TECHNOLOGY DIGEST
TIMELY TECHNOLOGY TRANSFER

TD-16-019
©JUNE 2016

The work described in this document was performed by Transportation Technology Center, Inc.,
a wholly owned subsidiary of the Association of American Railroads.

Train Handling Prior to Undesired Emergency Brake Applications in Warm Weather

Scott Cummings and Alexander Keylin

Summary

Transportation Technology Center, Inc. (TTCI) has found that only a minority (36 percent) 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. 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 200 UDEs that occurred in warm weather on trains in motion. These events were presumably initiated by a control valve on a freight car due to a cause other than an air hose separation. In the instances involving the train brakes, the UDE typically occurred immediately after the initiation of a minimum service application. The train brakes were released at the time of the UDE in the other 64 percent of cases analyzed. In 80 percent of the UDEs that occurred while the train brakes were released, the throttle and dynamic brake commands in the 60 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. There is a general understanding of likely causes of UDEs, but many questions remain unanswered. Specific variables and their combinations leading to UDEs prove difficult to quantify. Previous studies have shown discrepancies between tests in laboratory conditions, field tests, computer modeling, and general observations.

TTCI's future work will focus on ER files downloaded from trains in colder weather to evaluate any differences in train conditions contributing to UDEs. Carefully controlled service stability testing under a variety of environmental conditions will be conducted on brake control valves removed from service.

Please contact **Scott Cummings (719) 584-0739** with questions or concerns regarding this *Technology Digest.* E-mail: scott_cummings@ttci.aar.com.

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 during warm weather incidents while the train is in motion.

For decades, UDEs have been a problem in freight railroads. UDEs often result in increased fuel expenses, increased wear and tear on braking equipment, schedule disruptions, and in some cases, damage to rolling stock including derailments. Some causes of UDEs are relatively well researched. Cars with defective brake control valves, informally known as “kickers” or “dynamiters,” are prone to initiating UDEs. Other UDEs are caused by air hose separation and can be seen as desirable brake applications resulting from an undesirable condition.[1] However, there are many UDEs that cannot be traced to such obvious equipment malfunctions; those can be particularly difficult to research and to mitigate.

BACKGROUND

In the late 1980s, Association of American Railroads (AAR) conducted extensive research and a series of reports examining the causes and mitigation methods for UDEs.[1-6] Key findings of these studies were:

1. UDEs are very elusive and may be difficult to replicate in laboratory or field tests.
2. Most UDEs are caused by a combination of fluctuation of brake pipe pressure and quick service activity of normal service brake application. Air brake control valves do not have to be defective to initiate UDEs under these conditions.
3. The Repair Track Air Brake Test cannot reliably detect defective control valves that are capable of causing UDEs. A new test procedure should be implemented.
4. Fluctuation of brake pipe pressure may be caused by the slack action associated with train handling. Field tests showed that slack action combined with service brake application was capable of producing short-duration pressure changes that were slightly below the rates which resulted in emergency applications in laboratory conditions. It is possible that the field tests failed to produce UDEs because the test consist was too short (32 cars).
5. Slack action is more severe in trains containing many cars with long travel draft systems, such as end-of-car cushioning. Such trains are probably more susceptible to UDEs. Also, UDEs are very rare in articulated double-stack trains, which are less prone to slack action. However, any car may be capable of producing UDEs under the right conditions.
6. At ambient temperatures close to 32°F, condensing moisture in brake pipes may contribute to the UDEs, but more research is necessary.
7. AB, ABD, and ABDW control valves should be modified to become less sensitive to small, abrupt pressure changes.

Since the publication of these reports, publically available documents describing additional UDE research have been very limited. However, improvements have been made in the design of brake control valves with the goal of making them less prone to UDEs. In addition, stabilization retrofits are available for older style valves (ABDS and ABDWS emergency portions). The Single Car Air Brake Test[7] was codified by AAR in 1991 and includes a test of the service stability of the control valves by venting brake pipe pressure through a 0.1360-inch diameter orifice for cars with up to 75 feet of brake pipe, or a 0.1875-inch diameter orifice for cars with more than 75 feet of brake pipe. 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.[8] 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 the summer and early autumn of 2015 by two Class 1 railroads, to be referred to as “RR A” and “RR B.” Instances of UDE were identified by the railroad personnel and relevant ER data files, along with the approximate time of UDEs, were transmitted to TTCI. The intention was to examine the conditions of the train prior to the UDE to gain some quantifiable understanding about the conditions under which UDEs occur. The focus was on UDEs caused by freight cars, as opposed to issues with the power or end-of-train device.

