EA02-025

TEXAS INSTRUMENTS, INC.'S 9/10/03 ATTACHMENT

REQUEST NO. 7

BOX 8

PART A-U

PART L

Tests Currently in Progress
Last updated: 2/15/99

Ignition Re-creation:
Objective – to recreate the conditions that caused an engine fire in the application.
Description:

1. 10 switches are filled with a mix of brake fluid, water, and detergent. 2 switches are filled with each of the following concentrations: 0%, 4%, 6%, 10%, and 75%. 14 volts is being applied to 1 terminal and the hexport is grounded. Current flow varies from about 0.5 mA to a high of about 5.0 mA. 0% switches were remove for #3 called out below.
2. On 2 of the above switches approximately 1 amp is being conducted through the terminals in-order to create heat in the switch.

Results to date:
Re filled the 75% device. Current flows have decrease. Fluid has discolored. Temperatures are stable. Occasionally we have to refill the switches with solution.

Wiebull Testing:
Objective – To determine if snap discs have a characteristic life similar to quiet discs.

Description:
A population of 30 77PS12-1 (snap discs) is being cycled to failure.

Results to date:
Results to date:
First failure at 728,008.
Population now has 800,000 cycles.

Wear Correlation:
Objective – To develop a spectrum of dimensions and visual cues that can be use to estimate the % of life left on switches returned from the field.

Description:
Switches are being removed from the cycler at increments of 200K cycles. 2 switches at each interval. These switches will be disassembled and wear at the following points will be characterized:

1. Kapton degradation
2. Pin
3. Pin guide
4. Arm bump
5. Converter/washer interface

Results to date:
900K cycles.
2 with 200K cycles were removed – Currently being photographed
2 with 400K cycles were removed – Currently being photographed
2 with 600K cycles were removed – Currently being photographed
2 with 600K cycles were removed – Currently being photographed
2 with 800K cycles were removed – Currently being photographed

Future Plans
DOE:
In order to run multiple moisture levels the pressure cycler needs to be modified. Parts needed for the modification are being ordered today. The goal is to have this DOE running by the end of the week. Factor's being investigated on the first pass are moisture and snap vs quiet. Future passes will include temperature and pressure. Clutch load – 10 parts

Matrix

Auto-ignition testing:

Ignition via heating element:

Objective is to get a fire started within the switch by installing a very small electrical heating element. With a small heating element built into a switch, we will fill the connector cavity with brake fluid, and slowly increase the current in the heating element. We will increase the current until ignition, or until the heating element burns out (continuity is lost).

Samples to test:

1) Dry
2) Pure brake fluid with metal shavings
3) 6% brake fluid solution

Results:

We have had significant trouble building reliable heaters within the pressure switch. However, two out of several attempts has created great amounts of smoke. Next step is to add a mechanism to create a spark while the heavy smoke is being produced.

Creating a heating element with corrosion:

The purpose of this test is to increase the contact's arm enough to generate significant heating.

Filling the switch with salt water and holding the arm at 14 volts and hexport at ground will generate corrosion.

Results:
N/A

End of document.

→ Vehicle Instrumentation
(Bk Switch on)

→ Brake Switch - (pedal position)

→ DuPont – calls

→ Dow

→ Brake Fluid conductivity

Morris, Irene

From: Dague, Bryan
Sent: Monday, February 15, 1999 3:54 PM
To: Rahman, Aziz
Cc: Beringhause, Steven; Baumann, Russell; McGuirk, Andrew
Subject: Monday update

Tests Currently in Progress
Last updated: 2/15/99

Ignition Re-creation:
Objective – to recreate the conditions that caused an engine fire in the application.
Description:

1. 10 switches are filled with a mix of brake fluid, water, and detergent. 2 switches are filled with the following concentrations: 0%, 4%, 6%, 10%, and 75%. 14 volts is being applied to 1 terminal and the hexport is grounded. Current flow varies from about 0.5 mA to a high of about 5.0 mA.
2. On 2 of the above switches approximately 1 amp is being conducted through the terminals in-order to create heat in the switch.

Results to date:
Re filled the 75% device. Current flows and temperatures are stable, but have decreased during the last couple of days.

Weibull Testing:
Objective – To determine if snap discs have a characteristic life similar to quiet discs.

Description:
A population of 30 77PS/2-1 (snap discs) is being cycled to failure.

Results to date:
No failures at 600K cycles.

Wear Correlation:
Objective – To develop a spectrum of dimensions and visual cues that can be use to estimate the % of life left on switches returned from the field.

Description:
Switches are being removed from the cycler at increments of 200K cycles. 2 switches at each interval. These switches will be disassembled and wear at the following points will be characterized:

1. Kapton degradation
2. Pin
3. Pin guide
4. Arm bump
5. Converter/washer interface

Results to date:
600K cycles.
2 with 200K cycles were removed – awaiting dissection.
2 with 400K cycles were removed – awaiting dissection.
2 with 600K cycles were removed – awaiting dissection.

Future Plans:
DOE:
In order to run multiple moisture levels the pressure cycler needs to be modified. Parts needed for the modification are being ordered today. The goal is to have this DOE running by the end of the week. Factor's being investigated on the first pass are moisture and snap vs quiet. Future passes will include temperature and pressure.

Auto-ignition testing:
Objective is to get a fire started within the switch by installing a very small electrical heating element. With a small heating

element built into a switch, we will fill the connector cavity with brake fluid, and slowly increase the current in the heating element. We will increase the current until ignition, or until the heating element burns out (continuity is lost).

Other:
Potential design changes will be address under a separate cover.

End of document

77PS Wear Correlation 02/16/99 SEM

sensor	Kapton layer 1 (Fluid side)	Kapton layer 2 Fluid side	Kapton layer 3 Fluid side	Pin	Pin	Bump Arm	Disc
200K #1	200K01K1 ✓	200K01K2	200K01K3	200K01P1	200K01P2	200K01B01	200K01D01
200K #2							
400K #1							
400K #2							
600K #1	600K01K1						
600K #2							
			↑ Furthest from fluid				

Ford 77 ps Fluid Temperature Testing

Technician : LCC **Date :** 2-16-95 **Time :** 12:00 noon

Temperature Readings

	1	2	3	4	5
	76	59	109	84	61
Peak	79	110	120	90	119

Current Readings

1	2	3	4	5
X	x	Y	Y	.21 ma @ 75% H_2O

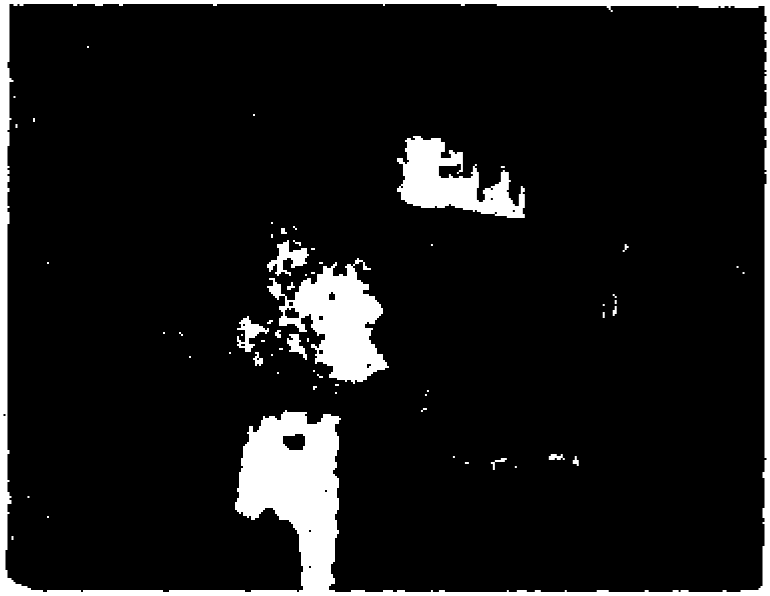
Volts 13.58

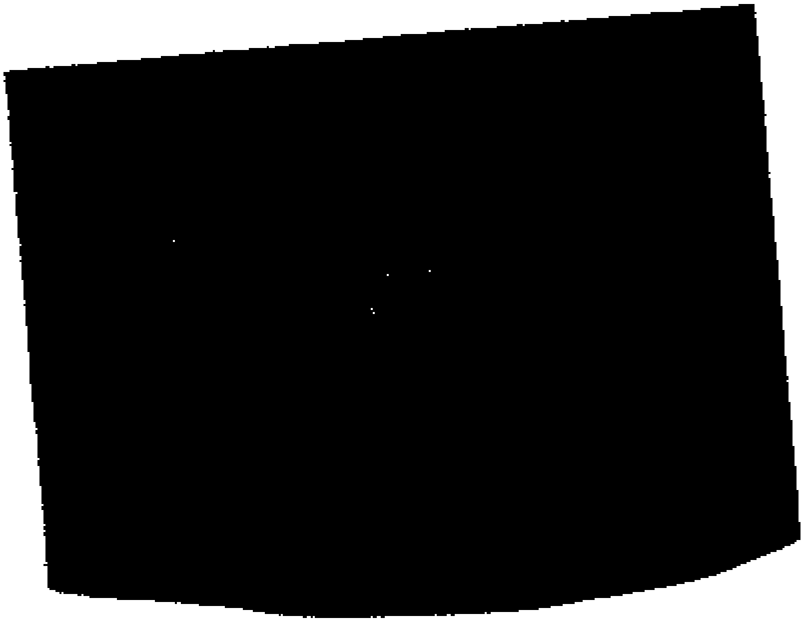
NOTES : (please include any information and observations)…….

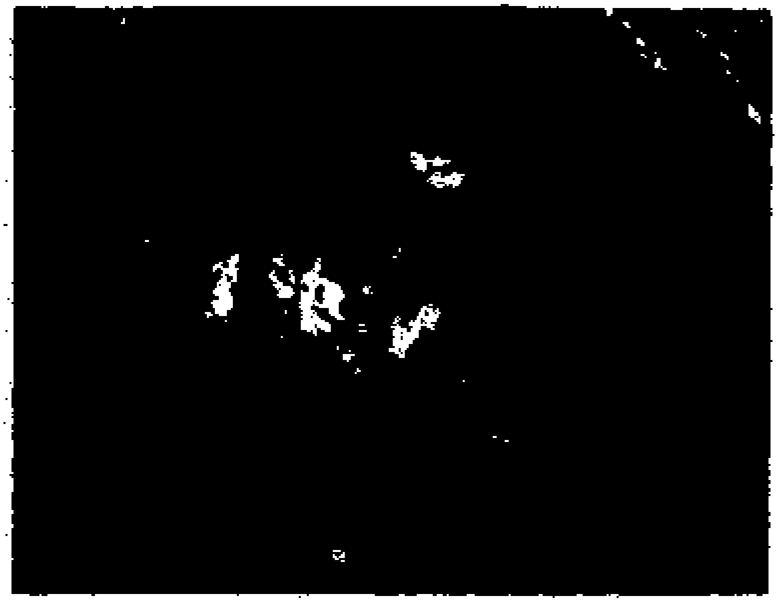
DEVICE STILL DO NOT SHOW ANY SIGNS OF OVER HEATING. THE 75% WATER WITH LOOSER CONTACTS HOLDS STEADY WITH ONLY FLUCTUATION OF +/- .03 MA. DEVICE REMOVED FOR INTENTIONAL OVERHEAT TEST AND RESTARTED @ 4100 [illegible] START MA WAS 3.08 MA AND ROSE RAPID 1.5MA IN LESS THAN 2 MINS.

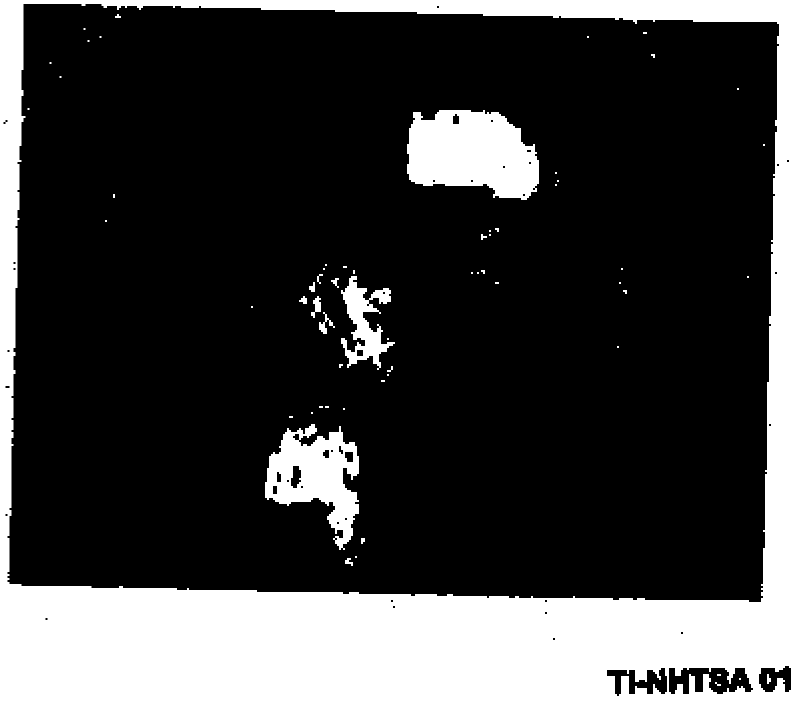
Ambient Temperature 78°

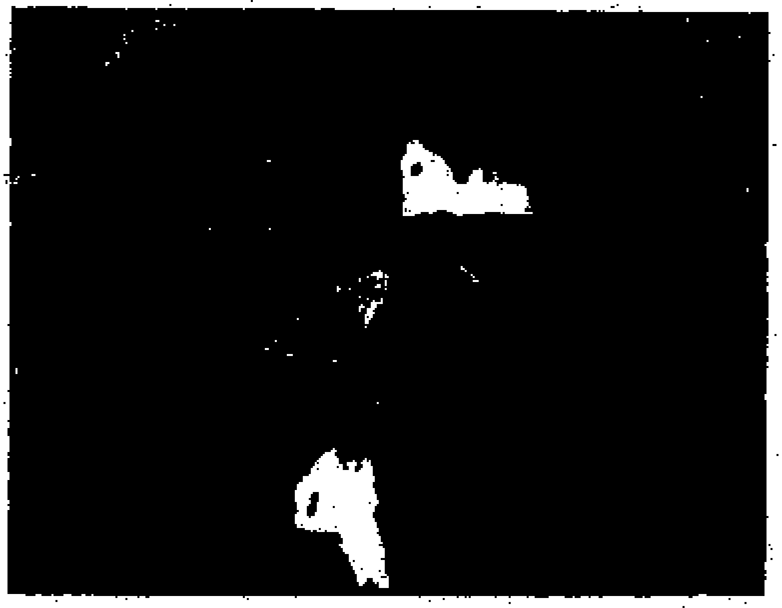
Oven Temperature 78°











Epstein, Sally

From: McGuirk, Andy [a-mcguirk@email.mc.ti.com]
Sent: Tuesday, February 16, 1999 7:18 AM
To: Rowland, Thomas
Cc: Sharpe, Robert; Dodd, Bob; Pechonis, John; Baker, Gary; Beringhause, Steven; Bertosh, Bob
Subject: FW: Brake Pressure Switch Log

Importance: High

tom, by copy of this note we will look to gary baker and bob dodd and steve beringhause for information about the '99 town car today which reportedly was launched without a p/s in the brake system for cruise system.

we will also determine our analysis protocols for these texas return units before noon today, tuesday.

a

AUTOMOTIVE SENSORS AND CONTROLS QRA MANGER
34 FOREST ST M/S 23-05
ATTLEBORO, MA 02703
TEL : (508) 236-3080
FAX : (508) 236-3745
PAGE: (800) 467-3700 PIN 604-2044

From: Rahman, Aziz
Sent: Monday, February 15, 1999 8:30 PM
To: Dague, Bryan; Beringhause, Steven; McGuirk, Andy; Sharpe, Robert; Baker, Gary; Baumann, Russ
Subject: FW: Brake Pressure Switch Log

Received second wave of parts from Texas junkyards. All F2VC parts. Most of them with connector attached. Some of them with prop valves & servos. 2 from underhood fires. Analysis will start tomorrow PM. Please let me know if there are any specifics to look at, before we disassemble these. I was thinking of doing some quick voltage drops, insulation resistance checks. Obviously lots of pictures. Any quick way to test these parts for leaks, prior to disassembly?

By the way, Steve R. did mention that the Electrical System folks were looking into using a Brake Pedal Position Sensor as a replacement for the Brake Pressure Switch as a corrective /containment action. Have we determined what they use in the 99 Town Car?

From: Rahman, Aziz
Sent: Monday, February 15, 1999 8:22 PM
To: 'Fred Porter (Ford)'; 'Norm LaPointe (Ford)'; 'Steve LaRouche (Ford)'; 'Steve Reimers (Ford)'
Subject: Brake Pressure Switch Log

Attached is a log file with information on the devices under review. It also contains switches received today from John McInerney,In addition to Steve L's analysis summary file, I will be using this log to track incoming parts. Please advise if I have missed any data.

i disabled file to conserve space and e-mail time.....

Please let me know if you cannot open the file. Steve/Norm, can you please e-mail me the last update on your analysis summary file? Thanks.

Regards
Aziz,

Degue, Bryan

From: Degue, Bryan
Sent: Tuesday, February 16, 1999 8:03 AM
To: Rahman, Aziz
Subject: RE: Brake Pressure Switch Log

Aziz,

I did get your phone MSG last night, and it sounds like you are on the right track. Although I don't know what kind of environment you are working in, you might try to get some of the following measurements:

1) Calibration (actuation and release)? Not sure if you have the equipment there. At the same time you will see if there is a gross leaker.

2) Leak down test. Go up pretty high in pressure 200 to 3000 psi. If the kapton is cracked and there is a leak path filled with brake fluid, the brake fluid will seal the leak path at low pressures (5 to 10 psi).

3) Resistance from each terminal to the hexport. If the contact cavity is filled with brake fluid you will probably not get a stable reading. The voltage and current supplied by the meter is enough to start moving ions around in the solution. The electrodes start charging and the resistance reading starts changing. The right way to do measure impedance. This is done with a fancy meter, and with an AC voltage and current. This is why we were unable to get good readings on our brake fluid resistance experiment.

4) The real information will come when you dissect the switches. Paying close attention to the following:
   a) wear on the bumps (arm, converter, and cup)
   b) wear between the converter and washer
   c) Kapton degradation
   d) wear between the pin and the cup.

That is pretty much all I can think of.

Good luck and let me know what you find.

Regards,
Bry

From: Rahman, Aziz
Sent: Monday, February 15, 1999 [illegible] PM
To: Degue, Bryan; Beringhause, Steven; McGuirk, Andy; Sharpe, Robert; Baker, Gary; Baumann, Russ
Subject: FW: Brake Pressure Switch Log

Received second wave of parts from Texas junkyards. All F2VC parts. Most of them with connector attached. Some of them with prop valves & servos. 2 from underhood fires. Analysis will start tomorrow PM. Please let me know if there are any specifics to look at, before we disassemble these. I was thinking of doing some quick voltage drops, insulation resistance checks. Obviously lots of pictures. Any quick way to test these parts for leaks, prior to disassembly?

By the way, Steve R. did mention that the Electrical System folks were looking into using a Brake Pedal Position Sensor as a replacement for the Brake Pressure Switch as a corrective /containment action. Have we determined what they use in the 98 Town Car?

From: Rahman, Aziz
Sent: Monday, February 15, 1999 [illegible] PM
To: 'Fred Porter (Ford)'; [illegible] (Ford)'; [illegible] (Ford)'; [illegible] (Ford)'

Epstein, Sally

From: Beringhause, Steven [sberinghause@email.mc.ti.com]
Sent: Tuesday, February 16, 1999 2:13 PM
To: Rahman, Aziz

Aziz,

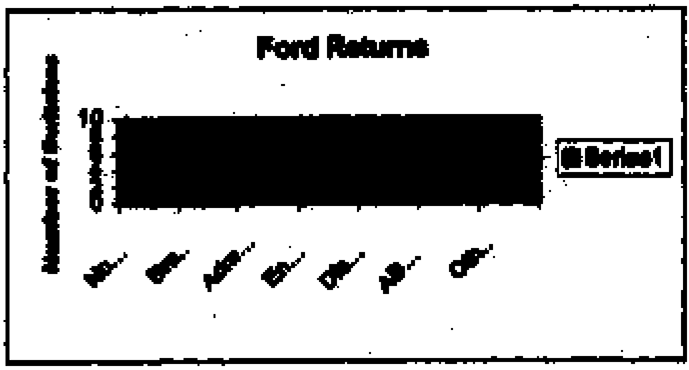
One comment on the switch testing, the plan looks good for junk yard parts. I would not run as aggressive a test plan on parts that were in a vehicle fire because we do not know what shape the seal is in from the fire and leakage might disrupt clues. My guess is that this matches the plan.

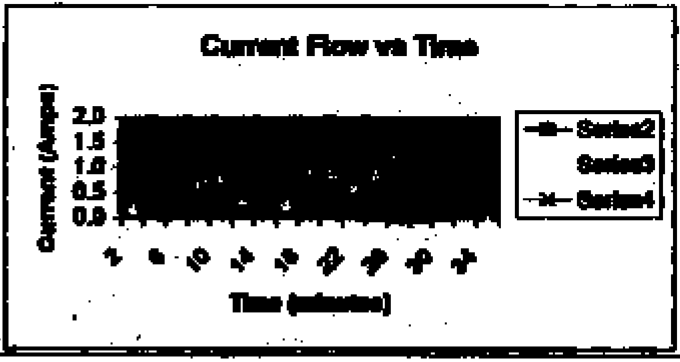
Steve

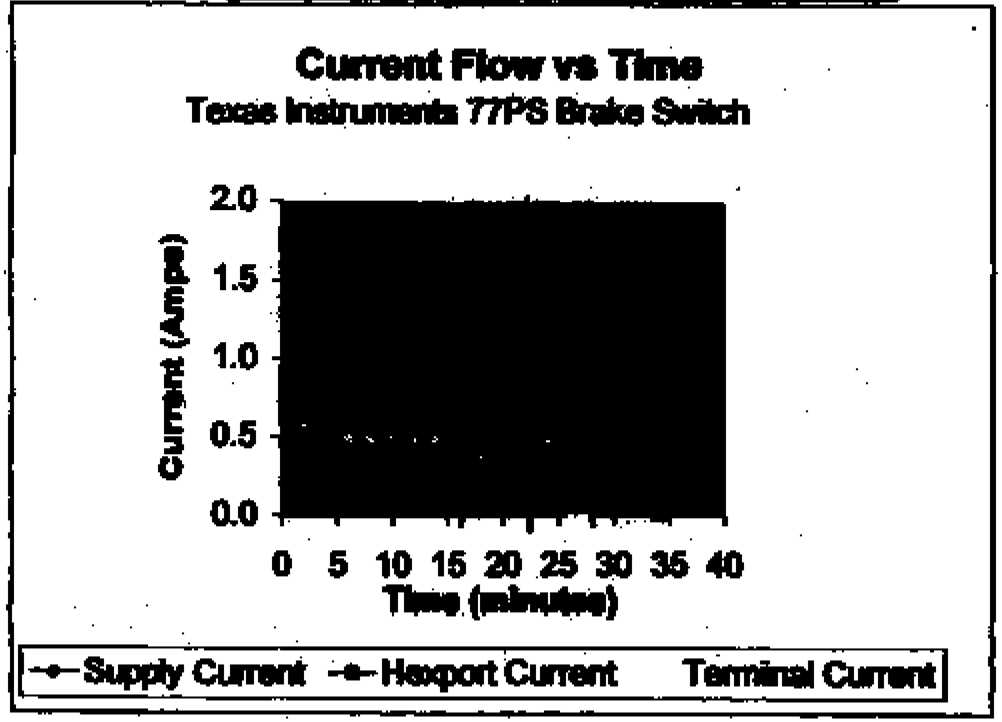
Brake Pressure Switch Test Log
Updated 2/[illegible]

Category	Test	Location	Test Parameters	Results Update
Lab Simulation	1	TI	Various Levels of Brake Fluid, Water, Detergent	[illegible]+ hours, [illegible]mA draw has reduced to [illegible]mA.
of Potential Ignition			14Vdc to one terminal, Housing Grounded	[illegible] has discolored.
in Switch	2	TI	Various Levels of Brake Fluid, Water, Detergent	[illegible]+ hours. [illegible] temperature.
			1 Amp through switch terminals	No significant temperature rise with time
	3	A/T	Brake Fluid in Switch, 24 VDC to one terminal	> [illegible] hours into test, max current 7mA
			Housing Grounded	No significant change with time
	4	A/T	Brake Fluid in Switch, 24 VDC to one terminal	[illegible] hours into test, max current [illegible]mA
			Housing Grounded, Ambient at 140 C	No significant temperature rise with time
	5	A/T	Brake Fluid in Switch, 10 Amps	Temperature rise of 20 C above room temp
			Through switch terminals	[illegible] reached steady state at 20 C
	6	TI	Weld heater element into Switch	2 tested. Immeasurable amounts of smoke, no ignition.
			[illegible]	[illegible] will be [illegible] as testing continues.
Life Cycle Reliability	7	TI	[illegible] psig pressure pulses at 120C ambient	[illegible] cycles.
of Pressure Switch			for [illegible]	Cycle count at [illegible]. Continue to failure.
Diaphragm Wear	8	TI	[illegible] psig pressure pulses at [illegible]C ambient	[illegible] every [illegible] cycles, characterized for wear
Field to Lab Correlation	9	Control Labs	Various Field [illegible]	[illegible] being [illegible]
Analysis of Hypothesis	10	TI	Various Levels of Brake Fluid, Water,	[illegible] underway. [illegible] 2/21.
Contributing Factors			Under [illegible] conditions, to failure	
Including Diaphragm Wear				
On-Vehicle Characterization	11	A/T	Monitor Pressure and Temperature	Logistics being worked out.
of Pressure & Temperature			at Switch Location for ABS and non-ABS	
Profile in Town Car			braking events.	

