EA02-025

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

REQUEST NO. 7

BOX 8

PART A-U

PART K

Epstein, Sally

From: DAGU%mimi@magic.itg.ti.com
Sent: Wednesday, February 10, 1999 12:32 PM
To: Rahman, Aziz
Subject: 77PS Design explanation

-MSG M#= 947380 FR=DAGU TO=ZIZ SENT=02/10/99 12:24 PM TYPE=N
RN=064 ST=C DIV=0050 CC=00357 BY=DAGU AT=02/10/99 12:24 PM

To: Baumann <Baumann>
Russ RUSB RUSB

Copy: Beringhause <Beringhause>
Steven <sberinghause@email.mc.ti.com>
Rahman <Rahman>
Aziz ZIZ ZIZ
McGuirk <McGuirk>
Andy <a-mcguirk@email.mc.ti.com>

From: "Dague, Bryan" <bdague@email.mc.ti.com>

Subj: 77PS Design explanation

Folks,

Here is a summary of how and why the 77PS is designed as it is. Please give me any comments you might have.

Aziz,
Read this and use the information as you see fit, but do not distribute it until we all agree on the wording.

Regards,
Bryan
****
Attorney Client Privileged Information

Brake Fluid Intrusion
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 and transmit force and movement to the sensing portion of the switch over the life of the application.

Background:
The pressure cavity is composed of the hexport, gasket, and 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 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 is varied.

There are two different ways that brake fluid may enter the contact cavity of TI's brake switches from the pressure cavity. Brake fluid could potentially leak past an impaired gasket seal, or leak through a damaged Kapton diaphragm.

The Gasket:
In order to create a fluid tight elastomeric seal, there must be proper

TI-NHTSA 0122

compression of the elastomer, sufficient backing of the seal material 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. Etylene Propylene for brake applications is common practice throughout the industry, and TI has been using this material in brake applications since 1988.

The gasket compression target was obtained from publish 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 crimp together.

Lastly, the movement/position of the gasket when pressure is applied must be controlled. 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 specifics details of these tests and the results can be seen in a number the following PV test reports:

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/92/60	77PSL5-2	1992
5.	PS/92/82	77PSL3-1	1992
6.	PS/93/11	77PSL6-1	1993
7.	PS/93/44	77PSL4-1	1993

In order to protect TI's customers from gasket-manufacturing issues there are several preventative actions in place. These actions include: hair nets, protective smocks, and cleaning procedures for the equipment As a result, TI's customer return rates, line fallout rates, and end of line acceptance tests indicate gasket-manufacturing anomalies are below measurable limits (less then 1 ppm). 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.

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

Basically, a single piece of Kapton consists of a 0.003-inch thick polyimide film laminated on both sides with a 0.001-inch thick FEP Teflon film. The polymide 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

TI-NHTSA 012215

using this material in pressure switch applications since 1981.

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 (see 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 is around 1 million cycles. 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. See attached IP reports.

While the similar manufacturing anomalies listed above can affect the Kapton diaphragms (see PFMEA Document # 503831), additional factors can cause leakage via the Kapton diaphragm. Material/chemical compatibility and stress/strain concentrations can also cause the Kapton diaphragms to leak. 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. When Kapton rupture 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. The first region to show break down is the circumferential area surrounding the converter button. See Endurance Test (report # PS/98/53). 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 will accelerate the aging of the base polymide. Chemical attach can come from two directions:

1) By entering the contact cavity via the 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 polymide base, embrittlement, and cracking of the base polymer. See Endurance Test (report PS/98/53).

End of Document.

Epstein, Sally

From: Watt, Jim [jwatt@email.mc.ti.com]
Sent: Thursday, February 11, 1999 8:56 AM
To: Baumann, Russ RUSB; Dague, Bryan; McGuirk, Andy; Beringhause, Steven
Subject: RE: 77PS Diaphragm Wear Out Cause & Effect Diagram

Importance: High
Sensitivity: Confidential

Ford 77P51.ppt

The below 77PS Diaphragm Wear Out Cause & Effect Diagram is fyi, comments. ....!

<<Ford 77P51.ppt>>

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

From: McGuirk, Andy
Sent: Wednesday, February 10, 1999 3:05 PM
To: Baumann, Russ RUSB; Dague, Bryan
Cc: Beringhause, Steven; 'Rahman, Aziz AIZ'; Watt, Jim
Subject: RE: 77PS Design explanation

Attorney Client Privileged Information

overall, an outstanding document draft. i made a number of changes and am on callback to discuss my thoughts.

i think it might be of value to discuss weibull success factor projections from the 'zillions' of 'es' test results we must have? we should also speak to the thunderbird applications ? maybe refer to the econoline issue of '93 with connector issues ?

we need some summary statement as to the ending of this document......

a
AUTOMOTIVE SENSORS AND CONTROLS QRA MANGER
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ATTLEBORO, MA 02703
TEL : (508) 236-3080
FAX : (508) 236-3745
PAGE: (800) 467-3700 PIN 604-2044

From: Dague, Bryan
Sent: Wednesday, February 10, 1999 1:24 PM
To: Baumann, Russ RUSB
Cc: Beringhause, Steven; Rahman, Aziz AIZ; McGuirk, Andy
Subject: 77PS Design explanation

Folks,

Here is a summary of how and why the 77PS is designed as it is. Please give me any comments you might have.

Aziz,
Read this and use the information as you see fit, but do not distribute it until we all agree on the wording.

Regards,
Bryan

****

Attorney Client Privileged Information

Brake Fluid Intrusion
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 and transmit force and movement to the sensing portion of the switch over the life of the 500,000 cycle specification which in turn traslates into an electrical switching reaction used in the automobile system as a redundant safety related cruise control shutoff switch..

Background:

The pressure cavity is composed of the hexport, gasket, and 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 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 is varied.

There are two different ways that brake fluid may enter the contact cavity of TI's brake switches from the pressure cavity. Brake fluid could potentially leak past an impaired gasket seal, or 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 seal material to prevent movement when pressure is applied, and finally the elastomer must be compatible with the working fluid and expected thermal ranges of the environment and application.

Fluid compatibility is typically established by the use of published tables. These tables list fluid groups and general material types. Lab testing is done with the specific fluid that the customer has specified for the application along with the specific compound formulated by the selected gasket supplier. Etylene Propylene for brake applications is common practice throughout the industry for seal gasket materials , and TI has been using this material in brake applications since 1989.

The gasket compression target was obtained from publish 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 crimp 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 specifics details of these tests and the results can be seen in a number the following PV test reports:

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

also, there are IP-2 tests of 6/95, 10/95, 1/96 and 8 /96 that are readily at hand and show fluid capability resistances

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

As a result of the process and product controls, TI's customer return rates including line fallout rates and end of line acceptance tests indicate gasket-manufacturing anomalies are below measurable limits (one leak return in 5 years from master cylinder leak testing or less then 1 ppm). 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 but in our expert opinion not in late life without early leak signs.

Kapton Diaphragms:

A pressure switch diaphragm must seal the pressure cavity, transmit pressures 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 of 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 polymide 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 a wide variety of pressure switch applications since 1961.

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 capability to meet the specified requirements (see 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 is around 1 million cycles which is well above the 500,000 cycles specified in the Ford (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.

While the similar manufacturing anomalies listed above can affect the Kapton diaphragms (see PFMEA Document # 503831), additional factors can cause leakage via the Kapton diaphragm. Material/chemical compatibility and stress/strain concentrations can also cause the Kapton diaphragms to leak. 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 rupture does occur, there are visual signs of de-lamination, cracking, and embritlement. The Kapton diaphragms break down first in the areas of highest stress and or strain. In our expert opinion, the first region to show break down is the circumferential area surrounding the converter button. See Endurance Test (report # PS/98/53). 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 will accelerate the aging of the base polymide. Chemical attach can come from two directions:

1) By entering the contact cavity via the electrical connector,

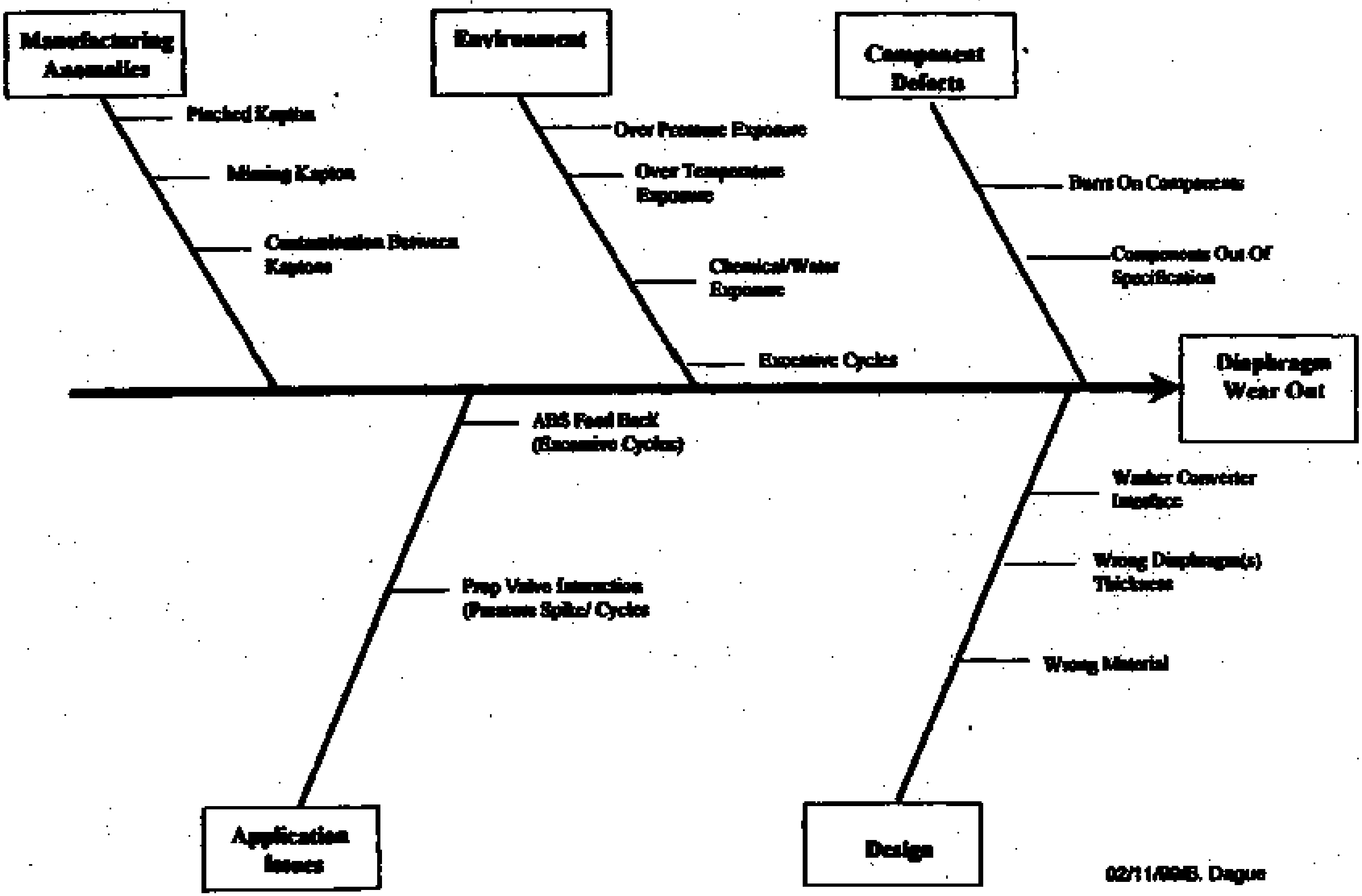
2) By being in solution in the brake fluid and entering the switch via the pressure port.

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 polymide base, embrittlement, and cracking of the base polymer. See Endurance Test (report PS/98/53).

End of Document.

TEXAS INSTRUMENTS

Ford Electronic Speed Control Deactivation Pressure Switch
TI P/N 77PSL Series
Wear Out Fishbone



02/11/99/B. Dague

TI-NHTSA 012269

Epstein, Sally

From: McGuirk, Andy [a-mcguirk@email.mc.ti.com]
Sent: Thursday, February 11, 1999 6:53 AM
To: Baumann, Russ; Dague, Bryan
Cc: Beringhause, Steven; Rowland, Thomas
Subject: RE: 77PS Overview

just some minor points and drop out tens line

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 604-2844

From: Dague, Bryan
Sent: Thursday, February 11, 1999 6:26 AM
To: Baumann, Russell
Cc: Beringhause, Steven; McGuirk, Andrew
Subject: 77PS Overview

CONFIDENTIAL

Guys,

Here is the latest......

Regards,
Bry

****
**

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 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 TM 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 TM 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 con act cavity of TI's brake switches from the pressure cavity are 1. brake fluid could potentially leak past an impaired

TI-NHTSA 012209

gasket seal, or 2. leak through a damaged or 'worn out' Kapton TM diaphragm.

