US Department
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National Highway
Traffic Safety
Administration

Memorandum

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Subject: FINAL REPORT – VRTC-DCD4072 "Investigation of Electronic Throttle Control on 2001-2003 Ford F-Supern Duty and Excursion (EA04-006)"

Date: NOV 2 9 2004

From: W. R. Demeto for
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-DCD4072
EA04-006

Investigation of Electronic Throttle Control

on 2001-2003 Ford F-Super Duty and Excursion

VEHICLE RESEARCH AND TEST CENTER
EAST LIBERTY, OHIO 43319

FINAL REPORT
NOVEMBER 2004

U.S. Department of Transportation
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16. Abstract

The objectives of this program were to determine the condition(s) under which the engine speed of subject vehicles would inappropriately remain at idle or return to idle when the accelerator pedal was fully depressed and to determine the range of Accelerator Pedal Sensor (APS) output voltages on a sample of in-use subject vehicles. Driving tests were conducted on a subject 2002 Ford F-350 vehicle. A field survey of APS output voltages for 30 subject vehicles was also conducted.

Testing showed: 1) The engine speed on the subject vehicles returned to idle when the APS output voltage exceeded 4.5 volts. 2) Full-Throttle position on the accelerator pedal could be achieved and maintained with approximately 12 lb of force on the pedal. 3) The engine speed on the test vehicle with a new accelerator pedal assembly did not initially return to idle until 150 lb of force was applied. The force required to cause the engine speed to return to idle diminished gradually to about 90 lb during the course of testing.

The back of the pedal stop on the accelerator pedal assembly rests on the padded and insulated rubber floor mat rather than on the steel firewall like the three mounting pads. An exemplar 2004 F-250 truck was inspected and found to have a cutout in the floor mat that allowed direct contact between the pedal stop and the firewall.

Field inspections showed: 1) None of the 30 vehicles inspected exhibited the anomaly. 2) The APS output voltage varied from 3.81 volts to 4.44 volts at a pedal force of 100 lb. 3) The application of 100 lb of force required a concentrated effort and "hand" bracing against the steering wheel for leverage. 4) Two of the replaced pedal assemblies were found to have a pedal stop and mounting pads that were not coplanar, indicating possible deformation.

The major conclusions reached during this test program were: 1) While the engine speed can be caused to return to idle under full-throttle conditions, the force on the accelerator pedal required to reach this condition greatly exceeds the force (about 12 lb) that would be required or expected during ordinary driving. 2) The inspection of 30 in-use subject vehicles subjected the accelerator pedal to a force (100 lb) more than eight times the force required to achieve and hold the accelerator pedal in the WOT position. None of the inspected vehicles demonstrated the anomaly at this force level. 3) Compared to the original "BA" pedals, replacement "BB" pedals with an additional WOT-stop performed better at higher pedal forces. The APS output voltage did not exceed 4.0 volts when 100 lb of force was applied to the accelerator pedal in any of the replacement "BB" pedals that were installed during the field survey. 4) The gradual reduction of the force required during the tests to cause the APS output voltage to exceed 4.5 volts suggests that repeated abuse of the "BA" accelerator pedal by consumers may cause permanent deformation of the accelerator pedal assembly. Over time, this may result in forces much lower than 100 lb being required to reach the 4.5-volt threshold for the APS output.

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1.0 Introduction

This program was performed at the Vehicle Research and Test Center (VRTC) at the request of the Office of Defects Investigation (ODI) of the National Highway Traffic Safety Administration (NHTSA). ODI opened an Engineering Analysis (EA04-006) on 2002 – 2003 Ford Super Duty and Excursion vehicles equipped with 7.3L diesel engines, Electronic Throttle Control (ETC), and power adjustable pedals.

The scope of EA04-006 was later expanded to include the 2001 model year and fixed accelerator pedals. ODI has received complaints on these vehicles concerning the engine speed remaining at idle or returning to idle when the accelerator pedal was fully depressed.

2.0 Background

The Accelerator Pedal Sensor (APS) is a three-wire potentiometer that receives a reference voltage from the Power Control Module (PCM) and returns a signal to the PCM that is directly proportional to the position of the accelerator pedal. If an electrical fault of the APS is detected by the PCM, the Malfunction Indicator Lamp (MIL) is illuminated on the instrument cluster. Specifications provided by Ford showed that the output signal from the APS should not exceed 4.5 volts at 135 lb of force on the accelerator pedal. An APS signal above 4.5 volts is considered by the PCM to be too high and will cause the PCM to allow the engine to operate only at low idle or to return to idle.

3.0 Objective

The initial objective of this program was to determine the condition(s) under which the engine speed of subject vehicles would inappropriately remain at idle or return to idle when the accelerator pedal was fully depressed by the driver. A subsequent objective was to determine the range of APS output voltages versus applied pedal forces on a sample of in-use subject vehicles.

