US Department
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National Highway
Traffic Safety
Administration

Memorandum

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Subject: FINAL REPORT: VRTC-DCD3060 "Leak Tests on Fuel Tanks from 1995-96 Volvo 850 Vehicles (EA03-008)"

Date: JUN 0 8 2004

From: Michael W. Monk
Director, Vehicle Research & Test Center

Reply to Attn. Of: NVS-310

To: Kathleen C. DeMeter
Director, Office of Defects Investigation

NVS-210

Attached are four (4) copies of the subject report. This completes the requirements for this program.

#

Attachments: Final Report (4)

VRTC-DCD3060
EA03-008

Leak Tests of Fuel Tanks from 1995-96 Volvo 850 Vehicles

VEHICLE RESEARCH AND TEST CENTER
EAST LIBERTY, OHIO 43319-0337

FINAL REPORT
JUNE 2004

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16. Abstract

The objective of the program was to verify and identify the existence and source of any leaks from eight "complaint" fuel tanks.

ODI and Volvo Cars of North America, LLC (VCNA) identified eight fuel tanks that were removed from 1995-96 subject vehicles due to fuel leaks. These fuel tanks were provided to the VRTC for inspection and leak testing. ODI, VRTC, and VCNA agreed on a test protocol to cooperatively conduct the leak tests at VRTC. The tests included inspections, both internal and external, and leak tests that consisted of using pressurized air in each fuel tank to detect leaks and using Stoddard solvent, in the tanks with confirmed leaks, to determine leak rates.

The major findings included:

1. Leaks were confirmed on five of the eight "complaint" tanks tested.
2. A leak was found at the same boss for the heat shield on the five test tanks with confirmed leaks. One tank also had a second leak at the single boss for the crash shield.
3. The leak rates for these five test tanks ranged from a trace to 1.85 ml/min when the test tank was not pressurized (0 kPa) and from a trace to 7.0 ml/min when the test tank was pressurized to 5 kPa.

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1.0 INTRODUCTION

The Vehicle Research and Test Center (VRTC) conducted this program at the request of the Office of Defects Investigation (ODI), National Highway Traffic Safety Administration (NHTSA). ODI opened an Engineering Analysis (EA03-008) in June 2003 in response to several complaints of alleged gasoline leaks from the fuel storage tanks in 1993 through 1996 Volvo 850 vehicles. One "complaint" fuel tank from a 1993 Volvo was tested at VRTC in September 2003. No leaks were confirmed in that tank during testing using pressurized air and submersion in a stock-watering tank. A videotape of that testing was previously sent to ODI.

Other complaints indicated that cracks developed in the plastic fuel tanks near the "seam," allowing fuel to leak out. Some noted leaks onto the exhaust pipe or from a heat shield mounting boss that is attached to the fuel tank. The orientation of the exhaust heat shield to its three mounting bosses (labeled A, B, and C) is shown in Figure 1.1 for a typical "complaint" fuel tank.

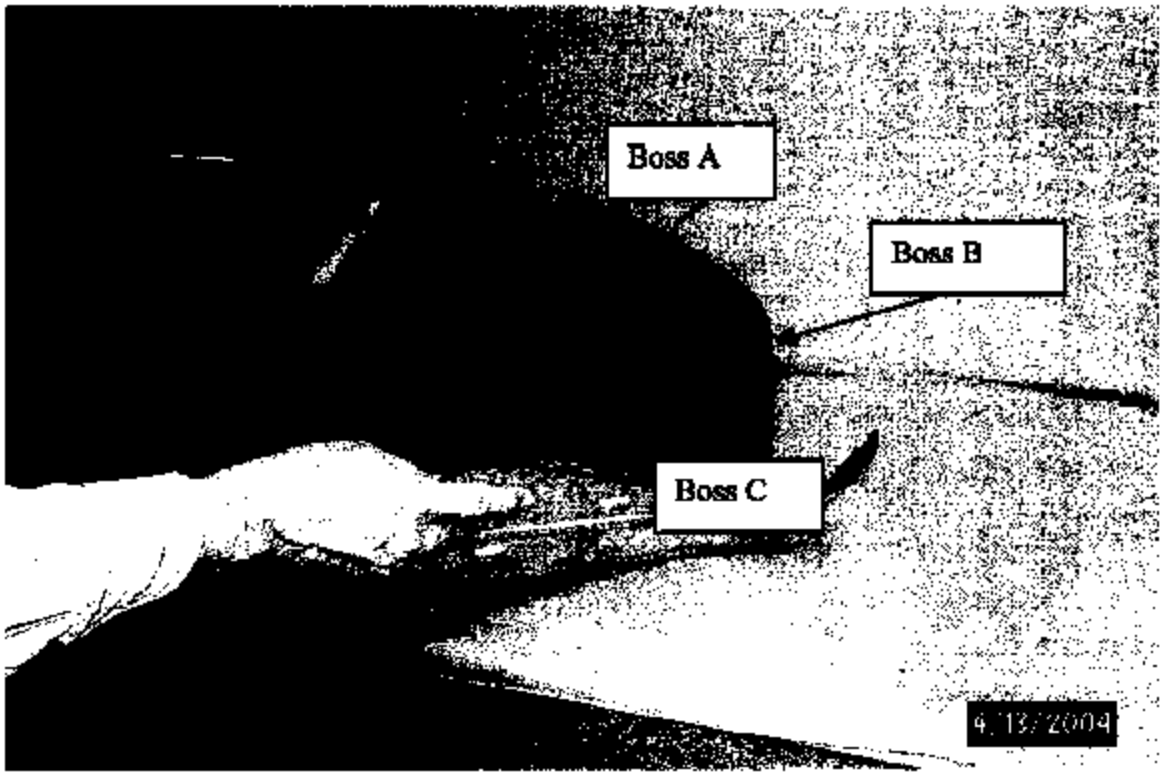

Figure 1.1 - Orientation of Heat Shield and Mounting Bosses on a Subject Fuel Tank

2.0 PROGRAM OVERVIEW

The objective of the program was to verify and identify the existence and source of any leaks from a sample of eight "complaint" fuel tanks. An overall view of a typical subject fuel tank is shown in Figure 2.1.

