EA02-025

TEXAS INSTRUMENTS, INC.'S

9/10/03

REQUEST NO. 7

BOX 9

PART A – R

PART I

Currey, Pat

From: McGuirk, Andy {a-mcguirk@email.mc.ti.com}
Sent: Tuesday, June 29, 1999 4:04 PM
To: Epstein, Sally
Subject: Ford5_20_99presentationppt.ppt

<<Ford5_20_99presentationppt.ppt>>

Agenda

8:00- 8:30	Introduction to TI	Douglas
8:30- 9:15	Supplier Delivery Rating Management	Perry/Spencer
9:15- 9:30	77PS Design Overview	Dague
9:30- 9:45	77PS Process Overview	Proia
9:45-10:15	QOS Overview	Watt
10:15-10:30	Break	
10:30-11:00	77PS Line tour	Proia
11:00-11:15	Travel to Bldg. 4	
11:15-11:45	Thermal Valve Design/ Process Overview	Kelsall
11:45-12:00	Thermal Valve Line tour	Kelsall
12:00-1:15	Travel to Mansfield and Lunch	Spencer
1:15-1:30	Transmission & Inertial Sensor Overview	Spencer
1:30-2:00	TRS Design Overview	Perkins
2:00-2:15	TRS Process Overview	Martin

Agenda

2:15-2:45	TRS Line Tour	Martin
2:45-3:00	TRS QOS Overview	A. Johnson?
3:00- 3:30	CAS/IVD Design/Process Overview	Johnson
3:30- 3:45	CAS/IVD Line Tour	Johnson
3:45- 4:00	Wrap Up and exit review	Spencer

Texas Instruments

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

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 01411B

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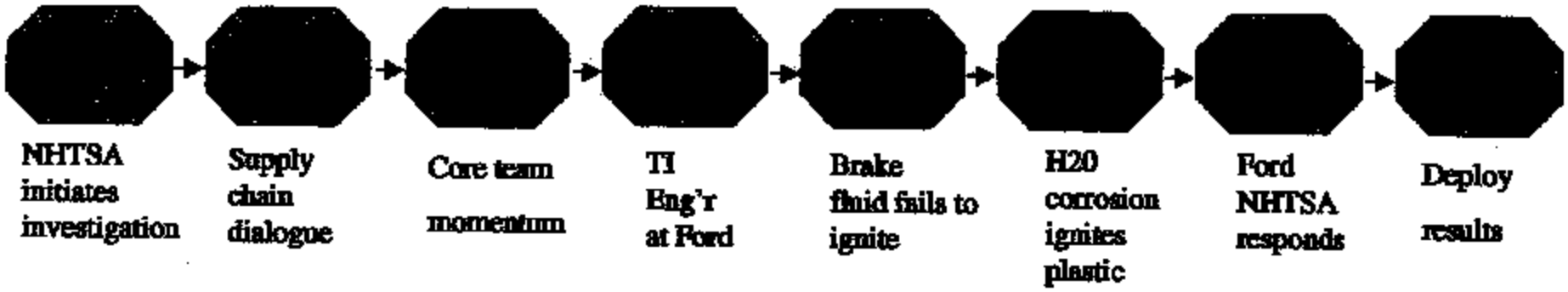
Attachment

OVERVIEW OF CONCERN TIME LINE



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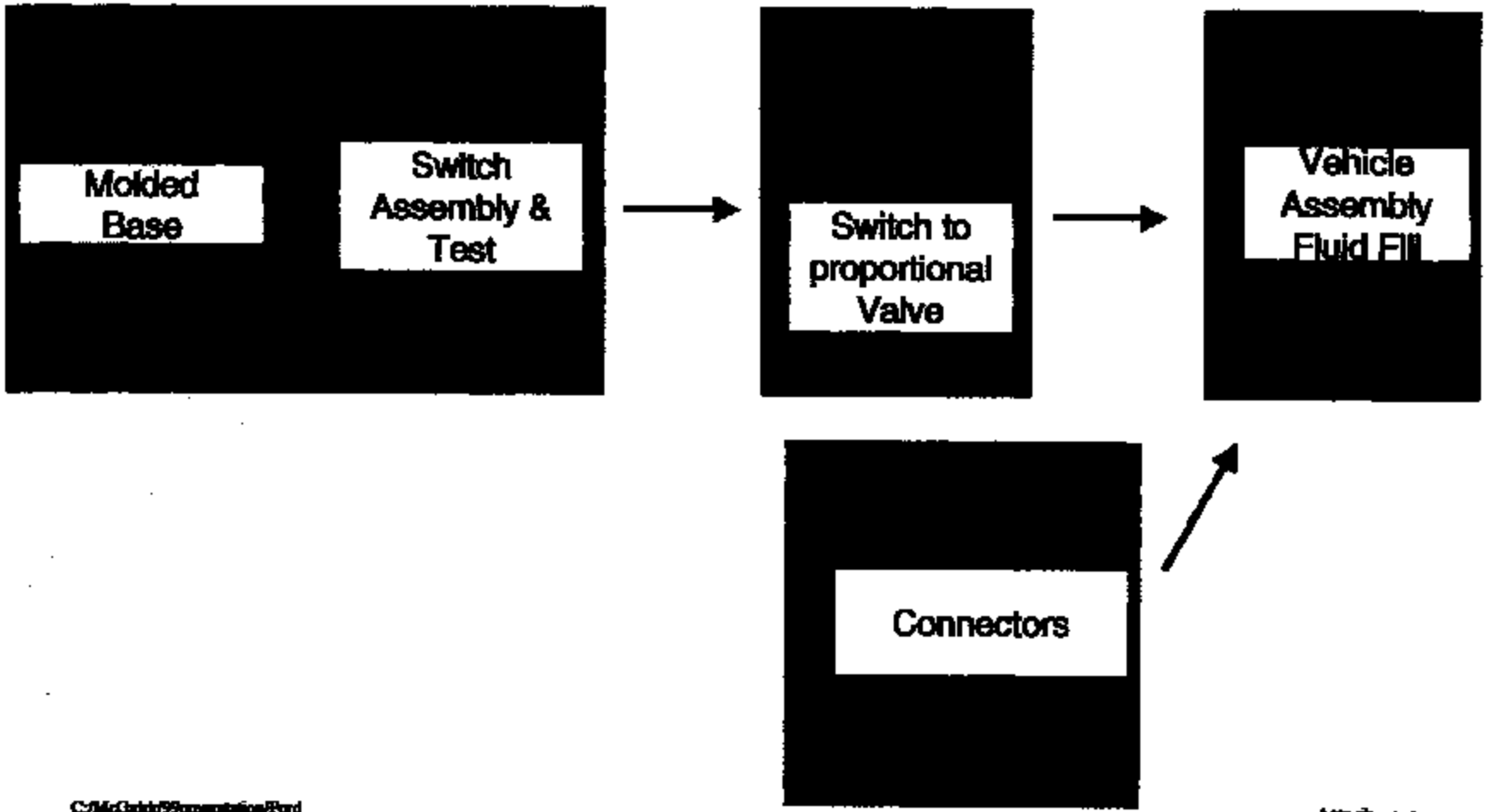
Attachment

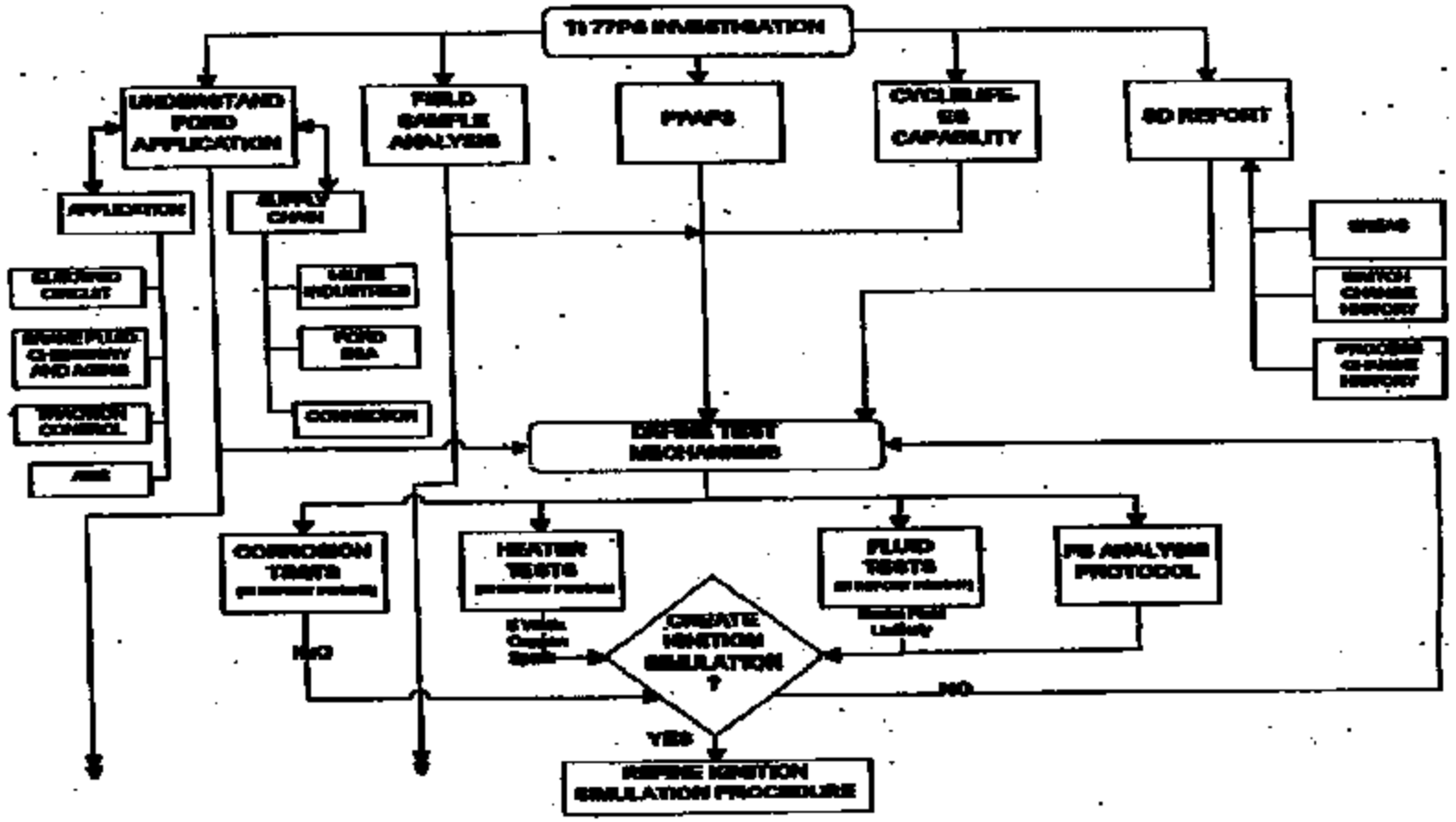
Brake Switch Overview

- 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

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



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

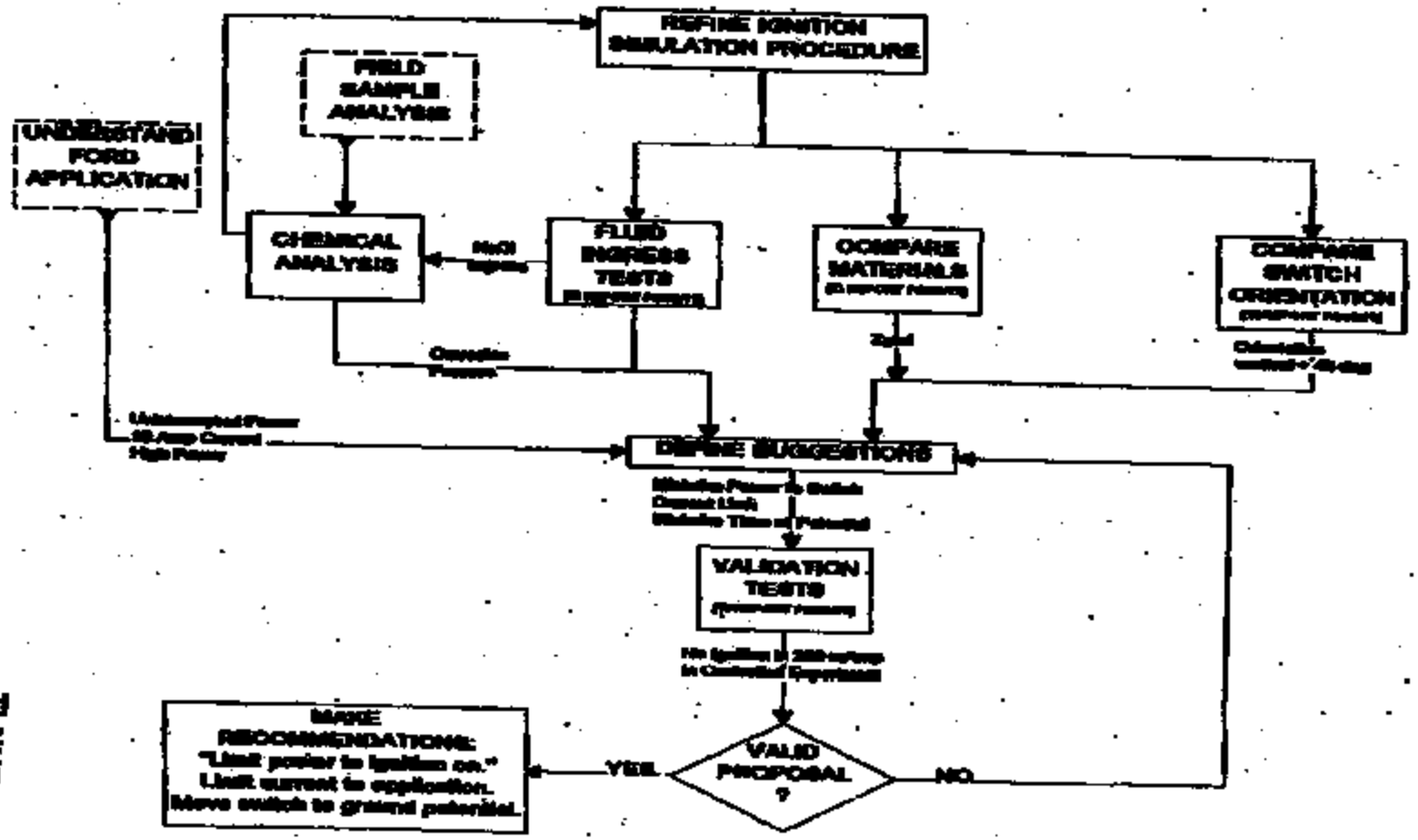


TI-NHTSA 014122

Attachment

Texas Instruments

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



TI-NHTSA 014123

Attachment

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

Ford recalls 279,000 cars because of risk of cruise-control fires

05/19/1999
Associated Press Newswires

DEARBORN, Mich. (AP) - Ford Motor Co. has recalled 279,000 full-size cars because of a cruise-control switch that could short-circuit and cause a fire.

The recall affects the 1992 and '93 Lincoln Town Car, Mercury Grand Marquis and Ford Crown Victoria. About 10,900 of the recalled cars are in Canada.

There have been 147 reports of fires and two injuries attributed to the defect, Ford spokeswoman Karen Shaughnessy said Tuesday.

The automaker said it is still obtaining replacement switches. Until the switch can be fixed, customers should take their cars to their dealer and have the cruise control disabled, Ford said.

AGENDA

- CONTRIBUTING FACTORS AND ROBUST DESIGN DIALOGUE
- OVERVIEW TIME LINE
- SYSTEM OVERVIEW
  - SWITCH AND CONNECTOR
- IS / IS NOT TABLE
- CAUSE AND EFFECT DIAGRAMS
- THEORIES
  - BRAKE FLUID IGNITION
  - PLASTIC IGNITION
- TEST RESULTS
- CONTRIBUTING FACTORS AND ROBUST DESIGN DIALOGUE
- ROBUST DESIGN ALTERNATIVES

Attachment

[redacted]

1. Connector Seal to P/S

2. Power continuously available
   A. Operator notifications

3. Switch orientation/location

4. Current limit / fuse

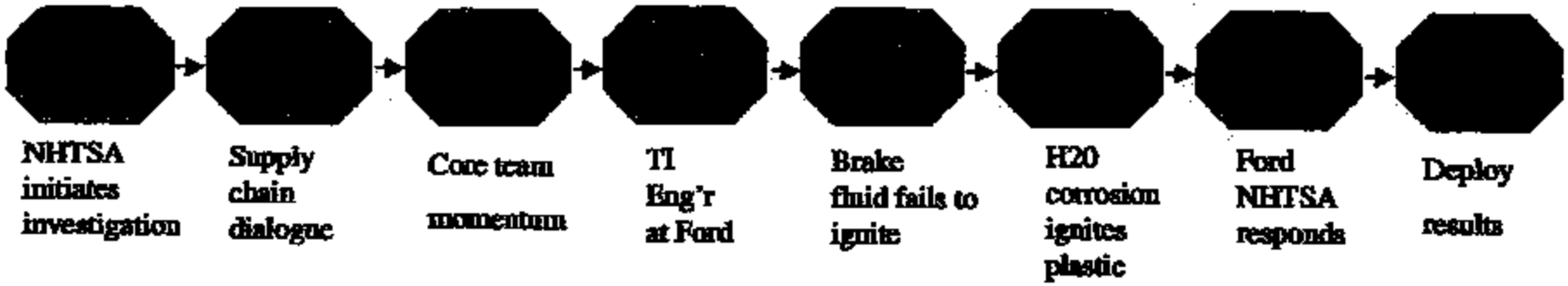
5. Hexport isolation

6. Plastic ignition robustness
   A. Nearby fuels

7. Kapton seal of P/S

8. Environmental seal of P/S

OVERVIEW OF CONCERN TIME LINE



Attachment

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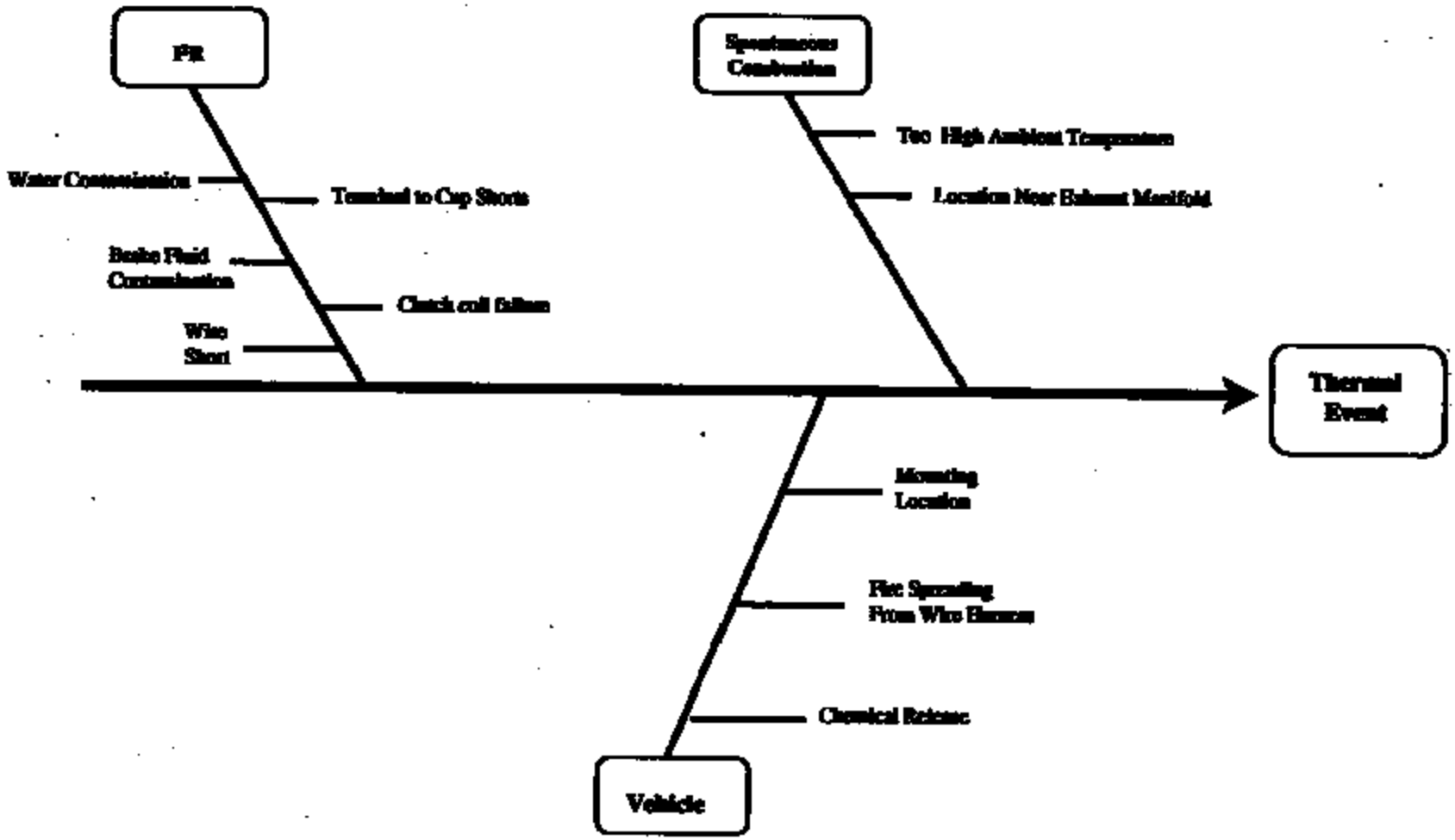
Texas Instruments

