EA02-025

TEXAS INSTRUMENTS, INC.'S

9/10/03

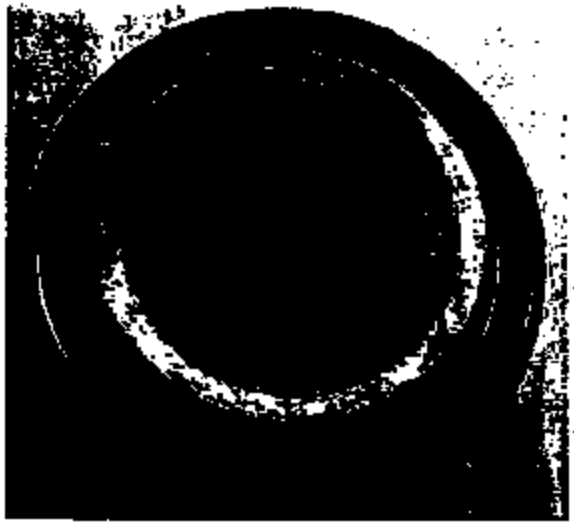
REQUEST NO. 7

BOX 9

PART A – R

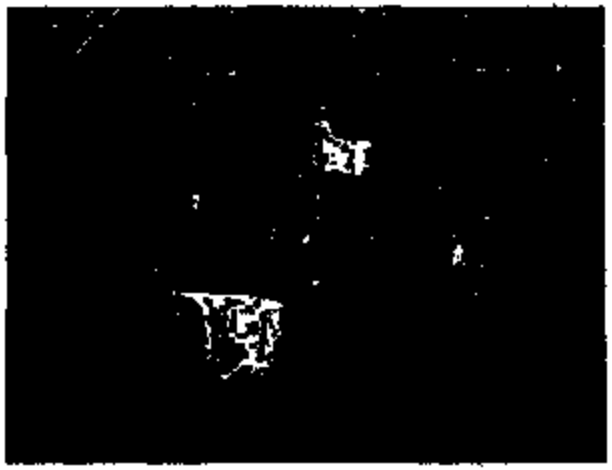
PART F

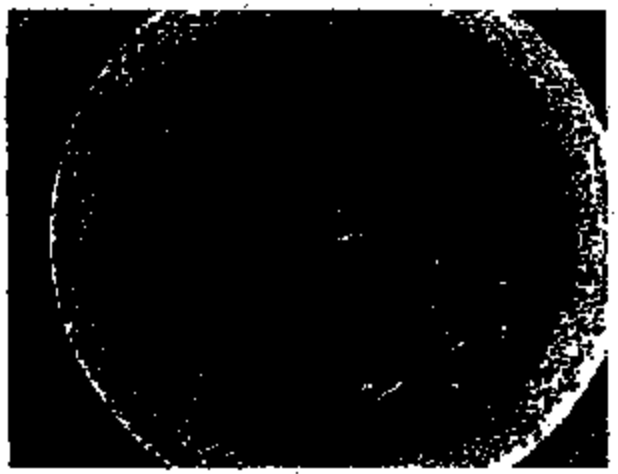
Lab Experiment-5% $NaCl/H_20$ and Continuous Power



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

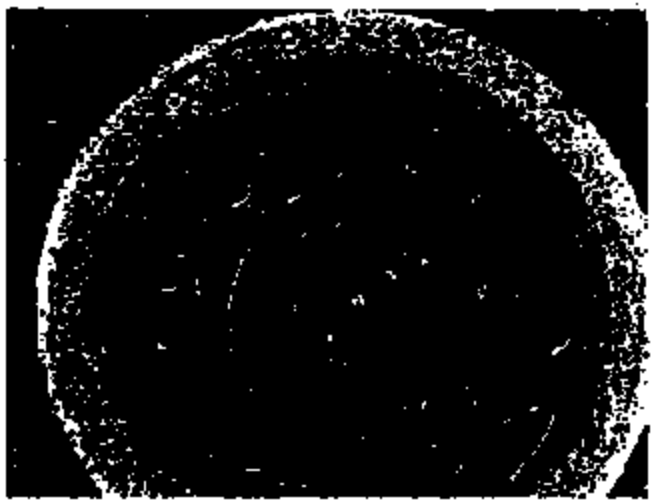
Lab Experiment- "New" Brake Fluid and Continuous Power (300 hours)





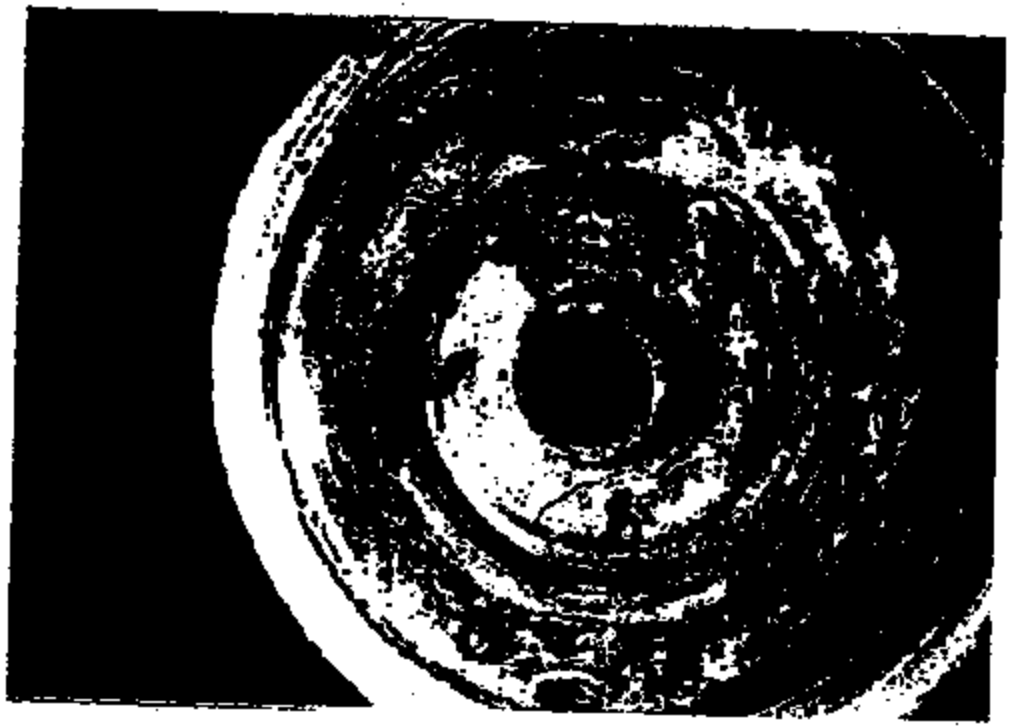
- Contact arm (Cu) corrodes - chemical analysis shows presence of Cu, C, and O on the cup surface.

Lab Experiment "New" Brake Fluid and Continuous Power (550 hours)



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

Memphis Switch Analysis



- Chemical analysis reveals K, S, Cu, C, and O.

Lab/Field Comparisons - Impact of Continuous Power

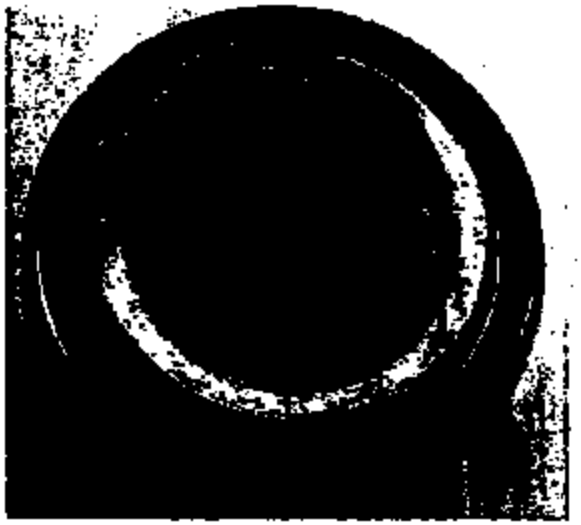
Experiment	Cup Visual Inspection	Chemical Analysis (Cup)
Lab/Salt Water		Na, Cl, Cu, C, O
Lab/Brake Fluid		Cu, C, O
Field/Memphis Switch		K, S, Cu, C, O

NA Hydraulic Switch History

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

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

Lab Experiment-5% $NaCl/H_20$ and Continuous Power



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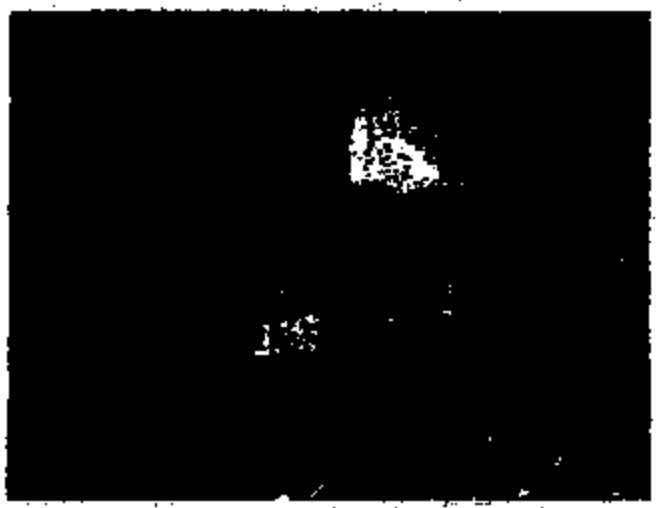
Lab Experiment- "New" Brake Fluid and Continuous Power (300 hours)

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

Lab Experiment "New" Brake Fluid and Continuous Power (550 hours)



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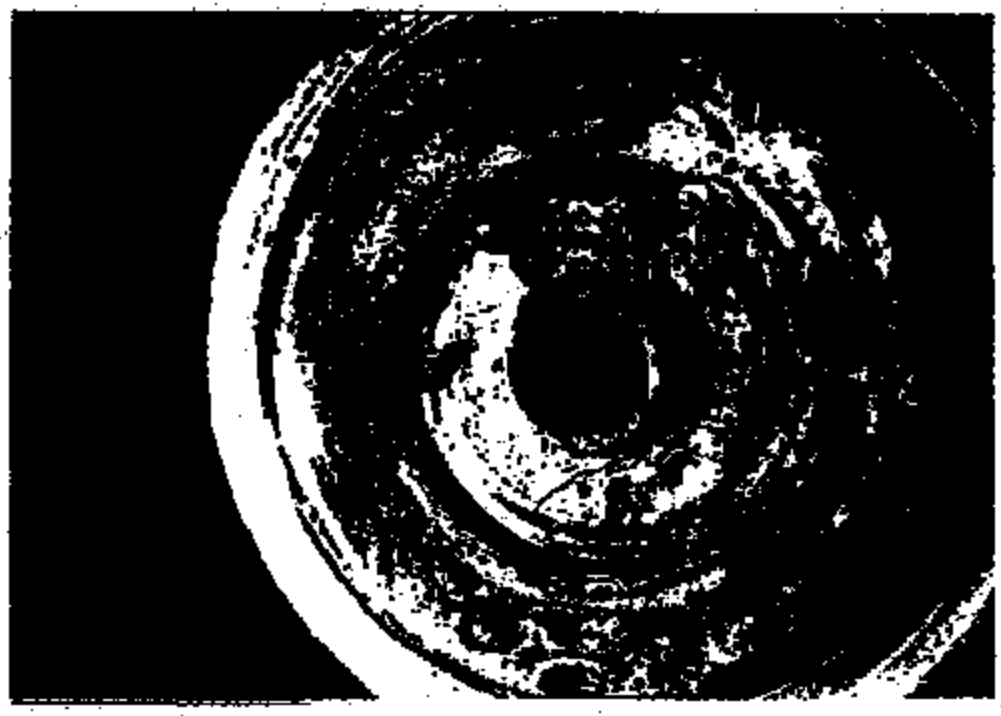
Memphis Switch Analysis



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Application:	Power Steering	Power Steering Suspension	Power Steering Suspension Transmission	Power Steering Suspension Transmission Cruise	Power Steering Suspension Transmission Cruise Clutch	Power Steering Suspension Transmission Cruise Clutch
Fluid:	Power Steering Fluid					
		Brake Fluid				
			Transmission Fluid			

- TI has some 16 years and 130 million units accumulated experience in hydraulic applications using multiple fluids
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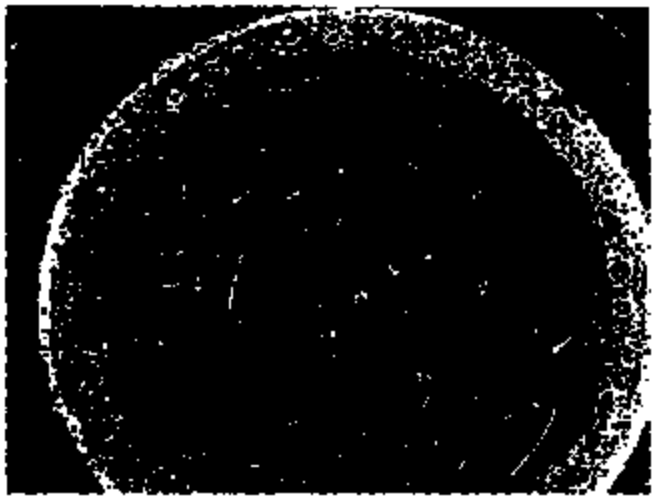

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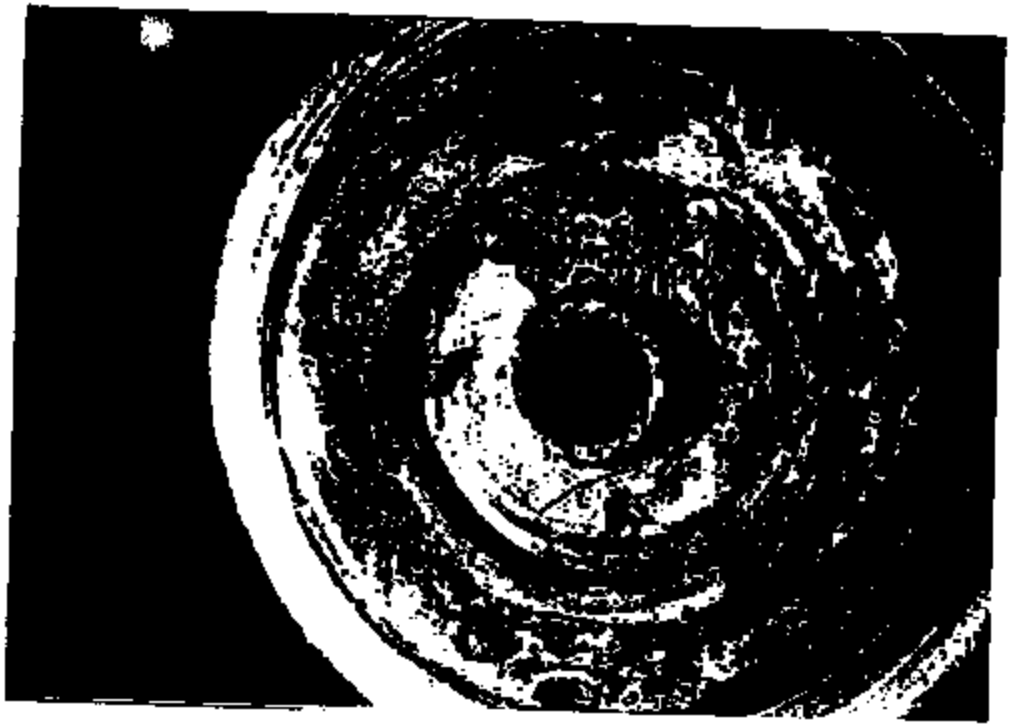
Memphis Switch Analysis



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Application:	Power Steering	Power Steering Suspension	Power Steering Suspension Transmission	Power Steering Suspension Transmission Cruise	Power Steering Suspension Transmission Cruise Clutch	Power Steering Suspension Transmission Cruise Clutch
Fluid:	Power Steering Fluid					
		Brake Fluid				
			Transmission Fluid			

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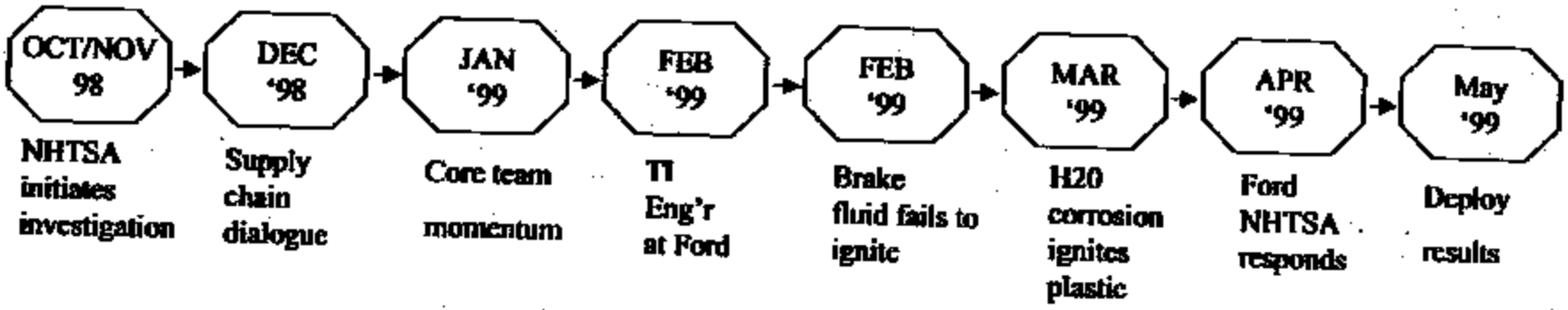
OVERVIEW OF CONCERN TIME LINE

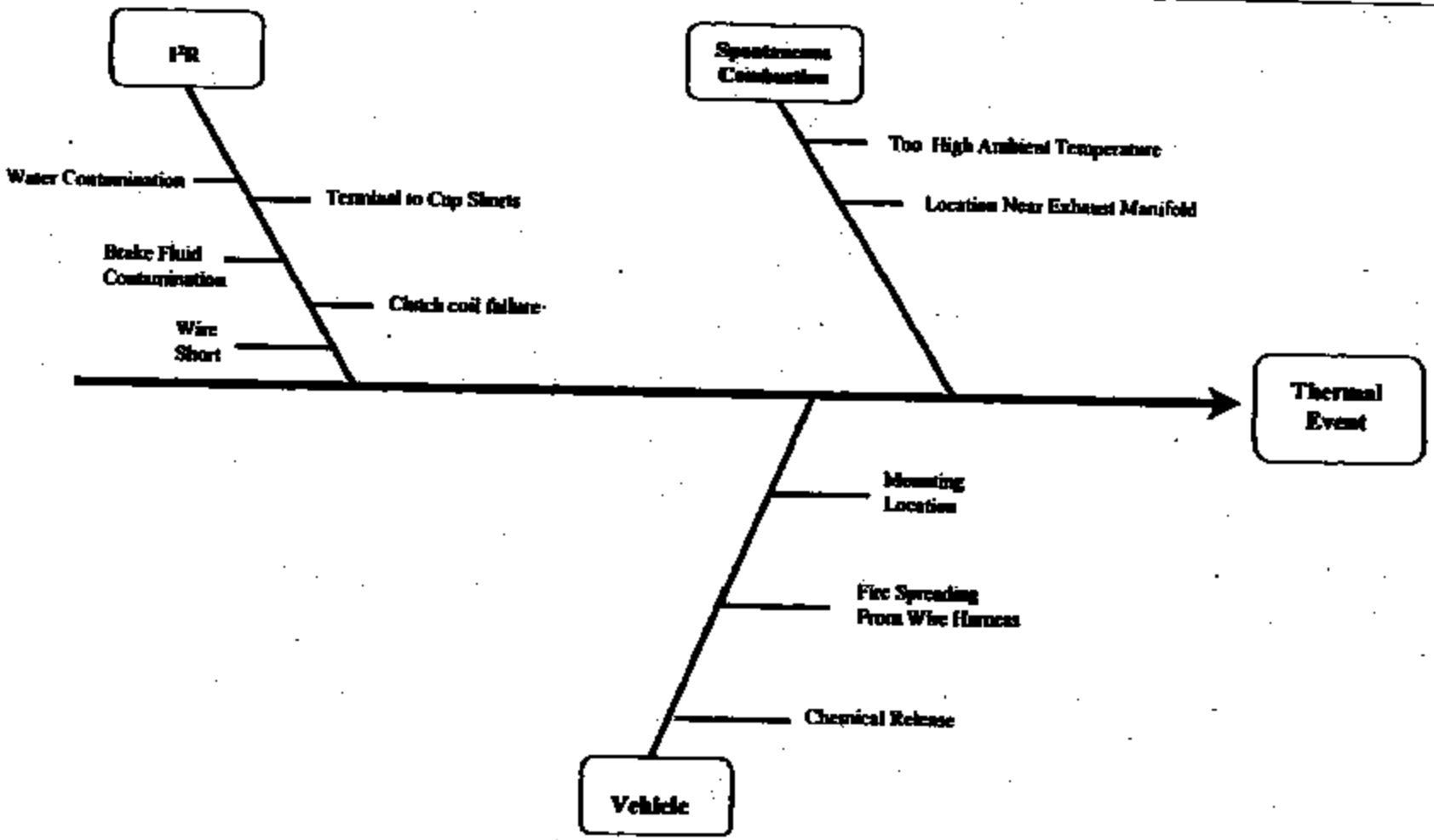


Brake Switch Overview

- Mounted under hood…14 inches under master cylinder
- Mounted on proportional valve at frame of vehicle
- Switch oriented approximately 25 degrees off vertical (connector up)
- Switch controls speed control…normally closed, opens at 130 psi
- Continuously powered by battery 15 amp connection

TEXAS INSTRUMENTS

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



TI-NHTSA 013870

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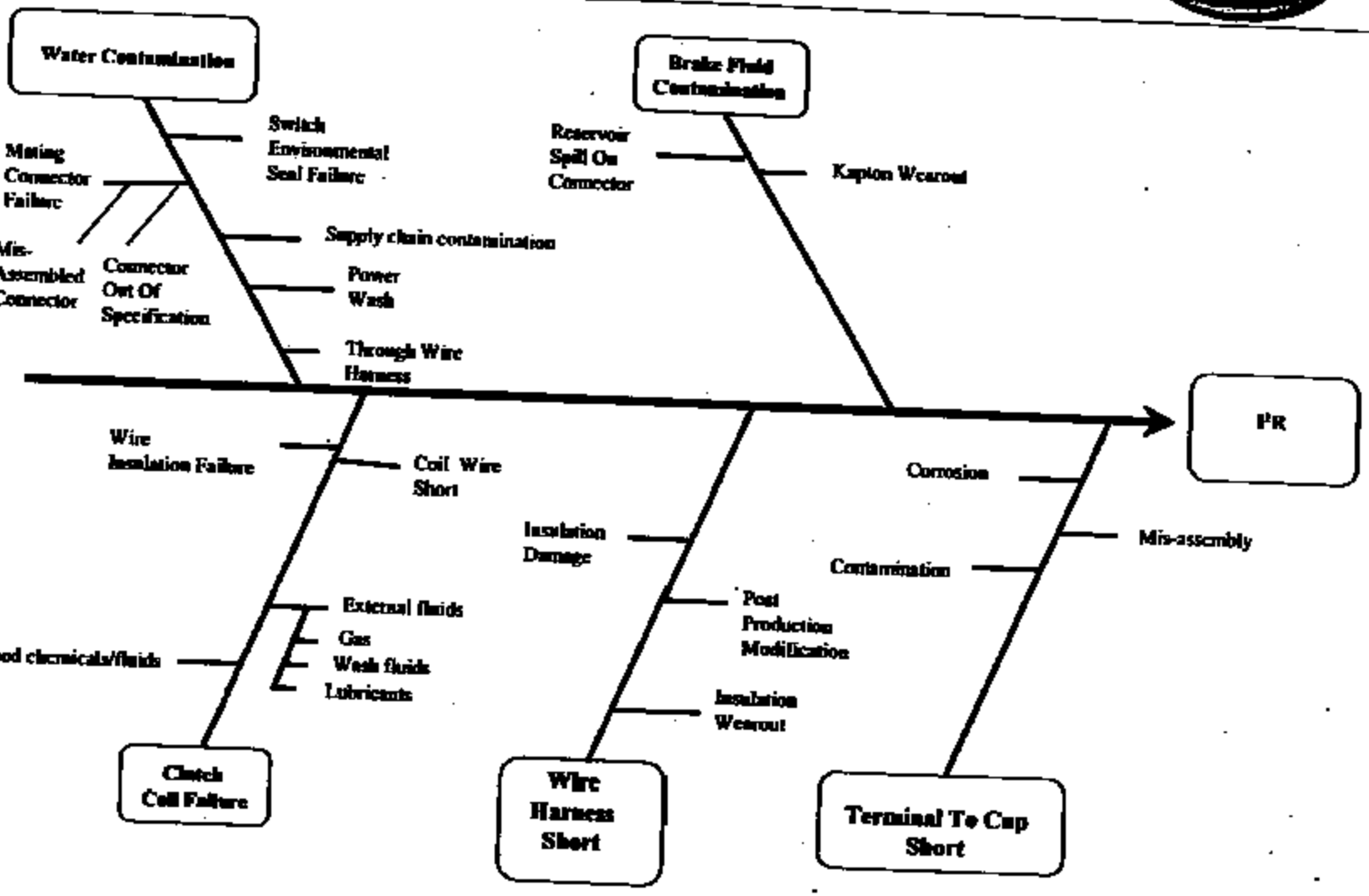
Attachment

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

TEXAS INSTRUMENTS



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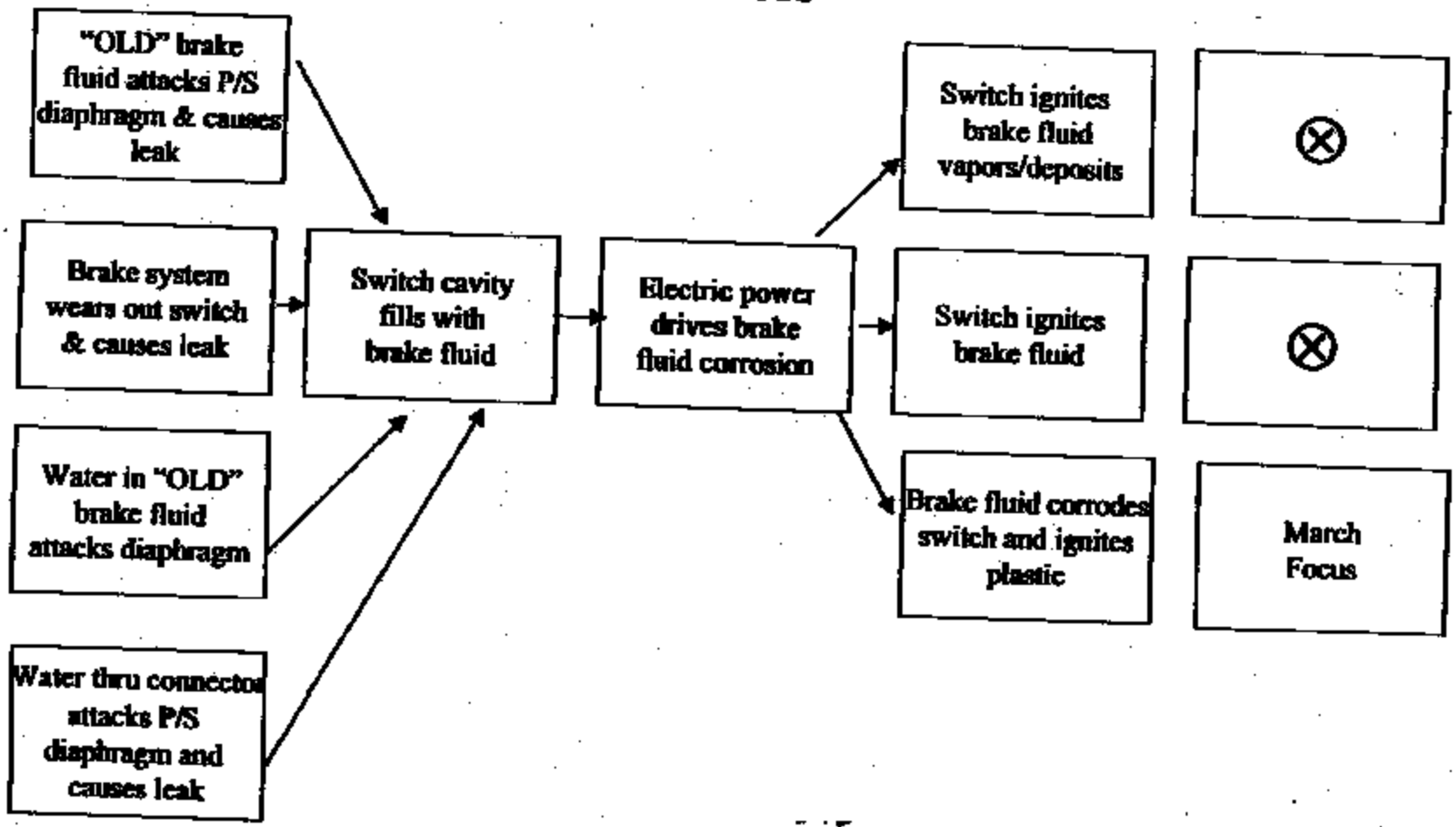
TEXAS INSTRUMENTS

