EA02-025

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

REQUEST NO. 7

BOX 8

PART A-U

PART M

Epstein, Sally

From:	Dague, Bryan [bdague@email.mc.ti.com]
Sent:	Monday, March 01, 1999 12:31 PM
To:	Beringhausen, Steven; Mulligan, Sean
Subject:	FW: corrected

Background Testing.doc

Sean,

Please give this report a number and file it.

Steve,
FYI.

Bry

From: Beebe, Charles
Sent: Monday, March 01, 1999 9:36 AM
To: Bryan Dague
Subject: corrected

OK, I added that information to the report How is it now? <<Background Testing.doc>>

Background Testing

Speed Control Deactivation Switch
Ford Part #XF1Z-9F924-AA

Background: Contact Bryan Daque X3234

Purpose: To test the ability of the switch (Ford Part #XF1Z-9F924-AA) to withstand excessive current and voltage.

Procedure: Step 1; drill a hole in switch body and install thermal coupler on contact near contact zone. Apply one amp of current across the contacts and note temperature readings after one minute. Step 2; increase the ampere to 2 amps and watch for temperature increase after one minute. Final step; increase the voltage to 20 volts resulting in 2.64 amp load and note any change in temperature after one minute.

Results: At all amperage loads no significant increase in temperature was observed.

	Starting Temperature	After one Minute	Δ Temperature
Step1:	25.5°C	25.5°C	0.0°C
Step2:	25.5°C	25.5°C	0.0°C
Step3:	25.5°C	25.8°C	0.3°C

Conclusion: When the switch is disassembled and inspected it is evident that by using load carrying members with an average thickness of .030", carrying a load of 1 to ~3 amps is not an issue.

GE Plastics

PRODUCT DATA SHEET

Product Support
General Electric Company
One Plastics Avenue, Pittsfield, MA [illegible]
[illegible]

PAGE 1 2 MAR 99 07:15

UL MATERIAL PROPERTIES REPORT
GE PLASTICS
AGENCY SERVICES

PRODUCT FAMILY: NORYL
UL REFERENCE FILE: E121562 E-19

PROPERTIES ON THIS PAGE APPLY TO ALL GRADES OF NORYL
LISTED BELOW:

GTX830

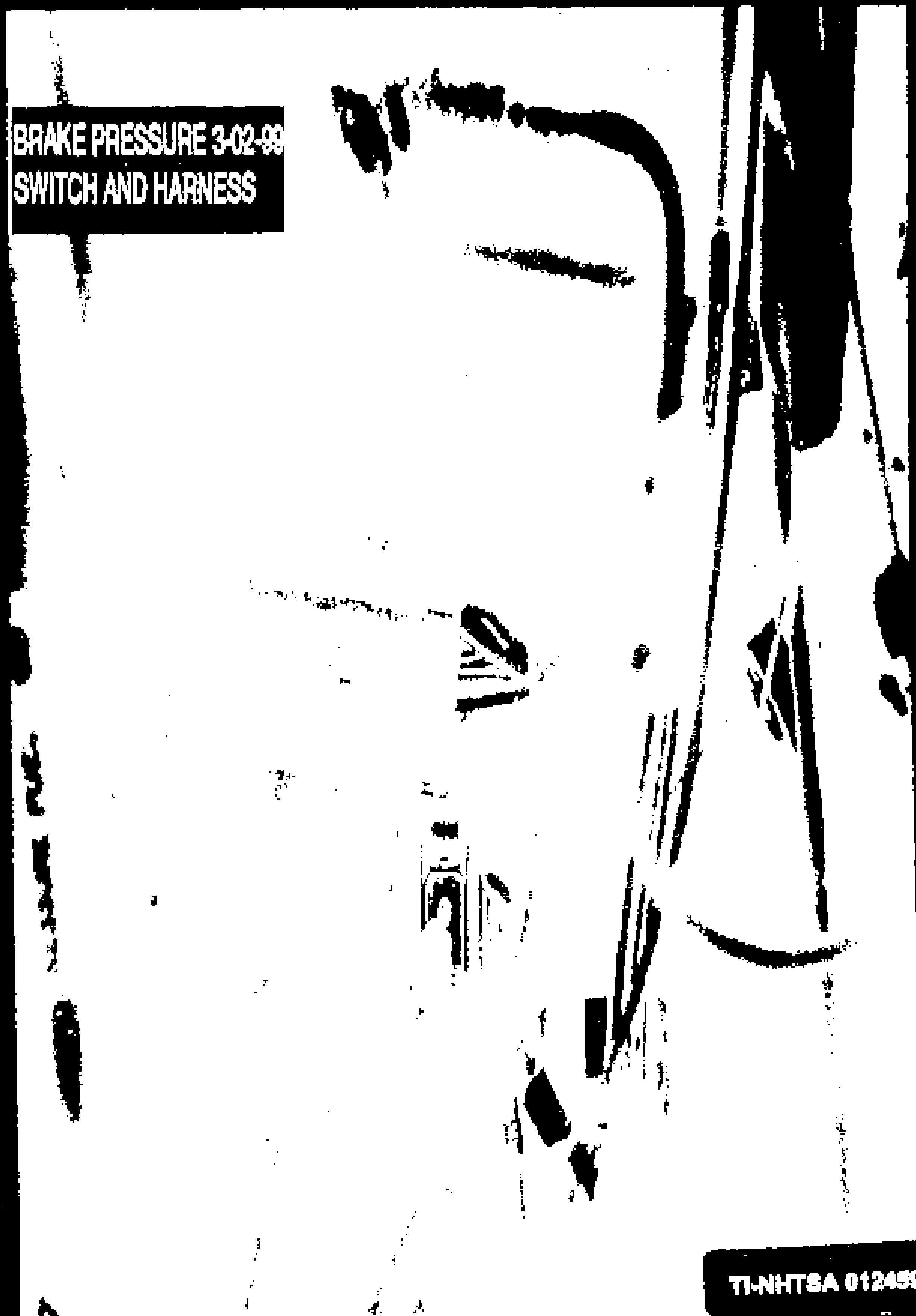
COLOR	THICK-NESS (MM)	FLAME CLASS	RTI ELEC	RTI W/IMP (DEG C)	RTI W/O IMP	HWI	HAI	HVTR	D495	CTI
BLACK	1.57 (.062")	HB	50	50	50	4	2	[illegible]	N/A	-
	3.10 (.12")	HB	50	50	50	4	[illegible]	[illegible]	4	2

FOOTNOTES

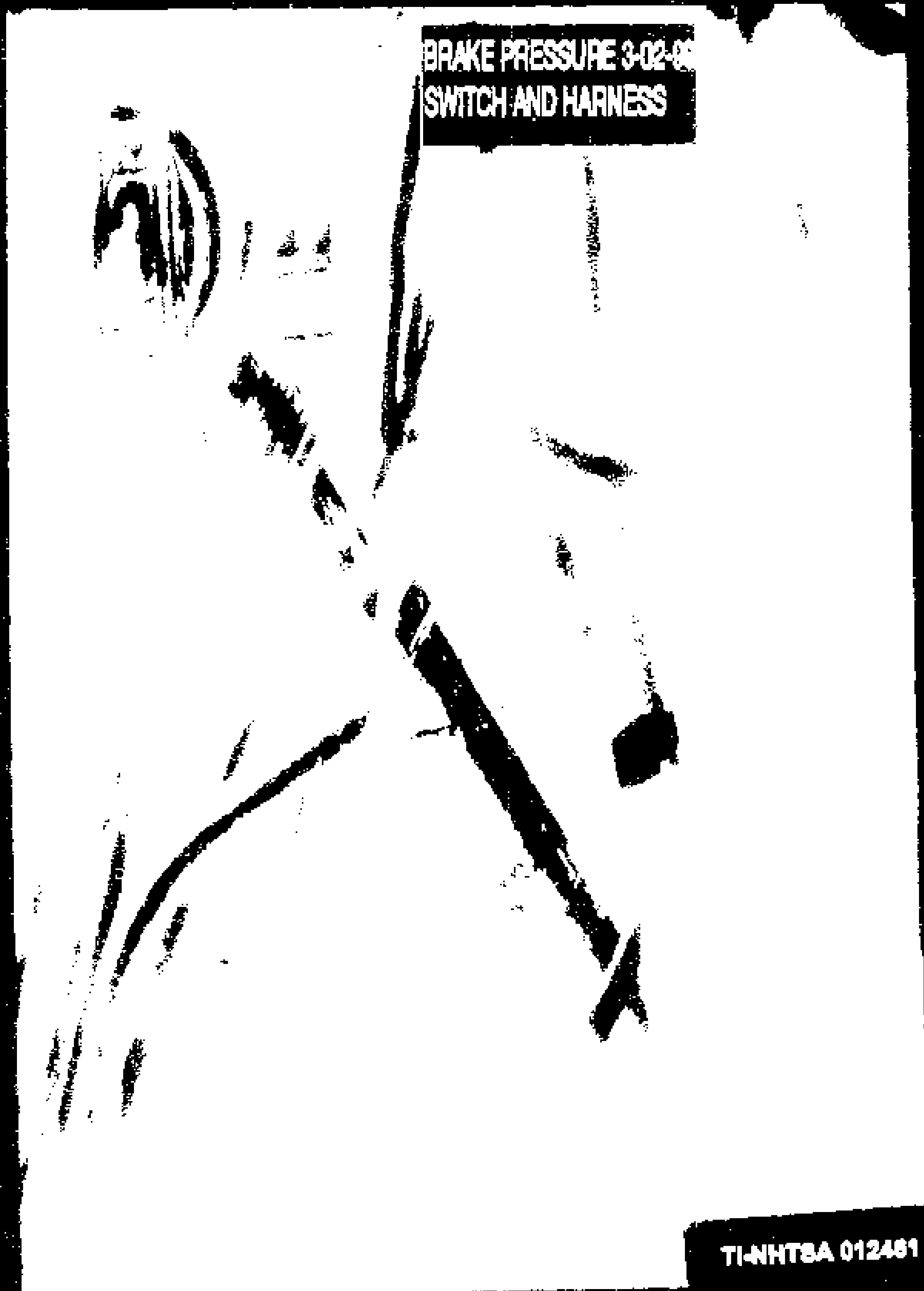
STANDARD GE-PLASTICS MATERIAL DISCLAIMER APPLIES

John 3/4/99

TI-NHTSA 012458


BRAKE PRESSURE 3-02-99
SWITCH AND HARNESS

TI-NHTSA 012460


BRAKE PRESSURE 3-02-9
SWITCH AND HARNESS

Proprietary Information: Attorney-Client Privilege Invoked
PS/99/05
3/2/99

77 PS Heated Device Testing

Abstract

The purpose of this test was to investigate possible ignition caused by excessive heat generated in the contact cavity of 77PS switches. Several methods were used to artificially generate electrical heat in the switches. Power input and temperature were recorded as well as observations.

Procedure

A heater wire coil was installed in each switch base where the contacts and arm assembly normally occupy. The heater was attached to the terminals by removing the contact arm, and grinding away the rivet. The stationary contact was drilled and crimping with a small wire cutter. The heater element measured a total resistance of 0.5 ohms.
A small hole was drilled into the terminal cavity to facilitate use of a K-type thermocouple wire to monitor cavity temperature.

A variable output DC power supply was used to power the heating element through the mating connector leads. The devices were placed in a fire-proof oven and allowed to stabilize to room temperature, 70°F. Voltage, current and temperature were recorded.

Three devices were tested: Device 1 had a brake fluid and 6% water mix injected in the contact cavity. Devices 2 and 3 were dry. Provisions were made for an external source of ignition by drilling a .040 hole on a 45° angle through each base and inserting a .042 Torrington pin. A hy-pot tester was used to generate a spark.

Data

The data obtained on device 1 is shown in Table 1, below.

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

Voltage (Volts)	Heater Current (Amps)	Internal Temperature (°F)
.27	1.0	100
.50	2.0	175
.80	2.9	220
.90	3.0	246
.98	3.2	349
1.6	2.0	300
.97	3.1	340
1.1	3.6	460
1.2	3.8	462
1.1	3.8	488
1.3	4.0	531
1.1	3.6	571
1.4	4.1	647
1.4	4.0	660

Notes on Table 1:

Out-gassing of fluids began at 220 °F and a noticeable hissing sound was present. Smoke was visible and the base was venting from the side at a temperature of 246 °F. Smoke vented until failure of the base at 660 °F. At this point power to heater was shut down and spark was generated using the hy-pot. Ignition of gases occurred at this point and the fire was extinguished.

The data obtained on device 2 is shown in Table 2, below.

Table 2.
Test 2 (dry device with spark)

Voltage (Volts)	Heater Current (Amps)	Internal Temperature (°F)	Notes
1.0	3.1	501	
1.09	3.0	743	
Connection failed. Test interrupted.			
1.06	3.02	596	
1.06	3.09	626*	Smoke became visible from terminal area.
1.12	3.15	650	
1.13	3.08	681	
1.13	3.26	692	A small burn through area in the base. Smoke began venting from burn through area.
1.13	3.18	707	
1.13	3.36	722	
1.20	3.52	758	
1.36	3.95	806	Base flopped over
1.36	4.00	875	

*Light smoke became visible from terminal area
** A small burn

Notes on Table 2:

Power was left on at the end of the test and spark was generated. The fumes ignited and extinguished rapidly. The upper portion of the switch did not ignite despite 1230 °F temperature .

TI-NHTSA 012464

Data obtained on Device 3 is shown in Table 3, below.

Table 3.
Test 3 (rapid temp. rise)

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

Notes on Table 3:

Readings for this test were made at approximately 20 second intervals. This was a fast happening event, where the internal temperature rise was very rapid. Smoke emitted at 300 °F. The device vented at the side of the base at 643 °F and the base did not fail until 1436 °F was achieved. A spark was applied at 1436 °F and fumes ignited . The heater instantly burned out and the fire was extinguished ..