Data analysis was accompanied by a number of challenges:

1. Different locomotives used different ER models. Thus, data format and number of recorded parameters between the data files varied. This required manual review of each ER file rather than automated data processing.
2. UDEs were not always easily identifiable in the data. For example, a sudden drop in brake pipe pressure reading was not necessarily associated with a UDE and

could be caused by other conditions, especially at zero speed during switching operations. For this reason, only data files with clearly distinguishable UDEs at speeds greater than 0 mph were selected for further analysis. In some of these files, multiple UDEs were identified.

3. Data resolution was one sample per second, 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 200 ER files (89 from RR A and 111 from RR B) were analyzed. Each UDE considered in this study occurred at a train speed greater than 0 mph and 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.

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 segregated by railroad and the combined sum of both railroads. Only a minority (36 percent) of the UDEs analyzed fit the historically accepted scenario of a problematic valve overreacting to a service brake application.

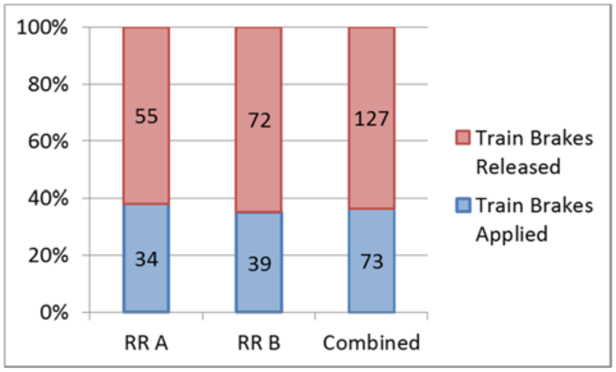

Figure 1. Train Brake Status Immediately Prior to UDE

Figures 2 and 3 further explore the cases in which train brakes were applied immediately prior to UDEs. Figure 2 shows the duration of time the train brakes were applied prior to UDE. Fifty-nine out of the 73 UDEs (81 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 9 seconds for RR A and 8 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[1], the median location of the car causing the UDE would be approximately 4,000 to 4,500 feet behind the lead locomotive.

Figure 3 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.[1]

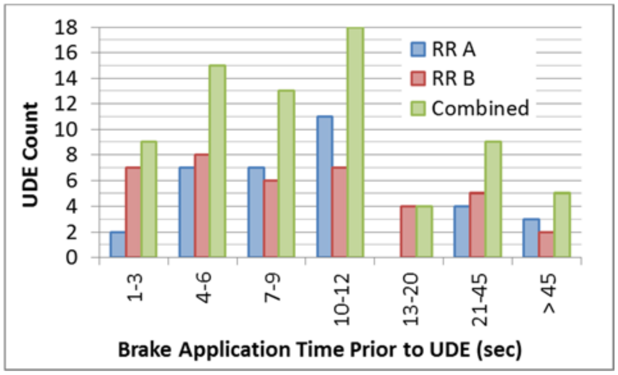

Figure 2. Train Brake Duration Immediately Prior to UDE

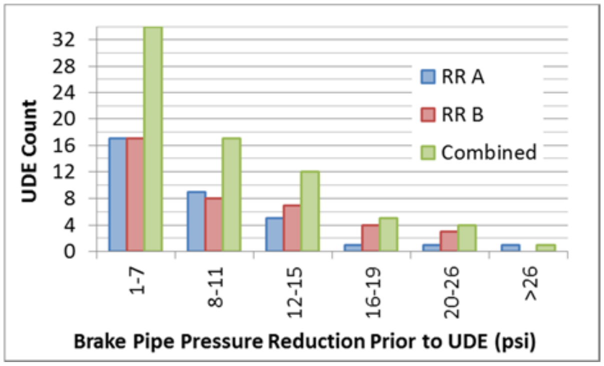

Figure 3. Train Brake Magnitude Immediately Prior to UDE

For the UDEs not accompanied by a service brake application, the train handling in the 60 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.[1] Figure 4 shows the trend of the throttle and dynamic brake for 127 UDEs not accompanied by a service brake application.

The “Train Start” category is intended to represent trains that have released the brakes and have started to move just prior to the UDE. Throttle control in the “Train Start” cases includes steady throttle and fluctuating throttle. The "Other" category represents trains that had been in idle for at least 20 seconds prior to UDE, plus two incidents in which the dynamic brake appeared to be applied but the ER file did not contain information about the dynamic brake setting.