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

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



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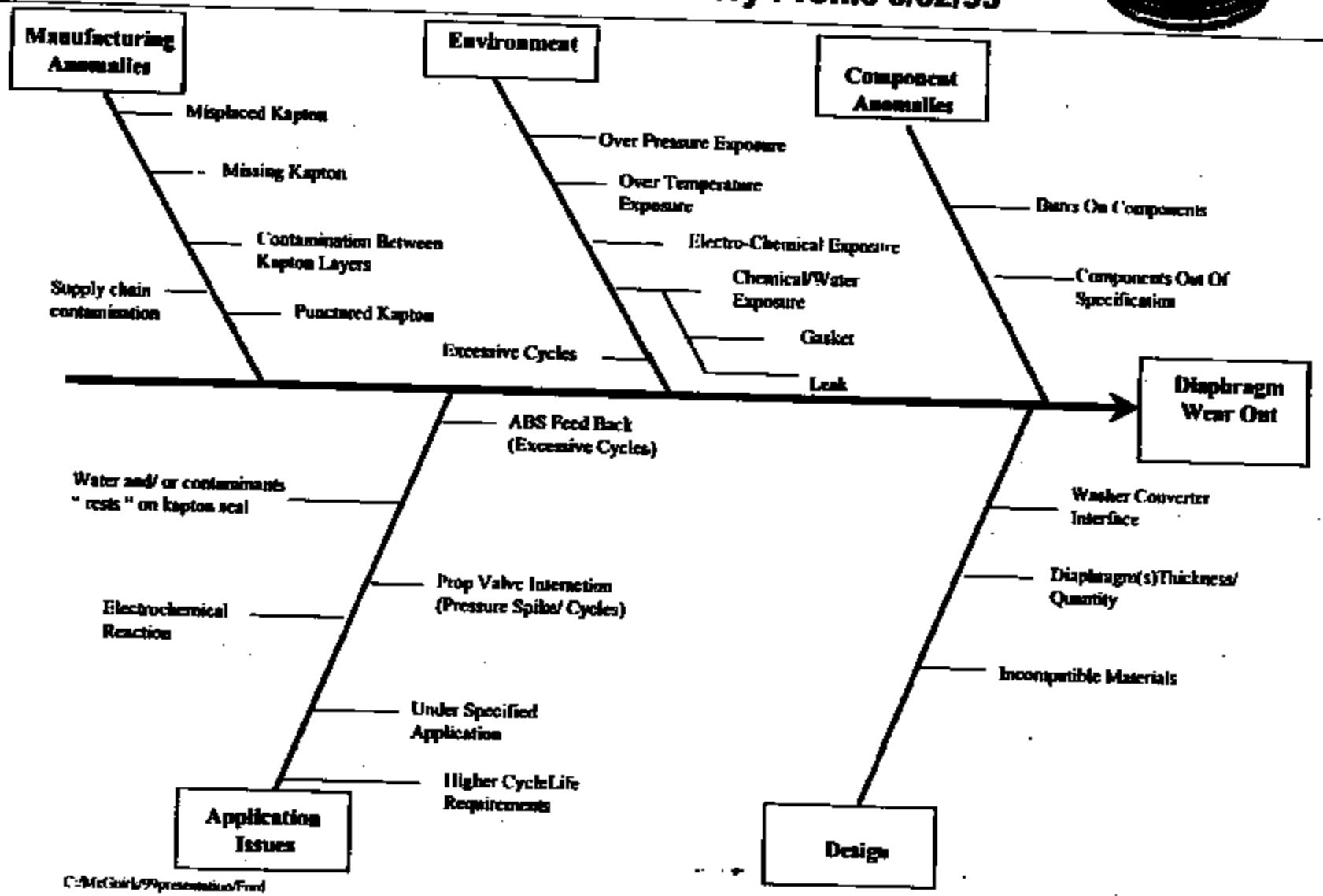
- TI and Ford not successful in creating ignition with "new" brake fluids

TEXAS INSTRUMENTS

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



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TEXAS INSTRUMENTS

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

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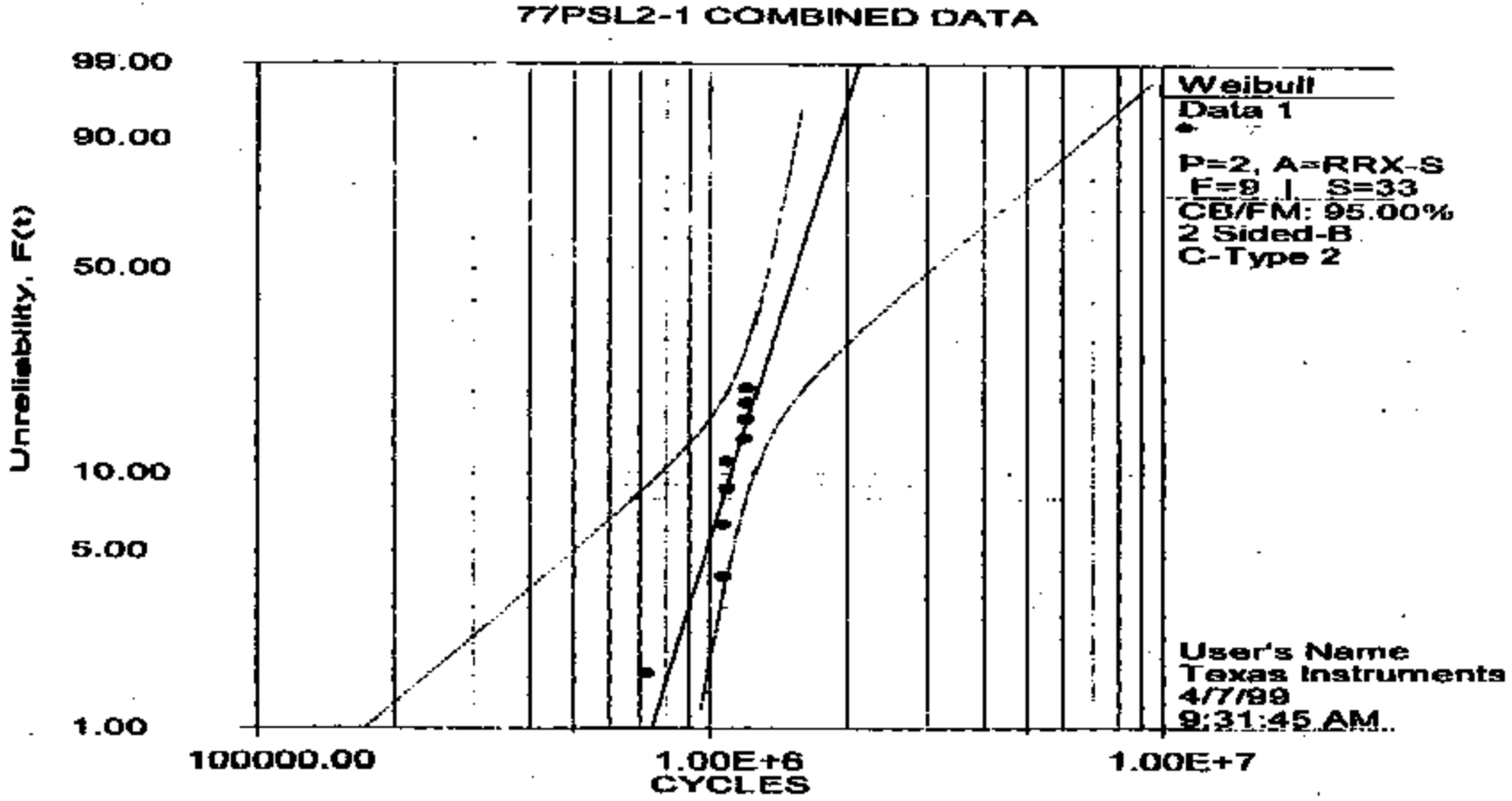

β=5.83, η=1.64E+6, ρ=0.91

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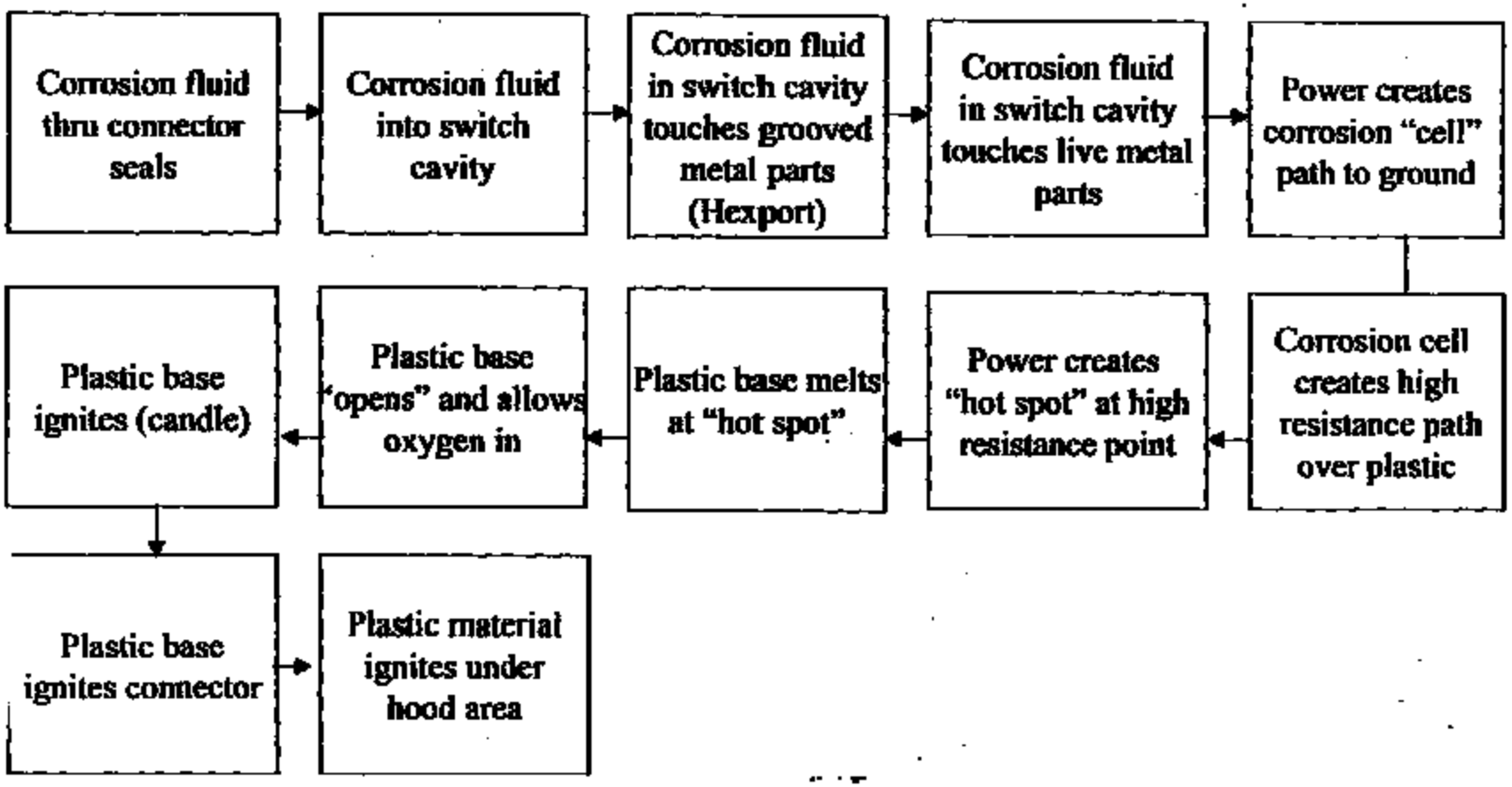
TI-NHTSA 013875

- "Town Car" switch meets accelerated/simulated life cycle specification shown by "success" and "end-of-life" testing

PROCESS FLOW DIAGRAM
"CORROSION" POTENTIAL CAUSE FLOW ANALYSIS



Texas Instruments

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

Ford

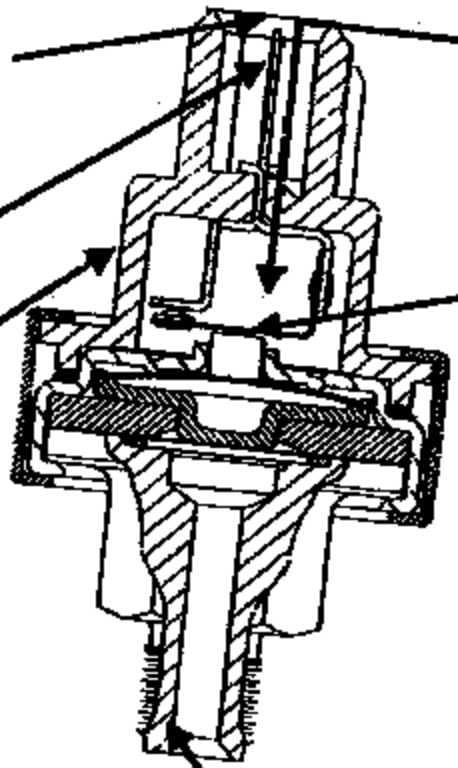
5. High current flow to case through water and ionic contamination

1. Water and "ionic" contamination (e.g. NaCl or cleaner) enters the switch cavity

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

4. Contact arm& terminal corrosion increases resistance (acts like heater wire).

6. Plastic connector melts. Once it opens, oxygen enters the switch cavity. Arm terminal/corrosion becomes "RED HOT" igniting the plastic



3. Hexport grounded accelerates corrosion

TI-WHTBA 013878

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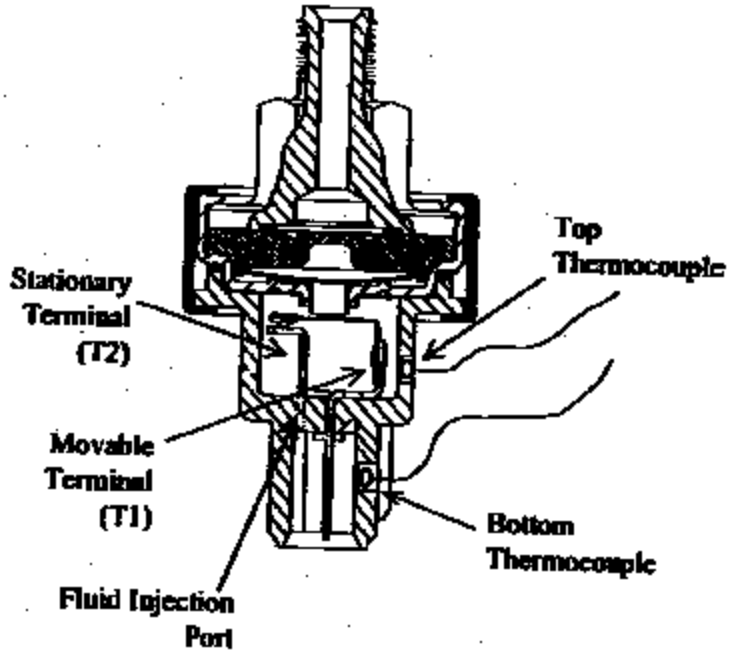
Attachment

5% Salt Water Ingress Experiment
Test 1



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03/15/99

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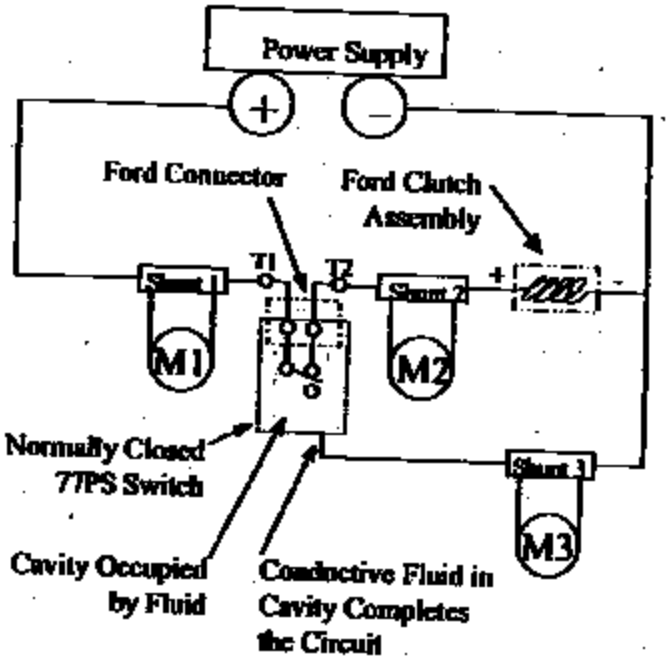


Test 1: Figure 1 and Figure 2.

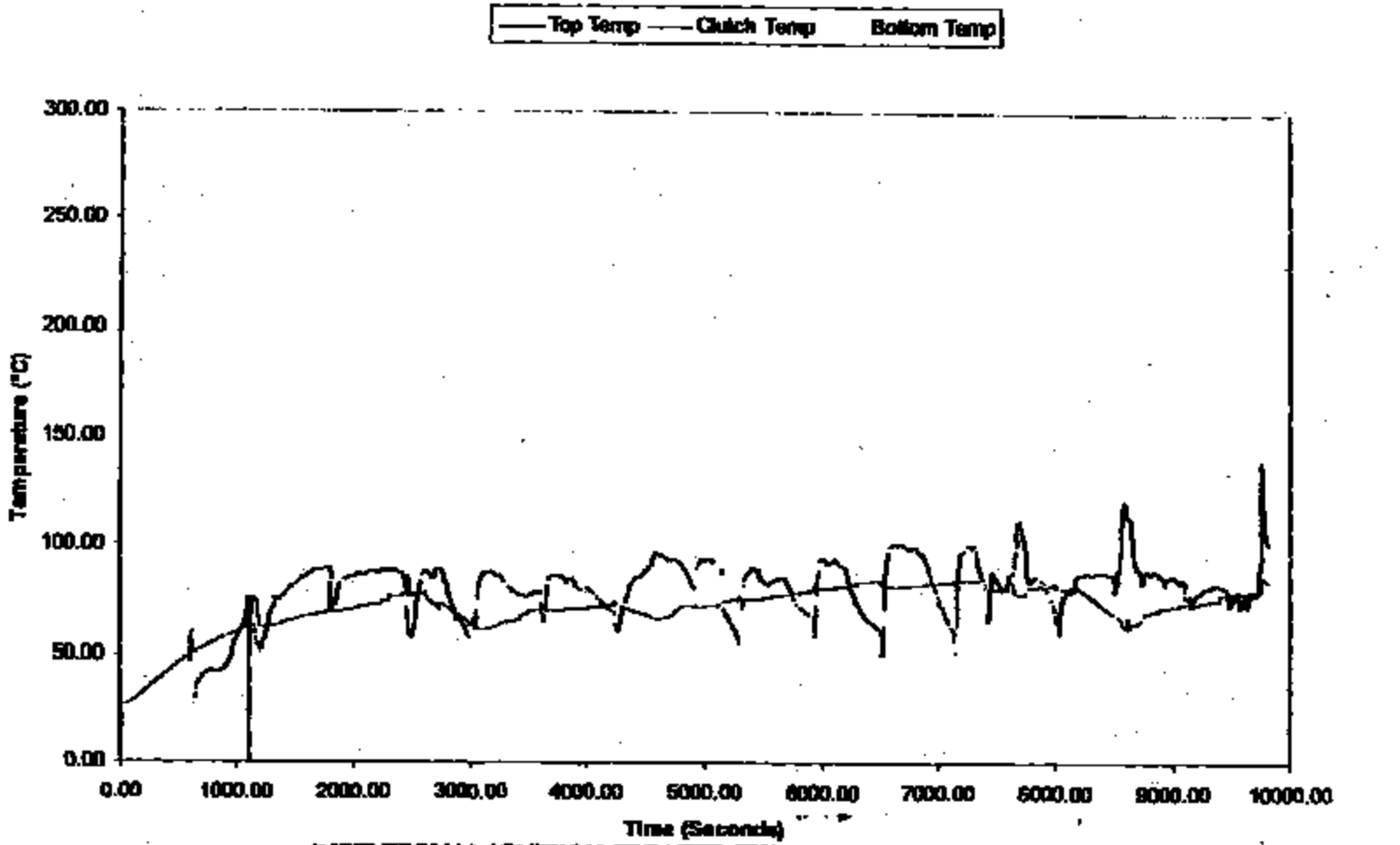
Attachment

TI-NHTSA 013878

Texas Instruments

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

5% Salt Water Ingress Experiment
Temperature vs. Time



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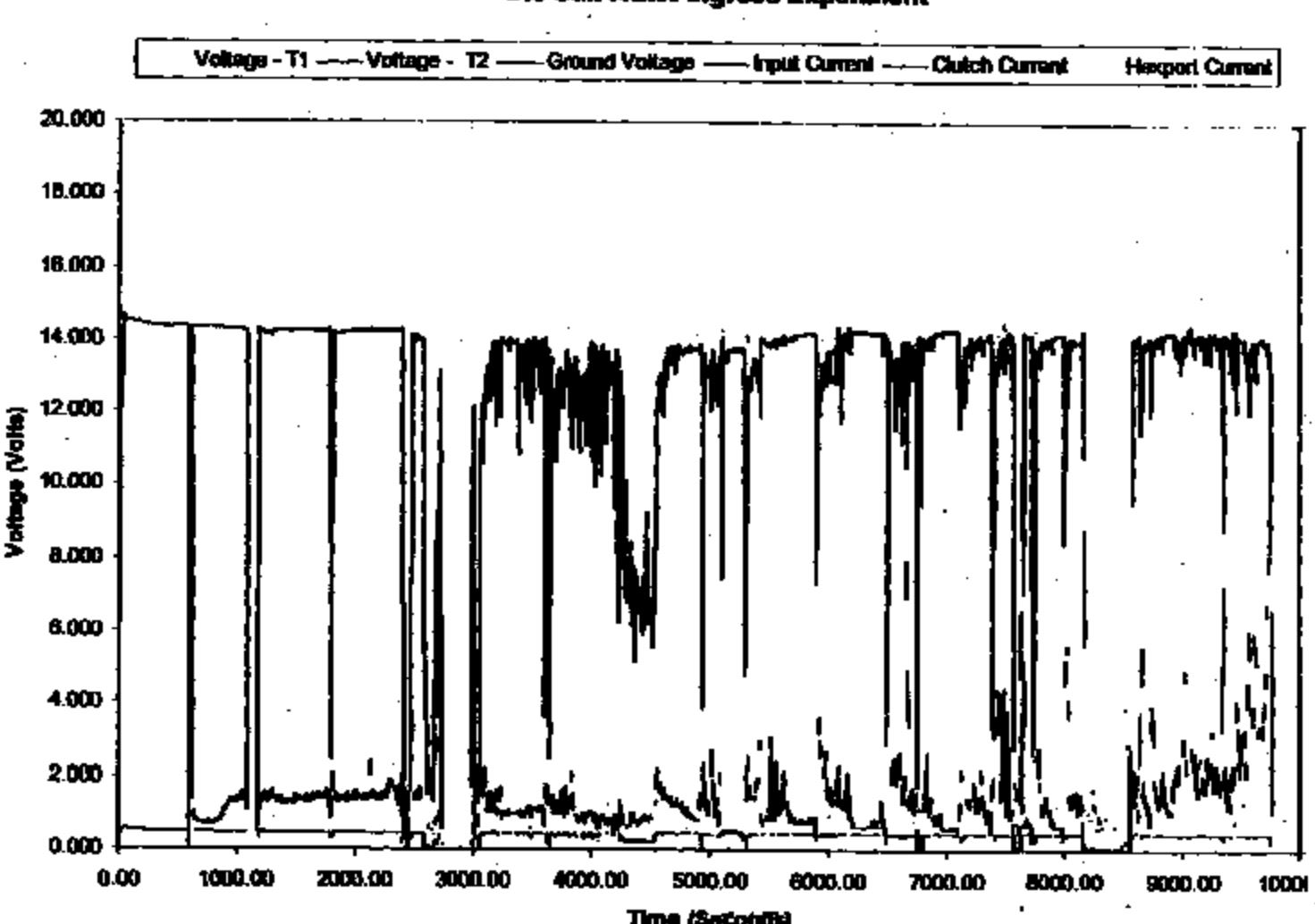
TL-NHTSA 013880

