SOUTHWEST RESEARCH INSTITUTE®

6220 CULEBRA ROAD • POST OFFICE DRAWER 28510 • SAN ANTONIO, TEXAS, USA 78228-0510 • (210) 684-5111 • www.swri.org

ISO 9001 Certified
ISO 14001 Certified

December 21, 2009

Via Email to rhodge@sbfilters.com

Mr. Robert Hodge
S&B Filters
787 South Wanamaker
Ontario, CA 91761

Subject: Letter Report, Test Results, Southwest Research Institute® (SwRI®)
Project No. 08.15217.01.009, "Water Spray Removal Testing"

Reference: S&B Filters P.O. No. 12619

Dear Mr. Hodge:

This report presents results of water spray removal testing conducted on a prototype inlet scoop provided by S&B Filters for evaluation. Four configurations were evaluated. Testing was conducted in accordance with SAE J2554, Engine Intake Air Water Separation Test Procedure, APR2003. Water spray removal testing was accomplished at 700 scfm. Proper droplet size and flow delivery were achieved by nozzle selection and pressure control. The spray nozzle was sized to provide a spray with a median volume diameter (MVD) of 1000 microns, based on nozzle performance specifications. The MVD is a value where 50% of the total volume (or mass) of liquid sprayed is made up of drops with diameters larger than the median value and 50% smaller than the median value. The MVD and the actual droplet size distribution (DSD) were not measured. For the specified airflow rate, SAE J2554 called for a water feed rate of 500 ml/min. Four test runs for record were accomplished, using the same experimental setup and test protocol as in the previous testing, as reported in our September 29, 2009 and October 29, 2009 reports. The general test arrangement is shown in Figure 1.

Test results are given in Tables 1 and 2 and Figures 2 through 6. Table 1 gives quantitative results in term of water penetration and removal. Table 2 gives before and end of test airflow resistance data. Figure 2 shows pre-test airflow resistance as a function of flow rate. While SAE J2554 is primarily intended to measure separation efficiency, it is apparent in this case that the parameter of most importance is water penetration to the upper filter unit and beyond. In particular, the target for allowable penetration is zero, since the filter should remain dry during vehicle operation in all weather and road conditions. While the amount of water penetrating the separator section was not zero, it was much improved compared to levels obtained previously, especially for test runs where the wrap material was added to the outlet of the lower scoop section. For these runs (3 and 4), the amount of water penetrating the separator section

decreased by an order of magnitude, while the amount penetrating the entire unit decreased by two orders of magnitude. General photographs taken during and after testing are shown in Figures 3 though 6.

Table 1. Water Spray Penetration: S&B Prototype Scoop (AY0015-00); 1000 µm Mean Volume Diameter (MVD) Spray (Single Spray Systems Co, 1/8 G-1, 0.031" Dia., Full Jet Nozzle at 24 psi,); Unit Airflow: 700 scfm*

Test Run for Record	Configuration	Water Penetrating Entire Unit, % (1)	Water Penetrating Separator Section, % (2)	Water Retained by Upper Unit/ and by Filter, % of total (3)	Water Exiting Separator Slot, % of total	Water Exiting Separator Slot and from Front of Scoop, % (4)
1	(a)	0.24	6.23	5.56/4.80	78.32	94.20
2	With filter wrap (b)	1.34	6.69	5.35/4.61	70.60	93.30
3	With filter wrap and wrap material (c)	0.044	0.78	1.01/0.78	61.23	98.94
4	With disposable filter and filter Wrap and wrap material (d)	0.036	0.70	0.66/0.45	40.98	99.29

Tests conducted: Dec 2009

(a) Prototype unit with previously used [Oct 2009] dry cotton filter. An initial test was conducted with the new cotton filter element provided with the unit. However, this test was considered a pre-test because it was uncertain if the proper nozzle distance was maintained throughout the test.

(b) Prototype unit with previously used [Oct 2009] dry cotton filter element + S&B Filter Wrap

(c) Prototype unit with another previously used [Oct 2009] filter element + S&B Filter Wrap + S&B Filter Wrap material added to lower scoop section

(d) Prototype unit with S&B Dry Disposable (white) filter element + S&B Filter Wrap + S&B Filter Wrap material added to lower scoop section

* At 20°C and 101.3 kPa

1. $$\text{Water penetration} = \left[\frac{\text{wt. of water collected downstream of unit}}{\text{total wt. of water collected}}\right] \times 100$$

2. $$\text{Water penetration} = \left[\frac{\text{wt. of water collected downstream of separator section}}{\text{total wt. of water collected}}\right] \times 100$$

3. $$\text{Water retained} = \left[\frac{\text{wt. of water collected in upper unit/filter}}{\text{total wt. of water collected}}\right] \times 100$$

4. Water exiting front of scoop is drainage from walls and upper unit coalescence for Tests 1 and 2, and likely, for the most part, from lower scoop walls and lower filter wrap material added to outlet of lower scoop section for Tests 3 and 4.

