AUTOMATED BRAKE TESTING AND THE BENEFITS OF FOUR PRESSURE TEST

Karen J. Carriere
Wabtec Corporation, Manitoba, Canada

Edward W. Gaughan
B.Sc. Eng.
Wabtec Corporation, Pennsylvania, USA

1.0 SUMMARY
Reliability and increased asset utilization has been the focus of railroads, particularly in heavy haul operations. North American maintenance principles have shifted from time based criteria to condition based criteria with periodic testing. The ability to accurately test, diagnose and repair the brake system of a freight car has obvious benefits to maintainers and operators. The deficiencies and subjectivity of manual testing has given way to the introduction of Automated Single Car Testing. This paper will review the benefits of automated single car testing. Data will be presented analysing brake equipment failure modes.

2.0 INTRODUCTION
The primary focus will be on the criteria of the four pressure test and the operational benefits associated with this method.

3.0 NOTATION
AAR – Association of American Railroads
ASCTD – Automated Single Car Test Device
ECP – Electronically Controlled Pneumatic Brakes
S-486 – CODE OF AIR BRAKE SYSTEM TESTS FOR FREIGHT EQUIPMENT—SINGLE CAR TEST 2013

4.0 HISTORY
The testing of air brakes in North America has experienced a prolonged metamorphosis, dating back to the 1930’s. The manual single car test device in use today is virtually identical to the 1930 configuration – see Figure 1.

4.1 Cause for Attention
The current parameters that govern the requirements for performing a single car test are as follows.

- Class 1/No. 1 test failure
  - No-set or Fails to release (or obvious defect)

- On line defect/failure
  - brakes cut-out, car set-out
  - Test according to AAR Field Manual, Rule 3, Chart A

- Periodic testing
  - AAR Field Manual, Rule 3, section A - over date

5.0 SINGLE CAR TEST
The Single Car Test is structured to determine the overall fitness and function of the brake system. In North America the testing requirements are spelled out in detail.
out in AAR Standard S-486 for the manual single car test [1]. SCT failure modes can be generally categorized as three basic types; Leakage, Functional and Measurement.

Leakage
- Brake Pipe Leakage
- System Leakage
- Brake Cylinder Leakage

Functional
- Service Stability
- Minimum Application/Quick Service Limiting Valve
- Positive Release
- Empty/Load
- Accelerated Application Valve
- Manual Release Valve
- Emergency Sensitivity / Equalization Pressure

Measurement
- Piston Travel
- Slack Adjuster Function

To accomplish the test the operator is required to perform the tests in the correct sequence, interpret the results, determine correct and efficient troubleshooting techniques and affect the correct repair.

Manual execution utilizing the manual test device is hampered by two factors:

1. Access into the car brake system is limited to only the brake pipe and brake cylinder pressures, through an end hose and an analog test gauge.

2. The execution of the test as well as the observation and interpretation of results are all prone to variations and subject to human error.

Our field studies involving the careful observation of present single car testing methods have revealed a number of problems. While efforts and intentions seem almost universally diligent, the manual single car test device and the conventional test procedure have certain inherent limitations:

- Correct testing is sufficiently complex as to require considerable training and experience, and because of this many operators appear to have some room for improvement.
- There are variations in test procedures as they are actually carried out.

It is not unusual for testers to misinterpret test results and to either overlook valve malfunctions or erroneously replace properly operating valve portions. There is considerable trial and error involved in the process. The present test is somewhat inefficient and quite time consuming to properly perform.

Automated or computerized testing addresses the deficiencies of the manual test by executing each test consistently, all pass / fail criteria are uniformly enforced.

6.0 AUTOMATED SINGLE CAR TESTING

Automated testing has been shown to improve car availability. A study presented to the FRA, analyzing repeat shop visits after being successfully single-car tested, produced data that demonstrates the impact of using an automated test device. [2].