Conclusions

Heat generated in the contact cavity of switches is not sufficient to initiate a thermal event. Vapors from base plastic melting and a catalyst such as a spark are necessary for ignition. In order to sustain an ignition, devices must be open to the atmosphere for a supply of Oxygen.

Summary of Chemical Properties
3/2/99

The following pages were supplied by Dupont and show chemical and physical properties for Teflon and Kapton. In summary, water will degrade the mechanical properties of Kapton, but Teflon is unaffected by water. This is the reason why the Teflon-Kapton-Teflon system was selected for Texas Instruments switch diaphragm (3 mil thick Kapton layer coated with 1 mil Teflon on both sides). Page 1 (marked with "A") indicates that the Teflon is non-reactive with water. While page 2 shows Teflon has a relatively low vapor transmission rate (marked with "B"). Page 3 shows how the mechanical properties of Kapton degrade with water and temperature exposure (marked with "C").

End of document.

Chemical Properties

DuPont FEP fluorocarbon film is chemically inert and solvent resistant to virtually all chemicals except molten alkali metals, fluorine at elevated temperatures, and certain complex halogenated compounds such as chlorine trifluoride at elevated temperatures and pressures.

In circumstances where end-use temperatures are close to the upper service limit 205°C (400°F), 50% sodium hydroxide, metal hydrides, aluminum chloride, ammonia, and certain amines ($R\text{-}NH_2$) may attack the film in a manner similar to molten alkali metals. Special testing is required when such extreme reducing or oxidizing conditions are evident.

With these exceptions noted, DuPont FEP fluorocarbon films exhibit a very broad range of chemical and thermal serviceability.

Due to the many complex aspects of performance in severe environments, final selection should be based on functional evaluations or experience under actual end-use conditions.

The chemical substances listed in Table 5 are representative of those with which DuPont FEP film has been found to be nonreactive.

Table 5
Typical Chemicals with Which DuPont FEP Film Is Nonreactive*

Abietic acid	Cyclohexanone	Hydrofluoric acid	Phthalic acid
Acetic acid	Dibutyl phthalate	Hydrogen peroxide	Pinene
Acetic anhydride	Dibutyl sebacate	Lead	Piperidine
Acetone	Diethyl carbonate	Magnesium chloride	Polyacrylonitrile
Acetophenone	Diethyl ether	Mercury	Potassium acetate
Acrylic anhydride	Dimethyl formamide	Methyl ethyl ketone	Potassium hydroxide
Allyl acetate	Di-isobutyl adipate	Methacrylic acid	Potassium permanganate
Allyl methacrylate	Dimethylformamide	Methanol	Pyridine
Aluminum chloride	Dimethylhydrazine, unsymmetrical	Methyl methacrylate	Soap and detergents
Ammonia, liquid	Dioxane	Naphthalene	Sodium hydroxide
Ammonium chloride	Ethyl acetate	Naphthols	Sodium hypochlorite
Aniline	Ethyl alcohol	Nitric acid	Sodium peroxide
Benzonitrile	Ethyl ether	Nitrobenzene	Solvents, aliphatic and aromatic**
Benzoyl chloride	Ethyl hexoate	2-Nitro-butanol	Stannous chloride
Benzyl alcohol	Ethylene bromide	Nitromethane	Sulfur
Borax	Ethylene glycol	Nitrogen tetroxide	Sulfuric acid
Boric acid	Ferric chloride	2-Nitro-2-methyl propanol	Tetrabromoethane
Bromine	Ferric phosphate	n-Octadecyl alcohol	Tetrachloroethylene
n-Butyl amine	Fluoronaphthalene	Oils, animal and vegetable	Trichloroacetic acid
Butyl acetate	Fluoronitrobenzene	Ozone	Trichloroethylene
Butyl methacrylate	Formaldehyde	Perchloroethylene	Tricresyl phosphate
Calcium chloride	Formic acid	Pentachloro-benzamide	Triethanolamine
Carbon disulfide	Furane	Perfluoroxylene	Vinyl methacrylate
Cetane	Gasoline	Phenol	Water
Chlorine	Hexachloroethane	Phosphoric acid	Xylene
Chloroform	Hexane	Phosphorus pentachloride	Zinc chloride
Chlorosulfonic acid	Hydrazine		
Chromic acid	Hydrochloric acid		
Cyclohexane			

A

*Based on experiments conducted up to the boiling points of the liquids listed. FEP resins have normal service temperatures up to 205°C (400°F). Absence of a specific chemical does not mean that it is reactive with FEP film.
**Some halogenated solvents may cause moderate swelling.

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Page 1

TEFLON FEP

Physical Properties

Absorption

Almost all plastics absorb small quantities of certain materials with which they come in contact. Submicroscopic voids between polymer molecules provide space for the material absorbed without chemical reaction. This phenomenon is usually marked by a slight weight increase and sometimes by discoloration.

DuPont FEP fluorocarbon films have unusually low absorption compared with other thermoplastics. They absorb practically no common acids or bases at temperatures as high as 200°C (392°F) and exposures of up to one year. Even the absorption of solvents is extremely small. Weight increases are generally less than 1% when exposed at elevated temperatures for long periods. In general, aqueous solutions are absorbed very little by DuPont FEP film. *Moisture absorption is typically less than 0.01% at ambient temperature and pressure.*

Permeability

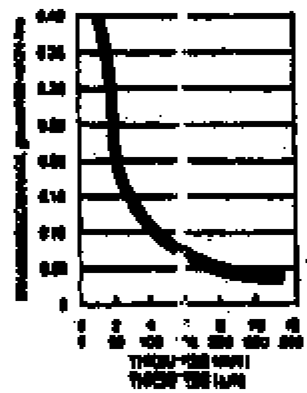
Many gases and vapors permeate FEP films at a much lower rate than for other thermoplastics (see Figure 13). In general, permeation increases with temperature, pressure, and surface contact area and decreases with increased film thickness. Table 6 lists rates at which various gases are transmitted through DuPont FEP fluorocarbon film, while Table 7 lists rates of vapor permeability for some representative substances. Note that the pressure for each material is its vapor pressure at the indicated temperature.

Table 6
Typical Gas Permeability Rates of DuPont FEP Fluorocarbon Film, 25 µm (1 mil) Thickness
(Test Method: ASTM D-1434 at 25°C (77°F))

Gas	Permeability Rate* $cm^3/(m^2 \cdot d \cdot MPa)$
Carbon Dioxide	25.9 × 10[illegible]
Hydrogen	34.1 × 10[illegible]
Nitrogen	5.0 × 10[illegible]
Oxygen	11.6 × 10[illegible]

*To convert to cm³/(100 in² · 24 h · atm), multiply by 0.0646.

Figure 13. Water Vapor Transmission Rate of DuPont FEP Film at 40°C (104°F) per ASTM E-96 (Modified)



Notes: Values are averages only and not for specification purposes. To convert the permeation values for 100 in² to those for 1 m², multiply by 15.5.

Table 7
Typical Vapor Transmission Rates of DuPont FEP Fluorocarbon Film, 25 µm (1 mil) Thickness
(Test Method: Modified ASTM E-96)

Vapor	Temperature °C	Temperature °F	Vapor Transmission Rate SI Units g/(m²·d)	Vapor Transmission Rate English Units (g/100 in²·d)
Acetic Acid	35	95	6.3	0.41
Acetone	35	95	14.7	0.95
Benzene	35	95	9.9	0.64
Carbon Tetrachloride	35	95	4.8	0.31
Ethyl Acetate	35	95	11.7	0.76
Ethyl Alcohol	35	95	10.7	0.69
Freon® F-12	23	73	373.0	24.0
Hexane	35	95	8.7	0.56
Hydrochloric Acid	25	77	<0.2	<0.01
Nitric Acid (Red Fuming)	25	77	160.0	10.3
Sodium Hydroxide, 50%	25	77	<0.2	<0.01
Sulfuric Acid, 98%	25	77	2 × 10[illegible]	1 × 10[illegible]
Water	39.5	103	7.0	[illegible]

5)

Page 2

TI-NHTSA 012468

[illegible] on KAPTON

[illegible]

TI-NHTSA 012469

Page 3

@ Ford 3/3/99

- 80 - Self Analysis
Andy

- Use/Continuing Oxalic Acid
instead of Salt

- Three Thoughts: Brake Fluid
: Conversion
: Own Sets

- Explain Brake Fluid Inhibitors
& Oxalic Acid For [illegible]

- Test Oxalic Acid w/ Kaptons

1. Connector Seal

1a. KAPTON SEAL   IMPROVE DURABILITY

2. Power continuously available

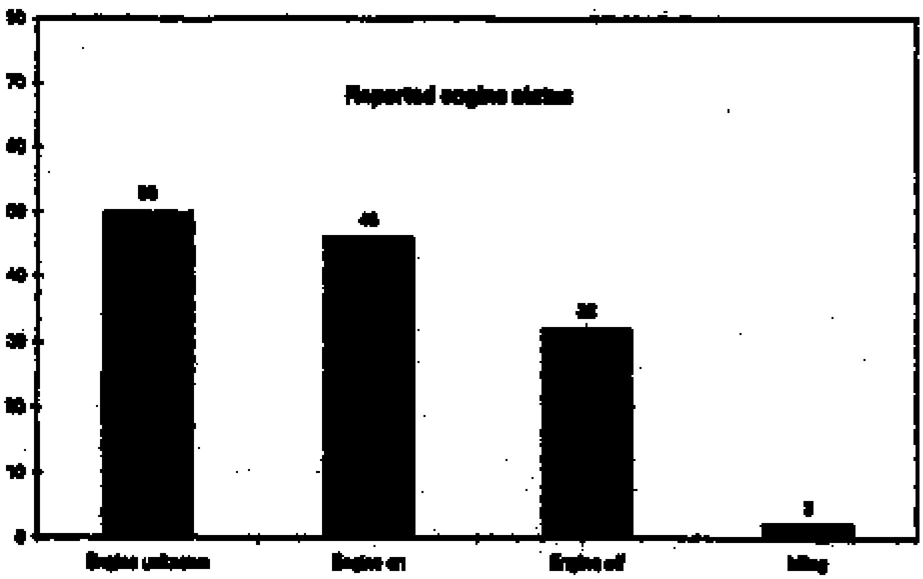
3. Switch orientation   MOVE SWITCH W/TUBING

4. Current limit / fuse   ADD FUSE (VALUE?)

5. Hexport isolation   INSULATED TUBING

6. Higher temperature plastic

92MY Town Car CQIS Pareto Analysis



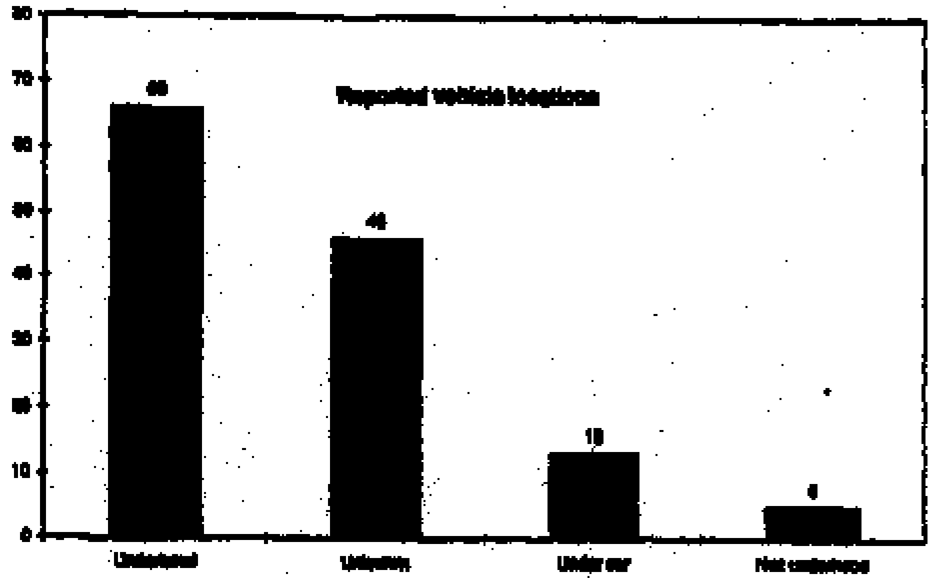
Note:
* Of the reported probable causes with the engine off:

* Unknown (category 6)	12
* Electrical (category 6,7,8,9,17,21)	8
* Left Front of vehicle (category 11)	4
* Statics (category 14,15,16)	2
* Gas lines (category 19)	2
* Right rear side (category 12)	1
* Dashboard (category 20)	1
* Spark plug wires (category 25)	1
* Liquid equipment (category 24)	1

Attachment4, by [illegible] x[illegible], created 2/19/1999, revision, page 1 of 1

TI-NHTSA 012472

98MY Town Car CQIS Pareto Analysis

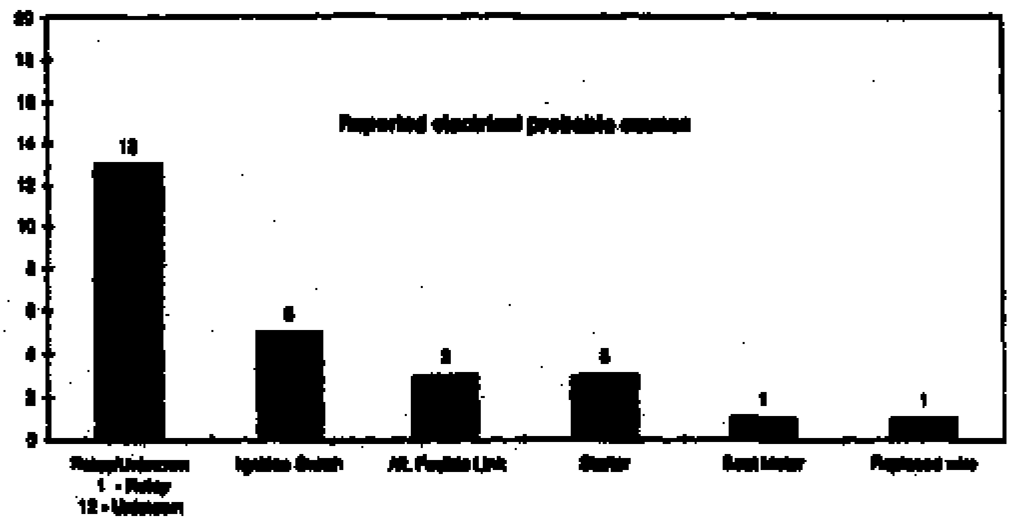


Notes:
* Underhood location is broken down into the following categories as probable causes:

(1) Underhood unknown	19	Out of a total of 66
(2) Brake related	14	Out of a total of 47
(3) Electrical related	13	Out of a total of 66
(4) Left front of vehicle	7	
(5) Engine leaving coolant	5	
(6) Gas lines	1	
(7) Battery on top of hood	1	
(8) Catalytic converter	1	
(9) A/C comp. (overhead)	1	
(10) Spark plug wires	1	
(11) Right rear side	1	

Attachment, by [illegible], created 2/12/1999, revisions, page 1 of 1

92MY Town Car CQIS Pareto Analysis



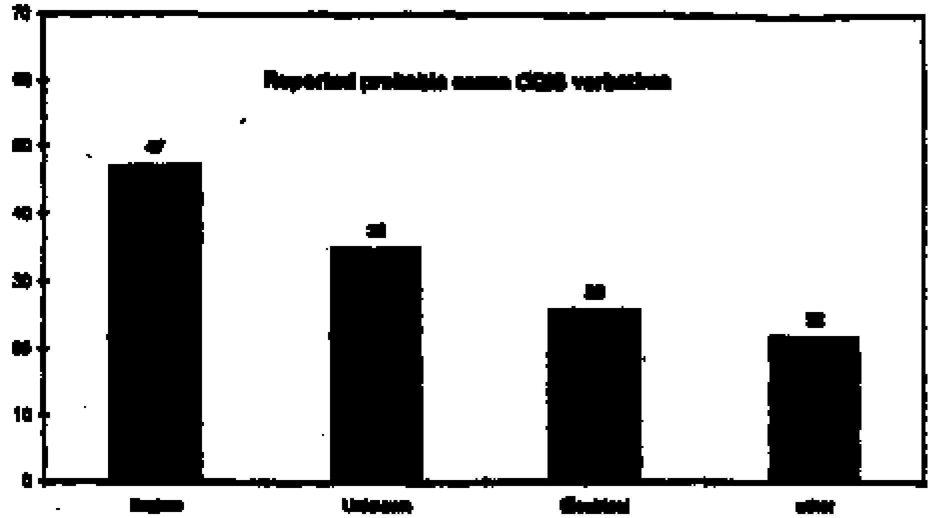
Note:
(1) Of the 13 probable electrical issues on the first bar, 12 are stated as an electrical issue without any other conclusion.

Relay/Unknown
- 1 - Relay
- 12 - Unknown

(2) Ignition Switch --
- 2 of the 5 ignition switches were previous recall issues that customers did not bring in for service.
- 3 are identified as possible ignition switch.

Achart8, by [illegible] [illegible], created 2/18/1999, revisions, page 1 of 1

98MY Town Car CQ38 Pareto Analysis



Notes:

(1) Brakes account for 47 out of 130 98MY Town Car CQ38 verbatims.
* Categories include these types of comments: Brake pressure switch, brakes lock-up, brake booster hangs-up, brake lines, frozen calipers, power brake unit, plastic piston caliper melts, brakes caught fire, undercut rotors, after market parts.

(2) Unknowns account for 35 out of 130 98MY Town Car CQ38 verbatims.
* No probable root cause identified.

(3) Electrical accounts for 26 out of 130 98MY Town Car CQ38 verbatims.
* Categories include these types of comments: 12 are reportedly an electrical issue with comments such as car shorted, possible electrical wire malfunction, electrical problem, electrical short, fire department stated electrical issue.
others include suspension relay, replaced a wire, ignition switch, starter, alternator fusible link, Seat motor.

(4) Other accounts for 22 out of 130 98MY Town Car CQ38 verbatims.
* Categorized included are battery on top of car hood, left front of vehicle, right rear side, gas lines, engine low or no coolant, catalytic converter, dashboard, spark plug wires, A/C compressor (overheated), liquid fuel equipment.

Attachm1, by Judall x[illegible], created 2/18/1999, revisions, page 1 of 1

FEB 22 '99 15:35 FM CHARLES ELECTRONICS 312 359 4146 TO [illegible] P.04/07

TI-NHTSA 012475

[illegible]

Summary of 130 '98MY Town Car CQIS Verbatims and Electrical Next Steps

SUMMARY

1.0 There are 4 main categories that the 130 CQIS verbatims can be binned to:
- (A). 36% or 47 out of 130 are reportedly brake related.
- (B). 27% or 35 out of 130 are reportedly unknown.
- (C). 20% or 26 out of 130 are reportedly electrical related.
- (D). 17% or 22 out of 130 have reported probable causes relating to systems other than brakes or electrical.

2.0 There are 4 main categories of the 130 CQIS verbatims for vehicle locations of the reported fires.
- (A). 51% or 66 out of 130 are reported to be underhood.
- (B). 35% or 46 out of 130 are reported to be unknown.
- (C). 10% or 13 out of 130 are reported to be under the car.
- (D). 4% or 5 out of 130 are reported not to be underhood.

3.0 There are 4 main categories of engine status for these 130 CQIS verbatims:
- (A). 38% or 50 out of 130 are reportedly engine unknown - not known whether engine was running or not.
- (B). 35% or 46 out of 130 are reportedly engine running.
- (C). 25% or 32 out of 130 are reportedly engine off.
- (D). 2% or 2 out of 130 are reportedly with engine idling.

NEXT STEPS:

1.0 Review OVQM CQIS verbatims for reported fires - target complete date is 2/26/1999.
2.0 Request FCSD to pull feature codes for the 130 related CQIS VIN's.
3.0 Request 12 previously burned vehicles be investigated per the electrical questions forwarded to JNema.

1LNLM81W1PY[illegible]	1LNLM82W[illegible]
1LNLM8[illegible]	1LNLM81W[illegible]
1LNLM8[illegible]W1NY7[illegible]	1LNLM82W[illegible]
1LNLM82W[illegible]Y7[illegible]17	1LNLM82W[illegible]
1LNLM8[illegible]	1LNLM81W[illegible]Y70[illegible]1
1LNLM81W[illegible]Y72[illegible]	1LNLM82W[illegible]17

A/summary by Jsmith, x[illegible], created 2/19/1999, revisions, page 1 of 1.

TI-001438

[illegible]

1. Connector Seal

2. Power continuously available

3. Switch orientation

4. Current limit / fuse

5. Hexport isolation

6. Higher temperature plastic

- Lack of Seal Integrity
  - Mating connection system integrity
  - Switch orientation collects water if connector leaks

Power System Configuration
  - Power continuously available
  - Available power higher than application need
  - Short to ground path

TEXAS INSTRUMENTS

Brake Pressure Switch
Potential Factors - 3/3/99

1. Connector Seal

1a. Kapton Seal

2. Power continuously available

3. Switch orientation

4. Current limit / fuse

5. Hexport isolation

6. Higher temperature plastic

Improved Kapton diaphragm

[illegible] (Value ?)

TEXAS INSTRUMENTS

Brake Pressure Switch
Potential Factors - 3/3/98

1. Connector Seal

1a. KAPTON SEAL — IMPROVE DURABILITY

2. Power continuously available

3. Switch orientation — MOVE SWITCH W/TUBING

4. Current limit / fuse — ADD FUSE (VALUE?)

5. Hexport isolation — INSULATED TUBING

6. Higher temperature plastic

Potential Actions

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

■ = fixed
□ = improved

TEXAS INSTRUMENTS

Brake Pressure Switch
Potential Factors - 3/3/99

[redacted]

1. Connector Seal

1a. Kapton Seal --- improve [illegible]

2. Power continuously available

3. Switch orientation — move switch w/ tubing

4. Current limit / fuse — add fuse (value?)

5. Hexport isolation — insulated tubing

6. Higher temperature plastic

— Greased guts?

— Seal terminals

— Heat shield

Test Notes
Last updated: 3/3/99

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

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

Results to date:
Unable to create a fire.

Corrosion/Ignition:
Objective – to recreate the conditions favorable to a thermal event.

Description:
Fill switch with a 5% salt water solution. Apply 12 volts to the terminal with the hexport grounded. Allow the water solution to boil/electrolisize until dry. Repeat as necessary to create a thermal event.

Results:
While we have been

application.

Repeated refills yielded no significant temperature increase In fact, current flows have decrease. Fluid has discolored. This test was suspended on 2/21/99. Internal inspection is planned for later today.

Weibull Testing:
This testing is complete. See specific test report.

Short to ground (inside switch):
This test is complete. See specific test report.

Wear Correlation:
This testing is complete. See specific test report.

Auto-ignition testing:
Ignition via heating element:
Objective is to get a fire started within the switch by installing a very small electrical heating element. With a small heating element built into a switch, we will fill the connector cavity with brake fluid, and slowly increase the current in the heating element. We will increase the current until ignition, or until the heating element burns out (continuity is lost).

Samples tested:
1) Dry
2) Pure brake fluid with metal shavings
3) 6% brake fluid solution

Results:
If a reliable heating element can be constructed inside the contact cavity, we have been able to increase the internal temperature of the swish to a high of 800 degrees F. Typically, we see smoke around 675 degrees F, and the base melts and falls off to the side as it approaches 800F.

By adding an ignition source (arc or open flame) we have been able to ignite the smoke and plastic.

Conclusions:
1) heat alone will not create a fire – must have a spark or open flame to ignite.
2) Brake fluid in the cavity actually slows the ignition process down – probably do to cooling effects.
3) 2 to 4 watts is required to attain the temperatures mentioned above.

Creating a heating element with corrosion:
The purpose of this test is to increase the contact's arm enough to generate the 2 to 4 watts needed to start smoking.

Filling the switch with salt water and holding the arm at 14 volts and hexport at ground is generating corrosion.

Results:
Resistance is being measured today.

DOE:
The equipment needed to modify the cycler arrived this morning. We are working to get the following parts on cycle today:
12 switches with snap discs and 0 % water in the brake fluid
12 switches with out snap and 0% water in the brake fluid.
12 switches with snap disc and 5% water in the brake fluid.
12 switches with out snap and 5% water in the brake fluid.

2 switches from each group will have the Ford loads applied.

Estimated running time for this test is 2 weeks. Results will be presented in Weibull plot format.

End of document.

TI 77PS Test Synopsis

This document is a synopsis of tests conducted by Texas Instruments during the 77PS investigation. The intent of this document is to highlight test findings which drove the investigation to its current state. Throughout the investigation, several tests were conducted with the same objective. When each objective was met, efforts were refocused to obtain a new level of understanding and to establish a new set of objectives. As such, tests have been categorized into (5) levels, representing the level of knowledge obtained from the group of tests conducted. Each level is listed below with a short description of the objective:

Not sure about this "level" thing ... suggestion

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

Level 1:

Objective:

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

Reference test log sheet — Maybe insert description title for each test

Test 1 Objective: Determine if switch ignition can occur under the following conditions:
Switch contact flooded with brake fluid mixed with varying amounts of % H_2O.
14 volts applied to one terminal, second terminal electrically floating. (No electrical load across switch terminals).
Switch hexport electrically grounded.

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

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

TI-NHTSA 012467

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

Results:

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

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

Test 6 Results: Ignition occurred in both wet and dry devices.
Wet device: The internal temperature of a wet device reached 660°F. A hole burned through the base of the switch (close to the heating element). The externally applied spark ignited the fumes which engulfed the switch.
Dry device: The internal temperature of a wet switch reached over 1000°F. The switch base flopped over. The externally applied spark ignited the fumes which engulfed the switch.

