

**EA09-009**

**December 17, 2009**

**Mack Trucks, Inc.**



# Opening Remarks

- EA09-009 opened on June 18, 2009
- Analysis proceeded with participation from Haldex, Meritor Wabco, Bendix, Mack Trucks, and NHTSA
- Activities included,
  - Quick analysis and response to brake system complaints,
  - Visiting dealers, and customers to inspect trucks and conduct FMVSS121 application and release timing tests,
  - Vehicle brake system performance testing using Performance Based Brake Tester (“PBBT”),
  - Laboratory testing and analysis of valves, compressors, and air dryers,
  - Chemical testing of contaminants found in components such as the relay valve,
  - Sampling/testing of air line to confirm the theory that source of BBSA (plastizer) is the air lines



# PA/NJ

- Bedford PA, June 15, 2009
- 2006 CXN613, VIN 1M1AK06YX6N008808
- 348,000 miles, 4 years of service
- Application: Regional haul truck-tractor
- Complaint – “Drive brakes seem to quit working”
- Installed 2 test gauges, control and delivery, prior to removal of the relay valve
  - Findings: Unable to hold control and delivery pressure
- Laboratory testing of service relay, compressor, and air dryer by Meritor/ Haldex
- Laboratory testing of foot valve by Bendix
- The overall condition of the air system was poor, the air dryer desiccant filter was fully contaminated w/oil and there was visible evidence (residue) of oil on the outside of air tank at automatic drain valve



# PA/NJ

## Findings from laboratory tests,

- Relay Valve,
  - Supply and delivery leakage exceeds new valve limits for all pressures tested with exception of 135 psi (full reservoir pressure), however this was not unexpected considering the overall condition of the vehicle's air system,
  - Air flow pressure build up times (0 to 60 psi), as tested per Meritor Wabco engineering product specification for new valves, exceeded the maximum allowable test limit by 86% (actual 0.232 sec versus 0.125 sec), however normal condition for in-service (i.e., used) valve,
  - Inlet seal torn and out of normal position,
  - Exhaust seal was cut where the metal seat makes contact with the rubber seal,
  - Seals soft and swollen, both BBSA (plastizer) and bi-products of bio-diesel found,
  - Condition of holding pressure as seen on vehicle test was not seen in laboratory or bench testing of the valve
- Compressor passed tests that were performed
- Air Dryer,
  - Desiccant coated with oil throughout the length of the bed. Degree of oil contamination resulted in heavy dark discoloration of the desiccant
- Foot valve by Bendix,
  - Valve within acceptable and expected specifications,
  - Minor pooling of oil observed in primary piston
  - Replaced on March 19, 2009 with a mileage of 326,747 miles. Original foot valve was not available for evaluation

*Relay valve, compressor, and air dryer filter were all original equipment*



# PA/NJ2

- Allentown PA, August 14 & 17<sup>TH</sup>, 2009
- 2006 CXN613, VIN 1M1AK06YX6N008811
- 329,421 miles, 4 years of service
- Application: Regional haul truck-tractor
- Complaint – No complaint
- Performance Based Brake Test (PBBT) performed
  - Total braking forces exceeds FMCSA minimum performance requirements for in-service vehicles
- Laboratory testing of service relay, and air dryer by Meritor/ Haldex



# PA/NJ2

## Findings from laboratory tests,

- Relay Valve,
  - Leakage, crack pressure, and release times were within new product specifications,
  - Air flow pressure build up times (0 to 60 psi), as tested per Meritor Wabco engineering product specification for new valves, exceeded the maximum allowable test limit by 45% (actual 0.181 sec versus 0.125 sec), however normal condition for in-service (i.e., used) valve,
  - Inlet seal had a depression,
  - Exhaust seal was cut where the metal seat makes contact with the rubber seal,
  - The inlet seal had a high level of softening while the exhaust seal had a moderate level of softening
- Air Dryer,
  - Desiccant found to have normal amounts of oil and the beads had a slight level of discoloration,
  - Desiccant canister was the original one installed at time of vehicle assembly