TEXAS INSTRUMENTS

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



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Texas Instruments

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

Ford

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

Cellanex 4300 Base

Cellanex 3316 Base

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

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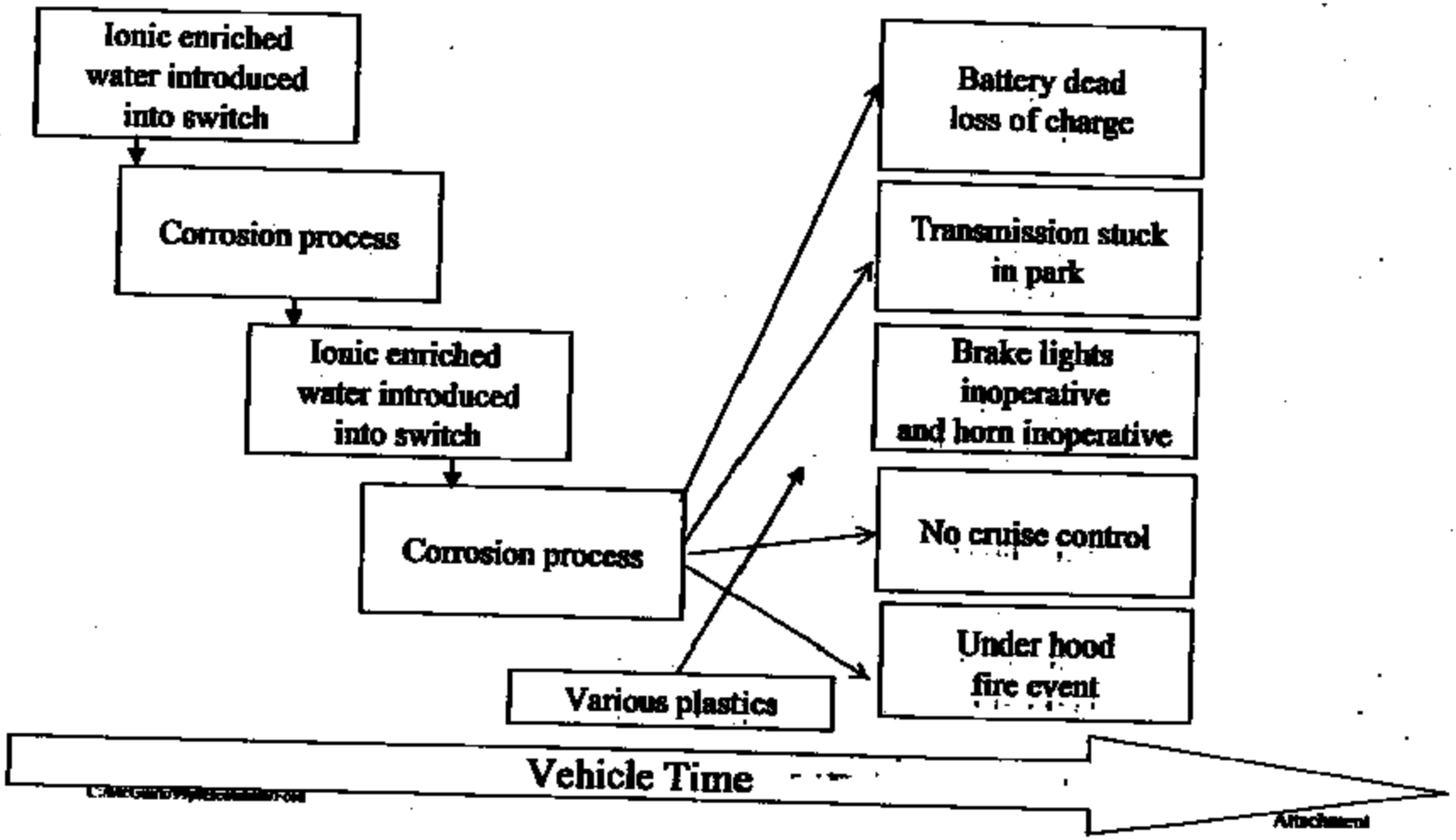
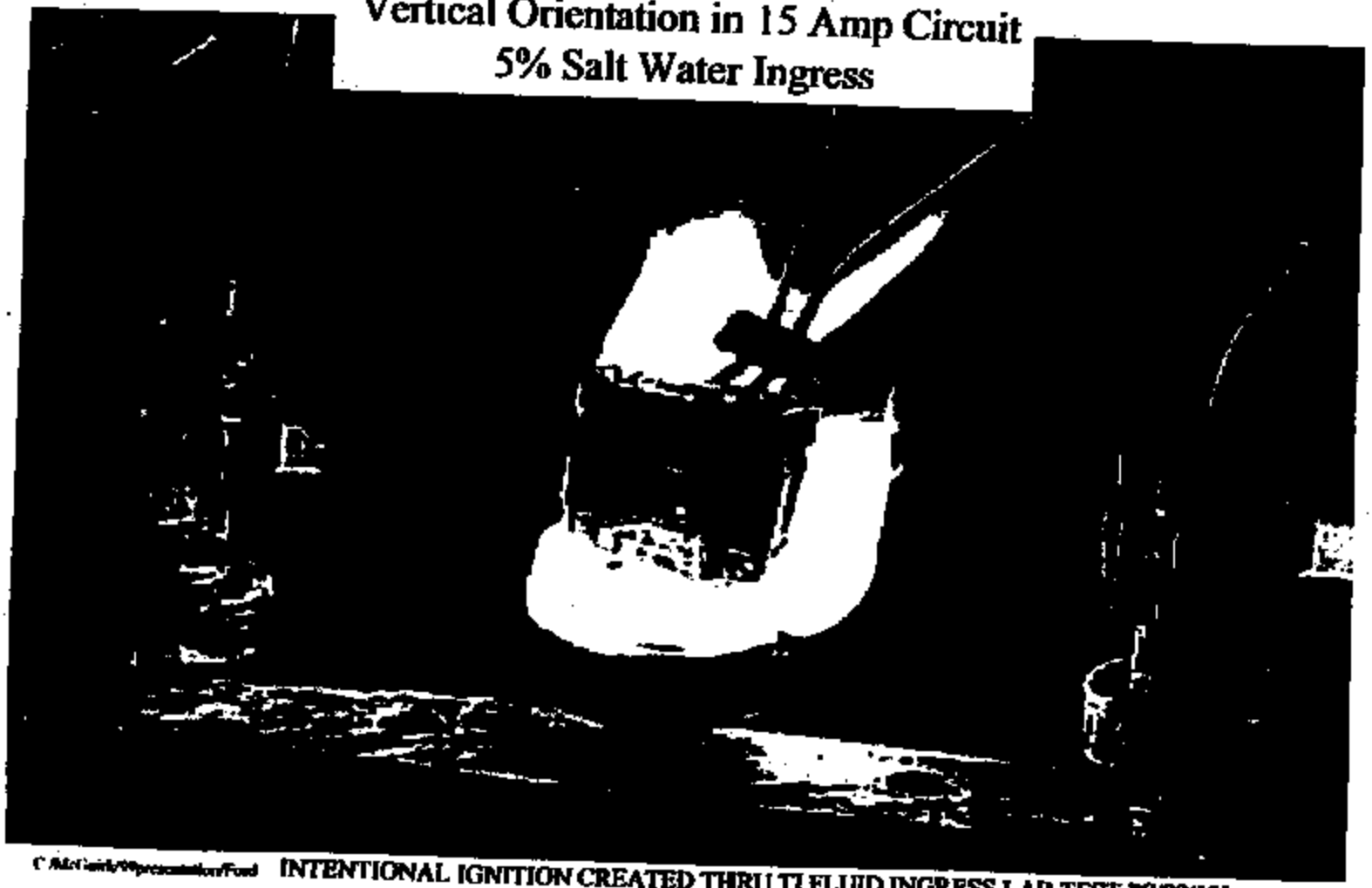
TI-NHTSA 013882

"Corrosion" potential cause time line
Theory Time Line



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



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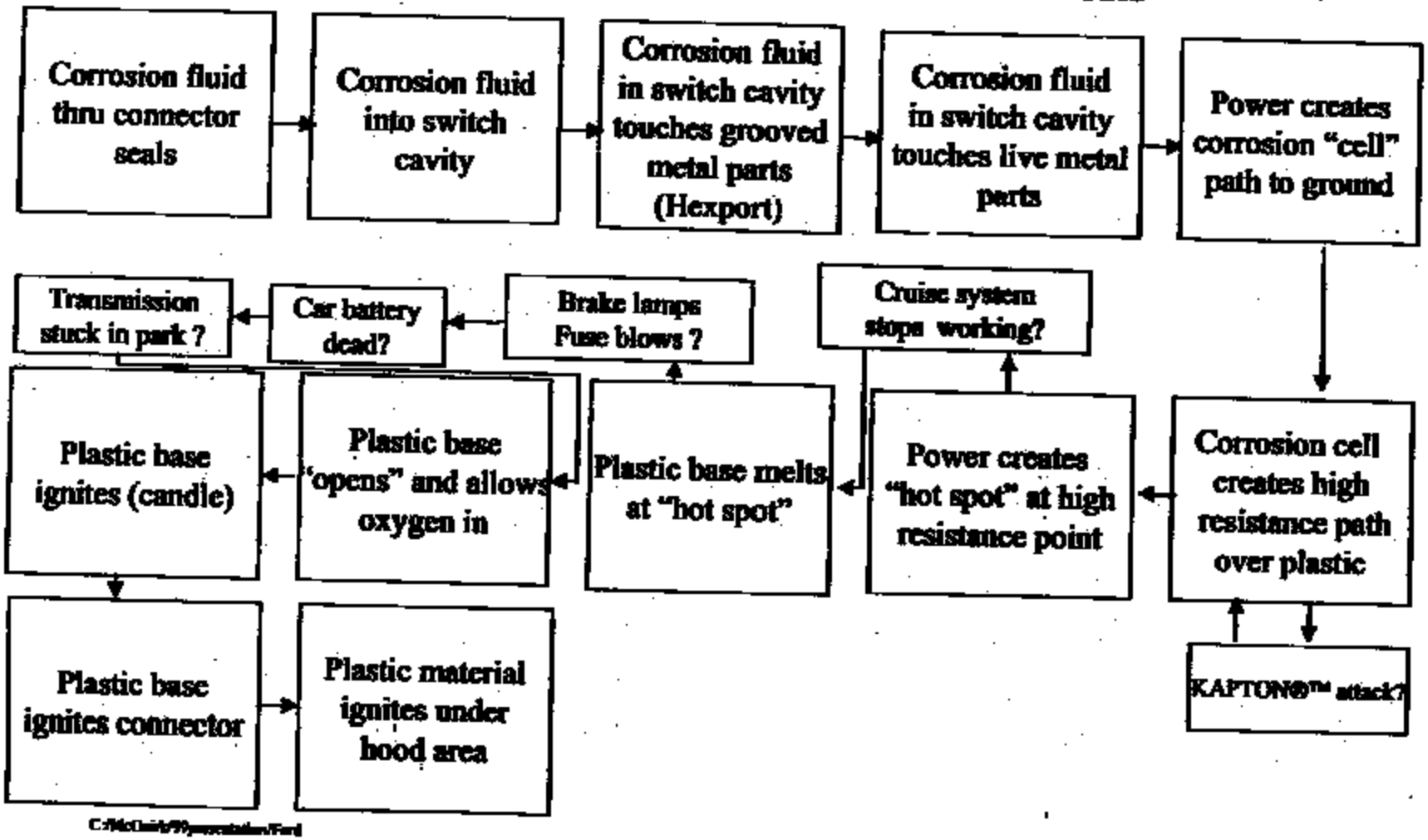
PROCESS FLOW DIAGRAM
"CORROSION" POTENTIAL CAUSE FLOW ANALYSIS



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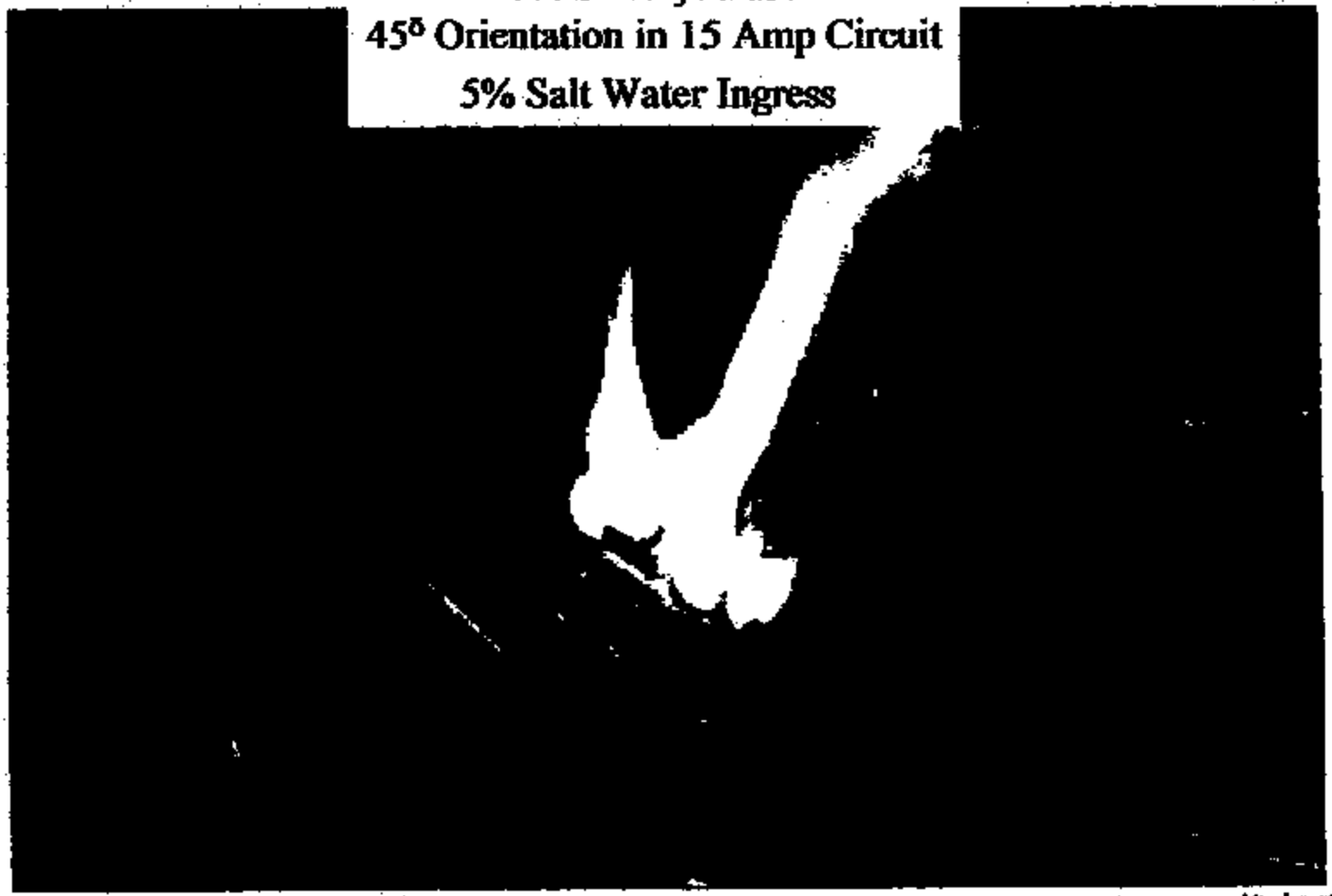
TI-NHTSA 013885

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



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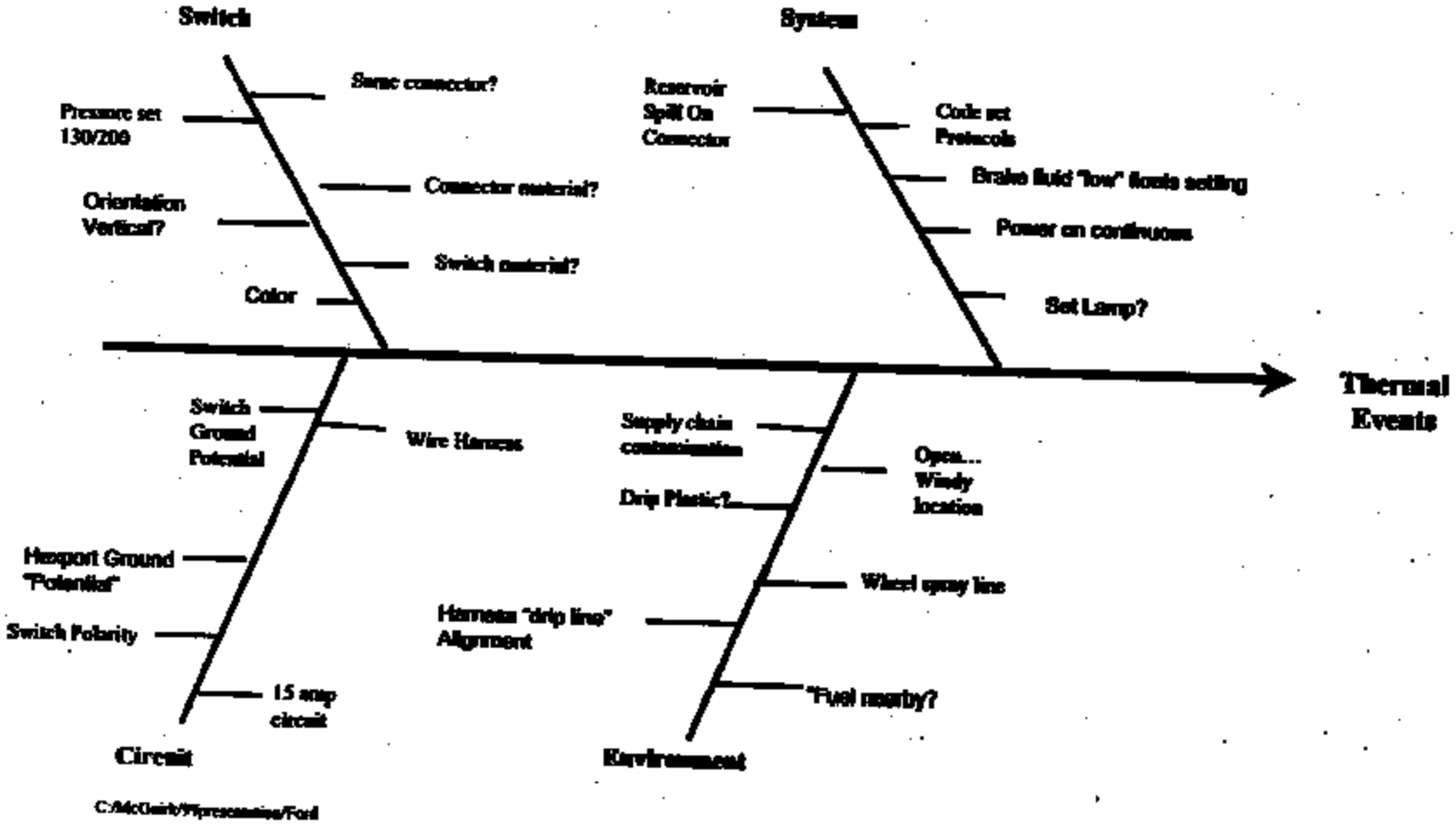
ECONOLINE VS. TOWN CAR P/S



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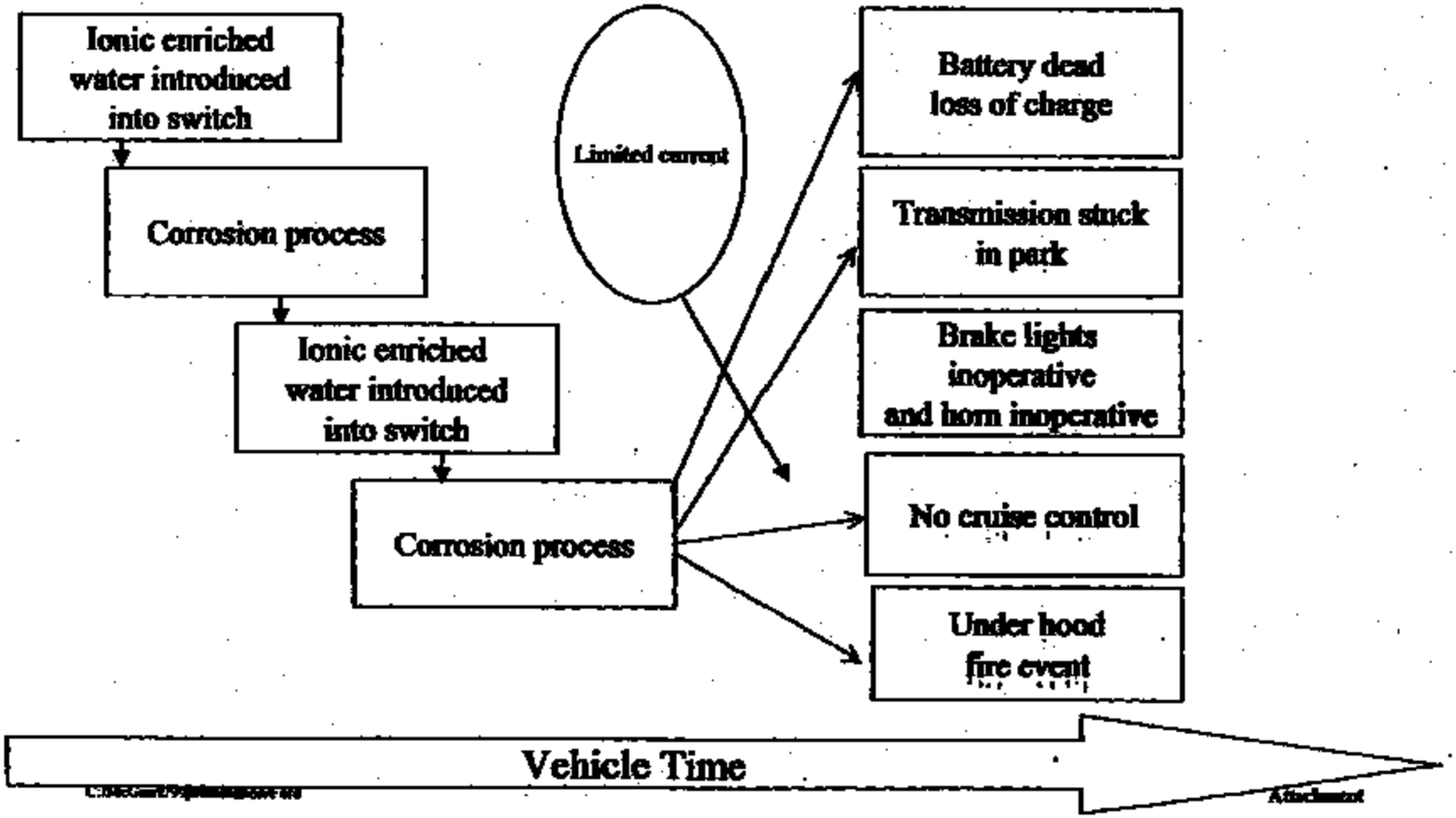
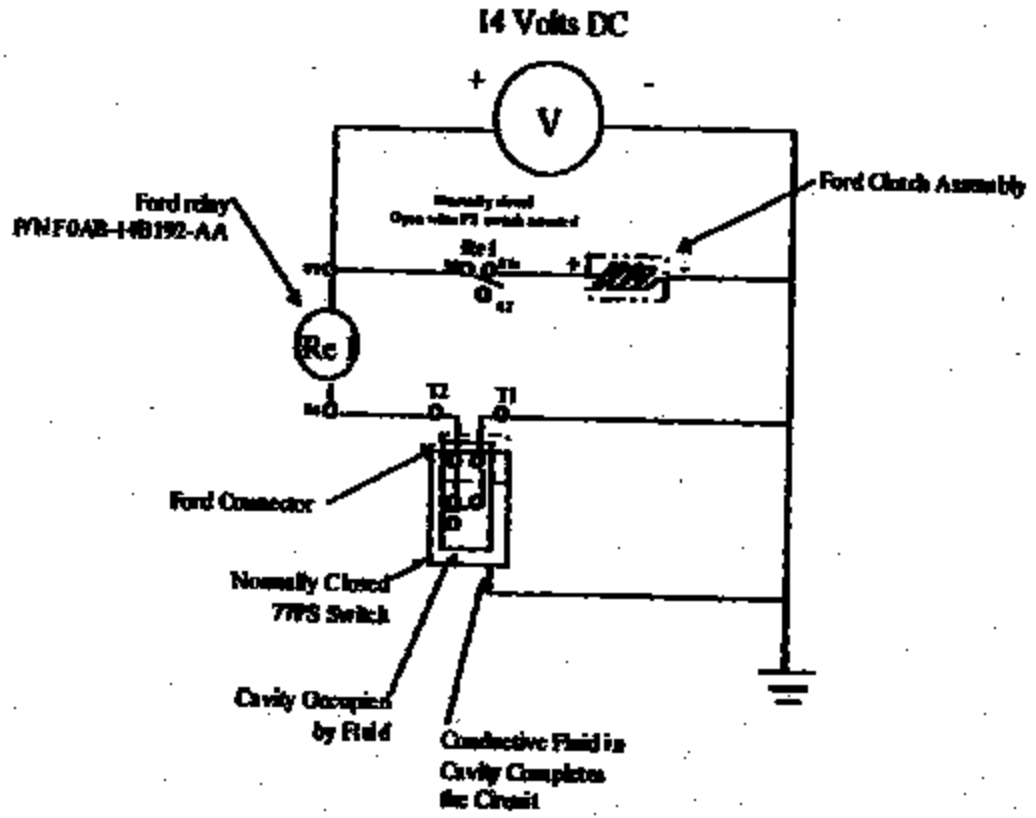
Attachment

"Corrosion" potential cause time line
Theory Time Line



77PS Proposed Wiring Schematic



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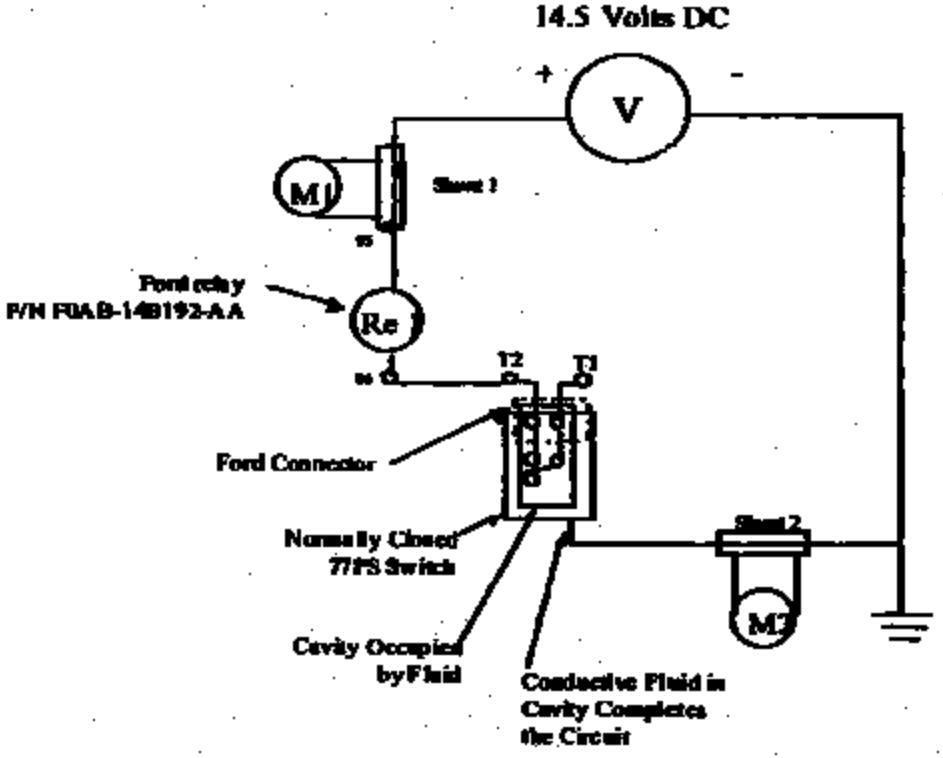
Attachment

200 mAmp Current Limit Circuit
Test Setup



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

TI-NHTSA 013890

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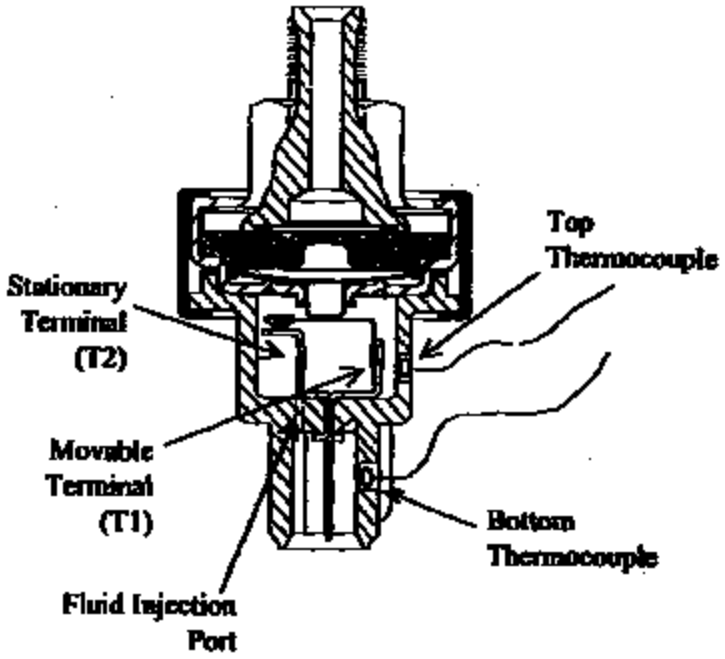
Attachment

