

November 30, 1972

PLAINTIFF'S EXHIBIT

FD-721

Friction Materials (R-120 R)1. 1975 Disc Brake Lining Development

A cooperative program was established with Component Engineering Office to develop new disc brake lining formulations for use on proposed 1975 4-wheel disc brake Pinto and Lincoln vehicles. Because of program changes and parts availability, dynamometer testing to date has been confined to the L - 1 (Lincoln Front Disc) brake.

Variations of two basic formulations have been fabricated and tested by FAST, FM-2, and brake dynamometer in an effort to find a brake lining which could satisfy both the new Federal requirements (Docket 70-27 Notice 5) for Job 1, 1975 and yet be suitable for normal customer usage. For reference, tests were performed on Borg Warner's 712C-1, the best resin/asbestos composite from car tests, and Bendix 7131N, the best semi-metallic lining from car tests. Borg Warner's lining was said to increase in effectiveness excessively, compared with rear drum brakes. The Bendix Semi-Met was said to almost make the Federal requirements, but was a potential high warranty risk for light customer usage.

One of our formulations was superior to the Borg Warner material in most relevant characteristics on the dynamometer simulation of the new Federal requirement. Of particular significance was a tendency for decreasing brake effectiveness during the dynamometer procedure, offering some potential for a disc/drum system. The brake fluid displacement for this sample was high. After testing it was found that the linings had not been machined flat on the back surface prior to riveting which could have resulted in excessive fluid displacement. Additional samples have been prepared of this formulation for testing on a disc/drum Lincoln. Variants of this formulation are being prepared for additional laboratory and dynamometer testing.

Personnel: Anderson, Johnson
Weintraub (Chemical Engineering Department)

8003 0251

PRODUCED BY FORD

SCF-FORD-0944

2. Ford of Europe Brake Assistance

Work on the Ford of Europe (FOE) pull, judder, and diagnostic programs continues. The pull problem on TC and MH cars appears to be severe with Ferodo linings and Leamington iron discs of different friction levels and with Textar linings when discs from different foundries are mixed. Improved controls appear to have resolved the latter case. Also the Textar material passed the required performance tests to replace the Ferodo material, if needed. A cast iron specification change was recommended by Process Research Department and Product Quality Office.

Our lining composition and friction interface findings were presented to FOE engineers and representatives of both vendors (see attached trip report). Technical discussions with Ferodo personnel led to a program to identify the lining constituents within the Ferodo linings which cause these linings to be abnormally sensitive to different cast irons and typically to increase in friction between ambient and normal operating temperatures. Ferodo, through FOE, has supplied us 12 variants of their base formulation for our laboratory evaluation.

Samples of brake discs, cast to the Process Research/Quality Control Office specifications, are being prepared by the Leamington Foundry.

The brake judder on FOE vehicles appears to be associated with the Ferodo linings. Judder tendency is believed to be related to the pull tendency of this lining, so the experimental Ferodo samples will also be used for judder evaluations. The rust formation and wet adhesion characteristics of these samples, when tested in conjunction with production discs, also will be investigated.

Additional comments and recommendations on diagnostic equipment, tests, and personnel are being prepared. A limited diagnostic facility is now planned for FOE Dunton Research Center.

Personnel: Anderson
Weintraub (Chemical Engineering Department)

8003 0252

PRODUCED BY FORD

3. Wet Clutches

The compliance of automatic transmission clutch plates was considered to be a factor in the generation of a driveline "clunk" upon shifting from Neutral to Drive or Reverse. A possible mechanism for this noise is as follows: the initial apply piston force generates enough torque to lock the clutch and/or separator plates from sliding on their splines; added clutch apply pressure then deflects the friction elements to a slight conical form, largely as a consequence of friction material compliance; upon completion of the clutch engagement the system dynamics results in a momentary drop of output torque; the reduced torque allows the clutch elements to slide on their splines, thereby releasing their stored energy; this elastic energy release produces an axial acceleration of the clutch drum assembly which impacts against a flat thrust washer/spacer; the resultant impact produces the observed "post engagement clunk."

Based on this hypothesis, the "clunk" could be eliminated, or reduced in severity, by extending the clutch application time, using a stiffer friction material, reducing spline drag, altering the metal thickness of the clutch elements, reducing the assembly endplay, and adding compliance to the thrust washer. Several of these have been tried by the Transmission Division with some success. We have studied the elastic behavior of the production clutch plates (SD1053 paper type material) and several comparable materials. Both production samples of new SD1053 showed an unusual elastic response; stiff, soft, then stiff again. The material appeared to have an elastic collapse behavior above 60 psi facing pressure. This was judged to be significant, since that was also the pressure above which the "clunk" occurred most frequently. Two used (1000 heavy duty clutch applications on a laboratory machine) samples of SD1053 were tested and found to behave elastically as most other paper-type friction materials. The

8003 0253

PRODUCED BY FORD

November 30, 1972

change presumably resulted from surface wear and the mechanical action of hard usage. Problem used samples of SD1053 have been requested, but not yet received. Also it was suggested to laboratory cycle the clutch plates from a vehicle which exhibits the "clunk" and retest in the same car to establish if the noise severity is significantly affected by heavy clutch plate usage and the associated changes of elastic response.

Transmission Division has requested a duplicate of our elastic response test apparatus for their laboratory. Our design is being modified to accept all standard sizes of clutch plates, to be simpler to use, and to heat and cool more rapidly.

Personnel: Anderson, Ting

Reports

SR-72-122 H. Wu and C. M. Jones, Heat Transfer Analysis of
Ford Rotary Engine Cooling Systems.

John E. Mayer, Jr.
John E. Mayer, Jr., Manager
Mechanical Research Department

8003-0254

PRODUCED BY FORD