4.0 Procedure

The following activities were undertaken for this project:

1. A subject vehicle (2002 F-350, VIN: 1FDWF36F52EC65276) was leased for testing. A pedal force transducer was installed on the accelerator pedal and the truck was driven with multiple applications of full or Wide Open Throttle (WOT) at varying pedal force

levels. A video camera was used to record the positions of the accelerator pedal and engine speed. Application forces on the accelerator pedal were verbally annotated on the videotape.

2. The physical layout of the accelerator pedal assembly and the mounting location in the subject vehicle were examined for compatibility.

3. After determining that the engine speed of the test vehicle could be made to remain at idle when WOT was applied, instrumentation was added to monitor input and output voltages of the APS during subsequent tests.

4. A New Generation Star Tester was used to determine whether any fault codes had been recorded in the PCM of the test vehicle.

5. An exemplar 2004 F-250 Super Duty truck was examined to determine how the accelerator pedal assembly was mounted.

6. A survey of APS output voltages versus applied pedal forces was performed on a random set of subject vehicles available for sale at local dealerships.

5.0 Results

The results of each testing activity listed above are presented below. The term "anomaly" will be used to describe the engine returning to idle speed when the accelerator pedal is depressed to the WOT position.

5.1 Driving Tests

The part number of the accelerator pedal on the subject test vehicle was 1C34-9F836-BA. The pedal assembly was manufactured on 3/8/02. The vehicle was manufactured in April 2002 so it is likely that the pedal assembly was original to the vehicle.

Fully depressing the accelerator pedal to the mechanical limit required only approximately 12 lb of force. The first pedal application to full throttle was fairly slow. The engine speed responded appropriately until the pedal force reached approximately 100 lb, whereupon the anomaly occurred.

The second application was somewhat quicker and more forceful. The engine accelerated normally until the pedal force reached approximately 120 lb, whereupon the anomaly occurred.

The third application was somewhat slower than the second application and the vehicle responded properly, even at 120 lb of pedal force.

The results of subsequent pedal applications indicated that the anomaly appeared to be dependent on the force applied to the pedal after reaching maximum pedal travel. During these tests, the anomaly usually occurred at pedal forces on the accelerator pedal between approximately 100 and 120 lb.

An attempt was made to determine whether the accelerator pedal needed to return to idle position in order for the engine to regain normal operation. With the anomaly occurring, the force on the accelerator pedal was slowly reduced while keeping the accelerator pedal fully depressed. The engine regained normal operation when the force on the accelerator pedal reached approximately 50 lb. The pedal was kept depressed at the mechanical limit throughout this test.

The mechanical stop that limits accelerator pedal travel was next shimmed approximately 3/32 inch so the pedal could not reach full travel. The engine response to the accelerator pedal was normal under this condition, even with rapid and heavy throttle applications.

After the shim was removed, the anomaly reoccurred when the pedal was fully depressed with as little as 20 lb of force. However, it is suspected that the installation and removal of the shim, along with a series of very high pedal force applications, may have caused abnormal deformation of the accelerator pedal assembly.

Throughout the driving tests, the MIL became illuminated each time the anomaly occurred. The MIL extinguished when normal engine operation resumed.

A new "BA" pedal assembly (manufactured on 7/31/02) was installed and additional tests, similar to those described above, were performed. A pedal force in excess of 150 lb was initially required to cause the anomaly to occur. The force required for the anomaly to occur was found

to be gradually lower on subsequent applications until a force of approximately 90 lb would cause the anomaly to occur.

5.2 Physical Examinations

A new accelerator pedal assembly was examined. Because the pedal assembly is mounted directly to the firewall over a rubberized and insulated floor mat, integral spacers are part of the pedal assembly to allow the assembly to be fastened firmly to the firewall. The assembly also has a mechanical stop that prevents excessive travel of the pedal. As shown in Figure 1, the three integral spacers for the mounting bolts and the back of the pedal stop are all coplanar.

