

The AAR Air Brake Rubber Components Improvement Project

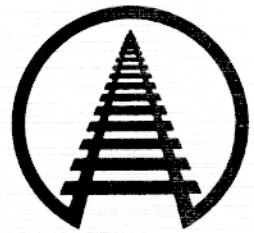
by
F. G. Carlson
TD94-008

Summary

The AAR's recently completed Sticking Brake Study indicates that rubber component failures are the primary cause of sticking brakes. The specific responsible component has been identified as the service piston diaphragm.

An ad-hoc committee of railroad and air brake supply industry representatives has been working with the AAR Research and Test Department to investigate different rubber materials for use in diaphragms. One of the main conclusions reached by the ad hoc committee is that ozone is the primary cause of control valve service and emergency piston diaphragm deterioration. Manufacturers are working on the development of new diaphragms that will be resistant to ozone attack.

A proposed Performance Specification for Testing of Air Brake Rubber Products (S-4001) has been developed and submitted to the AAR technical committees for review. The implementation date of this specification is tentatively set for July 1, 1994.



Association of American Railroads
Research and Test Department

May 1994



INTRODUCTION AND CONCLUSIONS

The recently completed Sticking Brake Study has found that rubber component failures are the primary cause of sticking brakes. The service piston diaphragm has been identified as the specific responsible component. An ad-hoc committee of railroad and air brake supply industry representatives has been working with the AAR Research and Test Department to investigate different rubber materials for use in diaphragms. This is part of an overall effort initiated by the AAR Brake Systems Subcommittee and the Mechanical Division Subcommittee on Research, to develop a performance specification for after market and new production air brake rubber components. The draft of the Performance Specification for Testing of Air Brake Rubber Products (S-4001) has been submitted to the AAR technical committees for review. The implementation date of this specification is tentatively set for July 1, 1994. Manufacturers have stated that they are working to have products capable of meeting this new specification.

The conclusions reached by the ad hoc committee to date are:

- Ozone is the primary cause of control valve service and emergency piston diaphragm deterioration. New diaphragms must be resistant to ozone.
- Rubber components used in air brake systems should be capable of operating reliably in -50°F environments.
- The use of alcohol in the brake system is strongly discouraged. Alcohol can dry out valve lubrication, and can cause premature rubber component failure.

TESTING REQUIREMENTS FOR DIAPHRAGMS

The findings of the rubber component study point to ozone aging as a significant cause of diaphragm deterioration. In reaching this conclusion, over

150 used diaphragms were examined. Sixty of these were examined by an expert rubber materials consultant from the University of Akron. Thirty three of the samples inspected by the consultant and used in general interchange service came from the Santa Fe Topeka air room, ten samples came from Canadian Pacific Western coal service, and seventeen samples came from CSX Florida phosphate service. This provided a sample range which included diaphragms from services with both hot and cold climates.

Questions have been raised whether the use of alcohol in cold weather and not ozone is the prime reason for diaphragm cracking and subsequent failure. The inspection and chemical analysis of the ATSF, CP and CSX diaphragms from revenue service has shown that this is not the case for these samples. The in-service diaphragms were compared to new diaphragms from all three manufacturers, and to used diaphragms from the New York Air Brake 150-car test rack, which had never been subjected to alcohol. The chemical analysis used was a soxhlet extraction, which uses acetone to remove all of the plasticizer from a rubber sample. Plasticizer is the ingredient that allows the rubber to remain flexible in cold temperatures. Loss of plasticizer would result in cracks and tears, similar to ozone deterioration.

Each test sample consisted of a one-inch diameter piece punched out of each diaphragm. For a worst case scenario, an OK diaphragm and a severely cracked diaphragm from each of the ATSF, CP and CSX samples were compared with new diaphragms from NYAB, Longwood (Aeroquip) and WABCO. The percentage of plasticizer contained in each sample is listed in Exhibit 1.

