EA02-025

TEXAS INSTRUMENTS, INC.'S

9/10/03

REQUEST NO. 7

BOX 9

PART A – R

PART E

Brake Pressure Switch Test Log, Updated 5/20/99

Category	Test	Location	Test Parameters	Results Update
Lab Simulation of Potential Ignition in Switch	1	TI	Vary water concentrations in "new" Brake Fluid 14Vdc to one terminal, hexport grounded Water Conc: 4%, 9%, 16%, 75%	250+ hours, Current draw in the 0.5mA to 5mA range Fluid has discolored. No Significant Temperature Rise. Test Suspended. Internal Analysis suspended.
	2	TI	New Brake Fluid 1 Amp through switch terminals 14Vdc to one terminal, hexport grounded	250+ hours. Constant temperature. No significant temperature rise with time Test Suspended.
	3	AVT	new' 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	new' Brake Fluid in Switch, 24 VDC to one terminal. Hexport Grounded, Ambient at 100 C	16 hours into test max current 5mA No significant temperature rise with time. Test suspended.
	5	AVT	new' Brake Fluid in Switch, 10 Amps Through switch terminals	Temperature rise of 20 C above room temp Delta T reached steady state at 29 C. Test suspended.
	6a	AVT	new' Brake Fluid in Switch approx. 60 Amps through Switch Terminals	Temperature rose to approx. 270 F. No smoke. No ignition Test suspended.
	6	TI	Build heater elements into Switch. Heat till failure, include sparking. (1) w/ solution of Brake Fluid and 6 wt. % H_2O	3 tested. Smoke observed, ignition observed on part w/water See attachment Test complete Brake fluid in cavity slows down heat build-up Smoke observed at 575 F, Base melts and falls off at 600 F
	6a	TI	Create heater by corroding spring arm Salt water solution, 14V between spring and hexport	One out of 15 devices increased resistance to 5 ohms. Others either very low resistance or megaohms It took about 100 hours to reach the 5 ohm stage. The 5 ohm device ignited under conditions similar to test 6.
	6b	TI	Re-run ignition test to understand repeatability and current path.	Switch ignition with repeated 5% water solution into switch Current path is through hexport. See plots and video. Additional test include tap water, old BF, new BF and other.
	6c	TI	Pure 'new' brake fluid with metal shavings	Metal shavings do not contribute significantly to brake fluid

TI-NHTSA 013738

Brake Pressure Switch Test Log, Updated 5/20/99

[illegible]				conductivity
[illegible]				[illegible]
Life Cycle Reliability of Pressure Switch	7	TI	0-1400 psig pressure pulses at 130C per ES	First leak observed at 728,000 cycles. Test Completed. See attached Weibull Chart.
[illegible]				[illegible]
Diaphragm Wear	8	TI	0-1400 psig pressure pulses at 130C	Parts withdrawn every 250k cycles, characterized for wear
[illegible]				[illegible]
Field vs Lab Correlation	9	Central Labs	Field returns, from dealer lots, junkyards	Parts in Central Labs, see Ford spreadsheet
[illegible]				[illegible]
Design Of Experiments (1) Evaluating Factors Effecting Diaphragm Wear Impulse test	10	TI	Vary water concentrations in 'new' Brake Fluid 12 stamp + 12 quiet switches w/ 0 % water in BF 12 stamp + 12 quiet switches w/ 5 % water in BF	Test Report being written investigation continues. Suspended at 1.3 million cycles with no leaks observed. Stamp samples suspended at 1.3 million cycles with 2 leaks observed at 1.3M. Quiet samples suspended at 800k cycles to assess following correction.
[illegible]				[illegible]
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.	Test at AVT.....see Ford charts...>500k in car?
[illegible]				[illegible]
Brake fluid analysis Used fluid at master cylinder.	11a	TI	Analyze used brake fluid at the master cylinder (UMC), used brake fluid at the caliper (UCA) and new brake fluid (NEW) for metal and water content.	Test complete. UMC: Cu = 415 (ug/ml), Fe = 6.5 (ug/ml), Cr = 0.88 (ug/ml), 1.1 %H2O. UCA: Cu = 592 (ug/ml), Fe = 8.5 (ug/ml), Cr = 1.9 (ug/ml), 1.1 %H2O. NEW: Cu = <0.01 (ug/ml), Fe = 0.02 (ug/ml), Cr = <.01 (ug/ml), 0.3 %H2O.
[illegible]				[illegible]
Spark Arc Study	12	Central Labs	Determine if arc/spark forms in switch using clutch loads and high speed video. Use dry switches as well as switches with various brake fluid water values.	Equipment set-up in progress at Central Labs. TI Experimented with no 'significant' sparks observed
[illegible]				[illegible]
Characterization of switches retrieved from field junkyards & other sources	13	Central Labs	Characterize electrical, mechanical and chemical aspects of returned switches	Data log and analysis procedure set up complete. Analysis of switches in progress.
[illegible]				[illegible]
Field Ingress Tests	13a	TI	Repeat ignition simulation with different fluids. 48 hour tests: 5% NaCl in tap water rain water (24 hour tests: tap water	Test complete. 5% NaCl sample resulted in an ignition. All brake fluid samples drew less than 3 mAmps. No corrosion visible on brake fluid samples. Rain water and tap water samples drew <10 mAmps and showed some signs of corrosion.

TI-NHTSA 013739

Brake Pressure Switch Test Log, Updated 5/20/99

			used brake fluid	Chemical analysis in process.
			used brake fluid w/ 5% H_2O	
			new brake fluid	
			new brake fluid w/ 5% H_2O	
Design Of Experiments (2)	13b	TI	Vary water concentrations in 'new' Brake Fluid	Test suspended. Analysis in process to assess test fixturing.
Repeat of test 10			10 amp + 20 quiet switches w/ 0 % water in BF	
			10 amp + 20 quiet switches w/ 5 % water in BF	
Compatibility of Kapton	14	Dupont	Characterize change in properties of Kapton	Test in progress (100) hours completed. Oxalic acid shows
with Oxalic Acid			with various % oxalic acid in brake fluid.	similar effects that water has on Kapton properties.
Evaluation of Plastic	15	TI	Assess properties and moldability of different	Test suspended.
Materials with Improved			grades of plastic resin with additives	Celanese and Noryl ignited 3/5 and 2/5 trials
Parameters			to improve plastic part performance	ZYTEL samples tested 1/5 ignitions
Long duration brake fluid	15a	TI	(4) samples with new brake fluid	Test suspended (550) hours completed.
ingress test.			(2) samples with used brake fluid	Used brake fluid current dropped off to <1/10 mAmp.
				New BF transport current can increase w/ time under cont. power.
Evaluation of Switch	15b	TI	Assess ignition sensitivity to switch orientation.	Test complete. Ignition is independent of switch orientation.
Orientation			Test vertical versus 45 degree.	simulated switch ignition can occur in vertical or 45 degree angle.
			Test rotational sensitivity in 45 deg. orientation.	Ignition appears not sensitive to switch rotational alignment.
Relay Circuit	16	TI	Repeat test 13a in Ford relay circuit for (48) hrs.	Test complete. No ignition. Corrosion rate drastically reduced.
Test			Bring switch to impending ignition in (15) Amp	Insufficient power in circuit to create or move toward ignition in lab
			circuit then place in relay circuit for (18) hrs.	Heater element was warm to the touch.
			Input max. circuit power into heater on switch.	
Long duration brake fluid	17	TI	(50) samples filled with new brake fluid	Test suspended. (312) hours completed.
ingress test number 2.			(1) hour of vibration per day	Average transport current is 1.9 mAmp (stdeviation = 1.6 mAmps)
			(1) hour soak at 100 deg C per day	

TI-NHTSA 013740

Brake Pressure Switch
Potential Thermal Event Theory Profile 5/20/99

TEXAS INSTRUMENTS

77psl2-1		GROSS QTY		COMPLETE	COMPLETE	BEGIN	IMPACT	COMMENTS/CONCERNS
COMPONEN	DESCRIPTIO	REQUIRED	SUPPLIER	1KK	2KK	PARTIAL	TO TI	
27406-1	CONVERTER	2,040,000	KF BASSLER	10 WKS	18 WKS	2 WKS	NONE	ADD OVERTIME/MATERIAL AVAILABILITY
27639-1	WASHER / A	2,040,000	DEMASTER	10 WKS	18 WKS	2 WKS	NONE	MATERIAL AVAILABILITY
27713-1	CUP 77PS	2,040,000	VALENTINE	8 WKS	10 WKS	1 WK	NONE	RAW MATERIAL AVAILABILITY
36656-27	57PS	2,040,000	DISC DEPT	12+ WKS	24 WKS	3 WKS	TOOL $?	POSSIBLE CAPACITY ISSUE
36900-1	HEXPORT 77	2,040,000	ELCO	10 WKS	25 WKS	3 WKS	NONE	RAW MATERIAL AVAILABILITY
74224-1	KAPTON	204	EIDUPONT	2 WKS	2 WKS	2 WKS	NONE	
27225-1	KAPTON ST	1,102	EIDUPONT	3 WKS	3 WKS	2 WKS	NONE	
74363-1	GASKET	2,040,000	JBL PARKER	8 WKS	18 WKS	3 WKS	NONE	ELIMINATE CORES WILL INCREASE DEL. BY 10%
36888-1	STATIONAR	2,040,000	KF BASSLER	10 WKS	18 WKS	2 WKS	NONE	ADD OVERTIME/MATERIAL AVAILABILITY/ REELS
28744-1	CONTACT-S	2,040,000	DERRINGER	4 WKS	8 WKS	1 WK	NONE	MATERIAL AVAILABILITY
36887-1	MOVABLE T	2,040,000	KF BASSLER	10 WKS	18 WKS	2 WKS	NONE	ADD OVERTIME/MATERIAL AVAILABILITY/REELS
27718-1	BE/CU ISSLE	440	BRUSH WELL	1 WK	2 WKS	1 WK	NONE	NONE
74916-1	RIVET	2,040,000	JOHN HASS	8 WKS	11 WKS	4 WKS	NONE	RAW MATERIAL AVAILABILITY
46515-2	PRESSURE S	2,040,000	INTMOLDIN	16 WKS	32 WKS	4 WKS	NONE	RAW MATERIAL CHANGEOVER/PRESS CAPACITY
74078-143	CERAMIN PI	2,040,000	PARATECH	7 WKS	15 WKS	2 WKS	NONE	
74247-4	BLUE O'RING	2,040,000	JBL PARKER	8 WKS	10 WKS	2 WKS	NONE	ELIMINATE CORES WILL INCREASE DEL. BY 10%
74797-1	CRIMP RING	2,040,000	VALENTINE	6 WKS	10 WKS	1 WK	NONE	RAW MATERIAL AVAILABILITY
74888-1	RED THREA	2,040,000	MARK IV CA	3 WKS	6 WKS	1 WK	NONE	
77PS	SWITCH		TI	7/15,8/1,8/15	250K/MONTH			7 day weeks, thru summer vacations, 'std' plastic mold

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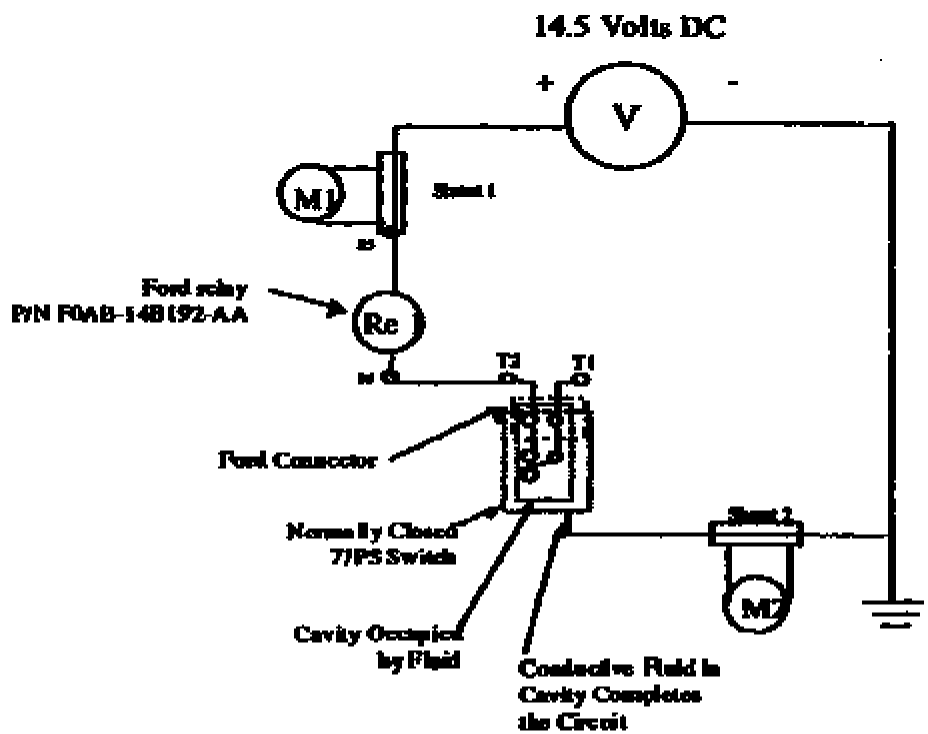
Attachment

TI-NHTSA 013741

Brake Pressure Switch
Potential Thermal Event Theory Profile 5/20/99

200 mAmp Current Limit Circuit
Test Setup



Worst case scenario is when the switch is actuated, which puts T2 at full voltage.
To facilitate testing, T1 is floating which keeps T1 and T2 at full voltage but limits current draw to .2 Amps (This test is harsher than worst case scenario).

Brake Pressure Switch
Potential Thermal Event Theory Profile 5/20/99

Texas Instruments

"Corrosion" potential cause time line
Theory Time Line

Ionic enriched water introduced into switch

↓

Corrosion process

↓

Ionic enriched water introduced into switch

↓

Corrosion process

Limited current

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

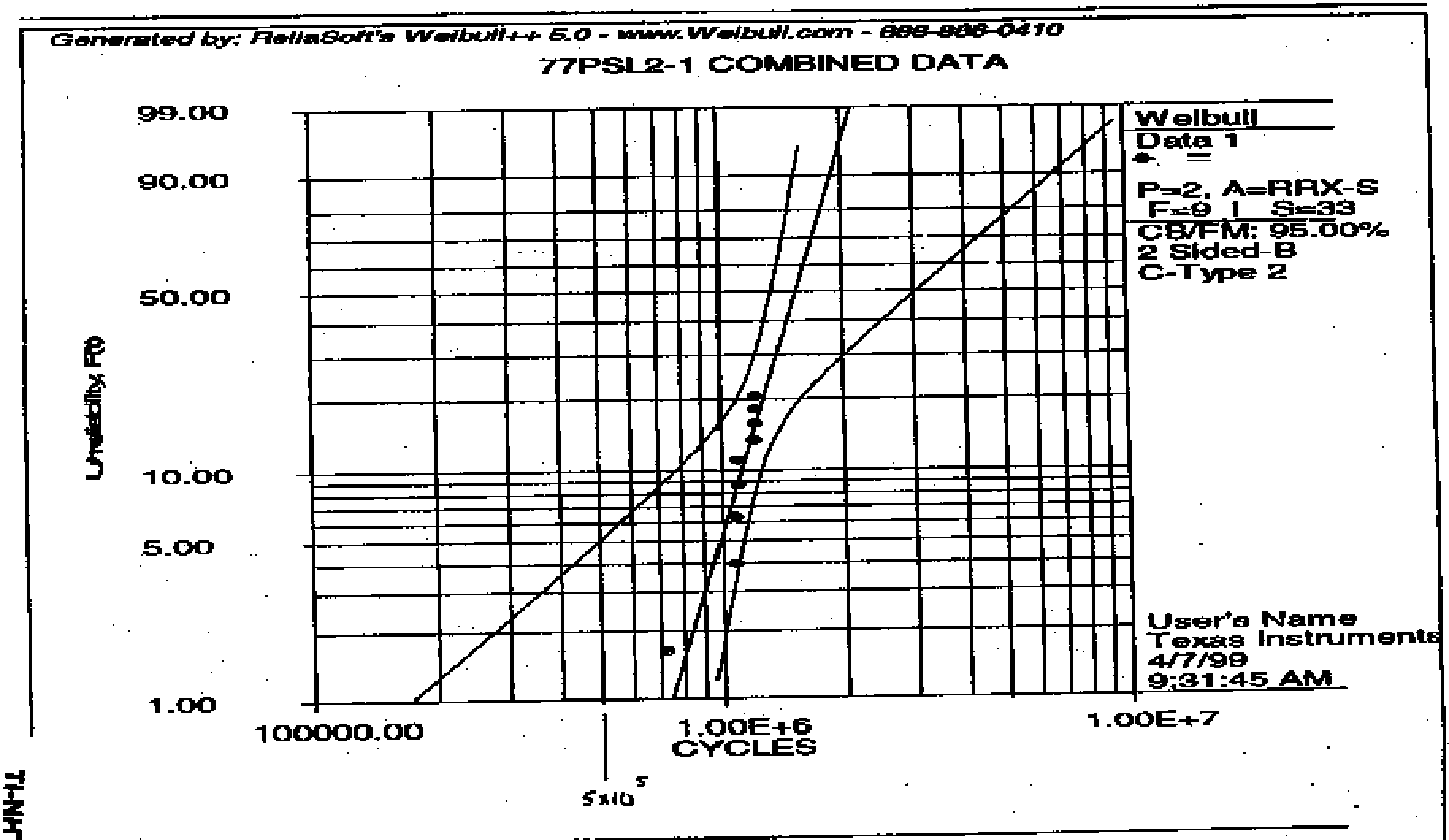
Vehicle Time →

Attachment

TI-NHTSA 019748

TEXAS INSTRUMENTS

Brake Pressure Switch
Potential Thermal Event Theory Profile 5/20/99



$\beta=5.83$, $\eta=1.64E+6$, $\rho=0.91$

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Attachment

TI-NHTSA 013747

TEXAS INSTRUMENTS

Brake Pressure Switch
Potential Thermal Event Theory Profile 5/20/99

77PS Noryl Base
45° Orientation in 15 Amp Circuit
5% Salt Water Ingress

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INTENTIONAL IGNITION CREATED THRU TI FLUID INGRESS LAB TEST PS/99/13 Attachment