ODI and Volvo Cars of North America, LLC (VCNA) identified eight fuel tanks that were removed from 1995-96 subject vehicles due to fuel leaks. These fuel tanks were provided to the VRTC for inspection and leak testing. ODI, VRTC, and VCNA agreed on a test protocol to cooperatively conduct the leak tests at VRTC. The test protocol, described in Section 4.0, consisted of inspections, both internal and external, and leak tests. The leak tests consisted of using pressurized air in each fuel tank to detect leaks and using Stoddard solvent, in the tanks with confirmed leaks, to determine leak rates.

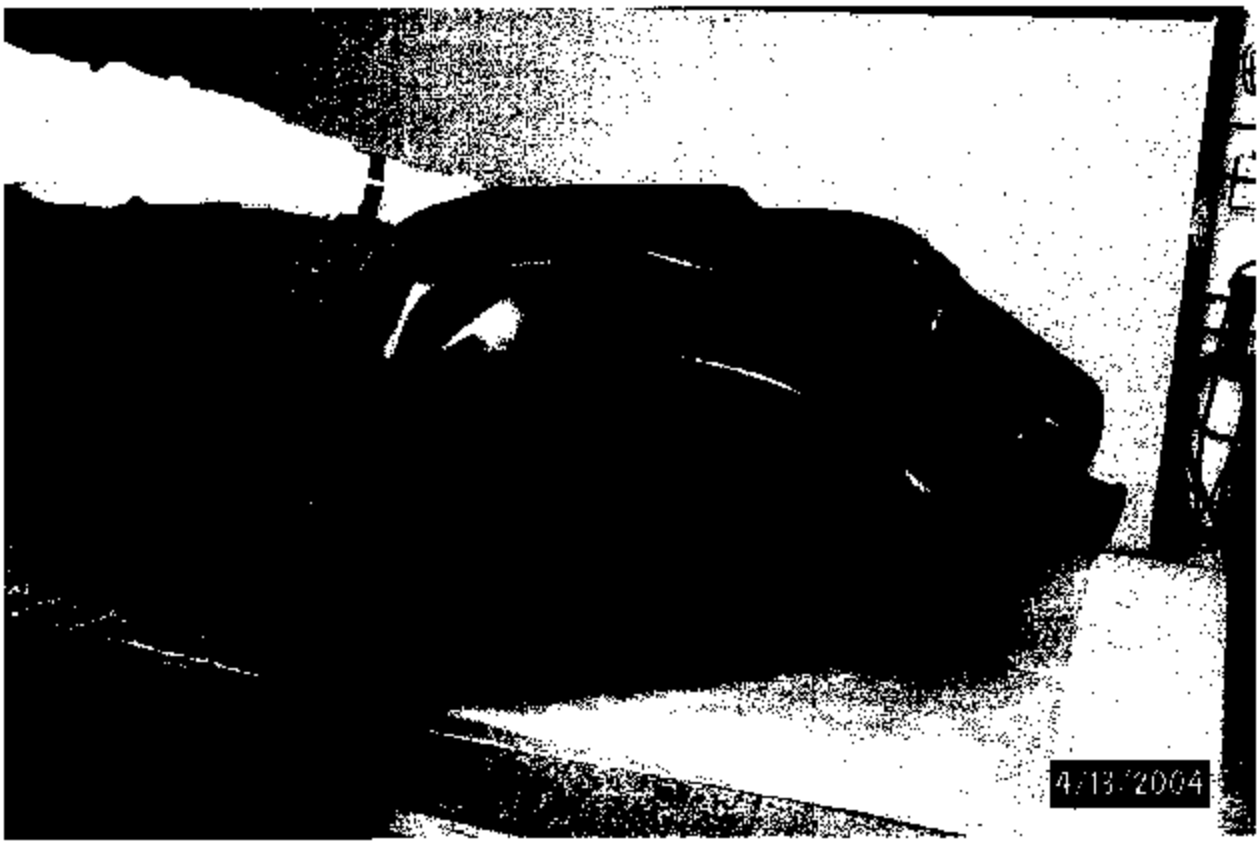

Figure 2.1 - Overall View of a Typical Subject Fuel Tank

3.0 COMPLAINT FUEL TANKS

ODI and VCNA furnished VRTC with eight fuel tanks removed from complaint vehicles, including one tank from a 1995 complaint vehicle and seven tanks from 1996 complaint vehicles. VCNA also furnished related components, such as the heat shield, crash shield, fuel pump, fuel level sensor, fuel inlet pipe, fuel delivery and return lines, and fittings, since most of the "complaint" fuel tanks were received without these components.

Table 3.1 lists these "complaint" fuel tanks, along with the vehicle owner's "complaint," and leak "source" information. The identification number marked on each fuel tank is the last four digits of the Vehicle Identification Number (VIN) of the "complaint" vehicle. The fuel tanks are listed in the chronological order of the vehicle build dates provided by ODI. The fuel tank part number and manufacturing date (within "date" circle shown) are stamped on the bottom of each fuel tank, as shown in Figure 3.1.