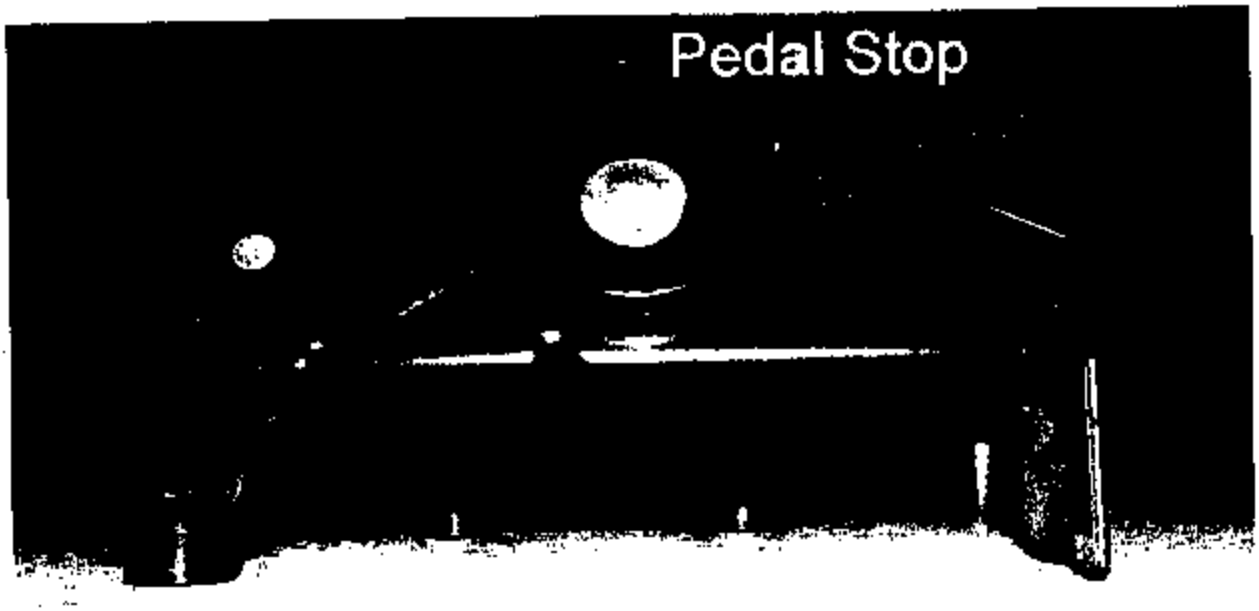

Figure 1
Coplanar Spacers and Pedal Stop

When the pedal assembly was mounted in a subject vehicle, the three spacers contacted the steel firewall through cutouts in the rubberized and insulated floor mat. Rather than having a cutout that also allowed the back of the pedal stop to contact the firewall, the pedal assembly was mounted with the floor mat between the pedal stop and the firewall. This condition produced a softer and more flexible support for the pedal stop than would be afforded had the pedal stop been in direct contact with the firewall. Figure 2 shows the area on the firewall where the pedal assembly mounts and the indentation in the floor caused by the back of the pedal stop. Figure 3 shows a close-up of the indentation in the floor mat caused by the pedal stop. It is not known if a

nearby cutout in the floor mat was meant to allow contact between the pedal stop and the firewall. This unused cutout was found to be common among all subject vehicles that were subsequently examined.