Texas Instruments

Brake Pressure Switch
Potential Thermal Event Theory Profile 5/20/99

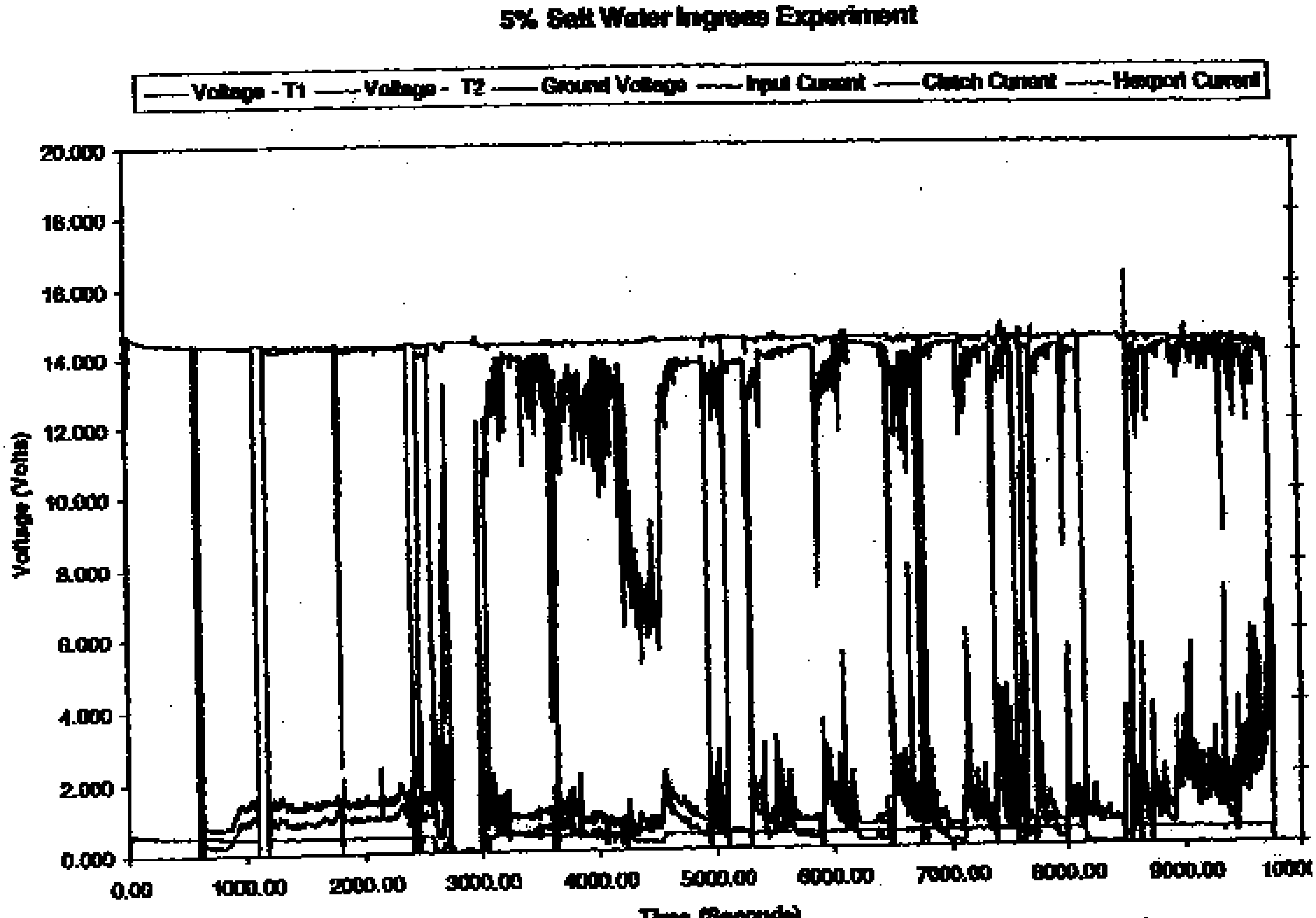
77PS Cellanex 4300 Base
Vertical Orientation in 15 Amp Circuit
5% Salt Water Ingress

C:/McGuire/99presentation/Ford INTENTIONAL IGNITION CREATED THRU TI FLUID INGRESS LAB TEST PS/99/13' Attachment

TI-NHTSA 013761

TEXAS INSTRUMENTS

Brake Pressure Switch
Potential Thermal Event Theory Profile 5/20/99



INTENTIONAL IGNITION CREATED THRU T1 FLUID INGRESS LAB TEST PS/99/13" Attachment

TI-NHTSA 013763

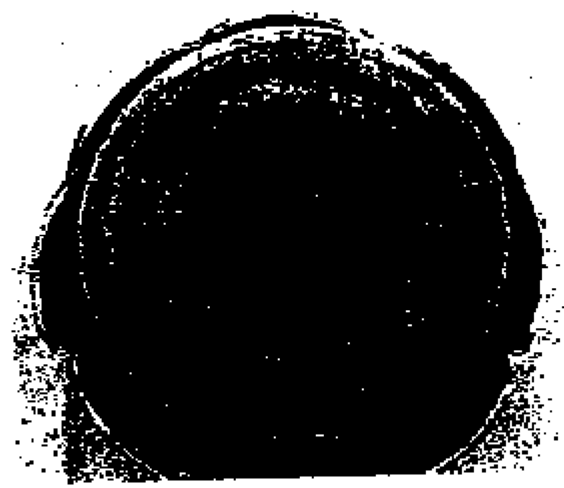
Brake Pressure Switch
Potential Thermal Event Theory Profile 5/20/99

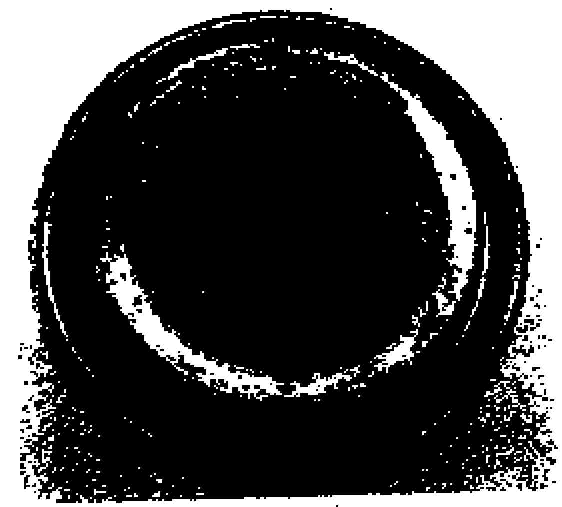
- TI and Ford not successful in creating ignition with "new" brake fluids

TEXAS INSTRUMENTS

Brake Pressure Switch
Potential Thermal Event Theory Profile 6/02/99

Lab Experiment-5% NaCl/H_20 and Continuous Power





- Contact arm (Cu) corrodes - chemical analysis shows presence of Na, Cl, Cu, and O on the cup surface

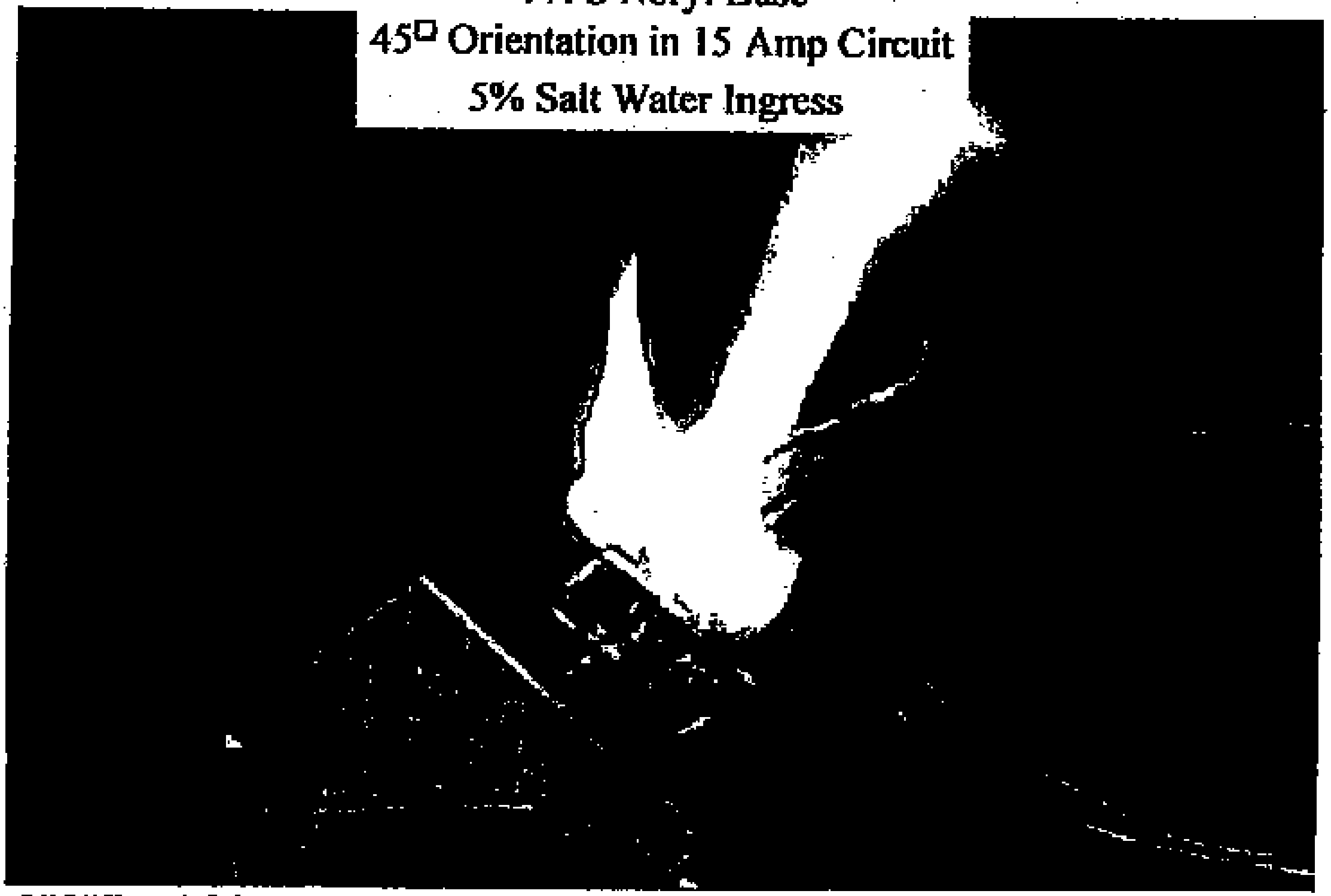
TEXAS INSTRUMENTS

Brake Pressure Switch
Potential Thermal Event Theory Profile 6/02/99

77PS Noryl Base

45° Orientation in 15 Amp Circuit

5% Salt Water Ingress



[illegible]

INTENTIONAL IGNITION CREATED THRU TI FLUID INGRESS LAB TEST PS/99/13' Attachment

TI-NHTSA 013789

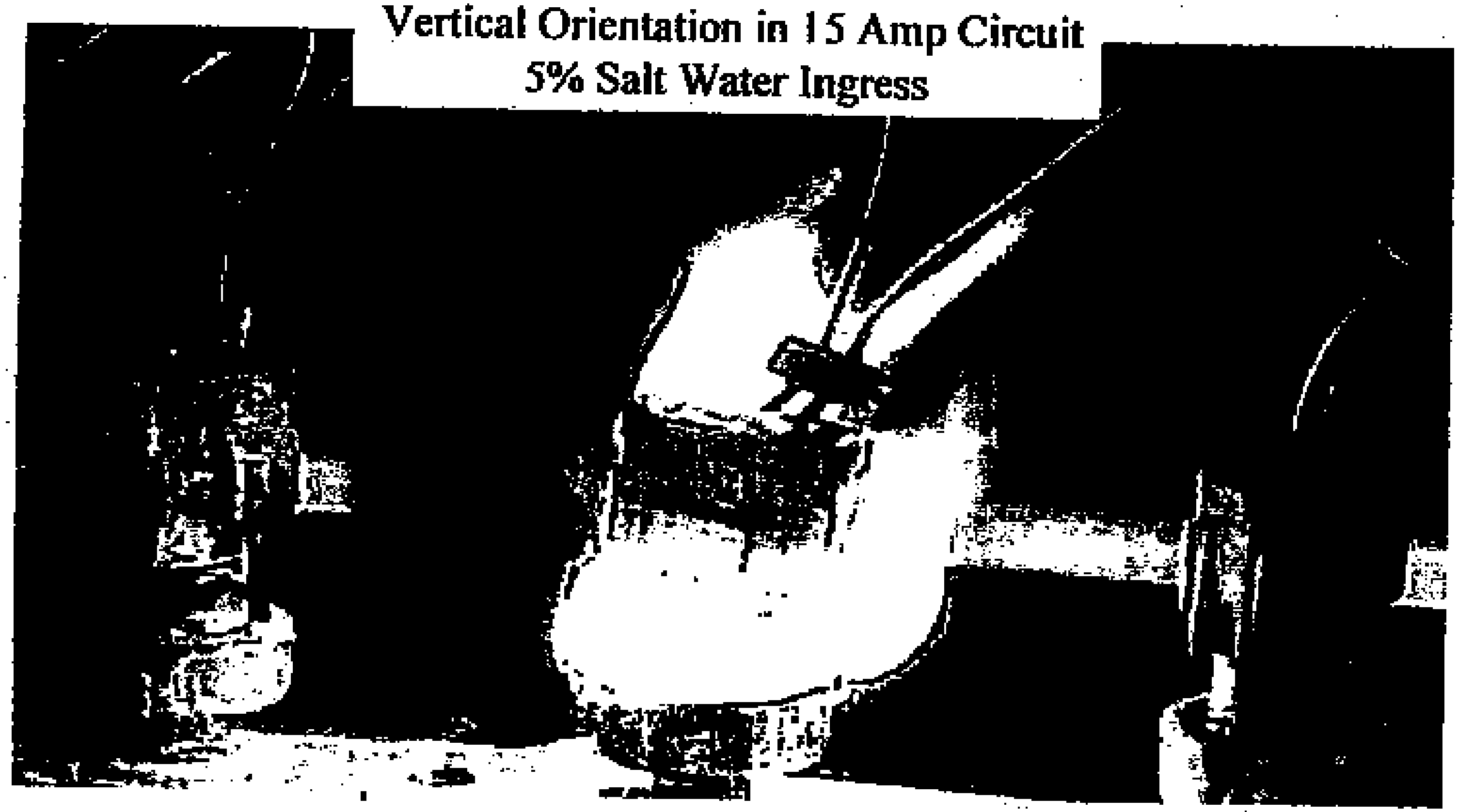
1

Texas Instruments

Brake Pressure Switch
Potential Thermal Event Theory Profile 6/02/99

Ford

77PS Cellanex 4300 Base
Vertical Orientation in 15 Amp Circuit
5% Salt Water Ingress

