# EA02-025

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

# REQUEST NO. 7

# BOX 8

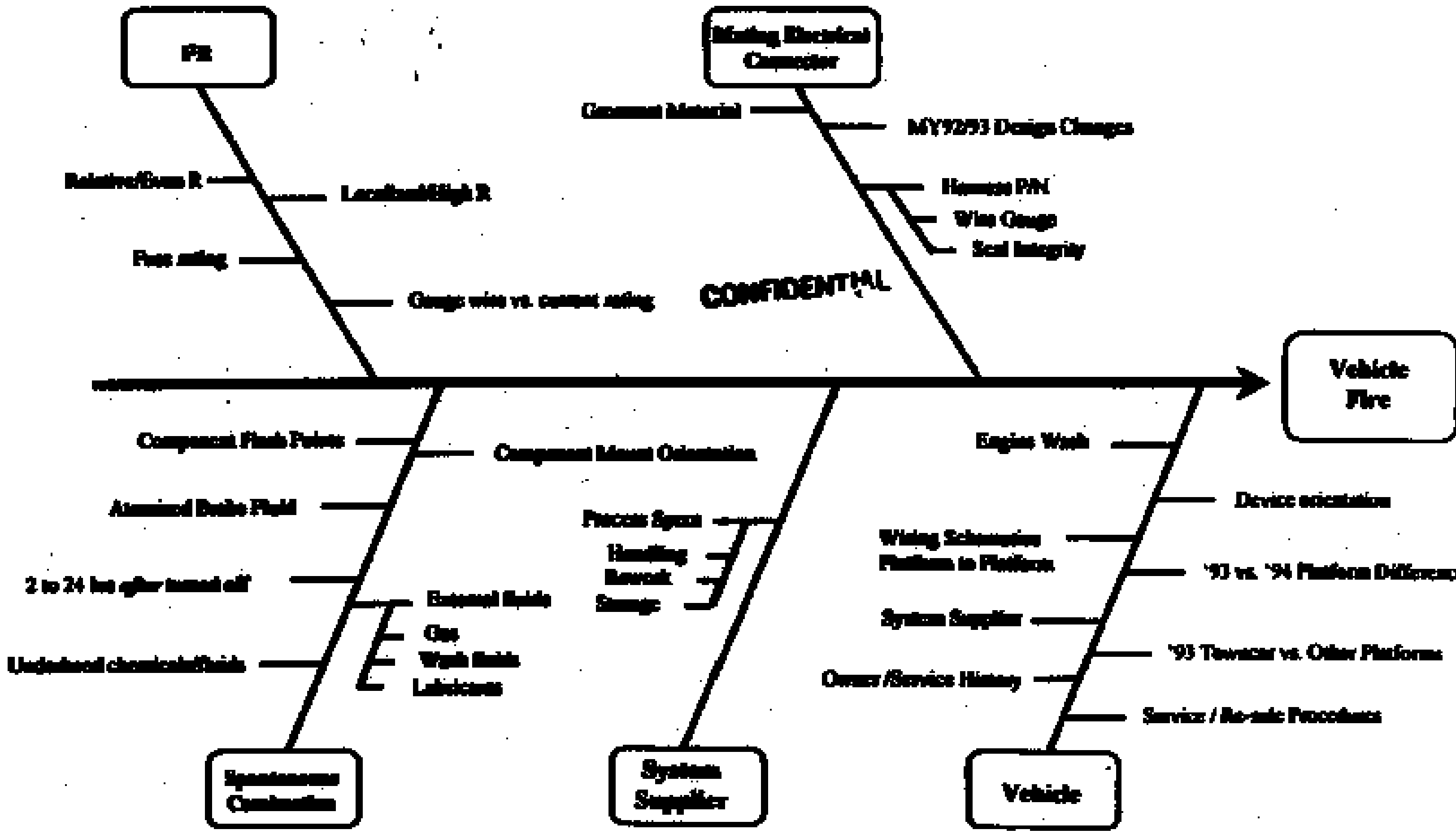
# PART A-U

# PART J

**DRAWINGS AVAILABLE UPON REQUEST**

Texas Instruments

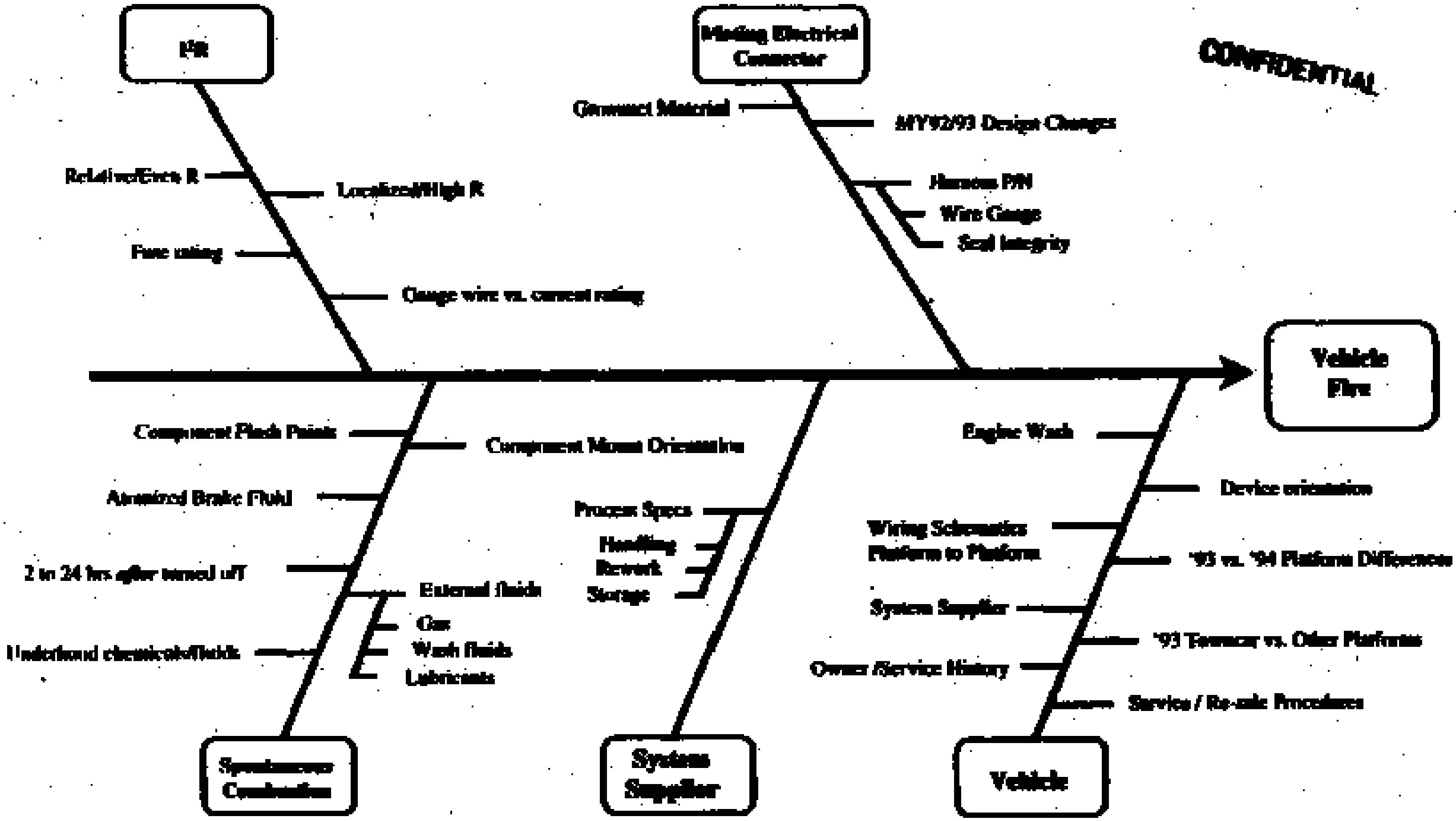
# Automotive Sensors & Controls
## Ford Visit - January 7, 1998



TEXAS INSTRUMENTS

# Automotive Sensors & Controls
## Ford Visit - January 7, 1998

CONFIDENTIAL

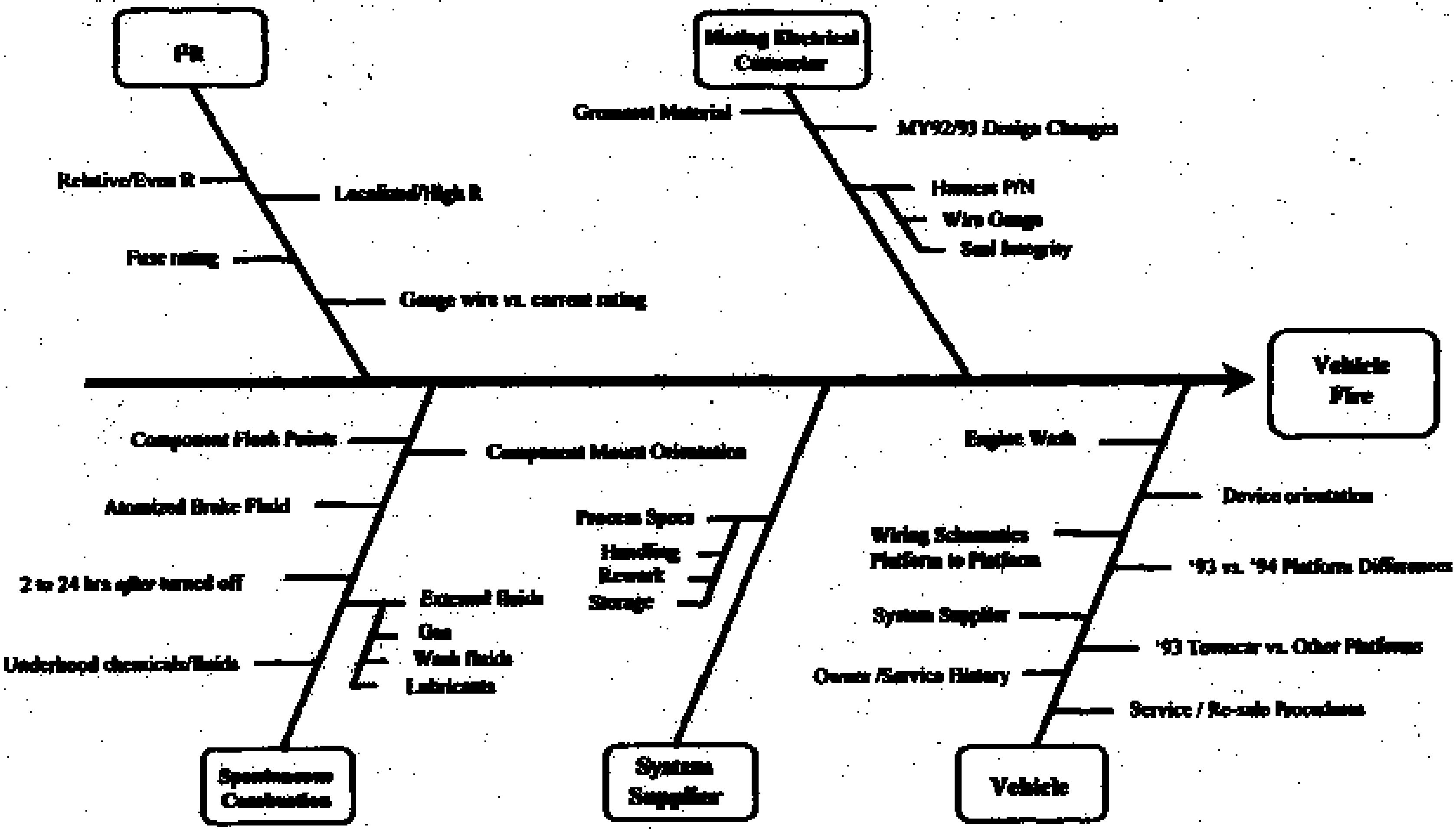





TI-NHTSA 012138

TEXAS INSTRUMENTS

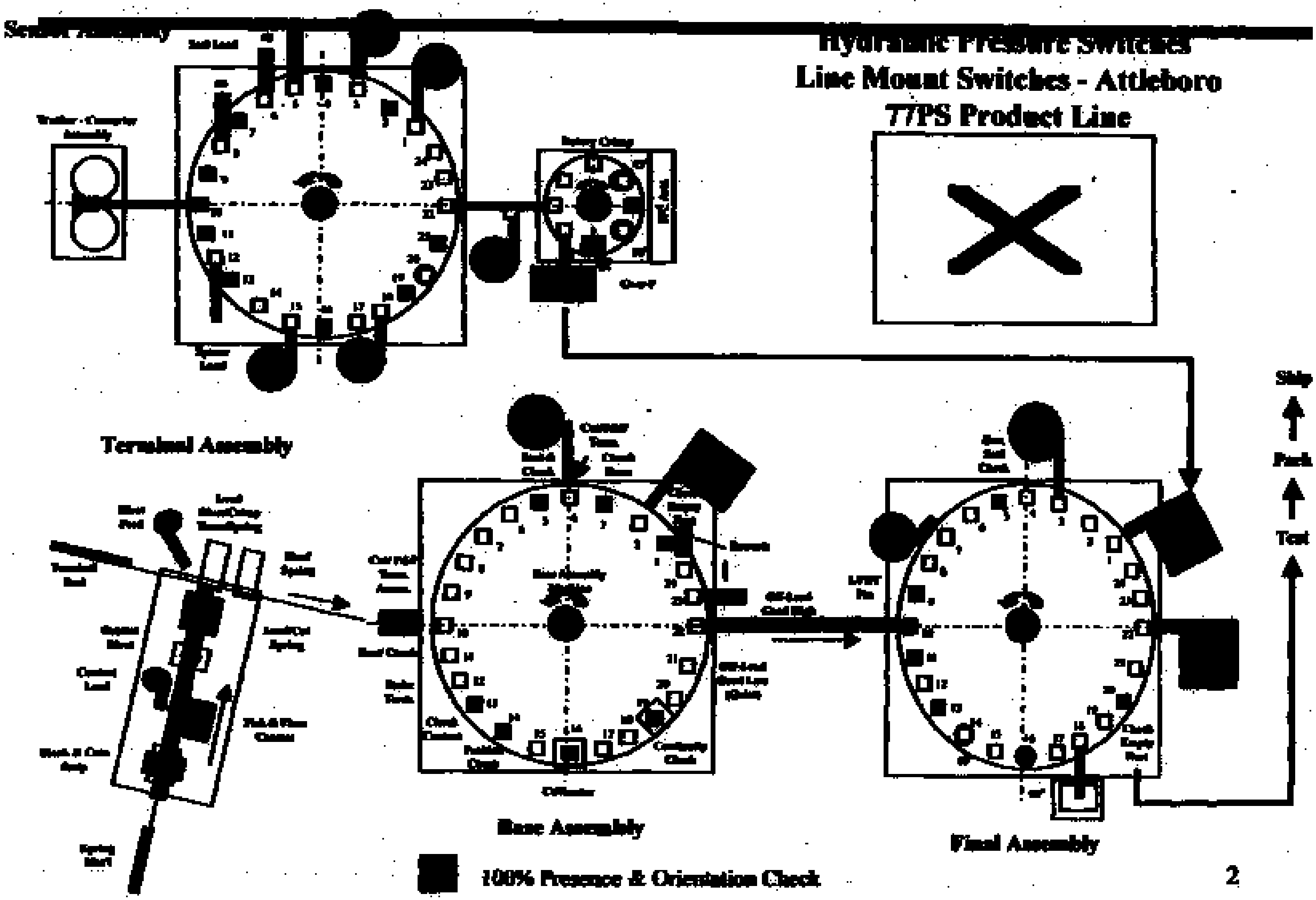
# Automotive Sensors & Controls
## Ford Visit - January 7, 1998



TEXAS INSTRUMENTS

**Automotive Sensors & Controls**
**Ford Visit - January 7, 1998**

**Hydraulic Pressure Switches**
**Line Mount Switches - Attleboro**
***77PS Product Line***



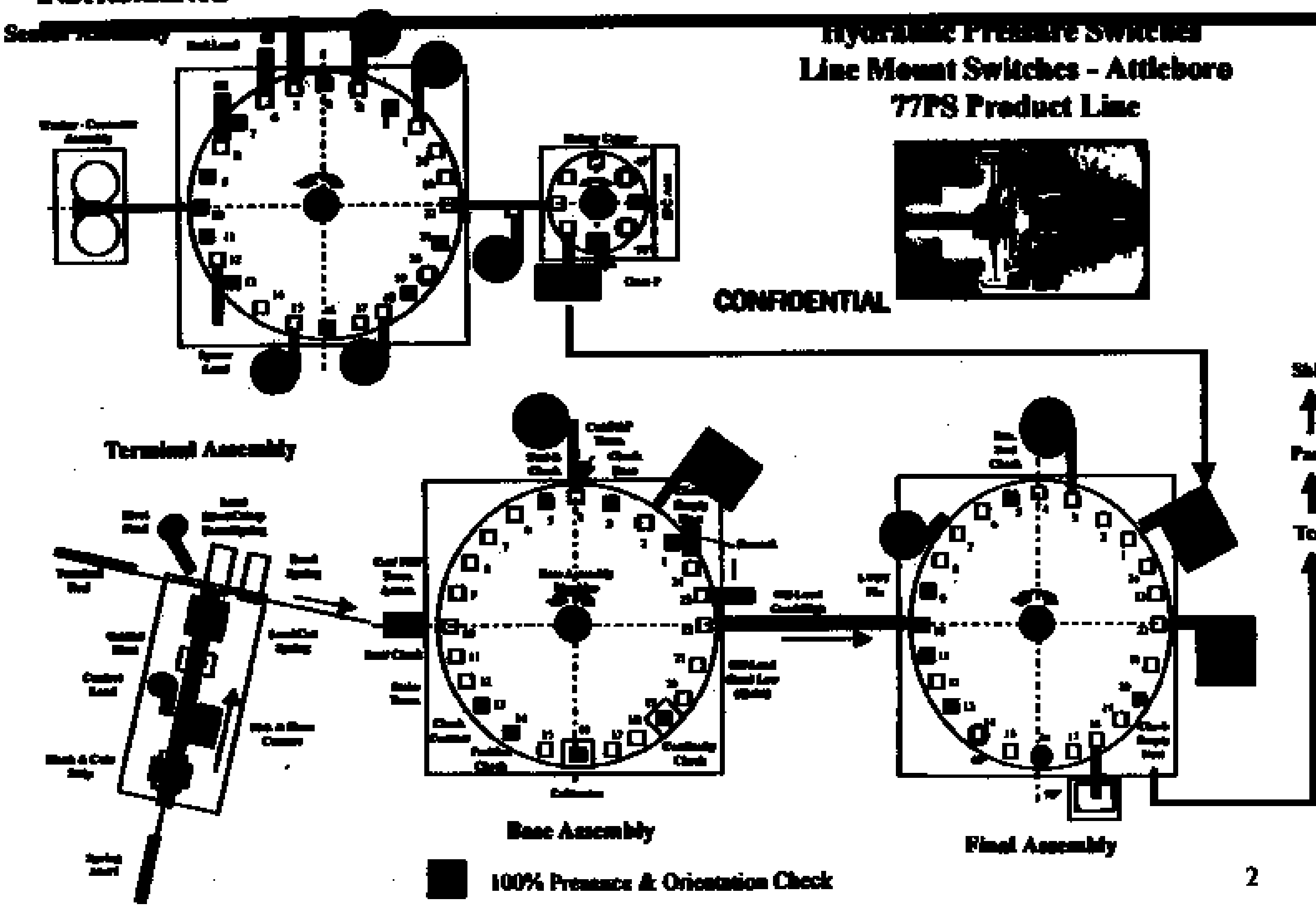

100% Presence & Orientation Check

Texas Instruments

**Automotive Sensors & Controls**
**Ford Visit - January 7, 1998**

## Hydraulic Pressure Switches
## Line Mount Switches - Attleboro
## 77PS Product Line

CONFIDENTIAL

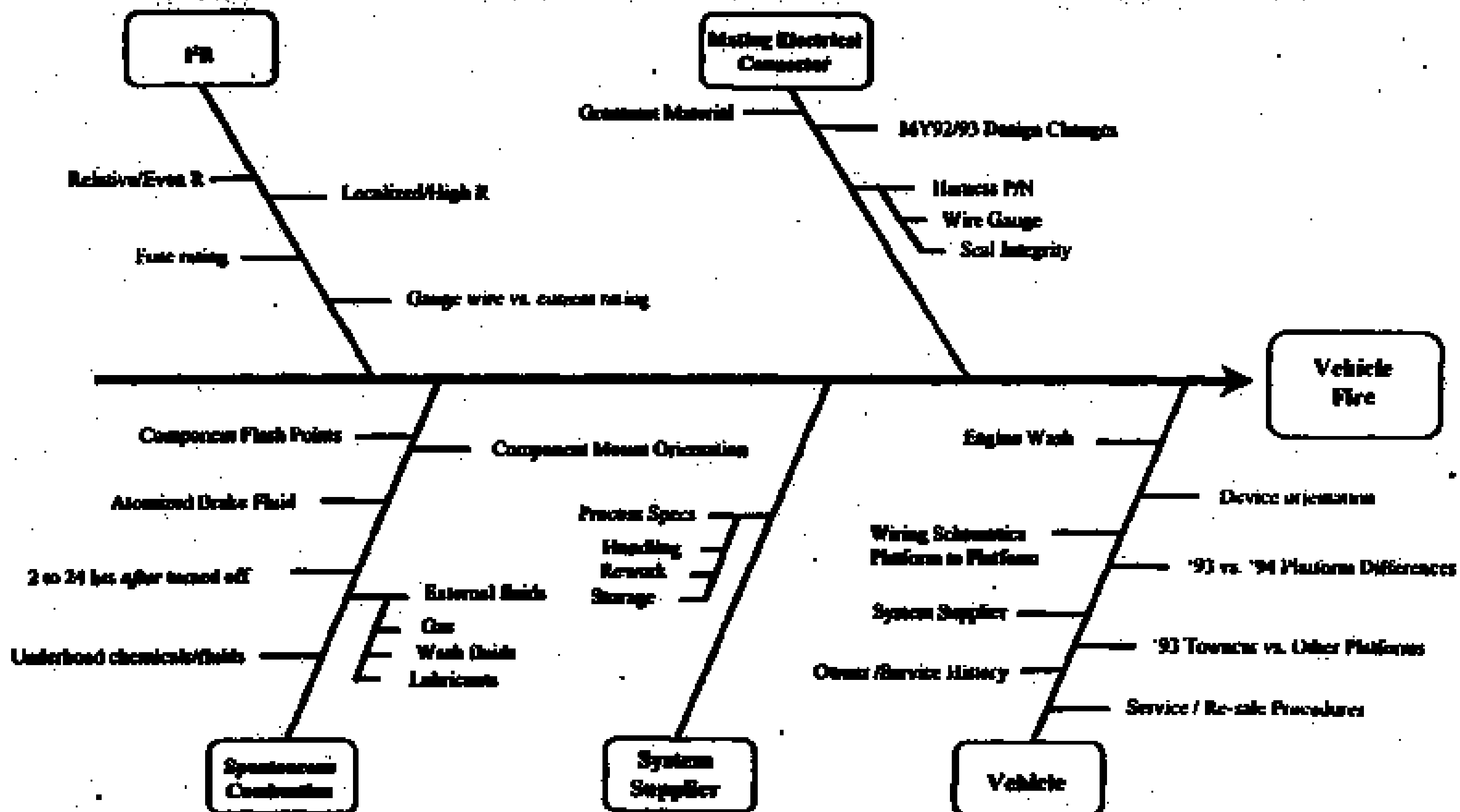





TI-NHTSA 012141

TEXAS INSTRUMENTS

# Automotive Sensors & Controls
## Ford Visit - January 7, 1998

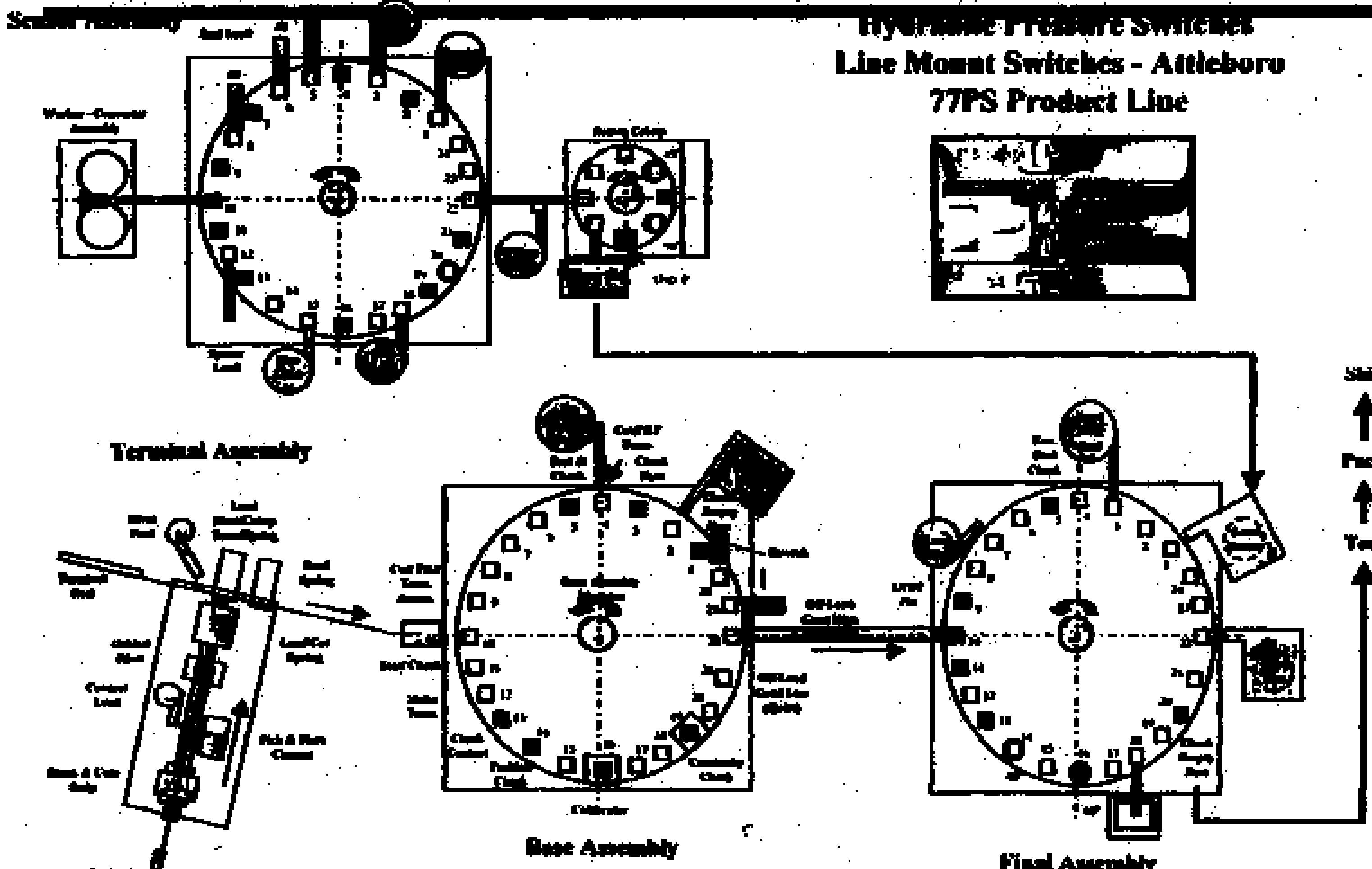



CONFIDENTIAL

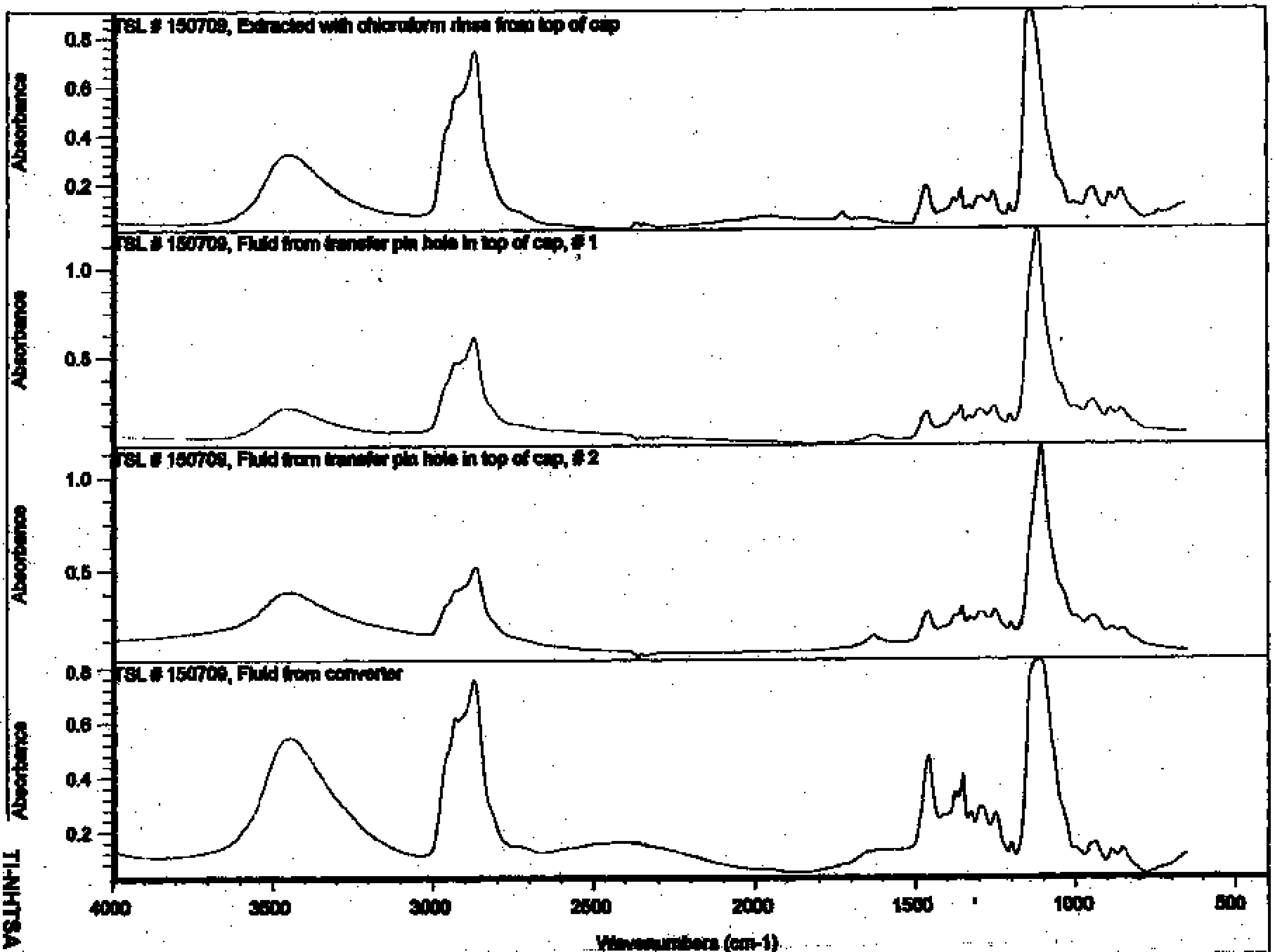
TI-NHTSA 012142

TEXAS INSTRUMENTS

## Hydraulic Pressure Switches
## Line Mount Switches - Attleboro
## 77PS Product Line



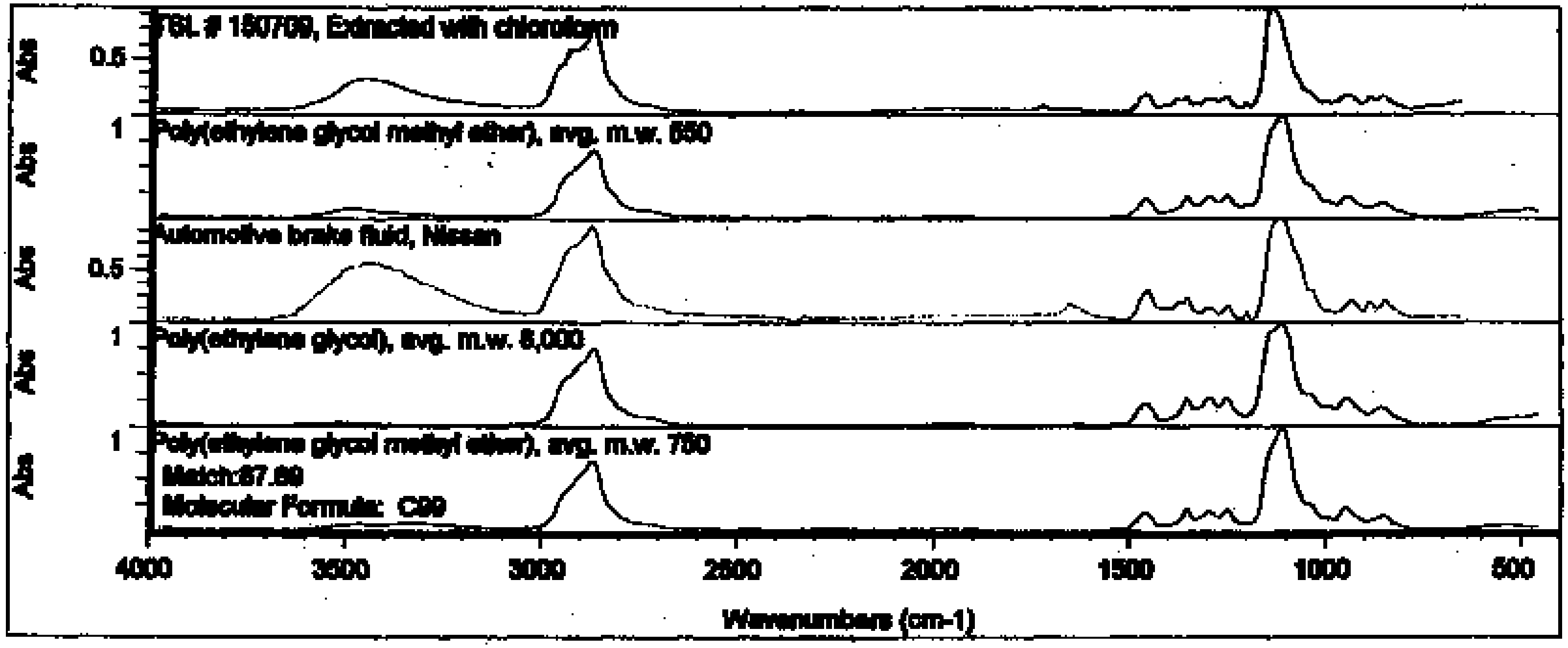

■ 100% Presence & Orientation Check



TSL # 150709, Extracted with chloroform rinse from top of cap
TSL # 150709, Fluid from transfer pin hole in top of cap, # 1
TSL # 150709, Fluid from transfer pin hole in top of cap, # 2
TSL # 150709, Fluid from converter
Absorbance
0.8
0.6
0.4
0.2
1.0
0.5
4000
3500
3000
2500
2000
1500
1000
500
Wavenumbers (cm-1)

## OMNIC Search

**Spectrum:** TSL # 150709, Extracted with chloroform
Fri Jan 08 11:18:42 1999
**Region:** 3995.85 649.98
**Search type:** Correlation
**Comment:**




| Index | Match | Compound name | Library |
|---|---|---|---|
| 10394 | 90.49 | Poly(ethylene glycol methyl ether), avg. | Aldrich Condensed Phase |
| 99 | 89.55 | Automotive brake fluid, Nissan | TSL |
| 10392 | 87.98 | Poly(ethylene glycol), avg. m.w. 8,000 | Aldrich Condensed Phase |
| 10395 | 87.69 | Poly(ethylene glycol methyl ether), avg. | Aldrich Condensed Phase |
| 9540 | 87.10 | Brij 99; Polyoxyethylene(20) oleyl ether | Aldrich Condensed Phase |
| 9613 | 86.38 | Brij 35; Polyoxyethylene(23) lauryl ethe | Aldrich Condensed Phase |
| 9539 | 84.80 | Brij 76; Polyoxyethylene(20) stearyl eth | Aldrich Condensed Phase |
| 10393 | 83.20 | Poly(ethylene glycol methyl ether), avg. | Aldrich Condensed Phase |
| 9535 | 83.05 | Tetraethylene glycol diethyl ether, 98% | Aldrich Condensed Phase |
| 10388 | 82.99 | Poly(ethylene glycol), avg. m.w. 600 | Aldrich Condensed Phase |

TNHTSA 012145

**Kill, Beth**

**From:** Kill, Beth
**Sent:** Friday, January 08, 1999 3:15 PM
**To:** Degue, Bryan
**Cc:** Hopkins, Al
**Subject:** TSL # 150709, Fluid identification

Objective:
Isolate and identify the fluid samples found in customer returned device.