No Description	9
Brake Fluid Leak	6
Administrative Parts Return	4
Engagement Troubles	2
Disengagement Troubles	2
ABS Warning Light	1
Other Electrical Accessory Trouble	1




Current Flow vs Time
Current (Amps)
2.0
1.5
1.0
0.5
0.0
Time (minutes)
Series2
Series3
Series4


Current Flow vs Time
Texas Instruments 77PS Brake Switch
Current (Amps)
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
30
35
40
Time (minutes)
Supply Current
Hexport Current
Terminal Current

time	Supply Cur	Hexport Cu	Terminal C	Check
2	0.8	0.2	0.6	0.0
4	1.2	0.7	0.5	0.0
6	1.4	1.0	0.6	-0.1
8	1.2	0.7	0.5	0.0
10	1.3	0.8	0.5	0.0
12	0.9	0.4	0.5	0.0
14	0.9	0.4	0.5	0.0
16	0.7	0.3	0.5	-0.1
18	1.9	1.4	0.4	0.2
20	1.4	0.9	0.4	0.1
22	1.0	0.6	0.4	0.0
24	1.3	0.9	0.5	-0.1
26	1.4	1.3	0.0	0.1
28	0.7	0.8	0.0	-0.1
30	1.1	0.6	0.5	0.0
32	0.9	0.4	0.4	0.1
34	0.4	0.0	0.4	0.0
36				
38				
40				

TI Switch ID #	SO #	TI Date Code	VIN #	Car Build Date
789-5	32394	2125		
789-9	32377	2045		
789-6	32407	2120		
789-4	32392	2029		
789-3	32409	2036		
789-7	32318	0149		
E	32907	2052		
B	31907	2052		
D	32114	2052		
812-17	56271	2104		
812-21	65345	2036		
812-26	65365	2052		
812-30	66072	2050		
812-18	56455	2005		
812-19	56874	1252		
812-24	65570	1331		
812-25	56256	2009		
812-22	65966	2056		
812-8	65445	2013		
812-6	57066	1347		
812-5	56956	2057		
812-4	56945	2055		

February 17, 1999

TEXAS INSTRUMENTS

FACSIMILE TRANSMITTAL

TO:	Name:	AZIZ RAHMAN – TI EMPLOYEE
	At Company:	FORD MOTOR COMPANY
	FAX Number:	313-390-4145
FROM:	Charlie Douglas	
	TEXAS INSTRUMENTS MS 23-1	
	Phone Number:	(508) 236-3657
	FAX Number:	(508) 236-1598

Total number of pages (including header page): 15

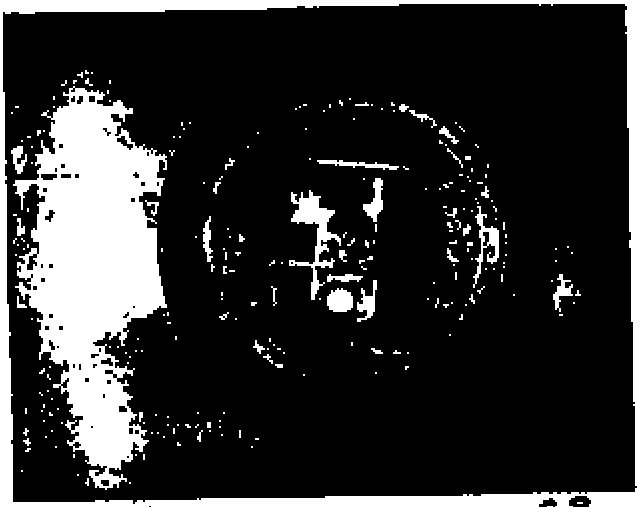
COMMENTS:

Upon receipt of this fax, please pass on to Aziz Rahman (TI Employee), who is visiting your plant today being Wednesday, February 17, 1999.

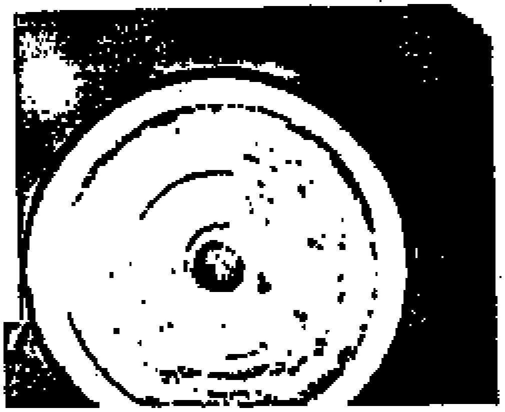
Thank you.

Table 2.

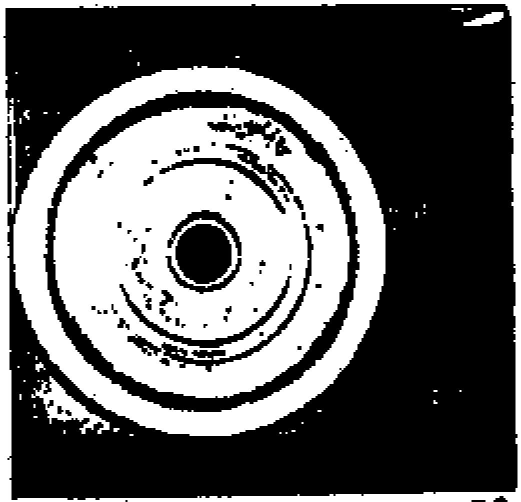
F5TA-9F924-CA SPEED CONTROL DE-ACTIVATION SWITCH						10/18/93	
T.I. P/N	77PSL9-9						
RESULTS FROM SHOWER TEST							
HOURS OF EXPOSURE TO DATE:				324			
SWITCH #	ACT	REL	mv DROP	TERM TO TERM @ 300 PSI	TERM TO CASE 600 VDC MEGGER	CONNECTOR STATUS	INGRESS
A1	200	182	4	> 20 MEGAOHM	64 GIGA-OHM	LATCHED	NONE
A2	242	176	4	"	100 GIGA-OHM	ROCKED	MINOR
B1	239	172	4.2	"	65 GIGA-OHM	LATCHED	NONE
B2	208	165	4.2	"	50 GIGA-OHM	ROCKED	MINOR
C1	[illegible]	174	4	"	120 GIGA-OHM	LATCHED	NONE
C2	[illegible]	[illegible]	5.9	[illegible]	[illegible]	ROCKED	MAJOR
D1	246	179	4.3	> 20 MEGA-OHM	120 GIGA-OHM	LATCHED	NONE
D2	[illegible]	186	4.1	[illegible]	[illegible]	ROCKED	MAJOR
E1	257	192	4.1	> 20 MEGA-OHM	110 GIGA-OHM	LATCHED	NONE
E2	250	169	4.2	"	[illegible]	ROCKED	MAJOR
F1	253	182	4	"	107 GIGA-OHM	LATCHED	NONE
F2	[illegible]	[illegible]	4	[illegible]	[illegible]	ROCKED	MAJOR
	***	= INTERMITTENT ACTUATION					



C8

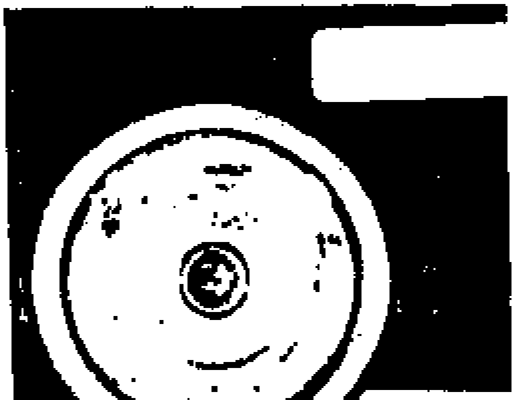


E2



E2

F2

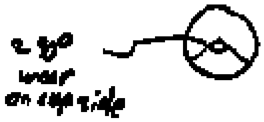


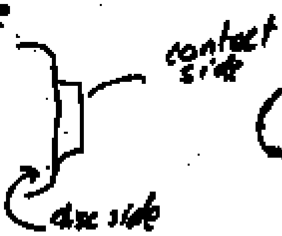
F2

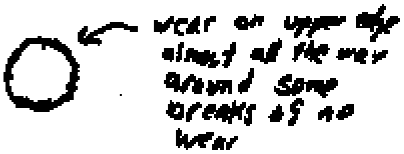
Cup wear | wear correlation 77 PS | 2/12/99

<u>400K Device #1 observations</u> ✓

- Cup worn more on disc side







<u>600K Device #1 observations</u> ✓

- There is almost a continuous ring of wear on both cup side and contact side outer edges
- There is also wear on inside surface

<u>500K Device #1</u> ✓

- very little sign of wear on disc side
- small areas of wear begin to show on electrical contact side

<u>300K Device #2</u> ✓

- Shows almost a continuous ring of wear on disc side and contact side outer edges
- some wear on inner surface as well

maybe redo →

<u>400K Device #2</u> ✓

- Shows signs of irregular wear! some wear along edge of contact side, some wear on disc side

<u>600K Device #2</u> ✓

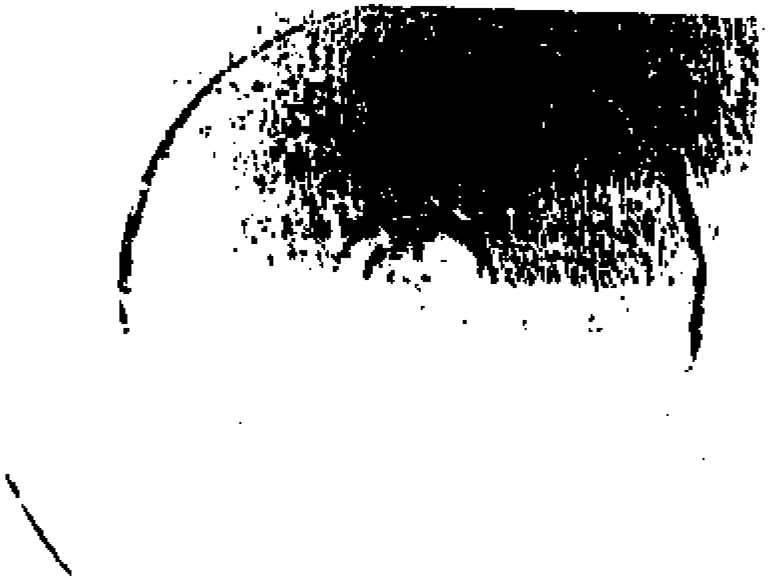
- continuous ring of wear along contact side heavier in places
- wear along ~180° of edge on disc side then line of wear slightly offset toward center the rest of 180°
- some wear in center of 1 place

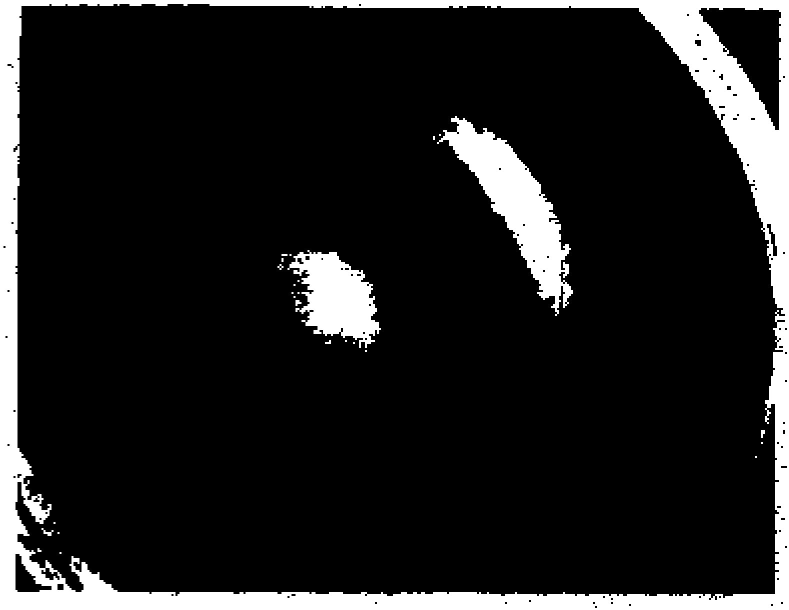
wear correlation
77 PS

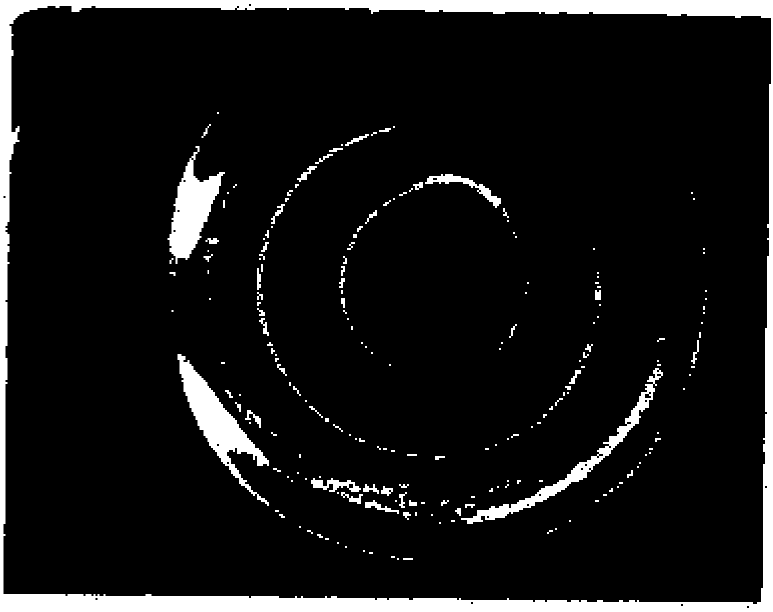
2/17

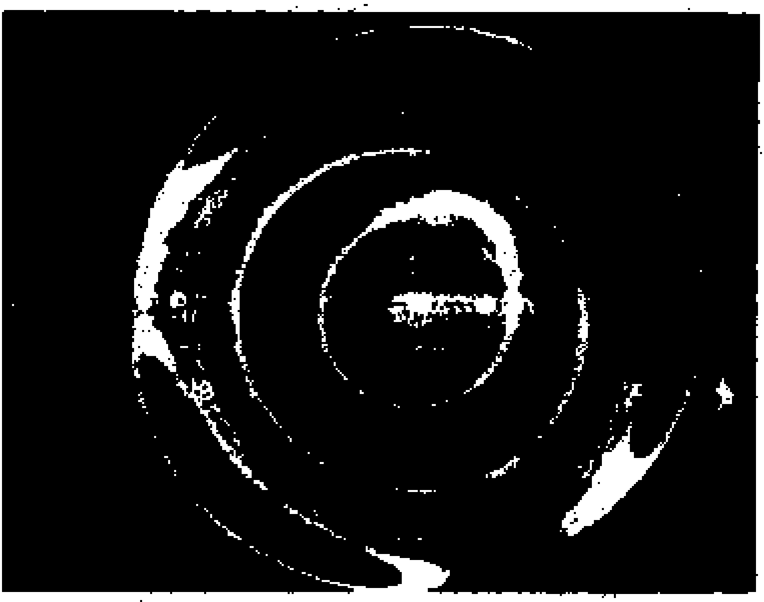
- Failed 2 729,008 cycles
- uncrimped
  ↳ fluid in electrical cavity / contactors   Coat much, not enough coat everything
  ↳ very little wear on bump
  ↳ small piece of metal filing on inside housing

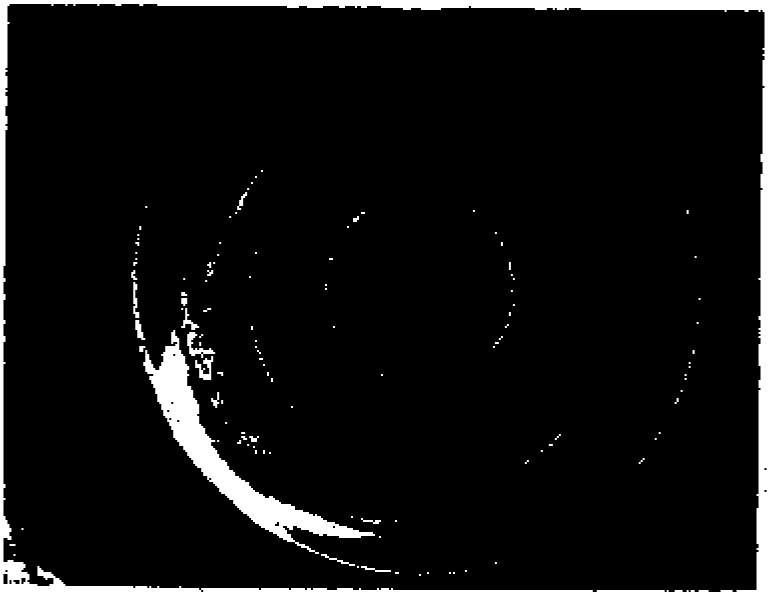
<u>Under microscope.</u>











Epstein, Sally

From: Watt, Jim [jwatt@email.mc.ti.com]
Sent: Wednesday, February 17, 1999 10:10 AM
To: Pechonis, John; McGuirk, Andy; Rahman, Aziz
Cc: Bartosh, Bob
Subject: RE: 77PS Loose Metal Part?

Ford 77PS return history .XLS

Andy,

I updated the below 77PS return history file, where the one 77PSL3-3 that was returned from Tokico, 11/20/97, was open circuit due to a distorted arm. Upon repeated testing through the pressure tester, the discrepant switch was culled out, which indicates more of an internal discrepant material handling issue.

<<Ford 77PS return history .XLS>>

Jim Watt, QRA, msgid: jw02; mail station 12-33; page (508)236-1010, no. (0696)
ph (508) 236-1719;
fax (508)236-3153

From: McGuirk, Andy
Sent: Wednesday, February 17, 1999 9:29 AM
To: Pechonis, John; Watt, Jim
Cc: Bartosh, Bob
Subject: FW: 77PS Loose Metal Part?

is this contact arm rivet related ? any history here?

a

AUTOMOTIVE SENSORS AND CONTROLS QRA MANGER
34 FOREST ST M/S 23-05
ATTLEBORO, MA 02703
TEL : (508) 236-3080
FAX : (508) 236-3745
PAGE: (800) 467-3700 PIN 604-2044

From: Rahman, Aziz
Sent: Tuesday, February 16, 1999 8:56 PM
To: Beringhause, Steven; Daque, Bryan; Baumann, Russ; McGuirk, Andy; Baker, Gary; Sharpe, Robert; Douglas, Charles
Subject: 77PS Loose Metal Part?
Importance: High

Please review attached messages. Jack Paskus is Luxury VC Chief Engineer. Do any of you know what the previous history with a "Loose Metal Part" is all about? Could he be talking about the spring arm potentially separating due to corrosion, mechanical fatigue thermal effects etc and causing shorts? Please advise on effects of an assumed loose metal part in the switch cavity.

Do we know which switch terminal is hot and which is grounded through the module? Is the stationary terminal hot or the movable?

Thanks
Aziz.

From: Steve Reimers[SMTP:sreimers@ford.com]
Sent: Tuesday, February 16, 1999 6:13 PM
To: jname@ford.com; nlapoint@ford.com; rnevi@ford.com; slarouch@ford.com; Aziz Rahman, Texas
Subject: (U)

Can you help me get smart regarding the "LOOSE METAL PART" mentioned above?

Steve Reimers   building 5 3C043
AVT Chassis E/E System Applications   mail drop 5011
39-03286 SREIMERS   sreimers@ford.com   fax 39-03286   ;>
*** Forwarding note from SCOLE1 --DRBN005 02/16/99 18:04 ***
To: SREIMERS--DRBN007
cc: DGOEL   --DRBN005

From: Sam L. Cole   USAET(UTC -05:00)
Subject: (U)
THE PREVIOUS CONCERN OF THE "LOOSE METAL PART" WAS MENTIONED IN THE LAST MEETING WITH JACK. HE WILL WANT A FOLLOW UP ON THIS AT THIS FRIDAY'S MEETING. PLEASE GET UP TO SPEED ON THE HISTORY OF THIS CONCERN. IF IT TURNS OUT THAT THIS MAY BE A CAUSE, THEN WE WILL NEED TO KNOW WHEN THE ISSUE WAS IN THE FIELD, WHEN IT WAS FIXED AND HOW MANY ARE OUT THERE TO BE CONCERNED ABOUT. THANKS.

Thank You,
Sam
Ext. 21959
BLDG. 2, 22J31 - MD# 1220 - SCOLE1@FORD.COM
*** Forwarding note from SREIMERS--DRBN007 02/16/99 16:52 ***
To: SCOLE1 --DRBN005   DGOEL   --DRBN005

FROM: Steve Reimers   USAET(UTC -05:00)
Subject: (U)
I have the part to show and a take-apart version too. I am not familiar with the previous problem but a loose metal part in the switch cavity is definitely a potential cause of this concern.

Steve Reimers   building 5 3C043
AVT Chassis E/E System Applications   mail drop 5011
39-03286 SREIMERS   sreimers@ford.com   fax 39-03286   ;>
*** Forwarding note from DE7AWAYR--DRBN007 02/16/99 13:41 ***
Subject: AWAY Facility/VM messages
This note was generated by the AWAY Facility/VM 5799-FLP (c)IBM Corp.
DO NOT REPLY TO THIS NOTE

AWA110I This mail item is being routed to you from SCOLE1 at DRBN005 on behalf of FPORTER at DRBN007.

To: FPORTER --DRBN007
cc: TMASTERS--DRBN005   TDONOVAN--DRBN005
    DGOEL   --DRBN005

From: Sam L. Cole   USAET(UTC -05:00)
Subject: (U)
I UNDERSTAND THAT THERE WILL BE A FOLLOW UP MEETING WITH JACK RASKUS THIS FRIDAY ON THE TOWN CAR INVESTIGATION. I MET WITH JACK TODAY FOR A 1 ON 1, AND HE REQUESTED SOME SPECIFIC INFO. AT FRIDAYS MEETING, PLEASE BRING A SAMPLE SWITCH TO SHOW JACK.

ALSO, HE IS INTERESTED IN KNOWING OUR PROGRESS AND INVESTIGATING IF THE PREVIOUS PROBLEM WITH THE INTERNAL COMPONENTS BREAKING LOOSE IS A

POTENTIAL CAUSE OF THIS CONCERN. PLEASE BE PREPARED TO DISCUSS THIS ON FRIDAY. THANKS.

