Asset Health Monitoring & Effective Brake Maintenance

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A New Age for Equipment Evaluation

**Cause for Attention - Current:**
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

**Cause for Attention – New:**
Technology Driven Train Inspections
- Warm/Cold Wheels

Bad Actor/UDE Identification
- Record of Undesired Emergency
Asset Health Monitoring

Multiple Industry Initiatives

• Asset Health Strategic Initiative (AHSI)

• Technology Driven Train Inspections (TDTI) / Automated Train Brake Effectiveness (ATBE)

• Automated/Computerized SCT Interval Extension

• Bad Actor - UDE Identification
Asset Health Management

Asset Health Strategic Initiative

Contributors

- Safety and Operations Management Committee (SOMC)
- Railinc Project Support Working Committee (RPSWC)
- Asset Health Task Force (AHTF)
  - All 7 Class 1 Railroads
  - 3 Private Car Owners
  - Amtrak
  - AAR, TTCI & Railinc
- Mechanical Committees – TSWC, RTWC, ASEC, EHMC, AEI, …
- IASC (architects)
- And more…
Asset Health Strategic Initiative

2013 and 2014 Project Work Supports Initial Scenarios

Industry Targets
- Improve Safety
- Lower Train & Yard Operations Costs
- Lower Repair & Maintenance Costs
- Optimize Capital Expenditures

AHSI Targets
- Reduce Mechanical Service Interruptions
- Improve Inspection Quality
- Increase Yard & Shop Efficiency

AHSI Projects
- Asset Information Repository
- E-Train
- Inspection Quality

AHSI Scenarios
- Detector-based Brake Effectiveness
- Bad Actor Identification
- Electronic Class I Air Slip

Learn more at www.railinc.com

Technology Driven Train Inspections (TDTI)

Canadian Pacific

Automated Train Brake Effectiveness (ATBE)

- Obtained waiver from Transport Canada June 18, 2011
- Waived requirement for No. 1 Brake Test on trains using ATBE in BC South Coal Loop
- Process utilizes wayside Hot Wheel Detectors (HWD)

**Criteria:**

- **Hot Wheels:** Wheel Temperature > 200°F  
  Sigma Level > 3.0
- **Cold Wheels:** Wheel Temperature < 70°F  
  Sigma Level < -3.0

  Train Average Wheel Temperature > 200°F
Technology Driven Train Inspections (TDTI)

AAR Request for Waiver FRA-2013-0080

WTD Data as Alternative to Class 1A / 1000 mile inspection

Improved ability to detect defects such as:

• actual brake shoe force versus visible piston travel
• broken or bound brake rigging
• defective slack adjuster
• brakes that fail to apply or hold during operation
• low brake cylinder pressure/force
• empty/load device malfunction
Technology Driven Train Inspections

**AAR Request for Waiver FRA-2013-0080**

WTD Data as Alternative to Class 1A / 1000 mile inspection

- UP Coal Trains in Powder River Basin Service
- Round Trip of approximately 2600 miles

Criteria:

- Trains passing over a specified detector must meet minimum thresholds (95% operable) of brake effectiveness to forego Class 1A brake tests.

- Threshold for individual cars is 30 percent or lower temperature when compared average temperature of the train.

- A car found with six abnormal readings will be set out for repairs at next mechanical facility.

**CHALLENGE: ENSURE ROOT CAUSE OF FAILURE IS IDENTIFIED & CORRECTED.**
Automated/Computerized SCT Interval Extension

SCT Required Test Interval Extension to 24 months

Rule 3, Section A

• Extending test interval requirements on cars tested using automated test devices.

- Extension from 12 month requirement of SCT for cars on Repair track per Chart A
Application to Extend Test Interval from 12 to 24 months

Application to FRA (2013-0030) sited the following benefits:

- 85% of all cars tested (manual or ASCTD) under this 1 year rule had no brake related defects according to AAR records.

- 98% of cars tested under this 1 year rule using an ASCTD for the preceding test found no brake related defects according to AAR records.

- Automatic Single car tests statistically demonstrate much lower rates of repeat defects than do manual single car tests.

- Single car tests using the ASCTD are a safer testing methodology than the manual test because the ability to skip or forget part of the test code has been eliminated.

- A significant risk reduction results from eliminating craftsperson exposure from the performance of manual tests that can’t discover the root cause failure of the air brake system.