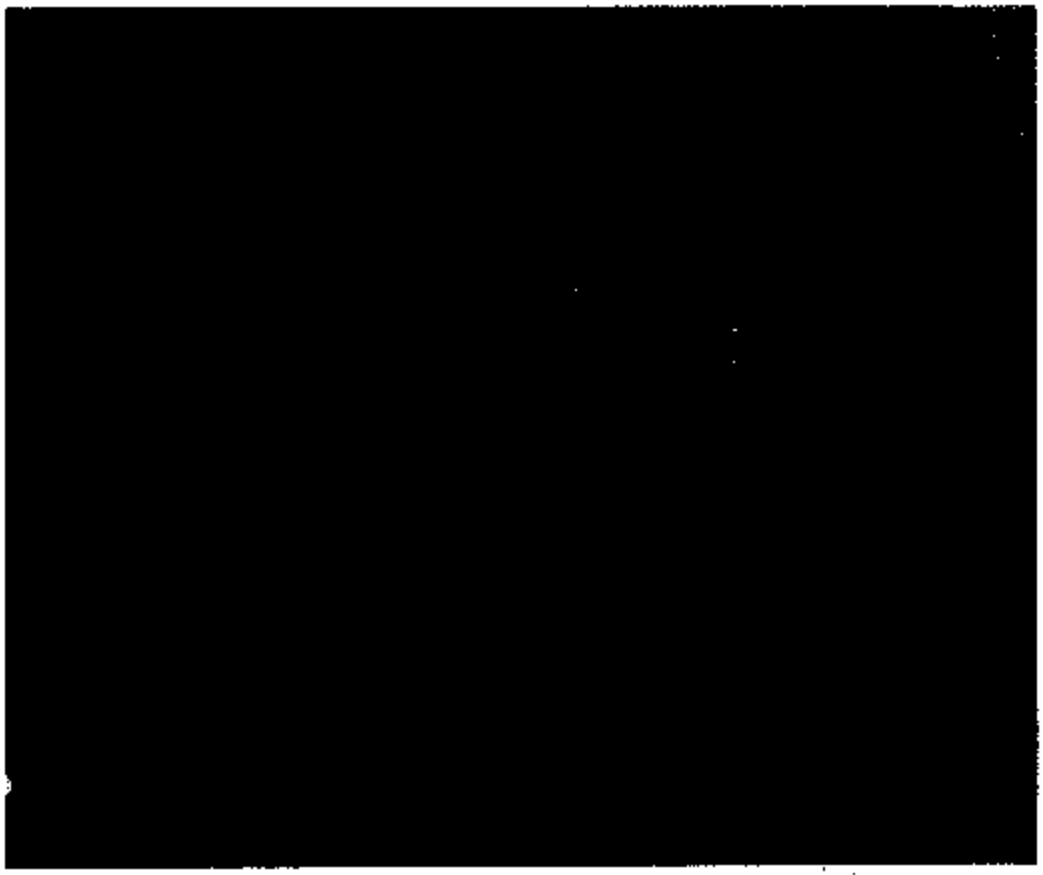

Figure 3.1 - Bottom View of a Typical Subject Fuel Tank

Table 3.1– Source Information for Volvo 850 Fuel Tanks Tested

Tank No (From State)	Body Style / Country Mfd	Engine Code	Build Date	Tank Replaced Date	Tank Replaced Odo (mi)	Complaint Summary	Date Tank Rec'd at VRTC from Source Noted
5629	4-door	B5234T	01'95	05'03	Unknown	Complaint was	From Volvo 3/29/04
(GA)	Sweden					leaks in both fuel tanks*	Dealer - N/A
0493	4-door	B5254F	06'95	06'03	157,000	Complaint was	From Volvo 4/02/04
(FL)	Sweden					leaks; split at seam (photo)	Dealer - Bergeron
7661	Sta Wgn	B5254F	10'95	10'03	162,000	VOQ notes	From Volvo 4/12/04
(CA)	Belgium					leaks from top when full	Dealer - Westside Volvo
8698	4-door	B5254F	10'95	08'03	146,300	Complaint was	Via Sweden 4/07/04
(FL)	Sweden					Tank leaks	Dealer - O'Steen Volvo
3886	4-door	B5254F	11'95	08'03	130,000	Complaint was	From ODI 3/15/04
(LA)	Sweden					leak at seam	Dealer - Hixson
4608	4-door	B5234T5	11'95	01'03	133,000	VOQ notes	From Volvo 4/05/04
(CA)	Belgium					leaks if filled over 12 gal	Dealer - McKevitt
0377	4-door	B5254F	12'95	04'04	148,000	VOQ notes	From Volvo 4/06/04
(AL)	Sweden					steady leak from tank	Dealer - Royal Auto
8329	4-door	B5254F	01'96	07'03	68,000	VOQ notes	From ODI 2/23/04
(FL)	Sweden					leak by heat shield	Dealer - Bob Cole's

NOTE: *This consumer had two vehicles – only one tank was available.

4.0 TEST PROCEDURE AND EQUIPMENT

The test procedure, described below, consisted of external and internal inspections, followed by tests to detect leaks and measure leak rate. The leak tests consisted of using pressurized air in each fuel tank to detect leaks and using Stoddard solvent, in the tanks with confirmed leaks, to determine leak rates.

4.1 Test Procedure

The test procedure consisted of three major testing steps:

Step 1 - Uniquely identify each test sample (last 4 digits of VIN) and perform a visual inspection (interior and exterior). Document manufacturing date, part number, and any other notable findings for each test tank.

Step 2 - Fit the test sample with relevant factory-installed components (except the fuel filler pipe and cap), i.e., fuel pump, fuel sender, heat shields, etc. (provided by Volvo), and perform a leak test using air pressure at 5 kPa and a leak detection spray (soapy water). Repeat this step after removing the heat shield so leaks around the attachment bosses can be seen more easily.

If any leak is found, document it with photographs. Identify and describe the leak source and the area of the tank from which it leaks.

Step 3 - Fill each "leaking" test sample to capacity (70 L or 18.5 gal as specified by Volvo) with Stoddard solvent and measure and record the amount of leakage expressed in ml/min at 0 kPa and 5 kPa for at least 5 minutes.

4.2 Test Equipment

A list of the test equipment used during the test program is shown in Table 4.1. The digital camera was used to photograph each test tank as received, tank leaks or other relevant findings noted during the inspections and testing, and typical test setups.

A miniature video camera was used to inspect the interior of each test tank during Step 1 of the test procedure. The interior view, especially of the mounting bosses for the heat shield, was observed on a large video monitor. Possible cracks in the plastic were documented on a digital video recorder. A typical test setup for the internal inspections is shown in Figure 4.1.