The Gasket:

In order to create a fluid tight elastomeric seal, there must be proper compression of the elastomer, sufficient backing of the seal material 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 for brake applications is common practice throughout the industry, for seal gasket materials, and TI has been using this material in brake applications since 1988.

The gasket compression target was obtained from publish 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 E8-F2VC-9F924-AA . Specifically, burst testing, impulse testing, and thermal cycle tests were performed to confirm that the gasket performed as intended. The specifics details of these tests and the results can be seen in the PV test report numbers listed below: (copies can be provided on request).

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Test Report #	TI Switch Part number	Year Tested
1. PS/91/49	77PSL2-3	1991
2. PS/91/49	77PSL2-1	1991
3. PS/92/49	77PSL3-1	1992
4. PS/92/80	77PSL5-2	1992
5. PS/92/82	77PSL3-1	1992
6. PS/93/11	77PSL4-1	1993
7. PS/93/44	77PSL4-1	1993

Gasket-manufacturing anomalies can be produced from out of spec gaskets, contamination of the gasket, or GASKETsealing 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 TM 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 TOchemical attack BY the brake fluid.

Basically, a single piece of Kapton TM 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

TI-NHTSA 012270

polymide 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 TM 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 TM 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 TM 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 TM 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 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.

Manufacturing & PV anomalies such as pinched Kapton TM can affect the Kapton TM diaphragm seal performance (see PFMEA Document # 503831). Results of the analyses of the pressure switch from Tennessee showed curved marks on the diaphragm that may have been caused by a pinched Kapton TM. Material/chemical compatibility and stress/strain concentrations can also cause the Kapton TM diaphragms to leak. 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 TM fatigue occurs well over 0.5 million full-scale pressure cycles in our history of simulated and accelerated life testing. When Kapton TM fatigue does occur, there are visual signs of de-lamination, cracking, and embrittlement. The Kapton TM 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/98/53). 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 polymide. 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 TM 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 TM include de-lamination of the Teflon from the base polymide base, embrittlement, and cracking of the base polymer. See Endurance Test (report PS/98/53).

Authored by Bryan Daque. Call Andy McGuirk (508) 236-3080 or Bryan Daque (508) 236-3234 with questions.

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Brake Fluid Intrusion 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

CONFIDENTIAL

~~Carrey~~, Pat

From:	Beringhause, Steven [sberinghause@email.mc.ti.com]
Sent:	Thursday, February 11, 1999 9:10 AM
To:	Sullivan, Martha
Subject:	FW: 77PS Overview

From: Dague, Bryan
Sent: Thursday, February 11, 1999 8:48 AM
To: Baumann, Russell; Beringhause, Steven; Rahman, Aziz; McGuirk, Andrew
Subject: 77PS Overview

Guys,

Here is the finial draft. Aziz to deliver to the customer??

Please advise if I need to fax it to somone.

I am having copies of the appendix made today.

Regards,
Bry

****

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.

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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 TM diaphragm.

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

TI-NHTSA 012273

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.

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3.	PS/92/49	77PSL3-1	1992
4.	PS/92/80	77PSL5-2	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 then 1 ppm (one leaker return in 5 years from master cylinder leak testing).

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Typically, Kapton TM fatigue occurs well over 0.5 million full-scale pressure cycles in our history of simulated and accelerated life testing. When Kapton TM fatigue does occur, there are visual signs of de-lamination, cracking, and embrittement. The Kapton TM 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/98/53). 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.

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

TI-NHTSA 012275

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
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6. Customer Specification (ES-F2VC-9F924_AA)
7. PFMEA
8. IP Test Reports
9. Endurance Test Report

Epstein, Sally

From: McGuirk, Andy [a-mcguirk@email.mc.ti.com]
Sent: Thursday, February 11, 1999 12:09 PM
To: Rahman, Aziz; Baumann, Russ
Subject: RE: 77PS Overview

Attorney-Client privileged communication

same.... we want to go on record again that we have given further consideration and sti[ll] believe that the use of a normally open relay upstream would be a good way to resolve th[e] concern. we want to see us taken out of the always powered circuit as we think that would be a good basic design practice

a

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

From: Rahman, Aziz
Sent: Thursday, February 11, 1999 12:51 PM
To: McGuirk, Andy
Subject: RE: 77PS Overview

If you are talking about the normally open relay upstream of the switch, I already reviewed that with Fred on Day 1. Is the de-electric circuit you are talking about the same relay approach, or something new?

From: McGuirk, Andy
Sent: Thursday, February 11, 1999 11:09 AM
To: Rahman, Aziz
Subject: RE: 77PS Overview
Importance: High

lets talk ASAP about delivery of a new letter about the switch de-electric circuit proposal we sent earlier
AUTOMOTIVE SENSORS AND CONTROLS QRA MANGER
34 FOREST ST M/S 23-05
ATTLEBORO, MA 02703
TEL : (508) 236-3080
FAX : (508) 236-3745
PAGE: (800) 467-3700 PIN 604-2044

From: Rahman, Aziz
Sent: Thursday, February 11, 1999 11:02 AM
To: Baumann, Russ; Bexinghause, Steven; McGuirk, Andy; Dague, Bryan
Subject: RE: 77PS Overview

Team,

Thanks for the info below. I have reviewed test report 98/14 with them and will review this info at the next opportune time. I will let you know if I need a hard copy.

From: Daque, Bryan
Sent: Thursday, February 11, 1999 8:48 AM
To: Baumann, Russell; Beringhause, Steven; Rahman, Aziz; McGuirk, Andrew
Subject: 7728 Overview

Guys,

Here is the finial draft. Aziz to deliver to the customer??

Please advise if I need to fax it to somone.

I am having copies of the appendix made today.

Regards,
Bry

****

Proprietary Information

7728 Overview
2/10/99

TI's 7728 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 T 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 TM diaphragms is to provide a flexible fluid tight seal between the pressure cavi 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 TM 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 alwa 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 Propyle is used in the 7728 and is standard throughout the industry for seal gasket materials. 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 533794 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	77PSL5-2	1992
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Authored by Bryan Dague. Call Andy Mcguirk or Bryan Dague with questions.

7795 Overview Appendix

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9. Endurance Test Report

TI-NHTSA 012280

Epstein, Sally

From:	DAGU%mimi@magic.itg.ti.com
Sent:	Thursday, February 11, 1999 2:47 PM
To:	Rahman, Aziz
Subject:	FW: TSL # 150709, Fluid identification

-MSG M#= 985122 FR=DAGU TO=ZIZ SENT=02/11/99 02:39 PM TYPE=N
R#=067 ST=C DIV=0050 CC=00357 BY=DAGU AT=02/11/99 02:39 PM

To: Rahman <Rahman>
Aziz ZIZ ZIZ

From: "Dague, Bryan" <bdague@email.mc.ti.com>

Subj: FW: TSL # 150709, Fluid identification

From: Hopkins, AL
Sent: Thursday, February 11, 1999 1:58 PM
To: Dague, Bryan
Cc: Baumann, Russell
Subject: FW: TSL # 150709, Fluid identification

This is the work that Beth had done to show that the fluid from the switch from the Lincoln Town car fire was almost certainly brake fluid.

Regards,

Al

From: Kill, Beth
Sent: Friday, January 08, 1999 3:15 PM
To: Dague, 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.

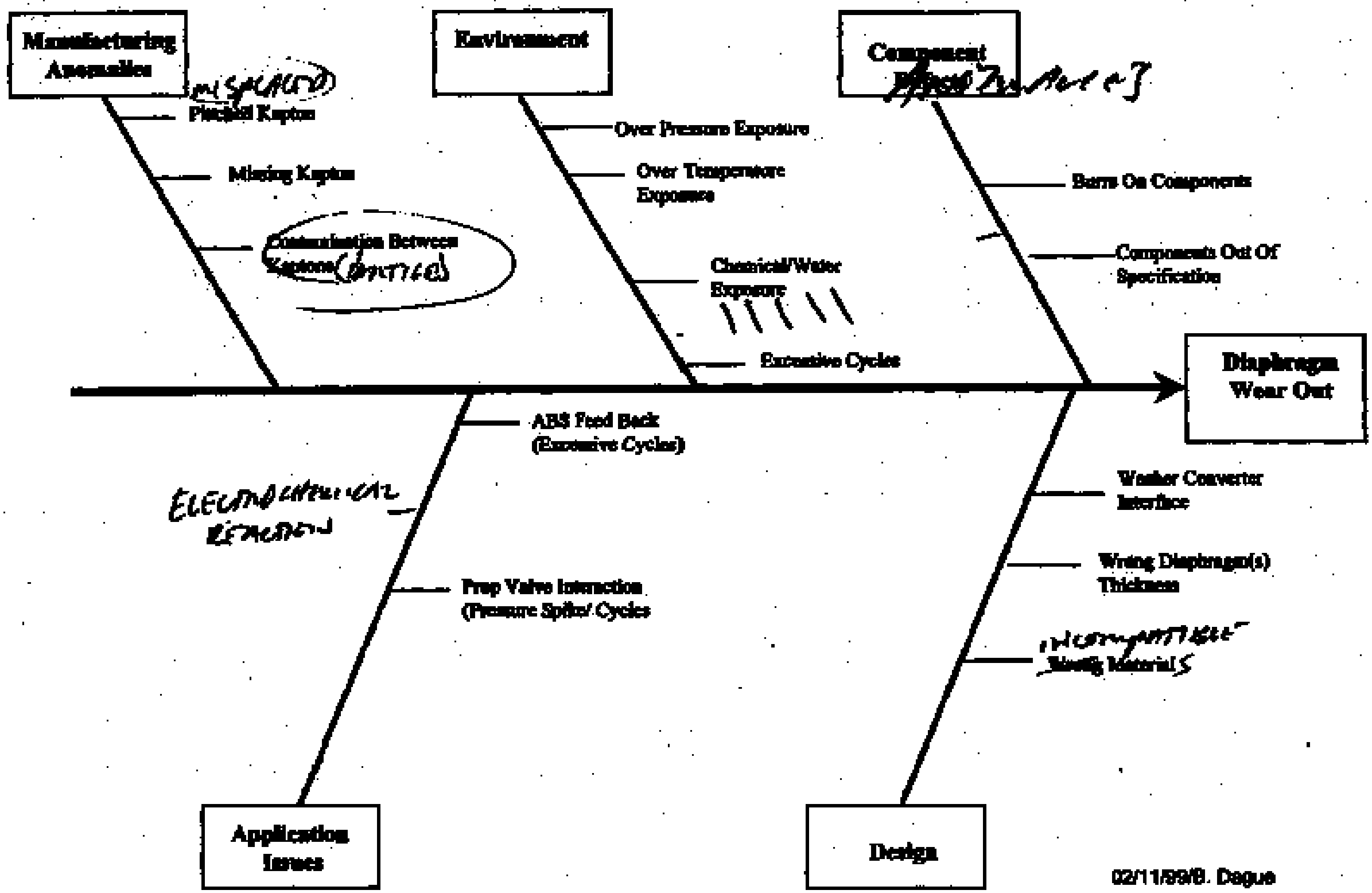
I will forward the spectral data to you by internal mail. Please let me know if I can discard the remaining fluid samples, or if you would like me to forward these to you also.

