

commercially available, but they lack field service data to assure satisfactory performance for the full range of automotive applications.

4.2 Introduction to Friction Material Formulations

Little has been published about the specific formulations of friction materials, since they are considered to be proprietary compositions by the friction material manufacturers. This section of the report reviews the more common forms of both asbestos and non-asbestos lining materials and presents data regarding performance under vehicle or simulated vehicle braking conditions.

Friction materials for automobiles contain four general types of ingredients: reinforcing agents--usually fibers, friction modifiers, fillers, and binders. Most automotive friction materials use thermosetting resins in their binder systems. These resins, often of the two-step (Novolac) phenolic type and generally modified for both processing and functional purposes, provide the matrix to bond the various constituents together. Internal pressures generated during processing and fade testing can reach 1000 psi, so binder resins require good tensile strength at elevated temperatures. Binder resins provide more than just structural attributes to the brake lining. Thermal stability, friction level, fade, fade recovery, dimensional stability, wear life, and other performance characteristics of the brake lining are determined, at least in part, by the choice and amount of binder resin.

Reinforcing agents provide the structural elements to support the friction material in service. Brake linings experience a range of loadings that require strength, stiffness, and toughness. The reinforcing agents contribute to the stiffness and strength of the friction material composite. Usually these agents are fibrous and most often provide other attributes to the brake lining, such as wear resistance and improved dimensional stability.

Since chrysotile asbestos has been used as a reinforcing agent in friction materials for about 80 years, its performance attributes are fairly well known. Chrysotile asbestos was chosen because of its unique combination of physical, thermal, mechanical, tribological, processing,