Report No. CDOT-DTD-R-2004-15
Final Report

USING INFRARED TECHNOLOGY TO DETECT HOT OR DEFECTIVE BRAKES ON TRUCKS

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DEPARTMENT OF TRANSPORTATION RESEARCH

August 2004

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH BRANCH

Technical Report Documentation Page

1. Report No. CDOT-DTD-R-2004-15	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle USING INFRARED TECHNOLOGY TO DETECT HOT OR DEFECTIVE BRAKES ON TRUCKS		5. Report Date August 2004 6. Performing Organization Code
7. Author(s) Derek L. Richard		8. Performing Organization Report No. CDOT-DTD-R-2004-15
9. Performing Organization Name and Address Washington Group International, Inc. 7800 E. Union Avenue, Suite 100 Denver, CO 80237		10. Work Unit No. (TRAIS) 11. Contract or Grant No. 99 HAA 00116
12. Sponsoring Agency Name and Address Colorado Department of Transportation - Research 4201 E. Arkansas Ave. Denver, CO 80222		13. Type of Report and Period Covered Final Report 14. Sponsoring Agency Code 92.08
15. Supplementary Notes Prepared in cooperation with the US Department of Transportation, Federal Highway Administration		

16. Abstract

This study investigated the use of infrared thermometers to detect hot or defective brakes on trucks traveling through the eastbound Port Of Entry (POE) on I-70 in Dumont, CO. The objective of this evaluation was to develop brake temperature screening criteria that can be used to identify potential brake-related problems. Brake temperatures were measured and Level 4 brake inspections were performed on trucks traveling through the POE. The measured brake temperatures were then compared to the brake violation data contained in the brake inspection reports to correlate brake temperatures with brake functionality and to develop effective brake temperature screening criteria.

A low-temperature threshold of greater than 101 F below the average brake temperature for the truck and a high-temperature threshold of 500 F produced the best correlation with the brake inspection data. Applying these screening criteria resulted in a brake violation rate of 58 percent of the screened trucks. This is significantly higher than the 35 percent brake violation rate for the entire study sample. In addition, 33.33 percent of the screened trucks were placed out of service (OOS), twice the percentage of the total sample placed OOS (16.67 percent). These results were confirmed by an additional field test using these screening criteria, in which 67 percent of the screened trucks were found to have brake violations and 33 percent of the screened trucks were placed OOS. If implemented, the screening system should result in more brake violations being identified by the inspectors and fewer trucks with good brake systems being subjected to an inspection. If the technology becomes available to install this screening system within the travel lanes similar to a Weigh-in-Motion system, the potential for accidents will also decrease, as brake temperature screening could be accomplished without the need for trucks to exit and enter the interstate.

17. Keywords hot brakes, infrared, temperature, screening, automation, safety, steep grades	18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161

19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 70	22. Price

USING INFRARED TECHNOLOGY TO DETECT HOT OR DEFECTIVE BRAKES ON TRUCKS

by

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Sponsored by the
Colorado Department of Transportation
In Cooperation with the
U.S. Department of Transportation
Federal Highway Administration

August 2004

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ACKNOWLEDGEMENTS

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I would like to recognize the Dumont Port of Entry staff for their assistance in conducting this research. Their valuable knowledge and hard work made this project possible, and their sense of humor made the process an enjoyable one. Their efforts are greatly appreciated.

EXECUTIVE SUMMARY

Both the trucking industry and PrePass[1] have expressed an interest in allowing trucks to bypass the eastbound Dumont Port of Entry (POE). This POE is currently being automated to include Automated Vehicle Identification (AVI) and Weigh-in-Motion (WIM) technologies. CDOT and POE personnel believe that this study is very timely in order to: 1) develop criteria that can used to identify potential brake-related problems, 2) develop parameters that can be used as functional requirements for any automated technology that is implemented, 3) demonstrate that the screening criteria reveals a high level of confidence and therefore has application for random pull-in rates, and 4) show that POE could use the screening criteria at other fixed and mobile inspection locations. When the port automation is completed, CDOT estimates 25 to 35 percent of the trucks traveling on eastbound I-70 may initially bypass the port. This might result in between approximately 5,000 to 7,000 trucks each month (gradually increasing over time) bypassing the POE without the possible added safety benefit of a brake check. The six percent downgrade from Genesee to Morrison downstream from the port adds additional concern, as it is a roadway segment that has experienced numerous truck-related accidents throughout the years.

This study investigated the use of infrared thermometers to detect hot or defective brakes on trucks traveling through the eastbound Dumont POE. The first part of the study collected background brake temperature and axle weight data for randomly selected five-axle trucks. These data were analyzed by vehicle classification and axle weight groupings to determine a normal operating temperature range for the specific truck classification and the incremental weight groups, as appropriate. The second portion of the study involved measuring brake temperatures and conducting Level 4 brake inspections[2] on randomly selected five-axle trucks as

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[1] PrePass is an automatic vehicle identification (AVI) system that allows participating transponder-equipped commercial vehicles to bypass Port Of Entry Facilities that are equipped with AVI and Weigh-in-Motion (WIM) technologies, provided that their operating credentials are in order and their vehicles are within legal weight limitations.

[2] The Commercial Vehicle Safety Alliance (CVSA) designates Level 4 inspections as Special Inspections. POE only conducts Level 4 inspections in conjunction with studies that require data of a special nature. For this study, the Level 4 inspection consisted of a visual inspection of the brake system, including the air lines, as well as a measurement of brake push rod travel distance to determine brake adjustment.

they traveled through the POE. The measured brake temperatures were then compared to the brake violation data contained in the brake inspection reports to correlate brake temperatures with brake functionality and to develop effective brake temperature screening criteria. The most effective screening criteria were determined based on an analysis of the false positives, false negatives, and percent correct produced by each set of criteria. The final test evaluated the ability of the selected screening criteria to identify hot or malfunctioning brakes in a separate sample of trucks.

The initial tests resulted in a wide range of normal "baseline" brake operating temperatures for trucks of various weights. Though there was a definite trend toward higher average temperatures as axle weight increased, temperatures varied widely within each axle weight group. The temperatures measured for the driver's side and the passenger's side brake drums were remarkably similar overall, with averages of 245 F and 246 F, respectively. A total of 163 trucks were analyzed during the initial data collection period in April 2004.

The correlation tests evaluated a total of 54 trucks during May and June 2004. Though the baseline tests showed a wide variation in brake temperatures across all weight ranges, screening criteria were developed as best-fit parameters using the recorded brake temperature and inspection data. After performing several analyses on the screening criteria, a low-temperature threshold of greater than 101 F below the average brake temperature for the truck and a high-temperature threshold of 500 F were chosen as the best correlation with the brake inspection data. Applying these screening criteria resulted in a brake violation rate of 58 percent. This is significantly higher than the 35 percent brake violation rate for the entire study sample. In addition, 33.33 percent of the screened trucks were placed out of service (OOS)[3], twice the percentage of the total sample placed OOS (16.67 percent). These results were confirmed in a final field test using these screening criteria, in which 67 percent of the screened trucks were found to have brake violations and 33 percent of the screened trucks were placed OOS.

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[3] A truck is placed OOS when an inspector determines that the vehicle- or driver- related violations are severe enough to prevent further travel. The majority of the trucks placed out of service during this study involved brakes that were out of adjustment or significant leaks in an air line.

In the 54-truck sample, 23 trucks were PrePass vehicles. Of these, 12 trucks had one or more brake violations and 2 were placed OOS following inspection. In the final field test, 11 of the 18 trucks sampled were PrePass vehicles. Of these, 3 had one or more brake violations and 2 were placed OOS following inspection.

If POE inspectors had the ability to screen trucks for inspection based on brake temperatures, a greater percentage of screened/inspected trucks would be found to have brake violations. This, in conjunction with current Inspector Selecting System[4] procedures, would result in a more effective and efficient use of inspectors' time and POE resources, as it would allow them to sort-out vehicles that have potentially hot brakes. It would also allow a greater percentage of trucks with brakes in good condition to avoid the delay and inconvenience of an inspection. If this screening system were installed within the travel lane similar to a Weigh-in-Motion system, the potential for accidents will also decrease, as fewer trucks would be required to exit and enter the interstate for inspection at the POE. Current technology, however, is not at the point where mainline screening is feasible.

Based on the results of this study, it is recommended that a brake temperature screening system be implemented at the eastbound Dumont POE to identify trucks with potentially defective or hot brakes. All trucks with one or more brakes identified by the screen as potentially defective or hot should be subjected to at least a minimum inspection to determine whether or not they should be allowed to continue on the steep downhill grade east of the port.

While the screening criteria developed in this study would help identify trucks with brake violations, it has not been shown to identify other safety violations that POE inspectors look for

[4] The Inspection Selection System provides a recommendation to aid roadside inspectors based on the safety status of the responsible carrier. The main goal of the Inspection Selection System is to prioritize and target carriers with poor safety performance. Carriers with the highest priority are given a recommendation of "inspect" based on poor safety history. This system is supported by the Federal Motor Carrier's Safety Administration.

during a full Level 1[5] inspection. Though poor brake conditions may often indicate poor conditions of other truck components, POE should continue to use their comprehensive inspection program to identify other vehicle/driver safety violations that are not brake-related.

Implementation Statement

It is recommended that a brake temperature screening system be used at the eastbound Dumont POE to identify trucks with potentially defective or hot brakes. To meet the temperature screening standards developed in this study, the selected screening equipment should be capable of measuring the absolute temperature of the brake drums with reasonable accuracy. In addition, an automated system will need to compute the average brake drum temperature for the truck, identify the coolest brake drum temperature, and determine the difference between the two values. The system will then identify for inspection any truck where this difference exceeds 101 F, as well as any truck with a brake drum temperature that exceeds 500 F. Ideally, these parameters could be adjusted as needed by POE inspectors if experience shows that different upper or lower temperature thresholds are more effective at identifying trucks with brake violations.

After implementation of the screening system, a review should be conducted periodically to determine the continuing effectiveness of the system in identifying those trucks with potential brake violations, and if an adjustment in the screening criteria is warranted. This evaluation can easily be accomplished by comparing inspection data using the screening system to inspection data prior to the screening system. The screening system should result in more brake violations being identified by the inspectors, and fewer trucks with good brake systems being subjected to an inspection.

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[5] The CVSA Level 1 inspection involves an examination of the driver's license, medical examiner's certificate and waiver, if applicable, evidence of alcohol or drugs, driver's record of duty status as required, hours of service, seat belt, vehicle inspection report, brake system, coupling devices, exhaust system, frame, fuel system, turn signals, brake lamps, tail lamps, head lamps, lamps on projecting roads, safe loading, steering mechanism, suspension, tires, van and open-top trailer bodies, wheels and rims, windshield wipers, emergency exits on buses and hazardous materials requirements, as applicable.

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LIST OF ACRONYMS

AVI	Automated Vehicle Identification
CDOT	Colorado Department of Transportation
CVSA	Commercial Vehicle Safety Alliance
F	Degrees Fahrenheit
FHWA	Federal Highway Administration
IRISystem	Infrared Inspection System
ITS	Intelligent Traffic Systems
MDT	Mountain Daylight Time
MP	Milepost
Mph	Miles per Hour
OOA	Out of Adjustment
OOS	Out of Service
PBBT	Performance-Based Brake Testing
POE	Port of Entry
WB50	50-foot Wheelbase
WIM	Weigh-in-Motion

1.0 INTRODUCTION

1.1 Background

1.1.1 Brake Systems

In slowing or stopping a vehicle, brakes convert kinetic energy into thermal energy. Truck brakes create a great amount of heat during use. The amount of heat produced can be greatly reduced through proper use of engine compression or 'Jake brakes' to slow the vehicle, and by controlling truck speed to increase stopping distances. Brakes that are not adjusted properly or heavy loads can result in drum temperatures of 800-1000 degrees Fahrenheit (F). (1) Brake linings that have reached a certain temperature, dependent on the lining materials and conditions, will begin to smoke and may eventually catch on fire. Not only is this condition dangerous due to the potential for brake failure, the adjacent tire may explode due to the high temperatures and close proximity of the flame. This presents a hazard for the driver, the port of entry (POE) inspectors, and others who may be in the vicinity of the tire when such an explosion occurs.

In addition, as brake linings heat up, their coefficient of friction will decrease. This can result in 'slick' brake linings above a certain temperature. This is known as brake fade. The effect of temperature on brake lining friction varies based on the quality of the lining material. While higher-quality linings will typically maintain their original coefficient of friction (near 0.4) to 500 F, it begins to deteriorate as temperatures continue to increase. Inferior linings begin to experience a nearly linear drop in their coefficients of friction starting at 200 F. (1)

The heat generated by excessive brake use also affects the drums. The brake drum will expand as the temperature rises, increasing approximately 0.01 inch in diameter per 100 degree Fahrenheit rise in temperature. (1) At 600 F the drum diameter will be 0.055 inch larger than at 50 F. This will typically increase the pushrod stroke by 0.40 inch. (1) If the brakes are not adjusted properly, the shoes may not fully engage the drums or may not make contact at all. This increases the stopping distance and may create a runaway truck hazard on long downhill grades. This risk, coupled with the potential for brake fade, underlines the dangers associated with high brake temperatures.

1.1.2 Port of Entry Automation

As part of a statewide electronic screening program focused on commercial vehicles, the Colorado Department of Transportation (CDOT) has automated nearly all-existing commercial vehicle POEs along interstate and non-interstate highways in Colorado. These ports have Automated Vehicle Identification (AVI) and Weigh-in-Motion (WIM) technologies that allow properly credentialed commercial vehicles to bypass the respective POE facility provided that their vehicles are within legal weight limitations. Qualified PrePass carriers are eligible to bypass the automated port facilities.

PrePass carriers must possess a satisfactory safety rating. This safety rating is determined from a number of carrier and/or truck inspections with results compiled by the Federal Motor Carrier Safety Administration’s (FMCSA) Safety and Fitness Electronic Records (SAFER). If a carrier’s safety rating becomes unsatisfactory, that carrier is removed from the PrePass system. A removed carrier may reapply to PrePass after its rating becomes satisfactory. Since PrePass vehicles must adhere to stricter safety standards, keeping PrePass vehicles on the highway will allow safety inspectors to concentrate on more unsafe carriers.

The rationale for POE automation is that it benefits the trucking industry as well as the traveling public. POE automation allows motor carriers to promote safer operations as well as reduce delivery costs and increase profit margins – primarily by saving time, reducing fuel consumption, and reducing vehicular wear and tear. Similarly, these projects benefit Colorado by:

- Reducing safety hazards of vehicles exiting and re-entering the highway;
- Lowering the potential for accidents and breakdowns immediately outside port facilities;
- Improving the throughput of weigh and inspection stations, allowing agency operations to be streamlined;
- Reducing vehicle emission and noise levels;
- Allowing enforcement personnel to focus on unsafe and illegal carriers; and
- Promoting economic vitality through enhanced motor carrier operations.

Ports within Colorado that are currently automated include I-70 at Limon (AVI/WIM westbound, AVI eastbound), I-70 at Dumont (AVI/WIM westbound) (AVI/WIM eastbound currently being automated), I-70 at Loma (AVI/WIM eastbound, AVI westbound), I-25 at Fort Collins (AVI/WIM both directions), I-25 at Monument (AVI/WIM both directions), I-25 at Trinidad (AVI/WIM northbound), I-76 at Fort Morgan (AVI/WIM westbound, AVI eastbound), US-287 at Lamar (AVI/WIM northbound, AVI southbound), and US-160 at Cortez (AVI both directions). The eastbound I-70 POE at Dumont is currently being automated to include AVI and WIM technologies. This automation was proposed due to the heavy traffic congestion in the area, and will increase effective throughput as large numbers of commercial vehicles will not be exiting and entering the traffic flow. There are times when the volume of trucks overwhelms the facility, and the POE must be closed to clear the truck traffic. However, there is also a concern that automation of the Dumont POE without the ability to detect hot or smoking brakes might allow a greater number of trucks with overheated brakes to bypass the port and may result in increased instances of truck brake failure downstream of the port.

1.1.3 Previous Research

A 1999 study by the Federal Highway Administration's (FHWA) Office of Motor Carriers compared various performance-based brake testing (PBBT) technologies to conventional Commercial Vehicle Safety Alliance (CVSA) truck inspection procedures and pass-fail criteria. (2) Ten states participated in the study and 2,865 trucks were inspected. Roller dynamometers, flat plate testers, and breakaway torque testers were tested at various sites for at least one year in the field. Infrared brake drum temperature measurement and an on-board decelerometer were tested less extensively. Brakes detected by the PBBT and CVSA Level 4 inspections as weak or defective were in agreement for 53 to 88 percent of the brakes, with variations depending on the test location and the PBBT used. Between 19.5 and 39.2 percent of the 2,865 trucks tested were placed out of service (OOS) by the PBBT criteria, varying by the PBBT used, compared to 13.8 percent placed OOS by the CVSA inspections. Researchers using the infrared brake temperature measurement PBBT found a wide range of brake drum temperatures for brakes that appeared to be working properly. This led to their conclusion that the usefulness of the brake temperature PBBT was limited to detecting inoperative brakes or brakes that were severely out of adjustment.

A Federal Motor Carrier Safety Administration study performed in 2000 evaluated the ability of an infrared brake screening technology to screen trucks for brake problems. (3) The Infrared Inspection System (IRISystem) uses infrared cameras housed in mobile vans. The infrared cameras create an image depicting the relative temperatures of the wheels on selected vehicles. This system is generally used with truck speeds under 10 miles per hour (mph), though experienced operators can screen vehicles moving at speeds up to 35-40 mph. Screening was based on the IRISystem operator's judgment (visual determination) that individual wheels or brakes were significantly hotter or colder than the other wheels or brakes on the vehicle. This evaluation involved four states over a one-year period.

