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Proterial Cable America Consulting

Addendum to Technical Report in Support of Proterial Cable America, Inc. Second Supplemental Petition for Inconsequential Noncompliance—FMVSS 106, Brake Hoses

1. On April 21, 2023, Proterial Cable America, Inc. ("PCA") submitted to the National Highway Traffic Safety Administration ("NHTSA") a Second Supplemental Petition for Determination of Inconsequential Noncompliance (the "Second Supplemental Petition").[1] Attached to the Second Supplemental Petition was an Exponent Report titled "Technical Report in Support of Proterial Cable America, Inc. Second Supplemental Petition for Inconsequential Noncompliance—FMVSS 106, Brake Hoses" of the same date (the "Second Supplemental Technical Report"). Exponent's Second Supplemental Technical Report summarized safety test results completed up to the date of the report and indicated that some conditioning and durability testing of Nylon and PVC brake hose assemblies ("BHAs") was ongoing.[2] This Addendum summarizes the completed safety testing described in Section 7 of the Second Supplemental Technical Report, and provides additional information regarding noncompliance overlaps discussed in Section 8 of the Second Supplemental Technical Report.

2. The completed testing does not alter and further supports Exponent's observations and conclusions in the Second Supplemental Technical Report, or Exponent's prior technical reports filed in connection with PCA's Initial Petition for Determination of Inconsequential Noncompliance filed on August 19, 2022, and PCA's Supplemental Petition for Determination of Inconsequential Noncompliance filed on November 10, 2022. The test results completed after the submission of the Second Supplemental Technical Report were comparable to results of prior testing. The testing demonstrated that:

[1] In re: 22E-061, Brake Hose Assemblies – Proterial Cable America, Inc.'s Second Supplemental Petition for Determination of Inconsequential Noncompliance, April 21, 2023.

[2] Exponent, Inc. "Technical Report in Support of Proterial Cable America, Inc. Second Supplemental Petition for Inconsequential Noncompliance—FMVSS 106, Brake Hoses", April 21, 2023.

a. Nylon and PVC BHA exposure to both high temperature impulse ("HTI") and water absorption conditioning (consecutively) does not affect the structural integrity of the BHA.

b. Each of the tested Nylon and PVC BHAs completed the conditioning (HTI and water absorption) and motorcycle suspension stroke durability testing without BHA leakage, rupture, or failure.

c. Each of the tested BHAs exceeded the FMVSS 106 5,000 psi requirement for burst strength (S.5.3.2). Half of the BHAs (3 Nylon and 3 PVC BHAs) were pressurized until burst failure, burst strengths ranged from 14,650 psi to 15,091 psi for Nylon BHAs and from 13,356 psi to 14,607 psi for PVC BHAs.

d. The other half of the BHAs were tested for slow tensile strength (3 Nylon and 3 PVC BHAs), each of the tested BHAs exceeded the FMVSS 106 325 lbf requirement (S5.3.4). Tensile strengths ranged from 567 lbf to 571 lbf for Nylon BHAs and from 474 lbf to 492 lbf for PVC BHAs.

3. The results of these safety tests indicate that the various combinations of noncompliances over the life of a motorcycle impose no incremental risk to motorcycle riders and therefore are inconsequential to motor vehicle safety.

1 Addendum to Second Supplemental Technical Report Section 7: Performance of Nylon and PVC BHAs Subjected to Multiple FMVSS 106 Requirements

4. Exponent conducted additional safety testing on production Nylon and PVC BHAs[3] that covered a combination of failures observed in the engineering test and production test records. In this Safety Testing Program, Nylon and PVC BHAs were subject to HTI conditioning, Water Absorption conditioning, and 300,000 cycles of accelerated suspension stroke durability testing to simulate the motorcycle lifetime. The Nylon and PVC BHAs were then subjected to pressure and sensitivity testing, Burst Strength, and/or Tensile Strength testing.

5. The testing was carried out on six BHAs each for Nylon and PVC at PCA's Indiana facility (HTI, Water Absorption, Leak, Burst Strength, and Tensile Strength), and Exponent's Menlo Park facility (Suspension Stroke Durability testing). Of the six BHAs for each hose type, three were pressurized until burst to evaluate the end-of-life burst strength of the BHAs, and three were subjected to tensile testing to evaluate the end-of-life tensile strength of the BHAs.