Table 4.1 – Test Instruments and Equipment

Test Equipment	Model / Serial Number	Manufacturer
Digital camera	DC265 / EKM 91102063	Kodak
Miniature video camera	CVX V1 / 100201	Sony
Digital video recorder	GV-D900 / 25374	Sony
Video monitor	CF27D50 / 58433850	Toshiba
Pump (air)	D0A-P104-AA / 0483	Cole Parmer
Digital pressure gauge	DPG700-100 / 00108	RIS
Transfer pump (fluid)	870-872-876-360 / FO 228000A	Northern Industries
Calibrated Pitchers (2) 3.8L		Rubbermaid
Bread pans (2) 6.5"X4.25"X2.5"		
Stop watch		Heuer
Graduated cylinder - 100ml	3022	Pyrex
Vial - 15ml	8082	Pyrex
Syringe - 12ml		Ideal
Syringe - 3cc		BD

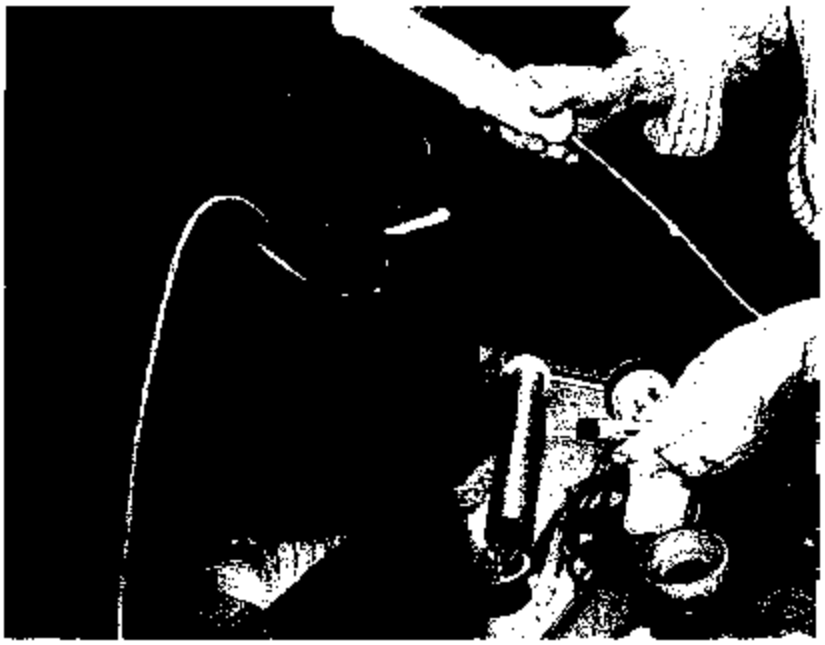

Figure 4.1 - Typical Test Setup for Inspection Inside Fuel Tank

An air pump and a digital pressure gauge were used to supply and monitor the 5- kPa air inside each test tank during Step 2 of the test procedure. A typical test setup for this step in the testing is shown in Figure 4.2.

For Step 3 of the test procedure, a transfer pump and calibrated pitchers were used to fill the test tanks, that had air leaks in Step 2, to capacity (70 L or 18.5 gal as specified by Volvo) with Stoddard solvent, a commonly used substitute for gasoline during crash testing. The test setup was similar to that shown for Step 2, except liquid was used in the test tanks instead of an air pressure of 5 kPa. Small bread pans were used to collect the fluid that leaked and a stopwatch was used to determine the leak rate. Graduated cylinders, vials, and syringes were used to measure the amount of fluid that leaked.

Figure 4.2 - Typical Test Setup for Air-leak Tests

5.0 INSPECTION AND TEST RESULTS

The tests consisted of three major steps, including external and internal inspections, air-leak tests to detect leaks, and fluid-leak tests to measure leak rate.

5.1 Inspection Results

A summary of the inspection results for the eight "complaint" fuel tanks is shown in Table 5.1. The manufacturing dates for the test tanks ranged from 1/09/95 through 1/02/96.

Although the overall construction of the test tanks was similar (same Part Number 9142618), a visual inspection of the exterior of each test tank revealed some differences. Four of the eight test tanks had a single boss (blue circle) for a crash shield on the side of the tank as shown for Tank 5629 in Figure 5.1.

