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Train Handling Prior to Undesired Emergency Brake Applications in Cold Weather

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Summary

Transportation Technology Center, Inc. (TTCI) has found that only a minority of the undesired emergency brake applications (UDEs) evaluated in a study of locomotive event recorder (ER) files fit the historically accepted scenario of a problematic valve overreacting to a service brake application. This statement is valid whether the ambient temperatures are above or below the freezing temperature of water. TTCI is conducting a root cause analysis of UDEs under the Association of American Railroads' Strategic Research Initiative on Improved Brake System Performance.

Two major railroads contributed ER files from a total of 212 UDEs that occurred in January 2016 on trains in motion. These cases were compared to 200 UDEs that took place in the summer of 2015. These events were presumably initiated by a control valve on a freight car due to a cause other than an air hose separation. Regardless of temperature, the majority of UDEs analyzed did not occur in response to a service brake application. In the majority of the UDEs that occurred while the train brakes were released, the throttle and dynamic brake commands in the 30 seconds prior to the UDE indicate at least the possibility of a slack action event that could have been a contributing factor in the UDE.

UDEs have long been a widespread problem in the rail industry; the consequences of which include increased fuel expenses, increased wear and tear on braking equipment, schedule disruptions, and in some cases, damage to rolling stock and derailments. Colder weather can freeze condensation in the brake pipes, leading to unforeseen consequences to the braking system.

TTCI's future work will focus on conducting carefully controlled service stability testing under a variety of environmental conditions on brake control valves removed from cars that are suspected to have caused UDEs while in service.

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INTRODUCTION

Through a manual evaluation of locomotive event recorder (ER) files, TTCI is investigating the train conditions present at the time of the UDE to gain an improved, quantifiable understanding of UDE root causes. The analysis in this *Technology Digest* pertains specifically to UDEs initiated by brake control valves on freight cars in motion and how colder weather affects UDEs.

For decades, UDEs have been a problem in freight railroads and cause increased fuel expenses, increased wear and tear on braking equipment, schedule disruptions, and in some cases, damage to rolling stock including derailments. Cold weather can change the physical properties of the system and lead to condensing moisture in the brake pipes, which can freeze in cold weather.

BACKGROUND

In the late 1980s, Association of American Railroads (AAR) conducted extensive research and published a series of reports examining the causes and mitigation methods for UDEs as summarized in a previous *Technology Digest*.[1] This work produced several findings. First, UDEs are very elusive and may be difficult to replicate in laboratory or field tests. Most UDEs were found to be caused by fluctuation of brake pipe pressure due to slack action associated with train handling. Trains with many cars and/or a long travel draft systems are more likely to experience a UDE, but not as likely in double-stack trains. It was also found that below 32°F condensing moisture in the brake pipe may contribute to UDEs.

Since the publication of this work, publically available documents describing additional UDE research have been limited. Improvements have been made in the design of brake control valves with the goal of making them less prone to UDEs. Older style valves can receive stabilization retrofits and the AAR's Single Car Air Brake Test[2] can help to identify unstable control valves. Recently, as part of the AAR's Asset Health Strategic Initiative, railroads are sending consist lists of trains that experience UDEs to Railinc so that suspect cars that repeatedly appear in multiple trains with UDEs can be identified and investigated.[3] Despite the improvements brought about by these changes, the UDE problem persists in the industry.

METHODOLOGY

Increased computerization of railroads has made collection and analysis of data from locomotive ERs easier and more cost-effective. Onboard data from a large number of trains can be processed and potentially used to identify and quantify conditions associated with UDEs without some of the difficulties and expenses associated with field tests.

The ER data used in this study was collected during January of 2016 by two Class I railroads, to be referred to as "RR A" and "RR B." The warm weather cases used for comparison were obtained during the summer and early autumn of 2015 from the same railroads.[1] Instances of UDE were identified by the railroad personnel and relevant ER data files, as well as the approximate time of UDEs, were transmitted to TTCI. The conditions of the train prior to the UDE were examined to gain some quantifiable understanding about the conditions under which UDEs occur. The UDEs that occurred in freezing weather were then compared to UDEs in warmer weather to determine if the freezing moisture in the brake pipes contributes to UDEs. The study focused on UDEs caused by freight cars, as opposed to issues with the power or end-of-train devices.

Data analysis was accompanied by a number of challenges as described previously[1] including one sample per second ER data resolution, which did not allow quantifying brake pipe pressure changes over very short time durations that may potentially have caused UDEs on cars near the controlling locomotive.

A total of 212 new ER files (50 from RR A and 162 from RR B) were analyzed and compared to the 200 ER files gathered in the summer of 2015. Each UDE considered in this study was presumably initiated by a control valve on a freight car due to a factor other than a sudden and complete brake pipe leak via air hose separation or other brake pipe failure. Analyzed variables included train speed, brake pipe pressure prior to UDE, time from the last service brake application, air flow through the brake pipe, throttle and dynamic brake use patterns prior to the UDE, occurrence of multiple UDEs in a row, and other relevant observations. Temperature data was obtained through wunderground.com's historical weather data of the closest location and time to the actual event. This was usually data from the nearest airport within an hour of the event.