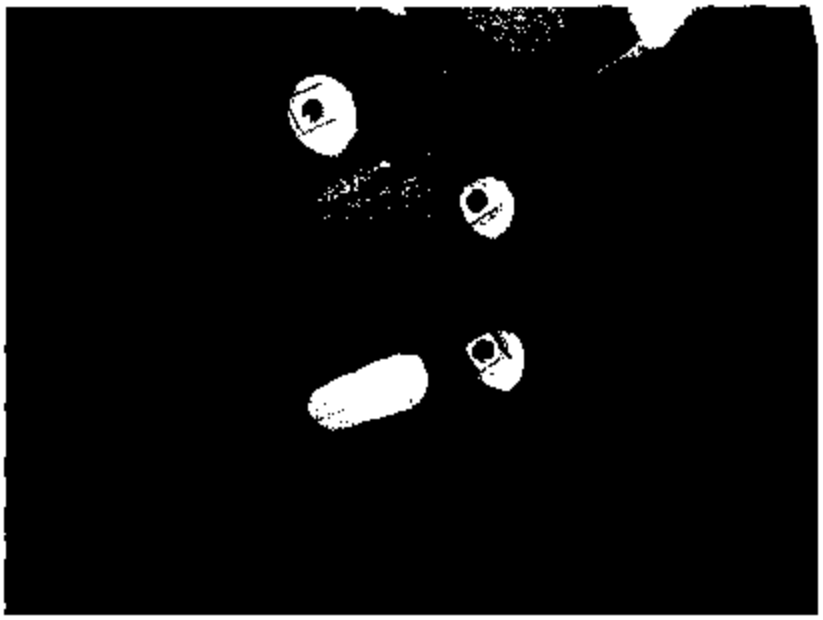

Figure 2
Accelerator Pedal Mounting Area on Firewall

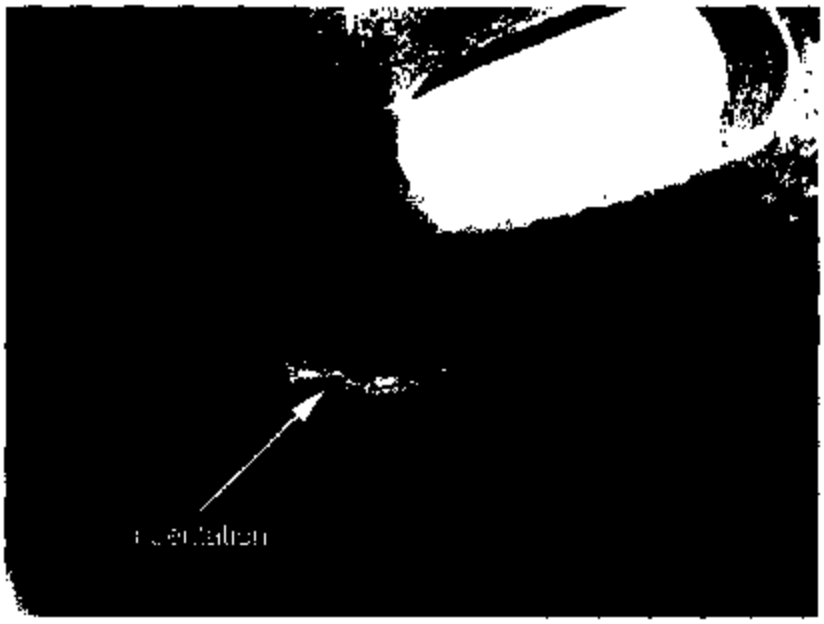

Figure 3
Indentation on Floor Mat Caused by Pedal Stop

5.3 Instrumented Testing

Digital voltmeters were installed in the vehicle to monitor the Idle Validation Switch (IVS) voltage and the APS voltage. It was determined that the anomaly occurred when the APS output voltage exceeded 4.5 volts. The occurrence of the anomaly was found to be solely dependent on the force applied to the accelerator pedal that exceeded the force required for WOT. In all tests, minimal force on the accelerator pedal (10 to 15 lb) allowed normal operation. Increased force caused a gradual increase in the APS output signal voltage.

Two additional accelerator pedal assemblies were purchased from an authorized Ford dealership. The boxes in which they were shipped both showed the same part number (1C34-9F836-BA) as the one that was previously purchased. However, the label carrying the part number that was affixed to the pedal assembly carried a BB suffix, rather than the BA suffix listed on the earlier parts. Ford informed ODI that all current orders for replacement parts should be filled with the "BB" pedal. The "BB" pedal assembly incorporated a full-throttle stop bar that contacted the back of the existing idle stop at WOT before the pedal arm contacted the original pedal stop. Eleven pedal assemblies were measured to determine the clearance between the pedal arm and the original pedal stop when the new full-throttle stop bar was engaged. Clearance on these 11 pedals ranged from 0.060 inch and 0.082 inch. Figure 4 shows a "BA" pedal assembly. Figure 5 shows a "BB" pedal assembly.

The new "BB" pedal assembly was installed in the test truck and pedal applications up to 135 lb were performed. There was no appreciable permanent change in the zero-force idle voltage or the minimum-force full-voltage during these tests. The full throttle voltage only increased by 140 mv between 12 and 135 lb of pedal force and never exceeded 4.01 volts.