Of the wheels screened during the study, 11 percent were 'cold' and one percent was excessively hot (as determined by the inspector). The most common cause for the hot wheels witnessed in this study was a flat tire. Of the wheels identified by the IRISystem as cold, 76 percent were found to have a brake-related defect in subsequent Level 1 inspections. Of the vehicles identified as having hot or cold brakes by the IRISystem, 59 percent were placed OOS in a Level 1 inspection and 79 percent of these OOS vehicles had brake violations. Screening effectiveness standards for Kentucky, the only state mentioned to have such standards, require that at least 50 percent of the vehicles screened as problematic by the IRISystem must be confirmed as defective by Level 1 inspections. The IRISystem met this standard in each of the four states that took part in this study. It was noted that wheel covers on nearside wheels obstructed the IRISystem camera's view of the brake components. If the system only monitors trucks from one side, brake violations on nearside wheels may be difficult to detect. A majority of the problematic brakes identified by the system were located on the far-side wheels. Wheels that were unobservable to the operator were assumed to be normal.

1.1.4 Safety

During the five-year period from 1998 to 2003, there were 98 accidents where large trucks were at fault on eastbound I-70 between MP 231.89 and MP 258.72. These accidents resulted in 64 injuries and six fatalities. The most common type of accident was a rear end collision (21 crashes), followed by truck overturning (18 crashes), and same-direction sideswiping (15 crashes). Eighty crashes took place at non-intersection segments of the interstate and 17 crashes were associated with interchange areas. A majority of the accidents occurred during daylight hours (67 crashes) and most (72 crashes) had no associated inclement weather conditions. Road conditions were dry for 67 of the crashes. No apparent contributing factor was found for 83 of the crashes. Detailed accident data are included in **Appendix A**.

Although data on runaway truck ramp use were not available for this section of I-70, the two runaway truck ramps on westbound I-70 just west of the Eisenhower Tunnel were used a total of 106 times over the five-year period from 1995-1999, a rate of nearly twice per month. (4)

1.2 Study Objectives

The I-70 eastbound POE at Dumont is currently being automated with AVI/WIM technologies. Both the trucking industry and PrePass – the automated bypass vendor – will benefit from the automation of this facility. When implemented, CDOT estimates 25 to 35 percent of the trucks traveling on eastbound I-70 may initially bypass the port. This might result in between approximately 5,000 to 7,000 trucks each month (gradually increasing over time) bypassing the POE without the possible added safety benefit of a brake check. Automation of the Dumont POE without the ability to detect hot or smoking brakes may allow some trucks with overheated brakes to bypass the port and may result in increased instances of truck brake failure downstream of the port. The 6 percent downgrade from Genesee to Morrison downstream from the port adds additional concern, as it is a roadway segment that has experienced numerous truck-related accidents throughout the years.

CDOT would like to have an automated mechanism in place to allow for identification of trucks with hot and/or defective brakes. Currently the POE Officers use two methods to detect defective brakes. The first method identifies trucks that have visibly smoking brakes. These trucks are normally pulled to the side of the parking area to allow the brakes to cool and for any necessary adjustments to be made. The other method is a random safety inspection. There may be instances where nonfunctioning cold brakes or maladjusted non-smoking brakes would go undetected. This study will investigate the use of infrared thermometers to detect the above problems. This may provide a useful tool for POE inspectors to easily detect brake problems before these vehicles proceed through another long downhill grade. Technology does not currently exist to allow mainline brake temperature screening at freeway speeds. If, in the future, automatic brake temperature detection systems become available, this information would provide valuable baseline data for determining brake temperature screening criteria. This will also provide information as to the extent of the problem of overheated brakes. By evaluating the brake temperatures and inspection data of a large number of trucks entering the POE, researchers should be able to determine if there is a verifiable correlation between brake temperature and functionality.

1.3 Scope of Study

The eastbound POE at Dumont is an ideal spot to observe trucks with hot brakes. The downhill grades from the Eisenhower Tunnel and Berthoud Pass are just above this port, and port officers notice trucks with smoking brakes several times daily. The intent of this study is to support CDOT staff in evaluating an Intelligent Traffic Systems (ITS) Operational Test to detect, identify, and measure brake temperatures on trucks operating on eastbound I-70 at the Dumont POE.

The study will consist of three parts. The first portion will gather background brake temperature and axle weight data. That data will then be analyzed by vehicle classification and axle weight groups to determine a normal operating temperature range for the specific truck classification and the incremental weight groups, as appropriate. The second portion of the study will compare measured brake temperatures to brake violation data contained in Level 4 inspection reports in an attempt to correlate brake temperatures with brake functionality. The final test will evaluate the ability of the selected screening criteria to identify hot or malfunctioning brakes in a separate sample of trucks. The results of this study will determine whether or not brake temperature data can be used as a screening tool to identify trucks with potential brake violations at the Dumont POE.

2.0 DESCRIPTION OF STUDY

2.1 Initial Tests

The goal of the initial tests was to get a large data sample of brake drum temperatures. This allowed for a baseline analysis to determine a normal operating temperature range for trucks coming through the eastbound Dumont POE. Brake drum temperatures were measured using a handheld high temperature infrared thermometer manufactured by Extech Instruments. The thermometers had a temperature range of –58 F to +1400 F, with a resolution of 0.1 F and an accuracy of +/- 2 percent at temperatures below 932 F. The thermometers were factory-calibrated. Prior to each testing period, all thermometers were field-tested to ensure that measured temperatures agreed to within 2 F for each thermometer used. Brake drum temperatures were measured from beneath the vehicle. The thermometers were held within two feet of the drum surface, as recommended by the manufacturer.

Tests to measure baseline drum temperatures were conducted over four 4-hour testing periods during April of 2004. Two of these testing periods occurred from 8 am to 12 pm MDT and two testing periods occurred from 12 pm to 4 pm MDT. Ambient temperatures during the baseline tests varied from 40 F to 68 F, representing a typical range of temperatures experienced at this site during this time of year. All tests were performed under dry road conditions. Trucks were selected for testing at random from all five-axle trucks traveling through the POE. Five-axle tractor/trailer combinations were by far the most abundant vehicle class traveling through the port, and thus were chosen for this portion of the study to provide a large sample size of comparable axle configurations. Brake temperatures were measured immediately after the vehicle passed over the POE scales. POE Clearance Reports with truck identification and weight data were printed for each truck studied. Truck identification data and brake drum temperature data were recorded on previously prepared data sheets. Examples of the data sheets used are included as **Appendix B** to this report. For safety reasons and to reduce the amount of time needed to test each truck, two POE inspectors (one inspector worked each side of the vehicle) measured drum temperatures from beneath the vehicles and analysts standing beside the trucks recorded the data. Due to access limitations, the front (steering) axle brake temperatures were not measured. This testing process took less than 5 minutes per truck, including weighing, with most tests lasting approximately 3 minutes. Rapid testing was important to obtain as large a sample population as possible during the testing period and to reduce the amount of time the brakes had to cool down before the temperatures were measured. A total of 163 trucks were tested during the initial data collection periods.

2.2 Secondary Tests

The goal of the secondary tests was to determine if there is a correlation between brake drum temperatures and brake system violations. The data collected during these tests were used to develop screening criteria based on measured brake temperatures. Additional data collection periods were then conducted to evaluate the ability of the selected screening criteria to identify hot or malfunctioning brakes in a separate sample of trucks.

2.2.1 Correlation Tests

Correlation tests were conducted over three 4-hour testing periods, one 8-hour testing period, and one 1-hour testing period (ended due to inclement weather) during May and June of 2004. One 4-hour testing period occurred from 8 am to 12 pm and the other two occurred from 12 pm to 4 pm; the 8-hour testing period occurred from 8 am to 4 pm; and the 1-hour testing period occurred from 12 pm to 1 pm, all times MDT. Ambient temperatures during the correlation tests varied from 47 F to 75 F. To conduct these tests, trucks were selected at random from all 5-axle trucks traveling through the POE. Brake drum temperatures were measured and recorded for each truck selected, as in the initial tests. Each truck then underwent a Level 4 brake inspection, performed by the POE inspectors. The Level 4 inspections included a visual inspection of the brake system, including the air lines, as well as a measurement of brake push rod travel distance to determine brake adjustment. In addition to the POE Clearance Report printout for each truck tested, an Examination Report was prepared documenting the results of the Level 4 inspections. The Examination Reports included a description of any brake violations, as well as an indication of whether the truck was placed OOS due to the violations. As these tests were more involved than those performed during the initial tests, the time required to test each truck increased to an average of almost 24 minutes per truck inspected. A total of 54 trucks were inspected during the correlation tests.

In order to correlate brake temperatures to brake conditions, only violations that would affect current brake performance were considered. Therefore, only violations for out of adjustment (OOA)[6] or inoperative brakes, insufficient brake linings, mechanical brake violations, and significant air leaks (sufficient to put the truck OOS) were included. Chafed brake hoses would not affect current brake performance or temperature but may affect future brake performance if a leak develops. Likewise, a minor air leak (not sufficient to put the truck OOS) is not likely to cause a measurable change in current brake performance.

The data from the correlation tests were analyzed to determine the most effective temperature screening criteria for brake violations. This was performed using a spreadsheet that included all recorded brake temperature, axle weight groups, and brake violation data from the correlation tests. The spreadsheet was set up to allow various temperature criteria (high and low) to be set, based on axle weight groupings, facilitating a rapid analysis to determine the most effective screening parameters as related to the brake violation data for each truck. The screening criteria effectiveness of the selected parameters was evaluated based on percent correct, percent false positives (brakes selected as outside the temperature criteria that had no corresponding violations), and percent false negatives (brake violations that were not caught by the screening criteria). . Minimization of false positives and false negatives was important to reduce the number of trucks with brake violations that were not caught, and to reduce unnecessary inspections for trucks with normal brakes, respectively.

2.2.2 Effectiveness of Screening Criteria

Using the information from the correlation analysis, a final 4-hour test was performed in June of 2004 to test the effectiveness of the brake temperature screening criteria. This test occurred from 8 am to 12 pm MDT, with the ambient temperature varying from 65 F to 70 F. For this test, five-axle trucks entering the POE were selected at random and their brake drum temperatures were measured as in the previous tests. For each truck tested, a POE Clearance Report detailing the vehicle weight data was produced. Trucks with one or more brake drums having a temperature outside of the predetermined screening limits then underwent a Level 4 brake inspection to

[6] Per CVSA standards, brakes were considered OOA if pushrod travel exceeded two inches.

determine whether or not any of their brakes were in violation. Trucks with all brake drum temperatures within the screening limits were not evaluated further. For each truck inspected, a copy of the Vehicle Examination Report was attached to the Clearance Report for further analysis. A total of 18 trucks were tested for this analysis.

Tables A – C below show the traffic volumes and number of trucks traveling on eastbound I-70 near the Dumont POE during the various study periods. The traffic volumes were collected during the study periods by continuous traffic counters located on I-70 at MP 242.2 (just east of Idaho Springs), which was the closest traffic count location available. Estimated truck volumes were computed using data collected for eastbound I-70 at the Eisenhower Tunnel during the study periods, which was the closest vehicle classification site available. The truck percentages were computed based on the number of Class 9 vehicles and above (vehicles with wheelbase greater than 50 feet long) recorded during the study period divided by the total vehicle count during the same time period. This group includes five-axle single trailers and larger vehicles. The truck percentage value obtained from the Eisenhower Tunnel data was then multiplied by the total traffic volume recorded at MP 242.2 to produce the estimated total number of trucks traveling through the Dumont POE during the study periods.

Table A. Traffic Counts: Initial Testing Periods – Baseline Data

Date	Test Period	Total Vehicle Count	% Trucks (>WB50[1])	Estimated Truck Volume During Testing
4/13/2004	12 pm – 4 pm	4804	8.26	397
4/15/2004	8 am – 12 pm	3617	9.76	353
4/20/2004	8 am – 12 pm	3532	8.30	293
4/28/2004	12 pm – 4 pm	4371	9.92	434
Total				1477

[1]: WB50 refers to trucks with a wheelbase length of 50 feet.
Source: CDOT Traffic Analysis

Table B. Traffic Counts: Secondary Testing Periods – Correlation Data

Date	Test Period	Total Vehicle Count	% Trucks (>WB50)	Estimated Truck Volume During Testing
5/19/2004	8 am – 12 pm	3618	11.89	430
5/25/2004	12 pm – 4 pm	4309	9.40	405
6/11/2004	8 am – 4 pm	11306	6.94	785
6/16/2004	12 pm – 1 pm	1202	10.31	124
6/22/2004	12 pm – 4 pm	5347	7.99	427
Total				2171

Source: CDOT Traffic Analysis

Table C. Traffic Counts: Effectiveness of Screening Criteria Test

Date	Test Period	Total Vehicle Count	% Trucks (>WB50)	Estimated Truck Volume During Testing
6/29/2004	8am – 12 pm	4442	7.35	326
Total				326

Source: CDOT Traffic Analysis

Table D shows the sample sizes obtained for the various phases of testing, as a percentage of the total estimated truck volume passing through the Dumont POE during the testing periods. Of the 235 trucks tested for this study, 105 (45%) were identified as PrePass vehicles.

Table D. Testing Period Sample Sizes

Testing Phase	Estimated Truck Volume During Testing	Number of Trucks Tested	% of Truck Volume Tested	Number of PrePass Tested	PrePass % of Sample
Initial Tests	1477	163	11.04	70	43%
Secondary Tests – Correlation Tests	2171	54	2.49	24	43%
Screening Criteria Test	326	18	5.52	11	61%

3.0 STUDY RESULTS

3.1 Initial Tests

The initial tests resulted in a wide range of normal "baseline" brake operating temperatures for trucks of various weights. The results of the initial tests are displayed in **Figure 1**, with the brake drum temperatures plotted as a function of the combined weights of each set of axles - axles 2 and 3 (drive axles) and axles four and five (trailer axles). The combined axle weights were taken from the POE Clearance Reports printed for each truck that was tested. Though there was a definite trend toward higher average temperatures as axle weight increased, temperatures varied widely within each axle weight group. The temperatures measured for the driver's side and the passenger's side brake drums were remarkably similar overall, with averages of 245 F and 246 F, respectively. A total of 163 trucks were analyzed during the initial tests.

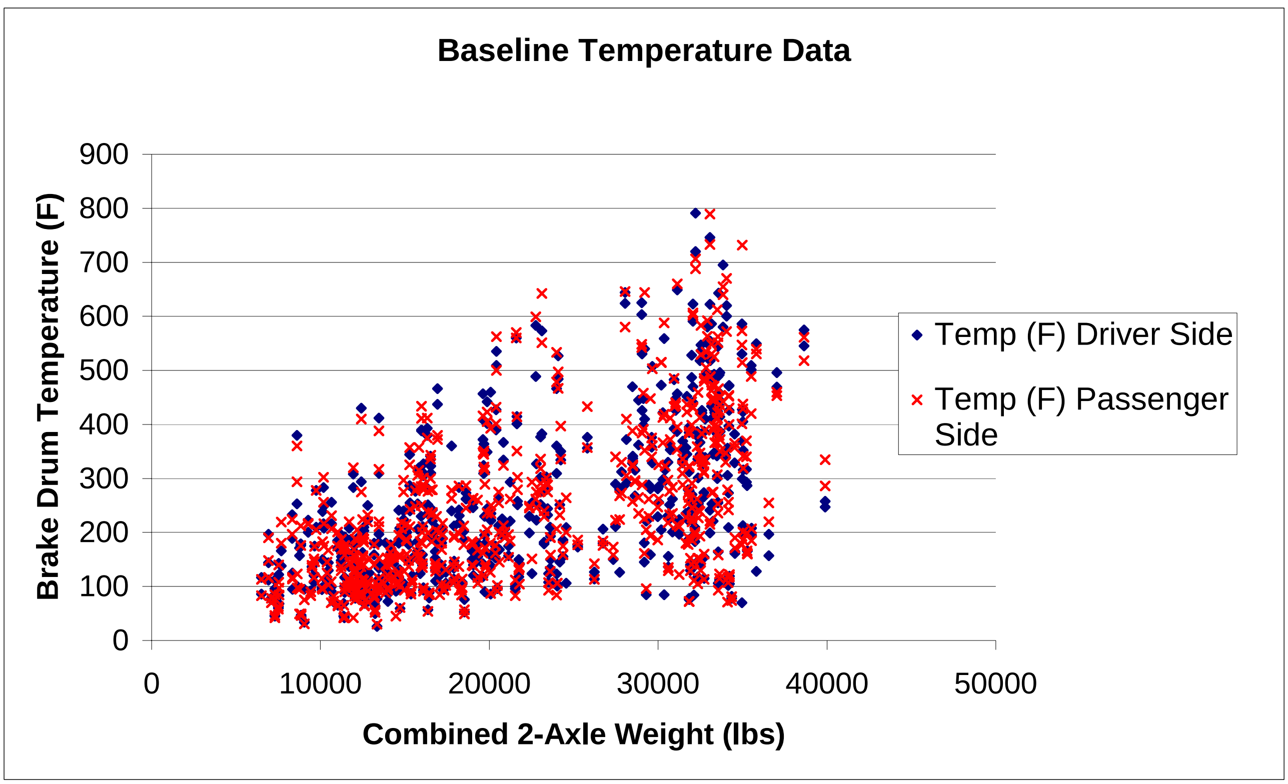


Figure 1. Baseline Temperature Data

A summary of the temperature data for each weight group is presented in **Table E** for the drive axles, and the data for the trailer axles is summarized in **Table F**. For comparison, average temperatures and the 95-percent confidence limits for the population average (high and low) are given for each weight group. The confidence limits for the population average were determined based on the sample size using a two-sided statistical t-test. As mentioned above, average temperatures tended to increase with axle weight. This is to be expected, as increased vehicle weight requires the brakes to work harder to bring the vehicle to a stop from a given speed, resulting in a greater amount of thermal energy produced for a heavier truck than for a lighter truck. An exception to this trend was seen in the trailer axles, with the average temperature of the 30,000 – 35,000 pound weight group (351 F) exceeding the average temperature of the 35,000 – 40,000 pound weight group (340 F). There was also a broad overlap in the range of temperatures measured among different weight groups. The wide variation in brake temperatures within individual weight groups makes it difficult to specify absolute temperature limits for normal operation. Factors such as distance traveled prior to temperature measurement, use of engine compression to slow the truck (‘Jake’ brakes), and a driver’s experience with steep grades can often influence brake temperatures to a greater extent than vehicle weight or brake performance. In addition, the temperature of inoperative (cold) brakes is more likely to be influenced by ambient temperatures than by vehicle weight.