5% Salt Water Ingress Experiment
Test 1



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03/15/99

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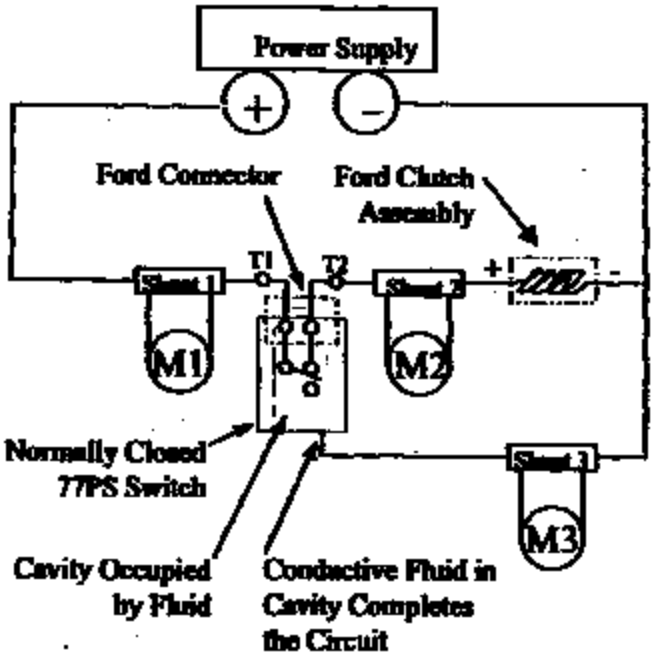
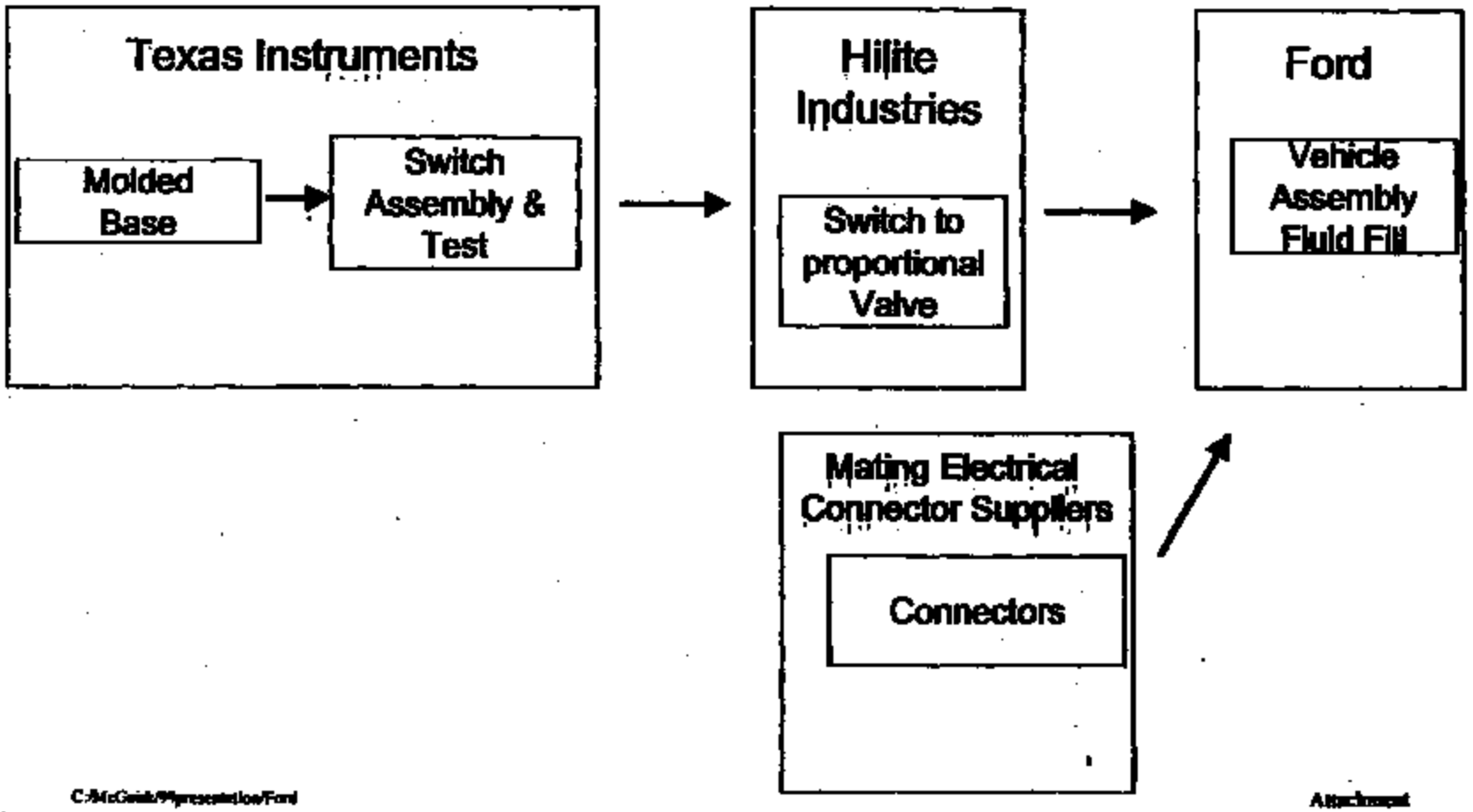


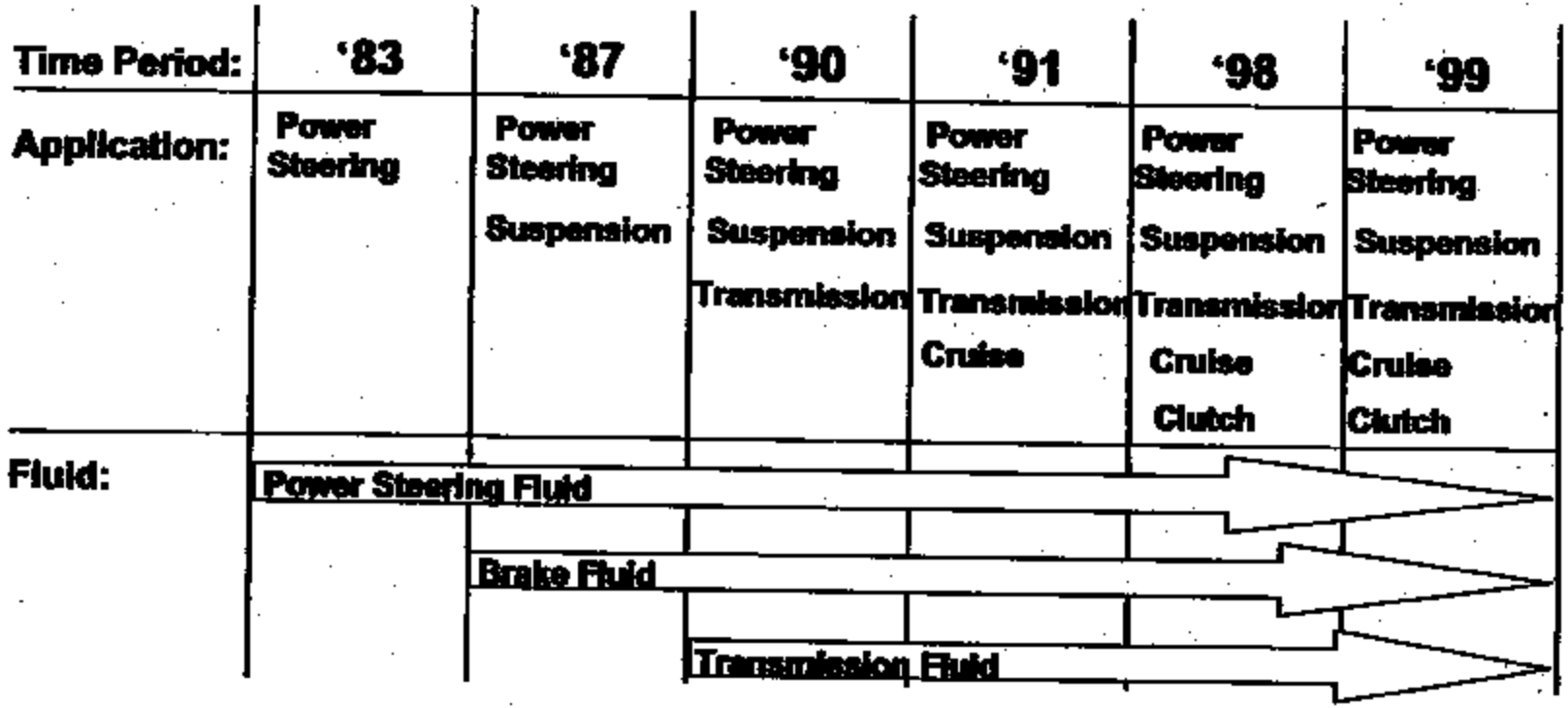
Test 1: Figure 1 and Figure 2.

Attachment

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



NA Hydraulic Switch History



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Attachment

TI-NHTSA 013883

TEXAS INSTRUMENTS

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

77pst2-1		GROSS QTY		COMPLETE	COMPLETE	BEGIN	IMPACT	COMMENTS/CONCERNS
COMPONEN	DESCRIPTIO	REQUIRED	SUPPLIER	6WK	2WK	PARTIAL	TO TI	
27408-1	CONVERTER	2,040,000	KF BASSLE	10 WKS	18 WKS	2 WKS	NONE	ADD OVERTIME/MATERIAL AVAILABILITY
27639-1	WASHER/A	2,040,000	DEMASIER	10 WKS	18 WKS	2 WKS	NONE	MATERIAL AVAILABILITY
27713-1	CUP 77PS	2,040,000	VALENDINE	6 WKS	10 WKS	1 WK	NONE	RAW MATERIAL AVAILABILITY
36858-27	57PS	2,040,000	DISC DEPT	12+ WKS	24 WKS	3 WKS	TOOL $?	POSSIBLE CAPACITY ISSUE
36900-1	HEXPORT 7	2,040,800	JELCO	10 WKS	25 WKS	3 WKS	NONE	RAW MATERIAL AVAILABILITY
74224-1	KAPTON	204	E DUPONT	2 WKS	2 WKS	2 WKS	NONE	
27225-1	KAPTON SI	1,102	E DUPONT	3 WKS	3 WKS	2 WKS	NONE	
74353-1	GASKET	2,040,000	JEL PARKER	8 WKS	16 WKS	3 WKS	NONE	ELIMINATE CORES WILL INCREASE DEL BY 10%
36866-1	STATIONAR	2,040,000	KF BASSLE	10 WKS	18 WKS	2 WKS	NONE	ADD OVERTIME/MATERIAL AVAILABILITY/ REELS
28744-1	CONTACT-S	2,040,000	DERINGER	4 WKS	8 WKS	1 WK	NONE	MATERIAL AVAILABILITY
36867-1	MOVABLE T	2,040,000	KF BASSLE	10 WKS	18 WKS	2 WKS	NONE	ADD OVERTIME/MATERIAL AVAILABILITY/REELS
27716-1	BEGU ISSUE	449	BRUSHWEL	1 WK	2 WKS	1 WK	NONE	NONE
74016-1	RIVET	2,040,000	JOHNHASS	8 WKS	11 WKS	4 WKS	NONE	RAW MATERIAL AVAILABILITY
40515-2	PRESSURE S	2,040,000	MEMOLDIN	16 WKS	32 WKS	4 WKS	NONE	RAW MATERIAL CHANGEOVER/PRESS CAPACITY
74076-143	CERAMIN PI	2,040,000	PARATECH	7 WKS	15 WKS	2 WKS	NONE	
74247-4	BLUE ORING	2,040,000	JEL PARKER	6 WKS	10 WKS	2 WKS	NONE	ELIMINATE CORES WILL INCREASE DEL BY 10%
74797-1	CRIMP RING	2,040,000	VALENTINE	6 WKS	10 WKS	1 WK	NONE	RAW MATERIAL AVAILABILITY
74868-1	RED THREA	2,040,000	MARK V CA	3 WKS	6 WKS	1 WK	NONE	

77PS	SWITCH	TI	7/15,8/1,8/1	250K/MONTH		7 day weeks, thru summer vacations, 'old' plastic mold

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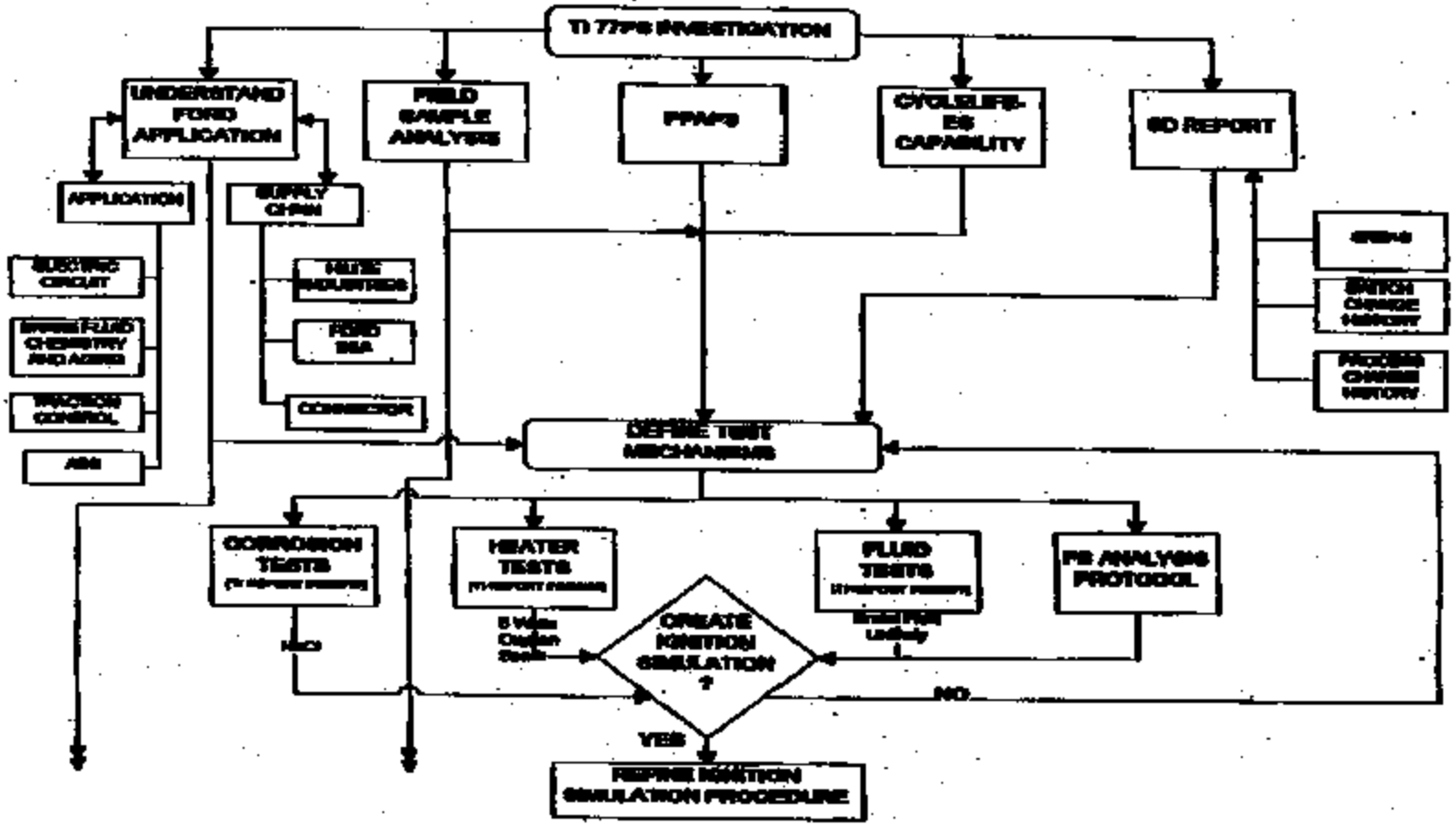
Attachment

TI-NHTSA 013994

TEXAS INSTRUMENTS

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



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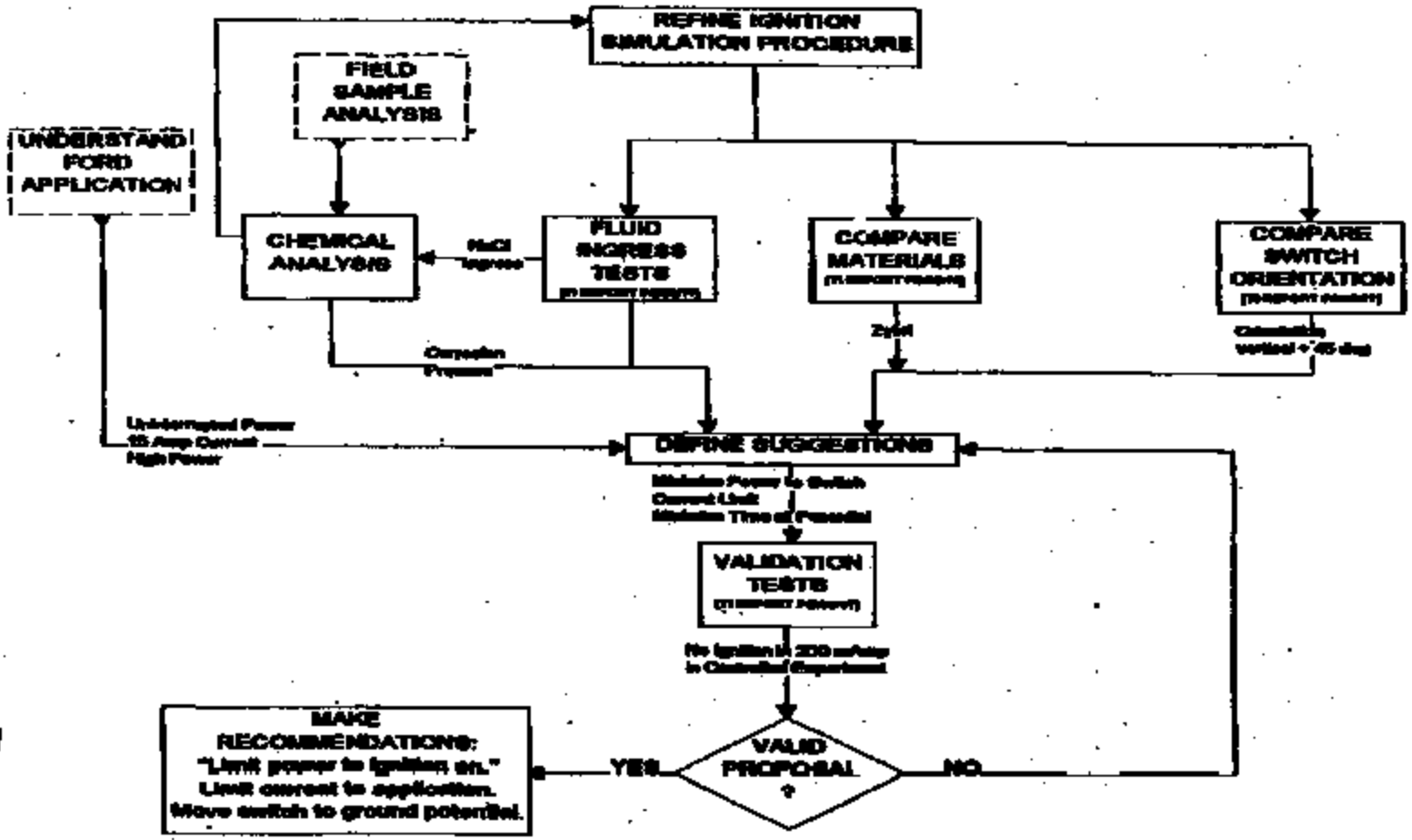
Attachment

TI-HHTSA 013806

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



TL-NHTSA 013806

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TEXAS INSTRUMENTS

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

Ford

Category	Test	Location	Test Parameters	Results Update
Lab Simulation of Potential Ignition In Switch	1	TI	Very water concentrations in "new" Brake Fluid 14Vdc to one terminal, Ioexport grounded Water Conc: 4%, 6%, 18%, 75%	250+ hours, Current draw in the 0.5mA to 5mA range Fluid has discolored. No Significant Temperature Rise. Test Suspended. Internal Analysis suspended.
	2	TI	New Brake Fluid 1 Amp through switch terminals 14Vdc to one terminal, Ioexport grounded	250+ hours. Constant temperature. No significant temperature rise with time Test Suspended.
	3	AVT	"new" Brake Fluid in Switch, 24 VDC to one terminal. Ioexport Grounded	> 300 hours into test, max current 7mA No significant change with time. Test ongoing
	4	AVT	"new" Brake Fluid in Switch, 24 VDC to one terminal. Ioexport Grounded, Ambient at 100 C	18 hours into test max current 5mA No significant temperature rise with time. Test suspended.
	5	AVT	"new" Brake Fluid in Switch, 16 Amps through switch terminals	Temperature rise of 20 C above room temp Delta T reached steady state at 20 C. Test suspended.
	5a	AVT	"new" Brake Fluid in Switch approx. 50 Amps through Switch Terminals	Temperature rose to approx. 270 F. No smoke. No ignition Test suspended.
	6	TI	Build heater element into Switch. Heat till failure, include sparking. With Fluid & Dry	2 tested. Smoke observed, ignition observed on part w/heater Bias attachment Test complete Brake fluid is costly slows down heat build-up Smoke observed at 575 F. Base melts and falls off at 600 F
	6a	TI	Create heater by corroding spring area Salt water solution, 14V between spring and Ioexport	One out of 15 devices increased resistance to 5 ohms. Others either very low resistance or regardless It took about 100 hours to reach the 5 ohm stage. The 5 ohm device ignited under conditions similar to test 6.
	6b	TI	Re-run ignition test to understand repeatability and current path.	Switch ignition with repeated 5% water solution into switch Current path is through Ioexport. See plots and video. Additional test include tap water, old BF, new BF and other.

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TI-NHTSA 013997

TEXAS INSTRUMENTS

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

	6c	TI	Flow 'new' brake fluid w/ Fe metal shavings	Metal shavings do not contribute significantly to brake fluid conductivity
Life Cycle Reliability of Pressure Switch	7	TI	0-1400 psig pressure pulses at 125C per SS	Fluid leak observed at 720,000 cycles. Test Completed. See attached Weibull Chart.
Diaphragm Wear	8	TI	0-1400 psig pressure pulses at 125C.	Parts withdrawn every 200K cycles, characterized for wear
Field vs Lab Correlation	9	Central Labs	Fluids returns, from dealer lots, junkyards	Parts to Central Labs, see Fluid spreadsheet
Design Of Experiments (1) Evaluating Factors Shooting Diaphragm Wear Impulse test	10	TI	Vary w alter concentrations to 'new' Brake Fluid 12 temp + 12 cycle on lichen w/ 0 % w alter in BF 12 temp + 12 cycle on lichen w/ 5 % w alter in BF	Test Report being written investigation continues. Suspended at 1.2 million cycles with no leaks observed. Temp samples suspended at 1.5 million cycles with 2 leaks observed at 1.3M. Cyclic samples suspended at 800k cycles to assess flattening mechanism.
On-Vehicle Characterization of Pressure & Temperature Profile in Tow'n Car	11	AVT	Monitor Pressure and Temperature at Switch Location for ABS and non-ABS braking events.	Test at AVT.....was Fluid change...>500k in car?
Brake fluid analysis Used fluid at master cylinder.	11a	TI	Analyze used brake fluid at the master cylinder (UMC), used brake fluid at the caliper (UCA) and new brake fluid (NEW) for metal and w alter content.	Test complete. UMC: Cu = 418 (ug/ml), Fe = 5.8 (ug/ml), Cr = 0.65 (ug/ml), 1.1 %H20. UCA: Cu = 882 (ug/ml), Fe = 5.8 (ug/ml), Cr = 1.9 (ug/ml), 1.1 %H20. NEW: Cu = <0.01 (ug/ml), Fe = 0.82 (ug/ml), Cr = <.01 (ug/ml), 0.3 %H20.
Spark Arc Study	12	Central Labs	Determine if arc/spark forms in switch using clutch brake and high speed video. Use dry switches as well as switches with various brake fluid w alter mixes.	Equipment set-up in progress at Central Labs. TI Experimented with no 'significant' sparks observed
Characterization of switches retrieved from field junkyards & other sources	13	Central Labs	Characterize electrical, mechanical and chemical aspects of returned switches	Data log and analysis procedure set up complete. Analysis of switches in progress.
Fluid Ingress Tests	13a	TI	Repeat ignition simulation with different fluids. (3) long tests: 3% NaCl in Dip w alter Rain w alter (24 hour tests: Dip w alter Used brake fluid Used brake fluid w / 3% H2O New brake fluid New brake fluid w / 6% H2O	Test complete. 3% NaCl sample resulted in an ignition. All brake fluid samples drew less than 3 mAmps. No corrosion visible on brake fluid samples. Rain w alter and Dip w alter samples drew <10 mAmps and showed some degree of corrosion. Chemical analysis in process.

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Attachment

TI-AHTBA 013099

TEXAS INSTRUMENTS

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

Compatibility of Kapton	14	Depont	Characterize change in properties of Kapton	Compatibility of Kapton	14	Depont	Characterize change in properties of Kapton
with Oxalic Acid			with various % oxalic acid in brake fluid.	with Oxalic Acid			with various % oxalic acid in brake fluid.
Evaluation of Plastic	15	TI	Assess properties and suitability of different	Evaluation of Plastic	15	TI	Assess properties and suitability of different
Materials with Improved			grades of plastic resin with additives	Materials with Improved			grades of plastic resin with additives
Parameters			to improve plastic part performance	Parameters			to improve plastic part performance
Long duration brake fluid	15a	TI	(4) samples with new brake fluid	Long duration brake fluid	15a	TI	(4) samples with new brake fluid
ingress test.			(2) samples with used brake fluid	ingress test.			(2) samples with used brake fluid
Evaluation of Switch	15b	TI	Assess ignition sensitivity to switch orientation.	Evaluation of Switch	15b	TI	Assess ignition sensitivity to switch orientation.
Orientation			Test vertical versus 45 degree.	Orientation			Test vertical versus 45 degree.
			Test rotational sensitivity in 45 deg. orientation.				Test rotational sensitivity in 45 deg. orientation.
Relay Circuit	16	TI	Repeat test 13a in Ford relay circuit for (48) hrs.	Relay Circuit	16	TI	Repeat test 13a in Ford relay circuit for (48) hrs.
Test			Bring switch to impending ignition in (15) Amp	Test			Bring switch to impending ignition in (15) Amp
			circuit then place in relay circuit for (18) hrs.				circuit then place in relay circuit for (18) hrs.
			Input max. circuit pow er into heater on switch.				Input max. circuit pow er into heater on switch.