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

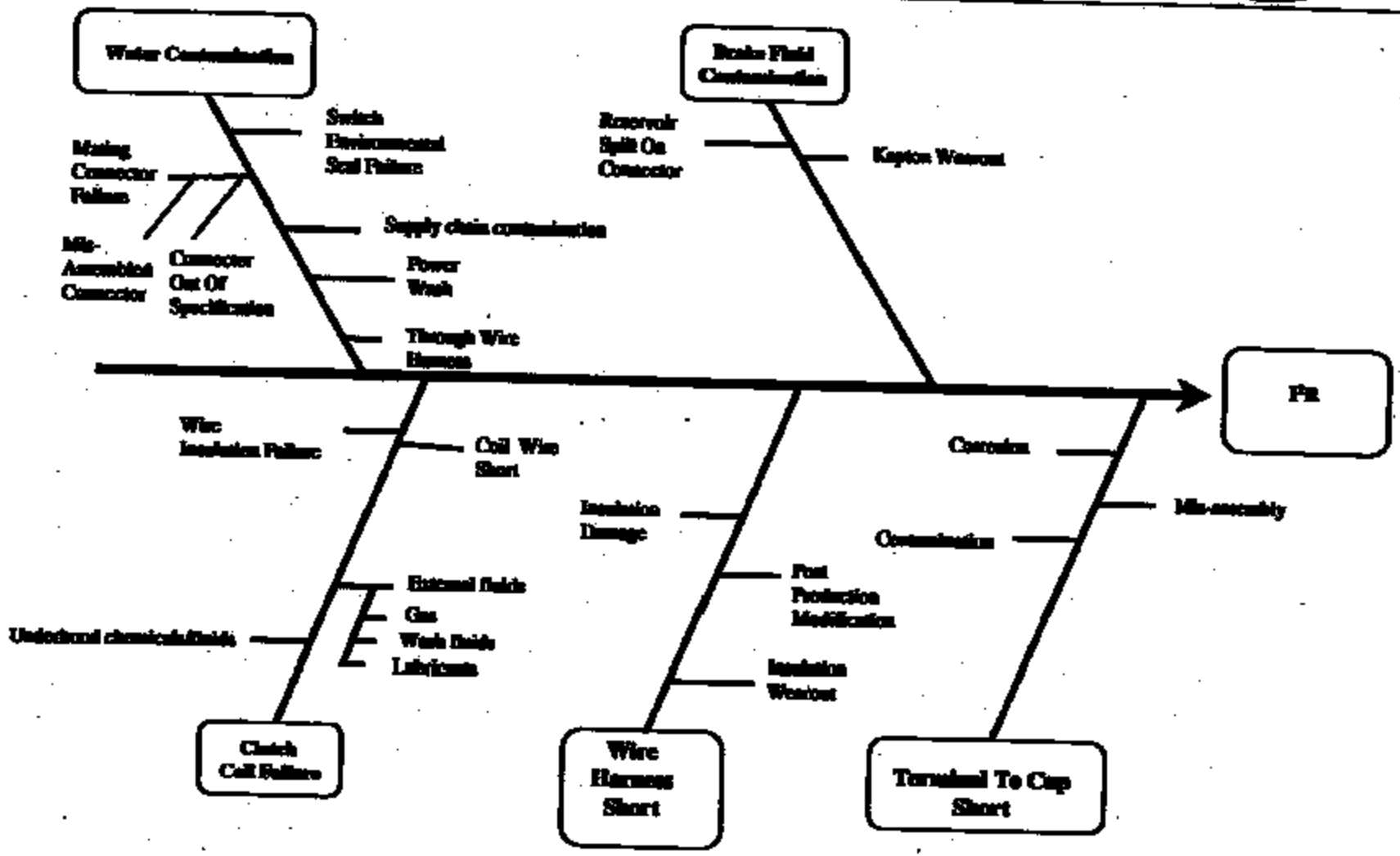


TI-NHTSA 014126

Attachment

Texas Instruments

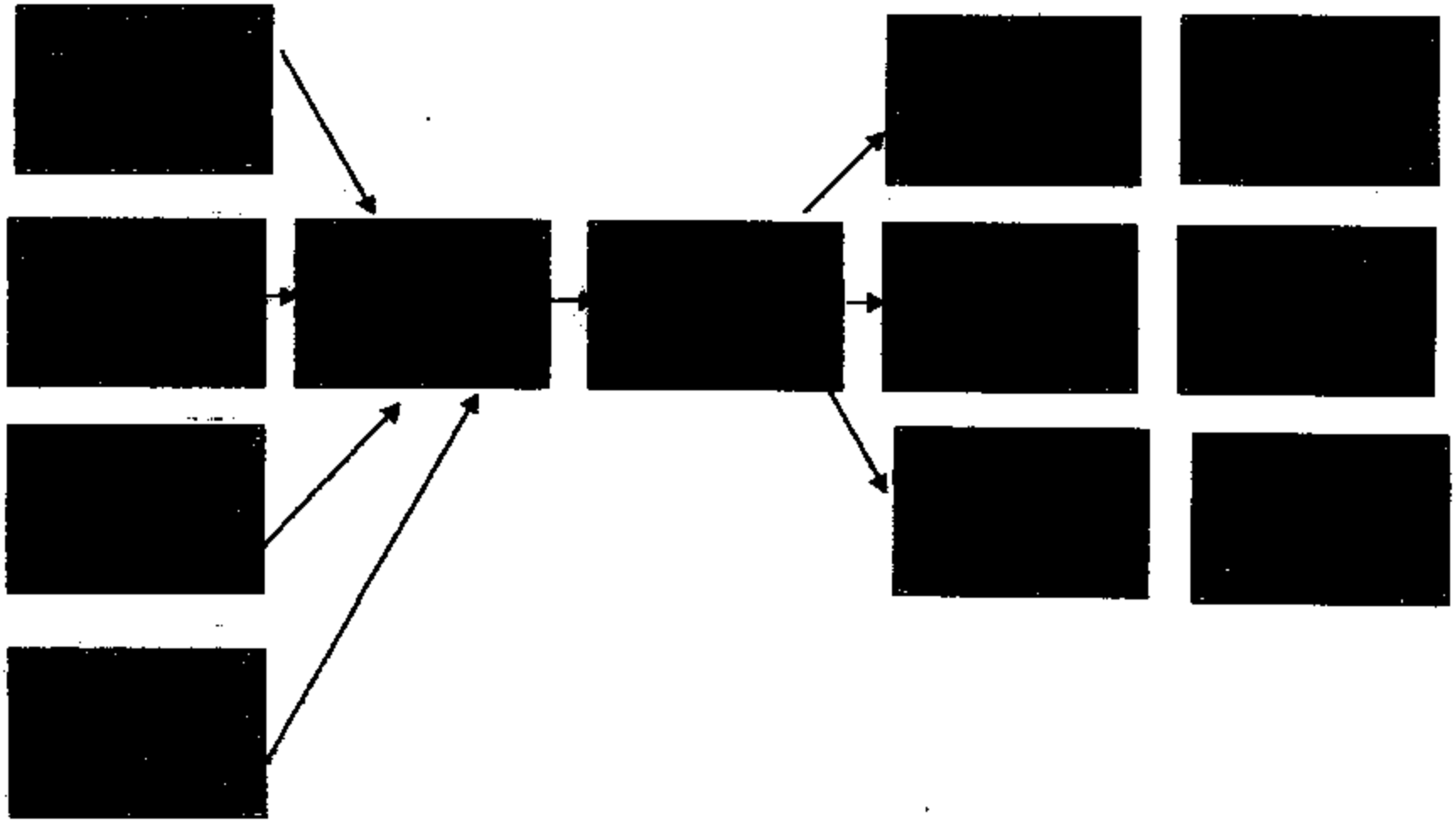
Brake Pressure Switch
Potential Thermal Event Theory Profile 5/20/99



TI-NHTSA 041430

Attachment

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



Attachment

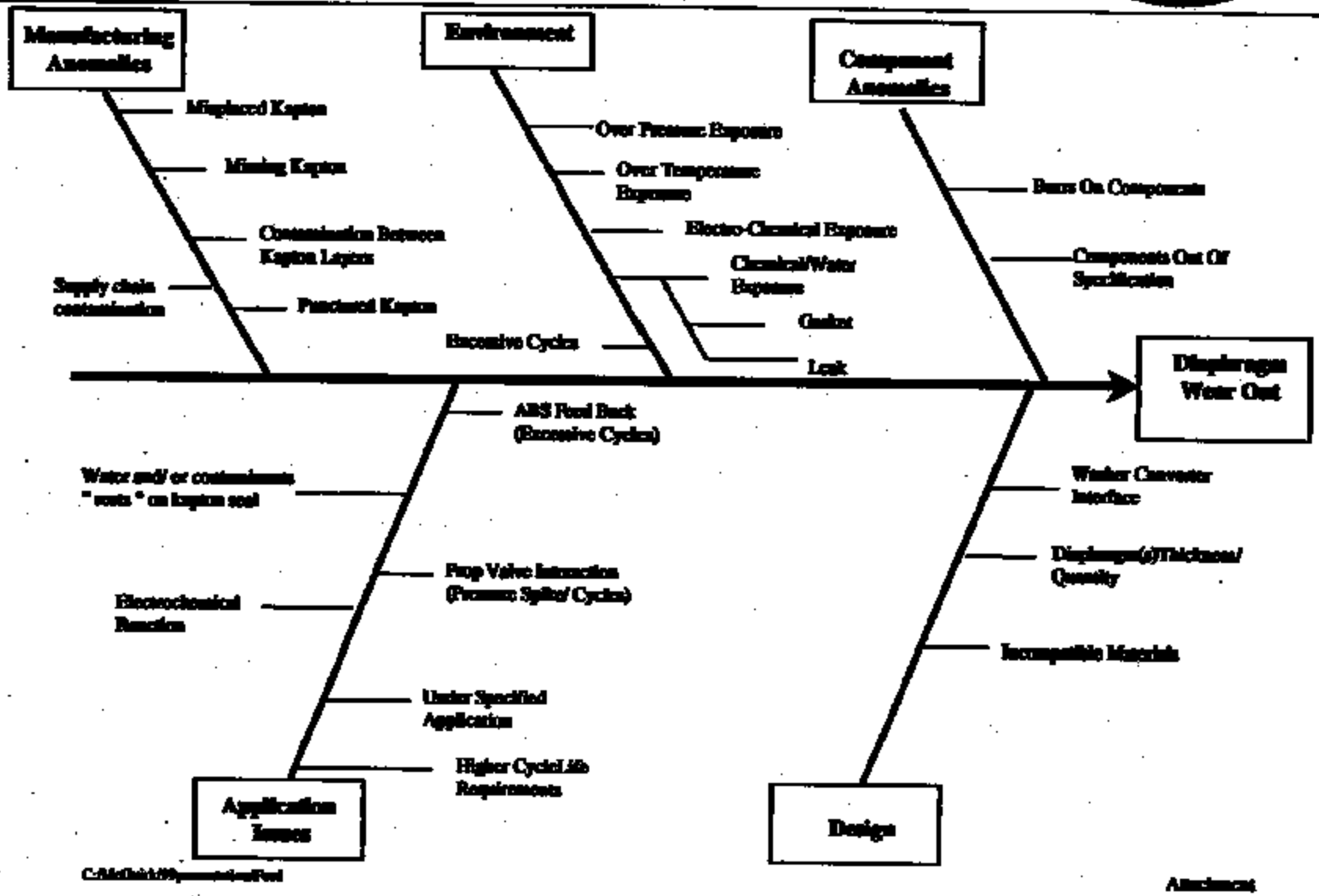
Excel spreadsheet

Attachment

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

Texas Instruments

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

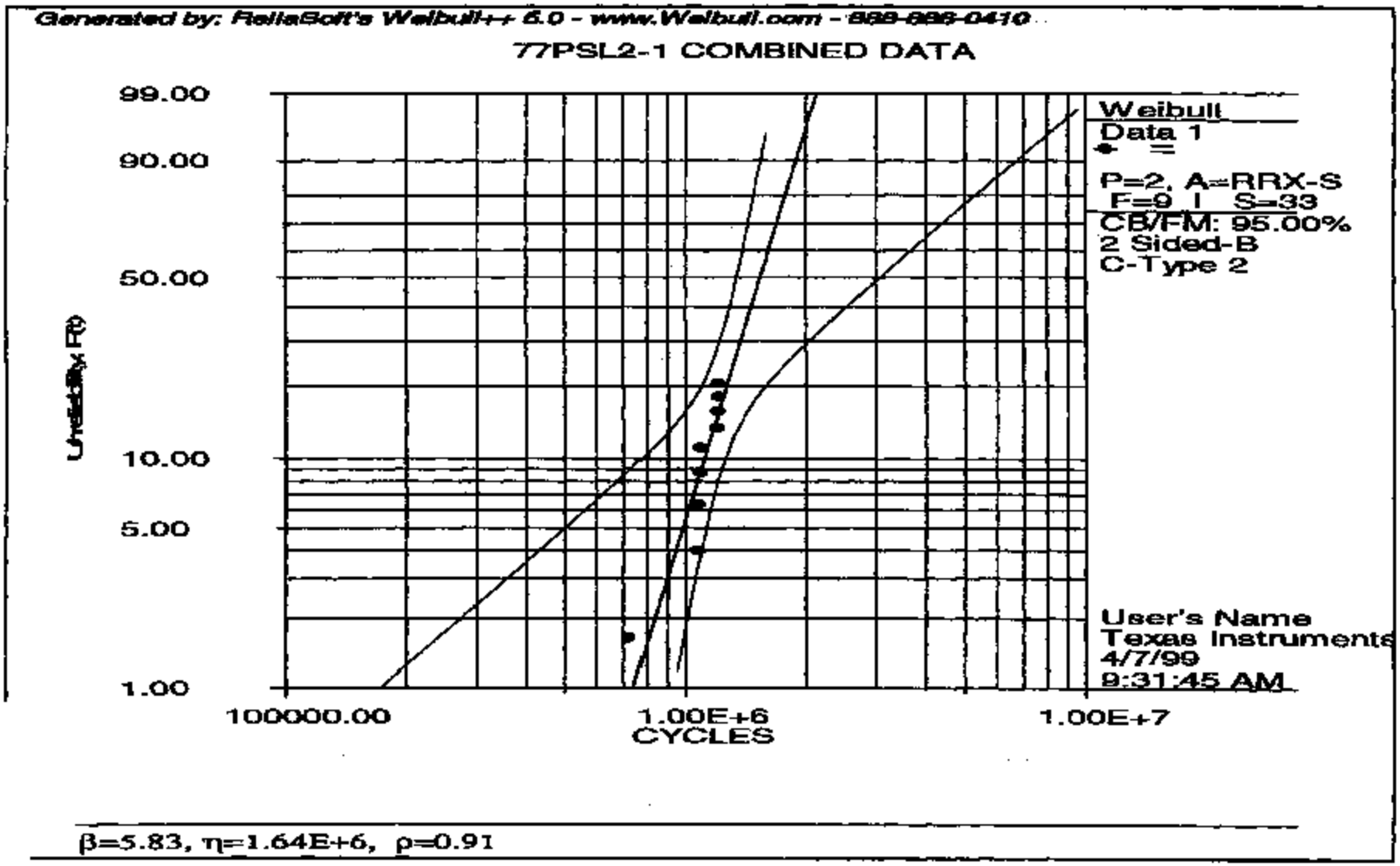


TI-NHTSA 014134

Attachment

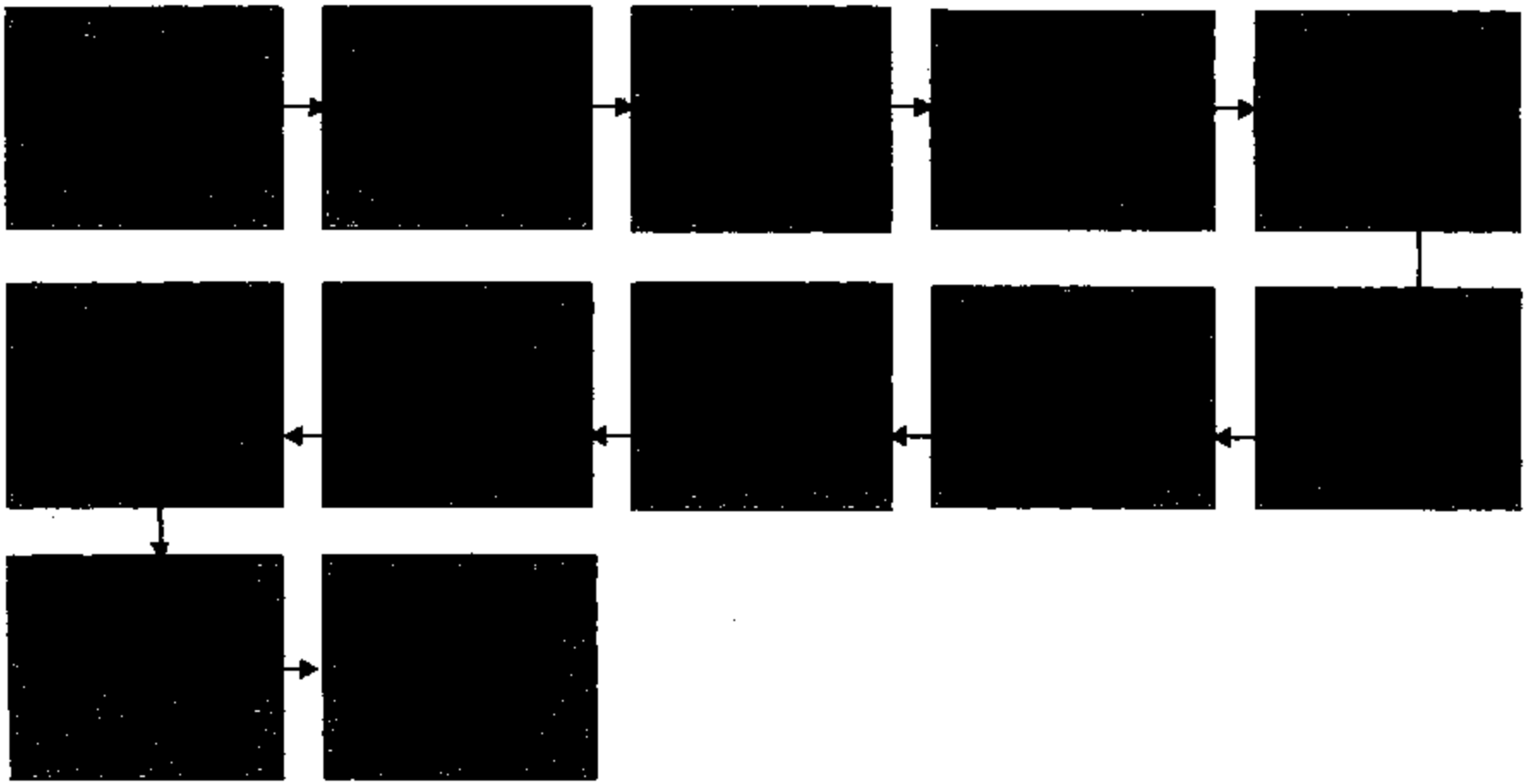
Texas Instruments

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



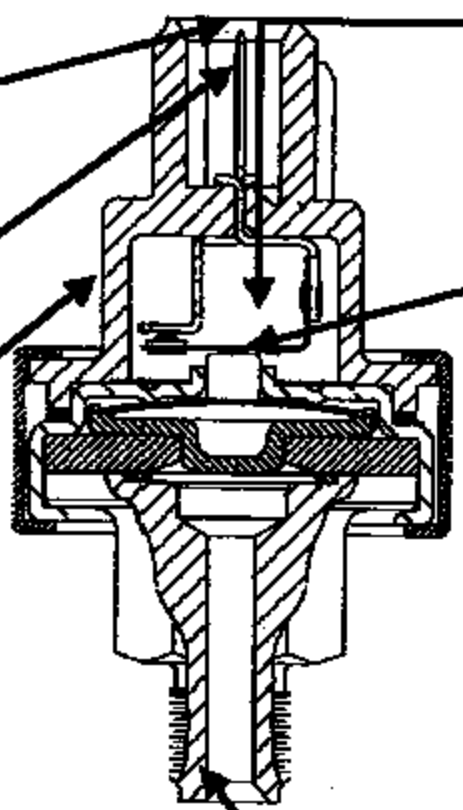
- "Town Car" switch meets accelerated/simulated life cycle specification shown by "success" and "end-of-life" testing

PROCESS FLOW DIAGRAM
"CORROSION" POTENTIAL CAUSE FLOW ANALYSIS



TEXAS INSTRUMENTS

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



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

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

3. Hexport grounded accelerates corrosion

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

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

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

TI-NHTSA 014138

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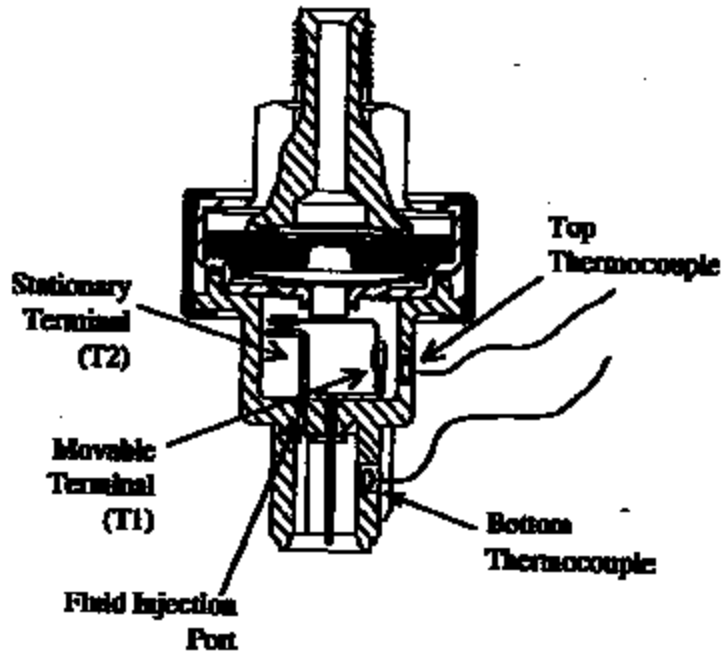
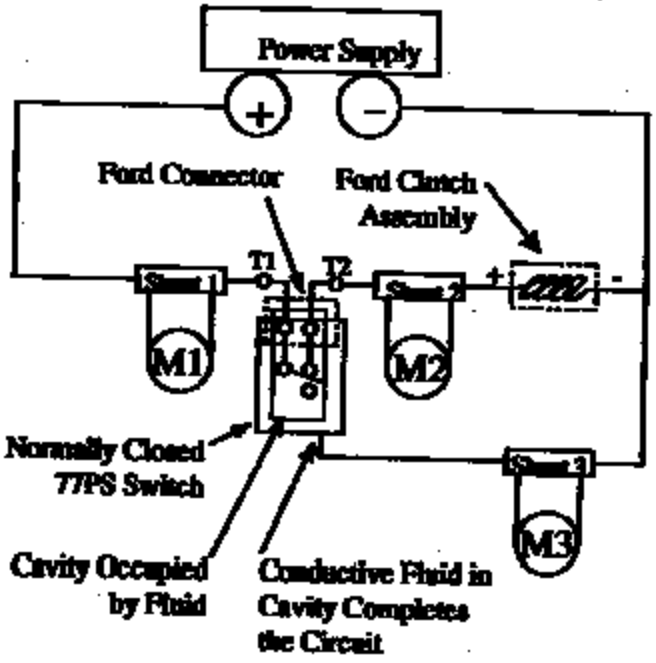
Attachment

5% Salt Water Ingress Experiment
Test 1



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



Test 1: Figure 1 and Figure 2.