Thank You,
Sam
Ext. 21959
BLDG. 2, 22J31 - MD# 1220 - SCOLE1@FORD.COM

Ford Motor Company
77PS Style
Pressure Switches

 # Events - by year of return

Root Cause Analysis(Corrective Action Reports)

	1994	1995	1996	1997	1998	Total Events
Contaminated Terminals	0	0	0	0	1	1
Continuity Anomaly(Distorted contact arm assembly)	1	0	0	1	0	2
Wrong Parts Shipped	0	0	3	3	0	6
Damaged Threads/ Hexport	0	5	1	0	0	6
Noisy Switch	0	0	1	0	0	1
Cracked Bases	0	0	1	0	0	1
Vacuum Dependency	0	1	0	0	0	1
Device Leak	0	1	0	0	0	1
Incorrect Code	0	1	0	0	0	1
Low Rel Cal(Contam on Stationary Contact Surface)	0	1	0	0	0	1
(Total)	1	9	6	4	1	

Root Cause Analysis(Return Device Analysis)

	1994	1995	1996	1997	1998	
Failure Due To Customer	n/a	n/a	0	0	0	0
Contaminated Terminals	n/a	n/a	0	1	0	1
Trouble Not Found	n/a	n/a	0	1	3	4
Damaged Base	n/a	n/a	0	1	0	1
(Total)	n/a	n/a	0	3	3	

(n/a= not available)

Total 1994 Ford Motor (77PS) customer returns: 1

Total 1995 Ford Motor (77PS) customer returns: 9

Total 1996 Ford Motor (77PS)year to date customer returns: 6

Total 1997 Ford Motor (77PS) customer returns: 7

Total 1998 Ford Motor (77PS) customer returns: 4

Total 1999 Ford Motor (77PS) customer returns year to date: none

Prepared by Jim Watt 7/29/99

Currey, Pat

From: McGuirk, Andy [a-mcguirk@email.mc.ti.com]
Sent: Wednesday, February 17, 1999 2:44 PM
To: Baker, Gary; Baumann, Russ; Beringhause, Steven; Dague, Bryan; Hopkins, AL
Cc: Douglas, Charles; Rahman, Aziz; Rowland, Thomas; Sharpe, Robert; Sullivan, Martha
Subject: 77PS UPDATE

When: Thursday, February 18, 1999, 2:00 PM - 3:00 PM, (GMT-05:00) Eastern Time (US & Canada)
Where: 23A

~~*~*~*~*~*~*~*~*

I WANT TO REVIEW FORD'S ANALYSIS SPREADSHEET (ALL, LED BY STEVE WITH THEORIES), OUR UPDATED CAUSE AND EFFECT DIAGRAM (BRYAN), OUR 'SCIENCE FAIR' EXPERIMENTS RESULTS(STEVE AND BRYAN), AND REVIEW A PROPOSAL FOR OUR RESPONSE TO FORD'S POSSIBLE QUESTION POSED FROM AZIZ ABOUT TI POSITION (ANDY).

ALSO, I WANT TO UNDERSTAND FORD'S DATA ABOUT ABS (C/O AZIZ FROM TEVES) AND PROP VALVE PRESSURE TRACES, AS WELL AS DATA FROM DOW C/O FORD ABOUT BRAKE FLUID AS IT RELATES TO FIRES AS WELL AS KAPTON (C/O AZIZ FROM FORD).

FINALLY, WE SHOULD UNDERSTAND BRAKE SWITCH AND KAPTON WEAROUT WITH ANOTHER FORD PLATFORM...STEVE DID WE COLLECT ANY SAMPLES FROM SIMILAR AGE VEHICLES?

WE SHOULD ALSO DISCUSS THE POTENTIAL BRAKE PEDAL POSITION 'SOLUTION' (CHARLIE AND ROB...BRIEF GARY SO HE CAN DELIVER) AND BE PREPARED TO HELP FORD UNDERSTAND THEIR RISKS IN THAT PATH.

A

McGuirk, Andy

To: Sullivan, Martha; Rowland, Thomas; Baumann, Russ; Baker, Gary;
Cc: Beringhause, Steven; Pechonis, John; Rahman, Aziz; Bartosh, Bob
Subject: Ford overview.... 2/18 plans Update

attorney client privileged communication

I have an appointment to talk to Steve Reimers who is acting for Fred Porter at 2:45 thursday today.

I want to lead us thru discussions:

REVIEW FORD'S ANALYSIS SPREADSHEET (ALL, LED BY STEVE WITH THEORIES),

leak?, priority ?

OUR UPDATED CAUSE AND EFFECT DIAGRAM (BRYAN),

ABS?

OUR 'SCIENCE FAIR' EXPERIMENTS RESULTS(STEVE AND BRYAN),

REVIEW A PROPOSAL FOR OUR RESPONSE TO FORD'S POSSIBLE QUESTION POSED FROM AZIZ ABOUT TI POSITION (ANDY). no results

UNDERSTAND FORD'S DATA ABOUT ABS (C/O AZIZ FROM TEVES) AND PROP VALVE PRESSURE TRACES. ..do we do at TI?

DATA FROM DOW C/O FORD ABOUT BRAKE FLUID AS IT RELATES TO FIRES no results

WELL AS KAPTON (C/O AZIZ FROM FORD). no results

UNDERSTAND BRAKE SWITCH AND KAPTON WEAROUT WITH ANOTHER FORD PLATFORM...STEVE DID WE COLLECT ANY SAMPLES FROM SIMILAR AGE VEHICLES? no results

WE SHOULD ALSO DISCUSS THE POTENTIAL BRAKE PEDAL POSITION 'SOLUTION' TO HELP FORD UNDERSTAND THEIR RISKS IN THAT PATH.

6

AUTOMOTIVE SENSORS AND CONTROLS QRA MANAGER
34 FOREST ST M/S 23-05
ATTLEBORO, MA 02703
TEL : (508) 236-[illegible]
FAX : (508) 236-3745
PAGER: (800) 467-3706 PIN 004-2044

From: McGuirk, Andy
Sent: Thursday, February 18, 1999 9:52 AM
To: Sullivan, Martha; Rowland, Thomas; Baumann, Russ; Baker, Gary
Cc: Beringhause, Steven; Pechonis, John; Rahman, Aziz; Bartosh, Bob
Subject: Ford overview...., 2/18 'status' Update

attorney client privileged communication

Ford has seen switch 'wear out' in several samples where brake fluid is believed to have leaked into the switch cavity (total of 7 switches 'analyzed' to 'complete scientific conclusions' from 1 P/S thermal event, 3 underhood thermal events, 2 cruise inops and 1 reference). there are 24 switches awaiting analysis at Ford, and in fact a faster paced analysis scheme is under review at Ford in order to work thru this backlog. (Steve, do we recommend this approach?...lets respond ASAP)

Ford has concluded the Town Car underhood fire and thermal event and thermal anomaly history (my 92? and my 93?) is comprised of:
149 total events...broken down by Ford as follows

127 unknown causes
17 potential other causes
5 pressure switch causes.....................or said a different way, Ford might say that P/S is the number one known cause

another cut at this..........broken down by Ford

105 events status unknown
39 events with engine off
5 events with engine on................ or said a different way, Ford might say engine on/off has little effect.......

Ford's executive team has established a plan to achieve root cause phase by March 3rd.

We believe Ford has obtained a two month 'window' from NHTSA.... April 14th 'public disclosure' plan

Ford's executive team seems to be frustrated by the inability to get to root cause....to turn on/off by the 'science fair' type testing being done at both TI and Ford to create the issue

We have presented the concept of de-power of the P/S as a containment mechanism....the Ford 1st line people do not seem to be moving toward this....more Friday

We have also presented the concept of the possible application of the AFT as a containment mechanism...little movement here too.

Ford's current thought seems to be that the preferred containment solution might be to replace the P/S with a Brake Pedal position sensor as is on-board the '99 Town Car. Looks like first line folks are focused here.....seems like Ford 1st line guys do not want to 'tap' into brake lines in the future?

Ford continues to move slowly.... no Dow or Dupont or Teves involvement 'results' yet....seems like they're still fixing to get ready

Ford's Fred Porter (my primary contact) is on vacation and I am making plans to connect with his 'aides' either late today (he's out ?) or first tomorrow to discuss and direct some of these points. I will publish a 'plan' memo early afternoon today.

AUTOMOTIVE SENSORS AND CONTROLS QRA MANAGER
34 FOREST ST M/S 23-04
ATTLEBORO, MA 02703
TEL : (508) 236-3084
FAX : (508) 236-3745
PAGE: (888) 467-3700 PIN 404-2044

From: Rahman, Aziz
Sent: Wednesday, February 17, 1999 5:16 PM
To: Beringhause, Steven; Dague, Bryan; McGuirk, Andy; Baumann, Russ; Sharpe, Robert
Subject: 2/17 Update

Main event: 2PM core team meeting. Highlights:

- Manager Len Brown agitated that Dow has not shown up yet. Will probably get them on board tomorrow or Friday.
- Exec. meeting at 4.pm Friday. TI not invited. Will present test plan (copy with Steve B.).
- Ford team in DC today at NHTSA, asking for two months for public action.
- People surprised that on-vehicle characterization has not yet occurred. Leads provided on expediting this.
- Increasing tempo on getting more parts back for analysis.
- Re-emphasized need to study warranty data more closely for trending, and special causes.
- Increasing speculation that pure heat is not sufficient to ignite. Need spark.
- Will present brake pedal position sensor to execs as possible containment.

Two tests conducted today at AVT labs:

- Passed about 54 Amps at about 1V, through switch terminals, no fluid. Temp in connector area increased to about 162 F before system went open circuit. Dissection revealed spring arm deformed and twisted away from stationary. Will have pictures tomorrow.

- Passed about 60 Amps at about 1V through switch terminals, with switch based filled with approx 50% Brake Fluid, 50% salt water. Temp in connector area increased to about 270 F and stayed there. No smoke or ignition. Dissection revealed spring arm deformed. Pictures tomorrow.

-Will set up calibration station in Central Lab tomorrow.

- Will be returning to MA Friday 2pm flight.Later flights not available because of vacation week. Per Steve B.'s input, will plan to return next week

Regards
Aziz.

Evaluation Process
ake Pressure switch / Harness

date
ode

tes/Date	Comments
ROUCH	If not correct conduct X-Ray to determine fit-up between base lip and red seal.
ROUCH	Visual check of Red Seal, Dirt lines, Indentation mark.. Indentation mark must be 360 degrees.
L	Visual check of dirt lines on mated switch base
UCH	Cut insulation longitudinally to check for wicking along wires. If signs of corrosion, identify color, save samples for chem Ld.
A L	Stationary Terminal is closest to the outside connector keying tab.

original 2/18/99
revised tbd

Evaluation Process
Brake Pressure switch / Harness

TI-NV

port

4L

Do not perform on parts from underhood fires, as may disturb diaphragm/other condition
Do not perform on parts from underhood fires, as may disturb diaphragm/other condition
Do not perform on parts from underhood fires, as may disturb diaphragm/other condition

he analysis surface.
ce of contamination during cutting of crimp ring.

LAROCH

eal

tographs (Digital camera with macro lens plus instant microphotography) and document observations where appropriate.

FOR Selected Samples ONLY.

nergy Dispersive Analysis of X-rays) analysis on the inside of the ring and on various surfaces of the plastic base.

up.
. Particularly look for evidence of corrosion or arcing
de and on the indented ring that lines up with interior wall of the switch cavity

debris to try to examine the underlying metal surface.
nent surfaces revealed by removal of cup.

printed 2/18/99 10:48 AM
uncontrolled document

original 2/18/99
revised tbd

Steve [illegible]
AVT Chassis E/E System Applications
33-[illegible] [illegible] [illegible]@ford.com
Building # [illegible]
mail drop [illegible]
fax 33-[illegible]

*** Forwarding note from [illegible] --[illegible] 02/18/99 13:48 ***
To: [illegible]
cc: [illegible]

FROM: John Joyce [illegible](UTC -05:00)
Subject: (U)Pressure Tests

Steve,

I got your note and will be on vacation tomorrow through Wednesday. Here's the info.

The more I think about this, the more I think TC activation may be the mechanism.

I am not sure of the order of the things connected and that can influence the low frequency amplitude of the signals. But the short answer is to instrument for 0-200 bar and sample at 1 kHz or more.

Since I'm not sure of where the pressure switch is hydraulically connected I'll give you pressures at nodes and states I do know. The worst case for the switch would be to be connected between the HCU and the prop valve, which is where I think it is.

This is the low frequency component of the signal. I'll talk about the high-frequency component further down.

MC - HCU NODE
Maximum Pressure - ~175 Bar
Achieved by putting maximum vacuum (high revving engine and suddenly closed throttle) then standing on the pedal as hard as you can. I don't remember this number very well it might be as low as ~120 or as high as 200. It also depends on your leg strength. This type of pressure is VERY RARE at this node. For this car, the driver will typically apply <30 bar and very rarely exceed 70 bar.

HCU - PROP VALVE NODE

Standing Still - Same as MC pressure - see above.

ABS Maximum - ~110 Bar
This is achieved by loading to GVW and performing an ABS stop. You may find that you are pedal effort limited, not limited by ABS control. It's pretty rare to get this high of pressure in this mode.

TCS Maximum - ~180 Bar
This is a good candidate. On this vehicle because the HCU had to pump through the prop valve to do the brakes-only traction control, the pressures coming out of the HCU got very high. The pressure relief valve on the pump very crudely limited the peak pressure which could be developed - not the control - put another way, because the pressure at the rear brakes had to restrain the entire powertrain (no engine intervention) and push through a prop valve, it was often possible to drive through the TC - the engine would overpower the brakes, even though very high pressures were being generated at the HCU. The noise during TC activation in these applications was very dependent upon the pressure relief valve opening point. So the pressure relief valve value got changed a few times over the years as performance was sacrificed for NVH. Also the tolerance on the pressure relief valves was fairly large - a total of 40 bar, at that time I believe. The pressure relief valve pressure might be anywhere from [illegible] to 180 bar depending on part-to-part variation and the design generation that was agreed upon.

You can achieve this easiest by getting the rear wheels off the ground and putting the car in drive. Get into the throttle hard, but not so hard that you drive out of first gear or faster than ~15 mph. If you maintain this for a while, the thermal model to protect the rear linings will disable the Traction Control. You will then need to wait for them to cool, before the function will be reenabled. You can dramatically accelerate
the cooling time by cruising (without braking) at about 40 mph.

Typical drivers can regularly get high pressures in this mode.

PROP VALVE - REAR WHEEL NODE
ABS Maximum Pressure ~70 Bar
Load to GVW and perform an ABS stop at maximum pedal effort.

TCS Maximum Pressure ~180 Bar
This pressure level is strongly dependent upon the pressure relief valve level - see above.

Standing Still
Same as ABS Maximum Pressure

High Frequency Content
The high frequency content has two parts. If you are not in ABS or Traction Control there is essentially no high frequency content - the pressure is modulated at <10 Hz. This is basically limited by [illegible] response times and hydraulic damping in the ABS orifices.

High Frequency Content Due to Control
During ABS/TC events the pressure is changed in quick steps. Typically it will increase by ~10 Bar in a few milliseconds, and this type of change occurs about every 10ms. The pressure will decrease by about 30 Bar every 200 ms. There can be quite a bit of variation in these numbers, but these are pretty typical. (Actually the numbers I assigned were for ABS, swap "increase" and "decrease" for TC activation.)

High Frequency Content Due to Shock Waves
This is a secondary effect from the control. Generally it is large right at the outlet of the HCU. It is damped and dissipated the farther you

get from the HCU. The shock wave is generated from the cyclical pulsing of the pump as well as the sudden changes in pressure when a solenoid valve is snapped open or shut.

The amplitude of this can be really big - I haven't looked at it in this generation unit for a few years, but I think it's about 80 bar peak-peak right at the HCU. It will fall off as you move further away from the HCU.

The frequency is pretty high and I think some components are above the 1 kHz level. But you can get a very good idea of the disturbances by sampling at ~10kHz.

Regards,
John Joyce

1 Bar = 100 kPa = 14.50 psi

Ford ES-F2VC-9F924-AA Impulse Test 5×10^5 ~ 0-1450 psi / 100 Bar / 10^4 kPa

Continental®
TEVES

Continental
Automotive Systems
Business Unit

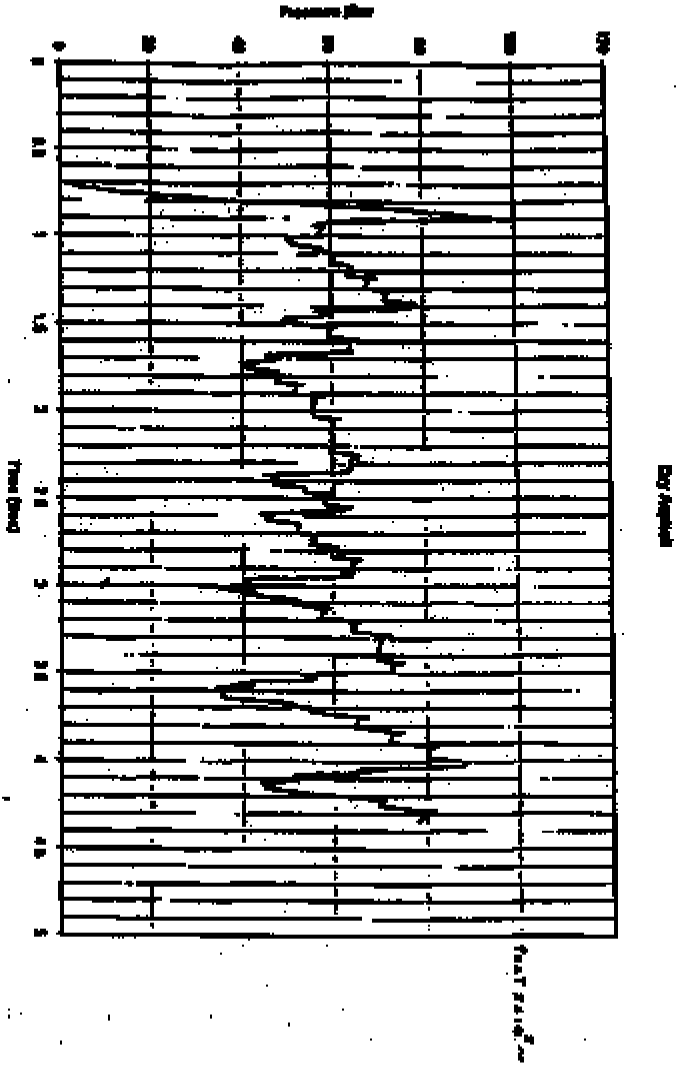
Telefax

To	Joe Evans	From	Brian Hildebrand
Company		Dept.	
Dept.		Fax No.	
Fax No.		Phone No.	
Date	3/5/99	Pages including cover sheet	

Typical ABS rear axle
Pressure traces.

- Dry asphalt
- Snow
- ice

Not for
MY 92 & 93,
but close
Ste



33.11 Brake limiting device and anti-slide systems

As the brakes are initially applied, a miniscule degree of slip occurs between the tyres and road, but the slip as well as the brake torque progressively increase with the load applied to the brake pedal, until the wheels actually lock and the tyres slide along the road. During the last phase of brake application the rate of angular deceleration of the wheels becomes considerably greater than the linear rate of deceleration of the vehicle without any wheels sliding.

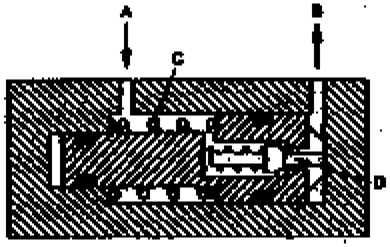
It is well known that the coefficient of friction between the tyres and the road is reduced with the onset of sliding, which is therefore to be avoided if the shortest possible braking distance is to be achieved.

The point at which wheel-lock will occur is dependent upon the vertical forces between the tyres and the road. Therefore, application of the brakes transfers, in effect, some of the weight from the rear wheels to the front ones, so during hard braking the rear wheels will tend to slip earlier than those at the front. A vehicle having a static front : rear weight distribution of 60 : 40 would generally have adequate adhesion for all its brakes to perform effectively when its weight distribution ratio coincides with a braking ratio of about 70 : 30. At higher decelerations this level may rise to 80 : 20, so if the rear wheels are not progressively relieved of some of the braking effort they are liable to slide. Sliding rear wheels have no capacity for exerting any additional grip on the road to produce any stabilising force. Consequently, the vehicle becomes unstable when braked hard and, given the slightest lateral disturbance, its rear end may slide sideways, causing the vehicle to swing round through as much as 180° or more.

To prevent this unstable condition from arising, a *brake pressure apportioning valve* can be fitted in the hydraulic system. Its function is to reduce the control pressure applied to the rear brakes relative to that to the front ones and, preferably, it should cater for both the fully laden and driver-only conditions. A whole range of such valves is produced by Lucas Girling, the principles of which are explained later.

In the nineteen-sixties it became common practice to insert a simple *pressure-limiting valve* in the line to the rear brakes only. This allowed the applied pressure to be transmitted up to a predetermined level to both front and rear brakes, after which the pressure in the line to the rear brakes was either held constant or its rate of increase was reduced. However, this pressure characteristic was constant regardless of the load carried, so the rear brakes were significantly under-utilised when the vehicle was fully laden.

Hydraulic pressure from the master cylinder is applied at *A*, in Fig. 33.18, and transmitted through the axial hole in the centre of the shouldered piston and on through the metering valve D, whence it goes through the outlet *B* to the rear brakes. At the same time it acts upon the crown of the piston. Because the effective area of the crown is greater than that of the shoulder on the other side of the piston, it progressively pushes the piston back, compressing the spring C, until the metering valve is seated. Then, any further increase acting on the smaller diameter of the shoulder of the piston pushes it to the right as viewed in the illustration, again opening the metering valve. Thus, the pressure applied through outlet B to the rear brakes continues to increase, as shown in Fig. 33.22(a), the front : rear pressure ratio at the brakes being predetermined



A From master cylinder
B To rear brakes
C Spring
D Metering valve

Fig. 33.18 Diagram of a pressure-conscious brake apportioning valve

by the ratio of the smaller and larger effective areas of the shouldered piston and the force exerted by the internal spring.

The Motor Vehicle

Twelfth Edition

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IN-SERVICE BRAKE PERFORMANCE TEST PROCEDURE PASSENGER-CAR AND LIGHT-DUTY TRUCK —SAE J201 MAR97

SAE Recommended Practice

Report of Brake Committee approved April 1974. Reaffirmed by the SAE Brake Standards Committee 7—Road Test Procedures May 1989 and March 1997.

Foreword—This Reaffirmed Document has been changed only to reflect the new SAE Technical Standards Board Format.

1. Scope—This SAE Recommended Practice establishes a uniform procedure for testing the brake systems (service and parking) of all passenger cars, light-duty trucks, and multipurpose passenger vehicles up to and including 4500 kg (10 000 lb) GVWR.

1.1 Purpose—The purpose of the test code is to evaluate brake system performance of vehicles in service for compliance with regulations.

1.1.1 The test code is expected to be utilized as a basis for a brake evaluation conducted by State or Federal officials engaged in highway safety programs.

1.1.2 The primary consideration is that this test requires a minimum of instrumentation, time, driver skill, and cost to conduct.

2. References—There are no referenced publications specified herein.

3. Instrumentation

3.1 Decelerometer (U-tube or equivalent)

3.2 Pedal force indicator

3.3 Pedal travel indicator

3.4 Speedometer

3.5 Stop watch

4. Installation Details

4.1 Install and adjust decelerometer on vehicle.

4.2 Install pedal force and travel indicator to manufacturer's procedure and calibrate.

4.3 Brake system is to be tested as received without any changes or adjustments.

5. Vehicle Test Weight

5.1 The vehicle is to be tested at the "as received" load excluding passengers. Official observer permissible.

5.2 The load may be repositioned or removed if a hazardous condition exists.

6. Test Facility

6.1 Selected test area shall be a paved 3.7 m (12 ft) lane of adequate length, dry, clean, straight, essentially level, and not heavily traveled.

6.2 Provide a 15% grade of sufficient length and skid resistance to support the entire test vehicle.

7. Test Procedure

7.1 Test Notes—(To be recorded on data sheet—Figure 1.)

7.1.1 Vehicle make, model name, year, and serial number.

7.1.2 Vehicle odometer reading.

7.1.3 Condition of each tire.

7.1.4 Type of brake (disc, drum) (power, manual).

7.1.5 Brake warning lamp operation.

7.1.6 Brake stop lamps operation.

7.1.7 Any change in pedal height when held for 10 s at 89 N (20 lb) pedal force.

7.1.8 Any change in pedal height when held for 10 s at 667 N (150 lb) pedal force and if pedal reached its limit of travel.

