



## Micro-damage formation of a rubber hose assembly for automotive hydraulic brakes under a durability test

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### ABSTRACT

A rubber hose assembly for an automotive hydraulic brake in operation is subjected to the combined stresses of cyclic pressure, cyclic bending and torsion as well as thermal load. The rubber hose in the assembly is composed of ethylene-propylene diene monomer (EPDM) rubber layers reinforced by polyvinyl acetate (PVA) braided fabrics. A durability tester with loading rigs for applying the above cyclic stresses was run to investigate the failure mechanisms in the rubber hose assembly. Failure examination was performed for the metal clamped, and thus compressed, region of the rubber hose assembly at every 100 thousands cycles of bending and torsion. A polished section of the compressed hose showed that some interfacial delamination between the EPDM rubber and PVA fabric layers initiated with several branched cracks in the outer rubber layer at 400,000 test cycles approaching the durability limit. The fracture surface revealed a relatively weak interfacial strength. Such initial cracks gradually grew into the outer rubber skin layer leading to the final rupture of the hose.

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## 1. Introduction

The rubber hose assembly for an automotive hydraulic brake contains the passage of brake oil, the pressure of which induces friction between the rotating disk and caliper [1]. Relative displacement of each part of the brake hose assembly during the braking operation causes the brake hose to be under the complex loading of bending, torsion, and hydraulic pressure. Due to the importance of safe vehicles operation a reliability standard (RS R0043) for the hose assemblies of automotive hydraulic brakes was established by the Korea Agency for Technology and Standards (KATS) in the year 2004 [2].

The rubber hose for an automotive hydraulic brake is composed of three rubber layers (inner ethylene-propylene diene monomer (EPDM), intermediate natural rubber (NR), and outer EPDM layers) and two reinforcement fabric layers (inner and outer). EPDM rubber has excellent resistance to ozone, heat, and weather. Because of its low degree of unsaturation in chemical structure, EPDM has high resistibility against oxidation and ozone, and stable insulation properties even at high temperatures [3–5]. Various stresses are applied to a hydraulic brake hose in process. Parts of the hydraulic brake hose compressed by a metal clamp may suffer high stresses combined with large bending and torsional moments.

In this study, a durability test of the rubber hose assembly for automotive hydraulic brakes was performed under the combined test conditions of repeated pressure, bending, torsion, and thermal loads which can occur during vehicle operation. The failure mechanisms of the rubber hose were examined at every 100 thousand cycles of bending and torsion. The tested hose assembly specimens were analyzed both at micro- and macro-levels.

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## 2. Experimental

### 2.1. Rubber hose assembly and durability test

The rubber hose assembly (model: E072) for automotive hydraulic brakes used in this study was made by Hwa-Seung Rubber and Automotive. The internal structure of the rubber hose is composed of three rubber layers and two reinforcement fabric layers as illustrated in Fig. 1. Table 1 shows the dimensions and kinds of material of the respective layers composing the brake hose assembly. During the braking operation in the field the brake hose assembly is subjected to combined loads such as bending, torsion, oil pressure and thermal load (see Fig. 2).

The maximum combined load of bending and twisting moments is supposed to occur at a site compressed by the metallic clamp (see the arrow indicating the compressed site in Fig. 2). Fig. 3 shows a durability tester that can conduct the fatigue test under combined loads. Brake oil (DOT – 4, Kukdong-Jeuen Co.) that satisfies the US automobile safety standard (FMVSS

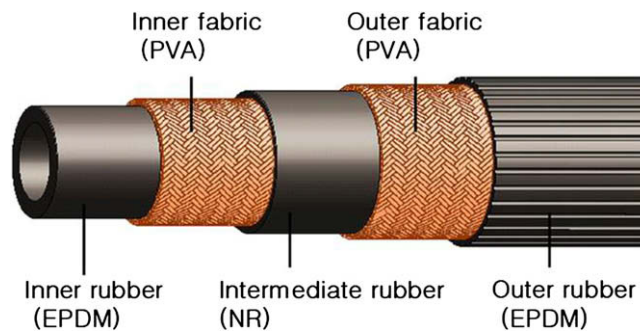


Fig. 1. Structure of rubber hose for automotive hydraulic brake.

Table 1

Dimensions and materials of the brake hose

	mm	Material
Inner diameter of brake hose	3.4	
Outer diameter of brake hose	10.5	
Thickness of inner rubber layer	1.27	EPDM
Thickness of outer rubber layer	1.25	EPDM
Outer diameter of inner fabric	6.5	PVA
Outer diameter of outer fabric	8.0	PVA

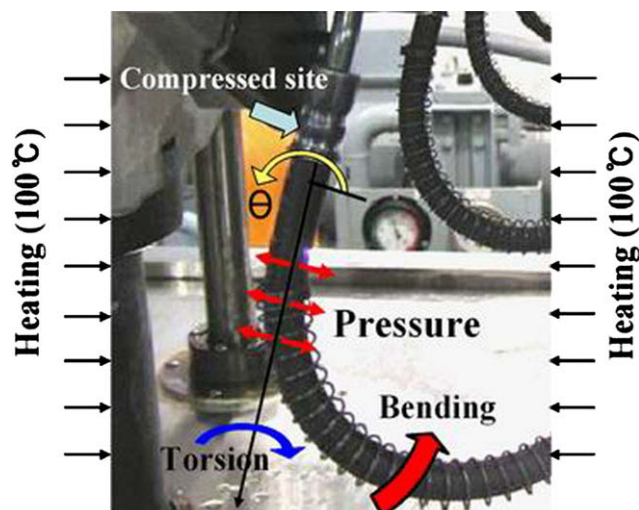


Fig. 2. Various stresses in the hydraulic brake hose.

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