[3] The Nylon and PVC BHAs were manufactured between May 9 and May 11, 2022. The BHAs were manufactured on production lines with production procedures, operators, and components (nipple, socket, adapter, hose stock) except for the banjo fitting which was a straight banjo fitting without protective plating. These samples were originally fabricated for FMVSS 106 whip resistance testing.

6. The following results were observed for the Nylon BHAs:

    a. Each BHA completed the HTI conditioning without leakage or damage to the BHA.

    b. Each BHA completed the water absorption conditioning without damage to the BHA.

    c. Each BHA completed the 300,000 cycles of full suspension stroke durability testing without leakage, rupture, or failure.

    d. Five of the six tested BHAs completed the 500 psi, 1,000 psi, 1,500 psi, 2,000 psi, 2,500 psi, 3,000 psi, 3,500 psi, 4,000 psi, 4,500 psi, and 5,000 psi two-minute hold periods without BHA leakage, rupture, or failure.

    e. One of the tested BHA presented a leak during the 5,000 psi two-minute hold period (above the FMVSS 106 requirement). The leak occurred from the pre-crimp location of the end fitting and measured 3 drops during a five-minute hold, or 0.18 ml of fluid. The BHA did not rupture or fail. There was no pressure drop in the test.

    f. Each of the BHAs passed the 5,000 psi burst pressure requirement of FMVSS 106 S5.2.2.

    g. Three of the BHAs were subject to pressurization until burst. The burst strength ranged from 14,650 psi to 15,091 psi, greatly exceeding the FMVSS 106 S5.3.2 requirement of 5,000 psi.

    h. Three of the BHAs were subject to slow tensile strength testing. The tensile strength ranged from 567 lbf to 571 lbf, greatly exceeding the FMVSS 106 S5.3.4 requirement of 325 lbf.

7. The following results were observed for the PVC BHAs:

    a. Each BHA completed the HTI conditioning without leakage or damage to the BHA.

    b. Each BHA completed the water absorption conditioning without damage to the BHA.

    c. Each BHA completed the 300,000 cycles of full suspension stroke durability testing without leakage, rupture, or failure.

    d. Each of the BHAs completed the 500 psi, 1,000 psi, 1,500 psi, 2,000 psi, 2,500 psi, 3,000 psi, 3,500 psi, 4,000 psi, 4,500 psi, and 5,000 psi two-minute hold periods without BHA leakage, rupture, or failure.

e. Each of the BHAs passed the 5,000 psi burst pressure requirement of FMVSS 106 S5.2.2.

f. Three of the BHAs were subject to pressurization until burst. The burst strength ranged from 13,356 psi to 14,607 psi, greatly exceeding the FMVSS 106 S5.3.2 requirement of 5,000 psi.

g. Three of the BHAs were subject to slow tensile strength testing. The tensile strength ranged from 474 lbf to 492 lbf, greatly exceeding the FMVSS 106 S5.3.4 requirement of 325 lbf.

8. The results of these safety tests indicate that the various combinations of noncompliances over the life of a motorcycle impose no incremental risk to motorcycle riders and therefore are inconsequential to motor vehicle safety. The Nylon and PVC BHAs provide safe and reliable brake function over the entire lifespan of a motorcycle.

2 Addendum to Second Supplemental Technical Report Section 6: PVC HTI Failure

9. PCA test records reported a HTI failure for three out of three tested PVC BHAs for a test report dated around August 30, 2007.[4] This is the only recorded HTI failure for PVC BHAs in the PCA test records. The report recorded passing results for FMVSS 106 requirements for BFC, Tensile Strength, and Burst Strength. Each of the HTI failures was reported to not pass the 4,000 psi two-minute pressure hold. Each of the failed BHAs passed the 5,000 psi and 7,000 psi FMVSS 106 Burst Strength requirement for a BHA with an ID larger than 3 mm and equal to or smaller than 3 mm, respectively. The burst strengths were reported as 7653.8 psi, 8,108.2 psi, and 9,017 psi, for the three tested BHAs.

10. Exponent conducted additional safety testing to evaluate the safety and performance of PVC BHAs when subject to multiple tests, including HTI, discussed in Section 1 *supra*. The PVC BHAs completed the Safety Testing Program without leakage, rupture, or failure.

a. Each of the PVC BHAs satisfied the FMVSS 106 Burst Strength requirement (FMVSS 106 S5.3.2) by sustaining 4,000 psi pressure for two-minutes and pressures exceeding 5,000 psi without rupture. The BHAs also sustained 5,000 psi pressure for two-minutes without leakage, rupture, or failure.