Figure 2: Cars requiring repeat shopping when tested with Manual Tester

Figure 3: Cars requiring repeat shopping when tested with Automated Testers

Figure 2 illustrates that the cars tested with the manual test device had an average of 13.71% of these cars were re-shopped. Figure 3 shows that cars tested with an automated test device had only 2.19% cars re-shopped – an 11.5% improvement.

Automated Single Car Test Devices (ASCTD) have been in production for 20 years and have gained wide acceptance in North America as an efficient and accurate method of qualifying the brake system on a freight car.

Automated Test Devices may be capable of performing both end-of-car and 4- pressure single car tests. These test devices also provide flexibility to perform additional testing beyond a Single Car test and the required Daily Test. Programmed Application & Release Test (Pump & Dump) may be available for those cars not requiring a full SCT. In addition, the ASCTD can be manipulated through manual operations offering all the flexibility of a manual tester and may be utilized to perform
brake shoe force tests or other special testing as required.

6.1 End of Car Automated Testing

End-of-Car testing emulates the manual test procedure – monitoring Brake Pipe and Brake Cylinder pressures as well as flow. Using this method the car is charged through the Brake Pipe at the B end of the car as depicted in Figure 4.

6.2 Four Pressure Automated Testing

The ASCTD four pressure test (also referred to as 4-port test) monitors and assesses four key input pressures – Brake Pipe, Auxiliary Reservoir, Emergency Reservoir and Brake Cylinder – both upstream and downstream of the empty/load device as seen in Figure 5.

The 4-port test capability can be attained with the application of a 4-port Automatic Single Car Test (ASCT) Receiver. Four port test receivers may be applied directly to a new Pipe Bracket, Figure 6, or by the application of an access plate, Figure 7.

This combined with programmable logic, allows for a far more accurate and comprehensive test. With four precisely measured pressures available, the performance of the valve during testing is readily evident and not subject to guesswork and interpretation. When failures are encountered diagnostic help is provided to ensure the appropriate corrective action is taken.

For example, any leakage from either reservoir or the brake cylinder is directly detectable and
measurable; the rates of change of individual pressures can be measured; and critical operating pressure differentials can also be discerned. None of this can be achieved when manually testing with only a visual pressure gauge to go by. Adding a brake cylinder pressure reading helps but is still not nearly as comprehensive as having all four critical pressures available.

7.0 DATA

Data was collected from automated single car tests on over 10,000 mixed freight service cars. All tests were performed using 4 port capabilities. A summary of the test results are shown in Figure 9.

![Figure 9: Data Summary of 4-port Test Results](image)

Leakage test failures overshadow all other test failures as shown in Figure 10.

![Figure 10: Percentage of Leakage Failures](image)

Over 38% of all test failures are for system leakage and leakage into/out-of brake cylinder. A breakdown of the components found to be defective is shown in Figure 11.

![Figure 11: Percentage Failure by Component](image)

Control valve defects represent over 40% of defective components. This is attributed to age, time in service, utilization, operating environment, severe vibration and other environmental factors associated with the type of service.

Of the 3,635 failed tests 20% of the failures were attributed to faults that are only detectable with the 4-Port test. A breakdown of the failure modes are tabulated in Figure 12.

8.0 BENEFITS OF 4-PORT TESTING

The test devices that incorporate the enhanced four pressure testing method provide benefits to freight car maintainers and operators in three key areas – Asset Utilization, Safety and Training/People.

8.1 Asset Utilization

Four pressure testing allows for improved asset utilization by three means; reduced testing time, improved consistency and quality of test, and diagnostic feedback for failed tests.