TI-MHTBA 013686

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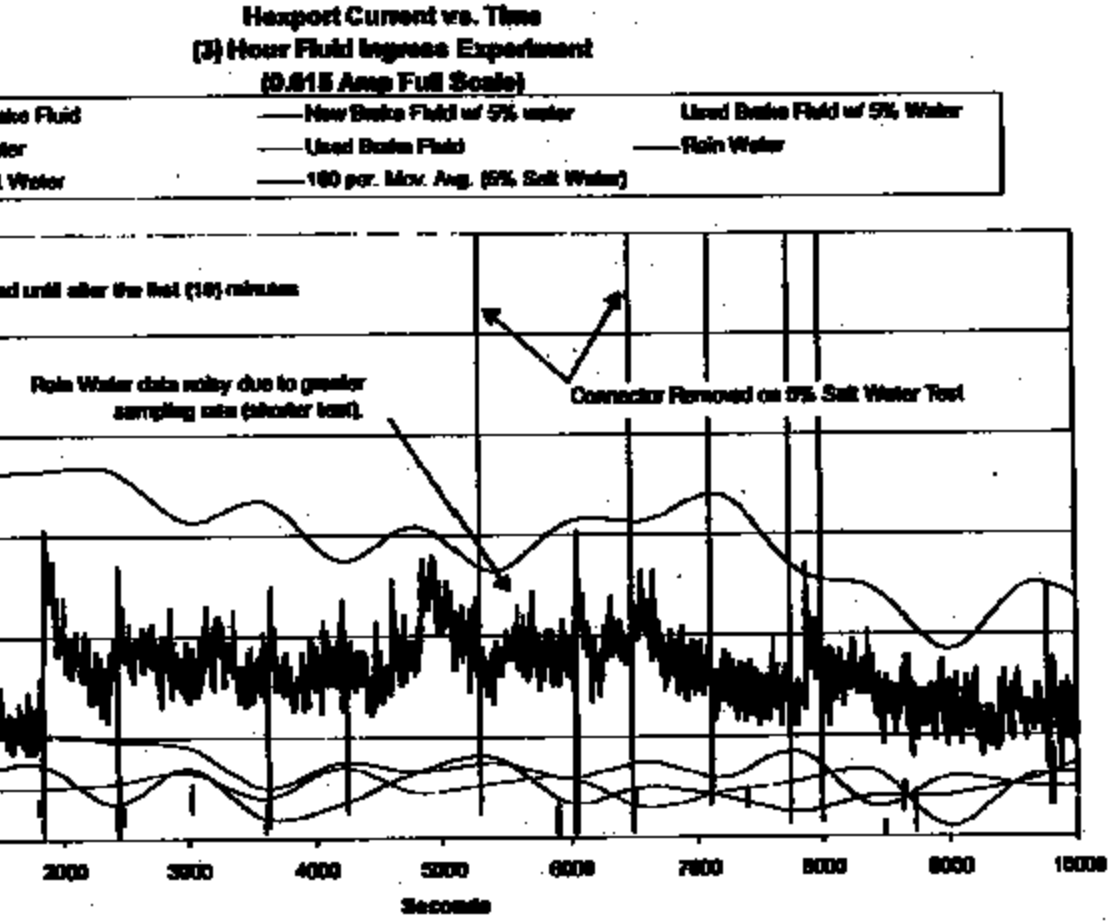
Attachment

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

Texas Instruments



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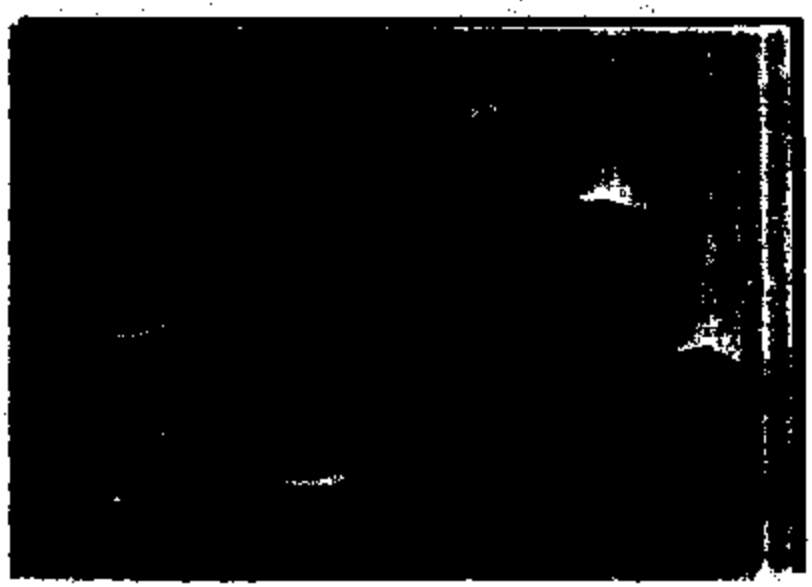
TI-NHTSA 013900

Low Cost
Automotive Pressure Switches



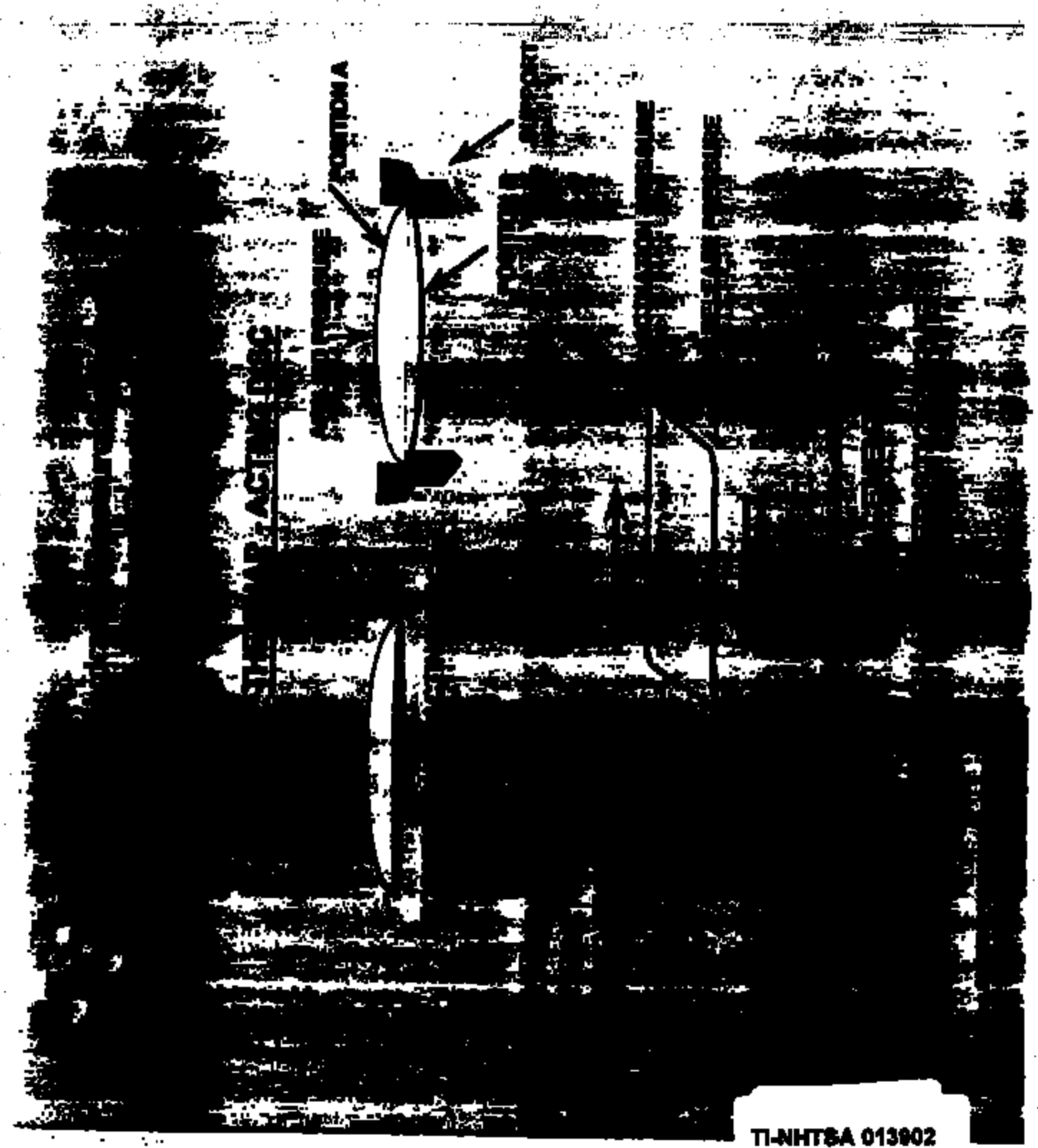
TI's pressure switches provide low cost, on/off controls for many automotive systems. The snap action disc reacts to changing pressure by reversing its curvature and activating electrical switch contacts.

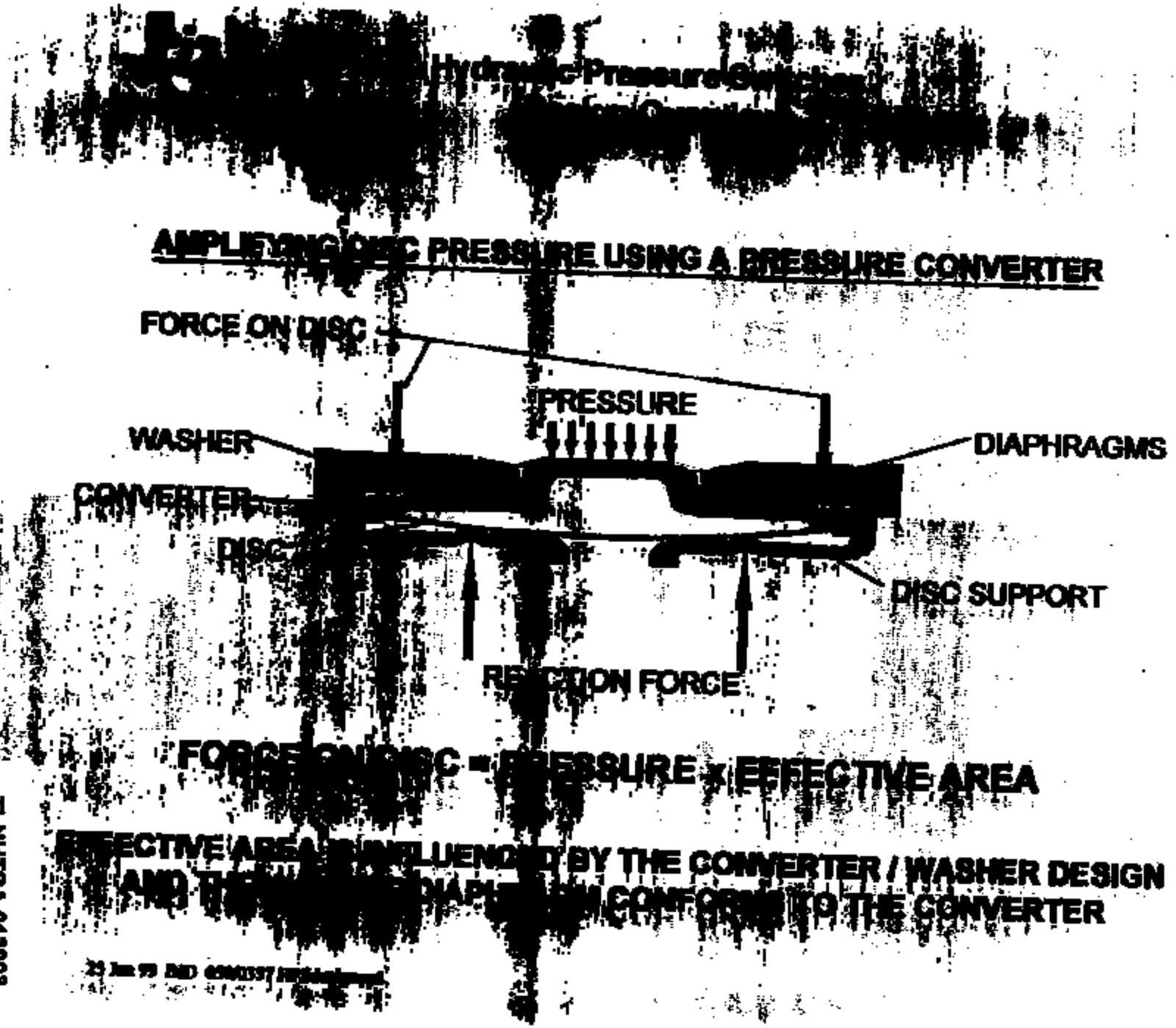
Key Features Include:

- Designed for underhood environment
- Designed for line or pump mount applications
- Low weight
- Custom packaging for specific application needs
- Automotive temperature range of -30 to 125°C
- Normally open and normally closed contact logic
- Industry proven since 1984

Typical Applications

- A/C systems
- Power Steering Systems
- Cruise Control Systems
- Brake Systems
- Transmissions
- Suspension


TI-NHTSA 013902



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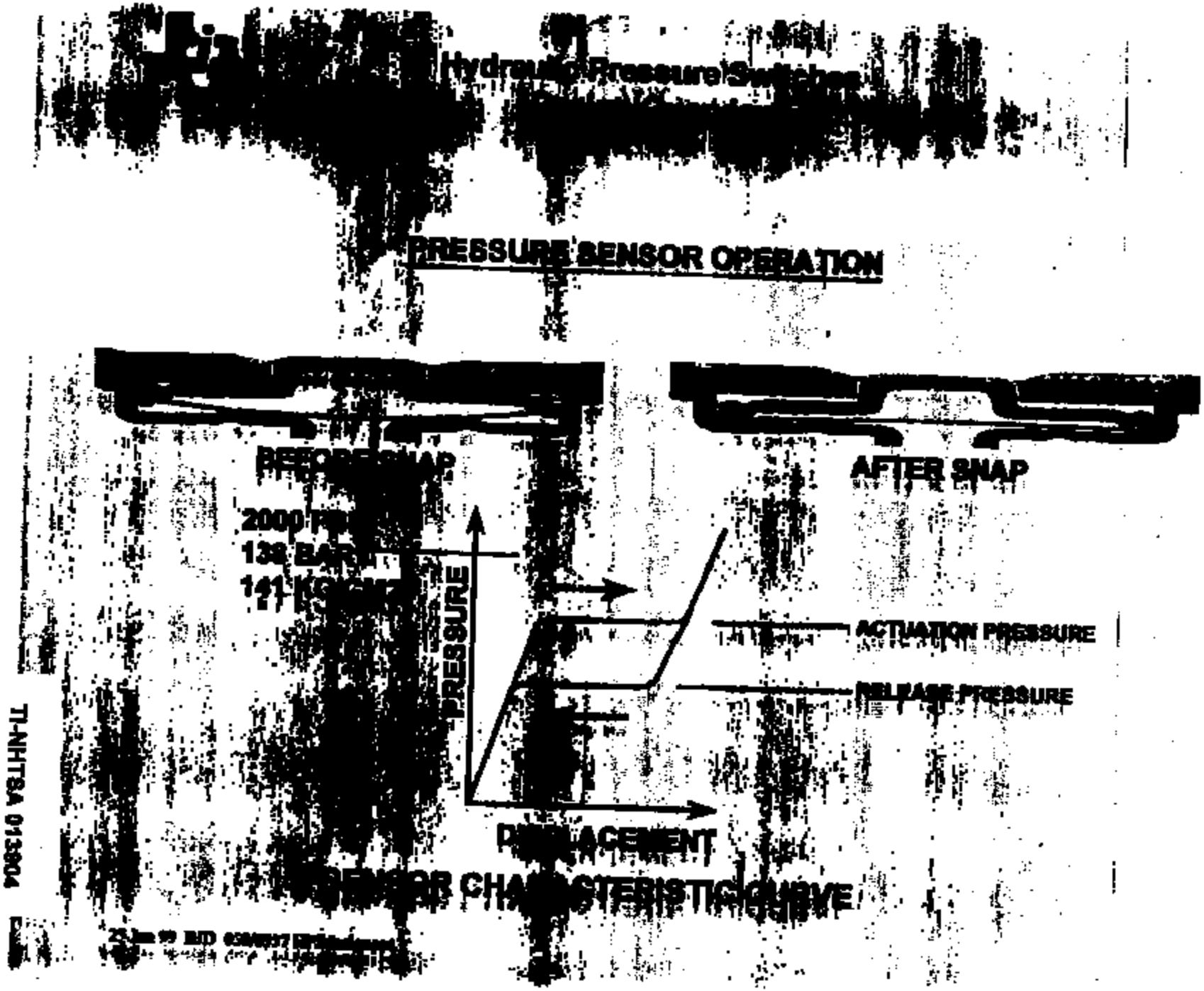

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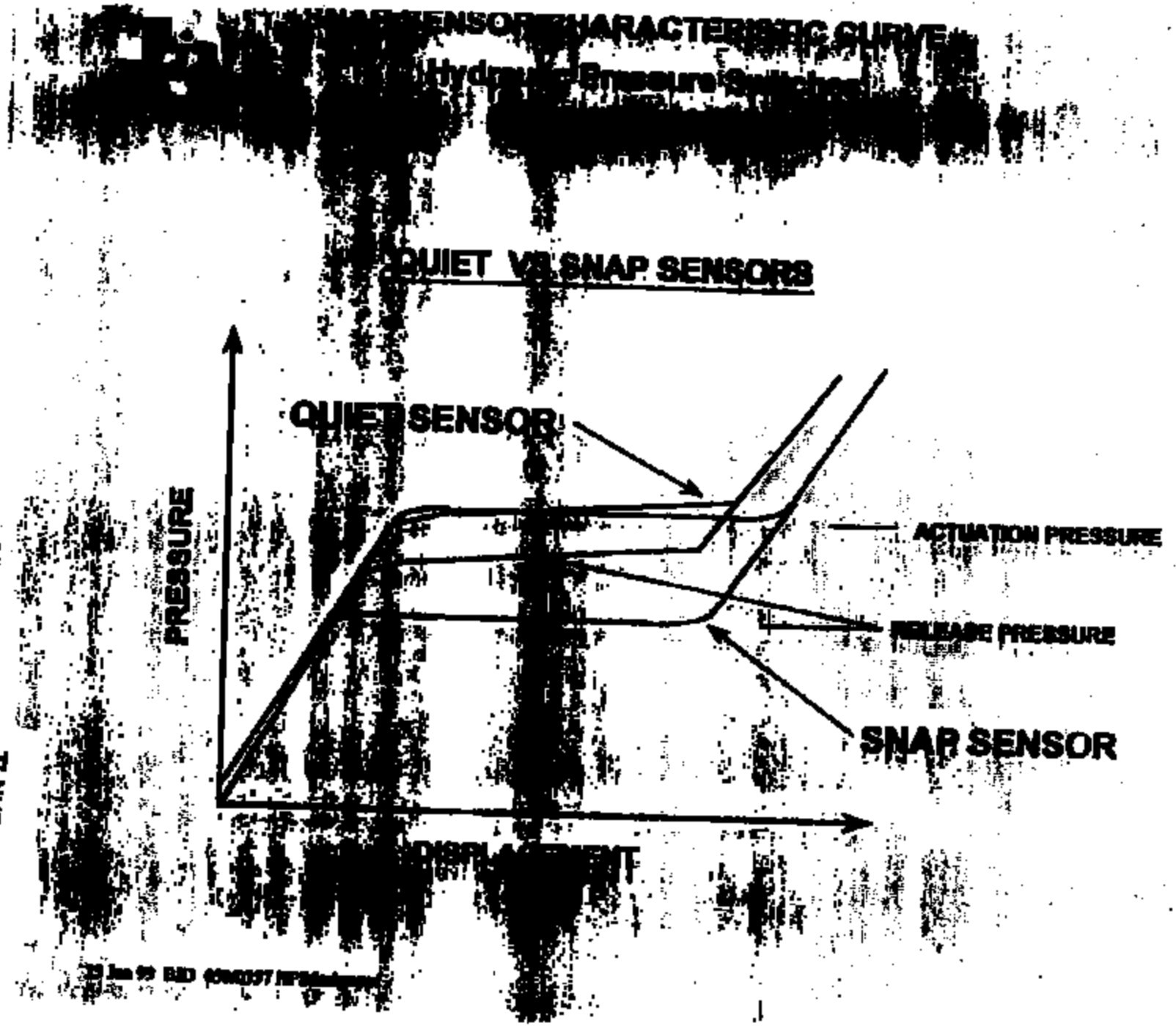

QUIET VS SNAP SENSORS
QUIET SENSOR
PRESSURE
ACTUATION PRESSURE
RELEASE PRESSURE
SNAP SENSOR

USING DISC MOTION TO MAKE / BREAK CONTACTS

BEFORE SNAP

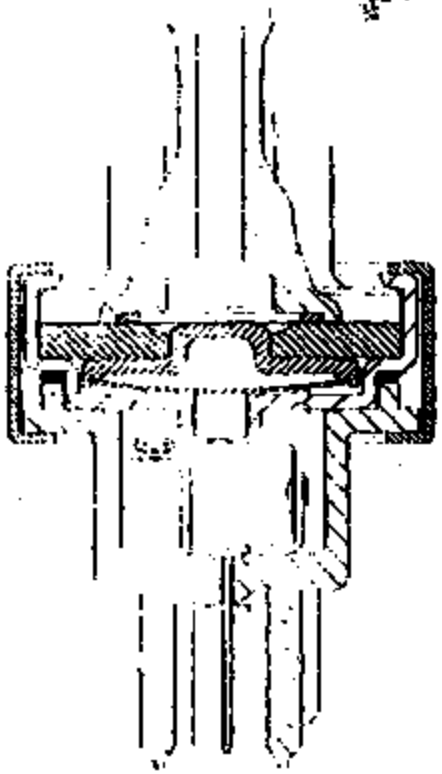
AFTER SNAP

PRESSURE SWITCH LOGIC

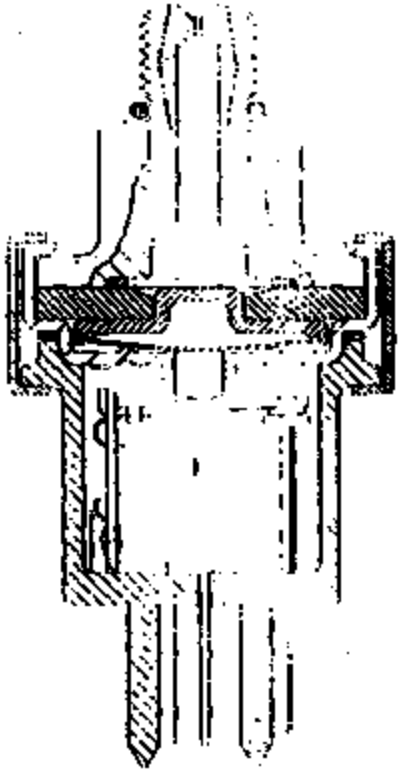
NORMALLY CLOSED

NORMALLY OPEN

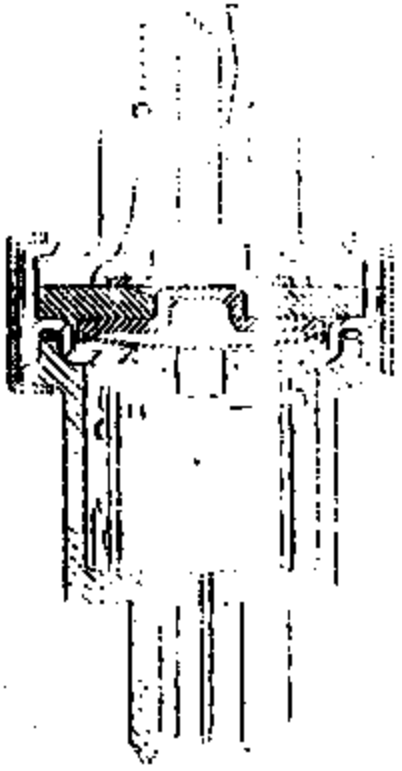
PRESSURE SWITCH ASSEMBLIES



L - SHAPED SPRING
NORMALLY CLOSED

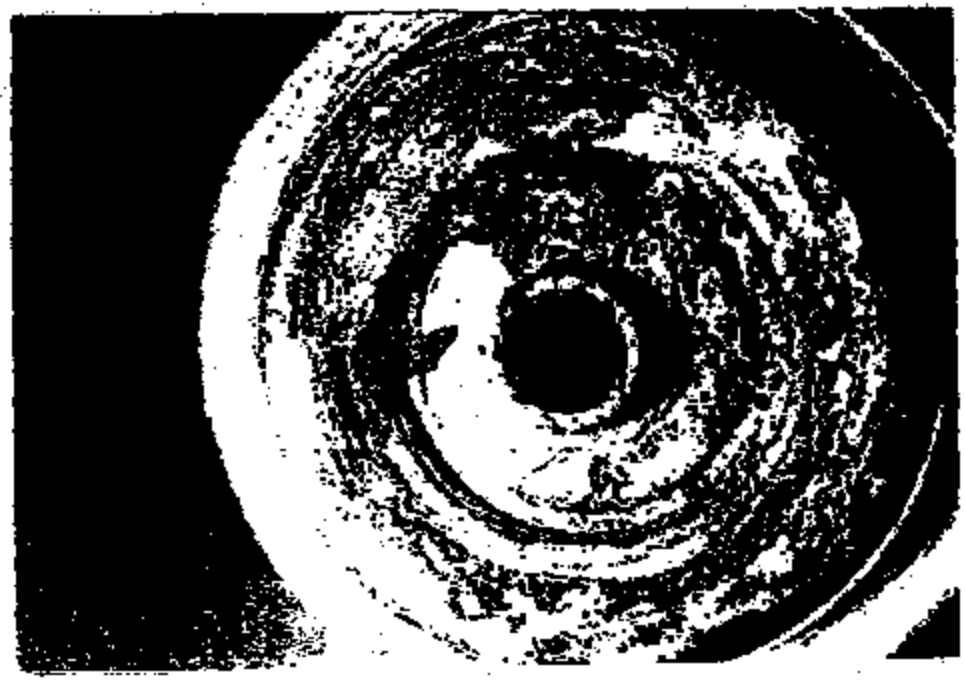


S - SHAPED SPRING
NORMALLY CLOSED



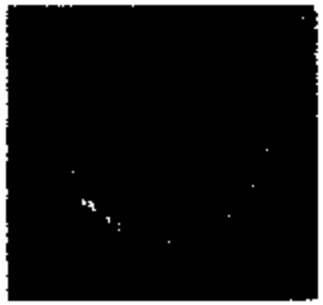
S - SHAPED SPRING
NORMALLY OPEN

Memphis Switch Analysis



- Chemical analysis reveals K, S, Cu, C, and O.

Lab/Field Comparisons - Impact of Continuous Power

Experiment	Cup Visual Inspection	Chemical Analysis (Cup)
Lab/Salt Water		Na, Cl, Cu, C, O
Lab/Brake Fluid		Cu, C, O
Field/Memphis Switch		K, S, Cu, C, O

TEXAS INSTRUMENTS

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

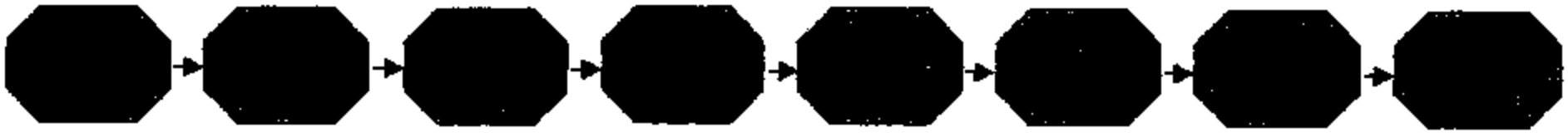
NA Hydraulic Switch History

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

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

TI-NHTSA 013912

OVERVIEW OF CONCERN TIME LINE



NHTSA initiates investigation

Supply chain dialogue

Core team momentum

TI Eng'r at Ford

Brake fluid fails to ignite

H20 corrosion ignites plastic

Ford NHTSA responds

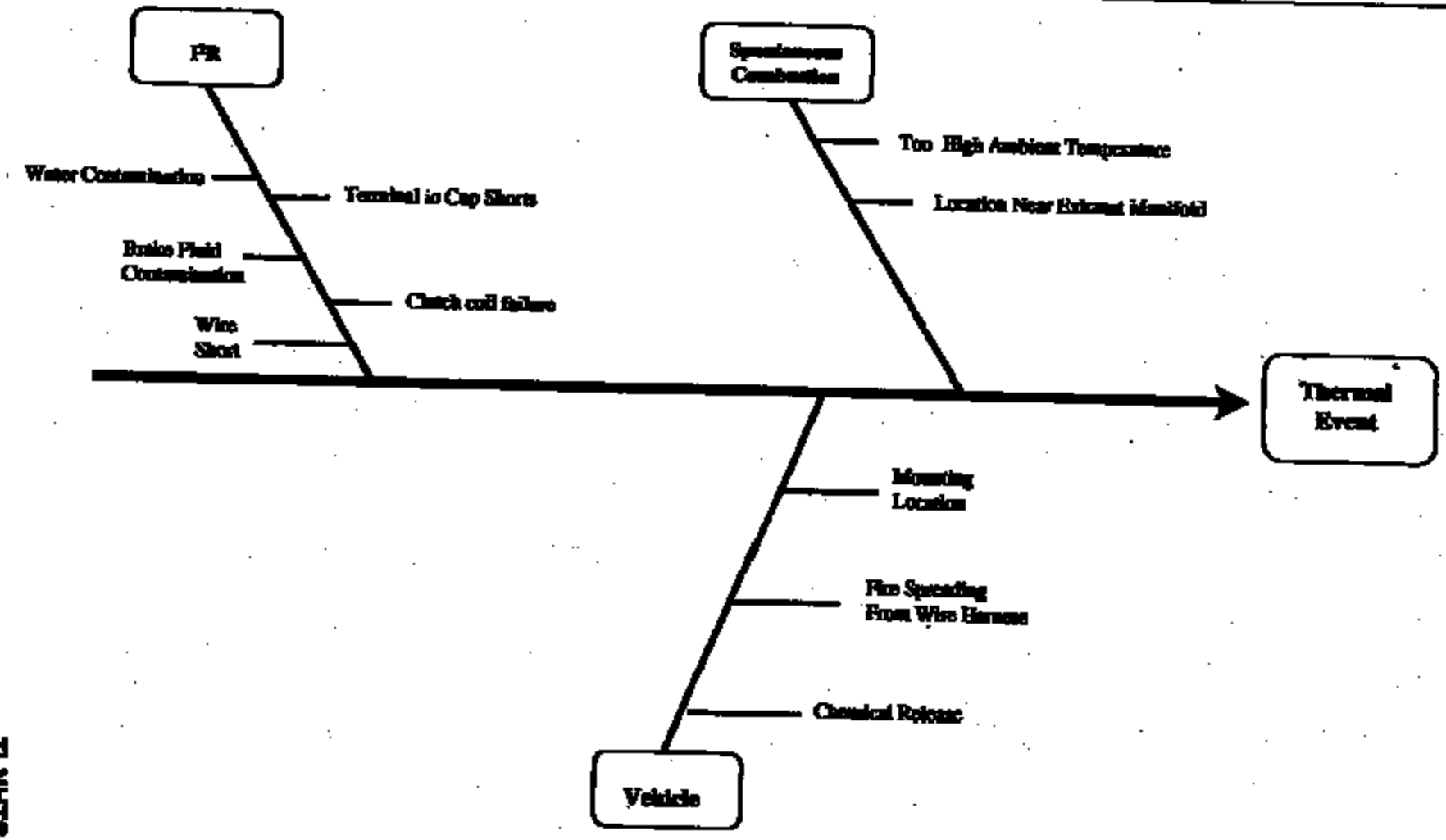
Deploy results

Brake Switch Overview

- Mounted under hood…14 inches under master cylinder
- Mounted on proportional valve at frame of vehicle
- Switch oriented approximately 25 degrees off vertical (connector up)
- Switch controls speed control…normally closed, opens at 130 psi
- Continuously powered by battery 15 amp connection

