EA02-025

TEXAS INSTRUMENTS, INC.'S

9/10/03

REQUEST NO. 7

BOX 9

PART A – R

PART O

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 Brake Pressure Switch Test Log.

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_20.
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_20 in brake fluid.
(2) with 6% H_20 in brake fluid.
(2) with 10% H_20 in brake fluid.
(2) with 75% H_20 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.

TI-NHTSA 014686

- 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 cannot 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 014589

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_2O 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_2O 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_2O 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. It is unknown if this corrosion, under continuous power conditions, can eventually lead to sufficient current draw to drive an ignition.

- 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. There has been no increase in hexport current. These results are consistent with results previously found in Test 15a.

TI-NHTSA 014591

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_20 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_20 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_20.
(1) tap water
(1) rain water
(1) used brake fluid
(1) used brake fluid with 5 wt. % H_20
(1) new brake fluid
(1) new brake fluid with 5 wt. % H_20
The switch filled with 5 wt. % NaCl in H_20 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. Because of its' significantly higher conductivity, an ionic rich fluid such as NaCl in H_20 is necessary to cause an ignition.

- Test 15

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

Results: When 5 wt. % NaCl in H_20 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 1out 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_20 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. There is not enough power in the proposed circuit to create ignition.

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
Spark

The 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 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.
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 the switch with brake fluid, brake fluid and water, and brake fluid, 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 heating of the pressure switch.

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

We therefore focused our recent testing on the third option. Initial testing included putting 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. 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 were put across 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 but no fire started. Eventually the plastic melted to the point that it broke open exposing room air to the inside of the connector. 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. The conclusions from this experiment are:

1. With enough heat and a spark for ignition the plastic will 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 this test, 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 and allowing it to become a heater.
2. There is an electrical short outside the switch that drives high current through the switch.
3. The high current through the contact arm 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.

Please call Steve Berkighause with any questions.

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
Spark

The 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 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.
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 the switch with brake fluid, brake fluid and water, and brake fluid, 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 heating of the pressure switch.

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

We therefore focused our recent testing on the third option. Initial testing included putting 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. 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 were put across 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 but no fire started. Eventually the plastic melted to the point that it broke open exposing room air to the inside of the connector. 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. The conclusions from this experiment are:

1. With enough heat and a spark for ignition the plastic will 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 this test, 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 and allowing it to become a heater.
2. There is an electrical short outside the switch that drives high current through the switch.
3. The high current through the contact arm 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.

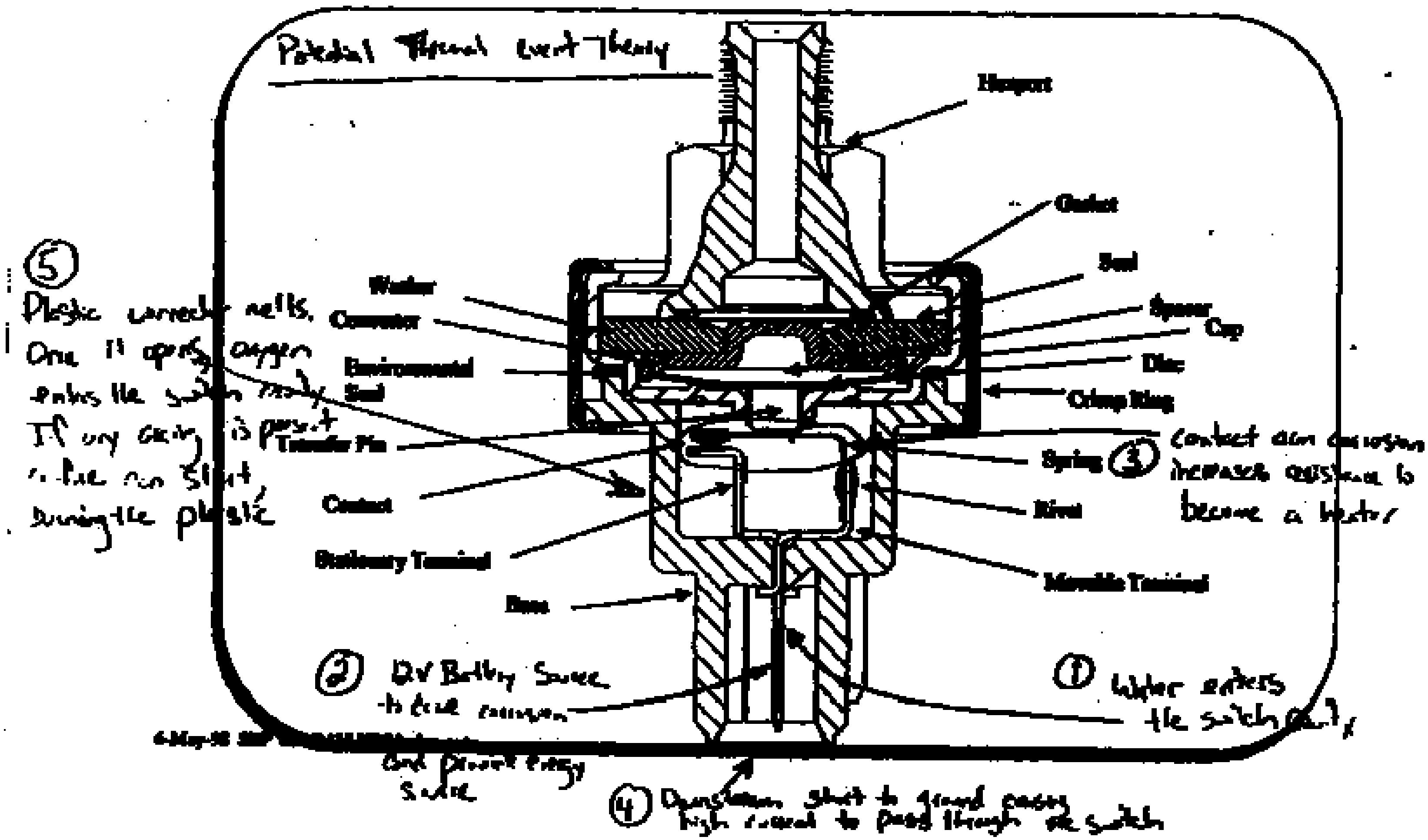
We are currently running tests where we are trying to reproduce the fire using the contact arm as the heater.

Please call Steve Beringhause with any questions.

Texas Instruments

Hydraulic Pressure Switches
Design Capability Summary

Pressure Switch Cross Section



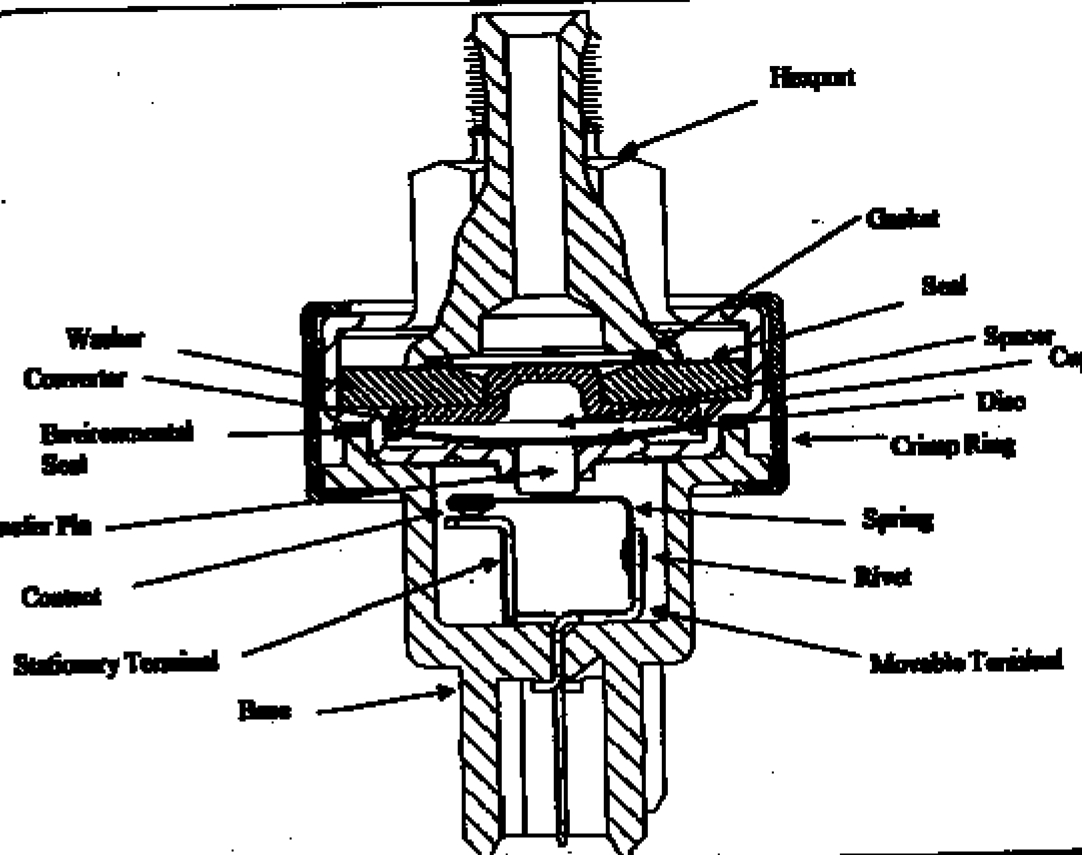
6-May-98

TI-NHTSA 014889

TEXAS INSTRUMENTS

Hydraulic Pressure Switches
Design Capability Summary

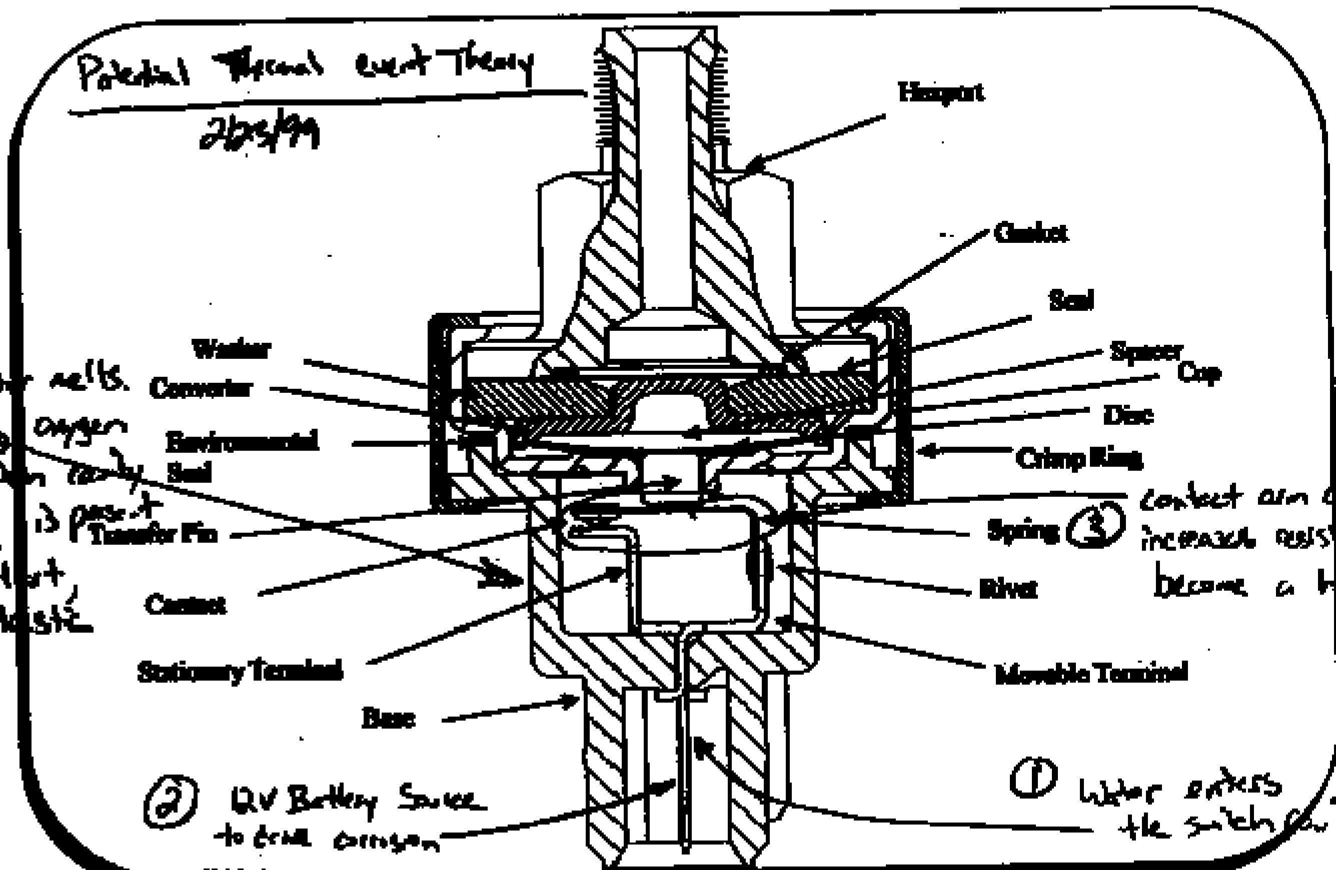
Pressure Switch Cross Section



TEXAS INSTRUMENTS

Hydraulic Pressure Switches
Design Capability Summary

Pressure Switch Cross Section



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

(4) Downstream short to ground causes

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)

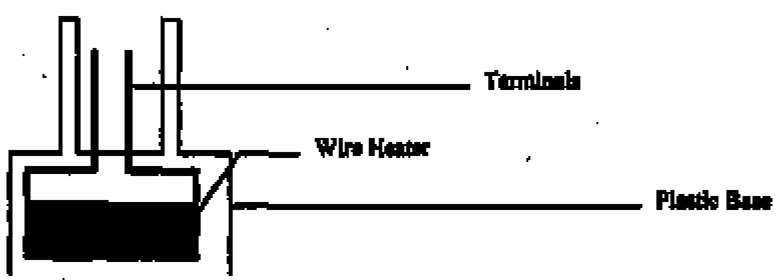
Volts	Heater Current	Internal Temperature (F)
1.0	3.6	300
1.2	4.0	360
1.2	3.8	643
1.3	3.7	650
1.3	3.7	800
1.3	3.7	930
1.3	3.7	967

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 .

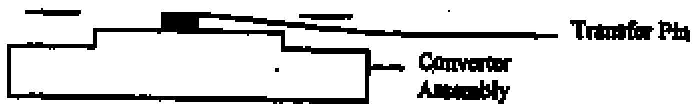
IV . Conclusions .

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



TI-NHTSA 014606



TI-NHTSA 014807

Examine field returns:

Switch w/ harness (before disengagement);

Electrical properties, connector engagement, connector and harness damage, wire corrosion, wicking, contaminants, contaminant sources, debris.

—— Norm work plan here

Switch w/o harness ;

Electrical properties, Mechanical properties, terminal cavity contaminants, terminal cavity damage, terminal corrosion or damage.

Switch cavity terminal corrosion, contaminants, contaminant ingress site(s), wear / damage.

Pressure cavity components wear / damage, contaminants.

Electrical properties:

Switch w/ harness (before disengagement)

@ 0 psid
- Wire 1 to Wire 1 resistance
- Wire 1 to Hex Port resistance
- Wire 2 to Hex Port resistance

@ 180 psid
- Wire 1 to Wire 1 resistance
- Wire 1 to Hex Port resistance
- Wire 2 to Hex Port resistance

Harness w/o switch

- Wire 1 to Wire 1 resistance
- Wire 1 to Hex Port resistance
- Wire 2 to Hex Port resistance
- Current Leakage Terminal 1 to 2

Switch w/o harness

@ 0 psid

- Terminal 1 to Terminal 2 resistance
- Terminal 1 to Hex Port resistance
- Terminal 2 to Hex Port resistance
- Voltage drop @ 750 milliamps
- Current Leakage Terminal 1 to Hex Port
- Current Leakage Terminal 2 to Hex Port
- Current Leakage Terminal 1 to 2
- Hex Port to Cap resistance

@ 180 psid

- Terminal 1 to Terminal 2 resistance
- Terminal 1 to Hex Port resistance
- Terminal 2 to Hex Port resistance
- Voltage drop @ 750 milliamps
- Current Leakage Terminal 1 to Hex Port
- Current Leakage Terminal 2 to Hex Port

Mechanical properties:

- Switch opening pressure
- Switch closing pressure
- Proof Test for fluid leakage

1) Flash points
Asia has material spec?

- 2 base materials Celanex, [illegible] [illegible])
- Kapton and Teflon
  Gasket = seal (potting)

2) Δ's in material — PSVC — PZAC
Lowered at "G" 7?5?2-1 ⇒ 77?5?3-1 [illegible] material bigger

3) DFMEA : PFMEA ? any fire occurrences
we identify leaks for potential effects, none related to fire
?, 8, 7, ?, 8, 2, 5, 8, ?, 27, ?, (DFMEA)
? ?, ?, ?, [illegible], [illegible] [illegible] [illegible] ?, ?

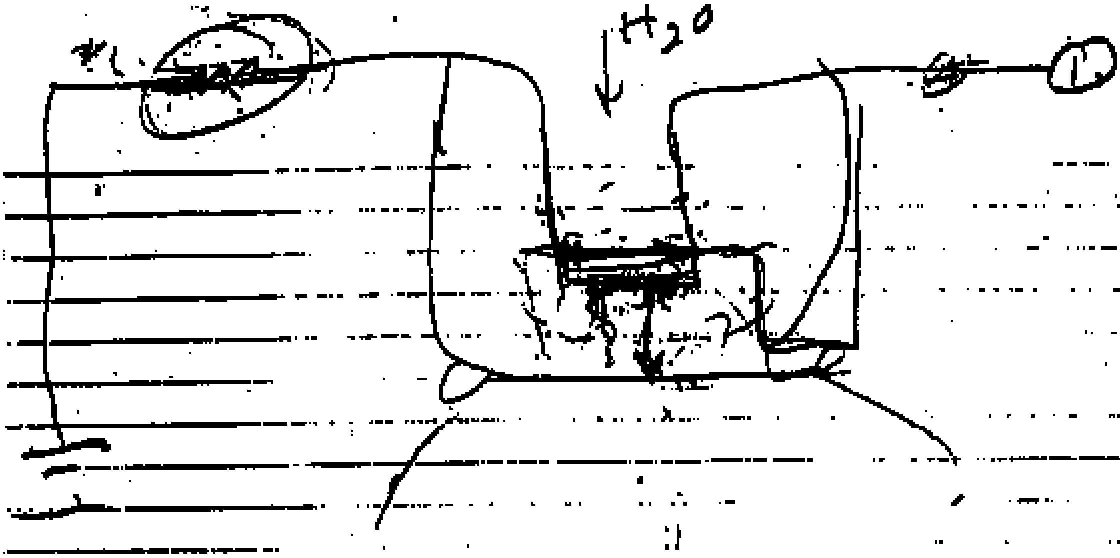
4) Terminal position = SPC — measure daily (Spec sheet) height
Terminal push out (Spec ?
Separation (Spec = 2 ?
Alignment (Spec = ?

5) IP Testing
Recent testing no problems

6)

7) Externally Testing
① Conductivity of brake fluid with diff water levels
In progress
② Understand conductivity of switch to ground with contaminated fluid
③ Brake fluid [illegible] in switch w/ the same failure on left arm
Done

8) Outside Ford
Land Rover (with ABS) hot only on ignition [illegible] [illegible]
5795 Anti-lock rear brake circuit
1 year



Corrosion – Internal terminals to case ground

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

Where is the HeateR:

1. Thru corroded ~~frame~~ spring arm contact & terminal
2. Thru remains of the spring arm between terminal
3. Thru remains of spring arm to case
4. Between terminals in terminal 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 quiet/water switches / brake fluid w/ water – new parts. 1993?
2. High temp plastic
3.

TAKING THE

R THANK YOU FOR YOUR TIME TO MEET WITH ME ON WEDS MAR 17.

FOR SOME FOUR MONTHS

R THE TEXAS INSTRUMENTS AUTOMOTIVE SENSORS & CONTROLS [illegible] TEAM HAS BEEN SUPPORTING THE FORD DIAGNOSTIC TECHNICAL TEAM WITH FACTS, DATA AND ANALYSIS REGARDING OUR BRAKE SWITCH [illegible] PRESSURE SWITCH. ANALYSIS [illegible] WE HAVE RESIDENT [illegible]

[illegible] THE LAST 6 CONSECUTIVE [illegible] TEAM [illegible]

INDICATING [illegible] STAND

MEETINGS (AND INTEND TO CONTINUE IN THIS ARENA ??) [illegible]

[illegible] IS A RECAP OF ACTIVITIES & [illegible]

INITIALLY THERE WAS SPECULATION THAT BRAKE FLUID LEAKAGE CONTRIBUTED TO THERMAL EVENTS [illegible]

R BOTH TI & FORD ATTEMPTED TO RECREATE THERMAL EVENTS WITH BRAKE FLUID IN SDS THE CAVITY WITHOUT SUCCESS.