*Air dryer cartridge and service relay valve were original equipment*



# TX

- Denver CO, April 23<sup>rd</sup>, 2009
- 2006 CV713, VIN 1M2AG11C56M053191
- 107,786 miles, 2.8 years of service
- Application: Regional truck (“Roll-off)
- Complaint – Service Brake issue
- Laboratory testing of service relay by Meritor/ Haldex
- Laboratory testing of foot valve and park brake control valve by Bendix
- Vehicle was being used in Bio-Diesel study, B20 being used



# TX

## Findings from laboratory tests,

- Relay Valve,
  - Supply and delivery leakage of relay valve met Meritor Wabco product specification limits,
  - Air flow pressure build up times (0 to 60 psi), as tested per Meritor Wabco engineering product specification for new valves, exceeded the maximum allowable test limit by 119% (actual 0.274 sec versus 0.125 sec), however normal condition for in-service (i.e., used) valve,
  - Inlet seal was swollen, deformed, and torn,
  - Exhaust seal was cut where the metal seat makes contact with the rubber seal,
  - Seals excessively soft and swollen; both BBSA (plastizer) and bi-products of bio-diesel found
- Foot valve by Bendix,
  - Performance degraded as compared to new valve; failed primary side leakage test,
  - Excessive amount of plunger travel required prior to delivery of air pressure,
  - Seals did not show signs of chemical incompatibility (i.e., were not swollen or degraded),
  - Seals did exhibit wear; both inlet and exhaust valves had deep compression sets,
  - Metal chips were found in the rubber,
  - Free height of rubber spring was below the lower specification limit,
  - Primary piston o-ring was slightly softer than the lower specification limit of a new part
- Park brake control valve, performed within parameters defined for a new valve



# FRN/ PA1 and PA2

- Franconia PA, August 4 & 5<sup>TH</sup>, 2009
- 2007 CXN612, VIN 1M1AK01Y77N004367 (FRN/PA1) & 1M1AK01Y57N004366 (FRN/PA2)
- 131,382 & 127,126 miles respectively, 3.1 years of service for both
- Application: Regional haul truck-tractor
- Complaint – No complaint
- FMVSS121 application and release timing tests performed prior to removal of valves; the vehicles fully complied with the requirements
- Laboratory testing of service relay, compressor, and air dryer by Meritor/ Haldex
- Laboratory testing of foot and park brake control by Bendix
- Overall condition of air system was very good with clear evidence of proper maintenance



# FRN/ PA1 and PA2

Findings from laboratory tests,

- Relay Valve,
  - Virtually no leakage was found; crack pressures and release pressures were consistent with new valve performance,
  - Application timing was marginally slower (23 m-sec) than the Meritor Wabco engineering product specification limits for new valves,
  - Inlet seals had deep depressions but were not cut, swollen, or deformed,
  - Exhaust seal on FRN/ PA1 had a witness mark and showed evidence of a cut beginning to form,
  - Exhaust seal on FRN/ PA2 showed a cut had occurred around the seat depression,
  - BBSA found at seals and some softening had occurred
- Compressor passed tests that were performed
- Air Dryer,
  - Desiccant filter was in very good condition and had been replaced,
  - Purge valve components coated with oil,
  - Lip seal on the piston exhibited some softening and swelling
- Foot valve,
  - Performed within parameters defined in the Bendix specification defined for a new valve,
  - Heavy impressions were found on the inlet/exhaust valves,
  - Rubber springs showed compression, which may contribute to differential spike at lower pressure. The measured compression is not beyond what is expected for vehicles that have been in service for this length of time,
  - Durometer readings indicate minimal difference from nominal values,
  - Some oil was present inside the valves
- Park Brake Control,
  - Exhaust seal of the tractor plunger contaminated and damaged,
  - Failed 120 psi leakage test at primary supply port with buttons pushed in,
  - Double check valves contaminated with oil