7.1.9 If parking brake application will lock the wheels with the vehicle on the 15% grade.

7.1.10 Any unusual brake or vehicle noises.

7.1.11 Any unusual brake action such as pulls, roughness, etc.

7.1.12 If wheel slide occurred during the brake snubs and designate whic wheel.

7.1.13 Maximum sustained deceleration attained.

7.1.14 Maximum pedal force required.

7.2 Static Check

7.2.1 Verify warning lamp operation as indicated by vehicle manufacturer.

7.2.2 If vehicle is so equipped, observe brake warning lamp indicator durin test.

7.2.3 With vehicle stopped and the engine running, apply 89 N (20 lb) force t the brake pedal and hold for 10 s.

7.2.4 Note if there is any change in pedal height during the 10 s.

7.2.5 With vehicle stopped and the engine running, apply 667 N (150 lb) forc to the brake pedal and hold for 10 s.

7.2.6 Note if there is any change in pedal height during the 10 s or if the peda reaches the limit of its travel.

7.3 Parking Brake

7.3.1 Drive vehicle up a 15% grade, apply the service brake to stop, and hol the vehicle.

7.3.2 Place transmission selector in neutral.

7.3.3 Apply the parking brake up to the regulatory load, but do not exceed 89 N (200 lb) force for a foot-operated mechanism or 443 N (100 lb) for a hand operated mechanism. Remove foot or hand from the parking brake apply mechanism.

7.3.4 Release the service brake.

7.3.5 Observe if wheels remain locked.

7.4 Preliminary Snub Test to Acquaint Driver with Vehicle—(To be conducted within 3.7 m [12 ft] wide test lane):

7.4.1 SNUBS REQUIRED—1.

7.4.1.1 Snub Speed—48 to 16 km/h (30 to 10 mph).

7.4.1.2 Snub Deceleration (Sustained)—3 m/s^2 (10 ft/s^2).

7.4.1.3 Moderate apply rate (do not exceed 667 N [150 lb]).

7.4.1.4 Abort snub if wheel slide occurs and discontinue test.

7.4.2 SNUBS REQUIRED—1.

7.4.2.1 Snub Speed—64 to 32 km/h (40 to 20 mph).

7.4.2.2 Snub Deceleration (Sustained)—5 m/s^2 (16 ft/s^2).

7.4.2.3 Moderate apply rate (do not exceed 667 N [150 lb]).

7.4.2.4 Abort snub if wheel slide occurs and discontinue test.

7.5 Highway Stopping Test—(To be conducted within the 3.7m [12 ft] wide test lane):

7.5.1 STOPS REQUIRED—1.

7.5.1.1 Initial Speed—80 to 97 km/h (50 to 60 mph) or maximum practical speed attainable within the test area if less than 80 km/h (50 mph).

7.5.1.2 Sustained Deceleration Attainable—Not to exceed 6 m/s^2 (20 ft/s^2).

7.5.1.3 Pedal Force—667 N (150 lb) maximum.

7.5.1.4 Brake Apply Rate—Maximum rate possible when maintaining deceleration control (not a spike) up to
6 m/s^2 (20 ft/s^2).

7.6 Repeat Testing

7.6.1 If the vehicle brake systems exhibit marginal performance with respect to the regulatory requirements, tests for 7.4 or 7.5 may be repeated.

8. Report Form—General Data and Report Form, Figure 1.

LIGHT TRUCK

CONFIDENTIAL

CORPORATE PRODUCT ACCEPTANCE SPECIFICATIONS

SYSTEM: Brake

PAGE NO. 06.00-C-3

DATE 16 Dec 88

6. ENVIRONMENTAL — (Reserved)

7. DURABILITY

7.1 ACCELERATED DURABILITY: All brake system components must complete accelerated durability without failure, becoming loosened or detached. Replacement of worn linings or pads is permissible during this test.

7.2 SPIKE TEST — See USA and EAO Local Market Requirement.

7.3 BRAKE WEAR TEST:

7.3.1 Vehicle brake wear rate is to be estimated using the Customer Correlated Cost of Ownership Circuit or equivalent, and the life objective will defined in the Program Objectives.

7.3.2 Brake wear measurement to be in accordance with CETP 06.00-R-401 or equivalent. The useful life of the lining material is considered terminated if the material thickness falls below the following:

- 0.2 mm above rivet head where steel or aluminum rivets are used to fix the linings.
- 0.0 mm i.e., level with rivet heads where copper or brass rivets are used to fix the linings.
- 1.0 mm from shoe platform for molded or bonded linings.
- 1.5 mm from backplate for disc pads.

Produced by Ford

LIGHT TRUCK

CONFIDENTIAL

LOCAL MARKET REQUIREMENTS — USA

SYSTEM: Brake

PAGE NO. 06.00-C-USA-1

DATE: 16 Dec 88

BRAKE

5.5 TRAILER TOWING:

5.5.1 Service Brakes: The vehicle's service brakes must be capable of stopping the vehicle/trailer combination without exceeding the following stopping distances:

Initial Speed	GCM of 4536 kg or Less	GCM Over 4536 kg
64 km/h	46 m	60 m
96 km/h	148 m	176 m

The tests are to be conducted on a level, dry, concrete surface as described in ETP F4-14 or equivalent under the following conditions:

- Stops are to be made with trailer brake system (if any) inoperable.
- Service brake pedal force must not exceed 670 N force during stop.
- Initial brake temperature is to be 65°C to 120°C before stop.
- Ambient temperatures between 0°C and 38°C accepted for testing.
- Brake lining to be burnished and in good serviceable condition before test.
- Vehicle/trailer combination must meet handling requirements specified in Section 00.00TT (5.5) during stops.
- Heaviest GCM loading recommended for vehicle/trailer combination must be utilized for vehicle/trailer being tested.
- Vehicle is to be loaded to rated GVM, including trailer tongue weight in vehicle weight.
- All stops are to be made with vehicle in gear.

7.2 SPIKE TEST:** The vehicles must be capable of completing 7 cycles of spike stops per ETP F4-12L. The 7 cycles are to be tested with vehicle at GVM. The following requirements must be met at the completion of the 7 cycles.

7.2.1 Post Spike Stop Check Stops:

- The brake pedal shall not go to the floor.
- The brake failure warning light shall not be illuminated.
- There shall be no wheel lock-up below 3.66 m/sec^2 and the vehicle shall remain in a 3.7 m lane.

7.2.2 Post Check Stop Inspection:

- Each wheel must be capable of being rotated freely by one person.
- The linings shall not show any significant cracking or looseness relative to its attaching plate.
- The linings shall not show any significant shift relative to its attaching plate.
- There shall be no significant loss of torque at any foundation brake attachment.
- There shall be no significant permanent deformation of any brake component.

**Currently being considered for incorporation as a worldwide requirement.

Produced by Ford

CORPORATE PRODUCT ACCEPTANCE SPECIFICATIONS

SYSTEM: Brake
PAGE NO. 06.00-C-1
DATE: 1987 Sep 15

BRAKE

SYSTEM DESCRIPTION AND CONTENT

This specification covers the requirements of the complete Brake System incorporating the following Subsystems:

06.01 Front Drum Brake
06.02 Rear Drum Brake
06.03 Front Disc Brake
06.04 Rear Disc Brake
06.05 Parking Brake and Actuation
06.06 Hydraulic Brake Actuation
06.07 Power Brake
06.08 Air Brake
06.09 Skid Control
06.10 Auxiliary Brake

In addition to the requirements listed in this specification or in the Subsystem specifications, the Brake System shall comply with all the applicable requirements listed in the Complete Vehicle System 00.00 and all applicable regulatory requirements listed in the specific vehicle Program Feature Description document.

1. GENERAL

1.1 JURY EVALUATION: Under all conditions of controlled braking on level asphalt surfaces, the acceptability of the following brake characteristics is to be determined by jury evaluation:

1.1.1 NVH: There shall be no objectionable brake roughness, judder, noise, vehicle deviation or squeal.

1.1.2 Steering Function: The braked front wheels must not, to a noticeable extent, affect the steering function.

1.1.3 Pedal Feel: Acceptance level for pedal feel is a jury evaluation rating of 7 minimum. Evaluation is to take place with vehicle at curb mass and at GVM. Stops should be made from various speeds including a 120 km/h maximum.

1.2 BRAKE DRUM AND DISC LIFE OBJECTIVES: Brake drum and disc condition, including crazing, shall be evaluated on a Cost of Ownership Circuit or equivalent, and the life objectives will be defined in the program objectives.

1.3 VEHICLE SYSTEM FAILURE: The Brake System shall provide at least secondary brake performance in the event of a failure in the Suspension, Steering, Chassis or Body Systems, provided the failure does not render the vehicle undriveable.

2. PACKAGE

2.1 PEDAL TRAVEL: The available pedal travel must be sufficient to allow bottoming of the pistons within the master cylinder with a minimum overtravel of 13 mm (as measured at the pedal pad centerline) between the pedal assembly and the floor/dash panels, carpeting, insulation or other travel limiting components. The minimum overtravel requirement must prevail when the maximum master cylinder stroke and booster valve travel and nominal body design dimensions are considered. Carpets, mats and insulation are defined to be travel limiting components at their compressed height. Overtravel is defined as the distance the top face of the pedal pad could move if the pedal assembly were not constrained by the bottomed out master cylinder. Overtravel is the chordal length described by the pad centerpoint arc. Vehicles equipped with a cable damper hydraulic power assist unit shall meet 90% of the pedal travel requirement, noted above, during power-off mode.

2.2 BRAKE CONTROLS: It must be possible to apply 700 N effort to the foot pedal (Service Brake) and 400 N to the handbrake (Parking Brake) with the controls at their applied position. It must also be possible to apply 700 N effort to the foot brake pedal at the extreme of travel resulting from a failed hydraulic brake line.

3. APPEARANCE — (Reserved)

4. SERVICE AND ASSEMBLY

4.1 DRUM AND DISC RECONDITIONING: The disc/drum and foundation brake design must be such that all performance requirements are achieved with:

4.1.1 Disc Thickness: Disc thickness reduced by 0.75 mm from new by in-service machining and/or wear.

4.1.2 Drum Diameter: Drum diameter increased by 1 mm from new by in-service machining and/or wear.

5. PERFORMANCE

5.1 GENERAL

5.1.1 Lining Test Condition: See EAO Local Market Requirements.

5.1.2 Lane Control: During all performance tests vehicle deviation shall result in any part of the vehicle or its body projecting beyond a 3.7 m wide lane.

CORPORATE PRODUCT ACCEPTANCE SPECIFICATIONS

SYSTEM: Brake
PAGE NO. 06.00-C-2
DATE: 18 Jan 88

5.2 PERFORMANCE EVALUATION

5.2.1 Mountain Brake Test: All vehicles must complete the Mountain Brake Test for Light Trucks, ETP 74-114 or equivalent, with a projected lining service life of 100 cycles for a GVMR equal to or less than 2268 kg with a proportionally reduced projected life requirement, based upon the ratio of the GVMR's, for a GVMR greater than 2268 kg and less than 4536 kg. For vehicles with a GVMR equal to or greater than 4536 kg, the minimum projected lining service life must be at least 50 cycles.

5.2.2 City Traffic Wear Test: All vehicles must be capable of completing the City Traffic Wear Test, P3-39A, or equivalent, with a minimum projected lining service life of 16 000 km.

5.2.3 Master Cylinder Pistons: Throughout the full dynamic portions of the above tests, the master cylinder pistons must not bottom out in either primary or secondary chambers.

5.3 STATIC PERFORMANCE: The service brake actuating mechanism must be capable of withstanding a static load of 1700 N without any permanent deformation when the load is applied perpendicular to the center of the pedal pad.

5.4 COLD BRAKES: The brake is considered to be cold when the temperature of the disc or drum is below 100°C. Additional service brake tests shall be conducted with discs/drums below 40°C and below 0°C to evaluate the effect of low ambients.

5.4.1 Service Brake: See EAO Local Market Requirements.

5.5 HOT BRAKES:

5.5.1 Recovery from Fade: The recovery procedure described in EATM 06.00-30-02 or equivalent must be carried out following EEC/71/320 or equivalent fade tests detailed in EATM 06.00-30-20 or equivalent. The last recovery stop of this procedure must be within +25% of the deceleration achieved with cold brakes.

5.5.2 Simulated Alpine Brake Test: During test, CETP 06.00-R-301 or equivalent, the following requirements must be fulfilled:

— The pedal effort must not exceed 700 N.

— The pedal travel must not be exhausted.

— The wear of usable material of pads or linings must not exceed 30% after 500 stops.

— The service brake must remain functional after the test. This requirement is to be verified on a judgement basis.

During a soak period of 10 minutes immediately after the braking cycles the pedal travel must not be exhausted if depressed in 1 minute intervals with the maximum effort obtained during braking.

5.6 PERFORMANCE ON LOW FRICTION SURFACES: In addition to adhesion utilization computer calculations, a practical evaluation of performance on low friction surfaces will be carried out laden and unladen. On a surface where the coefficient of friction between tire and surface (mu) lies between 0.2 and 0.4, the vehicle must achieve without any wheel lock a brake deceleration factor (deceleration/g) of at least 60% mu.

5.7 BRAKE PADS/LININGS

5.7.1 Lining Glazing: After completion of 3000 km running at 25% payload on the Bishop Stortford circuit or equivalent, the brake pads/linings shall not exhibit glazing and shall provide cold performance within ±15% of that measured before the test.

5.7.2 Brake Lining and Pad Wear Dimensions: Brake linings and pads should be dimensioned such that all shoes or pads on the same axle have on average a life within 20% of the most durable.

5.8 PART FAILED SYSTEM:

5.8.1 Deceleration: Where one circuit of a dual circuit brake system fails and with brake performance tests conducted to EATM 06.00-30-01 or equivalent a deceleration of 2.2 m/sec^2 must be achieved from 80 km/h, under all conditions of loading up to GVM. Vehicle deviation shall be contained within a 3.7 m wide lane.

5.8.2 Jury Evaluation: Each circuit of a dual circuit brake system shall fulfill the following requirement: During braking test according to the minimum braking performance conditions of FMVSS 105-75, the vehicle shall keep its directional stability on a dry, level, concrete road within a 3.7 m wide straight lane while steering corrections are allowed. Acceptability of performance, vehicle deviation and steering corrections required with a part failed system is also to be evaluated by jury evaluation.

5.9 TRAILER TOW: See USA Local Market Requirements.

TABLE 3.4. CUMULATIVE PERCENT RIGHT FOOT FORCE DISTRIBUTION: 276 FEMALE DRIVERS

	STANDARD MOTIVATION		INDUCED MOTIVATION	
Pressure (lbs)	Frequency	Cumulative Percent	Frequency	Cumulative Percent
281+	9	100.00	32	100.00
261-280	14	96.74	21	88.41
241-260	2	91.67	11	80.80
221-240	13	90.94	27	76.81
201-220	27	86.23	32	67.03
181-200	31	76.45	44	55.43
161-180	28	65.22	29	39.49
141-160	36	55.07	32	28.99
121-140	46	42.03	26	17.39
101-120	27	25.36	9	7.97
81-100	21	15.58	5	4.71
61-80	16	7.97	6	2.90
41-60	4	2.17	1	.72
21-40	2	.72	1	.36
	Σ=276		Σ=276	

50th percentile=152.7

5th percentile= 70.3

50th percentile=193.7

5th percentile=102.3

TABLE 3.5. CUMULATIVE PERCENT RIGHT FOOT FORCE DISTRIBUTION: 323 MALE DRIVERS

	STANDARD MOTIVATION		INDUCED MOTIVATION	
Pressure (lbs)	Frequency	Cumulative Percent	Frequency	Cumulative Percent
281+	160	100.00	221	100.00
261-280	22	50.46	25	31.58
241-260	28	43.65	16	23.84
221-240	27	34.98	18	18.89
201-220	24	26.63	19	13.31
181-200	25	19.20	15	7.43
161-180	12	11.46	4	2.79
141-160	7	7.74	2	1.55
121-140	5	5.57	1	.93
101-120	8	4.02	0	.62
81-100	3	1.55	1	.62
61-80	1	.62	1	.31
41-60	1	.31	0	-
21-40	0	-	0	-
	Σ=323		Σ=323	

50th percentile=279.1

5th percentile=133.1

50th percentile=N.A.

5th percentile=190.1

lbs (Table 2.5). Note that these results are very similar to those obtained in the pilot study for the analogous test conditions (see Table 2.1). Performance at the 50th percentile could not be determined for highly motivated males since the majority of male subjects exceeded the 300 lb limit of the force gauge. Figures 2.4 and 2.5 show the cumulative percent of foot-force capability as achieved by females and males in the two trials.

Person Product-Moment correlations performed on a random sample of 100 subjects (57 males and 43 females) showed that foot weight (W_F) is highly correlated with total body weight (W_B): $r_{W_F \cdot W_B} = .83$. However, for this sample of subjects, body weight and right foot force (F) with standard motivation had a low correlation of $r_{W_B \cdot F} = .24$. A sample of 46 females produced a correlation of $r_{W_B \cdot F} = 0.26$ between body weight and right-foot force produced with a standard instruction. The same sample attained a correlation of $r_{W_B \cdot F} = .18$ when body weight was compared with right-foot force produced under an induced motivation.

DISCUSSION

A comparison of the above results with those obtained in the Harvard study produces the following findings. The 50 female subjects tested by Stoudt et al., attained a mean force of 201 lbs and a 5th percentile force of 126 lbs, averaged over all five trials. The Harvard subjects were tested five times (all on the right foot) under conditions corresponding to the "induced" motivation condition of this study. The measured forces increased with each successive trial, suggesting that both a learning and motivational effect were present. The subjects in the HSRI study were tested four times. Only two of the tests were on the right foot, the first in the "standard" and the second in the "induced motivation condition.

where, with the cooperation of officials, a greater age range of subjects could be tested. Experimenters followed a procedure identical to that used in the second day of the pilot study. The force gauge was visible. Subjects were given the "standard" instructions and data recorded for the right and left foot. Foot order was alternated across subjects. Right- and left-foot force measurements were then taken with the "induced" instructions. In addition, foot length, body weight, lower leg weight (with subject seated and legs resting on the scale), and lower-leg height were measured.

Subjects. The study sample consisted of 276 female and 323 male drivers. The females were 16 to 79 years of age with a mean age of 32.5 years. Their weights ranged from 89 to 225 lbs with a mean of 135.9 lbs. The males were 16 to 89 years of age with a mean age of 31.8 years. Their weights ranged from 119 to 285 lbs with a mean of 178.1 lbs. The age and weight distribution of subjects is shown in Tables 2.2 and 2.3. It should be noted that younger drivers (16-24 years) are over represented in the sample. Accordingly, the measured distribution is not likely to be an underestimate of the pedal-force capability of the driver population.

RESULTS

Tables 2.4 and 2.5 show the cumulative frequency distributions of maximum force achieved by female and male subjects, respectively, with the right foot. (Left-foot data are not shown because of the high correlation that was found for the two feet.) For the standard motivation instruction, the 5th and 50th percentiles of maximum force achieved by the 276 females (Table 2.4) are respectively, 70.3 lbs and 152.7 lbs. For the induced motivation instruction, the 5th and 50th percentiles are equivalent to 102.3 lbs and 193.7 lbs. Males, on being given the standard instruction, attained a 5th percentile force of 133.1 lbs and a 50th percentile level of 279.1

1. Report No.

2. Government Accession No.

3. Recipient's Catalog No.

4. Title and Subtitle

Brake Force Requirement Study: Driver-Vehicle Braking Performance as a Function of Brake System Design Variables

5. Report Date

April 10, 1970

6. Performing Organization Code

7. Author(s) R.G. Mortimer, L. Segel, H. Dugoff, J.D. Campbell, C.M. Jorgeson, R.W. Murphy

8. Performing Organization Report No.

HuF-6

9. Performing Organization Name and Address

Highway Safety Research Institute
University of Michigan
Ann Arbor, Michigan 48105

10. Work Unit No.

11. Contract or Grant No.

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Final Report
July 1, 1968-April 10, 1970

12. Sponsoring Agency Name and Address

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National Highway Safety Bureau
Washington, D.C. 20591

14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract The objective of this study was to define those brake characteristics, within the space bounded by the relationship between brake pedal force and vehicle deceleration, which lead to acceptable driver-vehicle performance. A driver-vehicle braking test was performed in which the deceleration/pedal force ratio, the pedal displacement, the surface-tire friction, and driver characteristics (age, weight) were systematically varied in order to determine the influence of these variables upon minimum stopping distance and other performance variables. The tests that were performed on a low coefficient of friction surface showed that high values of deceleration/pedal force gain result in large number of wheel lockups and lower mean deceleration in bringing the vehicle to a stop, compared to intermediate or low deceleration/pedal force gain levels. Tests conducted on intermediate and high coefficient of friction surfaces showed that high and intermediate deceleration/pedal force gains produced greater mean decelerations and greater frequencies of wheel lockups than lower gain systems. The frequency of loss of lateral control was significantly greater with the high deceleration/pedal force gain brakes on all surfaces than with lower gains. There were minor benefits of 2.5 inch pedal displacement compared to zero inches. Potential brake failures and their effects upon pedal force requirements were analyzed. The implications of the findings for a vehicle braking standard were shown in terms of deceleration/pedal force gain and pedal force.

17. Key Words

BRAKING, DECELERATION, STOPPING DISTANCE, DRIVER BRAKING, PEDAL FORCE, PAVEMENT FRICTION, BRAKE FAILURE.

18. Distribution Statement

Availability is unlimited. Document may be released to the Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151 for sale to the public.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
unclassified	unclassified	xx + 200	

*** Forwarding note from MREESE --DRBN003 03/08/99 11:33 ***
To: [illegible]--DRBN007
cc: TRAZIL --DRBN005 LSMITH9 --DRBN001
DSTLVEST--DRBN001
FROM: M. P. REESE USA(EST)(UTC -05:00)
Subject: Brake Dump Switch Re-location; 1992/1993/1994 TOWN CAR
STEVE, FURTHER SERVICE MANUALS PROVIDE A LITTLE MORE LIGHT:
* 1993 MODEL (ON PAGE 10-03-1, SPEED CONTROL SYSTEM) AND 1994 MODEL (ON PAGE 10-03-1, SPEED CONTROL SYSTEM - ELECTRONIC) MANUALS CONTAIN THIS SENTENCE. "THE SYSTEM OPERATES INDEPENDENT OF ENGINE VACUUM, THEREFORE NO VACUUM LINES ARE REQUIRED."
* I WILL FIND AND CHECK A 1992 MODEL MANUAL.
THIS SOMEWHAT SUPPORTS A SPACE BEING AVAILABLE ON THE TOWN CAR BRAKE PEDAL AND BRACKET ASSEMBLY. I WILL TRY TO BE READY, WHEN SOMEONE COMES TO CHECK.
Regards,
M. P. Reese 313-337-7142 (313-621-4875 FAX)
OPD LVC - Brakes Mail Drop 1228 [illegible] 2 20401

*** Forwarding note from [illegible]--DRBN007 03/08/99 12:11 ***
To: MREESE --DRBN003
cc: JEVANS9 --DRBN005 MREASE --DRBN005
AZAPARAD--DRBN009 TRAZIL --DRBN005
FKOHL --DRBN007 Foster, F.J. YKATAH --DRBN004
FROM: Steve Reiman USA(EST)(UTC -05:00)
Subject: Brake Dump Switch Re-location
Please contact Joe Byrne, Bruce Foote, and A. Zapanadan when you are ready for the check. These guys should be able to provide a good study check.
Steve Reiman building 5 2E040
AVT Chassis E/E System Applications mail drop 5041
39-02286 SREIMERS sreiman@ford.com fax 39-02286 ?