[illegible] DURING THE NEXT TWO WEEKS TI WILL EXPERIMENT WITH "OLD" AGED BRAKE FLUID USING OUR MOST CURRENT RECREATION TEST METHOD

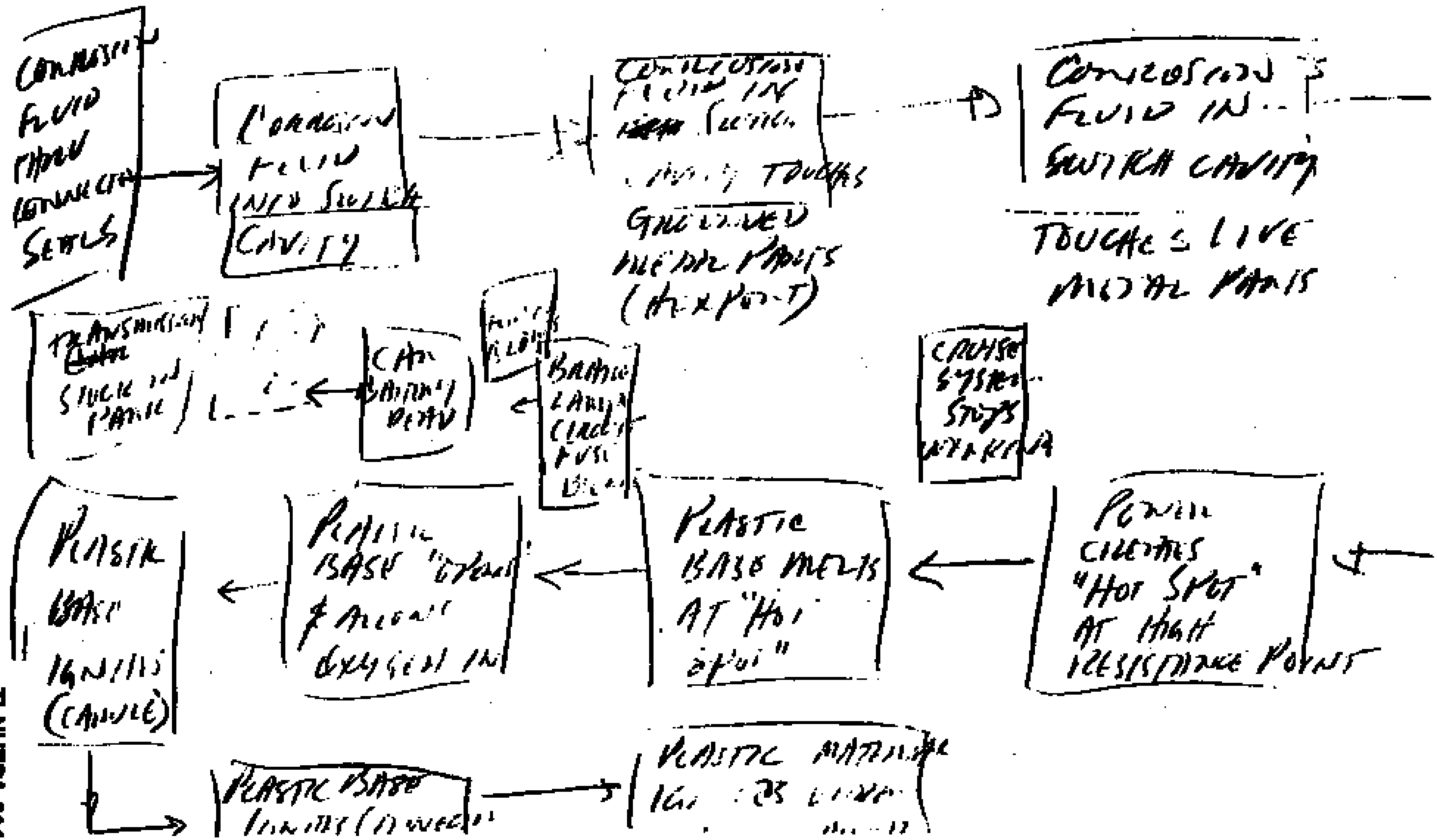
TI-NHTSA 014613

¶ WE ALSO INVESTIGATED SWITCH CAPABILITY (ACCELERATED SIMULATED LIFE TESTING) AND USING [illegible] ANALYTICAL TECHNIQUES DEMONSTRATED THE ABILITY OF THE 92-93-94 TOWN CAR BRAKE SWITCH TO CONSISTENTLY, CYCLE EXCEED 4 [illegible] SPECIFICATION.

PRELIMINARY FIELD RETURNS AND [illegible] SALVAGE YARD SAMPLES HAVE SHOWN IN SEVERAL [illegible] EROSION PROBLEMS WITH BRAKE FLUID LEAKAGE. HOWEVER, LAB TESTING AND NOT REPEATED [illegible] WITH "NEW" BRAKE FLUID LEAKAGE & "OLD" BRAKE FLUID IS BEING TESTED TODAY

SOME OF THESE SWITCHES EXHIBITED EVIDENCE OF BEING WORN OUT THROUGH EXPOSURE (EARLY INDICATIONS) TO MANY VEHICLE CYCLES AND THERE APPEARS TO BE A "APPLICATION CYCLE" QUANTITY [illegible] 18505.

Process Flow Diagram
"Corrosion" Potential Cause Flow Analysis



TI-NHTSA 014816

From Pinta

CREATE EVENTS

NOS 100%

FUSE DISCUSSION ← NET

Memphis -
NaCl NOT IN?!

BASE IN PRESENCE OF BRAKE FLUID

CAUSE →

* BEST SOLUTION -
NEW PRESSURE SWITCH

LOOK

Steve,

Quick update:

#1) Ranke Fluid Ω Test —

* 5% NaCl H_2O/BF w/ small iron dite
  14 volts @ 2.5 mA → ≈ 5.6 kΩ

* 80% NaCl H_2O/BF
  2.49 volts @ 21.25 mA → 114 Ω

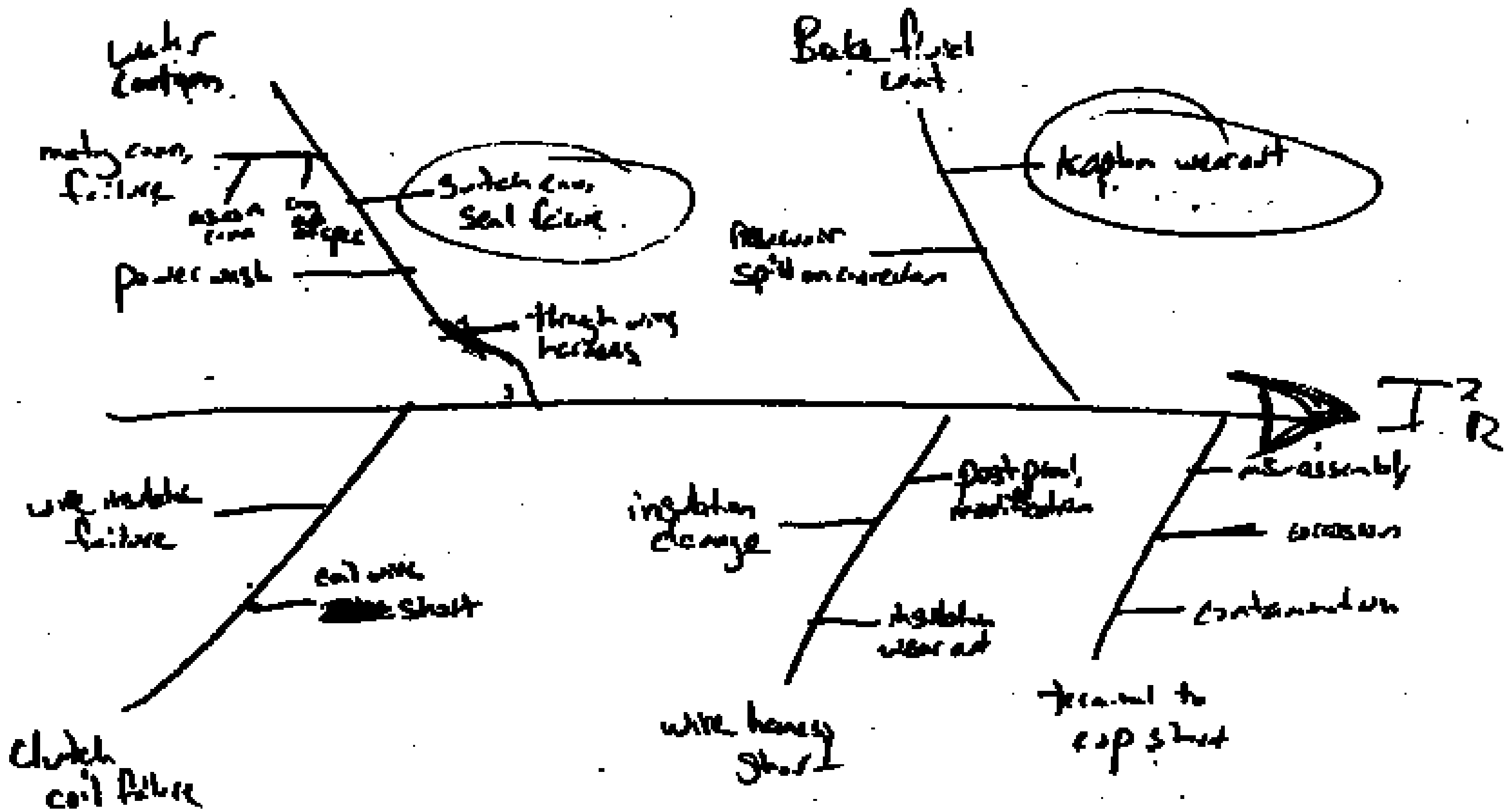
* 5% NaCl H_2O/BF w/ "lot" of metal
  14.0 volts @ .5 mA → 28 kΩ

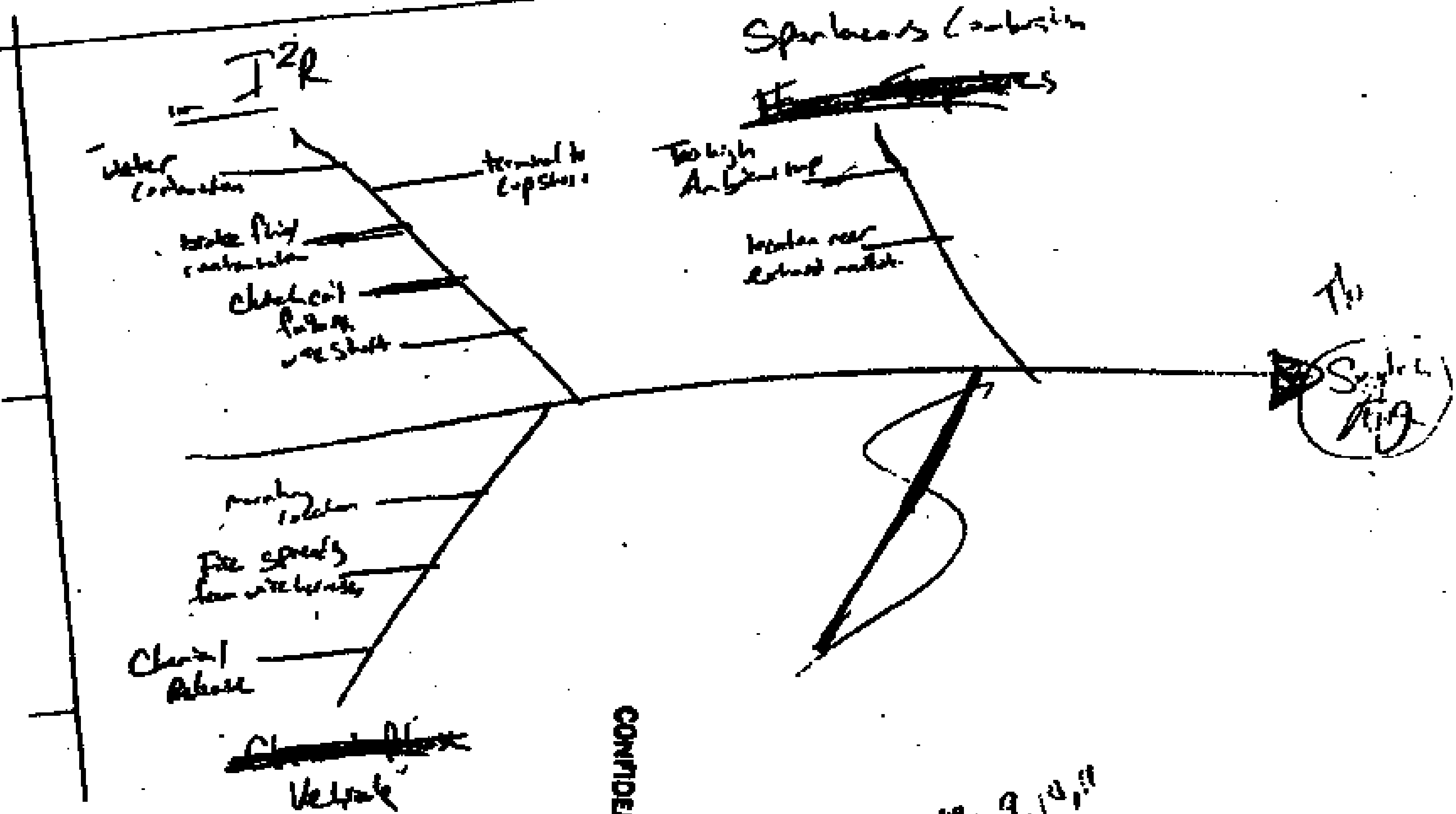
→ Conclusion:
The only way to get low Ω at high i is to fill switch with NaCl + H_2O. This results in electrolysis of solution [illegible] much heat. Can not get below about 100Ω w/o adding NaCl + H_2O.

#2) We had a couple more leakers today on the Weibull Test. Next data later today.

Call me.

Bay X3234


Bake fluid cont
Kapton wear out
Switch cav. seal failure
power wash
I²R
misassembly
corrosion
contamination
terminal to cap short
wire harness short
insulation damage
insulation wear out
clutch coil failure
coil wire short
wire module failure



CONFIDENTIAL

Countermeasure Actions

* MSG To Steve + [illegible] on 77PSF2-1 Base

* Mating Connector Exposed to [illegible] B.F. seals?

48 Parts total

* Corrosion Analysis of RTMs + Returned Parts.

	0%	5%
77PSF2-1 (3mm)		
Quiet w/ spec cal		
47PS		
Quiet w/ higher cal.		

controls
* Measure [illegible] [illegible] @ [illegible] may zork
* Randomize

* Strip Chart Recorder + Film * Current Flow [illegible] w/ + w/o clutch coils

*

~~[illegible]~~

- Launch date

Ford

Dec/Jan	4/month	? Nov 1991 - 57PS manual crimper ? Feb 1992 - Automated crimper
Feb	6	
March	24	
April	22	
May	20	
June	20	
Dec	6	

- Part met spec - impulse - Feb '92 - 6/6/92 - 7/10/92
- Daily Impulse test data? (Rating)
- SPC - crimp height
- Continuous improvement by Dec.?
- 80? - teardrop?

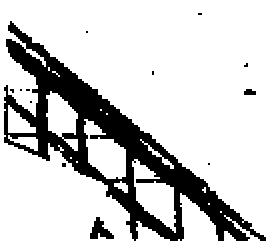
Norm LePointe
Ron Stevens
Steve Rivers
Fred Parker

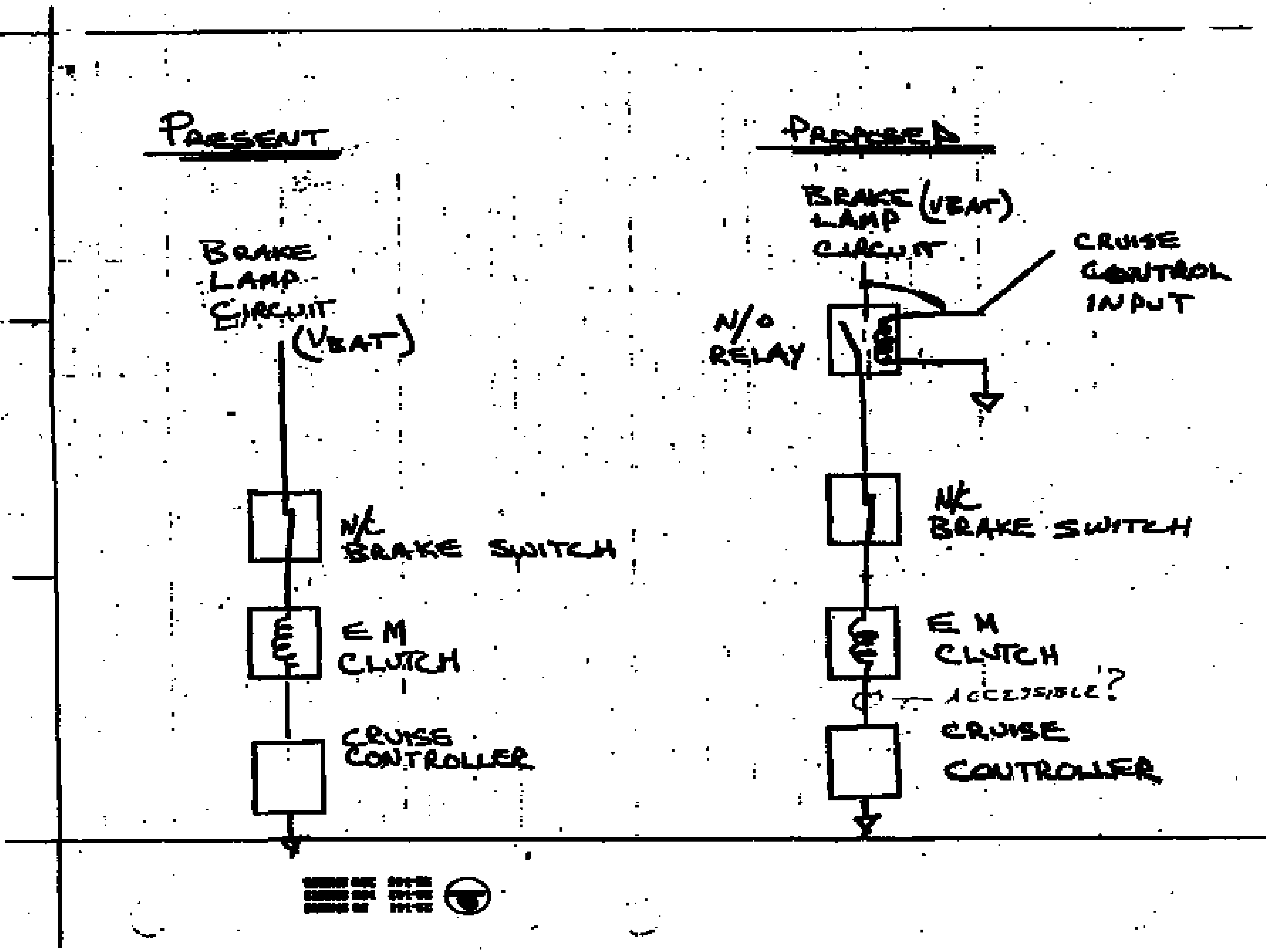
→ What were crimp pressures at launched

- create tear drop. - send

NHTSA - Meeting w/ther tomorrow or Friday (25K vehicles)
- Recall on Nov '91 → Nov 92 vehicles
- replace switch connector shell - silicone seal ? foam seal
- letters go out after 150K switches received

~$100/vehicle
Are we sharing the costs? - Norm LaPointe
"Not part of this discussion" - Fred P




PRESENT
BRAKE
LAMP
CIRCUIT
(VBAT)
N/C
BRAKE SWITCH
E M
CLUTCH
CRUISE
CONTROLLER
PROPOSED
BRAKE (VBAT)
LAMP
CIRCUIT
CRUISE
CONTROL
INPUT
N/O
RELAY
N/C
BRAKE SWITCH
E M
CLUTCH
ACCESSIBLE?
CRUISE
CONTROLLER

AZIZ RAHMAN

★

2 PIECES

NEED SWITCH

& INTO PRESSURE STATION

OFFSET KEYWAY FOR RENAULT

★ SAMPLES OF PARTS EX ZDK

NHTSA
PI
EA
517
552 9980

(13) CURRENT BRAKE FLUID

(14) BRAKE FLUID w/ CONTAMINATION

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

Collect '94 Samples

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

- Electrical system issue?

↳ Sensors from Ford... Any??

1/2 amps

100 milli amp Load

- Function by itself is not enough to light up..

- Seems to need a spark....

3 amps inductive / 15 amps inductive with brake fluid

[illegible]

3 SWITCHES FROM JINXYAN[illegible]
(TEXAS?) WHICH DO NOT SHOW
SIGNS OF ELECTRICAL DEGRADATION

☆ IS THIS SOMETHING NEW?

CORROSION ☆ CONTAMINATION THRU CON[illegible]
SEA[illegible]

☆ RUBBER BOOT AROUND
CONNECTOR BODY.....

— WISH WE COULD HAVE
EXTRA INSULATION IN SWITCHE[illegible]

☆ FUSE / LIMIT ELECTRICITY ✓

☆ — FIRE RETARD / HI TEMP ✓

Impulse Testing PC086

* Impulse Test is to monitor:
  - Disc Cracking issue
  - Spring breakage issue
  - Post function / performance

* Recommendations

- Q.C. Submissions

(1.0) 4 devices per lot for functional test per ES-F2VC-9F924-AA (or 9F924 ES spec.) 77PS
F37A - 3N824-AA 3N824 ES spec 87PS

actually higher freq than 3N824 ES.

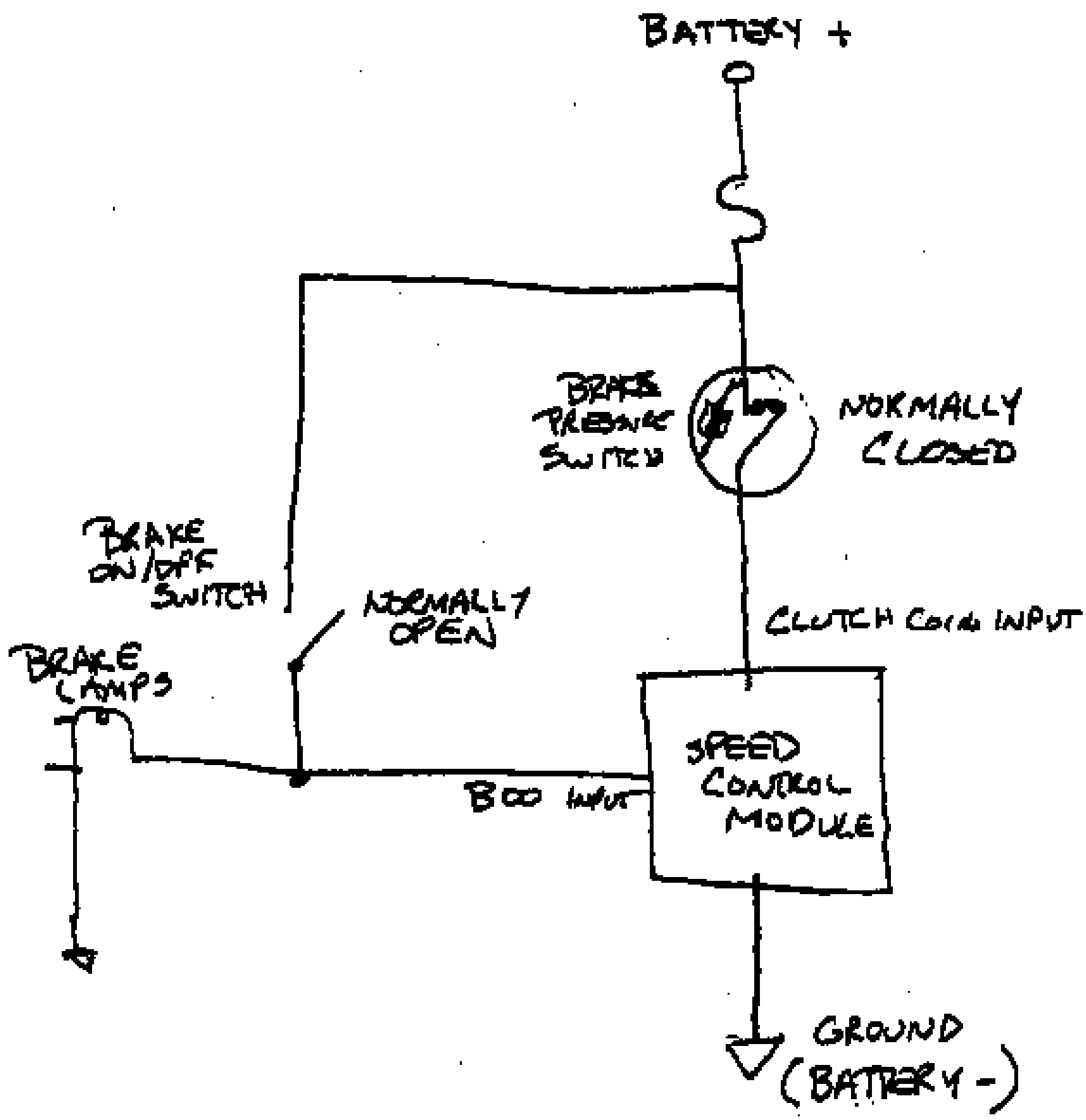
(2.0) 3 devices each quarter for impulse durability test per ES standard.