- Relief on this rule will encourage further test improvements with the ASCTD such as the four-port test.
Manual Single Car Test

Air Brake Shoppings
Union Pacific - 2010 - 2012

Avg. 13.71%
Automated Single Car Test

Avg. 2.71%
Testimonials

NS Automated SCT Program – 14.8% reduction in return shop visits

"NS already has noticed a manual vs. automated testing difference in the number of cars returning to the shops because of brake failure. Sixteen percent of cars that were manually tested were re-shopped compared with 1.2 percent of electronically tested cars, says NS Superintendent of Air Brakes Sam Butler." *

BNSF Automated SCT Program – 2.4% reduction repeat brake failures

"Between Jan. 1 and July 31, BNSF carmen performed 41,548 electronic air brake tests and 21,878 manual tests. Of the cars tested 1,653 or 3.9 percent of electronically tested cars had repeat brake system failures compared with 1,379 or 6.3 percent of manually tested cars." - Dana Maryott*

* Progressive Rail – September 2006
MA-146-12107

Maintenance Advisory for Inspection and Repair of Suspect Bad Actor Undesired Emergency (UDE) Equipment.

- Equipment identified by the AAR AIR/E-Train Technical Advisory Group
- Equipment belonging to participating Class 1 Roads and private car owners that are involved in the study.
- Equipment directed to a shop or repair track for inspection and repair. The suspected conditions on this equipment are to be evaluated as shown below.
  - A general inspection of the equipment must be performed with the “Suspect UDE Car Inspection and Repair Worksheet”
  - Perform Single Car Air Brake Test (SCABT) - automated SCABT (S-4027) is preferred. One additional service stability test to be performed.
  - Results of the inspection submitted to Railinc.

**CHALLENGE: ENSURING THE ROOT CAUSE OF THE UDE IS IDENTIFIED & CORRECTED**
# Suspect UDE Car Inspection and Repair Worksheet

**Important Note:** The following components must be inspected prior to performing any tests or repairs to identify any conditions prior to the tests.

<table>
<thead>
<tr>
<th>Process Step</th>
<th>Inspect for:</th>
<th>Condition</th>
<th>Comments</th>
<th>Corrective Action Taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>Draft System Type</td>
<td>Reference Type Draft System Configuration According to AAR Field Manual</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coupler</td>
<td>Measure Coupler height from Top of rail</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coupler</td>
<td>Inspect draft pocket for non compliance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncoupling Lever</td>
<td>Inspect for excessive wear and slack</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncoupling Lever</td>
<td>Is toggle clearance correct?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>End Arrangement Type</td>
<td>Reference Type End Arrangement Applied to Car According To AAR Field Manual</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>End Arrangement</td>
<td>1. Bent, broken, defective arrangements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Non-standard arrangements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Reworked or fabricated arrangements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Note: Particular attention must be paid to trolley arrangements for proper travel and conditions. Note conditions in comment column.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The purpose of the following checklist is to ensure we are capturing the data required to possibly uncover the reasons behind an Undesired Emergency event (UDE). The Class 1 Railroads, and some private car owners, have agreed to flag and inspect equipment that could potentially be the root cause of UDE events. In order to unearth the root cause the Technical Advisory Group (TAG) must filter the data to reveal any correlation of inspection data that could lead to a possible solution to the problem. The person completing this form is helping uncover a failure mode that is elusive. Your participation and attention to detail by completing this form correctly could potentially help lead to a commonality.

*Note: The Instructions below apply to both ends - A and B*

### Draft System Type

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Draft Gear</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EOC</td>
</tr>
<tr>
<td></td>
<td>COC</td>
</tr>
</tbody>
</table>

### End Arrangement

<table>
<thead>
<tr>
<th>00 = Good Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 = Worn-out (Enter Comments)</td>
</tr>
<tr>
<td>02 = Broken</td>
</tr>
<tr>
<td>03 = Missing</td>
</tr>
<tr>
<td>04 = Defective (Comments required)</td>
</tr>
<tr>
<td>05 = Bent</td>
</tr>
<tr>
<td>08 = Wrong (not standard to car) - Enter Comments</td>
</tr>
</tbody>
</table>

***Instructions***:
- In the drop-down, please select the type of cushioning device the car is equipped with.

***Instructions***:
- This will be a mandatory field that will require input from the inspector. Please indicate if any damage is present to the end arrangement or if it was found in good condition. Some end arrangements have been "fied modified" to facilitate continued movement of the equipment. If this be the case, and the modified apparatus is still attached to the car, please indicate this here. The "not standard" component should be removed and replaced with the correct end arrangement. Note: in some cases a Coupler Mounted Bracket may have been installed per acceptable repairs outlined in the AAR field manual. This change or modification is ok.
Effective Brake Maintenance

Meeting the Challenges of Asset Health Monitoring
Cause for Attention

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

Technology Driven Train Inspections
• Warm/Cold Wheels

Bad Actor/UDE Identification
• Record of Undesired Emergency
What is the brake output of this car?
Single Car Test
- Improved S-486-2013
  - Mandatory June 1, 2014
- Automated Single Car Test
- 4-port/pressure Automated Test
- S-4027 Automated Tester Specification Revision in progress

Possible Additional Test Criteria
- Extended Maintained Reduction Test
- Hot & Cold Wheel Criteria – Check list
- Time Based Criteria for Repeat Offenders
Importance of Diagnosing Brake Failures

Three categories of SCT failures:

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
Ensuring the Best SCT

Analog

Digital

Digital Flow and BP readings

Digital Cylinder readings
3.5 System Leakage Test

If performing only the system leakage test per the *Field Manual of AAR Interchange Rules*, Rule 3, Chart A, complete paragraph 3.1, “Preliminary Procedures, Inspections, and Car Set-Up,” and paragraph 3.2, “Connecting the Device to the Car,” prior to conducting test 3.5.2 and test 3.5.3.