Table E. Drive Axle Temperature Summary

Combined - Axles 2&3 (Drive Axles)				
Combined Axle Weight Range	**Average Temp (F)**	**Std Dev (F)**	**2-Sided 95% Confidence Limits for Population (F)**	
			Low	**High**
0-15000 lbs	111	41	97	125
15000-20000 lbs	191	98	159	223
20000-25000 lbs	244	131	189	299
25000-30000 lbs	315	153	218	412
30000-35000 lbs	346	156	302	390

Table F. Trailer Axle Temperature Summary

Combined - Axles 4&5 (Trailer Axles)				
Combined Axle Weight Range	Average Temp (F)	Std Dev (F)	2-Sided 95% Confidence Limits for Population (F)	
			Low	High
0-15000 lbs	155	75	135	175
15000-20000 lbs	240	85	204	276
20000-25000 lbs	285	141	213	357
25000-30000 lbs	315	125	239	391
30000-35000 lbs	351	161	298	404
35000-40000 lbs	340	138	252	428

3.2 Secondary Tests

3.2.1 Correlation Tests

The first phase of the secondary tests investigated whether or not there was a correlation between brake drum temperatures and brake violations, as determined by a Level 4 brake inspection. The results of the 54 brake inspections performed for these tests, and the associated brake drum temperatures for these trucks, were entered into a spreadsheet. These data were used to analyze the ability of various temperature screening criteria to identify brakes with violations. A screening criteria assessment was developed by comparing trucks selected for 'screening' (using temperature thresholds) in conjunction with trucks that actually exhibited a brake violation in the Level 4 inspection. As mentioned previously, only violations for OOA or inoperative brakes, insufficient brake linings, mechanical brake violations, and significant air leaks (sufficient to put the truck OOS) were considered, as these were the types of violations that would have a measurable affect on brake performance at the time of the study. Of the 54 trucks selected at random for this test, 19 trucks (35 percent) had one or more of the above brake violations and 9 trucks (17 percent) were placed OOS. The screening criteria was assessed based on the percentage of the trucks that were correctly screened or correctly not screened (% Correct), the percentage that were screened but had no brake violation (% False Positive), and the percentage that were not screened but had a brake violation (% False Negative). **Table G** and **Figure 2** show the screening assessment results for all temperature screening criteria studied.

Table G. Screening Criteria Assessment

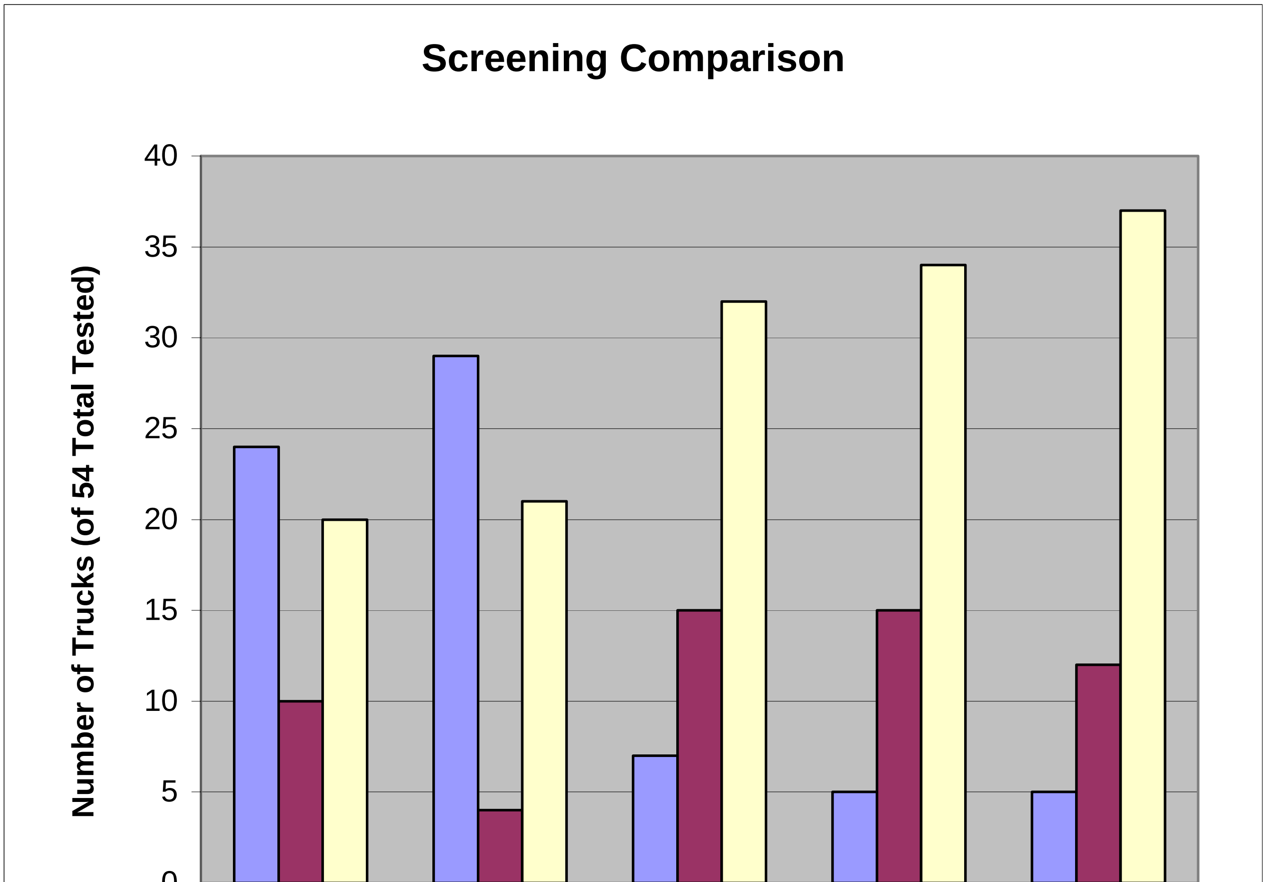
Screening Criteria	# Trucks Screened	# Placed OOS	% False Positives[1]	% False Negatives[2]	% Correct[3]	% of Screened Trucks with Violations[4]
Screen Using +/- One Standard Deviation, by Weight Group:	33	5	44%	19%	37%	27%
Screen Using Quartiles, by Weight Group:	44	8	54%	7%	39%	34%
Screen Using 500 F Max/<45% of Remaining Average:	11	1	13%	28%	59%	36%
Screen Using 500 F Max/<37% of Remaining Average:	9	1	9%	28%	63%	44%
Screen Using 500 F Max/>101 F Below the Average:	12	4	9%	22%	69%	58%

[1] False Positives are those trucks outside the screening thresholds that have no brake violations.

[2] False Negatives are those trucks within the screening thresholds that did have brake violations.

[3] % Correct includes trucks correctly screened and correctly not screened.

[4] % Screened with Violations is the percentage of the screened trucks that had brake violations.



	Screen Using +/- One Standard Deviation, by Weight Class:	Screen Using Quartiles, by Weight Class:	Screen Using 500 F Max/<45% of Remaining Average:	Screen Using 500 F Max/<37% of Remaining Average:	Screen Using 500 F Max/>101 F Less Than Average:
False Positives	24	29	7	5	5
False Negatives	10	4	15	15	12
Correct	20	21	32	34	37

Figure 2. Screening Comparison

Screen Using Plus or Minus One Standard Deviation, by Weight Group:

The first temperature screening criteria to be tested used one standard deviation difference above and below the average temperature for each axle weight grouping, as listed in **Tables H** and **I**. Any truck with one or more brake drums with a temperature that was outside of the temperature range for the given axle weight grouping was selected as 'screened'. The classification for each truck as either screened or not screened was then compared to the actual brake violation data from the truck's inspection report. The plus or minus one standard deviation screening criteria produced poor results, as shown in **Figure 2** and **Table G**. A total of 44 trucks were screened (81 percent of all trucks tested). Of the screened trucks, 27 percent had brake violations. The

Table H. Drive Axle Temperature Summary – Standard Deviation Range

Combined - Axles 2&3 (Drive Axles)				
Combined Axle Weight Range	Average Temp (F)	Std Dev (F)	1 Std Dev Range (F)	
			Low	High
0-15000 lbs	111	41	70	152
15000-20000 lbs	191	98	93	289
20000-25000 lbs	244	131	113	375
25000-30000 lbs	315	153	162	468
30000-35000 lbs	346	156	190	502

Table I. Trailer Axle Temperature Summary – Standard Deviation Range

Combined - Axles 4&5 (Trailer Axles)				
Combined Axle Weight Range	Average Temp (F)	Std Dev (F)	1 Std Dev Range (F)	
			Low	High
0-15000 lbs	155	75	80	230
15000-20000 lbs	240	85	155	325
20000-25000 lbs	285	141	144	426
25000-30000 lbs	315	125	190	440
30000-35000 lbs	351	161	190	512
35000-40000 lbs	340	138	202	478

false positives, at 44 percent, were greater than the number of trucks being correctly assessed (37 percent).

Screen Using the First and Third Quartiles, by Weight Group:

The next temperature range tested against the previously recorded truck data using the 1st quartile (lower limit) and 3rd quartile (upper limit) temperatures for each axle weight grouping, as listed in **Tables J** and **K**. A total of 33 trucks were screened (61 percent of the trucks tested). Of the screened trucks, 34 percent had brake violations. As shown in **Figure 2** and **Table G** this range produced a slightly higher correct percentage (39 percent) than the standard deviation range, but had a higher false positive percentage (54 percent). A very low false negative percentage (7 percent) was produced, which is expected given the high number of trucks that were incorrectly screened (false positives).

Table J. Drive Axles (2 & 3) Temperature Summary with Quartiles

Combined Axle Weight Range	Average Temp (F)	Quartile Range (F)	
		1st	3rd
0-15000 lbs	111	85	137
15000-20000 lbs	191	117	245
20000-25000 lbs	244	152	281
25000-30000 lbs	315	192	376
30000-35000 lbs	346	230	437

Table K. Trailer Axles (4 & 5) Temperature Summary with Quartiles

Combined Axle Weight Range	Average Temp (F)	Quartile Range (F)	
		1st	3rd
0-15000 lbs	155	98	196
15000-20000 lbs	240	178	300
20000-25000 lbs	285	182	391
25000-30000 lbs	315	227	386
30000-35000 lbs	351	225	471
35000-40000 lbs	340	206	462

Screen Using 500 F Max/Less Than 45% of Average for Remaining Brakes:

Based on the first two temperature screening assessments, it was concluded that screening criteria based on weight groups would not produce adequate results due to the high temperature variation within weight groupings and the large overlap in temperature ranges between weight groupings. Therefore, alternative temperature screening criteria were developed in an attempt to better correlate measured brake drum temperatures with brake inspection data. Based on a visual inspection of the baseline data gathered during the initial tests, the bulk of measured brake drum temperatures for all weight groups were below 500 F. A statistical analysis of the data confirms this assumption, as the highest standard deviation-based upper limit is 512 F and the highest 3^{rd} quartile-based upper limit is 471 F. In addition, even high-quality brake linings begin to see a general reduction in their coefficient of friction when the drum temperature exceeds 500 F. (1) Based on the baseline tests and a review of available brake material information, it was determined that setting an upper temperature limit of 500 F for all brake drums was reasonable. This would allow inspectors to identify all trucks coming through the POE with potentially dangerous overheated brakes.

In order to screen out those brakes that were non-functioning or 'cold', several different lower-limit criteria were developed and tested. The first to be tested was based on a previous FHWA study that found brake defects were likely when the lowest drum temperature was below 45 percent (based on the Fahrenheit scale) of the average drum temperature for the remaining brakes on the truck. (2) This threshold would screen out any brake that is operating at a significantly lower temperature than the remaining brakes. A relative low-temperature threshold should result in identifying those brakes that are severely out of adjustment or non-functioning without producing as many false positives as the previous criteria tested.

Using the low temperature threshold of 45 percent of the average temperature for the remaining brakes, and the upper temperature threshold of 500 F, produced much better results than the previous screening criteria, as shown in **Figure 2 and Table G**. Of the 54 trucks tested, 11 were screened (20 percent) with increased accuracy (59 percent correctly assessed) and very few false positives (13 percent). Of the screened trucks, 36 percent had brake violations. There were a greater number of false negatives using these criteria than in the previous tests, with 15 trucks (28 percent) with brake violations not having been screened.

Screen Using 500 F Max/Less Than 37% of Average for Remaining Brakes:
For the next analysis, the 45 percent difference lower threshold was replaced with various other percent differences in an effort to determine the best low-temperature screening criteria based on our data set. The best correlation with the study data was achieved using a lower temperature threshold of 37 percent of the average temperature of the remaining brakes. The upper temperature threshold of 500 F was retained. As seen in **Figure 2** and **Table G**, this resulted in a slightly more accurate (63 percent correct) screen, with less false positives (9 percent) and an equal amount of false negatives (28 percent) as the previous screen. Only 9 trucks (17 percent) were screened using this method. Of the screened trucks, 44 percent had brake violations.

Screen Using 500 F Max/Greater Than 101 F Below the Average:
The final correlation analysis evaluated a low-temperature screening threshold based on an absolute difference between the average brake drum temperature for the truck and the truck's lowest brake drum temperature. Using this method, the temperature difference does not vary

according to the overall average brake temperature for the truck as it did in the previous two analyses that used a percentage of the average. As in the previous two evaluations, an upper temperature threshold of 500 F was used. A low temperature threshold of greater than 101 F below the average for the truck produced the best correlation with the study data of any of the screening criteria evaluated. As shown in **Figure 2** and **Table G**, these criteria resulted in 12 trucks being screened. This was the most accurate screen yet, with 69 percent of the trucks being correctly assessed for brake violations or the lack thereof. The false positives were the same as for the previous set of screening criteria analyzed (9 percent), and the false negatives improved to 22 percent of the total number of trucks tested. Of the screened trucks, 58 percent had brake violations and 33 percent were placed OOS due to these violations.

Using the set 101 F temperature difference from the mean results in a temperature range that becomes more sensitive, relative to the average temperature, as the average temperature increases. For example, given an average brake temperature of 400 F for a truck, using a lower limit of 37 percent of the average results in a low temperature threshold of 148 F, which is 252 F lower than the average. A temperature threshold of 101 F below the average is more sensitive and would detect more out of adjustment brakes before they become inoperable. Based on this analysis, using the 101 F–below–the average threshold improved the screening accuracy and did not cause an increase in the number of false positives. This would result in more efficient use of POE resources.

3.2.2 Effectiveness of Screening Criteria

The final test demonstrated the ability of the most effective temperature screening criteria from the correlation tests to screen a new sample of trucks for brake violations. As mentioned above, a low-temperature threshold of greater than 101 F below the average brake temperature for the truck and a high-temperature threshold of 500 F resulted in the best correlation with the brake inspection data from the 54 previously tested trucks. Therefore, those parameters were used to select trucks to undergo a Level 4 inspection out of a random sample of all five-axle trucks passing through the Dumont POE during a 4-hour test period.

A total of 18 trucks were randomly selected for brake temperature measurement during the test period. Of this sample, 5 trucks had one or more brake temperature(s) that was greater than 101 F below the average brake temperature for the truck. Three of these trucks, and one additional truck, had at least one brake temperature above 500 F, resulting in a total of 6 trucks being outside of the screening limits. Four of these trucks were PrePass vehicles. Of the 6 trucks screened to undergo a Level 4 inspection, 4 (67 percent) were found to have brake violations, including 3 of the PrePass trucks. Two of these, both PrePass trucks, were placed OOS for brake violations. The results of this test are summarized in **Tables L** and **M**.