Table 2. Pre- and Post-test Airflow Restriction Values*

Test Run for Record	Configuration	Pre-test Restriction, "of water	Post-test Restriction, "of water
1	(a)	10.6	11.8
2	With filter wrap (b)	10.6	13.1
3	With filter wrap and wrap material (c)	13.2	17.5
4	With disposable filter and filter Wrap and wrap material (d)	13.4	19.0

Tests conducted: Dec2009

* At 700 scfm, 20°C and 101.3 kPa

(a) Prototype unit with new cotton filter element, as received.

(b) Prototype unit with new cotton filter element, as received, + S&B Filter Wrap

(c) Prototype unit with previously used [Oct 2009] filter element + S&B Filter Wrap + S&B Filter Wrap material added to lower scoop section

(d) Prototype unit with S&B Dry Disposable (white) filter element + S&B Filter Wrap + S&B Filter Wrap material added to lower scoop section

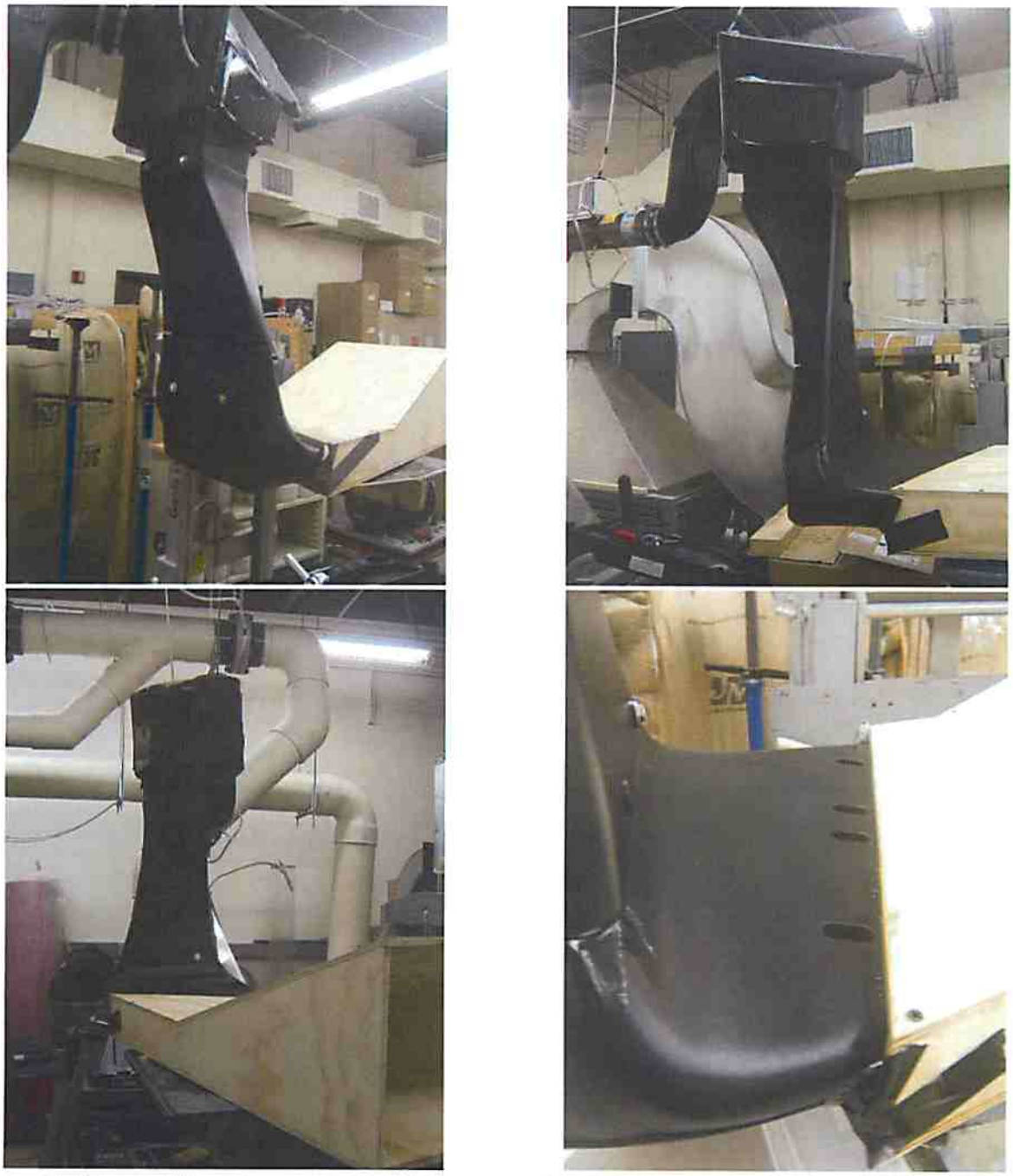

Figure 1. General Test Arrangement (spray wand moved back and forth across scoop inlet) [Bottom 2 rows show wrap material applied to outlet of lower scoop section]

Figure 1. General Test Arrangement (spray wand moved back and forth across scoop inlet) [Bottom 2 rows show wrap material applied to outlet of lower scoop section] (Continued)