The hand brake inspection (paragraph 3.6) can be made while the car brake system is being charged.

1. Move the rotary valve handle to Position 1.
2. Cut in the control valve by slowly opening the branch pipe cut-out cock.

**TEST 3.5.1**—During charge, there must be no venting of air from the retaining valve, and the brake cylinder piston(s) must remain in the release position.

3. After the car has had sufficient time to charge (approximately 8 minutes), close the flowrator by-pass cock.

**TEST 3.5.2**—Soap both reservoir pipes, fittings, and gaskets. No leakage is allowed.

**TEST 3.5.3**—The top of the ball must stabilize below the condemning line.

4. Open the flowrator by-pass cock.

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**Test 3.5.2**—Soap both reservoir pipes, fittings, and gaskets. No leakage is allowed.

**Troubleshooting:**

- No leakage is allowed. Completely drain system and repair as required.
System Leakage Test is performed with cut-out cock open allowing air to be supplied to control valve and reservoirs.

TEST 3.5.1 – During charging, there must be no venting of air from the retaining valve, and the brake cylinder piston(s) must remain in the release position.
TEST 3.5.2 – Soap reservoir pipes, fittings, and gaskets. No leakage allowed.
Technology Advantage
System Leakage Diagnostics

LKG FROM BRAKE PIPE LINE = 407.0
LKG FROM VALVE AND RESERVOIRS = 50.8
SOAP RELATED PIPING AND GASKETS FOR LKG.
500 EXCEEDS RANGE OF FLOW METER. YES:END

S91 BP9.7 A10.3 E10.4 DC0.0 3.5
BC Leakage Test
Leakage Points – Control Valve

1. Service Pipe Bracket Gasket (no leakage)
2. Emergency Pipe Bracket Gasket (no leakage)
   - mounting gasket face (no leakage)
   - bottom cylinder vent (no leakage)
4. Emergency In-Shot valve cover (no leakage)
5. Retaining Valve (use judgement)
BC Leakage Test
Leakage Points – BC Circuit

1. Pipe/Hose and flanges to E/L (no leakage)
2. E/L pipe bracket gaskets (no leakage)
   E/L covers and vent ports (no leakage)
3. Pipe/Hose and flanges to Cylinder (no leakage)
4. Cylinder vent in non-pressure head (no leakage)
Applied Leakage – Leakage Points

1. Service vent port (use judgment)
2. Emergency vent/AAV Exhaust vent (use judgment)
3. Brake Cylinder pressure level
Technology Advantage – BC Leakage

On failed test operator may choose diagnostic help. Leakage levels are displayed for reservoirs and BC.
Technology Advantage

BC Pressure Maintaining

Troubleshooting ASCTD - BC leakage

4 Port - Minimum Application Test

Pressure - psi

Time - seconds
4-Port Testing

4-port testing accesses the brake system at the pipe bracket for monitoring and direct control.

- 4 Pressures:
  - Brake Pipe
  - Brake Cylinder
  - Auxiliary Reservoir
  - Emergency Reservoir
4-Port Exclusive Tests

Quick Service Limiting Valve operation in service portion

- Best indicator of over-age valve that is likely to have problems at lower temperatures
- The QSLV defects due to age, type of service, vibration environment, etc. result in either failure to open or leakage of brake pipe into cylinder – Wabtec confirms that the QSLV open/close as expected as well as confirming acceptable leakage
- Potential excessive brake cylinder pressure / Hot Wheel
- Potential No-Set

Auxiliary-BP pressure release differentials

- Indicator of over-age or contamination/vibration debris
- The Wabtec test measures actual pressure differential to achieve a brake release as well as the timing qualification and determines if the BP/AR Release differential is within acceptable limits
  - Too Low – potential Undesired Release / Cold Wheel
  - Too High – potential Stuck Brake / Hot Wheel
4-Port Exclusive Tests

4-Port Emulates the Original S-486 Applied Leakage Test

• Emergency Reservoir leakage detection on service applications
  - Leakage can reduce emergency braking and service release effectiveness in a train
  - **Potential Diminished Service Accelerated Release/Warm Wheel**