Conclusion:

A switch ignition can occur under the following laboratory conditions:

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

Brake fluid does not contribute to the ignition process

Level 2:

Objective:

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

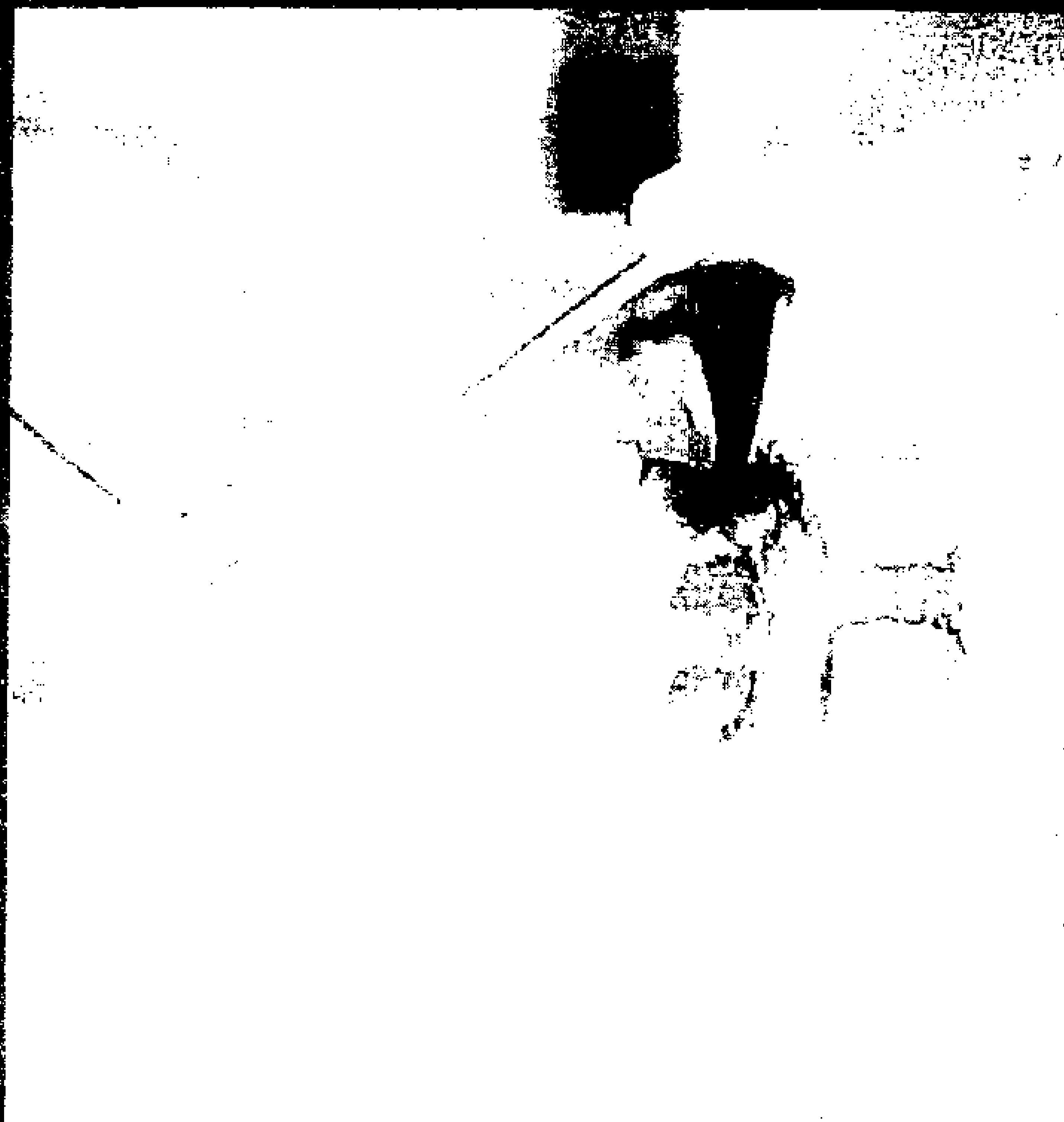
Test 6a Objective: Determine if corrosive degradation of switch electrical components can cause an increase in electrical resistance (and thus a source of heat) in the switch which may lead to an ignition.

DOE

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

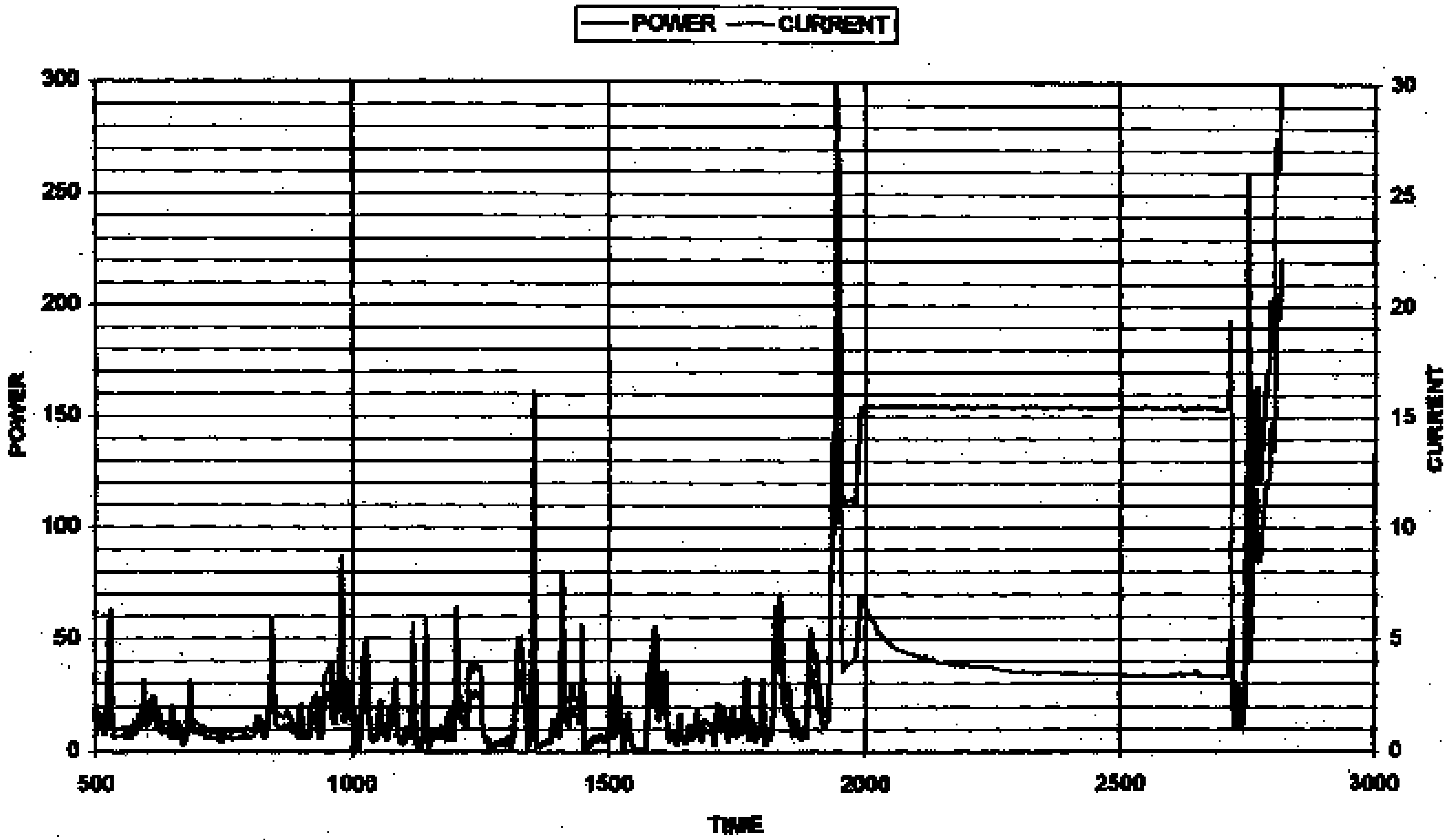
f... to include

Results:

