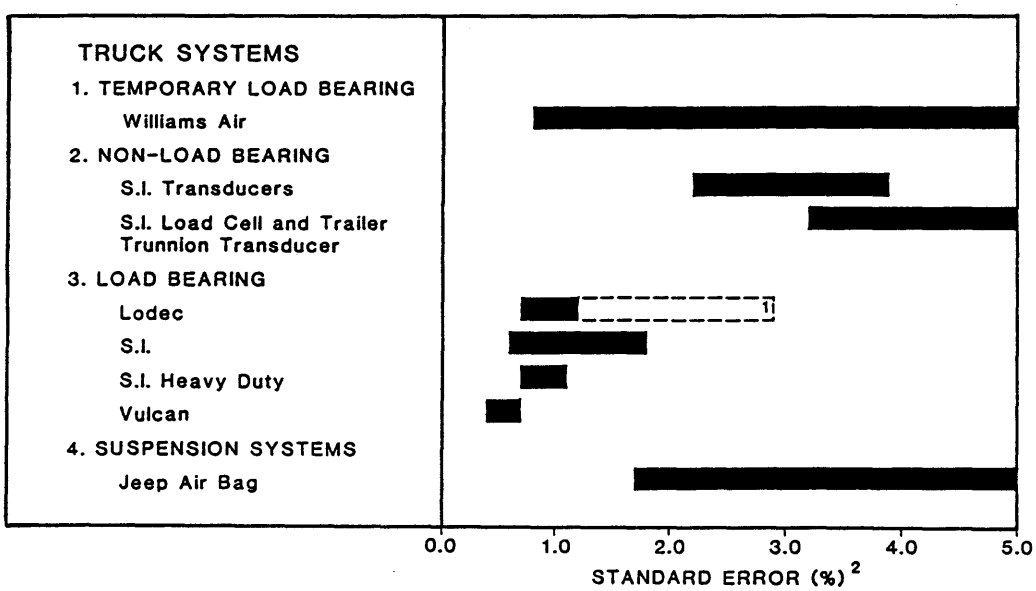
d) Suspension-System Scales

Air-bag axle suspensions modulate air pressure to control vehicle height as a result of changing load. During this study, observations were made on an experimental system utilizing an air pressure transducer to indicate load weight from a 'Neway' air-bag suspension on a tractor-jeep.

RESULTS AND DISCUSSION

a) Accuracy

Scale system 'accuracy' used in this study was a comparison of the truck's indicated payload with the mill-scale net weight. The unit of comparison was Standard Error Percentage which was determined statistically using the driver's log-book entries and the mill-scale load summaries. This unit provides a measure of repeatability for comparison between systems and seasons of operation. However, it did not account for the variation in the driver's ability to interpret the indicated weights on the cab display. Figure 1 provides an overall summary of scale accuracy for the systems monitored during the study.



[1] Load cell accuracy detioration after cracking
[2] The lower the standard error percentage, the more accurate the scale

Figure 1. A Summary of Scale Accuracy.

The two systems with the largest range of accuracy (Williams Air and Jeep Air Bag) illustrate the influence of driver application and interpretation of scale accuracy. The first Williams system monitored used two air gauges in the cab to displayed pounds (U.S. manufacturer) of bunk loading. The driver had to interpret the gauge readings based on previous loading results at the mill-yard scale and also judge if the bunk had lifted high enough for a true weight reading or if the height-limiting valve was stuck. The requirement for some driver dedication and commitment to this weighing activity was evident by a wide range of accuracy between owner/operators and hired drivers.

The jeep air-bag system required that the driver be very conscious of loading conditions when interpreting the reading. Factors such as side slope, grade, jeep-axle height (in relation to the tractor tandems) and residual suspension windup (as a result of braking) all influenced the results. However, driver awareness and experience did improve the accuracy results.