RESULTS

Each UDE was classified as to the status of the train brakes by reviewing the time history of the brake pipe pressure immediately prior to the UDE. Figure 1 shows the service brake application status of each UDE from January 2016 segregated by railroad and the combined sum of both railroads. Only a minority (38 percent) of the UDEs analyzed fit the historically accepted scenario of a problematic valve overreacting to a service brake application.

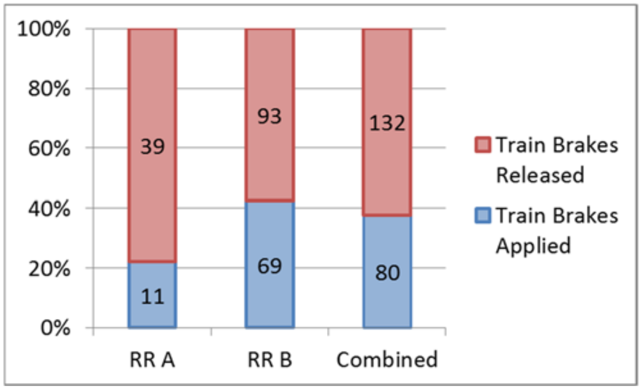

Figure 1. Train Brake Status Immediately Prior to UDE

The UDEs were sorted into two groups: 33 UDEs from January that occurred at a temperature below 32°F and 179 UDEs from January that occurred over 32°F. These two groups were compared to 200 UDEs from summer 2015 when no cases took place in freezing temperatures. Figure 2 compares these groups and shows how freezing temperatures may affect the percentage of UDEs occurring due to a valve overreacting to the service brake application. Chi-square analysis shows no statistical difference with respect to temperature.

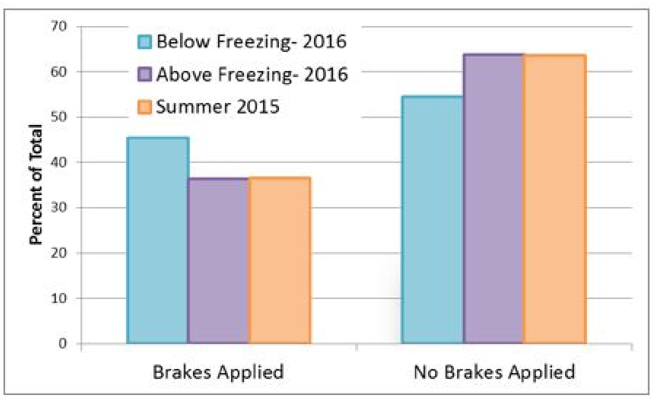

Figure 2. Effect of Cold Weather on UDE Base Cause

Figures 3 and 4 further explore the cases of the January 2016 UDEs in which train brakes were applied immediately prior to UDEs. Figure 3 shows the duration of time the train brakes were applied prior to UDE. Seventy-two out of the 80 UDEs (90 percent) shown in Figure 2 occurred within the first 20 seconds of the service brake application, indicating that the service brake application was the most likely initiating cause of the UDE. The median time between the initiation of a service brake application and the UDE was 8 seconds for RR A and 10 seconds for RR B. This includes the time necessary to propagate the service brake pipe pressure reduction to the car that triggered the UDE and the time for the emergency brake pipe pressure reduction to propagate to the locomotive or the end-of-train device. If the pressure signal propagates at a rate of approximately 1,000 feet per second,[4] the median location of the car causing the UDE would be approximately 4,000 to 5,000 feet behind the lead locomotive. There was no significant difference in brake duration or magnitude due to freezing temperatures.

Figure 4 shows the magnitude of the brake pipe pressure reduction prior to the UDE. The majority of these instances occurred during a minimum service application of 7 psi or less. None of the UDEs appeared to be associated with the recharging of the brake pipe to release a service brake application, as has been suggested previously.[4]