Table L. Summary of Screening Test Results

Screening Criteria Test				
# Trucks Sampled	**# Trucks Screened**	**% False Positives**	**% Screened With Brake Violations**	**% Screened Placed OOS**
18	6	33%	67%	33%

Table M. Screened Truck Information

Truck #	Axle #	Driver Side Temp. (F)	Passenger Side Temp. (F)	Brake Violations	Out of Service?	PrePass Truck?
2	2	513	504	-	No	No
	3	498	464	-		
	4	564	631	Passenger brake OOA		
	5	657	632	-		
3	2	670	546	Passenger brake OOA	Yes	Yes
	3	706	595	Passenger brake OOA; brake pod loose		
	4	56	400	Both brakes OOA		
	5	523	478	Both brakes OOA		
6	2	484	387	-	No	No
	3	248	436	-		
	4	330	331	-		
	5	363	350	-		
9	2	546	503	-	No	Yes
	3	577	544	-		
	4	553	563	-		
	5	430	542	-		
11	2	145	260	Both brakes OOA; Driver brake inadequate lining; oil soaked	Yes	Yes
	3	145	338	Both brakes OOA		
	4	203	223	-		
	5	345	357	-		
18	2	311	425	Passenger brake inadequate lining; crack in shoe	No	Yes
	3	440	431	-		
	4	468	471	-		
	5	549	502	-		

4.0 CONCLUSIONS AND RECOMMENDATIONS

The results of this study indicate that using brake temperature as a screening tool can effectively identify trucks with brake violations. Though the initial baseline tests showed a wide variation in brake temperatures across all weight ranges, screening criteria were developed as best-fit parameters using brake temperature and inspection data obtained at the Dumont POE. A low-temperature threshold of greater than 101 F below the average brake temperature for the truck and a high-temperature threshold of 500 F resulted in the best correlation with the brake temperature and inspection data. These screening criteria resulted in a brake violation rate of 58 percent for the trucks selected by the screen for inspection. This is significantly higher than the 35 percent brake violation rate for the entire 54-truck test sample. In addition, the percentage of screened trucks that were placed OOS (33.33 percent) was twice as high as the percentage of the total sample placed OOS (16.67 percent). These results were confirmed by an additional field test of the screening criteria, in which 67 percent of the screened trucks were found to have brake violations and 33 percent of the screened trucks were placed OOS.

If POE inspectors had the ability to screen trucks for inspection based on brake temperatures, a larger percentage of inspected trucks would be found to have brake violations. This would result in a more effective and efficient use of inspectors' time and POE resources, as it would allow inspectors to sort out vehicles that have potentially hot brakes. It would also allow a greater percentage of trucks with brakes in good condition to avoid the delay and inconvenience of an inspection. If the technology becomes available to install this screening system within the travel lanes similar to a Weigh-in-Motion system, the potential for accidents will also decrease, as brake temperature screening could be accomplished without the need for trucks to exit and enter the interstate.

The relatively high number of rear end collisions and trucks overturning described in the accident report for this section of I-70 indicate that several trucks were unable to control their speed or stop when necessary. This could be the result of decreased brake effectiveness due to brake fade or drum expansion caused by increased brake temperatures. The brake temperature screening criteria would be particularly useful in identifying potentially dangerous overheated brakes before they reach the point of failure. The selected high-temperature threshold identifies all trucks with brake temperatures above 500 F, based on the baseline temperature data from this study and brake fade information for various brake lining materials. This method of directly identifying hot brakes is more effective than the current practice of identifying only those hot brakes that are visibly smoking. The amount of smoke produced from a hot brake varies greatly based on lining materials and the amount of oil and other debris on or around the brake. As a result, a brake that is close to catching on fire or running out of push rod travel due to drum expansion may be allowed to return to the interstate immediately after it is weighed if the inspector does not detect any smoke. This could be especially dangerous at a location like the Dumont POE, as there is a long and steep descent downstream of the port location.

The results of this study are limited in that all tests were performed at a single POE location, following a long downhill grade. Future studies may not have comparable results if they are performed at locations preceded by more gradual road grades. A certain amount of brake use is needed to establish the temperature differential required to exceed the screening criteria for OOA or non-functioning brakes. Without the need for greater-than-normal brake usage, brakes that are out of adjustment or in otherwise poor condition may go undetected by brake temperature screening. The results of this study could be applied to other locations preceded by similarly steep downhill grades.

RECOMMENDATIONS

Based on the results of this study, it is recommended that a brake temperature screening system be used at the eastbound Dumont POE to identify trucks with potentially OOA or otherwise defective or hot brakes. Preferably, the screening equipment would be installed within the travel lanes of I-70 prior to the POE location so that PrePass trucks with normal brakes could bypass the port altogether. All trucks with one or more brakes identified by the screen as potentially defective or hot should then be subjected to a minimum inspection to determine whether or not they should be allowed to continue on the steep downhill grade east of the port. Current technology, however, is not at the point where mainline screening is feasible. Screening inside the POE, on the other hand, is possible with a low speed system. This would target most commercial vehicles and PrePass vehicles pulled in for random checks. The temperature screen alone would be difficult to use for enforcement of brake violations due to the great temperature variability seen in normally functioning brakes. The screen is better suited for use as a tool for further inspection.

To meet the temperature screening standards developed in this study, the selected screening equipment should be capable of measuring the absolute temperature of the brake drums with reasonable accuracy. In addition, an automated system will need to compute the average brake drum temperature for the truck, identify the coolest brake drum temperature, and determine the difference between the two values. The system will then identify for inspection any truck where this difference exceeds 101 F, or any truck with a brake drum temperature that exceeds 500 F. Ideally, these parameters could be adjusted as needed by POE inspectors if experience shows that different upper or lower temperature thresholds are more effective at identifying trucks with brake violations.

After implementation of the screening system, a review should be conducted periodically to determine the continuing effectiveness of the system in identifying those trucks with potential brake violations, and if an adjustment in the screening criteria is warranted. This evaluation can easily be accomplished by comparing inspection data using the screening system to inspection data prior to the screening system. The screening system should result in more brake violations being identified by the inspectors, and fewer trucks with good brake systems being subjected to an inspection.

While the screening criteria developed in this study would help identify trucks with brake violations, it has not been shown to identify any of the many other safety violations that POE inspectors look for during a full Level 1 inspection. Though poor brake conditions may often indicate poor conditions of other truck components, POE should continue to use their comprehensive inspection program to identify other vehicle/driver safety violations that are not brake-related.

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APPENDIX A: DETAILED ACCIDENT SUMMARY REPORT

Visual FoxPro

Colorado Department of Transportation
Transportation Safety and Traffic Engineering
Detailed Accident Summary Report

04/06/2004

Job #: 20040406160151

Highway: 70A **Begin:** 231.89 **End:** 258.72 **From:** 01/01/1998 **To:** 12/31/2002

Eastbound I-70, at fault large trucks

Severity

PDO:	59	
INJ:	34	64 :Injured
FAT:	5	6 :Killed
Total:	98	

Multi-Vehicle

One Vehicle:	49
Two Vehicles:	38
Three or More:	11
Unknown:	0
Total:	98

Location

On Road:	66	Off in Median:	0
Off Road Left:	16	Unknown:	1
Off Road Right:	15		
Off Road at Tee:	0	**Total:**	98

Accident Type

Overturning:	18	Domestic Animal:	0	Tree:	0
Other Non Collision:	10	Wild Animal:	5	Large Boulder:	0
School Age Peds:	0	Light/Utility Pole:	0	Rocks in Roadway:	0
Other Pedestrians:	0	Traffic Signal Pole:	0	Barricade:	0
Broadside:	1	Sign:	1	Wall/Building:	0
Head On:	0	Bridge Rail:	2	Crash Cushion:	1
Rear End:	21	Guard Rail:	4	Mailbox:	0
Sideswipe (Same):	15	Median Barrier:	5	Other Fixed Object:	3
Sideswipe (Opposite):	0	Bridge Abutment:	0	Involving Other Object:	1
Approach Turn:	0	Column/Pier:	0	Road Maintenance Equipment:	0
Overtaking Turn:	0	Culvert/Headwall:	0	Unknown:	1
Parked Motor Vehicle:	3	Embankment:	2	**Total:**	98
Railway Vehicle:	0	Curb:	0		
Bicycle:	0	Delineator Post:	5	Total Fixed Objects:	23
Motorized Bicycle:	0	Fence:	0	Total Other Objects:	1

Lighting Conditions

Daylight:	67
Dawn or Dusk:	5
Dark - Lighted:	5
Dark - Unlighted:	20
Unknown:	1
Total:	98

Weather Conditions

None:	72	Dust:	0
Rain:	2	Wind:	2
Snow/Sleet/Hail:	19	Unknown:	1
Fog:	2	**Total:**	98

Road Description

At Intersection:	0
At Driveway Access:	0
Intersection Related:	0
Non Intersection Urban:	0
In Alley:	0
Non Intersection Rural:	80
Highway Interchange:	17
Unknown:	1
Total:	98

Road Conditions

Dry:	67
Wet:	11
Muddy:	0
Snowy:	6
Icy:	7
Slushy:	3
Foreign Material:	0
With Road Treatment:	0
Dry w/Icy Road Treatment:	0
Wet w/Icy Road Treatment:	0
Snowy w/Icy Road Treatment:	0
Icy w/Icy Road Treatment:	2
Slushy w/Icy Road Treatment:	0
Unknown:	2
Total:	98

Mainline/Ramps/Frontage Rds

Mainline:	91
Crossroad (Ramp A):	6
Frontage Rd:	1

Ramps

B:	0	H:	0
C:	0	I:	0
D:	0	J:	0
E:	0	K:	0
F:	0	T:	0
G:	0		

Intsx Frontage/Ramps

M:	0	N:	0
O:	0	P:	0

		HOV Lanes:	0
Uknwn:	0	**Total:**	98

Accident Rates

PDO:	0.03 MVMT	Total:	0.05 MVMT
Injury:	0.02 MVMT		
Fatal:	0.24 100 MVMT		

ADT: 43276 **WHI:** -2.50 **Length:** 26.82 **Coris File:** tcoris2003.dbf

Visual FoxPro

Colorado Department of Transportation
Transportation Safety and Traffic Engineering
Detailed Accident Summary Report

04/06/2004

Job #: 20040406160151

Highway: 70A **Begin:**231.89 **End:**258.72 **From:**01/01/1998 **To:**12/31/2002

Eastbound I-70, at fault large trucks

Vehicle Type	Veh 1	Veh 2	Veh 3
Passenger Car/Van:	0	29	8
Passenger Car/Van w/Trl:	0	1	0
Pickup Truck/Utility Van:	0	6	1
Pickup Truck/Utility Van w/Trl:	0	1	0
Truck 10k lbs or Less:	0	0	0
Trucks > 10k lbs/Bus > 15 People:	98	10	1
School Bus < 15 People:	0	0	0
Non School Bus < 15 People:	0	0	0
Motorhome:	0	0	0
Motorcycle:	0	0	0
Bicycle:	0	0	0
Motorized Bicycle:	0	0	0
Farm Equipment:	0	0	0
Hit and Run - Unknown:	0	0	0
Other:	0	1	0
Unknown:	0	1	1
Total:	**98**	**49**	**11**

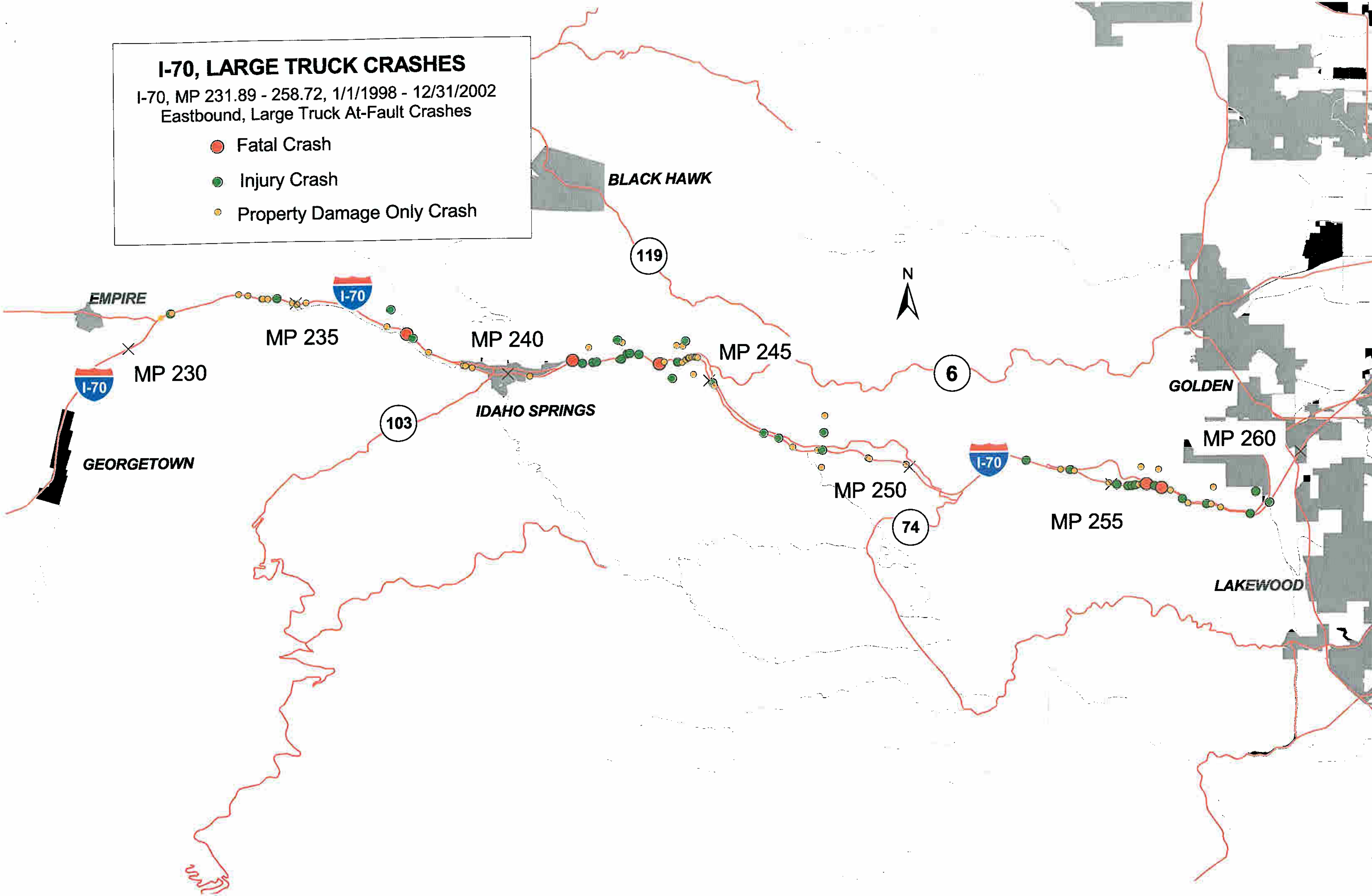
Vehicle Movement	Veh 1	Veh 2	Veh 3
Going Straight:	68	29	4
Slowing:	4	10	3
Stopped in Traffic:	0	3	1
Making Right Turn:	2	1	0
Making Left Turn:	1	0	0
Making U-Turn:	0	0	0
Passing:	2	0	0
Backing:	2	0	0
Enter/Leave Parked Position:	0	0	0
Starting in Traffic:	0	1	0
Parked:	0	3	1
Changing Lanes:	10	0	0
Avoiding Object in Road:	0	0	0
Weaving:	0	0	0
Other:	9	1	1
Unknown:	0	1	1
Total:	**98**	**49**	**11**

Contributing Factor	Veh 1	Veh 2	Veh 3
No Apparent Contributing Factor:	83	46	9
Asleep at the Wheel:	0	0	0
Illness:	0	0	0
Distracted by Passenger:	0	0	0
Driver Inexperience:	4	0	0
Driver Fatigue:	2	0	0
Driver Preoccupied:	1	0	0
Driver Unfamilar with Area:	6	0	0
Driver Emotionally Upset:	0	0	0
Evading Law Enforcement Officier:	0	0	0
Physical Disability:	0	0	0
Unknown:	2	3	2
Total:	**98**	**49**	**11**

Direction	Veh 1	Veh 2	Veh 3
North:	0	2	0
Northeast:	0	0	0
East:	98	41	9
Southeast:	0	0	0
South:	0	0	0
Southwest:	0	0	0
West:	0	5	1
Northwest:	0	0	0
Unknown:	0	1	1
Total:	**98**	**49**	**11**

Condition of Driver	Veh 1	Veh 2	Veh 3
No Impairment Suspected:	92	43	9
Alcohol Involved:	1	1	0
RX Drugs or Medication Involved:	0	0	0
Illegal Drugs Involved:	0	0	0
Alcohol and Drugs Involved:	0	0	0
Driver/Pedestrian not Observed:	5	3	1
Unknown:	0	2	1
Total:	**98**	**49**	**11**

ADT: 43276 **WHI:** -2.50 **Length:** 26.82 **Coris File:** tcoris2003.dbf


I-70, LARGE TRUCK CRASHES
I-70, MP 231.89 - 258.72, 1/1/1998 - 12/31/2002
Eastbound, Large Truck At-Fault Crashes
Fatal Crash
Injury Crash
Property Damage Only Crash
BLACK HAWK
119
N
EMPIRE
I-70
MP 235
MP 240
MP 245
6
MP 230
IDAHO SPRINGS
103
GEORGETOWN
GOLDEN
MP 260
MP 250
74
MP 255
LAKEWOOD

APPENDIX B: SAMPLE DATA SHEETS

Inspection Date ____________________   Inspection Period ____________________
Ambient Temperature ____________________   Sheet ____________________

DOT # ____________________
VIN ____________________
Name on Carrier ____________________

Axle#	Driver Side Temp (^oF)	Passenger Side Temp (^oF)	Inspection Note
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

DOT # ____________________
VIN ____________________
Name on Carrier ____________________

Axle#	Driver Side Temp (^oF)	Passenger Side Temp (^oF)	Inspection Note
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

DOT # ____________________
VIN ____________________
Name on Carrier ____________________

Axle#	Driver Side Temp (^oF)	Passenger Side Temp (^oF)	Inspection Note
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

DOT # ____________________
VIN ____________________
Name on Carrier ____________________

Axle#	Driver Side Temp (^oF)	Passenger Side Temp (^oF)	Inspection Note
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

DOT # ____________________
VIN ____________________
Name on Carrier ____________________