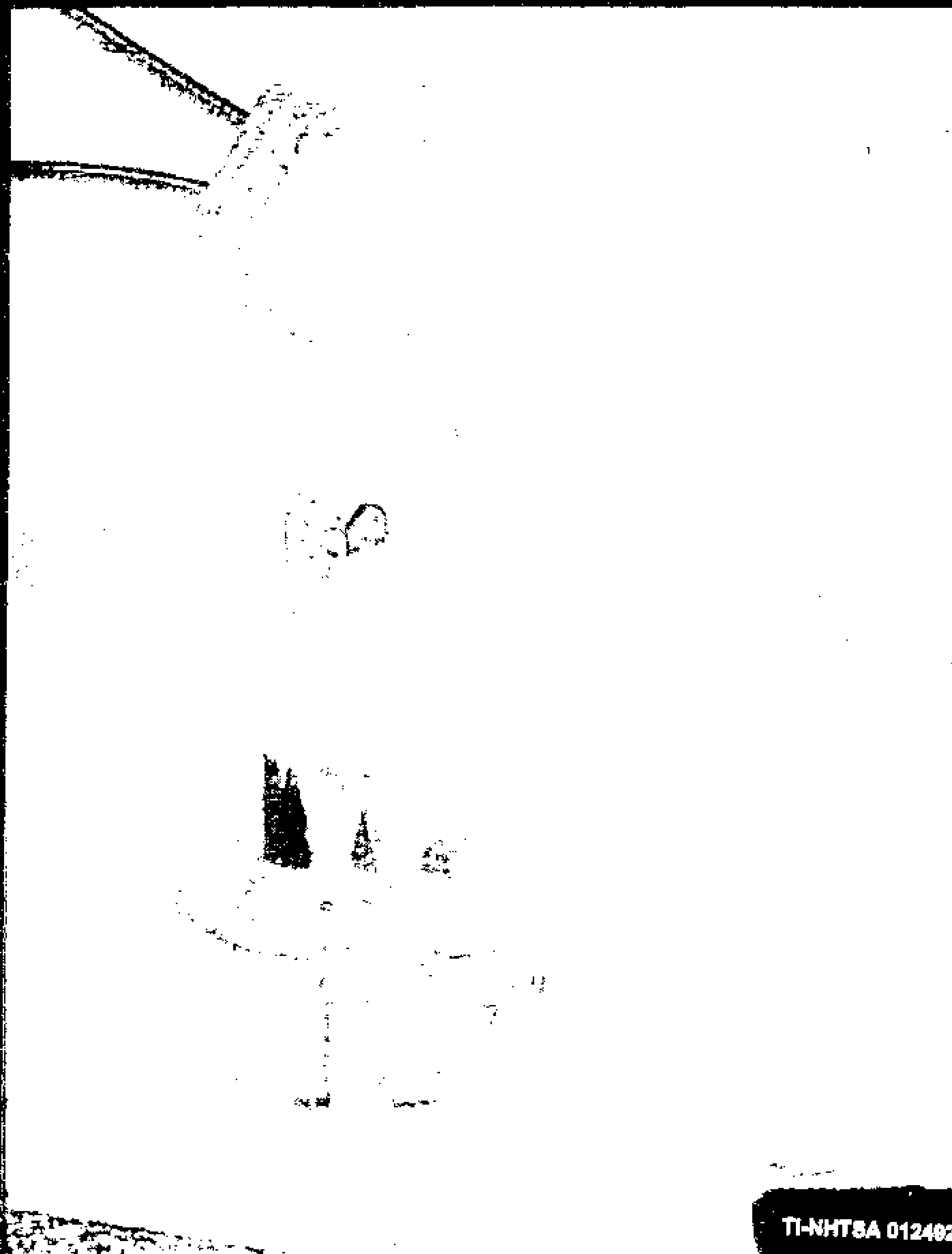


TI-NHTSA 012490

ZYTEL BASE
5% SALT WATER INGRESS
VERTICAL ORIENTATION



TI-NHTSA 012481

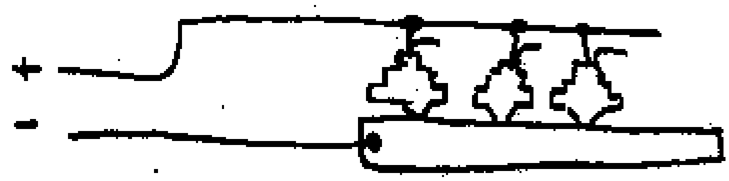


TI-NHTSA 012492

5-8-99

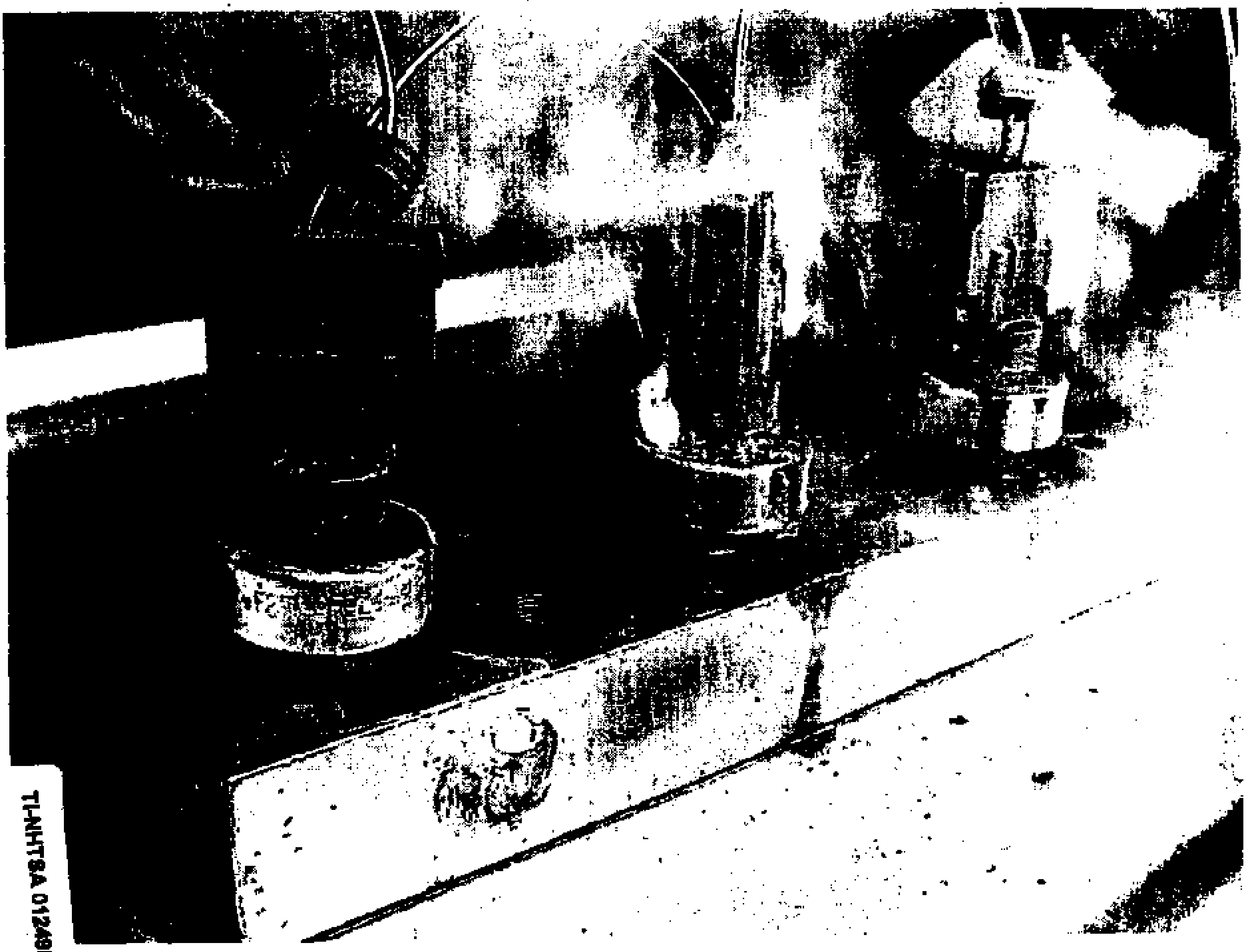
5 Pc ~~[illegible]~~ Vertical Burn test

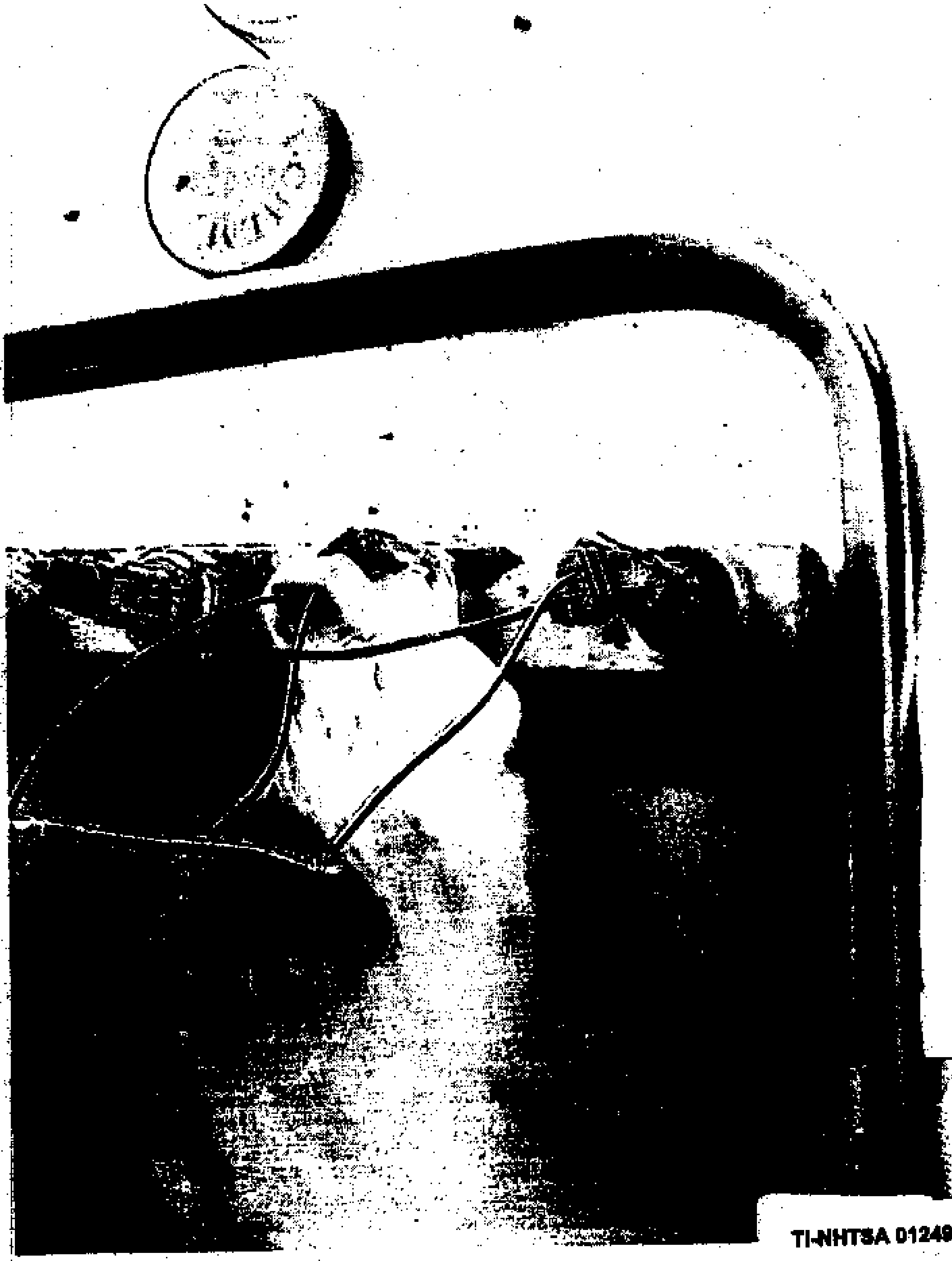
5 PC Set up on Common manifold. DEVICES Power with 14.5 VDC And Limited to 25 Amps to Protect Power Supply - Side of Device was Floated.



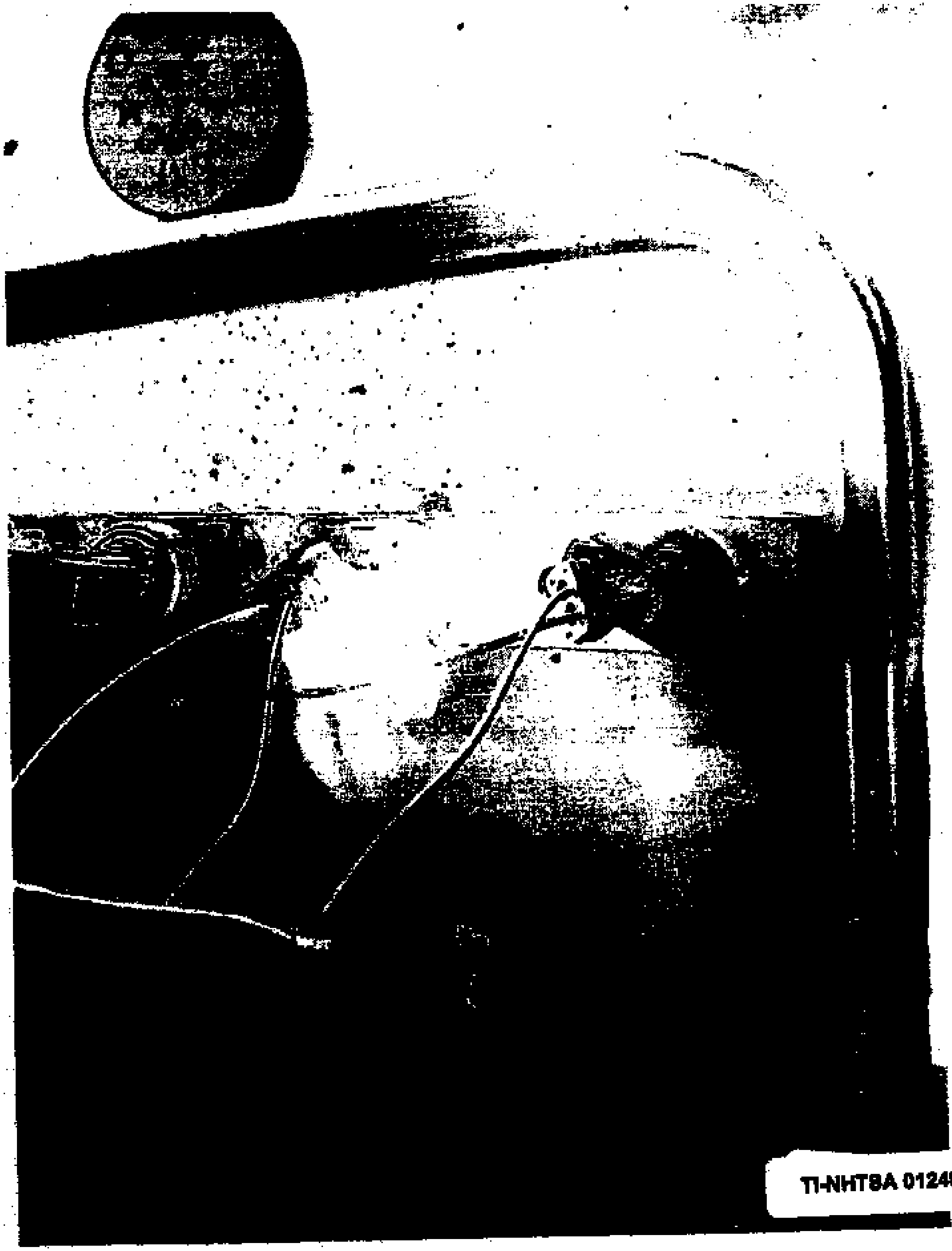
A Solution of 5% (ASTM) Salt And tap water was injecte. into the Device And Power Applied To Devices. Devices were Filled on as needed basis for Duration of Test.

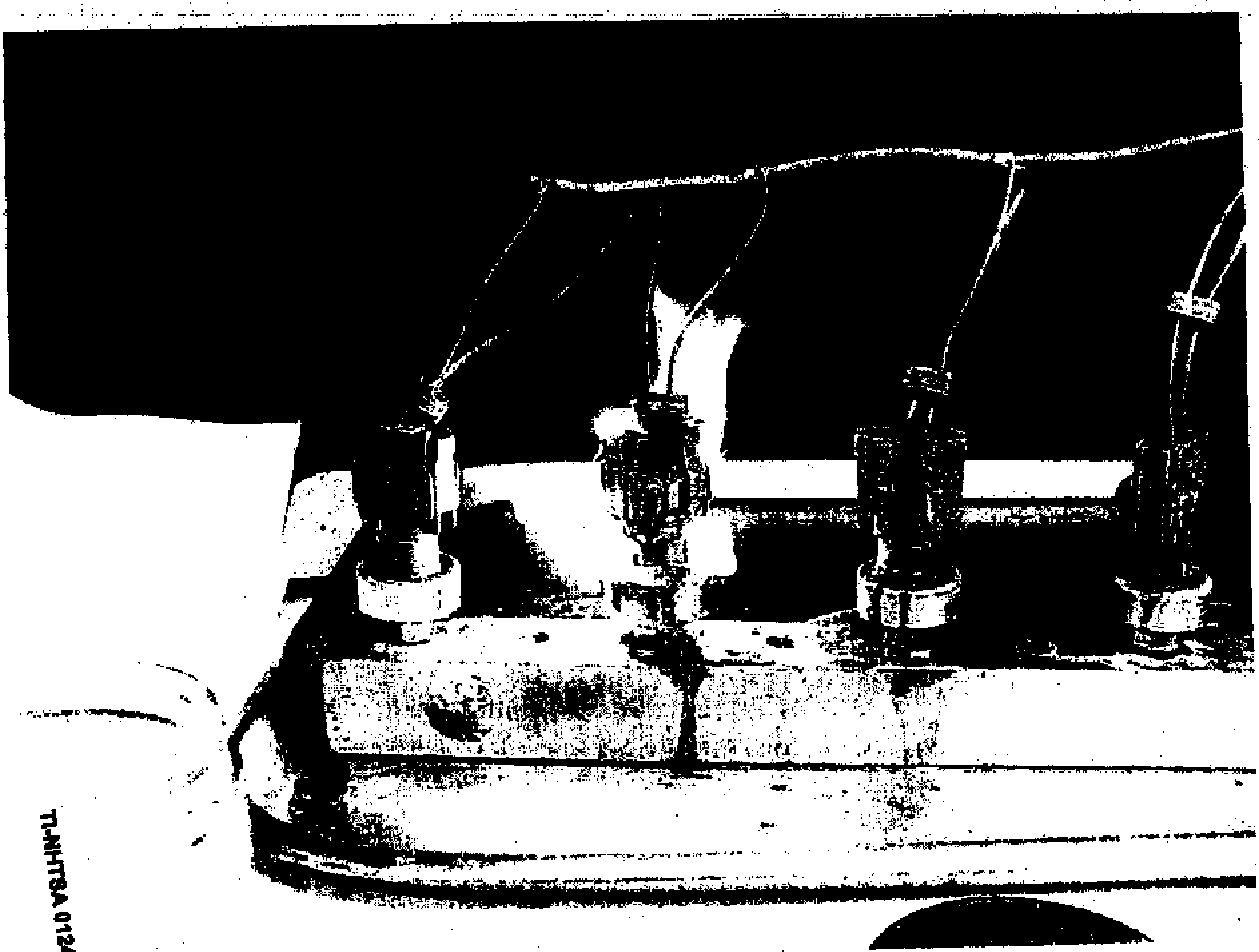
Resuts: 3 of the 5 DEVICES IGNITED, 1 BURNED APPX 35% of BASE But Did not ignite, 1 SHOWED VERY Slow Action for Duration of Test AND UPON Removal found + Terminal Had CORRODED AWAY AND Broken Away From Switch Terminal