The most accurate truck scales were the load-bearing electronic load-cell systems. As Figure 1 indicates, their was a tight range of accuracy for the three manufacturers evaluated. This type of scale required very little direct interpretation by the driver. The displayed bunk weights on the cab indicator directly represented the signal from the strain gauges and any abnormal reading usually indicated some type of system failure.

b) <u>Reliability</u>

Through out the study, FERIC personnel performed the repairs and maintenance on the systems monitored. All the systems required some maintenance to keep them functioning correctly. A monthly inspection routine was established to check for cracking on the load cells and damage on all the hoses and wires, as well as to clean the truck-to-trailer couplings and to moisture seal all the power and signal cables. This routine inspection required an average of 40 minutes per truck, however, the amount of maintenance required varied widely between systems and, in most cases, increased after the first hauling season. Figure 2 illustrates the level of maintenance recorded for the various truck systems monitored.

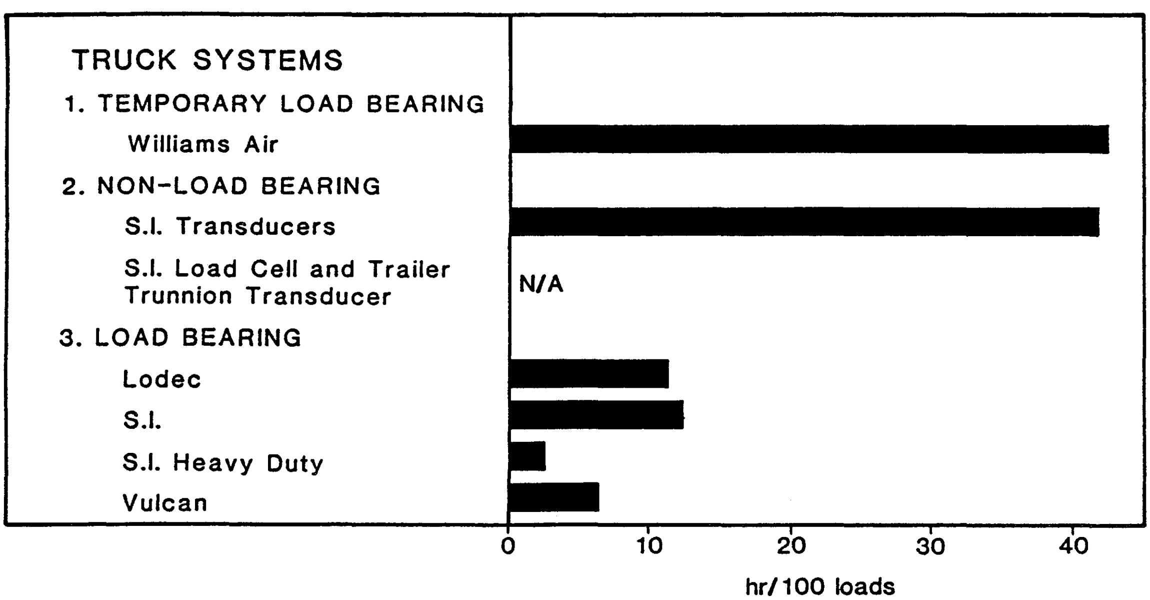


Figure 2: A Summary of Scale Maintenance Requirements.

The Williams Air Scales required the most maintenance of all the systems tested, however, they required the least technical knowledge to repair, and generally, the least expensive parts. Because most of the routine maintenance could be performed by a driver during the course of his shift, these systems were well accepted by owner/operators who maintained their own trucks.

The electronic load-cell scales required the least amount of maintenance during the study, however, this level of maintenance could be significantly influenced by the quality of installation and the diagnostic ability of the mechanic. Electronic load-cell maintenance is beyond the ability of many truckers, can require expensive parts, and is frequently viewed with apprehension.

c) Scale Cost/Benefit

Throughout the scale study, many log-hauling contractors claimed they could operate more cost effectively without scales than with scales when the capital and operating costs were considered. A survey was undertaken to clarify this claim and the results are illustrated in Figures 3 & 4.