(3.0) 5 devices per operating day as follows, or upon major tool work on TRD:
- Base ASSY's newly mfg. that day.
- 87PSL2-2 sensor assemblies (worst case) = Dreher = Rimer = Fulton's
- offset calibration TRD by engineering.
- Devices must pass functional evaluation to 87PSL2-2 defaults prior to submission.
- Failures to engineering

(4.0)

TI-NHTSA 014828

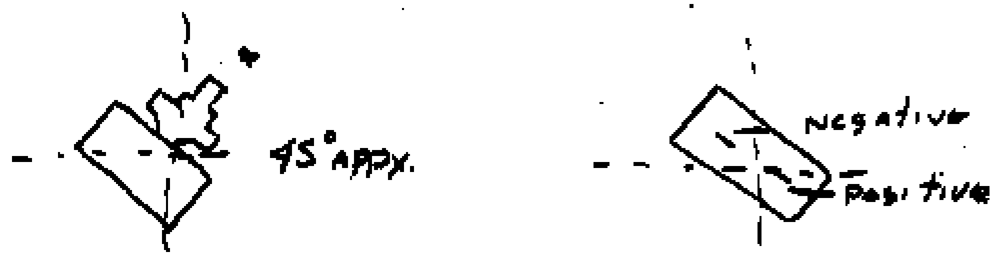
EXHIBIT NO. 8



BATTERY +
BRAKE PRESSURE SWITCH
NORMALLY CLOSED
BRAKE ON/OFF SWITCH
NORMALLY OPEN
BRAKE LAMPS
CLUTCH COIL INPUT
BOO INPUT
SPEED CONTROL MODULE
GROUND (BATTERY -)

Fire Retardant Plastic
Burn Test 2

77 PS



Device Filled at 10 min interval for 1st 30 min 5 min interval after 3
Data Logged every 5 sec.
1140 Device Filled every 2.5 min

TI-NHTSA 014628

(1.) Select which devices we want info on.

- Single device
- Family of devices. 775 vs. 770
- All devices.

(2.) Select time frame

- Start date / End date
- daily to Annually.

weekly data summary should be available ... back 52 weeks.

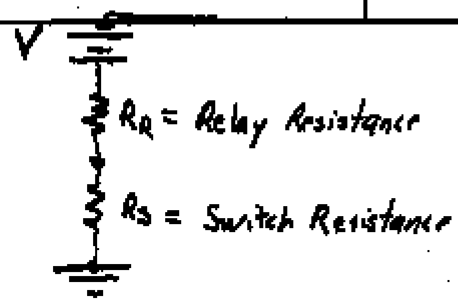
(3.) Select code line for ... produced or Total ...

... summaries which ... meet criteria.

(4.) Ability to exclude select codes from ... calculation. However, there should still be a report which itemizes all codes in a PARETO.

... actions

- Code list for ... 1-80 ...
- Design summary pages Chart / bars desired. ...
- PSM notified.



Ohm's law $\Rightarrow$ $i = \dfrac{V}{R_R + R_S}$

P_S = Power dissipated in switch $= i^2 R_S = \left(\dfrac{V}{R_R + R_S}\right)^2 R_S$

$P_S = V^2 \dfrac{R_S}{(R_R + R_S)^2} = V^2 R_S (R_R + R_S)^{-2}$

Let $u = R_S$, $v = (R_R + R_S)^{-2}$

$\therefore P_S = V^2 u v$

$\dfrac{dP_S}{du} = V^2 [u v' + u' v]$

$= V^2 \left[R_S [-2 (R_R + R_S)^{-3} \times 1] + (R_R + R_S)^{-2} \right]$

$= V^2 \left[\dfrac{-2 R_S}{(R_R + R_S)^3} + \dfrac{1}{(R_R + R_S)^2} \right]$

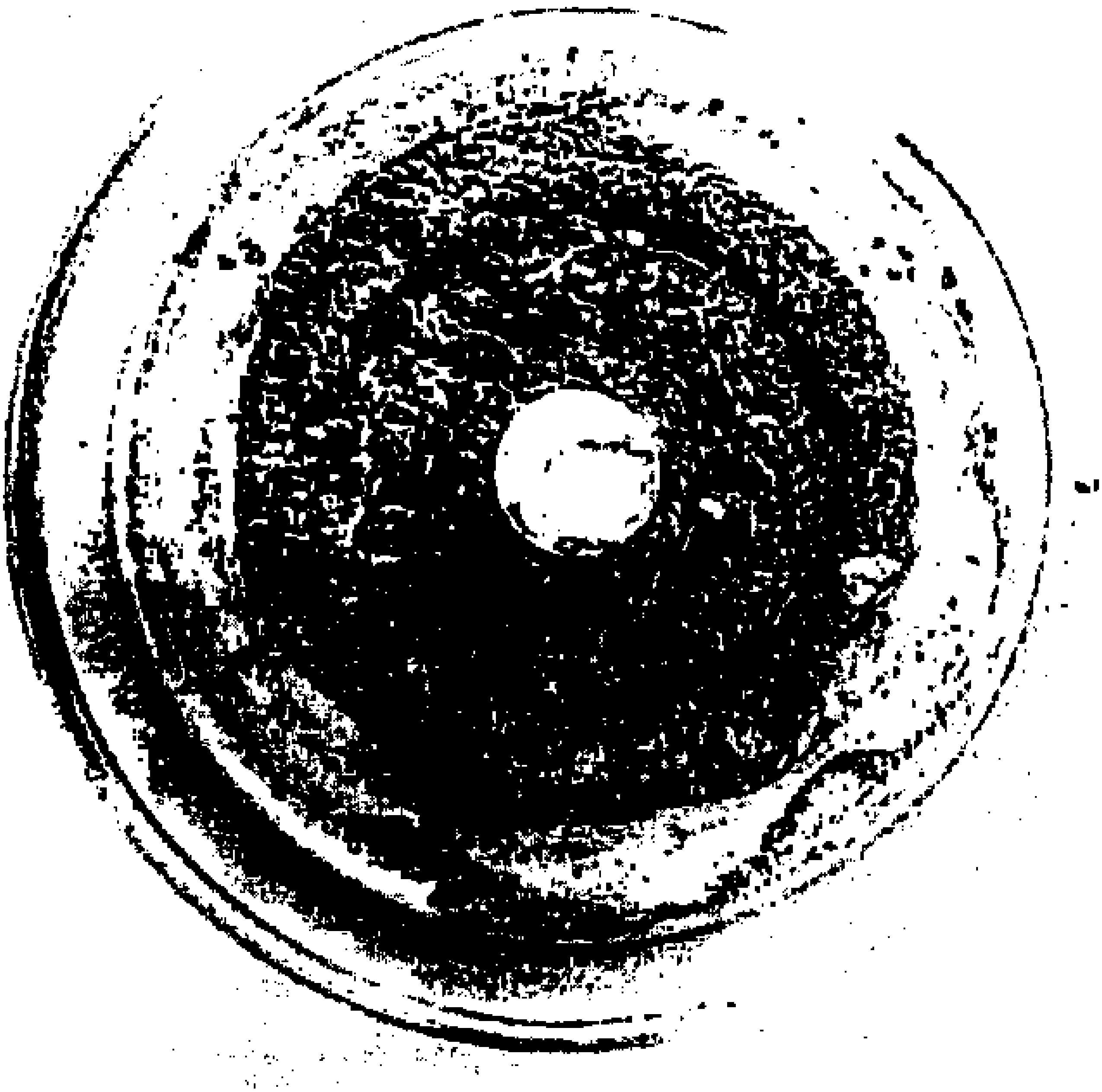
$= V^2 \left[\dfrac{-2 R_S}{(R_R + R_S)^3} + \dfrac{(R_R + R_S)}{(R_R + R_S)^3} \right]$

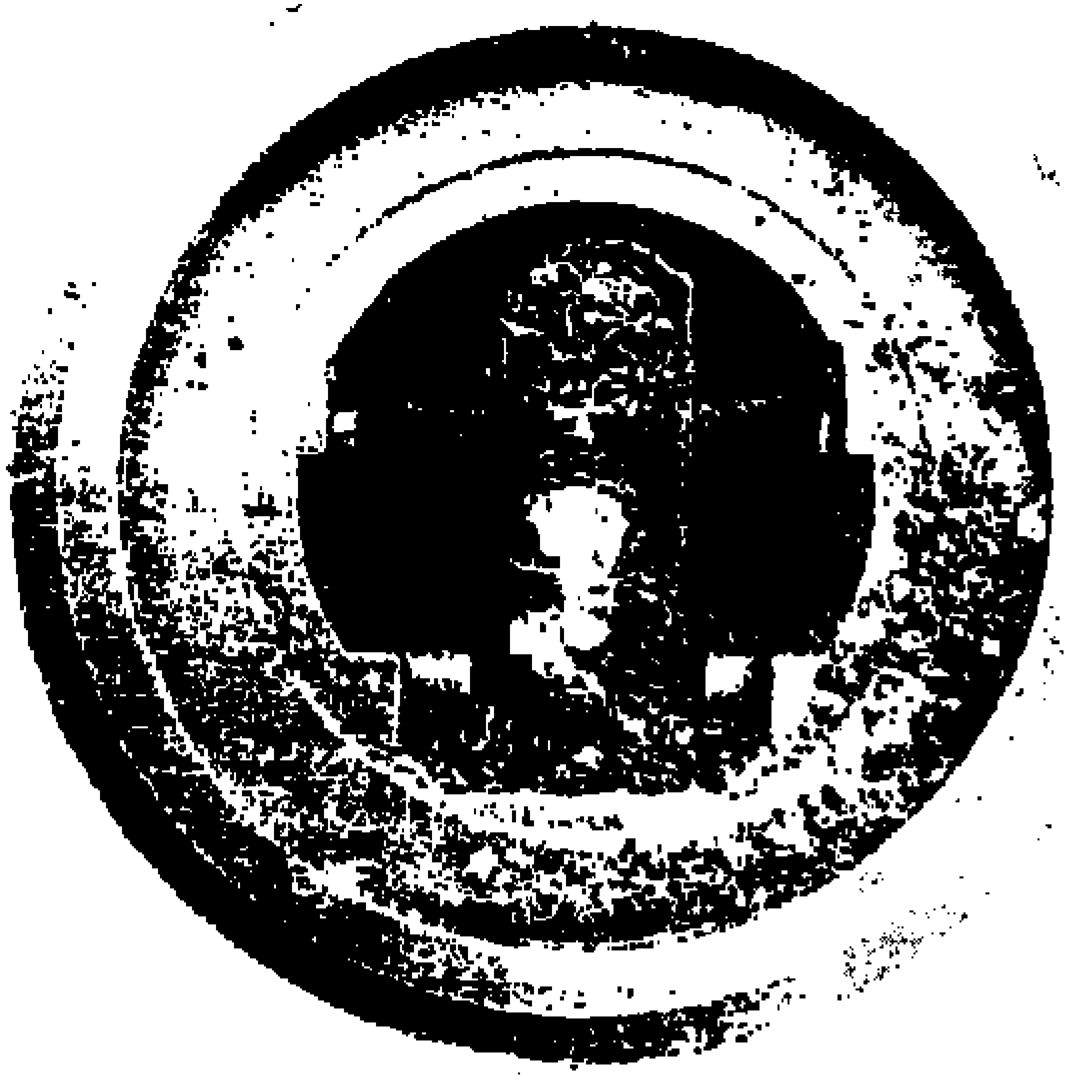
set $= 0$ $\quad = V^2 [-2 R_S + R_R + R_S] = 0$

$-R_S + R_R = 0 \Rightarrow R_R = R_S$

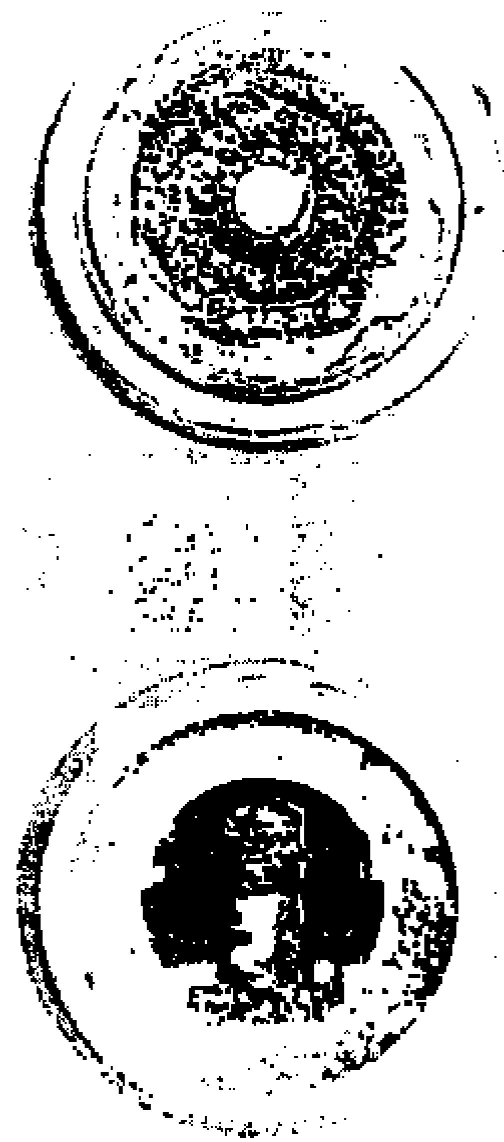
$\Rightarrow$ Max power when $R_S = R_R$

TI-NHTSA 014630

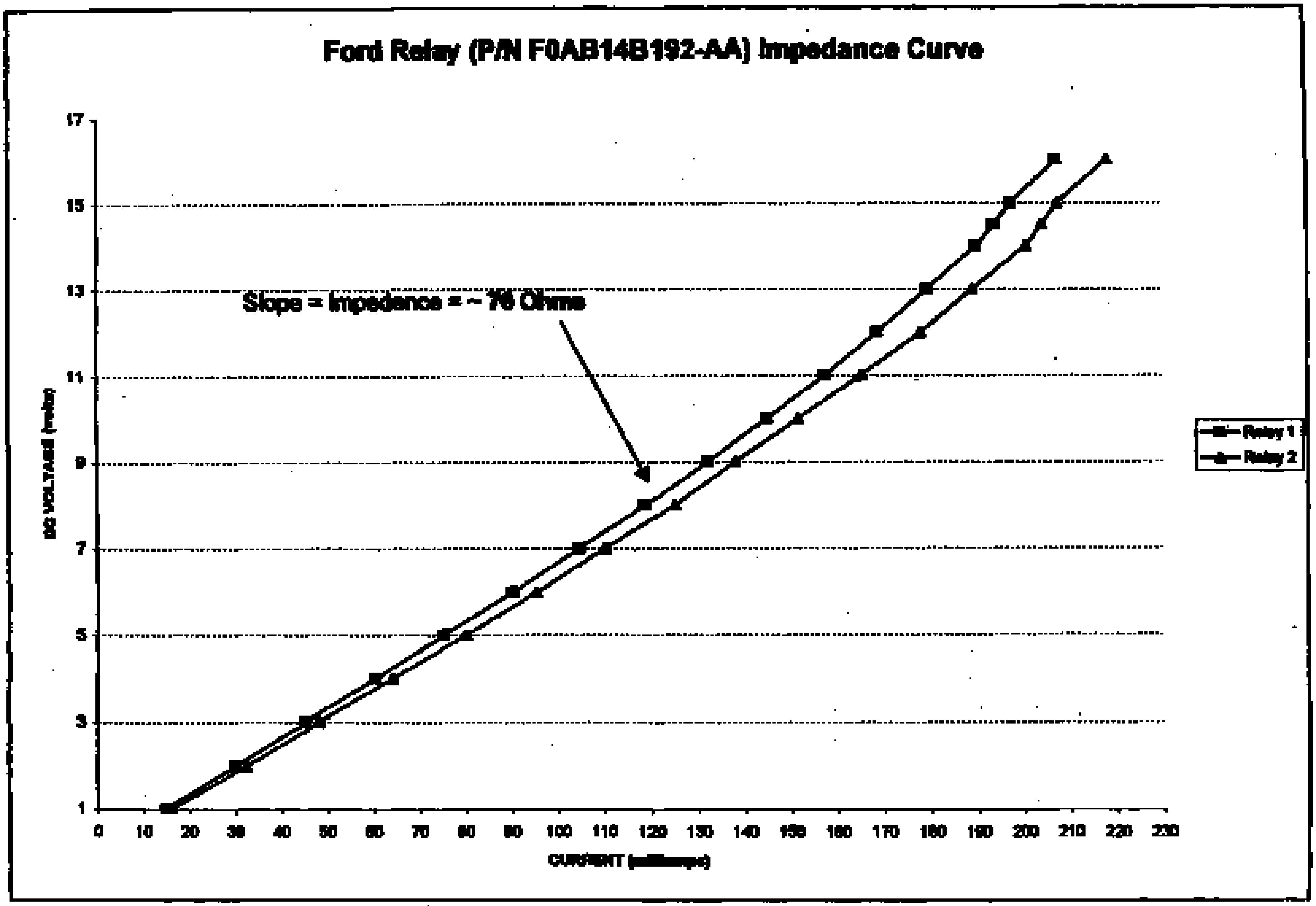




TI-NHTSA 014632



TI-NHTSA 014633



TI-NHTSA 014634

Relay # 1

Voltage (DC)	Current
1.0	14.86 mA
2.0	29.98 mA
3.0	45.20 mA
4.0	60.40 mA
5.0	75.30 mA
6.0	90.20 mA
7.0	104.8 mA
8.0	118.90 mA
9.0	132.10 mA
10.0	145.0 mA
11.0	157.4 mA
12.0	168.70 mA
13.0	179.40 mA
14.0	190.0 mA
14.5	194.0 mA
15.0	197.6 mA
16.0	207.5 mA

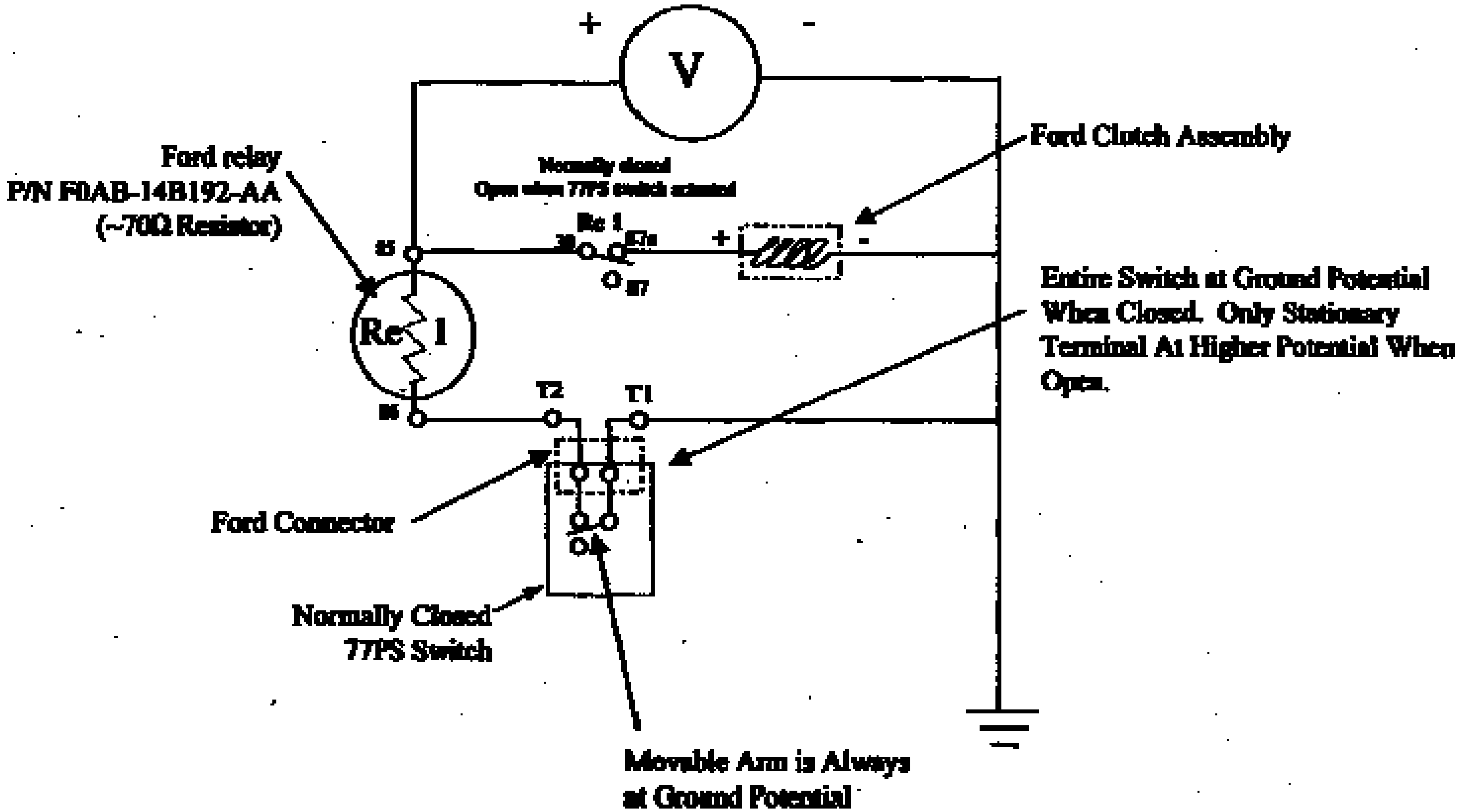
Relay # 2

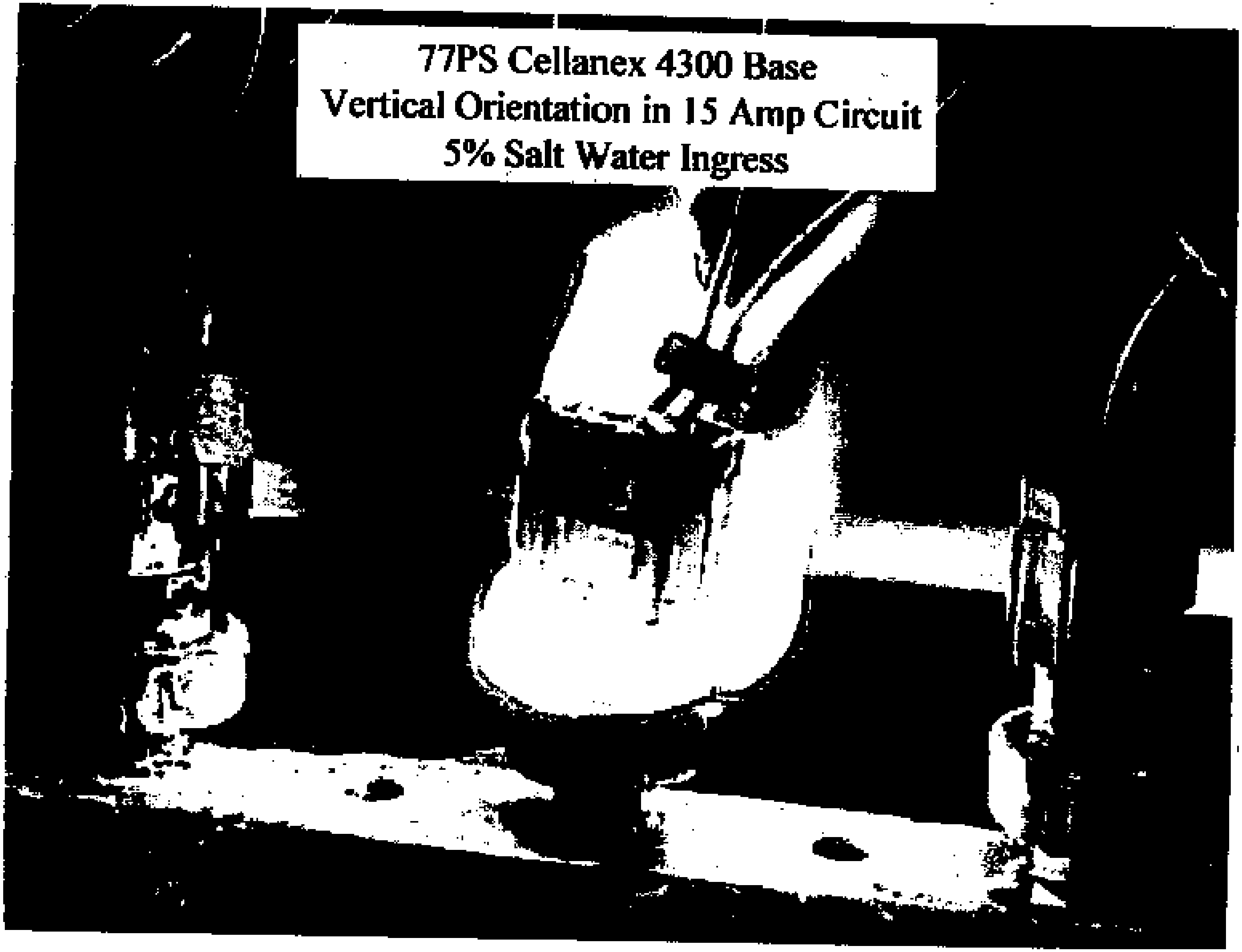
Voltage	Current
1.0	16.15 mA
2.0	32.43 mA
3.0	48.2 mA
4.0	64.1 mA
5.0	80.1 mA
6.0	95.4 mA
7.0	110.4 mA
8.0	125.0 mA
9.0	138.0 mA
10.0	151.8 mA
11.0	165.2 mA
12.0	178.0 mA
13.0	189.2 mA
14.0	200.8 mA
14.5	204.3 mA
15.0	207.7 mA
16.0	218.4 mA