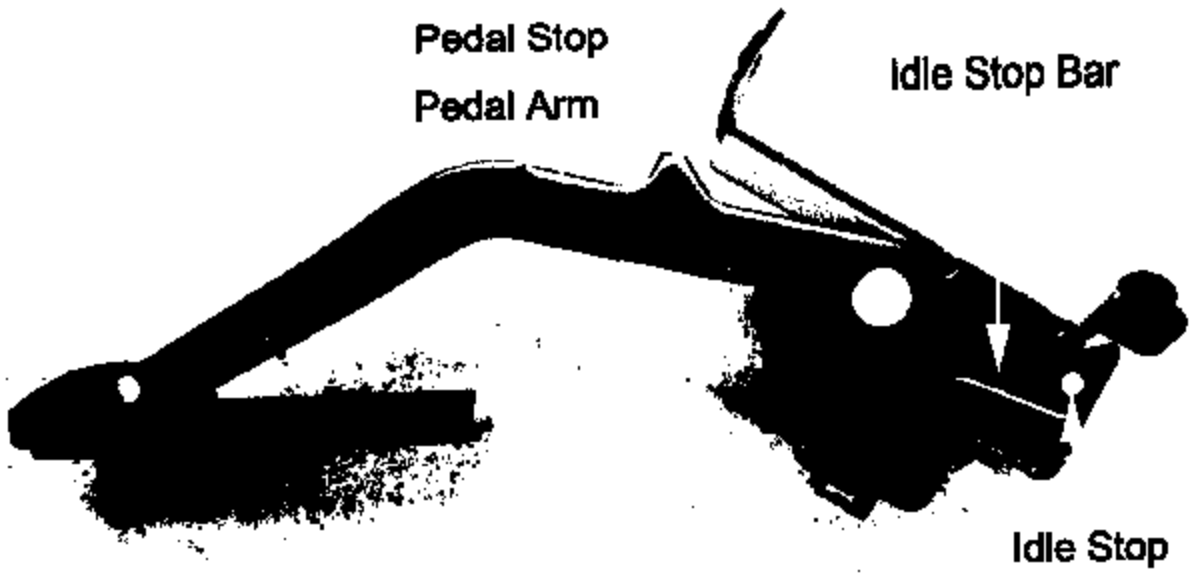

Figure 4
"BA" Pedal Assembly

Figure 5
"BB" Pedal Assembly

5.4 Fault Code Determination

A New Generation Star Tester was connected to the diagnostic port of the subject test vehicle. The PCM was found to have three fault codes stored:

P0221 - Throttle Switch B Circuit Performance
P0122 - Accelerator Pedal Sensor Circuit Low Input
P0123 - Accelerator Pedal Sensor Circuit High Input

The PCM was reset and attempts were made to induce new fault codes. Fault code P0123 was set in the PCM by depressing the accelerator pedal until the APS output voltage exceeded 4.5 volts with the ignition switch in the Run position. Fault code P0221 was set in the PCM by disconnecting the wiring harness from the APS with the ignition switch in the Run position. Fault code P0122 could not be reproduced during these tests.

5.5 Late Model Inspections

The method of mounting the accelerator pedal assembly was inspected on a new 2004 F250 Super Duty (VIN: 1FTSF31PX4EC94603) at a Ford dealership. Although the pedal assembly (P/N 3C44-9F836-AC) had a different wiring configuration, it appeared to be mechanically similar to the "BB" pedal assembly. A cutout in the floor mat allowed the pedal stop to contact the steel firewall. Figure 6 shows the accelerator pedal assembly of this vehicle.

Figure 6
Accelerator Pedal Assembly of 2004 F-250 Super Duty Truck

5.6 In-Use Vehicle Inspections

Thirty new "BB" pedal assemblies were purchased from an authorized Ford dealership. A search was performed on the Internet for subject vehicles listed for sale at used-vehicle dealerships in Ohio. Appropriate dealers were contacted and a request was made to allow VRTC personnel to inspect the subject vehicles and replace the accelerator pedal assembly as desired by VRTC at no cost to the dealership. The inspection consisted of reading and recording the APS output voltage with up to 100 lb of force, applied in 10-lb increments, on the accelerator pedal. Original "BA" accelerator pedal assemblies were replaced with new "BB" pedal assemblies if the output voltage exceeded 4.0 volts at less than 70 lb of applied pedal force. Two vehicles already had a "BB" pedal in place. Replaced "BA" pedal assemblies were kept by VRTC for possible testing. None of the thirty vehicles that were inspected exhibited the anomaly at 100 lb of force on the accelerator pedal.

A summary of the inspections is shown in Table 1. Graphical representations of the APS output voltages for the As-Found and Replacement pedal assemblies are shown in Figures 7 and 8 respectively.

The 19 pedal assemblies that were exchanged by VRTC were physically measured to determine whether the three mounting points and the pedal stop were coplanar. Each pedal assembly was placed on a flat surface (0.0005-inch accuracy) so that the three mounting points contacted the flat surface. Any clearance that existed between the flat surface and the pedal stop was then measured. The pedal assembly from Vehicles 10 and 17 had minimal clearance (0.007 inch and 0.005 inch respectively) between the back of the pedal stop and the flat surface. The back of the pedal stop on the remaining 17 pedal assemblies was coplanar with the mounting pads and made contact with the flat surface.