TEXAS INSTRUMENTS

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



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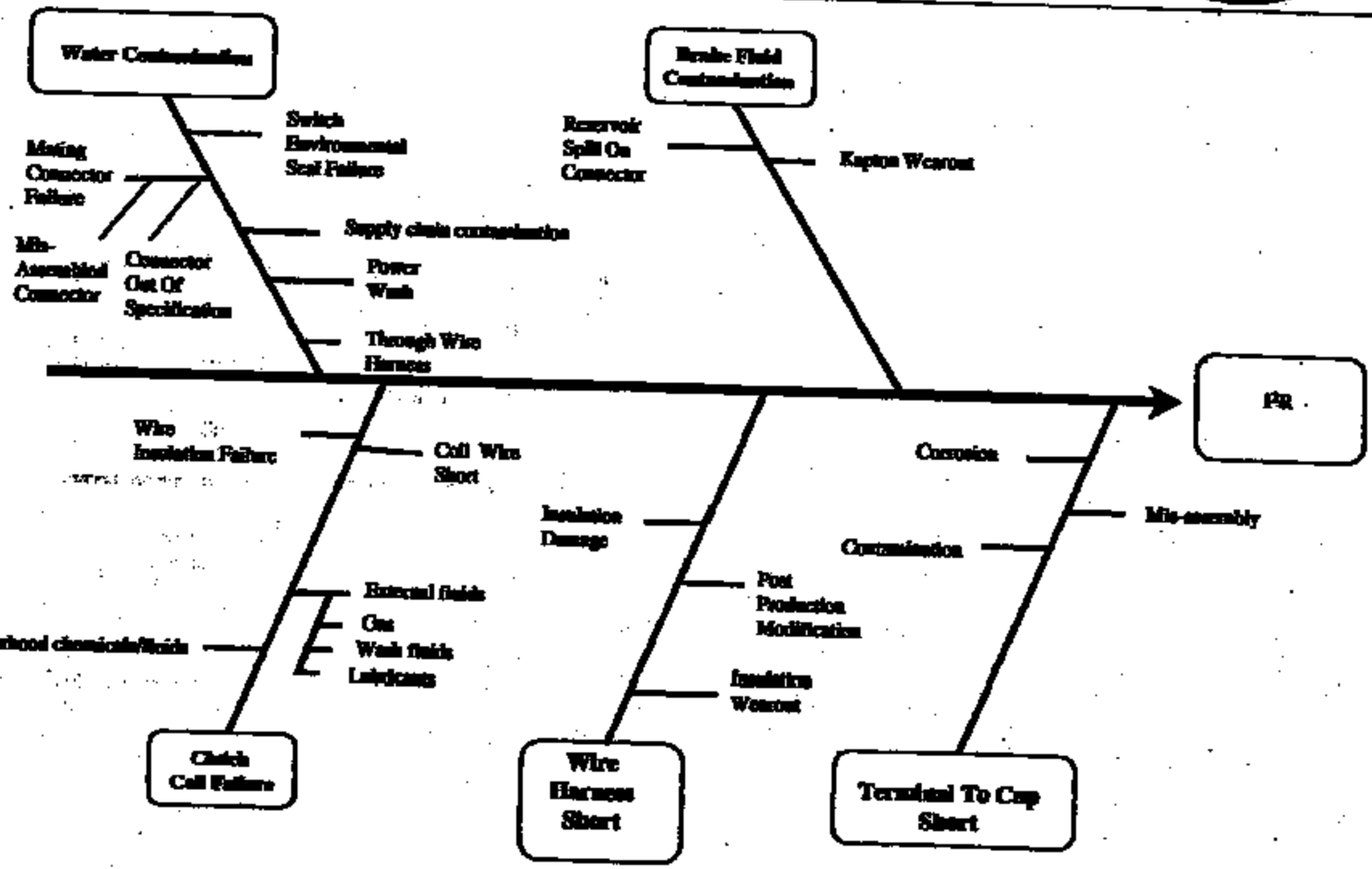
TEXAS INSTRUMENTS

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



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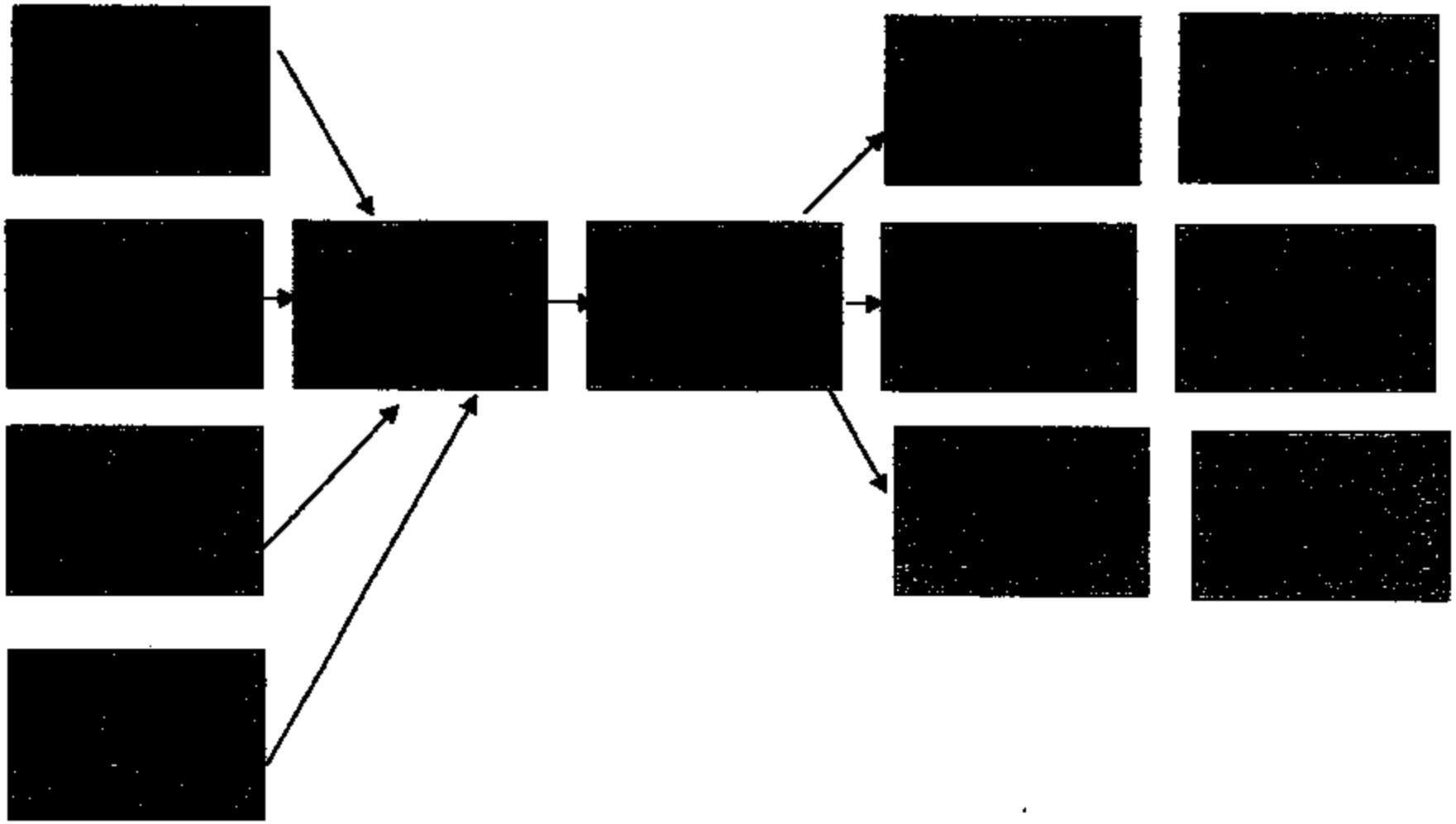
TI-NHTSA 013010

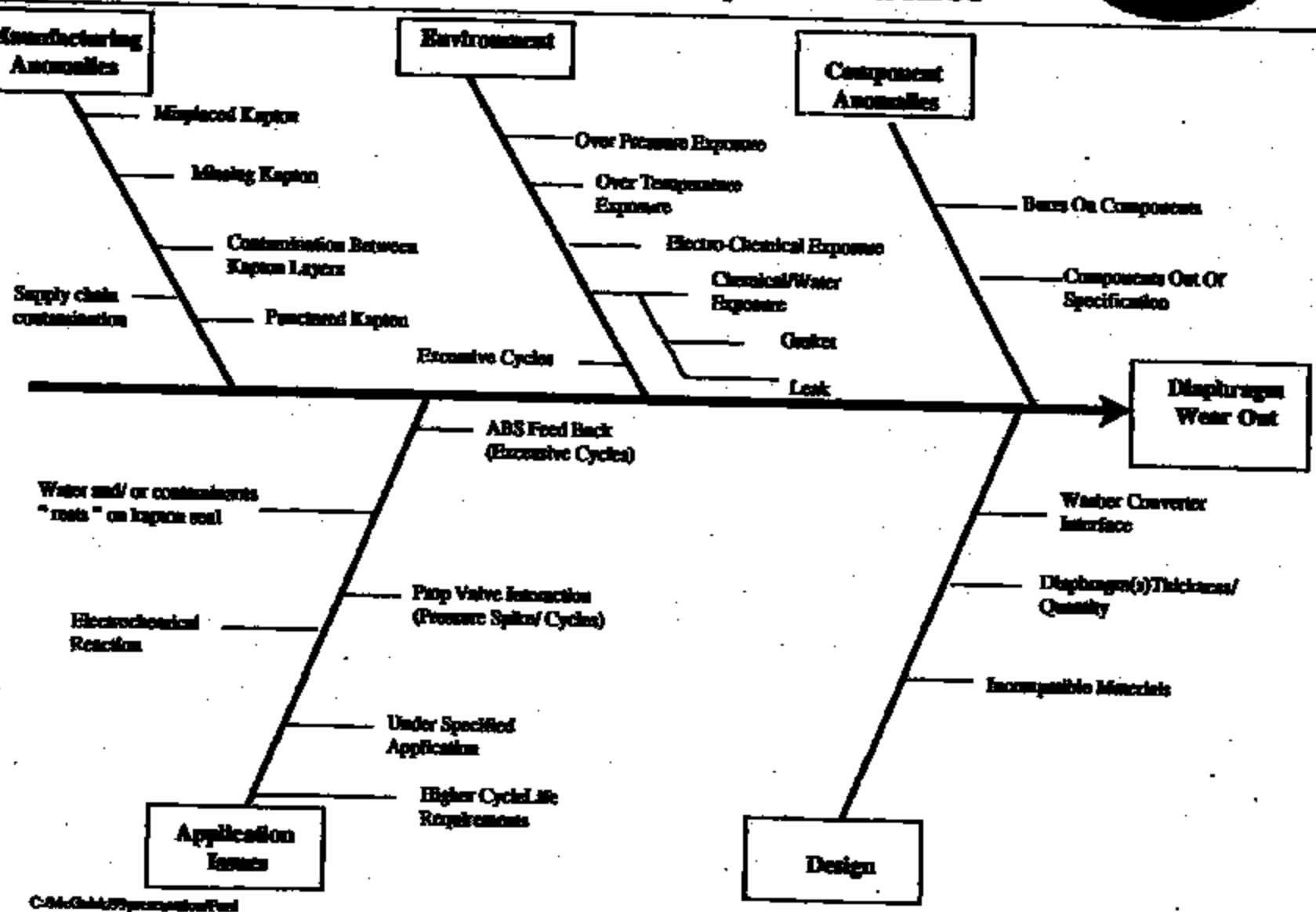
REFINED BRAKE FLUID IGNITION THEORY
POSSIBLE CAUSE THEORIES
"FEB '99 FOCUS"



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

TEXAS INSTRUMENTS

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



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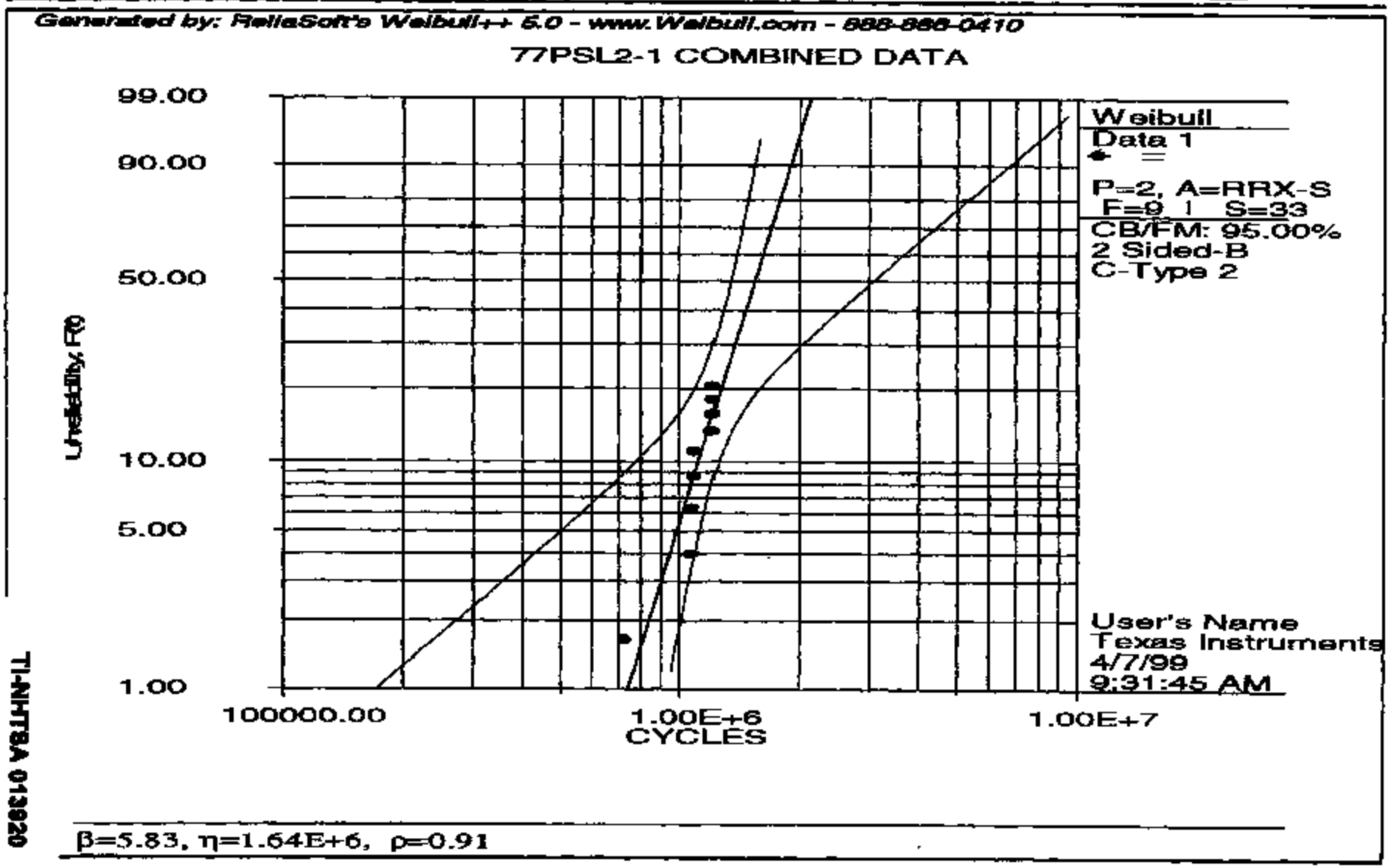
TEXAS INSTRUMENTS

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



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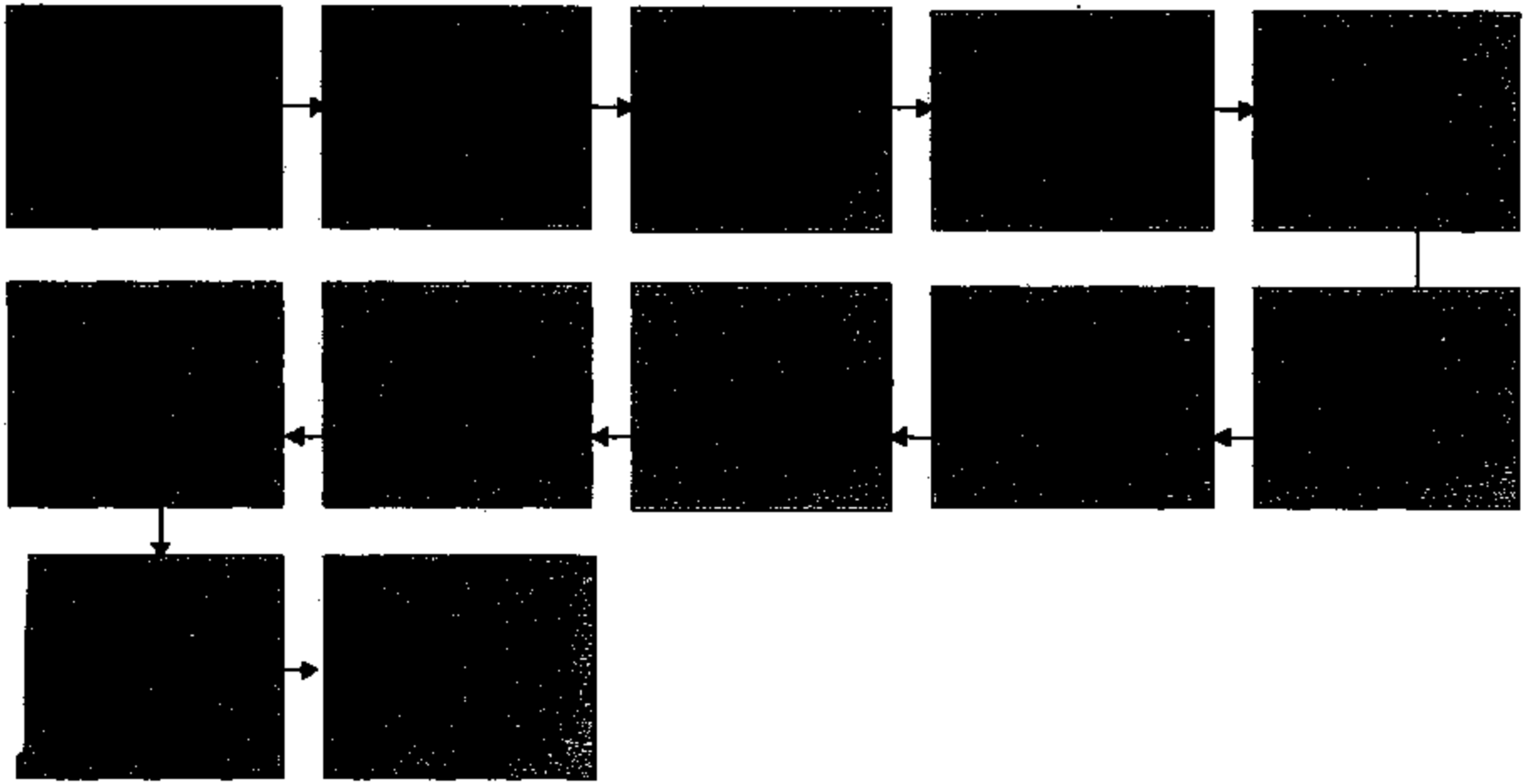
- "Town Car" switch meets accelerated/simulated life cycle specification shown by "success" and "end-of-life" testing

PROCESS FLOW DIAGRAM
"CORROSION" POTENTIAL CAUSE FLOW ANALYSIS



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

TEXAS INSTRUMENTS

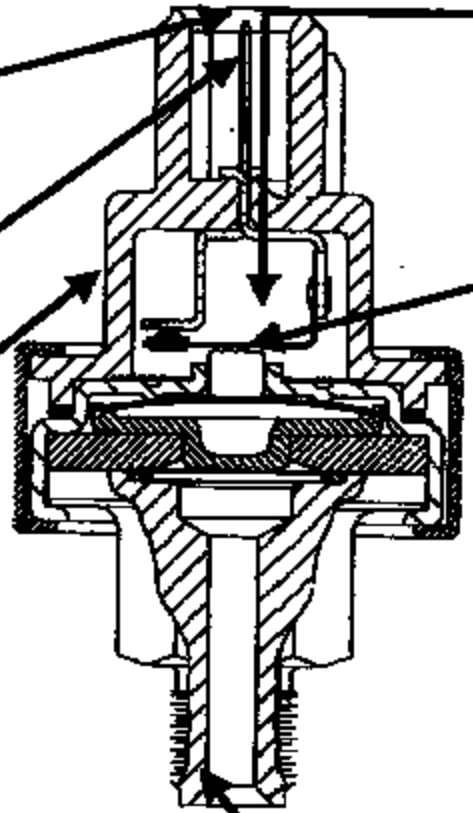
5. High current flow to case through water and ionic contamination

1. Water and "ionic" contamination (e.g. NaCl or cleaner) enters the switch cavity

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

4. Contact arm& terminal corrosion increases resistance (acts like heater wire).

6. Plastic connector melts. Once it opens, oxygen enters the switch cavity. Arm terminal/corrosion becomes "RED HOT" igniting the plastic



3. Hexport grounded accelerates corrosion

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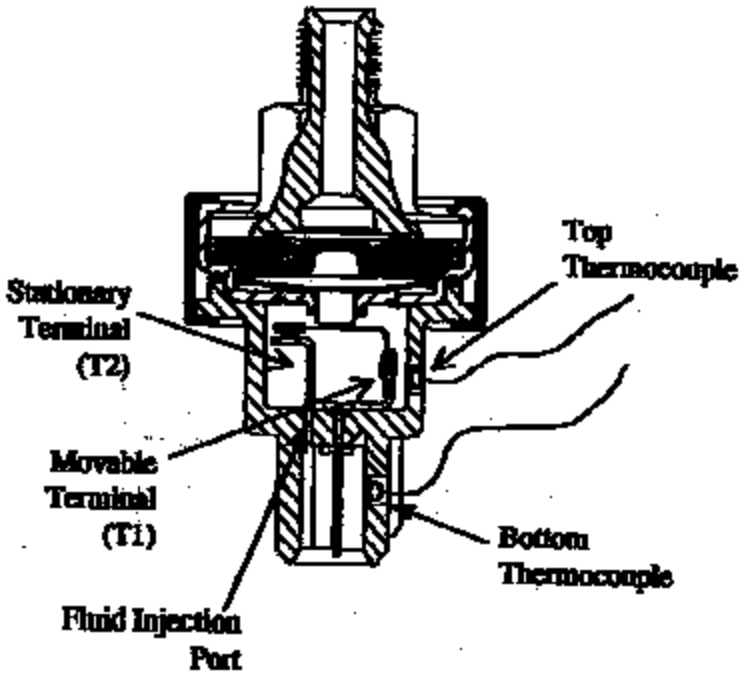
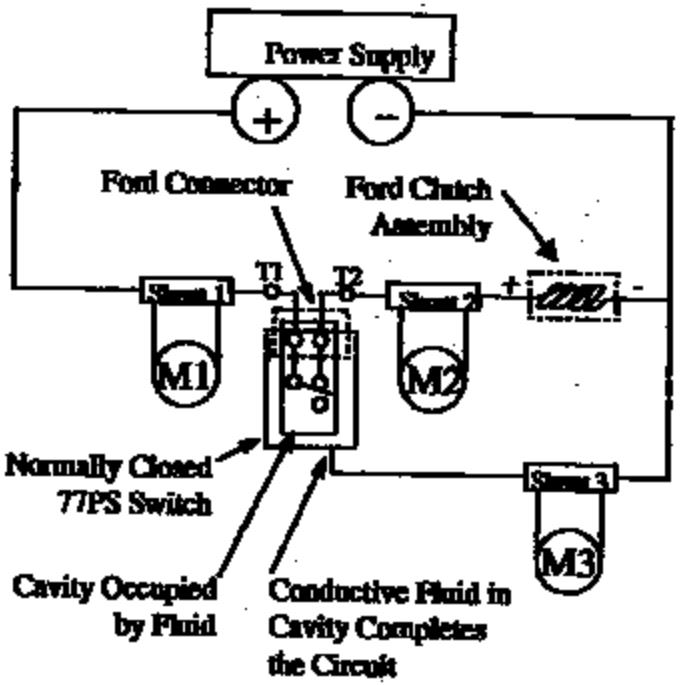
Attachment

TI-NHTSA 013923

5% Salt Water Ingress Experiment
Test 1



TI Report PS/99/12
03/15/99



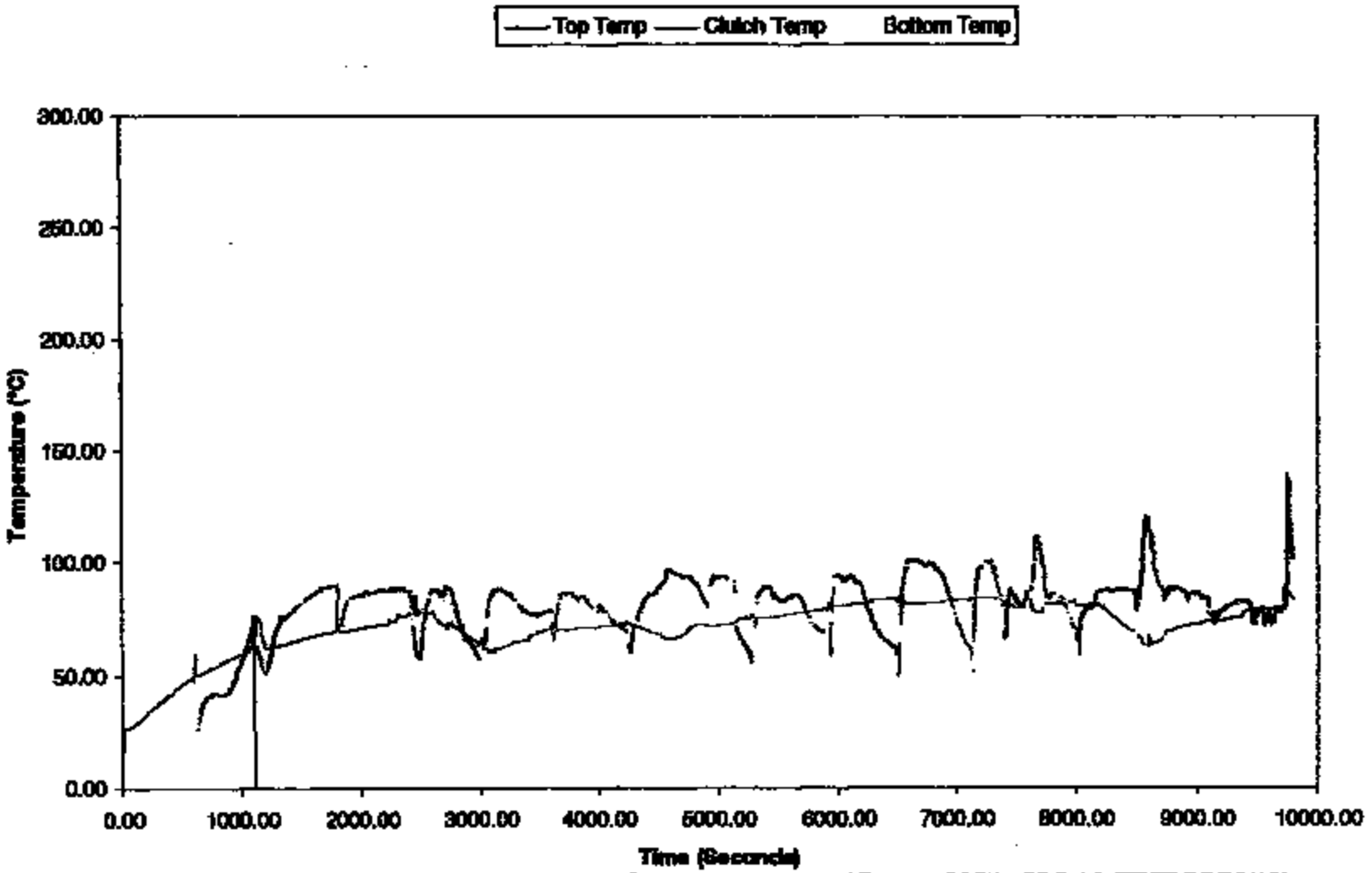
Test 1: Figure 1 and Figure 2.