Regards,

Beth
Ext. 3069 MS 10-16 Fax 1670

TEXAS INSTRUMENTS

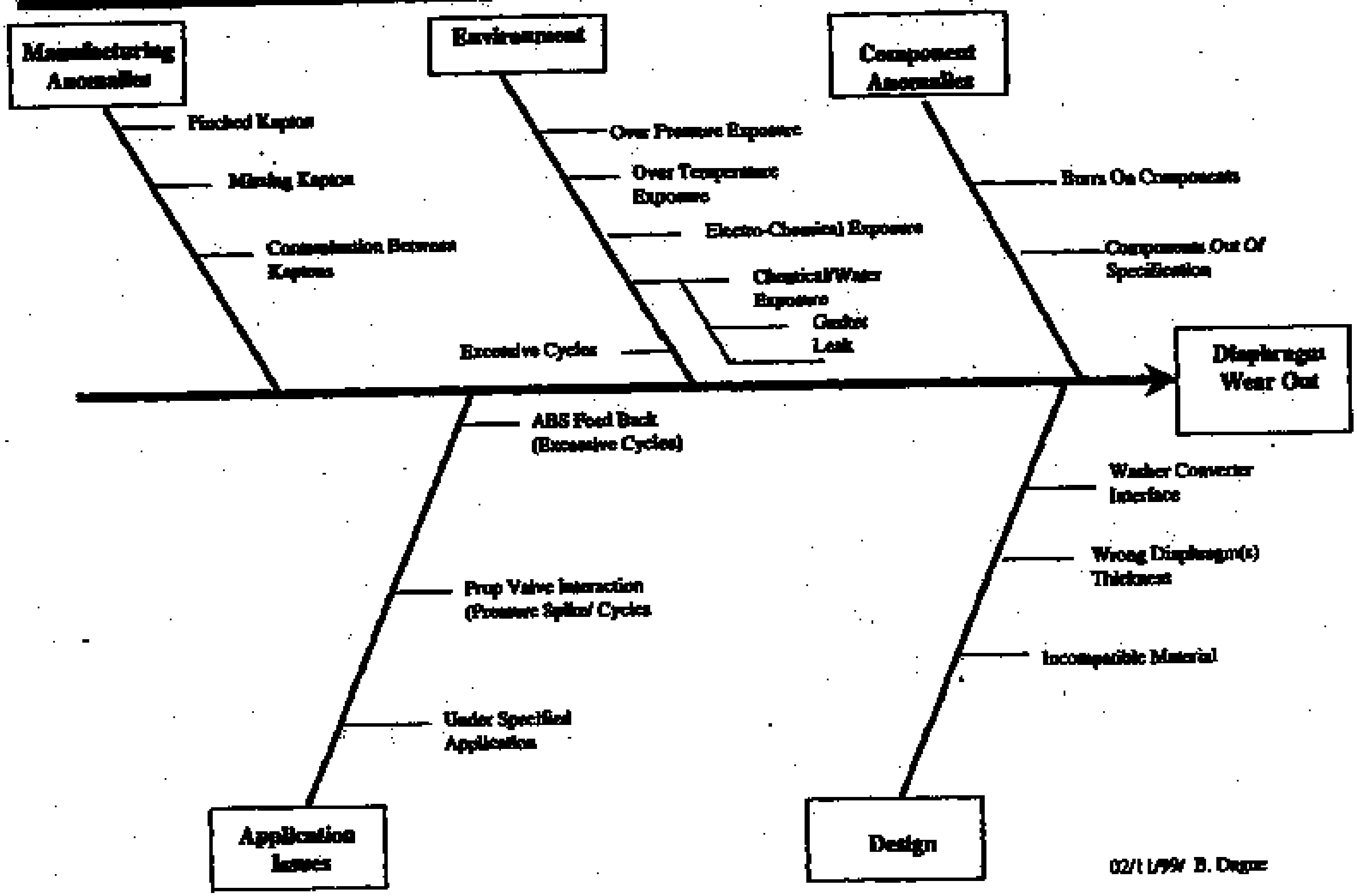
Ford Electronic Speed Control Deactivation Pressure Switch
TI P/N 77PSL Series
Wear Out Fishbone



02/11/99/B. Dague

TI-NHTSA 012284

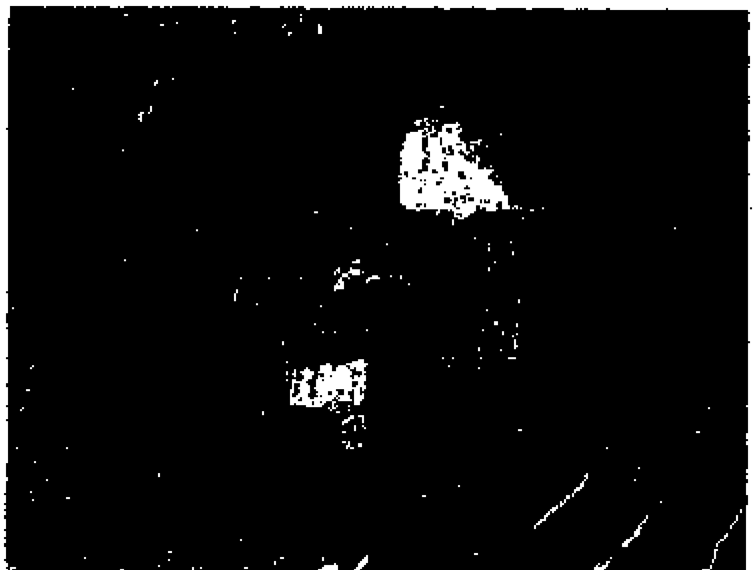
Ford Electronic Speed Control Deactivation Pressure Switch
TI P/N 77PSL Series
Wear Out Fishbone

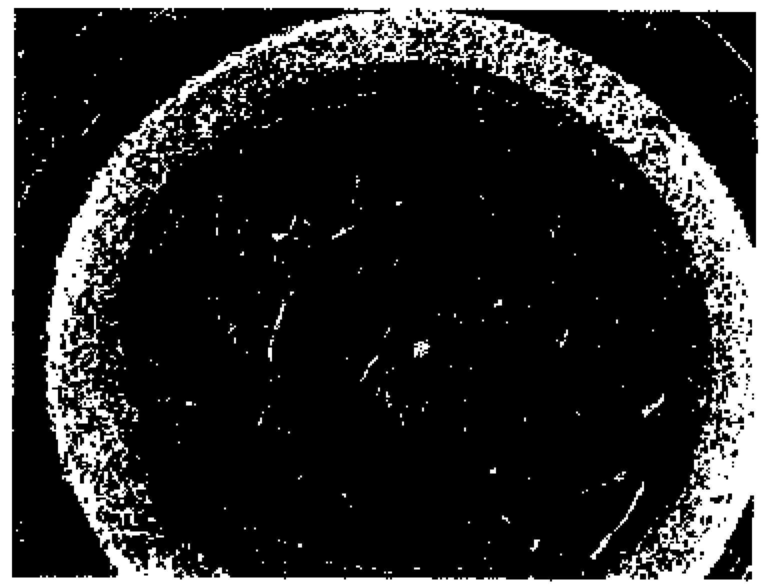


02/11/99/ B. Degnc

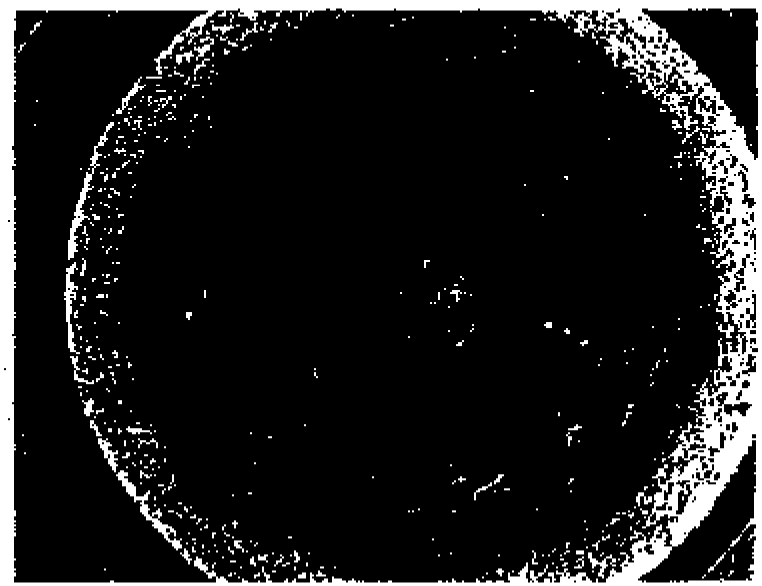
TI-NHTSA 012265

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



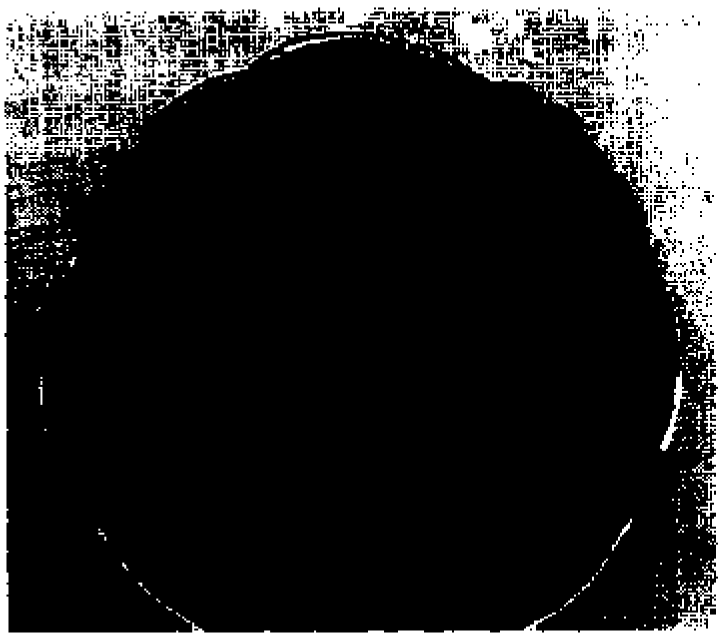


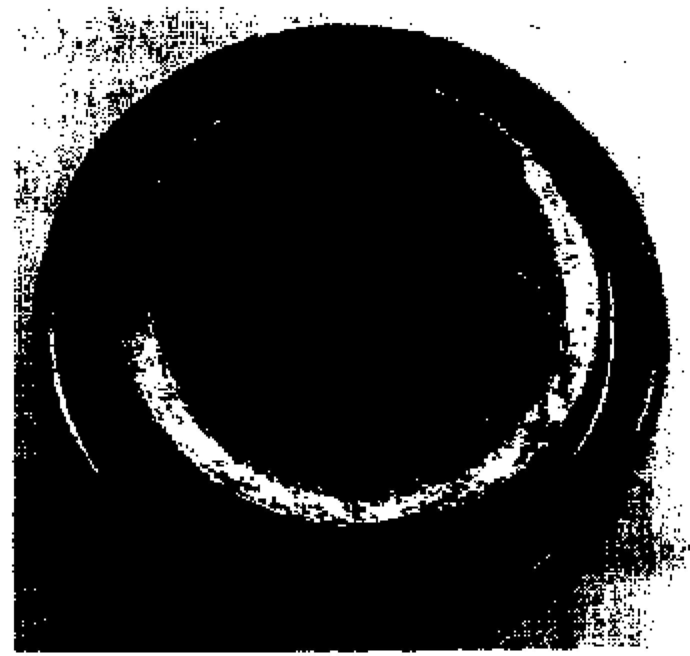
77PS Long Duration Brake Fluid Test
300 Hours at Continuous Power



77PS Memphis Switch

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





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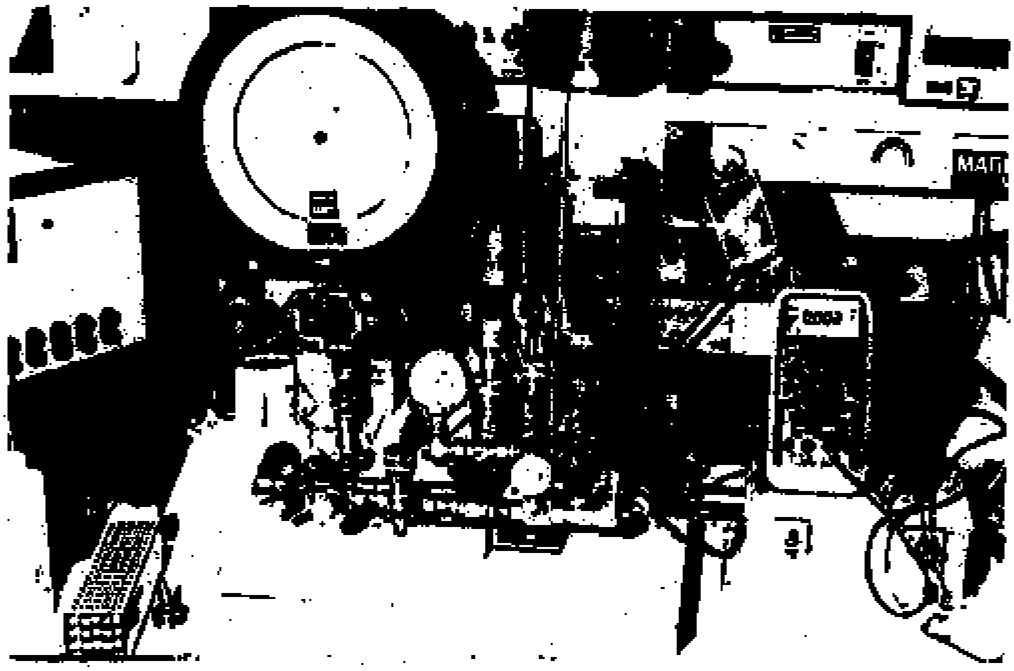