*Service relay valve, compressor, air dryer, foot valve, and park brake control valve were original equipment*



# RDG/PA1 and PA2

- Reading PA, August 5 & 6<sup>TH</sup>, 2009
- 2005 CXN613, VIN 1M1AK01Y75N001692 (RDG/PA1) & 1M1AK01Y55N001691(RDG/PA2)
- 625,670 miles and 426,294 miles respectively, 4.5 years of service for both
- Application: Regional haul truck-tractor
- Complaint – No complaint at time of inspection; however, relay valve on RDG/PA1 was replaced in July 05 for alleged rear brake problems, mileage at time of replacement was 82,000 miles
- FMVSS121 application and release timing tests performed prior to removal of valves; the vehicles fully complied with the requirements
- Laboratory testing of service relay, compressor, and air dryer by Meritor/ Haldex
- The air dryer assembly had been replaced. The replacement dryer was not installed according to Meritor's specifications; the required pressure control check valve was not installed at the system reservoir, which results in insufficient purging of water contaminants



# RDG/PA1 and PA2

Findings from laboratory tests,

- Relay Valve,
  - Leakage, crack pressure, and release times were within new vehicle specifications,
  - Air flow pressure build up times (0 to 60 psi), as tested per Meritor Wabco engineering product specification for new valves, exceeded the maximum allowable test limits by 9.6% (0.137 sec versus 0.125 sec) compared to a new valve, however normal condition for in-service (i.e., used) valve,
  - Exhaust seal had softened but was not swollen or cut,
  - Inlet seal had softened and was swollen and torn,
  - Valve seals showed signs of BBSA
- Compressor from RDG/PA1 passed tests that were performed
- Air Dryer,
  - Filter and desiccant beads had minimal amounts of oily residue,
  - Some contamination was found and seals showed signs of swelling



# RDG/PA3

- Reading, August 5 & 6<sup>TH</sup>, 2009
- 2005 CXN613, VIN 1M1AK01Y45N001696
- 537,204 miles, 4.5 years of service
- Application: Regional haul truck-tractor
- Complaint – No complaint at time of inspection,
- **Meritor service relay valve had been replaced with a Bendix valve in June 2006 at 232,880 miles**
- FMVSS121 application and release timing tests performed prior to removal of valves, the vehicle fully complied with the requirements
- Laboratory testing of air dryer by Meritor
- Laboratory testing of service relay, foot, and park brake control valves by Bendix
- The air dryer assembly had been replaced. The replacement dryer was not installed according to Meritor's specifications; the required pressure control check valve was not installed at the system reservoir, which results in insufficient purging of water contaminants



# RDG/PA3

Findings from laboratory tests,

- **Relay Valve,**
  - Initial test found valve leaking between service cover and body; further inspection found that the static o-ring was out of place and pinched (after o-ring replaced, valve passed tests),
  - Heavy oil and grit contamination found,
  - Inlet/exhaust seat showed signs of wear from the oil mix contaminates
- **Air Dryer,**
  - Filter and desiccant beads were heavily coated with large amounts of an oily residue and the beads were dark in color,
  - Some contamination was found and seals showed signs of swelling
- **Foot valve,**
  - Performed within parameters defined in the Bendix specification defined for a new valve,
  - Heavy impressions were found on the inlet/exhaust valves,
  - Rubber springs showed compression, which may contribute to differential spike at lower pressure. The measured compression is not beyond what is expected for vehicles that have been in service for this length of time,
  - Durometer readings indicate minimal difference from nominal values,
  - Some oil was present inside the valve
- **Park Brake Control,**
  - Failed 120 psi leakage test at primary supply port with buttons pushed in,
  - Double check valve contaminated with oil and damaged