Results:
First, I rinsed the cap, excluding the transfer pin hole, with chloroform. I filtered the mixture to remove the solids, and then evaporated the solvent. The remaining residue was identified as brake fluid by FT-IR spectroscopy. The match factor was 89% compared to a reference sample of Nissan brake fluid in my database. Visual comparison of the Nissan fluid to the sample suggests the fluid from the sample contains less water. This may be due to slightly different formulations produced by different manufacturers.

Next, I scanned the samples of fluid, provided by Al, from the transfer pin hole and the converter of this device. The two samples from the transfer pin hole are identical to the fluid rinsed from the cap with chloroform. The fluid from the converter also appears to be brake fluid, but appears to contain slightly more water than the other samples.

I will forward the spectral data to you by internal mail. Please let me know if I can discard the remaining fluid samples, or if you would like me to forward these to you also.

Regards,

*Beth*

Ext. 3099    MS 10-16    Fax 1670



TI-NHTSA 012146

# TECHNICAL SERVICE LABS

TEST NO. 150709

LOG NO. ______

TEST NO. 150709

| | | | |
|---|---|---|---|
| *PCC I.D. | 127 | STATE YOUR PROBLEM SAMPLE DESCRIPTION | INFORMATION DESIRED: |
| REQUESTOR COST CENTER | 357 | Failure Analysis of Returned switch. | → Try to determine the following: ① Did switch leak? ② signs of corrosion? ③ signs of arcing? ④ other signs of fire ignition? |
| PRODUCT CODE | 069 | | |
| REQUESTOR | DAGUE | | |
| MAIL STATION | 12-29 | | |
| EXTENSION | 3234 | | |
| MSG ID | Dagu | | |
| DATE SUBMITTED | 1/7/99 | | |
| DATE REQUIRED | 1/7/99 | | |
| NO. OF SAMPLES | 1 | | |
| COMPOSITION | | | |

REPORT OF RESULTS:

DATE RECEIVED ______ DATE OUT ______

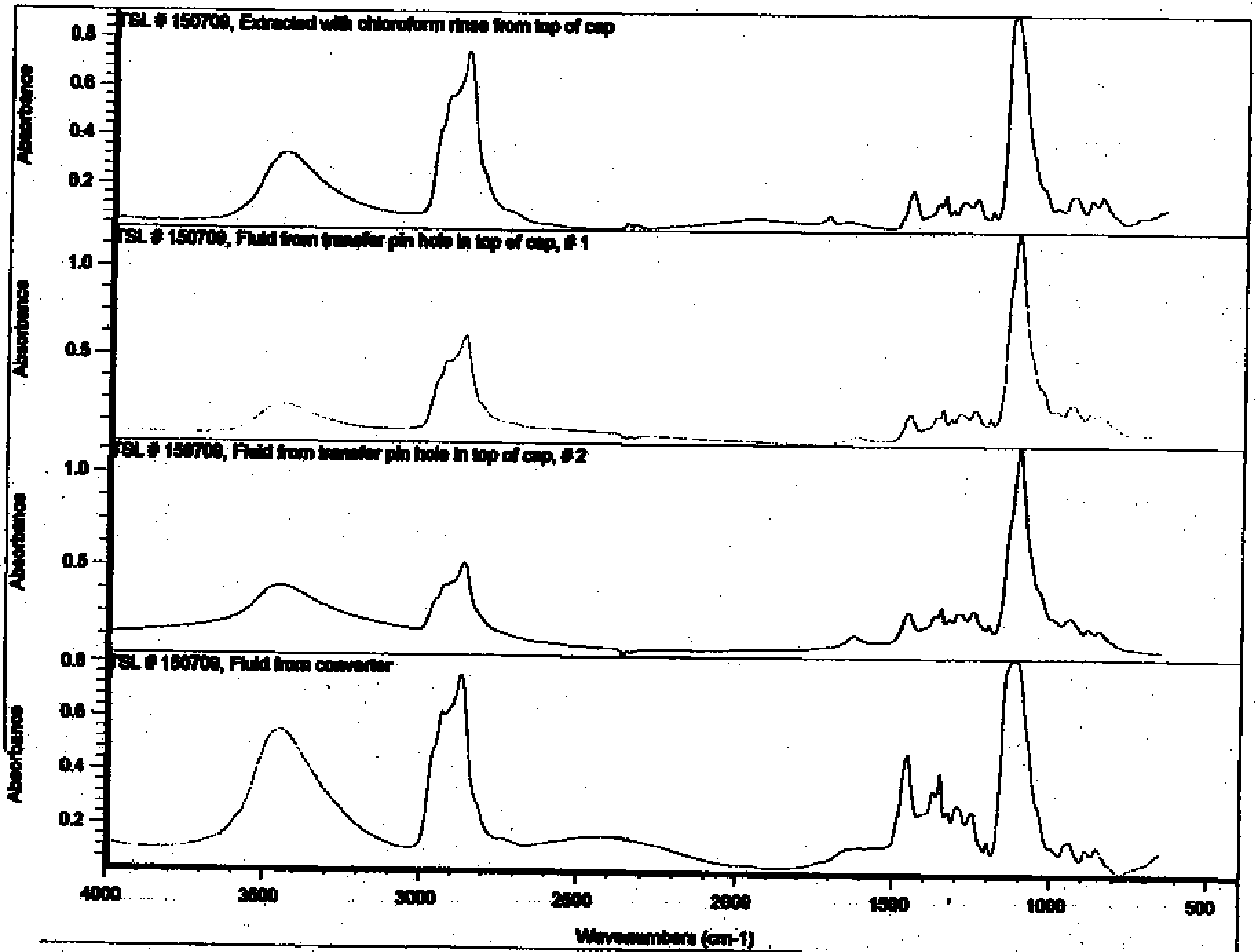
| | | | |
|---|---|---|---|
| TECHNICIAN | | | |
| HOURS WORKED | | | |
| PROCEDURE USED | | | |
| | | | |

*PCC I.D.

| | | | |
|---|---|---|---|
| MC=325 | TM=431 | CLKE=122 | FACIL=514 |
| PC=127 | WIRE=432 | CAN=954 | FACIL=521 |
| VERS=158 | EPD=621 | AD DEV=286 | FACIL=531 |
| AFCC=463 | PEP=622 | EMCD=877 | STAFF=855 |
| IMD=430 | CSD=835 | | |

DISTRIBUTION: White and Yellow - Lab Pink - Requestor

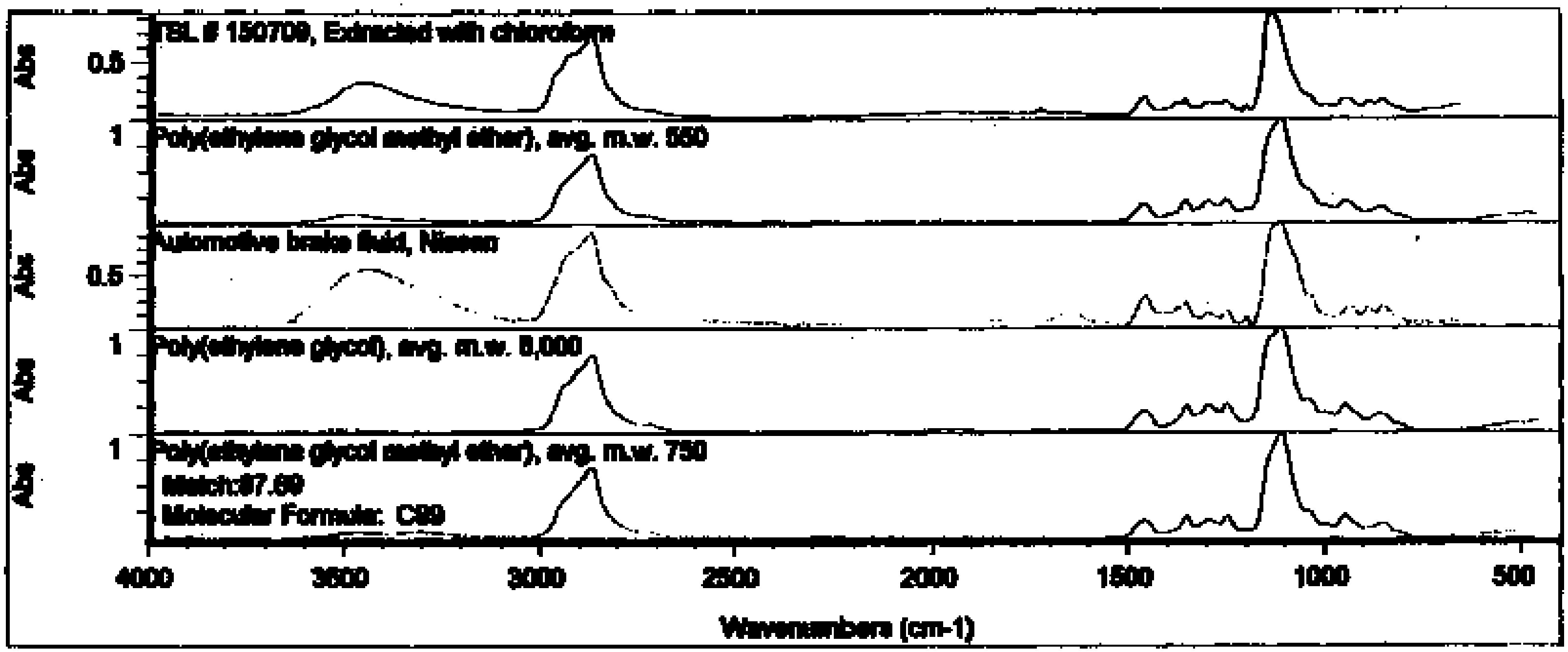
TI-NHTSA 012147




TI-NHTSA 012146

## OMNIC Search

Spectrum: TSL # 150709, Extracted with chloroform
Fri Jan 08 11:18:42 1999
Region: 3995.85 649.98
Search type: Correlation
Comment:




| Index | Match | Compound name | Library |
|---|---|---|---|
| 10394 | 90.09 | Poly(ethylene glycol methyl ether), avg. | Aldrich Condensed Phase |
| 90 | 89.55 | Automotive brake fluid, Nissan | TSL |
| 10392 | 87.98 | Poly(ethylene glycol), avg. m.w. 8,000 | Aldrich Condensed Phase |
| 10393 | 87.69 | Poly(ethylene glycol methyl ether), avg. | Aldrich Condensed Phase |
| 9548 [?] | 87.10 | Brij 98; Polyoxyethylene(20) oleyl ether | Aldrich Condensed Phase |
| 9613 [?] | 86.38 | Brij 35; Polyoxyethylene(23) lauryl ethe | Aldrich Condensed Phase |
| 9539 | 84.80 | Brij 78; Polyoxyethylene(20) stearyl eth | Aldrich Condensed Phase |
| [illegible] | 83.20 [?] | Poly(ethylene glycol methyl ether), avg. | Aldrich Condensed Phase |
| 9535 [?] | 83.05 [?] | [illegible] glycol [illegible] ether, 98% | Aldrich Condensed Phase |
| [illegible] | 82.99 [?] | Poly(ethylene glycol), avg. m.w. 600 | Aldrich Condensed Phase |

TI-NHTSA 012148

1-20-99

**Ford 77ps Issue Notes**

Device's removed only from vehicles with ABS systems . Non ABS cars did not have this device installed nor did the proportioning valve have provisions to install the device .

All devices removed showed corrosion down threads of device close to sealing area .

None of the switches were removed from cars that had been on fire . Please note that did see others with out 77ps installed that have caught fire in the dashboard and upper outer fire wall of vehicle .

All of the device had some amount of water in the sheathing that covers the wires to the device . This moisture was present regardless of whether the engine compartment was covered on not .

Devices did require a noticeable amount of torque for removal from proportioning valve .

None of the devices showed any external leaking of brake fluid nor a build up of dust and dirt on device .

One of the cars that a device was removed was a 1988 town car with ABS this car had a fire above our device .

1-21-99

# Ford 77PS Issue Recovered Parts Analysis

External switch condition ______________________________
______________________________
______________________________

## Remove Connector

Terminal Condition ______________________________
______________________________

Switch Pocket ______________________________
______________________________

## Remove Crimp Ring

Contact Assembly ______________________________
______________________________
______________________________

Sensor Assembly ______________________________
______________________________
______________________________

Transfer Pin ______________________________
______________________________

Environmental Seal ______________________________

## Disassemble Sensor

Kapton Condition ______________________________
______________________________
______________________________

Snap Disc ______________________________
______________________________

Washer ______________________________

Converter ______________________________

Hex port internal ______________________________

1-21-99

# Ford 77Ps Recovered Parts Analysis

**Make**

---

**Model**

---

**Year**

---

**Date Recovered**

---

**Recovery Location**

---

**Mileage**

---

**TI Test #**

---

**Technician**

---

**Date Tested**

---

**Device Photograph** **Kapton Photograph**

[illegible]

TO BE USED FOR REFERENCE ONLY

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 2 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 3 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 4 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 5 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 6 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 7 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 8 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

1) Need to affect application
2) TI interest
3) No response to Ford

* Volume production ending on [illegible]
* Run testing to re-create fire conditions
* List all items which can lead to water in brake fluid
* ppm level on leak related defects
* [illegible] / Application
* List of tests TI will run

TI-NHTSA 012153

[illegible]

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 2 | [illegible] ✓ | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 3 | [illegible] ✓ | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 4 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 5 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 6 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 7 | [illegible] ✓ | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 8 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

✓ [illegible]

7710 Ignition ...



# 77PS Ignition Re-creation

**Abstract**

The purpose of this test was to investigate possible sources of ignition caused by fluid build-up in the contact cavity of 77PS switches. The contact cavities of a sample of switches were filled with varying amounts of brake fluid, water, salt, and metal particles. The sample was placed in a test bed with a common electrical ground. Power was applied to the terminals of each switch which allowed the fluid to be the conductive path to the grounded hexport bodies. Fluid temperature was recorded and observations noted.

## Procedure

### Test Sample 1 (TS1) Procedure

TS1 consisted of (10) 77PS switches. A small hole was drilled into the base of each switch. (5) different solutions of a brake and tap water mix were injected into the contact cavity of the switches. The percent water concentration in brake fluid that was injected into each switch is outlined in Table 1, below. A K-type thermocouple was placed into the fluid of (5) of the switches, to monitor fluid temperature. The sample was placed in a test bed with a common electrical ground.

On devices 2A and 5A, an external 12 Ω resistor was placed from the second terminal to ground. This was done to create an electric path through the switch contact as an additional source of heat in those (2) devices. 14 Volts was applied to the first terminal of all switches. To facilitate continuous testing, switches were placed in an oven and powered over several days. The oven was used only as a safety precaution to contain potential ignitions. Ambient temperature and oven temperature were periodically recorded. Fluid levels were monitored and replenished as required.

At the completion of this test, device 3A was exposed to a salt water solution and powered at 14 volts for approximately 60 hours. This was an effort to quantify corrosion. All the switches were then disassembled and observations were recorded.

Table 1.

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

Test Sample 2 (TS2) Procedure

TS2 was used to accelerate switch contact corrosion; therefore causing a high resistance across switch terminals.
TS2 consisted of (9) 77PS switches. A small hole was drilled into the base of each switch. (3) solutions of tap water with different concentrations of salt were injected into the contact cavity of the switches. The percent salt concentration injected into each switch is outlined in Table 2, below. Metal dust and filings were also injected into the fluid of (2) switches as noted in Table 2..

Table 2.

| Test Device # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| % NaCl in tap water (by weight) | 2.5 | 2.5 | 2.5 | 5 | 5 | 5 | 10 | 10* | 10** |

NOTES: * indicates metal dust from a switch washer was added to mixture (one time only).
** indicates large metal filings were added to mixture (one time only).

The sample was placed in a test bed with a common electrical ground. Power was applied to the terminals of each switch and the current and voltage draw was recorded. Power was applied to all switches until the water evaporated. (Note: in some cases the switches were placed in an oven at a higher temperature to accelerate evaporation). The resistance across switch terminals was recorded. Fluids were again injected into the switches, and the test was repeated several times.

Data

TS1 data

The raw data obtained in TS1 is shown in Table 3, below. Photos of the connector arm degradation are displayed in Figure 1 and Figure 2. Figure 2 also shows connector arm corrosion of device 3A when exposed to salt/water solution and powered for approximately 60 hours.

Table 3.

| | | | Device # | | | | |
|---|---|---|---|---|---|---|---|
| Date: | 2/11/99 | | | | | | |
| Time: | 14:40 | Temperature | 1A | 2A | 3A | 4A | 5A |
| Ambient Temp. (°F): | 84 | (°F) Running | 86 | 86 | 85 | 84 | 86 |
| Oven Temp. (°F): | 86 | (°F) Peak | 87 | 98 | 86 | 85 | 98 |
| Date: | 2/12/99 | Temperature | | | | | |
| Time: | 11:05 | (°F) Running | 98 | 94 | 89 | 99 | 100 |
| Ambient Temp. (°F): | 79 | (°F) Peak | 112 | 99 | 95 | 104 | 106 |
| Oven Temp. (°F): | 83 | | | | | | |
| Date: | 2/13/99 | Temperature | | | | | |
| Time: | 9:30 | (°F) Running | 87 | 96 | 107 | 88 | 103 |
| Ambient Temp. (°F): | NA | (°F) Peak | 88 | 101 | 111 | 91 | 104 |
| Oven Temp. (°F): | NA | | | | | | |
| Date: | 2/15/99 | Temperature | | | | | |
| Time: | 13:30 | (°F) Running | 83 | 81 | 105 | 82 | 96 |
| Ambient Temp. (°F): | 81 | (°F) Peak | 99 | 103 | 121 | 97 | 117 |
| Oven Temp. (°F): | 81 | | | | | | |
| Date: | 2/16/99 | Temperature | | | | | |
| Time: | 12:00 | (°F) Running | 76 | 84 | 109 | 84 | 81 |
| Ambient Temp. (°F): | 78 | (°F) Peak | 79 | 100 | 120 | 90 | 119 |
| Oven Temp. (°F): | 78 | | | | | | |

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

## TS2 data

Table 4, below shows the currents and voltages measured for TS2.

Table 4.

| Device # (% NaCl) | Voltage (Volts) | Current (mA) | Notes |
|---|---|---|---|
| 1 (2.5%) | 14.03 | ~400 | It was very difficult to obtain accurate current readings due to ionization of the fluid. Current readings dropped very rapidly as the electrodes charged. Due to instrument limitations, the reported current readings are probably less than actual. |
| 2 (2.5%) | 14.08 | ~750 | |
| 3 (2.5%) | 14.08 | ~830 | |
| 4 (5.0%) | 14.08 | ~800 | |
| 5 (5.0%) | 14.08 | ~830 | |
| 6 (5.0%) | 14.06 | ~1100 | |
| 7 (10%) | 14.06 | ~1200 | |
| 8 (10%) | —— | >1400 | Current limited |
| 9 (10%) | —— | >1400 | Current limited |

**Results**

TS1 showed that brake/water build up in the connector cavity was not sufficient to cause an ignition when powered by 14 Volts. The peak temperature recorded during the test was 121°F, which is well below a cause for concern.

TS2 failed to produce a source of high resistance across terminals caused by contact corrosion. To date, the highest measured resistance across terminals is 5 Ω.

**Conclusions**

This test eliminated brake/water fluid build up in the switch contact cavity as a possible source of ignition. Efforts continue to cause high switch contact resistance via corrosive elements.

Figure 1.

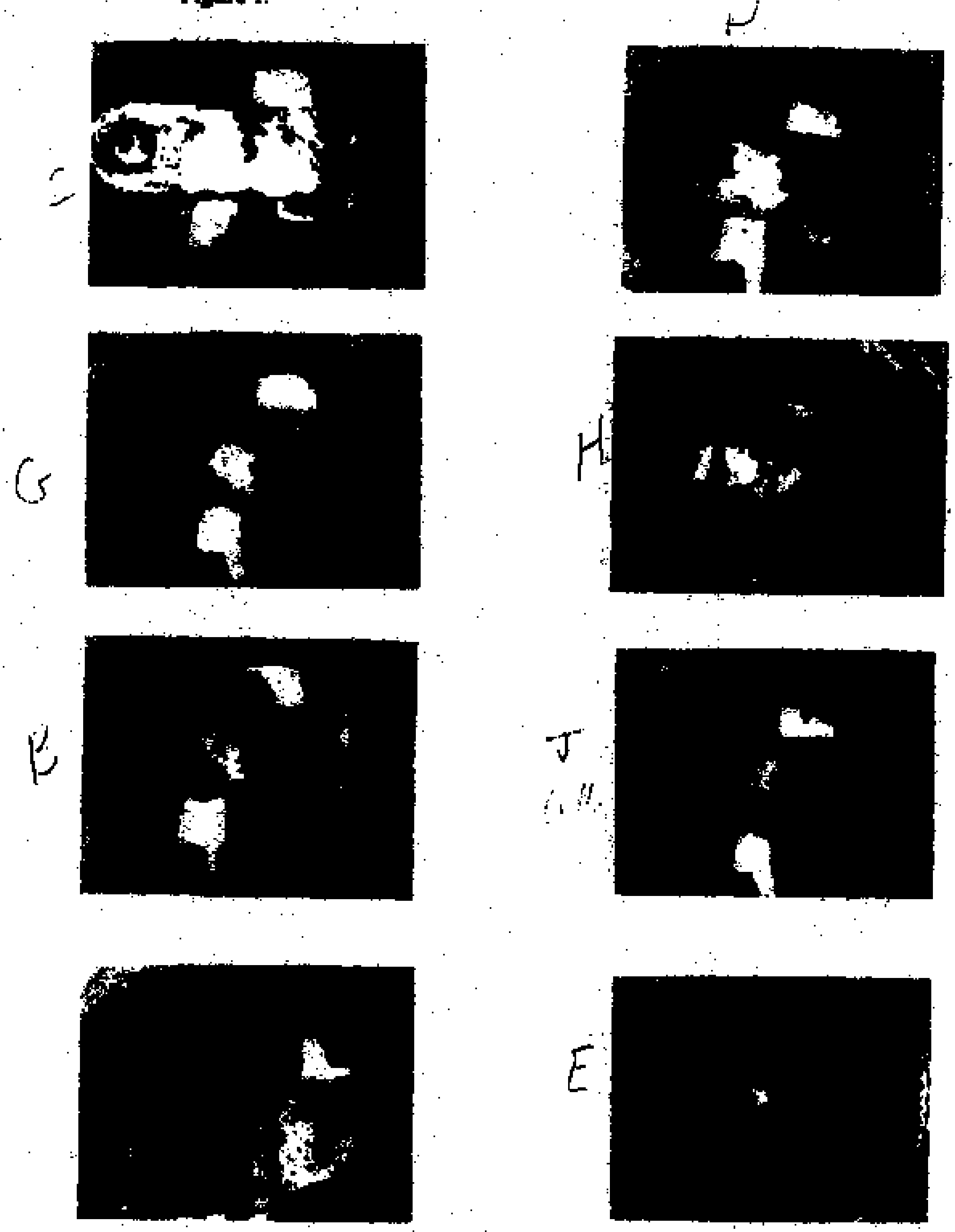
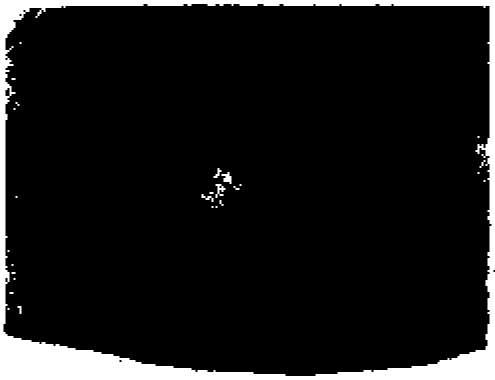
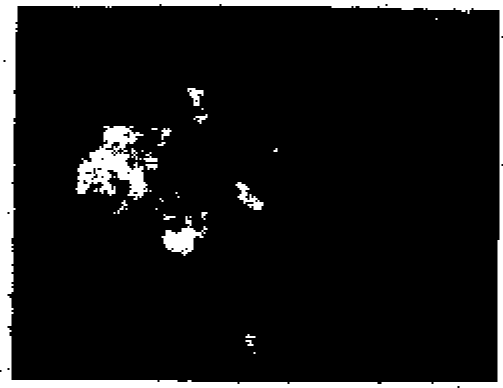


Figure 2.

F



I



Salt water corrosion of switch 3A.

# Ford 77ps Fluid Temperature Testing

There will be 10 samples tested on a common manifold , the manifold is a common ground for the electrical portion of the test . Devices will be drilled through top of connector pocket to allow access to contact area .The contact cavity shall be filled with a solution of brake fluid and tap water . All devices will have 14.00 volts DC applied direct from a power supply with no resistive load in line to one terminal allowing fluid to become the resistive load .

Two of the devices shall have a 12 ohm resistor from second terminal to ground crating a electrical load through terminals and contacts . Temperature will be monitored and recorded in one of each device of each solution and with the devices that have electrical loads connected to terminals for loading the contacts . A temperature recorder must be used to keep constant readings of device/fluid temperature and have the ability to record and hold peak temperatures .

Solution concentrations are by volume not weight .

Solution 1 - 0% added water used for devices #1and #2

Solution 2 - 4% added water used for devices #3 and #4

Solution 3 - 6% added water used for devices #5 and # 6

Solution 4 - 10% added water used for devices #7 and #8 (SAE Standard)

Solution 5 - 75% added water used for devices #9 and #10

Lance Cambra

# Ford 77 ps Fluid Temperature Testing

**Technician :** LEC **Date :** ~~[illegible]~~ Thursday 2-11-99 **Time :** 240 PM

**Temperature Readings**

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Running Current | 86 | 86 | 95 | 89 | 86 |
| Peak | 87 | 98 | 96 | 95 | 94 |

**Current Readings**

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| NA | NA | NA | NA | 5.80 mA Fell to 5.08 @ 2:55 |

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

This was Initial start up of Test 1% & 75% have Constant Load. These Devices are Temp. monitored also

Ambient Temperature
89°F

Oven Temperature
86°F

# Ford 77 ps Fluid Temperature Testing

**Technician :** LEC **Date :** 2-12-99 **Time :** 11:05 AM

**Temperature Readings**

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Running | 98 | 94 | 89 | 97 | 100 |
| Peak | 112 | 99 | 95 | 109 | 106 |

**Current Readings**

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| – | – | – | – | .57 mA |

Voltage 19.05

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

Fluid Levels are Difficult to see Due to confined area and lack of available light. Do not understand high Temp. Reading of #2 T-couple. Removed and Tested T-couple and Read normal - interchanged #2 & #3 T-couple and #3 Read high. T-couples Returned to original Position and assume that 4% solution and/or contact current is showing a effect on Temperature

**Ambient Temperature**

79°

**Oven Temperature**

83°

TI-NHTSA 012163

# Ford 77 ps Fluid Temperature Testing

**Technician :** **Date :** 2-13 **Time :** 9:70

**Temperature Readings**

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| 87 | 96 | 107 | 88 | 102 |

**Current Readings**

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| X | K | K | Y | .47 mA |

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

Ambient Temperature

Oven Temperature

Peak Temp

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| | | | 91 | 104 |

TI-NHTSA 012164

# Ford 77 ps Fluid Temperature Testing

**Technician :** [illegible] **Date :** [illegible] **Time :** [illegible]

**Temperature Readings**

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 99 | [illegible] | 121 | 77 | 117 |

**Current Readings**

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

[illegible] 14.0

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

[illegible]

Ambient Temperature

Oven Temperature

# Ford 77 ps Fluid Temperature Testing

**Technician :** **Date :** **Time :**

**Temperature Readings**

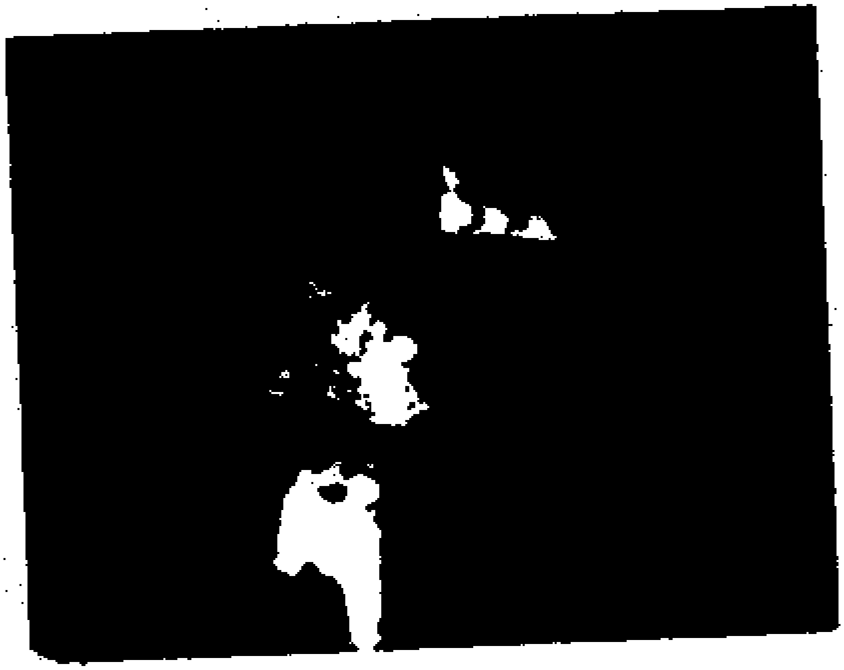
| **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|

**Current Readings**

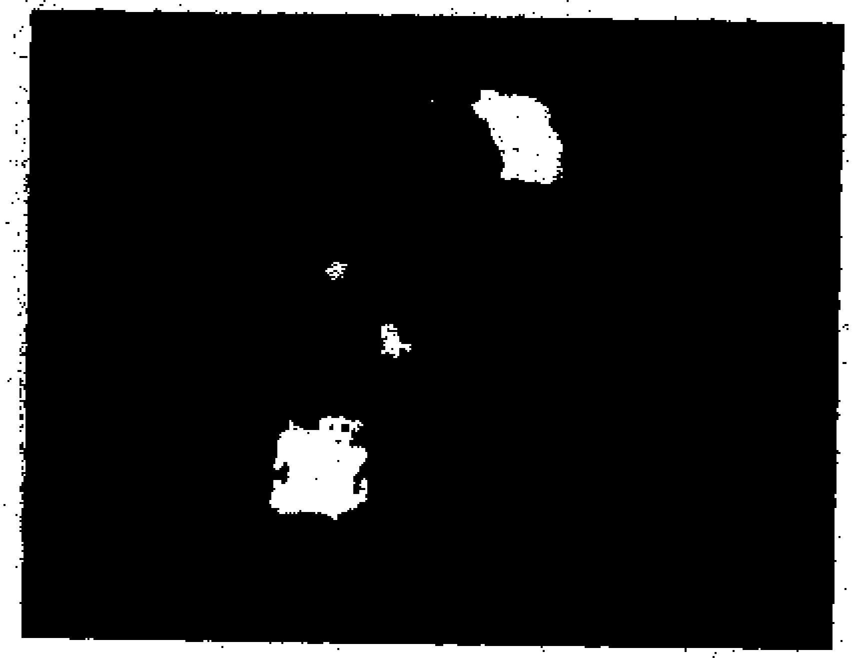
| **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|

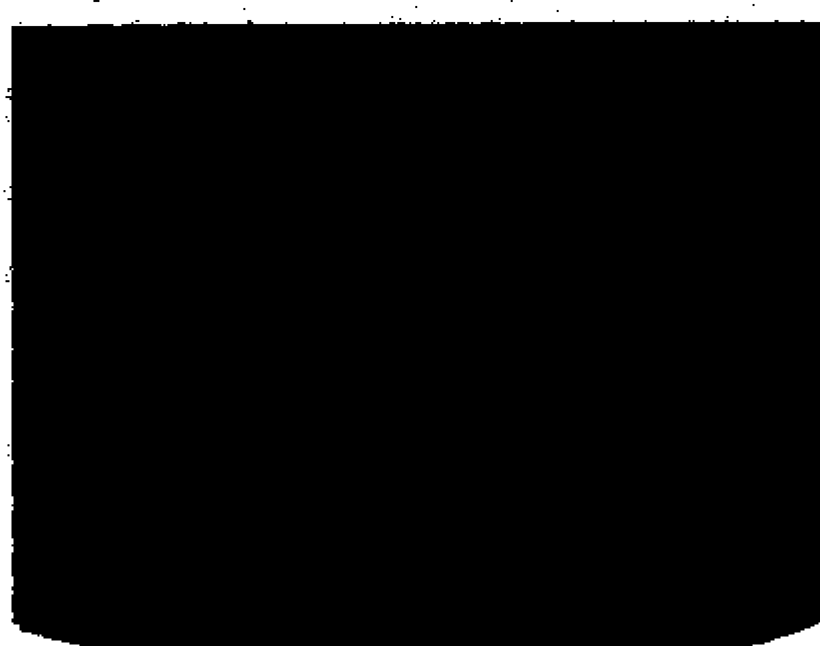
**NOTES :** (please include any information and observations).......