[4] PCA testing included both engineering tests and production tests. HTI testing was only conducted in engineering tests.

b. Burst strengths greatly exceeded the 5,000 psi requirement under FMVSS 106 S5.3.2.[5]

c. Tensile strengths greatly exceeded the 325 lbf. requirement under FMVSS 106 S5.3.4.[6]

11. The results of these safety tests indicate that the PVC HTI noncompliance does not adversely affect performance of the brake system when subjected to severe motorcycle lifetime usage, over the life of a motorcycle impose no incremental risk to motorcycle riders and therefore are inconsequential to motor vehicle safety. The PVC BHAs provide safe and reliable brake function over the entire lifespan of a motorcycle. The purpose of FMVSS 106, "to reduce deaths and injuries occurring as a result of brake system failure from pressure or vacuum loss due to hose or BHA rupture," is satisfied, and, accordingly, the noncompliance conditions are inconsequential to motor vehicle safety.

3 Addendum to Second Supplemental Technical Report Section 8: Analysis and Discussion of Noncompliance Overlap

12. Analysis and discussion of noncompliance overlaps were discussed in Section 8 of the Second Supplemental Technical Report. Exponent reviewed an analysis of PCA's shipping data, and compared the part numbers and date ranges to Exponent's independent analysis of Engineering Test and Production Test failures. The analysis provides the potential quantity of affected BHAs in the field for each noncompliance overlap combination in the field.

13. For Nylon BHAs, the following noncompliance overlaps and potentially affected BHAs in the field were identified:

a. Whip/Water Whip Resistance + BFC + HTI: 1,053,978 BHAs.

b. Whip/Water Whip Resistance + BFC + HTI + Constriction: 11,840 BHAs.

c. BFC + HTI: 23,166 BHAs.

14. For PVC BHAs, the following noncompliance overlaps and potentially affected BHAs in the field were identified:

a. Whip/Water Whip Resistance only: 4,005,100 BHAs.

b. Burst Strength only: 11,576 BHAs.

[5] Three out of six of the BHAs were subject to pressurization until burst.

[6] Three out of six of the BHAs were subject to tensile strength testing.

c. Tensile Strength only: 153,245 BHAs.

d. Whip/Water Whip Resistance + Tensile Strength: 788,879 BHAs.

e. Whip/Water Whip Resistance + Burst Strength: 39,299 BHAs.

f. Whip/Water Whip Resistance + Constriction: 9,925 BHAs.

g. Whip/Water Whip Resistance + Tensile Strength + HTI: 27,145 BHAs.

h. Whip/Water Whip Resistance + Tensile Strength + Burst Strength: 12,855 BHAs.

i. Burst Strength + Tensile Strength: 2,850 BHAs.

j. HTI + Tensile Strength: 0 BHAs.[7]

15. Exponent completed additional safety testing, discussed in Section 1 *supra*, on Nylon and PVC BHAs that considered each noncompliance condition except constriction, which was evaluated in the Constriction Safety Testing discussed in Section 2 and 8 of the Second Supplemental Technical Report. In the additional Safety Testing Program, Nylon and PVC BHAs were subject to a test program which covered the following noncompliances and noncompliance overlaps:

a. For Nylon BHAs:

i. Whip/Water Whip Resistance + BFC + HTI

ii. BFC + HTI

b. For PVC BHAs:

i. Whip/Water Whip Resistance only

ii. Burst Strength only

iii. Tensile Strength only

iv. Whip/Water Whip Resistance + Tensile Strength

v. Whip/Water Whip Resistance + Burst Strength

vi. Whip/Water Whip Resistance + Tensile Strength + HTI

[7] Each PVC BHA within the HTI + Tensile Strength noncompliance overlap combination also belonged to the Whip Resistance + Tensile Strength + HTI noncompliance overlap combination, item g. in the list.

vii. Whip/Water Whip Resistance + Tensile Strength + Burst Strength

viii. Burst Strength + Tensile Strength

ix. HTI + Tensile Strength

16. The results of these safety tests indicate that the various combinations of noncompliances over the life of a motorcycle impose no incremental risk to motorcycle riders and therefore are inconsequential to motor vehicle safety. Additionally, Exponent conducted the Constriction Safety testing, a test program that considered constriction noncompliance and noncompliance overlaps. The Constriction Safety testing demonstrated that the combination of noncompliances which included constriction are inconsequential to motor vehicle safety.