*** Forwarding note from TRAZIL --DRBN005 03/08/99 10:48 ***
To: SREIMERS--DRBN007
cc: TRAZIL --DRBN005 DSTLVEST--DRBN001
JEVANS9 --DRBN005 [illegible] --DRBN005
AZAPARAD--DRBN009 FKOHL --DRBN007
FROM: M. P. REESE USA(EST)(UTC -05:00)
Subject: Brake Dump Switch Re-location
STEVE, I HAVE NO PROBLEM WITH JOE, BRUCE, OR AL LOOKING AT THE DESIGNER'S TUBE TO SEE THE PACKAGE AVAILABLE AROUND THE [illegible] TOWN CAR BRAKE PEDAL AND BRACKET ASSEMBLY (-2455-), BUT THEY ARE NOT THE RELEASE ACTIVITY THAT WOULD TRY TO RELEASE AN ELECTRICAL SWITCH INTO THAT ENVIRONMENT. SPEED CONTROL IS THAT RELEASE ACTIVITY.
I WILL BE OUT FOR A FEW DAYS. I WILL ASK A CUBE DESIGNER TO COORDINATE WITH JOE, BRUCE, AND AL. PACKAGE REVIEW BY SPEED CONTROL DESIGN AND RELEASE?
NEWS ABOUT 1992 MODEL TOWN CAR. THE 1992 SERVICE MANUAL SHOWS THIS FOR THE SPEED CONTROL SYSTEM:
* EARLY PRODUCTION VEHICLES USED A VACUUM DUMP VALVE, ON THE BRAKE PEDAL AND BRACKET ASSEMBLY. PAGE 10-030-1.
* LATE PRODUCTION VEHICLES, LIKE 1993 AND 1994 MODEL TOWN CAR. "THE SYSTEM OPERATES INDEPENDENT OF ENGINE VACUUM. THEREFORE NO VACUUM LINES ARE REQUIRED."
THIS WAS NOT A JOB #1 CHANGE. THAT RESULT I DO NOT HAVE.
THIS IS ANOTHER PLACE WHERE THE SPEED CONTROL RELEASE ENGINEER COULD HELP; THAT IS, EXACTLY WHEN EARLY PRODUCTION STOPPED AND LATE PRODUCTION STARTED (VIN, DATE, ETC.).
Regards,
M. P. Reese 313-337-7142 (313-621-4875 FAX)
OPD LVC - Brakes Mail Drop 1228 [illegible] 2 20401

*** Forwarding note from SREIMERS--DRBN007 03/08/99 10:05 ***
To: FKOHL --DRBN007 TECHNODY--VISTEON
FROM: Steve Reiman USA(EST)(UTC -05:00)
Subject: Brake Dump Switch Re-location
The D&R is from Visteon. Who do you recommend to do the package review of Marc y's switch relocation design?
Steve Reiman building 5 2E040
AVT Chassis E/E System Applications mail drop 5041
39-02286 SREIMERS sreiman@ford.com fax 39-02286 ?

MSG FROM: FKOHL --DRBN007 TO: FKOHL --DRBN007 03/08/99 08:29:14
To: SREIMERS--DRBN007
cc: TECHNODY--VISTEON [illegible]--VISTEON
FKOHL --DRBN007 MREESE --DRBN003
FROM: Fred Kohl USA(EST)(UTC -05:00)
Subject: Brake Dump Switch Re-location
The Speed Control Group did release the old vacuum dump valve but the packaging of the valve on the brake pedal support was handled by the brake group.
I am unsure on who does packaging of a electrical switch in this area, but the current responsibility is with Brake group and AVT.
Regards, Fred Kohl, Visteon Speed Control (Sunbox)
PROFS ID: FKOHL Phone TBD Pager (888) 377-6289
IBM Mail: [illegible]
Mailing Address: FTC C[illegible]

MSG FROM: SREIMERS--DRBN007 TO: FKOHL --DRBN007 03/08/99 09:13:04
To: FKOHL --DRBN007
FROM: Steve Reiman USA(EST)(UTC -05:00)
Subject: Brake Dump Switch Re-location
This should [illegible] the choice of switch.
Steve Reiman building 5 2E040
AVT Chassis E/E System Applications mail drop 5041
39-02286 SREIMERS sreiman@ford.com fax 39-02286 ?

*** Forwarding note from YKATAH --DRBN004 03/08/99 14:41 ***
To: [illegible]--DRBN007 [illegible] --DRBN00[illegible]
[illegible] --DRBN00[illegible]
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[illegible] --DRBN00[illegible] [illegible]--DRBN00[illegible]
[illegible]--VISTEON [illegible] --DRBN00[illegible]
[illegible]--VISTEON FKOHL --DRBN007

USA(EST)(UTC -05:00)
FROM: Fred Kohl
Subject: Brake Dump Switch Re-location
Want to clarify who has D&R for electrical deactivation switch, it is AVT.
The current electrical dump switch is released by AVT, believe Mike Salmaca is the engineer: MSALMACA 1-313-845-0807

Speed Control Group released a vacuum switch for the old vacuum system. Also, this switch was packaged by the Brake Group on the brake pedal support bkt.

Regards, Fred Kohl. Visteon Speed Control (Sunbox)
PROFS ID: FKOHL Phone TBD Pager (888) 377-6289
IBM Mail [illegible]
Mailing Address: FTC C[illegible]

From: JKAFAFI --DRBN004 Date and time 03/08/99 15:09:14
To: [illegible]--DRBN00[illegible] JKAFAFI --DRBN004
cc: FKOHL --DRBN007
[illegible]--DRBN00[illegible]

From: Joseph Kafafi USA(EST)(UTC -04:00)
Subject: Brake Dump Switch Re-location
Sal, we are contacting the AVT switch group which have responsibility for the dump switch. Fred Kohl and myself have spoken to Mike Salmaca who is the release engineer for AVT and he will speak to his supervisor so that we could get someone to review the packaging. I am also contacting Mark [illegible] from [illegible] who make these switches to review packaging. I am [illegible] for setting up a review for tomorrow morning. Thanks

Regards,
Joseph Kafafi
Advanced Vehicle Technology, [illegible]
PH: 313-248-[illegible]. Tech Pager: (313) [illegible]-6782, FAX: 313-248-[illegible]

*** Forwarding note from SREIMERS--[illegible] 03/12/99 10:43 ***
To: FKOHL --[illegible]
FROM: Steve Reimers USAET(UTC -05:00)
Subject: Alternate Dome Switch
Is the brake pedal mounted switch a viable replacement for the Texas switch as far as the speed control electronics is concerned? Is this switch input compatible with the speed controls in 92 and 93 town cars?
Steve Reimers building 5 3C040
AVT Chassis E/E System Applications mail drop 5011
39-03284 SREIMERS sreimers@ford.com fax 39-03284 ;>

MSG FROM: FKOHL --[illegible] TO: SREIMERS--[illegible] 03/15/99 08:22:17
To: SREIMERS--[illegible]
cc: [illegible]--VISTEON [illegible]--VISTEON
FKOHL --[illegible]
FROM: Fred Kohl USAET(UTC -05:00)
Subject: Alternate Dome Switch
Yes, the pedal mounted switch currently used is compatible electrically with the 92 and 93 Town Car.
I do not know if mounting in the vehicle and wiring harness requirements can easily be met. Chassis would have to answer the mounting / packaging questions and EESE would have to address the wiring harness issue.
The current Town Car dome switch engineer is Mike [illegible]([illegible]) 84-54087.
Regards,__ Fred Kohl, Precision Speed Control ([illegible])
PROFS ID: FKOHL Phone TBD Pager (800) 377-[illegible]
Mail Stop([illegible])
Mailing Address: ETC C375

*** Forwarding note from SREIMERS--[illegible] 03/05/99 12:20 ***
To: MREESE --[illegible]
FROM: Steve Reimers USAET(UTC -05:00)
Subject: Brake Dome Switch Re-location
Marty, I am asked what the status of this design work. Have you got any good words I can pass on to my manager? I would like to give Jack Probus a sense of where we are on this task, what the next step(s) are and when they are targeted to complete. My meeting with Probus is tuesday at 2:30.
thanks,
Steve Reimers building 5 3C040
AVT Chassis E/E System Applications mail drop 5011
39-03284 SREIMERS sreimers@ford.com fax 39-03284 ;>

*** Forwarding note from MREESE --[illegible] 03/05/99 16:13 ***
To: SREIMERS--[illegible]
cc: TRAZIL --[illegible] [illegible] --[illegible]
FROM: M. F. REESE USAET(UTC -05:00)
Subject: Brake Dome Switch Re-location
I AM OPTIMISTIC ABOUT ABILITY TO PACKAGE THE CURRENT PRODUCTION SWITCH ON THE BRAKE PEDAL AND BRACKET ASSEMBLY IN 1992/1993/1994 TOWN CARS. I WILL KNOW MORE (BUT NOT EVERYTHING) ABOUT TIMING AT THE CONCLUSION OF A 9:00 AM MEETING WITH CHASSIS ENGINEERS. GENERAL OPTIMISM COMES FROM THE BRAKE PEDAL AND BRACKET ASSEMBLY DRAWINGS; THEY (SO FAR) SHOW EVOLUTION OVER THE
MODEL YEARS, AND INVOLVE ONLY ONE SUPPLIER.
WERS AND DOCMAN ARE NOT IN GOOD SHAPE FOR THIS 1992/1993/1994 MODEL TASK. THAT SLOWS THE ADVANCE. FACILITATES [illegible].
ALWAYS, I MUST CONSIDER EFFECTS ON FMVSS 105, VEHICLE TEST, BRAKE SYSTEM.
I INTEND T CALL YOU ABOUT NOON ON MONDAY 1999 MAR 08.
Regards,
M. F. Reese 313-317-7542 (313-621-4675 FAX)
OPD LVC - Brakes Mail Drop 1229 BUILDING 2 3N031

*** Forwarding note from SREIMERS--[illegible] 03/27/99 16:15 ***
To: MREESE --[illegible]
cc: FPORTER --[illegible] Porter, F.J.

FROM: Steve Reimers USAET(UTC -05:00)
Subject: Brake Dome Switch Re-location
Marty, Please call Fred Porter with the update from your meeting. I will be at [illegible] most of the day.

Steve Reimers building 5 3C040
AVT Chassis E/E System Applications mail drop 5011
39-03284 SREIMERS sreimers@ford.com fax 39-03284 ;>

*** Forwarding note from MREESE --[illegible] [illegible] 11:24 ***
To: SREIMERS--[illegible] FPORTER --[illegible]
cc: TRAZIL --[illegible] [illegible] --[illegible]
FROM: M. F. REESE USAET(UTC -05:00)
Subject: Brake Dome Switch Re-location - DESIGN ORDER
STEVE, THE RESULT OF THE MEETING THIS MORNING IS THAT WE WILL HAVE A FEASIBLE,
CLEAR SOLUTION (FOR SWITCH MOUNTED TO BRAKE PEDAL ASSEMBLY, ON 1992/1993/1994
TOWN CAR) BY NOON FRIDAY 1999 MAR [illegible].
IN MAKING THIS SOLUTION, WE ARE BEING VERY CAREFUL SO THAT WE DO NOT MAKE SOMETHING ELSE WORSE. THE HISTORY IS VAGUE.
ANY GOOD NEWS, ABOUT OTHER SOLUTIONS?
Regards,
M. F. Reese 313-317-7542 (313-621-4675 FAX)
OPD LVC - Brakes Mail Drop 1229 BUILDING 2 3N031

*** Forwarding note from MREESE --[illegible] [illegible] 14:27 ***
To: SREIMERS--[illegible]
cc: TRAZIL --[illegible] [illegible] --[illegible]
[illegible] --[illegible] [illegible] --[illegible]
FROM: M. F. REESE USAET(UTC -05:00)
Subject: Brake Dome Switch Re-location - DESIGN ORDER RESULTS
STEVE, THERE IS A PLACE FOR A SWITCH TO BE LOCATED ON THE 1992/1993/1994 TOWN CAR BRAKE PEDAL ASSEMBLY. IT IS THE "KEYHOLE" IN THE PEDAL ASSEMBLY'S BRACKET, WORKING WITH THE FLAT SURFACE ON THE PLASTIC ADAPTER (ON THE PEDAL
ASSEMBLY'S ARM). THESE FEATURES WERE USED TO MOUNT THE VALVE ASSEMBLY - SPEED CONTROL (-9C[illegible]) AND THE CLIP - SPEED CONTROL VACUUM VALVE (-9C[illegible]) ON OTHER MODEL YEAR/CARLINE PANTHER CARS. SWITCH AND WIRING CLEARANCE TO STEERING COLUMN CRUSH ZONE WILL DEPEND ON DIMENSIONS OF SWITCH TO BE USED, AND WIRING ROUTING. (THE 1999 MODEL SWITCH, AT THIS LOCATION, DOES INTERFERE WITH THE CRUSH ZONE.) A DIFFERENT/NEW SWITCH WILL BE NEEDED.
IT IS TIME FOR THE CHECK TO VERIFY THESE RESULTS, THAT I REQUESTED DURING THE 1999 MAR 08 MEETING. THE CHECK IS NEEDED, BECAUSE REFERENCES (DESIGN LAYOUTS,
WERS, DOCMAN, ETC.) THAT WE HAVE AVAILABLE (AND RECOVERED FROM ARCHIVES) ARE
NOT PERFECT. I REQUEST REVIEW BY THE APPROPRIATE DESIGN AND RELEASE (SWITCH AND WIRING) ENGINEERS. PLEASE RELAY THIS REQUEST.
IF THIS SOLUTION DOES NOT HOLD UP TO THE CHECK, THEN WE WILL NOT BE ABLE TO ADD A SWITCH ON THE BRAKE PEDAL AND BRACKET ASSEMBLY.
Regards,
M. F. Reese 313-317-7542 (313-621-4675 FAX)
OPD LVC - Brakes Mail Drop 1229 BUILDING 2 3N031

*** Forwarding note from SREIMERS--[illegible] [illegible] 17:24 ***
To: [illegible] --[illegible]
cc: FPORTER --[illegible] Porter, F.J. MREESE --[illegible]
FKOHL --[illegible]
FROM: Steve Reimers USAET(UTC -05:00)
Subject: Brake Dome Switch Re-location
Joe, Can you do the checking that Marty is requesting? Do you know who the design and release engineer(s) is for the brake pedal mounted switch and the harness is?
Steve Reimers building 5 3C040
AVT Chassis E/E System Applications mail drop 5011
39-03284 SREIMERS sreimers@ford.com fax 39-03284 ;>

Data Log
Brake Pressure Switch

VIN	Event	Mileage	Term-Hexport Resistance	Leaker?	Kapton #1	Kapton #2	Kapton #3	Present Status
PY622977	Sv. Fire				crack	crack	crack	Analyses Complete
PY686224	Underhood Fire				no info	no info	no info	Analysis Complete
NY748119	Underhood Fire							Sw not available
NY763705	Underhood Fire							Analysis in Progress
VX145373	Cruise Insp		4.8MEGAOHMS	yes	crack	crack	crack	Analysis Complete
NX768774	Reference		OPEN	no	worn, no crack	worn, no crack	worn, no crack	Analysis Complete
NY763065	Cruise Insp		4MEGAOHM	yes	crack	crack	crack	Analysis Complete
NX763858	Reference	78164	OPEN					
PY734049	Reference	71337	OPEN					
PY628176	Reference	66667	OPEN					
py682539	Reference	69349						Analyses in Progress
py728811	Reference	47325						Analyses in Progress
NX728439	Reference	46622	OPEN					
PX169221	Reference	65814	OPEN					
PX657765	Reference	??	OPEN					
PY666375	Reference	42234	OPEN					
PY728386	Reference	91369	OPEN					
PX695376	Reference	68669	OPEN					
NY746386	Reference	53237	OPEN					
PX623672	Reference	94145	OPEN					
PY696374	Reference	??	OPEN					
BY638884	Reference	97199	OPEN					
PY680226	Reference	72114	OPEN					
PY686766	Reference		OPEN					
PY774356	Reference	67649	OPEN					
PY764576	Reference	42821	OPEN					
PX643616	Reference	43531	OPEN					
??	Reference	??						
PX629834	Reference	62282	OPEN					
φ								
PY636868	Reference							
PX163820	Reference	166669						
PX641686	Reference	??						
PX163312	Reference	40842						
PY610384	Reference	73115						
NY724366	Underhood Fire	??						
PY750172	Reference	??						

Data Log
Brake Pressure Switch

NY733191	Undecided Five	105510
PY758158	Reference	??
PX151140	Reference	72814
NY757405	Reference	??
PY743858	Reference	??
PY7430413	Reference	105048

Epstein, Sally

From: McGuirk, Andy [a-mcguirk@email.mc.ti.com]
Sent: Friday, February 19, 1999 7:52 AM
To: Rahman, Aziz
Subject: FW: Test up date

Brake Pressure Switch Test Log

AUTOMOTIVE SENSORS AND CONTROLS QRA MANGER
34 FOREST ST M/S 23-05
ATTLEBORO, MA 02703
TEL : (508) 236-3080
FAX : (508) 236-3745
PAGE: (800) 467-3700 PIN 604-2044

\-----------
From: Dague, Bryan
Sent: Friday, February 19, 1999 7:25 AM
To: Rahman, Aziz SIZ
Cc: Beringhause, Steven; McGuirk, Andrew; Pechonis, John
Subject: Test up date

Aziz,

Here is the updated test matrix.

<<Brake Pressure Switch Test Log>>

Please note the following test require a brake fluid pressure cycler:

1) the wiebull testing (test # 7)
2) the impulse/lab to field correlation study (test #8)
3) DOE (test#10)
4) Now maybe a inductive load pressure cycling test (test#12??)

Needless to say we have limited equipment. It takes about 2 weeks to get 1 million cycles. Can you get some input as to what the priority should be?

Regards,
Bry

Brake Pressure Switch Test Log
Updated 2/16/99

Category	Test	Location	Test Parameters	Results Update
Lab Simulation	1	TI	Various Levels of Brake Fluid, Water, Detergent	150+ hours, 5mA draw has reduced to 0.5mA.
of Potential Ignition			14Vdc to one terminal, hexport grounded	Fluid has discolored.
in Switch	2	TI	Various Levels of Brake Fluid, Water, Detergent	150+ hours. Constant temperature.
			1 Amp through switch terminals	No significant temperature rise with time
	3	AVT	Brake Fluid in Switch, 24 VDC to one terminal	> 200 hours into test, max current 7mA
			Hexport Grounded	No significant change with time
	4	AVT	Brake Fluid in Switch, 24 VDC to one terminal	16 hours into test max current 5mA
			Hexport Grounded, Ambient at 100 C	No significant temperature rise with time
	5	AVT	Brake Fluid in Switch, 16 Amps	Temperature rise of 20 C above room temp
			Through switch terminals	Delta T reached steady state at 20 C
	6	TI	Build heater element into Switch	2 tested. Smoke observed, no ignition.
			Heat till failure	A sparking device will be added as testing continues.
Life Cycle Reliability	7	TI	0-1400 psig pressure pulses at 135C ambient	First failure at 728,000 cycles.
of Pressure Switch			per ES	Cycle count at 900,000. Continue to failure.
Diaphragm Wear	8	TI	0 1400 psig pressure pulses at 13C ambient	Parts withdrawn every 200k cycles, characterized for wear
Field vs Lab Correlation	9	Central Labs	Various Field returns, from dealer lots, junkyards	Parts in Central Labs, being processed
Design Of Experiments	10	TI	Various Levels of Brake Fluid, Water,	Equipment modifications underway. Start expected 2/24.
Evaluating Factors			Under ES conditions, to failure	
Effecting Diaphragm Wear				
On-Vehicle Characterization	11	AVT	Monitor Pressure and Temperature	Logistics being worked out.
of Pressure & Temperature			at Switch Location for ABS and non-ABS	
Profile in Town Car			braking events.	

Pechonis, John

From: Dague, Bryan
Sent: Friday, February 19, 1999 8:25 AM
To: Rahman, Aziz ZIZ
Cc: Beringhause, Steven; McGuirk, Andrew; Pechonis, John
Subject: Test up date

Aziz,

Here is the updated test matrix.

Brake Pressure Switch
Test Log.xls

Please note the following test require a brake fluid pressure cycler:

1) the wiebull testing (test # 7)
2) the impulse/lab to field correlation study (test #6)
3) DOE (test#10)
4) Now maybe a inductive load pressure cycling test (test#12??)

Needless to say we have limited equipment. It takes about 2 weeks to get 1 million cycles. Can you get some input as to what the priority should be?

Regards,
Bry

Brake Pressure Switch Test Log
Updated 2/15/00

Category	Test	Location	Test Parameters	Results Update
Lab Simulation	1	TI	Various Levels of Brake Fluid, Water, Detergent	1000+ hours, 5mA draw has reduced to 0.5mA.
of Potential Ignition			14Vdc to one terminal, hexport grounded	Fluid has discolored.
in Switch	2	TI	Various Levels of Brake Fluid, Water, Detergent	150+ hours. Constant temperature.
			1 Amp through switch terminals	No significant temperature rise with time
	3	A/T	Brake Fluid in Switch, 24 VDC to one terminal	> 250 hours into test, max current 7mA
			Hexport Grounded	No significant change with time
	4	A/T	Brake Fluid in Switch, 24 VDC to one terminal	18 hours into test max current 5mA
			Hexport Grounded, Ambient at 150 C	No significant temperature rise with time
	5	A/T	Brake Fluid in Switch, 15 Amps	Temperature rise of 20 C above room temp
			Through switch terminals	Delta T reached steady state at 20 C
	6	TI	Hold heater element into Switch	2 tested. Incredible amounts of smoke, no ignition.
			Heat till failure	A sparking device will be added as testing continues.
Life Cycle Durability	7	TI	[illegible] pressure pulses at 150C ambient	First failure at [illegible] cycles.
of Pressure Switch			to [illegible]	Cycle count at [illegible]. Continue to failure.
Corrosion in Water	8	TI	[illegible] pressure pulses at 150 ambient	Parts submitted every 2000 cycles, characterized for wear
[illegible]	9	Central Labs	Various Fluid mixtures, [illegible]	Parts in Central Labs, [illegible]
Design of Experiments	10	TI	Various Levels of Brake Fluid, Water,	Equipment modifications underway. Start expected 2/24.
Evaluating Factors			Under [illegible] conditions, to failure	
Affecting Diaphragm Wear				
On Vehicle Characterization	11	A/T	Monitor Pressure and Temperature	Logistics being worked out.
of Pressure & Temperature			at Switch Location for ABS and non-ABS	
Profile in Test Car			braking events.	

Epstein, Sally

From: Dague, Bryan [bdague@email.mc.ti.com]
Sent: Friday, February 19, 1999 11:01 AM
To: Rahman, Aziz; 'Rahman, Aziz ZIZ'
Subject: FW: More info

Ford Tests Currently in Progre

From: Dague, Bryan
Sent: Friday, February 19, 1999 7:35 AM
To: 'Rahman, Aziz ZIZ'
Subject: More info

Aziz,

Here are my notes on what we are doing here. It might offer you a bit more detail that the spread sheet has room for.

<<Ford Tests Currently in Progress>>

Did you get your hands on that pressure station yesterday??

Regards,
Bry

Tests Currently in Progress
Last updated: 2/15/99

Ignition Re-creation:
Objective – to recreate the conditions that caused an engine fire in the application.
Description:

1. 10 switches are filled with a mix of brake fluid, water, and detergent. 2 switches are filled with the following concentrations: 0%, 4%, 6%, 10%, and 75%. 14 volts is being applied to 1 terminal and the hexport is grounded. Current flow varies from about 0.5 mA to a high of about 5.0 mA.
2. On 2 of the above switches approximately 1 amp is being conducted through the terminals in-order to create heat at the switch.

Results to date:
Re filled the 75% device. Current flows and temperatures are stable, but have decreased during the last couple of days.

Weibull Testing:
Objective – To determine if snap discs have a characteristic life similar to quiet discs.

Description:
A population of 30 77PS/2-1 (snap discs) is being cycled to failure.

Results to date:
No failures at 600K cycles.

Wear Correlation:
Objective – To develop a spectrum of dimensions and visual cues that can be use to estimate the % of life left on switches returned from the field.

Description:
Switches are being removed from the cycler at increments of 200K cycles. 2 switches at each interval. These switches will be disassembled and wear at the following points will be characterized:

1. Kapton degradation
2. Pin
3. Pin guide
4. Arm bump
5. Converter/washer interface

Results to date:
600K cycles.
2 with 200K cycles were removed – awaiting dissection.
2 with 400K cycles were removed – awaiting dissection.
2 with 600K cycles were removed – awaiting dissection.

Future Plans:
DOE:
In order to run multiple moisture levels the pressure cycler needs to be modified. Parts needed for the modification are being ordered today. The goal is to have this DOE running by the end of the week. Factor's being investigated on the first pass are moisture and snap vs quiet. Future passes will include temperature and pressure.

Auto-ignition testing:
Objective is to get a fire started within the switch by installing a very small electrical heating element. With a small heating element built into a switch, we will fill the connector cavity with brake fluid, and slowly increase the current in the heating element. We will increase the current until ignition, or until the heating element burns out (continuity is lost).

Epstein, Sally

From: Dague, Bryan [bdague@email.mc.ti.com]
Sent: Friday, February 19, 1999 11:04 AM
To: Rahman, Aziz; 'Rahman, Aziz ZIZ'
Subject: FW: Test up date

Brake Pressure Switch Test Log

From: Dague, Bryan
Sent: Friday, February 19, 1999 7:25 AM
To: 'Rahman, Aziz ZIZ'
Cc: Beringhause, Steven; McGuirk, Andy; Pechonis, John
Subject: Test up date

Aziz,

Here is the updated test matrix.

<<Brake Pressure Switch Test Log>>

Please note the following test require a brake fluid pressure cycler:

1) the wiebull testing (test # 7)
2) the impulse/lab to field correlation study (test #8)
3) DOE (test#10)
4) Now maybe a inductive load pressure cycling test (test#12??)