Ambient Temperature Oven Temperature

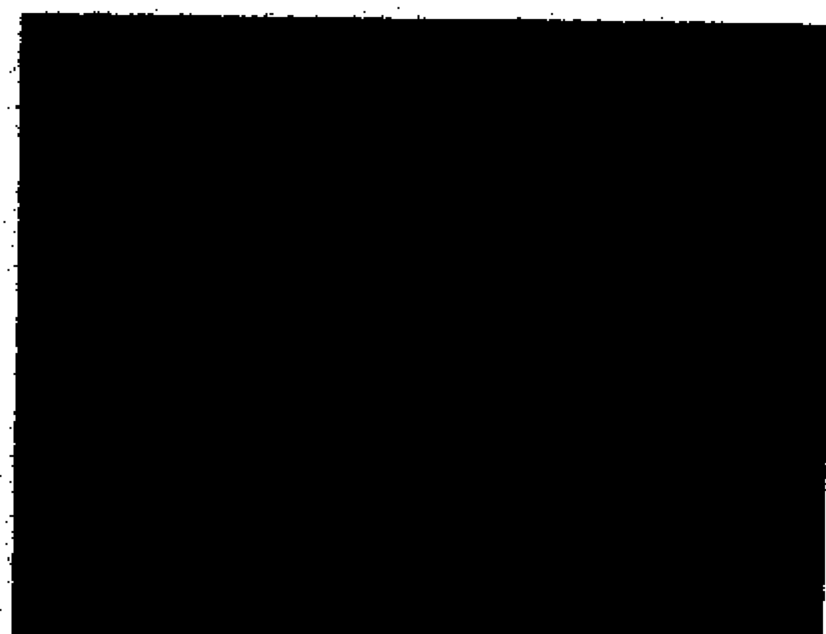


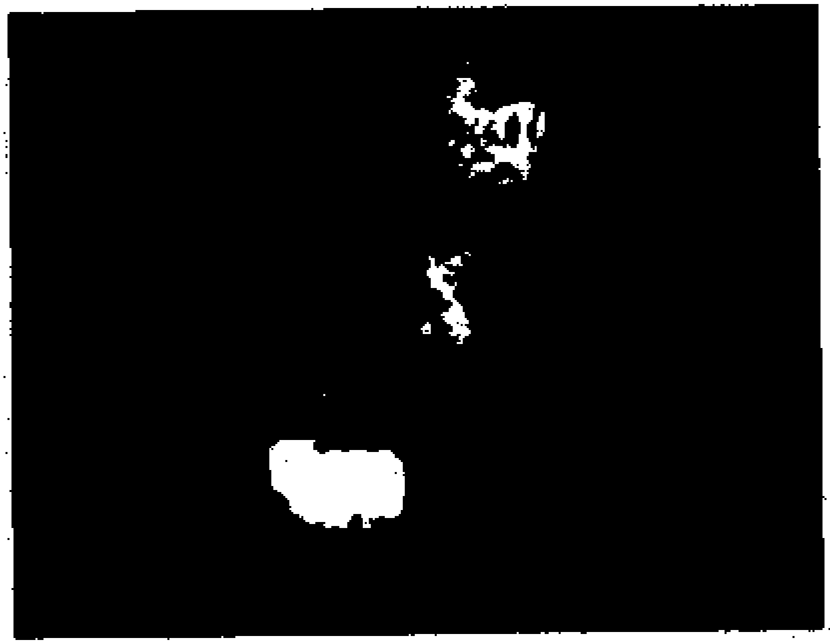
TI-NHTSA 012167

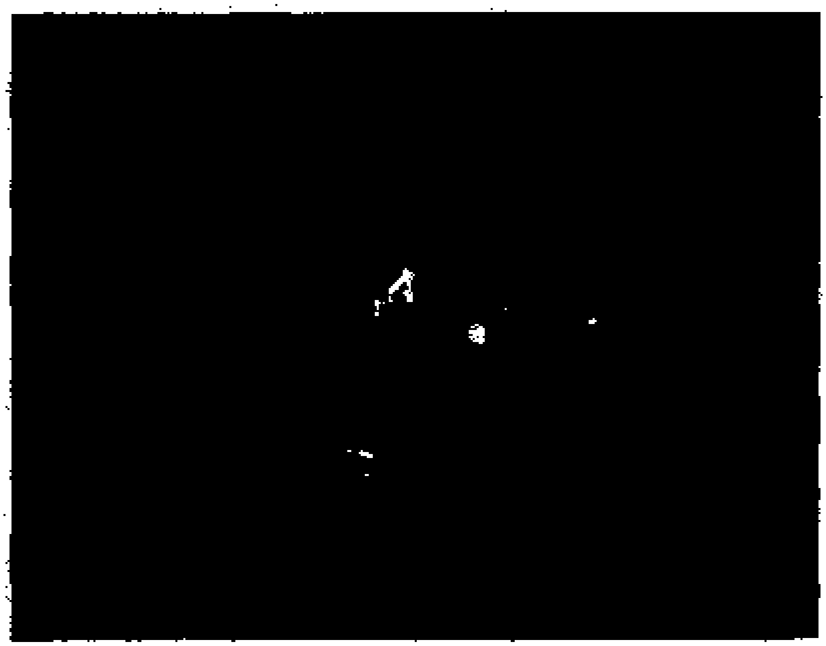


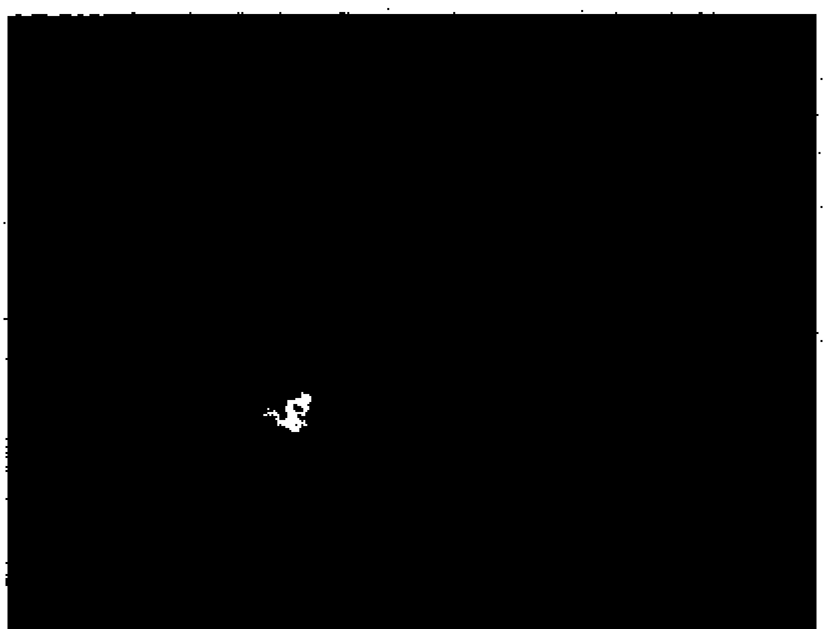


TI-NHTSA 012168









TI-NHTSA 012171

# 77PS Ignition Re-creation

**Abstract**

The purpose of this test was to investigate possible sources of ignition caused by fluid build-up in the contact cavity of 77PS switches. The contact cavities of a sample of switches were filled with varying amounts of brake fluid, water, salt, and metal particles. The sample was placed in a test bed with a common electrical ground. Power was applied to the terminals of each switch which allowed the fluid to be the conductive path to the grounded hexport bodies. Fluid temperature was recorded and observations noted.

**Procedure**

<u>Test Sample 1 (TS1) Procedure</u>

TS1 consisted of (10) 77PS switches. A small hole was drilled into the base of each switch. (5) different solutions of a brake and tap water mix were injected into the contact cavity of the switches. The percent water concentration in brake fluid that was injected into each switch is outlined in Table 1, below. A K-type thermocouple was placed into the fluid of (5) of the switches, to monitor fluid temperature. The sample was placed in a test bed with a common electrical ground.

On devices 2A and 5A, an external 12 Ω resistor was placed from the second terminal to ground. This was done to create an electric path through the switch contact as an additional source of heat in those (2) devices. 14 Volts was applied to the first terminal of all switches. To facilitate continuous testing, switches were placed in an oven and powered over several days. The oven was used only as a safety precaution to contain potential ignitions. Ambient temperature and oven temperature were periodically recorded. Fluid levels were monitored and replenished as required.

At the completion of this test, device 3A was exposed to a salt water solution and powered at 14 volts for approximately 60 hours. This was an effort to quantify corrosion. All the switches were then disassembled and observations were recorded.

**Table 1.**

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

Table 3.

| | | Device # | | | | |
|---|---|---|---|---|---|---|
| | Temperature | 1A | 2A | 3A | 4A | 5A |
| Date: 2/11/99<br>Time: 14:40<br>Ambient Temp. (°F): 84<br>Oven Temp. (°F): 86 | (°F) Running | 86 | 86 | 85 | 84 | 86 |
| | (°F) Peak | 87 | 98 | 86 | 85 | 98 |
| Date: 2/12/99<br>Time: 11:05<br>Ambient Temp. (°F): 79<br>Oven Temp. (°F): 83 | Temperature | | | | | |
| | (°F) Running | 98 | 94 | 89 | 99 | 100 |
| | (°F) Peak | 112 | 99 | 95 | 104 | 106 |
| Date: 2/13/99<br>Time: 9:30<br>Ambient Temp. (°F): NA<br>Oven Temp. (°F): NA | Temperature | | | | | |
| | (°F) Running | 87 | 96 | 107 | 88 | 103 |
| | (°F) Peak | 88 | 101 | 111 | 91 | 104 |
| Date: 2/15/99<br>Time: 13:30<br>Ambient Temp. (°F): 81<br>Oven Temp. (°F): 81 | Temperature | | | | | |
| | (°F) Running | 83 | 81 | 105 | 82 | 96 |
| | (°F) Peak | 99 | 105 | 121 | 97 | 117 |
| Date: 2/16/99<br>Time: 12:00<br>Ambient Temp. (°F): 78<br>Oven Temp. (°F): 78 | Temperature | | | | | |
| | (°F) Running | 76 | 84 | 109 | 84 | 81 |
| | (°F) Peak | 79 | 100 | 120 | 90 | 119 |

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

TS2 data

Table 4, below shows the currents and voltages measured for TS2.

Table 4.

| Device # (% NaCl) | Voltage (Volts) | Current (mA) | Notes |
|---|---|---|---|
| 1 (2.5%) | 14.03 | ~400 | It was very difficult to obtain accurate current readings due to ionization of the fluid. Current readings dropped very rapidly as the electrodes charged. Due to instrument limitations, the reported current readings are probably less than actual. |
| 2 (2.5%) | 14.08 | ~750 | |
| 3 (2.5%) | 14.08 | ~830 | |
| 4 (5.0%) | 14.08 | ~800 | |
| 5 (5.0%) | 14.08 | ~830 | |
| 6 (5.0%) | 14.06 | ~1100 | |
| 7 (10%) | 14.06 | ~1200 | |
| 8 (10%) | ----- | >1400 | Current limited |
| 9 (10%) | ----- | >1400 | Current limited |

Test Sample 2 (TS2) Procedure

TS2 was used to accelerate switch contact corrosion; therefore causing a high resistance across switch terminals.
TS2 consisted of (9) 77PS switches. A small hole was drilled into the base of each switch. (3) solutions of tap water with different concentrations of salt were injected into the contact cavity of the switches. The percent salt concentration injected into each switch is outlined in Table 2, below. Metal dust and filings were also injected into the fluid of (2) switches as noted in Table 2..

Table 2.

| Test Device # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| % NaCl in tap water (by weight) | 2.5 | 2.5 | 2.5 | 5 | 5 | 5 | 10 | 10* | 10** |

NOTES: * indicates metal dust from a switch washer was added to mixture (one time only).
** indicates large metal filings were added to mixture (one time only).

The sample was placed in a test bed with a common electrical ground. Power was applied to the terminals of each switch and the current and voltage draw was recorded. Power was applied to all switches until the water evaporated. (Note: in some cases the switches were placed in an oven at a higher temperature to accelerate evaporation). The resistance across switch terminals was recorded. Fluids were again injected into the switches, and the test was repeated several times.

Data

TS1 data

The raw data obtained in TS1 is shown in Table 3, below. Photos of the connector arm degradation are displayed in Figure 1 and Figure 2. Figure 2 also shows connector arm corrosion of device 3A when exposed to salt/water solution and powered for approximately 60 hours.

**Results**

TS1 showed that brake/water build up in the connector cavity was not sufficient to cause an ignition when powered by 14 Volts. The peak temperature recorded during the test was 121°F, which is well below a cause for concern.

TS2 failed to produce a source of high resistance across terminals caused by contact corrosion. To date, the highest measured resistance across terminals is 5 Ω.

**Conclusions**

This test eliminated brake/water fluid build up in the switch contact cavity as a possible source of ignition. Efforts continue to cause high switch contact resistance via corrosive elements.

Figure 1.

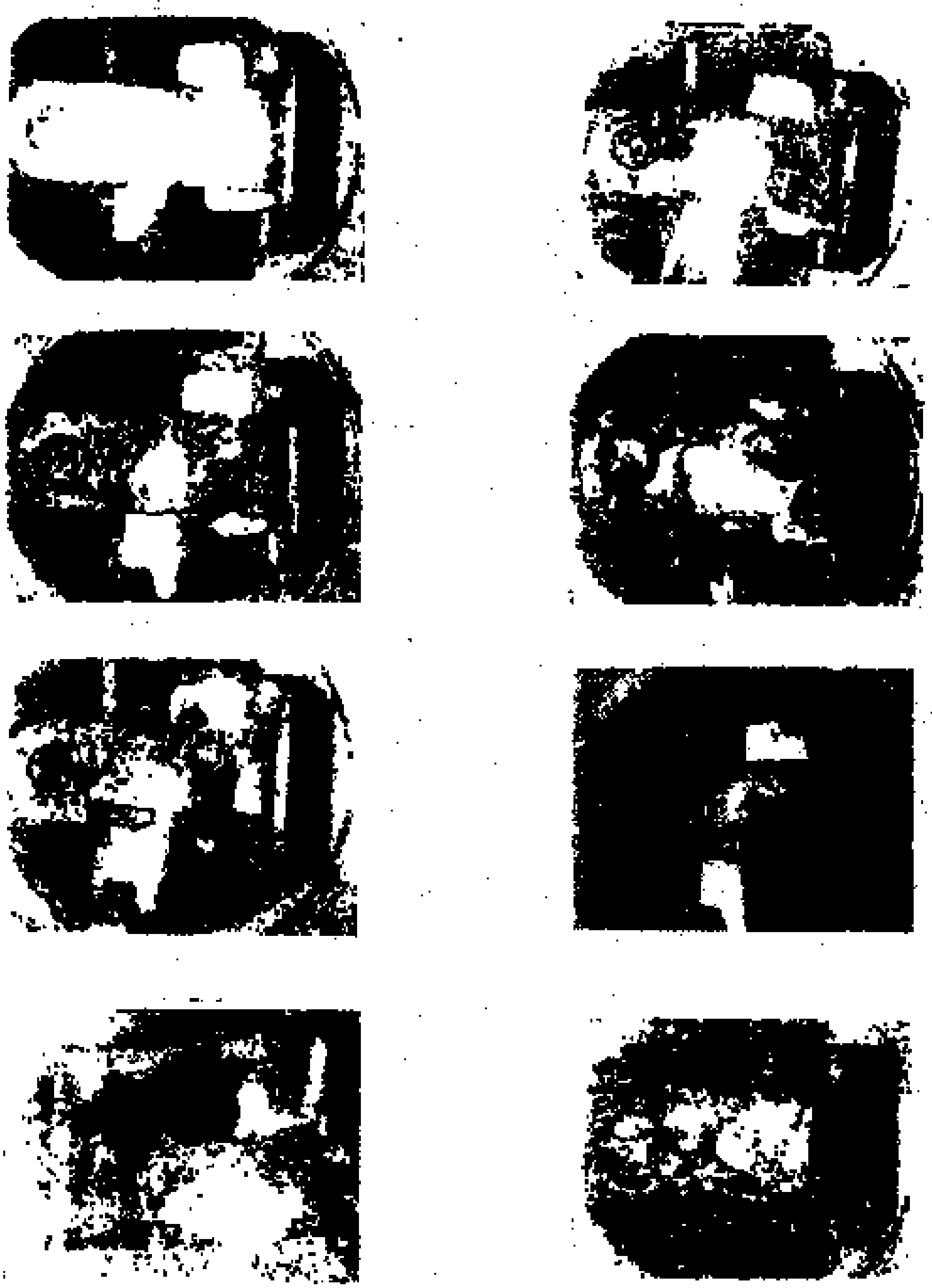
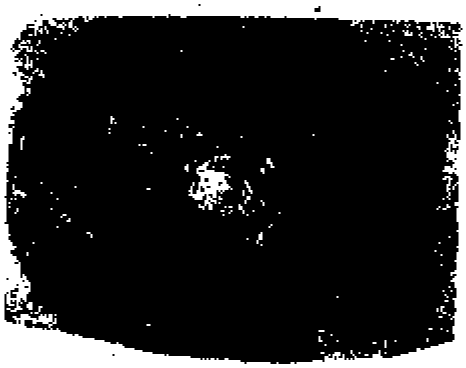
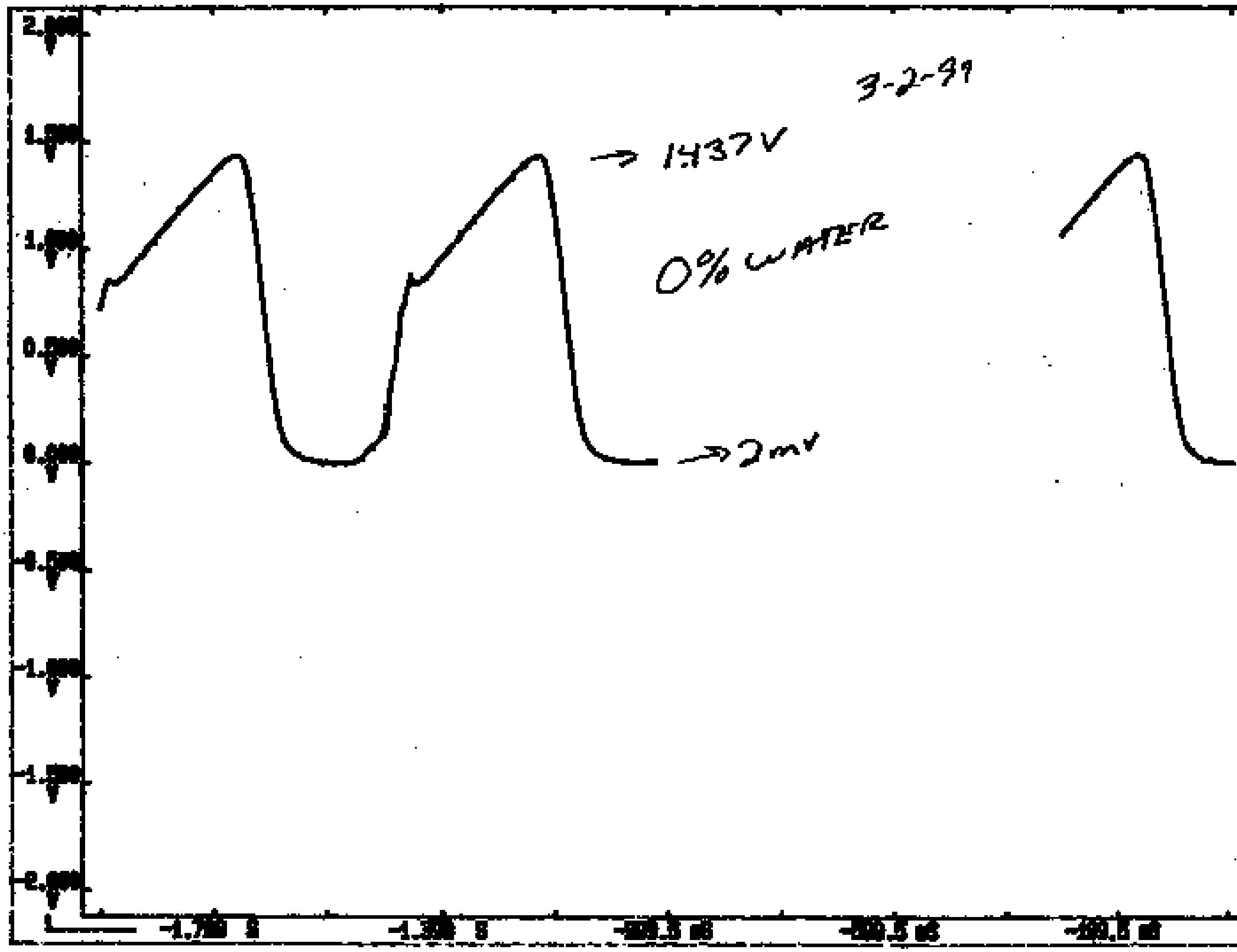
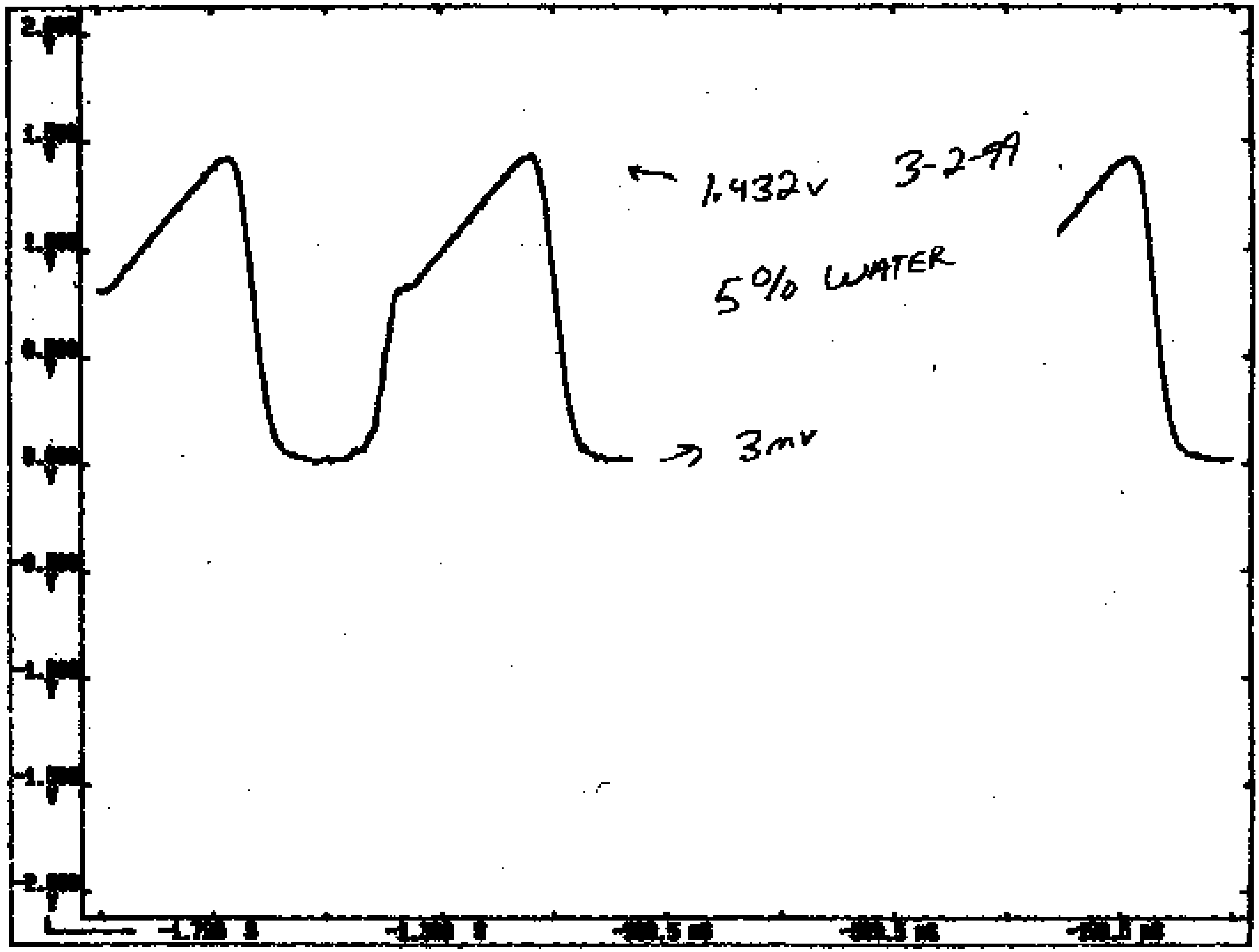


Figure 2.



Salt water corrosion of switch 3A.


3-2-99
1437V
0% WATER
2mV


1.432v 3-2-99
5% WATER
3mv

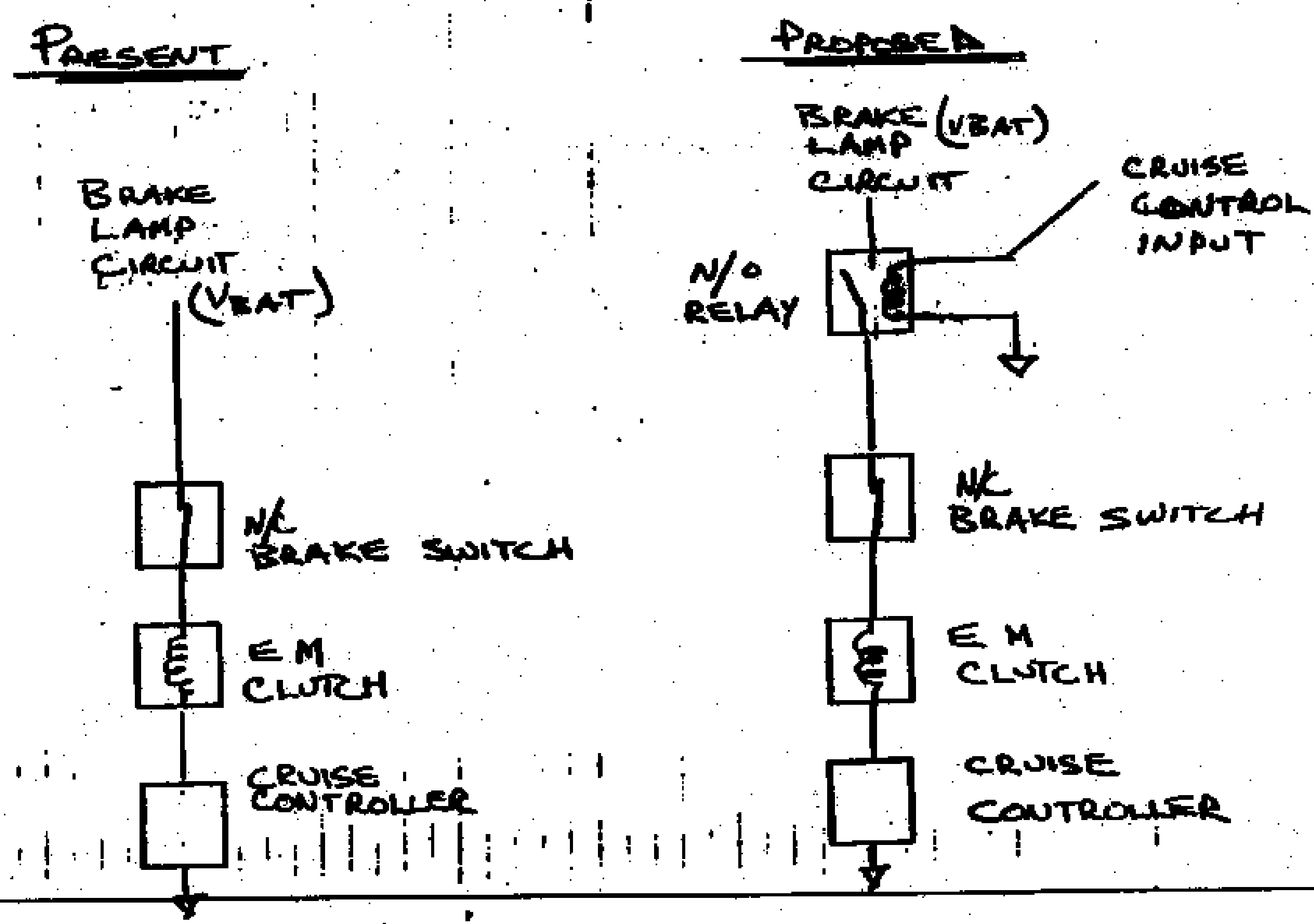
## Potential Cruise Control Circuit Modification

- Present cruise control circuit results in a continuous application of battery voltage to the cruise control pressure switch

- Water ingress into the switch due to misuse (power washing) or seal degradation presents an electrolyte to the switch electrical conductors
  - accelerated corrosion can result
  - Kapton degradation can result

- Cruise control circuit modification to remove continuous application of battery voltage is recommended
  - insertion of a Normally Open relay in series (upstream) of the cruise control pressure switch, that is closed (energized) only when cruise control is switched on is recommended

- This circuit change will remove the continuously applied batter voltage as a potential source of ignition of brake and other automotive fluids