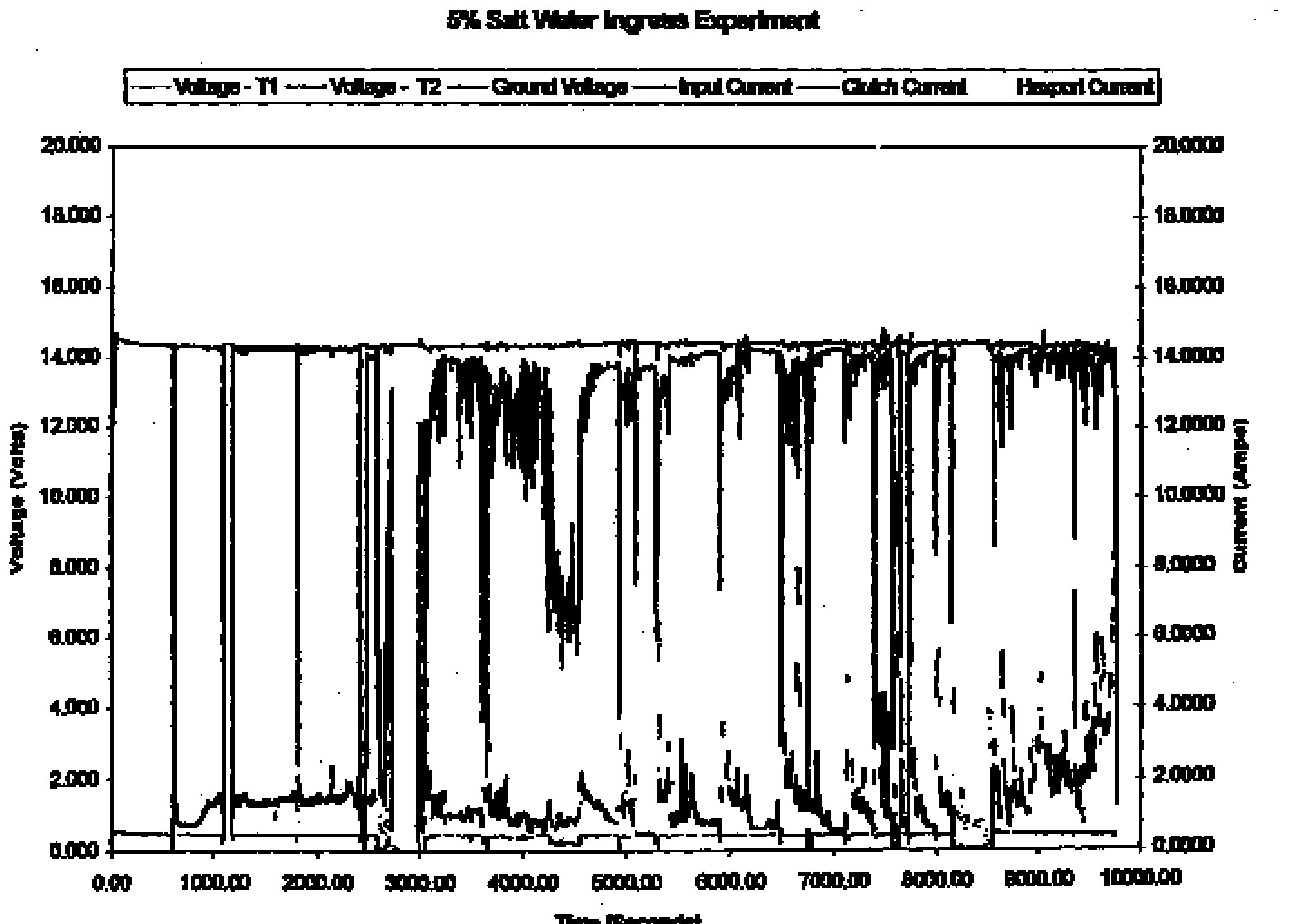


INTENTIONAL IGNITION CREATED THRU TI FLUID INGRESS LAB TEST PS/99/11 Attachment

Not Enough Printer Memory -- See User's Guide

Texas Instruments

Brake Pressure Switch
Potential Thermal Event Theory Profile 6/02/99

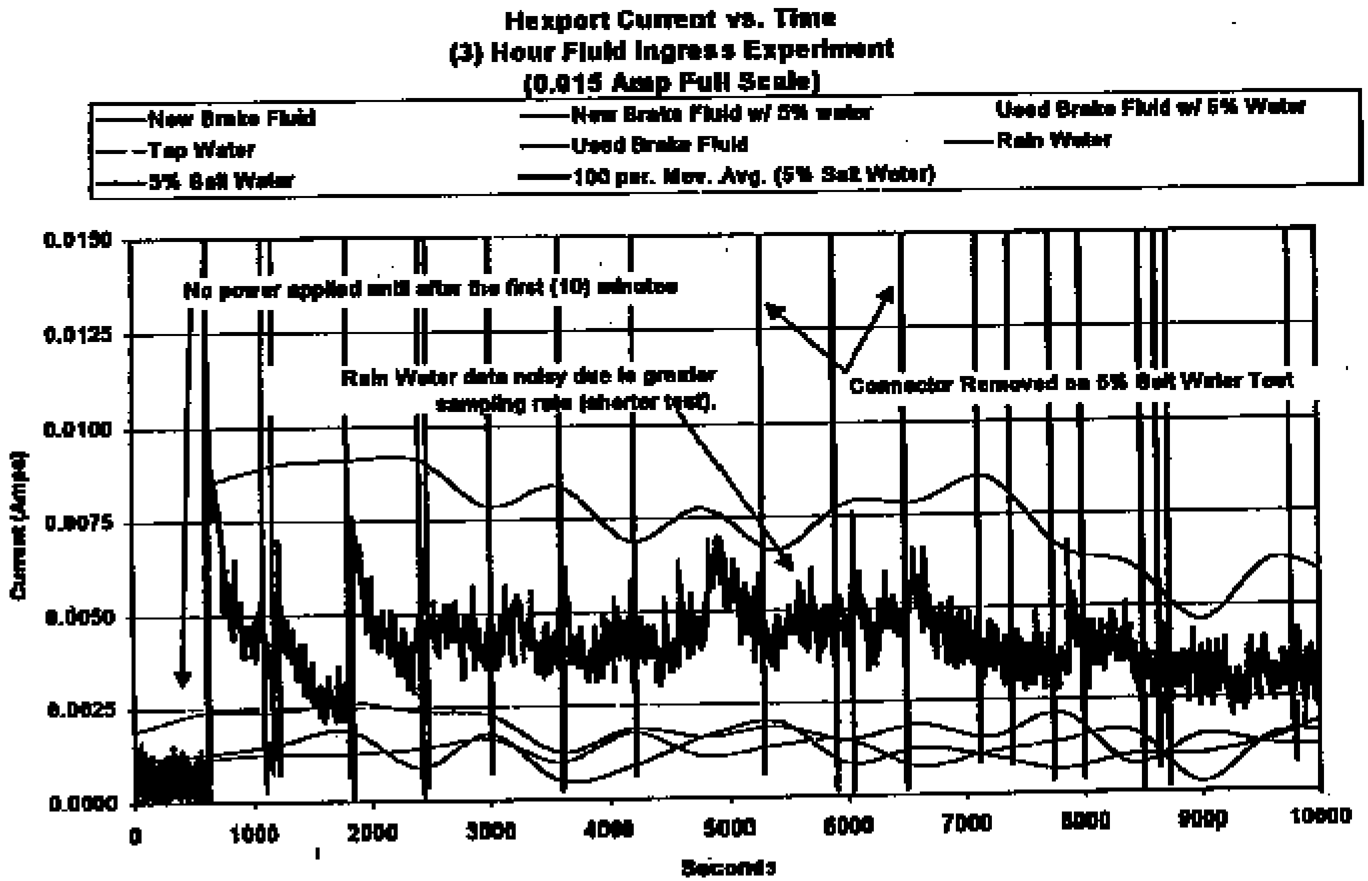


INTENTIONAL IGNITION CREATED THRU TI FLUID INGRESS LAB TEST PS/99/13' Attachment

TI-NHTSA 013763

TEXAS INSTRUMENTS

Brake Pressure Switch
Potential Thermal Event Theory Profile 6/02/99



TI-NHTSA 013765

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Attachment

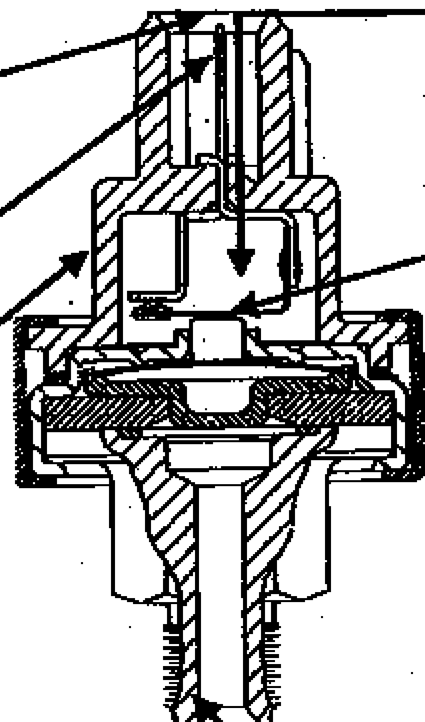
Brake Pressure Switch Test Log, Updated 6/22/99

				coductanly
Life Cycle Reliability of Pressure Switch	7	TI	0-1400 psig pressure pulses at 135C on TS	First leak observed at 778,080 cycles Test Completed. See attached Weibull Chart.
Diaphragm Wear	8	TI	0-1400 psig pressure pulses at 135C	Parts withdrawn every 200k cycles, characterized for wear [redacted]
Field vs Lab Correlation	9	Central Labs	Field returns, from dealer lots, junkyards.	Parts in Central Labs, see Ford spreadsheet
Design Of Experiments (1) Evaluating Factors Effecting Diaphragm Wear Impulse test	10	TI	Vary water concentrations in 'new' Brake Fluid 12 snap + 12 quiet switches w/ 0 % water in BF 12 snap + 12 quiet switches w/ 5 % water in BF	Test Report being written investigation continues. Suspended at 1.3 million cycles with no leaks observed. Snap samples suspended at 1.3 million cycles with 2 leaks observed at 1.3M. Quiet samples suspended at 500k cycles to assess tubing anomalies.
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.	Test at AVT.....see Ford charts...>500k in car?
Brake fluid analysis Used fluid at master cylinder	11a	TI	Analyze used brake fluid at the master cylinder (UMC), used brake fluid at the caliper (UCA) and new brake fluid (NEW) for metal and water content	Test complete. UMC: Cu = 416 (ug/ml), Fe = 5.6 (ug/ml), Cr = 0.09 (ug/ml), 1.1 %H2O UCA: Cu = 592 (ug/ml), Fe = 5.5 (ug/ml), Cr = 1.9 (ug/ml), 1.1 %H2O NEW: Cu = <0.01 (ug/ml), Fe = 0.02 (ug/ml), Cr = <.01 (ug/ml), 0.3 %H2O [redacted]
Spark /Arc Study	12	Central Labs	Determine if arc/spark forms in switch using clutch loads and high speed video. Use dry switches as well as switches with various brake fluid water ratios.	Equipment set-up in progress at Central Labs. TI Experimental with no 'significant' sparks observed [redacted]
Characterization of switches retrieved from field junkyards & other sources	13	Central Labs	Characterize electrical, mechanical and chemical aspects of returned switches	Data log and analysis procedure set up complete. Analysis of switches in progress. [redacted]
Fluid Ingress Tests	13a	TI	Repeat ignition simulation with different fluids. (3) hour tests: 5% NaCl in tap water rain water (24) hour tests: tap water	Test complete. 5% NaCl sample resulted in an ignition. All brake fluid samples drew less than 3 mAmps. No corrosion visible on brake fluid samples. Rain water and tap water samples drew <10 mAmps and showed some signs of corrosion.

TI-NHTSA 013787

TEXAS INSTRUMENTS

Brake Pressure Switch
Potential Thermal Event Theory Profile 6/02/99



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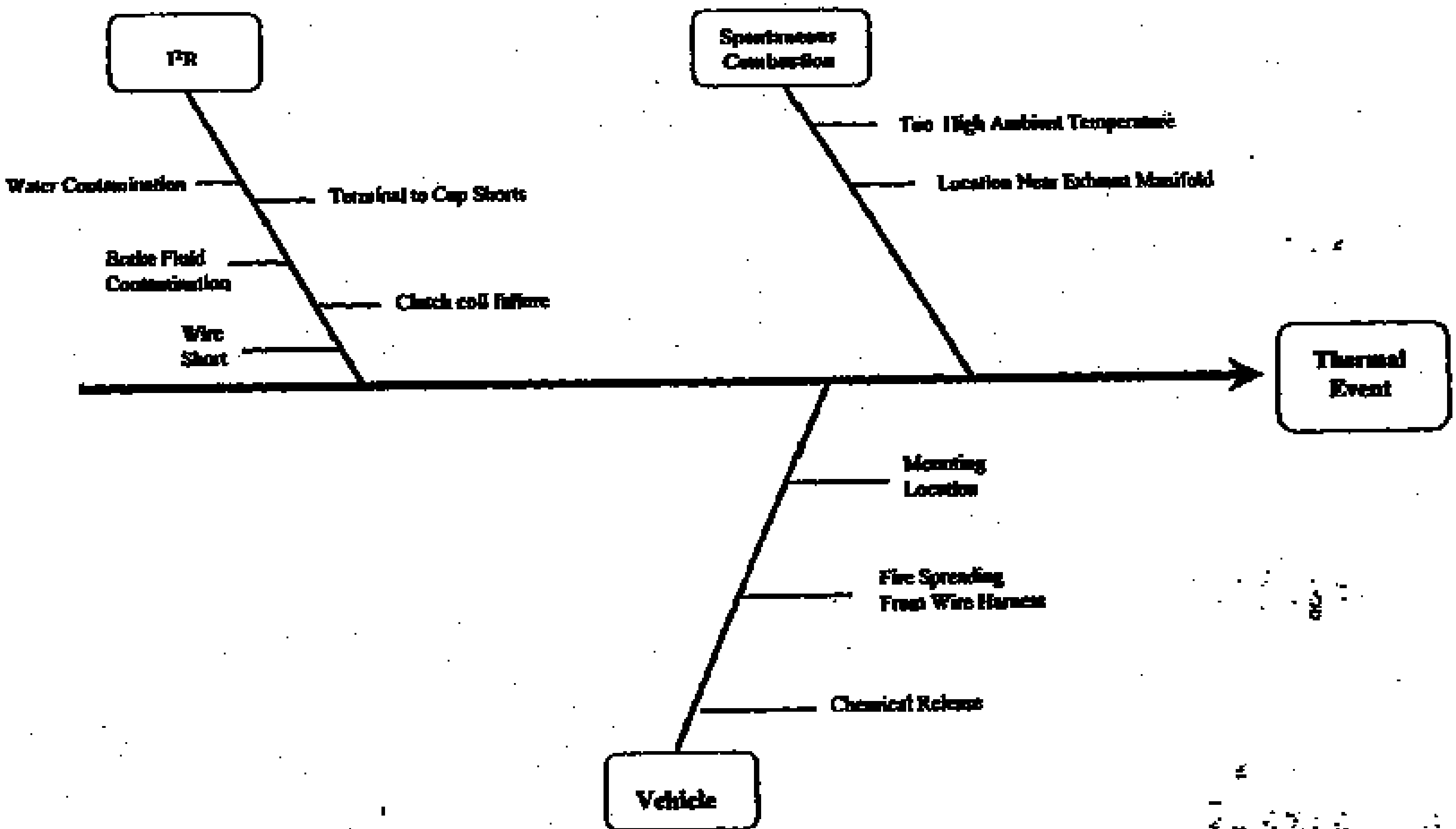
Attachment

TI-NHTSA 013769

TEXAS INSTRUMENTS

Brake Pressure Switch
Potential Thermal Event Theory Profile 6/02/99



TI-NHTSA 013771

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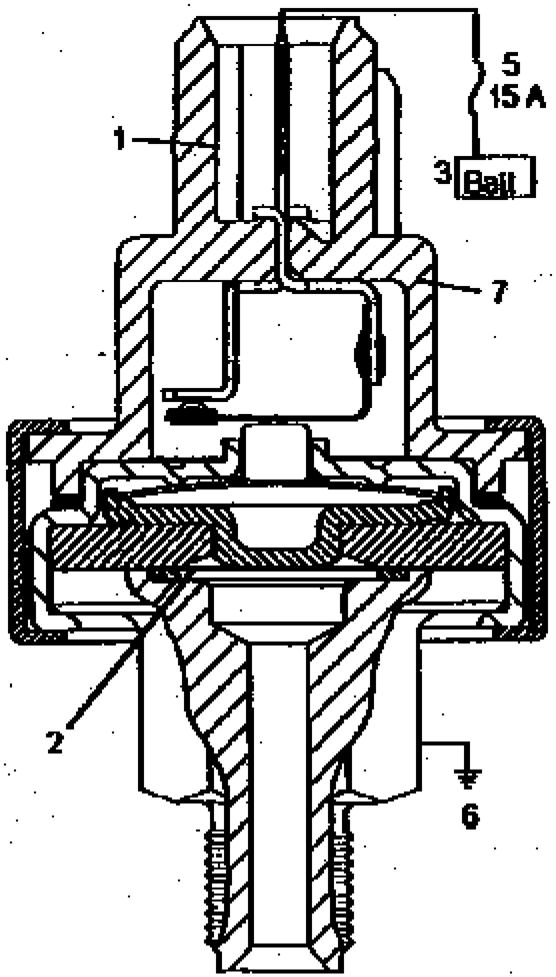
Attachment

Contributing Factors



1. Connector Seal
2. Kapton Life
3. Continuous Power
4. Switch Orientation
5. Current Capability
6. Grounded Hex-Port
7. Plastic Parameters

TI-NHT8A 013773

Brake Pressure Switch
Potential Thermal Event Theory Profile 5/20/99

TEXAS INSTRUMENTS

	8a	TI	Run "new" brake fluid with metal shavings	Metal shavings do not contribute significantly to brake fluid conductivity
Life Cycle Reliability of Pressure Switch	7	TI	0-1400 psig pressure pulses at 130C per 5?	First leak observed at 700,000 cycles. Test Completed. See attached Weibull Chart.
Diaphragm Wear	8	TI	0-1400 psig pressure pulses at 130C	Parts w/ [illegible] every 200k cycles, characterized for wear.
Field vs Lab Correlation	9	Central Labs	Field returns, laboratory tests, junkyards.	Parts in Central Labs, see Ford spreadsheet
Design Of Experiments (1) Evaluating Factors Effecting Diaphragm Wear Impulse test	10	TI	Vary water concentrations in "new" Brake Fluid. 12 snap + 12 quiet switches w/ 0 % water in BF. 12 snap + 12 quiet switches w/ 5 % water in BF	Test Report being written, investigation continues. Suspended at 1.3 million cycles with no leaks observed. Snap samples suspended at 1.2 million cycles with 2 leaks observed at 1.2M. Quiet samples suspended at 900k cycles to [illegible].
On-Vehicle Characterization of Pressure & Temperature Profile in Town Car	11	AVT	Monitor Pressure and Temperature at the hub Location for ABS and non-ABS braking events.	Test at AVT, ...see Ford charts...>[illegible] in car?
Brake fluid analysis Used fluid at master cylinder.	11a	TI	Analyze used brake fluid at the master cylinder (UMC), used brake fluid at the caliper (UCA) and new brake fluid (NEW) for metal and water content.	Test complete. UMC: Cu = 4.15 [illegible], Fe = 5.8 [illegible], Cr = 0.08 [illegible], 1.1 % H2O. UCA: Cu = [illegible], Fe = [illegible], Cr = 1.9 [illegible], 1.1 % H2O. NEW: Cu = <0.02 [illegible], Fe = 0.02 [illegible], Cr = <.01 [illegible], 0.2 % H2O.
Spark Arc Study	12	Central Labs	Determine if arc/spark forms in sw [illegible] using clutch leads and high speed video. Use dry switching as well as switches with various brake fluid water mixes.	Equipment set-up in progress at Central Labs. TI Experimented with no "significant" sparks observed.
Characterization of switches retrieved from field junkyards & other sources	13	Central Labs	Characterize electrical, mechanical and chemical aspects of returned switches	Data log and analysis procedure set up complete. Analysis of switches in progress.
Fluid Ingress Tests	13a	TI	Repeat ignition simulation with different fluids.	Test complete.
			48 hour tests:	5% NaCl sample resulted in [illegible].
			5% NaCl in tap water	All brake fluid samples drew less than 3 mAmps. No corrosion
			tap water	visible on brake fluid samples.
			[illegible] hour tests:	Tap water and tap water samples drew <10 mAmps and showed some signs of corrosion.
			tap water	Chemical analysis in process.
			used brake fluid	
			used brake fluid w/ 5% H_2O	
			new brake fluid	
			new brake fluid w/ 5% H_2O	

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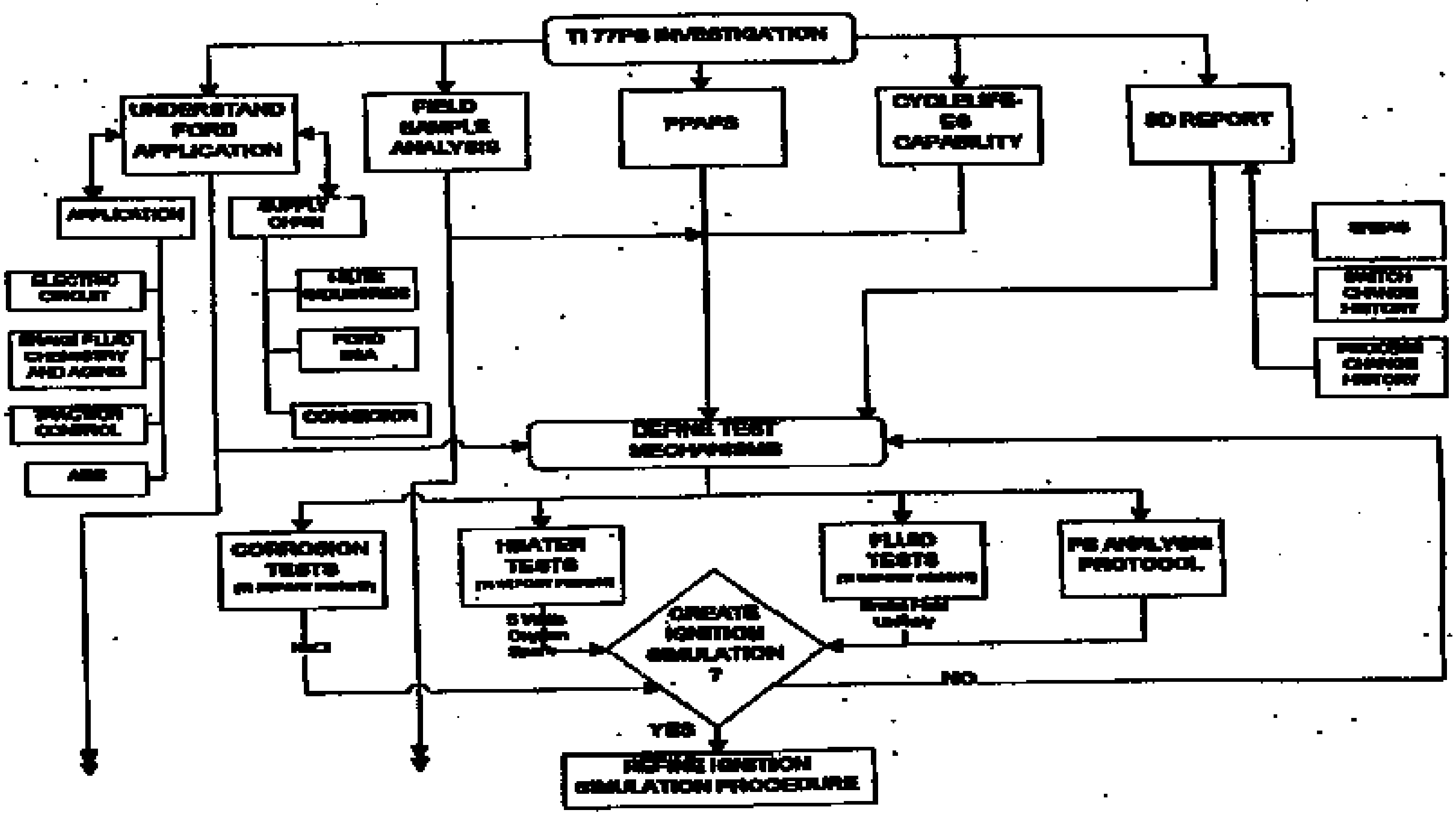
Attachment