Needless to say we have limited equipment. It takes about 2 weeks to get 1 million cycles. Can you get some input as to what the priority should be?

Regards,
Bry

Brake Pressure Switch Test Log
Updated 2/16/99

Category	Test	Location	Test Parameters	Results Update
Lab Simulation	1	TI	Various Levels of Brake Fluid, Water, Detergent	150+ hours. 5mA draw has reduced to 0.5mA.
of Potential Ignition			14Vdc to one terminal, hexport grounded	Fluid has discolored.
in Switch	2	TI	Various Levels of Brake Fluid, Water, Detergent	150+ hours. Constant temperature.
			1 Amp through switch terminals	No significant temperature rise with time
	3	AVT	Brake Fluid in Switch, 24 VDC to one terminal	> 200 hours into test, max current 7mA
			Hexport Grounded	No significant change with time
	4	AVT	Brake Fluid in Switch, 24 VDC to one terminal	16 hours into test max current 5mA
			Hexport Grounded, Ambient at 100 C	No significant temperature rise with time
	5	AVT	Brake Fluid in Switch, 16 Amps	Temperature rise of 20 C above room temp
			Through switch terminals	Delta T reached steady state at 20 C
	6	TI	Build heater element into Switch	2 tested. Incredible amounts of smoke, no ignition.
			Heat til failure	A sparking device will be added as testing continues.
Life Cycle Reliability	7	TI	0-1400 psig pressure pulses at 135C ambient	First failure at 728,088 cycles.
of Pressure Switch			per ES	Cycle count at 600,000. Continue to failure.
Diaphragm Wear	8	TI	0-1400 psig pressure pulses at 13C ambient	Parts withdrawn every 200k cycles, characterized for wear
Field vs Lab Correlation	9	Central Labs	Various Field returns, from dealer lots, junkyards	Parts in Central Labs, being processed
Design Of Experiments	10	TI	Various Levels of Brake Fluid, Water,	Equipment modifications underway. Start expected 2/24.
Evaluating Factors			Under ES conditions, to failure	
Effecting Diaphragm Wear				
On Vehicle Characterization	11	AVT	Monitor Pressure and Temperature	Logistics being worked out.
of Pressure & Temperature			at Switch Location for ABS and non-ABS	
Profile in Town Car			braking events.	

Epstein, Sally

From: Rahman, Aziz (arahman@email.mc.ti.com)
Sent: Friday, February 19, 1999 11:12 AM
To: Sharpe, Robert
Subject: Test Log.xls

Test Log.xls

<<Test Log.xls>>

Brake Pressure Switch Test Log

Updated 2/16/99

Category	Test	Location	Test Parameters	Results Update
Lab Simulation	1	TI	Various Levels of Brake Fluid, Water, Detergent	150+ hours, 5mA draw has reduced to 0.5mA.
of Potential Ignition			14Vdc to one terminal, hexport grounded	Fluid has discolored
in Switch	2	TI	Various Levels of Brake Fluid, Water, Detergent	150+ hours. Constant temperature
			1 Amp through switch terminals	No significant temperature rise with time
	3	AVT	Brake Fluid in Switch, 24 VDC to one terminal	> 200 hours into test, max current 7mA
			Hexport Grounded	No significant change with time
	4	AVT	Brake Fluid in Switch, 24 VDC to one terminal	16 hours into test max current 5mA
			Hexport Grounded, Ambient at 100 C	No significant temperature rise with time
	5	AVT	Brake Fluid in Switch, 16 Amps	Temperature rise of 20 C above room temp
			Through switch terminals	Delta T reached steady state at 20 C
	6	TI	Build heater element into Switch	2 tested. Smoke observed, no ignition
			Heat til failure	A sparking device will be added as testing continues.
Life Cycle Reliability	7	TI	0-1400 psig pressure pulses at 135C ambient	First leak observed at 720,000 cycles
of Pressure Switch			per ES	Cycle count at 900,000. Continue to failure.
Diaphragm Wear	8	TI	0-1400 psig pressure pulses at 13C ambient	Parts withdrawn every 200k cycles, characterized for wear
Field vs Lab Correlation	9	Central Labs	Various Field returns, from dealer lots, junkyards	Parts in Central Labs, being processed
Design Of Experiments	10	TI	Various Levels of Brake Fluid, Water,	Equipment modifications underway. Start expected 2/24.
Evaluating Factors			Under ES conditions, to failure	
Effecting Diaphragm Wear				
On-Vehicle Characterization	11	AVT	Monitor Pressure and Temperature	Logistics being worked out
of Pressure & Temperature			at Switch Location for ABS and non-ABS	
Profile in Town Car			braking events	

Pechonis, John

From: McGuirk, Andy
Sent: Friday, February 19, 1999 11:44 AM
To: Dague, Bryan; Watt, Jim; Beringhause, Steven
Cc: Rahman, Aziz; Baumann, Russ; Pechonis, John
Subject: MATERIAL FOR AZIZ
Importance: High

AZIZ WILL COME INTO THE PLANT SATURDAY TO PICK UP FOLLOWING ITEMS:

SAMPLES OF P/S FROM THE KAPTON CHARACTERIZATION TESTING WE HAVE DONE HERE (PROVIDES FORD THE 'SAME' SAMPLES WE HAVE COLLECTED FROM THE 'EVERY 200,000K' CYCLE TEST TO CHARATERIZE WEAR STATES.
............BRYAN AND STEVE, PLS COORDINATE THESE INTO AZIZ OFFICE FOR HIS PICK UP

OFFSET KEYWAY CONNECTOR TO FIT THE PRESSURE SWITCHES WE ARE ALL TALKING ABOUT....PRESSURE TESTER HAS WRONG (?) CONNECTOR AND NEEDS RIGHT CONNECTOR HARNESS
............BRYAN AND STEVE, PLS COORDINATE INTO AZIZ OFFICE FOR HIS PICK UP

'CORRECT' PRESSURE FITTING TO CONNECT INTO PRESSURE STATION AND INTO SWITCH QUICK CONNECT.
............BRYAN AND STEVE AND JIM WATT, PLS COORDINATE INTO AZIZ'S OFFICE FOR SAT PICKUP

IF THERE ARE ANY QUESTIONS, PAGE AZIZ BEFORE NOON TODAY............JIM WATT, PLS 'HOVER' OVER THIS TO ASSURE IT HAPPENS

A

AUTOMOTIVE SENSORS AND CONTROLS QRA MANAGER
34 FOREST ST M/S 23-05
ATTLEBORO, MA 02703
TEL : (508) 236-3080
FAX : (508) 236-3140
PAGE: (800) 467-3700 PIN 604-2844

Dague, Bryan

From: McGuirk, Andy
Sent: Friday, February 19, 1999 6:21 PM
To: Sullivan, Martha; Baumann, Russ; Beringhause, Steven; Baker, Gary
Cc: Rowland, Thomas; Dague, Bryan; Pechonis, John; Rahman, Aziz; Douglas, Charles; Watt, Jim; Sharpe, Robert
Subject: FORD CONF CALL OF 2/19

ATTORNEY CLIENT PRIVILEGED COMMUNICATION

STEVE BERINGHAUSE AND I HELD A CONFERENCE CALL WITH STEVE REIMERS OF FORD TO PROVIDE DETAILED BRIEFING TO HIM FOR HIS 4PM EXECUTIVE LEVEL MEETING (HE'S FILLING IN FOR FRED PORTER)

SUMMARY:
STEVE REIMERS WAS PREPPED FOR THE FORD EXEC MEETING WITH OUR TEST MATRIX AND UPDATE...HE WAS LEANING TOWARDS KAPTON WEAR OUT AS A KEY CONTRIBUTOR...AND WE HELPED HIM BALANCE WITH LACK OF IGNITION IN THE AGREED UPON TESTS TO DATE POINTING OUT WE THOUGHT SOME ELECTRICAL ANOMALY HAD TO BE HAPPENING TO DRIVE IGNITION.

WE COVERED A NUMBER OF POINTS IN SOME 50 MINUTES OF TELECON:

THE TEST NUMBER 7 RUN WOULD BE DONE MONDAY....THIS WAS SET UP AS A TEST TO LEAK POINT OF SOME 30 UNITS. 1ST ONE LEAKED AT 725,000 CYCLES VS 500,000 SPEC. (THERE WILL BE INTEREST IN A WEIBULL STATISTIC STATEMENT FROM THIS TESTING (JIM)

TESTING TO CHARACTERIZE WEAR OUT 'STAGES' OF KAPTON TO CONTINUE....PROVIDE FORD PHYSICAL SAMPLES VIA AZIZ MONDAY.

THERE WERE QUESTIONS ABOUT THE '93 ECONOLINE HARNESS....SWITCH LOCATION AND ORIENTATION

WE WILL ESTABLISH A D.O.E. STARTING MONDAY TO USE QUIET AND SNAP SWITCHES WITH CLEAN AND H20 CONTAMINATED BRAKE FLUID RUNNING SOME 10 UNITS ON AUTO CRUISE SERVO-MOTOR LOADS TO DETERMINE SIGNIFICANT EFFECTS AND WEAR OUT 'ACCELERATORS' TEST SHOULD RUN FOR 10 DAYS. THIS STARTS TO FORM THE BASIS FOR LONGER CYCLE LIFE SWITCH

DISCUSSED ABS AND TRACTION CONTROL VEHICLE OPTION PACKAGES AND WILL BE GETTING FORD INFO ABOUT THIS 'SOON'

AS WE DISCUSSED H20 CONTAMINATED BRAKE FLUID I ASKED IF IT IS A MATTER OF SERVICE RECORD THAT CAR BRAKE SYSTEMS 'ATTAIN' SUFFICIENT WATER CONTENT TO FREEZE.....UNKNOWN AND NOT COMMITTED RESPONSE FROM FORD

STEVE B EXPLAINED OUR UNDERSTANDING OF CAUSES OF KAPTON WEAR-OUT ACCELERATION....H20, STRESS FROM HIGH PRESSURES, STRESS FROM 'VACUUM' OR HYDRAULIC SHOCK, WEAR-OUT FROM EXCESSIVE CYCLES...THIS LED TO 'DISMISSED' DISCUSSION OF TOWNCAR HYDRAULIC SYSTEM PRESSURES IN THE TRACTION CONTROL EVENTS WHICH WE POINTED OUT AS A POSSIBLE EXAMPLE OF A SIGNIFICANT STRESS RISER IN THE SYSTEM

STEVE B EXPLAINED WE WERE NOT SEEING THE POSSIBILITY OF IGNITION OF A SWITCH WITH CLEAN

FLUID...LEADING TOWARD OUR BELIEF THAT SOME CONFOUNDING CREATED BY H2O CORROSION OF THE SWITCH AND/OR INTERNAL ARM MIGHT BE PATH TO CREATE HIGH RESISTANCE BUT THAT THE SYSTEM WOULD HAVE TO DRIVE SIGNIFICANT POWER BACK INTO THE SWITCH TOO.... STEVE REIMERS WAS NOT 'LISTENING' TO US VERY MUCH AT THIS TIME...

INTERNAL TI TO-DOS FOR ME TO DRIVE:
ASIDE FROM ABOVE ACTIONS...

STEVE B AND I AGREED WE WILL NEED TO CREATE THE SITUATION IN LAST PARAGRAPH AND DOCUMENT TO FORD EARLY NEXT WEEK SO WE COULD FOCUS DOWN TO LIKELY AREAS.

TI WILL NEED TO EXPAND THE TEST MATRIX TO COVER MANY OF THE ITEMS WE ARE DOING AND GAIN THE CREDIT THAT WE ARE WORKING IN MANY AREAS

TI NEEDS TO DOCUMENT THE APPROACH TO INCREASED SWITCH LIFE WITH A PLAN WHICH WOULD INCLUDE OUR POSITION AGAINST POWER ON AT ALL TIMES

I WILL RE-ENGAGE WITH FRED PORTER BY TUESDAY MORNING UPON HIS RETURN FROM VACATION

A

AUTOMOTIVE SENSORS AND CONTROLS QRA MANAGER
34 FOREST ST M/S 21-05
ATTLEBORO, MA 02703
TEL : (508) 236-1080
FAX : (508) 236-3745
PAGE: (800) 457-3700 PIN 604-3044

From: McGuirk, Andy
Sent: Friday, February 19, 1999 10:27 AM
To: Sullivan, Martha; Baumann, Russ; Beringhause, Steven; Baker, Gary
Cc: Rowland, Thomas; Dague, Bryan; Peabody, John; Rahman, Aziz; Douglas, Charles; Watt, Jim
Subject: FORD PRESSURE IN SYSTEM...CYCLES C/O (A)Pressure Tests

ATTORNEY CLIENT PRIVILEGED COMMUNICATION

I HAVE BRIEFLY REVIEWED AND BOLD NOTED SEVERAL AREAS (AS WELL AS ADDED BLUE NOTES FOR CLARITY) FOR OUR FIRST CONSIDERATION. SEEMS THE TRACTION 'CONTROL' OR, AS IT WAS CALLED THE 'AUGMENTATION' , MECHANISMS ARE FINALLY BEING REVIEWED AS CYCLE CONTRIBUTOR IN THE SYSTEM AND THIS FORD NOTE SHOULD MAKE IT A KEY FOCAL POINT BY LATER TODAY...

ONE CAN SEE THERE ARE A LARGE NUMBER OF PRESSURE AND CYCLE COMBINATIONS IN THIS SYSTEM INCLUDING SHOCK WAVES AS WELL AS CONTROL WAVES....MIGHT BE THESE SYSTEMS THAT 'LIMIT' THE WEAR OUT ISSUE TO THIS PLATFORM AND YEARS.

BRIEFLY STATED FOR YOUR REFERENCE BELOW; OUR SWITCH WAS SPEC'D BY FORD TO 'OPERATE' 500,000 CYCLES TO 1450 PSI, AND 'PROOF' (IE, RUN UP TO PRESSURE AND 'STILL' FUNCTION AFTER EXPOSURE) TO 3000 PSI, AND 'BURST' (IE, NOT RUPTURE DURING 30 SECONDS EXPOSURE) OF 7000 PSI.

A

AUTOMOTIVE SENSORS AND CONTROLS QRA MANAGER
34 FOREST ST M/S 23-08
ATTLEBORO, MA 02703
TEL : (508) 236-3080
FAX : (508) 236-3745
PAGER: (800) 467-3700 PIN 664-2044

From: Rehman, Aziz
Sent: Friday, February 19, 1999 8:57 AM
To: McGuirk, Andy; Beringhause, Steven; Dague, Bryan; Baumann, Russ; Sharpe, Robert; Baker, Gary; Douglas, Charles
Subject: FW: (U)Pressure Tests

GOOD INFO.

From: Steve Reimers[SMTP:sreimers@ford.com]
Sent: Friday, February 19, 1999 8:16 AM
To: Aziz Rehman, Texas
Subject: (U)Pressure Tests

fyi... I gave him a copy of your test plan and asked what pressure range and frequency we should instrument for.

Steve Reimers building 5 3C043
AVT Chassis E/E System Applications mail drop 5011
39-03286 SREIMERS . sreimers@ford.com fax 39-03286 ;>
*** Forwarding note from JJOYCE1 --DRBN007 02/18/99 19:40 ***
To: SREIMERS--DRBN007
cc: FPORTER --DRBN007

FROM: John Joyce USAET(UTC -05:00)
Subject: (U)Pressure Tests

Steve,

I got your note and will be on vacation tomorrow through Wednesday. Here's the info.

The more I think about this, the more I think TRACTION CONTROL activation may be the
mechanism (? CYCLES AND LINE PRESSURES).

I am not sure of the order of the things connected and that can influence the low frequency amplitude of the signals. (WE HAVE INDICATED THE P/S LOCATION COULD BE KEY IN THIS ISSUE.. MASTER CYLINDER VS PROP VALVE MOUNTING BEING ONE POINT I HAVE TRIED TO MAKE CLEAR) But the short answer is to instrument for 0-250 Bar and sample at 1 kHz or more.

Since I'm not sure of where the pressure switch is hydraulically connected I'll give you pressures at nodes and states I do know. **worst case for the switch would be to be connected between the HCU and the prop valve , which is where I think it is.**

This is the low frequency component of the signal. I'll talk about the high-frequency component further down.

MC - HCU NODE

Maximum Pressure - ~175 Bar (1 BAR IS 14.5 PSI, 2537 PSI)
Achieved by getting maximum vacuum (high revving engine and suddenly close throttle) then standing on the pedal as hard as you can. I don't remember this number very well it might be as low as ~130 or as high as 220 (3190! PSI). It also depends on your leg strength. This type of pressure is VERY RARE at this node. For this car, the driver will typically apply <20 bar and very rarely exceed 50 bar.

HCU - PROP VALVE NODE
Standing Still - Same as MC pressure - see above.

ABS Maximum - ~110 Bar (1595 PSI)
This is achieved by loading to GVW and performing an ABS stop, you may find that you are pedal effort limited, not limited by ABS control. It's pretty rare to get this high of pressure in this mode.

TCS Maximum - ~180 Bar(2610 PSI)
This is a good candidate. On this vehicle because the HCU had to pump through the prop valve to do the brakes-only traction control, the pressures coming out of the HCU got very high. The pressure relief valve on the pump VERY OFTEN dictated the peak pressure which could be developed - not the control - put another way, because the pressure at the rear brake had to restrain the entire powertrain (no engine intervention) and push through a prop valve, it was often possible to drive through the TC - the engine could overpower the brakes, even though very high pressures were being generated at the HCU. The noise during TC activation in these applications was very dependent upon the pressure relief valve opening point. So the pressure relief valve value got changed a few times over the years as performance was sacrificed for NOISE VIBRATIONHARSHNESS. Also the tolerance on the pressure relief valves was fairly large - a total of 40 bar, at that time I believe. The pressure relief valve pressure might be anywhere from 90 to 180 bar depending on part-to-part variation and the design generation that was agreed upon.

You can achieve this easiest by getting the rear wheels off the ground and putting the car in drive. Get into the throttle hard, but not so hard that you drive out of first gear or faster than ~15 mph. If you maintain this for a while, the thermal model to protect the rear linings will disable the Traction Control. You will then need to wait for them to cool, before the function will be reenabled. You can dramatically accelerate the cooling time by cruising (without braking) at about 40 mph.

Typical drivers can **regularly** get high pressures (2610 PSI) in this mode.

PROP VALVE - REAR BRAKE NODE
ABS Maximum Pressure ~70 Bar
Load to GROSS VEHICLEWEIGHT and perform an ABS stop at maximum pedal effort.

TCS Maximum Pressure ~100 Bar
This pressure level is strongly dependent upon the pressure relief valve level - see above.

Standing Still
Same as ABS Maximum Pressure

High Frequency Content

The high frequency content has two parts. If you are **not** in ABS or Traction Control there is practically no high frequency content - the pressure is modulated at <10 Hz. This is basically limited by Booster response times and hydraulic dampening in the ABS orifices.

High Frequency Content Due To Control

During ABS/TC events the **pressure is changed in quick steps**(CYCLES?).
Typically
it will increase by ~10 Bar in a few milliseconds, and this type of change occurs about every 100ms. The pressure will decrease by about 20 Bar every 300 ms. There can be quite a bit of variation in these numbers, but those are pretty typical. (Actually the numbers I assigned were for ABS, swap "increase" and "decrease" for TRACTION CONTROL activation.)

High Frequency Content Due to Shock Waves

This is a secondary effect from the control. Generally it is worst right at the outlet of the HCU. It is dampened and dissipated the further you get from the HCU. The shock wave is generated from the cyclical pulsing of the pump as well as the sudden changes in pressure when a solenoid valve is snapped open or shut.

The amplitude of this (Shock Waves) **can be really big** - I haven't looked at it in this generation unit for a few years, but I think it's about 50 Bar peak-peak (725 PSI)
right at the HCU. It will fall off as you move further away from the HCU.

The frequency is pretty high and I think some components are above the 1 KHz level, but you can get a very good idea of the disturbances by sampling at ~1KHz.

Regards,
John Joyce

02/23/99 SMM

time 11:30

salt ↓		PS	V	i	
	1		14.03	~400 mA	at initial reading
2.5%	2		14.04	~950	
	3		14.05	~930	
	4		14.04	~800	
5%	5		14.04	~920	
	6		14.06	>1100	
	7		14.06	1200	supply current limited
10%	8			>1400	
	9				

14Ω

~V

02/22/99 5PM

77PS salt + H_2O mix.

(3) units w/ 2.5% salt/H_2O mix
(3) units w/ 5 % salt/H_2O mix
(5) units w/ 10 % salt/H_2O mix

injected w/ mixtures 18:00

02/22/99

cup = 10.51 g

need 54.5 g / 56. 5 g of 5% mix = 2.825 g salt

$\frac{2.825}{x} = .025 = 113\text{ g}$

113.4g measured adding tap water

71.9 g of 5% = 3.595 g salt

$\frac{x\text{ g salt} + 3.595}{(71.9 + x)} = .1$

$7.19 + .1x = x + 3.595$

$.9x = 7.19 - 3.595$

$.9x = 3.595$

$x = 3.99$

$\frac{3.99 + 3.595}{75.9}$

initial reading

%salt	V	i
2.5%		
2.5		
2.5		
5		
5		
5		
10		
10		
10		

Brake Pressure Switch Test Log
Updated [illegible]

Category	Test	Location	Test Parameters	Results Update
Lab Simulation of Potential Ignition in Switch	1	TI	Various Levels of Brake Fluid, Water Switch 14Vdc to one terminal, hexport grounded Water Conc: 0%, 4%, 6%, 10%, 75%	500+ hours, Current draw in the 0.5mA to 8mA range Fluid has dissolved. No Significant Temperature Rise. Test Suspended. Internal Analysis in Progress.
	2	TI	Various Levels of Brake Fluid, Water, 1 Amp through switch terminals	250+ hours. Constant temperature. No significant temperature rise with time Test Suspended.
	3	AVT	Brake Fluid in Switch, 24 VDC to one terminal Hexport Grounded	> 300 hours into test, max current 7mA No significant change with time. Test ongoing
	4	AVT	Brake Fluid in Switch, 24 VDC to one terminal Hexport Grounded, Ambient at 105 C	18 hours into test max current 5mA No significant temperature rise with time. Test suspended.
	5	AVT	Brake Fluid in Switch, 1x Amps through switch terminals	Temperature rise of 20 C above room temp Switch reached steady state at 20 C. Test suspended.
	5a	AVT	Brake Fluid in Switch approx. 5x Amps through Switch Terminals	Temperature rose to approx. 270 F. No smoke. No ignition Test suspended.
	6	TI	Fluid heater elements into Switch with & w/o Fluid. Heat till failure and/or sparking Dry Pure brake fluid with metal shavings 6% brake fluid solution	2 tested, Smoke observed, Ignition observed on part with heater [illegible] See attachment Test ongoing Brake fluid in cavity slows down heat build-up. Smoke observed at 676 F, [illegible] and falls off at 800 F
	6a	TI	Create heater by coupling spring and [illegible] between spring and hexport	Test in progress
Life Cycle Reliability of Pressure Switch	7	TI	0-1400 psig pressure pulses at 135C per TI [illegible]	First leak observed at 720,000 cycles Test Completed. See attached Weibull Chart.
Diaphragm Wear	8	TI	0-1400 psig pressure pulses at 135C ambient	Parts withdrawn every 250K cycles, characterized for wear
Field vs Lab Correlation	9	Central Labs	Various field returns, from dealer lots, junkyards	Parts in Central Labs, being processed
Design Of Experiments of Influencing Factors Driving Diaphragm Wear	10	TI	Various Levels of Brake Fluid, Water, DOE 17 snap switches and 0 % water in the brake fluid 12 quad switches and 0% water in the brake fluid 17 snap switches 5% water in the brake fluid 17 quad switches 5% water in the brake fluid With Latch Loads and Without Latch Loads	Equipment modifications underway. Start expected [illegible]. Expected Completion of first step [illegible] Pressure and Temperature will be added to DOE matrix in the next round
On-Vehicle Characterization of Pressure & Temperature Profile in Town Car	11	AVT	Monitor Pressure and Temperature at Switch Location for ABS and non ABS braking events.	Logistics being worked out.
Spark Arc Study	12	Central Labs	Determine if arc/spark forms on switch in the [illegible] using switch leads and high speed video Use dry switches as well as switches with various brake fluid water levels	Equipment set-up in progress at Central Labs. Expected start 3/24
Characterization of switches retrieved from field junkyards & other sources	13	Central Labs	Characterize structural, metallurgical and chemical aspects of returned switches	Data log and analysis procedure set up complete. Analysis of switches in progress.

