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TESTING ALGORITHMS FOR A PASSENGER TRAIN BRAKING PERFORMANCE MODEL

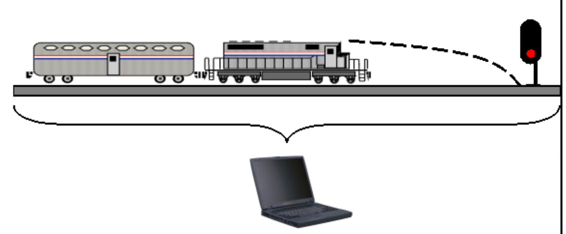
SUMMARY

The Federal Railroad Administration's Office of Research and Development funded a project to establish performance model to develop, analyze, and test positive train control (PTC) braking algorithms for passenger train operations. With a good braking algorithm to predict accurate stopping distances from PTC system enforcement, railroad operational efficiency will not be degraded.

Previously, researchers used computer simulations supplemented with limited field testing track to find an approach to evaluate PTC braking enforcement algorithms for freight train operations. This approach has shown the potential to drastically reduce development time and costs for the freight sector. It also facilitates use of a greater variety of enforcement scenarios to be tested. A similar approach is envisioned for use in the development and evaluation of PTC braking enforcement algorithms for passenger trains.

As was shown in related freight train system testing, an adequately detailed model of the braking system is essential to ensure that the goals of PTC can be met and that required safety levels can be achieved. It is noted that simulation software capable of modeling braking performance for passenger trains, including sufficient detail of the characteristics of the air brake systems and the effects of varying wheel-rail adhesion conditions, is not yet available.

The first phase of work focused on three specific tasks: (1) developing the requirements for the passenger air brake control valve and



Improved PTC Enforcement Braking Performance for Passenger Train Operations through Computer Modeling

associated model components; (2) surveying passenger and commuter agencies in the United States to determine what brake system hardware they currently use; and (3) establishing a plan to develop the brake system model components and passenger train brake model.

Given the urgency of implementing PTC within mandated deadlines (2012 in California and 2015 elsewhere), the Transportation Technology Center, Inc., was also tasked with evaluating whether an empirical model could be developed and ready to use in less time than the development of a more detailed, scientifically pure model.

Output from this effort includes a requirements specification document for design of a passenger train braking performance model. The report also includes a summary of the survey of passenger operators on braking hardware currently in use.

One conclusion of the project is that a stand-alone model focused on passenger braking systems would be the best and most easily available tool for industry use. A list of proposed steps of how to move the effort forward was also submitted.

BACKGROUND

Positive train control (PTC) is a rapidly emerging technology intended to enhance the safety of train movements. A requirement for the installation of PTC within rail infrastructure has been made by the Department of Transportation, Federal Railroad Administration, as mandated under the Rail Safety Improvement Act of 2008, for certain passenger, freight, and mixed train operations. Safety will be improved with the installation of onboard systems capable of accurately predicting the stopping distance of trains and applying the brakes automatically as an action of last resort if an engineer fails to act.

As a related benefit, the technology might also improve train performance and throughput capacity when future generation systems are fully developed. However, current predictive braking enforcement algorithms force trains to initiate braking to an upcoming stop or lower speed limit "target" considerably sooner than conventional train handling practices, resulting in increased operating time and reduced line capacity.

Therefore, a braking enforcement algorithm capable of protecting targets without unnecessarily interfering with railroad operations is critical to the successful implementation of PTC. An approach for developing and evaluating the performance characteristics of an enforcement algorithm through the use of computer simulations, supplemented by limited field testing on track, has shown the potential to drastically reduce development time and costs for PTC efforts related to freight equipment. It also facilitates a greater variety of enforcement scenarios to be tested.

To develop and evaluate enforcement algorithm logic for freight trains, a braking performance simulator, an essential component of the methodology, was needed that incorporated an adequately detailed model of the braking system to ensure that the proper safety levels and goals of PTC are met.