Truck A (Figure 3) was equipped with electronic load-cell scales and Truck B (Figure 4) had no scales. Both trucks were 5-axle pole-trailer combinations and both trucks averaged the same load weights over a 160-load sample. However, Truck B had more underloads, resulting in lost revenue, and more overloads, resulting in fines or payload penalties. When these results were extrapolated over an operating year, Truck A earned approximately $5500 more revenue than Truck B. A load-cell scale system costs approximately $5000, has a life expectancy of four years, and an operating cost (repairs) of about $2600/year. The net cost benefit, based on this survey, indicates a potential saving of $2600/year for the trucker with a scale system (ie; $5500/yr revenue - $2600/yr repair cost - $1300/yr deprec cost = $2600). The reduced load variation for the truck with scales translates to a payback period of about two years when compared to the lost revenue from underloading and the penalties from overloading without scales.

d) Scale-System Improvements

The second objective of this project was to initiate scale improvements as a result of study observations. Although this did not occur through any formal process, there were a number of improvements that resulted during the four-year evaluation.

Within the first year of the study, it became apparent that the standard Lodec structural bars were underdesigned for B.C. loading. Two of the test cells had cracked within 11 months of use and two more were cracked within the second year. At first, the manufacturer claimed that the cracks would not reduce scale accuracy, which had been a standard response to the trucking community for many years. However, the data analysis demonstrated that the cracking was influencing scale accuracy (Figure 1) and Lodec responded by developing a heavy-duty version for the B.C. application. Both Structural Instrumentation and Vulcan quickly followed Lodec with the release of their own heavy-duty load-cell systems.

The project maintenance records illustrated that the greatest source of scale problems resulted with the wiring between the load cells and the cab displays. Documenting this fact contributed to two significant scale developments. The first was a radio-telemetry scale-communication system that FERIC and RMS developed in cooperation with the Science Council of B.C. This system initially sent the trailer scale data directly to the cab display via radio signals. It worked so well that it was expanded to send both the tractor- and trailer-scale data to the log loader allowing the operator to distribute the load for legal axle weights. The trailer-to-tractor radio telemetry package is now marketed by Lodec. The second advance was the introduction of two-wire scale-signal cords in place of the more delicate four-wire cords. This meant that the scale wiring could then be routed through the trailer light-connectors simplifying connection and maintenance.