Table 1 - Summary of Subject Vehicle Inspections

Insp. No.	Year	Model	VIN	Veh. Mfg. Date	Odometer Reading	Pedal Mfg. Date	Pedal Part Number	Replaced	Voltage @ 100 lb PF		PF when APS @ 4.0 V	Dealer
									Orig.	Repl.		
1	2001	F-250	1FTNW21F41EC43530	Feb-01	74,481	11/21/2003	1C34F9836BB	Prior	3.90	N/A	N/A	Magnam
2	2002	F-250	1FTNW21F42EA36282	Aug-01	31,580	7/12/2001	1C34F9836BA	Yes	4.18	3.94	40	Magnam
3	2002	F-350	1FDWF37F82EC51273	Mar-02	14,042	3/5/2002	1C34F9836BA	Yes	4.26	3.89	15	Magnam
4	2001	F-350	1FDSW35F81EA85613	Oct-00	31,321	9/13/2000	1C34F9836BA	Yes	*	*	*	Magnam
5	2002	F-250	1FTNF21F82EA33532	Aug-01	18,367	7/9/2001	1C34F9836BA	Yes	4.21	3.93	30	Magnam
6	2001	F-250	1FTNF21F21ED77965	Jun-01	45,705	6/5/2001	1C34F9836BA	Yes	4.12	3.81	50	Liberty
7	2002	F-250	1FTNX21F22EC33316	Feb-02	39,565	2/4/2002	1C34F9836BA	Yes	4.44	3.99	15	Liberty
8	2001	F-350	1FTWW33F21EB18517	Oct-00	67,792	9/20/2000	1C34F9836BA	No	3.94	N/A	N/A	Kerns
9	2001	F-350	1FTWW33F71ED75401	Jun-01	72,595	5/15/2001	1C34F9836BA	Yes	4.15	3.88	50	Kerns
10	2001	F-350	1FTSW31F31EC27781	Feb-01	79,109	2/1/2001	1C34F9836BA	Yes	4.20	3.87	40	Kerns
11	2001	F-350	1FTWW33F11EB48690	Nov-00	84,092	11/1/2000	1C34F9836BA	No	3.81	N/A	N/A	Kerns
12	2002	F-350	1FDWW33F72EB26738	Oct-01	31,853	10/8/2001	1C34F9836BA	Yes	4.07	3.84	60	Kerns
13	2002	F-250	1FTNX21F62ED29470	May-02	47,221	5/14/2002	1C34F9836BA	Yes	4.23	3.81	15	Townsend
14	2002	F-350	1FTWW33FX2EC10752	Feb-02	48,543	1/18/2002	1C34F9836BA	Yes	4.22	3.99	15	Peffley
15	2001	F-350	1FTWW32F81EB52480	Dec-00	82,533	11/14/2000	1C34F9836BA	No	3.99	N/A	N/A	Peffley
16	2002	F-250	1FTNX21F52EA33095	Aug-01	33,927	6/6/2001	1C34F9836BA	No	4.09	N/A	70	Hatfield
17	2002	F-350	1FTSW31F02EC76776	Apr-02	31,563	3/18/2002	1C34F9836BA	Yes	4.22	3.87	30	Hatfield
18	2002	F-350	1FTNW21F42ED49347	Jun-02	78,729	11/21/2003	1C34F9836BB	Prior	3.82	N/A	N/A	Hatfield
19	2001	F-250	1FTNX21F51EB51498	Dec-00	39,976	11/10/2000	1C34F9836BA	No	4.01	N/A	100	Buckeye
20	2002	F-350	1FTSW30F42ED70323	Jun-02	33,597	6/12/2002	1C34F9836BA	Yes	4.21	3.94	20	Reichert
21	2001	F-250	1FTNW21F61ED26468	May-01	90,933	4/11/2001	1C34F9836BA	No	4.08	N/A	70	Coughlin
22	2002	F-250	1FTNW21F22ED41621	May-02	72,569	5/15/2002	1C34F9836BA	Yes	4.35	3.83	15	Coughlin
23	2002	F-350	1FTWW33F42EA34457	Aug-01	69,816	7/19/2001	1C34F9836BA	Yes	4.14	3.96	40	Coughlin
24	2002	F-350	1FTSW31F52EC73050	Mar-02	49,945	3/4/2002	1C34F9836BA	Yes	4.26	3.98	15	Coughlin
25	2001	F-250	1FTNW21F21EB34435	Nov-00	56,807	10/24/2000	1C34F9836BA	No	3.96	N/A	N/A	Coughlin
26	2001	F-350	1FTWW33F91ED19041	May-01	73,761	4/4/2001	1C34F9836BA	No	4.10	N/A	80	Hillsboro
27	2002	F-350	1FDWF37F82EB72783	Jan-02	64,459	11/30/2001	1C34F9836BA	Yes	4.17	3.99	40	Hillsboro
28	2002	F-350	1FTSX31F22EB35107	Nov-01	34,121	10/9/2001	1C34F9836BA	Yes	4.20	3.79	30	Sherwood
29	2002	F-250	1FTNW21F72EC44379	Mar-02	31,997	2/15/2002	1C34F9836BA	Yes	4.33	3.97	15	Sherwood
30	2001	F-350	1FTWW32F11EA88668	Oct-00	43,810	9/25/2000	1C34F9836BA	No	3.96	N/A	N/A	Ohio Limo
								Maximum	4.44			
								Minimum	3.81			

* = Measured over 4.0 volts but recorder malfunctioned.
Results were similar to Vehicles 3 & 5.

