



US Department  
of Transportation

Federal Railroad  
Administration

# Research Results

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## Evaluation of the Brake Piston Travel Sensor System

### SUMMARY

The Federal Railroad Administration (FRA) successfully concluded its research project to study and measure air brake piston stroke and provide data wirelessly to the locomotive engineer. FRA's Office of Research and Development funded this four-phase project. A remote sensing mechanism was developed to determine whether the air brakes were applied on railroad freight cars or whether foreign debris is caught between the brake shoe and the wheel of the rail car. Measuring the piston stroke and relaying that measurement to the locomotive engineer in real time will help improve brake efficiency and the overall safety of railroad transportation.

Extensive research was conducted to evaluate the appropriate sensor and communication method to measure air brake piston travel. Several sensors were evaluated including piezoelectric films, fiberoptics, Hall Effect, as well as proximity sensors, while considering the challenging railroad environment and cost before selecting the appropriate sensor. In the first phase, a prototype sensor system was developed and installed for a New York Air Brake-type brake cylinder on a Norfolk Southern freight car, as seen below in Figure 1. In subsequent phases of the project, a system for Wabtec and TMB-type air brakes was developed and sensors were installed for four hopper cars on Southern Company cars for the FRA's Advanced Concept Train program. Another system will be designed and installed on three hopper cars, one container car, and one tank car in Chicago.

A sensor was successfully installed to measure brake piston displacement, which is determined when the brakes are applied and the status is relayed to the locomotive engineer, via the On-board Monitoring and Control System (OBMCS). The results of this project will demonstrate the cost effectiveness and safety benefits of remotely measuring brake piston travel.



Figure 1. Brake piston travel sensor arrangement.

The overall goal was to improve railroad safety by determining the status of the air brake system during inspection and operation. The railroad industry does not have such a mechanism to determine whether the air brakes are applied effectively in real time. A physical inspection of the air brakes on each car could provide the status of the brakes. However, that method is time consuming, requires physical access to each car, and may place the inspector at risk while conducting a physical examination of each brake piston.

In lieu of the cumbersome, physical inspection practice, FRA sought a way to electronically assess brake performance and provide the information to the locomotive engineer in real time.

## BACKGROUND

FRA has had an interest in studying the effects of monitoring critical railroad operating components for many years. One of these components was the air brake piston displacement system. The inability to assess braking capacity poses an obvious safety problem to the railroad industry. Currently, the brakeman physically inspects the brakes before the train leaves the yard. Human factors errors may lead to incidents. Railroads want to be aware of probable brake problems and potential brake failure. FRA recognized this need and developed a system to address the brake piston travel issue.

FRA recognized that a remote monitoring system, which could determine the status of the air brakes and relay that information to the locomotive engineer, should be evaluated. FRA supported the development a prototype system.

## OBJECTIVES

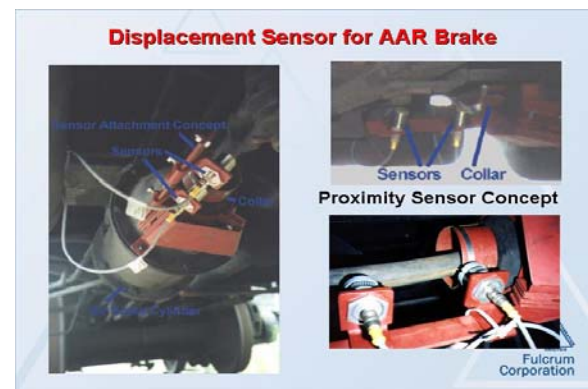
FRA's goals included finding an appropriate sensor, developing the monitoring system, and providing useful information to the locomotive engineer regarding braking status. In addition, FRA believed that an effective monitoring system

would lower maintenance costs, because preventive maintenance is typically less expensive than replacement or damage due to total brake failure.

## METHODS

This research was conducted in four phases. Phase I involved developing and installing a prototype system on a New York Air Brake-type braking system. Information was researched and reviewed on various sensors for placement on the air brakes. The information gathered addressed cost, power requirements, operating temperature, input requirements, and other relevant variables.

Phase II continued the evaluation of sensors. Four types of sensors were evaluated (i.e. linear displacement, magnetic, fiberoptic, and laser). Communication devices to relay the status to the locomotive engineer were also evaluated.



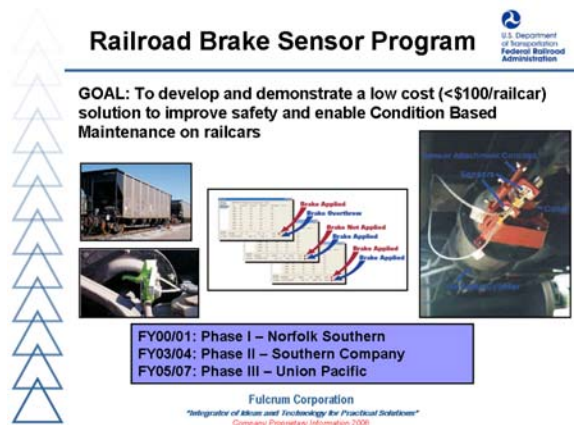
**Figure 2. Brake piston travel indicator and sensors installed on freight car.**

In Phase III, the brake piston travel sensor system was installed on a railroad freight car, as shown in Figure 2, and for a revenue service demonstration on Norfolk Southern Railroad. The system performance was evaluated.

Phase IV involved the design of sensors for two different types of air brakes, that were installed on three Union Pacific hopper cars, one container car, and one hazardous tank car. Phase IV is ongoing with the goal of making the sensors more flexible and accurate.

## FINDINGS

This research involved component evaluation and system design as well as installation and testing.



**Figure 3. Screen shot of brake sensor system program overview.**

FRA believes the results of the research conducted were positive and will improve safety. Despite the challenges of the railroad environment to sensor operation and the relay of the collected data, a prototype system was developed that met the objectives and goals, as noted in Figure 3 above.

Complex issues were encountered concerning the effects of the railroad environment on the sensors. When placed under rail cars, the sensors were subject to debris, significant variance in temperature, as well as contact with snow, dust, water, and oil. The system design had to be rugged and useful in all weather conditions. Additionally, challenges had to be resolved regarding wireless transmission on trains potentially 2 to 3 miles long where sight distance was often obstructed by the topography of the land.

There was also consideration of the impact of the system sensors on existing hardware to ensure the current method of checking piston travel was minimally impacted by the research being conducted.

### ACKNOWLEDGEMENTS

FRA wants to acknowledge the participation of various organizations and key people who contributed to the success of this project.

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### KEYWORDS

Brakes, Hall Effect Sensors, Norfolk Southern, Southern Company, Union Pacific

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