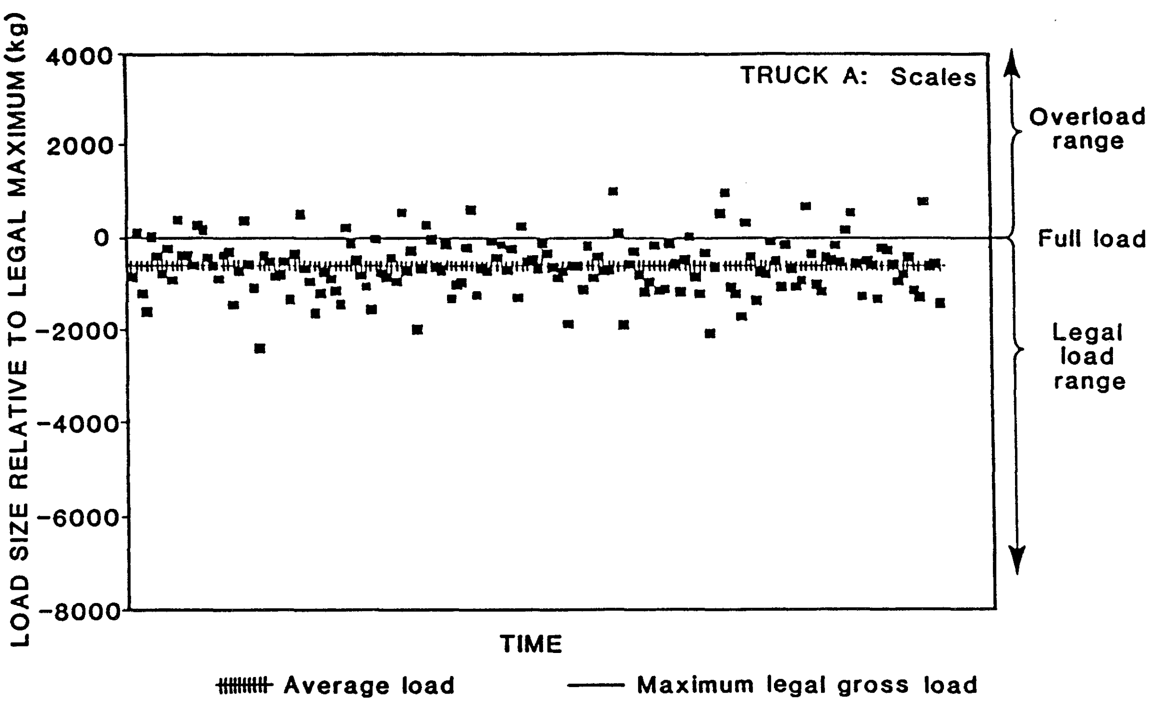


Figure 3. Payload Distribution for a Truck with a Load-Cell System.

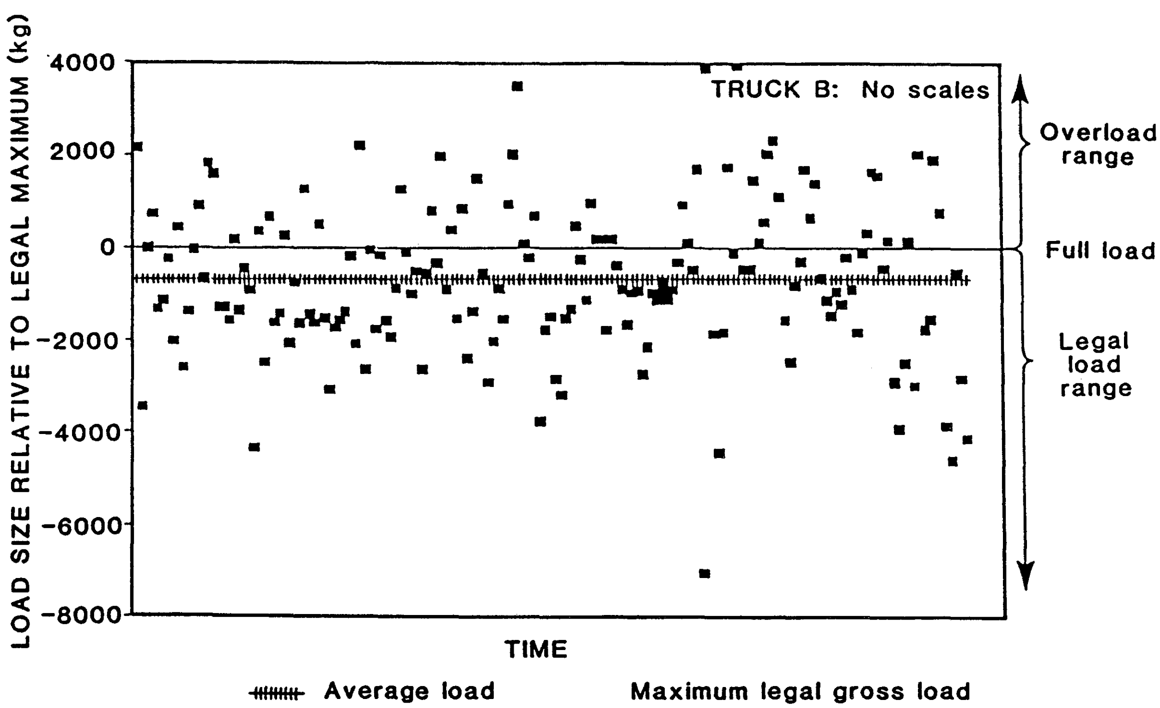


Figure 4. Payload Distribution for a Truck without a Scale System.

CONCLUSIONS

The accuracy of on-board scale systems is dependent on system selection, installation technique, calibration and maintenance programs, and driver commitment. The study observed accuracy ranges of 0.3 to >5 standard error percentages for the systems monitored.

Scale-system reliability is dependent on the quality of installation, the effectiveness of routine system maintenance, the diagnostic ability of the service mechanics, and the availability of replacement parts. The study observed scale-system maintenance and repair requirements that ranged from 2.6 to 42.6 hours/100 loads hauled.

On-board truck scales can increase hauling revenue by reducing load-size variation, and achieve investment payback in less than two years.