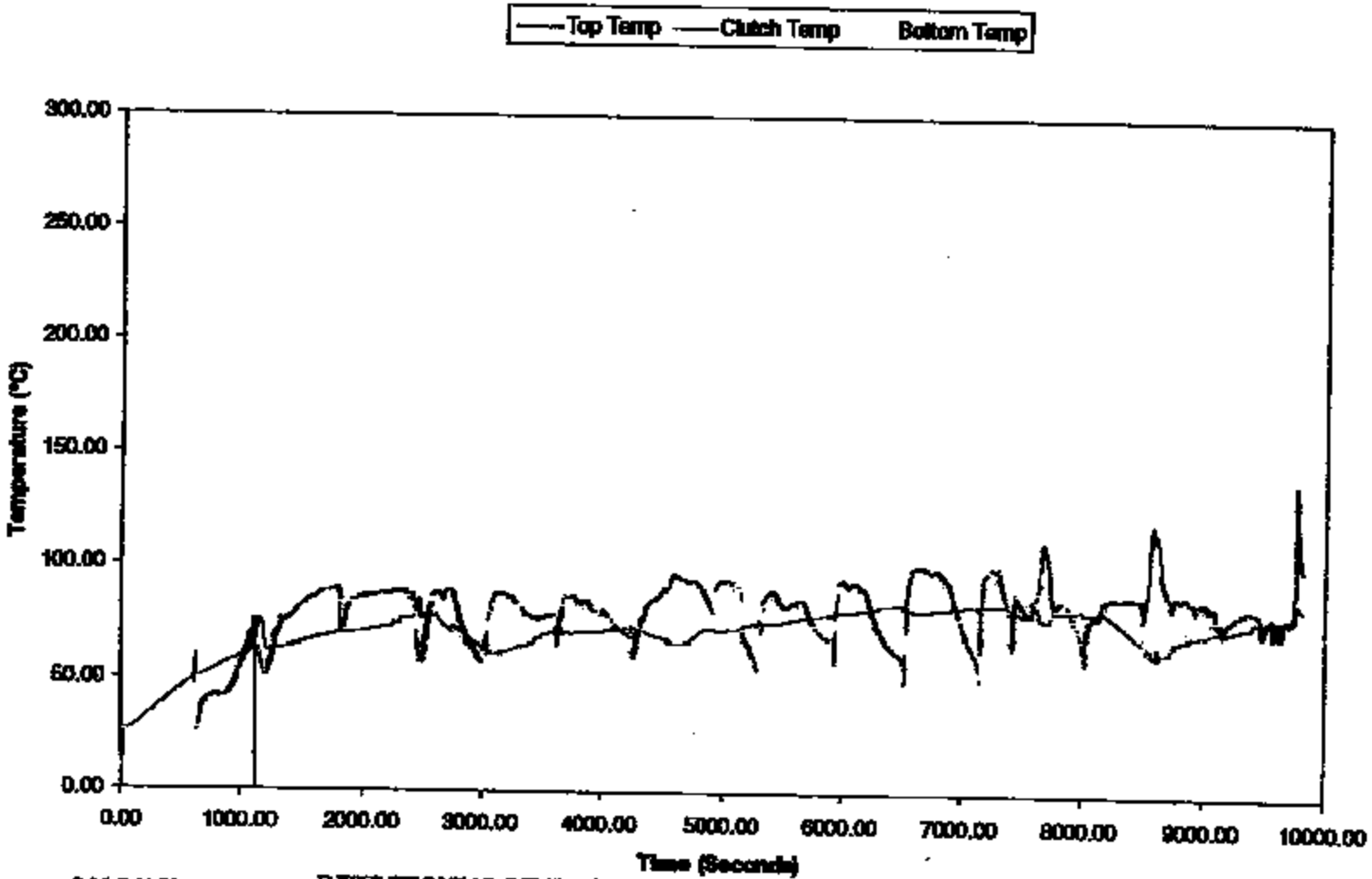
Attachment

TI-NHTSA 014138

TEXAS INSTRUMENTS

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

5% Salt Water Ingress Experiment
Temperature vs. Time



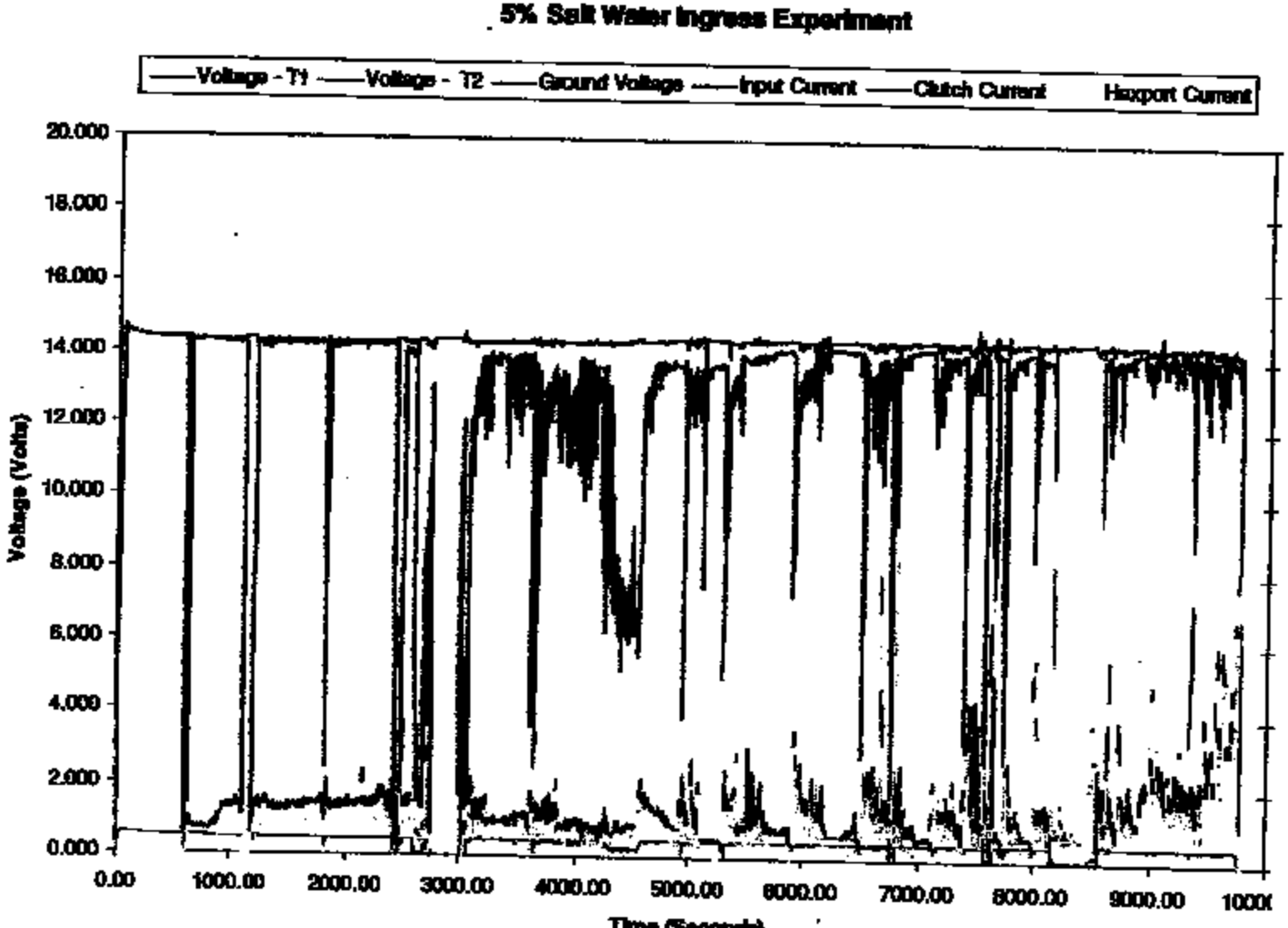
INTENTIONIAL IGNITION CREATED THRU TI FLUID INGRESS LAB TEST PS/99/13'

Attachment

TI-NHTSA 014140

TEXAS INSTRUMENTS

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



C:\McQuick\99ptransmission\Ford INTENTIONIAL IGNITION CREATED THRU TI FLUID INGRESS LAB TEST PS/99/13* Attachment

TI-NHTSA 014141

Texas Instruments

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

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

Cellanex 4300 Base

Cellanex 3316 Base

INTENTIONIAL IGNITION CREATED THRU TI FLUID INGRESS LAB TEST PS/99/13"

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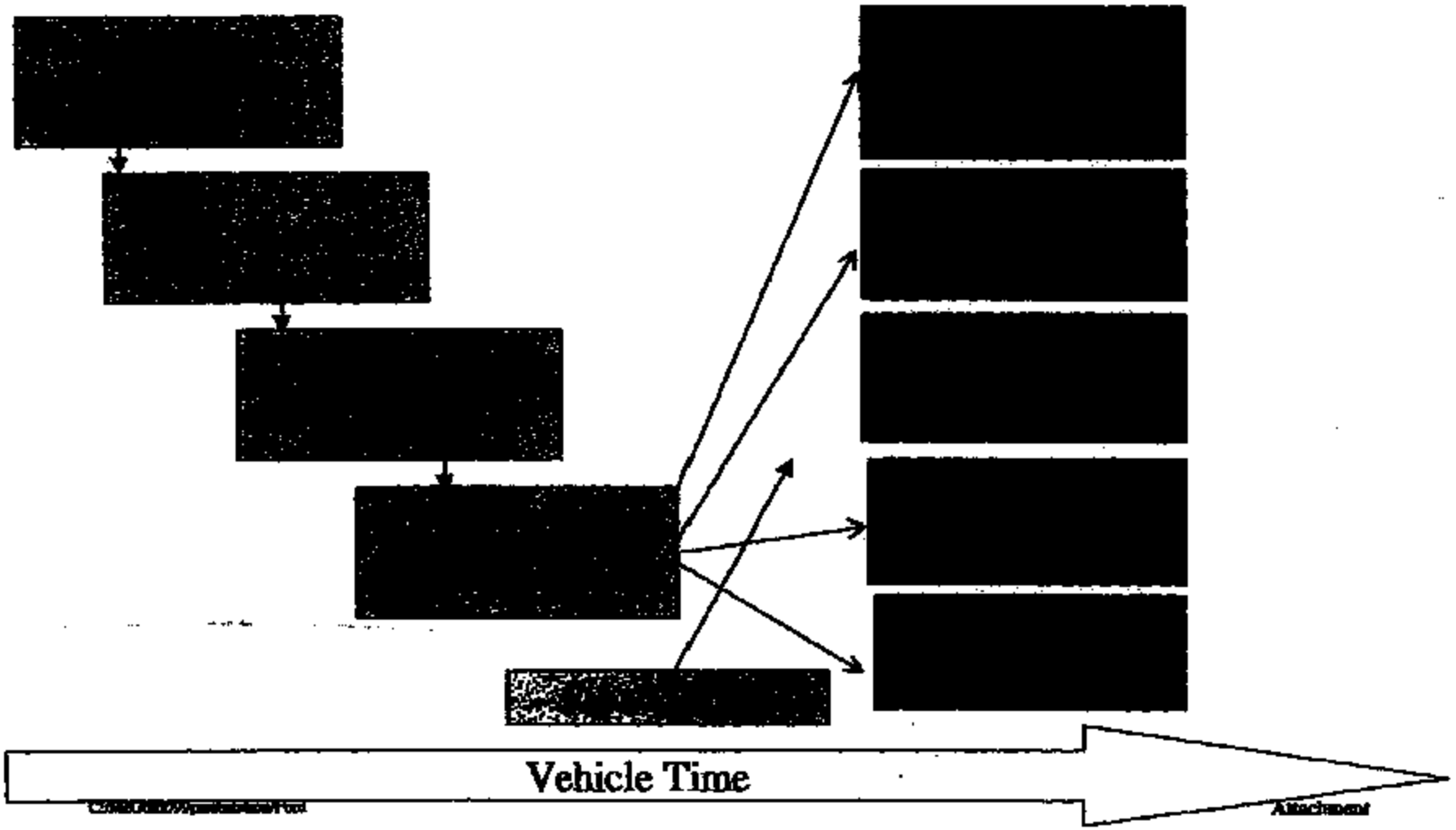
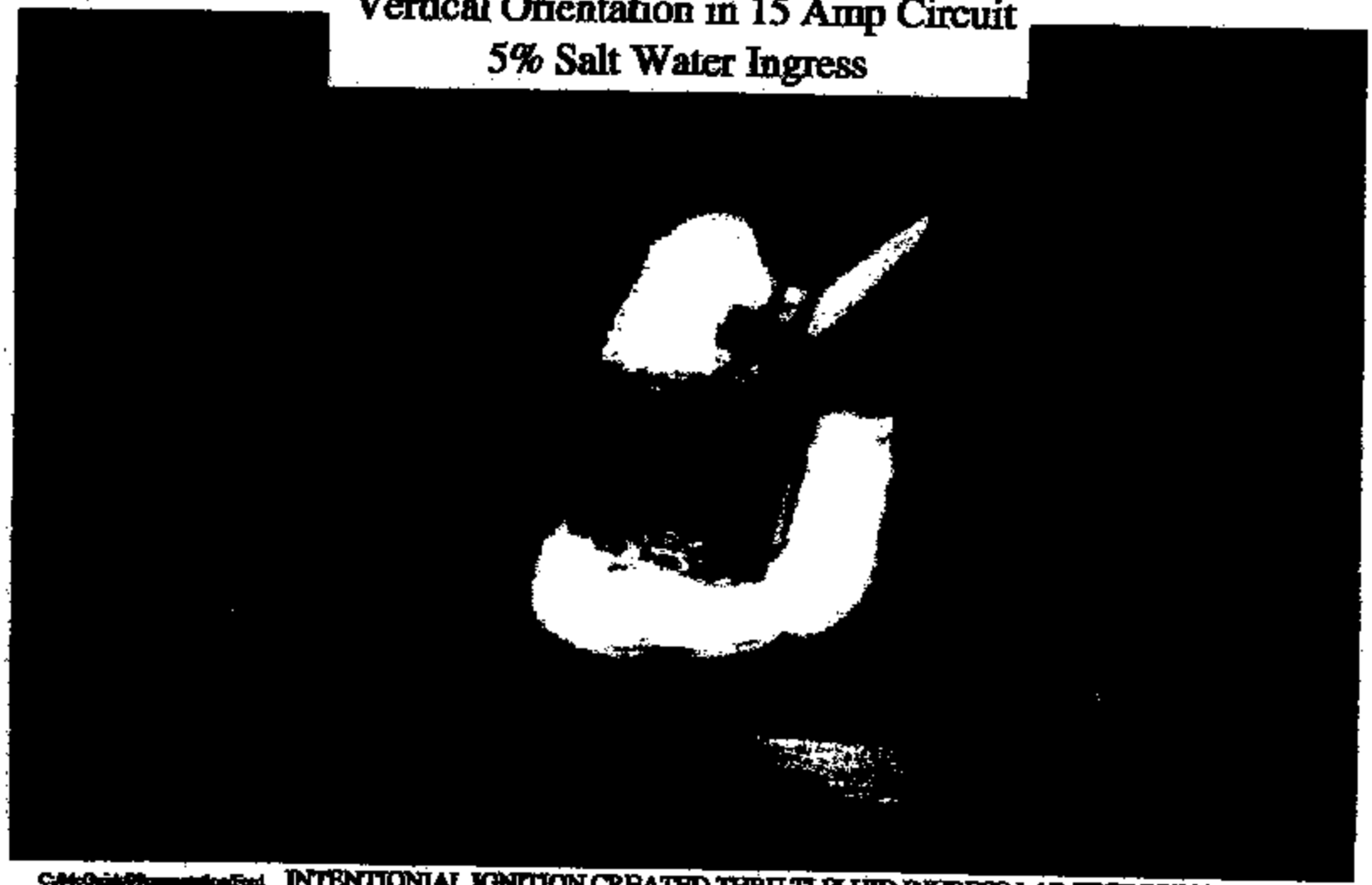
Attachment

TI-NHTSA 01442

"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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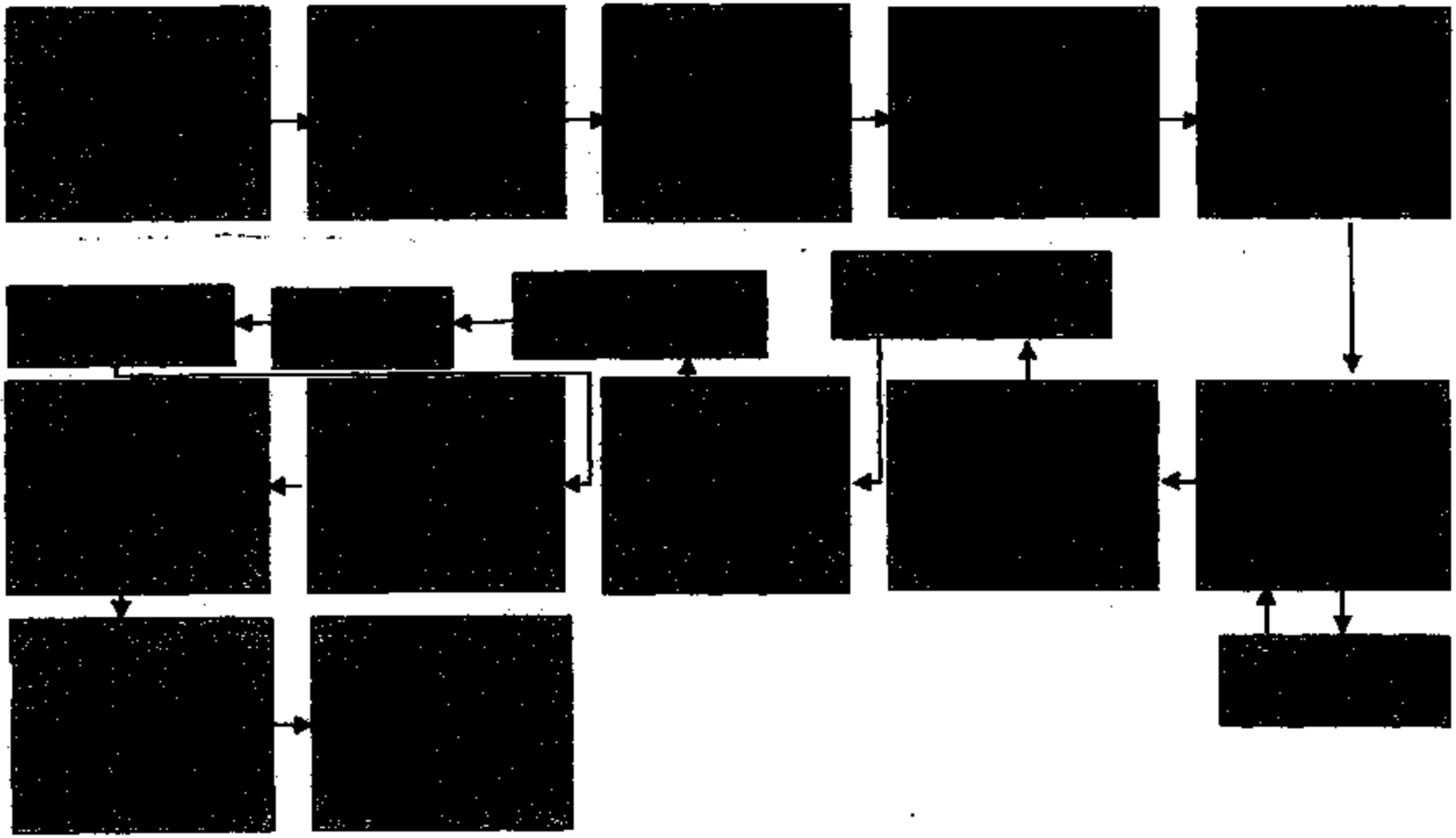
PROCESS FLOW DIAGRAM
"CORROSION" POTENTIAL CAUSE FLOW ANALYSIS