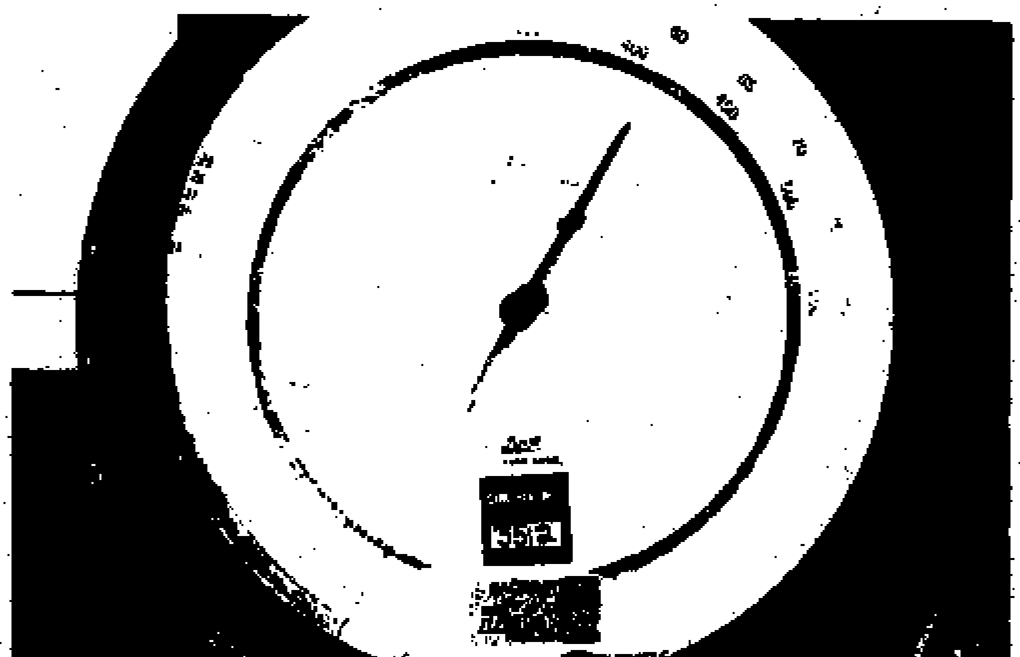

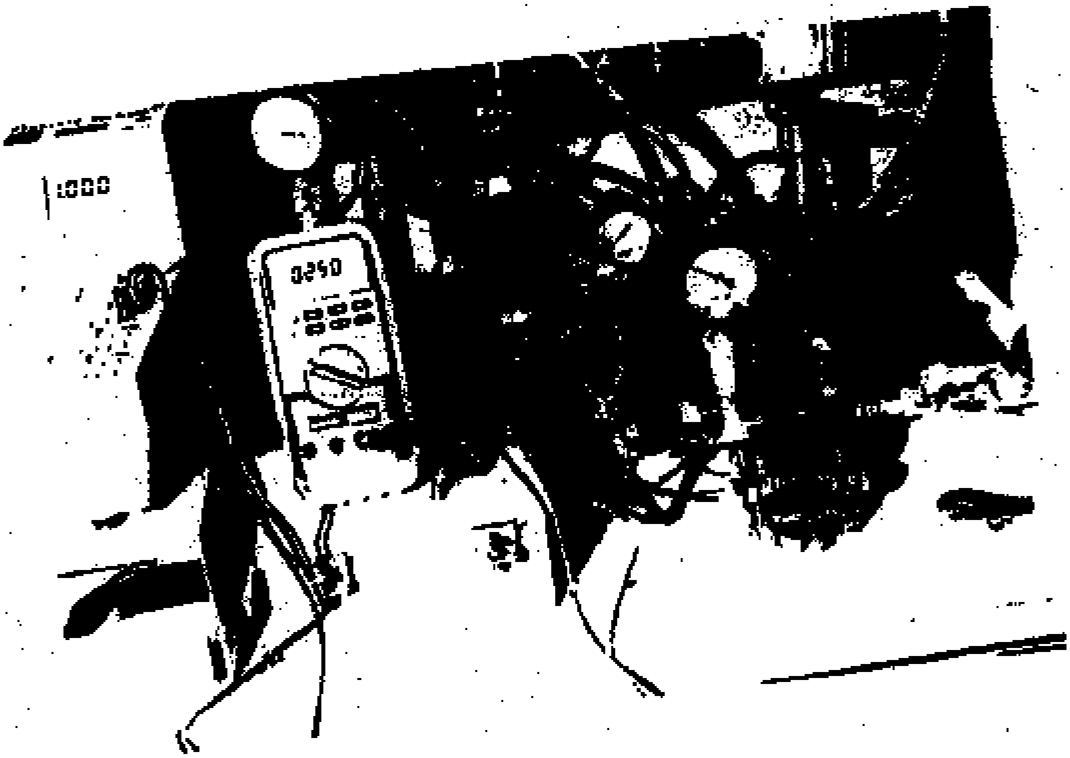
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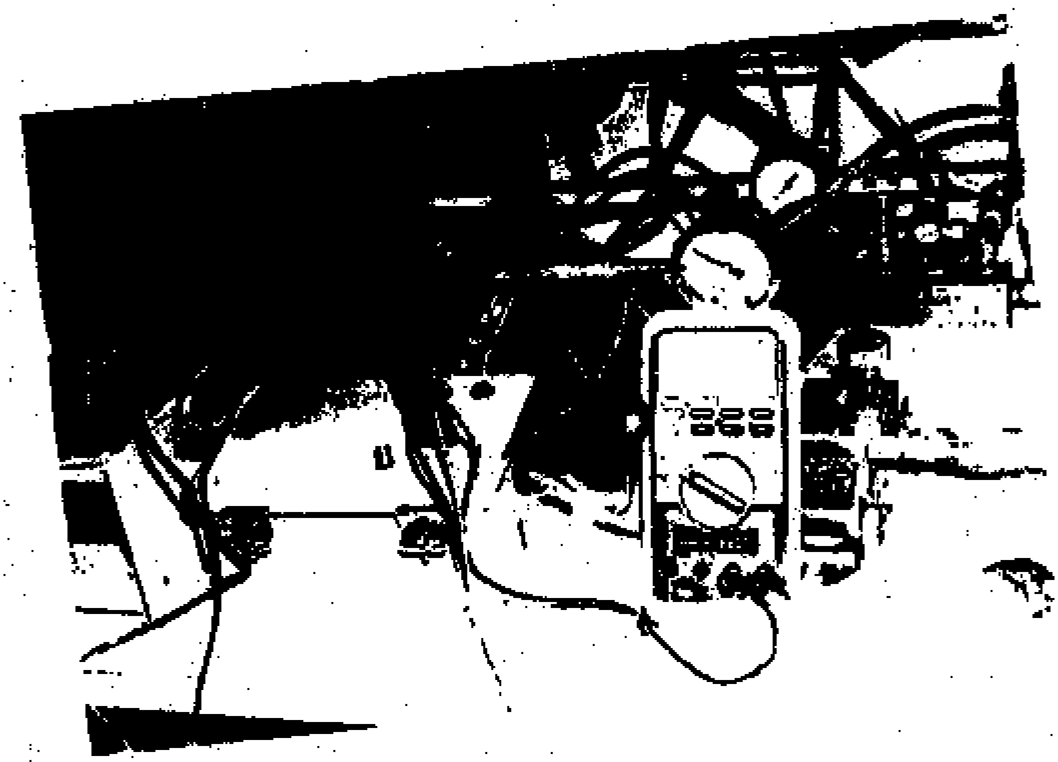
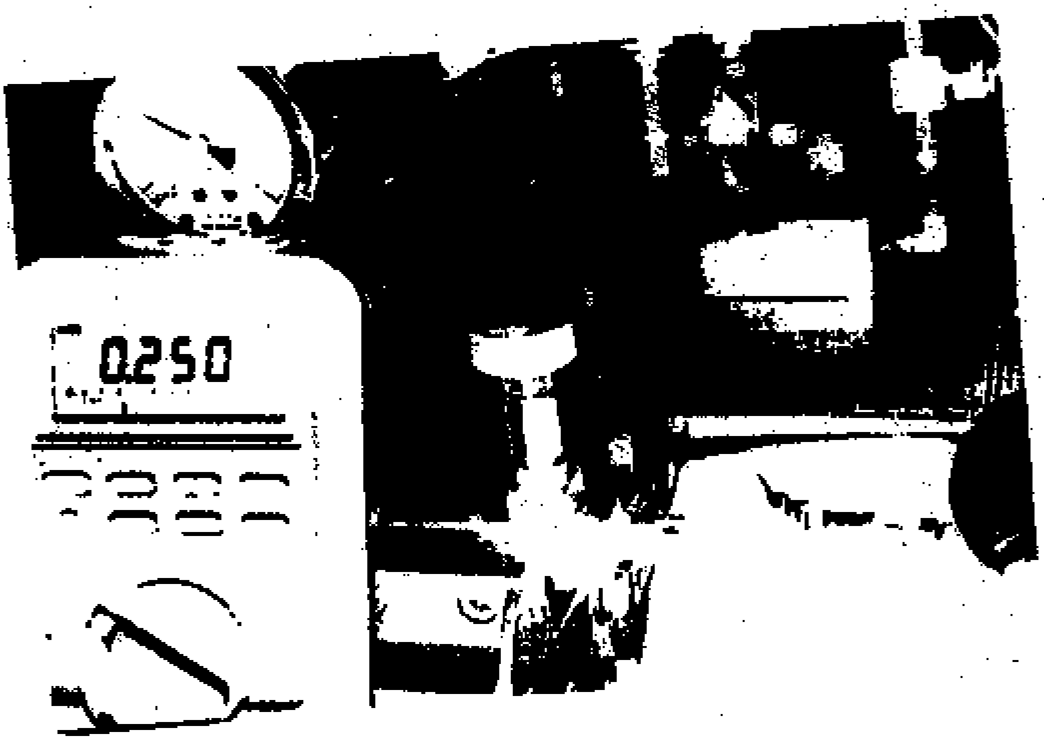
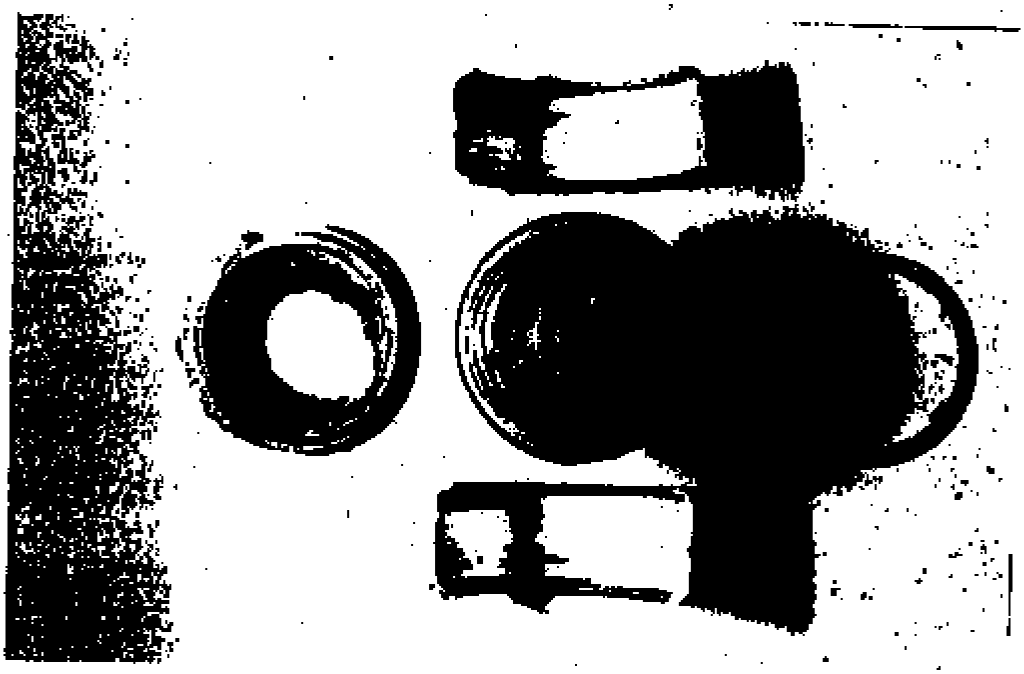
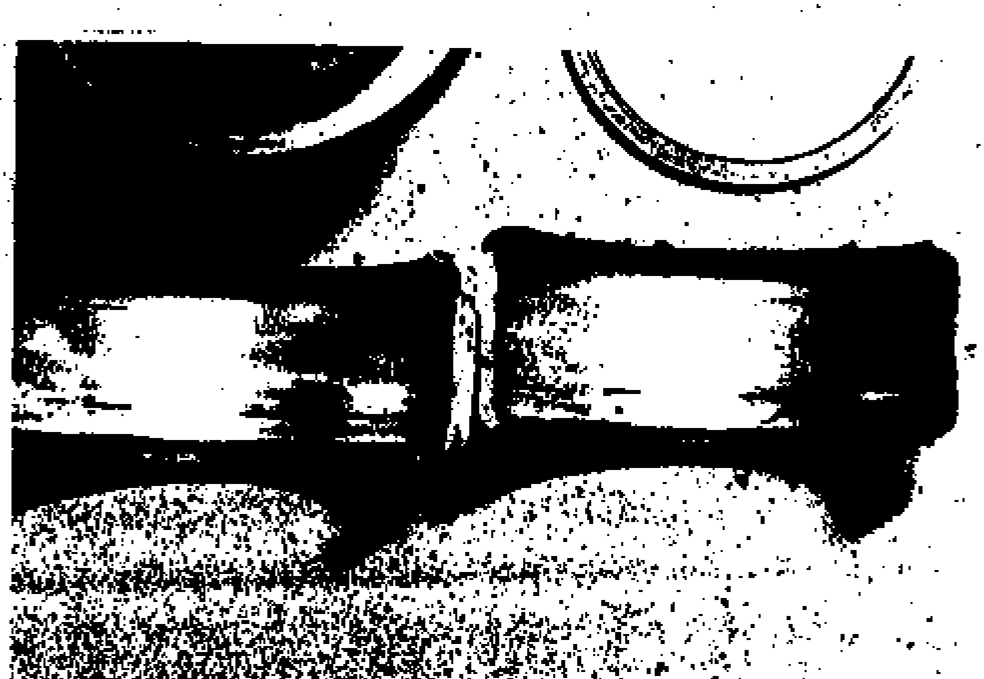