TLNHTSA 012181

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/92/82 | 6/17/92 | N/A | N/A | |
| A3-1 | 77PSL3-1 | PS/92/62 | 4/13/92 | N/A | N/A | |
| | | PS/92/82 | 6/17/92 | 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/92/82 | 6/17/92 | N/A | N/A | |
| A5 | 77PSL5-2 | PS/92/80 | 8/12/92 | N/A | N/A | P/N CORRECTION 2/8/96 |
| A6 | 77PSL6-1 | PS/93/32 | 5/3/93 | purple o-ring) | N/A | |
| | | PS/93/11 | 2/12/93 | | N/A | |
| A7 (WIN 88) | 77PSL3-2 | PS/92/80 | 8/12/92 | N/A | N/A | |
| A7-1 | 77PSL3-2 | PS/92/82 | 6/17/92 | 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 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| P/N: | | 77PSL2-1 | | | | DATE: | 1/14/97 | | |
| A. CALIBRATION SPEC | | | | POST TEST | | | | | |
| | ACT | 90-160 | | A.S.M.P. | | | | | |
| | REL | 20 MIN | | A.S.M.P. | | LAB TEST # | 532-16-64 | | |
| B. MILLIVOLT DROP | < 200 | | | A.S.M.P. | | | | | |
| C. CURRENT LEAKAGE | | | | A.S.M.P. | | | | | |
| D. PROOF | | 3000psi | | A.S.M.P. | | | | | |
| POST TESTS: | | | | | | IP-2 TEST | | POST TESTS: | |
| DEVICE # | PROOF | ACT | REL | MVD | CUR.LK | VIBRATION | | A,B,C,D | |
| 1 | OK | 134 | 59.6 | 0.19 | OK | # 1-6 | | | |
| 2 | OK | 121.4 | 58.9 | 0.32 | OK | | | | |
| 3 | OK | 134.7 | 69.9 | 0.21 | OK | | | | |
| 4 | OK | 131.6 | 76.4 | 0.21 | OK | | | | |
| 5 | OK | 129.4 | 60.4 | 0.22 | OK | | | | |
| 6 | OK | 131.3 | 61.3 | 0.25 | OK | | | | |
| 7 | OK | 133.6 | 65.4 | 0.29 | OK | VACUUM | | A,B,C,D | |
| 8 | OK | 134.4 | 66.7 | 0.21 | OK | # 7-12 | | | |
| 9 | OK | 125.6 | 60 | 0.29 | OK | | | | |
| 10 | OK | 122.4 | 65.3 | 0.22 | OK | | | | |
| 11 | OK | 127.6 | 69.6 | 0.21 | OK | | | | |
| 12 | OK | 124.7 | 62.8 | 0.19 | OK | | | | |
| 13 | OK | 113.6 | 57.5 | 0.19 | OK | TEMP.CYCLE | | A,B,C,D | |
| 14 | OK | 123.4 | 59.7 | 0.26 | OK | # 13-18 | | | |
| 15 | OK | 126.4 | 54.4 | 0.41 | OK | | | | |
| 16 | OK | 116.9 | 60.6 | [redacted] | | | | | |
| 17 | OK | 121.9 | 61.9 | [redacted] | | | | | |
| 18 | OK | 118.6 | 63.2 | [redacted] | | | | | |
| 19 | OK | 120.1 | 66.4 | [redacted] | | | | /A. 1/YR.ONLY | |
| 20 | OK | 114.4 | 64.6 | [redacted] | | | | | A,B,C,D |
| 21 | OK | 114.8 | 61.2 | [redacted] | | | | | |
| 22 | OK | 117.1 | 63.1 | [redacted] | | | | | |
| 23 | OK | 114.4 | 66.1 | [redacted] | | | | | |
| 24 | OK | 117.4 | 63.4 | [redacted] | | | | | |
| 25 | OK | 118.2 | 65.6 | [redacted] | | | | | |
| 26 | OK | 114.5 | 64.4 | [redacted] | | | | | |
| 27 | OK | 114.6 | 67.6 | [redacted] | | | | | |
| 28 | OK | 110.6 | 66.6 | [redacted] | | | | | |
| 29 | OK | 112.9 | 66.4 | [redacted] | | | | | |
| 30 | OK | 123.6 | 72.6 | [redacted] | | | | | |
| 31 | OK | 130.6 | 66.5 | [redacted] | | | | | A,B,C,D |
| 32 | OK | 134.6 | 66.9 | [redacted] | | | | | |
| 33 | OK | 128.9 | 60.2 | [redacted] | | | | | |
| 34 | OK | 131.6 | 63.4 | 0.22 | OK | | | | |
| 35 | OK | 128.1 | 66.9 | 0.27 | OK | | | | |
| 36 | OK | 121.6 | 64.6 | 0.56 | OK | | | | |
| 37 | OK | 124.4 | 68.6 | 0.23 | OK | | | | |
| 38 | OK | 137 | 63.9 | 0.37 | OK | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| P/N: | | | | | | DATE: | | | |
| A. CALIBRATION SPEC | | | | POST TEST | | | | | |
| | ACT | | | A.S.M.P. | | | | | |
| | REL | | | A.S.M.P. | | | | | |
| B. MILLIVOLT DROP | | | | A.S.M.P. | | | | | |
| C. CURRENT LEAKAGE | | | | A.S.M.P. | | | | | |
| D. PROOF | | | | A.S.M.P. | | | | | |
| POST TESTS: | | | | | | IP-2 TEST | | POST TESTS: | |
| DEVICE # | PROOF | ACT | REL | MVD | CUR.LK | | | | |
| 39 | OK | 132.2 | 61.4 | 0.19 | OK | | | | |
| 40 | OK | 136.4 | 70.1 | 0.22 | OK | | | | |
| 41 | OK | 132.8 | 69.5 | 0.25 | OK | | | | |
| 42 | OK | 136.9 | 67.4 | 0.19 | OK | | | | |
| 43 | OK | 141.4 | 70.3 | 0.8 | OK | | HUMIDITY | | A,B,C,D |
| 44 | OK | 141.1 | 63.3 | 0.21 | OK | | #43-48 | | |
| 45 | OK | 140.2 | 66.3 | 0.27 | OK | | | | |
| 46 | OK | 132.4 | 68.6 | 0.32 | OK | | | | |
| 47 | OK | 135.8 | 62.2 | 0.23 | OK | | | | |
| 48 | OK | 154.4 | 56.7 | 0.23 | OK | | | | |
| 49 | OK | 123.7 | 59.7 | 0.19 | OK | | SALT SPRAY | | A,B,C,D |
| 50 | OK | 133.4 | 68.1 | 0.63 | OK | | #49-54 | | |
| 51 | OK | 148.6 | 48.8 | 0.61 | OK | | | | |
| 52 | OK | 141.2 | 64.5 | 0.25 | OK | | | | |
| 53 | OK | 130.4 | 60.4 | 0.23 | OK | | | | |
| 54 | OK | 144.3 | 50.4 | 0.22 | OK | | | | |

| 77PSL5-2 IP-2 TEST STATUS | | | | | | | | 3/96 | |
|---|---|---|---|---|---|---|---|---|---|
| RI - | | | | | | | | | |
| | | ACT | REL | VOLT.DROP | CURR.LEAK | PROOF | VIBRATION | STATUS | |
| I. VIBRATION | PRE-TEST | OK | OK | OK | OK | OK | OK | | |
| (6 PCS) | POST TEST | OK | OK | OK | OK | OK | OK | COMPLETE | |
| | | | | | | | | | |
| K. VACUUM | PRE-TEST | OK | OK | OK | OK | OK | OK | | |
| (6 PCS) | POST TEST | OK | OK | OK | OK | OK | OK | COMPLETE | |
| | | | | | | | | | |
| M. TEMP.CYCLING | PRE-TEST | OK | OK | OK | OK | OK | OK | | |
| (6 PCS) | POST TEST | OK | OK | OK | OK | OK | OK | COMPLETE | |
| | | | | | | | | | |
| H. FLUID RESISTANCE: | PRE-TEST | OK | OK | OK | OK | OK | OK | COMPLETE | |
| POST TESTING: | | | | | | | | | |
| E. IMPULSE | PRE-TEST | OK | OK | OK | OK | OK | OK | | |
| (3 PCS) | POST TEST | OK | OK | OK | OK | OK | OK | COMPLETE | |
| | | | | | | | | | |
| J. TERM. STRENGTH | PRE-TEST | OK | OK | OK | OK | OK | OK | | |
| | POST TEST | OK | OK | OK | OK | OK | OK | COMPLETE | |
| | | | | | | | | | |
| G. HUMIDITY | PRE-TEST | OK | OK | OK | OK | OK | OK | | |
| (6 PCS) | POST TEST | OK | OK | OK | OK | OK | OK | COMPLETE | |
| | | | | | | | | | |
| H. SALT SPRAY | PRE-TEST | OK | OK | OK | OK | OK | OK | | |
| (6 PCS) | POST TEST | OK | OK | OK | OK | OK | OK | COMPLETE | |

TI-NHTSA 012185

# TEST MATRIX

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 77PS IP-2 TESTS | | | SAMPLE SIZE: 54PCS. | | | |
| | FORD BRAKE SPEC. # (INVERTED DELTA) ES--F2VC-9F924-AA | | | | | | | |
| **PRE-TESTING:** | | | | **TEST ACCEPTANCE:** | | **AMT.** | | **WHERE:** |
| | III - D PROOF | | | A.S.M.P. | | ALL | | QA INSP. |
| | III - A CALIBRATION: | | | 100% | | ALL | | L.T. /B.12 |
| | | ACT | | | | | | |
| | | REL | | | | | | |
| | III - MVD | | | A.S.M.P. | | ALL | | L.T. /B.12 |
| | III - CURRENT LEAKAGE | | | A.S.M.P. | | ALL | | QA INSP. |
| **IP-2 TESTS:** | | | | **POST TESTS:** | | | | |
| | III - I VIBRATION | | | A,B,C,D | | 6PCS | # 1-6 | ETL /B.10 |
| | III - K VACUUM | | | A,B,C,D | | 6PCS | # 7-12 | ETL /B.10 |
| | III - L TEMP CYCLING | | | A,B,C,D | | 6PCS | # 13-18 | L.T. /B.12 |
| | III - M FLUID RESISTANCE | | | E,G,H,J | **POST TESTS:** | | # 19-54 | TSL /B.10 |
| | | **III - E IMPULSE | | | A,B,C,D | 12PCS | # 19-30 | L.T. /B.12 |
| | | **III - J TERMINAL STRENGTH | | | A,B,C,D | 12PCS | # 31-42 | QA INSP. |
| | | **III - G HUMIDITY | | | A,B,C,D | 6PCS | # 43-48 | ETL /B.10 |
| | | **III - H SALT SPRAY | | | A,B,C,D | 6PCS | # 49-54 | ETL /B.10 |

NOTE: III - M FLUID RESISTANCE IS ONLY REQUIRED 1/ YR., HOWEVER ALL OTHER POST TESTS STILL NEED TO BE ACCOMPLISHED 2 / YR.
(ie: III- E / J / G / H)

# TEST WORKSHEET

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| P/N: | | 77PSL2-1 | | | DATE: | | 12/9/98 | | |
| A. CALIBRATION SPEC | | | | POST TEST | | | | | |
| | ACT | 90-160 | | A.S.M.P. | | | | | |
| | REL | 20 MIN | | A.S.M.P. | | LAB TEST # | 522-15-64 | | |
| B. MILLIVOLT DROP <200 | | | | A.S.M.P. | | | | | |
| C. CURRENT LEAKAGE | | | | A.S.M.P. | | | | | |
| D. PROOF | | 3000psi | | A.S.M.P. | | | | | |
| | | | | | | | | | |
| PRE TESTS: | | | | | | IP-2 TEST | | POST TESTS: | |
| | | | | | | | | | |
| DEVICE # | PROOF | ACT | REL | MVD | CUR.LK | VIBRATION | | A,B,C,D | |
| 1 | OK | 137.5 | 51.2 | 0.06 | OK | # 1-6 | | | |
| 2 | OK | 131.3 | 46.8 | 0.06 | OK | | | | |
| 3 | OK | 135.4 | 69 | 0.05 | OK | | | | |
| 4 | OK | 131.2 | 60 | 0.06 | OK | | | | |
| 5 | OK | 129.9 | 61.1 | 0.06 | OK | | | | |
| 6 | OK | 138.3 | 62.4 | 0.06 | OK | | | | |
| 7 | OK | 131.6 | 63.4 | 0.05 | OK | VACUUM | | A,B,C,D | |
| 8 | OK | 139.9 | 66.4 | 0.11 | OK | # 7-12 | | | |
| 9 | OK | 121.4 | 64.4 | 0.1 | OK | | | | |
| 10 | OK | 120.2 | 63.2 | 0.09 | OK | | | | |
| 11 | OK | 128.8 | 69.4 | 0.06 | OK | | | | |
| 12 | OK | 129.2 | 61.2 | 0.06 | OK | | | | |
| 13 | OK | 128.2 | 58.6 | 0.06 | OK | TEMP.CYCLE | | A,B,C,D | |
| 14 | OK | 132.2 | 63.3 | 0.07 | OK | # 13-18 | | | |
| 15 | OK | 131.3 | 68.4 | 0.08 | OK | | | | |
| 16 | OK | 121.2 | 69.7 | 0.06 | OK | | | | |
| 17 | OK | 134.4 | 69.4 | 0.06 | OK | | | | |
| 18 | OK | 131.9 | 66.4 | 0.07 | OK | | | | |
| 19 | OK | 127.3 | 63.4 | 0.08 | OK | FLUID RES. | E,G,H,J | | |
| 20 | OK | 123.7 | 56.6 | 0.07 | OK | # 19-54 | IMPULSE | | A,B,C,D |
| 21 | OK | 129.2 | 68.5 | 0.05 | OK | | #19-30 | | |
| 22 | OK | 133 | 65.4 | 0.05 | OK | | | | |
| *23A | OK | 130.8 | 68.4 | 0.09 | OK | | | | |
| 24 | OK | 130.7 | 65.5 | 0.06 | OK | | | | |
| 25 | OK | 134.4 | 69.5 | 0.06 | OK | | | | |
| 26 | OK | 129.9 | 69.9 | 0.07 | OK | *23A & 30A | REPLACEMENT PCS. | | |
| 27 | OK | 130.2 | 63.4 | 0.09 | OK | DUE TO TEST SET-UP ERROR | | | |
| 28 | OK | 128.5 | 55.4 | 0.09 | OK | | | | |
| 29 | OK | 128.8 | 67.1 | 0.07 | OK | | | | |
| *30A | OK | 134.8 | 70.4 | 0.06 | OK | | | | |
| 31 | OK | 129.1 | 64 | 0.05 | OK | | TERM.STR | | A,B,C,D |
| 32 | OK | 133.3 | 69.5 | 0.08 | OK | | #31-42 | | |
| 33 | OK | 127.2 | 64.3 | 0.09 | OK | | | | |
| 34 | OK | 127.9 | 66.6 | 0.06 | OK | | | | |
| 35 | OK | 123.5 | 60.4 | 0.06 | OK | | | | |
| 36 | OK | 139.9 | 46.6 | 0.06 | OK | | | | |
| 37 | OK | 123.1 | 67.7 | 0.09 | OK | | | | |
| 38 | OK | 139.2 | 68.1 | 0.07 | OK | | | | |

TEST WORKSHEET

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| P/N: | | | | | DATE: | | | | |
| A. CALIBRATION SPEC | | | | POST TEST | | | | | |
| | ACT | | | A.S.M.P. | | | | | |
| | REL | | | A.S.M.P. | | | | | |
| B. MILLIVOLT DROP | | | | A.S.M.P. | | | | | |
| C. CURRENT LEAKAGE | | | | A.S.M.P. | | | | | |
| D. PROOF | | | | A.S.M.P. | | | | | |
| PRE TESTS: | | | | | | IP-2 TEST | | POST TESTS: | |
| DEVICE # | PROOF | ACT | REL | MVD | CUR.LK | | | | |
| 39 | OK | 128 | 57.8 | 0.05 | OK | | | | |
| 40 | OK | 127.9 | 64.1 | 0.06 | OK | | | | |
| 41 | OK | 128.8 | 61.2 | 0.06 | OK | | | | |
| 42 | OK | 132.6 | 58.1 | 0.06 | OK | | | | |
| 43 | OK | 134.5 | 63.4 | 0.06 | OK | | HUMIDITY | | A,B,C,D |
| 44 | OK | 127.4 | 59.9 | 0.06 | OK | | #43-48 | | |
| 45 | OK | 132.2 | 60.1 | 0.07 | OK | | | | |
| 46 | OK | 128.1 | 60.1 | 0.17 | OK | | | | |
| 47 | OK | 128.9 | 60.4 | 0.08 | OK | | | | |
| 48 | OK | 139.4 | 64.4 | 0.08 | OK | | | | |
| 49 | OK | 124.5 | 62.3 | 0.05 | OK | | SALT SPRAY | | A,B,C,D |
| 50 | OK | 131.5 | 5 6.3 | 0.06 | OK | | #49-54 | | |
| 51 | OK | 136.1 | 62.1 | 0.07 | OK | | | | |
| 52 | OK | 135.5 | 61.6 | 0.09 | OK | | | | |
| 53 | OK | 131.8 | 59.4 | 0.05 | OK | | | | |
| 54 | OK | 131.1 | 58.5 | 0.08 | OK | | | | |

Ford Motor Company
77PS Style
Pressure Switches

**# Events - by year of return**

**Root Cause Analysis(Corrective Action Reports)**

| | 1994 | 1995 | 1996 | 1997 | 1998 | Total Events |
|---|---|---|---|---|---|---|
| Contaminated Terminals | 0 | 0 | 0 | 0 | 1 | 1 |
| Continuity Anomaly | 1 | 0 | 0 | 1 | 0 | 2 |
| Wrong Parts Shipped | 0 | 0 | 3 | 3 | 0 | 6 |
| Damaged Threads/ Hexport | 0 | 5 | 1 | 0 | 0 | 6 |
| Noisy Switch | 0 | 0 | 1 | 0 | 0 | 1 |
| Cracked Bases | 0 | 0 | 1 | 0 | 0 | 1 |
| Vacuum Dependency | 0 | 1 | 0 | 0 | 0 | 1 |
| Device Leak | 0 | 1 | 0 | 0 | 0 | 1 |
| Incorrect Code | 0 | 1 | 0 | 0 | 0 | 1 |
| Low Release Calibration | 0 | 1 | 0 | 0 | 0 | 1 |
| (Total) | 1 | 9 | 6 | 4 | 1 | |

**Root Cause Analysis(Return Device Analysis)**

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

(n/a= not available)

TI-NHTSA 012189

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

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

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

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

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

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

Prepared by Jim Watt 2/8/99

[illegible]

ES-F2UC-9F924-AA

Specs

-> MSDS on Brake Fluid

-> SAES

-> $H_2O$ conductivity

- Mounting circulation, Location

- wire

Timing

2/8/99

Ford Specs in Cust Serv.

ESF2VC9F924-AA

ESF2AF-1A269-AA

ESE53C 3N824 AA

ESE57A3N824 AA

ESE75C 2C283 AA

ESE75C3N824-AA

ES-E53C-3N824-AA

ES-E75C-3N824-AA

ESF37A-3N824-AA

WSS-M99P9999-A1

TI-NHTSA 012101

[illegible] FOR REFERENCE ONLY

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 1 [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 2 [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 3 [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 4 [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 5 [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 6 [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 7 [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 8 [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

Check

Flammability data on:
1) Noryl
2) Celluex

TI-NHTSA 012182

88 T-Bird S.C. 14-39

on Brake Proportioning Value
Horizontal on side of Crome rail
Front facing

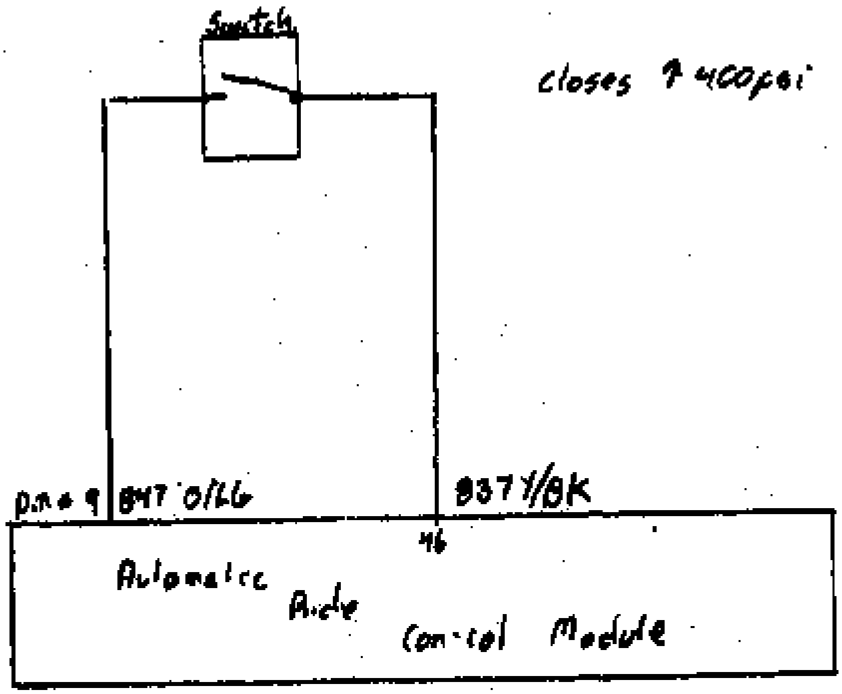
92yrs 37 T-Bird T.C. 86-92 Mark VII NO

90 FBird/XA7

93 Mark VIII NO

96 NO

closes @ 400psi




wiring location orientation Description

86 → 88 T Bird Mark VIII

77PS Brake Fluid Intrusion
2/8/99

There are a couple potential ways in which brake fluid could be introduced into the connector cavity of the TI Pressure Switch. However, the scope of this paper will be limited to the potential failure of the kapton and gasket, which form the seal between the pressure cavity and connector cavity.

The purpose of the gasket is to provide a fluid tight seal between the hexport and the kapton diaphragms (3 layers are used in TI's brake switches). The Kapton's purpose is to act as a fluid tight diaphragm. In other words, the kapton is used to seal fluid in the pressure cavity, transmit pressure to the converter, and follow convert movement as pressure is applied. Leakage into the connector cavity may result if the gasket or Kapton diaphragm fail to seal.

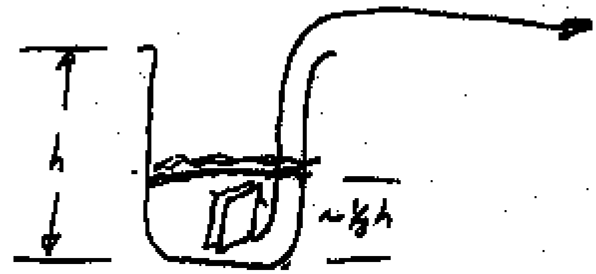
Although manufacturing anomalies of the gasket rarely occur, they can cause significant leaks. A misplaced gasket, out of spec gasket, or contaminated gasket will create a leak early in life.

While the same manufacturing anomalies mentioned above can also effect the Kapton, there are additional application factors that could create leaks through the Kaptons.

TI-NHTSA 012194

B. Dague 2/8/99

## Brake Fluid Ω Test
### Procedure




1%

1 l = 1000 ml
10 ml

① Weigh Empty Beaker.

② Weigh Beaker w/ ≈ 1/3 h of Brake Fluid.

③ Put Plate in Beaker/Fluid.

④ Measure Ω.

⑤ Calculate 1% $H_2O$ by Volume

⑥ Add 1% $H_2O$.

⑦ Mix $H_2O$ + brake Fluid.

⑧ Measure Ω.

⑨ go to ⑥ (until 25% $H_2O$ is obtained).

⑩ Repeat For

## Epstein, Sally

**From:** McGuirk, Andy [a-mcguirk@email.mc.ti.com]
**Sent:** Tuesday, February 09, 1999 10:35 AM
**To:** Rahman, Aziz; Beringhause, Steven
**Subject:** FW: 77 p/s 'durability' baseline information

**Importance:** High
**Sensitivity:** Confidential

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

----------
From: Watt, Jim
Sent: Monday, February 08, 1999 4:31 PM
To: McGuirk, Andy; Douglas, Charles
Subject: RE: 77 p/s 'durability' baseline information
Importance: High
Sensitivity: Confidential

Andy,

the below 8-D file references the only leaker for the data base that I forwarded to you earlier today. The leaker was found and returned from Tokico USA, Berea, KY, and caused by a misplaced gasket on a sensor assembly:

<<car95_30.doc>>

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

----------
From: McGuirk, Andy
Sent: Saturday, February 06, 1999 10:54 AM
To: Baumann, Russ; Rose, Elaine; Watt, Jim
Cc: Beringhause, Steven; Dague, Bryan; Pechenis, John; Rowland, Thomas; Sullivan, Martha; Baker, Gary; Rahman, Aziz; Sharpe, Robert
Subject: 77 p/s 'durability' baseline information

attorney - client privileged communication

Jim and Elaine, as I mentioned in my telecons, I would like us to move forward in quickly assembling data that we can use to help Ford understand our 'sensor' assembly durability baseline in the brake switch package. This, as I see it, would be composed of 3 major sections per below (please feel free to insert your ideas also) and for the most part needs to be delivered early w/o Feb 8th:

A) I want to demonstrate that manufacturing anomalies did not escape to the field in the form of a projection of hydraulic fluid leakers through the supply chain.... and we can help achieve this objective by assembling data that demonstrates our history of hydraulic leak rates in the subject time-frame of MY92 and MY 93 as seen in our factory floor and/or customer feedback. Jim, please take the lead on getting this done ASAP. we should consider customer AIQ spreadsheets and NMR data coupled with 8D's of the time to build a case for the low PPM leak rates of the sensor assembly further protected by downstream supply chain testing at the TIER-one and OEM. Also, there may be an opportunity to integrate manufacturing test data as a validator of that leak rate number as well as using the leak test data from impulse testing as an alternate source. there will be a building need to deliver data and evidence by Tuesday via Aziz and we should consider an alternate path of anecdotal estimate should the records not be readily available. (I know we will need to identify and recall records and that will take time)

B) I want to demonstrate that the sensor assembly is mechanically durable and surpasses the 'expected' life cycles as expressed on the Ford specs....and we can achieve this objective by assembling ES 'impulse' testing data from the timeframe of interest. In an ideal situation we would take this raw data and project into WEIBULL success-testing estimate of cycle capability in the 'accelerated simulated' cyclers used in our process controls. Elaine please coordinate the data collection here. (We will likely turn to reliability experienced quality engineers Paul spaceman and Tushar Parikh to convert the data to information). Again, should we run out of time, we will need to turn to whatever relevant 'recent' data we have to propose our position and support with historical based data once we sort through the files and record recall process. Bryan, please inject any life test data from other qualification platforms here so we have 'test-to-failure' data if available.

Also, we should make a side note of the pressure profile used in the cycler process for future use with Aziz during his upcoming dialogues with Ford.

C) I want to demonstrate that the sensor is chemically resistant per the IP and PPAP testing and surpasses 'expected' exposures per the Ford Specs... and we can achieve this by assembling both relevant IP testing and PPAP results to demonstrate compliance. There may also be other testing history of the period that would convey that durability of the switch assembly in the typical automotive fluid environment of gas-oil-coolant-fluids in the proper orientation and connector protection. Elaine, please assemble this data and we will provide to Aziz to deliver to Ford. Again, should we run out of time, delivery of the readily available records from '95-'96-'97 per your Friday work would suffice as a starting point.

To provide some further clarity, I have included the focal part numbers from Charlie Douglas below. As we assemble data and translate into information please track the differences between 57 and 77 and 87 styles but also integrate the brake sensor assembly data and treat it as a family. As you discover the level of effort and resource needs, pls see John or me for help in getting people assigned or priority provided.

thank you for your continued support here,

a

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

-----------
From: Douglas, Charles
Sent: Friday, February 05, 1999 8:43 AM
To: McGuirk, Andy; Rose, Elaine
Subject: 77PS Matrix

Andy / Elaine,

Per our discussion:

<<File: Lincoln.doc>>
Regards,

Charlie

Charlie Douglas
(508) 236-3657 (P)
(508) 236-1598 (F)
c-douglas2@ti.com

— PHOTOS OF APPLICATION ... MODIFY & MAKE CUSTOMER SIMULATE.

(ANY/WHAT) WHAT PART USED WHERE? TIER 1 FLEXAM?

DOG BONES (WHAT) — CELERITY Y300/3316 | NONYL IGNITION TESTS SWITCHED
• ΔS, • FOTOS, • VIDEO/TAPE, SALE PARTS, SO THE & NOT BURN

— CYCLE PROFILE OF TESTER FOR WETBULL
• RATE OF ... COMPARED TO VEHICLE DATA
— SOME CONDITIONS ... UTA? ... ΔT, ΔP

0 → 300 PSI .34
0 → 450 PSI .74

HOW ... — TEST CONDITIONS FROM TEXAS ← SPECS / STATUS

★ — A. HOPKINS ANALYSIS OF CORROSION AFTER TEST

— DOE UPDATE ← WETBULL ... QUIET / WETBULL ... NOISY

→

- COPY OF WARRANTY DATA
- COPY OF DECISION MATRIX
-

Aug 29 2008 ... 0/8 ...

BRAKE FLUID & SALT TESTING (Y300)

Received 2/9/99

# TI Brake Pressure Switch Questions

Rob these are the questions I captured from our 2/4/99 meeting.

What does TI DFEMA say about this failure mode?
Rob Sharpe by 2/10/99

What are TI in-process test failures?
Rob Sharpe by 2/10/99

Provide color photos of Econoline? Rob Sharpe by 2/8/99

What is the difference in the base materials that look different?
Rob Sharpe by 2/16/99

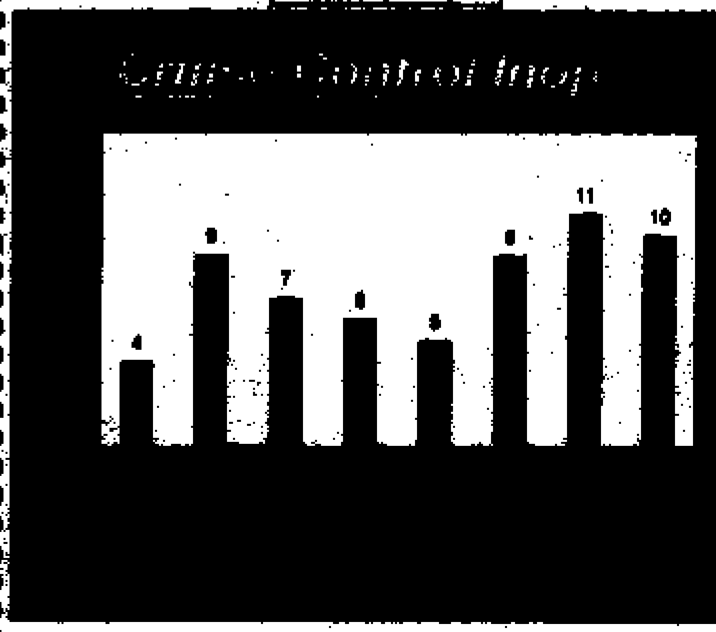
TI analysis results of the Memphis parts ( crease marks in diaphragm, etc) ?
Rob Sharpe by 2/9/99

What are the material call-outs for 1992 and 1993?
Rob Sharpe by 2/9/99

+ the questions Rob wrote down.

| Vin | engine | miles | Build | | | | |
|---|---|---|---|---|---|---|---|
| [illegible] | 3.8L | 6200 | 10/02/98 | | | | |
| [illegible] | 3.8L | 3300 | 10/16/98 | | | | |
| [illegible] | 3.8L | | 10/21/98 | | | | |
| [illegible] | 3.8L | 3300 | 10/23/98 | | | | |
| [illegible] | 3.8L | 4370 | 11/03/98 | | | | |
| [illegible] | 3.8L | 27284 | 11/03/98 | | | | |
| [illegible] | 3.8L | 520 | 11/06/98 | | | | |
| [illegible] | 3.8L | 8 | 11/10/98 | | | | |
| [illegible] | 3.8L | 11087 | 11/10/98 | | | | |
| [illegible] | 3.8L | 684 | 11/16/98 | | | | |
| [illegible] | 3.8L | 12 | 11/23/98 | | | | |
| [illegible] | 3.8L | 4410 | 11/23/98 | | | | |
| [illegible] | 3.8L | 6840 | 11/24/98 | | | | |
| [illegible] | 3.8L | 60 | 12/01/98 | | | | |
| [illegible] | 3.8L | 3846 | 12/03/98 | | | | |
| [illegible] | 3.8L | 1073 | 12/04/98 | | | | |
| [illegible] | 3.8L | 980 | 12/04/98 | | | | |
| [illegible] | 3.8L | 272 | 12/04/98 | | | | |
| [illegible] | 3.8L | 177 | 12/04/98 | | | | |
| [illegible] | 3.8L | 866 | 12/13/98 | | | | |
| [illegible] | 3.8L | 100 | 01/04/99 | | | | |
| [illegible] | 3.8L | 91000 | 01/08/99 | | | | |
| [illegible] | 3.8L | 2 | 01/19/99 | | | | |
| [illegible] | 3.8L | 2008 | 01/19/99 | | | | |
| [illegible] | 3.8L | 2348 | 01/21/99 | | | | |
| [illegible] | 3.0L | 3460 | 01/22/99 | | | | |
| [illegible] | 3.8L | 7 | 02/01/99 | | | | |
| [illegible] | 3.8L | 67 | 02/04/99 | | | | |
| [illegible] | 3.8L | 11088 | 02/09/99 | | | | |
| [illegible] | 3.8L | 1229 | 02/20/99 | | | | |
| [illegible] | 3.0L | 1300 | 02/22/99 | | | | |
| [illegible] | 3.0L | 2 | 03/01/99 | | | | |
| [illegible] | 3.8L | 188 | 03/03/99 | 2FMZA51[illegible] | 3.8L | 320 | 04/30/99 |
| [illegible] | 3.8L | 8 | 03/05/99 | 2FMZA51[illegible] | 3.0L | 7 | 04/30/99 |
| [illegible] | 3.8L | 848 | 03/10/99 | 2FMZA51[illegible] | 3.8L | 510 | 04/30/99 |
| [illegible] | 3.0L | 7 | 03/12/99 | 2FMZA51[illegible] | 3.8L | 488 | 04/30/99 |
| [illegible] | 3.0L | 6 | 03/12/99 | 2FMZA5[illegible] | 3.8L | 17 | 05/03/99 |
| [illegible] | 3.8L | 1400 | 03/12/99 | 2FMZA51[illegible] | 3.8L | 3 | 05/03/99 |
| [illegible] | 3.8L | 8 | 03/16/99 | 2FMZA5[illegible] | 3.8L | 422 | 05/03/99 |
| [illegible] | 3.8L | 12 | 03/22/99 | 2FMZA51[illegible] | 3.8L | 30 | 05/04/99 |
| [illegible] | 3.8L | 2800 | 04/12/99 | 2FMZA5[illegible] | 3.8L | 1342 | 05/04/99 |
| [illegible] | 3.8L | 6600 | 04/16/99 | 2FMZA51[illegible] | 3.8L | 281 | 05/05/99 |
| [illegible] | 3.8L | 1912 | 04/20/99 | 2FMZA51[illegible] | 3.8L | 680 | 05/05/99 |
| [illegible] | 3.8L | 1553 | 04/21/99 | 2FMZA5[illegible] | 3.8L | 397 | 05/05/99 |
| [illegible] | 3.8L | 442 | 04/23/99 | 2FMZA5[illegible] | 3.8L | 470 | 05/10/99 |
| [illegible] | 3.8L | 851 | 04/23/99 | 2FMZA5[illegible] | 3.8L | 408 | 05/12/99 |
| [illegible] | 3.8L | 1299 | 04/26/99 | | | | |

| Build | Freq |
|---|---|
| Oct-98 | 4 |
| Nov-98 | 9 |
| Dec-98 | 7 |
| Jan-99 | 6 |
| Feb-99 | 5 |
| Mar-99 | 9 |
| Apr-99 | 11 |
| May-99 | 10 |




139/2000

28
2786
2952

TI-NHTSA 012201

4° - 5:15 P Brainstorm w/Len 2/10/99

- Get Dow on TEAM

~~ASK~~ ASK THEM HOW FIRE STARTS WITHIN CONSTRAINTS [14 v, Black Substance, 15 AMP MAX CURRENT, VEH. TEMPERATURES.]