17. Exponent's completed testing has addressed all noncompliance conditions identified in Section 8 of the Second Supplemental Technical Report. The results of these safety tests indicate that the various combinations of noncompliances for Nylon and PVC BHAs over the life of a motorcycle impose no incremental risk to motorcycle riders and therefore are inconsequential to motor vehicle safety.

18. The purpose of FMVSS 106, "to reduce deaths and injuries occurring as a result of brake system failure from pressure or vacuum loss due to hose or BHA rupture," is satisfied, and, accordingly, the noncompliance conditions are inconsequential to motor vehicle safety.

4 Addendum to Second Supplemental Technical Report Section 2.1: FMVSS 106 S5.3.1 Constriction Test Requirement and Brake System Design

19. Discussion of anti-lock braking system ("ABS") modulator orifice dimensions was provided in Section 2.1 of the Second Supplemental Technical Report, paragraph 44. Since the filing of the report, Exponent has conducted additional analysis of an ABS modulator unit from a Harley-Davidson motorcycle to evaluate the internal orifice dimensions.

20. Exponent performed destructive examination of an ABS unit for a 2021 H-D Low Rider S 114 softail (FXLRS) motorcycle (part number 41100044C), shown in Figure 1.

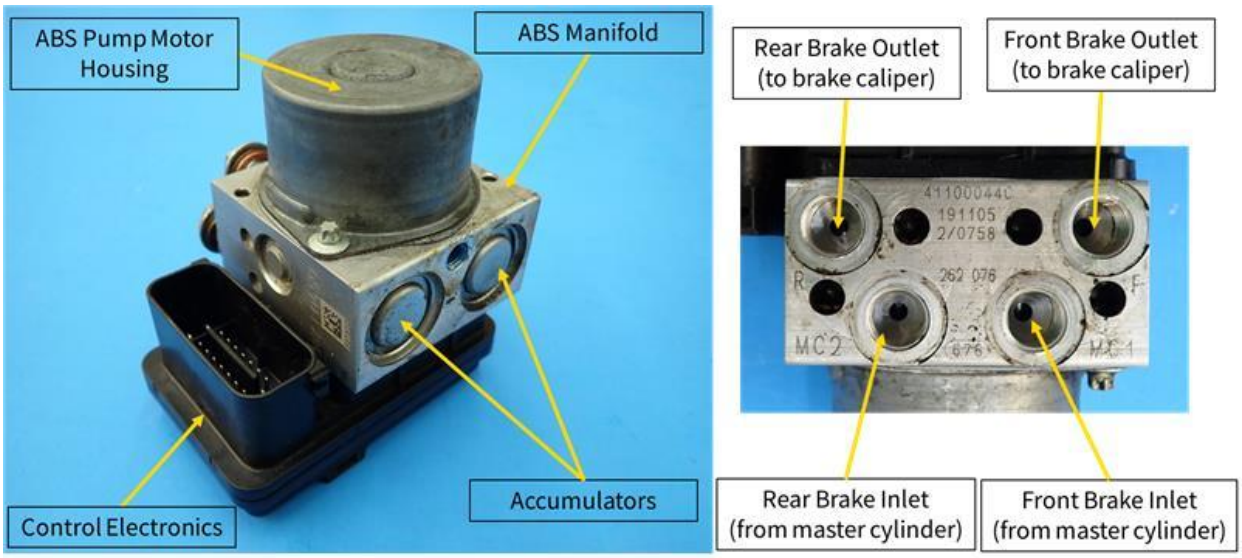

Figure 1. ABS unit examined by Exponent.

21. Exponent conducted a destructive disassembly of the ABS unit, demonstrated in Figure 2. Removing the electronics controller exposed the solenoid valves which rapidly engage and disengaged during ABS function. Underneath each solenoid valve, which are press fit in place and sealed with an aluminum ring, there are orifices. The smallest orifice observed in the ABS unit (measured using a pin gauge[8]) had a diameter of 0.027 inches, or 0.69 mm, the orifice was located at one of the solenoid valves. Exponent observed additional orifices within the ABS module, the diameters ranged from 0.027 inches to 0.057 inches, or approximately 0.69 mm to 1.45 mm. Additional orifices may be present within other components of the ABS unit, Exponent did not evaluate those.