TI-NHTSA 013776

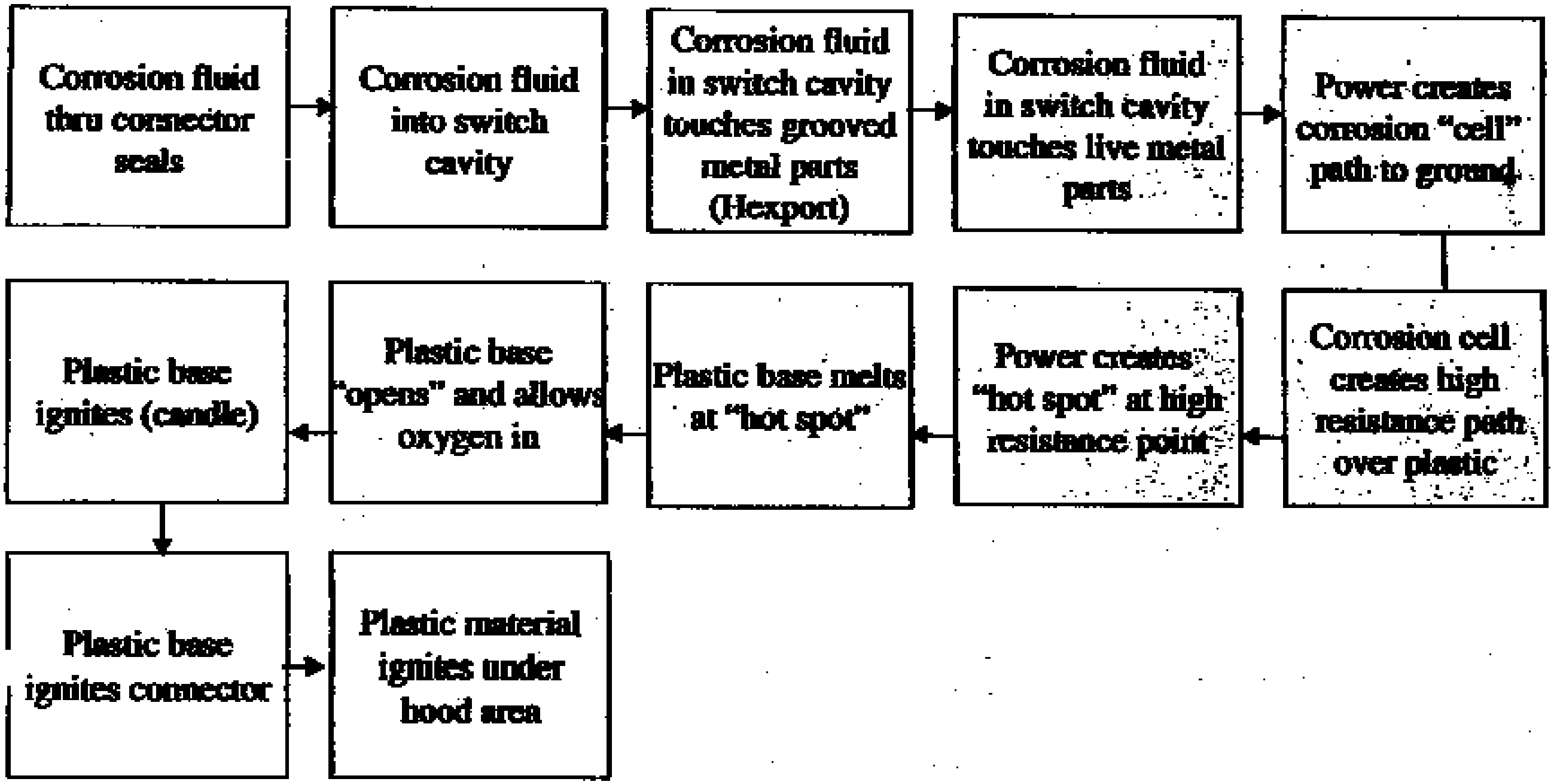
Brake Pressure Switch
Potential Thermal Event Theory Profile 5/20/99



Attachment

TI-NHTSA 013777

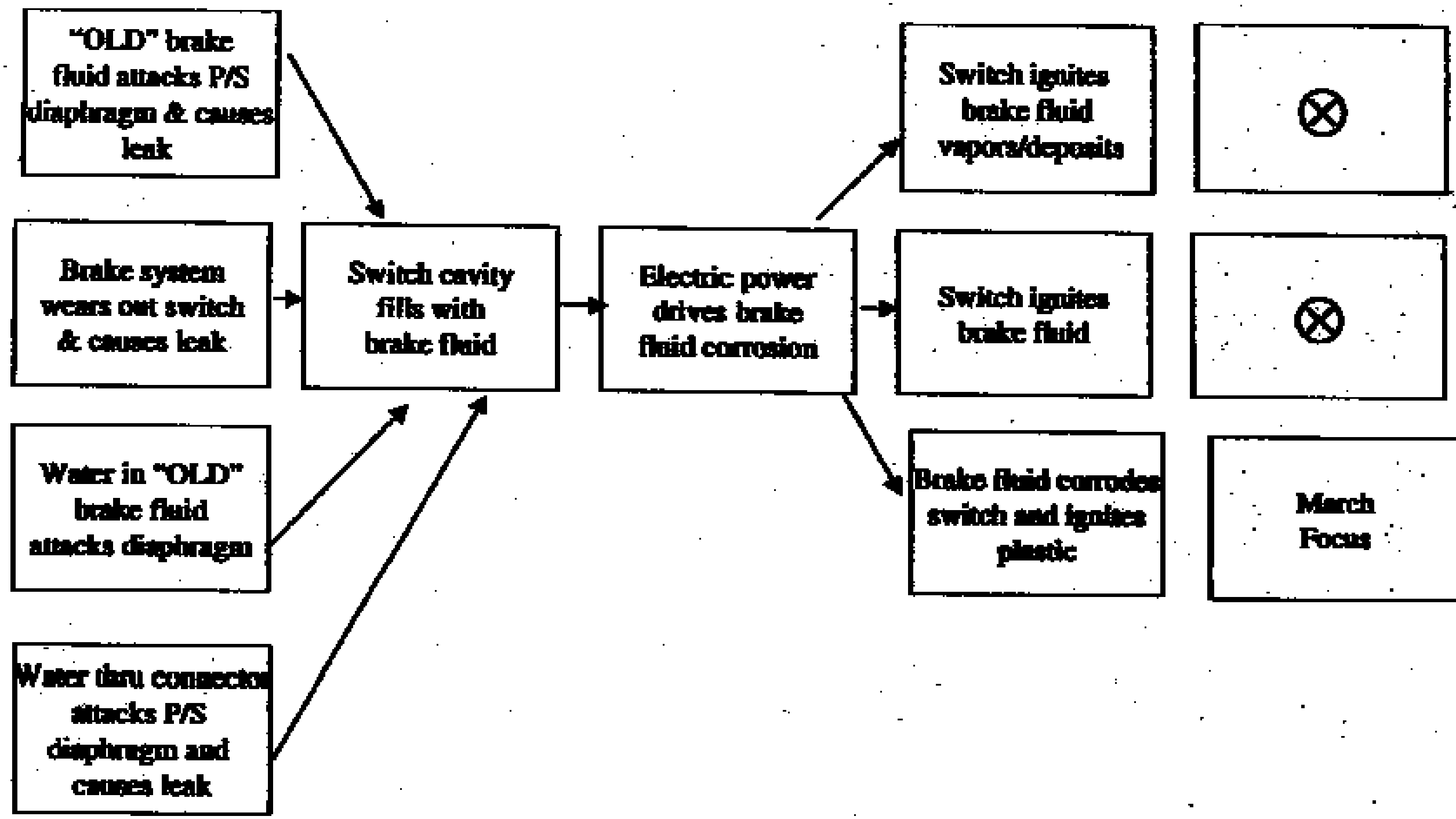
PROCESS FLOW DIAGRAM
"CORROSION" POTENTIAL CAUSE FLOW ANALYSIS



Texas Instruments

Brake Pressure Switch
Potential Thermal Event Theory Profile 5/20/99

REFINED BRAKE FLUID IGNITION THEORY
POSSIBLE CAUSE THEORIES
"FEB '99 FOCUS"



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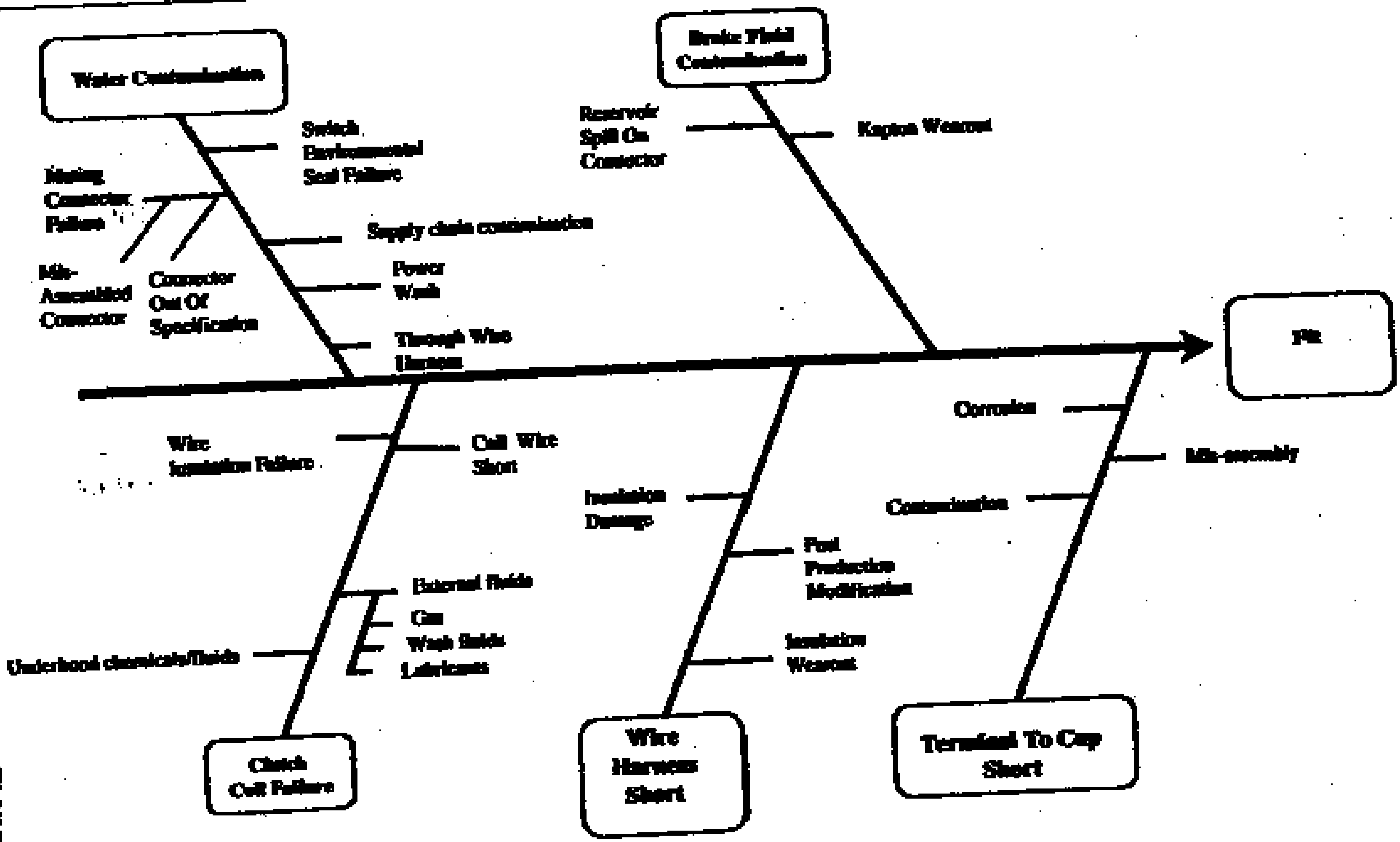
Attachment

Brake Pressure Switch

Potential Thermal Event Theory Profile 5/20/99

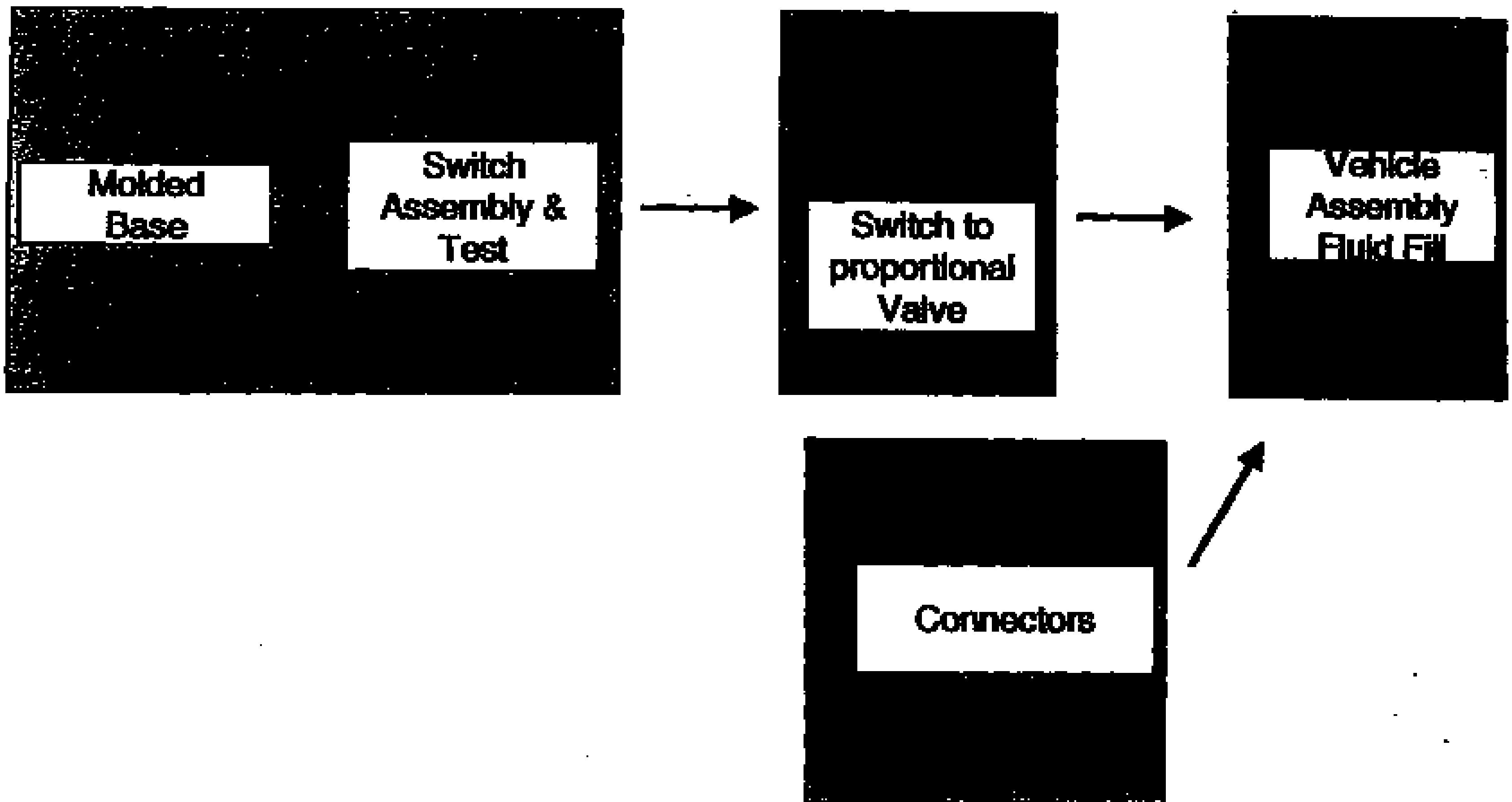


Attachment

TEXAS INSTRUMENTS

Brake Pressure Switch
Potential Thermal Event Theory Profile 5/20/99

PRESSURE SWITCH "FLOW DIAGRAM"
('92, '93, TOWN CAR)



Brake Pressure Switch

Potential Thermal Event Theory Profile 5/20/99

TEXAS INSTRUMENTS

Today's Date: UPDATED [illegible]

Scope or Effect Description

1. Operational Definition (Problem Statement): TOWN CAR UNDERHOOD FIRES			
2. Description	IS	IS NOT	Get Information
WHAT	Town Car MY '92, '93, '94	Crown Victoria? Grand Marquis? T8 Super Coupe? MY '91, '95, '96? '92, '93 Recycling?	COMPARE PLATFORMS
	FIRES… - Electrical pressure switch - Connector - Servo system - Electrical Distribution	Not only pressure switches	COLLECT/TEST OTHER SYSTEM COMPONENTS FOR "SYNERGY" COMPARE VEHICLE OPTIONS FOR SYNERGY
	SYSTEM ISSUES… - Cruise inoperative - Locked in park - Horn inoperative - Brake lights inoperative - Discharged battery - Door locks? - Hazard lamps?	Other circuits	COMPARE WARRANTY
WHERE	Driver side hood Medium height in engine compartment	Passenger side hood Dash – pass compartment Not high in engine comp	EVALUATE HEAT SOURCES
		Not low in engine comp	
WHEN	1-24 hours after parking ignition off After 4-5 years After XXX miles	Not while driving Not while ignition on Not before 3 years? Not before YYY miles	EVALUATE POWER AND HEAT AND WIND SOURCES REVIEW MILES
	After AAA switch cycles	Not Before BBB cycles	
HOW BIG	149 cars / [illegible] ratio "candle size" flame	Not all cars? Not "explosion"	COMPARE PLATFORMS READ FIRE RPTS
	Several pressure switches	Not all underhood fires Not all pressure switches	PARETO UNDERHOOD

TEXAS INSTRUMENTS

Brake Pressure Switch
Potential Thermal Event Theory Profile 5/20/99

[redacted]

OVERVIEW OF CONCERN TIME LINE

OCT/NOV 98	DEC '98	JAN '99	FEB '99	FEB '99	MAR '99	APR '99	May '99
NHTSA initiates investigation	Supply chain dialogue	Core team momentum	TI Eng'r at Ford	Brake fluid fails to ignite	H20 corrosion ignites plastic	Ford NHTSA responds	Deploy results

Texas Instruments

Brake Pressure Switch
Potential Thermal Event Theory Profile 5/20/99

1. Connector Seal to P/S

2. Power continuously available
   A. Operator notifications

3. Switch orientation/location

4. Current limit / fuse

5. Hexport isolation

6. Plastic ignition robustness
   A. Nearby fuels

7. Kapton seal of P/S

8. Environmental seal of P/S

C:\Mc\Limit\99presentation\Ford

Attachment

TI-NHTSA 013791

77PSL2-1: Impulse Data Results 11/91 - 12/92

18-Mar-92	4,000	10	-
23-Apr-92	2,000	5	-
3-May-92	2,000	5	-
5-May-92	2,000	5	-
6-May-92	2,000	5	-
14-Sep-92	2,000	5	-
22-Sep-92	4,000	10	-
30-Sep-92	4,000	10	-
7-Oct-92	4,000	10	-
7-Oct-92	4,000	10	-
16-Oct-92	4,000	10	-
21-Oct-92	2,000	5	-
20-Oct-92	4,000	10	-
29-Oct-92	4,000	10	-
29-Oct-92	4,000	10	-
30-Oct-92	4,000	10	-
4-Nov-92	4,000	10	-
10-Nov-92	4,000	10	-
10-Nov-92	4,000	10	-
11-Nov-92	4,000	10	-
17-Nov-92	2,000	5	-
20-Nov-92	4,000	10	-
4-Dec-92	2,000	5	-
9-Dec-92	2,000	5	-
14-Dec-92	2,000	5	-
16-Dec-92	4,000	10	-
16-Dec-92	4,000	10	-
16-Dec-92	4,000	10	-
21-Dec-92	2,000	5	-
21-Dec-92	4,000	10	-
Totals units	[illegible]	[illegible]	-

TI-NHTSA 013793

NA Hydraulic Switch History

Time Period:	'83	'87	'90	'91	'98	'99
Application:	Power Steering	Power Steering	Power Steering	Power Steering	Power Steering	Power Steering
		Suspension	Suspension	Suspension	Suspension	Suspension
			Transmission	Transmission	Transmission	Transmission
				Cruise	Cruise	Cruise
					Clutch	Clutch

Fluid:

- TI has some 16 years and 130 million units accumulated experience in hydraulic applications using multiple fluids
- TI has some 12 years of brake system application experience working with brake fluids

Brake Pressure Switch Test Log, Updated 5/21/99

Category	Test	Location	Test Parameters	Results Update
Lab Simulation	1	TI	Vary water concentrations in 'new' Brake Fluid	250+ hours, Current draw in the 0.5mA to 5mA range .
of Potential Ignition			14Vdc to one terminal, hexport grounded	Fluid has discolored.
in Switch			Water Conc: 4%, 6%, 10%, 75%	No Significant Temperature Rise. Test Suspended.
				Internal Analysis suspended.
	2	TI	New Brake Fluid	250+ hours. Constant temperature.
			1 Amp through switch terminals	No significant temperature rise with time
			14Vdc to one terminal, hexport grounded	Test Suspended.
	3	AVT	'new' Brake Fluid in Switch, 24 VDC to one	> 300 hours into test, max current 7mA
			terminal. Hexport Grounded	No significant change with time. Test ongoing
	4	AVT	'new' Brake Fluid in Switch, 24 VDC to one	15 hours into test max current 8mA
			terminal. Hexport Grounded, Ambient at 100 C	No significant temperature rise with time. Test suspended.
	5	AVT	'new' 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. Test suspended.
	5a	AVT	'new' Brake Fluid in Switch approx. 50 Amps	Temperature rose to approx. 270 F. No smoke. No ignition
			through Switch Terminals	Test suspended.
	6	TI	Build heater elements into Switch.	3 tested. Smoke observed. Ignition observed on part w/heater
			Heat till failure, include sparking.	See attachment
			(1) w/ solution of Brake Fluid and 5 wt. % H_2O	Test complete
				Brake fluid in cavity slows down heat build-up
				Smoke observed at 675 F, Base melts and falls off at 800 F
	6a	TI	Create heater by corroding spring arm	One out of 15 devices increased resistance to 5 ohms.
			Salt water solution, 14V between spring	Others either very low resistance or megaohms
			and hexport	It took about 100 hours to reach the 5 ohm stage.
				The 5 ohm device ignited under conditions similar to test 6.
	6b	TI	Re-run ignition test to understand	Switch ignition with repeated 5% water solution into switch
			repeatability and current path.	Current path is through hexport.
				See plots and video.
				Additional test include tap water, old BF, new BF and other.
	6c	TI	Pure 'new' brake fluid with metal shavings	Metal shavings don't contribute significantly to BF conductivity.