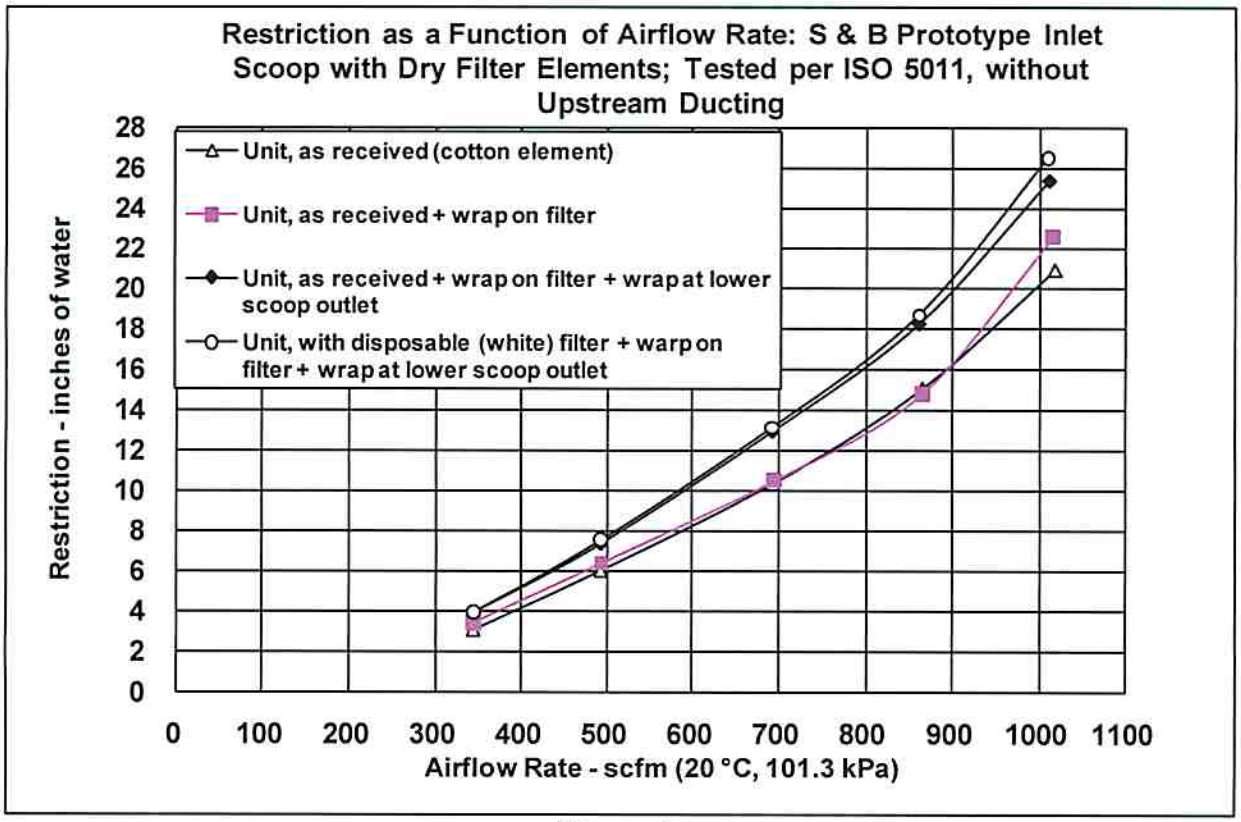

Figure 2

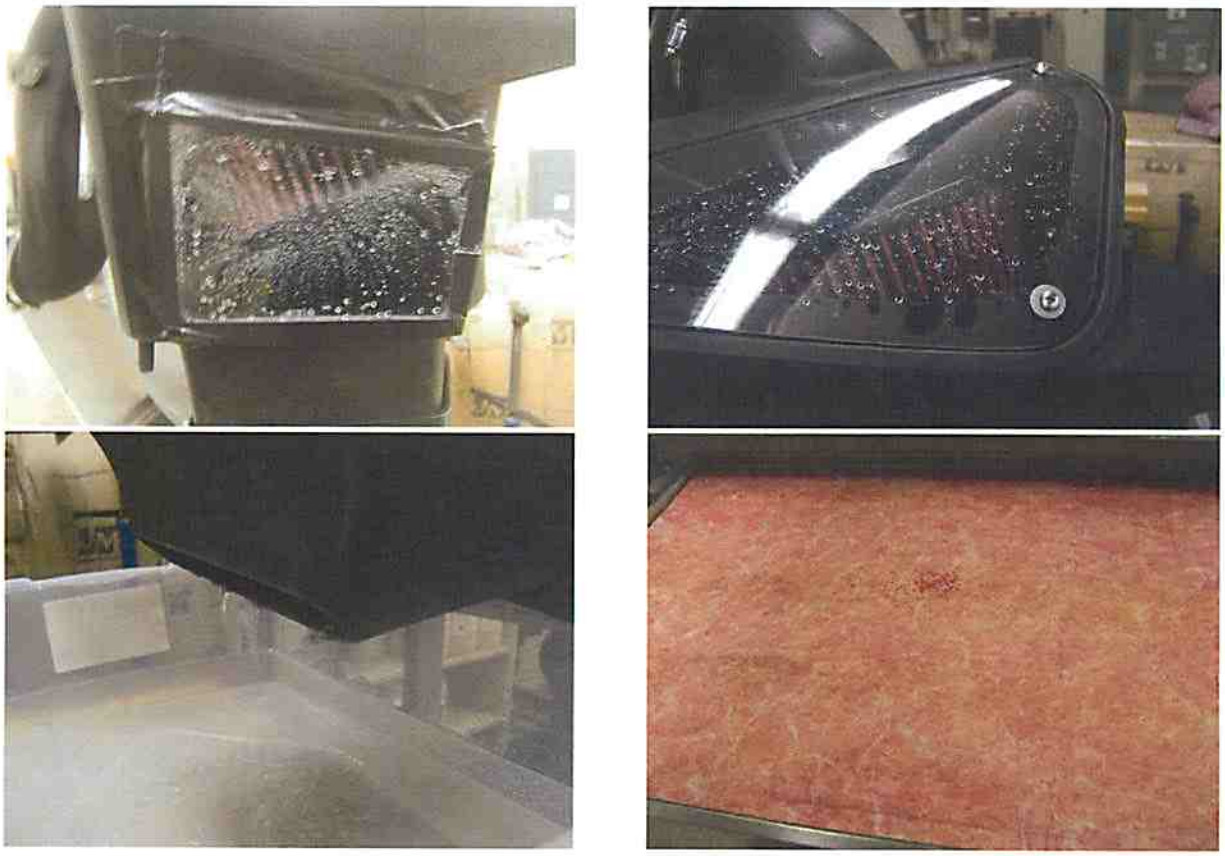

Figure 3. Some General Photographs during and after Testing (Run 1; Unit with Cotton Filter)

Figure 4. Some General Photographs during and after Testing (Run 2; Unit with Wrapped Cotton Filter)

Figure 4. Some General Photographs during and after Testing (Run 2; Unit with Wrapped Cotton Filter) (Continued)

Figure 5. Some General Photographs during and after Testing (Run 3; Unit with Wrapped Cotton Filter + Wrap Material on Outlet of Lower Scoop Section)

Figure 5. Some General Photographs during and after Testing (Run 3; Unit with Wrapped Cotton Filter + Wrap Material on Outlet of Lower Scoop Section) (Continued)

Figure 6. Some General Photographs during and after Testing (Run 4; Unit with Wrapped Disposable Filter + Wrap Material on Outlet of Lower Scoop Section)

Figure 6. Some General Photographs during and after Testing (Run 4; Unit with Wrapped Disposable Filter + Wrap Material on Outlet of Lower Scoop Section) (Continued)

If you have any questions concerning the test program or the results, please do not hesitate to contact me at (210) 522-2626 during normal business hours. For your convenience, our facsimile number is (210) 522-5720 and my e-mail address is mtreuhaft@swri.org.

Submitted by:

Martin B. Treuhaft

Martin B. Treuhaft, Manager
Filtration & Fine Particle Technology

Approved by:

Steven D. Marty

Steven D. Marty, P.E., Director
Fuels & Lubricants Technology Department
Fuels & Lubricants Research Division

/lsr