TI-NHTBA 012292





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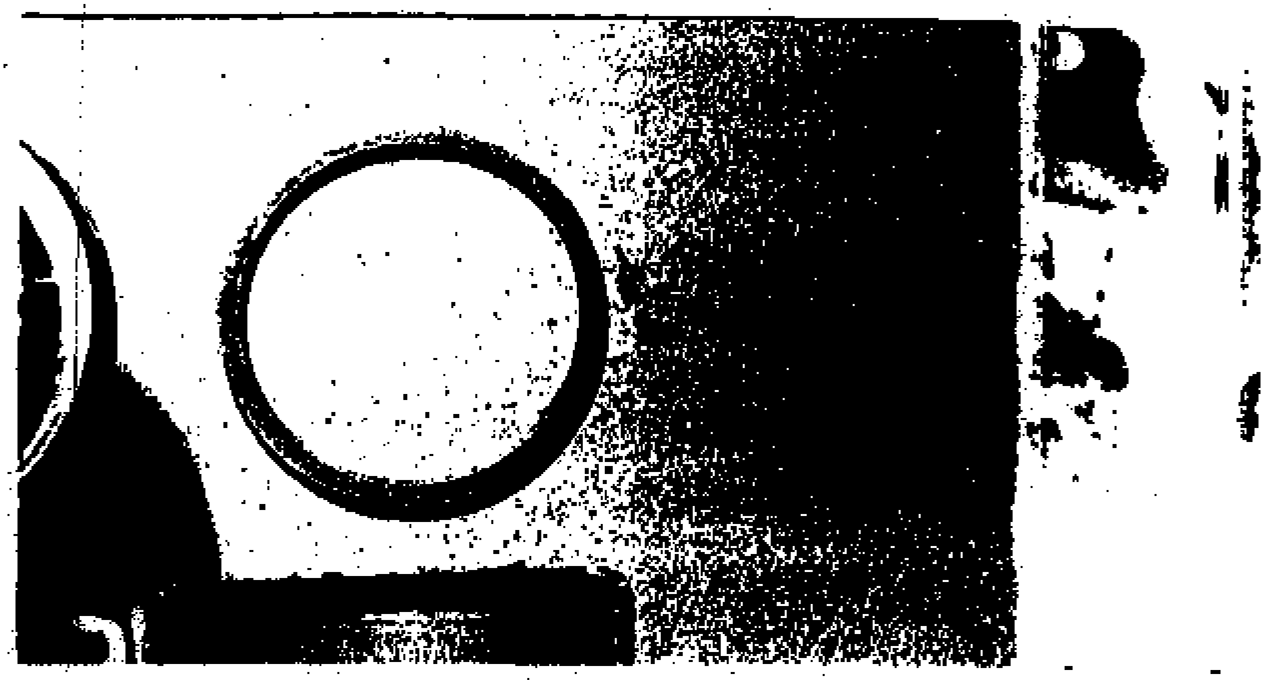

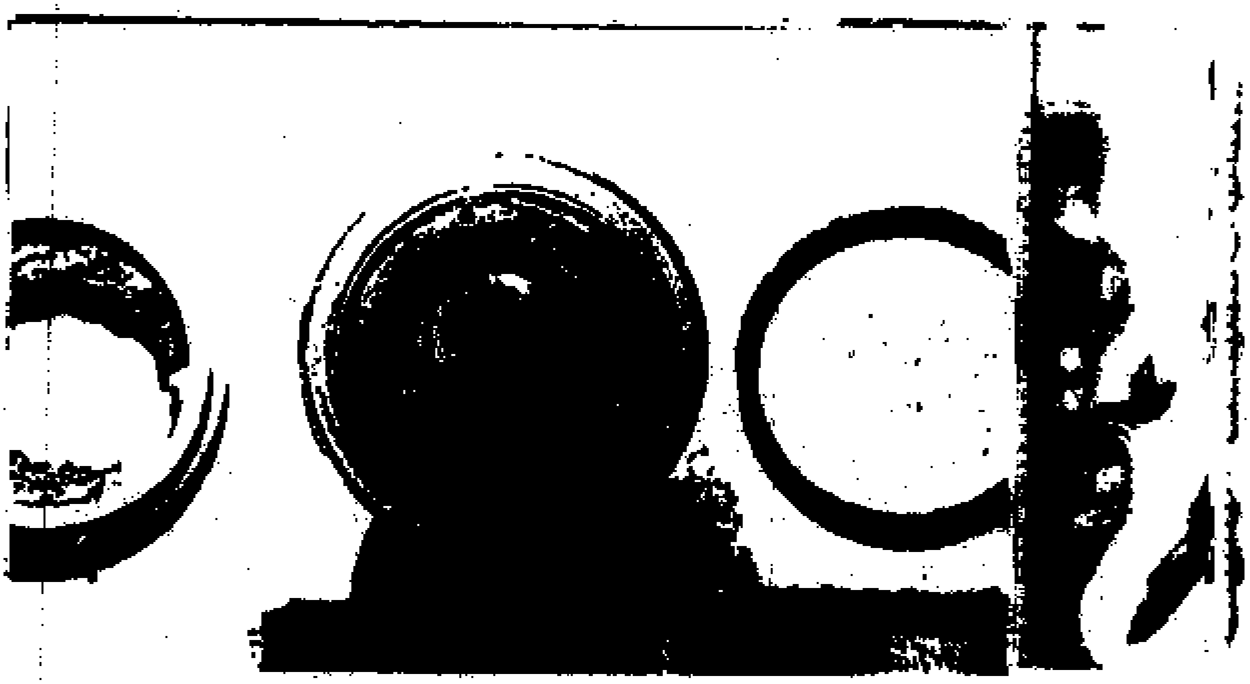

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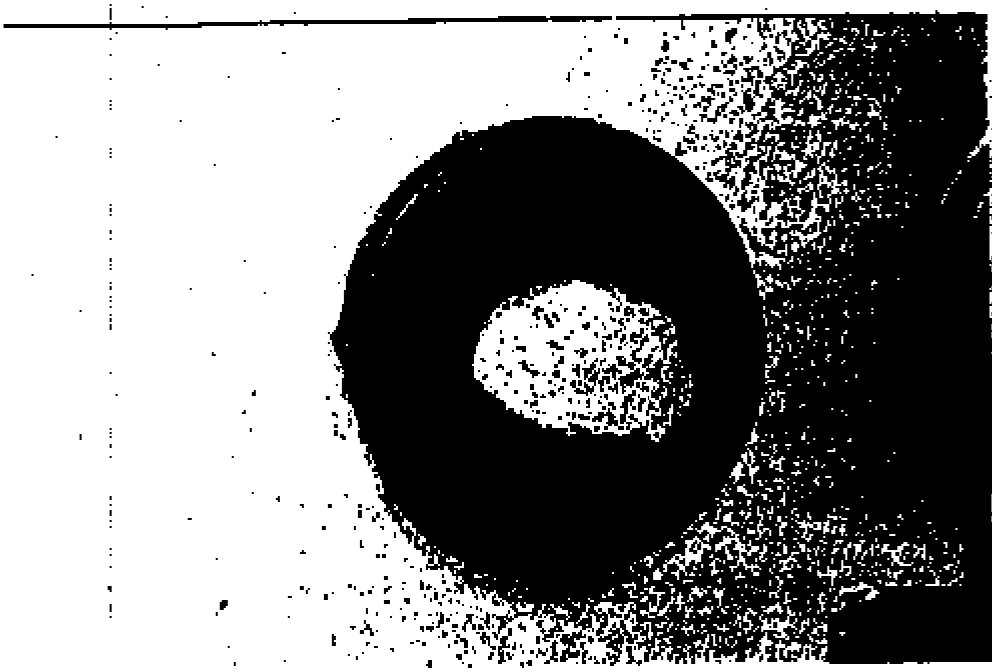

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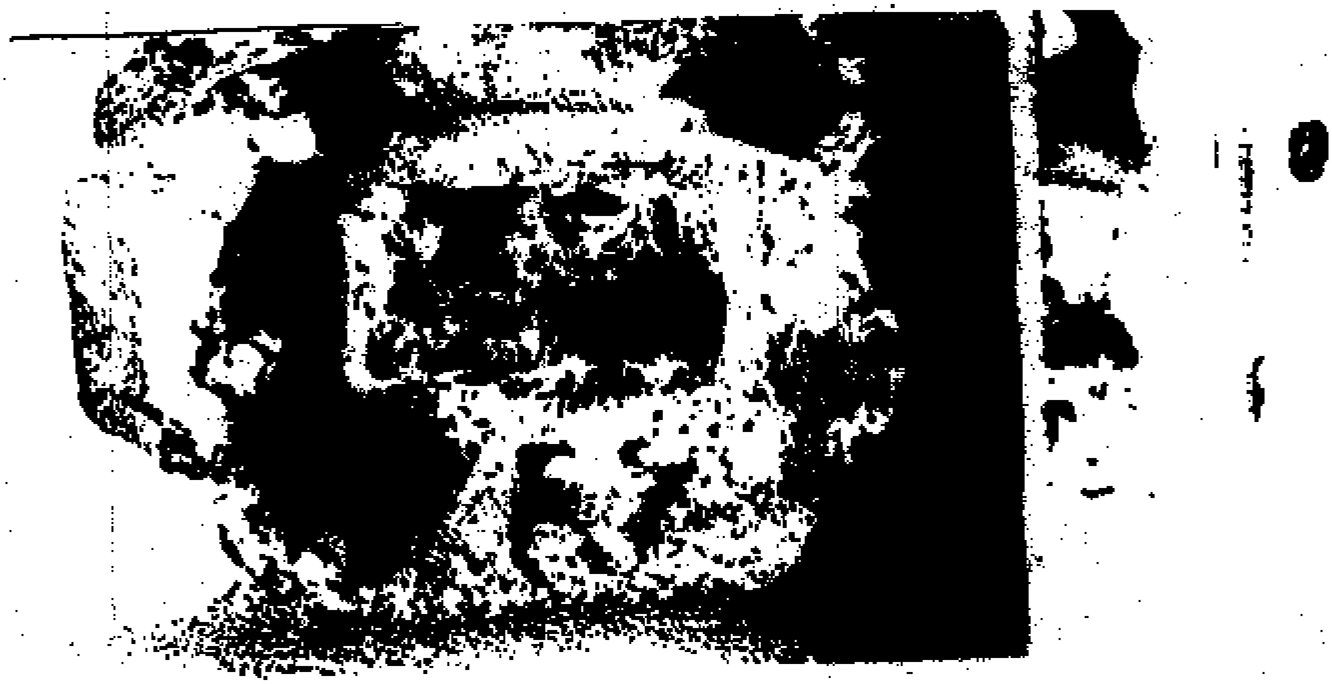
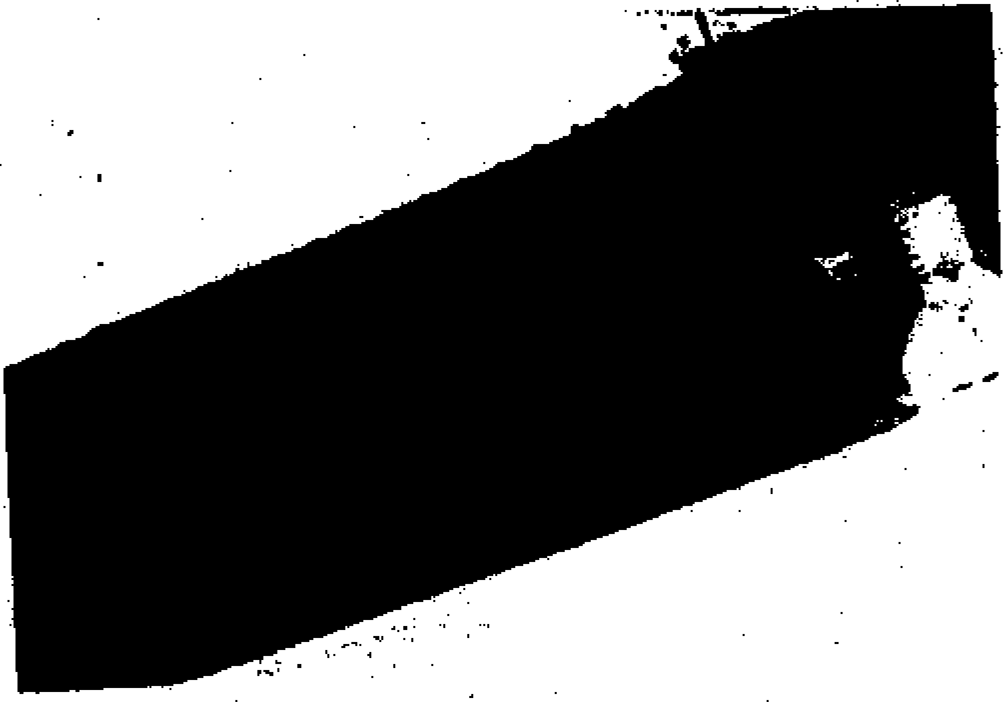
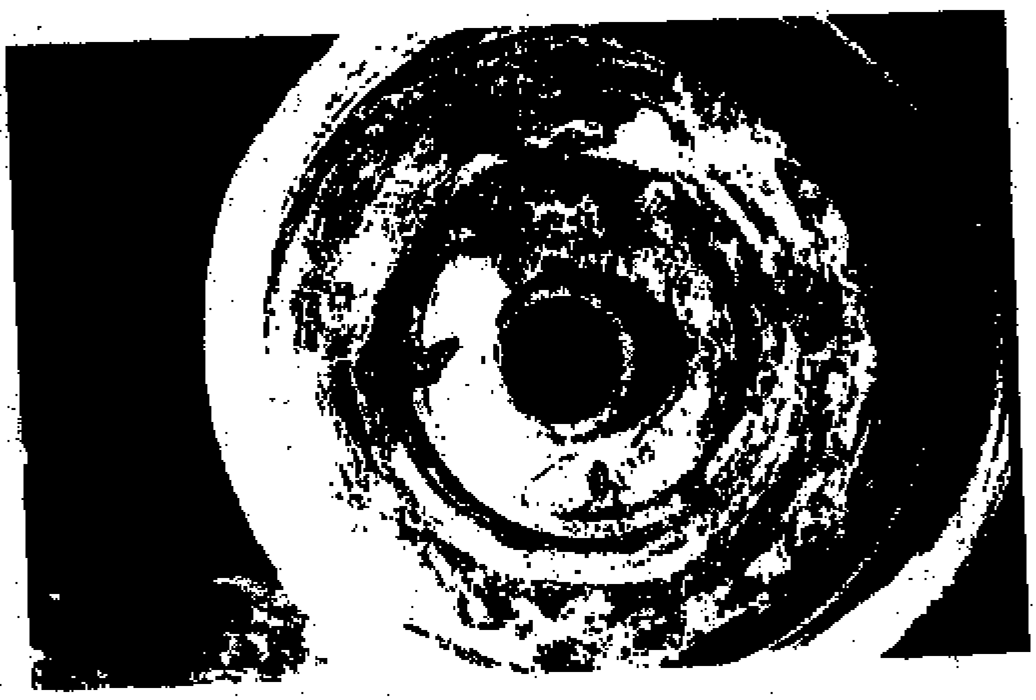