TI-NHTSA 013797

Brake Pressure Switch Test Log, Updated 5/21/99

			(24) hour tests:	Rain water and tap water samples drew <10 mAmps and showed
			tap water	some signs of corrosion.
			used brake fluid	Chemical analysis in process.
			used brake fluid w/ 5% H_2O	
			new brake fluid	
			new brake fluid w/ 5% H_2O	
Design Of Experiments (2)	13b	TI	Vary water concentrations in 'new' Brake Fluid	Test suspended. Analysis in process to assess test fixturing.
Repeat of test 10			10 amp + 20 quiet switches w/ 5 % water in BF	
			10 amp + 20 quiet switches w/ 5 % water in BF	
Compatibility of Kapton	14	Dupont	Characterize change in properties of Kapton	Test in progress (109) hours completed. Oxalic acid shows
with Oxalic Acid			with various % oxalic acid in brake fluid.	similar effects that water has on Kapton proesties.
Evaluation of Plastic	15	TI	Assess properties and moldability of different	Test suspended.
Materials with Improved			grades of plastic resin with additives	Celanese and Noryl ignited 3/6 and 2/6 trials.
Parameters			to improve plastic part performance	ZYTEL samples tested 1/6 ignitions
Long duration brake fluid	15a	TI	(4) samples with new brake fluid	Test suspended (550) hours completed.
ingress test.			(2) samples with used brake fluid	Used brake fluid current dropped off to <1/10 mAmp.
				New BF leakage current can increase w/ time under cont. power.
Evaluation of Switch	15b	TI	Assess ignition sensitivity to switch orientation.	Test complete. Ignition is independent of switch orientation.
Orientation			Test vertical versus 45 degree.	Simulated switch ignition can occur in vertical or 45 degree angle.
			Test rotational sensitivity in 45 deg. orientation.	Ignition appears not sensitive to switch rotational alignment.
Relay Circuit	16	TI	Repeat test 13a in Ford relay circuit for (48) hrs.	Test complete. No ignition. Corrosion rate drastically reduced.
Test			Bring switch to impending ignition in (15) Amp	Insufficient power in circuit to create or move toward ignition in lab
			circuit then place in relay circuit for (18) hrs.	Heater element was warm to the touch.
			Input max. circuit power into heater on switch.	
Long duration brake fluid	17	TI	(50) samples filled with new brake fluid	Test suspended. (312) hours completed.
ingress test number 2.			(1) hour of vibration per day	Average leakage current is 1.0 mAmp (stdeviation = 1.6 mAmps)
			(1) hour soak at 100 deg C per day	

TI-NHTSA 013799

Currey, Pat

From: Prois, Stephen [s-prois@email.mc.ti.com]
Sent: Tuesday, May 18, 1999 3:21 PM
To: Beringhause, Steven
Cc: McGuirk, Andy; Pechonis, John; Dague, Bryan
Subject: 77PSL2_1.xls

<<77PSL2_1.xls>>

Steve,

I've summarized the data per our discussion. I have also reviewed the files in marketing without success. Please let me know if you need anything else.

Regards,

Steve

TI P/N: 77PSL2-1
Ford P/N: F2VC-9F924-AB

Date	Lot Size	Qty Impulse Tested	Qty Pass	Qty Leak	Comments
26-Nov-91	4,000	10	10	-	
26-Nov-91	4,000	10	10	-	
5-Dec-91	4,000	10	10	-	
5-Dec-91	4,000	10	10	-	
9-Dec-91	4,000	10	10	-	
9-Dec-91	2,000	5	5	-	
11-Dec-91	4,000	10	10	-	
11-Dec-91	4,000	10	10	-	
13-Dec-91	4,000	10	10	-	
14-Dec-91	4,000	10	10	-	
16-Dec-91	4,000	10	10	-	
16-Dec-91	4,000	10	10	-	
2-Jan-92	4,000	10	10	-	
6-Jan-92	4,000	10	10	-	
7-Jan-92	2,000	5	5	-	
8-Jan-92	4,000	10	10	-	
8-Jan-92	4,000	10	10	-	
14-Jan-92	4,000	10	10	-	
14-Jan-92	4,000	10	10	-	
15-Jan-92	4,000	10	10	-	
28-Jan-92	2,000	5	5	-	
31-Jan-92	4,000	10	10	-	
2-Feb-92	1,650	5	4	-	Broken spring
4-Feb-92	4,000	10	10	-	
5-Feb-92	4,000	10	10	-	
6-Feb-92	4,000	10	10	-	
10-Feb-92	4,000	10	10	-	
11-Feb-92	4,000	10	10	-	
12-Feb-92	4,000	10	10	-	
12-Feb-92	4,000	10	10	-	
14-Feb-92	4,000	10	10	-	
14-Feb-92	4,000	10	10	-	
14-Feb-92	4,000	10	10	-	
15-Feb-92	4,000	10	10	-	
24-Feb-92	4,000	10	10	-	
26-Feb-92	4,000	10	10	-	
26-Feb-92	4,000	10	10	-	
28-Feb-92	4,000	10	10	-	
28-Feb-92	4,000	10	10	-	
28-Feb-92	4,000	10	9	-	Continuity failure, terminal inside of base is not staked. Date code 2037. Sorted lot 100%.
6-Mar-92	4,000	10	10	-	

10-Mar-92	4,000	10	10	-
11-Mar-92	4,000	10	10	-
12-Mar-92	4,000	10	10	-
19-Mar-92	4,000	10	10	-
23-Apr-92	2,000	5	5	-
2-May-92	2,000	5	5	-
5-May-92	2,000	5	5	-
6-May-92	2,000	5	5	-
14-Sep-92	2,000	5	5	-
22-Sep-92	4,000	10	10	-
30-Sep-92	4,000	10	10	-
7-Oct-92	4,000	10	10	-
7-Oct-92	4,000	10	10	-
16-Oct-92	4,000	10	10	-
21-Oct-92	2,000	5	5	-
20-Oct-92	4,000	10	10	-
29-Oct-92	4,000	10	10	-
29-Oct-92	4,000	10	10	-
30-Oct-92	4,000	10	10	-
4-Nov-92	4,000	10	10	-
10-Nov-92	4,000	10	10	-
10-Nov-92	4,000	10	10	-
11-Nov-92	4,000	10	10	-
17-Nov-92	2,000	5	5	-
20-Nov-92	4,000	10	10	-
4-Dec-92	2,000	5	5	-
9-Dec-92	2,000	5	5	-
14-Dec-92	2,000	5	5	-
16-Dec-92	4,000	10	10	-
16-Dec-92	4,000	10	10	-
16-Dec-92	4,000	10	10	-
21-Dec-92	2,000	5	5	-
21-Dec-92	4,000	10	10	-
Totals	[illegible]	665	663	-

Currey, Pat

From: Proia, Stephen [s-proia@email.mc.ti.com]
Sent: Tuesday, May 18, 1999 3:35 PM
To: Beringhause, Steven
Cc: Pechonis, John; McGuirk, Andy; Dague, Bryan
Subject: 77PSL2_1.xls

Revised version of spreadsheet.

<<77PSL2_1.xls>>

Regards,

Steve

TI-NHTSA 013603

preliminary draft summary of TI record search findings of May 14-17 1999

summary by Steve Beckingham & Andy McGuirk May 19th 1999

TI P/N: 77PSL2-1

Ford P/N: F2VC-9F924-AB

Tested at 'room temp' per manufacturing ES requirements

Date	Lot Size	Qty Impulse Tested	Qty Leak
26-Nov-91	4,000	10	-
26-Nov-91	4,000	10	-
5-Dec-91	4,000	10	-
5-Dec-91	4,000	10	-
9-Dec-91	4,000	10	-
9-Dec-91	2,000	5	-
11-Dec-91	4,000	10	-
11-Dec-91	4,000	10	-
13-Dec-91	4,000	10	-
14-Dec-91	4,000	10	-
16-Dec-91	4,000	10	-
16-Dec-91	4,000	10	-
2-Jan-92	4,000	10	-
6-Jan-92	4,000	10	-
7-Jan-92	2,000	5	-
8-Jan-92	4,000	10	-
8-Jan-92	4,000	10	-
14-Jan-92	4,000	10	-
14-Jan-92	4,000	10	-
15-Jan-92	4,000	10	-
28-Jan-92	2,000	5	-
31-Jan-92	4,000	10	-
2-Feb-92	1,450	5	-
4-Feb-92	4,000	10	-
5-Feb-92	4,000	10	-
6-Feb-92	4,000	10	-
10-Feb-92	4,000	10	-
11-Feb-92	4,000	10	-
12-Feb-92	4,000	10	-
12-Feb-92	4,000	10	-
14-Feb-92	4,000	10	-
14-Feb-92	4,000	10	-
14-Feb-92	4,000	10	-
15-Feb-92	4,000	10	-
24-Feb-92	4,000	10	-
26-Feb-92	4,000	10	-
26-Feb-92	4,000	10	-
28-Feb-92	4,000	10	-
28-Feb-92	4,000	10	-
28-Feb-92	4,000	10	-
6-Mar-92	4,000	10	-
10-Mar-92	4,000	10	-
11-Mar-92	4,000	10	-
12-Mar-92	4,000	10	-

TI-NHTSA 013804

18-Mar-92	4,000	10	-
23-Apr-92	2,000	5	-
2-May-92	2,000	5	-
5-May-92	2,000	5	-
6-May-92	2,000	5	-
14-Sep-92	2,000	5	-
22-Sep-92	4,000	10	-
30-Sep-92	4,000	10	-
7-Oct-92	4,000	10	-
7-Oct-92	4,000	10	-
16-Oct-92	4,000	10	-
21-Oct-92	2,000	5	-
20-Oct-92	4,000	10	-
28-Oct-92	4,000	10	-
29-Oct-92	4,000	10	-
30-Oct-92	4,000	10	-
4-Nov-92	4,000	10	-
10-Nov-92	4,000	10	-
10-Nov-92	4,000	10	-
11-Nov-92	4,000	10	-
17-Nov-92	2,000	5	-
20-Nov-92	4,000	10	-
4-Dec-92	2,000	5	-
9-Dec-92	2,000	5	-
14-Dec-92	2,000	5	-
16-Dec-92	4,000	10	-
16-Dec-92	4,000	10	-
16-Dec-92	4,000	10	-
21-Dec-92	2,000	5	-
21-Dec-92	4,000	10	-
Totals units	265,600	663	-

TI-NHTSA 013805

Pechonis, John

From: Proia, Stephen
Sent: Tuesday, May 18, 1999 4:21 PM
To: Beringhause, Steven
Cc: McGuirk, Andy; Pechonis, John; Degue, Bryan
Subject: 77PSL2_1.xls

77PSL2_1.xls

Steve,

I've summarized the data per our discussion. I have also reviewed the files in marketing without success. Please let me know if you need anything else.

Regards,

Steve

TI P/N: 77PSL2-1
Ford P/N: F2VC-9F924-AB

Date	Lot Size	Qty Impulse Tested	Qty Pass	Qty Leak	Comments
26-Nov-91	4,000	10	10	-	
26-Nov-91	4,000	10	10	-	
5-Dec-91	4,000	10	10	-	
5-Dec-91	4,000	10	10	-	
9-Dec-91	4,000	10	10	-	
9-Dec-91	2,000	5	5	-	
11-Dec-91	4,000	10	10	-	
11-Dec-91	4,000	10	10	-	
13-Dec-91	4,000	10	10	-	
14-Dec-91	4,000	10	10	-	
16-Dec-91	4,000	10	10	-	
16-Dec-91	4,000	10	10	-	
2-Jan-92	4,000	10	10	-	
6-Jan-92	4,000	10	10	-	
7-Jan-92	2,000	5	5	-	
8-Jan-92	4,000	10	10	-	
8-Jan-92	4,000	10	10	-	
14-Jan-92	4,000	10	10	-	
14-Jan-92	4,000	10	10	-	
15-Jan-92	4,000	10	10	-	
28-Jan-92	2,000	5	5	-	
31-Jan-92	4,000	10	10	-	
2-Feb-92	1,650	5	4	-	Broken spring
4-Feb-92	4,000	10	10	-	
5-Feb-92	4,000	10	10	-	
6-Feb-92	4,000	10	10	-	
10-Feb-92	4,000	10	10	-	
11-Feb-92	4,000	10	10	-	
12-Feb-92	4,000	10	10	-	
12-Feb-92	4,000	10	10	-	
14-Feb-92	4,000	10	10	-	
14-Feb-92	4,000	10	10	-	
14-Feb-92	4,000	10	10	-	
15-Feb-92	4,000	10	10	-	
24-Feb-92	4,000	10	10	-	
26-Feb-92	4,000	10	10	-	
26-Feb-92	4,000	10	10	-	
28-Feb-92	4,000	10	10	-	
28-Feb-92	4,000	10	10	-	

Date: 18-May-99

TI P/N: 77PSL2-1
Ford P/N: F2VC-9F924-AB

Date	Lot Size	Qty Impulse Tested	Qty Leaks
26-Nov-91	4,000	10	-
26-Nov-91	4,000	10	-
5-Dec-91	4,000	10	-
5-Dec-91	4,000	10	-
9-Dec-91	4,000	10	-
9-Dec-91	2,000	5	-
11-Dec-91	4,000	10	-
11-Dec-91	4,000	10	-
13-Dec-91	4,000	10	-
14-Dec-91	4,000	10	-
16-Dec-91	4,000	10	-
16-Dec-91	4,000	10	-
2-Jan-92	4,000	10	-
6-Jan-92	4,000	10	-
7-Jan-92	2,000	5	-
8-Jan-92	4,000	10	-
8-Jan-92	4,000	10	-
14-Jan-92	4,000	10	-
14-Jan-92	4,000	10	-
15-Jan-92	4,000	10	-
28-Jan-92	2,000	5	-
31-Jan-92	4,000	10	-
2-Feb-92	1,650	5	-
4-Feb-92	4,000	10	-
5-Feb-92	4,000	10	-
6-Feb-92	4,000	10	-
10-Feb-92	4,000	10	-
11-Feb-92	4,000	10	-
12-Feb-92	4,000	10	-
12-Feb-92	4,000	10	-
14-Feb-92	4,000	10	-
14-Feb-92	4,000	10	-
14-Feb-92	4,000	10	-
15-Feb-92	4,000	10	-
24-Feb-92	4,000	10	-
26-Feb-92	4,000	10	-
26-Feb-92	4,000	10	-
28-Feb-92	4,000	10	-
28-Feb-92	4,000	10	-
28-Feb-92	4,000	10	-
6-Mar-92	4,000	10	-
10-Mar-92	4,000	10	-

TI-NHTSA 013808

11-Mar-92	4,000	10	-
12-Mar-92	4,000	10	-
18-Mar-92	4,000	10	-
23-Apr-92	2,000	5	-
3-May-92	2,000	5	-
5-May-92	2,000	5	-
6-May-92	2,000	5	-
14-Sep-92	2,000	5	-
22-Sep-92	4,000	10	-
30-Sep-92	4,000	10	-
7-Oct-92	4,000	10	-
7-Oct-92	4,000	10	-
16-Oct-92	4,000	10	-
21-Oct-92	2,000	5	-
20-Oct-92	4,000	10	-
29-Oct-92	4,000	10	-
29-Oct-92	4,000	10	-
30-Oct-92	4,000	10	-
4-Nov-92	4,000	10	-
10-Nov-92	4,000	10	-
10-Nov-92	4,000	10	-
11-Nov-92	4,000	10	-
17-Nov-92	2,000	5	-
20-Nov-92	4,000	10	-
4-Dec-92	2,000	5	-
9-Dec-92	2,000	5	-
14-Dec-92	2,000	5	-
16-Dec-92	4,000	10	-
16-Dec-92	4,000	10	-
16-Dec-92	4,000	10	-
21-Dec-92	2,000	5	-
21-Dec-92	4,000	10	-
Totals	[illegible]	648	-

TI-NHTSA 013809

77PS

IMPULSE TEST LOG SHEET

DISC LOT	DEVICE	START	STOP	DATE
11-2/11-1	77PSL2-3	4:00 PM	5:00 AM	11-07-91 [illegible]
11-3	77PSL2-3	[illegible]:15 AM		11-8-91
11-4	77PSL2-2	11:00 AM		11-12-91
11-7/11-6	77PS-	3:30 PM	4:3[illegible] AM	11-19-91 11-20-91
11-5	[illegible] 3	[illegible] AM		[illegible]-91
11-8/11-11	77PSL2-1	6:45 P.M.	8:10 AM	11-25-91 11-26-91
11-9/11-10	77PS L2-1	11:45 AM	10:30PM	11-26-91 11-26-91

77PS
IMPULSE TEST LOG SHEET

DISC LOT	DEVICE	START	STOP	DATE
12-1/12-2	77P-2-1	6:00 AM	9:30 PM	12/5/91
12-3/12-4	77PS L2-1	9:30 PM	11:00 AM	12-5-91 / 12/6/91
12-6/12-8	77PS L2-1	8:10 AM	7:55 AM	12/7/91 / 12/9/91
12-5	77PS L2-1	8:00 AM		12-9-91
12-10/12-11	77PS L2-1	6:00 PM	9:30 AM	12-11-91 / 12-11-91
12-7/12-9	77PS L2-1	8:00 AM		12-11-91
12-12/12-13	77PS L2-1	5:30 PM	6:50 AM	12-12-91 / 12-13-91
12-14/12-15	77PS L2-1	8:30 AM		12-13-91
12-16/12-17	77PS L2-1	10:05 PM		12-13-91
12-18/12-19	77PS L2-1	1:00 AM	1:10 PM	12-16-91
12-23	57PS-F3-5	4:50 PM		12-18-91