- Char'z REAL VEH Brake Pressure.

- " " " " " in ABS/TC EVENT.

- Thermo-couple Brk Pr switch after Veh. Driven & turned off.

- Take Rate of ABS

" " " ABS w/TC

- Are Leaks/Fires common to traction ASSIST.

- Black Substance: Copper, Zinc, Silver, Sulfur, Brake Fluid.

- Understand TC/ABS Pressure Pulse/

- HISTORY OF ELECTROLYSIS IN Brake Fluid.

— MODES OF APPLICATION.... MODIFY & [illegible] CLOSURE EVALUATE

(ANNOY) (WHAT) — WHAT PART WOULD WORK? FRIDAY?
TIER 1

(WHAT) — CELENCOR X30?/3316 (1-3) | NOMINAL IGNITION TESTS (3-5 TEAMS) [illegible]
• ΔS, • TIME, • VIDE | TIME, [illegible], SIZE • NOT BURN

— CYCLE PROFILE OF TESTER FOR WEIBULL
• FOUND COMPARED TO VEHICLE DATA...
• RATE OF [illegible]

— SOAK CONDITIONS — UTA, ΔT, ΔP

0 → 300 PSI .3G / ½ SEC
0 → 400 PSI .7G / .3 SEC

— TEST CONDITIONS FROM [illegible] ← 80%S / STATUS
→ DIFF ISSUE [illegible]

★ — A. HOPKINS ANALYSIS OF CORROSION AFTER TEST

— DOE UPDATE ← WEIBULL OF QUIET / WEIBULL OF NOISY

→

616 249 8002 [illegible]

- COPY OF WARRANTY DATA
- COPY OF DECISION MATRIX
-

TI-NHTSA 012219

— BRAKE FLUID & SALT TESTING [illegible]

# Ford 77 ps Fluid Temperature Testing

Technician : LEC Date : Thursday 2-11-99 Time : 2:40 PM

**Temperature Readings**

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Running Current | 86 | 86 | 85 | 89 | 86 |
| Peak | 87 | 98 | 86 | 85 | 94 |

**Current Readings**

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| NA | NA | NA | NA | 580 mA Fell to 5.08 @ 2:55 |

NOTES : (please include any information and observations)....... No current ...

This was initial start up of test 1% & 75% have constant load. These devices are Temp. monitored also.

Ambient Temperature
89°F

Oven Temperature
86°F

TI-NHTSA 012220

# Data Log
## Brake Pressure Switch

| VIN | Event | Mileage | Term-Hexport Resistance | Leaker? | Kapton #1 | Kapton #2 | Kapton #3 | Present Status |
|---|---|---|---|---|---|---|---|---|
| PY622977 | Sw. Fire | | | | crack | crack | crack | Analysis Complete |
| PY655224 | Underhood Fire | | | | no info | no info | no info | Analysis Complete |
| NY746119 | Underhood Fire | | | | | | | Sw. not available |
| NY703705 | Underhood Fire | | | | | | | Analysis in Progress |
| VX146373 | Cruise Inop | | 4.8MEGAOHMS | yes | crack | crack | crack | Analysis Complete |
| NX708774 | Reference | | OPEN | no | worn, no crack | worn, no crack | worn, no crack | Analysis Complete |
| NY760955 | Cruise Inop | | 4MEGAOHM | yes | crack | crack | crack | Analysis Complete |
| NX762658 | Reference | 76194 | OPEN | | | | | |
| PY724643 | Reference | 71367 | OPEN | | | | | |
| PY628175 | Reference | 89097 | OPEN | | | | | |
| py692329 | Reference | 96340 | | | | | | Analysis in Progress |
| py726011 | Reference | 47325 | | | | | | Analysis in Progress |
| NX729439 | Reference | 69922 | OPEN | | | | | |
| PX160233 | Reference | 65014 | OPEN | | | | | |
| PX637788 | Reference | ?? | OPEN | | | | | |
| PY668375 | Reference | 82224 | OPEN | | | | | |
| PY720088 | Reference | 91358 | OPEN | | | | | |
| PX665270 | Reference | 68688 | OPEN | | | | | |
| NY740208 | Reference | 53237 | OPEN | | | | | |
| PX623872 | Reference | 94145 | OPEN | | | | | |
| PY686374 | Reference | ?? | OPEN | | | | | |
| BY638884 | Reference | 57199 | OPEN | | | | | |
| PY650225 | Reference | 72114 | OPEN | | | | | |
| PY660735 | Reference | | OPEN | | | | | |
| PY774268 | Reference | 67549 | OPEN | | | | | |
| PY704575 | Reference | 42821 | OPEN | | | | | |
| PX649515 | Reference | 43001 | OPEN | | | | | |
| ?? | Reference | ?? | | | | | | |
| PX628834 | Reference | 66392 | OPEN | | | | | |
| PY638880 | Reference | | | | | | | |
| PX163828 | Reference | 100000 | | | | | | |
| RX641505 | Reference | ?? | | | | | | |
| PX163312 | Reference | 40842 | | | | | | |
| PY610384 | Reference | 73115 | | | | | | |
| NY724380 | Underhood Fire | ?? | | | | | | |
| PY760172 | Reference | ?? | | | | | | |

## [illegible] Log
## [illegible] Switch

| | | |
|---|---|---|
| NY733191 | Underhood Fire | 108810 |
| PY758156 | Reference | ?? |
| PX161140 | Reference | 72614 |
| NY757406 | Reference | ?? |
| PY742858 | Reference | ?? |
| PY7433413 | Reference | 105046 |

TI-NHTSA 012203

P Thank you for taking the time to meet with me on Weds Mar 17.

P For some four months the Texas Instruments Automotive Sensors & Controls [illegible] team has been supporting the Ford diagnostic team with technical facts, data and analysis regarding our [illegible] we have designed [illegible] Problems [illegible] the last 6 [illegible] team [illegible] (and intend to continue in this area ??) [illegible]

[illegible] a recap of the activities [illegible] that brake fluid leakage [illegible] contributed to thermal events [illegible]

P Both TI & Ford attempted to reproduce thermal events with brake fluid in the cruise switch circuit.

During the next two weeks TI will [illegible] with "VLO" [illegible] brake fluid using our most current [illegible] design [illegible]

Accelerated Simulated Life Testing

② We also investigated switch capability and using accelerated life techniques demonstrated the ability of the 92-93-94 Town Car Brake Switch to consistently exceed [illegible] specification.

Preliminary field returns and salvage yard samples have shown in several

corrosion

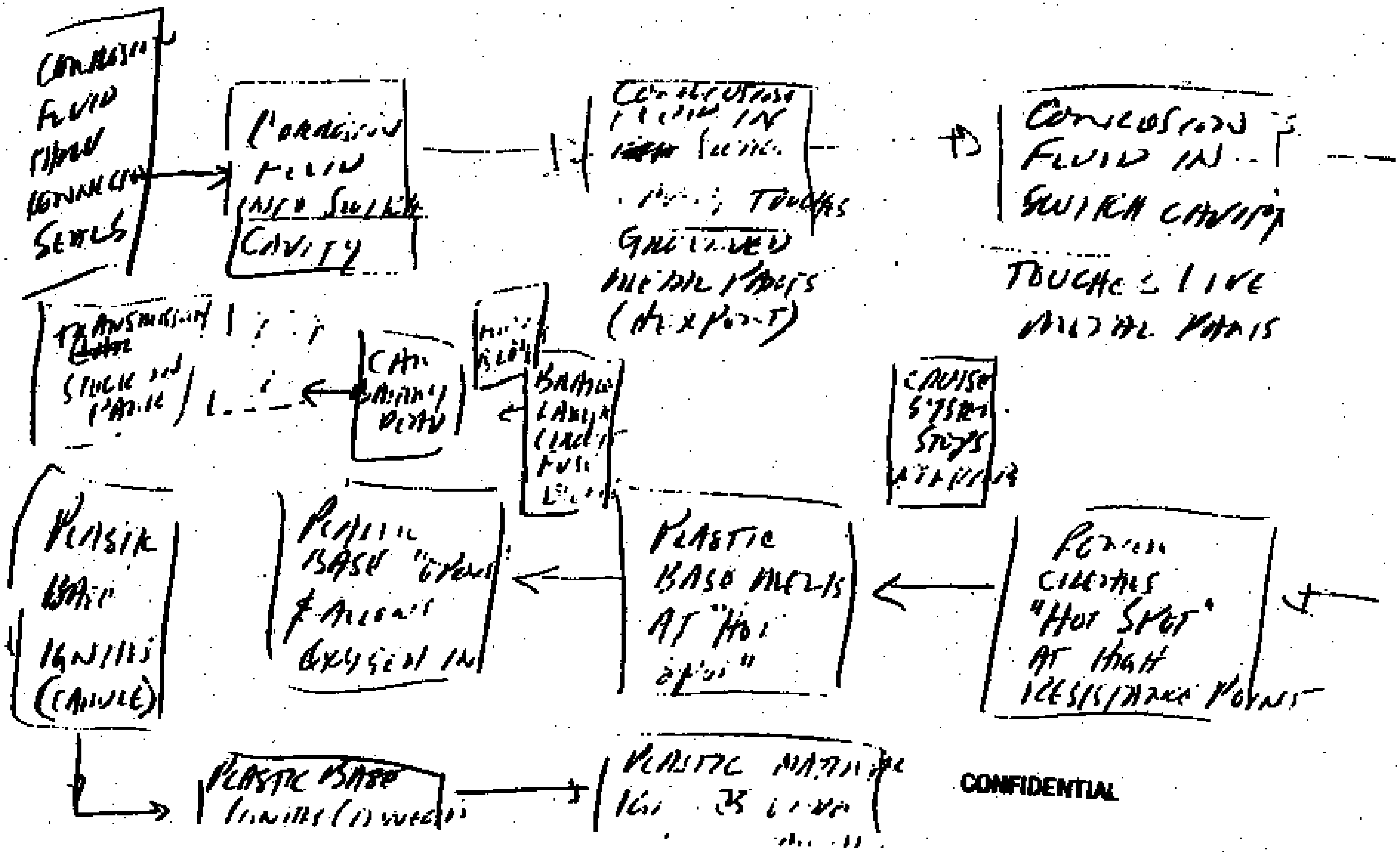
exhibited

Problem switches with brake fluid leakage. However, lab testing and [illegible] with "new" brake fluid leakage & "old" brake fluid is being tested today.

Some of these switches exhibited evidence of being worn out through early indications exposure to many vehicle cycles and these appear to be a significant cycle quantity [illegible] issue...

TI-NHTSA 012205

PROCESS FLOW DIAGRAM
"CORROSION" POTENTIAL CAUSE FLOW ANALYSIS



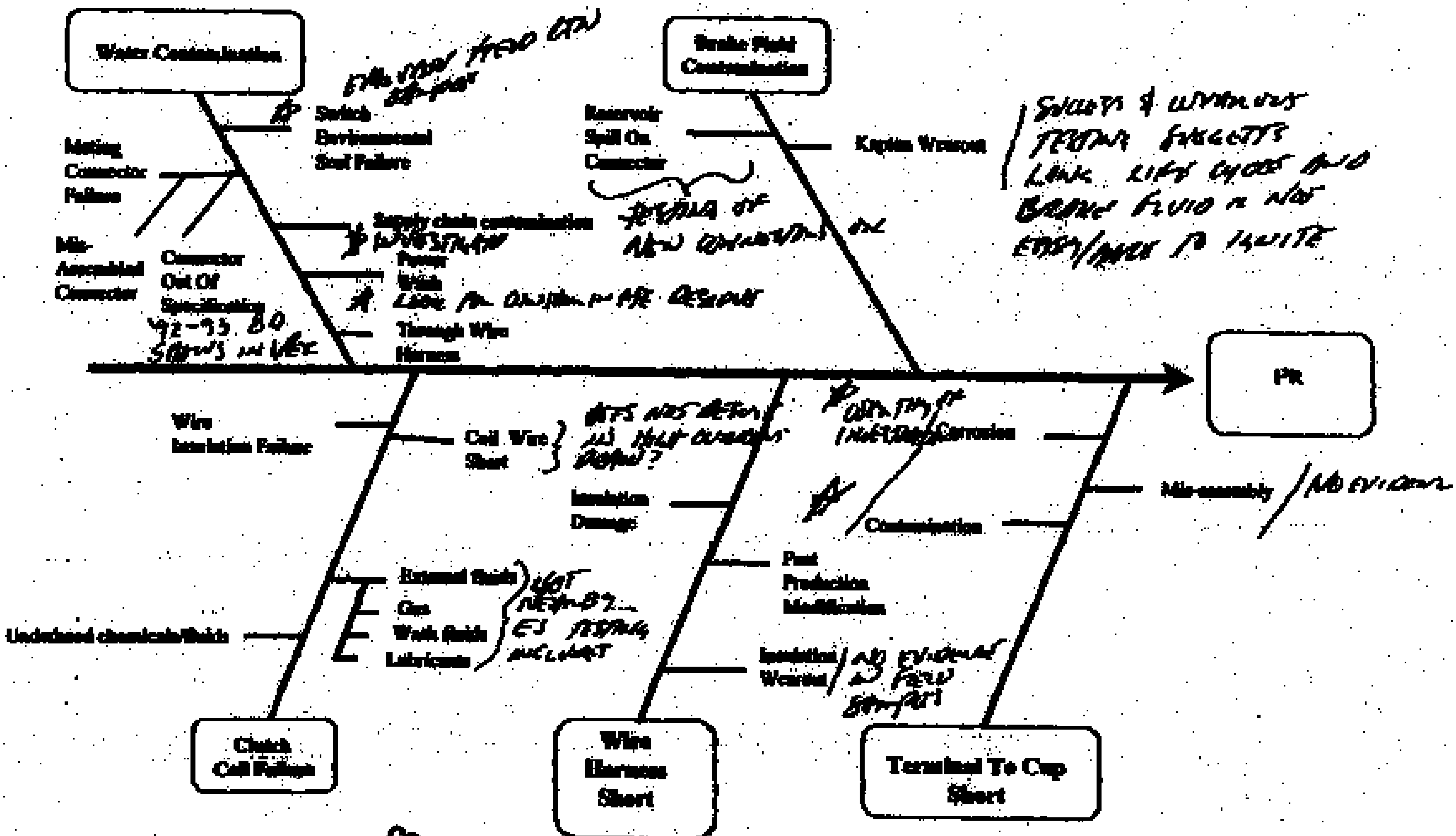

CONFIDENTIAL

TI-NHTSA 012206

TEXAS INSTRUMENTS

# Brake Pressure Switch
# Potential Thermal Event Theory Profile 4/26/99

[redacted]



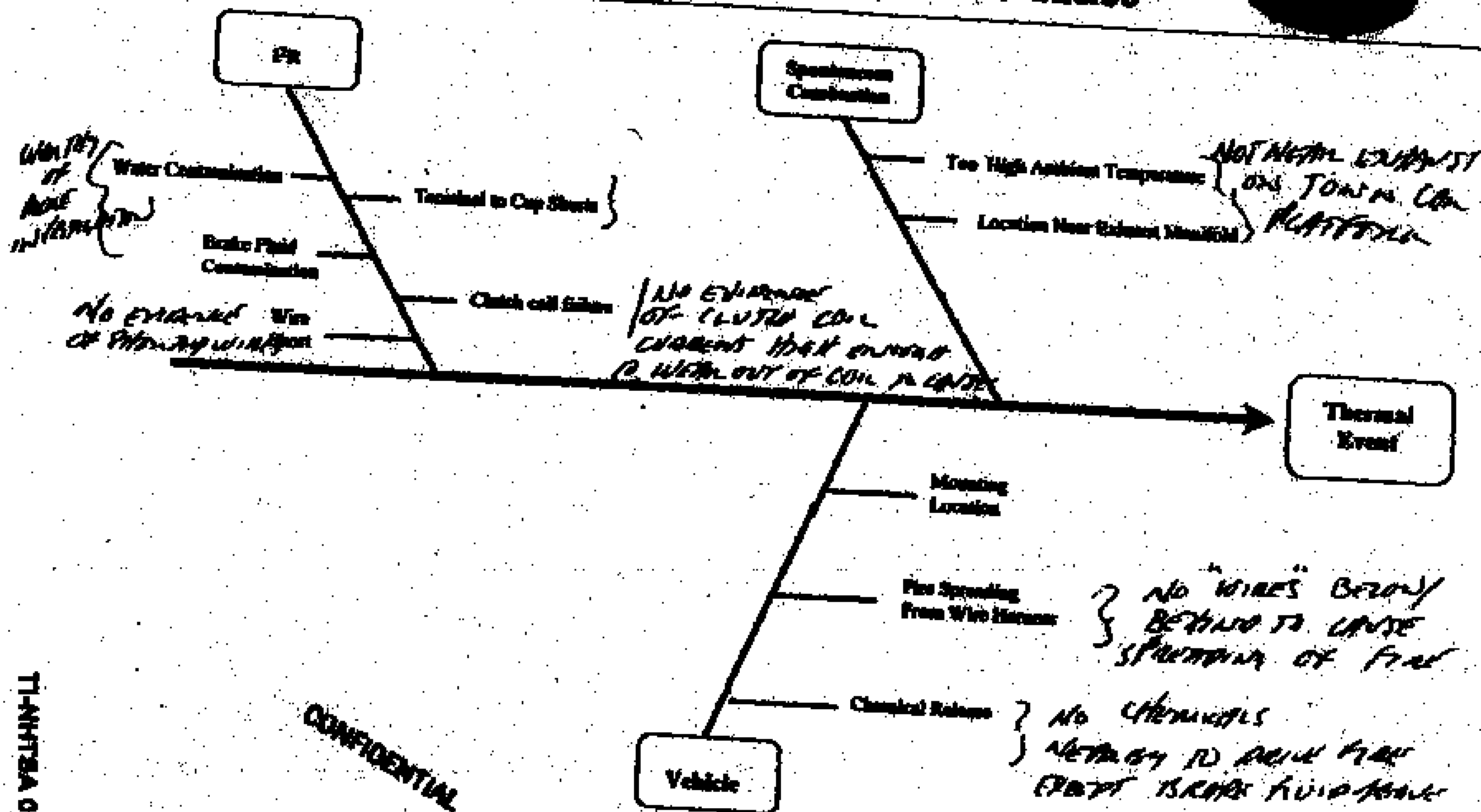

CONFIDENTIAL

C:\McGuire\Hypothesis

**TEXAS INSTRUMENTS**

# Brake Pressure Switch
# Potential Thermal Event Theory Profile 4/26/99

[redacted]

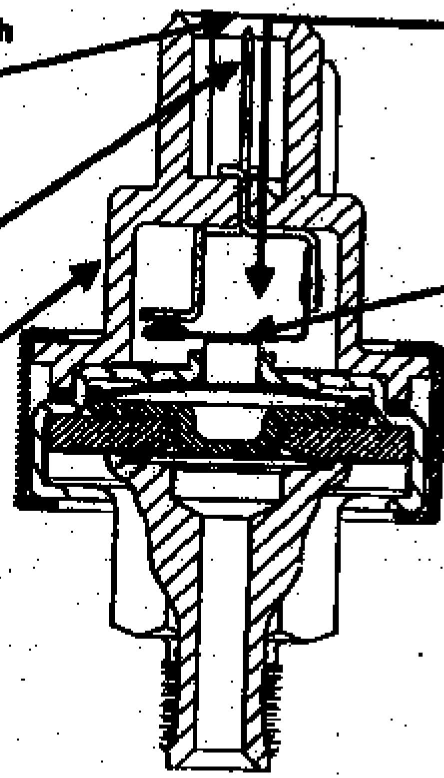


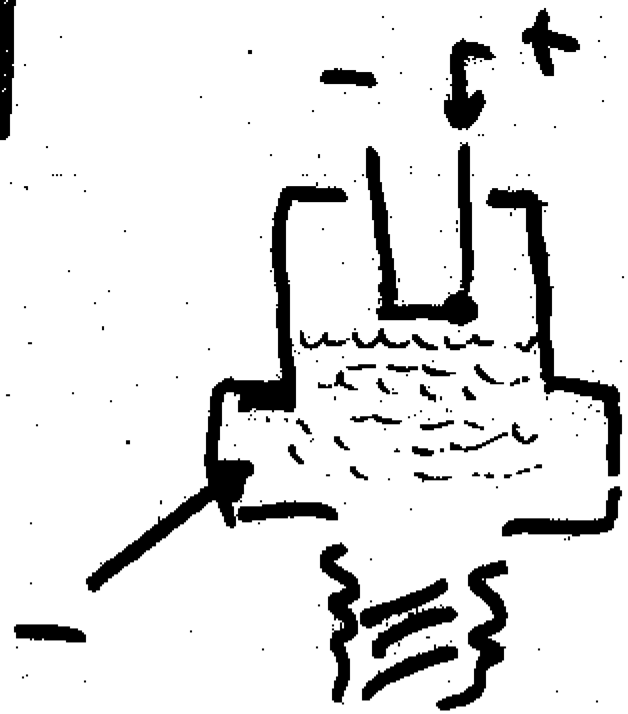

CONFIDENTIAL

TI-NHTSA 012208

TEXAS INSTRUMENTS

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



CONFIDENTIAL

From Phila

CREATE EVENTS

NOS 100%

FUSE DISCUSSION ← MAT

ANALYSIS -
NaCl NOT IN!

BASE IN PURPOSE OF BRAKE FLUID
CAUSE →

* BEST SOLUTION -
NEW PRIMER SYSTEM

TI-NHTSA 012210

FORD ACTIONS

* 020 BF INJECTED WITH WATER — GET BF SAMPLES

* MORE FINE DETAIL ON HOW TO PERFORM THE TEST

A&C PARTS...

92 TC — SENSE ELEMENTS RIGHT / PLACE
— WHAT DOES IT MEAN
— ABS ACTIVITY.... SOME ACTIVITY NOT ENOUGH TO GET TO FATTEN

Data Log
Brake Pressure Switch

Log Updated 2/[illegible]

ABS

| Sw # | Sw Date Code | Vehicle | VIN | Event | Mileage | Form / Report Rec'd | Leaks? | Kapton #1 | Kapton #2 | Kapton #3 | Present Status |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Memphis | [illegible] | Town Car | [illegible] | Sw. Fire | | | | crack | crack | crack | Analysis Complete |
| A | [illegible] | Town Car | [illegible] | Undetermined Fire | | | | no info | no info | no info | Analysis Complete |
| B | 2114 | Town Car | [illegible] | Undetermined Fire | | | | | | | Sw. not available |
| C | [illegible] | Town Car | [illegible] | Undetermined Fire | | | | | | | Analysis in Progress |
| D | | Crown Vic Police Car | [illegible] | Comp. Insp. | | 4 MEGAOHMS | yes | crack | crack | crack | Analysis Complete |
| E | 2137 | Town Car | [illegible] | [illegible] | | OPEN | no | stain, no crack | stain, no crack | stain, no crack | Analysis Complete |
| F | [illegible] | Town Car | [illegible] | Comp. Insp. | | 4MEGAOHM | yes | crack | crack | crack | Analysis Complete |
| 1 | [illegible] | Town Car | [illegible] | [illegible] | [illegible] | OPEN | | | | | |
| 2 | 2015 | Town Car | [illegible] | [illegible] | [illegible] | OPEN | | | | | |
| 4 | [illegible] | Town Car | [illegible] | [illegible] | [illegible] | OPEN | | | | | |
| 5 | [illegible] | Town Car | [illegible] | [illegible] | [illegible] | | | | | | Analysis in Progress |
| 6 | [illegible] | Town Car | [illegible] | [illegible] | [illegible] | | | | | | Analysis in Progress |
| 7 | [illegible] | Town Car | [illegible] | [illegible] | [illegible] | OPEN | | | | | |
| 8 | [illegible] | Town Car | [illegible] | [illegible] | [illegible] | OPEN | | | | | |
| 9 | [illegible] | Town Car | [illegible] | [illegible] | ?? | OPEN | | | | | |
| 10 | [illegible] | Town Car | [illegible] | [illegible] | [illegible] | OPEN | | | | | |
| 11 | [illegible] | Town Car | [illegible] | [illegible] | [illegible] | OPEN | | | | | |
| 12 | [illegible] | Town Car | [illegible] | [illegible] | [illegible] | OPEN | | | | | |
| 13 | [illegible] | Town Car | [illegible] | [illegible] | [illegible] | OPEN | | | | | |
| 14 | [illegible] | Town Car | [illegible] | [illegible] | [illegible] | OPEN | | | | | |
| 15 | [illegible] | Town Car | [illegible] | [illegible] | ?? | OPEN | | | | | |
| 16 | ?? | Town Car | [illegible] | [illegible] | [illegible] | OPEN | | | | | |
| 17 | ?? | Town Car | [illegible] | [illegible] | [illegible] | OPEN | | | | | |
| 18 | [illegible] | Town Car | [illegible] | [illegible] | | OPEN | | | | | |
| 19 | ?? | Town Car | [illegible] | [illegible] | [illegible] | OPEN | | | | | |
| 20 | ?? | Town Car | [illegible] | [illegible] | [illegible] | OPEN | | | | | |
| 21 | ?? | Town Car | [illegible] | [illegible] | [illegible] | OPEN | | | | | |
| 22 | [illegible] | ?? | ?? | [illegible] | ?? | | | | | | |
| 23 | ?? | Town Car | [illegible] | [illegible] | [illegible] | OPEN | | | | | |

From TX trip of 2/10 to 2/12, [illegible] Group

| | | | | | |
|---|---|---|---|---|---|
| 1 | [illegible] | Town Car | [illegible] | [illegible] | |
| 2 | [illegible] | Crown Vic Police Car | [illegible] | [illegible] | [illegible] |
| 3 | [illegible] | [illegible] | [illegible] | [illegible] | ?? |
| 4 | [illegible] | Crown Vic | [illegible] | [illegible] | [illegible] |
| 5 | [illegible] | Town Car | [illegible] | [illegible] | [illegible] |
| 6 | ?? | Town Car | [illegible] | [illegible] | ?? |
| 7 | [illegible] | Town Car | [illegible] | [illegible] | ?? |
| 8 | [illegible] | Town Car | [illegible] | [illegible] | [illegible] |
| 9 | [illegible] | Town Car | [illegible] | [illegible] | ?? |
| 10 | [illegible] | Crown Vic | [illegible] | [illegible] | [illegible] |
| 11 | [illegible] | Town Car | [illegible] | [illegible] | ?? |
| 12 | [illegible] | Town Car | [illegible] | [illegible] | ?? |
| 13 | [illegible] | Town Car | [illegible] | [illegible] | [illegible] |

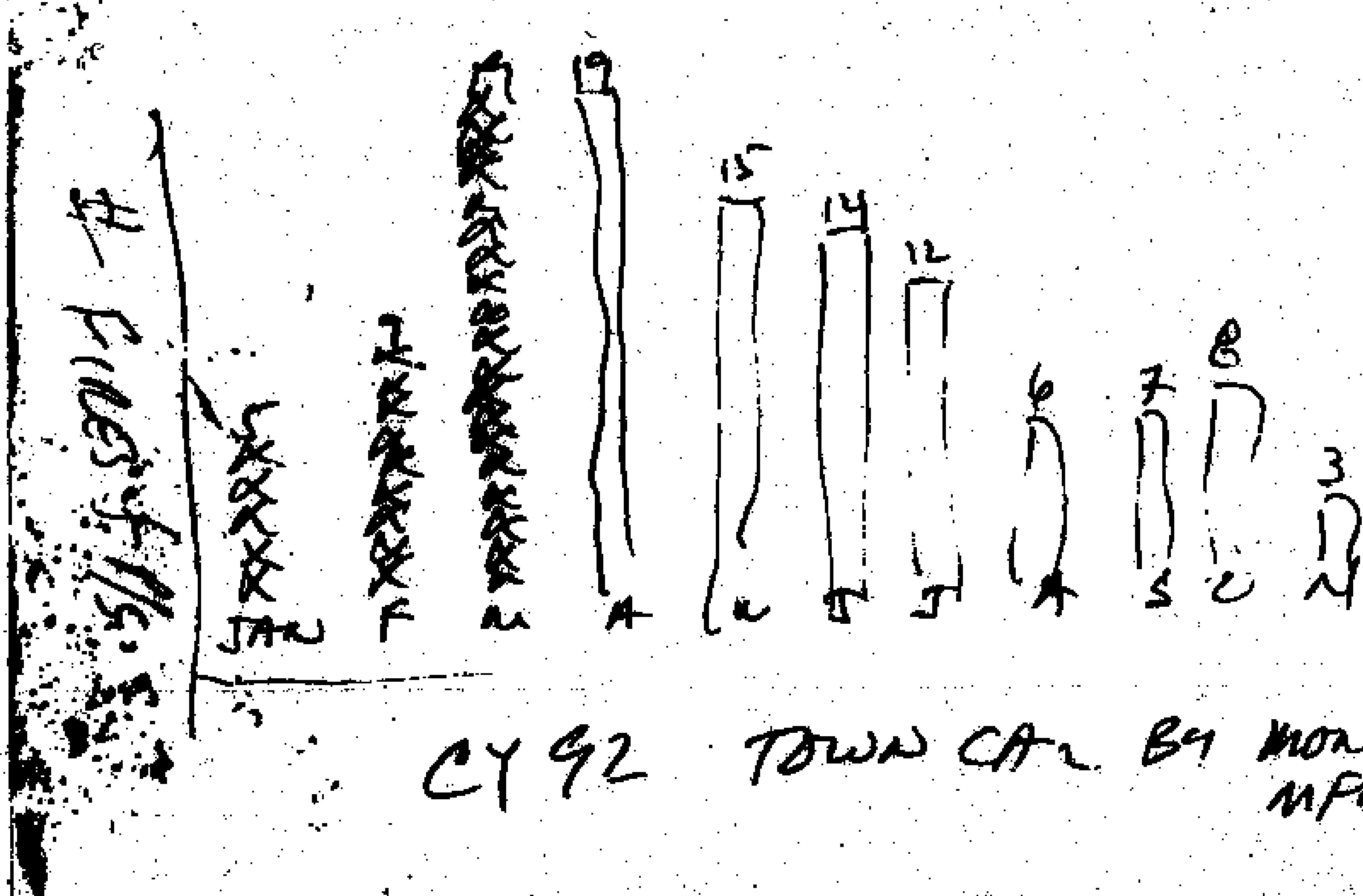
Undetermined Δ's
CV vs GM vs TC.

ABS STD TC [illegible] →

[illegible], 313 [illegible]
[illegible]@[illegible].com
[illegible] Switch Log [illegible]



revised 2/[illegible]




CY 92 TOWN CAR BY MONTH MFG

$\bar{X}$ MILES 68K MILES

**Proprietary Information**

**77PS Overview**
**2/10/99**

TI's 77PS switch family has been specifically designed to operate in an automotive braking system. The pressure cavity of the switch has been designed to seal brake fluid pressure and transmit pressure and movement to the sensing portion of the switch over the life as defined in Ford ES -F2VC-9F924-AA.

**Background:**
The pressure cavity is composed of the hexport, gasket, and three Kapton ™ diaphragms (called out as "seal" on attachment 1.). The purpose of the gasket is to provide a fluid tight seal between the hexport and the diaphragms. The purpose of the Kapton ™ diaphragms is to provide a flexible fluid tight seal between the pressure cavity and the internal components of the switch. Furthermore, the diaphragms are intended to transfer pressure to the converter, and follow the movement of the converter as pressure in the pressure cavity (brake line pressure) is varied.

Two known ways that brake fluid may enter the contact cavity of TI's brake switches from the pressure cavity are i. brake fluid could leak past an impaired gasket seal, or ii. brake fluid could leak through a damaged or 'worn out' Kapton ™ diaphragm.

**The Gasket**
In order to create a fluid tight elastomeric seal, there must be proper compression of the elastomer, sufficient backing of the elastomer to prevent movement when pressure is applied, and finally the elastomer must be compatible with the working fluid.

Fluid compatibility is typically established by the use of published tables. These tables list fluid groups and general material types. Lab testing is always done with the specific fluid that the customer has specified for the application along with the specific compound formulated by the selected gasket supplier. Ethylene Propylene is used in the 77PS and is standard throughout the industry for seal gasket materials. TI has been using this material in brake applications since 1988.

The gasket compression target was obtained from published industry standards (see Parker O-ring Handbook). In this particular design a nominal gasket compression of 24% was selected. The depth of the hexport gland shown on attachment #2 controls this attribute. This gland dimension is cut into the hexport at the time of manufacturing. As a result, this dimension in combination with the gasket dimensions determines the final gasket compression when the assembly is crimped together.

Lastly, the movement/position of the gasket when pressure is applied must be controlled and restrained. This design accomplishes this by selecting the outer diameter of the gasket to be slightly smaller than the inner diameter of the gasket gland of the steel plated hexport. Therefore, the hexport gland prevents the gasket from moving outwards when high pressure is applied to the switch.

The DFMEA outlines the types of tests that were selected and run to confirm that all of these parameters are selected correctly. The resulting design was exposed to test conditions that were intended to duplicate actual application conditions, and in some cases go beyond the intended limits to failure. See the DFMEA Document number 503794 and customer specification ES-F2VC-9F924-AA . Specifically, burst testing, impulse testing, and thermal cycle tests were performed to confirm that the gasket performed as intended. The specific details of these tests and the results can be seen in the PV test report numbers listed below: (copies can be provided on request).

| Test Report # | TI Switch Part number | Year Tested |
|---|---|---|
| 1. PS/91/48 | 77PSL2-3 | 1991 |
| 2. PS/91/49 | 77PSL2-1 | 1991 |
| 3. PS/92/49 | 77PSL3-1 | 1992 |
| 4. PS/92/80 | 77PSL3-2 | 1992 |
| 5. PS/92/82 | 77PSL3-1 | 1992 |
| 6. PS/93/11 | 77PSL6-1 | 1993 |
| 7. PS/93/44 | 77PSL4-1 | 1993 |

Gasket-manufacturing anomalies can be produced from out of spec gaskets, contamination of the gasket or sealing surfaces, and as a result, may cause leaks early in life. In order to protect TI's customer supply chain from gasket-manufacturing issues there are several preventative actions in place. These actions include: hair nets, protective smocks, and cleaning procedures for the equipment. TI's customer return rates indicated by past return and analysis records are less than 1 ppm (one leaker return in 5 years from master cylinder leak testing).