This data indicates that the leaching out of plasticizer due to the use of alcohol in cold climates did not cause the failure of the defective diaphragms in the test sample. The amount of plasticizer in the used diaphragms, even the cracked and torn defective diaphragms, is



<u>Sample</u>	<u>% Acetone Extraction</u>
NYAB New	11.80
WABCO New	12.15
AEROQUIP New	13.28
CP #9 - Severe Cracks	12.52
CP #5 - OK	12.76
CSX #8 - Severe Cracks	12.23
CSX #11 - OK	11.59
WABCO '79 - Severe Cracks	12.09
WABCO 1980 - OK	9.05
NYAB '82 - Severe Cracks	14.09
NYAB 1988 - OK	13.95
Aeroquip '88 - Severe Cracks	14.78
Aeroquip - OK	12.55

Exhibit 1. Plasticizer Extraction Tests on Diaphragms.

approximately the same as in the new diaphragms. In all cases, except the CP samples, the severely cracked diaphragms contained slightly more plasticizer than the OK diaphragms; so none of the sample diaphragms suffered a loss of plasticizer. Therefore, at least with these samples, alcohol does not appear to be a major cause in their failure. The cracking exhibited in the defective diaphragms in this sample was caused by ozone and oxygen attack.

It is possible that these diaphragms were never subjected to alcohol, or that alcohol use is not widespread enough to cause a significant proportion of diaphragm damage. However, **THIS DOES NOT CHANGE THE FACT THAT ALCOHOL IS HARMFUL TO THE AIR BRAKE SYSTEM.** Alcohol will dry out the lubrication in a control valve, and is capable of leaching plasticizer from rubber materials.

The primary cause of service piston diaphragm deterioration now appears to be mechanochemical. In other words, the ozone and oxygen in the environment which is concentrated in the carbodies of diesel-electric locomotives, is

increased about 6 times over atmosphere in the pressurized brake pipe. The ozone attacks the rubber at the folds of the diaphragm where the stress concentration is highest. If a diaphragm is not severely stressed, it will rarely exhibit ozone and oxygen cracking, even in an ozone rich environment. If a diaphragm is severely stressed, it will be attacked by the environment at the stress concentrations. This is supported by the fact that of all the used diaphragms examined in the course of this study, the service piston diaphragms were much more severely cracked than the other diaphragms used in the control valve. This is a result of the service piston diaphragm having the greatest amount of movement, being subjected to a large pressure differential for long periods of time (emergency applications), being subject to fold reversal, and having the greatest area of all the diaphragms in a control valve. Therefore, the service piston diaphragm experiences more stress than any other diaphragm in the control valve.

Some rubber materials have been identified which would be resistant to ozone aging and yet have about the same or better mechanical properties than the current materials. A section for new air brake diaphragms has been written into a draft air brake rubber performance specification, and testing of new materials by manufacturers is underway.

OTHER CONTROL VALVE RUBBER COMPONENTS

The Ad Hoc Committee has also written sections for performance testing of 'O' rings, 'K' rings, gaskets, and seals. The draft specification calls for testing these components at -50°F instead of the presently used -40°F. This represents a significant performance improvement for those railroads which operate in the very cold conditions common in Canada and the Northern U.S. This test requirement also presents a challenge to the manufacturers, because that extra 10° temperature drop causes significant changes in the physical properties of synthetic rubber materials.



BRAKE CYLINDER PACKING CUPS

The ad hoc committee is currently working on the last portion of the specification; brake cylinder packing cups and the related packing cup grease specification. The grease specification will be addressed first, because the grease can and does attack packing cup rubber. This can cause the packing cup to swell and lose the pressure seal

between the brake cylinder piston and the cylinder wall. The -50°F requirement also applies to packing cups and packing cup grease. Testing is currently under way to develop a specification for a packing cup grease which will operate satisfactorily at -50°F. When this grease specification is finalized, a packing cup specification can be written which will be compatible with the new packing cup grease.

Note: Contact F. G. Carlson (312) 808-5832 with questions or comments about this document.

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