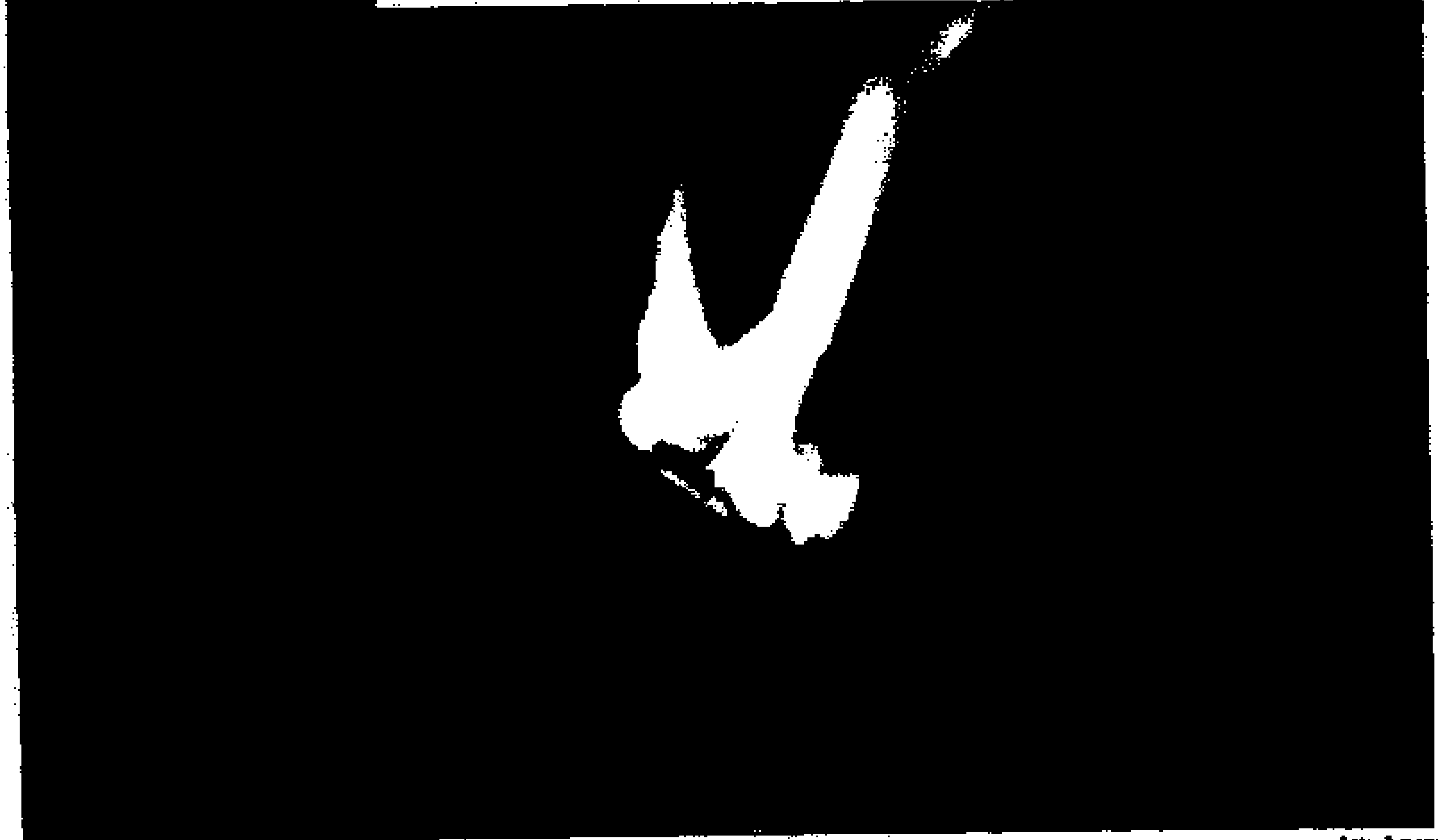


Attachment

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

TEXAS INSTRUMENTS

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

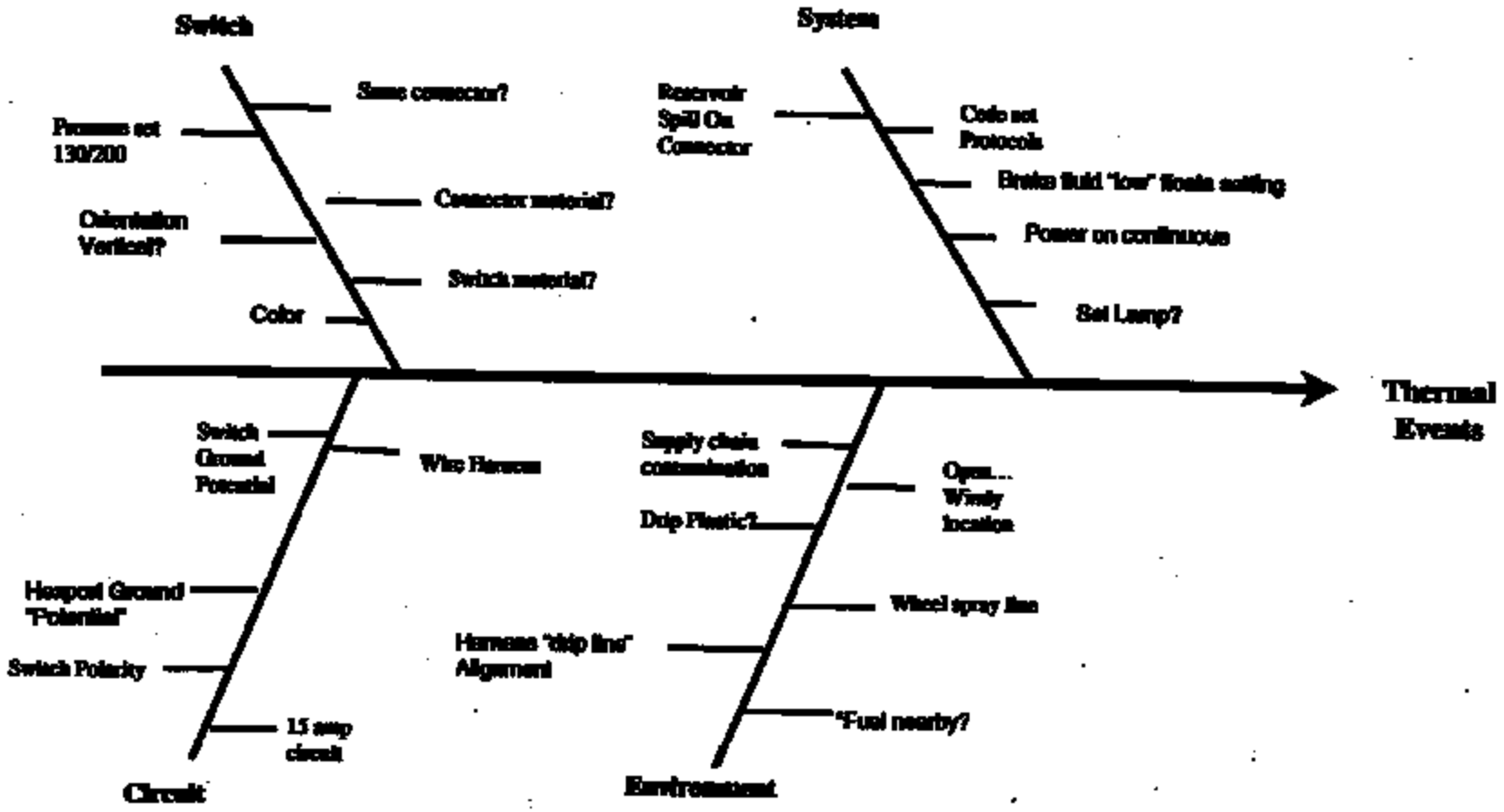


INTENTIONIAL IGNITION CREATED THRU TI FLUID INGRESS LAB TEST PS/99/13 Attachment

Texas Instruments

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

ECONOLINE VS. TOWN CAR P/S

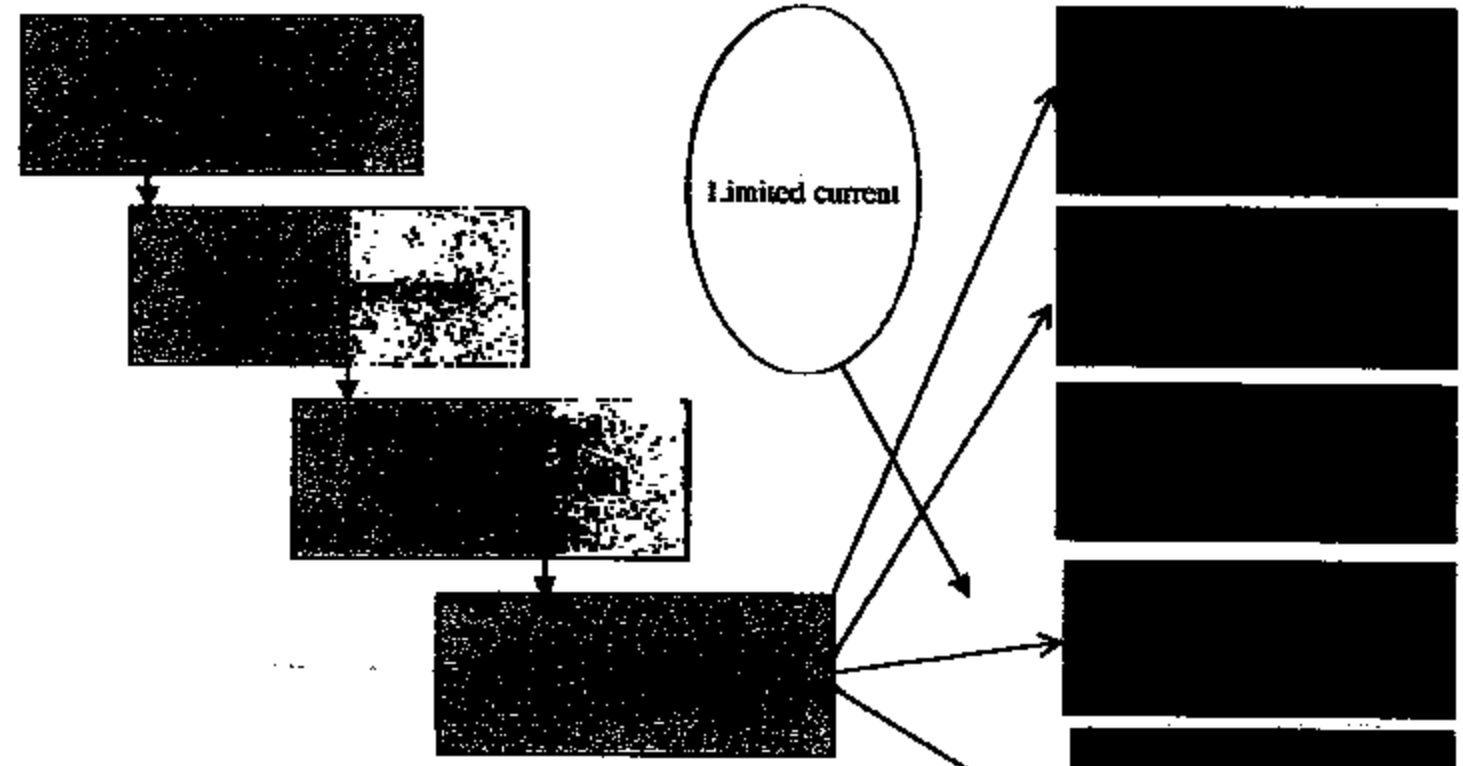


THNHTSA 014147

Attachment

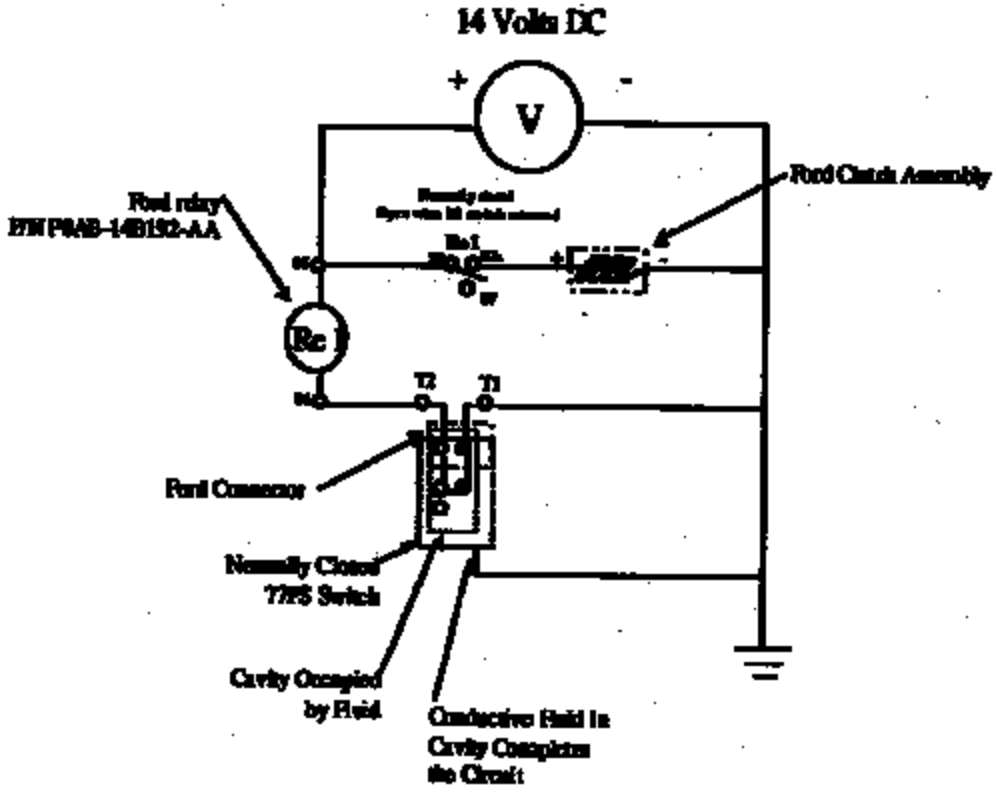
"Corrosion" potential cause time line

Theory Time Line

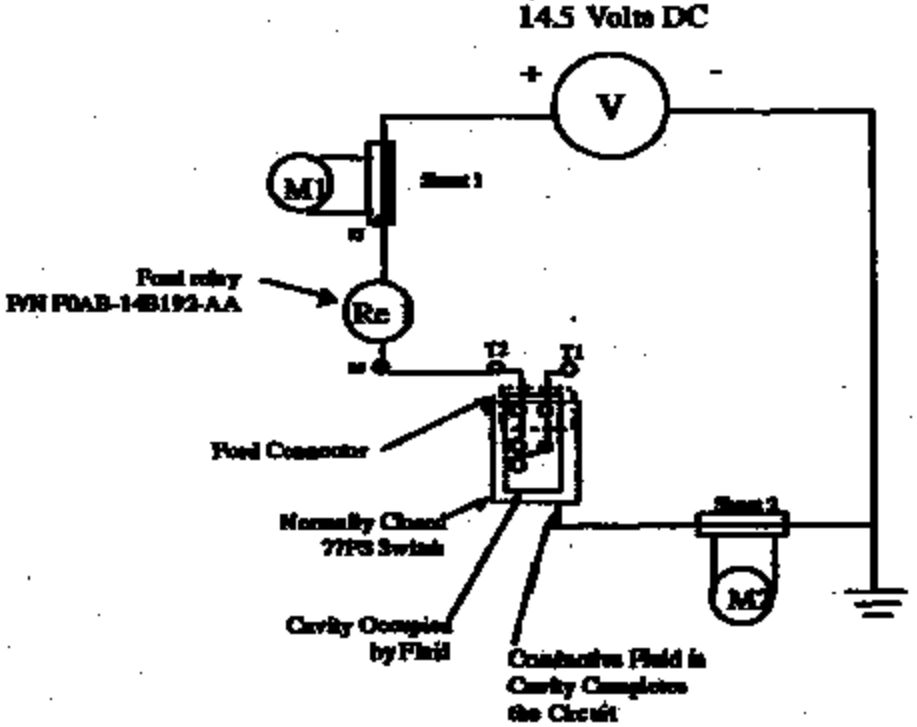


Vehicle Time

77PS Proposed Wiring Schematic



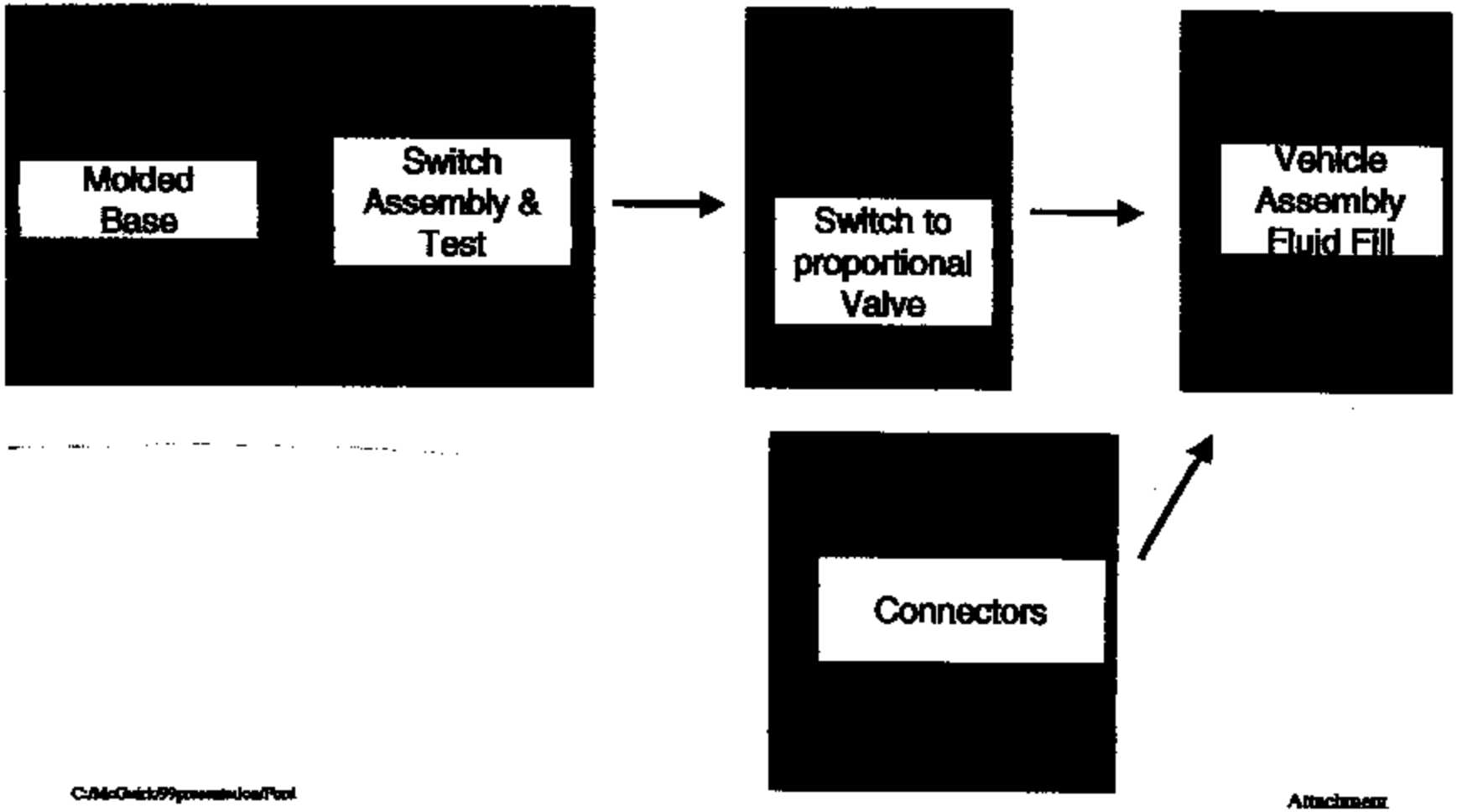
200 mAmp Current Limit Circuit Test Setup



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).

See low current stuff from sean

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



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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
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Texas Instruments

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

Today's Date: UPDATED [illegible]

Scope or Effect Description

1. Operational Definition (Problem Statement): TOWN CAR UNDERHOOD FIRES			
2. Description	IS	IS NOT	Get Information
WHAT	Town Car MY '92, '93, '94	Crown Victoria? Grand Marquis? TB Super Coupe? MY '91, '95, 96? '92, '93 [illegible]?	COMPARE PLATFORMS
	FIRES... - Electrical pressure switch - Connector - Servo system - Electrical Distribution	Not only pressure switches	COLLECT/TEST OTHER SYSTEM COMPONENTS FOR "SYNERGY" COMPARE VEHICLE OPTIONS FOR SYNERGY
	SYSTEM ISSUES... - Cruise inoperative - Locked in park - Horn inoperative - Brake lights inoperative - Discharged battery - Door locks? - Hazard lamps?	Other circuits	COMPARE WARRANTY
WHERE	Driver side hood Medium height in engine compart.	Passenger side hood Dash – pass. compartment Not high in engine comp. Not low in engine comp.	EVALUATE HEAT SOURCES
WHEN	1-44 hours after parking Ignition off After 4-6 years After XXX miles	Not while driving Not while ignition on Not before 3 years? Not before YYY miles	EVALUATE POWER AND HEAT AND WIND SOURCES REVIEW MILES
	After AAA switch cycles	Not Before BBB cycles	
HOW BIG	149 cars / [illegible] units "candle size" flame	Not all cars? Not "explosion"	COMPARE PLATFORMS READ FIRE RPTS
	Several pressure switches	Not all underhood fires Not all pressure switches	PARETO UNDERHOOD

Attachment

[illegible]

TI-NHTSA 014154

TEXAS INSTRUMENTS

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

Texas Instruments
Automotive Sensors & Controls
8D Report

Concern Title: 77 PS Thermal Events T.I. CAR Report Number: CAR 99-[illegible]	Open Date: 3/9/99 Updated: 4/[illegible]
Status Date: Vehicle: Lincoln Model: Town Car Plant: Various	Part Name: Electric Speed Control Deactivation Pressure Switch Part No: 77PS [illegible]-1
1. Team: J. [illegible] B. Dague, A. [illegible] A. McGuirk, C. Douglas G. [illegible], T. [illegible]	2. Problem Description: Under hood car fires

3. Containment Action(s):	% Effectiveness	Implementation Date
Under review, considering disabling speed control system.		

4. Root Cause See attachment 1, [illegible] Table,	% Contribution
(Theories of 3/15/99) - Water enters pressure switch thru connector - Continuous power drives corrosion - Corrosion creates high resistance - Resistance creates local heating - Several exposures over time (?) - Local heating ignites pressure switch and connector plastic - [illegible]	Unknown

5. Chosen Permanent Corrective Actions See attachment 2,3,4	Verification:	% Effectiveness:
Under Review: - Relay harness - [illegible] - Create ground fault protector - Improve connector seal - Eliminate constant power - Change PS orientation - Provide power feed/power reduction - Modify plastic parameters - Optimize polarity - Minimize ground potential	TBD by lab experiments	Unknown

6. Implemented Permanent Corrective Actions:	Implementation

7. Action(s) to Prevent Recurrence	Implementation
Eliminate constant power, reduce power to function used, [illegible]	

8. Congratulate Team	Close Date:	
		Reported By: A. McGuirk Dept. Name: QRA Manager Telephone No.: (508) 236-[illegible]

Attachment

TI-NHTSA 014155

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

77psi2-1		GROSS QTY		COMPLETE	COMPLETE	BEGIN	IMPACT	COMMENTS/CONCERNS
COMPONEN	DESCRIPTIO	REQUIRED	SUPPLIER	1ST	25K	PARTIAL	TO TI	
27405-1	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	CUP 77PS	2,040,000	VALENTINE	6 WKS	10 WKS	1 WK	NONE	RAW MATERIAL AVAILABILITY
39656-27	57PS	2,040,000	DISC DEPT	12+ WKS	24 WKS	3 WKS	TOOL $?	POSSIBLE CAPACITY ISSUE
39000-1	HEXPORT 7	2,040,000	ELCO	10 WKS	25 WKS	3 WKS	NONE	RAW MATERIAL AVAILABILITY
74224-1	KAPTON	204	EIDUPONT	2 WKS	2 WKS	2 WKS	NONE	
27225-1	KAPTON STI	1,102	EIDUPONT	3 WKS	3 WKS	2 WKS	NONE	
74353-1	GASKET	2,040,000	JBL PARKER	8 WKS	18 WKS	3 WKS	NONE	ELIMINATE CORES WILL INCREASE DEL. BY 10%
39899-1	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	DERRINGER	4 WKS	8 WKS	1 WK	NONE	MATERIAL AVAILABILITY
39897-1	MOVABLE T	2,040,000	KF BASSLE	10 WKS	18 WKS	2 WKS	NONE	ADD OVERTIME/MATERIAL AVAILABILITY/REELS
27718-1	BECU ISSU	449	BRUSHWELL	1 WK	2 WKS	1 WK	NONE	NONE
74916-1	RIVET	2,040,000	JOHN HASS	8 WKS	11 WKS	4 WKS	NONE	RAW MATERIAL AVAILABILITY
46515-2	PRESSURE S	2,040,000	INTMOLDIN	16 WKS	32 WKS	4 WKS	NONE	RAW MATERIAL CHANGEOVER/PRESS CAPACITY
74076-149	CERAMIN PI	2,040,000	PARATECH	7 WKS	15 WKS	2 WKS	NONE	
74247-4	BLUE O'RING	2,040,000	JBL PARKER	8 WKS	10 WKS	2 WKS	NONE	ELIMINATE CORES WILL INCREASE DEL. BY 10%
74797-1	CRIMP RING	2,040,000	VALENTINE	6 WKS	10 WKS	1 WK	NONE	RAW MATERIAL AVAILABILITY
74669-1	RED THREAI	2,040,000	MARK IV CA	3 WKS	8 WKS	1 WK	NONE	
77PS	SWITCH		TI	7/15,8/1,8/16	250K/MONTH			7 day weeks, thru summer vacations, 'add' plastic mold

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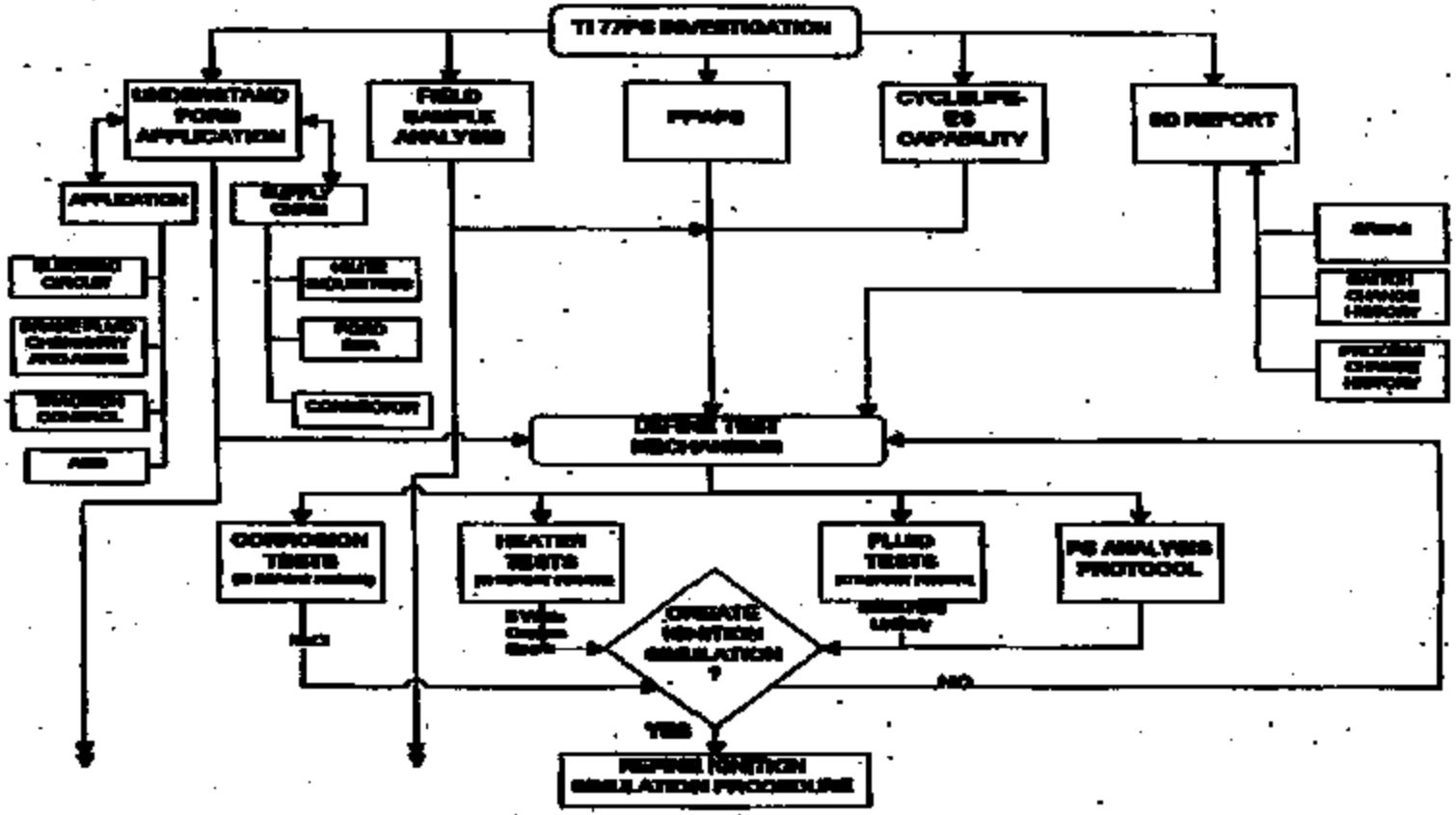
Attachment