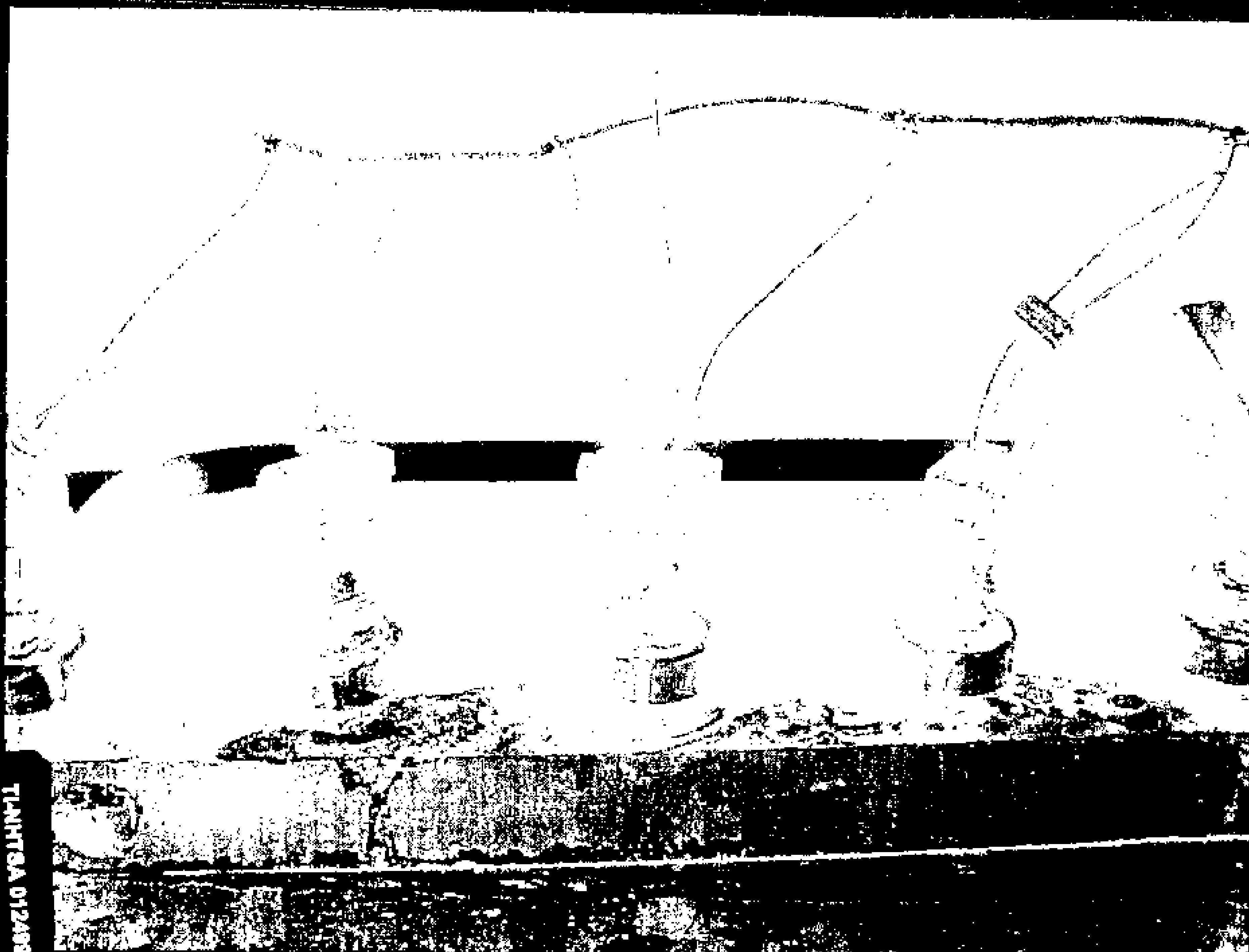


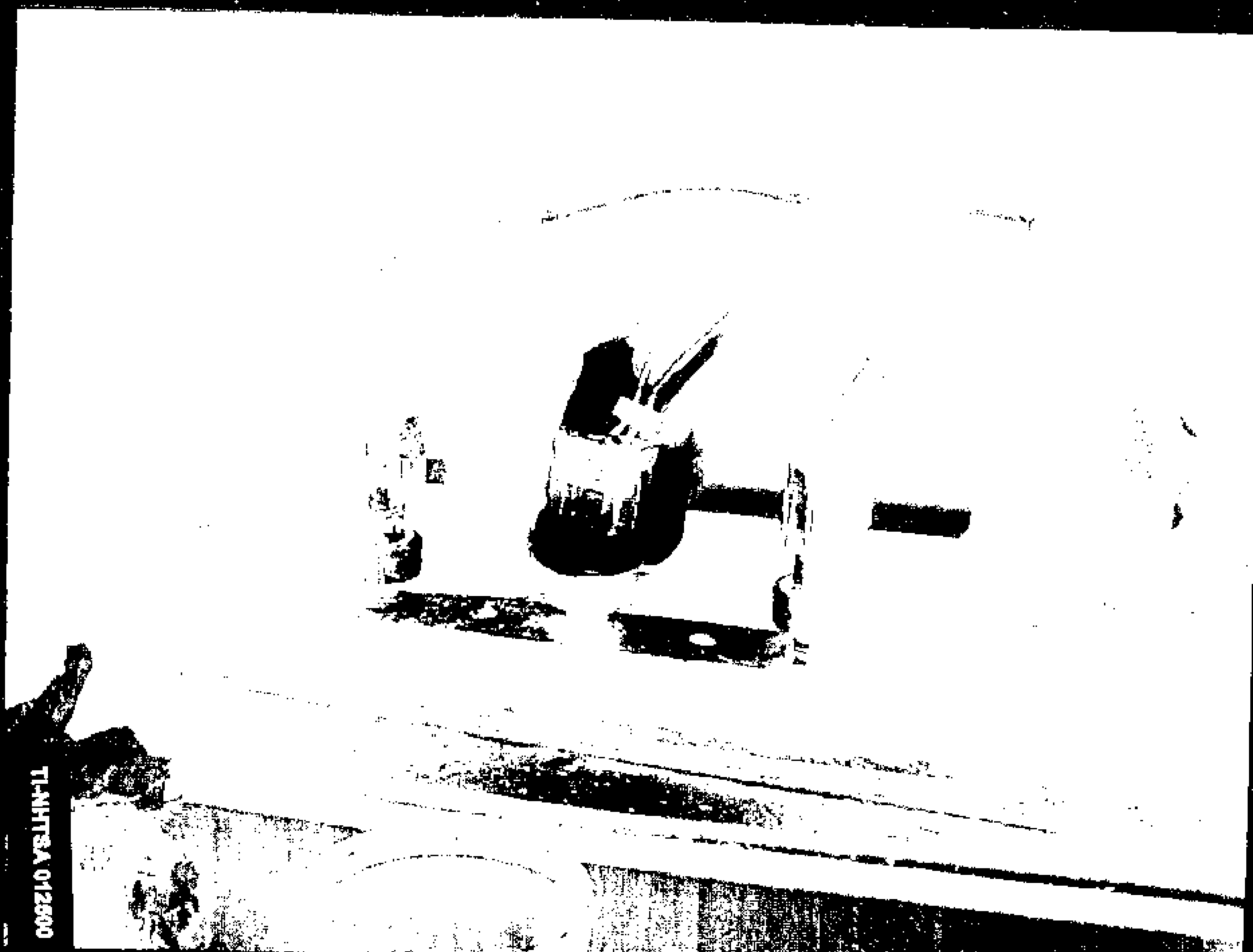


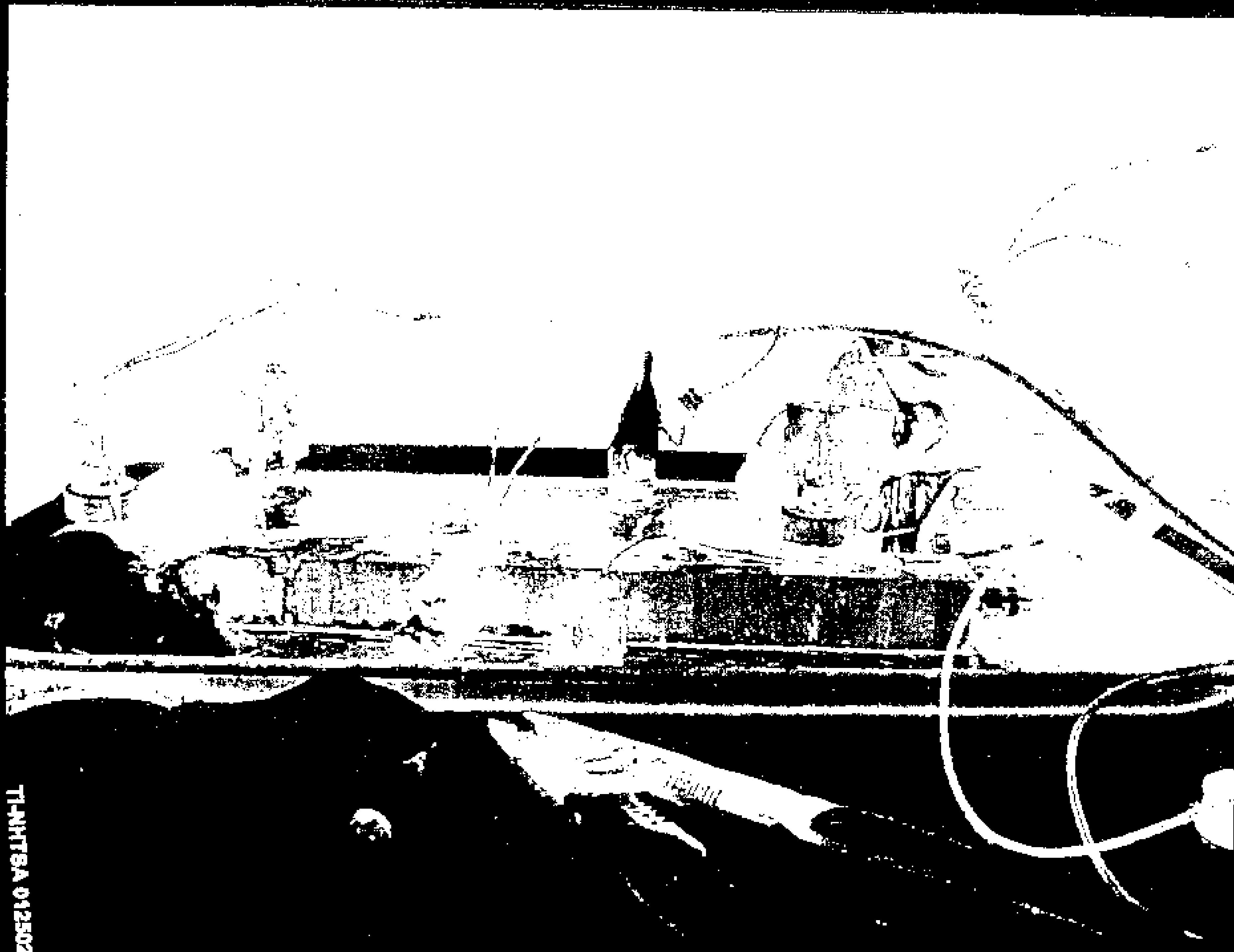
TI-NHTSA 012496

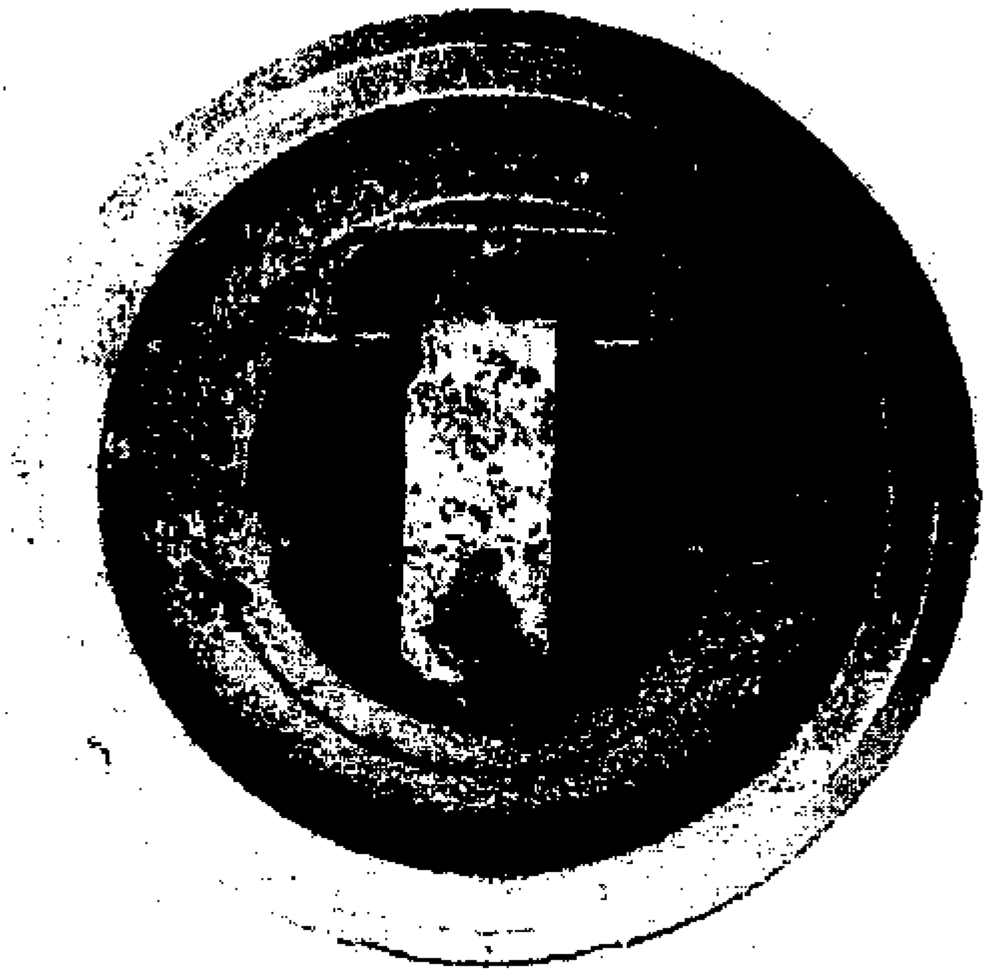










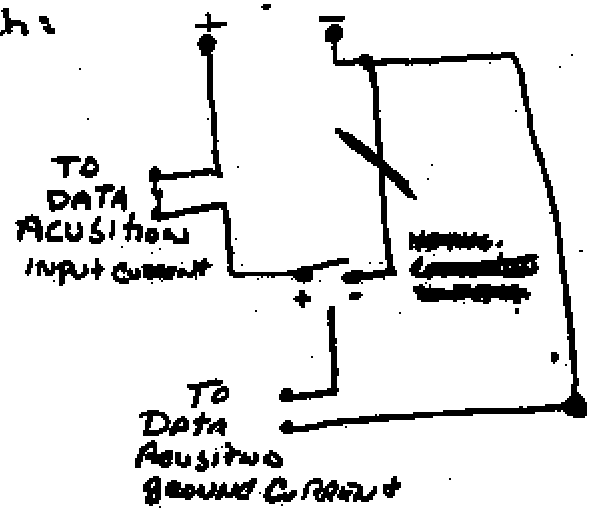


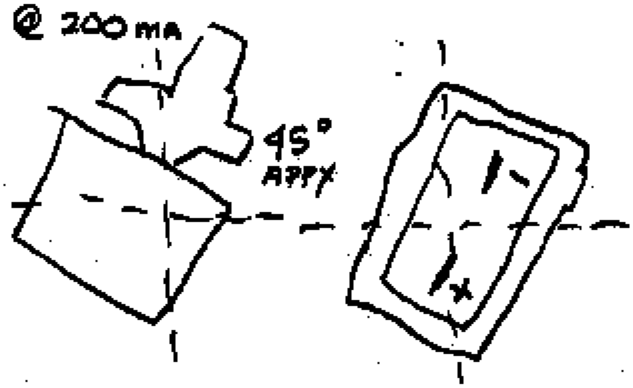
3-7-99

Current Limited Burn testing

Current Limiting Power Supply @ 200 mA

Sch:





DEVICE will Be connected to positive Terminal only with current in and current ground DATA logged. A solution of 5% salt will Be injected into Device at 10 min intervals or as Needed

Segunda Feira Efetuar Lista 3/8

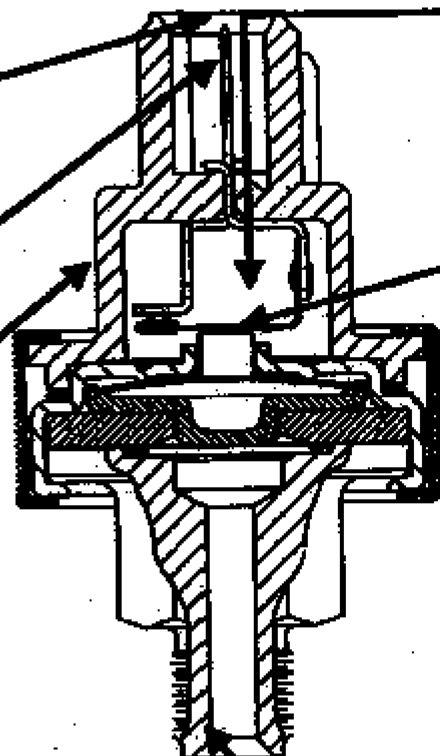
JOHN B.
- [illegible]
- Paints
-

- Write up Test Plan & Proposal [illegible]
  - Burn Test
  - Clutch Testing
- Weibull Plot
- Review Reports, others?
- Update Test Notes
- Call [illegible]
- Brake Fluid Parts on Corrosion
- Understand Early Failures
- Patents on [illegible]
  - [illegible] Shield
  - Others
- FU Report
- Jim A - T-Cycler Timing?
- FU Laptop ID # (Elaine 3189
- FU Bill [illegible]'s Car?
- People Plans for '00, MKT? SB?
- [illegible] switches?
- 77PS Failures - why?
- Vacuum Spread Sheet Backup?
- Brake Fluid From Climalite

T1-NHTSA 012805

TEXAS INSTRUMENTS

Brake Pressure Switch
Potential Thermal Event Theory Profile 3/8/99



Attachment 2

C:/McGuire/99presentation

TI-NHTSA 012606

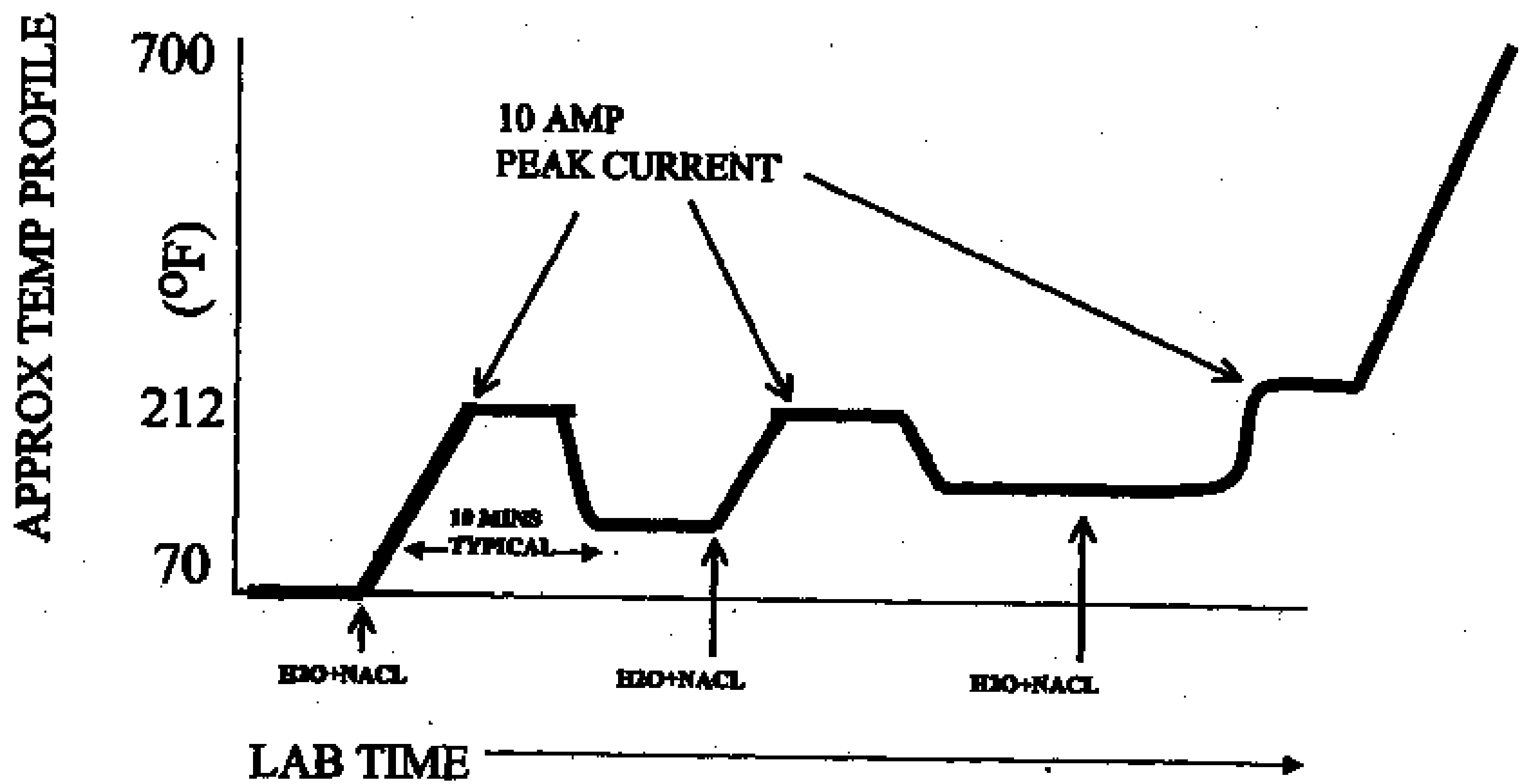
Texas Instruments

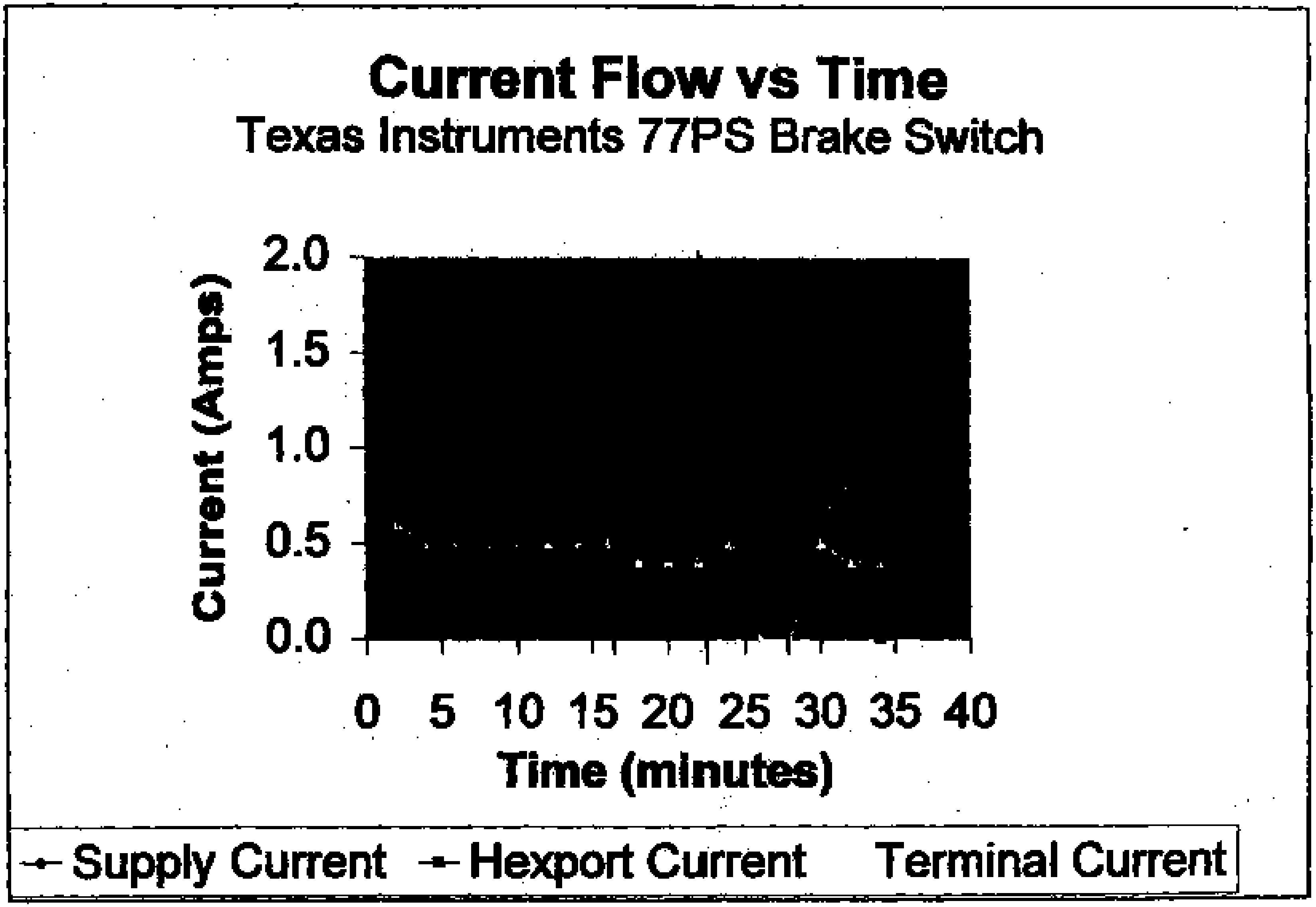
Brake Pressure Switch
Potential Thermal Event Theory Profile 3/8/99

1. Connector Seal to P/S
2. Power continuously available
3. Switch orientation
4. Current limit / fuse
5. Modify plastic parameters
6. Hexport isolation
7. Kapton seal of P/S
8. Environmental seal of P/S

TEXAS INSTRUMENTS

Brake Pressure Switch
Potential Thermal Event Theory Profile 3/8/99





TI-NHTSA 012509

Texas Instruments
Automotive Sensors & Controls

8D Report

Concern Title: 77 PS Thermal Events **T.I. CAR Report Number:** CAR 99-25	**Open Date:** 3/9/99 **Updated:**
Status Date: **Vehicle:** Lincoln **Model:** Town Car **Plant:** Various	**Part Name:** Electric Speed Control Deactivation Pressure Switch **Part No:** 77PS (2-)

1. Team: S. Beringhause B. Dague A. Rahman A. McGuirk C. Douglas G. Baker T. Rowland	**2. Problem Description:** Under hood car fires

3. Containment Action(s): Under review	**% Effectiveness:**	**Implementation Date:**

4. Root Cause: See attachment 1 (Theories of 3/9/99) - Water enters pressure /witch thru connector - Continuous power drives corrosion - Corrosion creates high resistance - Resistance creates local heating - Several exposures over time (?) - Local heading ignites pressure switch and connector plastic	**% Contribution:** Unknown

5. Chosen Permanent Corrective Action: See attachment 2,3,4 Under Review: - Improve connector seal - Eliminate constant power - Change P/S orientation - Provide power fuse - Modify plastic parameters	**Verification:** TBD by lab experiments	**% Effectiveness:** Unknown

6. Implemented Permanent Corrective Actions:	**Implementation:**
7. Action(s) to Prevent Recurrence	**Implementation:**

8. Congratulate Team	**Close Date:**	**Reported By:** A. McGuirk **Dept. Name:** QRA Manager **Telephone No.:** (508) 236-3800

Texas Instruments
Automotive Sensors & Controls

8D Report

Concern Title: 77 PS Thermal Events	Open Date: 3/9/99
T.I. CAR Report Number: CAR 99-25	Updated: 3/15/99 [illegible]
Status Dates — Vehicle: Lincoln; Model: Town Car; Plant: Various	Part Name: Electric Speed Control Deactivation Pressure S; Part No: 77PS 12-1

1. Team: S. Buckingham
B. Dague — A. Robinson
A. McGuirk — C. Douglas
G. Baker — T. Rowland

2. Problem Description:
Under hood car fires

3. Containment Action(s): considering disabling speed control system
Under review, ~~continuous power disconnect~~

% Effectiveness:

Implementation Date:

4. Root Cause: See attachment 1, IS - IS NOT Table, P

(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 notification ~~contamination~~ protocols

% Contribution: Unknown

5. Chosen Permanent Corrective Action: See attachment 2,3,4

Under Review:
- Contain fire
- Create ground fault protector
- Improve connector seal
- Eliminate constant power
- Change P/S orientation
- Provide power fuse / power reduction
- Modify plastic parameters

- optimize polarity
- move to leaving position

Verification: TBD by lab experiments

% Effectiveness: Unknown

6. Implemented Permanent Corrective Actions:

Implementation:

7. Action(s) to Prevent Recurrence
Eliminate constant power, reduce power to function only set value after "initial" electrical function

Implementation:

8. Congratulate Team

Close Date:

Reported By: A. McGuirk
Dept. Name: QRA Manager
Telephone No.: (508) 236-3800

TI-NHTSA 012511

Ccompsink/tmpbrdest 8d.doc

Epstein, Sally

From:	McGuirk, Andy [a-mcguirk@email.mc.ti.com]
Sent:	Tuesday, March 09, 1999 7:45 AM
To:	Beringhause, Steven; Dague, Bryan
Subject:	FW: Ticona's Celanex 4300 Brown - Flame Retardancy
Importance:	High

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

From: Roy, Norman
Sent: Tuesday, March 09, 1999 8:32 AM
To: McGuirk, Andy
Subject: FW: Ticona's Celanex 4300 Brown - Flame Retardancy
Importance: High

Andy,

Info from Ticona

From: Dunn, Kevin
Sent: Monday, March 08, 1999 1:32 PM
To: Roy, Norman
Subject: FW: Ticona's Celanex 4300 Brown - Flame Retardancy
Importance: High

FYI
Kevin

From: rfyurachek@ticona.com[SMTP:rfyurachek@ticona.com]
Sent: Monday, March 08, 1999 1:13 PM
To: kdunn@email.mc.ti.com
Subject: RE: Ticona's Celanex 4300 Brown - Flame Retardancy
Importance: High

Kevin:

Our polyester product specialist, Ken Pricse, has provided the following answers to your questions. Please let me know if you need any additional information.