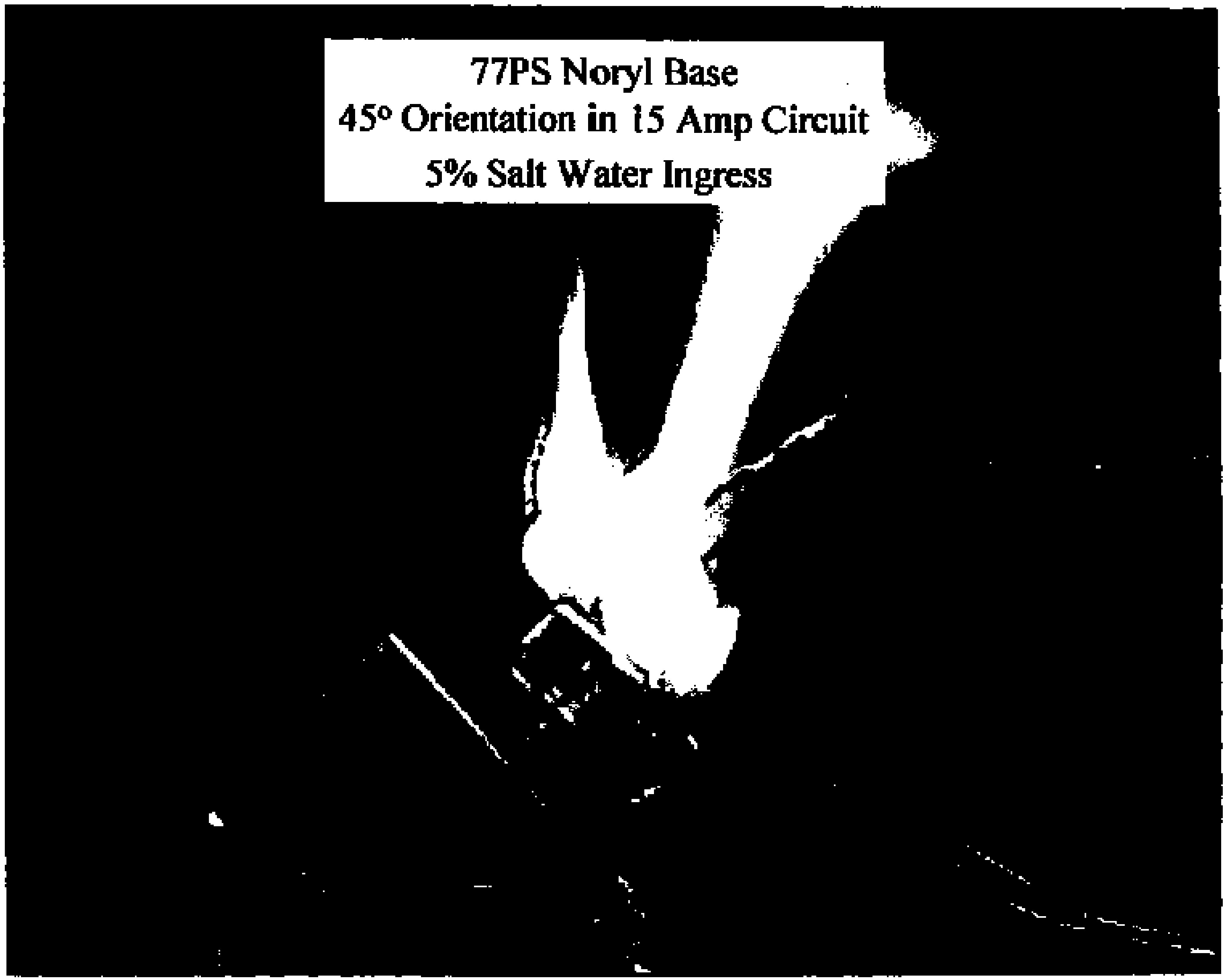
Note: Current drifts down as time passes and voltage held steady.

77PS Proposed Wiring Schematic

14 Volts DC

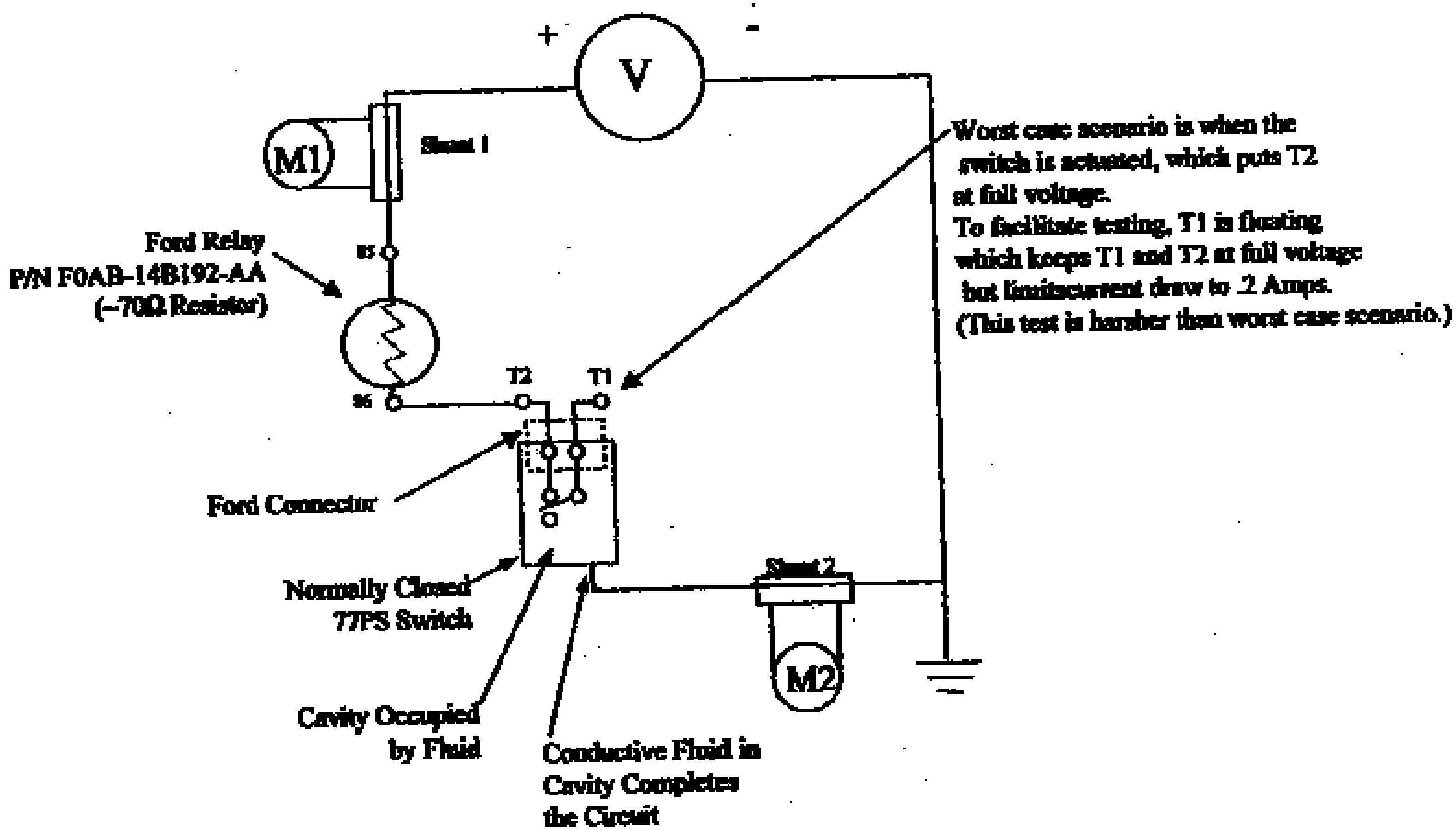



77PS Cellanex 4300 Base
Vertical Orientation in 15 Amp Circuit
5% Salt Water Ingress


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

200 mAmp Current Limit Circuit
Test Setup

14 Volts DC



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

Cellanex 4300 Base

Cellanex 3316 Base

TI-NHTSA 014840

Bryan, FYI

77ps_partlist.xls

77PS part differences.

	77PS2-1	77PS3-1	77PS4-1	
description	part number	part number	part number	EFFECT
CUP	27713-1	27713-1	27713-2	Spacer seat to bump height 4/1000 larger on -1 than on -2
HEXPORT	36900-1	36900-1	37867	4-1 C'Bore is .330 (.13 deeper than 2-1)
DISC	36656-27	36656-35	36656-35	"-35 measured height = .0275 +/- .0003"
(OR)	36656-28	36656-41	36656-41	"-41 measured height = .0291 +/- .0003"
				"-27 measured height = .0298 +/- .0003"
				"-28 measured height = .0310 +/- .0003"
				Crown height on 4-1 are ~ 2/1000 to 4/1000 lower than 2-1 (measured)
Base	46515-2	46515-3	46515-3	
DATE stamp	6280	7184	9046	

↑ 99

~~3-1 disc~~

3-1 = 4-1 disc in 2-1 cup

TI-NHTSA 014841

Be → not easily

→ Water in Brake Fluid, 1st tests   Not w/ Al

Cu

Cu → all samp...   even brass

New brake fluid used } not a lot of corrosion
Brake Fluid

white → Zinc Oxide
Green → copper (oxidation)
Red → Iron Oxide

Gently cleaned (can't analyze oil)

black plating removed from steels

Salt Bridge

potasium, sulfur

→ 4 Std [illegible] Natural

slow blow fuse

Running Air

Temp vs. time

4300

Potassium based fluids
distant Colors
Plastics

UL rated HB
Sustain fire
Ignite

Brake fluid salt water

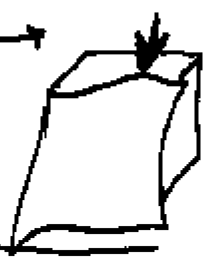
Dog bone

Noryl many colors

Ignition suspended

4300

Andy →



Town car → 4300
↘ 3316

8oz

8oz used brake fluid

[Brake fluid w/ Salt water]

Dow

Electrolysis
Corrosion }

Salt 200 m Amp
2 Amp

2 Amp
Amp
200 m Amp

New brake w/out inhibitors

4300

wheel side right rear brake

TI-NHTSA 014644

Kelsey Hayes: Calibration Data

77 PSL2-1 #21-300 File
—77 DATA—

	ACT	REL		ACT	REL	ACT	REL
	145.1	59.8		141.0	54.0	137.8	51.8
	138.5	48.8		140.3	42.8	132.5	50.7
	134.4	53.5		139.0	58.1	132.5	54.8
	135.6	48.2		133.6	50.4	139.2	49.8
	140.6	53.2		135.6	55.1	140.1	49.8
	141.9	51.0		132.9	58.1	144.4	57.8
	143.8	64.0		145.7	57.2	141.1	53.9
	133.9	52.0		140.7	50.3	147.2	55.7
	141.1	52.1		141.7	54.2	136.1	49.0
	140.0	53.8		137.2	45.4	139.9	55.4
	129.0	45.9		134.7	53.0	137.7	52.3
	137.4	54.3		136.6	59.8	133.6	39.7
	142.8	52.4		143.0	52.0	134.2	53.8
	135.6	59.2		146.6	49.2	136.8	57.7
	150.7	46.6	[illegible] *	162.1	57.8	153.4	53.3
	133.6	48.7		140.6	56.0	136.7	52.6
	140.0	51.7		128.9	50.1	140.7	59.2
>	142.0	45.6		144.3	62.5	139.0	44.6
	141.8	48.6		140.2	46.8	141.8	57.2
20 >	132.4	49.8		145.3	56.9	129.6	49.5
	135.1	53.2		138.8	50.4	135.3	51.8
	134.0	48.5		135.5	52.7	148.1	58.8
	144.6	47.7		142.9	52.7	147.1	55.2
	138.5	52.2		136.4	59.0	136.6	55.2
	147.9	58.1		127.9	51.4	133.3	53.1
	137.8	59.3		138.0	53.6	131.2	53.1
	135.5	58.1		138.7	51.1	136.8	50.1
	139.8	54.1		138.8	49.0	138.3	66.8
	139.3	47.8		137.6	53.3	138.4	54.9
	142.2	50.1		143.1	55.6	145.9	56.7
	137.8	58.5		141.3	51.1	142.9	51.8
	140.6	48.5	(70)	141.8	48.7	139.1	50.7
	135.4	59.1		142.9	48.6	143.8	53.4
	140.9	51.9		133.7	61.7	145.1	50.1
	153.0	57.4		142.2	51.4	131.9	51.6
>	142.1	58.2		140.4	50.7	140.1	53.0
	133.3	47.3		139.8	55.4	139.8	53.3
38 >	138.5	59.2		141.9	52.2	140.9	50.9

ACT	REL
143.6	55.8
143.9	47.8
137.7	45.2
139.2	53.8
142.1	56.0
139.3	46.7
138.2	48.4
130.1	48.4
138.0	48.4
141.1	55.7
138.3	54.6
137.9	55.2
134.6	57.4
136.3	50.2
139.9	56.2
147.0	53.1
141.8	59.5
135.0	43.9
134.7	60.8
139.8	50.9
143.5	56.7
133.4	56.4
136.7	48.9
138.5	48.9
138.1	57.8
(140) 140.7	50.7
138.0	46.9
140.8	55.6
129.4	[illegible].4
136.2	[illegible].4
151.0	53.7
140.0	49.3
141.8	54.7
139.0	50.5
141.5	56.8
130.6	52.3
137.4	49.3
133.2	64.7

ACT	REL
136.1	55.9
137.2	47.9
144.9	50.0
138.4	51.6
147.6	56.7
145.1	54.6
139.2	51.6
139.3	48.9
136.7	47.8
143.5	61.4
140.6	48.9
142.0	50.5
135.9	54.5
140.8	56.9
142.6	49.7
140.8	59.1
136.0	57.7
144.4	53.3
141.8	55.1
139.3	51.3
136.7	51.1
147.9	52.0
140.8	49.1
129.4	54.1
147.1	49.3
144.0	53.9
138.1	51.4
133.5	48.0
136.9	54.2
139.5	47.7
142.6	56.0
150.3	54.0
137.8	55.3
141.9	51.3
136.8	58.4
142.9	56.7
132.5	52.3
133.6	45.0

ACT	REL
139.2	53.2
137.2	56.5
144.0	60.9
143.6	55.0
141.2	49.9
142.6	50.8
142.3	47.8
139.3	43.4
146.9	52.5
142.1	55.3
143.6	49.2
140.3	47.9
144.8	53.9
138.7	51.9
135.6	54.1
139.7	52.8
139.7	53.0
145.3	54.6
144.8	56.4
(210) 144.0	51.1
144.7	56.4
141.8	57.1
146.2	54.5
135.5	57.4
143.2	49.6
139.3	49.6
139.9	60.7
135.0	54.1
145.2	50.1
139.9	61.8
143.4	50.2
142.1	54.0
138.2	57.2
150.5	54.6
144.6	59.1
137.0	50.6
138.2	53.3
140.1	52.7

ACT	REL	ACT	REL
141.5	56.0	144.8	52.8
131.9	54.9	139.9	54.7
146.4	52.5	136.5	51.2
141.3	57.9	149.1	50.2
136.5	55.7	145.4	60.8
145.7	55.6	135.1	46.2
140.8	54.6	141.2	61.7
146.4	49.9	139.1	53.9
138.5	47.6	140.4	53.9
134.1	45.5	135.6	52.9
140.5	54.1	130.2	50.5
133.3	55.0	149.0	55.8
139.8	47.7	138.0	45.0
138.9	55.1	133.2	52.4
138.8	52.5	→ 145.8	59.4
134.6	57.6	143.9	47.3
141.7	59.8	145.0	49.6
140.0	50.1	136.7	49.2
149.1	55.9		284
132.7	53.1		
140.2	51.1		
137.0	60.5		
139.2	58.5		
136.4	61.2		
145.4	52.2		
142.2	60.3		
140.9	[illegible]3.0		
134.3	[illegible]9.0		
135.3	51.7		
148.0	49.4		
137.1	59.0		
132.2	52.9		
142.4	55.6		
142.9	53.8		
138.6	52.0		
144.9	57.7		
140.7	52.5		
144.8	48.0		

38
7
266
+ 18
284
+ 20 (SENT 11-18)
~~30~~ 304 Dummies
− 1 H#
299

1 H4

yield 98.34

A1 .. H85

*

TI-NHTSA 014648

Suggested easily understood [illegible] in addition to report synopsis

TI-NHTSA 014649

TEST OBJECTIVE	TEST DESCRIPTION AND RESULTS	TEST CONCLUSION

LEVEL 1
Determine if a switch can ignite and what conditions are necessary for ignition.

Test 1
Brake Fluid with various concentrations of water
Results: No ignition occurred. No significant temperature rise observed. Current draw ranged from 0.5 mAmps to 5 mAmps over a period greater than (250) hours.

Test 2
Brake Fluid with various concentrations of water
Results: No ignition occurred. No significant temperature rise observed for a period greater than (250) hours.

Test 6
Heater Element
Results: Ignition occurred in both wet and dry 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 externally applied spark ignited the fumes which expelled the switch.

A switch ignition can occur under the following laboratory conditions:

- -5 Watts of electrical power is dissipated as heat into the switch. (Source of heat to melt plastic.)
- -A supply of Oxygen is available. (Hole burns through switch base)
- -An external spark is applied. (HyPot tester ignites fumes of switch)

LEVEL 2
Determine if an ignition can occur using only switch components and elements found in the switch environment.

(ie (5 watt [illegible] from Level 1

Test 6a
Corrosion tests
Results: No ignition occurred. No significant temperature rise observed. Current draw ranged from 0.5 mAmps to 5 mAmps over a period greater than (250) hours.

Brake fluid present in the contact cavity (wet device) and not present in the contact cavity (dry device).

Results:

Test 1 Results: No ignition occurred. No significant temperature rise observed. Current draw ranged from 0.5 mAmps to 5 mAmps over a period greater than (250) hours.

Test 2 Results: No ignition occurred. No significant temperature rise observed for a period greater than (250) hours.

Test 6 Results: Ignition occurred in both wet and dry devices.
<u>Wet device:</u> 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 externally applied spark ignited the fumes which engulfed the switch.
<u>Dry device:</u> The internal temperature of a wet switch reached over 1000°F. The switch base flopped over. The externally applied spark ignited the fumes which engulfed the switch.

Conclusion:

A switch ignition can occur under the following laboratory conditions:

-5 Watts of electrical power is dissipated as heat into the switch for (15) minutes. (Source of heat to melt plastic)
-A supply of Oxygen is available. (Hole burns through switch base).
-An external spark is applied. (Hy-Pot tester ignites fumes of switch).

Brake fluid does not contribute to the ignition process.

Level 2:

Objective:

Overall Objective: Determine if an ignition can occur using only switch components and elements found in the switch environment.

Metal filings + ? Test in Level 2.

how to include DOE

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.

Tests 7, 8, 10 and 13b Objective: Determine if switches meet specification, evaluate application and determine if switch seals leak brake fluid into the contact cavity

what results

Results: Results + conclusions ongoing. show good weibull plots.

Test 6a Results: A 5% NaCl in H_2O solution can corrode switch electrical components and cause an increase in electrical resistance. Repeated injections of the NaCl in H_2O solution, with the switch powered, can cause a switch ignition.

Tests 7 , 8 ,10 and 13b Results: Life cycle reliability DOE Diaphragm wear

Conclusion:

A switch ignition can occur under the following conditions:
5% NaCl in H_2O solution is injected, repeatedly, into contact cavity of a switch.
14 Volts is applied to the switch.
Hexport is grounded.
Current is limited at 15 Amps.

Level 3:

Objective:

Test 6b Objective: Understand the ignition process, determine the current path and establish a repeatable ignition method.

Results:

Test 6b Results: Multiple attempts at ignition, via injection of a 5% 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 method of switch ignition has been established. Based on hexport current measurements, the current path is from swtich terminals to hexport body. When a NaCl in H_2O solution is repeatedly injected into contact cavity of powered switches, electrolytic corrosion and the build up of deposits bridge an electric path from switch terminals to switch hexport body. When sufficient power is drawn through this bridge, 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:

Overall Objective: Compare and contrast variables influencing ignition using the established ignition method.