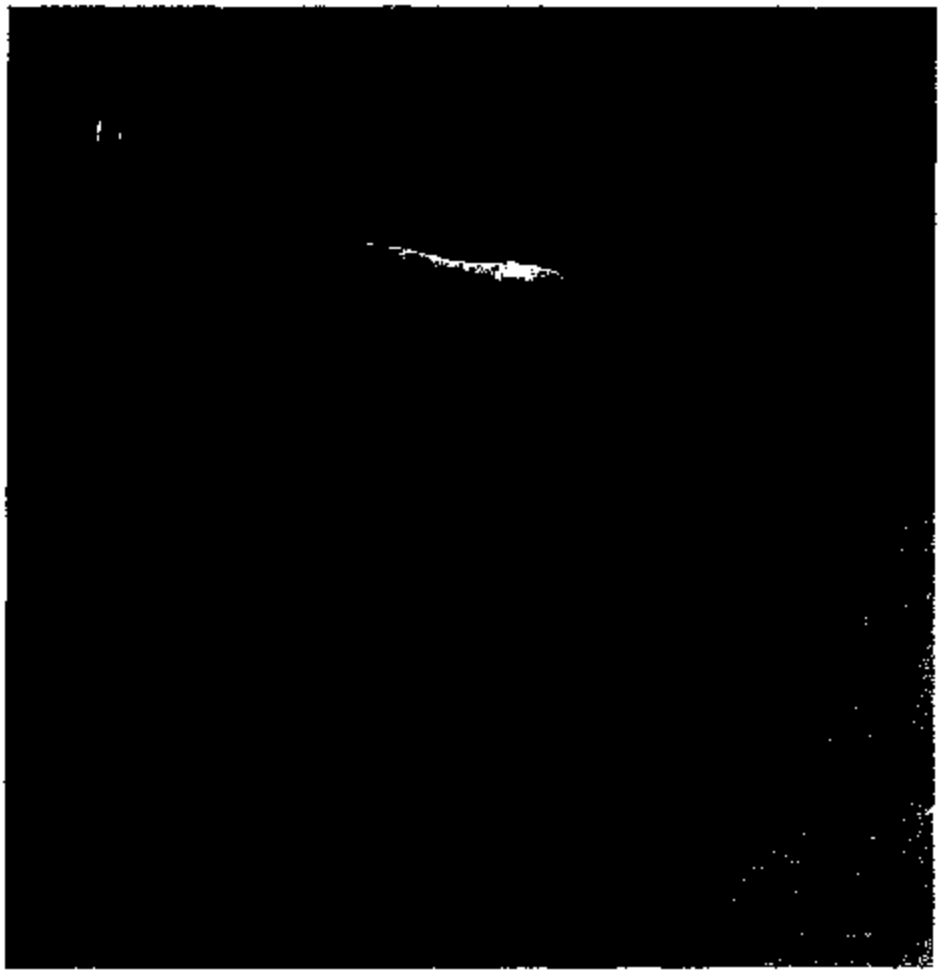

Figure 5.1 - Typical Boss for the Crash Shield on Some Test Tanks

Table 5.1 – Summary of Inspection Results

Tank No	Visual Inspection of Exterior	Visual Inspection of Interior	Mfg Date	Part No.	Other Findings
5629	C/S boss	Possible crack at H/S Boss B	1/09/95	9142618	Fuel vent hose damaged as rec'd
8493	No C/S boss	Possible cracks at H/S Bosses A & B	6/09/95	9142618	Plastic glob on seam
7661	No C/S boss	No cracks observed	9/11/95	9142618	
8698	No C/S boss	Possible crack at H/S Boss B	10/02/95	9142618	Epoxy repair attempt at H/S Boss B as rec'd
3886	C/S boss	Possible crack at H/S Boss B & C/S boss	11/22/95	9142618	Two screws in bottom of tank
4608	C/S boss	Possible crack at H/S Boss A	11/22/95	9142618	Only tank rec'd with OEM H/S
0377	C/S boss	No cracks observed	12/05/95	9142618	
8329	No C/S boss	Possible crack at H/S Boss B	1/02/96	9142618	

Notes: H/S = Heat Shield w/3 mounting bosses on end of all test tanks.
C/S = Crash Shield on four test tanks noted above; has only one mounting boss on side of tank.

A fuel tank vent hose (not tested) was found damaged as received on Tank 5629. It is not known if this was a possible cause for the "complaint" or if it was damaged during removal from the vehicle before being shipped to VRTC. Other observations made during the exterior inspections included a plastic glob on Tank 0493, as shown in Figure 5.2, and an apparent attempt to repair a leak at the boss for the heat shield with epoxy on Tank 0698, as shown in Figure 5.3. Two screws were also noted in the bottom of Tank 3886 and appeared to be a crude way to plug "drilled" drain-holes in the fuel tank. One of these "repair" screws can be seen in Figure 3.1, just to the right of the stamped part numbers.

Figure 5.2 - Plastic Glob on the Seam and to the Left of the Bosses for the Heat Shield on Test Tank 0493

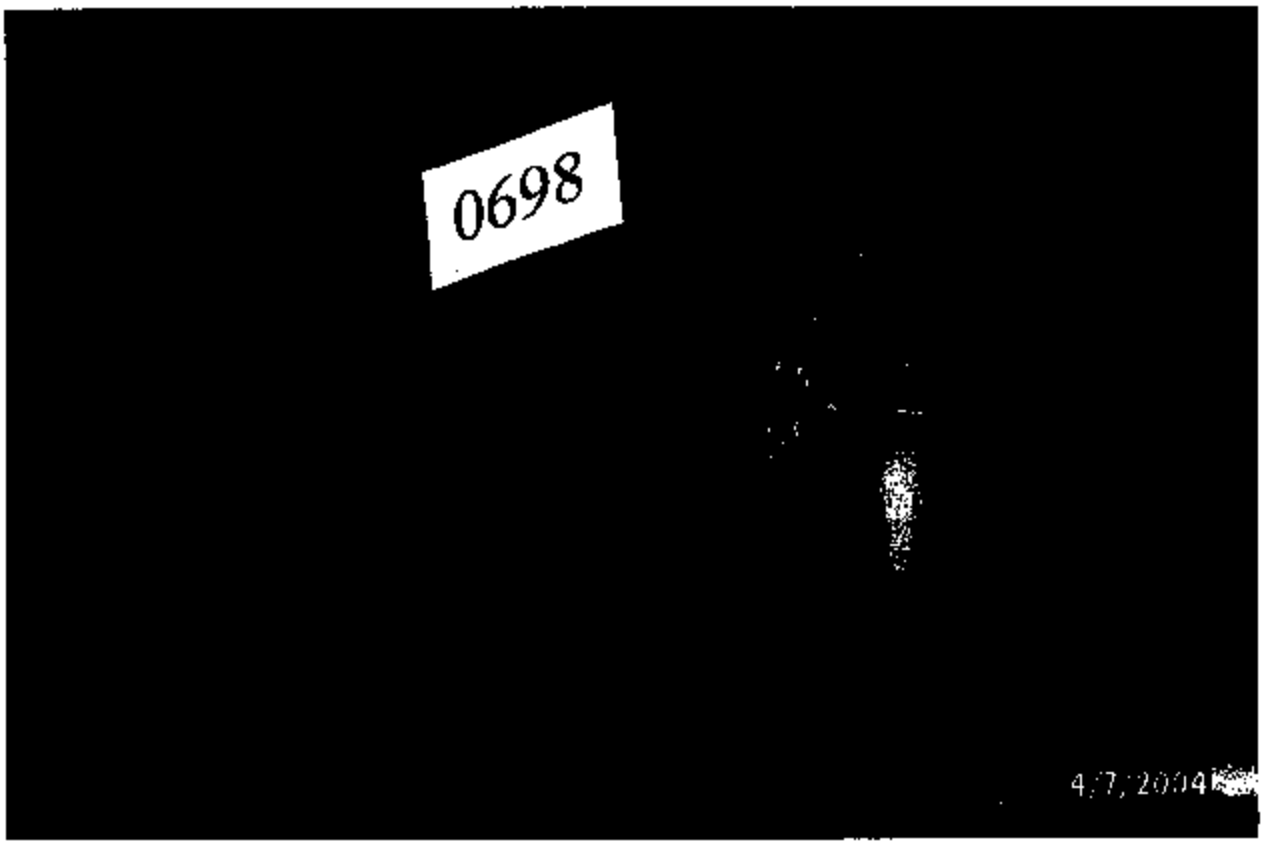

Figure 5.3 - Apparent Attempt to Repair Leak using Epoxy on Boss B of the Heat Shield on Test Tank 0698 (As Received)

Results for the inspection of the interior of the test tanks were mixed because of the difficulty in maneuvering the camera and the lighting of the interior. Lighting often caused shadows, leading to observations that were only "possible" cracks near the bosses for the shields. Several of the "possible" cracks were not confirmed during the subsequent air-leak tests. A view of a typical crack, as observed using the miniature video camera inside Tank 0493, is shown in Figure 5.4. This crack is shown in the upper left in the figure, above an apparent scratch mark. Subsequent air-leak tests, discussed in Section 5.2, confirmed a leak from this area.