Axle#	Driver Side Temp (^oF)	Passenger Side Temp (^oF)	Inspection Note
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

DOT # ____________________
VIN ____________________
Name on Carrier ____________________

Axle#	Driver Side Temp (^oF)	Passenger Side Temp (^oF)	Inspection Note
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

Analyst ____________________

Inspection Date ________________ Inspection Period ________________
Ambient Temperature ________________ Sheet ________________

#	DOT #	
	VIN	
	Name on Carrier	

Axle#	Driver Side Temp (^oF)	Inspection Note	Passenger Side Temp (^oF)	Inspection Note
1	-------------	--	-------------	--
2				
3				
4				
5				
6				
7				
8				
9				
10				

#	DOT #	
	VIN	
	Name on Carrier	

Axle#	Driver Side Temp (^oF)	Inspection Note	Passenger Side Temp (^oF)	Inspection Note
1	-------------	--	-------------	--
2				
3				
4				
5				
6				
7				
8				
9				
10				

#	DOT #	
	VIN	
	Name on Carrier	

Axle#	Driver Side Temp (^oF)	Inspection Note	Passenger Side Temp (^oF)	Inspection Note
1	-------------	--	-------------	--
2				
3				
4				
5				
6				
7				
8				
9				
10				

Analyst ____________________________

Inspection Date ______________ Inspection Period ______________
Ambient Temperature ______________ Sheet ______________

#	DOT #		Weight Range						
	VIN								
	Name on Carrier								
Axle#	**Driver Side Temp (°F)**	**Passenger Side Temp (°F)**	0-15000	15000-20000	20000-25000	25000-30000	30000-35000	35000-40000	**Temp Out of Range?**
2									
3									
4									
5									

#	DOT #		Weight Range						
	VIN								
	Name on Carrier								
Axle#	**Driver Side Temp (°F)**	**Passenger Side Temp (°F)**	0-15000	15000-20000	20000-25000	25000-30000	30000-35000	35000-40000	**Temp Out of Range?**
2									
3									
4									
5									

#	DOT #		Weight Range						
	VIN								
	Name on Carrier								
Axle#	**Driver Side Temp (°F)**	**Passenger Side Temp (°F)**	0-15000	15000-20000	20000-25000	25000-30000	30000-35000	35000-40000	**Temp Out of Range?**
2									
3									
4									
5									

#	DOT #		Weight Range						
	VIN								
	Name on Carrier								
Axle#	**Driver Side Temp (°F)**	**Passenger Side Temp (°F)**	0-15000	15000-20000	20000-25000	25000-30000	30000-35000	35000-40000	**Temp Out of Range?**
2									
3									
4									
5									

#	DOT #		Weight Range						
	VIN								
	Name on Carrier								
Axle#	**Driver Side Temp (°F)**	**Passenger Side Temp (°F)**	0-15000	15000-20000	20000-25000	25000-30000	30000-35000	35000-40000	**Temp Out of Range?**
2									
3									
4									
5									

Analyst: ______________

APPENDIX C: STUDY DATA

Initial Baseline Study Data						
Inspection Date	Last 4 Digits of VIN	Axle	Combined Axle 2&3 or 4&5 Weight (lbs)	Temp (F) Driver Side	Temp (F) Passenger Side	PrePass Vehicle?
4/13	1460	2	22760	489	262	no
4/13	1460	3	22760	583	599	
4/13	1460	4	21600	560	570	
4/13	1460	5	21600	560	560	
4/13	5837	2	30360	85	419	yes
4/13	5837	3	30360	559	588	
4/13	5837	4	34960	530	573	
4/13	5837	5	34960	586	547	
4/13	0929	2	28040	624	580	yes
4/13	0929	3	28040	644	646	
4/13	0929	4	38640	545	518	
4/13	0929	5	38640	575	561	
4/13	3062	2	30600	136	129	no
4/13	3062	3	30600	156	135	
4/13	3062	4	36560	197	255	
4/13	3062	5	36560	157	220	
4/13	8654	2	31840	237	276	yes
4/13	8654	3	31840	385	265	
4/13	8654	4	33480	342	410	
4/13	8654	5	33480	383	413	
4/13	1853	2	16440	79	85	no
4/13	1853	3	16440	89	88	
4/13	1853	4	13260	77	93	
4/13	1853	5	13260	89	96	
4/13	0782	2	12800	112	92	yes
4/13	0782	3	12800	99	109	
4/13	0782	4	6920	112	116	
4/13	0782	5	6920	112	117	
4/13	2246	2	14540	119	108	yes
4/13	2246	3	14540	93	122	
4/13	2246	4	11960	90	100	
4/13	2246	5	11960	86	106	
4/13	4986	2	24560	209	200	no
4/13	4986	3	24560	106	264	
4/13	4986	4	29980	281	247	
4/13	4986	5	29980	229	186	
4/13	7471	2	28500	337	323	no
4/13	7471	3	28500	341	325	
4/13	7471	4	39900	247	286	
4/13	7471	5	39900	258	335	
4/13	9414	2	20480	96	92	yes
4/13	9414	3	20480	97	102	
4/13	9414	4	21540	96	83	
4/13	9414	5	21540	100	112	
4/13	0085	2	31440	329	309	no
4/13	0085	3	31440	355	324	
4/13	0085	4	34060	600	572	
4/13	0085	5	34060	620	670	
4/13	2039	2	28480	328	257	no
4/13	2039	3	28480	470	388	
4/13	2039	4	33160	490	530	
4/13	2039	5	33160	586	548	
4/13	8511	2	12520	128	157	no
4/13	8511	3	12520	108	154	
4/13	8511	4	9660	122	174	
4/13	8511	5	9660	175	146	

Initial Baseline Study Data						
Inspection Date	Last 4 Digits of VIN	Axle	Combined Axle 2&3 or 4&5 Weight (lbs)	Temp (F) Driver Side	Temp (F) Passenger Side	PrePass Vehicle?
4/13	9162	2	24180	145	232	no
4/13	9162	3	24180	251	252	
4/13	9162	4	15840	320	315	
4/13	9162	5	15840	317	357	
4/13	4231	2	35020	197	186	yes
4/13	4231	3	35020	213	201	
4/13	4231	4	35280	166	160	
4/13	4231	5	35280	166	161	
4/13	9117	2	23380	279	301	no
4/13	9117	3	23380	303	292	
4/13	9117	4	23980	360	479	
4/13	9117	5	23980	466	533	
4/13	2867	2	23120	383	551	yes
4/13	2867	3	23120	573	642	
4/13	2867	4	24240	350	397	
4/13	2867	5	24240	334	336	
4/13	1709	2	14800	205	207	no
4/13	1709	3	14800	192	218	
4/13	1709	4	15300	240	211	
4/13	1709	5	15300	255	243	
4/13	5397	2	14140	161	163	no
4/13	5397	3	14140	177	153	
4/13	5397	4	13460	412	317	
4/13	5397	5	13460	309	388	
4/13	2082	2	23040	275	291	yes
4/13	2082	3	23040	302	318	
4/13	2082	4	24080	527	497	
4/13	2082	5	24080	484	467	
4/13	5609	2	12020	85	82	no
4/13	5609	3	12020	85	89	
4/13	5609	4	7100	79	70	
4/13	5609	5	7100	76	78	
4/13	5694	2	33060	622	789	no
4/13	5694	3	33060	746	733	
4/13	5694	4	33580	460	466	
4/13	5694	5	33580	643	450	
4/13	6996	2	18480	186	177	yes
4/13	6996	3	18480	202	212	
4/13	6996	4	16880	186	203	
4/13	6996	5	16880	208	230	
4/13	3571	2	33540	489	551	no
4/13	3571	3	33540	544	562	
4/13	3571	4	33500	346	366	
4/13	3571	5	33500	545	612	
4/13	7804	2	27340	151	158	no
4/13	7804	3	27340	150	173	
4/13	7804	4	25240	177	177	
4/13	7804	5	25240	173	186	
4/13	8363	2	30720	353	372	no
4/13	8363	3	30720	359	412	
4/13	8363	4	33320	444	471	
4/13	8363	5	33320	493	525	
4/13	1758	2	30840	262	284	no
4/13	1758	3	30840	201	235	
4/13	1758	4	37040	469	460	
4/13	1758	5	37040	496	453	

Initial Baseline Study Data						
Inspection Date	Last 4 Digits of VIN	Axle	Combined Axle 2&3 or 4&5 Weight (lbs)	Temp (F) Driver Side	Temp (F) Passenger Side	PrePass Vehicle?
4/13	0869	2	31840	312	321	yes
4/13	0869	3	31840	395	387	yes
4/13	0869	4	25815	356	357	yes
4/13	0869	5	25815	376	433	yes
4/13	4965	2	15440	120	106	no
4/13	4965	3	15440	152	112	no
4/13	4965	4	12180	185	185	no
4/13	4965	5	12180	189	205	no
4/13	2148	2	19060	140	138	no
4/13	2148	3	19060	120	179	no
4/13	2148	4	16635	242	237	no
4/13	2148	5	16635	221	279	no
4/13	3754	2	31980	143	141	yes
4/13	3754	3	31980	191	186	yes
4/13	3754	4	32700	266	310	yes
4/13	3754	5	32700	274	313	yes
4/13	8569	2	31780	279	254	no
4/13	8569	3	31780	237	273	no
4/13	8569	4	35220	293	340	no
4/13	8569	5	35220	317	370	no
4/13	4974	2	33640	112	115	yes
4/13	4974	3	33640	115	123	yes
4/13	4974	4	34220	105	118	yes
4/13	4974	5	34220	119	122	yes
4/13	2234	2	15900	124	154	yes
4/13	2234	3	15900	147	183	yes
4/13	2234	4	10400	110	145	yes
4/13	2234	5	10400	112	125	yes
4/13	0171	2	13440	107	98	yes
4/13	0171	3	13440	114	103	yes
4/13	0171	4	8340	95	114	yes
4/13	0171	5	8340	125	117	yes
4/13	4089	2	21740	150	135	no
4/13	4089	3	21740	118	131	no
4/13	4089	4	20100	222	235	no
4/13	4089	5	20100	235	250	no
4/13	6077	2	15280	344	325	no
4/13	6077	3	15280	287	357	no
4/13	6077	4	8600	253	294	no
4/13	6077	5	8600	380	360	no
4/15	9227	2	28120	291	305	no
4/15	9227	3	28120	372	410	no
4/15	9227	4	29620	376	340	no
4/15	9227	5	29620	358	375	no
4/15	8301	2	24020	104	106	yes
4/15	8301	3	24020	101	106	yes
4/15	8301	4	20760	225	197	yes
4/15	8301	5	20760	195	196	yes
4/15	6399	2	18200	283	286	no
4/15	6399	3	18200	242	137	no
4/15	6399	4	12800	223	232	no
4/15	6399	5	12800	250	220	no
4/15	8015	2	13200	68	83	yes
4/15	8015	3	13200	76	78	yes
4/15	8015	4	13340	77	94	yes
4/15	8015	5	13340	26	30	yes

Initial Baseline Study Data						
Inspection Date	Last 4 Digits of VIN	Axle	Combined Axle 2&3 or 4&5 Weight (lbs)	Temp (F) Driver Side	Temp (F) Passenger Side	PrePass Vehicle?
4/15	4058	2	33660	414	450	no
4/15	4058	3	33660	496	436	
4/15	4058	4	32720	488	480	
4/15	4058	5	32720	387	485	
4/15	9487	2	14700	131	159	yes
4/15	9487	3	14700	208	154	
4/15	9487	4	15220	148	137	
4/15	9487	5	15220	178	148	
4/15	3637	2	14340	120	118	no
4/15	3637	3	14340	142	154	
4/15	3637	4	10780	71	82	
4/15	3637	5	10780	74	73	
4/15	4235	2	29180	145	226	no
4/15	4235	3	29180	181	161	
4/15	4235	4	24360	155	159	
4/15	4235	5	24360	186	175	
4/15	9099	2	23460	232	275	no
4/15	9099	3	23460	244	288	
4/15	9099	4	19740	311	289	
4/15	9099	5	19740	90	172	
4/15	4144	2	32640	326	325	no
4/15	4144	3	32640	332	334	
4/15	4144	4	34200	472	400	
4/15	4144	5	34200	426	431	
4/15	5093	2	31640	235	180	no
4/15	5093	3	31640	357	228	
4/15	5093	4	35260	201	166	
4/15	5093	5	35260	287	199	
4/15	3642	2	17940	112	115	yes
4/15	3642	3	17940	139	146	
4/15	3642	4	11220	138	137	
4/15	3642	5	11220	148	129	
4/15	9009	2	16040	159	135	no
4/15	9009	3	16040	139	142	
4/15	9009	4	14640	188	156	
4/15	9009	5	14640	180	195	
4/15	3096	2	32060	591	602	no
4/15	3096	3	32060	623	606	
4/15	3096	4	35520	501	420	
4/15	3096	5	35520	509	489	
4/15	8726	2	16360	235	54	no
4/15	8726	3	16360	57	199	
4/15	8726	4	15960	284	285	
4/15	8726	5	15960	230	250	
4/15	5168	2	16020	147	180	yes
4/15	5168	3	16020	143	200	
4/15	5168	4	16600	189	234	
4/15	5168	5	16600	197	183	
4/15	1326	2	30280	422	366	yes
4/15	1326	3	30280	298	413	
4/15	1326	4	30680	225	276	
4/15	1326	5	30680	251	233	
4/15	8368	2	23240	179	240	no
4/15	8368	3	23240	182	229	
4/15	8368	4	13460	197	220	
4/15	8368	5	13460	182	211	

Initial Baseline Study Data						
Inspection Date	Last 4 Digits of VIN	Axle	Combined Axle 2&3 or 4&5 Weight (lbs)	Temp (F) Driver Side	Temp (F) Passenger Side	PrePass Vehicle?
4/15	9561	2	27480	211	223	no
4/15	9561	3	27480	290	340	
4/15	9561	4	32000	260	227	
4/15	9561	5	32000	270	245	
4/15	2447	2	15940	145	138	no
4/15	2447	3	15940	149	182	
4/15	2447	4	8320	189	224	
4/15	2447	5	8320	233	197	
4/15	4956	2	18400	108	114	yes
4/15	4956	3	18400	104	98	
4/15	4956	4	11020	185	201	
4/15	4956	5	11020	171	175	
4/15	0111	2	17900	114	107	no
4/15	0111	3	17900	134	137	
4/15	0111	4	12320	113	123	
4/15	0111	5	12320	122	142	
4/15	6162	2	20600	168	145	yes
4/15	6162	3	20600	168	200	
4/15	6162	4	12060	162	188	
4/15	6162	5	12060	177	154	
4/15	7131	2	16820	110	135	yes
4/15	7131	3	16820	130	128	
4/15	7131	4	9040	95	75	
4/15	7131	5	9040	34	31	
4/15	6168	2	31140	457	395	no
4/15	6168	3	31140	649	660	
4/15	6168	4	32360	301	459	
4/15	6168	5	32360	377	333	
4/15	8145	2	20360	175	162	no
4/15	8145	3	20360	153	176	
4/15	8145	4	17180	131	168	
4/15	8145	5	17180	181	180	
4/15	7586	2	22800	223	275	no
4/15	7586	3	22800	327	246	
4/15	7586	4	19300	176	260	
4/15	7586	5	19300	180	167	
4/15	0706	2	18360	107	93	yes
4/15	0706	3	18360	106	84	
4/15	0706	4	11440	117	158	
4/15	0706	5	11440	166	175	
4/15	9585	2	19680	364	351	no
4/15	9585	3	19680	407	321	
4/15	9585	4	16100	305	301	
4/15	9585	5	16100	327	279	
4/15	0688	2	33500	300	307	no
4/15	0688	3	33500	304	384	
4/15	0688	4	30040	256	262	
4/15	0688	5	30040	285	325	
4/15	073N	2	23600	134	191	no
4/15	073N	3	23600	210	128	
4/15	073N	4	16360	281	237	
4/15	073N	5	16360	251	276	
4/15	4289	2	13860	102	88	yes
4/15	4289	3	13860	181	140	
4/15	4289	4	9740	210	205	
4/15	4289	5	9740	278	278	

Initial Baseline Study Data						
Inspection Date	**Last 4 Digits of VIN**	**Axle**	**Combined Axle 2&3 or 4&5 Weight (lbs)**	**Temp (F) Driver Side**	**Temp (F) Passenger Side**	**PrePass Vehicle?**
4/15	3281	2	12680	69	75	yes
4/15	3281	3	12680	83	96	
4/15	3281	4	7680	138	180	
4/15	3281	5	7680	166	219	
4/15	1677	2	21640	401	351	no
4/15	1677	3	21640	415	414	
4/15	1677	4	16320	380	375	
4/15	1677	5	16320	393	412	
4/15	5731	2	12400	75	81	yes
4/15	5731	3	12400	90	89	
4/15	5731	4	9620	108	117	
4/15	5731	5	9620	120	151	
4/15	0974	2	14000	127	113	yes
4/15	0974	3	14000	143	121	
4/15	0974	4	9420	92	90	
4/15	0974	5	9420	92	83	
4/15	8971	2	17920	147	194	no
4/15	8971	3	17920	212	191	
4/15	8971	4	15740	165	164	
4/15	8971	5	15740	183	156	
4/15	9103	2	19660	309	345	yes
4/15	9103	3	19660	324	345	
4/15	9103	4	16520	335	300	
4/15	9103	5	16520	341	336	
4/15	1095	2	21680	258	302	no
4/15	1095	3	21680	251	279	
4/15	1095	4	16540	323	279	
4/15	1095	5	16540	310	343	
4/20	4198	2	33620	492	380	no
4/20	4198	3	33620	435	426	
4/20	4198	4	34980	299	732	
4/20	4198	5	34980	428	514	
4/20	2750	2	33360	433	447	yes
4/20	2750	3	33360	422	366	
4/20	2750	4	33260	221	275	
4/20	2750	5	33260	345	390	
4/20	6102	2	14000	86	93	yes
4/20	6102	3	14000	72	98	
4/20	6102	4	6500	86	83	
4/20	6102	5	6500	117	113	
4/20	6817	2	34960	70	178	no
4/20	6817	3	34960	369	401	
4/20	6817	4	23980	123	84	
4/20	6817	5	23980	309	207	
4/20	6115	2	14960	101	128	yes
4/20	6115	3	14960	105	93	
4/20	6115	4	12500	109	190	
4/20	6115	5	12500	133	224	
4/20	7484	2	12900	89	105	no
4/20	7484	3	12900	125	152	
4/20	7484	4	10640	91	70	
4/20	7484	5	10640	99	109	
4/20	9531	2	13240	63	57	yes
4/20	9531	3	13240	50	52	
4/20	9531	4	10120	150	183	
4/20	9531	5	10120	239	95	