**Kapton ™ Diaphragms:**
A pressure switch diaphragm must seal the pressure cavity, transmit pressure forces to the converter, and follow the converter motion without significantly affecting the switch calibration points. In addition, the diaphragm material must be resistant to chemical attack by the brake fluid.

Basically, a single piece of Kapton ™ in this design consists of a 0.003-inch thick polyimide film laminated on both sides with a 0.001-inch thick FEP Teflon film. The polyimide film has the ability to stretch without breaking (strains on the order of 70% before rupture), and the Teflon film is compatible with a wide range of chemicals. As a result of this layered construction, Kapton ™ was selected for its mechanical and chemical properties. Moreover, TI has been using this material in pressure switch applications since 1981. In this application three stacked Kapton ™ layers were used as the diaphragm seal.

To confirm the correct material was selected for this application we refer to the DFMEA. Specifically, this document identifies burst testing, impulse testing, and thermal cycle testing. These tests confirmed the Kapton's ™ ability to meet the specified requirements (PV reports listed above). Since temperature, chemical exposure, and stress levels all affect the life expectancy of the Kapton ™ diaphragms, additional testing is commonly done. A typical impulse test would include pressure cycles to 1450 psi, constant temperature of 135 C, and a cycle rate of 120 cycles/minute. Depending on the factors listed above, the life expectancy of a TI brake pressure switch can vary, but typically is around 1 million cycles which is well above the 500,000 cycles specified in the Ford specification (ES-F2VC-9F924-AA). (See Life Testing to Failure (PS/98/14))

In addition, continued conformance testing has been ongoing for many years at TI. The purpose of this testing is to confirm that the components, materials, and processes have remained stable over time and that the design intent is consistently being achieved. See attached IP reports which confirm 100% successful passing of all tests defined in the specification.

Manufacturing & PV anomalies such as pinched Kapton ™ can affect the Kapton ™ diaphragm seal performance (see PFMEA Document # 503831). Material/chemical compatibility and stress/strain concentrations can also cause the Kapton ™ diaphragms to fatigue. See DFMEA Document number 503796. In order to verify the correct design parameters were selected, the switch was subjected to a number of tests designed to simulate accelerated life testing of the application. See PS reports called out above. Life testing per the customer specification (ES-F2VC-9F924-AA) has shown acceptable performance.

Typically, Kapton ™ fatigue occurs well over 0.5 million full-scale pressure cycles in our history of simulated and accelerated life testing. When Kapton ™ fatigue does occur, there are visual signs of de-lamination, cracking, and embrittlement. The Kapton™ diaphragms break down first in the areas of highest stress and or strain. Typically, the first region to show break down is the circumferential area surrounding the converter button. See Endurance Test (report # PS/98/51). Again, diaphragm life depends on stress levels (pressure magnitude applied), temperature, and chemical exposure. The above mentioned tests were conducted in TI's Life Test lab with relatively controlled conditions.

Water has been shown to accelerate the aging of the base polyimide. Water can be introduced in two known ways:

1) By entering the contact cavity via the electrical connector
2) By being in solution in the brake fluid and entering the switch via the pressure port.

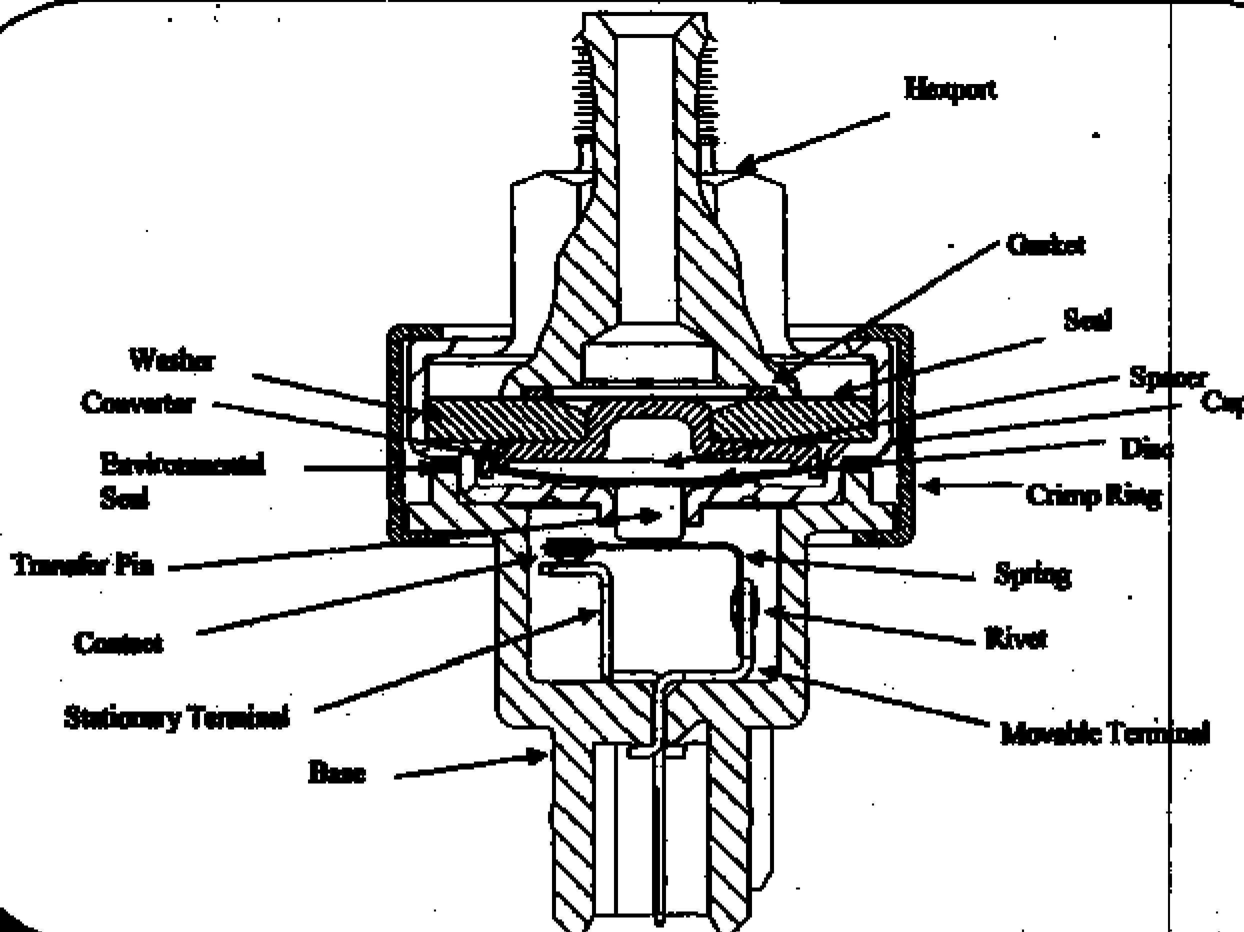
When water enters the connector it will "age" the Kapton™ diaphragms and make them appear as though they have reached the end of life. This condition leaves visual clues. Classic signs of chemical attack of the Kapton™ include de-lamination of the Teflon from the base polyimide base, embrittlement, and cracking of the base polymer. See Endurance Test (report PS/98/53).

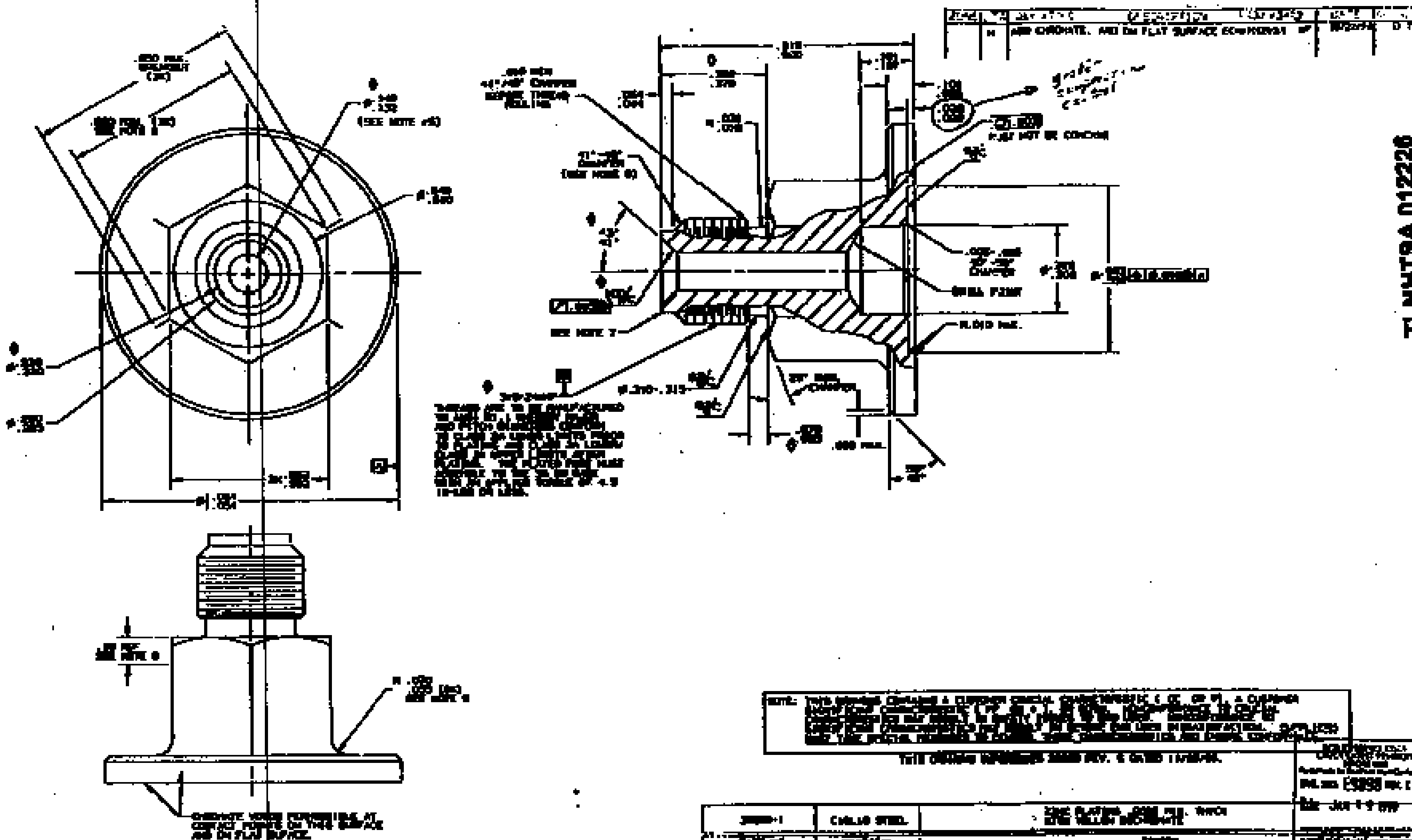
Authored by Bryan Dague. Call Andy Mcguirk or Bryan Dague with questions.

# 77PS Overview Appendix

1. Pressure Switch Cross Section
2. Hexport Print (TI # 36900)
3. Gasket Print (TI# 74353)
4. DFMEA for Gasket and Kapton Seal
5. Life Test to Failure Test Report (Weibull Analysis)
6. Customer Specification (ES-F2VC-9F924_AA)
7. PFMEA
8. IP Test Reports
9. Endurance Test Report

## Pressure Switch Cross Section





NOTE:

1. DIMENSIONS APPLY AFTER PLATING.
2. [illegible] TO BE SHIPPED, [illegible] AND STORED [illegible] PLASTIC [illegible]
3. [illegible] FLANGE [illegible] TO BE ROCKWELL [illegible] MINIMUM.
4. [illegible] TO FORD SPEC. [illegible]
5. [illegible] $\phi$.13[illegible] - .140 THROUGH HOLE [illegible]
6. 41°-49° CHAMFER [illegible] APPLIES IN AREAS WITHOUT THREAD.
7. BREAK EDGE [illegible] CHAMFER [illegible]
8. [illegible] TO BE [illegible] .017 [illegible] ALLOWED AT [illegible]
9. [illegible] AT THE CENTER OF HEX FLAT. [illegible] ALLOWED AT HEX CORNER.

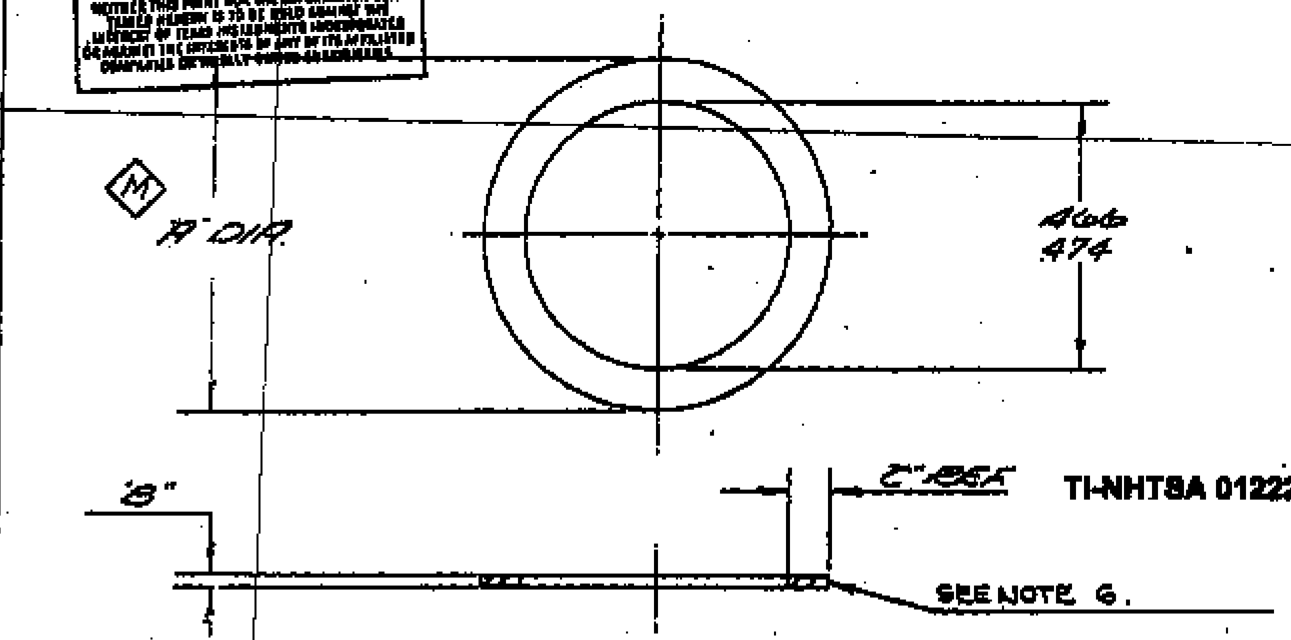
| | | |
|---|---|---|
| [illegible] | [illegible] STEEL | [illegible] |
| PART NO. | MATERIAL | FINISH |

| | | | |
|---|---|---|---|
| UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES | J.D. MAYALL | [illegible] | TEXAS INSTRUMENTS |
| TOLERANCES ON FRACTIONS [illegible] ANGLES [illegible] | C.D. WAGNER | [illegible] | TITLE: MODIFIED SAE J512 HEX PORT |
| | N.J. [illegible] | [illegible] | |
| MATERIAL | SIGNATURES ON FILE. REFER TO ELECTRONIC CHANGE NOTICE. | | SIZE: C · FSCM NO.: 82647 · DWG NO.: 36900 |

FOR REFERENCE ONLY
CHECK LATEST REVISION
BEFORE USE
Parts Made To This Print Must Conform To
ENG. STD. E9898 REV. E
Date JAN 1 9 1999

GASKET

REV. H 74353




TI-NHTSA 01222

NOTES:

1. PARTS MUST BE PURCHASED FROM T.I. ENGINEERING APPROVED VENDORS, LISTED BELOW.
2. MATERIAL CERTIFICATION REQUIRED WITH EACH SHIPMENT.
3. MATERIAL TO BE COMPATABLE WITH FREON-12 & REFRIGERANT OIL.
4. PARTS TO BE SHIPPED, ISSUED, AND STORED ON 4 FOOT +/- 6 INCH MANDRELS, SEALED IN PLASTIC BAGS AND SHIPPED IN CARDBOARD TUBES.
5. ALL CONTAINERS OF PARTS MUST BE MARKED TO REFLECT ANY MATERIAL LOT, TOOL OR PROCESS CHANGE.
6. (M) DASH 1 (-1) AND DASH 4 (-4) GASKET MUST HAVE FOUR (4) WHITE STRIPING INK MARKS, EQUALLY SPACED AROUND THE CIRCUMFERENCE, AND NOT LESS THAN 1/8 INCH WIDE. NO INK IS ALLOWED ON ANY OTHER SURFACE.

| PART NO. | MATERIAL | DUROMETER | COLOR | A (M) | B (M) | C |
|---|---|---|---|---|---|---|
| 74353-4 | ETYLENE PROPYLENE JBL COMPOUND E-7104-70 JBL PART NO. 6197E | 70 | BLACK | .670-.662 | .030-.036 | .063 |
| 74353-3 | ETHYLENE PROPYLENE JBL COMPOUND E-7064 | 70 | WHITE | .670-.662 | .030-.036 | .06 |
| 74353-2 | ETHYLENE PROPYLENE JBL COMPOUND E-7059 | 70 | WHITE | .599-.591 | .030-.036 | .06 |
| 74353-1 | ETHYLENE PROPYLENE JBL COMPOUND E-7104-70 JBL PART NO. 6197E | 70 | BLACK | .599-.591 | .030-.036 | .06 |

BY T. Dail 3.18.85
CH.
ENG.

TEXAS INSTRUMENTS INCORPORATED
ATTLEBORO, MASS., U.S.A.

KLIXON
CONTROL PRODUCTS DIVISION

DWG. SIZE A
PARTS LIST 74353

**POTENTIAL**
**FAILURE MODE AND EFFECTS ANALYSIS**
**(DESIGN FMEA)**

Page 1

___System
___Subsystem
_X_Component Pressure Switch

Model Year(s)/Vehicle(s) Various

Core Team Design Engineering, Manufacturing Engineering, Manufacturing, Quality

Design Responsibility Pressure Switch Group

Key Date [illegible]

Document Number [illegible]
Revision Level 0
Revision Date [illegible]
Original (Initial) Date [illegible]
Prepared By C. [illegible]

| Item / Function | Potential Failure Mode | Potential Effect(s) of Failure | Sev | Class | Potential Cause(s)/ Mechanism(s) of Failure | Occur | Current Design Controls | Detec | R.P.N. | Recommended Action(s) | Responsibility & Target Completion Date | Action Results: Actions Taken | Sev | Occ | Det | R.P.N. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIAPHRAGM (OR SEAL) (SR) (74176) Forms flexible element of fluid containment cavity. | Fails to contain fluid. | Fluid leakage. | 9 | | Gradual rupture over life due to improper design of supporting elements. Gradual rupture over life due to [illegible] [illegible] displacement. Gradual rupture over life due to stress concentrations caused by [illegible] strain distributions. Chemical attack due to incorrect material specified. Incorrect thickness (or # of layers) of diaphragm material. [illegible] [illegible] clamping of diaphragm. | 1 | Burst, impulse, and [illegible] cycle tests. Material [illegible] [illegible]. Comparison of design with similar products. | 1 | 9 | | | | | | | |
| Transfers pressure from fluid to pressure-sensing elements. | Change in area of pressure transfer over life. | Shift in setpoint over life. | 5 | | Diaphragm too stiff. Incorrect material specified. | 1 | Life testing of [illegible] at [illegible] points. | 1 | 5 | | | | | | | |

TI-NHTSA 012226

POTENTIAL
FAILURE MODE AND EFFECTS ANALYSIS
(DESIGN FMEA)

Page 2

___ System
___ Subsystem
_X_ Component  Pressure Switch

Design Responsibility Pressure Switch Group

Document Number [illegible]
Revision Level D
Revision Date 4-Nov-95
Original (Initial) Date 20-Dec-93

Model Year(s)/Vehicle(s) Various

Key Date 1995

Core Team: Design Engineering, Manufacturing Engineering, Manufacturing, Quality

Prepared by C. Wagner

| Item / Function | Potential Failure Mode | Potential Effect(s) of Failure | Sev | Class | Potential Cause(s)/ Mechanism(s) of Failure | Occur | Current Design Controls | Detec | R.P.N. | Recommended Action(s) | Responsibility & Target Completion Date | Action Results: Actions Taken | Sev | Occ | Det | R.P.N. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIAPHRAGM (OR SEAL) [illegible] (74178) | Excessive change of pressure transfer area versus pressure. | Excessively high pressures needed to adequately form pressure transfer area; wide signal or setpoints due to unpredictability at lower pressures. | 6 | | Diaphragm too stiff.<br>Incorrect material specified. | 1 | Force and pressure versus deflection testing to calculate effective areas. | 1 | 6 | | | | | | | |

TI-NHTSA 012229

# POTENTIAL
# FAILURE MODE AND EFFECTS ANALYSIS
## (DESIGN FMEA)



____ System
____ Subsystem
_X_ Component: Pressure Switch

Model Year(s)/Vehicle(s): Various

Core Team: Design Engineering, Manufacturing Engineering, Manufacturing Quality

Design Responsibility: Pressure Switch Group

Key Date: [illegible]

Document Number: [illegible]
Revision Level: C
Revision Date: [illegible]
Original (Initial) Date: [illegible]
Prepared By: C. [illegible]

| Item / Function | Potential Failure Mode | Potential Effect(s) of Failure | Sev | Class | Potential Cause(s)/ Mechanism(s) of Failure | Occur | Current Design Controls | Detec | R.P.N. | Recommended Action(s) | Responsibility & Target Completion Date | Action Results: Actions Taken | Sev | Occ | Det | R.P.N. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GASKET ([illegible]) Provides fluid seal between [illegible] and diaphragm. | Fails to provide adequate fluid seal. | Brake fluid leakage. | 9 | | Insufficient compression specified. | 1 | Review of general seal design principles. | 1 | 9 | | | | | | | |
| | | | | | Very excessive compression specified, leading to displacement from gland. | | Manufacturer's recommendations. | | | | | | | | | |
| | | | | | Incorrect ID and/or OD leading to displacement from gland. | | Burst, impulse, and thermal cycle tests. | | | | | | | | | |
| | | | | | Incorrect cross-section shape specified. | | Comparison with design of similar products. | | | | | | | | | |
| | | | | | Incorrect material specified, fluid incompatibility. | | | | | | | | | | | |
| | | | | | Incorrect design of sealing mechanism. | | | | | | | | | | | |

# Life Testing (to Failure) of 77PS Style Device
## Summary of Test Series 559-15-24

Author: Di Ha, Design Engineering
Date: April 8, 1998
Report No.: PS/98/14

### Purpose

The purpose of this test was to study the life expectancy of a 77PS style hydraulic pressure switch. The endurance test was run out to failure and a Weibull analysis performed. Failure was considered to be a leaking device.

### Sample Description

The devices placed on test was a 77PS brake pressure switch with a quiet disc. The use of a quiet disc results in less energy in the system due to a smaller displacement of the disc during actuation and release. The 77PSL3-4 device was used for test. Calibration requirements for this device are as follows:

Actuation Pressure: 200-300 psig
Release Pressure: 40 psig min.

### Procedure

24 switches were built on the manufacturing line. These parts were then calibrated prior to impulse testing. Results are included in this report.

Endurance testing was run to the following specification:

Temperature: 135C
Frequency: 2Hz
Total Cycles: 500,000
Electrical Load:
- 0-475,000 cycles: 13V +/- 1V, trace current
- 475,001-500,000 cycles: 13 +/- 1V, 750 +/- 50 mA

Operating Pressures:
- Pressure (Low): 0-40psig
- Pressure (High): 1400-1500 psig

After the completion of the 500,000 cycles, the switches were taken off test and calibrated to ensure they were functioning properly. They were then replaced on test and cycled to failure. The number of cycles at which each switch failed/leaked was noted. The test was stopped at 1,634,921 cycles. Six devices were on test when the test was suspended.

**Results**

All 24 switches passed the specification requirement of 500,000 cycles. Actuation drift after cycling was normal, averaging less than 5%. All devices were within specification after the post-500K calibrations.

Failure of the devices was first seen at 994K. Failures were seen up to 1,634,921 cycles, when the test was stopped.

**Conclusion**

Reliability of the switches to 500K cycles is 100 percent. However, we cannot guarantee a life cycle requirement of 1 million cycles, as there were leakage failures prior to the completion of 1 million cycles.

## Raw Data

| Device | Pre-Test Data Actuation (psig) | Release (psig) | Diff (psig) | Post 500K Actuation (psig) | Release (psig) | Diff (psig) | avrD (L/Hr/Test) | Act %Drift | # Cycles to Failure |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 255.6 | 188.8 | 66.8 | 245.8 | 182.0 | 63.8 | 0.18 | -3.8 | ** |
| 2 | 253.6 | 184.1 | 69.5 | 243.5 | 178.5 | 65.0 | 0.15 | -4.0 | 1,387,659 |
| 3 | 248.3 | 187.3 | 61.0 | 240.5 | 180.6 | 59.9 | 0.13 | -1.0 | ** |
| 4 | 249.5 | 182.0 | 67.5 | 240.2 | 177.6 | 62.6 | 0.16 | -3.7 | ** |
| 5 | 241.1 | 175.4 | 65.7 | 232.7 | 172.4 | 60.3 | 0.12 | -3.5 | 1,403,522 |
| 6 | 248.8 | 183.1 | 65.7 | 244.0 | 186.0 | 58.0 | 0.09 | -1.9 | 1,302,691 |
| 7 | 255.8 | 187.9 | 67.9 | 238.4 | 179.3 | 59.1 | 0.12 | -6.8 | 1,344,673 |
| 8 | 247.5 | 185.9 | 61.6 | 246.5 | 184.9 | 61.6 | 0.13 | -0.4 | 1,403,522 |
| 9 | 245.7 | 178.1 | 67.6 | 233.0 | 178.8 | 54.2 | 0.1 | -5.2 | 1,403,522 |
| 10 | 249.9 | 184.1 | 65.8 | 240.4 | 179.3 | 61.1 | 0.13 | -3.8 | 1,131,102 |
| 11 | 264.1 | 197.2 | 66.9 | 252.8 | 193.7 | 59.1 | 0.1 | -4.3 | 994,232 |
| 12 | 255.1 | 187.5 | 67.6 | 247.9 | 183.3 | 64.6 | 0.32 | -2.8 | ** |
| 13 | 248.2 | 186.3 | 62.0 | 239.0 | 176.2 | 62.8 | 0.3 | -3.7 | 1,488,221 |
| 14 | 261.4 | 189.6 | 71.8 | 250.3 | 191.5 | 58.8 | 0.07 | -4.2 | 994,232 |
| 15 | 250.4 | 188.0 | 62.4 | 240.1 | 181.2 | 58.9 | 0.09 | -4.1 | 1,131,102 |
| 16 | 255.1 | 183.4 | 71.7 | 240.7 | 176.7 | 64.0 | 0.31 | -5.6 | 1,359,659 |
| 17 | 244.2 | 176.2 | 68.0 | 234.7 | 176.2 | 58.5 | 0.11 | -3.9 | 1,418,250 |
| 18 | 251.5 | 187.8 | 63.7 | 240.1 | 183.1 | 57.0 | 2.37 | -4.5 | 1,472,621 |
| 19 | 254.0 | 192.2 | 61.8 | 247.1 | 182.1 | 65.0 | 3.48 | -2.7 | 1,511,726 |
| 20 | 256.8 | 190.7 | 66.1 | 252.2 | 189.6 | 62.6 | 0.3 | -1.8 | 1,418,250 |
| 21 | 251.7 | 182.3 | 69.4 | 241.6 | 182.4 | 59.2 | 0.08 | -4.0 | 1,325,190 |
| 22 | 250.1 | 183.6 | 66.5 | 239.7 | 182.9 | 58.8 | 0.12 | -4.2 | 1,359,659 |
| 23 | 249.1 | 180.4 | 68.7 | 246.6 | 182.4 | 64.2 | 0.22 | -1.0 | ** |
| 24 | 257.4 | 184.1 | 73.3 | 246.6 | 183.4 | 63.2 | 0.24 | -4.2 | ** |
| Average | 251.9 | 185.2 | 66.7 | 242.8 | 182.0 | 60.8 | 0.4 | -3.6 | ** |
| Sigma | 5.3 | 4.9 | 3.4 | 5.4 | 4.9 | 3.0 | 0.8 | 1.4 | |

** indicates that these devices were impulse tested to 1,634,921 cycles without failure.
The test was stopped with 1,634,831 cycles on 4/1/98.

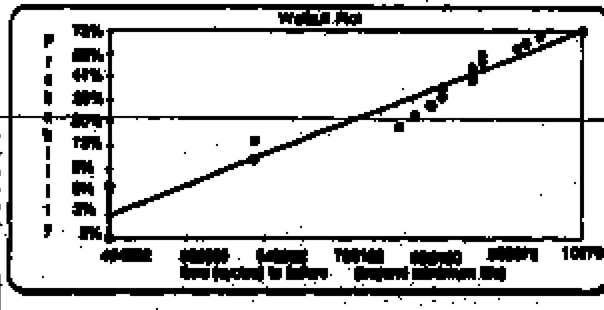
**Weibull Analysis**

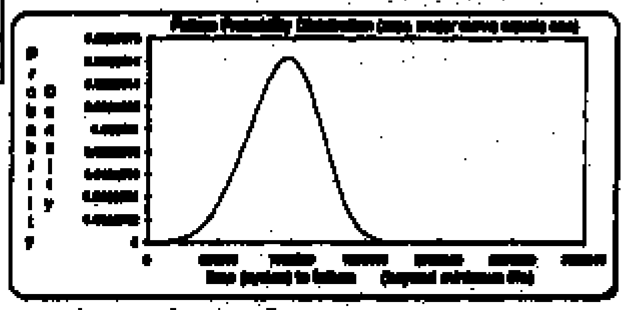
## 2 and 3 parameter WEIBULL ANALYSIS

[redacted]

Calculated Constants

[illegible]




NOTES: [illegible] Impulse Testing.

Date: [illegible]

## Engineering Specification

| PART NAME | PART NUMBER |
|---|---|
| [redacted] | [redacted] |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LET | | | | | | | | | | | | | | | | | | | | | |
| FR | | | | | | | | | | | | | | | | | | | | | |
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| FR | | | | | | | | | | | | | | | | | | | | | |

| DATE | LET | FR | REVISIONS | DR | CK |
|---|---|---|---|---|---|
| | | | ADDED DATA TO COMPLETE | | |
| | | | SPEC. & RETYPED | | |
| [illegible] | | | [illegible] | | [illegible] |

REFERENCE

PREPARED/APPROVED BY: [illegible signature]

CHECKED BY | DETAILED BY

CONCURRENCE/APPROVAL SIGNATURES

DESIGN ENGINEERING SUPERVISOR: [illegible signature]

DESIGN ENGINEERING MGT.

MANUFACTURING ENGRG.

QUALITY CONTROL: [illegible signature]

QUALITY ASSURANCE: [illegible signature]

ELECTRONICS DIVISION: [illegible signature]

▽ CONTROL ITEM — THE ▽ SYMBOL ALSO IDENTIFIES PRODUCT ENGINEERING DESIGNATED CRITICAL CHARACTERISTICS. THESE AND ADDITIONAL CRITICAL CHARACTERISTICS IDENTIFIED BY PROCESS ENGINEERING MUST APPEAR ON PROCESS/CONTROL PLANS AND REQUIRE PRODUCT ENGINEERING APPROVAL.

FRAME 1 OF 15 | REV | ▽ [illegible]

PD 3947-a1 (Previous editions may NOT be used)

Engineering Specification

## SWITCH ASSEMBLY - SPEED CONTROL DEACTIVATE

### I. General

This specification covers the test requirements for the speed control deactivate switch -9F924- [illegible]. Design changes on the switch assembly or its components shall not be made without compliance to Section V of this specification and written approval from the releasing Production Engineering Office.

This engineering specification is a supplement to the released drawing on the above part, and all requirements herein must be met in addition to all other requirements of the part drawing. Minimum measures necessary for demonstrating compliance to these requirements are given in each section.

The engineering tests, sample sizes, and test frequencies contained within this engineering specification reflect the minimum requirements established to provide a regular evaluation of conformance to design intent. The engineering test program is intended as a supplement to normal material inspections, dimensional checking and in-process controls, and should in no way adversely influence other inspection operations.

Q1 suppliers may implement different test sample sizes and frequencies providing these changes have been included in an alternate Control Plan approved by the design responsible Product Engineering Office and concurred in by SQA.

### II. PRODUCTION VALIDATION AND IN-PROCESS TESTS

- Production Validation (PV) Tests must be completed satisfactorily with parts from production tooling (and processes where possible) before ISIR approval and authorization for shipment of production parts can be effected. Parts must be revalidated completely, or per Section V whenever any change is made which could possibly affect part function or performance.

- In-Process Test Phase 1 (IP-1) - IP-1 tests are used to demonstrate process capability and must be completed using initial production parts from production tooling and processes prior to first production shipment approval. IP-1 tests are to continue in effect until process capability is demonstrated.