77PS

IMPULSE TEST LOG SHEET

DISC LOT	DEVICE	START	STOP	DATE
1-[illegible]/1-[illegible]	77PSL2-1	10:?? PM	11:45 AM	1-1-92 1-2-92
1-1/1-2	77PSL2-1	4:30 PM	5:30 AM	1-2-92 1-3-92
1-5/1-6	77PSL2-1	[illegible]	11:45 AM	1-5-92 1-6-92
1-3	77PSL2-1	2:30 PM	5:30 AM	1-6-92 1-7-92
1-7/1-8	77PSL2-1	11:17 PM	12:45 PM	1-7-92 1-8-92
1-9/1-10	77PSL2-1	12:50 PM	[illegible] AM	1-8-92 1-9-92
11-20/11-21	77PS F3.3	6:00 Pm	7:25 AM	1-9-92 1-10-92
1-11/1-12	77PSL2-1	10:30 a.m.	12:15 am	1-14-92 1-15-92
1-15/1-16	77PSL2-1	[illegible] am	[illegible]	1-15-92 1-15-92 1-16-92
1-17/1-18	77PSL2-1	2:00 Pm		1-15-92
1-14	77PSL2-1	11:50 a.m.	1:45 am	1-20-92 1-20-92

TPS

IMPULSE TEST LOG SHEET

DISC LOT	DEVICE	START	STOP	DATE
1-22	22-1	[illegible] 1-30-92 4:45 PM	1:15	1-20-92 1-31-92
1-23	22-1		~~12:15~~	1-31-92
1-21	22-1	1-31-92 4:00 PM	6:30 AM	2-1-92 2-4-92
1-24/1-25	22-1	9:25 AM	10'45	2-4-92
1-26/1-27	22-1	11:00 PM	12:20 PM	2-5-92
1-28/1-29	22-1	1:15 PM		2-5-92
2-4/2-3	22-1	12:00 PM	1:00 AM	2-10-92 2-11-92
2-5/2-6	22-1	1:45 AM		2-11-92 2-12-92
2-9/2-10	22-1	8:00 AM	[illegible]	[illegible] 92 2-13-92
2-7/2-8	22-1	9:35	[illegible]	2-13-92
[illegible]/2-11	22-1	6:15 PM	[illegible] AM	2-14-92

77PS

IMPULSE TEST LOG SHEET

DISC LOT	DEVICE	START	STOP	DATE
2-13/2-14	77PS	8:00 AM	9:30 PM	2-14-92
2-6/2-15	L2-2 X2-3/X2-1	10:00 PM 4:25 AM		2-14-92 2-14-92
2-1/2-16				
2-5/2-19	L2-3 / L2-1	6:45 PM	8:00 AM	2-17-92 2-18-92
2-3/2-4 2-6	L2-3 X2-3	8:10 AM 10:07 PM	11:45 AM 1:15 AM	2-18-92 2-21-92 2-22-92 2-24-92
2-20/2-21 1-20	L2-1 X2-3	3:30 PM 1:20 AM		2-22-92 2-24-92
2-26/2-27	77PS	2:40 PM	9:50 AM	2-25-92
2-24/2-25	77PS X2	3:25 [illegible]	[illegible]	[illegible]
2-28/2-29	77PS L2-1	11:45 AM	11:30 [illegible]	2-27-92 2-28-92

TPS

IMPULSE TEST LOG SHEET

DISC LOT	DEVICE	START	STOP	DATE
5-26/5-27	L3-1	3:30 PM	5:05 AM	5-27-92 5-28-92
3-24/3-25	L2-3	9:00 AM	11:00 PM	6-02-92 6-2-92
3-26/5-30	L2-3 / L3-1	11:00 PM	12:05 PM	6-2-92 6-03-92
5-31	L3-1	4:45 PM		06-3-92
6-2 & 6-3	L2-3	11:30 AM	12:30 AM	06-04-92 6-5-92
6-4	L2-3	11.30 AM	12:30 [illegible]	06-05-92 6-6-92
5-29/5-32	L3-1	9:50 AM	[illegible] 9:00 PM	06-09-92
6-6	L3-3	2:00 PM	[illegible] 3:00 [illegible]	06-16-92 6-17-92
6-7/6-9	L3-3	6:15 PM	8:05 AM	06-18-92 06-19-92
6-10/6-9	L3-3	9 PM	10:00 AM	6-22-92 6-23-92
6-11/6-12	L3-3	9:00 AM		6-25-92

TPS
IMPULSE TEST LOG SHEET

DISC LOT	DEVICE	START	STOP	DATE
6-13 & 6-14	L3-3	9:00 AM	10:10 PM	6-29-92
6-15	L3-3	6:23 PM	4:10 AM	6-29-92 6-30-92
6-16	+ 5 pcs Eng. sample L3-3	3:25 PM		6-30-92
		3:26 PM		6-30-92
7-3 / 7-2	L2-3	2:00 PM	approx 3:00 AM	7-08-92 7-9-92
7-4	L2-3	4:45 AM		7-9-92
100 / 102	L3-1	8:45 AM		7-23-92
101 / 102	L2-3	10:30 PM	11:55 PM	7-23-92 7-24-92
103 & 104	L3-1	9:30 AM 12:40 PM	[illegible]	7-24-92 7-27-92
105 / 106	L3-1	9:10 AM		7-28-92
109 / 111	L3-1	9:00 AM		

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77PS

IMPULSE TEST LOG SHEET

DISC LOT	DEVICE	START	STOP	DATE
112 / 113	L3-1	8:15 AM		7-29-92
114	L3-1	10:22 PM	1:50 PM	7-29-92 7-30-92
115 / 116	L3-1	2:00 PM	5:50 AM	8-04-92 8-5-92
117 / 118	L2-3 / L3-3	6:30 PM	8:00 AM	8-5-92 8-06-92
119 / 120	L3-1	5:45 PM	7:30 AM	8-6-92 8-07-92
121 / 122	L3-3 / L2-3	3:45 PM	5:00 AM	8-10-92 8-11-92
123 / 124	L2-3 /	5:20 PM	9:00 AM	8-11-92 8-12-92
126 / 130	L3-3 / L3-1	5:30 PM	7:00 AM	8-12-92 8-13-92
129	L3-1	7:00 AM		8-19-92
128 / 133	L3-3 / L3-1	2:25 PM		
134	L3-1	5:00 AM		8-20-92

TPS

IMPULSE TEST LOG SHEET

DISC LOT	DEVICE	START	STOP	DATE
249	L2-3	9:15 PM	8:40 AM ↔	10-26-92 / 10-27-92
250A/251A	L3-3	3:30 PM	5:15 AM	10-27-92
253/254	L2-1	3:30 PM	3:45 AM	10-28-92 / 10-29-92
252/255	L2-1	3:50 AM		10-29-92
256/257	L3-3	8:00 PM	9:30 AM	10-29-92 / 10-30-92
258/259	L3-3	9:45 AM		10-30-92
260/261	L2-3	10:00 PM	11:10 AM	11-2-92 / 11-03-92
262/261	L2-1	2:30 PM	3:48	
263	L5-2	5:10 AM	[illegible]	11-4-92 / 11-5-92
265/266	L3-3	7:00 PM	8:05 AM	11-5-92
267/268	L3-3	9:00 PM	8:10 AM	11-05-92 / 11-06-92

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TTPS

IMPULSE TEST LOG SHEET

DISC LOT	DEVICE	START	STOP	DATE
243	X [illegible]	10:[illegible] PM	11:10 AM	11-27-92 11-27-92
297/295	L3.3	6:45 PM	8:25 AM	11-30-92 12-1-92
300	L3-3	9:00 PM	1:15 PM	12-2-92 12-01-92
303/302	L2-3 / L2-3	3:30 PM	4:45 Am	12-03-92 12-02-92
296AA	L5-2	4:50 AM		12-03-92
305/306	L3-3	6:15 PM	7:40 AM	12-04-92 12-03-92
307	L2-1	8:00 AM	9:30 PM	12-04-92
308-309	L2 3	10:00 PM	10:55 AM	12-04-92 12-05-92
310	L2-1	10:55 PM	approx. 12:30 AM	12-08-92 12-9-92
312/311	TTPS L3 3	10:15 AM	11:35 AM	12-9-92 12-11-92
317/318	L3-3 / L2-1	2:35 PM		12-11-92

TIPS

IMPULSE TEST LOG SHEET

DISC LOT	DEVICE	START	STOP	DATE
325/319	X3-3 / X2-1	10:15 PM	11:40 AM →	12-15-92 → 12-16-92
321/322	L2-1	11:50 AM	approx 1:00 AM	12-16-92 / 12-17-92
323/331	X2-1 / L2-3	[illegible] AM	2:50 PM	12-17-92
320/324	L2-1	3:00 PM	approx 4:15 AM	12-17-92
326A/327A	L3-3	5:15 AM	7:00 PM	12-18-92
332/333	L3-3	7:30 PM	3:50 AM ↔	12-18-92 / 12-19-92
334/335	L2-3 / L2-1	11:00 AM	12:30 AM	12-19-92 / 12-20-92
336/337	X2-1	10:15 PM	11:45 AM ↔	12-20-92 / 12-21-92
296AA	L5-2	6:00 PM *	7:30 AM ↔	12-21-92 / 12-22-92
330	L3-3	7:40 AM	11:30 AM	12-22-92
338A/339A	L3-3	10:25 PM	11:30 AM	1-3-93 / 1-4-93

Proprietary Information: Attorney-Client Privilege Invoked
PS/99/03 Rev. A
5/18/99

77 PS Heater Coil Tests

Abstract

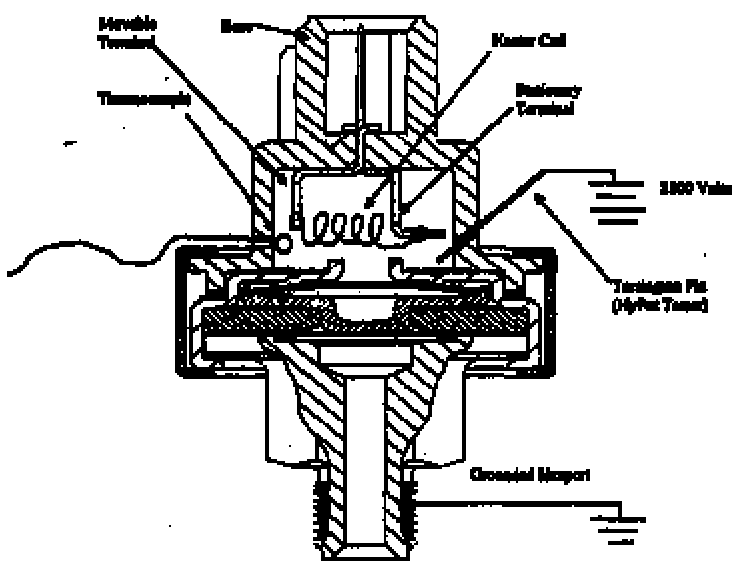
The purpose of this test was to investigate the possibility of switch ignition caused by excessive heat disipation in the contact cavity of 77PS switches. The intention was to determine the conditions necessary to nucleate a switch ignition. A heater coil was installed in the contact cavity of (3) 77PS switches. The contact cavity of (1) switch was filled with a solution of brake fluid with 6 wt. % water, the contact cavities of the other (2) switches remained dry. Power was applied to each heater coil until the switch base begun to melt. A spark was then generated inside the contact cavity of the switch. All (3) switches ignited during the test. In each ignition, contact cavity temperature exceeded 600°F when 5 Watts of power (approximate) was dissipated in the heater coil.

Procedure

Sample Preparation

(3) 77PSL2-1 switches were prepared for testing, as follows. (Refer to Figure 1 below).

Figure 1.
77PS test switch cross-section



TI-NH1TGA 013821

The electrical contact arm was removed from the switch base assembly. The rivet, holding the contact arm to the movable terminal, was ground off. A small hole was drilled through the stationary contact. A resistive wire coil was placed in the switch contact cavity, where the contact arm normally resides. The ends of the coil were crimped to the stationary and movable terminals.
A small hole was drilled through the side of the switch base (to accommodate a thermocouple). To facilitate use of an high voltage ignition source, an additional hole was drilled through the base at a 45° angle.
The modified base assembly was crimped into final assembly.

Wet device: Brake fluid with 6 wt. % water was injected into the contact cavity of only (1) of the (3) test switches.

A K-type thermocouple was inserted into the contact cavity through the previously drilled hole.

Test Setup

Each of the (3) switches was tested separately.
Each test switch was mounted in a manifold which was electrically connected to ground.
A .042 Torrington pin was inserted into the base of the switch leaving a gap of 0.030 inches (approximate) between the end of the pin and the cup of the switch. The pin was connected to the hot lead of a Hy-Pot tester without power. (When the Hy-Pot tester is powered, arcing occurs between the pin at 2500 Volt potential and the grounded cup of the switch). The Hy-Pot tester electric circuit is shown in Figure 1, above.
A variable output DC power supply was connected to the heating coil, through the switch mating connector leads.
The thermocouple was connected to a Fluke meter.

Test Procedure

Power was slowly applied to the heater coil in the switch. Voltage, current and temperature were recorded at regular intervals. Heater coil power was slowly increased during the test.
When localized base melting occcurred, the Hy_Pot tester was powered to create a spark in the contact cavity of the switch.

Data

The data obtained on test switch 1 is shown in Table 1, below.

Table 1.
Test Switch 1- Wet Device (readings made at (1) minute intervals (approximate))

Heater Voltage (Volts)	Heater Current (Amps)	Heater Power (Watts)	Internal Temperature (°F)	Notes
.27	1.0	0.3	100	
.50	2.0	1.0	176	
.80	2.8	2.3	220	Gas visible. Hissing sound audible.
.90	3.0	2.7	246	Smoke visible. Gases venting from side of base.
.96	3.2	3.1	349	
1.6	2.0	3.2	300	
.97	3.1	3.0	340	
1.1	3.6	4.0	450	
1.2	3.8	4.6	462	
1.1	3.8	4.2	488	
1.3	4.0	5.2	531	
1.1	3.6	4.0	571	
1.4	4.1	5.7	647	
1.4	4.0	5.6	650	Large hole developed in base. Power shut down. Internal spark deliberately generated. Ignition occurred.

The data obtained on test switch 2 is shown in Table 2, below.

Table 2.
Test Switch 2- Dry Device (readings made at (1) minute intervals (approximate))

Heater Voltage (Volts)	Heater Current (Amps)	Heater Power (Watts)	Internal Temperature (°F)	Notes
1.0	3.1	3.1	501	
1.09	3.0	3.3	743	
-	-		-	Connection failed. Test interrupted.
1.05	3.02	3.2	598	
1.09	3.09	3.3	626	Smoke became visible from terminal area.
1.12	3.16	3.5	650	
1.13	3.09	3.5	681	
1.13	3.28	3.7	692	A small burn through area in the base. Smoke began venting from burn through area.
1.13	3.18	3.6	707	
1.13	3.38	3.8	722	
1.20	3.52	4.2	756	
1.36	3.98	5.4	809	Base flopped over.
1.36	4.00	5.4	875	
-	-		1230	Base flopped over. Internal spark deliberately generated. Ignition occurred.

Data obtained on test switch 3 is shown in Table 3, below.

Table 3.
Test Switch 3- Dry Device (readings made at (20) second intervals (approximate))

Heater Voltage (Volts)	Heater Current (Amps)	Heater Power (Watts)	Internal Temperature (°F)	Notes
1.0	3.6	3.6	300	Smoke emanated from terminal area.
1.2	4.0	4.8	360	
1.2	3.8	4.6	643	Gases vented from the side of switch base.
1.3	3.7	4.8	680	↓
1.3	3.7	4.8	800	
1.3	3.7	4.8	938	
1.3	3.7	4.8	967	
-	-		1436	Base flopped over. Internal spark deliberately generated. Ignition occurred. The heater burned out and the fire was extinguished.

Results and Discussion

This was not a very controlled experiment due to difficulties in modifying the base assembly to accommodate a heater coil. Several unsuccessful attempts were made to install a heater coil prior to arrival at the aforementioned procedure. In this test, as the temperature of the heater coil increased, the coil tended to droop and make contact with the base of the switch. At the point of contact, localized base melting occurred and a hole breached the base. The spark, generated with the Hy-Pot tester, ignited the fumes within the contact cavity which then engulfed the base material of the switch.

From the data of Table 1 through 3, above, ignition occurred under the following conditions:

5 Watts of power dissipated in the heater coil.
Contact cavity temperature exceeded 600°F.
Hole breached in switch base.
Spark generated in contact cavity of the switch.

Brake fluid did not appear to contribute to the ignition process and did not ignite in this test.

Conclusions

5 Watts of power dissipated into the contact cavity of 77PS switches is sufficient to cause the switch base to outgas and melt. The heated vapor byproducts (fumes) of the base material melting, have proven to be combustible. When a spark is generated in the contact cavity of melting switches, where fumes have accumulated, the fumes ignite and engulf the switch. A solution of brake fluid with 6 wt. % water, in the contact cavity of (1) switch, did not contribute to the ignition process.