Attachment

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

TEXAS INSTRUMENTS

5% Salt Water Ingress Experiment
Temperature vs. Time



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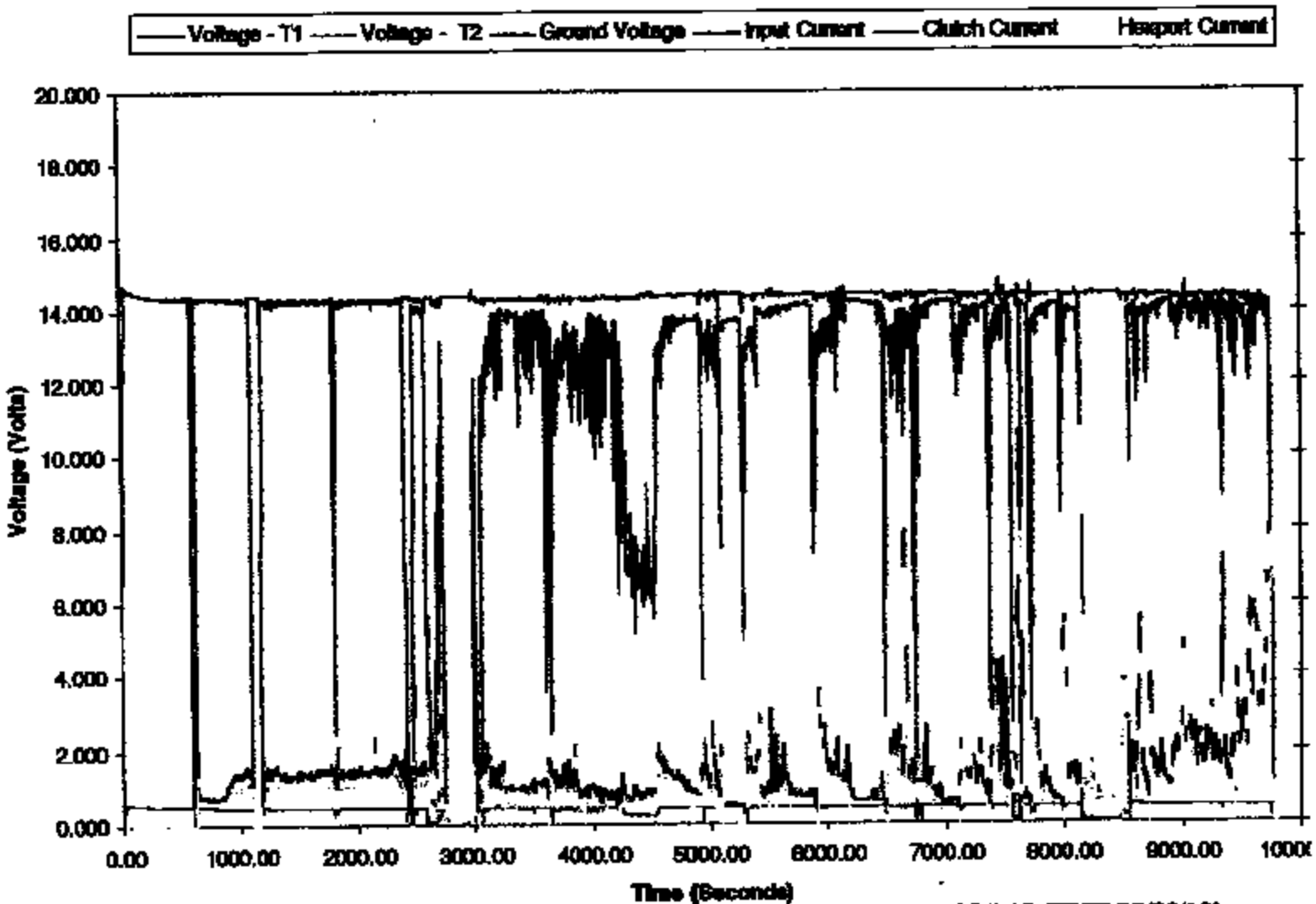
TI-NHTSA 013926

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

TEXAS INSTRUMENTS

5% Salt Water Ingress Experiment



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THNHT9A 013926

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

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

Cellanex 4300 Base

Cellanex 3316 Base

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

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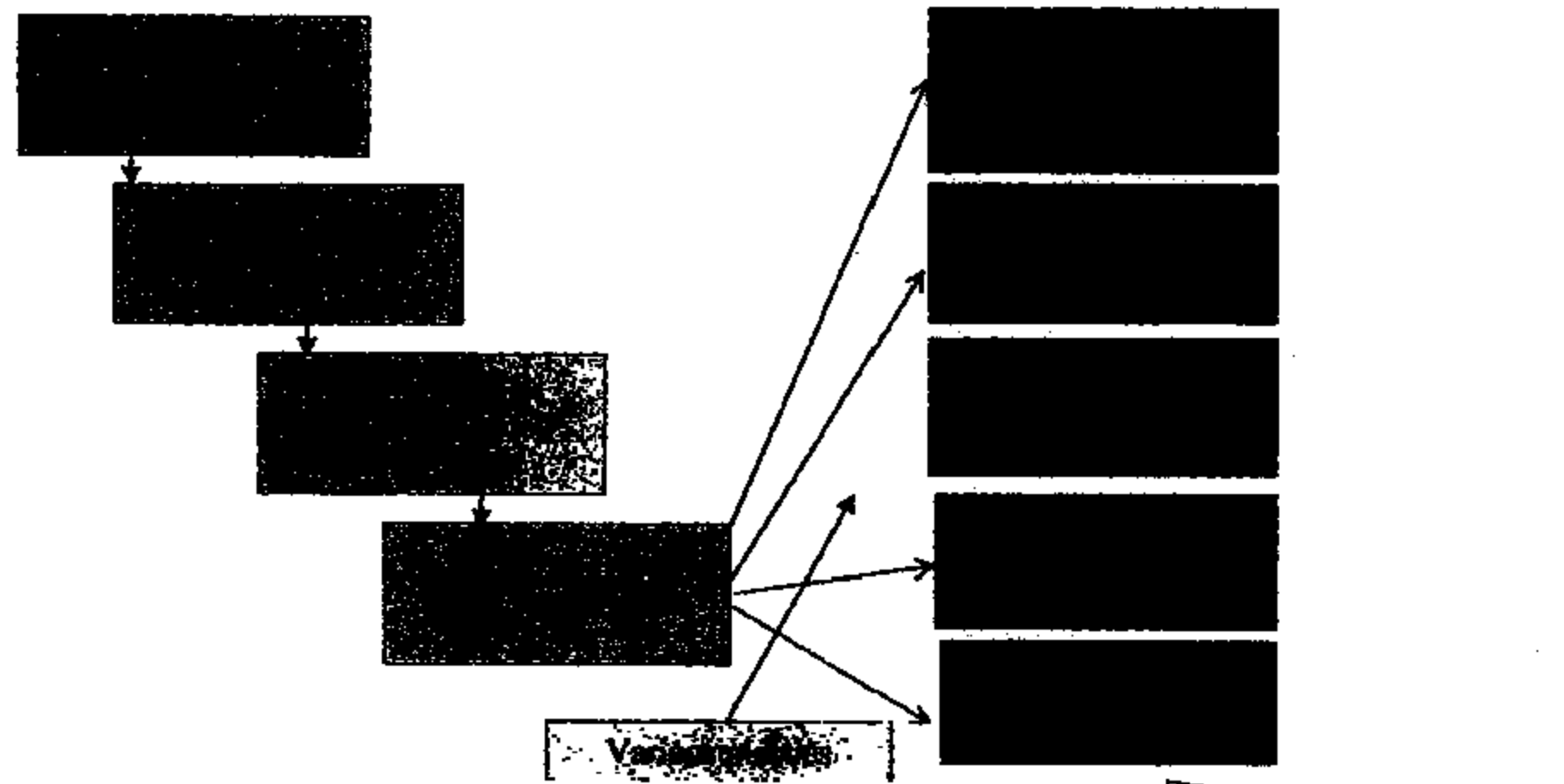
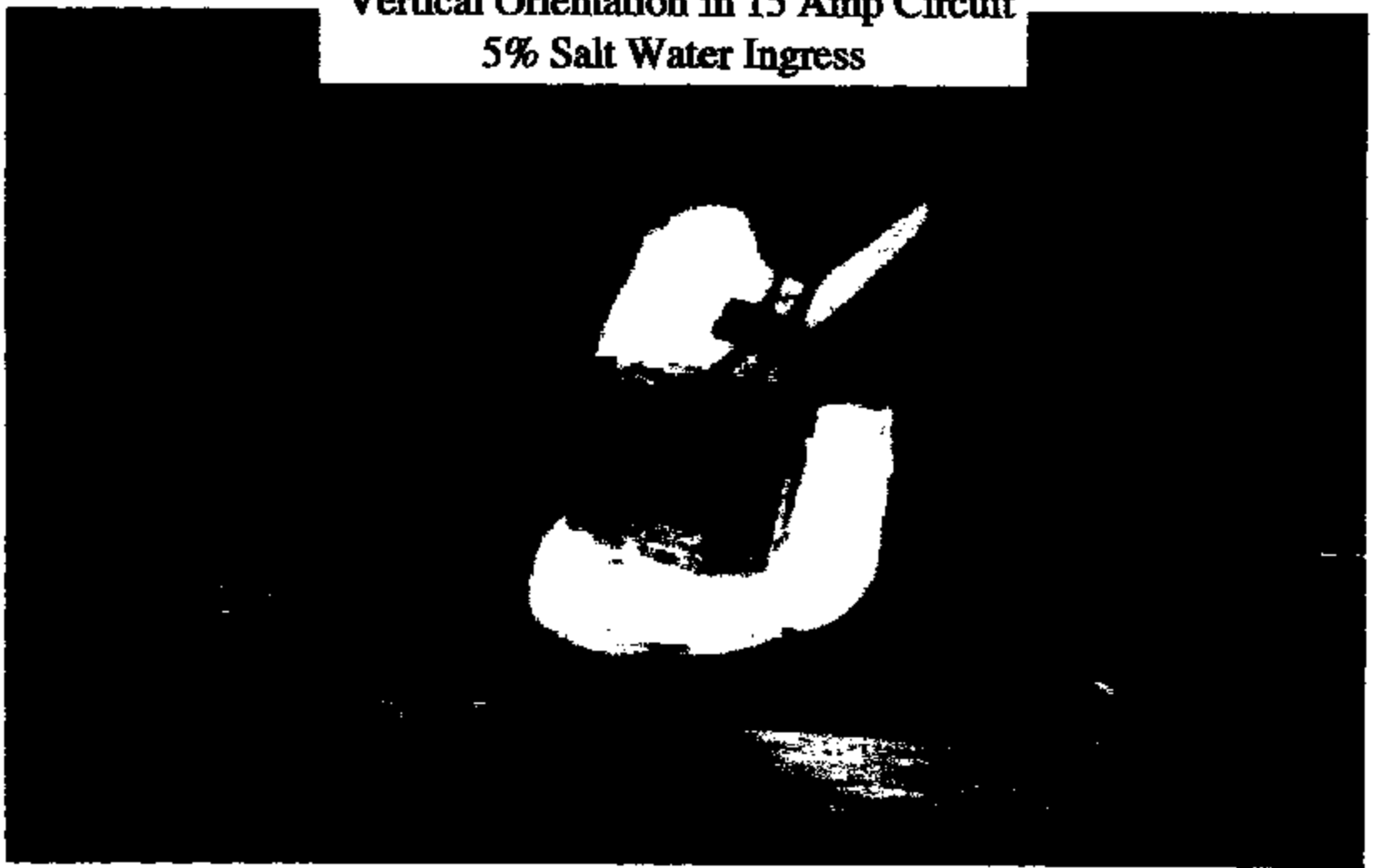
Attachment

"Corrosion" potential cause time line

Theory Time Line

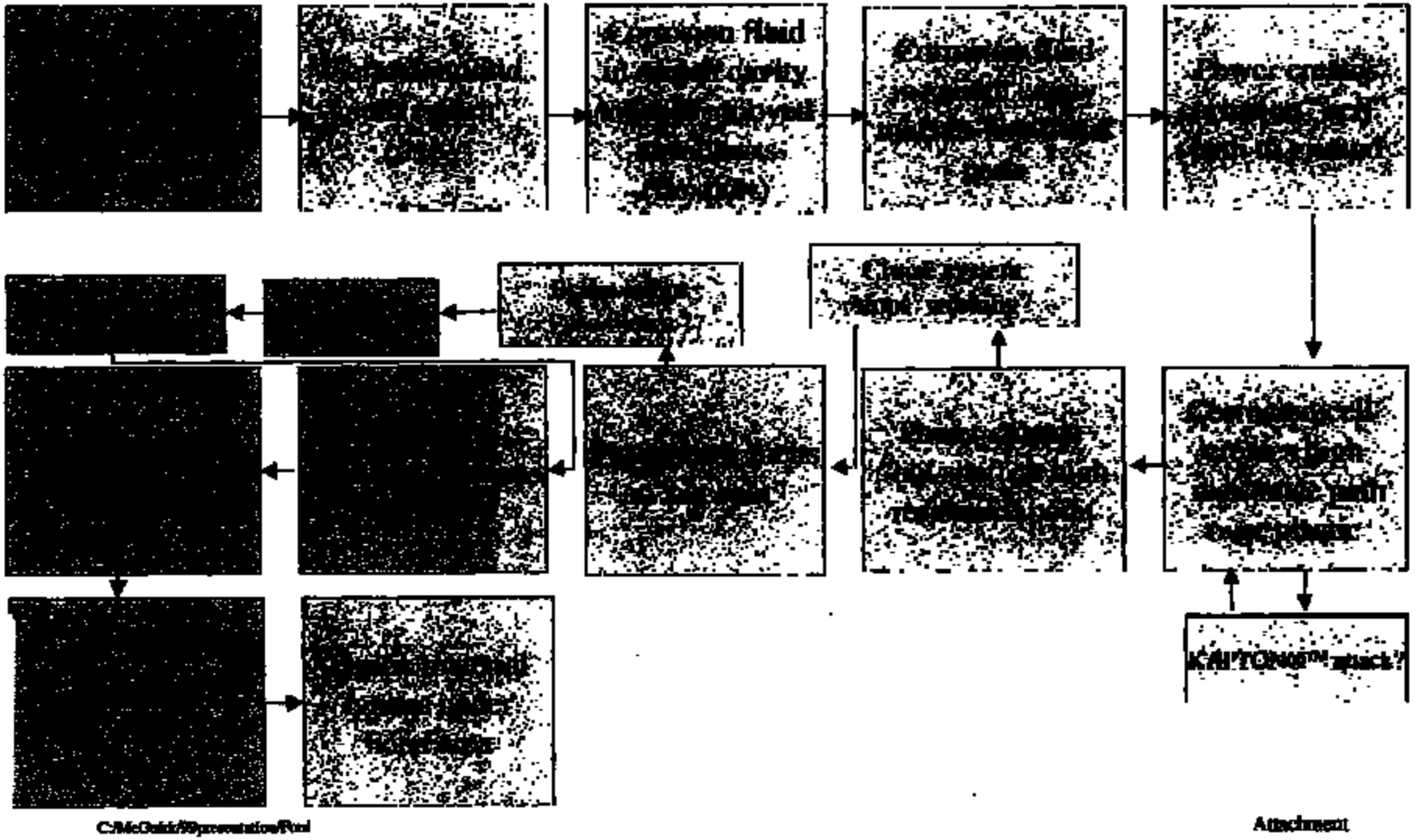


77PS Cellanex 4300 Base
Vertical Orientation in 15 Amp Circuit
5% Salt Water Ingress



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

PROCESS FLOW DIAGRAM
"CORROSION" POTENTIAL CAUSE FLOW ANALYSIS



Attachment

TEXAS INSTRUMENTS

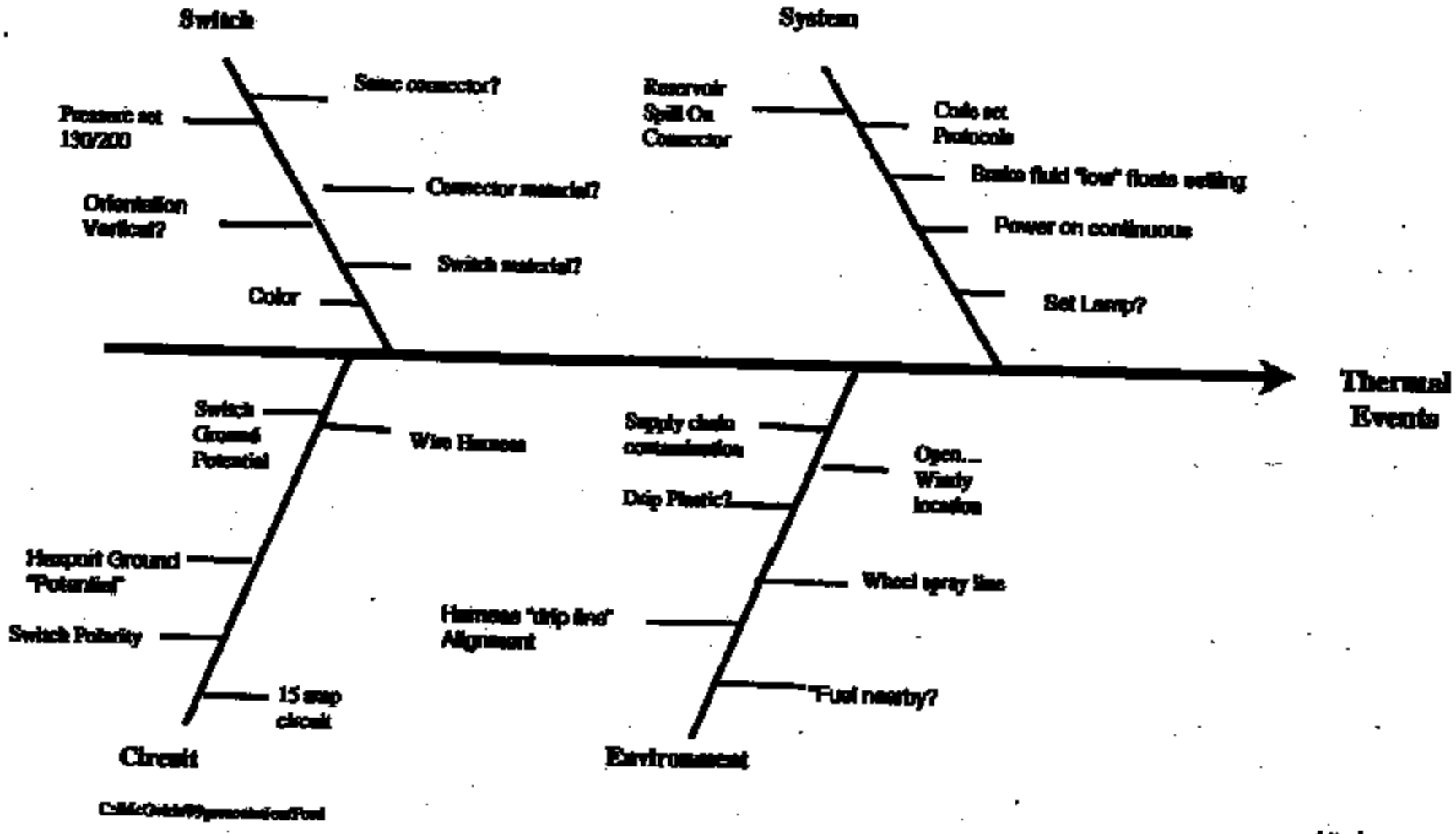
Brake Pressure Switch
Potential Thermal Event Theory Profile 6/02/99

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

Texas Instruments

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

ECONOLINE VS. TOWN CAR P/S



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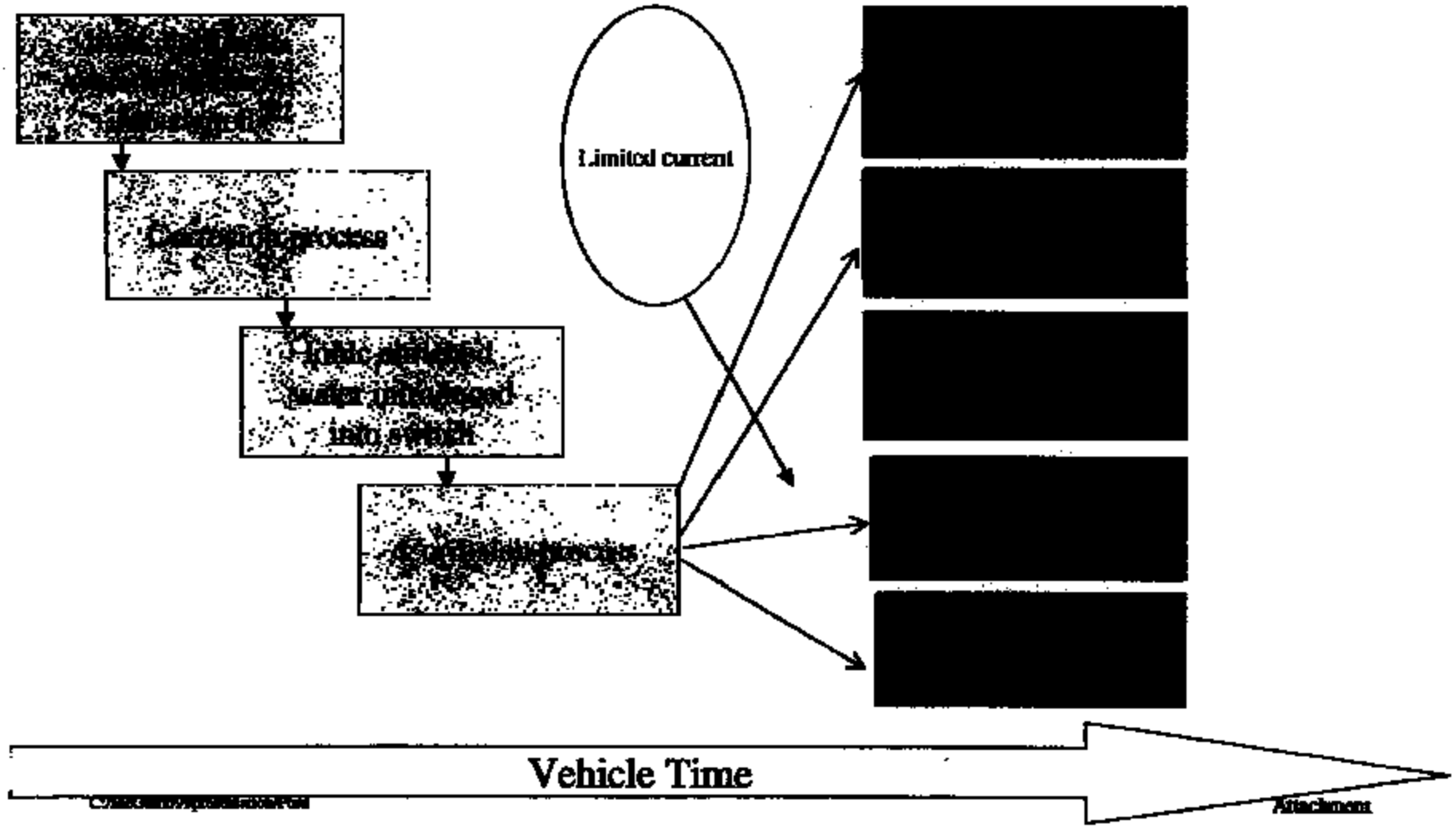
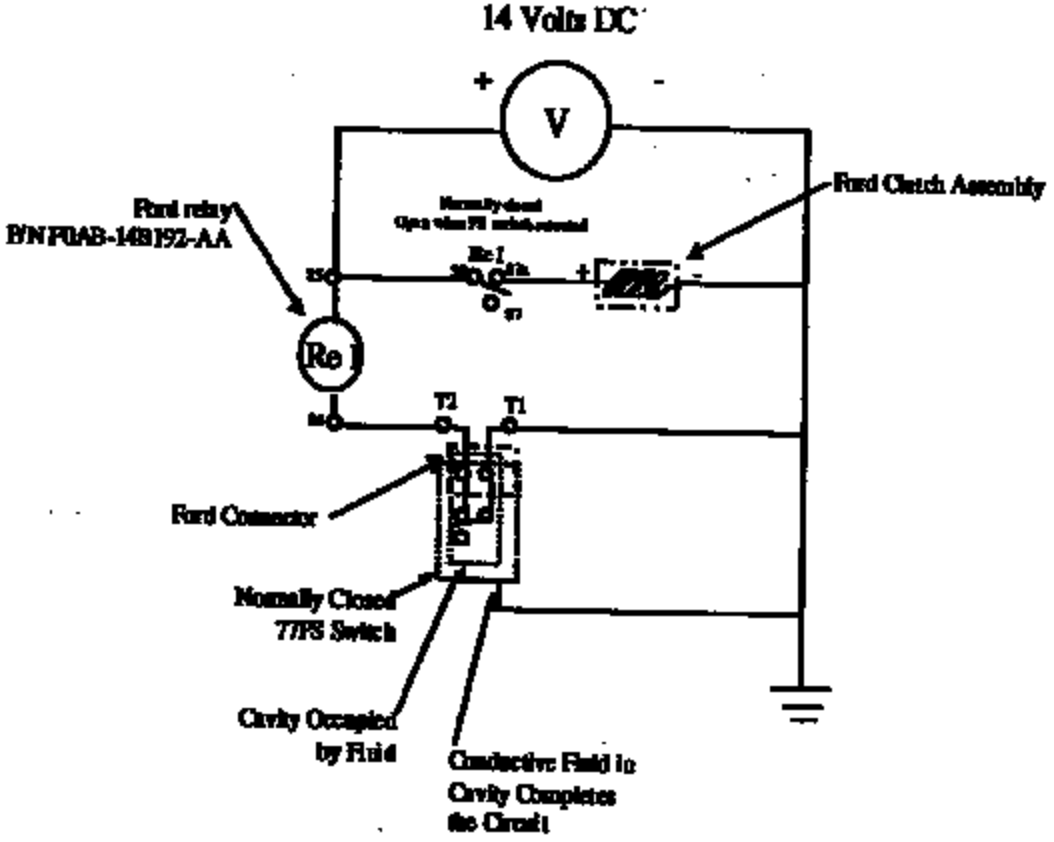
Attachment

"Corrosion" potential cause time line

Theory Time Line



77PS Proposed Wiring Schematic



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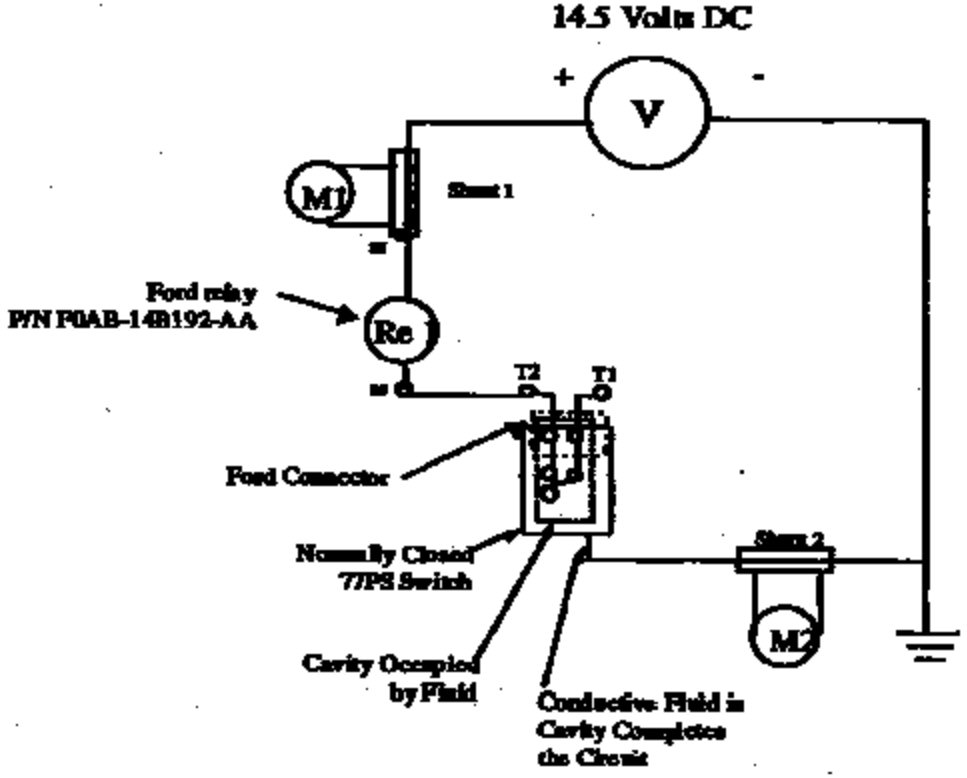
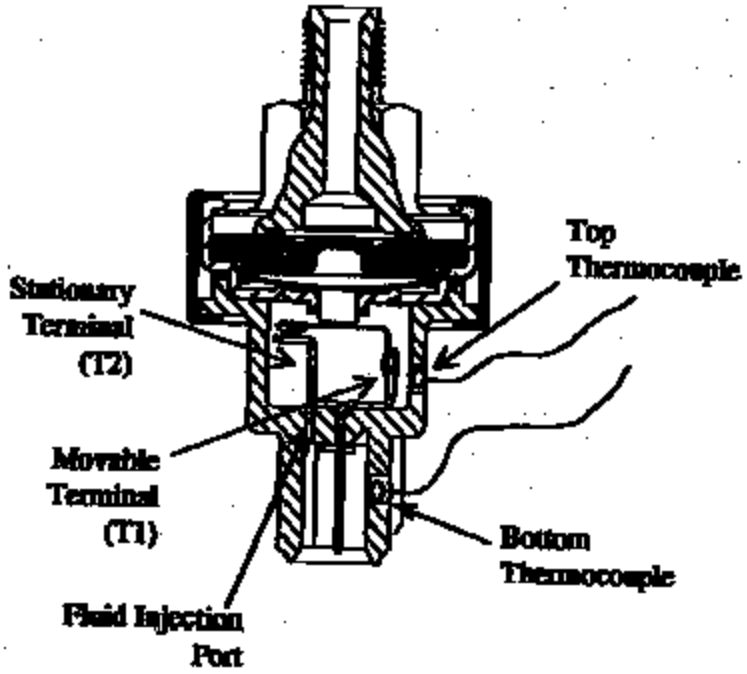
Attachment

200 mAmp Current Limit Circuit Test Setup

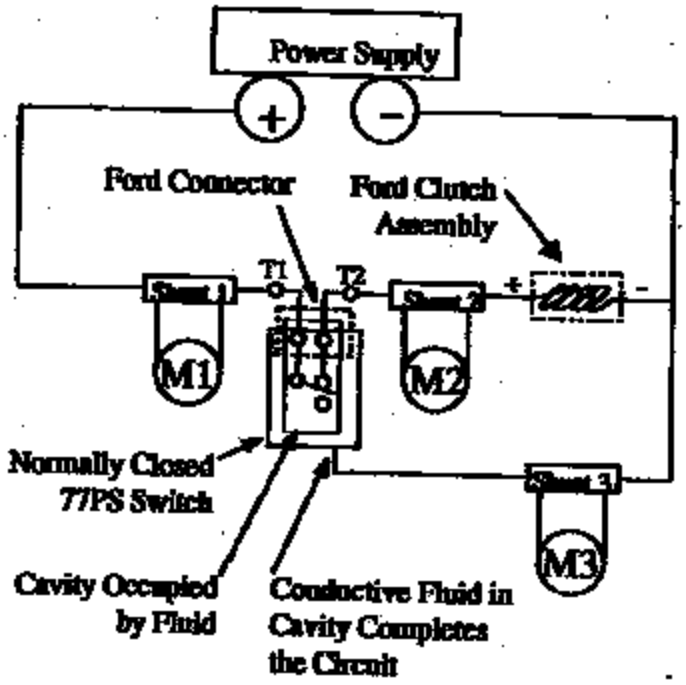


Worst case scenario is when the switch is actuated, which puts T2 at full voltage.
To facilitate testing, T1 is floating which keeps T1 and T2 at full voltage but limits current draw to .2 Amps (This test is harsher than worst case scenario).