8.1.1 Reduced testing time

The 4-port test can be performed in approximately 25 minutes as compared to 50 minutes for an end of car test. This results in a saving of at least 20 minutes for each passed single car test [3]. A comparison of the two test methodologies is shown in Figure 13.
Karen J. Carriere  
Wabtec Corporation

Automated Brake Testing and the Benefits Of Four Pressure Test

IHHA 2015 Conference  
21 – 24 June 2015  
Perth, Australia

**Figure 13: Automated Test Methodologies**

The four pressure test allows for simultaneous, multi-function processing saving test time. In addition, test sequencing has been optimized – see Figure 14 - to detect prevalent failures early in the test to minimize test time on failed cars. With the four pressure test over 90% of statistically complied test failures can be identified in the first 15 minutes of the test. [3]

**Figure 14: 4-Port vs. End of Car Test - “First 15 Minutes”**

**8.1.2 Improved consistency and quality of tests**

Because the ASCTD Four Port Test monitors and evaluates Brake Pipe, Auxiliary Reservoir, Emergency Reservoir and Brake Cylinder pressures the quality of the test is greatly improved. Several failures which can effect brake operation can only be detected with the four pressure test. As shown in this statistical analysis, 20% of all test failures can only be detected by the four pressure test.

Auxiliary and emergency reservoir leakage can effect car braking. Undetected auxiliary reservoir pressure can cause an undesired brake release after only 11 minutes of a partial brake application. Leakage out of Emergency reservoir can impact the brake cylinder equalization pressure developed during an emergency brake application. This level of leakage cannot be detected by an End of Car test, manual or automatic. Conversely, a high release differential can cause a stuck brake. Service release differential cannot be detected by an End of Car test, manual or automatic.

These types of failures can lead to hot or cold wheels in train operation. Failures that effect train operation and that are undetectable with an End of Car test can lead to repeat offender cars. Reducing these types of operational issues has been a major initiative of the railroads and can be further supported with a Four Pressure Single Car Test.

**8.1.3 Diagnostic feedback for failed tests**

Automated Testers have the ability to provide the car mechanic with accurate failure diagnostics. Based on the failure the operator can be directed to the most probable defective component. With visibility of the four input pressures along with flow, the feedback to the operator can be greatly improved resulting in more effective repairs and maintenance. The digital graphic display shows flow, Brake Pipe, both reservoirs as well as the brake cylinder pressure upstream and downstream of the empty/load valve. See Figure 15.

**Figure 15: Sample of Digital Display**

Improved diagnostics assure correct remedy, virtually eliminating trial-and-error repairs. Troubleshooting guidelines and methods to improve fault diagnosis are also available as part of the automated test.
As an example, when evaluating BC leakage the ASCTD will automatically adhere to critical waiting periods ensuring the test is executed correctly, preventing the possibility of a false failure.

If the Brake Cylinder Leakage test results in a failure due to leakage out of cylinder the operator may choose diagnostic help. An option to ‘MAINTAIN BC’ is available allowing the necessary pressure to be maintained while the source of the leak is investigated.

During the brake cylinder Leakage Test, leakage out of brake cylinder will eventually decrease to a low enough pressure that will cause the Quick Service Limiting Valve to open and maintain pressure at approximately 10-psi. The computerized test device ability to maintain a 21-psi test pressure provides a better chance of locating the leakage over an extended period of time, see Figure 16. [4]

This is just one example of the diagnostic assistance available. Depending on the test failure, instructions are displayed directing the operator to evaluate the appropriate components of the brake system to facilitate the correct repair.

8.2 Safety

The Four Pressure Test identifies failures undetectable with an End of Car Test, manual or automatic. Identifying such failures will allow for a greater margin of safety in train operations.

The 4-Port test monitors emergency reservoir pressure. Emergency reservoir leakage will diminish emergency brake cylinder pressure. As seen in Figure 17, holding a 12 psi reduction for 35 minutes with a 150+ cu in/min emergency reservoir leak will result in no greater brake cylinder pressure if an emergency application is required.

Figure 17: Emergency Reservoir Leakage

Monitoring reservoir pressure allows for other potential safety assessments. Evaluating manual release leakage after activation detects critical reservoir leakage and confirms proper lock-up of the release valve. This is a safety issue in the event leakage causes the brakes on a car to suddenly apply while work is being performed on the car. 4.1% of all failed tests are due to some form of manual release leakage.