*Foot valve and park brake control valve were original equipment*

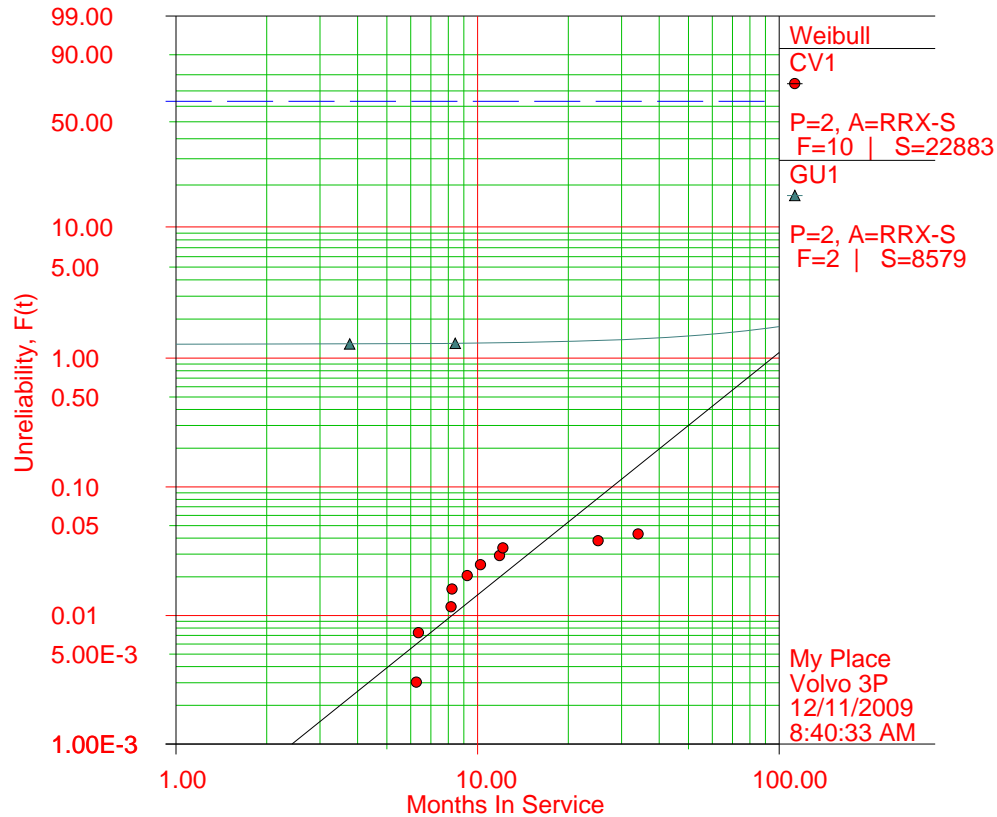




# Weibull Analysis, Construction

Generated by: ReliaSoft's Weibull++ 5.0 - www.Weibull.com - 888-886-0410

Mack Construction Models



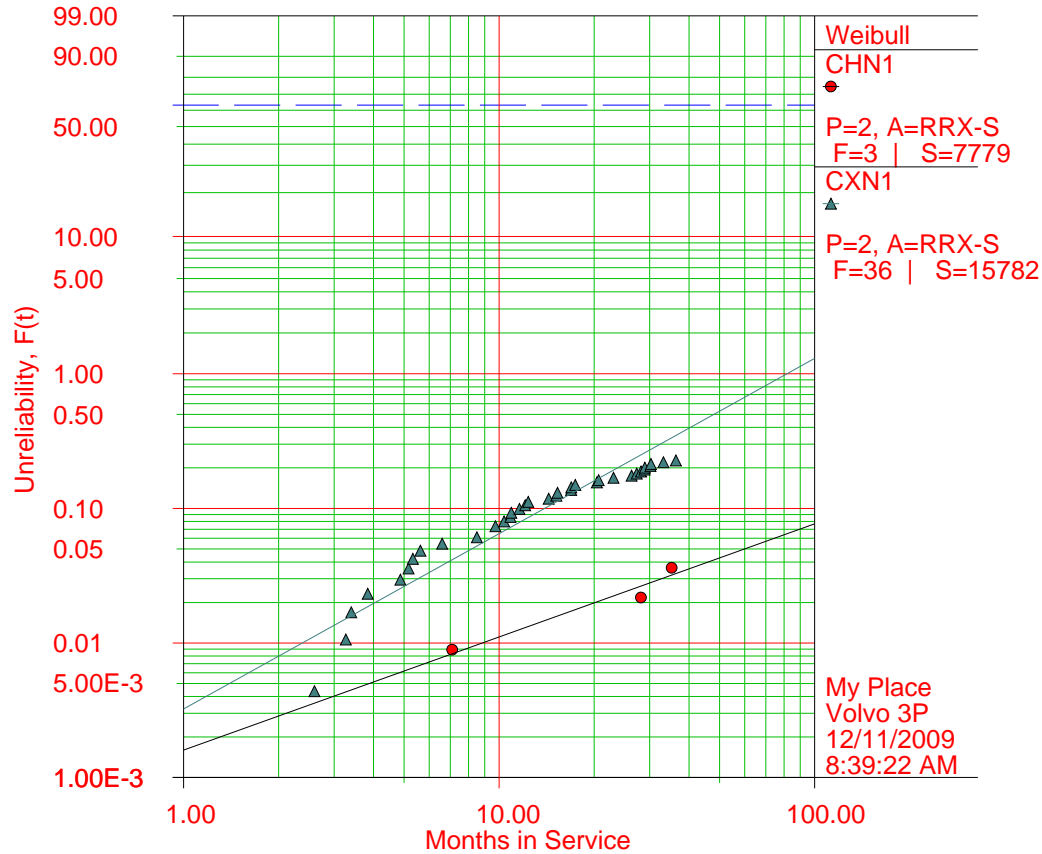
$\beta_1=1.89, \eta_1=1088.84, \rho=0.79$   
 $\beta_2=1.22, \eta_2=8049.71, \rho=1.00$



# Weibull Analysis, Highway

Generated by: ReliaSoft's Weibull++ 5.0 - www.Weibull.com - 888-886-0410

Mack Highway Models



$\beta_1=0.84, \eta_1=5.03E+5, \rho=0.97$   
 $\beta_2=1.30, \eta_2=2786.82, \rho=0.95$



# Other Relevant Information

- 68 suspect claims on service relay valves for period of Jan. 1, 2005 through current on a vehicle population of 89,298
- Proper preventative maintenance and dryer filter replacement reduces the effects of contamination,
  - Daily drainage of reservoirs,
  - Replacement of dryer cartridge (2- 3 years),
  - Periodic inspection and cleaning/replacement of components per TMC recommended practice, RP617A
- Vehicles that were examined, which showed signs of component contamination with seal damage (e.g., swelling, softening, cutting, and heavy impressions), still complied with FMVSS121 application and release timing requirements, and no discernible vehicle brake performance degradation was measured using PBBT on vehicles that were tested
- No accidents have been reported
- No customer complaints, only warranty claims
- Improved Meritor/ Haldex valve introduced into production in Jan. 2009, larger foot print to support exhaust seal. Additional changes to seal material planned for October 2010
- Coalescent filter introduced into production in late 2008. Parts notices to the aftermarket recommending the use of a coalescing filter published by Mack Trucks in September 2009 and by Meritor Wabco in December 2009
- Change in foot valve characteristics provides direct feedback to the driver if degradation occurs



# Conclusions

- Some degree of contamination in valves is expected, even if vehicle has been well maintained
- Periodic/ required maintenance mitigates risk of air brake system degradation
- Lack of proper air dryer maintenance has a significant negative impact on air brake system performance
- Vehicle air brake system can still comply with safety standards even with contaminated/ damaged seals as demonstrated through the vehicle and component testing that has been conducted