Epstein, Sally

From: Cagno, Lorraine [lcagno@email.mc.ti.com]
Sent: Wednesday, February 24, 1999 10:03 AM
To: Beringhause, Steven
Subject: Ford1.ppt

Ford1.ppt

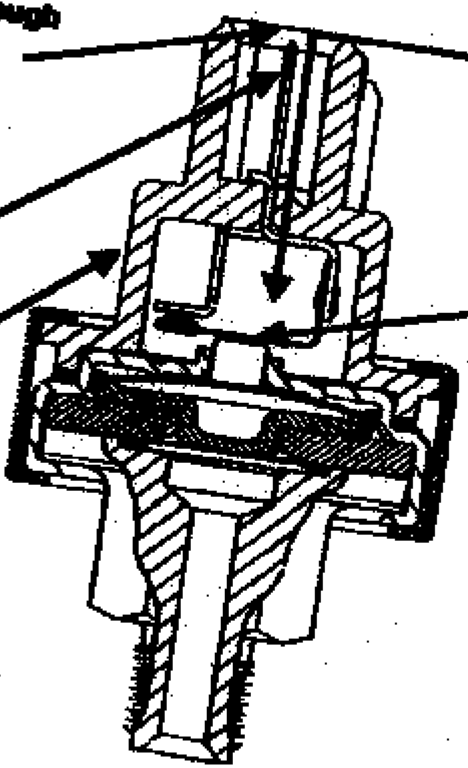
<<Ford1.ppt>>

Here you go!!!!!

Lorraine

TEXAS INSTRUMENTS

Brake Pressure Switch
Potential Thermal Event Theory - 2/24/99



4. Down stream short to ground causes high current to pass through the switch

1. Water enters the switch cavity

2. 12V Battery source to drive corrosion and provide energy

3. Contact arm corrosion increases resistance (heater wire).

5. Plastic connector melts. Once it opens, oxygen enters the switch cavity. If any arcing is present a fire can start, burning the plastic.

Epstein, Sally

From: Beringhause, Steven [sberinghause@email.mc.ti.com]
Sent: Wednesday, February 24, 1999 10:09 AM
To: Rahman, Aziz
Subject: FW: Ford1.ppt

Ford1.ppt

From: Cagno, Lorraine
Sent: Wednesday, February 24, 1999 11:03 AM
To: Beringhause, Steven
Subject: Ford1.ppt

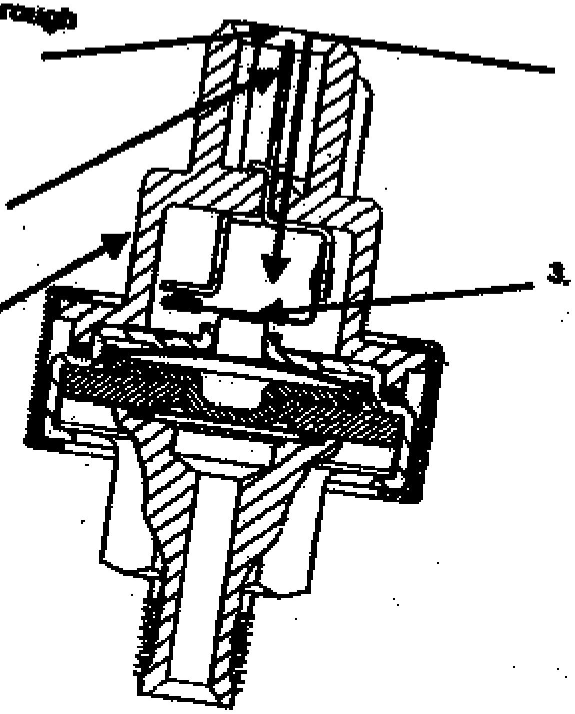
<<Ford1.ppt>>

Here you go!!!!!

Lorraine

TEXAS INSTRUMENTS

Brake Pressure Switch
Potential Thermal Event Theory - 2/24/99



4. Down stream short to ground causes high current to pass through the switch

2. 12V Battery source to drive corrosion and provide energy

5. Plastic connector melts. Once it opens, oxygen enters the switch cavity. If any arcing is present a fire can start, burning the plastic.

1. Water enters the switch cavity

3. Contact arm corrosion increases resistance (heater wire).

- - 2-29-99
L. Cambra

77 PS Heated Device Testing

I . Purpose

To determine if auto ignition can occur from the build up of excessive heat in the device . Leading to and igniting a fire to the device itself as well as the conditions and temperatures to cause results of this nature .

II . Procedure

Several attempts were made at reproducing auto ignition of the 77 PS device . A heater wire coil was installed into the base of the device in the area that the contacts and arm assembly normally occupy . The wire was attached to the terminals and connected firmly to the terminals by removing the contact arm and grinding away the rivet and drilling in the stationary contact and crimping with a small wire cutter . The heater wire used along with the coils had a total resistance of .5 ohms .
A small hole was drilled into the terminal cavity to facilitate use of a type k thermo couple wire .

The testing consisted of powering the heater coil with a variable output DC power supply to the leads of the mating connector . Temperature , voltage to the coil and current draw were monitored during testing . Device was placed in a fire proof enclosure (heat treating oven) and allowed to stabilize to room temperature of 70 degrees f .

Three devices were tested one with brake fluid and 6% water and two device's dry . Devices were given provisions for a external source if ignition by drilling a .040 hole on a 45 degree angle through base and inserted a .042 torrington pin to be inserted allowing a small gap for a spark to jump . This spark was accomplished by the use of a hy-pot tester that is used to test the dielectric breakdown of electrical devices . The use of this caused a arc to be created when device base failed and allowed the entrance of oxygen to the switch cavity and smoke from the plastic had to be present to induce flame .

III . Results / Discussions

Test 1- Wet Device (readings at appx.1 min. intervals)

Volts	Heater Current	Internal Temperature (F)
.27	1.0	100
.50	2.0	175
.80	2.9	220
.90	3.0	246
.98	3.2	349
1.6	2.0	300
.97	3.1	340
1.1	3.6	460
1.2	3.8	462
1.1	3.8	488

1.3	4.0	531
1.1	3.6	571
1.4	4.1	647
1.4	4.0	660

Out gassing of fluids began at 220 F a noticeable hissing sound was present at this point . Smoke was visible and base was venting from side at a temperature of 246 F . And smoke was being vented till failure of base at 660 F at this point power to heater was shut down and spark from hy-pot applied . Ignition of gasses occurred at this point and fire was extinguished .

Test 2 (dry device with spark)

Test 2

Volts	Heater Current	Internal Temperature (F)
1.0	3.1	501
1.09	3.0	743
	Connection failed and reconnected	
1.06	3.02	596
1.06	3.09	626
1.12	3.15	650
1.13	3.08	681

1.13	3.26	692
1.13	3.18	707
1.13	3.36	722
1.20	3.52	758
1.36	3.95	806
1.36	4.00	875

The dry device did not emit smoke or outgas until 626 F and at this time it was a light smoke emanating from terminal area . At 692 F a small burn thru area was created in the base and venting smoke this continued to 806 F where base failed and fell over . Power was left on at this point and spark applied to fumes where they ignited and extinguished quickly . The upper portion did not ignite despite 1230 F temperature .

Test 3 (rapid temp. rise)

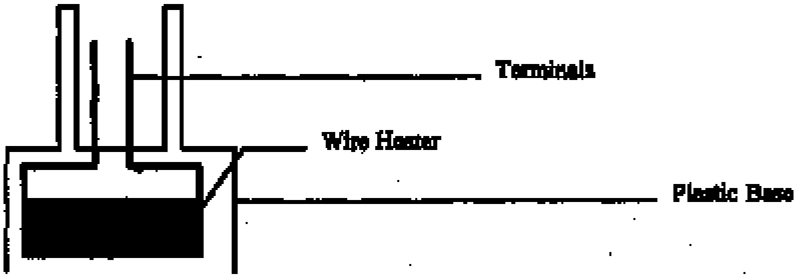
Volts	Heater Current	Internal Temperature (F)
1.0	3.6	300
1.2	4.0	360
1.2	3.8	643
1.3	3.7	650
1.3	3.7	800
1.3	3.7	930
1.3	3.7	967

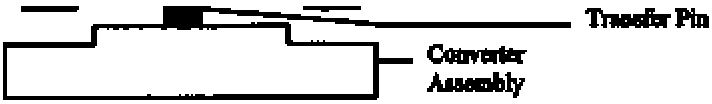
Smoke emitted at 300 F this was a fast happening event as the internal temperature rise was so rapid. Device vented at side of base at 643 F and base did not fail till 1436 F was achieved at this point spark was applied and fumes ignited. Heater instantly burned out and fire was extinguished. Reading for this test were in approximately 20 second intervals.

IV. Conclusions.

Devices will not ignite with heat alone, not allowing it to be a self sustaining thermal event. There must be smoke present from the plastics and a spark for the ignition of the device to be realized. The device must be open to atmosphere for the introduction of Oxygen to sustain ignition.

Terminal / Heater Attachment




Transfer Pin
Converter Assembly

~ 7-[illegible]-95
L. Cambron

Voltage Resistance Test

Test : Using one device measure resistance in Ohms using a standard VOM and record reading .

While observing exposed contacts at T2 and support ring through a microscope increase voltage with hy-pot test equipment until breakdown of resistance is seen and record voltage .

Repeat this sequence three time and record results

	Resistance	Hy-pot
1)	OPEN CIRCUIT	400 VOLTS
2)	OPEN CIRCUIT	450 VOLTS
3)	OPEN CIRCUIT	400 VOLTS
4)	13.9 Ohms	INSTANT

Conclusion : Device contacts proved to be open but exhibiting a very small gap between ring and contact terminal . After three voltage cycles contacts seemed to weld together causing a closed circuit . Post test inspection could not determine place that actual contact was established .

Epstein, Sally

From: Foelsche, Gerhard [afoelsche@email.mc.ti.com]
Sent: Wednesday, February 24, 1999 3:24 PM
To: Rahman, Aziz
Subject: FW: Search Results

SpecificMaterial.asp SpecificMaterial.asp

Aziz -

I found only two references, and I'm not sure they apply to what you wanted. I find no published ignition temperature information - but would not flamable fluids (e.g. ATF, etc.) burn before plastic if ignition were prone?

<<SpecificMaterial.asp>> Noryl GTX 830 (you asked for 430, which is no longer listed...)
<<SpecificMaterial.asp>> Celanex 4300

Are you sure we're not using the flame retardant grades of these polymers? Or the Heat Stabilized grades? These modifiers can make a huge difference in thermal capability / flame performance.

Call if you need more info. I did what I could on short notice, but our database link to Texas is down without a new account number. I'm looking into it for future use...

Regards, Best of Luck, and Good Health - Andy, x1242.

From: Andy Foelsche[SMTP:afoelsche@ti.com]
Sent: Wednesday, February 24, 1999 2:33 PM
To: afoelsche@ti.com
Cc: arahman@ti.com
Subject: Search Results

http://www.matls.com/SpecificMaterial.asp?bassnum=PGE531&group=General

NORYL GTX® 830 PPE+PA, 30% Glass Filler

Category: Polymer

Subcategory: Polyphenylene Ether/PPO; Thermoplastic; Nylon

Close Analogs:

Machinable sheet, rod, and tube (not moldable resin) are available from Boedeker Plastics, Inc., (800) 444-3485; E-mail: bpi@boedeker.com; www.boedeker.com.

Key Words: NORYL GTX 830 PPE+PA, 30% Glass Filler; Polyphenylene Ether; Polyamide; GE Plastics;

Composition:

Material Notes: Data provided by GE Plastics.

Click here to see a list of companies that sell this material.

PHYSICAL PROPERTIES	VALUES	COMMENTS	
Density, g/cc	1.33	ASTM D792	See other units
Linear Mold Shrinkage, cm/cm	0.003	0.002-0.003 at 3.2 mm.	
MECHANICAL PROPERTIES	VALUES	COMMENTS	
Tensile Strength, Ultimate, MPa	158	ASTM D638	See other units
Elongation %; break	7	ASTM D638	
Flexural Modulus, GPa	8.378	ASTM D790	See other units
Flexural Yield Strength, MPa	248	ASTM D790	See other units
Impact Strength, Izod, in J, J/cm, or J/cm²	1.05	J/cm; Notched, 23°C	
THERMAL PROPERTIES	VALUES	COMMENTS	
Deflection Temperature at 0.46 MPa, °C	254	ASTM D648	
Deflection Temperature at 1.8 MPa, °C	240	ASTM D648	

Vicat Softening Point, °C	248	ASTM D1525
Maximum Service Temperature, Air, °C	50	RTI Mechanical without Impact. RTI Mechanical with Impact is 50°C. RTI Electrical is 50°C.
UL RTI, Electrical, °C	50	
UL RTI, Mechanical with Impact, °C	50	
UL RTI, Mechanical without Impact, °C	50	
Flammability, UL94 (5=V-0; 4=V-1; 3=V-2; 1=HB)	1 (HB)	HB UL94 Rating, V-Series at 1.6 mm.
ELECTRICAL PROPERTIES	**VALUES**	**COMMENTS**

Click here to see a list of companies that sell this material.

Return Home

Return to Search Page

Automation Creations, Inc.

Ticona Celanex® 4300 Polyester (PBT), 30% Glass-Fiber

Category: Polymer

Subcategory: Polyester, TP; Thermoplastic; Polybutylene Terephthalate (PBT)

Close Analogs:

Machinable sheet, rod, and tube (not moldable resin) are available from Boedeker Plastics, Inc., (800) 444-3485; E-mail: bpi@boedeker.com; www.boedeker.com.

Data provided by Ticona.

Key Words: Ticona Celanex 4300 Polyester (PBT), 30% Glass-Fiber; Polybutylene Terephthalate; Hoechst Celanese Corporation;

Composition:

Material Notes: Good impact strength

Click here to see a list of companies that sell this material.

PHYSICAL PROPERTIES	VALUES	COMMENTS	
Density, g/cc	1.53	ASTM D792	See other units
Linear Mold Shrinkage, cm/cm	0.004	Flow Direction	
Water Absorption, %	0.01	ASTM D570	
Hardness, Rockwell M	91	ISO 2039-2	
MECHANICAL PROPERTIES	**VALUES**	**COMMENTS**	
Tensile Strength, Ultimate, MPa	130	ISO 527	See other units
Elongation %; break	3	ASTM D638	
Flexural Modulus, GPa	9	ISO 178	See other units
Flexural Yield Strength, MPa	205	ISO 178	See other units

Impact Strength, Izod, in J, J/cm, or J/cm²	1.15	J/cm²; Notched; ISO 180/1A	
THERMAL PROPERTIES	VALUES	COMMENTS	
Deflection Temperature at 0.45 MPa, °C	220	ISO 75	
Deflection Temperature at 1.8 MPa, °C	200	ISO 75	
Maximum Service Temperature, Air, °C	200	Deflection Temperature at 1.8 MPa load	
Flammability, UL94 (5=V-0; 4=V-1; 3=V-2; 1=HB)	1 (HB)	HB At 0.8 mm; UL94	
ELECTRICAL PROPERTIES	VALUES	COMMENTS	
Electrical Resistivity, Ohm-cm	1E+16	Lower Limit; ASTM D257	See other units
Dielectric Constant, Low Frequency	3.8	100 Hz	
Dielectric Strength, kV/mm	22	3.2 mm; 50% RH; ASTM D149	See other units
Dissipation Factor, Low Frequency	0.002	100 Hz	
Comparative Tracking Index, V	900	ASTM D3638	

Click here to see a list of companies that sell this material.

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TEXAS INSTRUMENTS

FACSIMILE TRANSMITTAL

TO: **Name:** Aziz Rahman

Location: (at Ford)

Mail Station:

Phone Number:

FAX Number:

FROM: Steve Beringhause

TEXAS INSTRUMENTS MS

Phone Number:

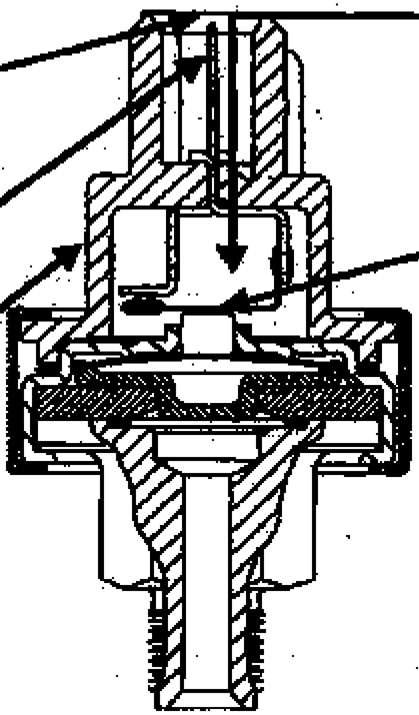
FAX Number:

Total number of pages (including header page): 2

COMMENTS:

Texas Instruments

Brake Pressure Switch
Potential Thermal Event Theory - 2/24/99



1. Water enters the switch cavity

2. 12V Battery source to drive corrosion and provide energy

3. Contact arm corrosion increases resistance (heater wire).

4. Down stream short to ground causes high current to pass through the switch

5. Plastic connector melts. Once it opens, oxygen enters the switch cavity. If any arcing is present a fire can start, burning the plastic.

TEXAS INSTRUMENTS

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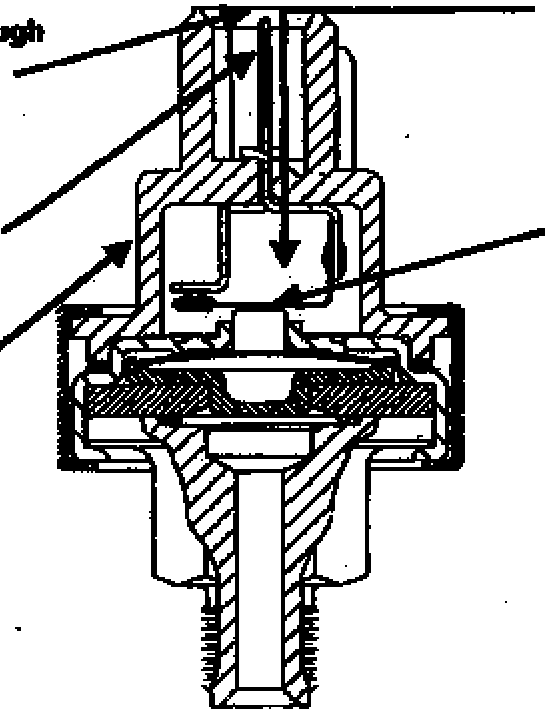

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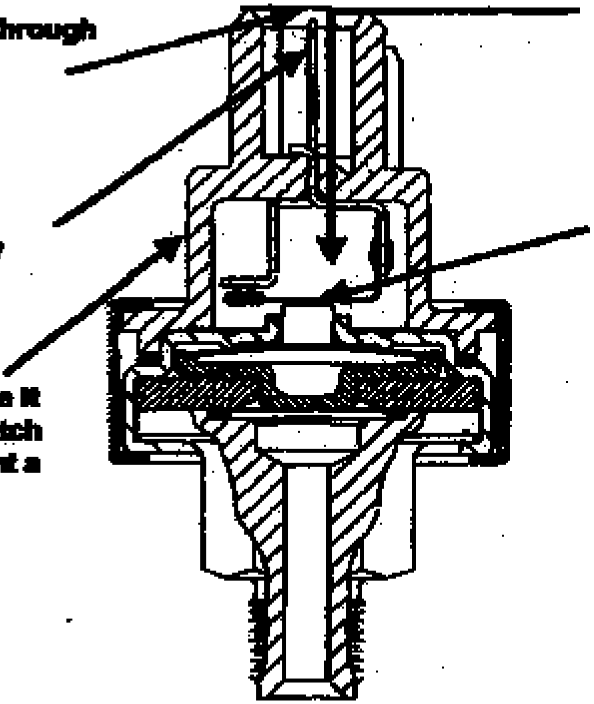

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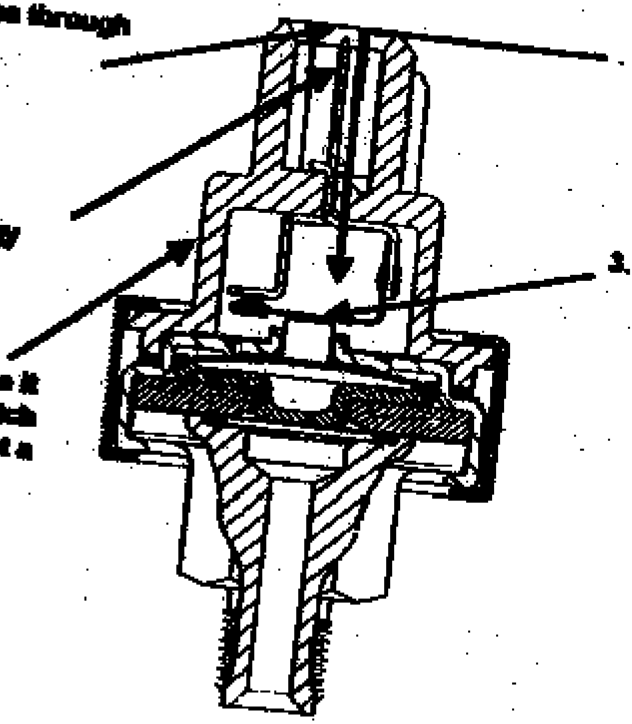
TEXAS INSTRUMENTS

* Apply in 3d format
Ford can control (10 yr proprietary)

Brake Pressure Switch
Potential Thermal Event Theory - 2/24/99



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Epstein, Sally

From: Dague, Bryan [bdague@email.mc.ti.com]
Sent: Wednesday, February 24, 1999 10:17 AM
To: Rahman, Aziz
Subject: test report update

Test Notes
Last updated: 2/23/99
Ignition Re-creation:
Objective - to recreate the conditions that caused an engine fire in the application.
Description:

1\. 10 switches are filled with a mix of brake fluid, water, and detergent. 2 switches are filled with each of the following concentrations: 0%, 4%, 6%, 10%, and 75%. 14 volts is being applied to 1 terminal and the hexport is grounded. Current flow varies from about 0.5 mA to a high of about 5.0 mA. 0% switches were remove for #3 called out below.

2\. On 2 of the above switches approximately 1 amp is being conducted through the terminals in-order to create heat in the switch.

Results to date:
Repeated refills yielded no significant temperature increase In fact, current flows have decrease. Fluid has discolored. This test was suspended on 2/21/99. Internal inspection is planned for later today.

Weibull Testing:
This testing is complete. See specific test report.

Short to ground (inside switch):
This test is complete. See specific test report.

Wear Correlation:
This testing is complete. See specific test report.

Auto-ignition testing:
Ignition via heating element:
Objective is to get a fire started within the switch by installing a very small electrical heating element. With a small heating element built into a switch, we will fill the connector cavity with brake fluid, and slowly increase the current in the heating element. We will increase the current until ignition, or until the heating element burns out (continuity is lost).

Samples tested:
1) Dry
2) Pure brake fluid with metal shavings
3) 6% brake fluid solution

Results:
If a reliable heating element can be constructed inside the contact cavity, we have been able to increase the internal temperature of the switch to a high of 800 degrees F. Typically, we see smoke around 675 degrees F, and the base melts and falls off to the side as it approaches 800F.

By adding an ignition source (arc or open flame) we have been able to ignite the smoke and plastic.

Conclusions:
1) heat alone will not create a fire - must have a spark or open flame to ignite.
2) Brake fluid in the cavity actually slows the ignition process down - probably do to cooling effects.
3) 2 to 4 watts is required to attain the temperatures mentioned above.

Creating a heating element with corrosion:
The purpose of this test is to increase the contact's arm enough to generate the 2 to 4 watts needed to start smoking.

Filling the switch with salt water and holding the arm at 14 volts and hexport at ground is generating corrosion.

Results:
Resistance is being measured today.

DOE:
The equipment needed to modify the cycler arrived this morning. We are working to get the following parts on cycle today:
12 switches with snap discs and 0 % water in the brake fluid
12 switches with out snap and 0% water in the brake fluid.
12 switches with snap disc and 5% water in the brake fluid.
12 switches with out snap and 5% water in the brake fluid.

2 switches from each group will have the Ford loads applied.

Estimated running time for this test is 2 weeks. Results will be presented in Weibull plot format.

End of document.