5% Salt Water Ingress Experiment
Test 1



TI Report PS/99/12
03/15/99

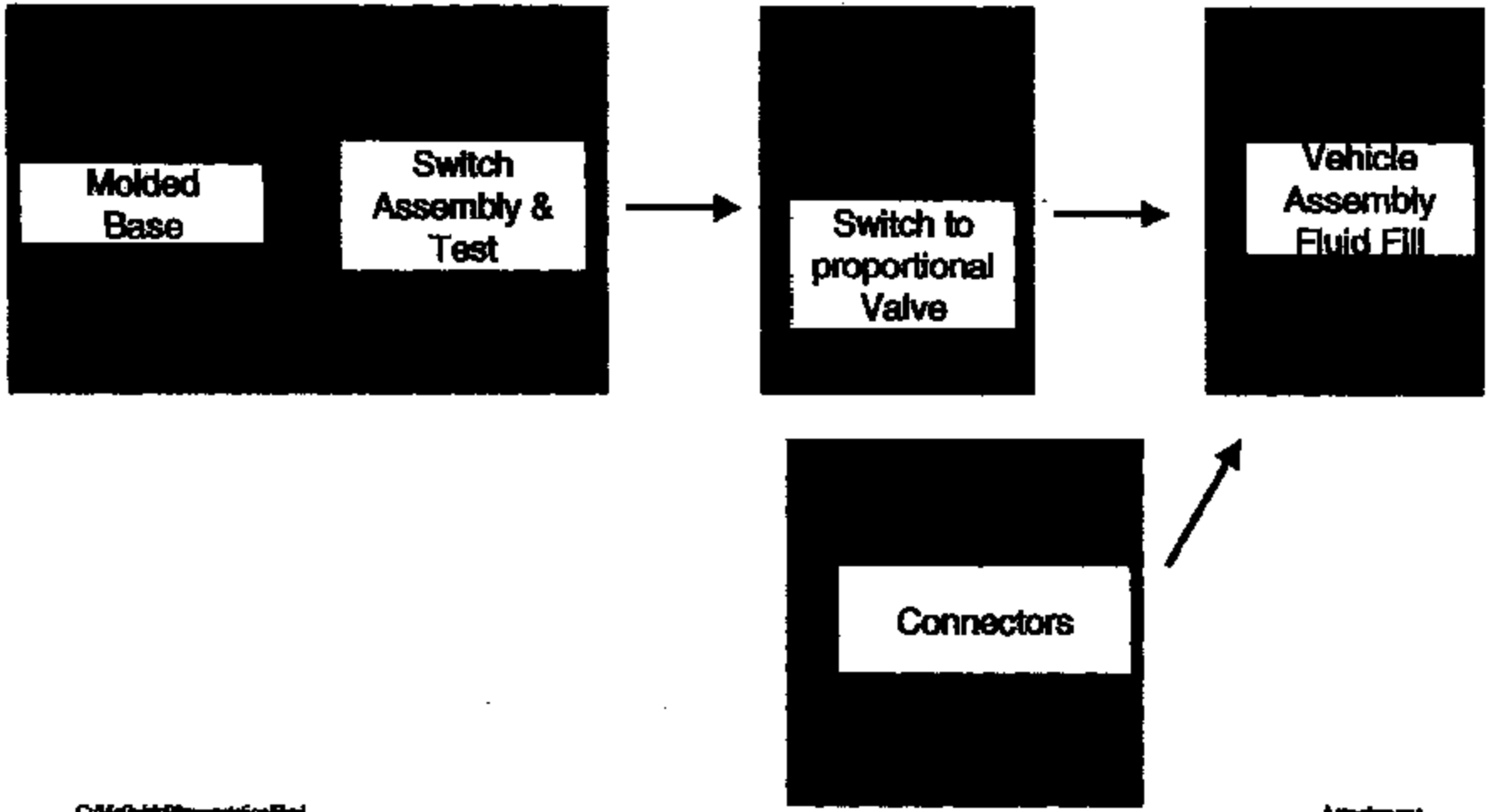


Test 1: Figure 1 and Figure 2.

Attachment

TI-NHTSA 013586

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



NA Hydraulic Switch History

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

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

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

77psB-1		GROSS QTY		COMPLETE	COMPLETE	BEGIN	IMPACT	COMMENTS/CONCERNS
COMPONEN	DESCRIPTIC	REQUIRED	SUPPLIER	1/2K	250K	PARTIAL	TO TI	
27406-1	CONVERTER	2,040,000	KF BASSLE	10 WKS	18 WKS	2 WKS	NONE	ADD OVERTIME/MATERIAL AVAILABILITY
27639-1	WASHER/A	2,040,000	DEMASTER	10 WKS	18 WKS	2 WKS	NONE	MATERIAL AVAILABILITY
27713-1	CUP77PS	2,040,000	VALENTINE	6 WKS	10 WKS	1 WK	NONE	RAW MATERIAL AVAILABILITY
28656-27	57PS	2,040,000	DSC DEPT	12+ WKS	24 WKS	3 WKS	TOOL $?	POSSIBLE CAPACITY ISSUE
36800-1	HEXFORM 77	2,040,000	ELCO	10 WKS	25 WKS	3 WKS	NONE	RAW MATERIAL AVAILABILITY
74224-1	KAPTON	204	E DUPONT	2 WKS	2 WKS	2 WKS	NONE	
27225-1	KAPTON ST	1,102	E DUPONT	3 WKS	3 WKS	2 WKS	NONE	
74353-1	GASKET	2,040,000	JBL PARKE	8 WKS	18 WKS	3 WKS	NONE	ELIMINATE CORES WILL INCREASE DEL. BY 10%
36868-1	STATIONAR	2,040,000	KF BASSLE	10 WKS	18 WKS	2 WKS	NONE	ADD OVERTIME/MATERIAL AVAILABILITY/ REELS
28744-1	CONTACT-S	2,040,000	DERINGER	4 WKS	8 WKS	1 WK	NONE	MATERIAL AVAILABILITY
36867-1	MOVABLE T	2,040,000	KF BASSLE	10 WKS	18 WKS	2 WKS	NONE	ADD OVERTIME/MATERIAL AVAILABILITY/REELS
27716-1	BE/CU ISSUE	449	BRUSH WEL	1 WK	2 WKS	1 WK	NONE	NONE
74916-1	RIVET	2,040,000	JOHNHASS	6 WKS	11 WKS	4 WKS	NONE	RAW MATERIAL AVAILABILITY
48515-2	PRESSURE S	2,040,000	MTM MOLDIN	16 WKS	32 WKS	4 WKS	NONE	RAW MATERIAL CHANGEOVER/PRESS CAPACITY
74078-143	CERAMIN PI	2,040,000	PARATECH	7 WKS	15 WKS	2 WKS	NONE	
74247-4	BLUE QTINE	2,040,000	JBL PARKE	6 WKS	10 WKS	2 WKS	NONE	ELIMINATE CORES WILL INCREASE DEL. BY 10%
74767-1	CRIMPTING	2,040,000	VALENTINE	6 WKS	10 WKS	1 WK	NONE	RAW MATERIAL AVAILABILITY
74868-1	RED THREAI	2,040,000	MARK IV CA	3 WKS	6 WKS	1 WK	NONE	
77PS	SWITCH		TI	7/15,8/1,8/15	250K/MONTH			7 day weeks, thru summer vacations, 'old' plastic mold

TI-NHTBA 013938

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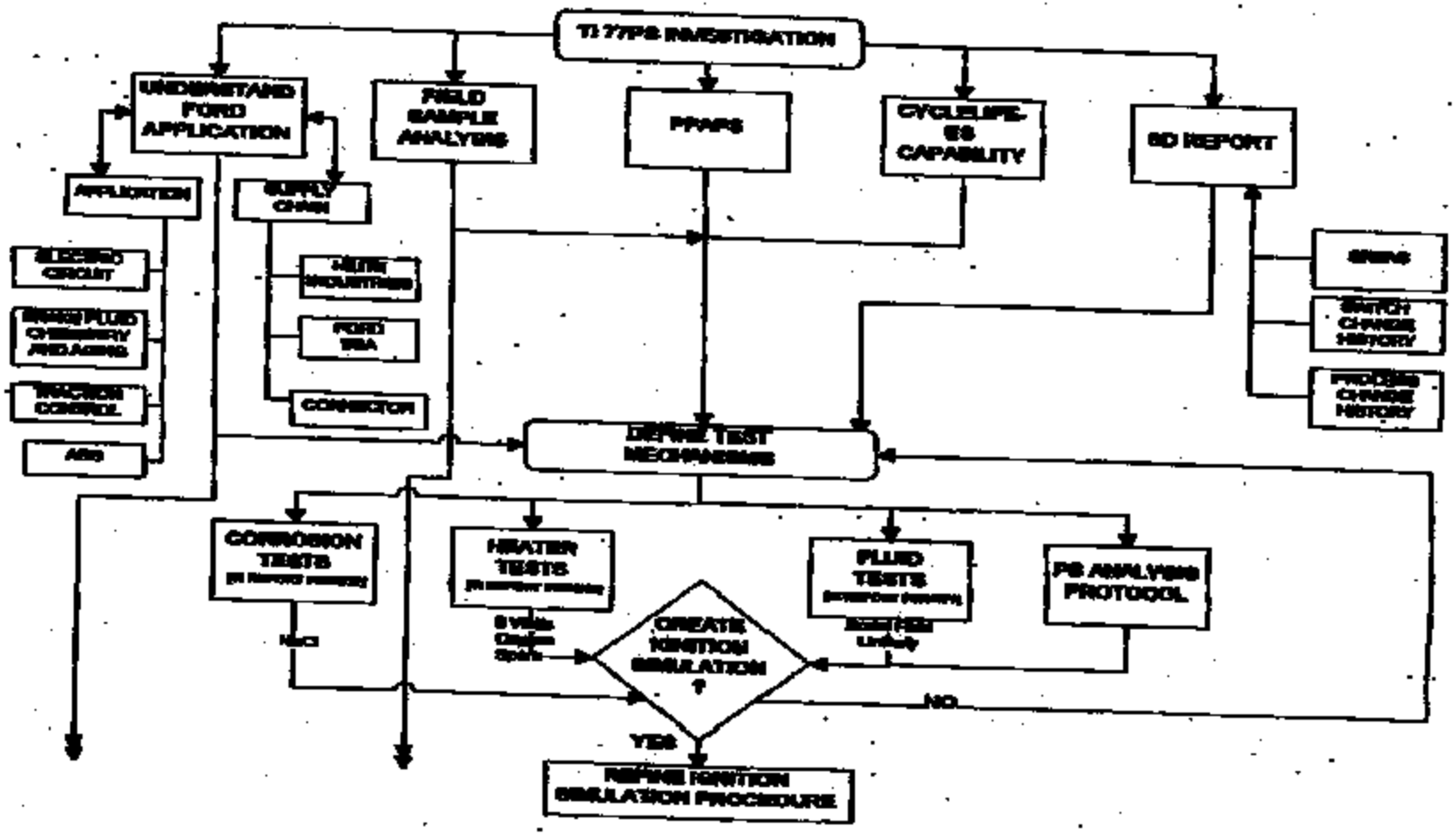
Brake Pressure Switch
Potential Thermal Event Theory Profile 6/02/99



TI-NHTSA 013940

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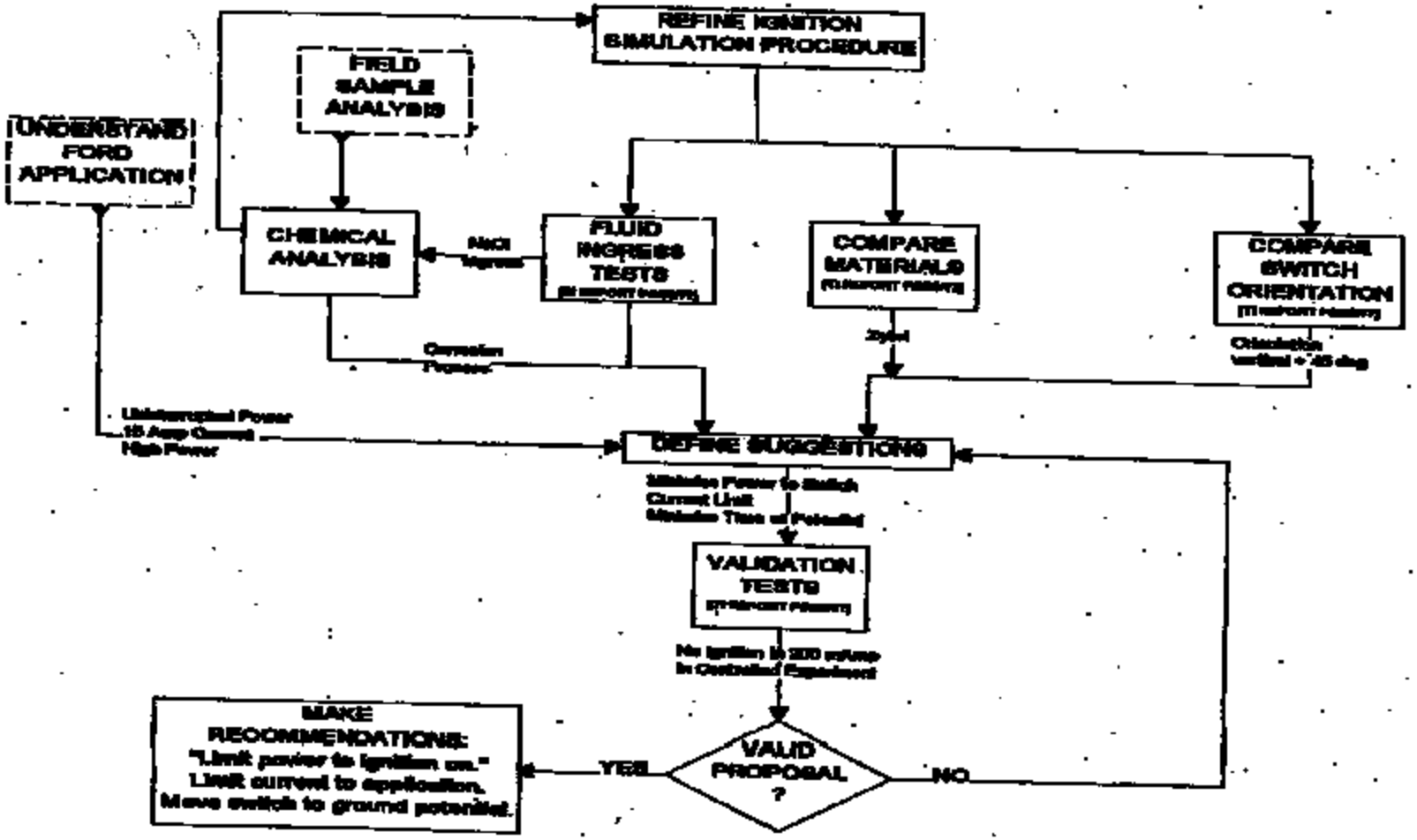
Attachment

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



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Attachment

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

Category	Test	Location	Test Parameters	Results Update
Lab Simulation	1	TI	Vary water concentrations in 'new' Brake Fluid	250+ hours, Current draw in the 0.5mA to 5mA range
of Potential Ignition			14Vdc to one terminal, hexport grounded	Fluid has discolored.
in Switch			Water Conc: 4%, 6%, 10%, 75%	No Significant Temperature Rise. Test Suspended.
				Internal Analysis suspended.
	2	TI	New Brake Fluid	250+ hours. Constant temperature.
			1 Amp through switch terminals	No significant temperature rise with time
			14Vdc to one terminal, hexport grounded	Test Suspended.
	3	AVT	new" Brake Fluid in Switch, 24 VDC to one	> 300 hours into test, max current 7mA
			terminal. Hexport Grounded	No significant change with time. Test ongoing.
	4	AVT	new" Brake Fluid in Switch, 24 VDC to one	16 hours into test max current 5mA
			terminal. Hexport Grounded, Ambient at 100 C	No significant temperature rise with time. Test suspended.
	5	AVT	new" Brake Fluid in Switch, 16 Amps	Temperature rise of 20 C above room temp
			Through switch terminals	Delta T reached steady state at 50 C. Test suspended.
	5a	AVT	new" Brake Fluid in Switch approx. 50 Amps	Temperature rose to approx. 270 F. No smoke, No ignition
			through Switch Terminals	Test suspended.
	6	TI	Build heater elements into Switch.	2 tested. Smoke observed, ignition observed on part w/heater
			Heat till failure, include sparking.	See attachment
			With Fluid & Dry	Test complete
				Brake fluid in cavity slows down heat build-up
				Smoke observed at 675 F, Base melts and falls off at 800 F
	6a	TI	Create heater by corroding spring arm	One out of 15 devices increased resistance to 5 ohms.
			Salt water solution, 14V between spring	Others either very low resistance or [illegible]
			and hexport	It took about 100 hours to reach the 5 ohm stage.
				The 5 ohm device ignited under conditions similar to test 6.
	6b	TI	Re-run ignition test to understand	Switch ignition with repeated 5% water solution into switch
			repeatability and current path.	Current path is through hexport.
				See plots and video.
				Additional test include tap water, old BF, new BF and other.

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Attachment

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

	6c	TI	Pump 'new' brake fluid with metal shavings	Metal shavings do not contribute significantly to brake fluid conductivity
Life Cycle Reliability of Pressure Switch	7	TI	0-1400 psig pressure pulses at 135C per SS	Pivot leak observed at 720,000 cycles. Test Completed. See attached Weibull Chart.
Diaphragm Wear	8	TI	0-1400 psig pressure pulses at 135C.	Parts withdrawn every 200k cycles, characterized for wear
Field vs Lab Correlation	9	Central Labs	Field returns, from dealer lots, junkyards	Parts in Central Labs, see Ford spreadsheet
Design Of Experiments (I)	10	TI	Very wet concentrations in 'new' Brake Fluid	Test Report being written investigation continues.
Evaluating Factors			12 wrap + 12 quiet switches w/ 0 % water in BF	Suspended at 1.3 million cycles with no leaks observed.
Effecting Diaphragm Wear			12 wrap + 12 quiet switches w/ 5 % water in BF	Wrap samples suspended at 1.3 million cycles with 2 leaks observed at 1.3M. Quiet samples suspended at 500k cycles to monitor fixturing anomalies.
Impulse test				
On-Vehicle Characterization of Pressure & Temperature Profile in Town Car	11	AVT	Monitor Pressure and Temperature at Switch Location for ABS and non-ABS braking events.	Test at AVT.....see Ford charts, ...>80C is our?
Brake fluid analysis Used fluid at master cylinder.	11a	TI	Analyze used brake fluid at the master cylinder (UMC), used brake fluid at the caliper (UCA) and new brake fluid (NEW) for metal and water content.	Test complete. UMC: Cu = 415 (ug/ml), Fe = 5.8 (ug/ml), Cr = 0.88 (ug/ml), 1.1 %H2O. UCA: Cu = 592 (ug/ml), Fe = 5.8 (ug/ml), Cr = 1.8 (ug/ml), 1.1 %H2O. NEW: Cu = <0.01 (ug/ml), Fe = 0.82 (ug/ml), Cr = <.01 (ug/ml), 0.3 %H2O.
Spark/Arc Study	12	Central Labs	Determine if sparks/arcs occur in switch using clutch tests and high speed video. Use dry switches as well as switches with vacuum brake fluid to water ratios.	Equipment set-up in progress at Central Labs. TI Experimented with no 'significant' sparks observed
Characterization of switches retrieved from field Junkyards & other sources	13	Central Labs	Characterize electrical, mechanical and chemical aspects of returned switches	Data log and analysis procedure set up complete. Analysis of switches in progress.
Field Ingress Tests	13a	TI	Pinpoint ignition simulation with different fluids.	Test complete.
			48 hour tests:	5% NaCl sample supplied by ignition.
			5% NaCl in tap water	All brake fluid samples drew less than 3 mAmps. No corrosion
			rain water	visible on brake fluid samples.
			168 hour tests:	Rain water and tap water samples drew <10 mAmps and showed
			tap water	some signs of corrosion.
			used brake fluid	Chemical analysis in process.
			used brake fluid w/ 5% H_2O	
			new brake fluid	
			new brake fluid w/ 5% H_2O	

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Brake Pressure Switch
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Compatibility of Kapton with Caustic Acid	14	Deposit	Characterize change in properties of Kapton with various % caustic acid in brake fluid.	Compatibility of Kapton with Caustic Acid	14	Deposit	Characterize change in properties of Kapton with various % caustic acid in brake fluid.
Evaluation of Plastic Materials with Improved Parameters	15	TI	Assess properties and moldability of different grades of plastic resin with additives to improve plastic part performance	Evaluation of Plastic Materials with Improved Parameters	15	TI	Assess properties and moldability of different grades of plastic resin with additives to improve plastic part performance
Long duration brake fluid bypass test	15a	TI	(4) samples with new brake fluid (2) samples with used brake fluid	Long duration brake fluid bypass test	15a	TI	(4) samples with new brake fluid (2) samples with used brake fluid
Evaluation of Switch Orientation	15b	TI	Assess ignition sensitivity to switch orientation. Test vertical versus 45 degree. Test rotational sensitivity in 45 deg. orientation.	Evaluation of Switch Orientation	15b	TI	Assess ignition sensitivity to switch orientation. Test vertical versus 45 degree. Test rotational sensitivity in 45 deg. orientation.
Relay Circuit Test	16	TI	Repeat test 13a in Ford relay circuit for (48) hrs. Bring switch to impending ignition in (15) Amp circuit then place in relay circuit for (16) hrs. Input max. circuit power into heater on switch.	Relay Circuit Test	16	TI	Repeat test 13a in Ford relay circuit for (48) hrs. Bring switch to impending ignition in (15) Amp circuit then place in relay circuit for (16) hrs. Input max. circuit power into heater on switch.

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Attachment

Brake Pressure Switch
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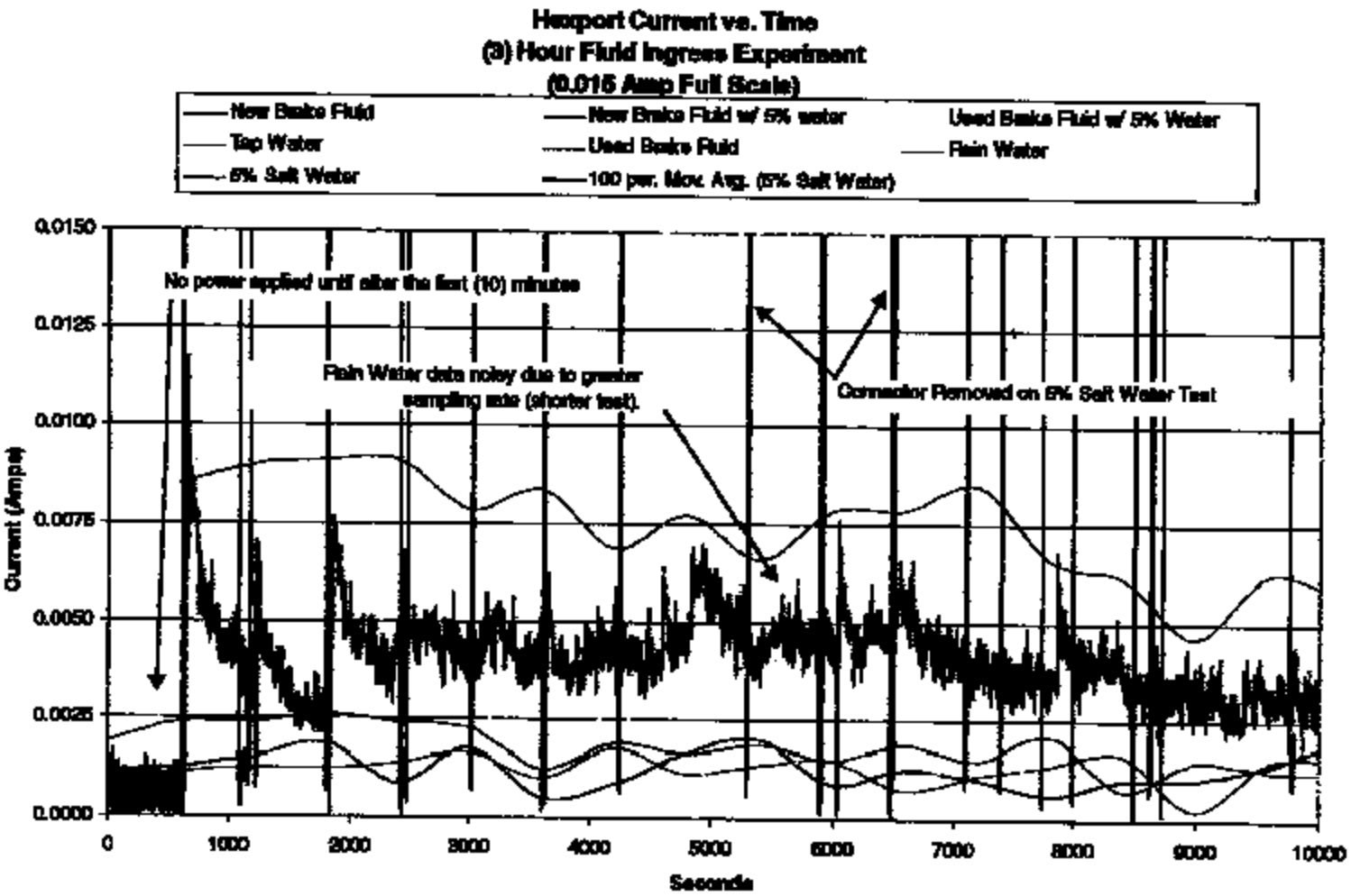

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Attachment

TI-NHTSA 013945

Stephen, Sally

From: Press, Stephen [s-press@email.mot.com]
Sent: Wednesday, June 02, 1999 1:56 PM
To: Sharpe, Robert
Subject: 7795_timeline.ppt

7795_timeline.ppt

<<7795_timeline.ppt>>
Here's the timeline you requested.

Steve

[redacted]

Timeline: F2VC-9F924-AB (TI P/N 77PSL2-1)