• Auxiliary leakage detection on service applications
  - 100 cubic-inches/min can result in an undesired brake release in 12 minutes
  - **Potential undesired brake release/ Cold Wheel**

• Brake pipe leakage measured on service applications
  - Detects additional leakage demand on train line air when applied
  - **Potential gradient increase with brake applied/Warm wheel**
SCT Progression

CHARGING SYSTEM

03:11

BP 89.6
AUX 89.5
EM 89.5
BC 0.0
BCdwn 0.0

Supply: 125
Cal: 4/9/2013
Battery: 14.3V
Daily test expires in 17:34:53

Flow
350
300
250
200
150
100
235

Device: 0

2010’s
Methods for Effective Maintenance

Correct Identification and correction of failure critical

• **SCT objective is to ensure proper brake system performance**
  - Improved layout and test identification
  - Additional test/evaluation criteria
  - Enhanced with Troubleshooting Appendix

• **Computerized/Automated Single Car Test Devices**
  - Computerized diagnostics promote accurate defect detection
  - Digital / Graphic displays offer enhanced ‘feedback’
  - 4-port/pressure test provides improved level of testing

Training - Providing basic understanding of operation is critical
Meeting the Challenges of Asset Health Monitoring

Exploring New Methods for Fault Detection
Brake Cylinder Leakage – Allowable Limits

S-486 Single Car Test Limits

• 10-psi maintained Brake pipe Reduction
  - After the brake pipe pressure has stabilized at 80 psi, wait 3 minutes.

• TEST 3.14.1—Note the pressure on the brake cylinder gauge. Brake cylinder pressure must be greater than 12 psi.
  - Wait an additional minute, then recheck the brake cylinder gauge

• TEST 3.14.2—No more than a 1 psi increase or decrease in brake cylinder pressure is allowed.

In order to evaluate the impact of the single car test measurement of brake cylinder leakage on the wayside detection process a series of 4-port test results on 202 cars were analyzed. 20 of the 202 cars failed the + / - 1-psi/min allowable leakage limits.
Special Criteria for Hot & Cold Wheels

**S-486 - Allowable Brake Cylinder Leakage**

- **Pressure - psi**: 31.1 psi, 43.3 psi
- **Time - sec**: 0 to 1800
- **Leakage Rates**:
  - -1.0 psi/min
  - +1.0 psi/min

The graph shows the allowable brake cylinder leakage over time for pressures of 31.1 psi and 43.3 psi, with leakage rates indicating -1.0 psi/min and +1.0 psi/min.
Cars That Pass BC Leakage – After 1-hour

202 'passed SCT' Cars - Cylinder after 1-HOUR

11.8% Cool-wheels
5.9% Warm-wheels

12 cars +10-psi
24 cars -10-psi
25-psi target pressure

11.8% - cool wheels  5.9% - warm wheels
Auxiliary Reservoir Leakage – Cold Wheel

AR Leakage tested twice during SCT

• System Leakage
  - Max. 225 cubic inches per minute

• 10 psi maintained Brake Pipe Reduction
  - Approx. 145 cubic inches per minute causes release in 5 min.
S-486 10- psi Reduction
Auxiliary Res. Leakage - 145 cu. in. @90 psi

145 cu.in./min. leakage out of Auxiliary Reservoir
Brake release in approx. 5 minutes
New AH Evaluation Criteria for Consideration

- Making Automated Testing Mandatory
  - 4-port/pressure testing

- Tighter limits for allowable leakage
  - Brake Cylinder
  - Auxiliary Reservoir

- Supplemental Tests
  - Extended Maintained Application Test
  - Check list specific to failure mode
  - Additional Stability Testing

- Criteria for Repeat Offenders
  - Time Based Maintenance Evaluation
    - Replace Components >12 years old
Summary & Conclusions
Benefits of Industry Initiatives

**AHSI / TDTI**
- Improve Safety
- Lower Train and Yard Operation Costs
- Lower Maintenance and Repair Costs
- Reduce Service Interruptions

**Automated/Computerized Testing**
- Improves capacity of fleet – fewer repeat trips to the repair track
- Increases quality of fleet – a tested car is a good car.
- Enhances effectiveness of the maintenance – Diagnostics assure correct remedy, no more trial-and-error repairs.

**BAD Actor / UDE Identification**
- Reduce Service Interruptions
- Reduce Stress on Components from UDE’s
Meeting the Challenge of Asset Health Monitoring

- New methods of evaluating equipment may require new methods/tests to identify root cause of failure
- Correct Identification and correction of failure critical
- Current SCT alone may not identify root cause of failure for:
  - Hot wheel
  - Cold wheel
  - Bad Actor/UDE

- Solutions
  - Additional testing
  - New limits for pass/fail criteria
  - Time based maintenance
  - Design improvements
Thank you

QUESTIONS?