Initial Baseline Study Data						
Inspection Date	Last 4 Digits of VIN	Axle	Combined Axle 2&3 or 4&5 Weight (lbs)	Temp (F) Driver Side	Temp (F) Passenger Side	PrePass Vehicle?
4/20	4717	2	18520	53	57	yes
4/20	4717	3	18520	76	49	
4/20	4717	4	17420	126	131	
4/20	4717	5	17420	106	102	
4/20	4716	2	14460	91	45	yes
4/20	4716	3	14460	118	104	
4/20	4716	4	8840	179	212	
4/20	4716	5	8840	176	176	
4/20	9221	2	18620	273	245	yes
4/20	9221	3	18620	262	287	
4/20	9221	4	19880	349	405	
4/20	9221	5	19880	402	423	
4/20	7667	2	32340	336	152	yes
4/20	7667	3	32340	118	105	
4/20	7667	4	32300	387	262	
4/20	7667	5	32300	145	359	
4/20	9999	2	14720	99	101	yes
4/20	9999	3	14720	59	61	
4/20	9999	4	11240	155	169	
4/20	9999	5	11240	195	187	
4/20	9284	2	29540	281	448	no
4/20	9284	3	29540	159	194	
4/20	9284	4	21240	221	262	
4/20	9284	5	21240	293	184	
4/20	8797	2	11380	45	42	yes
4/20	8797	3	11380	69	65	
4/20	8797	4	7300	45	46	
4/20	8797	5	7300	46	42	
4/20	7568	2	31700	452	437	no
4/20	7568	3	31700	345	423	
4/20	7568	4	34520	382	357	
4/20	7568	5	34520	329	365	
4/20	1291	2	29020	625	542	no
4/20	1291	3	29020	603	548	
4/20	1291	4	33840	580	655	
4/20	1291	5	33840	695	640	
4/20	7597	2	19780	180	135	no
4/20	7597	3	19780	165	141	
4/20	7597	4	11440	192	176	
4/20	7597	5	11440	169	168	
4/20	2656	2	33180	487	473	no
4/20	2656	3	33180	253	274	
4/20	2656	4	29120	448	391	
4/20	2656	5	29120	399	458	
4/20	3174	2	31240	197	122	no
4/20	3174	3	31240	224	211	
4/20	3174	4	31780	223	190	
4/20	3174	5	31780	186	178	
4/20	5340	2	32780	339	335	yes
4/20	5340	3	32780	410	389	
4/20	5340	4	31840	391	383	
4/20	5340	5	31840	278	323	
4/20	1428	2	12580	109	111	no
4/20	1428	3	12580	126	140	
4/20	1428	4	10200	208	175	
4/20	1428	5	10200	249	216	

Initial Baseline Study Data						
Inspection Date	Last 4 Digits of VIN	Axle	Combined Axle 2&3 or 4&5 Weight (lbs)	Temp (F) Driver Side	Temp (F) Passenger Side	PrePass Vehicle?
4/20	7885	2	11440	101	98	no
4/20	7885	3	11440	89	90	
4/20	7885	4	10460	130	103	
4/20	7885	5	10460	144	167	
4/20	5173	2	34160	273	256	yes
4/20	5173	3	34160	209	242	
4/20	5173	4	35040	316	341	
4/20	5173	5	35040	352	319	
4/20	5342	2	11740	158	143	no
4/20	5342	3	11740	186	144	
4/20	5342	4	8760	171	95	
4/20	5342	5	8760	157	49	
4/20	1362	2	23620	193	158	yes
4/20	1362	3	23620	150	191	
4/20	1362	4	20840	367	324	
4/20	1362	5	20840	334	213	
4/20	8971	2	17320	95	93	no
4/20	8971	3	17320	97	95	
4/20	8971	4	16100	98	91	
4/20	8971	5	16100	93	97	
4/20	9880	2	23520	124	107	yes
4/20	9880	3	23520	108	93	
4/20	9880	4	26220	127	142	
4/20	9880	5	26220	114	113	
4/20	8233	2	31840	78	72	yes
4/20	8233	3	31840	76	72	
4/20	8233	4	34360	82	81	
4/20	8233	5	34360	78	74	
4/20	4291	2	19620	457	416	no
4/20	4291	3	19620	372	348	
4/20	4291	4	11940	283	42	
4/20	4291	5	11940	308	320	
4/20	9659	2	12600	75	66	yes
4/20	9659	3	12600	69	64	
4/20	9659	4	7540	68	97	
4/20	9659	5	7540	83	84	
4/20	9425	2	14640	241	126	no
4/20	9425	3	14640	116	106	
4/20	9425	4	16800	152	141	
4/20	9425	5	16800	165	143	
4/20	6140	2	12060	78	75	yes
4/20	6140	3	12060	82	92	
4/20	6140	4	10080	94	97	
4/20	6140	5	10080	98	115	
4/20	8489	2	29440	288	230	no
4/20	8489	3	29440	225	262	
4/20	8489	4	29300	85	96	
4/20	8489	5	29300	221	205	
4/20	6723	2	14180	163	178	yes
4/20	6723	3	14180	169	140	
4/20	6723	4	11980	162	147	
4/20	6723	5	11980	165	158	
4/20	1321	2	11420	42	42	yes
4/20	1321	3	11420	44	45	
4/20	1321	4	8860	47	46	
4/20	1321	5	8860	44	49	

Initial Baseline Study Data						
Inspection Date	Last 4 Digits of VIN	Axle	Combined Axle 2&3 or 4&5 Weight (lbs)	Temp (F) Driver Side	Temp (F) Passenger Side	PrePass Vehicle?
4/20	0999	2	31920	130	129	yes
4/20	0999	3	31920	140	152	
4/20	0999	4	32120	84	111	
4/20	0999	5	32120	137	145	
4/20	6164	2	31980	528	399	no
4/20	6164	3	31980	487	442	
4/20	6164	4	32480	518	239	
4/20	6164	5	32480	367	193	
4/20	4976	2	32480	344	347	no
4/20	4976	3	32480	339	413	
4/20	4976	4	32540	547	529	
4/20	4976	5	32540	536	583	
4/20	5367	2	20920	206	201	no
4/20	5367	3	20920	210	190	
4/20	5367	4	20400	427	401	
4/20	5367	5	20400	390	432	
4/20	4089	2	17160	97	103	no
4/20	4089	3	17160	140	139	
4/20	4089	4	11700	137	109	
4/20	4089	5	11700	208	220	
4/20	9918	2	19040	254	263	no
4/20	9918	3	19040	246	263	
4/20	9918	4	22380	230	245	
4/20	9918	5	22380	199	249	
4/28	9029	2	32600	426	331	yes
4/28	9029	3	32600	421	383	
4/28	9029	4	32180	183	197	
4/28	9029	5	32180	210	200	
4/28	8343	2	13460	140	152	no
4/28	8343	3	13460	134	115	
4/28	8343	4	9280	223	215	
4/28	8343	5	9280	200	217	
4/28	0154	2	19620	118	120	no
4/28	0154	3	19620	142	162	
4/28	0154	4	13180	159	140	
4/28	0154	5	13180	180	178	
4/28	6102	2	13940	127	138	yes
4/28	6102	3	13940	117	153	
4/28	6102	4	6920	144	148	
4/28	6102	5	6920	197	190	
4/28	7579	2	34000	343	330	yes
4/28	7579	3	34000	353	347	
4/28	7579	4	34120	356	279	
4/28	7579	5	34120	306	71	
4/28	5066	2	20060	139	126	no
4/28	5066	3	20060	158	180	
4/28	5066	4	11600	94	102	
4/28	5066	5	11600	98	112	
4/28	7108	2	30420	296	323	no
4/28	7108	3	30420	316	323	
4/28	7108	4	33680	387	372	
4/28	7108	5	33680	444	350	
4/28	4867	2	31120	207	214	no
4/28	4867	3	31120	387	354	
4/28	4867	4	29200	540	644	
4/28	4867	5	29200	410	352	

Initial Baseline Study Data						
Inspection Date	Last 4 Digits of VIN	Axle	Combined Axle 2&3 or 4&5 Weight (lbs)	Temp (F) Driver Side	Temp (F) Passenger Side	PrePass Vehicle?
4/28	8791	2	19320	113	117	yes
4/28	8791	3	19320	155	106	
4/28	8791	4	22520	124	151	
4/28	8791	5	22520	255	293	
4/28	5360	2	19720	230	196	no
4/28	5360	3	19720	195	316	
4/28	5360	4	19880	442	205	
4/28	5360	5	19880	244	236	
4/28	5484	2	27720	279	268	no
4/28	5484	3	27720	126	224	
4/28	5484	4	34540	165	190	
4/28	5484	5	34540	161	171	
4/28	1298	2	11040	65	64	yes
4/28	1298	3	11040	66	66	
4/28	1298	4	7500	63	63	
4/28	1298	5	7500	60	58	
4/28	5565	2	12480	104	102	yes
4/28	5565	3	12480	108	113	
4/28	5565	4	11780	99	104	
4/28	5565	5	11780	107	111	
4/28	0209	2	12220	104	94	yes
4/28	0209	3	12220	120	85	
4/28	0209	4	7520	122	108	
4/28	0209	5	7520	143	140	
4/28	0642	2	31460	334	336	no
4/28	0642	3	31460	369	288	
4/28	0642	4	30940	392	433	
4/28	0642	5	30940	483	485	
4/28	2361	2	34140	102	107	yes
4/28	2361	3	34140	109	117	
4/28	2361	4	32720	115	113	
4/28	2361	5	32720	154	160	
4/28	7037	2	15360	87	91	yes
4/28	7037	3	15360	86	86	
4/28	7037	4	12000	89	110	
4/28	7037	5	12000	97	125	
4/28	2010	2	32380	250	241	no
4/28	2010	3	32380	254	227	
4/28	2010	4	28640	268	296	
4/28	2010	5	28640	315	294	
4/28	2661	2	33080	554	489	yes
4/28	2661	3	33080	518	488	
4/28	2661	4	33320	427	397	
4/28	2661	5	33320	347	445	
4/28	6224	2	34180	397	452	yes
4/28	6224	3	34180	471	454	
4/28	6224	4	32060	470	431	
4/28	6224	5	32060	441	432	
4/28	9146	2	15980	390	411	no
4/28	9146	3	15980	388	434	
4/28	9146	4	12420	294	275	
4/28	9146	5	12420	430	410	
4/28	2117	2	31040	426	435	no
4/28	2117	3	31040	448	440	
4/28	2117	4	33540	256	236	
4/28	2117	5	33540	255	253	

Initial Baseline Study Data						
Inspection Date	Last 4 Digits of VIN	Axle	Combined Axle 2&3 or 4&5 Weight (lbs)	Temp (F) Driver Side	Temp (F) Passenger Side	PrePass Vehicle?
4/28	3443	2	21140	157	196	no
4/28	3443	3	21140	175	154	
4/28	3443	4	15620	276	248	
4/28	3443	5	15620	281	277	
4/28	2012	2	15760	253	284	no
4/28	2012	3	15760	206	306	
4/28	2012	4	10660	216	231	
4/28	2012	5	10660	256	207	
4/28	5325	2	33520	424	422	no
4/28	5325	3	33520	438	396	
4/28	5325	4	29660	507	361	
4/28	5325	5	29660	329	503	
4/28	6335	2	16060	211	284	no
4/28	6335	3	16060	311	211	
4/28	6335	4	17760	240	263	
4/28	6335	5	17760	360	278	
4/28	6278	2	12400	124	108	no
4/28	6278	3	12400	128	137	
4/28	6278	4	9500	137	135	
4/28	6278	5	9500	136	139	
4/28	5851	2	32520	142	150	yes
4/28	5851	3	32520	150	130	
4/28	5851	4	33560	106	93	
4/28	5851	5	33560	164	158	
4/28	1838	2	26740	206	184	no
4/28	1838	3	26740	180	176	
4/28	1838	4	35540	208	185	
4/28	1838	5	35540	195	207	
4/28	7609	2	30180	473	514	yes
4/28	7609	3	30180	205	515	
4/28	7609	4	28840	362	265	
4/28	7609	5	28840	445	235	
4/28	3401	2	15120	183	160	yes
4/28	3401	3	15120	200	184	
4/28	3401	4	12580	210	182	
4/28	3401	5	12580	203	188	
4/28	4951	2	15080	186	187	yes
4/28	4951	3	15080	206	215	
4/28	4951	4	14920	240	275	
4/28	4951	5	14920	224	297	
4/28	3887	2	8620	100	97	no
4/28	3887	3	8620	99	123	
4/28	3887	4	7300	112	85	
4/28	3887	5	7300	96	77	
4/28	9731	2	12500	163	191	no
4/28	9731	3	12500	190	189	
4/28	9731	4	10180	283	256	
4/28	9731	5	10180	216	302	
4/28	6644	2	18220	218	198	yes
4/28	6644	3	18220	231	93	
4/28	6644	4	21780	141	104	
4/28	6644	5	21780	142	135	
4/28	7749	2	17060	120	85	no
4/28	7749	3	17060	142	200	
4/28	7749	4	17240	189	196	
4/28	7749	5	17240	204	217	

Initial Baseline Study Data						
Inspection Date	Last 4 Digits of VIN	Axle	Combined Axle 2&3 or 4&5 Weight (lbs)	Temp (F) Driver Side	Temp (F) Passenger Side	PrePass Vehicle?
4/28	0172	2	32220	791	688	no
4/28	0172	3	32220	720	706	
4/28	0172	4	32920	550	563	
4/28	0172	5	32920	580	592	
4/28	1488	2	33060	199	221	yes
4/28	1488	3	33060	241	215	
4/28	1488	4	32000	244	220	
4/28	1488	5	32000	222	291	
4/28	4399	2	20420	509	500	no
4/28	4399	3	20420	535	562	
4/28	4399	4	27840	312	330	
4/28	4399	5	27840	281	273	
4/28	5128	2	20560	213	255	yes
4/28	5128	3	20560	261	275	
4/28	5128	4	23040	252	276	
4/28	5128	5	23040	377	336	
4/28	9614	2	16940	437	372	no
4/28	9614	3	16940	466	380	
4/28	9614	4	20080	86	87	
4/28	9614	5	20080	460	393	
4/28	0911	2	30580	231	297	no
4/28	0911	3	30580	330	218	
4/28	0911	4	29040	530	288	
4/28	0911	5	29040	426	384	
4/28	3145	2	18980	166	183	yes
4/28	3145	3	18980	150	140	
4/28	3145	4	11980	138	130	
4/28	3145	5	11980	178	168	
4/28	0114	2	32840	528	505	yes
4/28	0114	3	32840	493	534	
4/28	0114	4	35820	128	539	
4/28	0114	5	35820	549	530	
4/28	5441	2	33160	434	446	no
4/28	5441	3	33160	410	463	
4/28	5441	4	35020	405	438	
4/28	5441	5	35020	423	429	

Correlation Study Data									
Inspection Date	Last 4 Digits of VIN	Axle	Combined Axle Weight (lbs) - 2&3 or 4&5	Temp (F) Driver (Left)	Temp (F) Passenger (Right)	Inspection Note	Truck Out of Service (OOS)?	Truck Brake Violation?	PrePass Vehicle?
5/19/2004	5076	2	12220	73	83		n	n	no
5/19/2004	5076	3	12220	84	81		n		
5/19/2004	5076	4	7980	90	96	brake hose/tubing chafing	n		
5/19/2004	5076	5	7980	106	129		n		
5/19/2004	6113	2	12340	118	103		n	yes	yes
5/19/2004	6113	3	12340	100	100		n		
5/19/2004	6113	4	6820	160	145		n		
5/19/2004	6113	5	6820	134	126	both sides out of adj.	n		
5/19/2004	2116	2	33860	514	488	lft (drvr) side brake tube chafing	n	n	yes
5/19/2004	2116	3	33860	502	470		n		
5/19/2004	2116	4	32320	533	342		n		
5/19/2004	2116	5	32320	504	469		n		
5/19/2004	4622	2	11840	181	184		n	n	no
5/19/2004	4622	3	11840	187	198	brake hose chafing/kinking	n		
5/19/2004	4622	4	12040	147	126		n		
5/19/2004	4622	5	12040	176	181		n		
5/19/2004	3203	2	32840	492	489	passenger side smoking. Ax 4 OOS	yes	yes	no
5/19/2004	3203	3	32840	464	433	rt brake hose chafing. Ax 4 OOS.	yes		
5/19/2004	3203	4	36940	302	374	brake air line chafed; 2nd ply exposed & broken; OOS	yes		
5/19/2004	3202	5	36940	440	461	rt brake out of adj (ooa) & brake hose chafed. Ax 4 OOS.	yes		
5/19/2004	3033	2	20040	289	263	Brake hose/tube chafing/kinking at slider (Ax 1, hole in line, OOS)	yes	n	no
5/19/2004	3033	3	20040	339	294	Ax 1, hole in air line, OOS.	yes		
5/19/2004	3033	4	22920	261	248	Ax 1, hole in air line, OOS.	yes		
5/19/2004	3033	5	22920	326	294	Ax 1, hole in air line, OOS.	yes		
5/19/2004	9348	2	20140	168	203	lft side: inadequate lining; crack in shoe	n	yes	no
5/19/2004	9348	3	20140	238	250		n		
5/19/2004	9348	4	14260	156	141		n		
5/19/2004	9348	5	14260	146	142		n		
5/19/2004	2917	2	12240	125	98		n	n	yes
5/19/2004	2917	3	12240	168	148	leak/constriction in brake connection, at left pod.	n		
5/19/2004	2917	4	9340	147	138		n		
5/19/2004	2917	5	9340	158	164	Lft side at air tank: brake hose chafing/kinking	n		
5/19/2004	6134	2	15000	89	133	Ax 4&5 OOS.	yes	yes	no
5/19/2004	6134	3	15000	102	88	rt side wearing unevenly. Ax 4&5 OOS.	yes		
5/19/2004	6134	4	15000	88	97	rt side: inop/defective brakes; no contact upon application. OOS	yes		
5/19/2004	6134	5	15000	113	95	rt & lft: Inop/def brakes; bottom shoe in contact w/ drum. OOS.	yes		