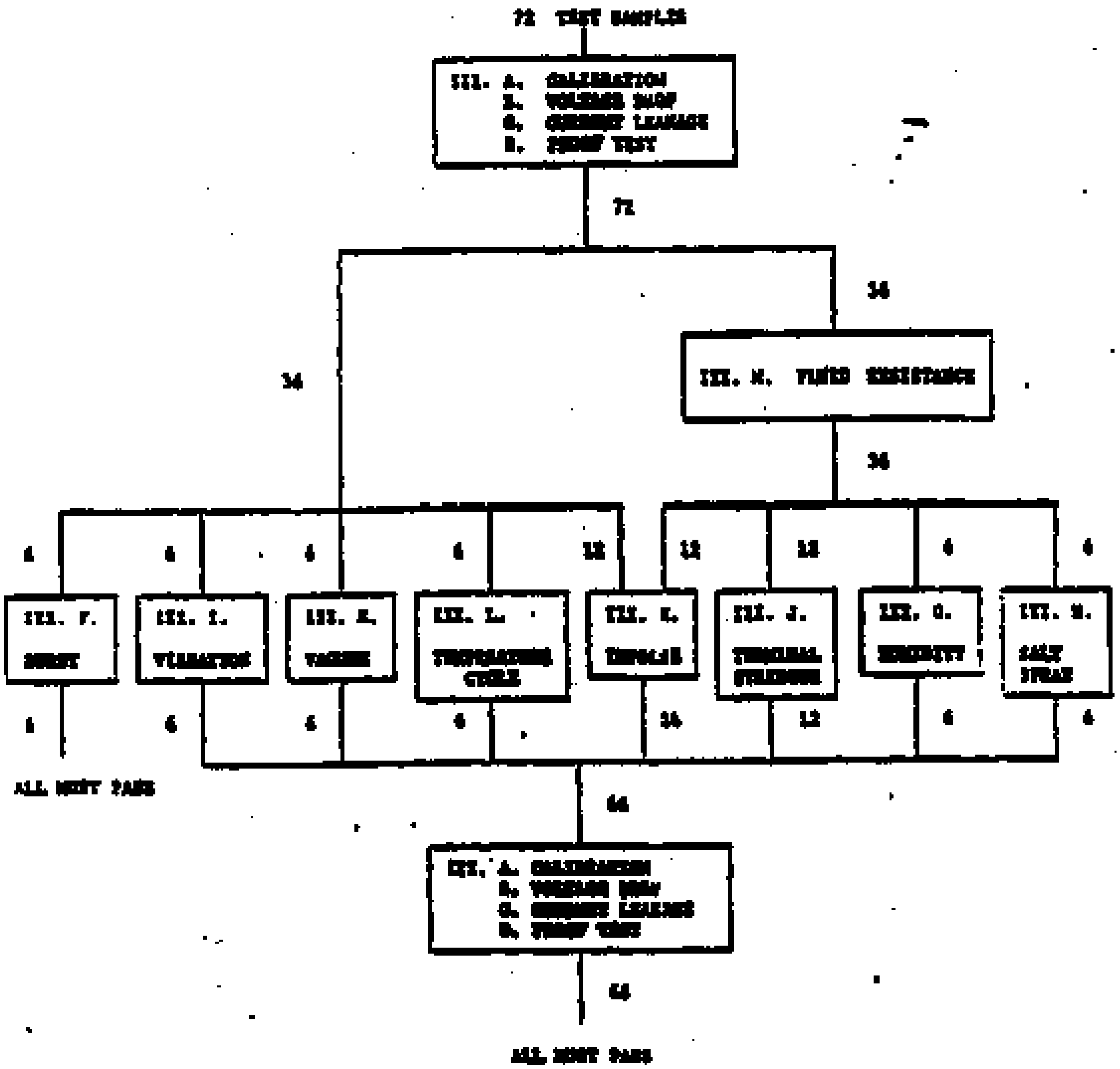
- In-Process Tests Phase 2 (IP-2) - IP-2 test program may be implemented only after process capability has been established. Tests must be completed with production parts on a continuing basis. Samples for these tests must be selected on a random basis to represent the entire production population as much as possible. In the event that any of the requirements in these tests is not met, the reaction plan specified in Ford Q101 Sect. 3.5, "Engineering Specification (ES) Test Performance Requirements" shall be invoked.

## SECTION III. TABLE OF TESTS

| Item | Test Name Functional Tests | PRODUCTION VALIDATION Minimum Sample Size | PRODUCTION VALIDATION Statistical Test Acceptance Criteria | IN-PROCESS IP-1 Minimum Sample Size | IN-PROCESS IP-1 Statistical Test Acceptance Criteria | IN-PROCESS IP-2 Minimum Sample Size | IN-PROCESS IP-2 Statistical Test Acceptance Criteria |
|---|---|---|---|---|---|---|---|
| III. | | | | | | | |
| ▽ A | Calibration | 72 | P90-.96 | 100% | All Must Pass | 100% | All Must Pass |
| B | Voltage Drop | 72 | P90-.96 | 12/Mo. | P90-.84 | 4/Lot | " " " |
| C | Current Leakage | 72 | P90-.96 | 3/Mo. | P90-.56 | 4/Lot | " " " |
| D | Proof Test | 72 | P90-.96 | 12/Mo. | P90-.84 | 4/Lot | " " " |
| F | [illegible] | 6 | P90-.72 | 3/Mo. | P90-.56 | 4/Lot | " " " |
| I | Vibration | 6 | P90-.72 | 3/Mo. | P90-.56 | 6/6 Mo. | P90-.72 |
| J | Terminal Strength | 32 | P90-.84 | 6/Mo. | P90-.72 | 4/Lot | All Must Pass |
| K | Vacuum | 6 | P90-.72 | 3/Mo. | P90-.56 | 6/6 Mo. | P90-.72 |
| L | Temperature Cycle | 6 | P90-.72 | 3/Mo. | P90-.56 | 6/6 Mo. | P90-.72 |
| M | Fluid Resistance | 36 | P90-.94 | 36/12Mo. | P90-.94 | 36/12Mo. | P90-.94 |
| | **Durability Tests** | | | | | | |
| III. | | | | | | | |
| E | Impulse | 24 | P90-.90 | 12/Mo. | P90-.84 | 1/3 Mo. | P90-.56 |
| G | Humidity | 6 | P90-.72 | 3/Mo. | P90-.56 | 6/6 Mo. | P90-.72 |
| H | Salt Spray | 6 | P90-.72 | 3/Mo. | P90-.56 | 6/6 Mo. | P90-.72 |

## Engineering Specification

### PRODUCTION VALIDATION FLOW CHART




| | | | |
|---|---|---|---|
| 4 16 | | | F28-V2VC-... |
| FRAME OF | REVISED | | NUMBER |

III. TEST PROCEDURES AND REQUIREMENTS

▽ A. Calibration

1. Test Requirements

a. Switch calibration is to be checked at room temperature (16°C-32°C) using ambient air or equivalent.

b. Calibration settings shall be specified on the part drawing with the settings checked after 2 or more pressure cycles with ambient air, or equivalent. Pressure cycle range is to be determined by the manufacturer to insure switch calibration stability. The cut-in and differential set points are to be measured while conducting 750 ± 50 milliamperes while 13.0 ± 1.0 volts D.C. is applied. The cut-in point is to be checked with increasing pressure.

c. The cut-out point is to be checked with decreasing pressure, and the differential set point is to be calculated using the cut-in pressure minus the cut-out pressure.

2. Acceptance Requirements

a. Nonconformance is defined as any switch point which falls outside the tolerance band specified on the part drawing.

B. Voltage Drop

1. Test Requirements

a. Voltage drop is to be measured after 2 or more cycles with ambient air or equivalent from 0 to 10,000 ± 172 kPa (1450 ± 25 PSI) while conducting 750 ± 50 milliamps and 13.0 ± 1.0 volts D.C. is applied to the switch. Under these conditions with the switch closed the voltage drop is to be measured. Millivolt connection interface to terminals to be less than 10 millivolts.

2. Acceptance Requirements

a. Nonconformance is defined as a voltage drop in excess of 200 millivolts.

III. TEST PROCEDURES AND REQUIREMENTS (cont'd)

C. Current Leakage

1. Test Requirements

a. Current leakage is to be checked with 500 volts, 60 Hz alternating current.

b. Current leakage is to be checked:

(1) Between the switch leads with the contacts open.
(2) Between the lead and the switch housing with contacts closed.
(3) Between either lead and switch housing with the contacts open.

2. Acceptance Requirements

a. Nonconformance is defined as any leakage current in excess of one hundred (100) microampere.

D. Proof Test

1. Test Requirements

a. Subject sample switches to Section A to establish their initial switching pressures.

b. Proof test is to be conducted using brake fluid or equivalent as the pressure medium. Test pressure shall be as specified on the part drawing. Test pressure shall be isolated from pressure source and held for not less than 30 seconds. — 3000 psi / 4500 psi — Pass Car / Truck

c. Recheck the switches to Section A.

2. Acceptance Requirements

a. No evidence of fluid leakage, seepage, or drop in test pressure greater than 430 KPa.(62 PSI) is permitted.

b. A change in cut-in and cut-out pressures greater than ± 5% from the initial value is not permitted.

c. The test samples must be destroyed after testing.

III. <u>TEST PROCEDURES AND REQUIREMENTS</u> (cont'd)

E. <u>Impulse</u>

1. <u>Test Requirements</u>

a. Test the switch for a total of 500,000 cycles. Cycle pressure between (low) 0-276 kPa (0-40 psi) and (high) 10,000 ± 345 kPa (1450 ± 50 psi).

1) 0 - 475,00 cycles: 13 ± 1 volts, trace current to monitor function.

2) 475,001 - 500,000 cycles: 13 ± 1 volts D.C., 750 ± 50 ma., per figure 4.

b. Brake fluid temperature to be 135 ± 14°C and ambient temperature to be 107°C min.

c. Cycle rate is to be 110-130 cycles per minute.

d. Switch must open and close each cycle.

2. <u>Acceptance Requirements</u>

a. After impulse test check to sections A, B, C, & D using the procedure established in each section.

b. Nonconformance is defined as any switch not meeting the criteria in sections A, B, C, & D.

c. Samples used for this test must be destroyed after all testing is completed.

F. <u>Burst</u>

1. <u>Test Requirement</u>

a. Burst strength is to be checked using brake fluid or equivalent as the pressure medium.

b. Pressurize the switch to 48.3 MPa (7000 PSI) minimum and hold for 30 seconds minimum.

2. <u>Acceptance Requirements</u>

a. Nonconformance is defined as any evidence of fluid leakage or seepage from the switch or threads. Samples used for this test must be destroyed after testing is completed.

G. Humidity

1. Test Requirements

a. Mount the switch in the test port in a humidity chamber. Currently released mating electrical connector must be installed before start of test.

b. Subject the switch to ten (10) continuous humidity cycles as follows:

(1) Raise temperature to 65 +10/-2 °C over 2.5 hours; at 90-98% relative humidity.

(2) Hold 3 hours at 65 +10/-2 °C at 90-98% relative humidity.

(3) Lower temperature to 25 +10/-2 °C over 2.5 hours; at 40-98% relative humidity.

2. Acceptance Requirements

a. Within 15 minutes after completion of the tenth humidity cycle check the switch to sections A, B, C, D, using the procedure established in each section.

b. Nonconformance is defined as any switch not meeting the criteria in sections A, B, C, or D.

H. Salt Spray

1. Test Requirements

a. Mount the switch in the test port in a salt spray chamber. The currently released mating electrical connector and wiring must be installed prior to start of test.

b. Expose the switch assembly to 72 hours of salt spray per ASTM B-117.

2. Acceptance Requirements

a. After exposure, check the switch to sections A, B, C, D, using the procedure established in each section.

b. Nonconformance is defined as any switch not meeting the criteria in sections A, B, C, or D. Samples used for this test must be destroyed after all testing is completed.

III. TEST PROCEDURES AND REQUIREMENTS (cont'd)

I. Vibration

1. Test Requirements

a. Mount the switch in the test port and attach the currently released mating electrical connector before start of test.

b. Switches are to be vibrated in all 3 planes with electrical continuity being monitored during the entire test. See Figure 1 for switch orientation in the 3 planes. Vibration tests are to be conducted at room temperature using brake fluid, ambient air, or equivalent as the pressure medium.

c. Internal pressure shall be maintained at 0 kPa G. when the switch is in the closed position and 1.1 times max actuation pressure shown on print when the switch is in the open position.

d. Vibrate the switch at 1.2 mm displacement (peak-to-peak) while varying the frequency uniformly from 5 to 30 to 5 Hz over a 3 minute period.

e. Vibrate the switch in alternate one-hour periods in the open and closed positions for a total of 8 hours in each plane. (Total test time is 24 hours).

2. Acceptance Requirements

a. After the entire vibration sequence check the switches to sections A, B, C, or D using the procedure established in each section.

b. Nonconformance is defined as any evidence of leakage or any change in electrical continuity/discontinuity during the vibration cycles, or any switch not meeting the criteria in sections A, B, C, or D. Samples used for this test must be destroyed after all testing is completed.

J. Terminal Strength

1. Test Requirements

a. Mount the switch in the test port.

(1) Apply a 49 ± 9 N axial force to each terminal.

(2) With a pendulum apply a 45 ± 5 N impact force to the switch housing at the connector end, perpendicular to the centerline axis of the switch. See Figure 2 for force application point and direction.

2. Acceptance Requirements

a. Check the switch to sections A, B, C, and D using the procedures established in each section.

b. Nonconformance is defined as any terminal or housing fracture, or any switch not meeting the criteria in sections A, B, C, or D.

K. Vacuum

1. Test Requirements

a. Mount the switch in the test port. Vacuum tests are to be conducted at room temperature using ambient air as the pressure medium.

b. Subject the switch to 5 cycles of vacuum from atmospheric pressure (760 mm Hg) to an absolute pressure of 1-6 mm Hg. Maintain the vacuum for a minimum of 60 seconds.

2. Acceptance Requirements

a. Check the switch to sections A, B, C, and D using the procedure established in each section.

b. Nonconformance is defined as any switch not meeting the criteria in sections A, B, C, and D.

III. TEST PROCEDURES AND REQUIREMENTS (cont'd)

L. Temperature Cycle

1. Test Requirements

a. Mount switches in test ports; test to be run using currently released brake fluid.

b. Repeat the following procedure 25 times.

(1) Lower the switch and fluid temperature to at least -40°C.

(2) Cycle the switches ten times at 10 seconds/cycles. One cycle consists of a pressure variation from 0 - 276 kPa.G (0-40 psi) to 10,000 ± 345 kPa.G (1450 ± 50 PSI). Note: Switch must open and close each cycle.

(3) Raise switch and fluid temperature to 38°C minimum. 120°F

(4) Repeat Step 2.

c. At completion of Step b, check switches per sections A, B, C, and D.

2. Acceptance Requirements

a. Nonconformance is defined as any evidence of switch fluid leakage, seepage, or not meeting the criteria of sections A, B, C, and D.

M. Fluid Resistance.

1. Test Requirements

a. Mount the switch in the test port and orient as installed in the vehicle.

b. Install the currently released mating electrical connector (with wire leads) to the switch.

c. Sequentially, immerse the switch into each of the specified fluids, at a temperature of 21 ± 1 °C, for 5 ± 1 second. Remove the switch and drain and store the switch for the specified time at room temperature, prior to immersing into the next fluid.

III. TEST PROCEDURES AND REQUIREMENTS (cont'd)

| Fluid | Drain Time | Storage Time |
|---|---|---|
| Reference Fuel C ASTM D471 | 60 ± 5 min. | none |
| 10W40 Engine Oil | 24 ± 1 hour | 14 days |
| Ethylene Glycol/ Water 50/50 by Volume | 24 ± 1 hour | 24 ± 1 hour |
| Brake Fluid DOT 3 | 24 ± 1 hour | 48 ± 1 hour |
| Automatic Transmission/ Power Steering Fluid (name) ESF-M2C138-CJ | 24 ± 1 hour | 14 days |
| Isopropyl Alcohol/ Water 50/50 by Volume | 24 ± 1 hour | none |
| Reference Fuel C, ASTM D471 with Methyl Alcohol 85/15 by Volume | 24 ± 1 hour | none |

d. Per the Flow Chart, subject the prescribed number of immersed switch's to the post immersion tests specified below:

III. E. Impulse
III. G. Humidity
III. H. Salt Spray
III. J. Terminal Strength

Acceptance Requirements

a. Switches must fully meet the requirements of the specified post immersion test.

b. Nonconformance is defined as any switch not meeting the criteria in sections A, B, C, or D. Samples used for this test must be destroyed after all testing is completed.

IV. STATISTICAL ANALYSIS METHODS

A. For PV, IP-1 and IP-2 tests, all samples tested must pass. [redacted] the notation PV-R is interpreted as minimum reliability equal to R, at a confidence C; then PV90-90 means a minimum reliability of 90% at 90% confidence.

B. All samples must pass in the statistical test acceptance criteria stated for tests with 100% frequency; or samples from lots, which could have a variable size.

V. REVALIDATION REQUIREMENTS

A. No change in design, material, process or component supplier shall be made without prior approval from the releasing Product Engineering Office. As part of approving a change, the releasing Product Engineering Office will establish the portion of the Product Validation tests required to be run to revalidate the switch. The following table is to be used as a guide in determining the type of tests required for revalidation requirements.

DESIGN CHANGE REVALIDATION

| Component | Process or Material Change or New Supplier |
|---|---|
| 1. Terminals, Contacts, or Connector | III, B, C, E, G, H, I, J, L, M. |
| 2. Case or Housing | All Tests |
| 3. Disc or Diaphragm | III, A, D, E, F, I, K, L. |
| 4. Fitting or Fluid Connection | III, D, E, F, H, L, M. |

B. Annual revalidation is not required on carryover switches.

VI. LOT DEFINITION

A lot is defined as no more than eight (8) hours of production up to 4,000 pieces. If shifts extend beyond eight (8) hours, or more than 4,000 pieces are produced in a shift, the product must be separated into at least two lots.

VII. RECORD RETENTION

A. Recording and record retention shall conform with Ford Q-101.

B. Production Validation test results and analysis are to be forwarded to the releasing Product Engineering Office before approval for shipment of production parts can be granted.

C. In-Process test results shall be available at the supplier's manufacturing facility for the releasing Product Engineering Office and Ford SQA or its representatives to review on request.

VIII. INSTRUCTIONS AND NOTES

All switches are to be identified with the Ford part number, supplier identification, and a date code indicating final assembly.

All test equipment and test procedures for testing to this specification must be approved by the releasing Product Engineering Office and no change in equipment or procedure may be made without their written concurrence.

Test part configuration is shown in Figure 3.

O-rings, if used in the design, shall be free from cuts, nicks, abrasions or any other damage which would result in a fluid leak.

All switches must have a shipping cap installed over the port threads to prevent contamination. All shipping caps must be approved by the releasing Product Engineering Office prior to production incorporation.

All switches that do not pass the calibration test are to either be readjusted and rechecked, or scrapped. (Salvage of component parts permitted with 100% reinspection).

If product nonconformance occurs for test sections III. B, C, D, E, F, and J, production shall be stopped and the problems corrected. All production lots shall be sorted 100% prior to shipment. Suspected nonconformance of any shipped parts shall be reported immediately to the releasing Product Engineering Office.

If nonconformance of the statistical acceptance criteria occurs for test sections III. G, H, I, K, L and M, a cause to recall the subject weeks production and to stop production may result.

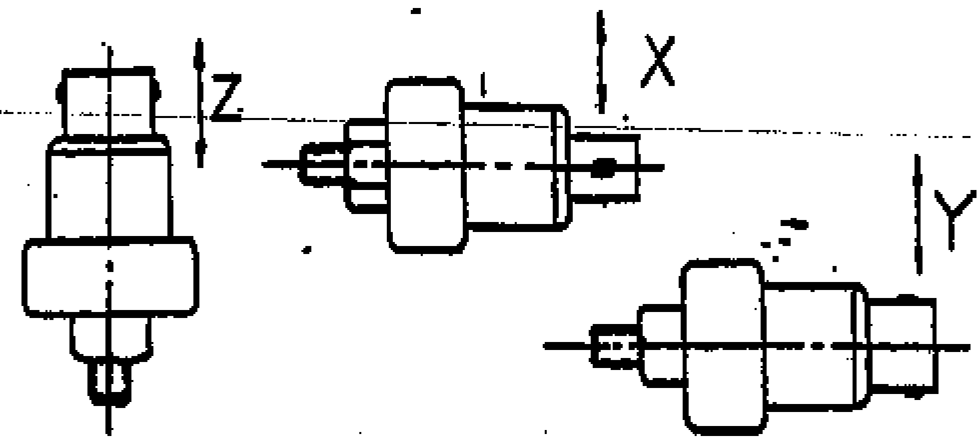
IX. COMPILATION OF REFERENCE DOCUMENTS

ASTM B-117, Salt Spray Testing

Ford Q-101, Quality System Standard - 1990 Edition

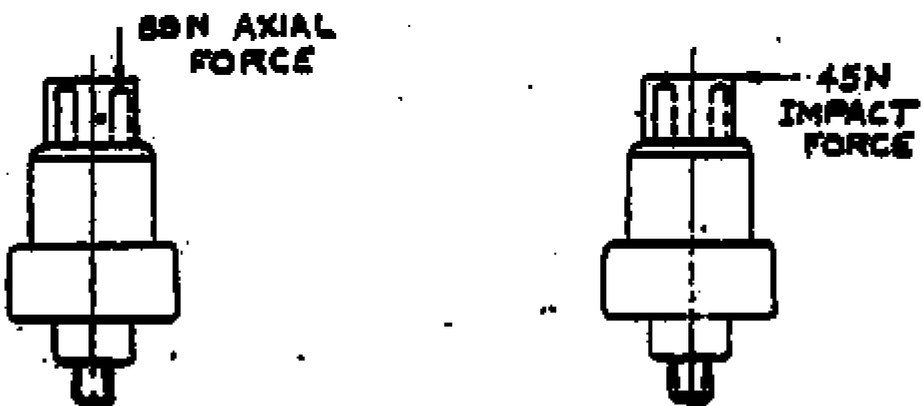
ES-F0ZB-14A464-AA, Specification - BLF Assy - Wire Connector

ES-F2VF-9C735-AA, Specification - Servo Assembly Speed Control



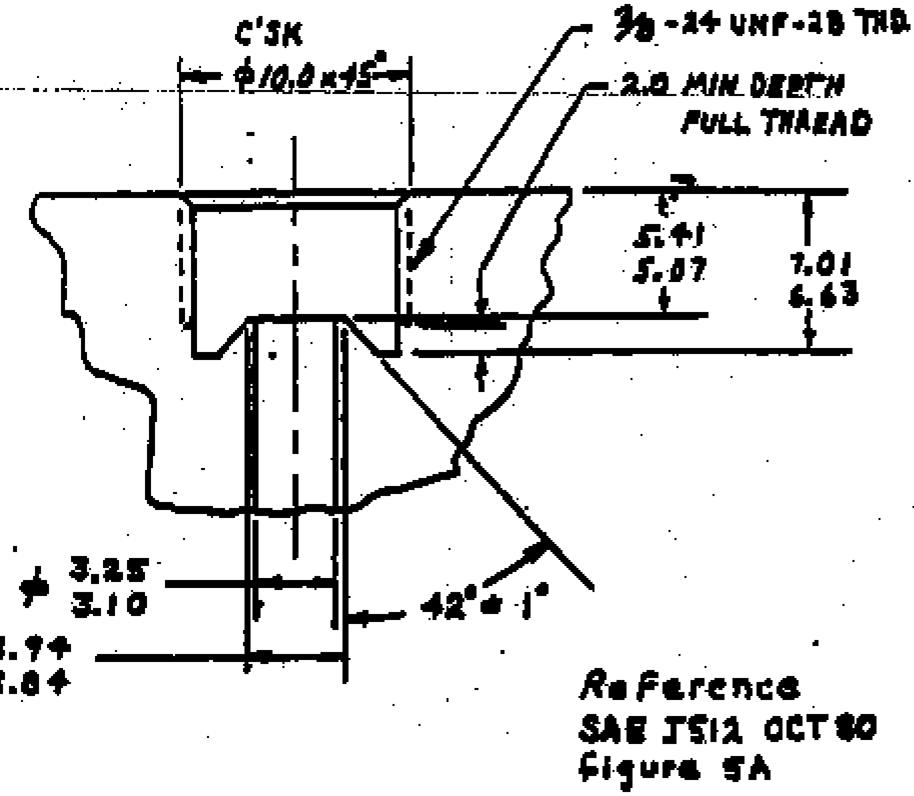

VIBRATION TEST - SWITCH ORIENTATION

FIGURE 1.



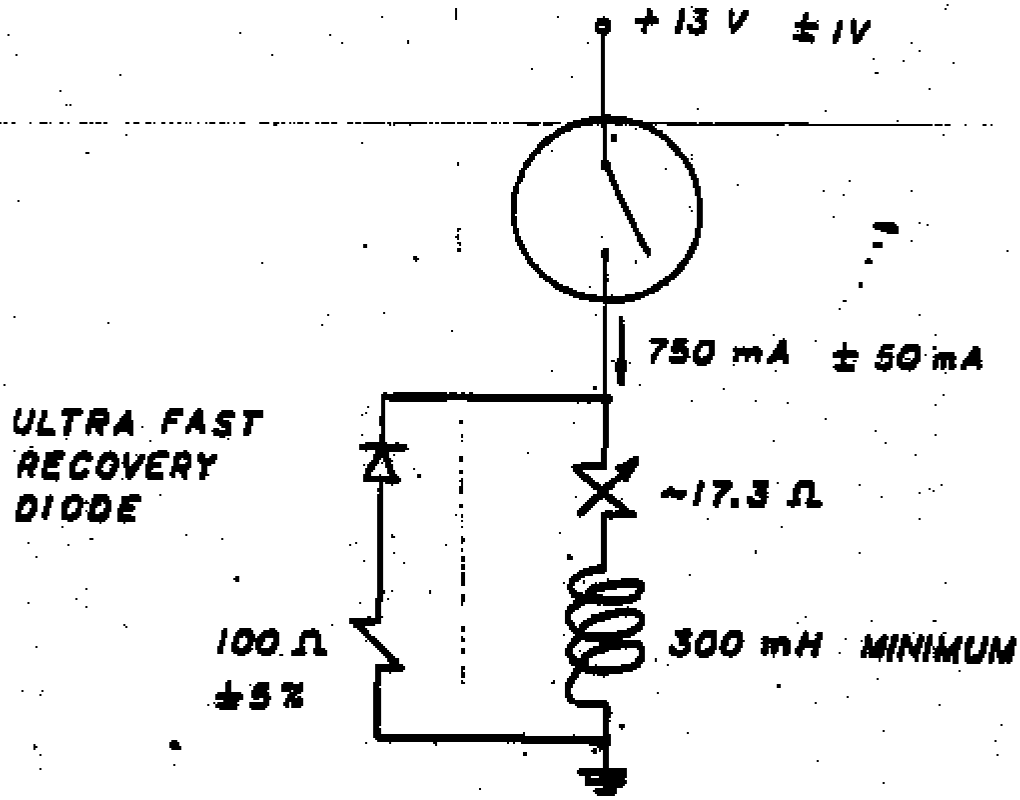

TERMINAL STRENGTH - LOAD ORIENTATION

FIGURE 2.




TEST FIXTURE PORT CONFIGURATION

FIGURE 3




DEACTIVATE SWITCH
TEST SET UP

FIGURE 4

Document #: [illegible]

# POTENTIAL
# FAILURE MODE AND EFFECTS ANALYSIS
# (PROCESS FMEA)

PROCESS: AUTOMATED SENSOR ASSEMBLY

PROCESS RESPONSIBILITY: MATT SELLERS/ANN REA

PREPARED BY: MATT SELLERS

MODEL YEAR(S)/VEHICLE(S): [illegible]

DESIGN/QUAL/MFG RESPONSIBILITY: KEITH ROSELLO / JIM WATT / PEGGY ALLEN

FMEA DATE (ORIG.) [illegible]
FMEA REVISION: B

| Item | Process Function/ Requirements | Potential Failure Mode | Potential Effect(s) of Failure | Sev | Class | Potential Cause(s)/ Mechanism(s) of Failure | Occur | Current Process Controls | Detec | R.P.N. | Recommended Action(s) | Responsibility & Target Completion Date | Action Results: Actions Taken | Sev | Occ | Det | R.P.N. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | FEED AND ASSEMBLE HEXPORT TO [illegible]. | DOES NOT FEED | NO SUBSEQUENT ASSEMBLY PERMISSIBLE YIELD LOSS | [illegible] | | MACHINE ERROR | 1 | PREVENTIVE MAINT. 100% PRESENCE CHECK VERIFY OPERATION OF CHECK PROBE | 1 | [illegible] | | | | | | | |
| | | DOES NOT INSERT PROPERLY | NO SUBSEQUENT ASSEMBLY PERMISSIBLE | [illegible] | | DEBRIS IN NEST; MACHINE ERROR | 1 | PREVENTATIVE MAINT. 100% PRESENCE CHECK | 1 | [illegible] | | | | | | | |
| | | LOADS MULTIPLE HEXPORT | NO SUBSEQUENT ASSEMBLY PERMISSIBLE | [illegible] | | MACHINE ERROR | 1 | PREVENTATIVE MAINT. 100% PRESENCE CHECK | 1 | [illegible] | | | | | | | |
| 2 | CONFIRM HEXPORT PRESENCE AND STYLE | FAILS TO IDENTIFY OUT OF SPEC HEXPORT | MIXED HEXPORT | [illegible] | | SET-UP ERROR | 1 | SET-UP MASTERS | 1 | [illegible] | | | | | | | |
| 3 | FEED AND ASSEMBLE GASKET TO HEXPORT GLAND | MISPLACED GASKET | LEAK BURST RESISTANCE DEGRADATION | [illegible] | | MACHINE ERROR OPERATOR INTERVENTION | 1 | 100% FUNCTION TEST CONTINUITY PROBE CYCLING AUDITS | 1 | [illegible] | | | | | | | |
| | | NO GASKET | LEAK BURST RESISTANCE DEGRADATION | [illegible] | | MACHINE ERROR OPERATOR INTERVENTION | 1 | 100% FUNCTION TEST CONTINUITY PROBE CYCLING AUDITS | 1 | [illegible] | | | | | | | |
| | | MULTIPLE GASKET | LEAK BURST RESISTANCE DEGRADATION YIELD LOSS | [illegible] | | OPERATOR INTERVENTION | 1 | 100% FUNCTION TEST | 1 | [illegible] | | | | | | | |
| 4 | CONFIRM GASKET PRESENCE | FAILS TO IDENTIFY MISSING OR OUT OF PLACE GASKET | LEAK | [illegible] | | MACHINE ERROR | 1 | SET-UP MASTERS | 1 | [illegible] | | | | | | | |
| 5 | BLANK AND ASSEMBLE (2) SEALS | ONLY (1) SEAL LOADED | REDUCED DIAPHRAGM LIFE | [illegible] | | OPERATOR DOES NOT TURN ON 2ND [illegible] | 1 | PROCESS SPECS MACHINE SET-UP MATERIAL KITTING | 1 | [illegible] | | | | | | | |

TI-NHTSA 012253

PROCESS: AUTOMATED SENSOR ASSEMBLY

PROCESS RESPONSIBILITY: MATT SELLERS/[illegible] REA

MODEL YEAR(S)/VEHICLE(S): [illegible]

DSGN/QUAL/MFG RESPONSIBILITY: KEITH ROSIELLO / JIM WATT / PEGGY ALLEN

FMEA DATE (ORIG.) [illegible]
FMEA REVISION: B

| Item | Process Function/ Requirements | Potential Failure Mode | Potential Effect(s) of Failure | Sev | Class | Potential Cause(s)/ Mechanism(s) of Failure | Occur | Current Process Controls | Detec | R.P.N. | Recommended Action(s) | Responsibility & Target Completion Date | Action Results: Actions Taken | Sev | Occ | Det | R.P.N. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | NO SEAL LOADED | LEAK | [illegible] | | MACHINE ERROR | 1 | 100% FUNCTION TEST<br>CONTINUITY PROBE | 1 | [illegible] | | | | | | | |
| | | IMPROPERLY CUT SEAL | LEAK<br>DIAPHRAGM LIFE FAILURE<br>YIELD LOSS | [illegible] | | MACHINE ERROR | 1 | 100% FUNCTION TEST<br>CONTINUITY PROBE<br>CYCLING AUDITS<br>PREVENTIVE MAINT. | 1 | [illegible] | | | | | | | |
| | | MISPLACED SEAL | LEAK<br>REDUCED DIAPHRAGM LIFE | [illegible] | | MACHINE ERROR OR STATIC | 1 | 100% FUNCTION TEST<br>CONTINUITY PROBE<br>ANTI-STATIC STATION<br>PREVENTIVE MAINT.<br>CYCLING AUDITS | 1 | [illegible] | | | | | | | |
| | | MORE THAN (1) SEALS LOADED | SHIFT IN SET POINTS | [illegible] | | STATIC BUILD UP | 1 | ANTI-STATIC STATION | 1 | [illegible] | | | | | | | |
| 6 | CONFIRM (2) SEALS PRESENCE | FAILS TO IDENTIFY MISSING OR OUT OF PLACE SEAL(S) | LEAK | [illegible] | | MACHINE ERROR | 1 | SET-UP [illegible] | 1 | [illegible] | | | | | | | |
| 7 | [illegible], BLANK AND ASSEMBLE ([illegible]) SEAL FOR [illegible] APPL STATIONS | NO SEAL LOADED | LEAK | [illegible] | | MACHINE ERROR | 1 | 100% FUNCTION TEST | 1 | [illegible] | | | | | | | |
| | | IMPROPERLY CUT SEAL | LEAK<br>DIAPHRAGM LIFE FAILURE [illegible] SUBSEQUENT ASSEMBLY<br>YIELD LOSS | [illegible] | | MACHINE ERROR | 1 | CONTINUITY PROBE<br>100% FUNCTION TEST<br>CONTINUITY PROBE<br>CYCLING AUDITS<br>PREVENTIVE MAINT. | 1 | [illegible] | | | | | | | |
| | | MISPLACED SEAL | LEAK<br>REDUCED DIAPHRAGM LIFE | [illegible] | | MACHINE ERROR OR STATIC | 1 | 100% FUNCTION TEST<br>CONTINUITY PROBE<br>ANTI-STATIC STATION<br>PREVENTIVE MAINT.<br>CYCLING AUDITS | 1 | [illegible] | | | | | | | |
| | | MORE THAN (1) SEAL LOADED | SHIFT IN SET POINTS | [illegible] | | STATIC BUILD UP | 1 | ANTI-STATIC STATION | 1 | [illegible] | | | | | | | |