TI-NHTSA 012297

TI-NHTSA 012298

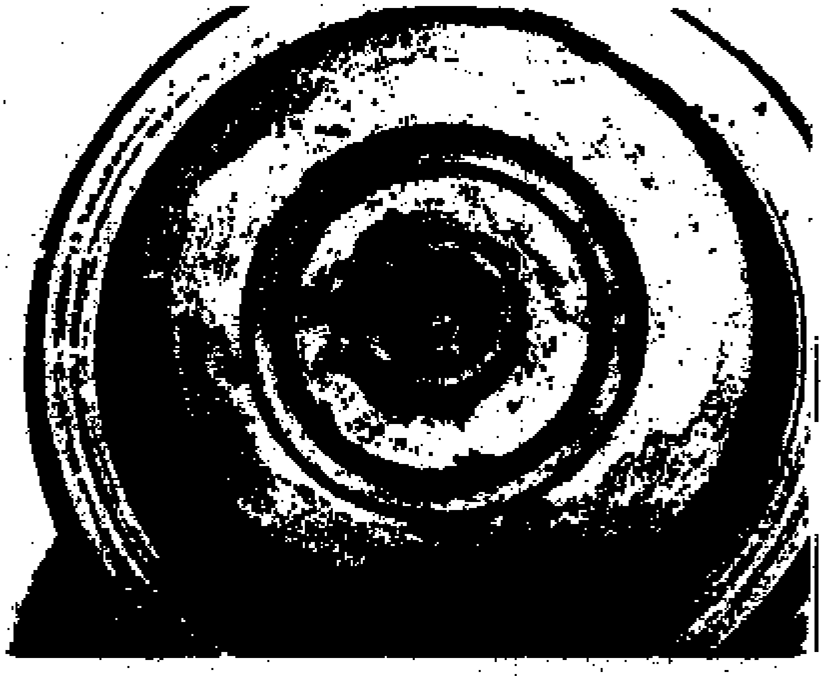
TI-NHTSA 012299

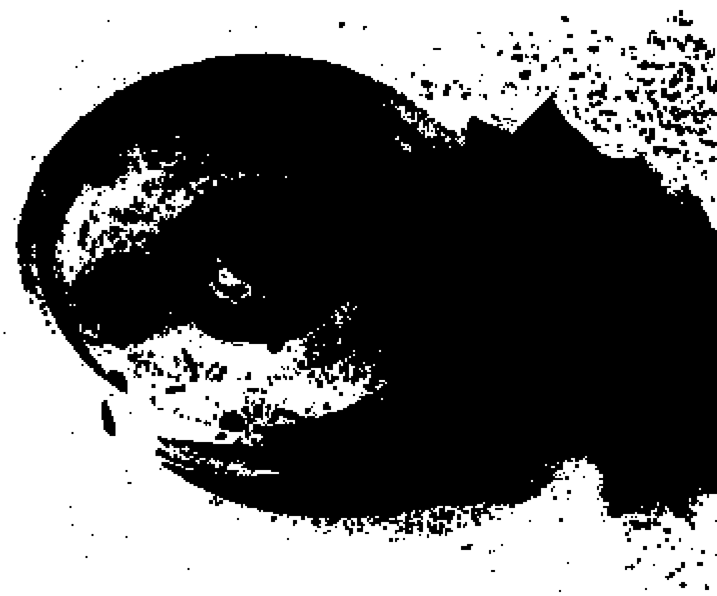


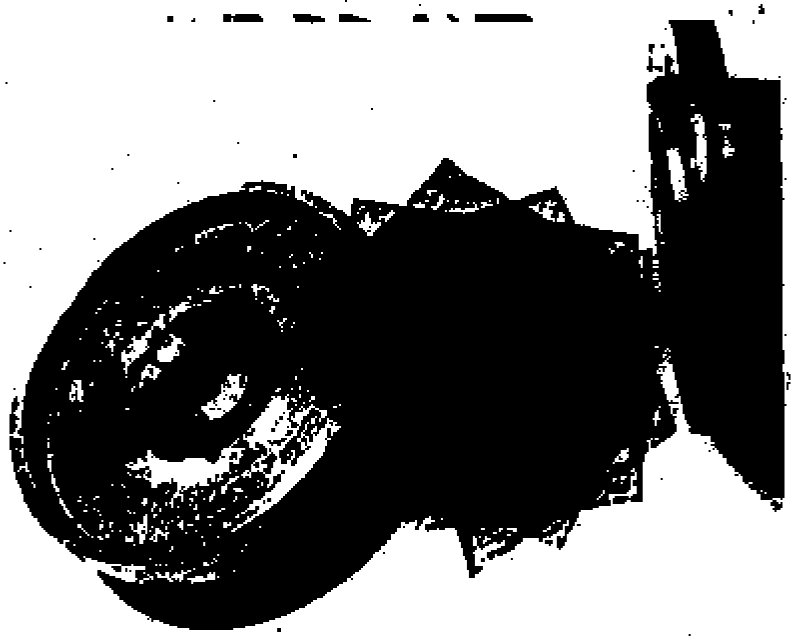


TI-NHTSA 012300

TI-NHTSA 012301







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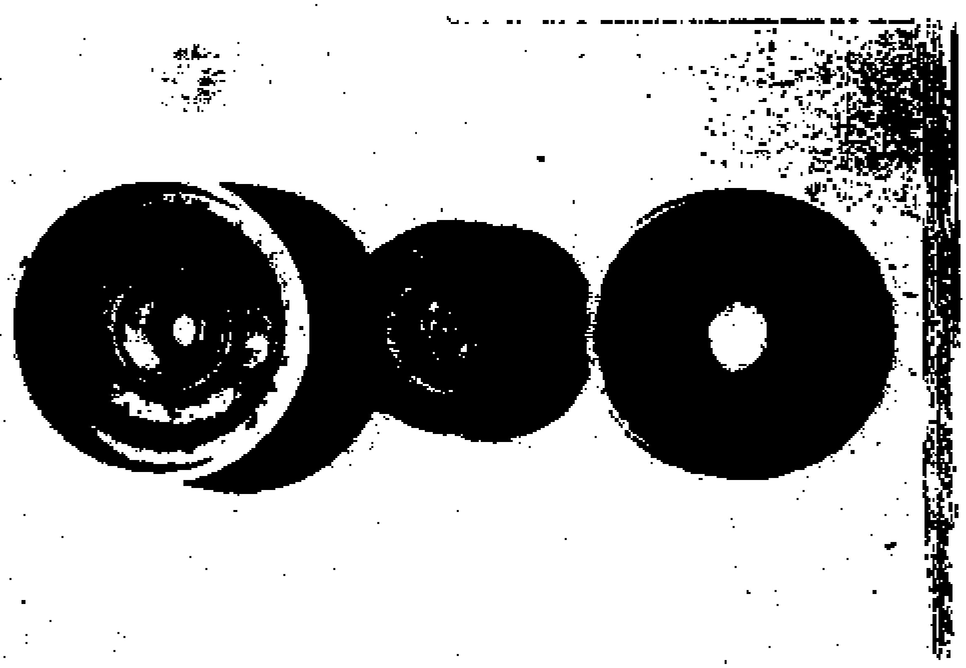