Simulation software capable of modeling braking performance for passenger trains, including sufficient detail of the characteristics of the air brake systems and the effects of varying wheel-rail adhesion conditions, is not currently available. Use of existing freight braking performance models for passenger applications is not sufficient, except in specific cases where passenger equipment is run with a single-pipe, freight-like configuration.

There are numerous differences between the brake systems of freight and passenger equipment. To begin, freight equipment typically uses a single air line system for both control and supply, whereas typical passenger equipment uses two separate air lines for the brake system. One line is used for control (brake pipe) with the other used for air supply (main reservoir pipe).

In simple terms, this allows the operator the ability to have controlled or graduated release of the brakes on passenger equipment, which is not available on freight equipment, other than on electronically controlled pneumatic applications.

In addition, it limits the opportunity for the operator to inadvertently run short of air within the train. In many cases, passenger equipment can also be used with single-line freight systems, but performance and capability is limited to that of a freight train braking system. The two-line system capability does, however, lead to significant differences within the control valve between freight (generally AB-type) and passenger (generally 26C or KE) equipment.

In addition to the differences in the operation of the control valves, other differences between freight and passenger braking systems include the ability for automatic blended braking of dynamic brakes and air brakes, combination disc and tread brakes, variable (proportional) load sensors, and wheel slip control systems to help optimize braking performance during low and variable adhesion conditions.

These details need to be accounted for properly to make the simulations accurate.

OBJECTIVES

This multiphased project is being performed to develop a train braking performance model for passenger trains with sufficient detail for use in the development and testing of a PTC enforcement algorithm.

Phase I work identifies the requirements and level of detail (determine specific items that need to be included) required for each of the model components to satisfy the overall model requirements needed for PTC enforcement algorithm development and testing for passenger trains.

METHODS

The effort described here is limited in scope to Phase I work tasks only. The approach for Phase I (identification of the requirements) was broken into three primary tasks: (1) survey the passenger and commuter rail industry to verify the most commonly used types of brake systems and hardware; (2) identify the brake system model components and level of detail required, based on the application requirements and the results of the industry survey; and (3) develop an approach for the next phase of work.

RESULTS

Results of Phase I include the generation of a requirements document for a passenger braking model. The model is envisioned as a stand-alone tool, incorporating the specific elements listed within this document. All of those are recognized to be necessary in order for the model to meet the needs of PTC program goals for passenger equipment.

The final report includes a summary of findings from the industry survey on braking equipment. Only 4 of 28 surveys were sent to passenger operators were returned; however, the general information provided helped solidify a path moving forward for the model to focus the effort on known types of control hardware and control systems. Many details about braking systems were also included that will help guide the effort.

CONCLUSIONS

The conclusion of this effort is to move forward with development of a stand-alone passenger braking model.

FUTURE ACTION

With the ongoing widespread implementation of PTC across both passenger and freight systems, as well as the idea that passenger (including commuter) equipment commonly interacts with freight operations, both types of equipment require accurate simulation models. Today, no readily available models represent the many types of passenger equipment in use with sufficient accuracy for PTC algorithm development needs. However, a significant effort is under way in which freight equipment and operations are being modeled with proven tools. With those considerations, it becomes clear that there is a need for a stand-alone passenger system braking simulation model to meet upcoming PTC implementation.

This work has produced the following recommendations: (1) develop a stand-alone passenger train braking performance model capable of calculating longitudinal passenger train response for use as an evaluation/ development tool for passenger PTC applications; (2) pursue a fluid dynamics model of the air brake system that will have the ability to accurately model not only the air-brake equipment but also the interface to variable load sensors and wheel slide control systems; and (3) develop the model to include the most common types of passenger equipment in operation today, with the ability to add additional components in the future, as necessary or possible.

A separate full report covers the results of the industry survey on passenger equipment, the requirements document for the proposed stand-alone braking model, and the decision process used in generating these conclusions.

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KEYWORDS

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