Texas Instruments

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



TI-NHTSA 01467

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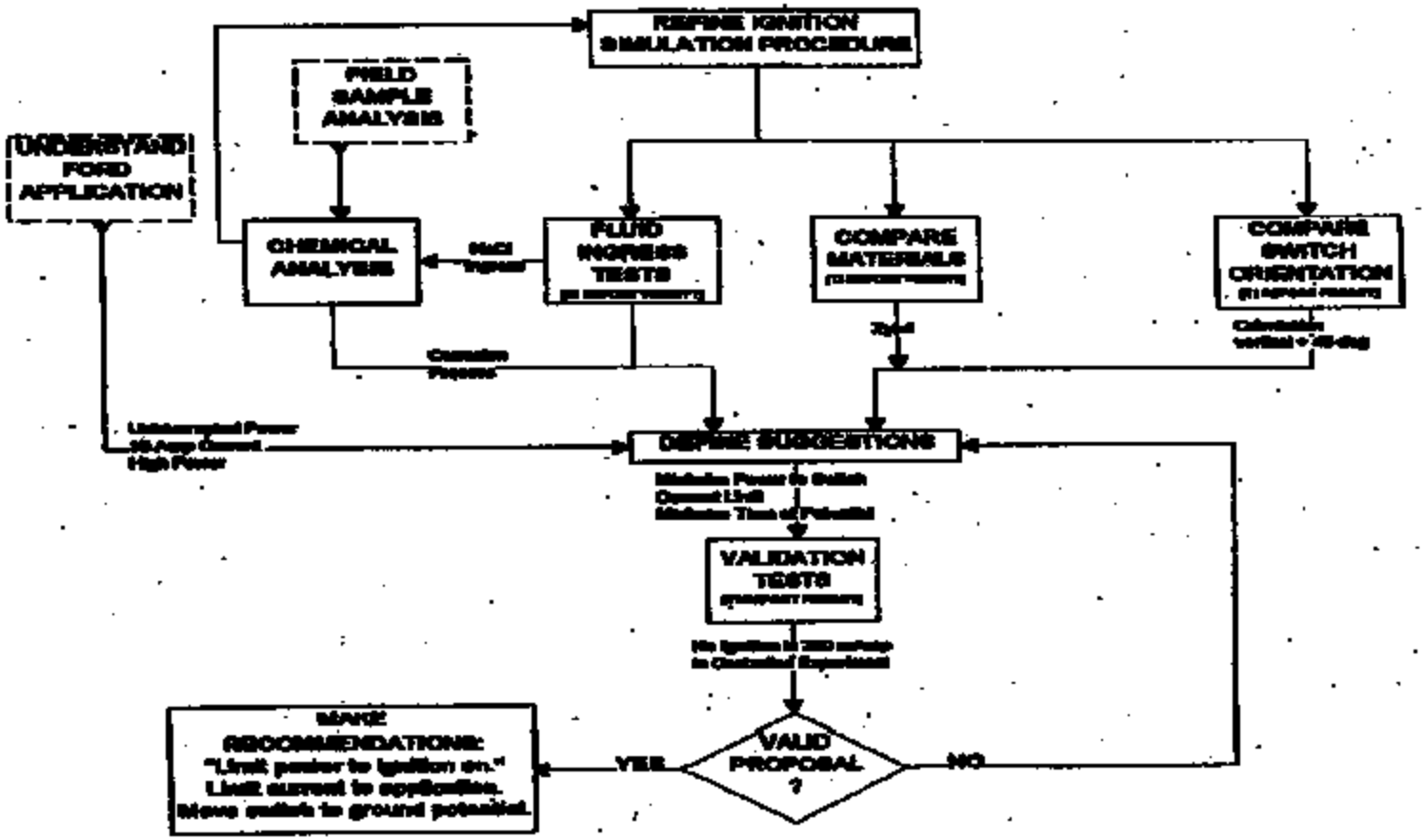
Attachment

Texas Instruments

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



Attachment

TI-HTSA 01458

Brake Pressure Switch

Potential Thermal Event Theory Profile 5/20/99

TEXAS INSTRUMENTS

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%, 70%	No Significant Temperature Rise. Test Suspended.
				Chemical 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 105 C	No significant temperature rise with time. Test suspended.
	5	AVT	"new" Brake Fluid in Switch, 10 Amps	Temperature rise of 20 C above ambient
			Through switch terminals	Delta T reached steady state at 20 C. Test suspended.
	5a	AVT	"new" Brake Fluid in Switch approx. 50 Amps	Temperature rose to approx. 270 F. No smoke. No ignition
			through Switch Terminals	Test suspended.
	6	TI	Solid [illegible] elements into Switch.	2 tested. Smoke observed, ignition observed on part w/heater
			Heat til failure, Isolate openings.	See attachment
			With Fluid & Dry	Test complete
				Brake fluid in cavity shows a slow heat build-up
				Smoke observed at 675 F, Base melts and falls off at 800 F
	4a	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 open
			and hexport	It took about 140 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

TI-NHTSA 014159

Brake Pressure Switch

TEXAS INSTRUMENTS Potential Thermal Event Theory Profile 5/20/99

	6b	TI	Run 'new' brake fluid with metal shavings	Metal shavings do not contribute significantly to brake fluid
				conductivity
Life Cycle Reliability	7	TI	0-1450 psig pressure pulses at 150C	First leak observed at 750,000 cycles.
of Pressure Switch.			per ES	Test Completed. See attached Weibull Chart.
Diaphragm Wear	8	TI	0-1450 psig pressure pulses at 150C.	Parts withdrawn every 250k cycles, characterized for wear
Field vs Lab Correlation	9	Central Labs	Field returns, from dealer lots, junkyards	Parts in Central Labs, see Ford spreadsheet
Design Of Experiments (1)	10	TI	Vary water concentrations in 'new' Brake Fluid	Test Report being written (investigation continuing).
Evaluating Factors			12 amp + 12 cyclic air bubbles w/ 0 % water in BF	Suspended at 1.3 million cycles with no leaks observed.
Effecting Diaphragm Wear			12 amp + 12 cyclic air bubbles w/ 5 % water in BF	Wet samples suspended at 1.3 million cycles with 2 leaks
Impulse test				observed at 1.3M. Other samples suspended at 300k cycles to [illegible]
				[illegible]
On-Vehicle Characterization	11	AVT	Monitor Pressure and Temperature	Test at AVT.... see Ford charts...[illegible]
of Pressure & Temperature			at the Switch Location for ABS and non-ABS	
Profile in Town Car			braking events.	
Brake fluid analysis	11a	TI	Analyze used brake fluid at the master cylinder	Test complete.
Used fluid at master cylinder.			(UMC), used brake fluid at the caliper (UCA)	UMC: Cu = 445 (ug/ml), Fe = 5.6 (ug/ml), Cr = 0.03 (ug/ml), 1.1 %H2O.
			and new brake fluid (NEW) for metal and water	UCA: Cu = [illegible] (ug/ml), Fe = 5.6 (ug/ml), Cr = 1.8 (ug/ml), 1.1 %H2O.
			content.	NEW: Cu = <0.01 (ug/ml), Fe = 0.02 (ug/ml), Cr = <.01 (ug/ml), 0.3 %H2O.
Spark/Arc Study	12	Central Labs	Determine if arc/spark forms in air bubble	Equipment set-up in progress at Central Labs.
			using dutch bench and high speed video.	[illegible] no 'significant' sparks observed
			Use dry air/bubbles as well as air/bubbles with	
			various brake fluid water mixes.	
Characterization of	13	Central Labs	Characterize electrical, mechanical	Data log and analysis procedure set up complete.
particles retrieved from field			and chemical aspects of recovered particles	Analysis of particles in progress.
junkyards & other sources				
Field Impulse Tests	13a	TI	Repeat ignition simulation with different fluids.	Test complete.
			12 hour tests:	5% NaCl sample resulted in an ignition.
			5% NaCl in tap water	All brake fluid samples drew less than 3 mAmps. No corrosion
			salt water	visible on brake fluid samples.
			200 hour tests:	Salt water and tap water samples drew <40 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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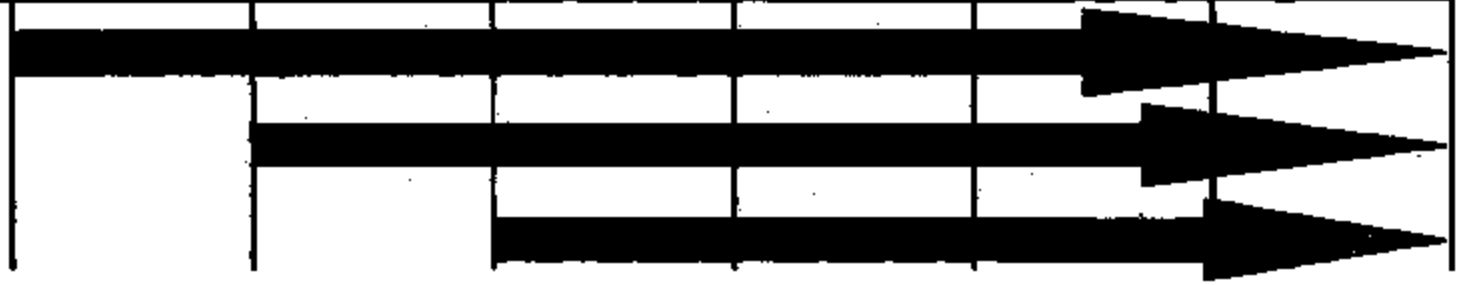
Attachment

TI-NHTSA 014160

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

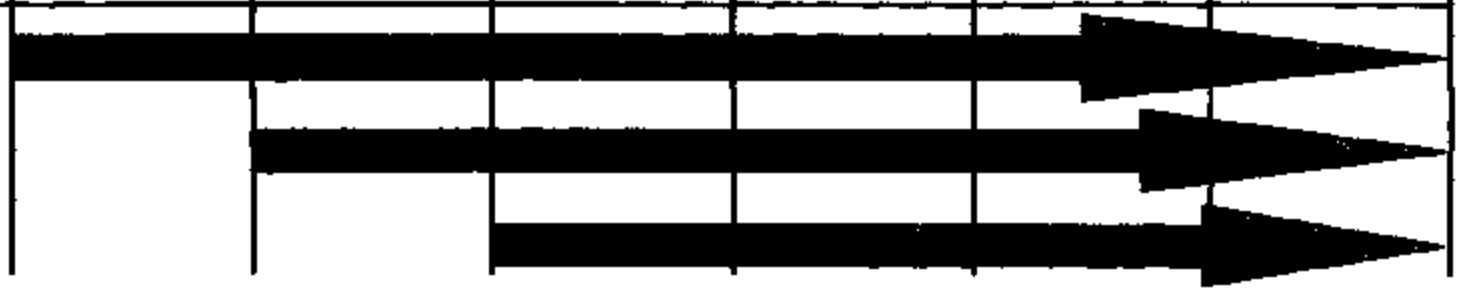
Compatibility of Kapton with Oxalic Acid	14	Dupont	Characterize change in properties of Kapton with various % oxalic acid in brake fluid.	Compatibility of Kapton with Oxalic Acid	14	Dupont	Characterize change in properties of Kapton with various % oxalic acid in brake fluid.
Evaluation of Plastic	15	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
bypass test.			(2) samples with used brake fluid	bypass 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 (10) Amp	Test			Bring switch to impending ignition in (10) Amp
			circuit then place in relay circuit for (16) hrs.				circuit then place in relay circuit for (16) hrs.
			Input max. circuit power into heater on switch.				Input max. circuit power into heater on switch.

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:						

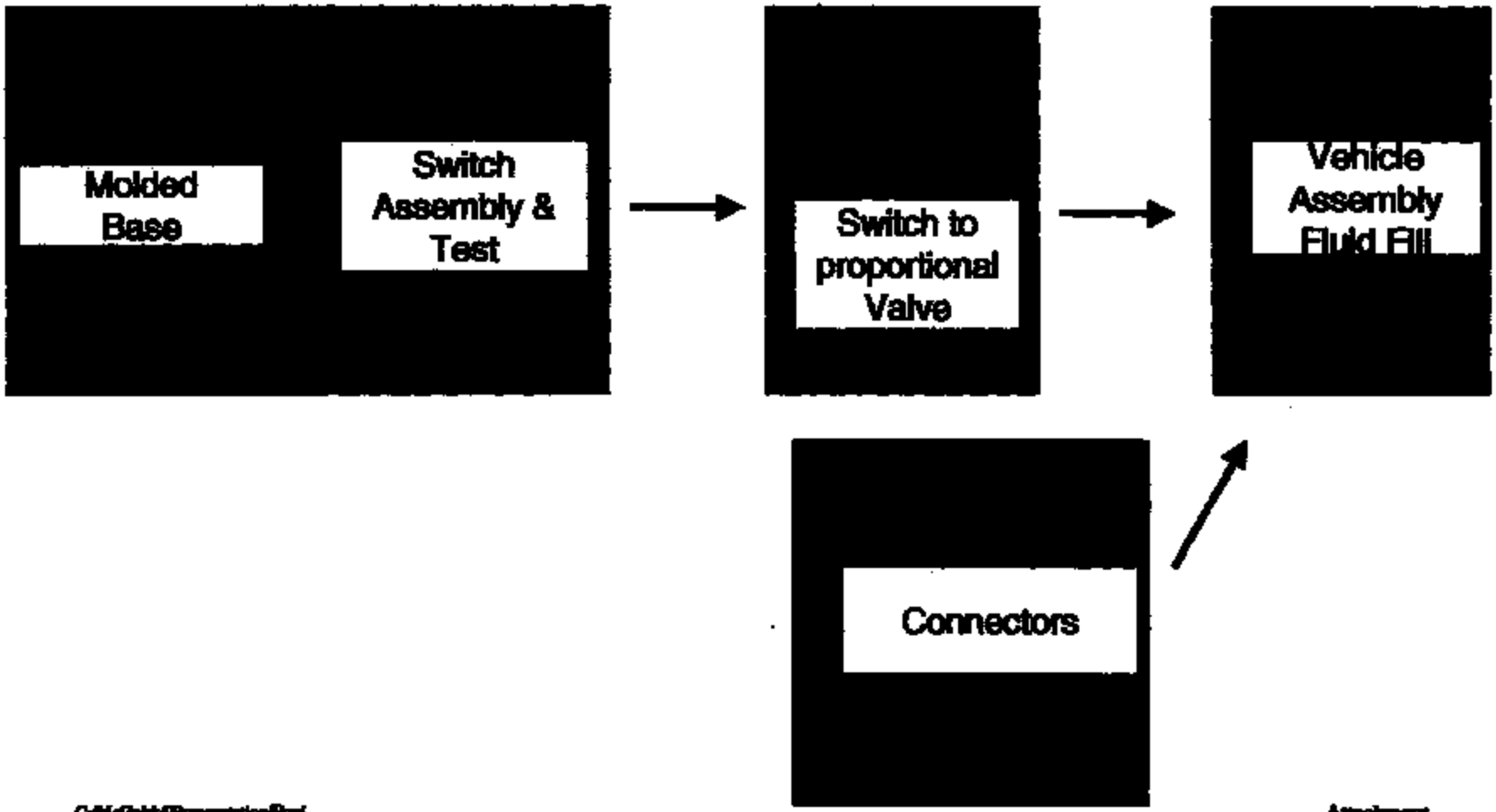
- TI has some 16 years and 130 million units accumulated experience in hydraulic applications using multiple fluids
- TI has some 12 years of brake system application experience working with brake fluids

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:						

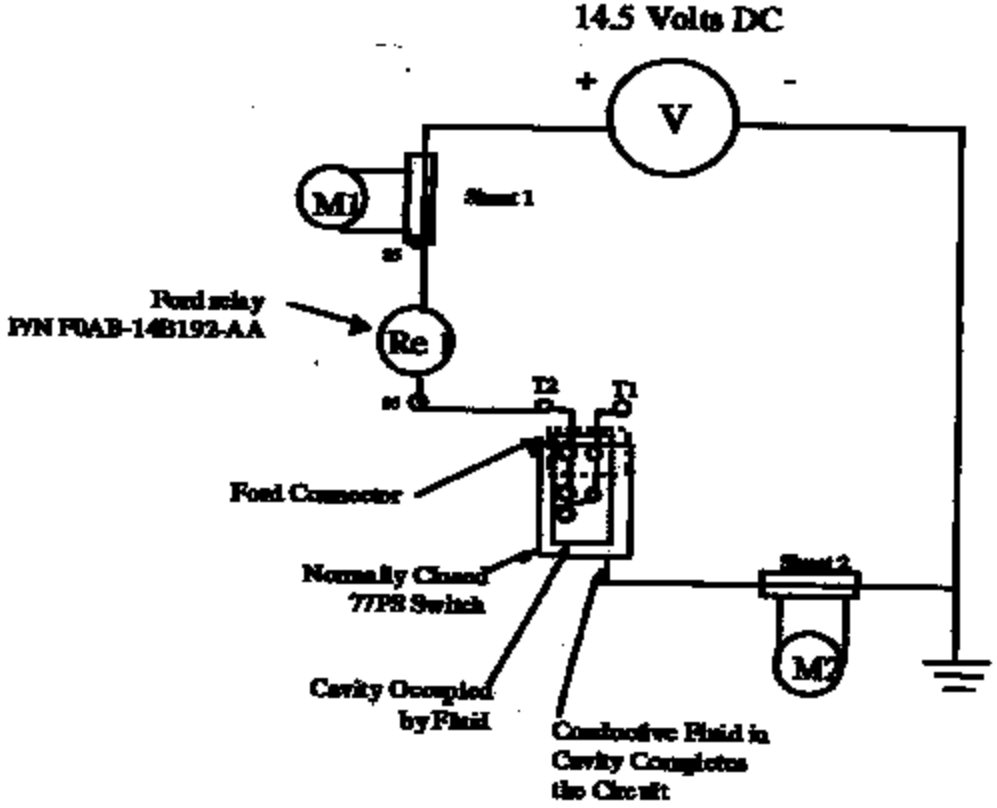
- TI has some 16 years and 130 million units accumulated experience in hydraulic applications using multiple fluids
- TI has some 12 years of brake system application experience working with brake fluids

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



See low current stuff from sean

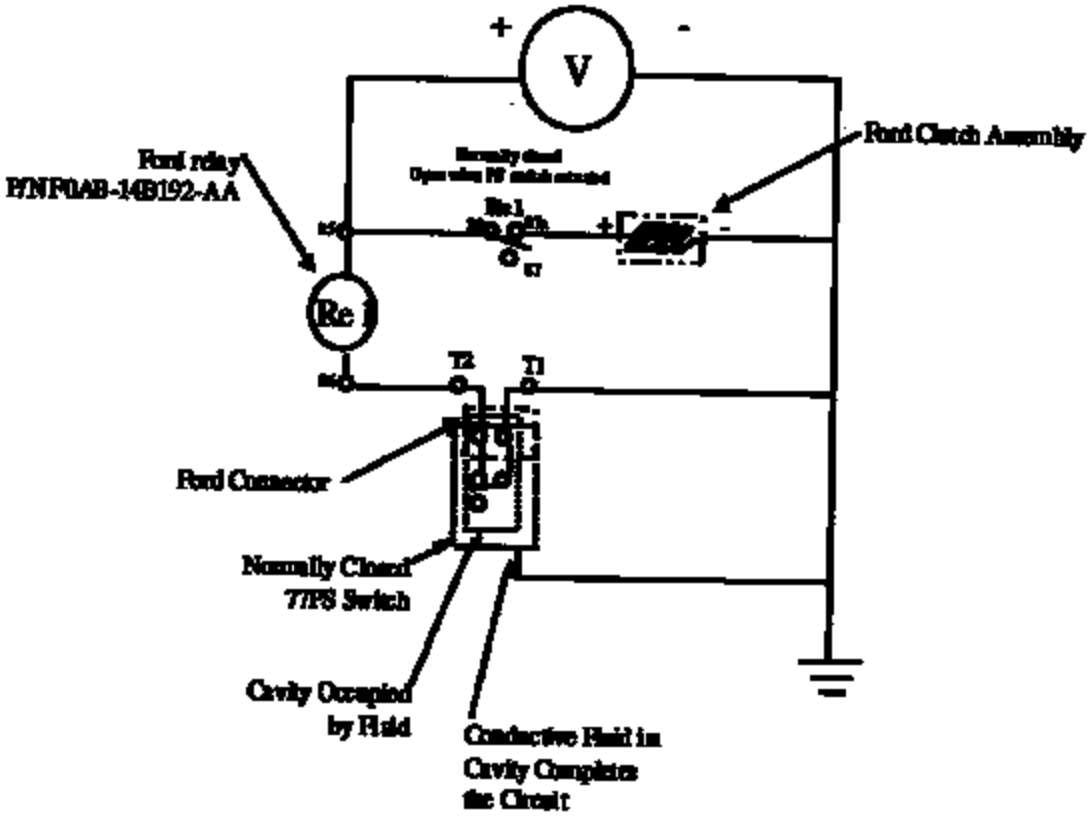
200 mAmp Current Limit Circuit Test Setup



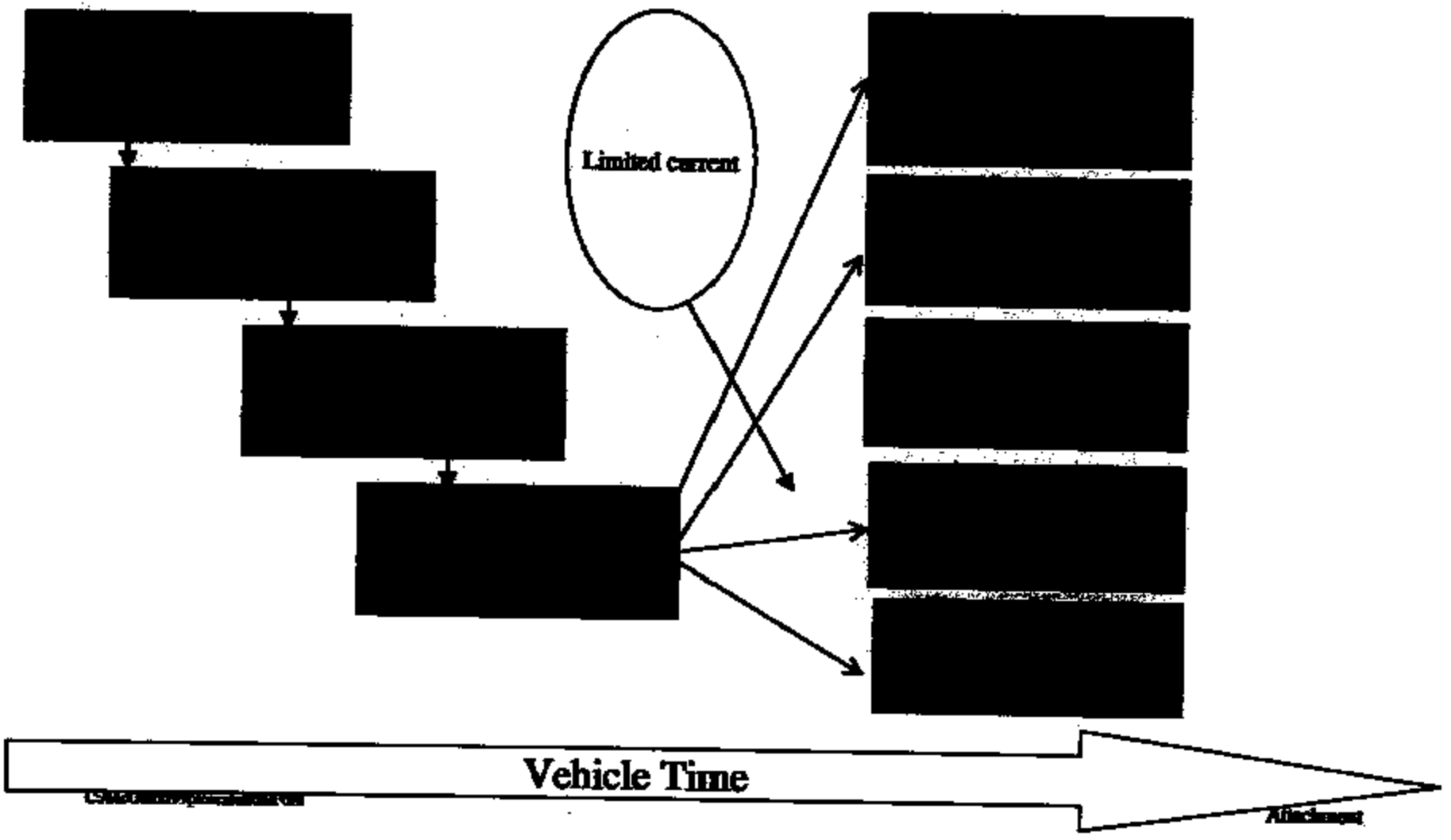
Worst case scenario is when the switch is actuated, which puts T2 at full voltage.
To facilitate testing, T1 is floating which keeps T1 and T2 at full voltage but limits current draw to .2 Amps (This test is harsher than worst case scenario).