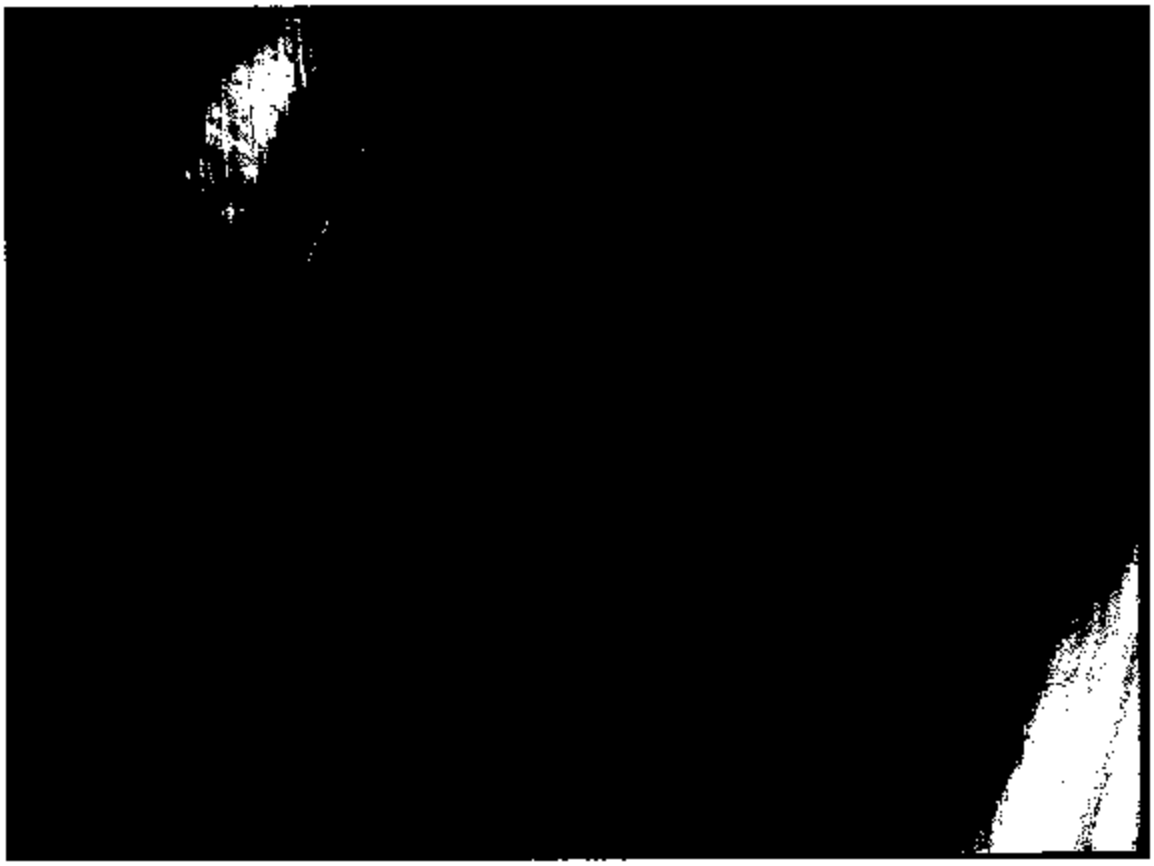

Figure 5.4 - View of the Crack Inside Tank 0493 by Boss B of the Heat Shield

5.2 Air-leak Test Results

A summary of the test results for the air-leak tests is shown in Table 5.2. Leaks were confirmed in five of the eight "complaint" fuel tanks tested.

All tanks were tested using air pressure at 5 kPa for a minimum of 5 min with the heat shield installed. These tests were repeated for at least 2 min after the heat shield was removed so that leaks, detected using soapy water, could be seen and documented more easily. A view of the leak in Tank 0493, with the heat shield installed, is shown in Figure 5.5. A view of the leak in Tank 0377, after the heat shield was removed, is shown in Figure 5.6. All five of the test tanks with confirmed leaks were found to be leaking around the same attachment point (Boss B) for the heat shield. In addition, one test tank also had a second leak around the single boss for the crash shield, as shown in Figure 5.7.

Table 5.2 – Summary of Air-leak Test Results

Tank No	Leaks Observed	Location of Tank Leak	Remarks
			All H/S screws were tightened to 5 Nm as specified by Volvo test engineer.
5629	None	N/A	Pressure tested about 10 min w/H/S on; did not use damaged OEM vent hose.
0493	Yes	H/S Boss B	Pressure tested about 5 min w/H/S on & 5 min w/H/S off
7661	None	N/A	Pressure tested about 5 min w/H/S on & 2 min w/H/S off
0698	Yes	H/S Boss B (near Epoxy patch)	Pressure tested about 5 min w/H/S on & 2 min w/H/S off
3886	Yes (two)	H/S Boss B & C/S only boss	Pressure tested about 6 min w/H/S on & 5 min w/H/S off
4608	None	N/A	Pressure tested about 5 min w/H/S on & 2 min w/H/S off
0377	Yes	H/S Boss B	Pressure tested about 5 min w/H/S on & 2 min w/H/S off
8329	Yes	H/S Boss B	Pressure tested about 5 min w/H/S on & 2 min w/H/S off

Notes: H/S = Heat Shield w/3 mounting bosses on end of all test tanks; Boss B is on the far right in view of H/S in Figure 1.1.
C/S = Crash Shield on four test tanks noted in Table 5.1; has only one mounting boss on side of tank.