8.3 Training/People

The ASCTD provides the car mechanic with a reliable tool to perform accurate single car testing. Each test is executed in a consistent and repeatable manner and provides precise measurement of both time and pressure qualifications. This eliminates the human variations and subjectivity that regularly occurs with the execution of manual testing.

The software and operator interface is user friendly and provides the car mechanic with on screen prompts and guidance to perform the required tasks during the test. Very little training is required for testing procedures as step by step instruction and inspection criteria are provided to the operator.

Human error is further avoided with the notification and requirement for the Daily Test to be performed. This routine qualifies the test device as ‘fit for service’ though a series of internal tests. This prevents the possibility of testing being performed with an ‘out-of-date’ machine resulting in possible regulatory infractions.

9.0 PROGRESSION OF AUTOMATED TESTING

Over the last 20 years the Wabtec Automated Test Device has also evolved. From a standalone test cart to a redesigned configuration available to be cart mounted or to be applied to a maintenance vehicle – see Figure 18.
Figure 18: Wabtec’s ASCTD Evolution

The operator display has also greatly advanced. A basic text display has progressed to a more user friendly digital graphic output with multiple options for integration of other user specified interface options – see Figure 19.

Digital Graphics

Figure 19: ASCTD Display Evolution

The newest enhancement to the ASCTD system is the browser based interface that allows the use of a hand-held device to control the device as well as interface with the users IT network for test record retention and car repair billing information.

Although the automated tester already has a valuable role in executing pneumatic testing on ECP overlay cars, further development is taking place to integrate ECP testing into the tester functions – see Figure 20.

10.0 SUMMARY

The automated 4-Port single car test provides a valuable tool which offers the means for more efficient and significantly upgraded testing of freight car brakes. The test time savings are quantifiable, but the superiority in the quality and reliability of testing is even more important.

Because the automated test device has the intrinsic capability to be highly efficient and precise, use of the improved test method is expected to expand in order to support new industry initiatives. For example, the browser based access, which allows for handheld device control as well as the integration with the end user’s IT network for electronic record keeping capabilities, may lend itself to new applications such as automatic repair billing, warranty claims, and the generation of progressing to more accurate and detailed statistical test data. Asset health management and electronic assessment of train brakes through detector based technology, as well as industry targets to improve inspection quality and facility efficiencies, are all supported through the use of automated/computerized testers.

Overall, this new test system has the potential to contribute in significant ways to improved productivity for car builders, railroads and car owners alike.

11.0 CONCLUSION

The objective of conducting the Single Car Test is to evaluate the general fitness of the brake system, diagnose faults and make necessary repairs. The ultimate goal is to return the car to service for an extended period of time; exception free.

The introduction of automated testing has delivered a consistent, accurate test while providing the operator with greater diagnostic and visibility to assist in the troubleshooting and remediation process. Computerized test devices offer a platform to not only display the status of the brake system during the test, but assist in the diagnosis of a failed test.
The automated, 4-Port test system has further enhanced the automated testing capability providing numerous clear and documented benefits. Overall impact on operations is significant, with definitive benefits in the following areas:

**Enhanced Car Effectiveness**
- Most effective way of testing air brake system to ensure it works as designed

**Improved Maintenance Efficiency and Effectiveness**
- Pinpoints root cause of air brake malfunctions (no trial & error repair), and tests cars in half the time of the industry standard.

**Reduction in ‘repeated’ Car Maintenance**
- Fewer return trips to repair shop for improper air brake corrections and side-effect damages (wheels).

**Increased Productivity of Car Fleet**
- More “good” cars in fleet means fewer cars in shop and more cars on the track.

**REFERENCES**

1. AAR S-486 – Code of air brake system tests for freight equipment—single car test 2013
2. FRA-2013-0030 BNSF and Union Pacific Railroad Companies (BNSF/UP) - Waiver Petition