Currey, Pat

From: McGuirk, Andy [a-mcguirk@email.mc.ti.com]
Sent: Wednesday, May 19, 1999 11:46 AM
To: Sharpe, Robert
Cc: Baumann, Russ
Subject: my first draft 77PSL2_1.xls

AUTOMOTIVE SENSORS AND CONTROLS QRA MANAGER
34 FOREST ST M/S 23-05
ATTLEBORO, MA 02703
TEL : (508) 236-3080
FAX : (508) 236-3745
MOBILE: (508) 208-6119
PAGE: (800) 467-3700 PIN 604-2044

<<77PSL2_1.xls>>

Regards,

andy

TI P/N: 77PSL2-1
Ford P/N: F2VC-9F924-AB

Date	Lot Size	Qty Inspected Tested	Qty Pass	Qty Leak	Comments
26-Nov-91	4,000	10	10	-	
26-Nov-91	4,000	10	10	-	
5-Dec-91	4,000	10	10	-	
5-Dec-91	4,000	10	10	-	
9-Dec-91	4,000	10	10	-	
9-Dec-91	2,000	5	5	-	
11-Dec-91	4,000	10	10	-	
11-Dec-91	4,000	10	10	-	
13-Dec-91	4,000	10	10	-	
14-Dec-91	4,000	10	10	-	
16-Dec-91	4,000	10	10	-	
18-Dec-91	4,000	10	10	-	
2-Jan-92	4,000	10	10	-	
6-Jan-92	4,000	10	10	-	
7-Jan-92	2,000	5	5	-	
8-Jan-92	4,000	10	10	-	
8-Jan-92	4,000	10	10	-	
14-Jan-92	4,000	10	10	-	
14-Jan-92	4,000	10	10	-	
15-Jan-92	4,000	10	10	-	
28-Jan-92	2,000	5	5	-	
31-Jan-92	4,000	10	10	-	
2-Feb-92	1,650	5	4	-	Broken spring
4-Feb-92	4,000	10	10	-	
5-Feb-92	4,000	10	10	-	
6-Feb-92	4,000	10	10	-	
10-Feb-92	4,000	10	10	-	
11-Feb-92	4,000	10	10	-	
12-Feb-92	4,000	10	10	-	
12-Feb-92	4,000	10	10	-	
14-Feb-92	4,000	10	10	-	
14-Feb-92	4,000	10	10	-	
14-Feb-92	4,000	10	10	-	
15-Feb-92	4,000	10	10	-	
24-Feb-92	4,000	10	10	-	
26-Feb-92	4,000	10	10	-	
26-Feb-92	4,000	10	10	-	
28-Feb-92	4,000	10	10	-	
28-Feb-92	4,000	10	10	-	
28-Feb-92	4,000	10	9	-	Continuity failure, terminal inside of base is not staked. Date code 2057. Sorted lot 100%.
6-Mar-92	4,000	10	10	-	

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10-Mar-92	4,000	10	10	-
11-Mar-92	4,000	10	10	-
12-Mar-92	4,000	10	10	-
18-Mar-92	4,000	10	10	-
23-Apr-92	2,000	5	5	-
2-May-92	2,000	5	5	-
5-May-92	2,000	5	5	-
6-May-92	2,000	5	5	-
14-Sep-92	2,000	5	5	-
22-Sep-92	4,000	10	10	-
30-Sep-92	4,000	10	10	-
7-Oct-92	4,000	10	10	-
7-Oct-92	4,000	10	10	-
16-Oct-92	4,000	10	10	-
21-Oct-92	2,000	5	5	-
20-Oct-92	4,000	10	10	-
29-Oct-92	4,000	10	10	-
28-Oct-92	4,000	10	10	-
30-Oct-92	4,000	10	10	-
4-Nov-92	4,000	10	10	-
10-Nov-92	4,000	10	10	-
10-Nov-92	4,000	10	10	-
11-Nov-92	4,000	10	10	-
17-Nov-92	2,000	5	5	-
20-Nov-92	4,000	10	10	-
4-Dec-92	2,000	5	5	-
9-Dec-92	2,000	5	5	-
14-Dec-92	2,000	5	5	-
16-Dec-92	4,000	10	10	-
16-Dec-92	4,000	10	10	-
16-Dec-92	4,000	10	10	-
21-Dec-92	2,000	5	5	-
21-Dec-92	4,000	10	10	-
Totals	**[illegible]**	**[illegible]**	**[illegible]**	**-**

TI-NHTSA 013827

Curry, Pat

From: McGuirk, Andy [a-mcguirk@email.mc.ti.com]
Sent: Wednesday, May 19, 1999 11:55 AM
To: Sharpe, Robert
Cc: Beringhause, Steven
Subject: FW: my second draft 77PSL2_1.xls

77PSL2_1.xls

AUTOMOTIVE SENSORS AND CONTROLS QRA MANAGER
34 FOREST ST M/S 23-05
ATTLEBORO, MA 02703
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MOBILE: (508) 208-6119
PAGE: (800) 467-3700 PIN 604-2044

From: McGuirk, Andy
Sent: Wednesday, May 19, 1999 12:45 PM
To: Sharpe, Robert
Cc: Baumann, Russ
Subject: my first draft 77PSL2_1.xls

AUTOMOTIVE SENSORS AND CONTROLS QRA MANAGER
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MOBILE: (508) 208-6119
PAGE: (800) 467-3700 PIN 604-2044

<<77PSL2_1.xls>>

Regards,

andy

TI-NHTSA 013826

Date: 19-May-99
TI record search findings of May 14-17 '99
TI P/N: 77PSL2-1
Ford P/N: F2VC-9F924-AB
Tested at 'room temp' per manufacturing ES requirements

Date	Lot Size	Qty Impulse Tested	Qty Leak
26-Nov-91	4,000	10	-
26-Nov-91	4,000	10	-
5-Dec-91	4,000	10	-
5-Dec-91	4,000	10	-
9-Dec-91	4,000	10	-
9-Dec-91	2,000	5	-
11-Dec-91	4,000	10	-
11-Dec-91	4,000	10	-
13-Dec-91	4,000	10	-
14-Dec-91	4,000	10	-
16-Dec-91	4,000	10	-
16-Dec-91	4,000	10	-
2-Jan-92	4,000	10	-
6-Jan-92	4,000	10	-
7-Jan-92	2,000	5	-
8-Jan-92	4,000	10	-
8-Jan-92	4,000	10	-
14-Jan-92	4,000	10	-
14-Jan-92	4,000	10	-
15-Jan-92	4,000	10	-
28-Jan-92	2,000	5	-
31-Jan-92	4,000	10	-
2-Feb-92	1,680	5	-
4-Feb-92	4,000	10	-
5-Feb-92	4,000	10	-
6-Feb-92	4,000	10	-
10-Feb-92	4,000	10	-
11-Feb-92	4,000	10	-
12-Feb-92	4,000	10	-
12-Feb-92	4,000	10	-
14-Feb-92	4,000	10	-
14-Feb-92	4,000	10	-
14-Feb-92	4,000	10	-
15-Feb-92	4,000	10	-
24-Feb-92	4,000	10	-
26-Feb-92	4,000	10	-
26-Feb-92	4,000	10	-
28-Feb-92	4,000	10	-
28-Feb-92	4,000	10	-
28-Feb-92	4,000	10	-
6-Mar-92	4,000	10	-
10-Mar-92	4,000	10	-
11-Mar-92	4,000	10	-
12-Mar-92	4,000	10	-

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18-Mar-92	4,000	10	-
23-Apr-92	2,000	5	-
2-May-92	2,000	5	-
5-May-92	2,000	5	-
6-May-92	2,000	5	-
14-Sep-92	2,000	5	-
22-Sep-92	4,000	10	-
30-Sep-92	4,000	10	-
7-Oct-92	4,000	10	-
7-Oct-92	4,000	10	-
16-Oct-92	4,000	10	-
21-Oct-92	2,000	5	-
20-Oct-92	4,000	10	-
29-Oct-92	4,000	10	-
29-Oct-92	4,000	10	-
30-Oct-92	4,000	10	-
4-Nov-92	4,000	10	-
10-Nov-92	4,000	10	-
10-Nov-92	4,000	10	-
11-Nov-92	4,000	10	-
17-Nov-92	2,000	5	-
20-Nov-92	4,000	10	-
4-Dec-92	2,000	5	-
9-Dec-92	2,000	5	-
14-Dec-92	2,000	5	-
16-Dec-92	4,000	10	-
16-Dec-92	4,000	10	-
16-Dec-92	4,000	10	-
21-Dec-92	2,000	5	-
21-Dec-92	4,000	10	-
Totals units	[illegible]	[illegible]	-

TI-NHTSA 013630

5/26/99
B. Lingow

Procedure

I Visual Inspection

II Signs of Connector Leak — yes / no

III Leak Check? — pass / Fail

IV Current Draw (Terminal to Nexport) (#)

V Open Crimp Ring

VI Connector Leak? — yes / NO

VII Environmental seal leak — pass / Fail

VIII Open Cup Crimp

IX Kapton Inspection
- [illegible]
- [illegible]

X Kapton Leak Check? — 0, 0, 1, 2, 3 [illegible]?

XI Gasket Inspection

	yes	NO
- pressure		
- [illegible]		
- compression set		
-		

XII package + Store

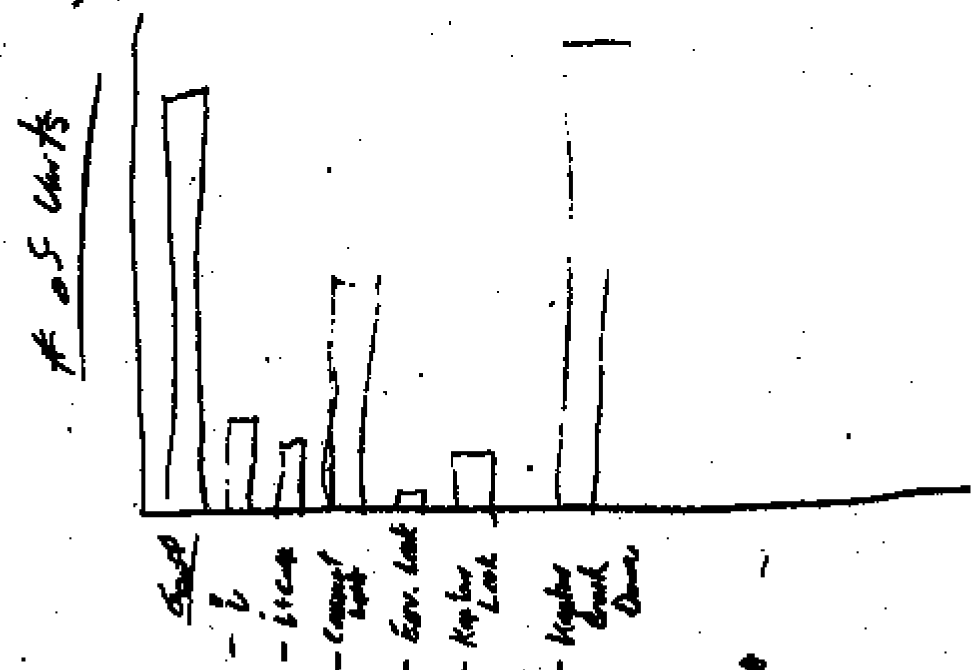
BD 5/25/99

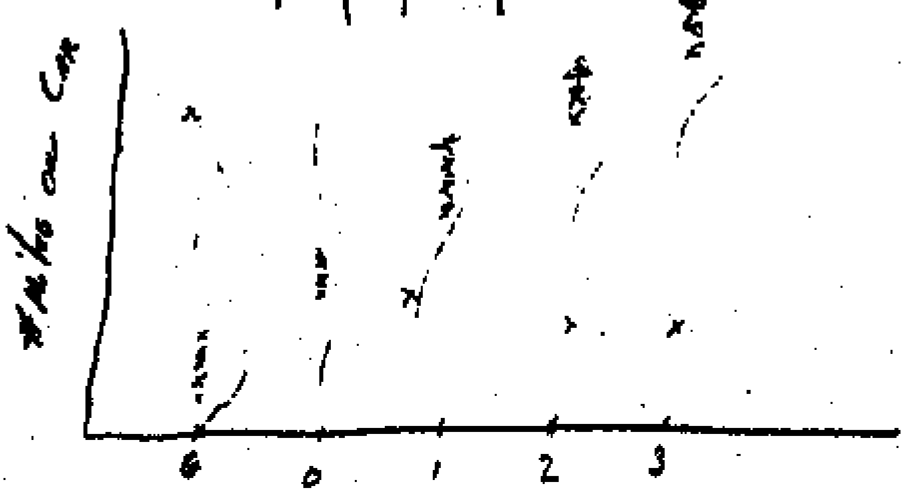
Objective:

1) Is/was PS Defective?

2) Leak → i → % Fire.. How does PS Leak?

3) How does PS wear?





5/25/99
B. Doyle

Results

* $i_{corrosion}$?
* Connector Leak?
* Environmental Seal?
* Kapton Leak?
* Kapton Breakdown/Condition — Kapton leak check? 1, 2, or 3?

good/Bad?

Possible Leak Paths

Connector
- Dome Bond - 2
- Insulator/Seal - 2
- Seal/connector - 1
- Seal/switch - 1
-

Environmental Body seal -

Pressure Cavity
- gasket
- Kaptons
-

Brake Pressure Switch Test Log, Updated 5/29/09

Category	Test	Location	Test Parameters	Results Update
Lab Simulation of Potential Ignition in Switch	1	TI	Vary water concentrations in 'new' Brake Fluid 14Vdc to one terminal, hexport grounded Water Conc: 4%, 6%, 10%, 78%	250+ hours, Current draw in the 0.5mA to 5mA range Fluid has discolored. No Significant Temperature Rise. Test Suspended. Internal Analysis suspended.
	2	TI	New Brake Fluid 1 Amp through switch terminals 14Vdc to one terminal, hexport grounded	250+ hours. Constant temperature. No significant temperature rise with time Test Suspended.
	3	AVT	new' Brake Fluid in Switch, 24 VDC to one terminal. Hexport Grounded	> 300 hours into test, max current 7mA No significant change with time. Test suspended
	4	AVT	new' Brake Fluid in Switch, 24 VDC to one terminal. Hexport Grounded, Ambient at 100 C	18 hours into test max current 5mA No significant temperature rise with time. Test suspended.
	5	AVT	new' Brake Fluid in Switch, 18 Amps Through switch terminals	Temperature rise of 20 C above room temp Delta T reached steady state at 20 C. Test suspended.
	5a	AVT	new' Brake Fluid in Switch approx. 80 Amps through Switch Terminals	Temperature rose to approx. 270 F. No smoke. No ignition Test suspended.
	6	TI	Build heater elements into Switch. Heat till failure, include sparking. (1) w/ solution of Brake Fluid and 6 wt. % H_2O	5 tested. Smoke observed, ignition observed on part wheeler See attachment. Test complete Brake fluid in cavity slows down heat build-up Smoke observed at 676 F, Base melts and falls off at 800 F
	6a	TI	Create heater by corroding spring arm Salt water solution, 14V between spring and hexport	One out of 15 devices increased resistance to 5 ohms. Others either very low resistance or megaohms It took about 100 hours to reach the 5 ohm stage. The 5 ohm device ignited under conditions similar to test 6.
	6b	TI	Re-run ignition test to understand repeatability and current path.	Switch ignition with repeated 5% water solution into switch Current path is through hexport. See plots and video. Additional test include tap water, old BF, new BF and other. Metal shavings do not contribute significantly to brake fluid
	6c	TI	Pass 'new' brake fluid with metal shavings	

Brake Pressure Switch Test Log, Updated 5/28/99

				coductivity
Life Cycle Reliability of Pressure Switch	7	TI	0-1400 psig pressure pulses at 135C per ES	First leak observed at 728,009 cycles. Test Completed. See attached Weibull Chart.
Diaphragm Wear	8	TI	0-1400 psig pressure pulses at 135C.	Parts withdrawn every 280k cycles, characterized for wear
Field vs Lab Correlation	9	Central Labs	"Field returns, from dealer lots, junkyards	Parts in Central Labs, see Ford spreadsheet
Design Of Experiments (1) Evaluating Factors Effecting Diaphragm Wear Impulse test	10	TI	Vary water concentrations in 'new' Brake Fluid 12 snap + 12 quiet switches w/ 0 % water in BF 12 snap + 12 quiet switches w/ 5 % water in BF	Test Report being written investigation continues. Suspended at 1.3 million cycles with no leaks observed. Snap samples suspended at 1.3 million cycles with 2 leaks observed at 1.3M. Quiet samples suspended at 500k cycles to assess fixturing anomalies.
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.	Test at AVT.....see Ford charts...>600k in car?
Brake fluid analysis Used fluid at master cylinder.	11a	TI	Analyze used brake fluid at the master cylinder (UMC), used brake fluid at the caliper (UCA) and new brake fluid (NEW) for metal and water content.	Test complete. UMC: Cu = 418 (ug/ml), Fe = 5.0 (ug/ml), Cr = 0.03 (ug/ml), 1.1 %H2O. UCA: Cu = 382 (ug/ml), Fe = 5.8 (ug/ml), Cr = 1.9 (ug/ml), 1.1 %H2O. NEW: Cu = <0.01 (ug/ml), Fe = 0.02 (ug/ml), Cr = <.01 (ug/ml), 0.3 %H2O.
Spark Arc Study	12	Central Labs	Determine if arc/spark forms in switch using clutch heads and high speed video. Use dry switches as well as switches with various brake fluid water mixes.	Equipment set-up in progress at Central Labs. TI Experimented with no 'significant' sparks observed
Characterization of switches retrieved from field junkyards & other sources	13	Central Labs	Characterize electrical, mechanical and chemical aspects of returned switches	Data log and analysis procedure set up complete. Analysis of switches in progress.
Fluid Ingress Tests	13a	TI	Repeat ignition simulation with different fluids. (3 hour tests): 5% NaCl in tap water rain water (24 hour tests): tap water	Test complete. 5% NaCl sample resulted in an ignition. All brake fluid samples drew less than 3 mAmps. No corrosion visible on brake fluid samples. Rain water and tap water samples drew <10 mAmps and showed some signs of corrosion.

Brake Pressure Switch Test Log, Updated 6/28/99

			used brake fluid	Chemical analysis in process.
			used brake fluid w/ 5% H_2O	
			new brake fluid	
			new brake fluid w/ 5% H_2O	
Design Of Experiments (2)	13b	TI	Vary water concentrations in 'new' Brake Fluid	Test suspended. Analysis in process to assess test findings.
Repeat of test 10			10 amp + 20 quiet switches w/ 0 % water in BF	
			10 amp + 20 quiet switches w/ 5 % water in BF	
Compatibility of Kapton	14	Dupont	Characterize change in properties of Kapton	Test in progress (100) hours completed. Oxalic acid shows
with Oxalic Acid			with various % oxalic acid in brake fluid.	similar effects that water has on Kapton properties.
Evaluation of Plastic	15	TI	Assess properties and moldability of different	Test suspended.
Materials with Improved			grades of plastic resin with additives	Celanese and Noryl ignited 3/5 and 2/5 trials
Parameters			to improve plastic part performance	ZYTEL samples tested 1/5 ignitions
Long duration brake fluid	15a	TI	(4) samples with new brake fluid	Test suspended (500) hours completed.
ingress test			(2) samples with used brake fluid	Used brake fluid current dropped off to <1/10 mAmp.
				New BF Ingress current can increase w/ time under cont. power.
Evaluation of Switch	15b	TI	Assess ignition sensitivity to switch orientation.	Test complete. Ignition is independent of switch orientation.
Orientation			Test vertical versus 45 degree.	Simulated switch ignition can occur in vertical or 45 degree angle.
			Test rotational sensitivity in 45 deg. orientation.	Ignition appears not sensitive to switch rotational alignment.
Relay Circuit	16	TI	Repeat test 13a in Ford relay circuit for (48) hrs.	Test complete. No ignition. Corrosion rate drastically reduced.
Test			Bring switch to impending ignition in (15) Amp	Insufficient power in circuit to create or move toward ignition in lab
			circuit then place in relay circuit for (96) hrs.	Heater element was warm to the touch.
			Input max. circuit power into heater on switch.	
Long duration brake fluid	17	TI	(50) samples filled with new brake fluid	Test suspended. (312) hours completed.
ingress test number 2.			(1) hour of vibration per day	Average Ingress current is 1.9 mAmp (stdeviation = 1.8 mAmps)
			(1) hour soak at 100 deg C per day	

TI 77PS Test Synopsis

This document is a synopsis of tests conducted by Texas Instruments during the 77PS investigation. The intent of this document is to highlight test findings which drove the investigation to its current state. Throughout the investigation, several tests were conducted with the same objective. When each objective was met, efforts were refocused to obtain a new level of understanding and to establish a new set of objectives. As such, tests have been categorized into (5) levels, representing the level of knowledge obtained from the group of tests conducted. Each level is listed below with a short description of the objective:

Level 1: Create a laboratory switch ignition without any restrictions on methods.
Level 2: Create a laboratory switch ignition using only conditions found in the switch operating environment.
Level 3: Understand the laboratory ignition mechanism.
Level 4: Compare factors contributing to laboratory ignition.
Level 5: Evaluate recommendations.

Refer to <u>Brake Pressure Switch Test Log</u>.

Level 1 Objective: Determine if a switch ignition can be created in the laboratory.

- Test 1

Objective: Determine if switch ignition can occur under the following laboratory conditions:

Switch contact cavity flooded with brake fluid mixed with varying amounts of % H_2O.
14 volts applied to one terminal, second terminal electrically floating. (No electrical load across switch terminals).
Switch hexport electrically grounded.

Results: (8) samples were tested total:
(2) with 4% H_2O in brake fluid.
(2) with 6% H_2O in brake fluid.
(2) with 10% H_2O in brake fluid.
(2) with 75% H_2O in brake fluid.

No ignition occurred. No significant temperature rise observed in all samples. Current draw ranged from 0.5 mAmps to 5 mAmps over a period greater than (250) hours.

- Test 2

Objective: Determine if switch ignition can occur under the following laboratory conditions:

Switch contact flooded with brake fluid.
14 volts applied to one terminal, second terminal connected to a 14 Ω resistor which is tied to ground. (1 Amp load across switch terminals).
Switch hexport electrically grounded.