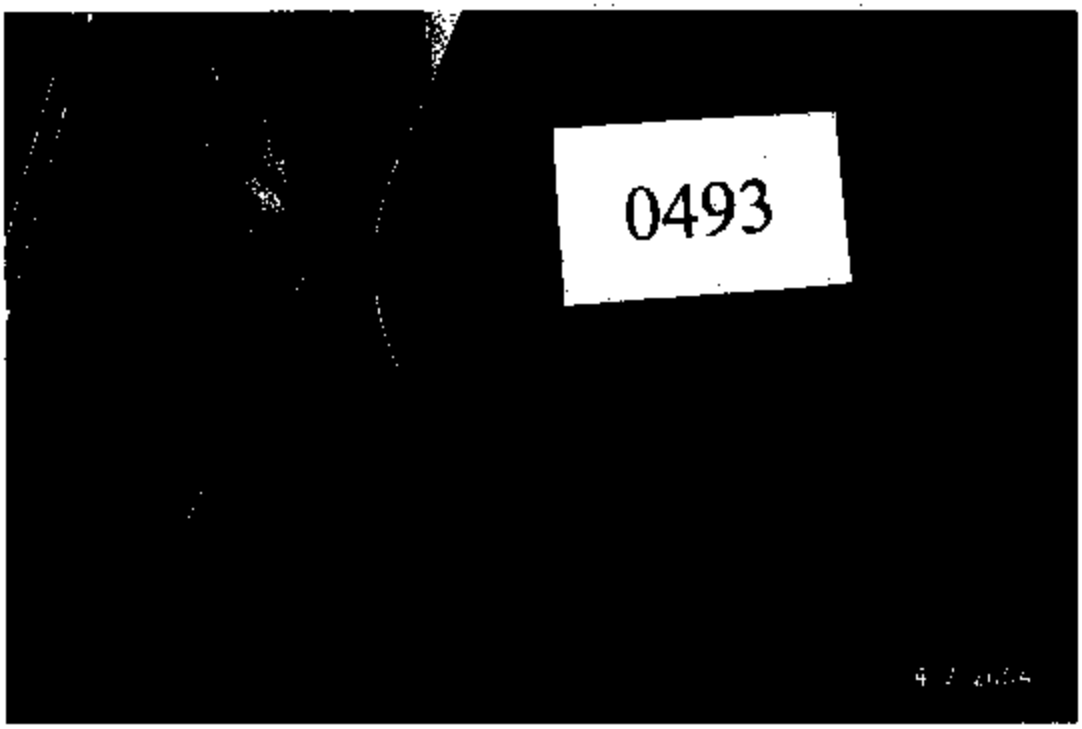

Figure 5.5 - View of the Leak in Tank 0493 by Boss B of the Heat Shield

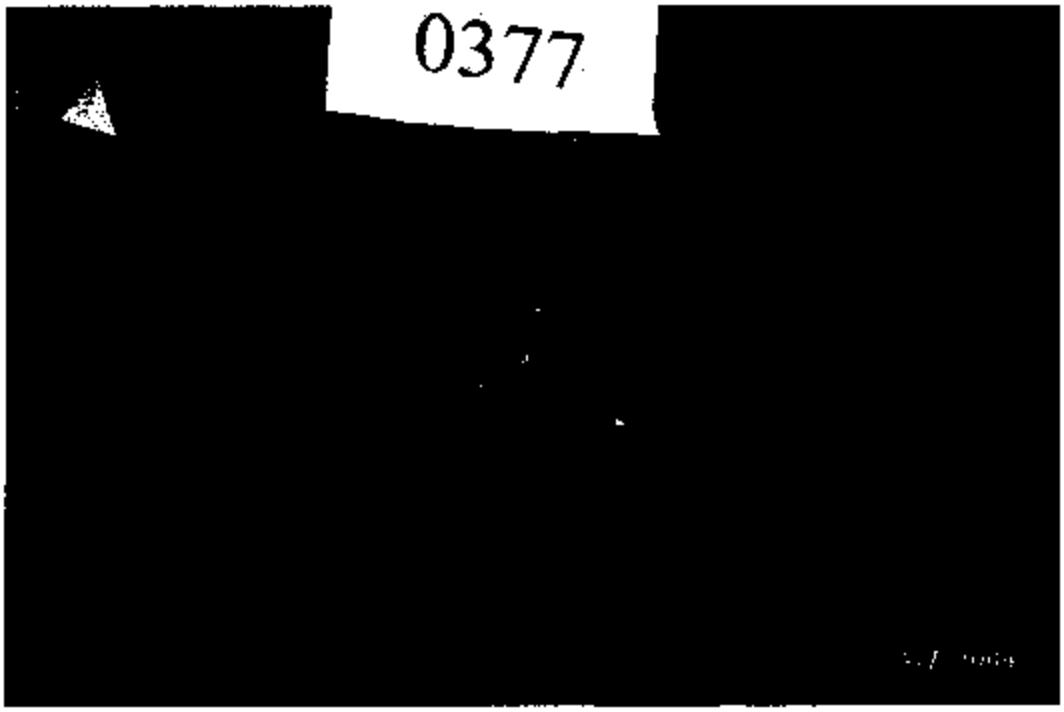

Figure 5.6 - View of the Leak in Tank 0377 by Boss B of the Heat Shield

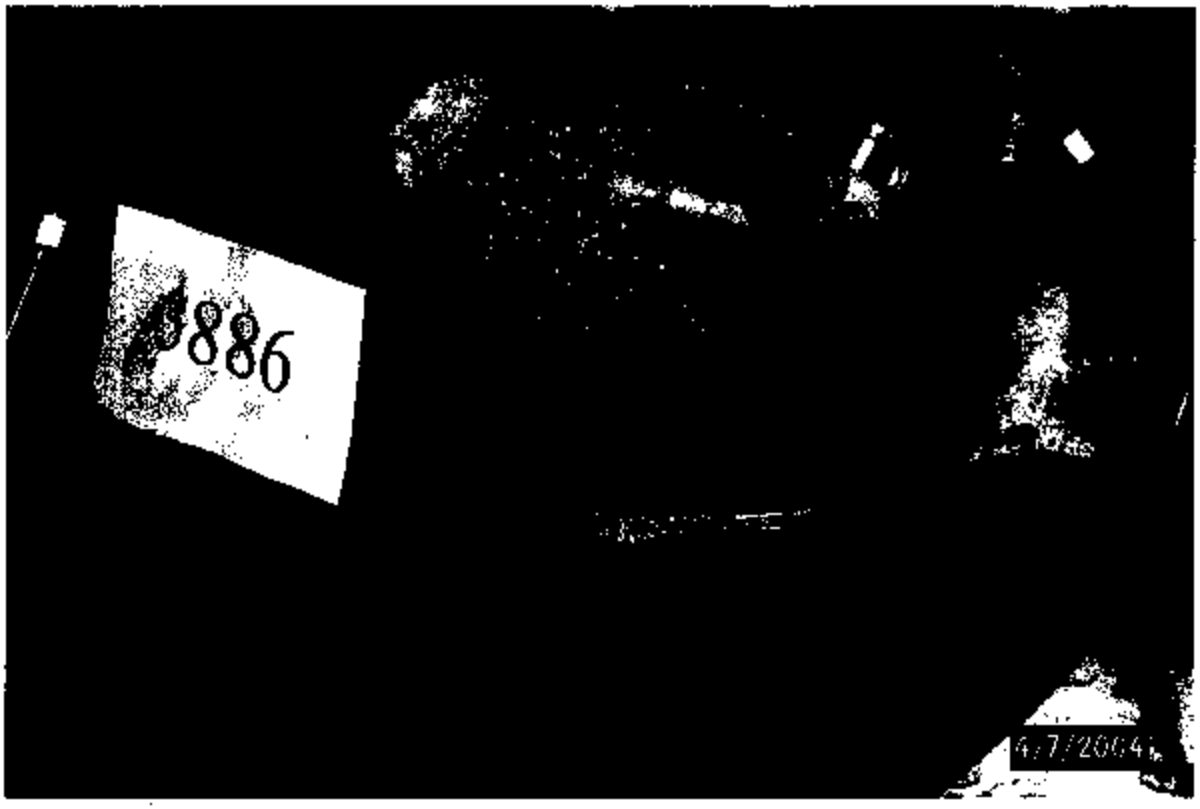

Figure 5.7 - View of a Second Leak in Tank 3886 by the Boss for the Crash Shield

5.3 Fluid-leak Test Results

A summary of the test results for the fluid-leak tests is shown in Table 5.3. Stoddard solvent was used to fill only the five "complaint" fuel tanks that had leaks confirmed in the previous air-leak testing. All tanks were tested for 5 min except for the first tank tested (Tank 8329). That tank was tested at 0 kPa for 15 min since the leak (2 ml) was small, as shown in Figure 5.8.

The leak rates for these five test tanks ranged from a trace to 1.85 ml/min when the test tank was not pressurized (0 kPa) and from a trace to 7.0 ml/min when the test tank was pressurized to 5 kPa. The test tank with the highest leak rate was Tank 0377 (1.85 ml/min at 0 kPa and 7.0 ml/min at 5 kPa). The test tank with the next highest leak rate was Tank 0493 (1.70 ml/min at 0 kPa and 4.0 ml/min at 5 kPa). Because the amount of fluid leaked varied widely for tests when the test tank was not pressurized (0 kPa) and when the test tank was pressurized to 5 kPa, two different measuring containers were used, as shown in Figures 5.9 and 5.10 for Tank 0493.

Table 5.3 – Summary of Fluid-leak Test Results

Test Order	Tank No	Leakage - 5 min at 0 kPa (ml)	Leak Rate at 0 kPa (ml/min)	Leakage - 5 min at 5 kPa (ml)	Leak Rate at 5 kPa (ml/min)	Remarks
1	8329	Trace (2 ml in 15 min)	0.13	3.25	0.65	At H/S Boss B
2	0377	9.25	1.85	35.00	7.00	At H/S Boss B
3	3886	At H/S Boss B: 0.50 ml	0.10	6.00	1.20	At H/S Boss B
3	3886	At C/S Boss: trace	N/A	7.25	1.45	At C/S which has only one boss
4	0493	8.50	1.70	20.00	4.00	At H/S Boss B