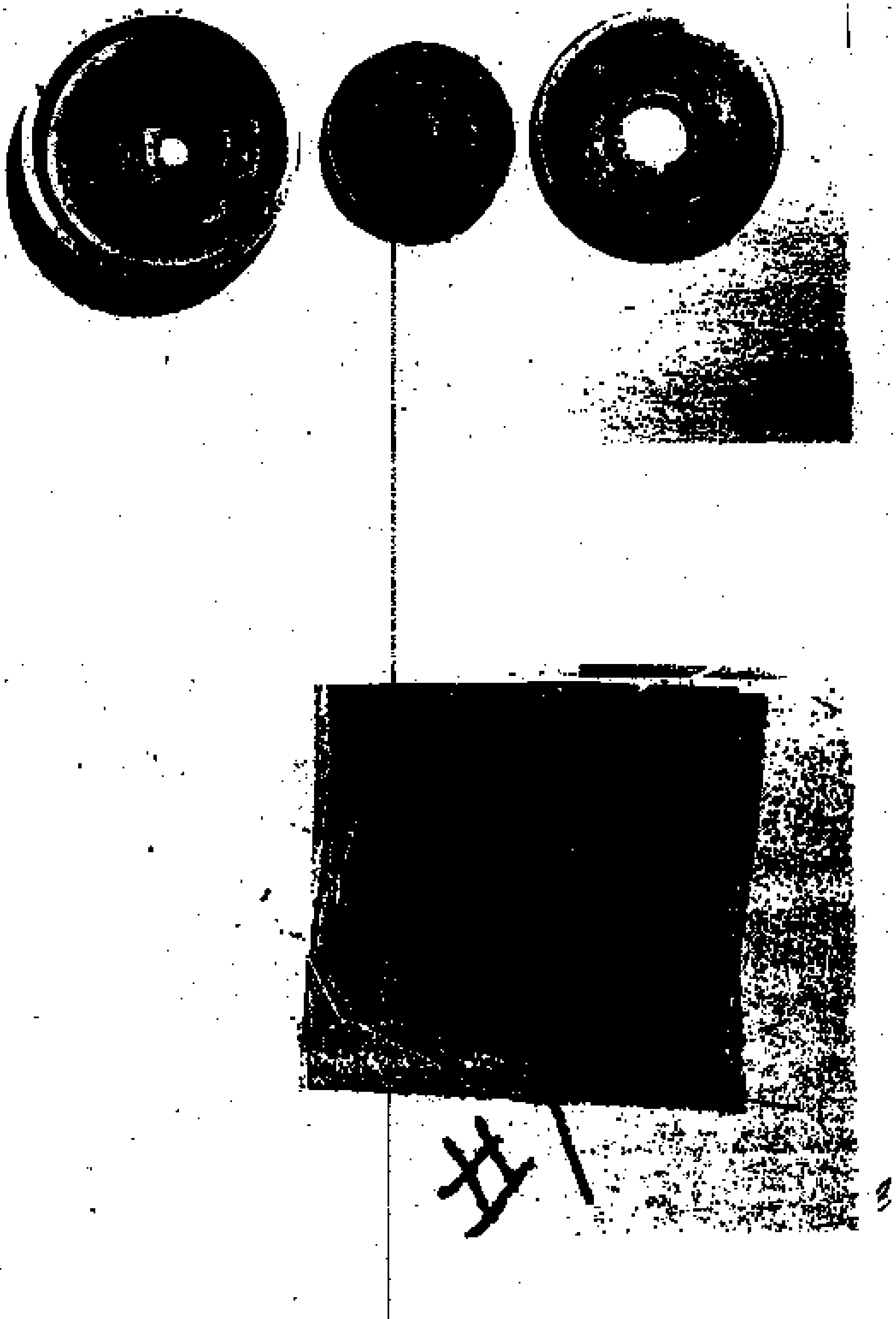

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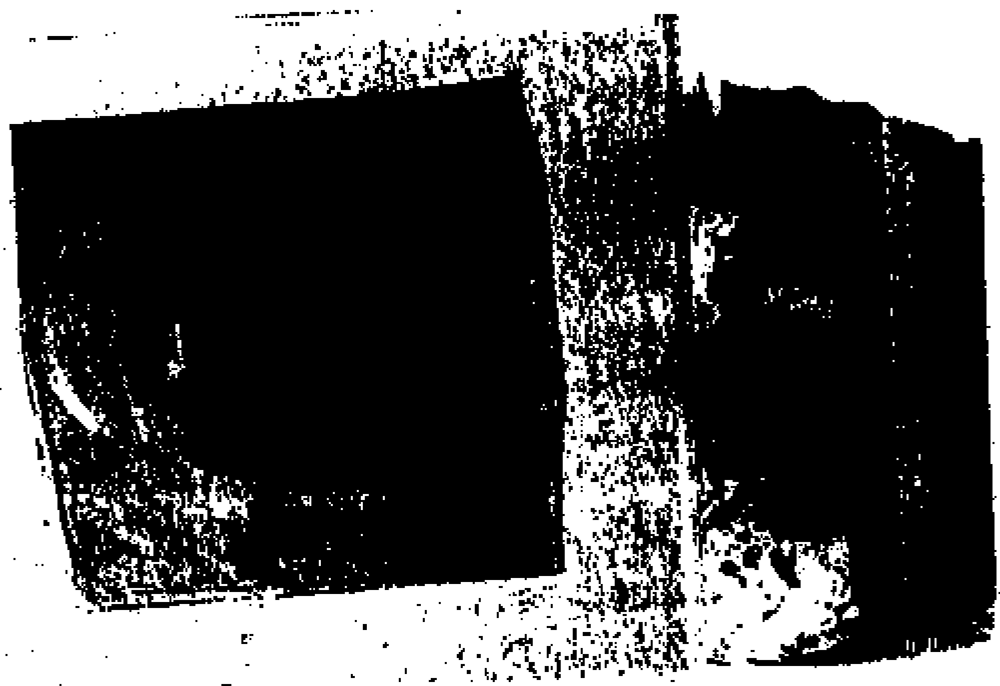
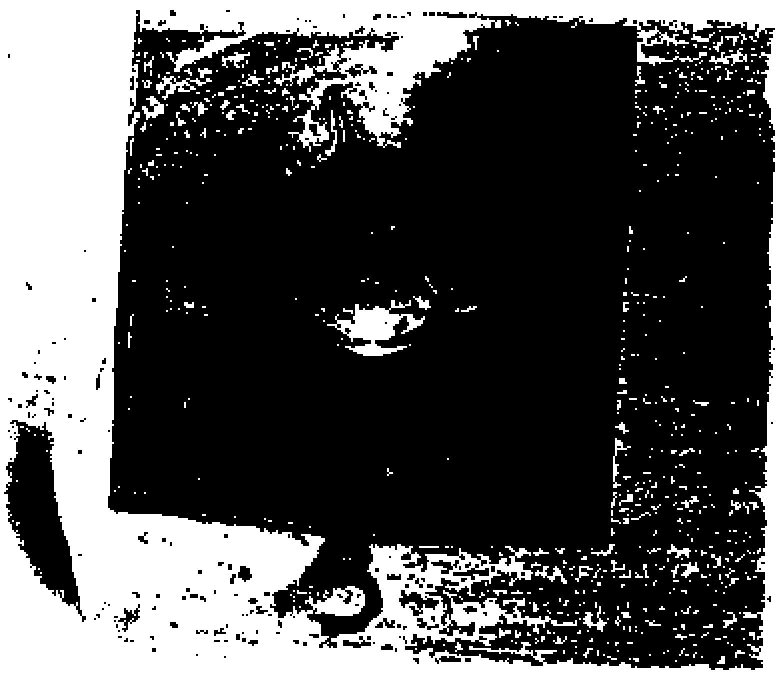
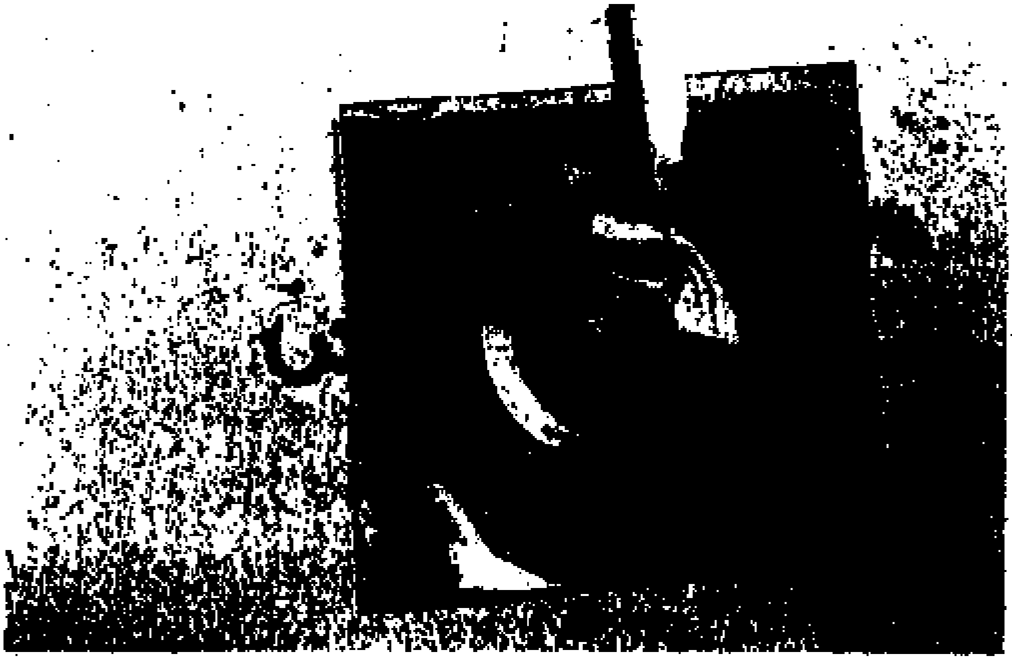
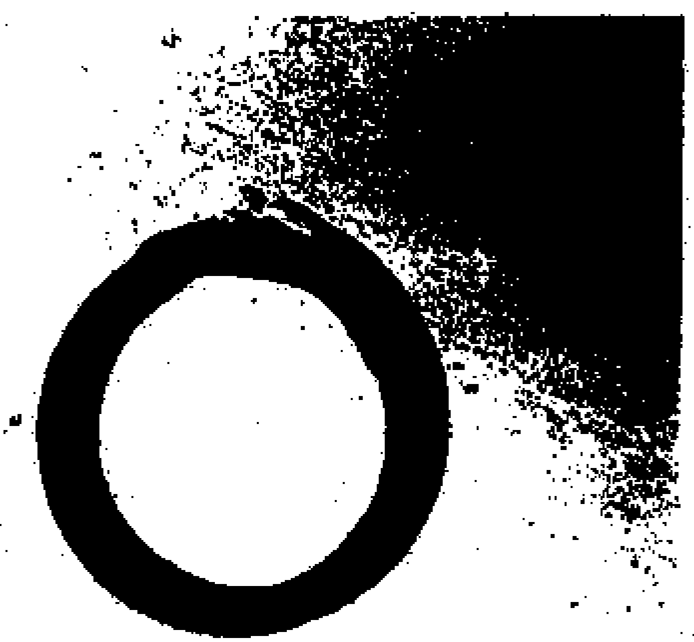








Bayou Dague
2/12/97

Wear/Life Factors:

- → * Max Pressure ✓
- → * snap vs quiet (quiet) ✓
- → * H_2O content ✓ 0%/5%
- * Other Chemicals? ✓
- * Temperature (135°C)
- * # of Kaptons - (3)
- *

Increase Life Actions (Short Term)

- * Teddy
- * Add Kaptons
- * EP Diaphragm
- *

Establish Application Requirements:

- * All switches
  - Bill car
  - Theses
  - other (Junk Yards)
- * Brake Fluid Samples
  - Bills car
  - Junk Yards
  -

* % H_2O ?
* # of cycles
* Max Pressure
*

TI-NHTSA 012309

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 [illegible] high temp. Reading of #2 T-couple. Removed and tested T-couple and read normal - interchanged #2 & #3 T-couple and #1 read high. T-couples returned to original position and assume that [illegible] 4% additional ... contact current is showing a effect on temperature

Ambient Temperature

79°

Oven Temperature

83°

TI-NHTSA 012310

Tests Currently in Progress
2/12/99

* Increase Ion con – add NaCl?
* Add Heater/coil to generate Ignition
* Add Metal Particles in connector ...

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

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

Results to date:
Current flows and temperatures are stable.

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

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

✓ Results to date:
No failures at 150K cycles.

Wear Correlation:

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

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

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

Results to date:
150K cycles. First 2 will be removed at 200K cycles.

* DOE wear

* Heating Element:

NaCl?

Epstein, Sally

From: Dague, Bryan [bdague@email.mc.ti.com]
Sent: Friday, February 12, 1999 7:28 AM
To: Rehman, Aziz
Subject: FW: 77PS Diaphragm Wear Out Cause & Effect Diagram - Updated a/o 5:00pm

Sensitivity: Confidential

Ford
77PS(diaphragm).ppt

From: Watt, Jim
Sent: Thursday, February 11, 1999 4:55 PM
To: 'Baumann, Russ RUSS'; Dague, Bryan; McGuirk, Andy; Beringhause, Steven
Subject: RE: 77PS Diaphragm Wear Out Cause & Effect Diagram - Updated a/o 5:00pm
Sensitivity: Confidential

<<Ford 77PS(diaphragm).ppt>>

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

From: Watt, Jim
Sent: Thursday, February 11, 1999 10:10 AM
To: Baumann, Russ RUSS; Dague, Bryan; McGuirk, Andy; Beringhause, Steven; Watt, Jim
Subject: RE: 77PS Diaphragm Wear Out Cause & Effect Diagram - Resend
Sensitivity: Confidential

<<File: Ford 77PS1.ppt>>

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

From: Watt, Jim
Sent: Thursday, February 11, 1999 9:55 AM
To: Baumann, Russ RUSS; Dague, Bryan; McGuirk, Andy; Beringhause, Steven
Subject: RE: 77PS Diaphragm Wear Out Cause & Effect Diagram
Importance: High
Sensitivity: Confidential

The below 77PS Diaphragm Wear Out Cause & Effect Diagram is fyi, comments. ...?

<<File: Ford 77PS1.ppt>>

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

From: McGuirk, Andy
Sent: Wednesday, February 10, 1999 3:05 PM
To: Baumann, Russ RUSB; Dague, Bryan
Cc: Beringhause, Steven; 'Rahman, Aziz ZIZ'; Watt, Jim
Subject: RE: 77PS Design explanation

Attorney Client Privileged Information

overall, an outstanding document draft. i made a number of changes and am on callback to discuss my thoughts.

i think it might be of value to discuss weibull success factor projections from the 'zillions' of 'as' test results we must have? we should also speak to the thunderbird applications ? maybe refer to the econoline issue of '93 with connector issues ?

we need some summary statement as to the ending of this document......

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: Dague, Bryan
Sent: Wednesday, February 10, 1999 1:24 PM
To: Baumann, Russ RUSB
Cc: Beringhause, Steven; Rahman, Aziz ZIZ; McGuirk, Andy
Subject: 77PS Design explanation

Folks,

Here is a summary of how and why the 77PS is designed as it is. Please give me any comments you might have.

Aziz,
Read this and use the information as you see fit, but do not distribute it until we all agree on the wording.

Regards,
Bryan
****
Attorney Client Privileged Information

Brake Fluid Intrusion
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 and transmit force and movement to the sensing portion of the switch over the life of the 500,000 cycle specification which in turn translates into an elctrical switching reaction used in the automobile system as a redundant safety related cruise control shutoff switch..