77PS Proposed Wiring Schematic

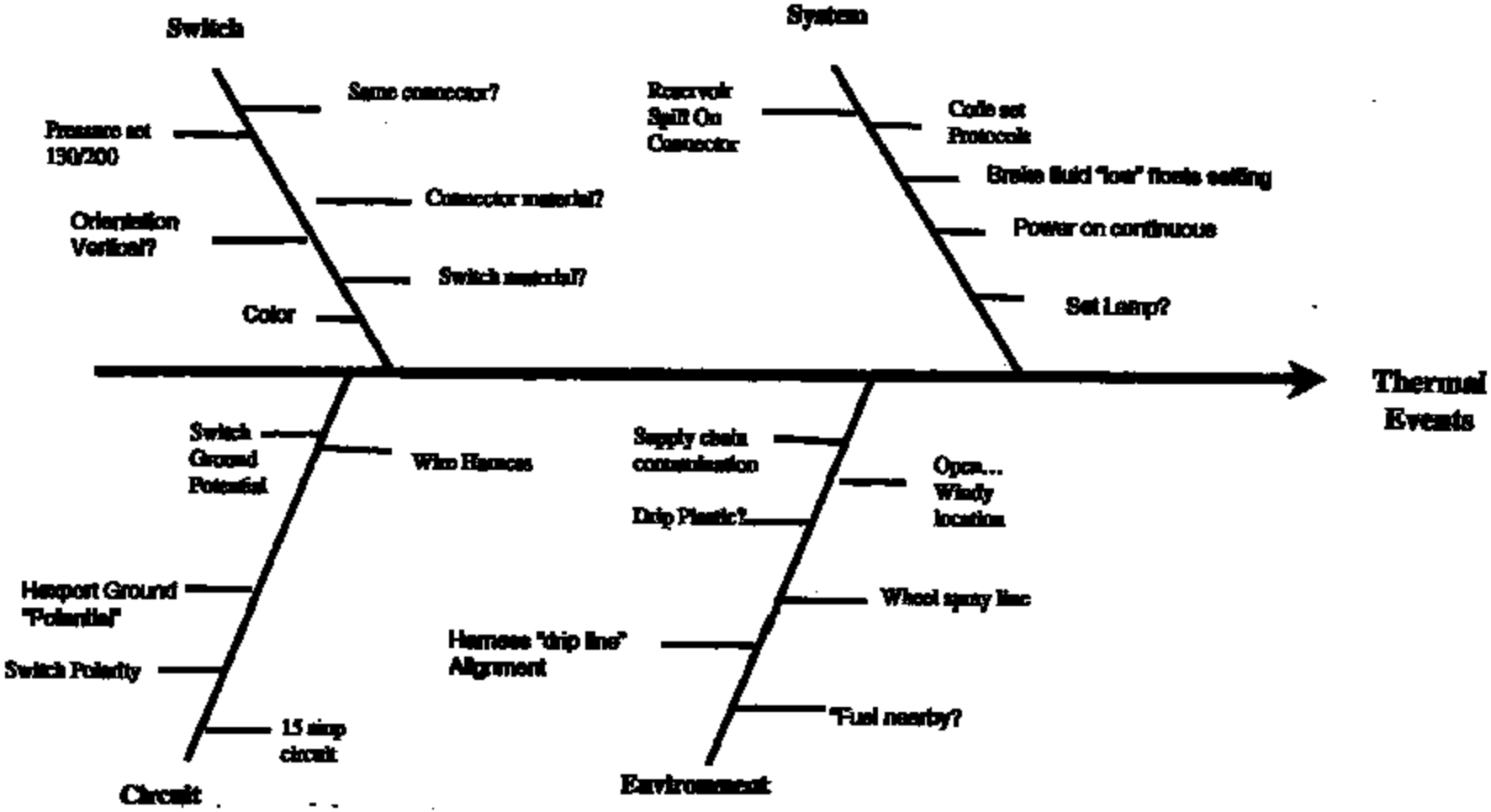
14 Volts DC



"Corrosion" potential cause time line
Theory Time Line



ECONOLINE VS. TOWN CAR P/S



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Attachment

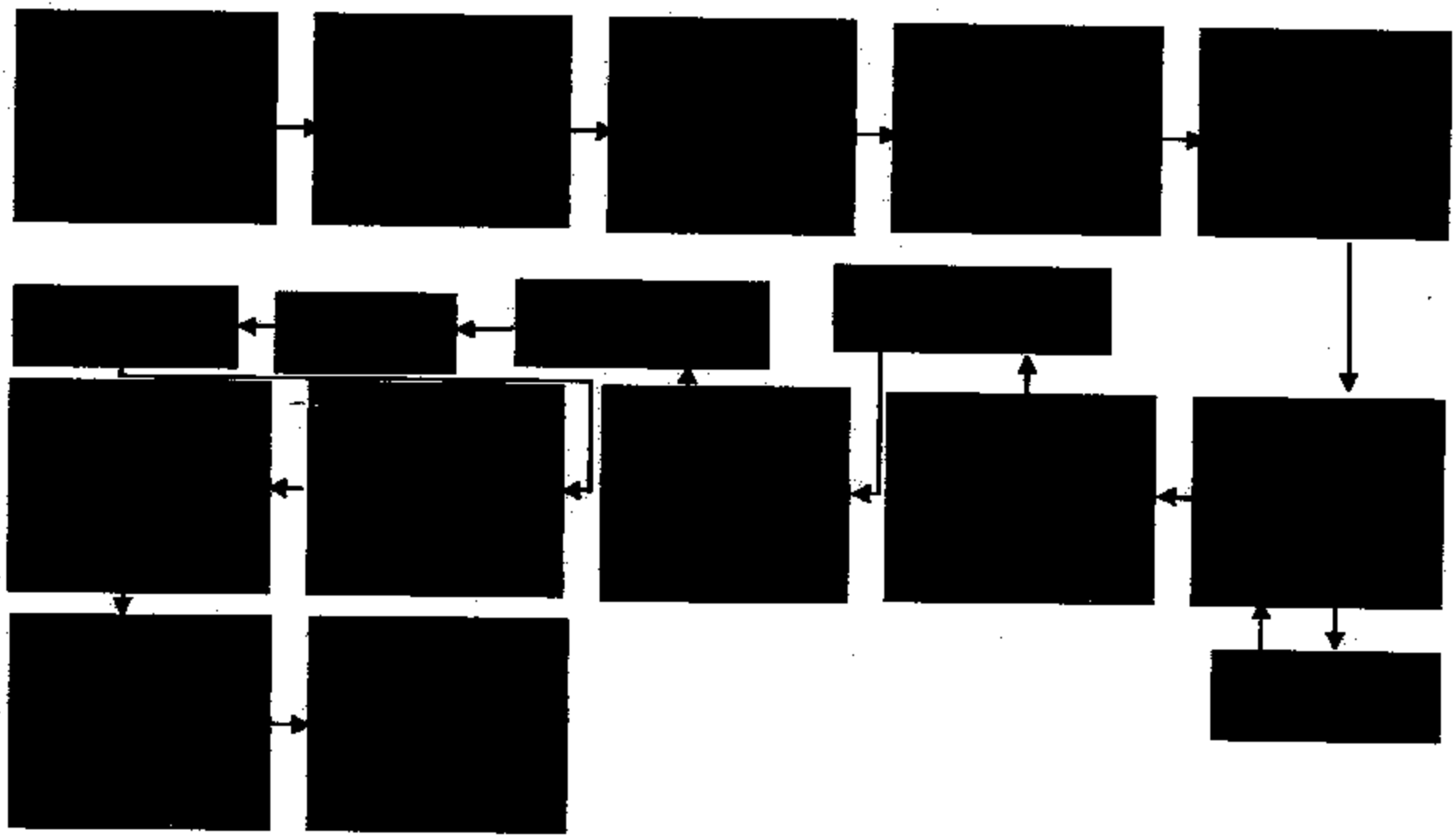
Texas Instruments

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

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

[redacted]

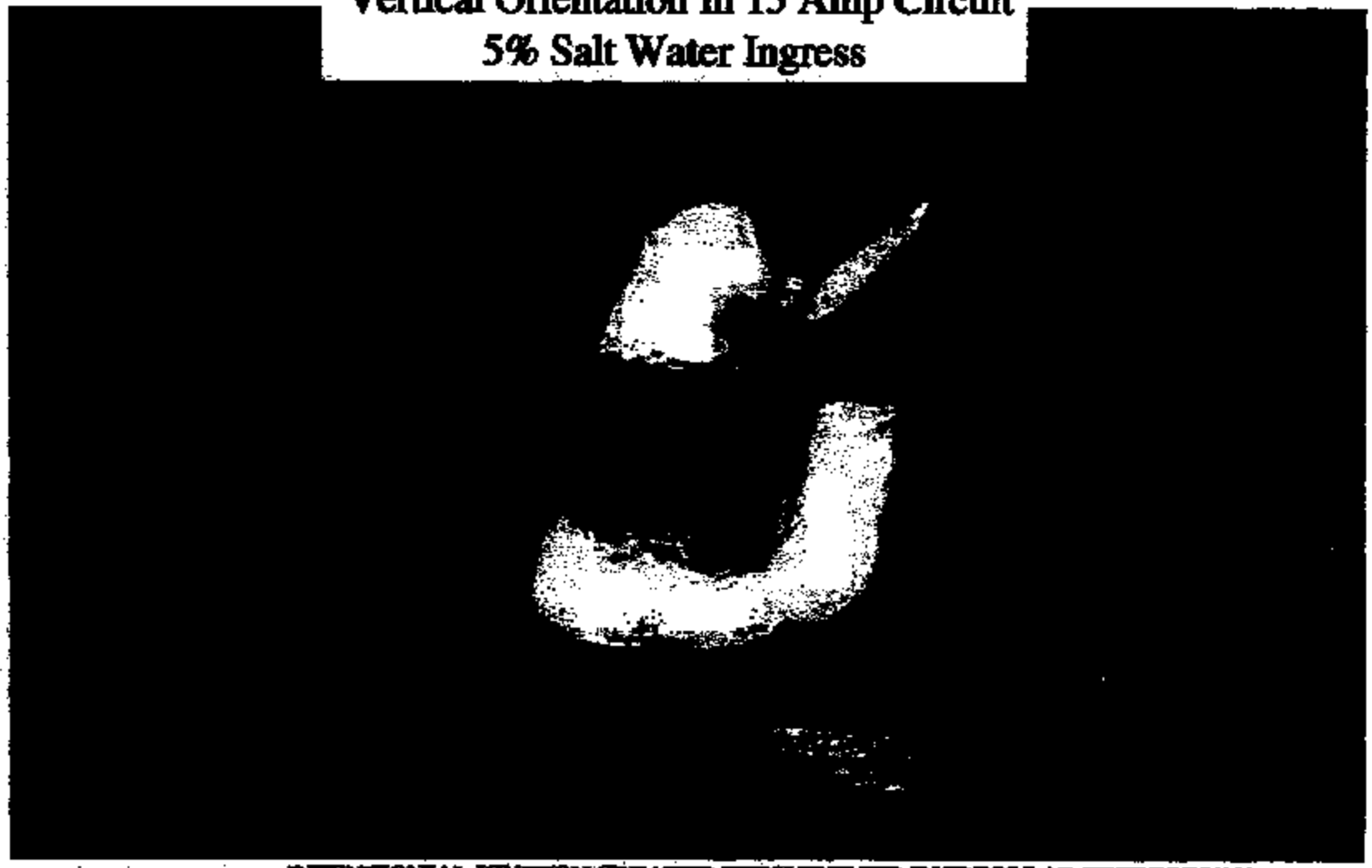
PROCESS FLOW DIAGRAM
"CORROSION" POTENTIAL CAUSE FLOW ANALYSIS



TEXAS INSTRUMENTS

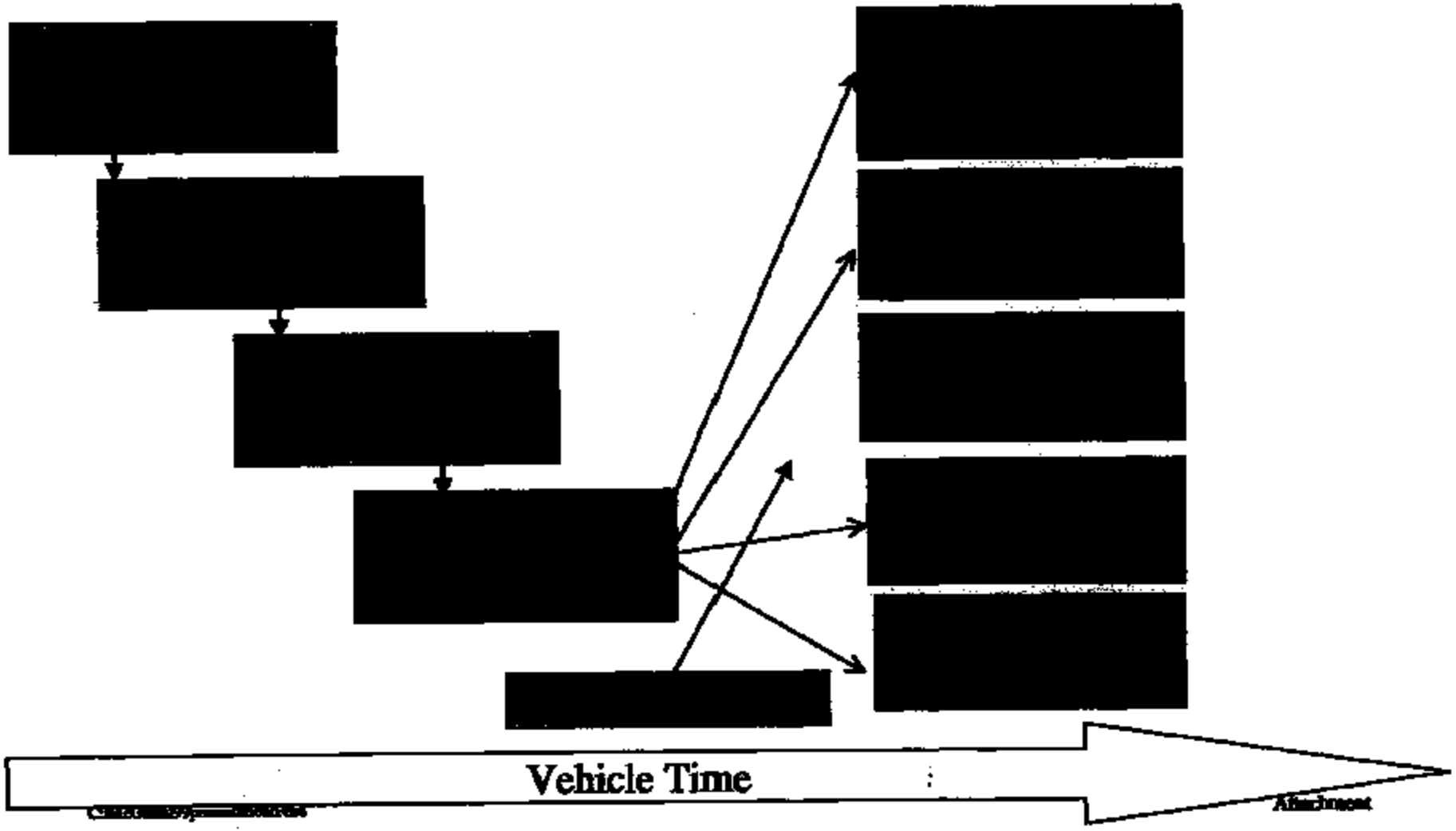
Brake Pressure Switch
Potential Thermal Event Theory Profile 5/20/99

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



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

"Corrosion" potential cause time line
Theory Time Line



Texas Instruments

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

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

Cellanex 4300 Base

Cellanex 3316 Base

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

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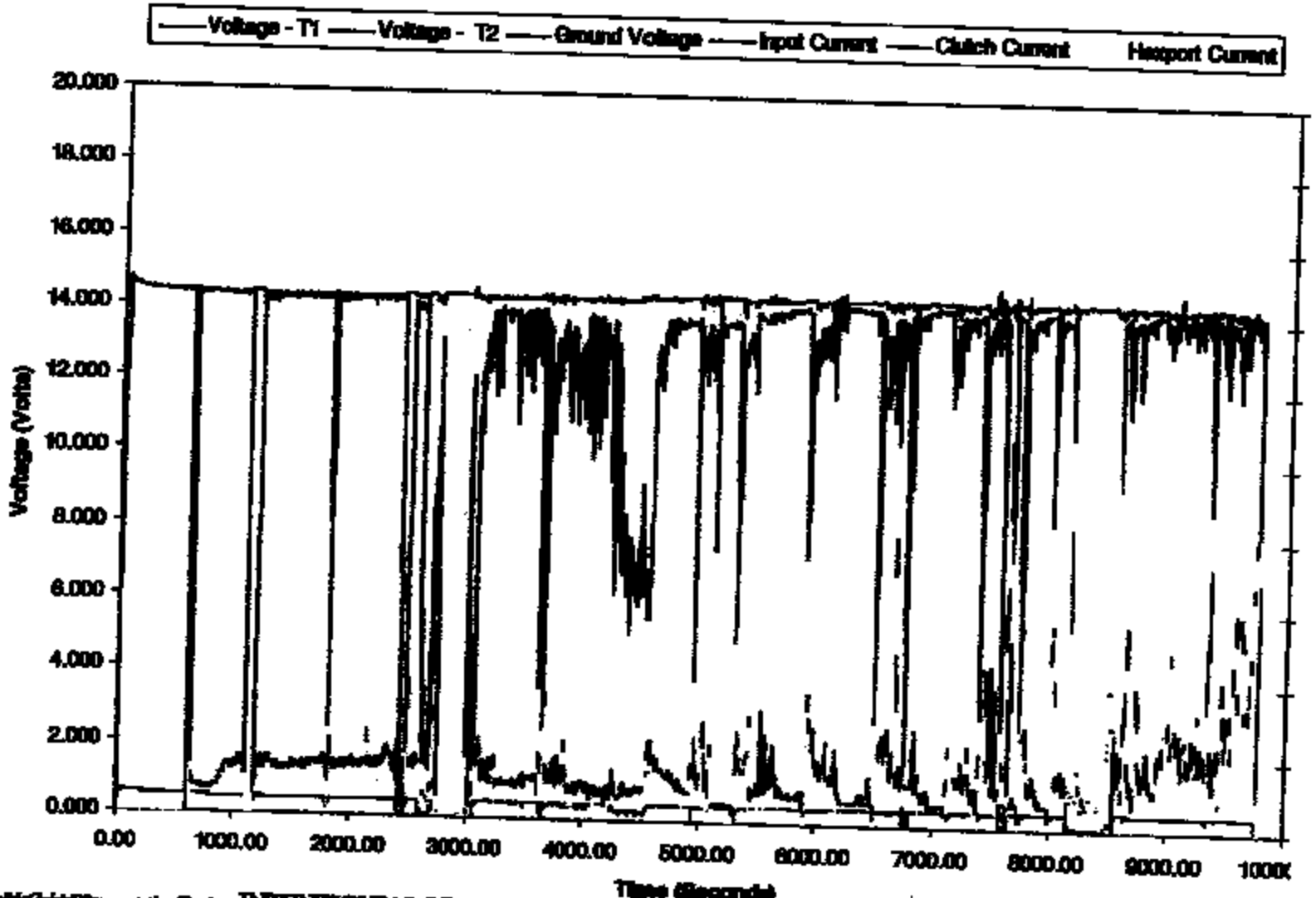
Attachment

Texas Instruments

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

5% Salt Water Ingress Experiment



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

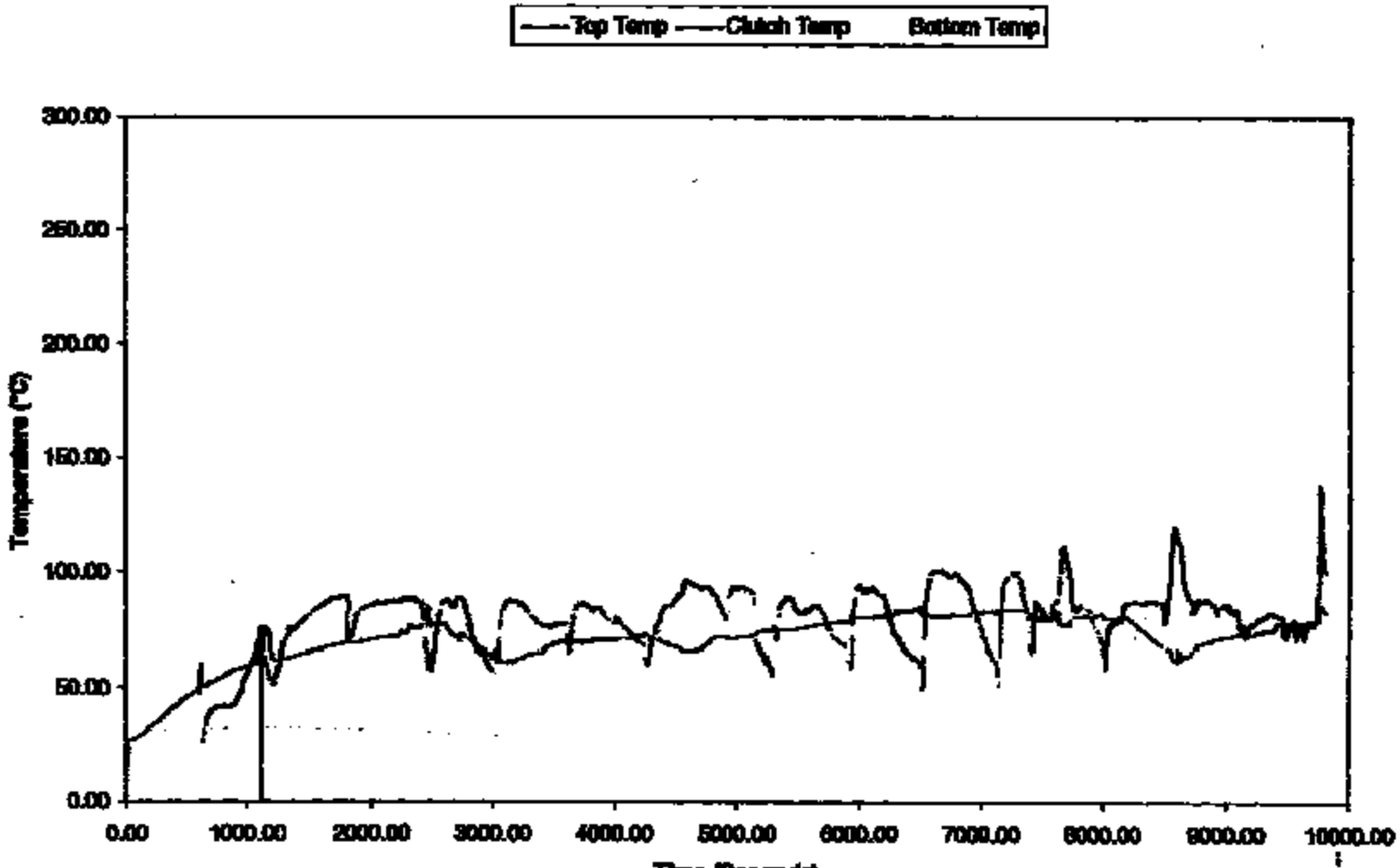
TI-NHTSA 014179

Texas Instruments

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

[redacted]

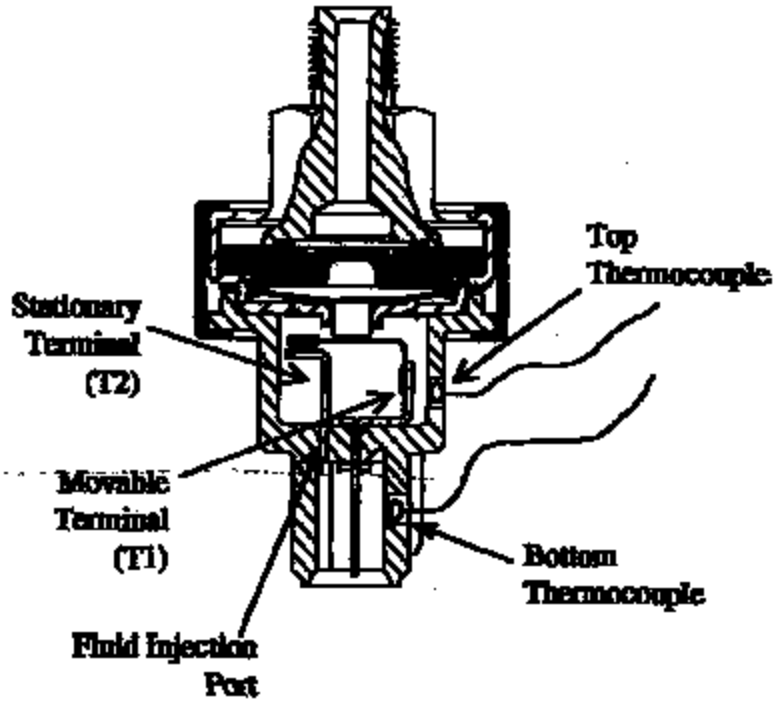
5% Salt Water Ingress Experiment
Temperature vs. Time