TEXAS INSTRUMENTS

Brake Pressure Switch
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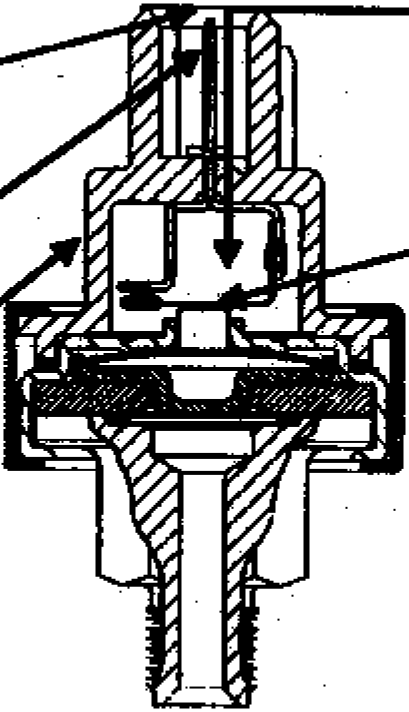

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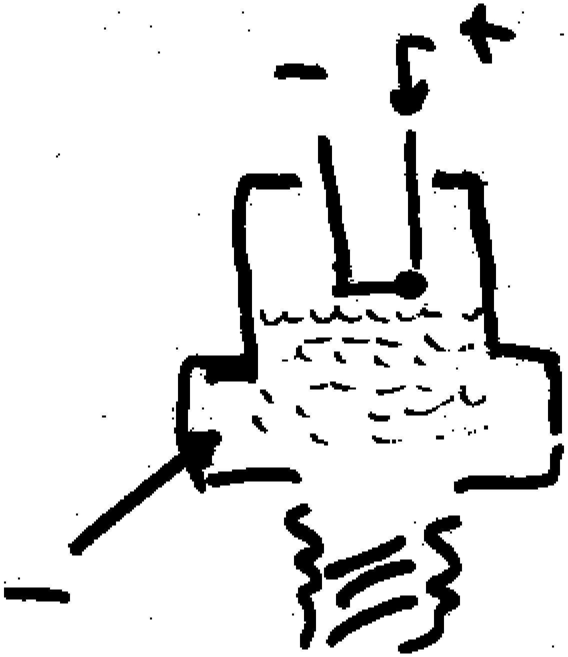

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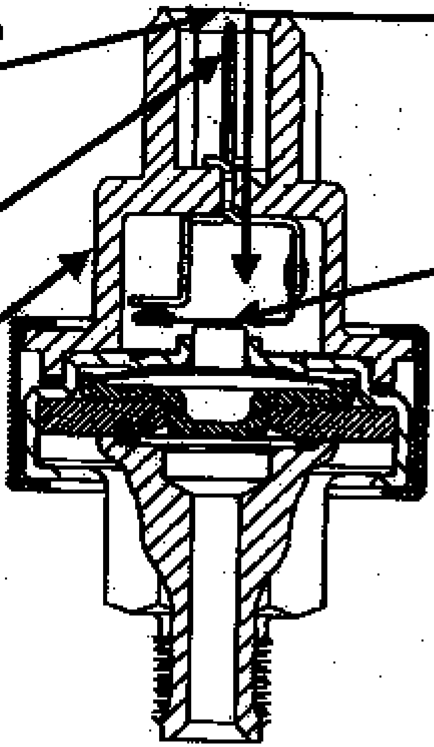
TEXAS INSTRUMENTS

Brake Pressure Switch
Potential Thermal Event Theory - 2/24/99



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PRELIMINARY

Preliminary Report – Texas Instruments
February 24, 1999

Ford '92 Town Car Thermal Event

Per Ford's request to try to recreate ignition of a fire in a TI brake pressure switch we have completed the following analysis:

A minimum of the following components are needed to cause a fire:

Energy Source
Fuel
Oxygen
Ignition source (spark)

One prevailing theory by Ford has been that if a fire was to start within the brake pressure switch, the energy source would be from the voltage applied to the switch (directly connected to battery) and excessive current flowing through the switch due to an electrical short. There are three known ways an electrical short can occur and result in high current through the switch:

1. By a highly conductive fluid shorting the electrical switch terminals to the internal cup, which is connected to the vehicle chassis ground.
2. By the contact arm detaching from the terminal and shorting the terminal to the same cup mentioned above.
3. By a short outside of the switch that results in high current through the switch terminals.

Initial testing was focused on number 1 above. By loading various switches with brake fluid, brake fluid with water, and brake fluid with water and metal filings, we have not been able to get high enough conductivity within the fluid to get more than about 5ma of current to flow. This current is not high enough to cause any significant heating of the pressure switch (less than 5 degrees F delta T from our tests).

Conclusions: We have not been able to get enough conductivity through contaminated brake fluid to provide enough current for a high delta T.

Number two above seems unlikely because analysis of the Reddick switch, which was in a fire, showed no arcing marks on the cup. In our experience the presence of arcing marks would indicate that metal was shorting to the cup.

Conclusions: The contact arm did not cause a short in the switch

Initial testing of number three above included driving about one amp of current through the switch terminals. This resulted in very little heating due to the low resistance of the contact arm and switch terminals (about 30F delta T). We then added a heater wire into the switch (about 0.5 ohms resistance) and two wires spaced a small gap apart and tied to a hypot tester to create a spark. About three volts and one amp powered the heater (this condition varied as the temperature increased). The heater boiled off the brake fluid and then started to melt the plastic connector. As the plastic connector melted smoke came out of the switch. The hypot tester was turned on to generate a continuous sparking condition but no fire started. Eventually the plastic melted to the point that it broke open exposing room air to the inside of the switch. It was at this point that the fire started, burning the connector. This test was repeated on a switch without brake fluid in the connector with essentially the same results.

Conclusions:

1. With enough heat and a spark for ignition the plastic can ignite.
2. Brake fluid in the connector slows down the process keeping the system cool.
3. There is not enough oxygen in the sealed switch to ignite the plastic.

Based on the results of these tests, our theory of what could cause a brake pressure switch to ignite is as follows:

1. The contact arm becomes corroded (probably through water entering the connector cavity) increasing its resistance.
2. There is an electrical short outside the switch that drives high current through the switch.
3. The high current through the contact arm dissipates power due to the increased resistance causes the switch to heat up melting the plastic.
4. Eventually the plastic opens allowing oxygen into the switch.
5. Arcing occurs either across the switch contacts or within the corroded contact arm.

We are currently running tests where we are trying to reproduce the fire using the contact arm as the heater.

PRELIMINARY

TI Proprietary Information: Attorney-Client Privilege Invoked

Figure 3.

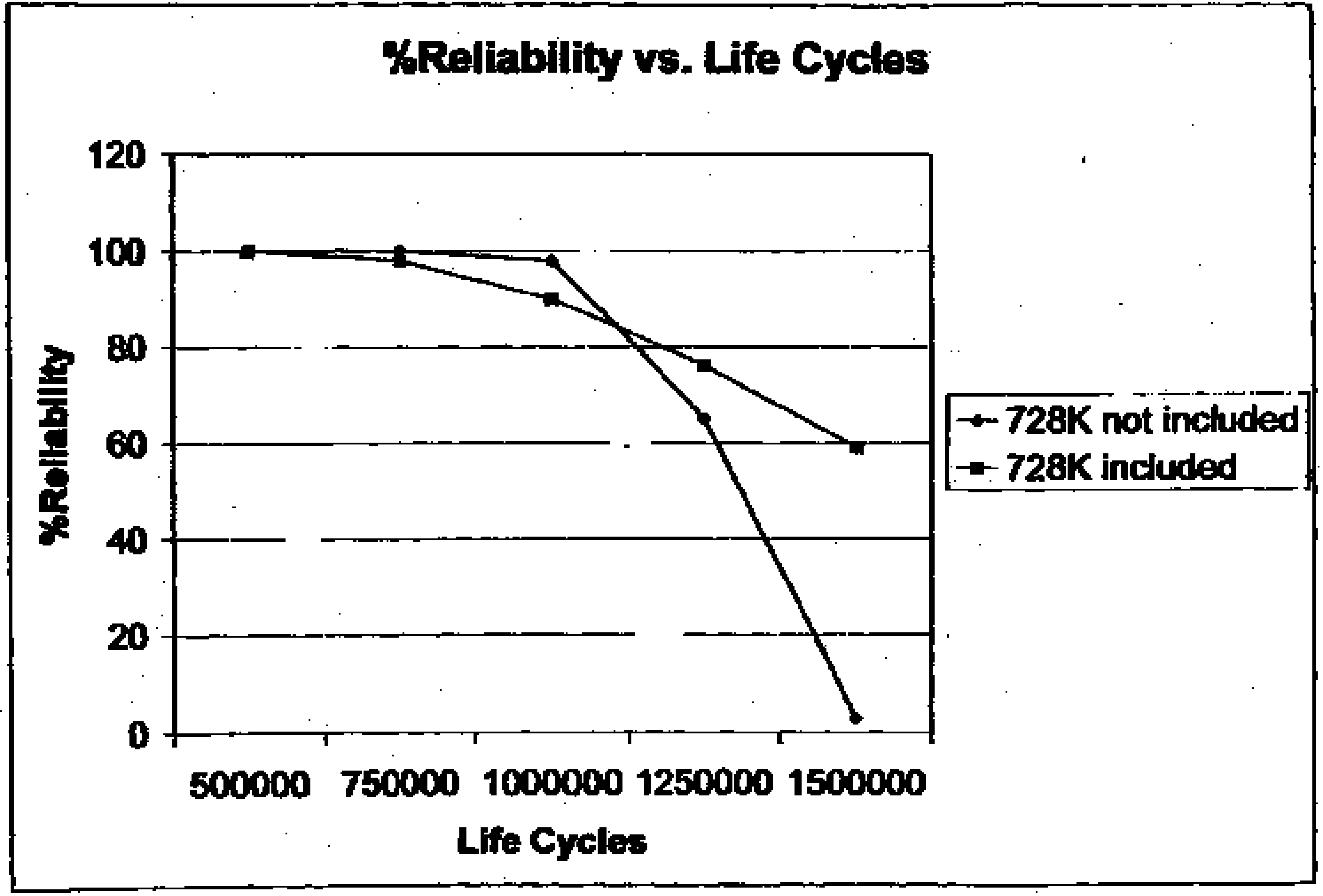
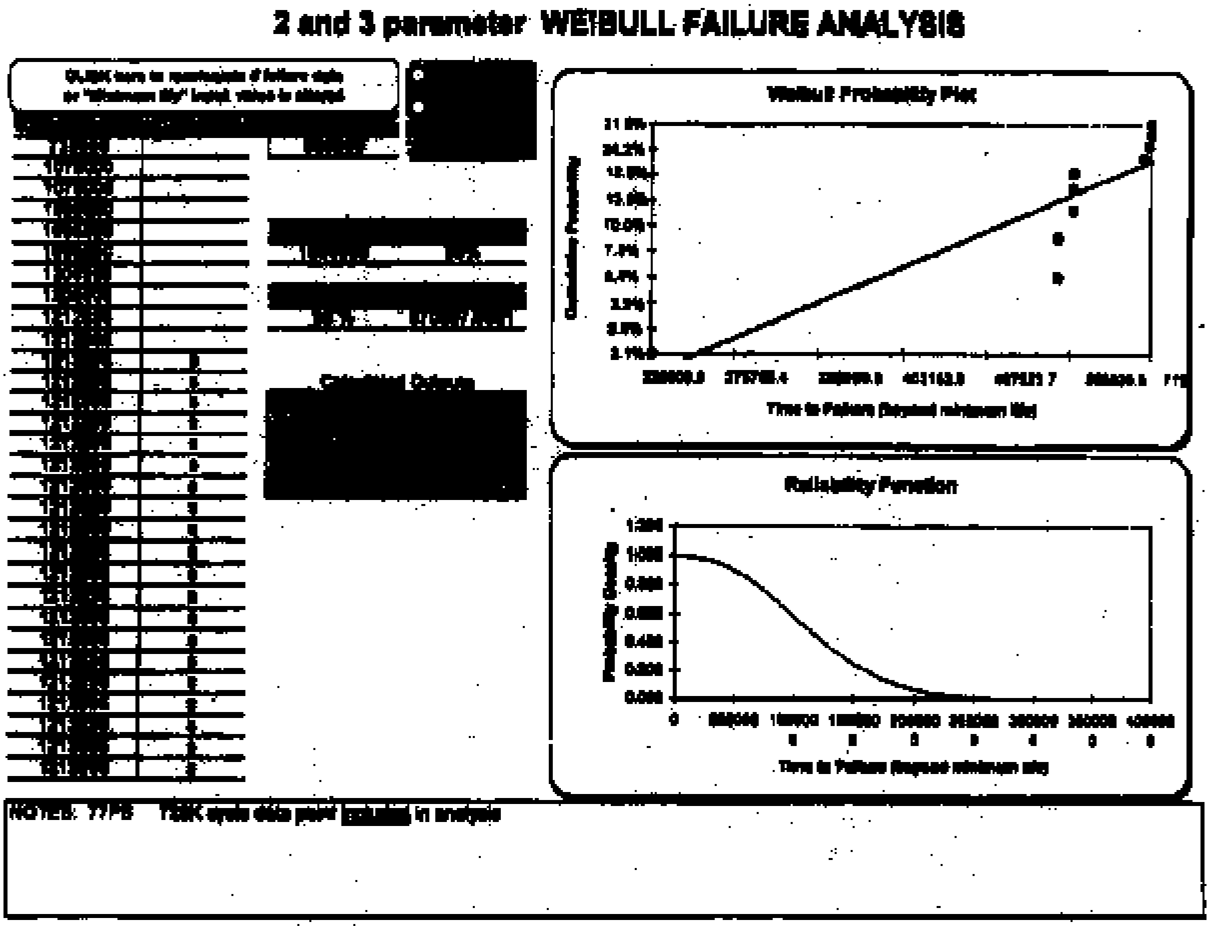


Figure ı.



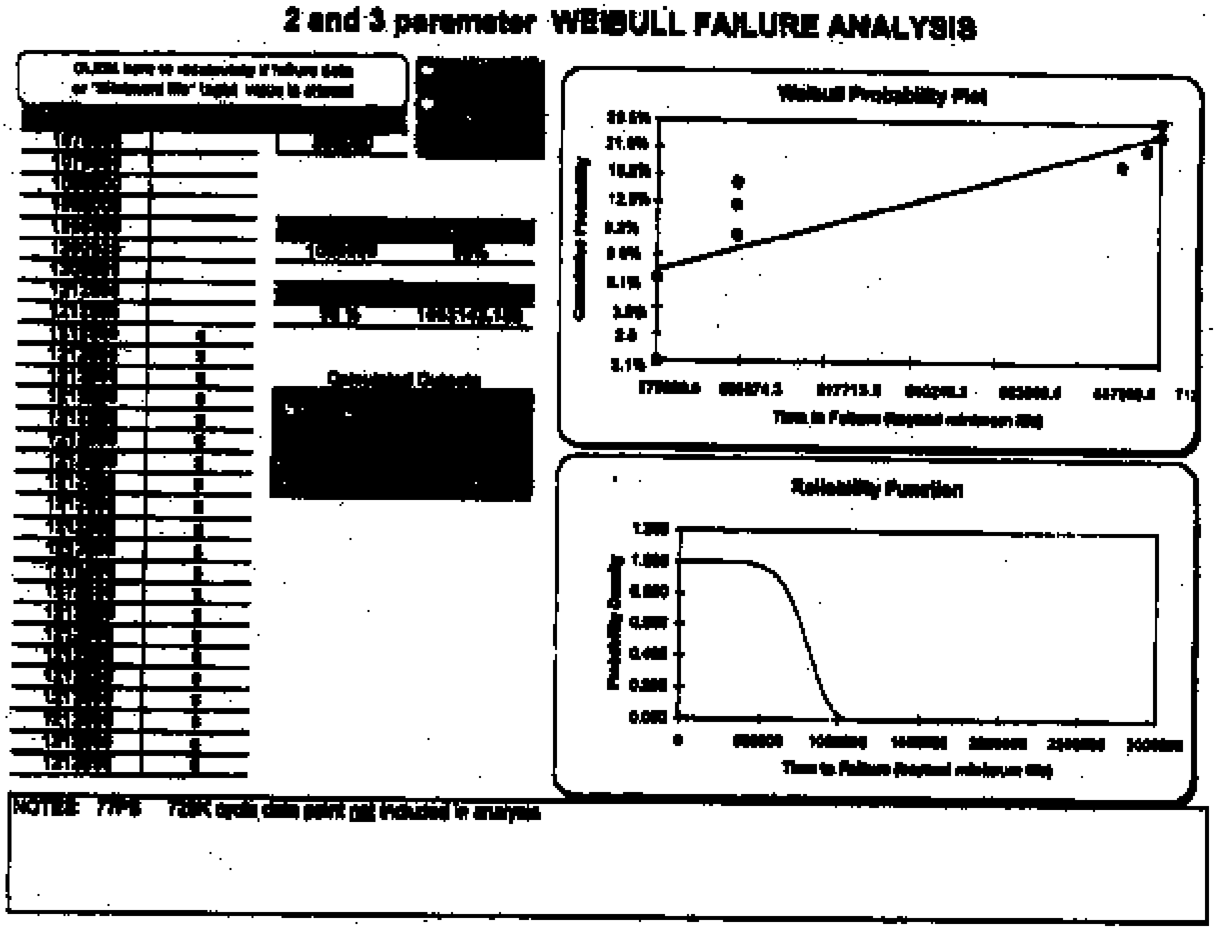
2 and 3 parameter WEIBULL FAILURE ANALYSIS

CLICK here to [illegible] of failure data or "Minimum life" [illegible] value is changed

Calculated Outputs

NOTES: [illegible] [illegible] cycle data point excluded in analysis

Figure 2.



2 and 3 parameter WEIBULL FAILURE ANALYSIS

NOTES: 77F5 725K cycle data point not included in analysis

TEXAS INSTRUMENTS

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Name: Aziz Rahman

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Mail Station:

Phone Number:

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FROM: Steve Beringhause

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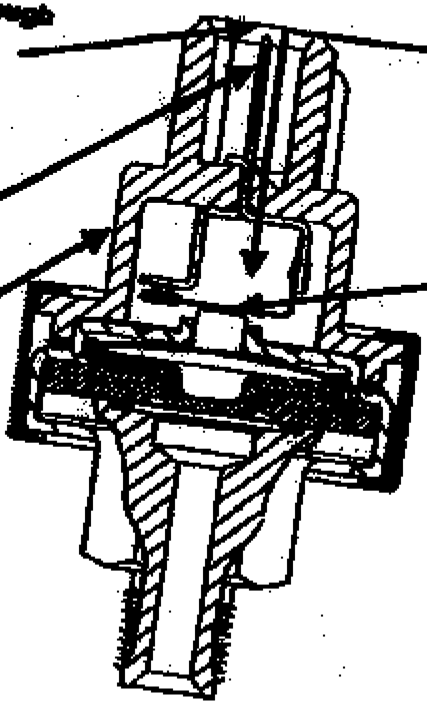

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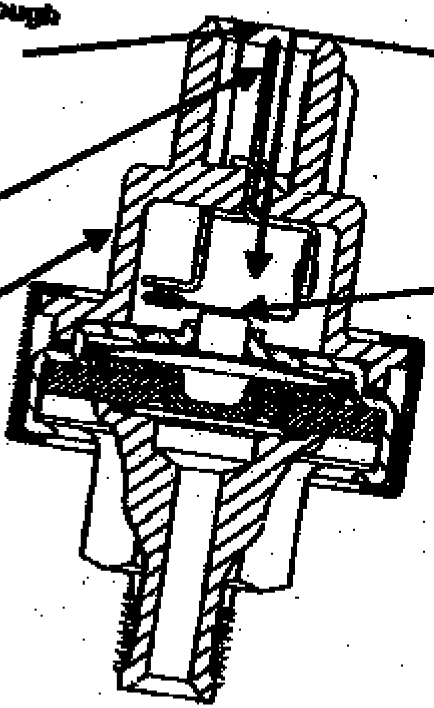

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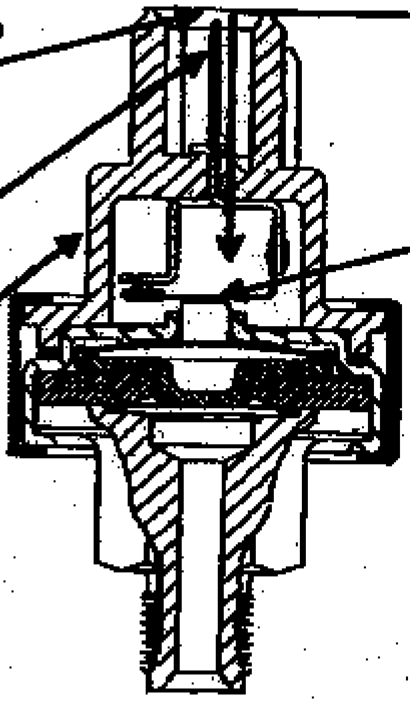

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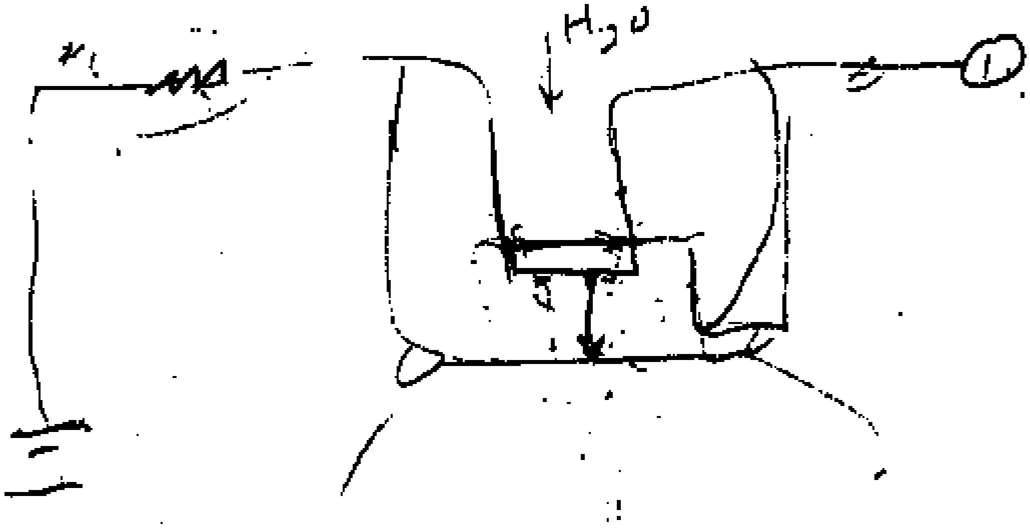

Corrosion – Internal terminals to case ground

Q – could it happen w/o case ground
Q – could it happen w/ brake fluid (old & dirty),

Where is the Heater R:

1. Thru corroded ~~[illegible]~~ spring arm contact & terminal
2. Thru remains of ~~the~~ spring arm between terminals
3. Thru remains of spring arm to case
4. Between terminals in sealed cavity

What drives the high current to cause fire:

① #3 above
* ② clutch coils burning out.
  ↳ plot V vs i for coil

---

1. what happened to quick/water switches / brake fluid & water – new parts / 95's?
2. High temp plastic
3.

TEXAS INSTRUMENTS

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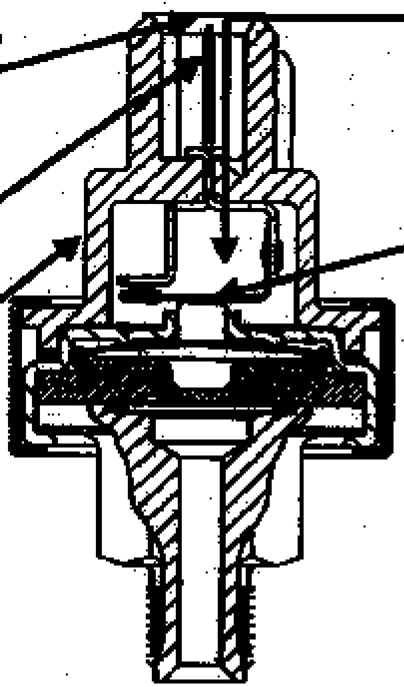

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Brake Pressure Switch Function-

- **Provide power to Speed Control Clutch circuit. Clutch engages servo-motor to pull throttle cable.**
- **Provide redundant sensing of brake application independent of the primary system deactivation mode by disconnecting power to clutch circuit causing servo-motor to release throttle cable.**
  - **Under Hard Braking only**
  - **Stop lamp signal is primary (normal braking)**