Test 13a Objective: Compare various fluids in the established ignition method.

Test 15 Objective: Compare the burn characteristics of various plastics as switch base material.

Test 15b Objective: Compare: 1) the probability of switch ignition in the vertical position verses a 45° orientation and 2) the probability of switch ignition as a function of rotational angle in the 45° orientation.

Results:

Test 13 Results: A switch filled with 5% NaCl in H_20 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.

Test 15 Results: Cellanex 4300 ignited 3 out of 5 attempts. Noryl ignited 2 out of 5 attempts. Zytel ignited 1out of 5 attempts.

Test 15b Results: Switch ignitions have occurred in different rotational angles.

Conclusion: Brake fluid is not ionic enough to cause the electrolytic corrosion and buildup of deposits necessary to create an ignition. An ionic rich fluid such as NaCl in H_20 is necessary to create an ignition.
Zytel subjectively performs best in burn tests when compared with Cellanex 4300, Cellanex 3316 and Noryl.
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: To test proposed relay circuit.

Results: (48) hours in worst case scenary.
(18) hours with impending burn switch.
Max power applied to heating element.

Conclusion: Cannot create an ignition in laboratory

Long term BF+I Test? in level 4? or 5?

TI-NHTSA 014662

TI-NHTSA 014653

TEST OBJECTIVE

TEST DESCRIPTION AND RESULTS

TEST CONCLUSION

LEVEL 1
Determine if a switch can ignite and what conditions are necessary for ignition.

Test 1
Brake Fluid with varied concentrations of water
Results: No ignition occurred. No significant temperature rise observed. Current draw ranged from 0.5 mAmps to 5 mAmps over a period greater than ([illegible]) hours.

Test 2
Brake Fluid with varied concentrations of water
Results: No ignition occurred. No significant temperature rise observed for a period greater than ([illegible]) hours.

Test 6
Heater Element
Results: Ignition occurred in both wet and dry devices. Wet device: The internal temperature of a wet device reached [illegible]°F. A hole burned through the base of the switch (close to the heating element). The externally applied spark ignited the fumes which engulfed the switch.

A switch ignition can occur under the following laboratory conditions:

- [illegible] Watts of electrical power is dissipated as heat into the switch. (Source of heat to melt plastic.)
- A supply of Oxygen is available. (Hole burns through switch base).
- An external spark is applied. (HyPot tester ignites fumes of switch).

LEVEL 2
Determine if an ignition can occur using only switch components and elements found in the switch environment.

Test [illegible]
Corrosion tests
Results: No ignition occurred. No significant temperature rise observed. Current draw ranged from 0.5 mAmps to 5 mAmps over a period greater than ([illegible]) hours.

Test 6a Results: A 5% NaCl in H_2O solution can corrode switch electrical components and cause an increase in electrical resistance. Repeated injections of the NaCl in H_2O solution, with the switch powered, can cause a switch ignition.

Tests 7 , 8 ,10 and 13b Results: Life cycle reliability DOE Diaphragm wear

Conclusion:

A switch ignition can occur under the following conditions:
5% NaCl in H_2O solution is injected, repeatedly, into contact cavity of a switch.
14 Volts is applied to the switch.
Hexport is grounded.
Current is limited at 15 Amps.

Level 3:

Objective:

Test 6b Objective: Understand the ignition process, determine the current path and establish a repeatable ignition method.

Results:

Test 6b Results: Multiple attempts at ignition, via injection of a 5% 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 method of switch ignition has been established. Based on hexport current measurements, the current path is from switch terminals to hexport body. When a NaCl in H_2O solution is repeatedly injected into contact cavity of powered switches, electrolytic corrosion ~~and the build-up of deposits bridge an electric path from switch terminals to switch hexport body~~. When sufficient power is drawn through ~~this bridge, 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:

Overall Objective: Compare and contrast variables influencing ignition using the established ignition method.

Test 13a Objective: Compare various fluids in the established ignition method.

Test 15 Objective: Compare the burn characteristics of various plastics as switch base material.

Test 15b Objective: Compare: 1) the probability of switch ignition in the vertical position verses a 45° orientation and 2) the probability of switch ignition as a function of rotational angle in the 45° orientation.

Results:

Test 13 Results: A switch filled with 5% NaCl in H_20 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.

Test 15 Results: Cellanex 4300 ignited 3 out of 5 attempts. Noryl ignited 2 out of 5 attempts. Zytal ignited 1out of 5 attempts. All using a NaCl and water solution

Test 15b Results: Switch ignitions have occurred in different rotational angles.

Conclusion: Brake fluid is not ionic enough to cause the electrolytic corrosion and buildup of deposits necessary to create an ignition. An ionic rich fluid such as NaCl in H_20 is necessary to create an ignition because of its significantly higher conductivity.
~~Zytal subjectively performs best in burn tests when compared with Cellanex 4300, Cellanex 3316 and Noryl.~~
Switch ignition does not appear to be sensitive to vertical orientation verses 45° orientation nor to rotational angle in the 45° orientation.

What does this mean

Level 5

Objective:

Test 16 Objective: To test proposed relay circuit.

Results: (48) hours in worst case scenary.
(18) hours with impending burn switch.
Max power applied to heating element.

Needs work

Discuss how much is max power

Conclusion: Cannot create an ignition in laboratory

Power is limited and not enough to create ignition

Test of switch on the edge of ignition?

TI-NHTSA 014656

Test 7 Objective: Determine if switches meet cycle life specification.

Test 15a Objective: Determine if long time switch exposure to brake fluid can lead to an ignition.

Results:

Test 6a Results: A 5% NaCl in H_20 solution can corrode switch electrical components and cause an increase in electrical resistance. Repeated injections of the NaCl in H_20 solution, with the switch powered, can cause a switch ignition.

Test 6c Results: Brake fluid with metal shavings does not conduct significant current.

Test 7 Results: Life cycle testing showed that switches exceeded cycle life specification.

Add PPAP from 11-97

Test 15a Results: Test is ongoing. Results to date show no increase in conductivity of both new and used brake fluid. After more than 350 hours of testing, current draw on each device is less than 20 mAmps.

Conclusion:

A switch ignition can occur under the following conditions:
5% NaCl in H_20 solution is injected into contact cavity of a switch.
14 Volts is applied to the switch.
Hexport is grounded.
Current is limited at 15 Amps.

Brake fluid with metal shavings is not conductive enough to create an ignition.

Switches meet engineering cycle life specification.

Long duration switch exposure to brake fluid has had no measurable effect on switches. After more than (350) hours of testing, current draw remains orders of magnitude below the levels needed to create ignition as simulated in laboratory experiments.

Level 3:

Objective:

Test 6b Objective: Understand the ignition process, determine the current path and establish a repeatable ignition method.

Results:

Test 6b Results: Multiple attempts at ignition, via injection of a 5% NaCl in H_20 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 has been established. Based on hexport current measurements, the current path is from switch terminals to hexport body.
When a NaCl in H_20 solution is repeatedly injected into the contact cavity of powered switches, electrolytic corrosion of the switch terminals 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:

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

Test 13a Objective: Compare various fluids in the established ignition method.

Test 15 Objective: Compare the burn characteristics of various plastics as switch base material.

Test 15b Objective: Compare: 1) the probability of switch ignition in the vertical position verses a 45° orientation and 2) the probability of switch ignition as a function of rotational angle in the 45° orientation.

Results:

Test 13 Results: A switch filled with 5% NaCl in H_20 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.

Test 15 Results: When 5% NaCl in H_2O was injected into switches with different base materials, the following results were obtained: Celanex 4300 ignited 3 out of 5 attempts. Noryl ignited 2 out of 5 attempts. Zytel ignited 1 out of 5 attempts.

Test 15b Results: Switch ignitions have occurred in different rotational angles.

Conclusion:

Brake fluid is not conductive enough to cause the electrolytic corrosion and necessary to create an ignition. Because of its' significantly higher conductivity, an ionic rich fluid such as NaCl in H_2O is necessary to cause an ignition. 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: To test proposed relay circuit.

Results:

A switch was injected with 5%Nacl in H_2O solution and placed in a 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 intact.
A 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 placed in the proposed relay circuit for(18) hours where it drew 160 mAmps, showed no visible activity and did not result in a burn. 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 the switch and 0.75 Watts of power was dumped into 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 not enough power to cause electrolytic corrosion or significant switch terminal heating, which is necessary for ignition. In previous tests, using a resistor as the heating element, approximately 5 Watts of power was necessary to create and ignition. There is not enough power in the proposed circuit to create ignition.

TI-NHTSA 014658

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

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

<u>Level 1:</u>

Objective:

Overall objective: Determine if a switch ignition can occur in the laboratory and what conditions are required to create an ignition.

Test 1 Objective: Determine if switch ignition can occur under the following conditions:
Switch contact 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.

Test 2 Objective: Determine if switch ignition can occur under the following conditions:
Switch contact flooded with brake fluid mixed with varying amounts of % H_2O.
14 volts applied to one terminal, second terminal connected to a 14 Ω resistor tied to ground. (1 Amp load across switch terminals).
Switch hexport electrically grounded.

Test 6 Objective: Determine if switch ignition can occur under the following conditions:
Heater element installed in contact cavity of the switch.
Power applied to the heating element until plastic base failure.

TI-NHTSA 014659

External spark applied to fumes from burn.
Brake fluid present in the contact cavity (wet device) and not present in the contact cavity (dry device).

Results:

Test 1 Results: No ignition occurred. No significant temperature rise observed. Current draw ranged from 0.5 mAmps to 5 mAmps over a period greater than (250) hours.

Test 2 Results: No ignition occurred. No significant temperature rise observed for a period greater than (250) hours.

Test 6 Results:Ignition occurred in both wet and dry 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 externally applied spark ignited the fumes which engulfed the switch.
Dry device: The internal temperature of a wet switch reached over 1000°F. The switch base flopped over. The externally applied spark ignited the fumes which engulfed the switch.

Conclusion:

A switch ignition can occur under the following laboratory conditions:

-5 Watts of electrical power is dissipated as heat into the switch for (15) minutes using a heating wire. (Source of heat to melt plastic)
-A supply of Oxygen is available. (Hole burns through switch base).
-An external spark is applied. (Hy-Pot tester ignites fumes of switch).

Brake fluid does not contribute to the ignition process

Level 2:

Objective:

Overall Objective: Determine if an 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.

Test 6c Objective: Determine if brake fluid with metal shavings is conductive enough to create an ignition.

Send test log w/ 6C update

Doug. Oberski

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: Refer to Test Log - - -

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

Level 1:

Objective:

Overall objective: Determine if a switch ignition ~~will~~ can occur in the lab and what conditions are necessary to create an ignition.

Test 1 Objective: Determine if switch ignition can occur under the following conditions:
Switch contact 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.

Test 2 Objective: Determine if switch ignition can occur under the following conditions:
Switch contact flooded with brake fluid mixed with varying amounts of % H_2O.
14 volts applied to one terminal, second terminal connected to a 14 Ω resistor tied to ground. (1 Amp load across switch terminals).
Switch hexport electrically grounded.

Test 6 Objective: Determine if switch ignition can occur under the following conditions:
Heater element installed in contact cavity of the switch.
Power applied to the heating element until plastic base failure.
External spark applied to fumes from burn.

Brake fluid present in the contact cavity (wet device) and not present in the contact cavity (dry device).

Results:

Test 1 Results: No ignition occurred. No significant temperature rise observed. Current draw ranged from 0.5 mAmps to 5 mAmps over a period greater than (250) hours.

Test 2 Results: No ignition occurred. No significant temperature rise observed for a period greater than (250) hours.

Test 6 Results: Ignition occurred in both wet and dry devices.
<u>Wet device:</u> 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 externally applied spark ignited the fumes which engulfed the switch.
<u>Dry device:</u> The internal temperature of a wet switch reached over 1000°F. The switch base flopped over. The externally applied spark ignited the fumes which engulfed the switch.

Conclusion:

A switch ignition can occur under the following laboratory conditions:

-5 Watts of electrical power is dissipated as heat into the switch for (15) minutes (using a heater wire)
(Source of heat to melt plastic)
-A supply of Oxygen is available. (Hole burns through switch base).
-An external spark is applied. (Hy-Pot tester ignites fumes of switch).

Brake fluid does not contribute to the ignition process

Level 2:

Objective:

Overall Objective: Determine if an 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.

Test 6c Objective: Determine if brake fluid with metal shavings is conductive enough to create an ignition.

Test 7 Objective: Determine if switches meet cycle life specification.

TI-NHTSA 014662

~~Tests 8, 10 and 13b Objective: Characterize switches using a DOE.~~

Test 15a Objective: Determine if long time switch exposure to brake fluid can lead to an ignition.

Results:

Test 6a Results: A 5% NaCl in H_2O solution can corrode switch electrical components and cause an increase in electrical resistance. Repeated injections of the NaCl in H_2O solution, with the switch powered, can cause a switch ignition.

Test 6c Results: Brake fluid with metal shavings does not conduct significant current.

Test 7 Results: Life cycle testing showed that switches ~~met~~ exceeded cycle life specification. ~~First leak on impulse [illegible] 228,000 [illegible]~~ ~~[illegible]~~.

~~Tests 8, 10 and 13b Results: DOE results under investigation.~~

Test 15a Results: Test is ongoing. Results to date show no increase in conductivity of both new and used brake fluid. After (x hours current draw all devices is less than 20 mA.

Conclusion:

A switch ignition can occur under the following laboratory conditions:
5% NaCl in H_2O solution is injected into contact cavity of a switch.
14 Volts is applied to the switch.
Hexport is grounded.
Current is limited at 15 Amps.

Brake fluid with metal shavings is not conductive enough to create an ignition.

Switches meet engineering cycle life specification.

Long duration switch exposure to brake fluid has had no measurable effect on switches. ~~Brake fluid appears to be benign to the switch.~~ After x hours current draw is significantly below the required level need for switch ignition based on the laboratory test results

Level 3:

Objective:

Test 6b Objective: Understand the ignition process, determine the current path and establish a repeatable ignition method.

Results:

Test 6b Results: Multiple attempts at ignition, via injection of a 5% NaCl in H_20 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 method of switch ignition has been established. Based on hexport current measurements, the current path is from switch terminals to hexport body. When a NaCl in H_20 solution is repeatedly injected into contact cavity of powered switches, electrolytic corrosion of the switch terminals 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:

Overall Objective: Compare and contrast variables influencing ignition using the established ignition method.

Test 13a Objective: Compare various fluids in the established ignition method.

Test 15 Objective: Compare the burn characteristics of various plastics as switch base material.

Test 15b Objective: Compare: 1) the probability of switch ignition in the vertical position verses a 45° orientation and 2) the probability of switch ignition as a function of rotational angle in the 45° orientation.

Results:

Test 13 Results: A switch filled with 5% NaCl in H_20 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.

Test 15 Results: When 5% NaCl in H_20 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 1out of 5 attempts , ~~but the power required to reach ignition was higher than that of other materials tested.~~

Test 15b Results: Switch ignitions have occurred in different rotational angles.

Conclusion:

Brake fluid is not ~~ionic~~ conductive enough to cause the electrolytic corrosion and necessary to create an ignition. Because of its' significantly higher conductivity, an ionic rich fluid such as NaCl in H_2O is necessary to cause an ignition.
~~Zytel had a lower burn probably than other materials tested. It also took more power, thus higher temperatures, to ignite Zytel than other materials tested~~ .
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: To test proposed relay circuit.

Results:

A switch was injected with 5%Nacl in H_2O solution and placed in a proposed current limiting circuit for (48) hours. The current drew remained constant at 180 mAmps throughout the test. There was no activity observed and the contact arm remained intact.
A 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 placed in the proposed relay circuit for(18) hours where it drew 160 mAmps, showed no visible activity and did not result in a burn. 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 the switch and 0.75 Watts of power was dumped into 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 not enough power to cause ~~electrolytic corrosion~~ necessary for ignition. In previous tests, using a resistor as the heating element, approximately 5 Watts of power was necessary to create and ignition. There is not enough power in the proposed circuit to create ignition.

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:

Not sure about this "level" thing for synopsis

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

Level 1:

Objective:

Overall objective: Determine if a switch ignition will occur and what conditions are necessary to create an ignition.

Maybe insert descriptive title for each test

Reference test log sheet

Test 1 Objective: Determine if switch ignition can occur under the following conditions:
Switch contact 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.

Test 2 Objective: Determine if switch ignition can occur under the following conditions:
Switch contact flooded with brake fluid mixed with varying amounts of % H_2O.
14 volts applied to one terminal, second terminal connected to a 14 Ω resistor tied to ground. (1 Amp load across switch terminals).
Switch hexport electrically grounded.

Test 6 Objective: Determine if switch ignition can occur under the following conditions:
Heater element installed in contact cavity of the switch.
Power applied to the heating element until plastic base failure.
External spark applied to fumes from burn.

Brake fluid present in the contact cavity (wet device) and not present in the contact cavity (dry device).

Results:

Test 1 Results: No ignition occurred. No significant temperature rise observed. Current draw ranged from 0.5 mAmps to 5 mAmps over a period greater than (250) hours.

Test 2 Results: No ignition occurred. No significant temperature rise observed for a period greater than (250) hours.

Test 6 Results: Ignition occurred in both wet and dry devices.
<u>Wet device:</u> 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 externally applied spark ignited the fumes which engulfed the switch.
<u>Dry device:</u> The internal temperature of a wet switch reached over 1000°F. The switch base flopped over. The externally applied spark ignited the fumes which engulfed the switch.

Conclusion:

A switch ignition can occur under the following laboratory conditions:

-5 Watts of electrical power is dissipated as heat into the switch for (15) minutes. (Source of heat to melt plastic)
-A supply of Oxygen is available. (Hole burns through switch base).
-An external spark is applied. (Hy-Pot tester ignites fumes of switch).

Brake fluid does not contribute to the ignition process

Level 2:

Objective:

Overall Objective: Determine if an ignition can occur using only switch components and elements found in the switch environment.

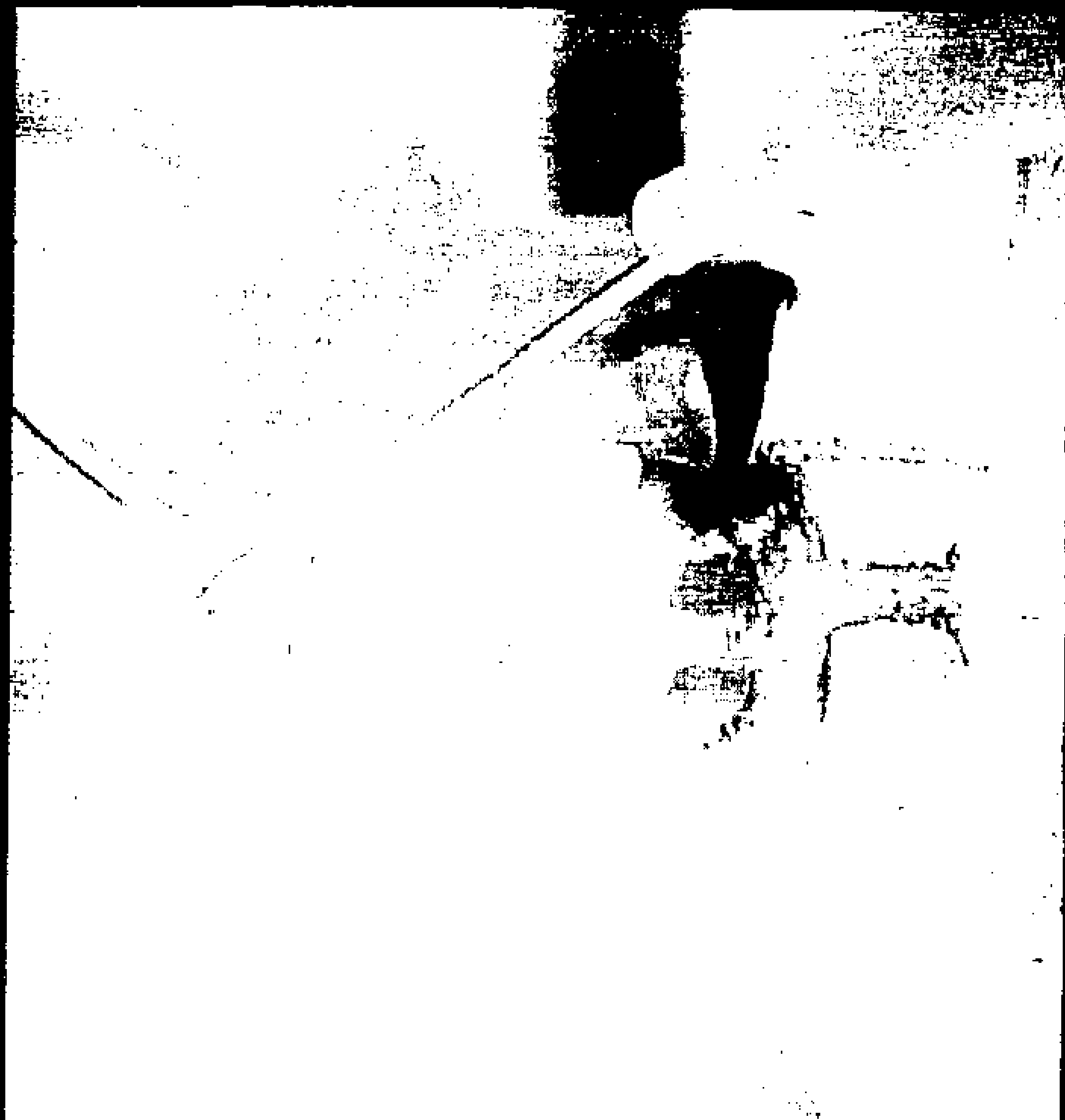
Test 6a Objective: Determine if corrosive degradation of switch electrical components can cause an increase in electrical resistance (and thus a source of heat) in the switch which may lead to an ignition.