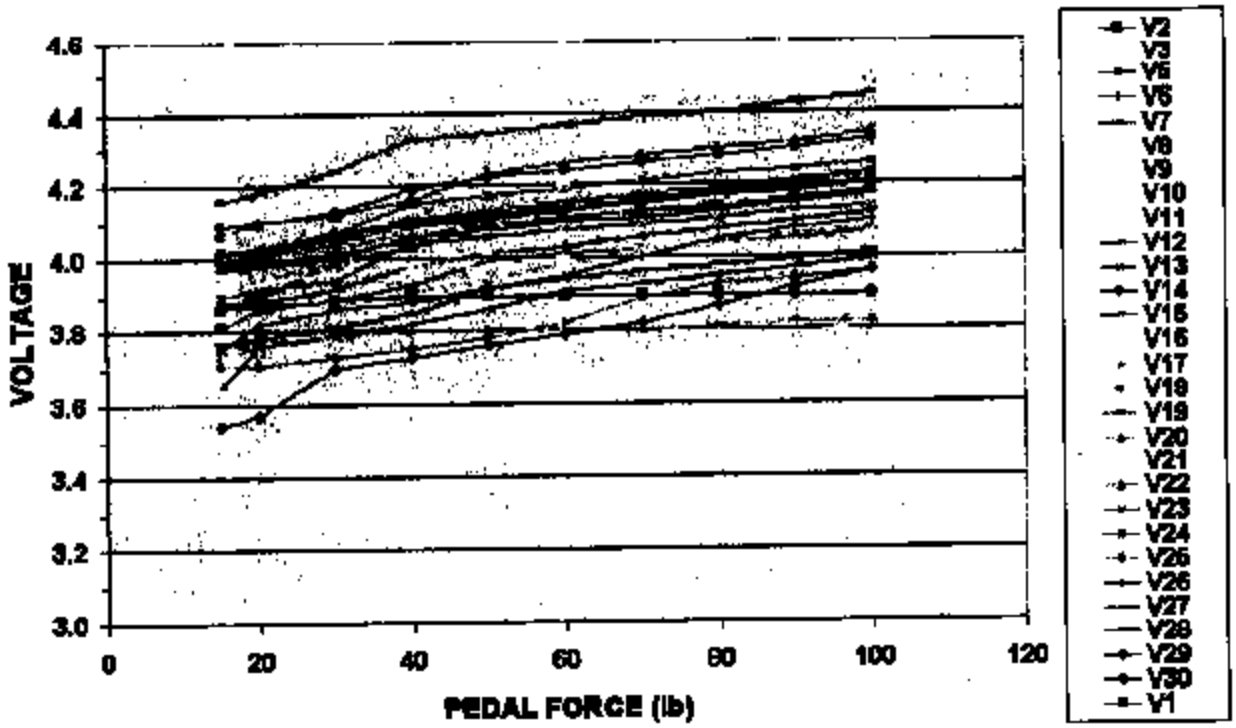

Figure 7 – As-Found APS Output Voltages
Note: Data recorder malfunction for V4

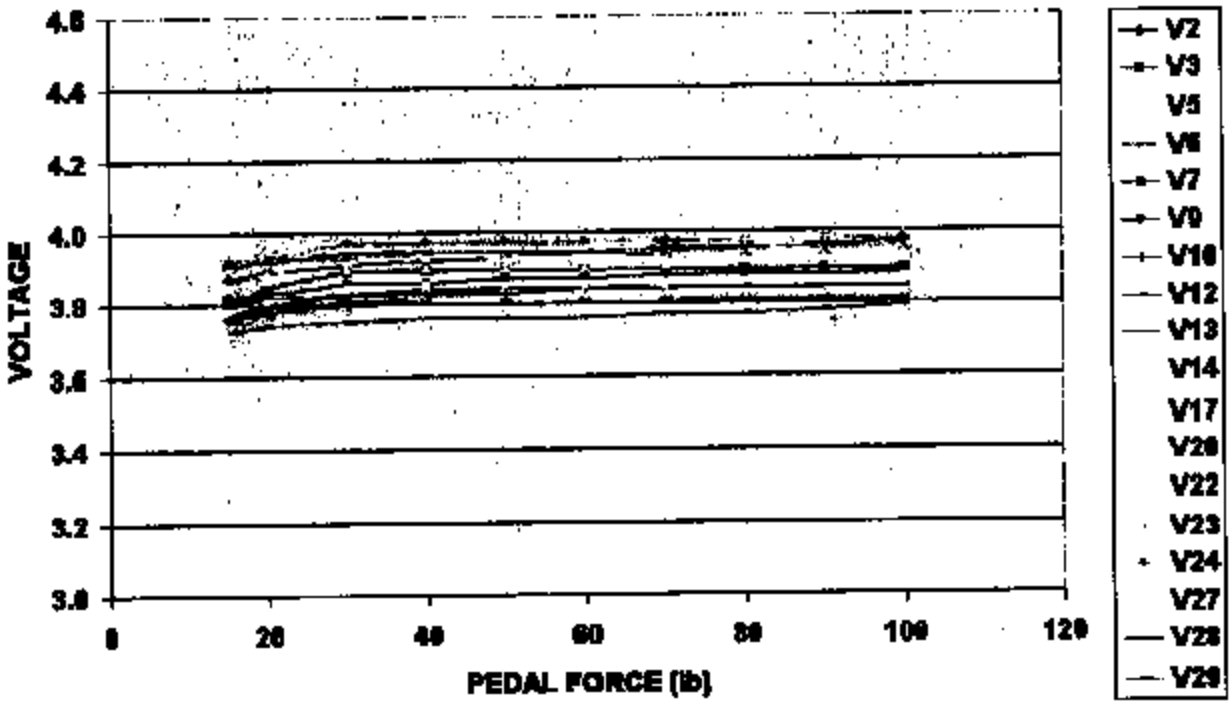

Figure 8 – Replacement APS Output Voltages

6.0 Discussion

The test results showed that the engine speed on the subject vehicles always returned to idle when the APS output voltage exceeded 4.5 volts. Ford specifications require that the APS output voltage not exceed 4.5 volts with 135 lb of force applied to the accelerator pedal.

Testing showed that the full throttle position on the accelerator pedal could be achieved and held with 12 lb of force on the accelerator pedal. The engine speed on the subject test vehicle, equipped with a new "BA" pedal, did not initially return to idle until 150 lb of force was applied to the accelerator pedal. However, the force required to cause the engine speed to return to idle (APS output voltage to exceed 4.5 volts) diminished gradually to about 90 lb during the course of testing of the subject test vehicle.

After a shim had been installed and removed in an attempt to eliminate the anomaly, only 20 lb of force on the accelerator pedal was required to cause the APS output voltage to exceed 4.5 volts. It is suspected, however, that the installation and removal of this shim, along with a series of very high pedal force applications with the shim installed, may have caused abnormal deformation of the accelerator pedal assembly.

Although the three mounting pads and the back of the pedal stop of the throttle pedal assembly are coplanar, the pedal stop rests on the padded and insulated rubber floor mat in subject vehicles rather than on the steel firewall like the three mounting pads. There is a cutout in the floor mat near the pedal stop but it is not in a proper location to allow the pedal stop to make contact with the firewall. An exemplar 2004 F-250 truck was inspected and found to have a cutout in the floor mat that allowed direct contact between the pedal stop and the firewall.