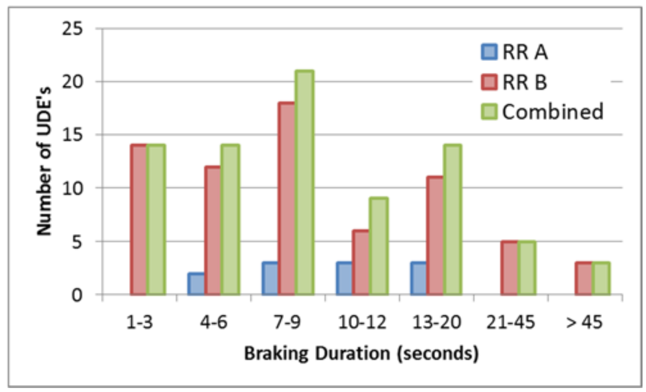

Figure 3. Train Brake Duration Immediately Prior to UDE

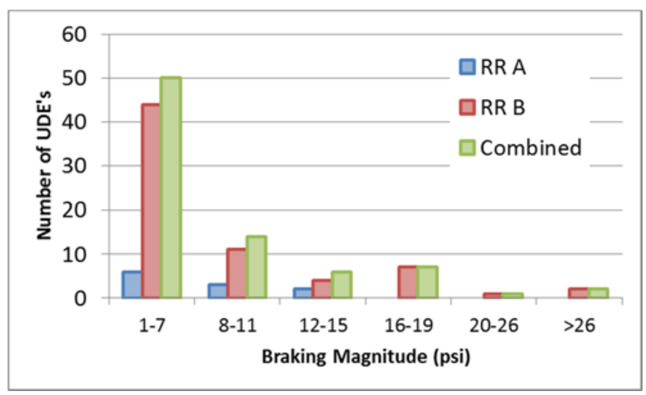

Figure 4. Train Brake Magnitude Immediately Prior to UDE

For the UDEs not accompanied by a service brake application, the train handling in the 30 seconds prior to the UDE could provide useful information about the root cause of the UDE. Slack action can create short duration pressure changes in the brake pipe due to the momentum of the air in the brake pipe. Such pressure changes have been suggested as a root cause of UDEs.[4] Slack action can also potentially cause UDEs by causing or relieving kinks in end hoses (and intermediate hoses depending on the end arrangement) in trains with leakage in the brake pipe thereby producing rapid pressure changes. Figure 5 shows the trend of the throttle and dynamic brake for UDEs that were not accompanied by a service brake application. The “Train Start” category is intended to represent trains that have released brakes and have just started moving. The “Other” category represents trains that had been in idle for at least 30 seconds prior to UDE, plus a few cases with ER files missing dynamic brake data. Figure 6 is a higher level summary of the throttle and dynamic brake data displayed in Figure 5.

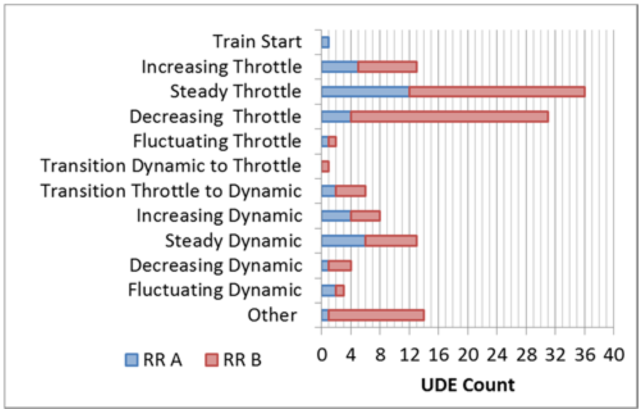

Figure 5. Throttle and Dynamic Brake Movements before UDE

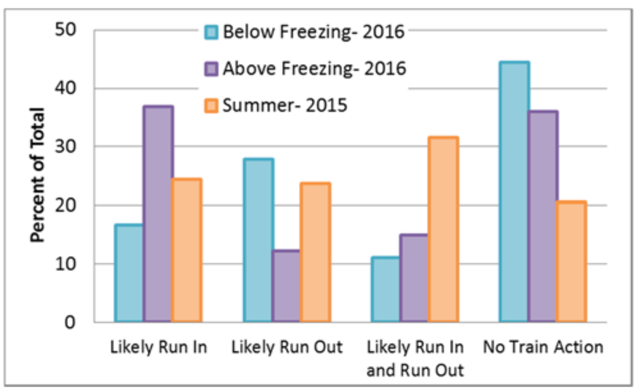

Figure 6. Probable Slack Action before UDE

January 2016 data results, compared to UDE data from the summer, show the most likely slack action scenarios are applied to each category of throttle and dynamic brake actions. Perhaps the most notable category here is the “No Train Action” containing UDEs where the throttle or dynamic brake were applied in the same setting for an extended period of time prior to UDE. Although chi-square analysis shows statistical difference overall with the data shown in Figure 6, no statistical difference is found when comparing the percentages associated with the “Below Freezing-2016” to the percentages associated with the data collected during warmer weather.

Some discrepancies exist between how the January and summer data were analyzed. For the summer 2015 UDEs not accompanied by a service brake application, throttle and dynamic brakes were analyzed 60 seconds before the UDE with more emphasis on the final 30 seconds, whereas analysis of handling commands for the January UDEs were strictly limited to the 30 seconds prior to the UDE. This may have increased the number of “No Train Action” cases, due to the fact that the throttle and dynamic brake are more likely to be constant for 30 seconds before the UDE than for 60 seconds.

CONCLUSION

TTCI conducted an analysis of ER files from UDEs occurring on moving trains, presumably initiated by a control valve on a freight car due to a cause other than an air hose separation. The ER files were recorded over a variety of ambient temperatures from two different time periods and two different railroads. The analysis showed the following:

- A minority of the UDEs analyzed fit the historically accepted scenario of a problematic valve overreacting to a service brake application.
- The majority of UDEs that occurred in the absence of service braking showed at least the possibility of train slack action immediately prior to the UDE.

FUTURE WORK

TTCI is collecting brake control valves for carefully controlled service stability testing under a variety of environmental conditions.

REFERENCES

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4. Carlson, Frederick G. and Dale E. Limbert. “Undesired Emergency Brake Applications. Causes and Recommendations.” Research Report R-756. AAR Technical Center, Chicago, IL. August 1990.