DOE
fun to
include

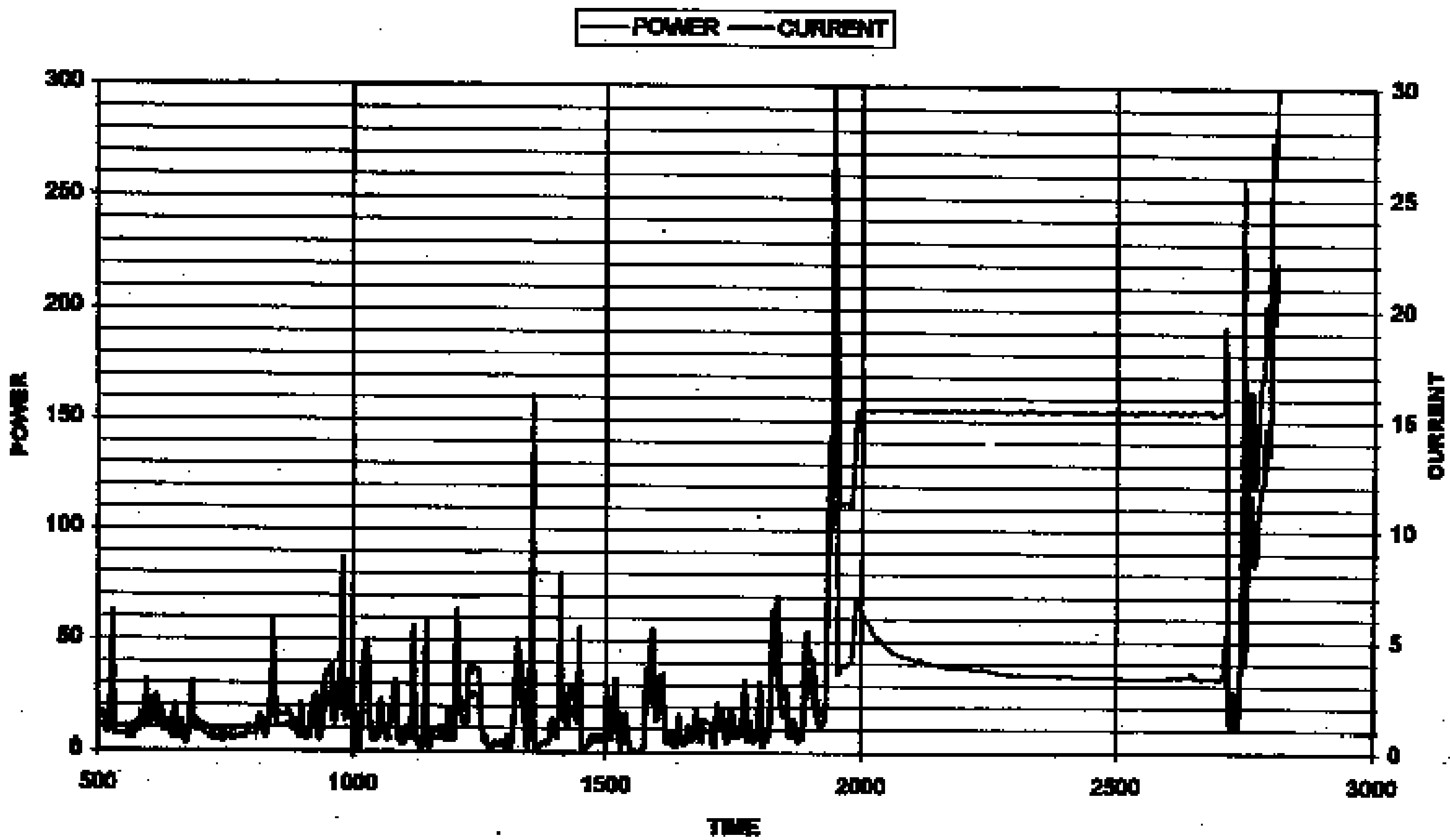
Tests 7, 8, 10 and 13b Objective: Determine if switches meet specification, evaluate application and determine if switch seals leak brake fluid into the contact cavity

Results:

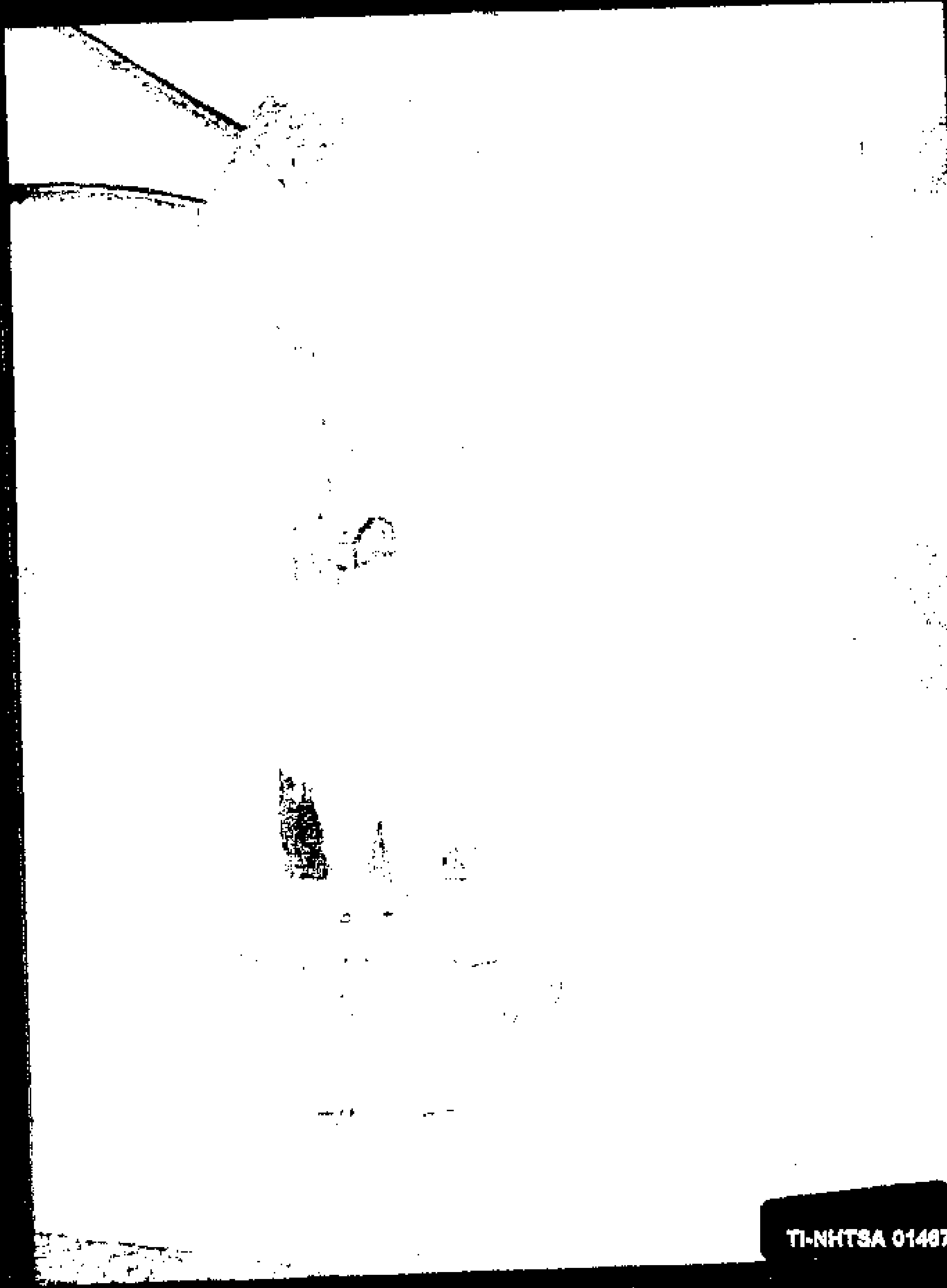
TI-NHTSA 014668



ZYTEL BASE
5% SALT WATER INGRESS
VERTICAL ORIENTATION



TI-NHTSA 014870



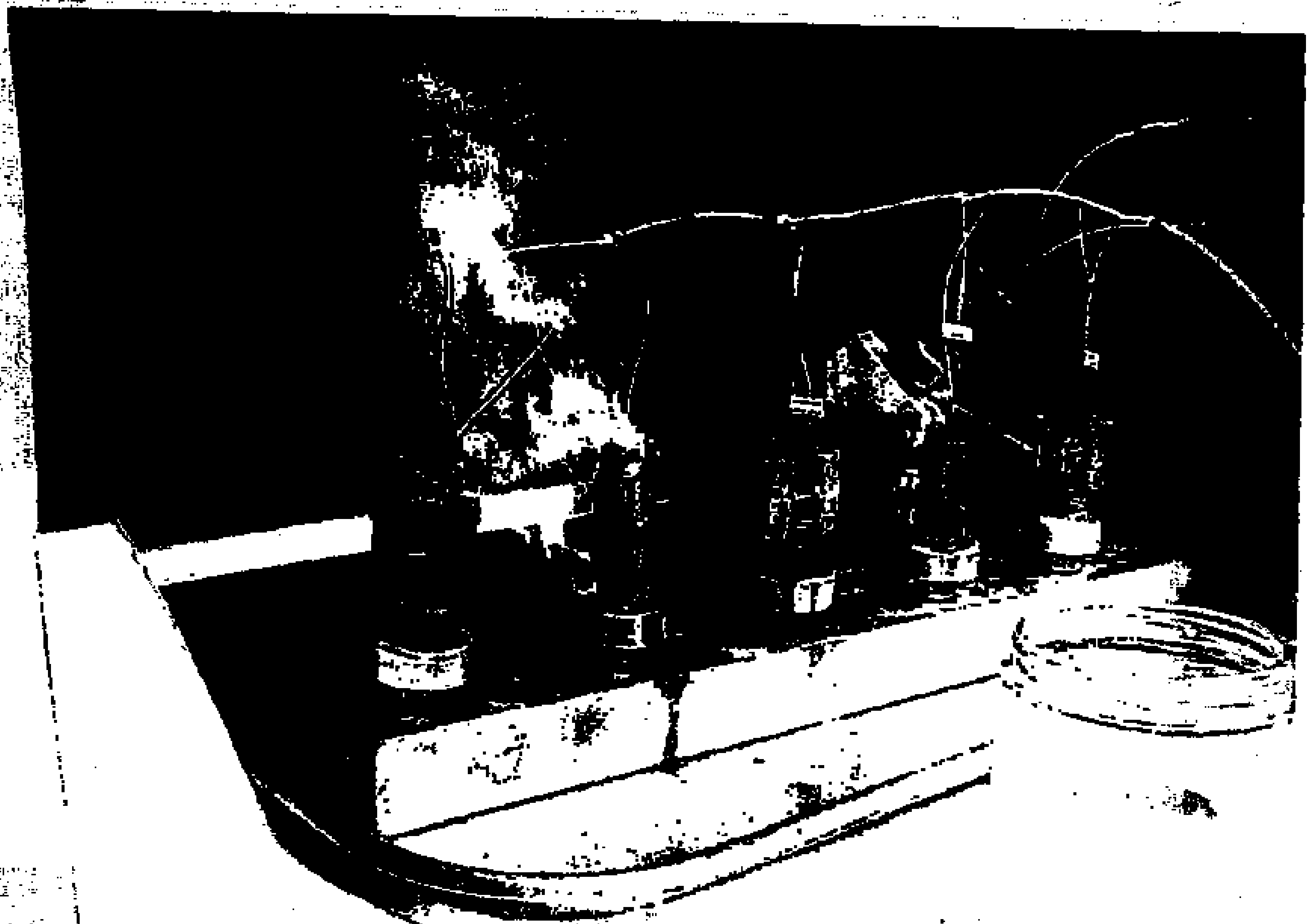
5-8-99

5 Pc ~~[illegible]~~ Vertical Burn test

5 PC set up on Common manifold. Devices Power with 14.5VDC and limited to 25 amps to Protect Power Supply – side of Device was Floated.

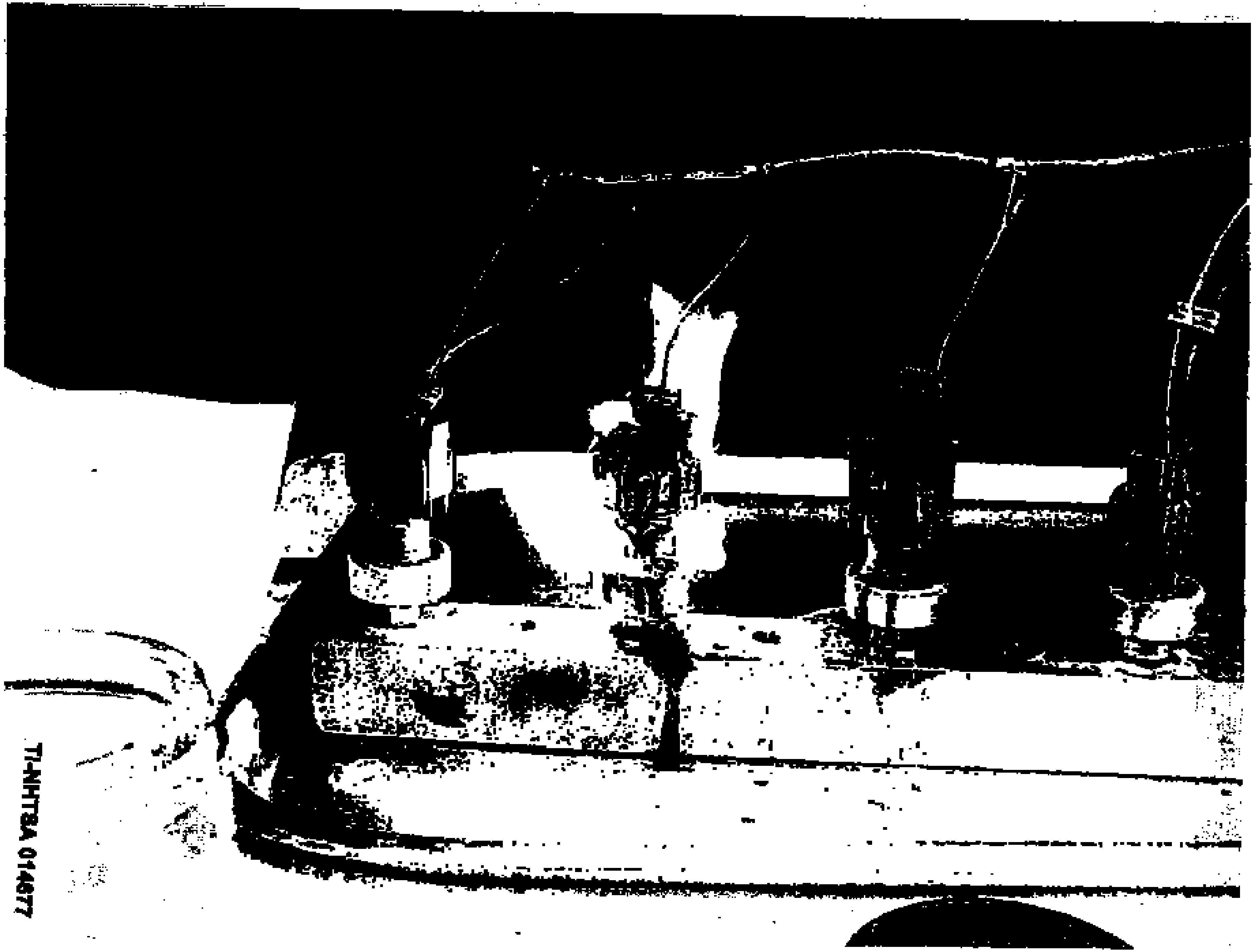
A solution of 5% (ASTM) salt and tap water was injecte[d] into the Device and Power applied to Devices. Devices were Filled on as needed basis for duration of Test.

Resuts: 3 of the 5 Devices ignited, 1 Burned appx 35% of Base But Did not ignite, 1 showed very slow action for duration of Test and upon Removal found + Terminal had corroded away and Broken away from switch Terminal

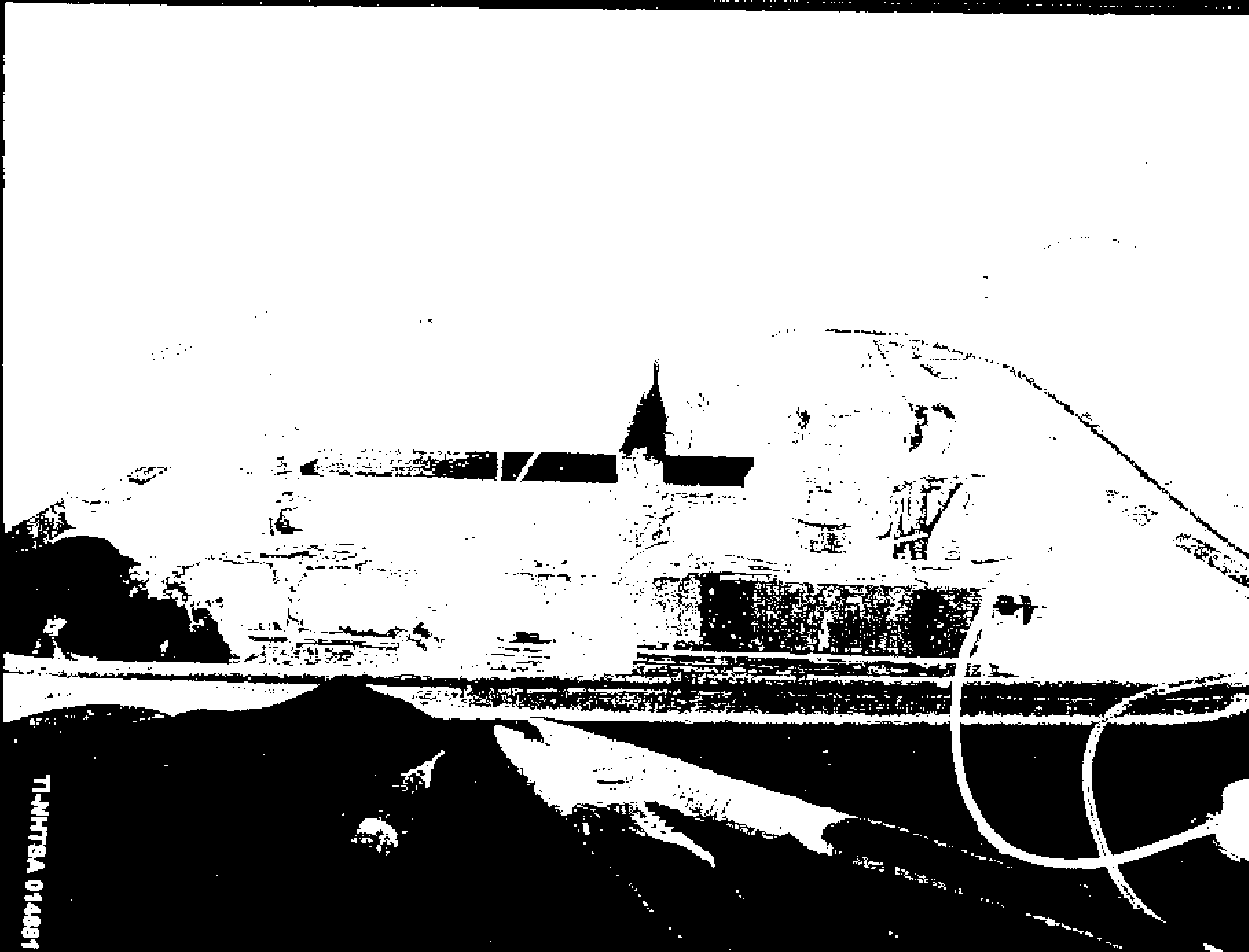


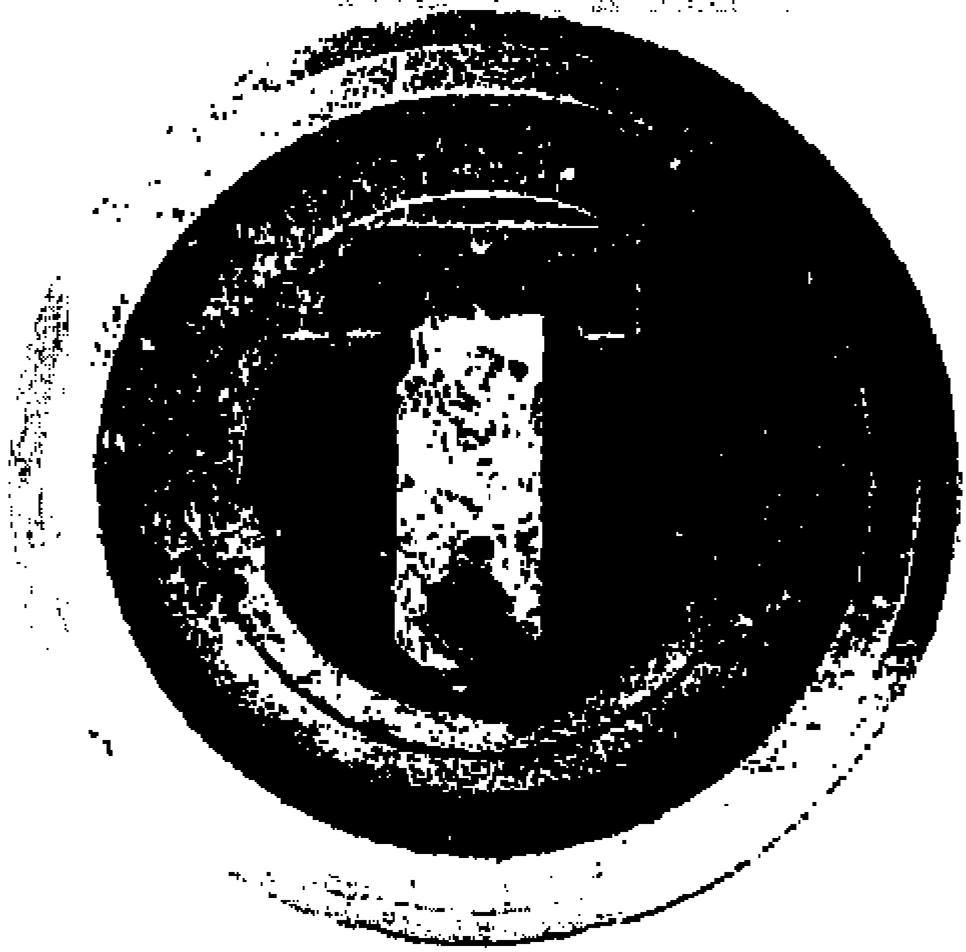
TI-NHTSA 014874

TI-NHTSA 014676




TI-NHT8A 014678

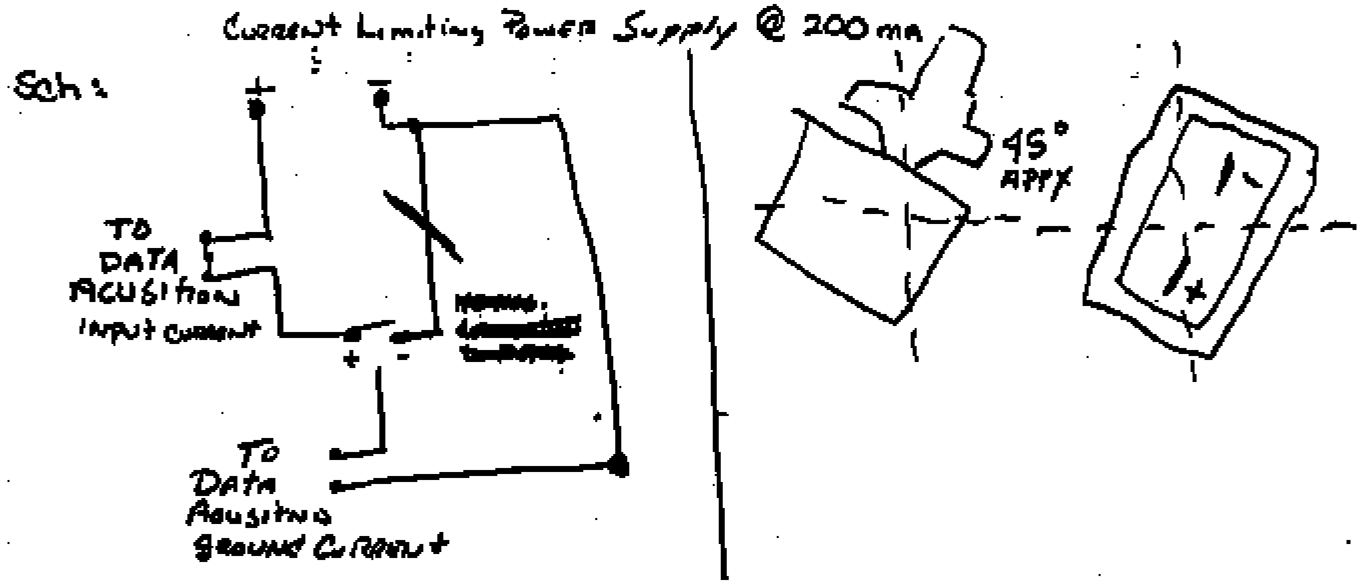




TI-NHTSA 014682

3-7-99

Current Limited Burn testing



DEVICE will Be connected to positive Terminal only with CURRENT IN AND CURRENT GROUND DATA LOGGED. A solution of 5% salt will Be ingated into Device At 10 min interuals or as Needed

TI-NHTSA 014683

77PSL2-1
5% Salt Water Ingress Experiment

Abstract

This experiment has demonstrated that ingress of a 5% NaCl / 95% tap water solution into the electrical connector cavity of 77PS2-1 switches can initiate a thermal event. To simulate accelerated rates of ingress, the salt water solution was injected into a 77PS2-1 switch at 10 minute intervals (approximate). The switch was powered at 14.5 volts for the duration of the test. At approximately 2 hours and 45 minutes into the test, the switch ignited into flames. The entire test was documented on video tape.