Results: (2) samples were tested. No ignition occurred. No significant temperature rise observed for a period over (250) hours.

Conclusion: A (1) Amp load through switch terminals did not ignite brake fluid in the contact cavity of switches.

- Test 6

Objective: Determine if switch ignition can occur under the following laboratory conditions:

Heater element installed in contact cavity of the switch.
Power applied to the heater element until plastic base melts.
Spark generated in contact cavity of switch.
Brake fluid present in the contact cavity (wet device) and absent in the contact cavity (dry device).

Results: (2) dry devices were tested and (1) wet device was tested. Ignition occurred in all devices.
Wet device: The internal temperature of a wet device reached 660°F. A hole burned through the base of the switch (close to the heating element). The applied spark ignited the fumes in the contact cavity of the switch and engulfed the base material of the switch.
Dry device: The internal temperature of a dry switch reached over 1000°F. The switch base flopped over. The applied spark ignited the fumes in the contact cavity of the switch and engulfed the base material of the switch.

Conclusion: A switch ignition can occur under the following laboratory conditions:

Heater element installed in the switch contact cavity.
5 watts of power dissipated in heating element.
Spark generated in the contact cavity of the switch.

Brake fluid did not contribute to the ignition process.

TI-NHTSA 013838

Level 2: Objective: Determine if a laboratory ignition can occur using only switch components and elements found in the switch environment.

- Test 6a

Objective: Determine if corrosive degradation of switch electrical components can cause an increase in electrical resistance (and thus a source of heat) in the switch, which may lead to an ignition.

Results: (1) out of (15) samples tested increased resistance to 5 Ωs. A solution of 5 wt. % NaCl in H_20 can corrode the electrical components of the switch and cause an increase in electrical resistance. Repeated injections of the solution of 5 wt. % NaCl in H_20 into the contact cavity of a switch, with the switch continuously powered at 14 Volts, can cause an ignition.

Conclusion: A switch ignition can occur under the following laboratory conditions:

A solution of 5% NaCl in H_20 is injected into contact cavity of a switch.
Continuous 14 Volt power applied to the switch.
Hexport is grounded.
Current is limited at 15 Amps.

- Test 6c

Objective: Determine if brake fluid with metal shavings is conductive enough to create an ignition.

Results: (3) devices with various size metal particles were tested. No significant current increase detected.

Conclusion: Metal shavings did not significantly increase conductivity brake fluid. Current levels measured were well below levels necessary to create an ignition.

- Test 7

Objective: Determine if switch meets cycle life specification.

Results: Tests conducted during the first quarter of 1999 show that switches exceed cycle life specification.
In the first quarter of 1999, a total of (42) 77PSL2-1 snap switches were impulse tested to over 1,000,000 cycles with only (1) leak below 1,000,000 cycles, which

occurred at 728,000 cycles. A Weibull analysis showed 99.9% reliability at 500,000 cycles at 95% confidence level.

Conclusions: Switches meet cycle life specification. First quarter, 1999 tests confirm impulse test findings made during the period between 1991 and 1992. During that period, (6) impulse tests on 144 devices of 57PS and 77PS construction, had no leaks when tested to 500,000 cycles. A Weibull analysis of first quarter, 1999 tests, showed 99.9% reliability at 500,000 cycles at 95% confidence level.

- Test 15a

Objective: Determine the long term corrosive effects of brake fluid on the electrical components of switches which are continuously powered at 14 Volts.

Results: Test was suspended after 550 hours of testing. (6) samples were tested with continuous 14 Volts power. The contact cavity of (4) switches contained new brake fluid and (2) switches contained old brake fluid. Switches with old brake fluid drew very little hexport current and showed a decrease in hexport current over time to less than 1/10 mAmp. Samples with new brake fluid showed an increase in hexport current to over 20 mAmps toward the end of the 550 hours of testing. Analyses of (1) sample with new brake fluid and (1) sample with old brake fluid revealed electrolytic corrosion of the contact arm of both switches. There was a much lower level of corrosion in the sample with used brake fluid than the sample with new brake fluid.

Conclusion: Brake fluid in the contact cavity of switches, which are at 14 Volts continuous power for over 500 hours, can cause electrolytic corrosion of the switch contact arm and an increase in hexport current.

- Test 17

Objective: Quantify the long term corrosive effects of new brake fluid on the electrical components of switches under the following laboratory conditions:

Contact cavity of switch flooded with new brake fluid.
Switches at continuous 14 Volts power.
Switches subjected to vibration for (1) hour per day.
Switches subjected to 100°C for (1) hour per day.

Results: Test suspended after (312) hours. (50) samples tested. The average hexport current draw after (312) hours is 1.9 mAmps with a standard deviation of 1.8 mAmps. These results are consistent with results previously found in Test 15a at the 300 hour point.

Conclusion: New brake fluid in the contact cavity of switches, has not caused an increase in hexport current after (312) hours at continuous 14 Volts power.

Level 3: Objective: Understand the laboratory ignition process, determine the current path and establish a repeatable ignition method.

- Test 6b

Objective: Understand the ignition process, determine the current path and establish a repeatable ignition method.

Results: Multiple attempts at laboratory ignition, via injection of a solution of 5 wt. % NaCl in H_2O into the contact cavity of switches, has resulted in a repeatability rate of approximately 50%. Plots of hexport current verses time show an increase in current until the point of ignition.

Conclusion: A repeatable laboratory method for switch ignition was established. Based on hexport current measurements, the current path is from switch terminals to hexport body.
When a solution of 5 wt. % NaCl in H_2O is repeatedly injected into the contact cavity of powered switches, electrolytic corrosion of the switch terminal results in an increase in terminal resistance. When sufficient power is drawn through the corrosive resistance, switch elements heat up and begin to glow red hot. A hole burns through the switch base and ignition occurs. There is arcing visible throughout the corrosion process which may provide the spark necessary for ignition.

Level 4: Objective: Compare and contrast variables influencing ignition using the established laboratory ignition method.

- Test 13a

Objective: Compare various fluids in the established ignition method.

Results: The following fluids were tested.
(1) NaCl in H_2O.
(1) tap water
(1) rain water
(1) used brake fluid
(1) used brake fluid with 5 wt. % H_2O
(1) new brake fluid
(1) new brake fluid with 5 wt. % H_2O
The switch filled with 5 wt. % NaCl in H_2O resulted in an ignition when average hexport current exceeded 2.5 Amps. Switches that were filled with tap water and rain water drew less than 10 mAmps over a (3) hour test and showed little signs of

corrosion. Switches filled with a matrix of new and used brake fluids, with water and without water, all drew less than 3 mAmps hexport current draw and showed no signs of corrosion over the (24) hour test.

Conclusion: Brake fluid is not conductive enough to cause the electrolytic corrosion and necessary current draw to create an ignition within a 3 hour lab test. Because of its' significantly higher conductivity, an ionic rich fluid such as NaCl in H_2O can cause an ignition in a 3 hour lab test exposure..

- Test 15

Objective: Compare the ignition characteristics of various plastics as switch base material.

Results: When 5 wt. % NaCl in H_2O was injected into switches with different base materials, the following results were obtained: Cellanex 4300 ignited 3 out of 5 attempts. Noryl ignited 2 out of 5 attempts. Zytel ignited 1 out of 5 attempts.

Conclusions: All plastics tested can ignite using the established laboratory ignition method.

- Test 15b

Objective: Determine if switch ignition can occur in the vertical position and 45° orientation. Determine if switch ignition can occur and at different rotational angles in the 45° orientation.

Results: Switch ignitions can occur in both the vertical and 45° orientation using the established laboratory ignition method.

Conclusion: Switch ignition does not appear to be sensitive to vertical orientation verses 45° orientation nor to rotational angle in the 45° orientation.

Level 5 Objective:

Test 16

- Objective: Test proposed relay circuit.

Results: (1) switch was injected with a solution of 5 wt. % Nacl in H_2O and placed in the proposed current limiting circuit for (48) hours. The current draw remained constant at 180 mAmps throughout the test. There was no activity observed and the contact arm remained mostly intact.
(1) switch was brought to an impending burn condition using the established burn method. An impending burn is a condition where a corrosive resistance has built

up in the switch and an ignition is imminent. The switch was then placed in the proposed relay circuit for (18) hours where it drew 160 mAmps, showed no visible activity and did not result in an ignition.
Because the proposed relay circuit acts as a resistor which limits current to the switch, the maximum power to the switch is limited to .75 Watts. A resistive wire was wrapped around the base of (1) switch and 0.75 Watts of power was dissipated in the wire. The wire became warm to the touch but had no effect on the switch.

Conclusion: 0.75 Watts, the maximum power in the proposed circuit design, is insufficient to cause substantial electrolytic corrosion or significant switch terminal heating, which is necessary to create an ignition. In previous tests, using a resistor as the heating element (see Test 6), approximately 5 Watts of power was necessary to create an ignition.

TI-NHTSA 013943

Proprietary Information: Attorney-Client Privilege Involved
PS/99/20
6/1/99

77PS Fluid Ignition Test

Abstract

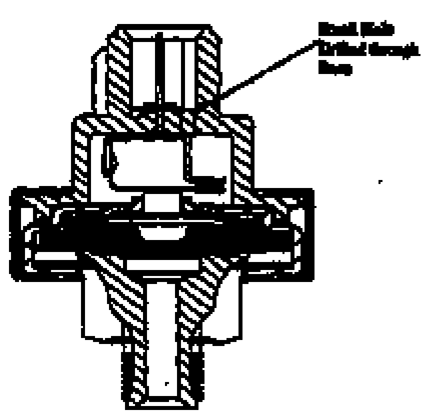
The purpose of this test was to investigate brake fluid ingress as a possible source of ignition in 77Ps switches in continuous power applications. The contact cavities of (10) normally closed switches were filled with solutions of brake fluid and various concentrations of water. The switches were torqued into a common test manifold, which was electrically grounded. Continuous, (14) volt power was applied to one terminal of all switches. (This condition allowed the fluid, in the contact cavity to become the conductive path to the electrically grounded hexport body of the switch). On (2) switches, 1 Amp of current was conducted through the switch contacts. No current was conducted through the terminals of (8) of the switches. No significant increase in temperature was observed on all switches. Visual analysis of the switch internal components showed a buildup of sooty deposits but no corrosion. This test provided no evidence that brake fluid ingress into the contact cavity of 77PS switches can cause an ignition.

Procedure

Sample preparation:

A small hole was drilled through the base of (10) 77PS switches (as shown in Figure 1, below.

Figure 1.



(5) solutions of a brake fluid, with different concentrations of tap water, were injected into the contact cavity of the switches as outlined in Table 1, below.

Table 1.

Test Device #	1A	1B	2A*	2B	3A	3B	4A	4B	5A*	5B
% tap water in brake fluid (by weight)	0	0	4	4	6	6	10	10	75	75

* 1 Amp conducted through the switch terminals of (2) samples.

A K-type thermocouple was placed into the fluid of (5) of the switches, to monitor fluid temperature.

Test Setup:

The switches were all torqued into a manifold which was electrically grounded.

14 Volts was applied to the one terminal of all switches. A 12 Ω resistor was wired from the second terminal to ground on devices 2A and 5A only. (This was done to create an electric path through the switch contact as a source of heat in those (2) devices). The second terminals, of the remaining switches, were left electrically floating.
To facilitate continuous testing, switches were placed in an oven and powered over several days. The oven was used only as a safety precaution for unattended testing.

Test Procedure:

A temperature data logger was use to record the peak fluid temperature of the switches over (24) hour intervals. Ambient and oven temperatures were recorded daily. Fluid levels were monitored and replenished as required. The hexport current draw of switch 5B was also recorded.

At the completion of this test, switch 3A was exposed to a salt water solution and powered at 14 volts for an additional 60 hours (approximate). (This was an effort to quantify salt water corrosion).
All the switches were disassembled for post testing analysis.

Data

The temperature data, collected during testing, is shown in Table 3, below. The Running Temperature is the switch fluid temperature at the time of measurement. The Peak Temperature is the peak temperature recorded, via data logger, over a (24) hour period.

Table 3.

			Device #				
Date:	2/11/99	Temperature	1A	2A	3A	4A	5A
Time:	14:40	(°F) Running	86	85	83	84	88
Ambient Temp. (°F):	84	((°F) Peak)	(87)	(98)	(86)	(85)	(98)
Oven Temp. (°F):	86						
Date:	2/12/99	Temperature					
Time:	11:05	(°F) Running	98	94	89	99	100
Ambient Temp. (°F):	79	((°F) Peak)	(112)	(99)	(93)	(104)	(106)
Oven Temp. (°F):	83						
Date:	2/13/99	Temperature					
Time:	9:30	(°F) Running	87	96	107	88	103
Ambient Temp. (°F):	NA	((°F) Peak)	(88)	(101)	(111)	(91)	(108)
Oven Temp. (°F):	NA						
Date:	2/16/99	Temperature					
Time:	13:30	(°F) Running	83	81	105	82	96
Ambient Temp. (°F):	81	((°F) Peak)	(99)	(103)	(121)	(97)	(117)
Oven Temp. (°F):	81						
Date:	2/16/99	Temperature					
Time:	12:00	(°F) Running	76	84	109	84	81
Ambient Temp. (°F):	78	((°F) Peak)	(79)	(100)	(120)	(90)	(119)
Oven Temp. (°F):	78						

Notes: Running temperature is the temperature at the time of reading.
Peak temperature is the peak temperature recorded between readings.

Photos, of the dissected switches, are shown in Figure 2 and Figure 3 of the Appendix. (Note: the test switch identifying marks were lost when the switches were disassembled. Therefore, photos can not be tied to particular switches).

Hexport current measurements, on switch 5B, fluctuated daily and dropped from 5 mAmps at the start of the test to 0.2 mAmps at the end of the test.

Results

Temperature measurements show that brake fluid ingress into the connector cavity of 77PS did not cause an ignition when powered at continuous, 14 Volts power. The peak temperature recorded during the test was 121°F, which is well below the flash temperature of brake fluid. Switches 2A and 5A, which had (1) Amp of current conducted through the switch contact, showed no additional increase in temperature when compared with the other switches. This may be attributed to a very low contact resistance resulting in insignificant additional power dissipation in switches 2A and 5A. Visual analysis all switches showed a buildup of black deposits but no corrosion.

At completion of the brake fluid test, switch 3A was injected with salt water and continuously powered with (14) volts for (60) hours. The switch was disassembled for post test analysis. An internal photo of switch 3A shows a high level of corrosion of internal components where the contact arm is completely corroded away (see Figure 3 of the Appendix).

Conclusions

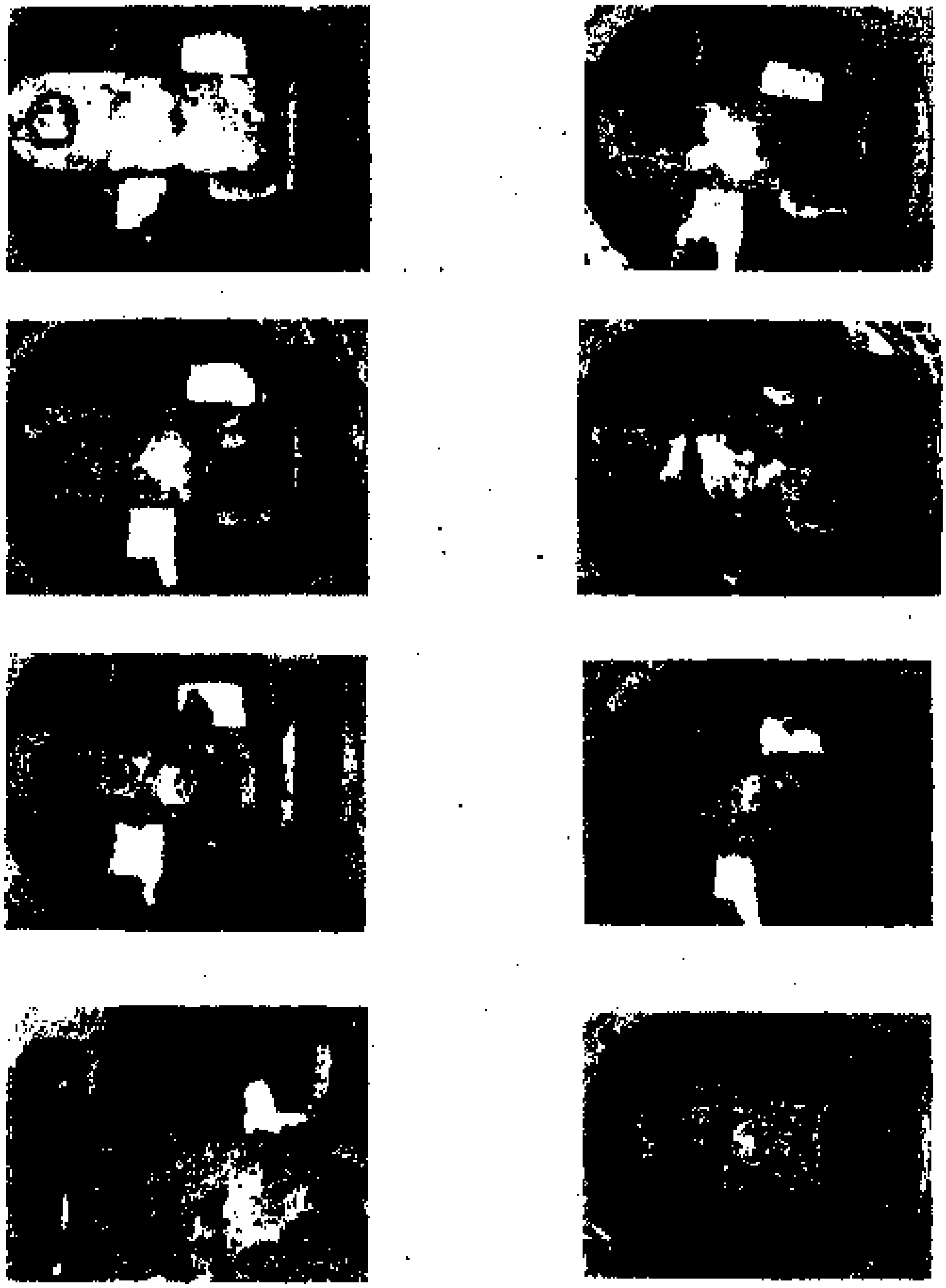
This test has provided no evidence to indicate brake fluid ingress as a possible source of ignition of 77PS switches in continuous power applications. (120) hours of testing showed no significant increase in temperature and no visible corrosion of internal components. Results showed that varying the concentration of water in the brake fluid between 0% to 75% did not affect temperature measurements or corrosion during the (120) hours of testing. Internal analysis of the switches showed varying amounts of deposits. However, due to a loss of identifying marks, no conclusions can be made with regard to deposits verses %water.

(1) switch, subjected to salt water ingress, for (60) additional hours of testing, showed a high degree of corrosion.

Proprietary Information: Attorney-Client Privilege Invoked
PS/99/20
6/1/99

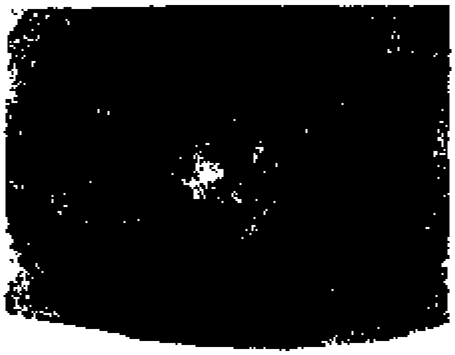
Appendix

Figure 2.



Appendix

Figure 3.



Salt water corrosion of switch 3A.