Correlation Study Data									
Inspection Date	Last 4 Digits of VIN	Axle	Combined Axle Weight (lbs) - 2&3 or 4&5	Temp (F) Driver (Left)	Temp (F) Passenger (Right)	Inspection Note	Truck Out of Service (OOS)?	Truck Brake Violation?	PrePass Vehicle?
5/19/2004	8718	2	22040	321	353		n	n	yes
5/19/2004	8718	3	22040	324	376		n		
5/19/2004	8718	4	21260	346	335	rt side: brk hose chafing/kinking at slider.	n		
5/19/2004	8718	5	21260	343	481		n		
5/25/2004	5288	2	29120	288	309	Ax 1,3,5 OOS	yes	yes	no
5/25/2004	5288	3	29120	376	276	lft & rt side 2" crack in shoes; Ax 1,3,5 OOS	yes		
5/25/2004	5288	4	14100	387	486	Ax 1,3,5 OOS	yes		
5/25/2004	5288	5	14100	460	500	lft & rt side 2" crack in shoes; Ax 1,3,5 OOS	yes		
5/25/2004	2362	2	12240	81	89	lft side loose jam nut	n	n	yes
5/25/2004	2362	3	12240	86	83	rt side loose jam nut	n		
5/25/2004	2362	4	9880	100	93		n		
5/25/2004	2362	5	9880	94	104		n		
5/25/2004	0228	2	22620	253	206		n	n	no
5/25/2004	0228	3	22620	241	232		n		
5/25/2004	0228	4	12720	226	311		n		
5/25/2004	228	5	12720	331	382		n		
5/25/2004	2910	2	12540	139	183		n	n	no
5/25/2004	2910	3	12540	180	178		n		
5/25/2004	2910	4	6400	67	55		n		
5/25/2004	2910	5	6400	64	70		n		
5/25/2004	3123	2	12980	106	124		n	n	no
5/25/2004	3123	3	12980	116	128		n		
5/25/2004	3123	4	11620	212	166		n		
5/25/2004	3123	5	11620	195	181		n		
5/25/2004	8971	2	19620	101	171		n	n	no
5/25/2004	8971	3	19620	246	142		n		
5/25/2004	8971	4	18520	322	333		n		
5/25/2004	8971	5	18520	297	385		n		
5/25/2004	6621	2	12360	114	102	Ax 1&3 OOS.	yes	yes	no
5/25/2004	6621	3	12360	89	60	rt side: 2.5"- OOA. Ax 1&3 OOS.	yes		
5/25/2004	6621	4	8760	109	121	Ax 1&3 OOS.	yes		
5/25/2004	6621	5	8760	122	144	Ax 1&3 OOS.	yes		
5/25/2004	2363	2	32240	88	97		n	n	yes
5/25/2004	2363	3	32240	116	105		n		
5/25/2004	2363	4	34180	118	114		n		
5/25/2004	2363	5	34180	115	150		n		

Correlation Study Data									
Inspection Date	Last 4 Digits of VIN	Axle	Combined Axle Weight (lbs) - 2&3 or 4&5	Temp (F) Driver (Left)	Temp (F) Passenger (Right)	Inspection Note	Truck Out of Service (OOS)?	Truck Brake Violation?	PrePass Vehicle?
5/25/2004	9122	2	31260	429	226		n	yes	yes
5/25/2004	9122	3	31260	511	479	lft side smoking; air leak at connection	n		
5/25/2004	9122	4	31980	403	479		n		
5/25/2004	9122	5	31980	520	526		n		
5/25/2004	9719	2	15620	65	63		n	n	no
5/25/2004	9719	3	15620	76	73		n		
5/25/2004	9719	4	15620	85	112		n		
5/25/2004	9719	5	15620	75	112		n		
5/25/2004	4602	2	33980	124	123		n	yes	yes
5/25/2004	4602	3	33980	121	131		n		
5/25/2004	4602	4	31780	134	126	lft side oil-soaked (leaky bearing).	n		
5/25/2004	4602	5	31780	248	192		n		
6/11/2004	2188	2	31120	669	636		n	n	yes
6/11/2004	2188	3	31120	638	720		n		
6/11/2004	2188	4	32740	538	530		n		
6/11/2004	2188	5	32740	530	547		n		
6/11/2004	1527	2	16180	188	121		n	n	no
6/11/2004	1527	3	16180	214	221		n		
6/11/2004	1527	4	12780	259	198		n		
6/11/2004	1527	5	12780	243	191		n		
6/11/2004	4542	2	12100	166	182		n	yes	yes
6/11/2004	4542	3	12100	139	135		n		
6/11/2004	4542	4	10660	154	186	lft side loose push rod	n		
6/11/2004	4542	5	10660	181	215		n		
6/11/2004	1354	2	27720	212	156		n	n	yes
6/11/2004	1354	3	27720	203	180		n		
6/11/2004	1354	4	31060	202	320		n		
6/11/2004	1354	5	31060	339	328		n		
6/11/2004	7241	2	33900	186	179	rt side air leak	yes	yes	yes
6/11/2004	7241	3	33900	220	215	Air leak, center	yes		
6/11/2004	7241	4	34160	216	240	Lft & Rt OOA; OOS	yes		
6/11/2004	7241	5	34160	258	228	lft & rt inoperative/defective; OOS	yes		
6/11/2004	7371	2	33080	168	368		n	n	no
6/11/2004	7371	3	33080	240	408		n		
6/11/2004	7371	4	33540	300	340		n		
6/11/2004	7371	5	33540	392	538		n		

Correlation Study Data									
Inspection Date	Last 4 Digits of VIN	Axle	Combined Axle Weight (lbs) - 2&3 or 4&5	Temp (F) Driver (Left)	Temp (F) Passenger (Right)	Inspection Note	Truck Out of Service (OOS)?	Truck Brake Violation?	PrePass Vehicle?
6/11/2004	5146	2	31600	189	202		n	n	no
6/11/2004	5146	3	31600	154	229		n		
6/11/2004	5146	4	31240	295	294		n		
6/11/2004	5146	5	31240	182	260		n		
6/11/2004	9318	2	16040	74	71		n	n	no
6/11/2004	9318	3	16040	70	74		n		
6/11/2004	9318	4	10740	73	74		n		
6/11/2004	9318	5	10740	71	76		n		
6/11/2004	9069	2	33420	181	190		n	n	yes
6/11/2004	9069	3	33420	186	183		n		
6/11/2004	9069	4	33640	257	249		n		
6/11/2004	9069	5	33640	265	198		n		
6/11/2004	6947	2	30840	362	357	air leak	yes	yes	no
6/11/2004	6947	3	30840	202	179	lft & rt OOA; OOS	yes		
6/11/2004	6947	4	29660	449	383	rt OOA; OOS; lft side air leak	yes		
6/11/2004	6947	5	29660	309	305	lft & rt OOA; OOS	yes		
6/11/2004	9745	2	19500	345	343		n	n	no
6/11/2004	9745	3	19500	326	249		n		
6/11/2004	9745	4	20140	209	230		n		
6/11/2004	9745	5	20140	205	224		n		
6/11/2004	6875	2	11560	68	67		n	n	yes
6/11/2004	6875	3	11560	71	71		n		
6/11/2004	6875	4	9600	72	79		n		
6/11/2004	6875	5	9600	72	76		n		
6/11/2004	4053	2	33820	97	104		n	n	yes
6/11/2004	4053	3	33820	108	106		n		
6/11/2004	4053	4	25740	128	143		n		
6/11/2004	4053	5	25740	130	143		n		
6/11/2004	6562	2	30840	380	253		yes	yes	no
6/11/2004	6562	3	30840	285	294	rt lining inadeq & oil soaked; rt air leak; OOS	yes		
6/11/2004	6562	4	28980	273	306	Lft & Rt OOA; OOS	yes		
6/11/2004	6562	5	28980	310	316	Lft & Rt OOA; OOS	yes		
6/11/2004	2040	2	27800	184	182		n	n	no
6/11/2004	2040	3	27800	232	203		n		
6/11/2004	2040	4	31000	237	273	lft air leak	n		
6/11/2004	2040	5	31000	284	308		n		

Correlation Study Data									
Inspection Date	Last 4 Digits of VIN	Axle	Combined Axle Weight (lbs) - 2&3 or 4&5	Temp (F) Driver (Left)	Temp (F) Passenger (Right)	Inspection Note	Truck Out of Service (OOS)?	Truck Brake Violation?	PrePass Vehicle?
6/11/2004	4393	2	19460	123	149		n	yes	no
6/11/2004	4393	3	19460	134	136	rt pushrod rubbing against chamber	n		
6/11/2004	4393	4	15400	186	272		n		
6/11/2004	4393	5	15400	183	203		n		
6/11/2004	9005	2	11860	109	142		n	yes	yes
6/11/2004	9005	3	11860	125	132		n		
6/11/2004	9005	4	8640	165	133		n		
6/11/2004	9005	5	8640	105	144	lft & rt pushrod rubbing against chamber	n		
6/11/2004	9405	2	12500	176	143	rt air leak	n	n	no
6/11/2004	9405	3	12500	176	140		n		
6/11/2004	9405	4	9200	192	205		n		
6/11/2004	9405	5	9200	205	247		n		
6/11/2004	4821	2	33120	668	570		n	yes	no
6/11/2004	4821	3	33120	584	522		n		
6/11/2004	4821	4	33580	479	489		n		
6/11/2004	4821	5	33580	657	517	rt lining inadeq; cracked	n		
6/11/2004	3952	2	24620	298	134	lft air leak; lft & rt OOA; OOS	yes	yes	yes
6/11/2004	3952	3	24620	252	226		yes		
6/11/2004	3952	4	23220	90	320		yes		
6/11/2004	3952	5	23220	302	338	rt OOA; OOS	yes		
6/16/2004	3202	2	19200	240	234		n	yes	no
6/16/2004	3202	3	19200	179	214		n		
6/16/2004	3202	4	15420	231	353	OOA, lft; Inadeq. Lining, lft	n		
6/16/2004	3202	5	15420	217	280		n		
6/22/2004	5365	2	32500	335	349		n	n	yes
6/22/2004	5365	3	32500	364	350		n		
6/22/2004	5365	4	32340	515	457		n		
6/22/2004	5365	5	32340	525	510		n		
6/22/2004	6054	2	8760	93	100		n	n	no
6/22/2004	6054	3	8760	100	117		n		
6/22/2004	6054	4	17040	105	100		n		
6/22/2004	6054	5	17040	110	110		n		
6/22/2004	2850	2	14680	202	157		n	n	yes
6/22/2004	2850	3	14680	184	205	Air leak, lft	n		
6/22/2004	2850	4	9740	225	267		n		
6/22/2004	2850	5	9740	175	250		n		

Correlation Study Data									
Inspection Date	Last 4 Digits of VIN	Axle	Combined Axle Weight (lbs) - 2&3 or 4&5	Temp (F) Driver (Left)	Temp (F) Passenger (Right)	Inspection Note	Truck Out of Service (OOS)?	Truck Brake Violation?	PrePass Vehicle?
6/22/2004	1747	2	32120	240	195		n	n	no
6/22/2004	1747	3	32120	265	280		n		
6/22/2004	1747	4	33140	246	238		n		
6/22/2004	1747	5	33140	257	250		n		
6/22/2004	6341	2	19140	307	307		n	yes	yes
6/22/2004	6341	3	19140	463	432		n		
6/22/2004	6341	4	18500	302	289	Inadeq lining, rt; crack in shoe, rt	n		
6/22/2004	6341	5	18500	291	313	Inadeq lining, lft; crack in shoe, lft	n		
6/22/2004	3780	2	32500	330	355		n	yes	yes
6/22/2004	3780	3	32500	340	386		n		
6/22/2004	3780	4	33620	422	87	OOA, lft	n		
6/22/2004	3780	5	33620	470	500		n		
6/22/2004	6153	2	18440	151	53		n	n	yes
6/22/2004	6153	3	18440	125	133		n		
6/22/2004	6153	4	11660	184	194		n		
6/22/2004	6153	5	11660	204	183		n		
6/22/2004	1090	2	32560	288	315		n	n	no
6/22/2004	1090	3	32560	320	360		n		
6/22/2004	1090	4	33860	415	390		n		
6/22/2004	1090	5	33860	450	485		n		
6/22/2004	1170	2	34360	138	152		n	n	no
6/22/2004	1170	3	34360	149	150		n		
6/22/2004	1170	4	22060	103	108		n		
6/22/2004	1170	5	22060	91	116		n		
6/22/2004	6264	2	23640	283	268		n	n	no
6/22/2004	6264	3	23640	268	328		n		
6/22/2004	6264	4	17220	398	253		n		
6/22/2004	6264	5	17220	393	366		n		
6/22/2004	2719	2	21960	206	222		n	n	no
6/22/2004	2719	3	21960	222	213		n		
6/22/2004	2719	4	12460	350	253		n		
6/22/2004	2719	5	12460	388	309	Brakes-loose jam nut, lft	n		
6/22/2004	4983	2	27520	310	356		n	n	yes
6/22/2004	4983	3	27520	461	429		n		
6/22/2004	4983	4	30520	400	346		n		
6/22/2004	4983	5	30520	468	499		n		

Screening Criteria Effectiveness Study Data

Inspection Date	Truck #	Last 4 Digits of VIN	Axle	Combined Axle Weight (lbs) - 2&3 or 4&5	Temp (F) Driver (Left)	Temp (F) Passenger (Right)	Inspection Note	Truck Out of Service (OOS)?	Defective Brake?	Temp above 500 F?	Low Temp >101 F Below Ave?	Truck Screened?	PrePass Vehicle?
6/29/2004	1	7956	2	19720	358	335	Not inspected	n	n	yes	yes	yes	no
6/29/2004	1	7956	3	19720	264	246	Not inspected	n		yes			
6/29/2004	1	7956	4	20740	350	405	Not inspected	n		yes			
6/29/2004	1	7956	5	20740	402	341	Not inspected	n		yes			
6/29/2004	2	7461	2	33800	513	504		n	yes	yes	yes	yes	no
6/29/2004	2	7461	3	33800	498	464		n		yes			
6/29/2004	2	7461	4	33300	564	631	rt brakes OOA	n		yes			
6/29/2004	2	7461	5	33300	657	632		n		yes			
6/29/2004	3	6433	2	34800	670	546	rt brake OOA; OOS	yes	yes	yes	yes	yes	yes
6/29/2004	3	6433	3	34800	706	595	rt brake OOA; rt brake pod loose; OOS	yes		yes			
6/29/2004	3	6433	4	34040	56	400	lft & rt brakes OOA; OOS	yes		yes			
6/29/2004	3	6433	5	34040	523	478	lft & rt brakes OOA; OOS	yes		yes			
6/29/2004	4	9487	2	17680	213	232	Not inspected	n	n	yes	yes	yes	yes
6/29/2004	4	9487	3	17680	285	214	Not inspected	n		yes			
6/29/2004	4	9487	4	18600	247	233	Not inspected	n		yes			
6/29/2004	4	9487	5	18600	246	244	Not inspected	n		yes			
6/29/2004	5	5098	2	12080	73	73	Not inspected	n	n	yes	yes	yes	no
6/29/2004	5	5098	3	12080	74	74	Not inspected	n		yes			
6/29/2004	5	5098	4	6820	70	78	Not inspected	n		yes			
6/29/2004	5	5098	5	6820	75	73	Not inspected	n		yes			
6/29/2004	6	2144	2	32260	484	387		n	n	yes	yes	yes	no
6/29/2004	6	2144	3	32260	248	436		n		yes			
6/29/2004	6	2144	4	32520	330	331	lft axles 4&5: Jam nut lose	n		yes			
6/29/2004	6	2144	5	32520	363	350	lft axles 4&5: Jam nut lose	n		yes			
6/29/2004	7	2211	2	14600	74	83	Not inspected	n	n	yes	yes	yes	yes
6/29/2004	7	2211	3	14600	77	91	Not inspected	n		yes			
6/29/2004	7	2211	4	9300	90	88	Not inspected	n		yes			
6/29/2004	7	2211	5	9300	90	103	Not inspected	n		yes			
6/29/2004	8	9247	2	34100	119	116	Not inspected	n	n	yes	yes	yes	yes
6/29/2004	8	9247	3	34100	128	157	Not inspected	n		yes			
6/29/2004	8	9247	4	34080	115	115	Not inspected	n		yes			
6/29/2004	8	9247	5	34080	118	118	Not inspected	n		yes			
6/29/2004	9	0416	2	33120	546	503		n	n	yes	yes	yes	yes
6/29/2004	9	0416	3	33120	577	544	rt loose brake pod	n		yes			
6/29/2004	9	0416	4	33040	553	563		n		yes			
6/29/2004	9	416	5	33040	430	542		n		yes			
6/29/2004	10	8565	2	11020	150	166	Not inspected	n	n	yes	yes	yes	yes
6/29/2004	10	8565	3	11020	108	91	Not inspected	n		yes			
6/29/2004	10	8565	4	7680	153	153	Not inspected	n		yes			
6/29/2004	10	8565	5	7680	126	152	Not inspected	n		yes			