Data:

Raw data from the data acquisition from this test, is presented in Appendix B.
Table 2, below, displays observations and notes made during the test.

Table 2.

Time Elapsed (minutes)	Observations
0	Test started, power applied.
10	Salt water solution injected into contact cavity.
20	Salt water solution injected into contact cavity.
30	Salt water solution injected into contact cavity.
40	Salt water solution injected into contact cavity.
43	Clutch actuation is irregular (possible contact arm failure).
50	Salt water solution injected into contact cavity.
60	Salt water solution injected into contact cavity.
70	Salt water solution injected into contact cavity.
80	Heavy activity (no solution added).
85	Video tape replaced.
86	Data Acquisition data saved and reset.
90	Salt water solution injected into contact cavity.
100	Salt water solution injected into contact cavity. More violent reactions.
110	Salt water solution injected into contact cavity.
120	Salt water solution injected into contact cavity.
125	Salt water solution injected into contact cavity.
130	Salt water solution injected into contact cavity.
135	Salt water solution injected into contact cavity.
140	Salt water solution injected into contact cavity.
145	Salt water solution injected into contact cavity.
150	Salt water solution injected into contact cavity.
155	Salt water solution injected into contact cavity.
159	Video zoom in on switch.

165	Switch ignition occurred.
166	Flames extinguished.

Appendices C1 through C6 contain switch photos taken during testing. They show smoke emanating from the test specimen as well as red hot, glowing internal components.

Figure 11, below, displays current and voltage measurements for the duration of the test. Sharp spikes in the data may be attributed to points where the connector was removed.

Figure 11.

5% Salt Water Ingress Experiment

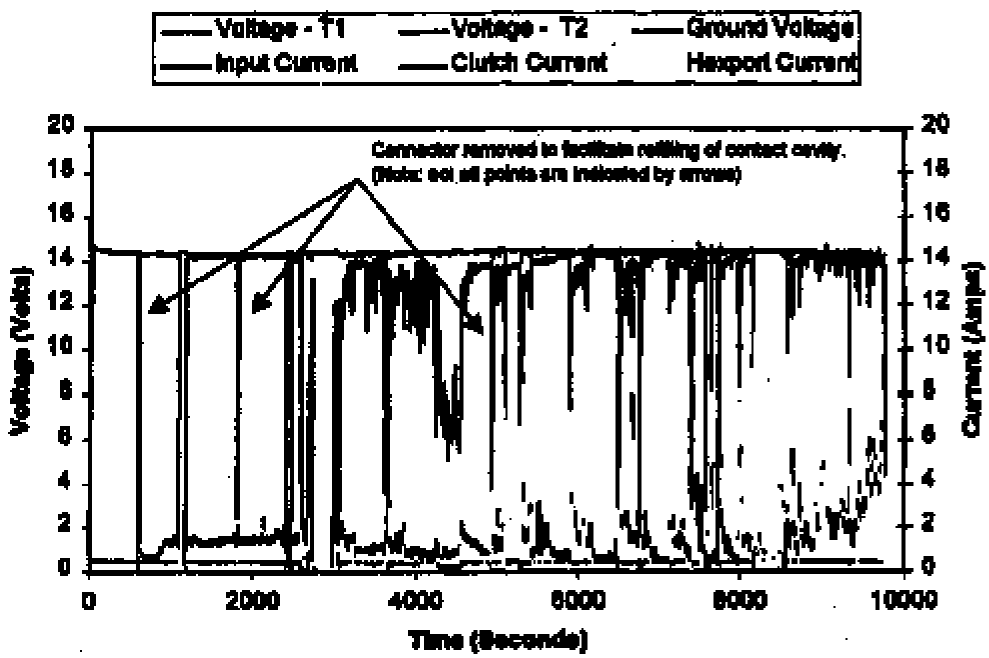


Figure 12, below, displays hexport current verses time. A (100) point moving average trendline was added to filter out data scatter and spikes recorded during refillings. The trendline shows that the hexport current remained relatively steady at approximately ¾ Amps (average) for the first 100 minutes of the test. Over the following 60 minutes of the test, the hexport current steadily increased until it reached approximately 2 ½ Amps (average) at which point ignition occurred and the test was stopped.

Figure 12.

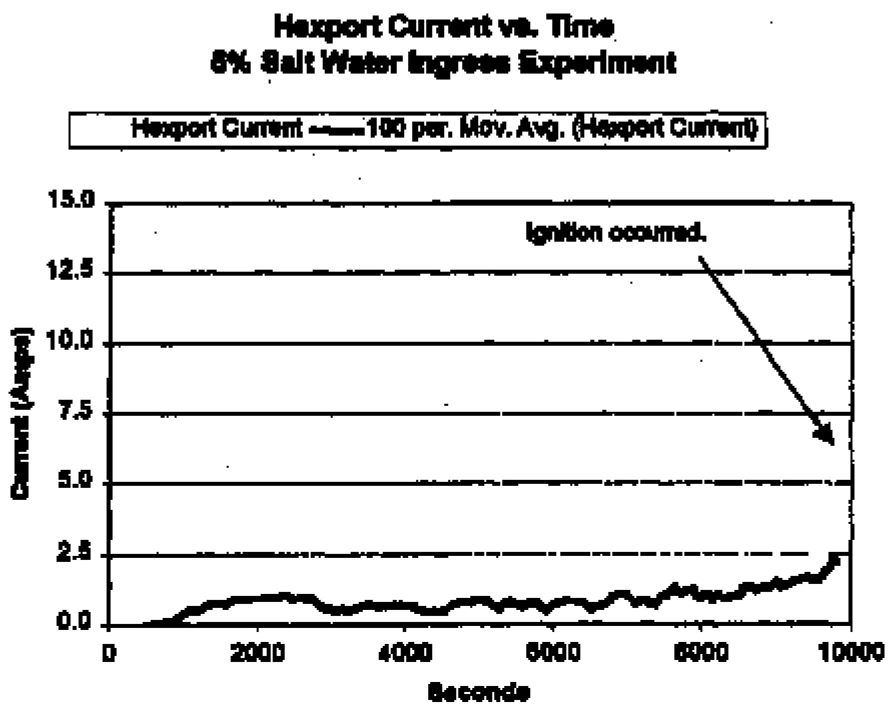
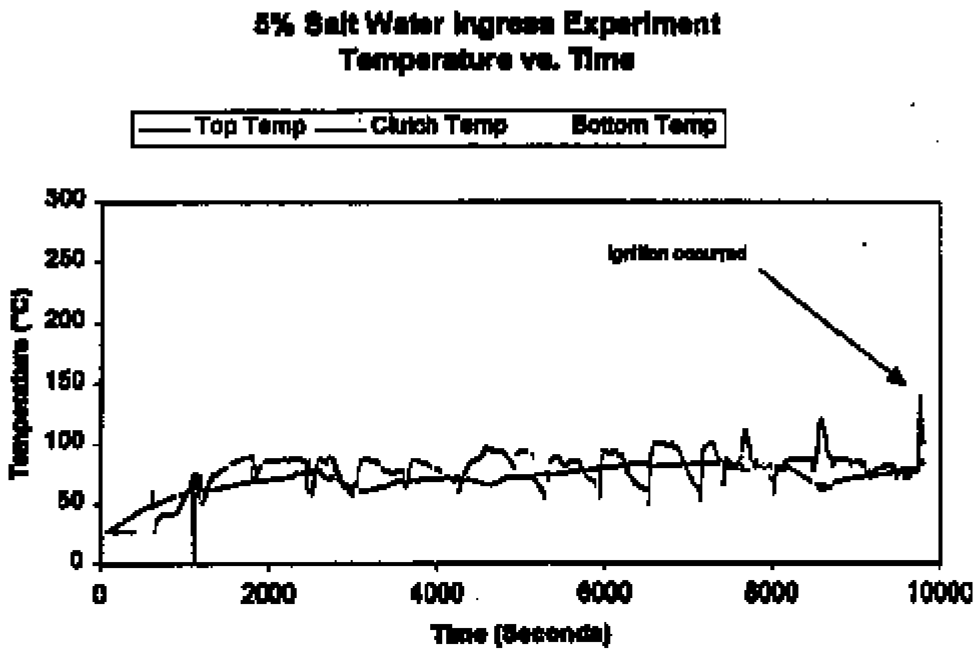


Figure 13, below, shows the thermocouple measurements made for the duration of the test. Relatively low temperatures were recorded up to the point of ignition where, over 250 ° F was recorded before flames were extinguished.

Figure 13.



Appendices D1 through D10 are photos of the switch at the end of testing. D8 and D9 show the internal corrosion build up in the switch.

Chemical analysis of switch corrosion and degree of arcing were not available at the time of publishing.

Results

This experiment has demonstrated that repeated salt water ingress into the contact cavity of a 77PSL2-1 switch, while the switch is powered, can cause an ignition. Evidence indicates that ionic corrosion of switch components builds up in the contact cavity of the switch. Over time, corrosion builds sufficiently to create an electric path from powered terminals to the grounded hexport body. As ionic corrosion continues to build, hexport current increases, (see hexport current data of figure 12), and internal component temperatures increase. This fact is illustrated by the red hot glow in the switch as captured on video as well as photographs (see Appendices C-5 and C-6). Eventually, a critical point is reached where, ignition occurs. In this case a hexport current of 2.5 Amps (average) was necessary to cause and ignition. It should be noted that a hole

burned through the switch base prior to ignition. This hole provided a source of oxygen necessary for ignition.
Approximately (8) ounces of solution were used to refill the contact cavity of the switch. Some of the solution immediately escaped from the hole that developed in the switch base.

Conclusion

This experiment has demonstrated that ingress of an ion rich fluid into the connector cavity of 77PSL2-1 switches can cause a thermal event. Repeated injections of a 5% NaCl / 95% tap water solution into contact cavity of a 77PSL2-1 switch resulted in an ignition (2) hours and (45) minutes into the test. The fluid injections simulated accelerated rates of ingress into the switch contact cavity. Evidence suggests that ionic corrosion buildup in the connector cavity creates a path from powered terminals to the hexport body. When the hexport current exceeded 2.5 Amps (average) a thermal event occurred. (Other factors may also be necessary to create an ignition).

TI Proprietary Information: Attorney-Client Privilege Invoked
PS/99/12 REV A
3/22/99

77PS Ionic Rich Fluid Ingress Experiment Report

Data
Results
Discussion
Conclusion

Section VII: New Brake Fluid With 5% Water Ingress Experiment
Data
Results
Discussion
Conclusion

Section IIX: Tap Water Ingress Experiment
Data
Results
Discussion
Conclusion

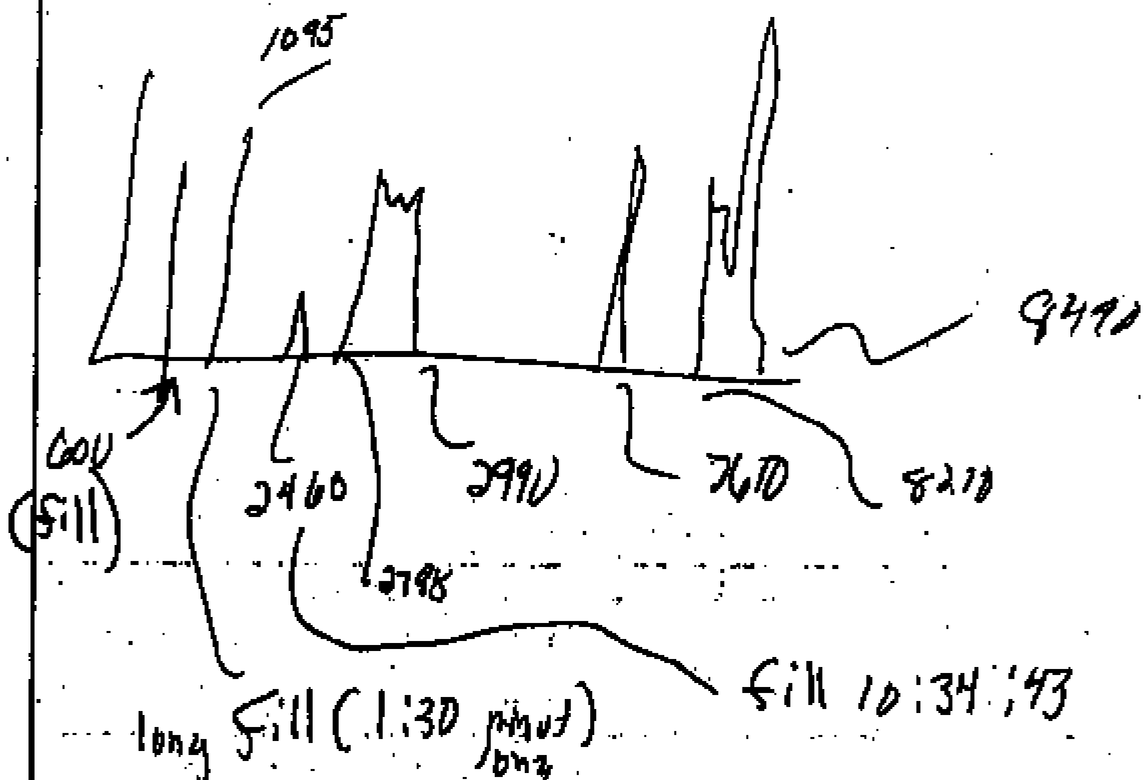
5% Salt

MVC-011L 2:10 Elapsed time = 12:12:32

Camera start time 10:02:

Power On Time stamp (Excel) 9:54:38
First Fill 10:04 28

high R 600
1095
2460



Brake Fluid Samples

	5% water				0% water		
Sample	date	k cycles	time	Sample	date	k cycles	time
A1	3/12/99			B1	3/12/99		
A2	3/15/99	240		B2	3/16/99	450	
A3	3/16/99		1630	B3	3/17/99		1445
A4	3/17/99		1445	B4	3/18/99		1265
A5	3/18/99		1250	B5	3/19/99		900
A6	3/19/99		900	B6			

TI-NHTSA 014692

Test/sample	Test Results/Conclusions	Chem Lab Results
Heater Tests	Power, oxygen and spark needed.	None in process
Ignition recreation 0% H_2O in brake fluid 4% H_2O in brake fluid 6% H_2O in brake fluid 10% H_2O in brake fluid 75% H_2O in brake fluid	Brake fluid with H_2O will not ignite in test setup.	None in process Identify chemical makup of corrosion. Quantify corrosion as a function of % H20 in brake fluid. Identify deposits. Quantify deposits as a function of % H20 in brake fluid.
Brake fluid analysis Used brake fluid. Master cylinder Caliper New brake fluid.		 Cu = 415 (ug/ml), Fe = 5.8 (ug/ml), Cr = 0.08 (ug/ml), 1.1 %H_2O. Cu = 592 (ug/ml), Fe = 5.5 (ug/ml), Cr = 1.9 (ug/ml), 1.1 %H_2O. Cu = <0.01 (ug/ml), Fe = 0.92 (ug/ml), Cr = <.01 (ug/ml), 0.3 %H_2O.
Corrosion Tests 5% salt in H20	Resistive heating element possible. Heating element is not across switch terminals but from terminal to ground.	None in process
Fluid Ingress Tests (3) hour tests 5% NaCl in tap water tap water rain water (24) hour tests used brake fluid used brake fluid w/ 5% H_2O new brake fluid new brake fluid w/ 5% H_2O	 Ignition. Large hexport current low hexport current low hexport current low hexport current low hexport current low hexport current low hexport current	 Cu deposits. Cu deposits. Cu deposits. Cu deposits. ~No corrosion. Black soot deposit composition Cu deposits. ~No corrosion. Black soot deposit composition Cu deposits. ~No corrosion. Black soot deposit composition Cu deposits. ~No corrosion. Black soot deposit composition
Virgin Switch Analysis (4) 2-1 switches		Cu content.

Black = Complete Red = Incomplete Blue = Not in Process

Test/sample	Test Results/Conclusions	Chem Lab Results
Material Comparison Celanex 4300 Celanex 3316 Noryl Zytel	Zytel performed best. All will burn in 15 amp circuit.	None in Process
Switch Orientation Vertical Horizontal Rotational	Orientation independent.	None in Process
Relay Circuit Tests (48) hour worst case scenario Impending burn Maximum power	Corrosion rate drastically reduced. Power not enough to nucleate an ignition.	Cannot differentiate between 15 Amp corrosion and 200mAmp corrosion (it looks similar but at 200mAmps, the arm is intact after (48) hours whereas the contact arm is dissolved in 45 minutes in 15 Amp test).
TI Memphis Findings		Phosphorus, Potassium and Sulfur present. Lot
Ford Central Findings Memphis A B C D E F		

Black = Complete Red = Incomplete Blue = Not in Process

Hrs	Sample	Cup, exc Fe, Cr, Zn or glass	Terminals or Blades, exc Cu, Zn, Ag
	5% NaCl in H20	Na, Cl, Cu, C, O	Na, Cl, C, O
	Table Salt: Noryl Base	Na, Cl, Cu, C, O	Na, Cl, C, O
16	16 Hr Impend Burn	Na, Cl, Cu, C, O	Na, Cl, C, O
48	200 mAmp Current	Na, Cl, Cu, C, O	Na, Cl, C, O
	Memphis	K, S, Cu, C, O	K, S, C, O
3	Rain Water	Cu, C, O	C, O
24	Tap Water	Cu, C, O	C, O
24	Used BF:	Cu, C, O	C, O
24	New BF	Cu, C, O	C, O
24	New BF: 5% H20	Cu, C, O	C, O
24	Used BF: 5% H20	Cu, C, O	Cl, C, O
576	New BF	Cu, C, O	Cl, C, O
312	New BF	Cu, C, O	C, O

Alkaline detergent as used

.erpreting the results of microanalysis carries the risk that a speck of non-characteristic contamination might be misinterpreted as being inherent to the sample. None the less, I am loath to not report any of our findings; I have compromised by listing them below:

- Ag, Cl and K were detected once on the cup of the 5% NaCl sample.
- S, and Sn were detected once on the cup of the Used BF w 5% H20 sample.
- Cl was detected on the blade of the New BF sample.
- Cl was detected on the blade of the Used BF sample.
- S was detected on one area and Cl in another on the blade of Rain Water sample.
- Cl and P were detected on one area of the blade on the 312 hour New BF sample
- There wasn't time while Ford was here to break the contacts/terminals out of the Memphis sample. Therefore, we couldn't get good spectra that we could have confidence were accurate. Nonetheless, there appears to be some glass (from pyrolyzed plastic) present and also, perhaps some phosphorous and maybe barium.
- Analysis of the sludge itself from the 312 and 576 hour samples showed Cu, C, O, Ag, and sometimes, Zn.
- S, and Ag was found on one area of the 24 Hr Tap Water cup sample.