None of the 30 subject vehicles inspected in the field during this program exhibited the anomaly at pedal forces up to 100 lb. On the 30 vehicles inspected, the APS output voltage varied from 3.81 volts to 4.44 volts at a pedal force of 100 lb. After the pedal assemblies were replaced on 19 of these vehicles, the maximum APS output voltage was less then 4.0 volts at the same pedal force. The application of 100 lb of force on the accelerator pedal during field testing for this program required a concentrated effort and "hand" bracing against the steering wheel for leverage.

Two of the replaced pedal assemblies were found to have a pedal stop and mounting pads that were not coplanar. This was an indication of possible deformation of these pedal assemblies.

7.0 Conclusions

The following conclusions were made, based on the inspections and tests conducted during this test program:

1. While the engine speed can be caused to return to idle under full-throttle conditions in some cases, the force on the accelerator pedal required to reach this condition greatly exceeds the force (about 12 lb) that would be required or expected during ordinary driving.

2. The inspection of 30 in-use subject vehicles subjected the accelerator pedal to a force (100 lb) more than eight times the force required to achieve and hold the accelerator pedal in the WOT position. None of the inspected vehicles demonstrated the anomaly at this force level although the APS output voltage for some of these vehicles was close to the 4.5-volt limit.

3. Compared to the original "BA" pedal, the replacement "BB" pedal, incorporating a new full-throttle stop bar, performs better at higher pedal forces. The APS output voltage did not exceed 4.0 volts when 100 lb of force was applied to the accelerator pedal in any of the replacement "BB" pedals that were installed during the field survey.

4. The gradual reduction of the force required during the tests to cause the APS output voltage to exceed 4.5 volts suggests that repeated high force applications on the "BA" accelerator pedal by consumers may cause permanent deformation of the accelerator pedal assembly. Over time, this may result in forces much lower than 100 lb being required to reach the 4.5-volt threshold for the APS output.