Background:
The pressure cavity is composed of the hexport, gasket, and 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 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 is varied.

There are two different ways that brake fluid may enter the contact cavity of TI's brake switches from the pressure cavity. Brake fluid could potentially leak past an impaired gasket seal, or 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 seal material to prevent movement when pressure is applied, and finally the elastomer must be compatible with the working fluid and expected thermal ranges of the environment and application.

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

The gasket compression target was obtained from publish 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 crimp 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 533794 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 specifics details of these tests and the results can be seen in a number the following PV test reports:

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	77PSL5-2	1992
5. PS/92/82	77PSL3-1	1992
6. PS/93/11	77PSL6-1	1993
7. PS/93/44	77PSL4-1	1993

also, there are IP-2 tests of 6/95, 10/95, 1/96 and 8 /96 that are readily at hand and show fluid capability resistances

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

As a result of the process and product controls, TI's customer return rates including line fallout rates and end of line acceptance tests indicate gasket-manufacturing anomalies are below measurable limits (one leak return in 5 years from master cylinder leak testing or less then 1 ppm). 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 but in our expert opinion not in late life without early leak signs.

Kapton Diaphragms:

A pressure switch diaphragm must seal the pressure cavity, transmit pressures 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 of 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 polymide 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 a wide variety of pressure switch applications since 1981.

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 capability to meet the specified requirements (see 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 is around 1 million cycles which is well above the 500,000 cycles specified in the Ford (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.

While the similar manufacturing anomalies listed above can affect the Kapton diaphragms (see PFMEA Document # 503831), additional factors can cause leakage via the Kapton diaphragm. Material/chemical compatibility and stress/strain concentrations can also cause the Kapton diaphragms to leak. 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 rupture does occur, there are visual signs of de-lamination, cracking, and embritlement. The Kapton diaphragms break down first in the areas of highest stress and or strain. In our expert opinion, the first region to show break down is the circumferential area surrounding the converter button. See Endurance Test (report # PS/98/53). 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 will accelerate the aging of the base polymide. Chemical attach can come from two directions:

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.

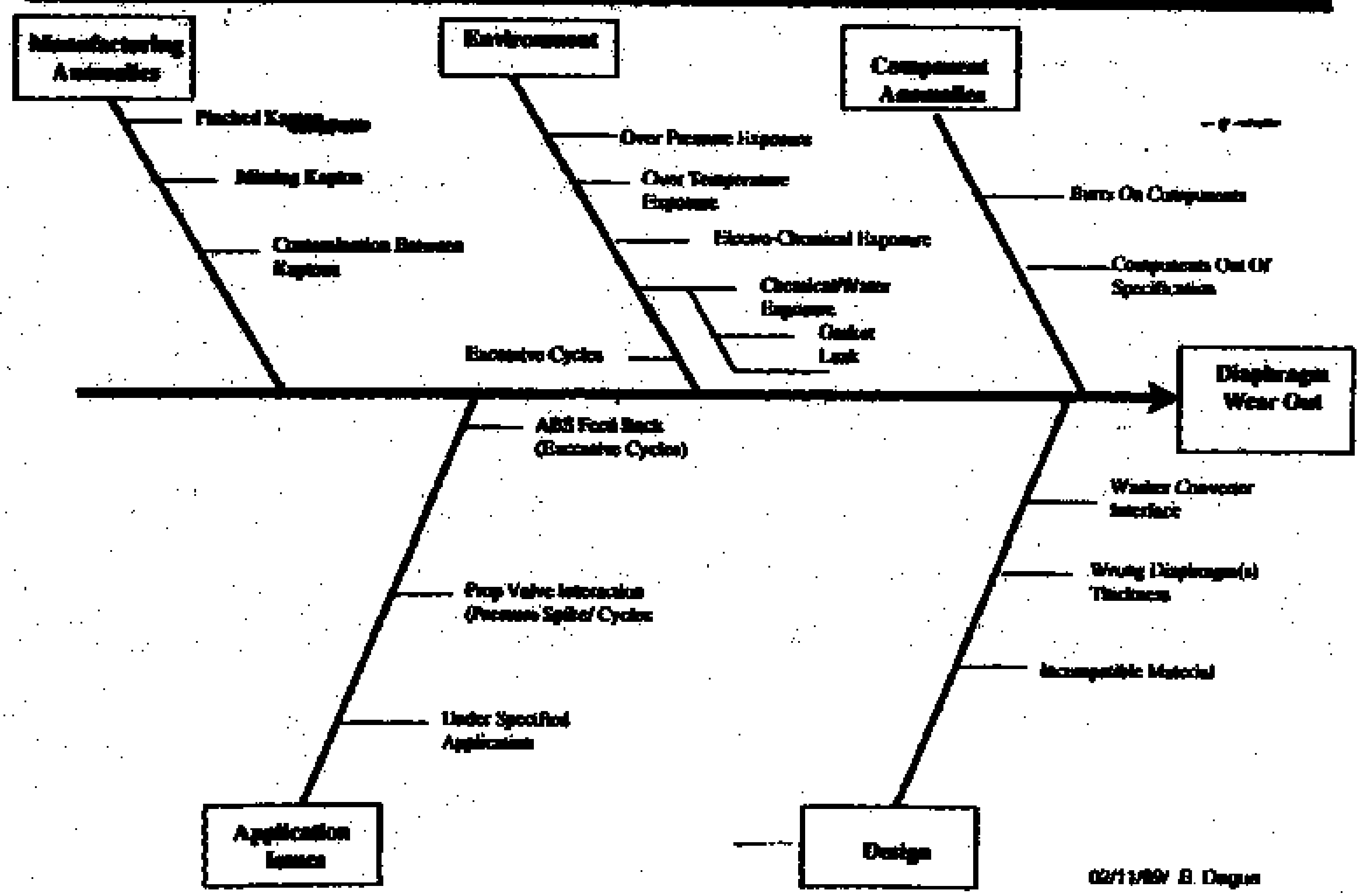
When water enters the connector it will "age" the Kapton diaphragms and make them appear as though they have reached the end of life. This condition leaves visual clues. Classic signs of chemical attack of the Kapton include de-lamination of the Teflon from the base polymide base, embrittlement, and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

End of Document.

TI-NHTSA 012318

TEXAS INSTRUMENTS

Ford Electronic Speed Control Deactivation Pressure Switch
TI P/N 77PSL Series
Wear Out Fishbone



02/11/99/ B. Dague

TI-NHT8A 012317

~ 2-12-99
L. Cambra

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 creating 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 #1 and #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

TI-NHTSA 012318

~ 2-12-94

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 012319

~ 1-10-95
L. Cambra

Voltage Resistance Test

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

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

Repeat this sequence three time and record results

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

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

~ 4-12-99
L. Cambra

Thermal Cycle Fluid Ingress Test

Purpose : To determine if fluid (water) will ingress into a sealed device after exposure to thermal cycling .

Test : Devices will undergo a 72hr thermal cycle with temperatures ranging from 125c to -40c . Each cycle will have a 4 hr soak at temp and a ½ hr . transition time between temperature excursions .

Post thermal cycling devices will be submitted to a soak of 125c and immersed into a cold water bath of 0c . A small percentage of salt will be added to the water for tracing purposes . Devices will be submerged to the top of the connector only and wires will remain exposed to the air . A 30 minute temperature soak and 5 minute immersion time will be considered 1 cycle . This will be repeated for 10 cycles and after all 10 cycles the device will be submitted to a high voltage current leak test from wire leads to ground . After a 24 hr set at room temperature .

Results : All ten samples passed current leak test at 1500 volts . No arcing or leakage to ground was observed .

2-29-99
L. Cambra

77 PS Heated Device Testing

I . Purpose

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

II . Procedure

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

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

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

III . Results / Discussions

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

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

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

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

Test 2 (dry device with spark)

Test 2

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

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

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

Test 3 (rapid temp. rise)

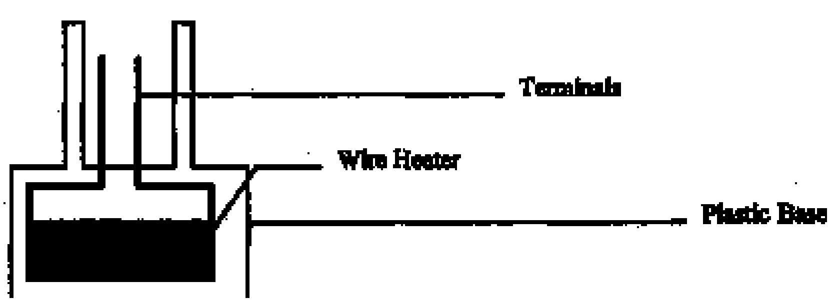
Volts	Heater Current	Internal Temperature (F)
1.0	3.6	300
1.2	4.0	360
1.2	3.8	643
1.3	3.7	650
1.3	3.7	800
1.3	3.7	930
1.3	3.7	967

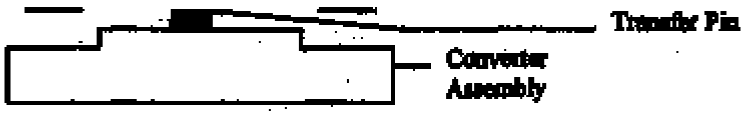
Smoke emitted at 300 F this was a fast happening event as the internal temperature rise was so rapid . Device vented at side of base at 643 F and base did not fail till 1436 F was achieved at this point spark was applied and fumes ignited . Heater instantly burned out and fire was extinguished . Reading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

IV . Conclusions .

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

Terminal / Heater Attachment




Transfer Pin
Converter Assembly

1-20-97

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 ____

1-21-94

Ford 77Ps Recovered Parts Analysis

Make ______________________________

Model ______________________________

Year ______________________________

Date Recovered ______________________________

Recovery Location ______________________________

Mileage ______________________________

TI Test # ______________________________

Technician ______________________________

Date Tested ______________________________

Device Photograph **Kapton Photograph**

Ford 77 ps Fluid Temperature Testing

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

Temperature Readings

1	2	3	4	5
87	96	107	88	103

Current Readings

1	2	3	4	5
K	K	✓	Y	.47 mA

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

Ambient Temperature **Oven Temperature**

Tank Temp

1	2	3	4	5
...		...	91	104

TI-NHTSA 012331

Epstein, Sally

From:	Lincoln, Maureen [mlincoln@email.mc.ti.com]
Sent:	Monday, February 15, 1999 1:05 PM
To:	Rahman, Aziz
Subject:	Weibull Analysis Information

Aziz,

Bryan asked me to forward this information to you.

Please find attached the Weibull Analysis spreadsheet from the TI web. There is a button in the upper right hand portion of the spreadsheet which will show the supporting documentation. You will need to enable the macro to open. I believe this has the information you are looking for. If you need anything more, or cannot open it, please let me know and I will fax it to you.

Regards
Maureen

<<stat__3.xls>>

TI-NHTSA 012332

Ford 77 ps Fluid Temperature Testing

Technician : LEC **Date :** 2-15-99 **Time :** 1:30

Temperature Readings

	1	2	3	4	5
	83	61	105	92	96
Peak	99	103	121	97	117

Current Readings

1	2	3	4	5
X	X	Y	Y	0 ma

Volts 14.20

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

Device #2 @ 75% Shows no Load - Also
Had little Fluid left - ReFilled and Restarted test
all Devices were full, All fluids are black in color - Re-Filled
Fluid on #2 @ 75% and ma Reading increased to .72 ma
and started to decrease

Ambient Temperature 61°

Oven Temperature 61°

TI-NHTSA 012333

Epstein, Sally

From:	Dague, Bryan [bdague@email.mc.ti.com]
Sent:	Monday, February 15, 1999 2:54 PM
To:	Rahman, Aziz
Cc:	Beringhause, Steven; Baumann, Russ; McGuirk, Andy
Subject:	Monday update

Tests Currently in Progress
Last updated: 2/15/99
Ignition Re-creation:
Objective - to recreate the conditions that caused an engine fire in the application.
Description:
1. 10 switches are filled with a mix of brake fluid, water, and detergent. 2 switches are filled with the following concentrations: 0%, 4%, 6%, 10%, and 75%. 14 volts is being applied to 1 terminal and the hexport is grounded. Current flow varies from about 0.5 mA to a high of about 5.0 mA.
2. On 2 of the above switches approximately 1 amp is being conducted through the terminals in-order to create heat in the switch.
Results to date:
Re filled the 75% device. Current flows and temperatures are stable, but have decreased during the last couple of days.

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

Description:
A population of 30 77PS2-1 (snap discs) is being cycled to failure.

Results to date:
No failures at 600K cycles.

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

Description:
Switches are being removed from the cycler at increments of 200K cycles. 2 switches at each interval. These switches will be disassembled and wear at the following points will be characterized:
1. Kapton degradation
2. Pin
3. Pin guide
4. Arm bump
5. Converter/washer interface

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

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

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

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

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

End of document