Screening Criteria Effectiveness Study Data														
Inspection Date	Truck #	Last 4 Digits of VIN	Axle	Combined Axle Weight (lbs) - 2&3 or 4&5	Temp (F) Driver (Left)	Temp (F) Passenger (Right)	Inspection Note	Truck Out of Service (OOS)?	Defective Brake?	Temp above 500 F?	Low Temp >101 F Below Ave?	Truck Screened?	PrePass Vehicle?
6/29/2004	11	7492	2	33840	145	260	lft & rt brakes OOA; OOS; lft inadeq lining; oil soaked	yes	yes	yes	yes	yes	yes
6/29/2004	11	7492	3	33840	145	338	lft & rt brakes OOA; OOS	yes		yes			
6/29/2004	11	7492	4	32440	203	223		yes		yes			
6/29/2004	11	7492	5	32440	345	357		yes		yes			
6/29/2004	12	8614	2	32060	357	288	Not inspected	n	n	yes	yes	yes	no
6/29/2004	12	8614	3	32060	296	314	Not inspected	n		yes			
6/29/2004	12	8614	4	33060	460	389	Not inspected	n		yes			
6/29/2004	12	8614	5	33060	468	492	Not inspected	n		yes			
6/29/2004	13	9655	2	28040	108	154	Not inspected	n	n	yes	yes	yes	no
6/29/2004	13	9655	3	28040	125	139	Not inspected	n		yes			
6/29/2004	13	6655	4	38620	108	134	Not inspected	n		yes			
6/29/2004	13	9655	5	38620	132	153	Not inspected	n		yes			
6/29/2004	14	7068	2	13460	230	201	Not inspected	n	n	yes	yes	yes	no
6/29/2004	14	7068	3	13460	166	192	Not inspected	n		yes			
6/29/2004	14	7068	4	10800	168	174	Not inspected	n		yes			
6/29/2004	14	7068	5	10800	193	177	Not inspected	n		yes			
6/29/2004	15	4739	2	14620	113	130	Not inspected	n	n	yes	yes	yes	yes
6/29/2004	15	4739	3	14620	122	132	Not inspected	n		yes			
6/29/2004	15	4739	4	10520	193	186	Not inspected	n		yes			
6/29/2004	15	4739	5	10520	204	206	Not inspected	n		yes			
6/29/2004	16	5473	2	12180	78	79	Not inspected	n	n	yes	yes	yes	yes
6/29/2004	16	5473	3	12180	79	79	Not inspected	n		yes			
6/29/2004	16	5473	4	6800	115	125	Not inspected	n		yes			
6/29/2004	16	5473	5	6800	118	101	Not inspected	n		yes			
6/29/2004	17	2433	2	17820	83	101	Not inspected	n	n	yes	yes	yes	yes
6/29/2004	17	2433	3	17820	90	101	Not inspected	n		yes			
6/29/2004	17	2433	4	19620	204	193	Not inspected	n		yes			
6/29/2004	17	2433	5	19620	186	196	Not inspected	n		yes			
6/29/2004	18	1491	2	17700	311	425	rt side inadeq lining; crack in shoe	n	yes	yes	yes	yes	yes
6/29/2004	18	1491	3	17700	440	431	rt air bag leaking	n		yes			
6/29/2004	18	1491	4	18100	468	471		n		yes			
6/29/2004	18	1491	5	18100	549	502		n		yes			

APPENDIX D: STUDY PROPOSAL

COLORADO TRANSPORTATION MANAGEMENT SYSTEM (CTMS)
PROGRAM / SYSTEMS MANAGER (STATEWIDE)
WORK SCOPE

Using Infrared Technology to Detect Hot Brakes on Trucks
Operational Test Project Evaluation

CDOT Contract 99 HAA 00116
WI Task Order #2100.010

January 21, 2004

The Colorado Department of Transportation (CDOT) is continuing its ambitious 5-year program, referred to as the Colorado Transportation Management System (CTMS) to rapidly develop and deploy Intelligent Transportation Systems (ITS) in Colorado.

Much of the CTMS to date has been devoted to addressing truck safety improvements statewide. Part of this work has provided port-of-entry automation at nearly every major port facility in Colorado. The Platteville Port of Entry on US 85 is not considered a major port facility, and therefore is not automated. Of the major port facilities, only eastbound I-70 at Dumont (in the mountains west of Denver) remains non-automated for reasons detailed herein. This task order will ultimately evaluate a proposed operational test to measure truck brake temperatures at highway speeds.

Washington Infrastructure Services (WI) is referred to hereinafter as the "Consultant." Similarly, the company selected by CDOT to develop and deploy the hot brakes detection system is referred to hereinafter as the "Vendor."

1.0 Introduction

As part of a statewide electronic screening program focused on commercial vehicles, CDOT has automated nearly all existing commercial vehicle ports-of-entry (POE) along Interstate and non-Interstate highways in Colorado. These projects, implemented through previous CTMS (or earlier projects) installed automated vehicle identification (AVI) and automated weigh-in-motion (WIM) technologies at the ports. These systems allow properly credentialed commercial vehicles to bypass the respective POE facility provided that their vehicles are within legal weight limitations.

The rationale for POE automation is that it benefits the trucking industry as well as the traveling public. POE automation allows motor carriers to: 1] reduce delays; 2] increase productivity; 3] reduce delivery costs; 4] increase profit margins – primarily by saving time, reducing fuel consumption and reducing vehicular wear and tear; 5] promote retention of skilled drivers; 6] help maximize fleet resources; and 7] promote safer operations.

Similarly, these projects benefit Colorado by: 1] reducing safety hazards of vehicles exiting and re-entering the highway; 2] lowering the potential for accidents and breakdowns immediately outside port facilities; 3] improving the throughput of weigh and inspection stations, allowing agency operations to be streamlined; 4] reducing vehicle emission and noise levels; 5] allowing enforcement personnel to focus on unsafe and illegal carriers; and 6] promoting economic vitality.

Ports that are currently automated include I-70 Limon, I-70 Dumont (westbound), I-70 Loma, I-25 Fort Collins, I-25 Monument, I-25 Trinidad, I-76 Fort Morgan, US-287 Lamar, and US-160 Cortez. The eastbound I-70 POE at Dumont is not similarly automated due to reasons having to do with steep downgrades upstream and downstream of the facility. The belief of CDOT and POE personnel is that highway safety demands that all trucks enter the eastbound port where officers can detain any/all trucks with hot and/or smoking brakes. Such stops provide the added benefit of time for the brakes to cool and adjustments made, if necessary. Additionally, an educational video is available inside the port facility that instructs drivers about mountainous driving, the use of runaway truck ramps and the upcoming downhill grade from Genesee to Morrison.

Both the trucking industry and PrePass – the automated bypass vendor – have expressed an interest in allowing trucks to bypass the Dumont station port. If implemented, CDOT estimates 25% to 35% of eastbound I-70 trucks would initially bypass the port. Statistically, this would result in between 5,000 to 7,000 trucks each month (gradually increasing over time) bypassing the POE without the possible added safety benefit of a brake check. The 6% downgrade from Genesee to Morrison downstream from the port further complicates matters, as it is a roadway segment that has experienced numerous truck-related accidents throughout the years.

If CDOT were to allow automation of this port, it would like to have a mechanism in place to allow for identification of trucks with hot and/or defective brakes. Currently the Port of Entry Officers use two methods to detect defective brakes. The first method identifies trucks that have visibly smoking brakes. These trucks are normally pulled to the side of the parking area to allow the brakes to cool. The other method is a random safety inspection. There may be instances where nonfunctioning cold brakes or maladjusted nonsmoking brakes would go undetected. This research project will test the use of infrared thermometers to detect the above problems. This may provide a useful tool for POE inspectors to easily detect brake problems before these vehicles proceed through another long downhill grade. If, in the future, automatic detections systems become available, this information would provide valuable baseline data. This will also provide valuable data as to the extent of the problem. By sampling the brake temperatures of a statistically large number of trucks entering the port of entry, researchers should be able to determine if there is a verifiable correlation between temperature and brake functionality.

The intent of this task order is to support CDOT staff in evaluating an ITS Operational Test to detect, identify and measure brake temperatures on trucks operating on EB I-70 at the Port of Entry at Dumont.

2.0 Project Description

This study will look at using infrared thermometers to detect trucks with brake problems. If this study is successful, it will give port of entry inspectors another tool to detect dangerous problems with truck brakes. It should also provide useful data that can be applied to the entire fleet to identify the extent of trucks that may be operating with non-functioning brakes. The study will consist of three parts. The first portion will gather background data. Researchers will use hand-held infrared thermometers to record temperatures from the outside wheels of trucks as they pass over the port of entry scale. That data will then be analyzed, by vehicle classification and within incremented weight ranges to determine an average normal operating temperature range for the specific classification and weight group and the standard deviation. The third portion of the study will have researchers take brake temperatures as they did in the first portion of the study. When the researchers detect a brake temperature that is outside of the average temperature, that truck will be flagged for an inspection by the port of entry safety inspector. The results of the inspection will show whether there is a correlation between the brake temperatures and brake problems.

3.0 Work Plan

The Consultant will assist CDOT forces in the collection of data to determine whether infrared thermometers can detect malfunctioning truck brakes. Following data collection, the raw data will be tabulated and analyzed and a draft and final evaluation report prepared and submitted to CDOT.

Field data will be collected in varying weather conditions to the extent possible depending on time of year. Note that because the fieldwork depends upon inspection schedules this might not be possible in all cases. CDOT and the Consultant will attempt to complete the fieldwork in similar weather conditions to provide the best possible data correlation.

3.1 Collection of Background Data

Data will be collected and compiled from two sources – file (or database) and the field.

The following data will be collected from CDOT and/or POE files for a common study period (specific month or months) to be determined by CDOT.

- Average Daily Traffic (ADT) on eastbound I-70 in the vicinity of Dumont (hourly distribution if available).
- Average Daily Truck Traffic on eastbound I-70 in the vicinity of Dumont (hourly distribution if available).
- Number of runaway truck incidents on runaway truck ramps downstream.
- Number of truck-related accidents at the eastbound port entrance/exit.
- Number of truck-related accidents on eastbound or downstream of Dumont.
- Number of trucks with smoking and/or on-fire brakes entering Port during data collection period.
- Applicable vehicle safety inspection reports.
- Applicable CSP accident investigation reports.

ADT data will be used to set the statistical basis for further analysis and to help identify the most likely hours of the day to conduct the field portions of the study. POE personnel will be contacted to confirm the selected hours of the day and to determine the best days of the week or times of the month to conduct the study (i.e. some periods have higher densities of loaded/unloaded trucks). Those periods with more loaded trucks will be identified for the fieldwork.

The Average Daily Truck Traffic information will be used so the study's sample sizes will be large enough to be statistically significant as compared to the overall truck count.

The number of truck-related incidents at the port terminals or downstream will be used for additional statistical background and/or comparison. Applicable vehicle inspection/investigation reports will likely be used to gain an understanding of critical thresholds for brake condition and temperature.

Because each truck must stop at Dumont, field personnel will be able to take a temperature reading on the wheels of each vehicle passing through the port. Temperatures will be taken on the wheels on both sides of the vehicles. The inspectors will also note the truck classifications (in accordance with the POE truck classification scheme), such as five-axle semi or three-axle single unit etc. In addition, vehicle identification numbers will be recorded so the weight data provided by the port of entry can be matched to the respective vehicle. These will be written down or electronically recorded and tabulated to form the database for the background condition. Also, the time of day, weather conditions, general traffic conditions and if the truck participates in PrePass or not will be noted.

Field personnel will use state-furnished equipment (probably an infra-red "gun" or other temperature reading device not requiring direct physical contact with the vehicle) to obtain brake temperature readings on all trucks passing through the port during the identified study periods. Specific wheels may be identified by CDOT for testing on every vehicle in addition to any that may be visibly smoking. Field personnel will be trained or instructed to take the readings in a consistent manner on all vehicles tested.

It is assumed for the purposes of the attached cost estimate that data collection for the background condition can be collected in no more than four (4) four-hour sessions and that the Consultant will provide two individuals for temperature readings. Additional time for training, travel time and coordination is included in the estimate.

3.2 Review of Background Data

The temperature information will be compiled and sorted by truck classification, axle weight and axle location. The axle weights for each truck classification will be grouped in 5,000-pound increments. This is necessary as the average brake temperature may be greater for a fully loaded truck rather than an empty truck. A statistical analysis will then be performed for each axle. There will be an average mean temperature and one and two standard deviations from the mean. This should provide a range of normal operating temperatures along with highs and lows outside the range.

3.3 Truck Inspection

Using the normal operating brake temperature information, data collectors will return to the Dumont Port of Entry. As in the first part of the study, the field personnel will take temperatures of the truck wheels as they drive over the port of entry scale facilities. If field personnel observe a brake temperature outside of the normal average temperature, they will contact a port of entry truck safety inspector. This truck will then be flagged to undergo a Class 1 safety inspection. The safety inspection will determine if there are any brake problems, among other safety issues. This operation will continue to obtain the proper truck sample size. As in the first part of the study, weight records, wheel temperatures, truck identification, time of day, weather conditions and general traffic conditions will be noted. In addition, a copy of the truck safety inspection report and identification whether the truck is a member of PrePass.

It is assumed for the purposes of the attached cost estimate that data collection for the truck inspection condition can be collected in no more than four (4) four-hour sessions and that the Consultant will provide two individuals for temperature readings and a third to assist with coordination of inspection activities at the POE. Additional time for training, travel time and coordination is included in the estimate.

3.4 Progress Report(s).

The Consultant will prepare a quarterly progress report in accordance with CDOT's Division of Transportation Development, Research Branch Reporting Requirements, which are attached to and made part of this task order, and submit it to the CDOT Project Manager. The CDOT Project Manager will provide the Consultant with a progress report template two weeks prior to the first progress report's due date.

3.5 Evaluation Report.

The Consultant will compile, organize and correlate the collected data. The first part of the study will provide the brake temperature analysis for each axle by vehicle classification by weight group. The second part of the study will analyze the data, and the third part will use the data to select trucks for inspection to see if there is a correlation between temperature and brake functionality. If there is a clear correlation, this will then be a useful tool for truck safety inspectors to screen trucks. It will also provide valuable background information for consideration in case a permanent automated system is developed, and it may also provide data that can be used to approximate the number of trucks operating on this segment of highway that may have brake problems. If there is no correlation between recorded brake temperatures and safety inspections, then the Consultant should provide a section in the final report for "lessons learned". That section shall include any trends observed from the data that were a surprise or did not fit into the general perceptions of the study parameters. In addition the Consultant should include any recommendations or ideas for any future studies that may have applicability within the parameters of this research study scope.

The draft report will be prepared with all required figures, charts, graphs, exhibits and photographs required or requested by CDOT. Five (5) copies of the draft report will be prepared and transmitted to CDOT for review and comment. Following completion of the review period, all applicable comments will be incorporated into the final report. Twenty five (25) copies of the final report (including an electronic copy) will then be prepared and transmitted to CDOT for filing and distribution. The Draft and Final Reports will be prepared in the format required by CDOT's Division of Transportation Development, Research Branch Reporting Requirements, which are attached to and made part of this task order.

4.0 Deliverables

The Consultant will deliver the following products and services during this task order.

- Personnel to collect background brake temperature data at the Dumont POE.
- Analysis showing brake temperature ranges for each axle by vehicle classification by weight group.
- Personnel to collect brake temperature data for safety inspections at the Dumont POE.

- One bound version of all “raw” data collected during the project.
- Quarterly Progress Report(s).
- Five (5) draft copies of the evaluation report.
- Twenty five (25) copies of the final evaluation report.
- Electronic copy of the final evaluation report.

5.0 Schedule

The period of performance for this task order is approximately four months, but could easily require a shorter or longer period depending on the implementation schedule of the Vendor. The approximate dates of significant schedule events shown below are therefore subject to that schedule.

Collection of Background Data	Week 1 – Week 2
Review of Background Data	Week 2 – Week 3
Truck Inspection	Week 4 – Week 6
Draft final evaluation report	Week 7 – Week 10
CDOT review	Week 11 – Week 13
Draft final report preparation	Week 14
CDOT review	Week 15
Final report preparation	Week 16

6.0 Costs

All work will be completed in accordance with the existing professional services contract in place between CDOT and WI. The total costs to provide the work outlined herein will not exceed $28,324.48 without written approval from CDOT.

7.0 Notice to Proceed

No work identified in this task order will begin until CDOT issues the Consultant a written Notice to Proceed. CDOT will not be responsible to pay for any work related to this task order that is performed by the Consultant prior to issuance of a written Notice to Proceed.