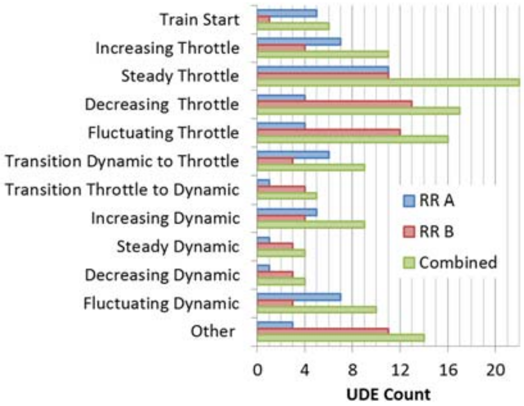

Figure 4. Throttle and Dynamic Brake Movements before UDE

Figure 5 is a higher level summary of the throttle and dynamic brake data displayed in Figure 4. Here the most likely slack action scenarios are applied to each category of throttle and dynamic brake actions. For example, the "Likely Run-In" category contains data from instances of decreasing throttle, increasing dynamic brake, and transition from throttle to dynamic brake. Perhaps the most notable category here is the "Likely No Significant 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.

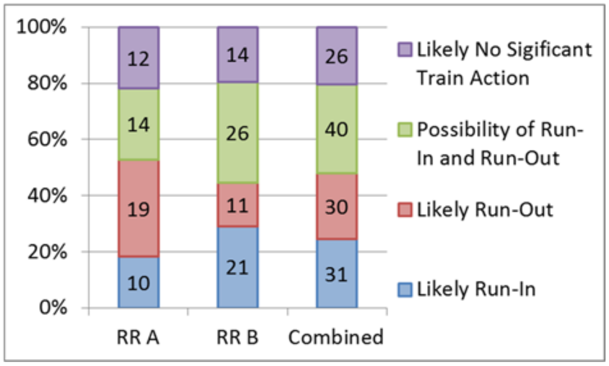

Figure 5. Probable Slack Action before UDE

CONCLUSION

An analysis of 200 ER files from UDEs, occurring in warm weather on moving trains, presumably initiated by a control valve on a freight car due to a cause other than an air hose separation showed the following:

- Only a minority (36 percent) of the UDEs analyzed fit the historically accepted scenario of a problematic valve overreacting to a service brake application. In these instances, the UDE typically occurred while a minimum service application was being applied.
- The train brakes were not involved in the other 64 percent of UDEs analyzed. In 80 percent of these instances, the throttle and dynamic brake commands in the 60 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.

FUTURE WORK

TTCI will conduct a similar investigation of ER files downloaded from trains in colder weather to evaluate any differences in train conditions contributing to UDEs.

In addition to the ER analysis, TTCI is collecting brake control valves for carefully controlled service stability testing under a variety of environmental conditions.

References

1. Carlson, Frederick G. and David E. Limbert. 1990. "Undesired Emergency Brake Applications. Causes and Recommendations." AAR Report No. R-756. AAR Technical Center, Chicago, Illinois.
2. Carlson, Fred G. and David G. Blaine. 1986. "Undesired Emergency Brake Application Study–Interim Report." AAR Report No. R-612. AAR Technical Center, Chicago, Illinois.
3. de Leon, Michael H. and David E. Limbert. 1990. "MOVPIPE – The Moving Brake Pipe Simulation Model: Analysis and Development." AAR Report No. R-755. AAR Technical Center, Chicago, Illinois.
4. Wilson, Frank S. and David E. Limbert. 1991. "A Computer Model of Freight Train Exhaust Valves." AAR Report No. R-757. AAR Technical Center, Chicago, Illinois.
5. de Leon, Michael H. and David E. Limbert. 1990. "A Computer Model of a Freight Train Brake Pipe." AAR Report No. R-759. AAR Technical Center, Chicago, Illinois.
6. Carlson, Frederick G. 1990. "Undesired Emergency Brake Applications. Transportation Test Center UDE Tests." AAR Report No. R-761. AAR Technical Center, Chicago, Illinois.
7. AAR *Manual of Standards and Recommended Practices*. Section E. Brakes and Brake Equipment. "Code of Air Brake System Tests for Freight Equipment – Single Car Test." Standard S-486. Adopted 1991. Last Revised 2013.
8. *AAR Maintenance Advisory* MA-0146. 2015.