[8] The pin gauges had a tolerance of +0.0002 inches / -0.0000 inches.

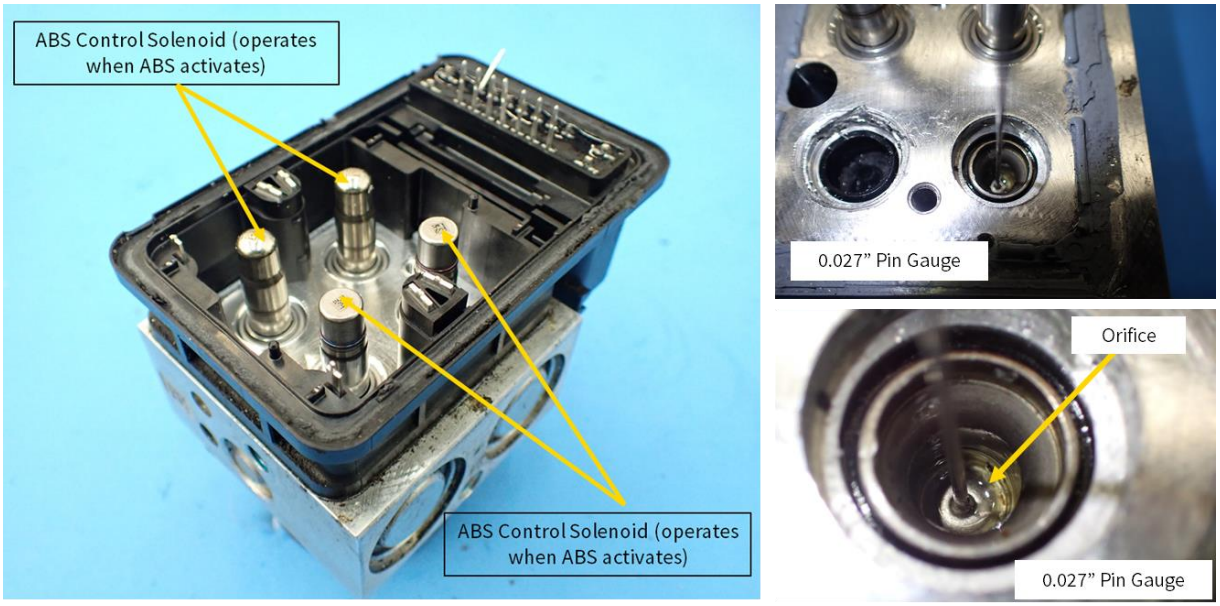

Figure 2. ABS unit with the electronics controller removed and ABS control solenoids exposed (left). With the solenoid valves removed the orifice underneath is visible and measurable with pin gauges.

22. The observed orifice diameters are significantly smaller than any constriction observed in the Nylon and PVC BHAs. The open area of the inspected ABS modulator orifice is approximately 0.374 mm^2, as compared to the minimum open area observed in Constricted BHAs (38.8% of the hose NID), ~2.3 mm^2, or ~6 times larger than the ABS modulator orifice.[9]

Sincerely,

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[9] A brake system supplier reported to Exponent that the diameter of the orifice within their anti-lock braking system ("ABS") modulator design is 0.4 mm (the ABS modulator was not for H-D motorcycles. Information on file with author). The open area of the reported ABS modulator orifice is approximately 0.126 mm^2, as compared to the minimum open area observed in Constricted BHAs (38.8% of the hose NID), ~2.3 mm^2, or ~18 times larger than the ABS modulator orifice.

This report describes analyses and testing of brake hose assemblies performed at the request of Proterial Cable America, Inc. Exponent, Inc. (herein "Exponent") has performed testing described in this report using Exponent equipment installed at the Exponent Engineering & Test Center facilities in Phoenix, Arizona; Natick, Massachusetts; and Menlo Park, California. Testing was also carried out at third-party test laboratories of Element Materials Technology in Des Moines, Iowa, a National Highway Traffic Safety Administration compliance test laboratory. Exponent reserves the right to supplement this report and modify conclusions based on a review of additional materials as they may become available.
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