TI-NHTSA 012254

PROCESS: AUTOMATED SENSOR ASSEMBLY

PROCESS RESPONSIBILITY: MATT [illegible] RCA

MODEL YEAR(S)/VEHICLE(S): [illegible]

DSGN/QUAL/MFG RESPONSIBILITY: KEITH ROSIELLO / JIM WATT / PEGGY ALLEN

FMEA DATE (ORIG.) [illegible]
FMEA REVISION: B

| Item | Process Function/ Requirements | Potential Failure Mode | Potential Effect(s) of Failure | Sev | Class | Potential Cause(s)/ Mechanism(s) of Failure | Occur | Current Process Controls | Detec | R.P.N. | Recommended Action(s) | Responsibility & Target Completion Date | Action Results: Actions Taken | S e v | O c c | D e t | R.P.N. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | SENSE ABSENCE/ CONFIRM (SRD) SEAL PRESENCE | FAILS TO IDENTIFY MISSING OR OUT OF PLACE SEAL | LEAK | 9 | | MACHINE ERROR | 1 | SET-UP MASTERS | 1 | 9 | | | | | | | |
| 9 | FEED AND ASSEMBLE CONVERTER TO WASHER | MISSING CONVERTER | INOPERATIVE SWITCH | 5 | | MACHINE MISFEED | 3 | 100% PRESENCE CHECK<br>100% FUNCTION TEST | 1 | 15 | | | | | | | |
| | | MISSING WASHER | INOPERATIVE DEVICE | 9 | | MACHINE MISFEED | 3 | 100% PRESENCE CHECK<br>100% FUNCTION TEST | 1 | 27 | | | | | | | |
| | | UPSIDE DOWN WASHER | LEAK<br>SHIFT IN SENSOR SET POINTS<br>REDUCED KAPTON LIFE | 9 | | MACHINE MISFEED<br>OPERATOR ERROR | 1 | POKE YOKE [illegible] TRACK<br>100% FUNCTION TEST<br>CYCLING AUDITS | 1 | 9 | | | | | | | |
| 10 | FEED AND ASSEMBLE WASHER/CONVERTER ASSEMBLY | DISLODGMENT OF CONVERTER | INOPERATIVE DEVICE | 5 | | AIR PICK AND PLACE ERROR | 1 | OPERATOR SET-UP<br>100% FUNCTION TEST<br>100% PRESENCE CHECK<br>PREVENTIVE MAINT.<br>CYCLING AUDITS | 1 | 5 | | | | | | | |
| | | NON-CONCENTRIC PLACEMENT | MISPLACED KAPTON<br>REDUCED KAPTON LIFE<br>MISPLACED DISC<br>INOPERATIVE DEVICE | 9 | | AIR PICK AND PLACE ALIGNMENT ERROR | 1 | OPERATOR SET-UP<br>100% FUNCTION TEST<br>100% PRESENCE CHECK<br>PREVENTIVE MAINT.<br>CYCLING AUDITS | 1 | 9 | | | | | | | |
| | | FAILS TO LOAD ASSEMBLY | NO SUBSEQUENT ASSEMBLY POSSIBLE<br>YIELD LOSS | 5 | | MACHINE ERROR | 1 | PREVENTIVE MAINT.<br>100% PRESENCE CHECK<br>VERIFY OPERATION OF CHECK PROBE | 1 | 5 | | | | | | | |
| | | LOADS MULTIPLE ASSEMBLIES | NO SUBSEQUENT ASSEMBLY POSSIBLE | 5 | | MACHINE ERROR | 1 | PREVENTIVE MAINT.<br>100% PRESENCE CHECK | 1 | 5 | | | | | | | |
| 11 | CONFIRM WASHER CONVERTER ASSEMBLY PRESENCE. | FAILS TO IDENTIFY MISSING OR OUT OF PLACE WASHER CONVERTER ASSEMBLY. | INOPERATIVE DEVICE | 8 | | MACHINE ERROR | 1 | YIELD MONITORING | 1 | 8 | | | | | | | |
| 12 | BLANK AND ASSEMBLE SPACER | MISPLACED SPACER | REDUCED DISC LIFE | 7 | | MACHINE ERROR | 1 | 100% FUNCTION TEST | 1 | 7 | | | | | | | |

TI-NHTSA 012255

PROCESS: AUTOMATED SENSOR ASSEMBLY

PROCESS RESPONSIBILITY: MATT BELLE/SHAWN REA

MODEL YEAR(S)/VEHICLE(S): 92/93/77/98/97P8

DESIGN/QUAL/MFG RESPONSIBILITY: KEITH ROSIELLO / JIM WATT / PEGGY ALLEN

FMEA DATE (ORIG.) 4/28/98
FMEA REVISION: B

| Item | Process Function/ Requirements | Potential Failure Mode | Potential Effect(s) of Failure | Sev | Class | Potential Cause(s)/ Mechanism(s) of Failure | Occur | Current Process Controls | Detec | R.P.N. | Recommended Action(s) | Responsibility & Target Completion Date | Action Results: Actions Taken | Sev | Occ | Det | R.P.N. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | CONTINUITY FAILURE<br>LOSS OF CALIBRATION<br>DRIFT OVER LIFE | | | | | CONTINUITY PROBE<br>CYCLING AUDITS<br>TRAPPED DISC PROBE | | | | | | | | | |
| | | NO SPACER | REDUCED DISC LIFE<br>LOSS OF CALIBRATION | 7 | | MACHINE ERROR<br>TOOL DULL,<br>BROKEN, OR<br>OTHERWISE MALF. | 1 | 100% FUNCTION TEST<br>CONTINUITY PROBE | 1 | 7 | | | | | | | |
| | | | DRIFT OVER LIFE | | | | | CYCLING AUDITS<br>PREVENTIVE MAINT. | | | | | | | | | |
| | | IMPROPERLY CUT SPACER; TOO LARGE | REDUCED DISC LIFE | 7 | | MACHINE ERROR | 1 | 100% FUNCTION TEST | 1 | 7 | | | | | | | |
| | | | LOSS OF CALIBRATION | | | TOOL DULL,<br>BROKEN, OR<br>OTHERWISE MALF. | | CONTINUITY PROBE | | | | | | | | | |
| | | | DRIFT OVER LIFE<br>CONTINUITY FAILURE | | | | | CYCLING AUDITS<br>PREVENTIVE MAINT. | | | | | | | | | |
| | | IMPROPERLY CUT SPACER; TOO SMALL | REDUCED DISC LIFE | 7 | | MACHINE ERROR | 1 | | 1 | 7 | | | | | | | |
| | | | LOSS OF CALIBRATION | | | TOOL DULL,<br>BROKEN, OR<br>OTHERWISE MALF. | | | | | | | | | | | |
| | | | DRIFT OVER LIFE | | | | | | | | | | | | | | |
| | | 2 OR MORE SPACERS LOADED | CONTINUITY FAILURE | 7 | | STATIC BUILD-UP | 1 | ANTI-STATIC STATION | 1 | 7 | | | | | | | |
| | | | LOSS OF CALIBRATION<br>DRIFT OVER LIFE | | | | | | | | | | | | | | |
| 13 | CONFIRM SPACER PRESENCE | FAILS TO IDENTIFY MISSING OR OUT OF PLACE SPACER | REDUCED DISC LIFE | 7 | | MACHINE ERROR | [illegible] | SET-UP MASTERS | 1 | [illegible] | | | | | | | |
| 14 | FEED AND ASSEMBLE DISC | MISPLACED DISC (TRAPPED) | CONTINUITY FAILURE | [illegible] | | MACHINE ERROR | [illegible] | CONTINUITY PROBE | 1 | [illegible] | | | | | | | |
| | | | | | | | | TRAPPED DISC PROBE<br>100% FUNCTION TEST | | | | | | | | | |
| | | UPSIDE DOWN DISC | CONTINUITY FAILURE | [illegible] | | MACHINE ERROR | [illegible] | 100% DISC PROBE | 1 | [illegible] | | | | | | | |
| | | | | | | | | TRAPPED DISC PROBE<br>100% FUNCTION TEST | | | | | | | | | |
| | | MULTIPLE DISC | CONTINUITY FAILURE<br>ACTUATION FAILURE | [illegible] | | MACHINE ERROR | [illegible] | 100% DISC PROBE<br>TRAPPED DISC PROBE | 1 | [illegible] | | | | | | | |
| | | WRONG DISC | LOSS OF CALIBRATION | [illegible] | | MIXED | 1 | 100% FUNCTION TEST<br>DISC SLIPS<br>ROUTE SLIPS | 1 | [illegible] | | | | | | | |
| | | | AUDIBLE SNAP ON CLOSE | | | | | | | | | | | | | | |

PROCESS: AUTOMATED SENSOR ASSEMBLY

PROCESS RESPONSIBILITY: MATT SELLERS/ANN REA

MODEL YEAR(S)/VEHICLE(S): [illegible]

DSGN/QUAL/MFG RESPONSIBILITY: KEITH RONELLO / JIM WATT / PEGGY ALLEN

FMEA DATE (ORIG.): [illegible]
FMEA REVISION: B

| Item | Process Function/ Requirements | Potential Failure Mode | Potential Effect(s) of Failure | Sev | Class | Potential Cause(s)/ Mechanism(s) of Failure | Occur | Current Process Controls | Detec | R.P.N. | Recommended Action(s) | Responsibility & Target Completion Date | Action Results: Actions Taken | Sev | Occ | Det | R.P.N. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | APPLICATIONS | | | | | | | | | | | | | | |
| | | MISSING DISC | CONTINUITY FAILURE | [illegible] | | MACHINE ERROR | 1 | 100% DISC PROBE<br>100% FUNCTION TEST | 1 | [illegible] | | | | | | | |
| 15 | CONFIRM DISC PRESENCE | FAILS TO IDENTIFY MISSING OR OUT OF PLACE DISC | INOPERATIVE DEVICE | 7 | | MACHINE ERROR | 1 | YIELD MONITORING | 1 | 7 | | | | | | | |
| 16 | FEED AND ASSEMBLE CUP | MISSING CUP | NO DEVICE OPERATION | [illegible] | | MACHINE INDEX ERROR | 1 | 100% PRESENCE CHECK<br>100% FUNCTION CHECK | 1 | [illegible] | | | | | | | |
| | | DISLODGEMENT OF INTERNAL COMPONENTS | INOPERATIVE DEVICE<br>LEAK | [illegible] | | MISALIGNED AIR PICK AND PLACE | 1 | TRAPPED DISC PROBE<br>100% FUNCTION TEST<br>CYCLING AUDITS | 1 | [illegible] | | | | | | | |
| | | MULTIPLE CUPS LOADED | NO SUBSEQUENT ASSEMBLY POSSIBLE | [illegible] | | MACHINE ERROR<br>INCORRECT OPERATOR INTERVENTION | 1 | 100% PRESENCE CHECK | 1 | [illegible] | | | | | | | |
| | | LOW RATIO CUP LOADED IN PLACE OF HIGH RATIO CUP | SHIFT IN DEVICE SET POINTS | [illegible] | | MIXED [illegible] | 1 | 100% FUNCTION CHECK | 1 | [illegible] | | | | | | | |
| | | | INCREASING SPRING PRE-LOAD<br>CREEP<br>CONTINUITY FAILURE | | | OPERATOR ERROR | | KAN BAN<br>LOT CONTROL | | | | | | | | | |
| | | HIGH RATIO CUP LOADED IN PLACE OF LOW RATIO CUP | SHIFT IN DEVICE SET POINTS | [illegible] | | MIXED [illegible] | 1 | 100% FUNCTION CHECK | 1 | [illegible] | | | | | | | |
| | | | INSUFFICIENT SPRING PRE-LOAD<br>CREEP<br>CONTINUITY FAILURE | | | OPERATOR ERROR | | KAN BAN<br>LOT CONTROL | | | | | | | | | |
| | CONFIRM CUP PRESENCE | FAILS TO IDENTIFY MISSING OR OUT OF PLACE CUP | INOPERATIVE DEVICE | 7 | | MACHINE ERROR | 1 | YIELD MONITORING | 1 | 7 | | | | | | | |

TI-NHTSA 012257

PROCESS: AUTOMATED SENSOR ASSEMBLY

PROCESS RESPONSIBILITY: MATT SELLERMANN FEA

MODEL YEAR(S)/VEHICLE(S): [illegible]

DSGN/QUAL/MFG RESPONSIBILITY: KEITH ROMELLO / JIM WATT / PEGGY ALLEN

FMEA DATE (ORIG.) 4/[illegible]
FMEA REVISION: B

| Item | Process Function/ Requirements | Potential Failure Mode | Potential Effect(s) of Failure | Sev | Class | Potential Cause(s)/ Mechanism(s) of Failure | Occur | Current Process Controls | Detec | R.P.N. | Recommended Action(s) | Responsibility & Target Completion Date | Action Results: Actions Taken | Sev | Occ | Det | R.P.N. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [illegible] | PRE-CRIMP SENSOR ASSEMBLY | UNDER CRIMP | DISPLACEMENT OF INTERNAL COMPONENTS DURING TRANSFER TO [illegible] CRIMPER | [illegible] | | BROKEN OR WORN TOOLS | [illegible] | OPERATOR SET-UP | [illegible] | [illegible] | | | | | | | |
| | | | | | | PRESSURE TOO LOW | | 100% FUNCTION TEST<br>PREVENTIVE MAINT. | | | | | | | | | |
| | | OVER CRIMP | DIFFICULT FINAL CRIMP DUE TO SIDE WALL STIFFENING | [illegible] | | EXCESS PRESSURE | [illegible] | PREVENTIVE MAINT. | 1 | 15 | | | | | | | |
| | | | | | | SET-UP ERROR | | SET-UP INSPECTION | | | | | | | | | |
| 19 | PROBE FOR TRAPPED DISC. | FAILS TO IDENTIFY MISSING OR TRAPPED DISC. | INOPERATIVE DEVICE. CONTINUITY FAILURE. | 7 | | MACHINE ERROR | 1 | YIELD MONITORING | 1 | 7 | | | | | | | |
| 20 | TRANSFER PRE-CRIMPED SENSOR ASSEMBLY TO SENSOR CRIMPER | UNLOCKED INTERNAL COMPONENTS | LEAK | [illegible] | | INSUFFICIENT PRE-CRIMP | 1 | PREVENTIVE MAINT. | 1 | [illegible] | | | | | | | |
| | | | CONTINUITY FAILURE | | | | | 100% FUNCTION TEST<br>SET-UP INSPECTION | | | | | | | | | |
| | | FAILS TO TRANSFER | EMPTY PUCK. NO EFFECT ON SUBSEQUENT OPERATIONS | [illegible] | | MACHINE ERROR | 1 | PREVENTIVE MAINT. | 1 | [illegible] | | | | | | | |
| | | TRANSFERS MULTIPLE SENSOR ASSEMBLIES | SENSOR DAMAGE | [illegible] | | INCORRECT OPERATOR INTERVENTION | 1 | OPERATOR AWARENESS<br>TRAINING | 1 | [illegible] | | | | | | | |
| 21 | UNLOAD [illegible] SENSOR ASSEMBLIES | FAILS TO UNLOAD | HEXPORT LOADED ONTO OCCUPIED NEST. | [illegible] | | UNLOAD FAILURE | 1 | EMPTY NEST PROBE | 1 | [illegible] | | | | | | | |
| 22 | CHECK EMPTY NEST. | FAILS TO IDENTIFY OCCUPIED NEST. | HEXPORT LOADED ONTO OCCUPIED NEST. | [illegible] | | UNLOAD FAILURE | 1 | YIELD MONITORING | [illegible] | [illegible] | | | | | | | |
| 23 | INSERT ASSEMBLY- PLACE EXTERNAL O-RING ON HEXPORT | FAILS TO PLACE O-RING ON [illegible] | IF UNDETECTED IN SUBSEQUENT OPERATION COULD CAUSE LEAK IN APPLICATION | [illegible] | | PICK & PLACE MIS-HANDLED O-RING | [illegible] | 100% O-RING CHECK ON CRIMP TABLE | [illegible] | [illegible] | ADD O-RING CHECK TO FINAL FUNCTION TEST AS A REDUNDANT CHK. | MFG. ENGINEERING | COMPLETE [illegible] | [illegible] | [illegible] | 1 | [illegible] |
| | | | | | | NO O-RING PRESENT AT TRACK DUE TO EMPTY BOWL FEED, CONTAMINATION IN TRACK, MISALIGNED TRACK | [illegible] | O-RING STATION P.M. PICTURE SLIP AND VISUAL AIDS FOR O-RING REQUIREMENTS | | | | | | | | | |

TI-NHTSA 012258

PROCESS: AUTOMATED SENSOR ASSEMBLY

PROCESS RESPONSIBILITY: MATT SELLERS/[illegible] FEA

MODEL YEAR(S)/VEHICLE(S): [illegible]

DESIGN/QUAL/MFG RESPONSIBILITY: KEITH [illegible]ELLO / JIM WATT / PEGGY ALLEN

FMEA DATE (ORIG.) [illegible]
FMEA REVISION: [illegible]

| Item | Process Function/ Requirements | Potential Failure Mode | Potential Effect(s) of Failure | Sev | Class | Potential Cause(s)/ Mechanism(s) of Failure | Occur | Current Process Controls | Detec | R.P.N. | Recommended Action(s) | Responsibility & Target Completion Date | Action Results: Actions Taken | Sev | Occ | Det | R.P.N. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | O-RING STATION NOT ACTIVATED | | 100% VISUAL INSPECTION AT PRESSURE TEST AND PACKING | | | | | | | | | |
| | | | | | | PICK & PLACE WORN, MISALIGNED OR NOT DESIGNED PROPERLY | | | | | | | | | | | |
| | | | | | | PUCK NOT LOCATED PROPERLY DUE TO MISALIGNED STOP OR CONTAMINATION BELT | | | | | | | | | | | |
| | | | | | | STRIPPER PIN FAILS TO REMOVE O-RING | | | | | | | | | | | |
| | | PLACES TWO O-RINGS ON ONE PART | HIGH ASSEMBLY TORQUE | [illegible] | | PUCK STOP FAILS TO RELEASE PUCK AT END OF CYCLE | [illegible] | 100% MULTIPLE O-RING CHECK ON CRIMP TABLE | [illegible] | [illegible] | ADD O-RING CHECK TO FINAL FUNCTION TEST | MFG. ENG. | COMPLETE [illegible] | 4 | [illegible] | 1 | [illegible] |
| | | | POTENTIAL INABILITY TO FULLY ASSEMBLE IN APPLICATION | [illegible] | | | [illegible] | 100% VISUAL INSPECTION AT PRESSURE TEST AND PACKING<br>P.M. FOR O-RING STATION | [illegible] | [illegible] | TEST | | | [illegible] | [illegible] | 1 | [illegible] |
| | | O-RING DAMAGED BY FEED SYSTEM OR PICK & PLACE | POSSIBLE LEAK IN APPLICATION | [illegible] | | PICK & PLACE AND FEED SYSTEM WORN OR NOT DESIGNED PROPERLY | 1 | P.M. FOR PICK & PLACE AND FEED SYSTEM<br>DESIGN VERIFICATION THROUGH DEBUG AND PROCESS HISTORY<br>Q.C. AUDIT FROM EACH LOT SUBJECTED TO FLUID LEAK CHECK | [illegible] | [illegible] | | | | | | | |
| | | THREADS DAMAGED BY PICK & PLACE | MAY RESULT IN HIGH INSTALLATION TORQUE | 4 | | PICK & PLACE AND FEED SYSTEM WORN, MISALIGNED OR NOT DESIGNED PROPERLY | [illegible] | P.M. FOR PICK & PLACE AND FEED SYSTEM | 2 | [illegible] | | | | | | | |
| | | | FINISHED DEVICE WILL NOT ASSEMBLE AT CUSTOMER | [illegible] | | PUCK NOT LOCATED PROPERLY | 1 | DESIGN VERIFICATION THROUGH DEBUG AND PROCESS HISTORY<br>Q.C. AUDIT FROM EACH LOT SUBJECTED TO THREAD QUALITY CHECK | 2 | [illegible] | | | | | | | |

TI-NHTSA 012288

PROCESS: AUTOMATED SENSOR ASSEMBLY

PROCESS RESPONSIBILITY: MATT SELLERMANN REA

MODEL YEAR(S)/VEHICLE(S): [illegible]

DESIGN/QUAL/MFG RESPONSIBILITY: KETH ROSIELLO / JIM WATT / PEGGY ALLEN

FMEA DATE (ORIG.) [illegible]
FMEA REVISION: B

| Item | Process Function/ Requirements | Potential Failure Mode | Potential Effect(s) of Failure | Sev | Class | Potential Cause(s)/ Mechanism(s) of Failure | Occur | Current Process Controls | Detec | R.P.N. | Recommended Action(s) | Responsibility & Target Completion Date | Action Results: Actions Taken | Sev | Occ | Det | R.P.N. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | O-RING NOT LOCATED PROPERLY ON THE ASSY. | MAY RESULT IN HIGH INSTALLATION TORQUE | [illegible] | | PICK & PLACE AND FEED SYSTEM WORN, MISALIGNED, OR NOT DESIGNED PROPERLY | [illegible] | P.M. FOR PICK & PLACE AND FEED SYSTEM | [illegible] | [illegible] | | | | | | | |
| | | | POTENTIAL O-RING DAMAGE DURING ASSEMBLY RESULTING IN LEAK | [illegible] | | PUCK NOT LOCATED PROPERLY | 1 | DESIGN VERIFICATION THROUGH DESIGN AND PROCESS HISTORY<br>Q.C. AUDIT FROM EACH LOT SUBJECTED TO THREAD QUALITY CHECK. 100% VISUAL CHECK AT PRESSURE TEST AND PACK | [illegible] | 16 | | | | | | | |
| 24 | TRANSFER SENSOR ASSEMBLY TO ROTARY CRIMP NEST. | FAILS TO TRANSFER | PRE-CRIMPED SENSOR ASSEMBLY LOADED ONTO OCCUPIED NEST. | [illegible] | | UNLOAD FAILURE | 1 | FIELD MONITORING | 1 | [illegible] | | | | | | | |
| 25 | 45 DEGREE CRIMP SENSOR ASSEMBLY | UNDER CRIMP | LOSS OF SPC CONTROL OF DIAMETER OR HEIGHT POTENTIAL DIAPHRAGM LIFE PROBLEM | [illegible] | | PRESSURE TOO LOW TOOL WEAR/BREAKAGE | 1 | SPC DIA. AND HEIGHT<br>PROCESS SPEC SET-UP<br>PREVENTIVE MAINT. 100% FUNCTION TEST CYCLING AUDITS | 1 | [illegible] | | | | | | | |
| | | OVER CRIMP | CRIMP DIAMETER TOO LARGE CAUSING DIFFICULT FINAL ASSY. COMPONENT DAMAGE POTENTIAL DIAPHRAGM LIFE PROBLEM | [illegible] | | PRESSURE TOO HIGH | [illegible] | SPC DIA. AND HEIGHT<br>PROCESS SPEC SET-UP PREVENTIVE MAINT.<br>100% FUNCTION TEST CYCLING AUDITS | 1 | [illegible] | | | | | | | |
| | | IMPROPER CRIMP | COMPONENT DAMAGE<br>CRIMP DIAMETER AND HEIGHT OUT OF SPEC. | [illegible] | | OPERATOR SET-UP<br>45 DEG. TOOL IN 45 DEG. SOURCE [illegible] GEOMETRY | [illegible] | SPC DIA. AND HEIGHT<br>PROCESS SPEC SET-UP<br>PREVENTIVE MAINT.<br>100% FUNCTION TEST CYCLING AUDITS | 1 | [illegible] | | | | | | | |
| | | FAILS TO CRIMP | COMPONENT DAMAGE AT 45 DEGREE CRIMP CRIMP DIAMETER AND HEIGHT OUT OF SPEC. | [illegible] | | MACHINE MALFUNCTION SET-UP ERROR | 1 | PREVENTIVE MAINT.<br>SET-UP SPECS | 1 | [illegible] | | | | | | | |

TI-NHTSA 012280

PROCESS: AUTOMATED SENSOR ASSEMBLY

PROCESS RESPONSIBILITY: MATT SELLERS/[illegible] REA

MODEL YEAR(S)/VEHICLE(S): [illegible]

DESIGN/QUAL/MFG RESPONSIBILITY: KEITH ROSELLO / JIM WATT / PEGGY ALLEN

FMEA DATE (ORIG.) [illegible]
FMEA REVISION: B

| Item | Process Function/ Requirements | Potential Failure Mode | Potential Effect(s) of Failure | Sev | Class | Potential Cause(s)/ Mechanism(s) of Failure | Occur | Current Process Controls | Detec | R.P.N. | Recommended Action(s) | Responsibility & Target Completion Date | Actions Taken | Sev | Occ | Det | R.P.N. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | IMPROPER TOOL [illegible] | SENSOR REGISTRATION ERROR: SENSOR DIAMETER OUT OF ROUND; SENSOR HEIGHT UNEVEN; MAJOR REGISTRATION ERROR – COMPONENT [illegible] | [illegible] | | IMPROPER ERROR MAINTENANCE SET-UP ERROR | 1 | SPC DIA. AND HEIGHT PREVENTIVE MAINT. | [illegible] | [illegible] | | | | | | | |
| 26 | VERIFY O-RING PRESENT ON SENSOR | FAILS TO DETECT MISSING O-RING | PART WILL BE UNLOADED INTO GOOD BIN AND COULD CAUSE LEAK IN APPLICATION IF UNDETECTED IN SUBSEQUENT [illegible] | [illegible] | | PROBE MISALIGNED, WORN OR IMPROPERLY DESIGNED | 2 | MASTER DEVICES [illegible] O-RING CHK ON FINAL FUNCTION CK | [illegible] | [illegible] | | | | | | | |
| | | | | | | PROBE CONTAMINATION PROBE STATION NOT ACTIVATED | | ALIGNMENT TOOL<br>VISUAL INSPECTION<br>PROBE P.M.'S | | | | | | | | | |
| | | FAILS TO DETECT O-RING PRESENT | PART WILL BE UNLOADED INTO BAD BIN RESULTING IN YIELD LOSS | 2 | | PROBE MISALIGNED, WORN OR IMPROPERLY DESIGNED | 2 | MASTER DEVICES ALIGNMENT TOOL | 1 | 4 | | | | | | | |
| | | | | | | PROBE CONTAMINATION<br>PART ALIGNMENT IN NEST | | PROBE DESIGN PROVEN THROUGH [illegible] & PROCESS HISTORY PROBE P.M.'S | | | | | | | | | |
| | | FAILS TO DETECT TWO O-RINGS PRESENT | PART WILL BE UNLOADED INTO GOOD BIN POSSIBLY RESULTING IN HIGH INSTALLATION TORQUE AT [illegible] | 4 | | PROBE MISALIGNED, WORN OR IMPROPERLY DESIGNED | 2 | MASTER DEVICES ALIGNMENT TOOL | [illegible] | [illegible] | | | | | | | |
| | | | | | | PROBE CONTAMINATION PROBE STATION NOT ACTIVATED | | PROBE P.M.'S<br>[illegible]<br>VISUAL INSPECTION | | | | | | | | | |
| | | O-RING DAMAGED BY PROBE TIP | LEAK IN APPLICATION | [illegible] | | PROBE MISALIGNED WORN OR IMPROPERLY DESIGNED | 1 | PROBE DESIGNED TO MINIMIZE THREAD CONTACT<br>PROBE P.M.'S<br>PROBE DESIGN PROVEN THROUGH RE-DESIGN AND PROCESS HISTORY | 2 | [illegible] | | | | | | | |
| 27 | [illegible] DEGREE CRIMP SENSOR ASSEMBLY | UNDER CRIMP | BURST RESISTANCE DEGRADED | [illegible] | | PRESSURE TOO LOW | 1 | SPC, DIA. AND HEIGHT | [illegible] | [illegible] | | | | | | | |

PROCESS: AUTOMATED SENSOR ASSEMBLY

PROCESS RESPONSIBILITY: MATT SELLERMAN [illegible]

MODEL YEAR(S)/VEHICLE(S): [illegible]

DESIGN/QUAL/MFG RESPONSIBILITY: KEITH ROBELLO / JIM WATT / PEGGY ALLEN

FMEA DATE (ORIG.) [illegible]
FMEA REVISION: B

| Item | Process Function/ Requirements | Potential Failure Mode | Potential Effect(s) of Failure | Sev | Class | Potential Cause(s)/ Mechanism(s) of Failure | Occur | Current Process Controls | Detec | R.P.N. | Recommended Action(s) | Responsibility & Target Completion Date | Actions Taken | Sev | Occ | Det | R.P.N. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | LEAK<br>CRIMP HEIGHT OUT OF SPEC., DIFFICULT FINAL ASSEMBLY CRIMPING | | | TOOL WEAR/BREAKAGE 45 DEG. TOOL IN 90 DEG. STATION | | PROCESS SPEC SET-UP<br>P.M./Q.C. AUDITS<br>100% FUNCTION TEST<br>CYCLING AUDITS | | | | | | | | | |
| | | OVER CRIMP | CRIMP DIAMETER TOO LARGE CAUSING DIFFICULT FINAL ASSY | [illegible] | | PRESSURE TOO HIGH | 1 | SPC. DIA. AND HEIGHT<br>PROCESS SPEC SET-UP PREVENTIVE MAINT. 100% FUNCTION TEST CYCLING AUDITS | 1 | [illegible] | | | | | | | |
| [illegible] | OVER-PRESSURE SENSOR ASSEMBLY | INSUFFICIENT CLIP | DRIFT OVER LIFE OR CALIBRATION CHANGE LEADING TO WELD LOSS | [illegible] | | IMPROPER LOCATION OF CP HEAD INCORRECT CP SETTINGS INADEQUATE SEAL [illegible] | 1 | 100% FUNCTION TEST. MIN. PRESSURE LEVEL GAGE. | 1 | [illegible] | | | | | | | |
| [illegible] | UNLOAD GOOD SENSOR ASSEMBLIES | FAILS TO UNLOAD GOOD SENSOR | TABLE WON'T INDEX PAST NEXT CYCLE (EMPTY NEST FAILURE) | [illegible] | | LOOSE/ MISADJUSTED OR IMPROPERLY DESIGNED PICK-UP JAWS | [illegible] | EMPTY NEST PROBE, NEST/CRIMPER PART | 1 | 4 | | | | | | | |
| | | | YIELD/UPTIME LOSS | [illegible] | | | [illegible] | JAW DESIGN PROVEN THROUGH DE-BUG & PROCESS HISTORY | 1 | [illegible] | | | | | | | |
| | | THREAD DAMAGE | POSSIBLY RESULTING IN HIGH INSTALLATION TORQUE | [illegible] | | JAWS WORN, MISALIGNED OR IMPROPERLY DESIGNED | [illegible] | JAW P.M.'S<br>JAWS DESIGNED TO MINIMIZE THREAD CONTACT DESIGN PROVEN THROUGH DEBUG & PROCESS HISTORY | [illegible] | [illegible] | | | | | | | |
| [illegible] | PICK & UNLOAD ASSEMBLY W/O O-RING | FAILS TO UNLOAD BAD SENSOR | TABLE WON'T INDEX PAST NEXT CYCLE (EMPTY NEST FAILURE) | [illegible] | | LOOSE/ MISADJUSTED OR IMPROPERLY DESIGNED PICK UP JAWS | [illegible] | EMPTY NEST PROBE NEST/CRIMPER PART. JAW DESIGN PROVEN THROUGH DEBUG & PROCESS HISTORY | 1 | 4 | | | | | | | |
| | | | UPTIME LOSS | [illegible] | | | [illegible] | | [illegible] | [illegible] | | | | | | | |
| | | THREAD DAMAGE | POSSIBLY RESULTING IN HIGH INSTALLATION TORQUE AT CUSTOMER | [illegible] | | JAWS WORN, MISALIGNED OR IMPROPERLY DESIGNED | [illegible] | JAW P.M.'S<br>JAWS DESIGNED TO MINIMIZE THREAD CONTACT DESIGN PROVEN THROUGH DEBUG & PROCESS HISTORY | [illegible] | [illegible] | | | | | | | |

TI-NHTSA 012282

PROCESS: AUTOMATED SENSOR ASSEMBLY

PROCESS RESPONSIBILITY: MATT SELLERS/[illegible] REA

MODEL YEAR(S)/VEHICLE(S): [illegible]

DSGN/QUAL/MFG RESPONSIBILITY: KEITH ROMELLO / JIM WATT / PEGGY ALLEN

FMEA DATE (ORIG.) [illegible]
FMEA REVISION: B

| Item | Process Function/ Requirements | Potential Failure Mode | Potential Effect(s) of Failure | Sev | Class | Potential Cause(s)/ Mechanism(s) of Failure | Occur | Current Process Controls | Detec | R. P. N. | Recommended Action(s) | Responsibility & Target Completion Date | Action Results: Actions Taken | Sev | Occ | Det | R. P. N. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [illegible] | CHECK EMPTY NEST. | FAIL TO IDENTIFY OCCUPIED NEST. | SENSOR ASSEMBLY LOADED ONTO OCCUPIED NEST. | [illegible] | | UNLOAD FAILURE | 1 | YIELD MONITORING | [illegible] | [illegible] | | | | | | | |

TI-NHTSA 012263