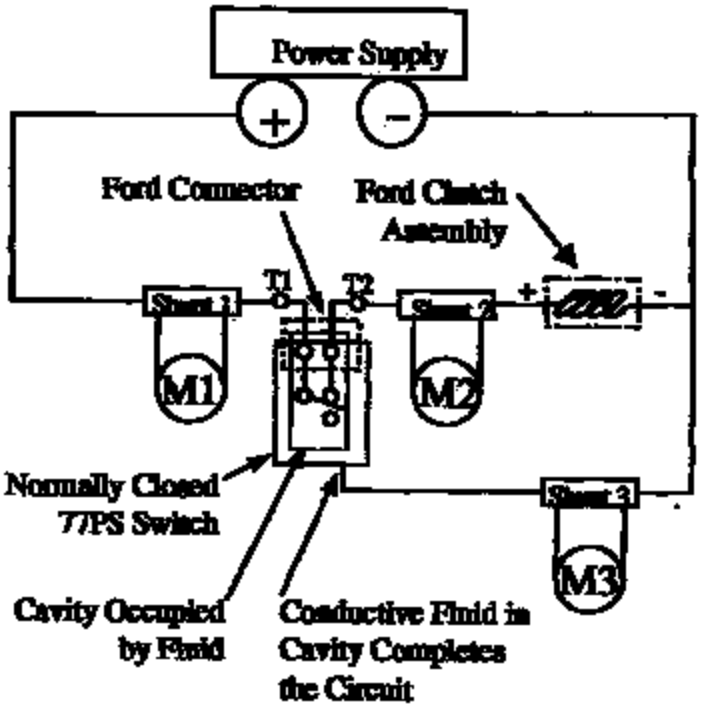
[redacted] INTENTIONAL IGNITION CREATED THRU TI FLUID INGRESS LAB TEST PS/99/13' Attachment

TI-NHTSA 014178

5% Salt Water Ingress Experiment
Test 1



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



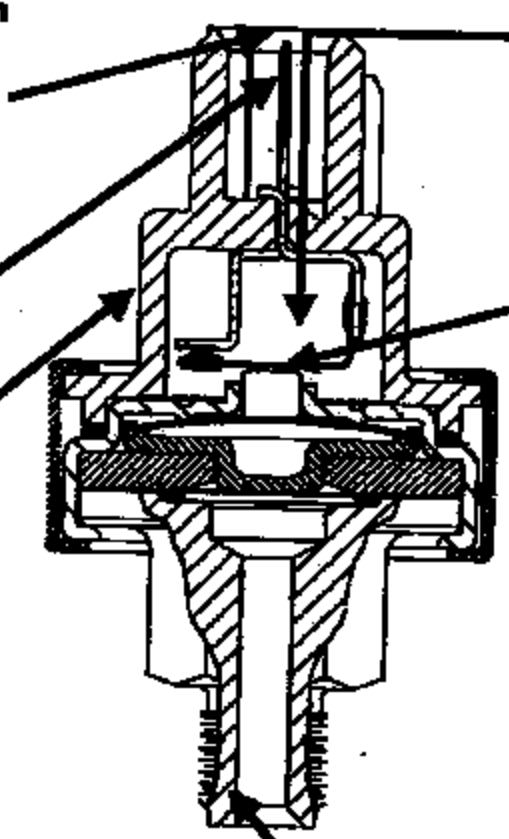
Test 1: Figure 1 and Figure 2.

Attachment

TI-NHTSA 014477

Texas Instruments

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



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

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

3. Hexport grounded accelerates corrosion

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

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

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

TI-NHTSA 01478

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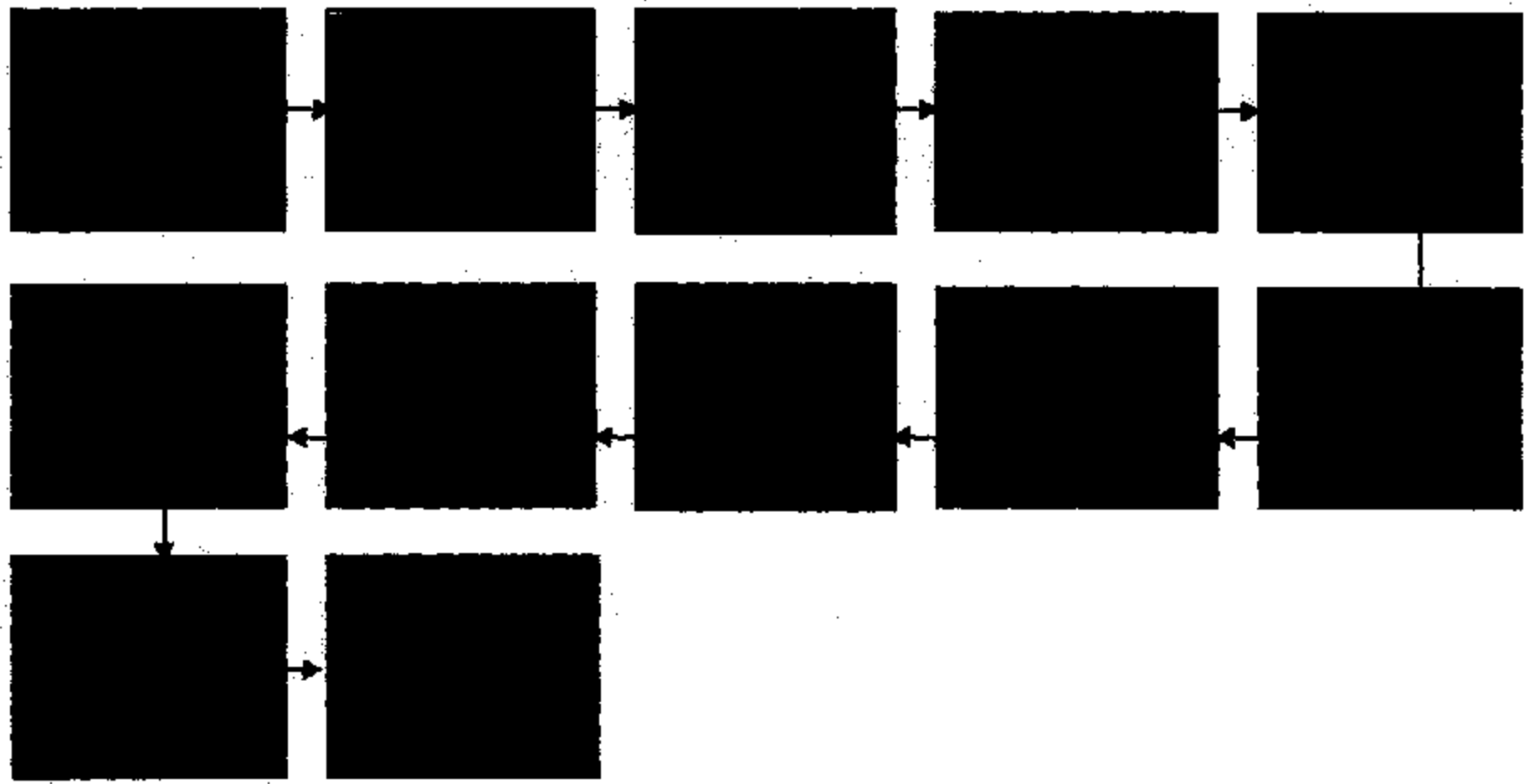
Attachment

PROCESS FLOW DIAGRAM
"CORROSION" POTENTIAL CAUSE FLOW ANALYSIS

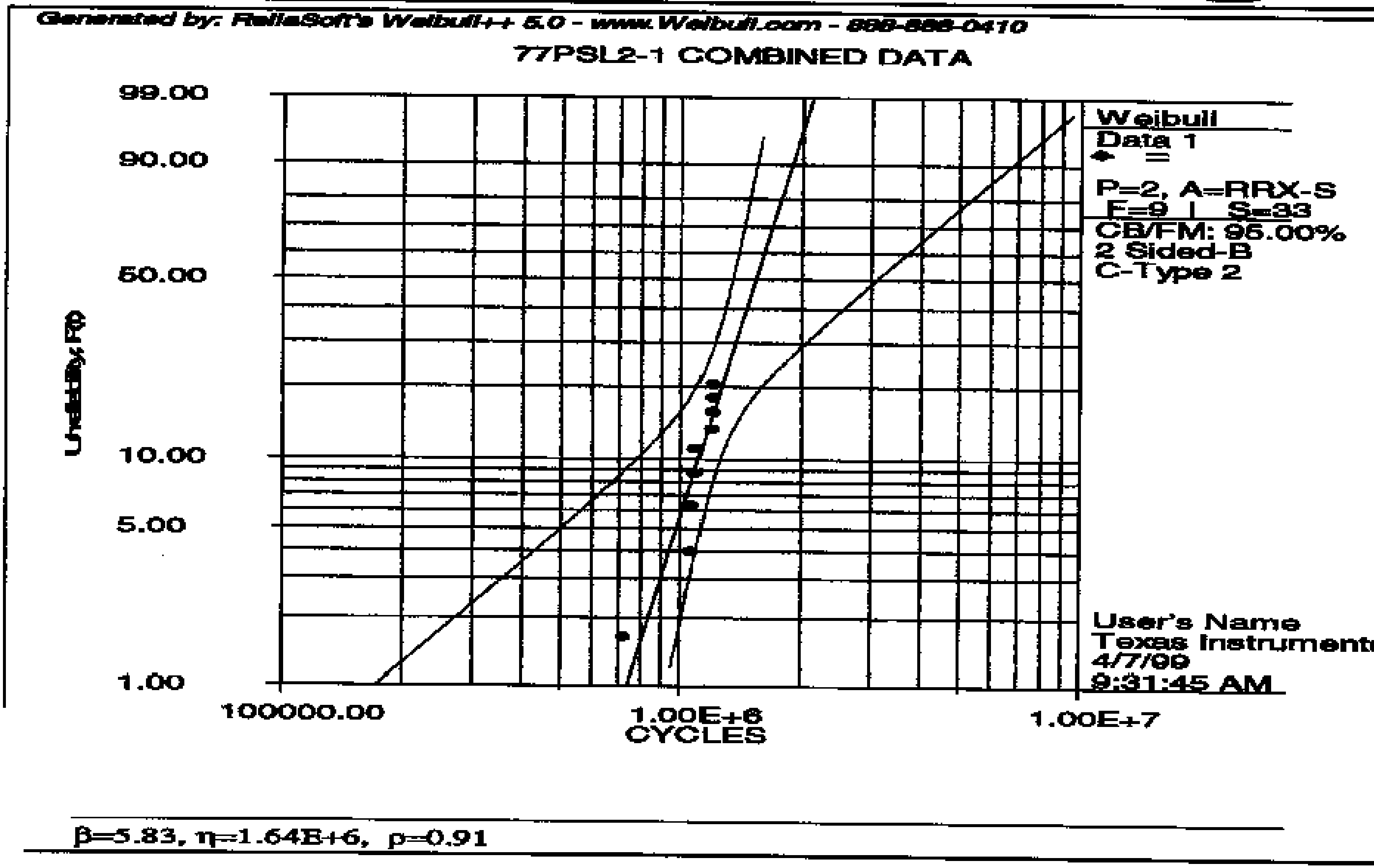


- "Town Car" switch meets accelerated/simulated life cycle specification shown by "success" and "end-of-life" testing

TEXAS INSTRUMENTS

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

[redacted]



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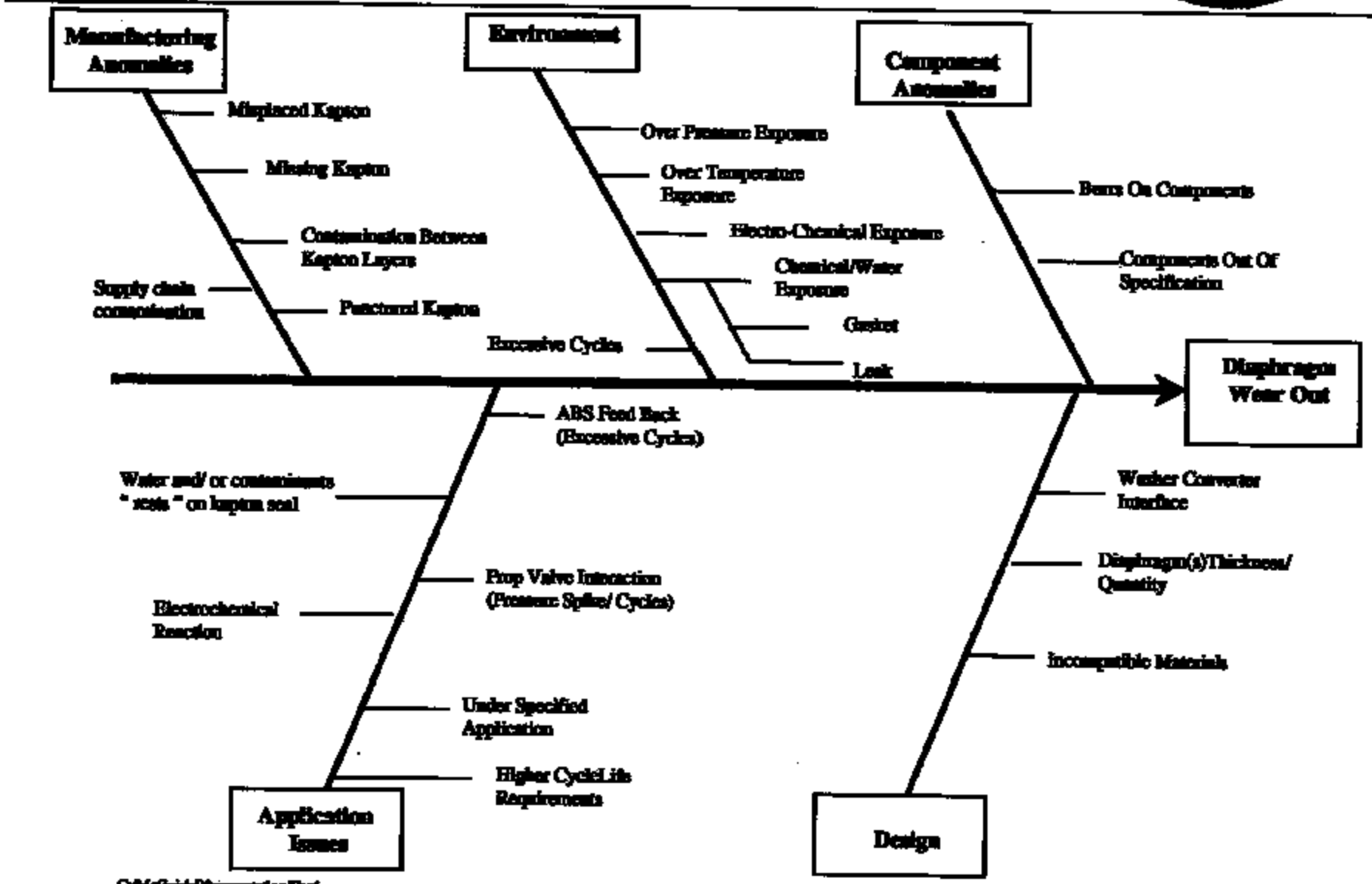
Attachment

TI-NHTSA 014181

TEXAS INSTRUMENTS

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



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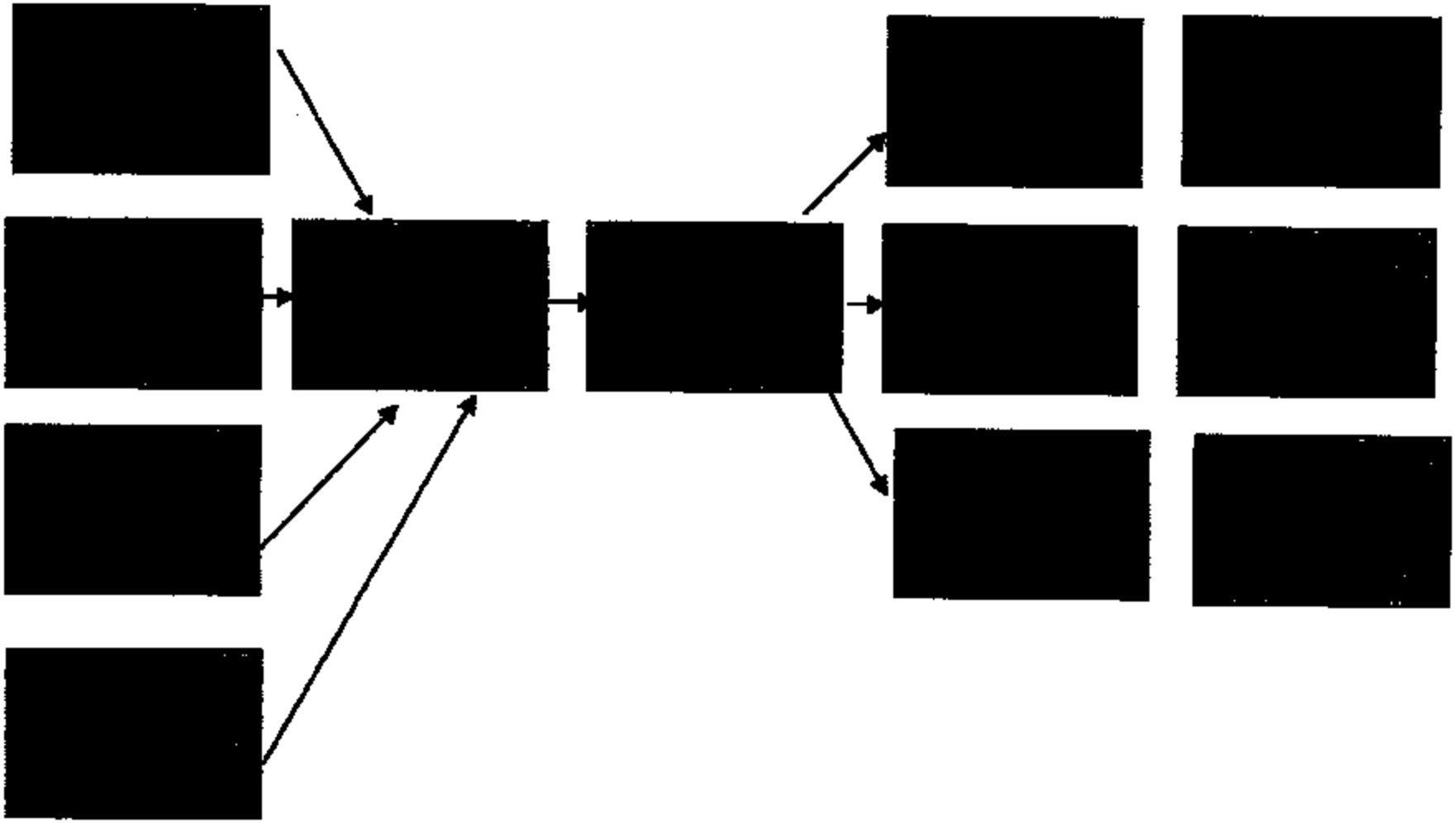
Attachment

TI-NHTSA 014182

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

Excel spreadsheet

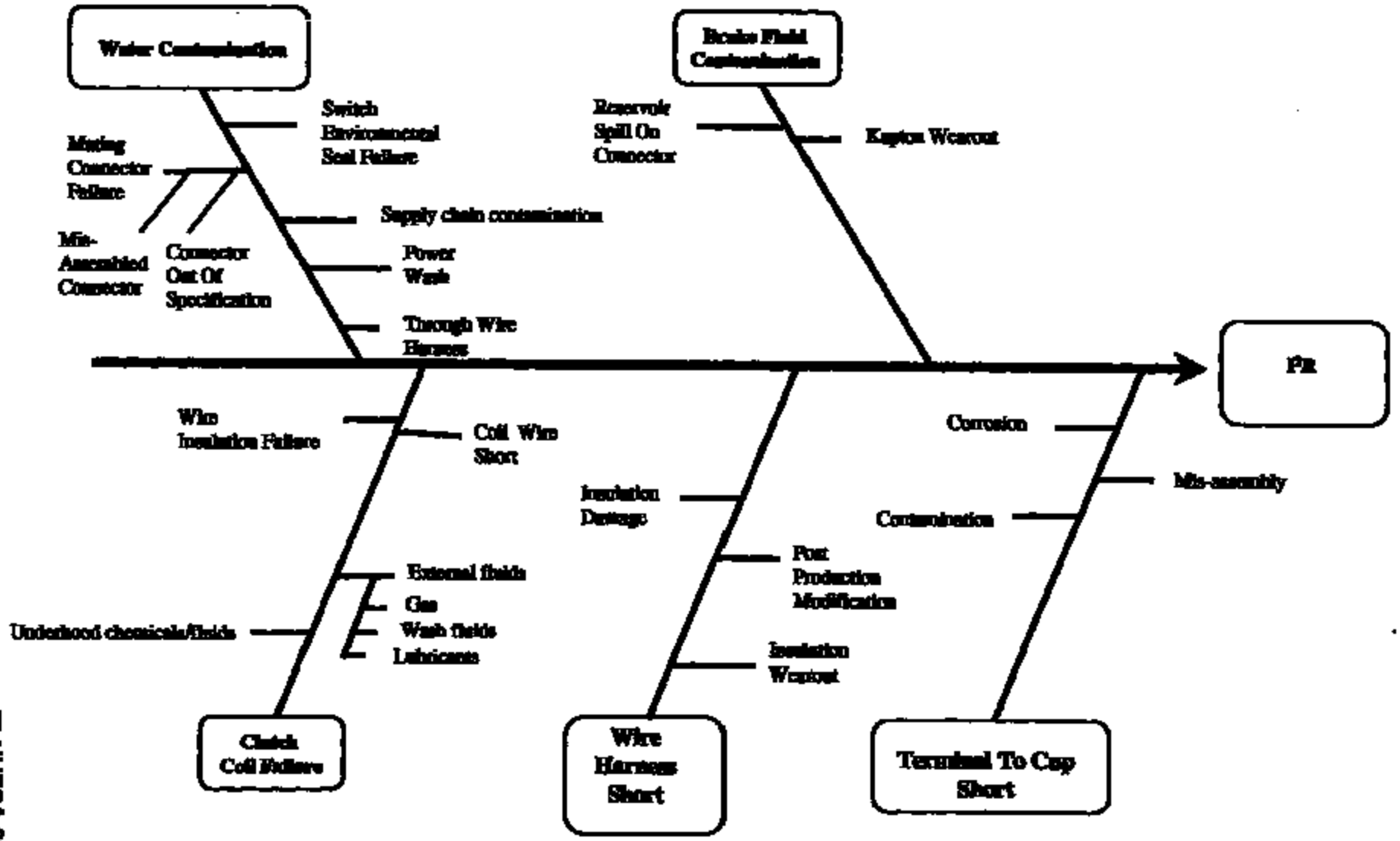
REFINED BRAKE FLUID IGNITION THEORY
POSSIBLE CAUSE THEORIES
"FEB '99 FOCUS"