5	0698	0	0	Trace	N/A	At H/S Boss B (near Epoxy "repair" patch)

Notes: H/S = Heat Shield w/3 mounting bosses on end of all test tanks; Boss B is on the far right in view of H/S in Figure 1.1.
C/S = Crash Shield on four test tanks noted in Table 5.1; has only one mounting boss on side of tank.

Figure 5.8 - Amount of Fluid that Leaked at 0 kPa from Tank 8329 in the "Catch" Pan

Figure 5.9 - Amount of Fluid that Leaked at 0 kPa from Tank 0493 in the Graduated 15-ml Vial

Figure 5.10 - Amount of Fluid (20 ml) that Leaked at 5kPa from Tank 0493 in the Graduated 100-ml Cylinder

All fluid leaks were found to be from the same attachment point (Boss B) for the heat shield. The leak rate for a secondary leak, found around the boss for the crash shield on only Tank 3886, ranged from a trace at 0 kPa to 1.45 ml/min at 5 kPa. The boss for the crash shield is located much higher on the fuel tank (see Figure 5.1) compared to the boss for the heat shield so the amount of leakage is more limited with a full fuel level.

The test tank with the lowest leak rate was Tank 0698 (only a trace at 5 kPa). However, it should be noted that an attempt to repair this tank had been made, as shown in Figure 5.3, before this tank was received by VRTC.

6.0 FINDINGS

Based on the inspections and tests performed on eight "complaint" fuel tanks from 1995-96 Volvo 850 vehicles during this test program, the following major findings were made:

1. Leaks were confirmed on five of the eight "complaint" tanks tested.

2. A leak was found at Boss B for the heat shield for the five test tanks with confirmed leaks. One tank also had a second leak at the single boss for the crash shield.

3. The leak rates for these five test tanks ranged from a trace to 1.85 ml/min when the test tank was not pressurized (0 kPa) and from a trace to 7.0 ml/min when the test tank was pressurized to 5 kPa.