Middle Shelf - Baker Memphis

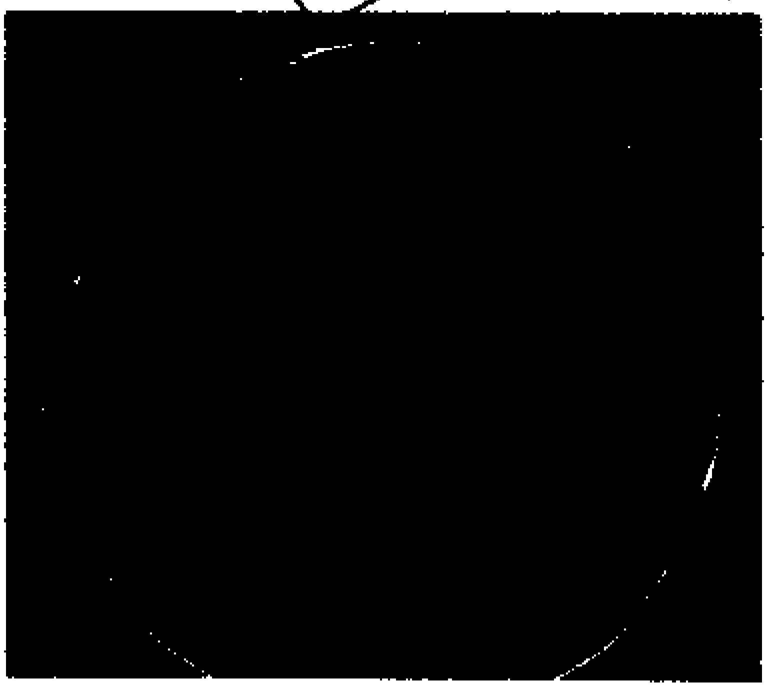
77PS Long Duration Brake Fluid Test
300 Hours at Continuous Power

C

D

77PS 5% NaCl in Water Test
(2) Hours at Continuous Power

A



B

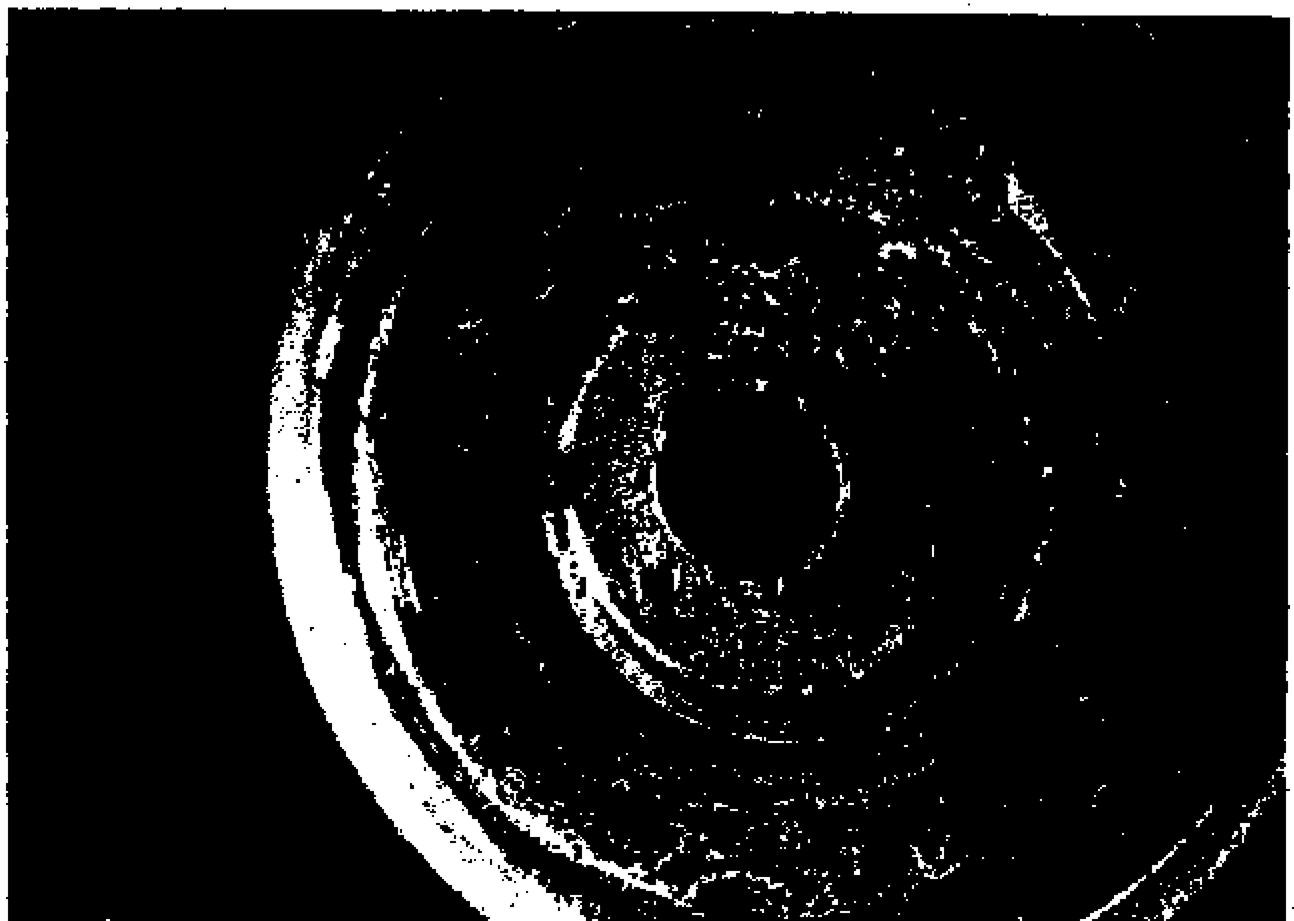
77PS Long Duration Brake Fluid Test
550 Hours at Continuous Power

E

F

6

77PS Memphis Switch



PPAP'S **ES - TEST REPORTS**

BINDER #	TI PART #	REPORT #	REPORT DATE	ADDENDUM	REPORT DATE
A1	77PSL2-1	PS/91/49	9/20/91	N/A	N/A
A1-1	77PSL2-1	PS/91/49	9/20/91	PS/91/49-A	12/19/91
A1-2	77PSL2-1	PS/91/25	9/20/91	PS/91/49-A	12/19/91
A1-3	77PSL2-1	PS/91/49	9/20/91	PS/91/49-A	12/19/91
A2	77PSL2-3	PS/91/48	9/20/91	N/A	N/A
A2-1	77PSL2-3	PS/91/48	(note: salt spray failures)		N/A
A3	77PSL3-1	PS/92/62	4/13/92	partial	N/A
(EN53)		PS/92/62	8/17/92	N/A	N/A
A3-1	77PSL3-1	PS/92/62	4/13/92	N/A	N/A
		PS/92/62	8/17/92	N/A	N/A
A3-2	77PSL3-1	PS/92/62	4/13/92	PS/91/49-A	12/19/91
		PS/91/49	9/20/91		
A4	77PSL3-3	PS/92/90	8/21/92	(-CA ADDENDUM)	
		PS/91/48	9/20/91	N/A	N/A
		PS/92/62	8/17/92	N/A	N/A
A5	77PSL3-3	PS/92/80	6/12/92	N/A	N/A
A6	77PSL6-1	PS/93/32	5/3/93	purple o-ring)	N/A
		PS/93/11	2/12/93		N/A
A7	77PSL3-2	PS/92/80	6/12/92	N/A	N/A
(WIN 88)					
A7-1	77PSL3-2	PS/92/62	8/17/92	N/A	N/A
A8	77PSL3-3	PS/91/48	9/20/91	PS/92/90	8/21/92
A9	77PSL4-1	PS/93/40	6/7/93	N/A	N/A

Differences in Ford Part Numbers

Part #	Actuation	Release	Base Color	Position	Material	Seal	Disc	
77PSL2-1	90-160	20 min.	Brown	2	Celanex	Metal to Metal	Snap	
77PSL2-3	200-300	40 min.	Black	1	Celanex	Metal to Metal	Snap	
77PSL3-1	90-200	20 min.	Natural	2	Noryl	Metal to Metal	Quiet	
77PSL3-2	90-160	20 min.	Grey	1	Noryl	Metal to Metal	Quiet	
77PSL3-3	200-300	40 min.	Red	1	Noryl	Metal to Metal	Quiet	
77PSL4-1	90-160	20 min.	Natural	2	Noryl	O-ring	Quiet	
77PSL5-2	90-160	20 min.	Natural	2	Noryl	Snubber	Quiet	*Service
77PSL6-1	90-160	20 min.	Dark Grey	1	Noryl	O-ring	Quiet	

- Terminal Positioning - The position of the terminals is controlled by many different methods:

1) The design of the nest that the base is placed into on the AMI table ensures the base is in the proper position so the terminals can only be inserted into the base in the proper orientation.

2) The design of the slot in the base only allows the terminal to be inserted in one direction.

3) The design of the terminal is such that if it is not properly inserted it will not be properly staked and will not pass the SPC controls.

4) SPC controls. We perform SPC on the terminal height, terminal position, and the terminal push-out strength.

5) The terminal position is also checked at the final function test. If the terminals are not positioned correctly they will not make contact with the pogo-pins and will not pass the millivolt drop test.

DOE 2

Group	Switch	% Brake Fluid
G1	77PSL2-1	0
G2	77PSL3-1	0
G3	77PSL4-1	0
G4	77PSL2-1	5
G5	77PSL3-1	5
G6	77PSL4-1	5

Group has 449813 cycles more than Group5.
-243190

DOE 2

GROUP: G1

DESCRIPTION: 77PSL2-1 w/ 0% water in brake fluid

DEVICE #	CYCLES (K)	FORD LOAD APPLIED (Y/N)	LEAKAGE MODE
G1-			
G1-			
G1-			
G1-			
G1-			
G1-			
G1-			
G1-			
G1-			
G1-			

GROUP: G2

DESCRIPTION: 77PSL3-1 w/ 0% water in brake fluid

DEVICE #	CYCLES (K)	FORD LOAD APPLIED (Y/N)	LEAKAGE MODE
G2-			
G2-			
G2-			
G2-			
G2-			
G2-			
G2-			
G2-			
G2-			
G2-			

GROUP: G3

DESCRIPTION: 77PSL4-1 w/ 0% water in brake fluid

DEVICE #	CYCLES (K)	FORD LOAD APPLIED (Y/N)	LEAKAGE MODE
G3-			
G3-			
G3-			
G3-			
G3-			
G3-			
G3-			
G3-			
G3-			
G3-			

DOE 2

GROUP: G4

DESCRIPTION: 77PSL2-1 w/ 5% water in brake fluid

DEVICE #	CYCLES (K)	FORD LOAD APPLIED (Y/N)	LEAKAGE MODE
G4-			
G4-			
G4-			
G4-			
G4-			
G4-			
G4-			
G4-			
G4-			
G4-			

GROUP: G5

DESCRIPTION: 77PSL3-1 w/ 5% water in brake fluid

DEVICE #	CYCLES (K)	FORD LOAD APPLIED (Y/N)	LEAKAGE MODE
G5-			
G5-			
G5-			
G5-			
G5-			
G5-			
G5-			
G5-			
G5-			
G5-			

GROUP: G6

DESCRIPTION: 77PSL4-1 w/ 5% water in brake fluid

DEVICE #	CYCLES (K)	FORD LOAD APPLIED (Y/N)	LEAKAGE MODE
G6-	843	N	
G6-			
G6-			
G6-			
G6-			
G6-			
G6-			
G6-			
G6-			
G6-			

					TSL 152705				
Sample ID	PPM	Avg	Std Dev	%H2O	**SAMPLE ID**		Avg	Std Dev	%H2O
A1	46281				B1	3452			
	46085					3709			
	45681	46016	306	4.63		3378	3513	174	0.35
A2	39829				B2	9258			
	39339					9295			
	39138	39433	359	3.94		9518	9357	141	0.94
A3	43527				B3	3828			
	44391					3908			
	44306	44075	476	4.41		3696	3811	107	0.38
A4	42671				B4	4056			
	43044					3800			
	43297	43004	315	4.30		3883	3913	131	0.39
A5	44279				B5	4010			
	44420					4077			
	44381	44360	73	4.44		4138	4075	64	0.41
A6	44291				STD*	3978			
	44116					3955			
	43570	43992	376	4.40		4006	3979	26	0.40
					Std contains 0.38 to 0.42% H2O				

77PS Vacuum Dependency Matrix

TI Part Number	# sorted	fall out	% fall out	disc type	cup PT#	cup height
77PSL2-1	1190	0	0.00	snap	27713-1	.090 - .092
77PSL2-3	no inventory			snap		
77PSL3-1			#DIV/0!	quiet	27713-1	.090 - .092
77PSL3-2	14000	18	0.13	quiet	27713-1	.090 - .092
77PSL3-3	1000	0	0.00	quiet	27288-1	.063 - .066
77PSL3-4	no inventory			quiet		
77PSL4-1			#DIV/0!	quiet	27713-2	.086 - .088
77PSL5-2	no inventory			quiet	27713-2	.086 - .088
77PSL6-1	no inventory			quiet	27713-2	.086 - .088

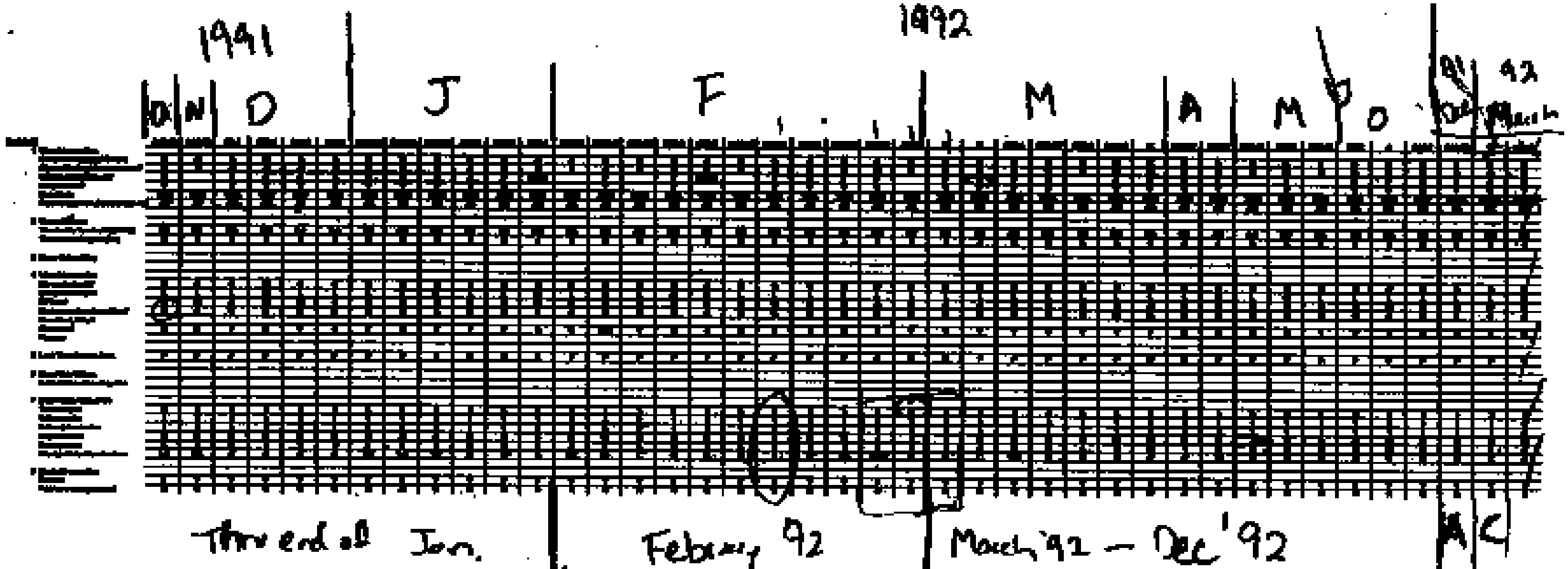
77PS
Documents 199

11:19 AM12/10/99

TI-NHTSA 014706

[illegible]	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Switch ID	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1 Visual inspection																		
General condition of Switch	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
Signs of leakage into connector?	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mating connector used?	F		F	F	F	F	F	F	F	F	F	F	NONE		F		F	NONE
[illegible]?	Y		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y			Y		Y	
Date Code	[illegible]	1271	[illegible]	1295	1897	1897	[illegible]	[illegible]	[illegible]	2009	2013	2014	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Part PN SUFFIX ([illegible])	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB
2 [illegible]:																		
Terminal to Terminal? ([illegible])	0.2	0.2	0.3	0.2	0.2	0.2	0.3	0.2	0.3	0.2	0.3	0.2	0.2	0.3	0.2	0.2	0.2	0.3
Terminal to [illegible]?([illegible])	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3 Open Crimp Ring																		
4 Visual inspection																		
Connector Leak?	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
[illegible]?	L	L	L	L	M	L	L	L	L	L	L	L	M	L	M	L	M	M
[illegible]?	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
[illegible]?	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
If seal bad, Why?																		
Corrosion?	N	N	N	Y	N	Y	N	Y	N	Y	Y	Y	N	N	YES	Y	N	N
Pictures																		
5 Leak Test [illegible]	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
6 Open [illegible] Crimp.																		
Estimated number of cycles																		
7 Diaphragm inspection																		
Teflon stretch	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Teflon cracks	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	1	2
Teflon delamination	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	2	1	2
[illegible] cracks	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Stain pattern	3	3	N	N	3	3	3	3	3	3	N	N	3	3	3	3	N	3
Wear particles/discoloration	1,C	1,C	C	C	C	C	O	1,O	1,O	1,C	C	C	C	1,O	C+	C	O	O
8 Gasket inspection																		
Present	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
[illegible] material	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

19	20	21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	27	[illegible]	[illegible]	[illegible]	[illegible]	32	[illegible]	[illegible]	[illegible]	[illegible]	37	[illegible]	[illegible]	40	41
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	E	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	D	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	A	[illegible]	[illegible]
G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	F	F	F	F		F	[illegible]	F	F	F		F	F	F	F		F		F	F	[illegible]	[illegible]
	Y	Y	Y	Y		Y	Y	Y	Y	Y		Y	Y	Y	Y		Y		Y	Y	[illegible]	Y
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB	AB
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	M	L	M	L	L	L	L	N
N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
N	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	Y	Y	Y	N	N
P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
3	3	3	3	3	N	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	N
1	1	1	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	N
1	2	1	1	2	2	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	N
N	1	N	N	1	1	1	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
2	3	3	3	3	3	3	N	3	N	N	3	N	N	1	N	2	N	N	N	N	N	N
C	3	C	1/C	1/2/C	D	C	C	C	1/C	C	D	D	D	C	1D	D	D	D	D	D	C	N
Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N



Thru end of Jan. — A

February 92 — B

March '92 – Dec '92 — C

Stain 9/13 = 69%   10/11 = 91%   5/16 = 31%   Total = 24/40 = 6

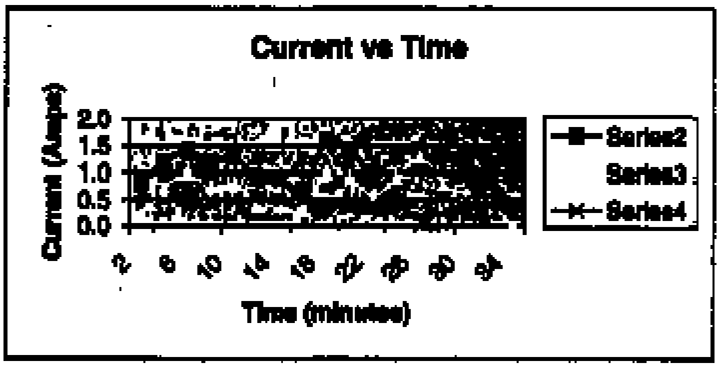
Potential Actions

	Improve connector seal	Re-orient connector	Re-locate switch to brake pedal	Improve kapton diaphragm	Insert in-line fuse with switch	Add power off switch	Re-locate switch to ground side	Re-locate switch to RUN circuit	Insulate switch from prop valve	Use flame retardant plastic
Connector Seal	□	□	■							
Kapton Life			■	□						
Continuous Power					□	■	■	■	■	
Switch Orientation		□	■						□	
Current Capability					□	■	■		■	
Grounded Hex-port			■				■		■	
Plastic Parameters										□

■ = fixed
□ = improved

TI-NHTSA 014710

time	I in	I (hexport)	I (terminal)	Check
2	0.8	0.2	0.6	0.0
4	1.2	0.7	0.5	0.0
6	1.4	1.0	0.5	-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	1.6	1.0	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-NHTSA 014712

Potential Actions

	Improve connector seal	Re-orient connector	Re-locate switch to brake pedal	Improve kapton diaphragm	Insert in-line fuse with switch	Add power off switch	Re-locate switch to ground side	Re-locate switch to RUN circuit	Isolate switch from prop valve	Use flame retardant plastic
Connector Seal	□	□	■							
Kapton Life			■	□						
Continuous Power			[illegible]		□	■	■	■	■	
Switch Orientation		□	■						□	
Current Capability			[illegible]		□	■	■		■	
Grounded Hex-port			■				■		■	
Plastic Parameters										□

■ = fixed
□ = improved

199701	FORD MOTOR CO.	77PSL2-1	0
199703	FORD MOTOR CO.	77PSL2-1	0
199705	FORD MOTOR CO.	77PSL2-1	714
199706	FORD MOTOR CO.	77PSL2-1	0
199709	FORD MOTOR CO.	77PSL2-1	0
199711	FORD MOTOR CO.	77PSL2-1	714
199711	HILITE INDUSTRIES, I	77PSL2-1	0
199712	FORD MOTOR CO.	77PSL2-1	0
199712	HILITE INDUSTRIES, I	77PSL2-1	1190
199802	FORD MOTOR CO.	77PSL2-1	952
199804	FORD MOTOR CO.	77PSL2-1	0
199805	FORD MOTOR CO.	77PSL2-1	0
199807	FORD MOTOR CO.	77PSL2-1	0
199808	FORD MOTOR CO.	77PSL2-1	476
199809	FORD MOTOR CO.	77PSL2-1	476
199810	FORD MOTOR CO.	77PSL2-1	952
199810	HILITE INDUSTRIES, I	77PSL2-1	0
199811	HILITE INDUSTRIES, I	77PSL2-1	238
199812	FORD MOTOR CO.	77PSL2-1	0
199901	FORD MOTOR CO.	77PSL2-1	476
199901	HILITE INDUSTRIES, I	77PSL2-1	0

TI 77PS INVESTIGATION

REPORT INDEX

TI REPORT #	DESCRITION
PS/99/08	Heater Tests
PS/99/19	Corrosion Tests
PS/99/20	Fluid Tests
PS/99/21	Fluid Ingress Tests
PS/99/22	Compare Base Materials
PS/99/23	Compare Switch Orientation
PS/99/24	Validation Tests

Brake Pressure Switch

F2VC-9F924-AB

Material List for MY 92/93

Component Name	Material	Comment
Gasket	Elastomer Ethylene Propylene	JBL Compound # E-7104-70
Diaphragm	Kapton, Polyimide	Dupont 500 FN131L, 3 Diaphragms per switch
Base	PBT, Plastic	Grade Celanex 4300
Calmp Ring	Aluminum	Grade # 5052
Spacer	Kapton, Polyimide	Dupont #200H,Friction Reducer on Disc
Rivet	Brass	CDA 260
Transfer Pin	Ceramic	Steatite , L-3 Grade
Environmental Seal	Silicone	JBL Compound # S7519
Converter	Cold Rolled Steel	Grade # 1008
Washer	Cold Rolled Steel, Zinc Plated	Grade # 1050
Cup	Cold Rolled Steel	Grade 1010
Spring Arm	Beryllium Copper	Grade # C17200
Movable Contact	Silver Plated Copper	Oxygen Free Cu, Fine Silver
Stationary Terminal	Brass + Silver Inlay	CDA 260
Movable Terminal	Brass	CDA 260
Disc	Stainless Steel	Grade 302
Hexport	Cold Rolled Steel, Zinc Plated	C10L10
Thread Cap	LDPE, Plastic	

and testing resumed.

Table 1
Cycles to leakage

Sample #	Group 1 (K cycles)	Group 2 (K cycles)	Group 3 (K cycles)	Group 4 (K cycles)
1	S	1175	1197	289
2	S	1181	1197	322
3	S	1192	1197	335
4	S	1192	S	335
5	S	1197	S	348
6	S	1199	S	378
7	S	S	S	380*
8	S	S	S	380*
9	S	S	S	380
10	S	S	S	387
11	S	S	S	387 [b]
12	S	S	S	387 [b]

Group 1: 77PSL2-1 (snap disc) w/ 0% water in brake fluid.
Group 2: 77PSL4-1 (no snap disc) w/ 0% water in brake fluid.
Group 3: 77PSL2-1 (snap disc) w/ 5% water in brake fluid.
Group 4: 77PSL4-1 (no snap disc) w/ 5% water in brake fluid.

DOE1 77PSL2-1 AND 77PSL4-1

Sample	ppm H2O	ppm H2O	ppm H2O	Avg	Std Dev	%RSD	Wt % H2O	
Clean	2829	3300		3065			0.31	
Caliper	11289	11320	11054	11221	116.76	1.19	1.11	
Master	11598	11008	11298	11301	294.01	2.94	1.13	
Cylinder #1	7794	7443	7458	7565	186.46	1.98	<u>0.76</u>	should be same as clean sample
Cylinder #2	27102	26503	26785	26797	299.67	3.00	<u>2.68</u>	should be 5%
Reference*	4055						0.41	

reference cor tains 0.38 to 0.42 % H2O

Fluid samples taken at the end of the test.

TI-NHTSA 014718

TI-NHTSA 014719