Attachment

Texas Instruments

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



TI-NHTSA 014193

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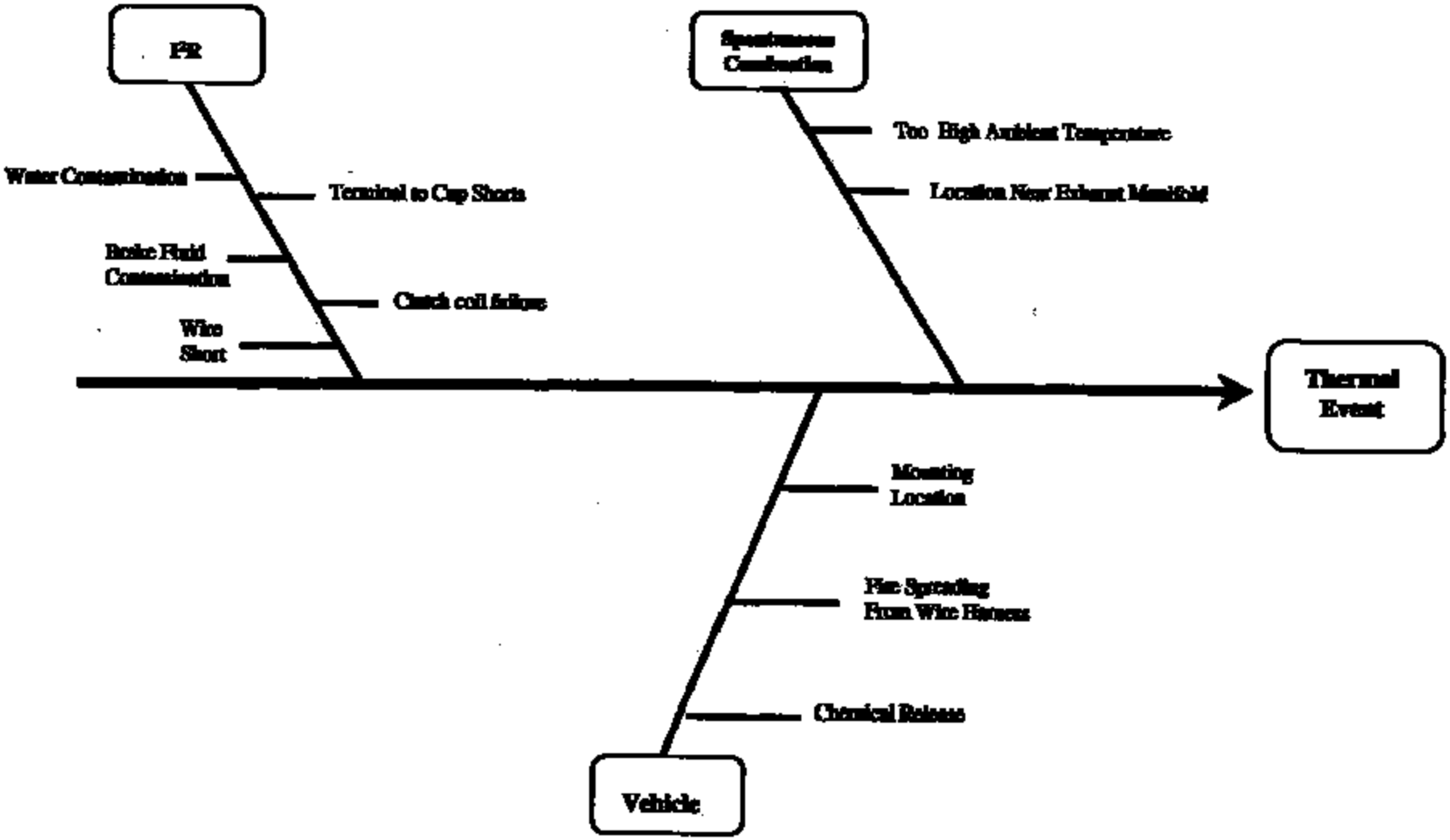
Attachment

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



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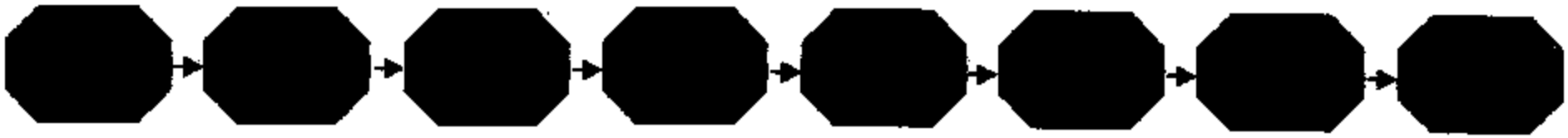
Attachment

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

OVERVIEW OF CONCERN TIME LINE



Attachment

AGENDA

- CONTRIBUTING FACTORS AND ROBUST DESIGN DIALOGUE
- OVERVIEW TIME LINE
- SYSTEM OVERVIEW
  - SWITCH AND CONNECTOR
- IS / IS NOT TABLE
- CAUSE AND EFFECT DIAGRAMS
- THEORIES
  - BRAKE FLUID IGNITION
  - PLASTIC IGNITION
- TEST RESULTS
- CONTRIBUTING FACTORS AND ROBUST DESIGN DIALOGUE
- ROBUST DESIGN ALTERNATIVES

1. Connector Seal to P/S

2. Power continuously available
   A. Operator notifications

3. Switch orientation/location

4. Current limit / fuse

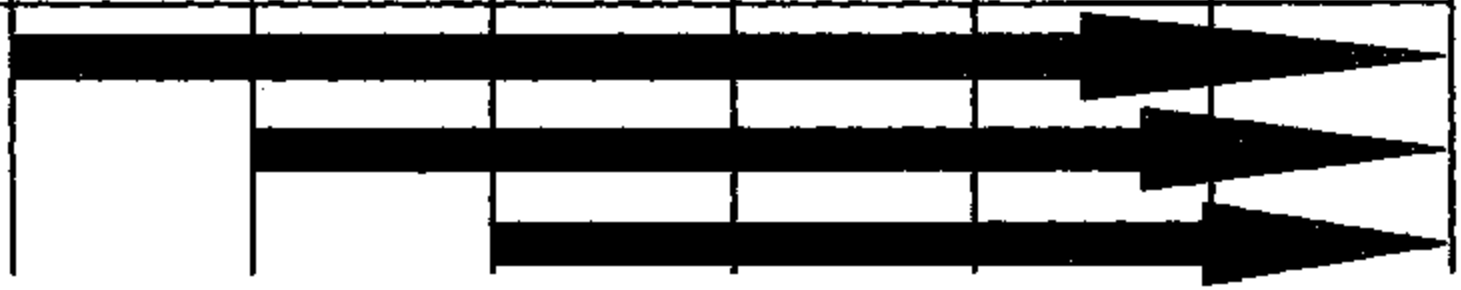
5. Hexport isolation

6. Plastic ignition robustness
   A. Nearby fuels

7. Kapton seal of P/S

8. Environmental seal of P/S

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
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Brake Pressure Switch

Potential Thermal Event Theory Profile 5/20/99

TEXAS INSTRUMENTS

Attachment

Texas Instruments
Automation Sensors & Controls
8D Report

Concern Title: 77 PS Thermal Events **T.I. CAR Report Number:** CAR [illegible]	**Open Date:** [illegible] **Updated:** 4/21/99
Status Date: **Vehicle:** Lincoln **Model:** Town Car **Plant:** [illegible]	**Part Name:** Electric Speed Control Deactivation Pressure Switch **Part No:** 77PS [illegible]
1. Team: S. Beringhause R. Dugas A. Roberts A. McGuirk C. Douglas G. Baker T. Rowland	**2. Problem Description:** Under hood car fires

3. Containment Action(s):	**% Effectiveness**	**Implementation Date**
Under review, considering disabling speed control system		

4. Root Cause: See attachment 1, IS - IS NOT Table,	**% Contribution**
(Theories of 3/15/99) - Water enters pressure switch thru connector - Continuous power drives corrosion - Corrosion creates high resistance - Resistance creates local heating - Several exposures over time (?) - Local heating ignites pressure switch and connector plastic - Operator protocol notification	Unknown

5. Chosen Permanent Corrective Actions See attachment 2,3,4	**Verification**	**% Effectiveness**
Under Review: - Relay bypass - Contact/[illegible] - Create ground fault protector - Improve connector seal - Eliminate constant power - Change PS orientation - Provide power fuse/power reduction - Modify plastic parameters - Optimize polarity - Move to ground potential	TBD by lab experiments	Unknown

6. Implemented Permanent Corrective Actions	**Implementation**

7. Action(s) to Prevent Recurrence	**Implementation**
Eliminate constant power, reduce power to function need, set such other "illegal" electrical function	

8. Congratulate Team	**Close Date:**	
		Reported By: A. McGuirk **Dept. Name:** QRA Manager **Telephone No.:** [illegible]

[illegible]

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

77ps18-1		GROSS QTY		COMPLETE	COMPLETE	BEGIN	IMPACT	COMMENTS/CONCERNS
COMPONEN	DESCRIPTIO	REQUIRED	SUPPLIER	1WK	2WK	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	CUP 77PS	2,040,000	VALENTINE	8 WKS	10 WKS	1 WK	NONE	RAW MATERIAL AVAILABILITY
36656-27	57PS	2,040,000	DSC DEPT	12+ WKS	24 WKS	3 WKS	TOOL $?	POSSIBLE CAPACITY ISSUE
36800-1	HEXPORT 77	2,040,000	B.CO	10 WKS	26 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 PARKER	8 WKS	18 WKS	3 WKS	NONE	ELIMINATE CORES WILL INCREASE DEL. BY 10%
36888-1	STATIONAR	2,040,000	KF BASSLE	10 WKS	18 WKS	2 WKS	NONE	ADD OVERTIME/MATERIAL AVAILABILITY/ REELS
26744-1	CONTACT-S	2,040,000	DERRINGER	4 WKS	8 WKS	1 WK	NONE	MATERIAL AVAILABILITY
36887-1	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	BRUSHWEL	1 WK	2 WKS	1 WK	NONE	NONE
74916-1	RIVET	2,040,000	JOHN HASS	8 WKS	11 WKS	4 WKS	NONE	RAW MATERIAL AVAILABILITY
46515-2	PRESSURE S	2,040,000	MERMOLDING	16 WKS	32 WKS	4 WKS	NONE	RAW MATERIAL CHANGEOVER/PRESS CAPACITY
74078-143	CERAMIN PR	2,040,000	PARATECH	7 WKS	15 WKS	2 WKS	NONE	
74247-4	BLUE OTHIC	2,040,000	JBL 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
74888-1	RED THREAL	2,040,000	MARK IV CA	3 WKS	6 WKS	1 WK	NONE	
77PS	SWITCH		TI	7/15,8/1,8/15	250K/MONTH			7 day weeks, thru summer vacations, 'std' plastic mold

TI-NHTSA 014194

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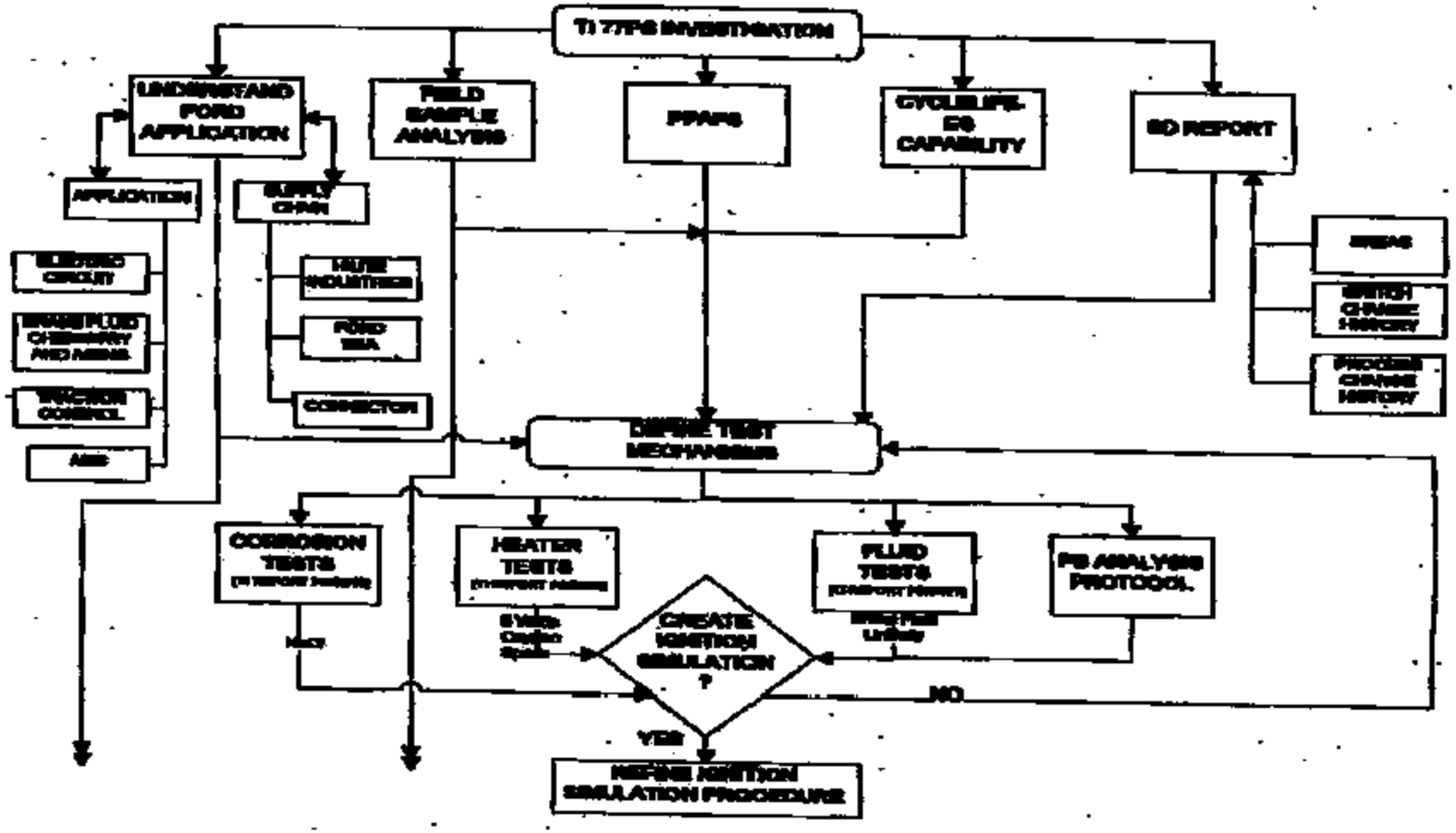
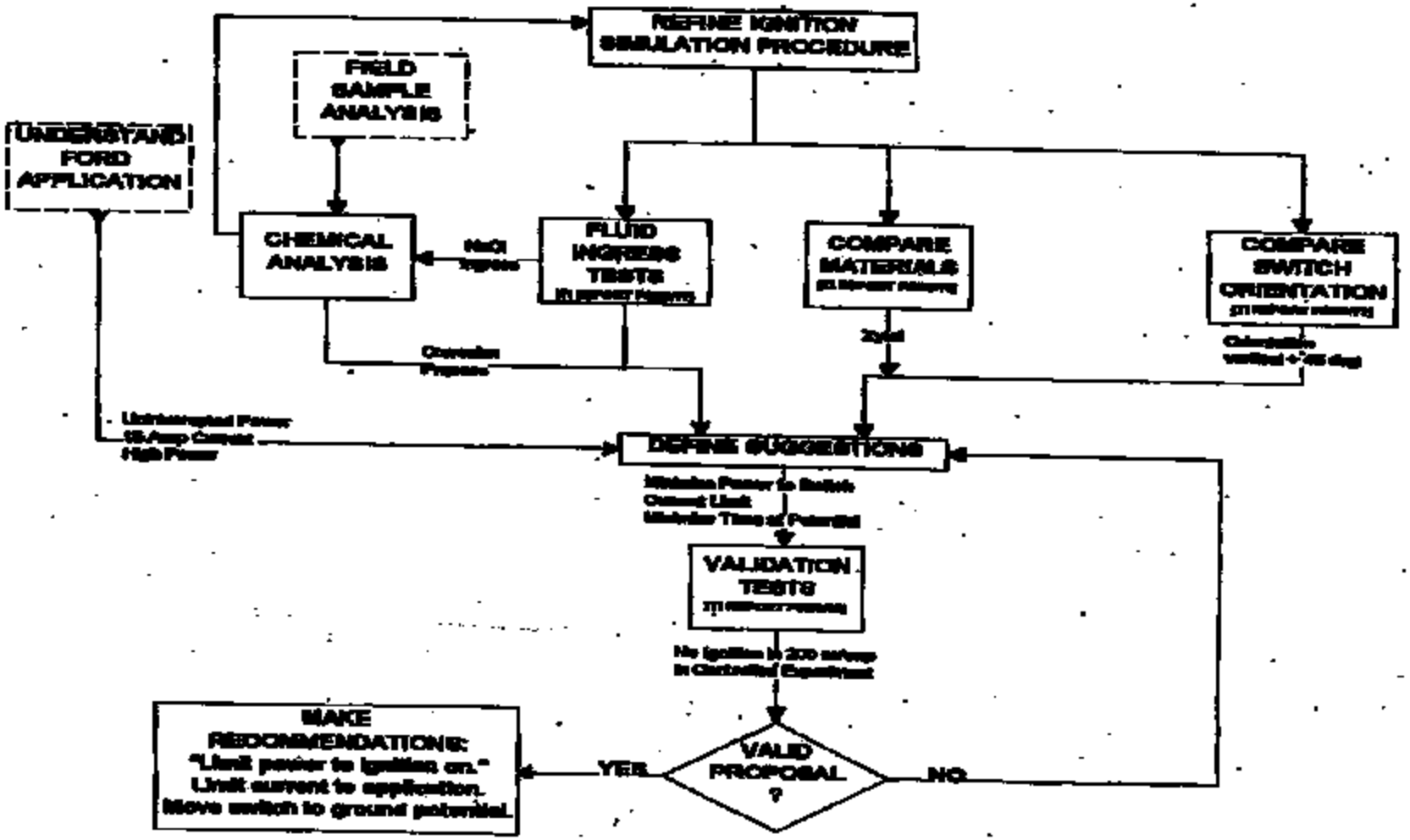
Attachment

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



Attachment

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



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Attachment

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

TEXAS INSTRUMENTS

Category	Test	Location	Test Parameters	Results Update
Lab Simulation	1	TI	Very water concentrations in "new" Brake Fluid	250+ hours, Current down 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%, 78%	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 6mA
			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 30 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 16 devices increased resistance to 5 ohms.
			Salt water solution, 14V bake on spring	Others either very low resistance or negative
			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 6% water solution into switch
			repeatability and current path.	Current path is through hexport.
				See photo and video.
				Additional test include tap water, old BF, new BF and other.

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Attachment

TI-NHTSA 041497

TEXAS INSTRUMENTS

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

[redacted]

	6b	TI	Run "new" brake fluid with metal shavings	Metal shavings do not contribute significantly to brake fluid conductivity
Life Cycle Reliability of Pressure Switch	7	TI	0-1400 psig pressure pulses at 135C per ES	First leak observed at 750,000 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, [illegible] lots, junkyards	Parts in Central Labs, see Ford spreadsheet
Design Of Experiments (T) Evaluating Factors Effecting Diaphragm Wear Impulse test	10	TI	Vary water concentrations in "new" Brake Fluid 12 snap + 12 quiet switches w/ 0 % water in BF 12 snap + 12 quiet switches w/ 5 % water in BF	Test Report being written [illegible] investigation continues. Suspended at 1.2 million cycles with no leaks observed. Snap samples suspended at 1.3 million cycles with 2 leaks observed at 1.3M. Quiet samples suspended at 500k cycles to assess [illegible] [illegible].
On-Vehicle Characterization of Pressure & Temperature Profile in Town Car	11	AVT	Monitor Pressure and Temperature at Switch Location for ABS and non-ABS braking events.	Test at AVT.....see Ford charts...>500k in car?
Brake fluid analysis Used fluid at master cylinder.	11a	TI	Analyze used brake fluid at the master cylinder (UMC), used brake fluid at the caliper (UCA) and new brake fluid (NEW) for metal and water content.	Test complete. UMC: Cu = 416 (ug/ml), Fe = 5.8 (ug/ml), Cr = 0.09 (ug/ml), 1.1 %H2O. UCA: Cu = [illegible] (ug/ml), Fe = 5.5 (ug/ml), Cr = 1.9 (ug/ml), 1.1 %H2O. NEW: Cu = <0.01 (ug/ml), Fe = 0.02 (ug/ml), Cr = <.01 (ug/ml), 0.3 %H2O.
Spark /Arc Study	12	Central Labs	Determine if arc/spark forms in switch using clutch tests and high speed video. Use dry switches as well as switches with various brake fluid water sizes.	Equipment set-up in progress at Central Labs. TI Experimented with no "significant" sparks observed
Characterization of switches retrieved from field junkyards & other sources.	13	Central Labs	Characterize electrical, mechanical and chemical aspects of returned switches	Data log and analysis procedure set up complete. Analysis of switches in progress.
Fluid Ingress Tests	13a	TI	Repeat ignition simulation with different fluids. (3) hour tests: 5% NaCl in tap water rain water (24) hour tests: tap water used brake fluid used brake fluid w / 5% H_2O new brake fluid new brake fluid w / 5% H_2O	Test complete. 5% NaCl sample resulted in an ignition. All brake fluid samples drew less than 3 mAmps. No corrosion visible on brake fluid samples. Rain water and tap water samples drew <10 mAmps and showed trace signs of corrosion. Chemical analysis in process.

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Attachment

TI-NHTSA 014199

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

TEXAS INSTRUMENTS

Compatibility of Kapton with Oxalic Acid	14	Dupont	Characterize change in properties of Kapton with various % oxalic acid in brake fluid.	Compatibility of Kapton with Oxalic Acid	14	Dupont	Characterize change in properties of Kapton with various % oxalic acid in brake fluid.
Evaluation of Plastic Materials with Improved Processors	15	TI	Assess properties and suitability of different grades of plastic resin with additives to improve plastic part performance	Evaluation of Plastic Materials with Improved Processors	15	TI	Assess properties and suitability of different grades of plastic resin with additives to improve plastic part performance
Long duration brake fluid ingress test.	16a	TI	(4) samples with new brake fluid (2) samples with used brake fluid	Long duration brake fluid ingress test.	16a	TI	(4) samples with new brake fluid (2) samples with used brake fluid
Evaluation of Switch Orientation	16b	TI	Assess ignition sensitivity to switch orientation. Test vertical verses 45 degree. Test rotational sensitivity in 45 deg. orientation.	Evaluation of Switch Orientation	16b	TI	Assess ignition sensitivity to switch orientation. Test vertical verses 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.

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

TEXAS INSTRUMENTS

Today's Date: UPDATED 04/21/99

Scope or Effect Description

Attachment

1. Operational Definition (Problem Statement): TOWN CAR UNDERHOOD FIRES			
2. Description	IS	IS NOT	Get Information
WHAT	Town Car MY '92, '93, '94	Crown Victoria? Grand Marquis? TB Super Coupe? MY '91, '95, 96 ? '92, '93 Recalled?	COMPARE PLATFORMS
	FIRES... - Electrical pressure switch - Connector - Servo system - Electrical Distribution SYSTEM ISSUES... - Cruise inoperative - Locked in park - Horn inoperative - Brake lights inoperative - Discharged battery - Door locks? - Hazard lamps?	Not only pressure switches Other circuits	COLLECT/TEST OTHER SYSTEM COMPONENTS FOR 'SYNERGY' COMPARE VEHICLE OPTIONS FOR SYNERGY COMPARE WARRANTY
WHERE	Driver side hood Medium height in engine compart.	Passenger side hood Dash – pass compartment Not high in engine comp. Not low in engine comp.	EVALUATE HEAT SOURCES
WHEN	1-24 hours after parking Ignition off After 4-5 years After XXX miles	Not while driving Not while ignition on Not before 3 years ? Not before YYY miles	EVALUATE POWER AND HEAT AND WIND SOURCES REVIEW MILES
	After AAA switch cycles	Not Before BBB cycles	
HOW BIG	1/8 cm / 22k volts "smoke size" Zones	Not all cars ? Not "explosion"	COMPARE PLATFORMS READ FIRE RPTS
	Several pressure switches	Not all underhood fires Not all pressure switches	PARETO UNDERHOOD

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