Celanex 4300 is rated HB down to a thickness of 0.71 mm in the UL-94 flammability testing, indicating slow burning performance. I believe standard 30% glass-filled PPO is also rated HB in the UL-94 test, but the customer can confirm this with the supplier.

The thickness and the orientation of the specimen do matter. Thinner sections tend to burn quicker, and therefore it is tougher to get thinner sections to pass this testing. The vertical burn testing is done to determine if a material is self-extinguishing.

If the plastic is exposed to something flammable such as gasoline, of course it will be more susceptible to burning.

Celanex 3316 has improved flame retardancy over Celanex 4300. Celanex 3316 is rated V-0 down to 0.38 mm in the UL-94 test, which means it is self-extinguishing.

Regards,

Bob Yurachek

-----Original Message-----
From: Dunn, Kevin [mailto:kdunn@email.mc.ti.com]
Sent: Friday, March 05, 1999 1:49 PM
To: rfyurachek@ticona.com
Subject: FW: Ticona's Celanex 4300 Brown - Flame Retardancy

Rob, Please provide answers to Norm's questions.

Thanks,
Kevin

From: Roy, Norman
Sent: Wednesday, March 03, 1999 8:45 AM
To: Dunn, Kevin
Subject: FW: Ticona's Celanex 4300 Brown - Flame Retardancy

Kevin, Resending

From: Roy, Norman
Sent: Monday, March 01, 1999 3:39 PM
To: Dunn, Kevin
Subject: Ticona's Celanex 4300 Brown - Flame Retardancy

Kevin,

Need the following information regarding the subject material:

1. What is the flammability rating? How does it compare to PPO, Natural, 30% glass filled.

2. What does it mean? How does it compare to the PPO rating above from a relative performance standpoint?

3. Can the material sustain it's own combustion, i.e., will it continue to burn when the ignition source has been removed. Does the orientation of the part matter in relation to the ignition source, vertical, horizontal and does the thickness matter?

4. At what temperature would the material begin to smoke and at what temperature would it begin to burn with an ignition source present for a standard UL thickness? Would exposure to oil, gasoline or other petroleum products enhance it's ability to sustain a flame when exposed briefly to an ignition source?

5. Can the flame resistance of this material be improved? If it can what is needed(more flame retardant, different flame retardant, color, filler, thickness, etc) and what is the relative improvement from the base line? Is

it quantifiable?

Urgent need for answers to these questions.

Regards,

Norm

Brake Pressure Switch Test Log, Updated 3/10/99

Category	Test	Location	Test Parameters	Results Update
Lab Simulation	1	TI	Various Levels of Brake Fluid, Water Switch	200+ 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: 0%, 4%, 6%, 10%, 75%	No Significant Temperature Rise. Test Suspended.
				Internal Analysis in Progress.
	2	TI	Various Levels of Brake Fluid, Water,	200+ hours. Constant temperature.
			1 Amp through switch terminals	No significant temperature rise with time
				Test Suspended.
	3	A/T	Brake Fluid in Switch, 24 VDC to one terminal	> 300 hours into test, max current 7mA
			Hexport Grounded	No significant change with time. Test ongoing
	4	A/T	Brake Fluid in Switch, 24 VDC to one terminal	10 hours into test max current 8mA
			Hexport Grounded, Ambient at 100 C	No significant temperature rise with time. Test suspended.
	5	A/T	Brake Fluid in Switch, 10 Amps	Temperature rise of 20 C above room temp
			Through switch terminals	Delta T reached steady state at 20 C. Test suspended.
	5a	A/T	Brake Fluid in Switch approx. 30 Amps through	Temperature rose to approx. 270 F. No smoke. No ignition
			Switch Terminals	Test suspended.
	6	TI	Build heater element into Switch.	2 tested. Smoke observed, ignition observed on part w/heater
			Heat till failure, include sparking.	See attachment
			With Fluid & Dry	Test complete
			Pure brake fluid with metal shavings	Brake fluid in cavity slows down heat build-up
			5% brake fluid solution	Smoke observed at [illegible] F. Base melts and falls off at [illegible] 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, current path	Current path is through hexport.
				See photo and video.
				Additional test include tap water, old BF, new BF and other.

Brake Pressure Switch Test Log, Updated 3/10/99

[illegible]				
Life Cycle Reliability	7	TI	0-1400 psig pressure pulses at 130C	First leak observed at 720,000 cycles.
of Pressure Switch			per ES	Test Completed. See attached Weibull Chart.
[illegible]				
Diaphragm Wear	8	TI	0-1400 psig pressure pulses at 15C ambient	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, being processed
[illegible]				
Design Of Experiments	10	TI	Various Levels of Brake Fluid, Water,	Test in progress
Evaluating Factors			DOE	
Effecting Diaphragm Wear				
			12 snap switches and 0 % water in brake fluid	Suspended at 1.3 million cycles with no leaks observed
			12 snap switches 5% water in brake fluid.	Suspended at 1.3 million cycles with 2 leaks observed at 1.3M
			12 quiet switches and 0% water in brake fluid.	Suspended at 1.3 million cycles with no leaks observed
			12 quiet switches 5% water in brake fluid.	Suspended at 500K cycles to assess [illegible]
			Test Report being written. Investigation continues.	
			DOE is being repeated.	
[illegible]				
On-Vehicle Characterization	11	AVT	Monitor Pressure and Temperature	Test in progress at AVT
of Pressure & Temperature			at Switch Location for ABS and non-ABS	
Profile in Town Car			braking events.	
[illegible]				
Spark Arc Study	12	Central Labs	Determine if [illegible] forms in switch	Equipment set-up in progress at Central Labs.
			using clutch loads and high speed video.	
			Use dry switches as well as switches with	
			various brake fluid water values.	
[illegible]				
Characterization of	13	Central Labs	Characterize chemical, mechanical	Data log and analysis procedure set up complete.
switches retrieved from field			and electrical aspects of returned switches.	Analysis of switches in progress.
junkyards & other sources				
[illegible]				
Compatibility of Kapton	14	Dupont	Characterize change in properties of Kapton	Progress update expected from Dupont by 3/26.
with Oxalic Acid			with various % oxalic acid in brake fluid.	
[illegible]				
Evaluation of Plastic	15	TI	Assess properties and moldability of different	Sample material: Celanex 3316 under evaluation
Materials with Improved			grades of plastic resin with additives	Samples Obtained see video.
Parameters			to improve performance	

Brake Pressure Switch Test Log, Updated 3/10/99

Category	Test	Location	Test Parameters	Results Update
Lab Simulation	1	TI	Various Levels of Brake Fluid, Water Switch	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: 0%, 4%, 8%, 10%, 75%	No Significant Temperature Rise. Test Suspended.
				Internal Analysis in Progress.
	2	TI	Various Levels of Brake Fluid, Water,	250+ hours. Constant temperature.
			1 Amp through switch terminals	No significant temperature rise with time
				Test Suspended.
	3	AVT	Brake Fluid in Switch, 24 VDC to one terminal	> 300 hours into test, max current 7mA
			Hexport Grounded	No significant change with time. Test ongoing
	4	AVT	Brake Fluid in Switch, 24 VDC to one terminal	16 hours into test, max current 6mA
			Hexport Grounded, Ambient at 100 C	No significant temperature rise with time. Test suspended.
	5	AVT	Brake Fluid in Switch, 10 Amps	Temperature rise of 20 C above room temp
			Through switch terminals	Delta T reached steady state at 20 C. Test suspended.
	5a	AVT	Brake Fluid in Switch approx. 50 Amps through	Temperature rose to approx. 270 F. No smoke. No ignition
			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
			Pure brake fluid with metal shavings	Brake fluid in cavity slows down heat build-up
			5% brake fluid solution	Smoke observed at 575 F, Base melts and falls off at 500 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	50% ignition rate with repeated fills of 5% salt water
			repeatability, current path	Test ongoing to understand actual current path via current
				meters on various paths. See Attachment

TI-NHTSA 012517

Brake Pressure Switch Test Log, Updated 3/10/99

Life Cycle Reliability	7	TI	0-1400 psig pressure pulses at 135C	
of Pressure Switch			per ES	First leak observed at 720,000 cycles.
				Test Completed. See attached Weibull Chart.
Diaphragm Wear	8	TI	0-1400 psig pressure pulses at 135C [illegible]	Parts [illegible] every 200k cycles, characterized for wear
Field vs Lab Correlation	9	Central Labs	Field returns, [illegible] lots, [illegible]	Parts in Central Labs being processed
Design Of Experiments	10	TI	Various Levels of Brake Fluid, Water,	Test in progress
Evaluating Factors			DOE	
Effecting Diaphragm Wear				
			12 snap switches and 0 % water in brake fluid	Suspended at 1.3 million cycles with no leaks observed
			12 snap switches 5% water in brake fluid.	Suspended at 1.3 million cycles with 2 leaks observed at 1.2M.
			12 quiet switches and 0% water in brake fluid.	Suspended at 1.3 million cycles with no leaks observed
			12 quiet switches 5% water in brake fluid.	Suspended at 500k cycles to assess [illegible]
			With Clutch Loads and Without Clutch Loads	no difference with/without clutch load
On-Vehicle Characterization	11	AVT	Monitor Pressure and Temperature	Test in progress at AVT
of Pressure & Temperature			at Switch Location for ABS and non-ABS	
Profile in Test Car			braking events.	
Spark Arc Study	12	Central Labs	Determine if arc/spark forms in switch	Equipment set-up in progress at Central Labs.
			using clutch loads and high speed video.	
			Use dry switches as well as switches with	
			various brake fluid water ratios.	
Characterization of	13	Central Labs	Characterize [illegible], [illegible]	
switches obtained from field			and chemical aspects of returned switches	[illegible] and analysis procedure set up complete.
[illegible] & other sources				Analysis of switches in progress.
Compatibility of Kapton	14	Dupont	[illegible] change in properties of Kapton	Progress update expected from Dupont by 3/20.
with Oxalic Acid			with various % oxalic acid in brake fluid.	
Evaluation of Plastic	15	TI	Assess properties and suitability of different	Sample material Celanex 3316 under evaluation

TI-NHTSA 012518

Materials with Improved			grades of plastic resin with additives	
Parameters			to improve performance	

Morris, Irene

From: Dague, Bryan
Sent: Wednesday, March 10, 1999 7:06 AM
To: McGuirk, Andrew; Beringhause, Steven; Baumann, Russell
Subject: FW: DOEreport

In case you guys wanted to read this over before our meeting this morning.

Bry

From: Mulligan, Sean
Sent: Tuesday, March 09, 1999 9:56 PM
To: Dague, Bryan
Subject: DOEreport

DOE_tests.doc

Bryan, here is the report. I have been having trouble with the Weibull sheets so you may not be able to change them.

Sean

TI-NHTSA 012520

77PS Life Cycle DOE Test to Leakage

Abstract

The purpose of this life cycle test was to quantify the life expectancy of 77PSL2-1 (snap disc) and 77PSL4-1 (quiet disc) hydraulic pressure switches. (12) 77PSL2-1 and (12) 77PSL4-1 switches were pressure cycled to leakage with pure brake fluid. (12) 77PSL2-1 and (12) 77PSL4-1 switches were pressure cycled to leakage with brake fluid combined with 5% water. Upon leakage, the suspect switches were removed and the number of cycles recorded. Weibull Analyses were then performed on the data.
Due to results obtained in this test, an investigation was conducted to determine why (1) group of switches failed before the (3) other groups. The results of the investigation are also presented in this report.

Procedure

(48) 77PS switches were used as a test sample. There were (4) groups of switches as outlined at the bottom of Table 1, below. (2) switches from each group were loaded through clutch assemblies provided by Ford. All switches were placed in an oven where a temperature of 135°C was maintained. The switches were cycled from 2 psi to 1450 psi at a frequency of 2 Hz. When a leaky switch was detected, the test was suspended and the switches were allowed to cool to ambient temperature. Leaky switches were removed and the number of cycles noted. The remaining switches were brought back up to 135°C and testing resumed.

Table 1
Cycles to leakage

Sample #	Group 1 (K cycles)	Group 2 (K cycles)	Group 3 (K cycles)	Group 4 (K cycles)
1	S	1175	1197	289
2	S	1181	1197	322
3	S	1192	1197	336
4	S	1192	S	335
5	S	1197	S	348
6	S	1235	S	378
7	S	S	S	380*
8	S	S	S	380*
9	S	S	S	380
10	S	S	S	387
11	S	S	S	387[$]
12	S	S	S	387[$]
Group 1: 77PSL2-1 (snap disc) w/ 0% water in brake fluid.				
Group 2: 77PSL4-1 (no snap disc) w/ 0% water in brake fluid.				
Group 3: 77PSL2-1 (snap disc) w/ 5% water in brake fluid.				
Group 4: 77PSL4-1 (no snap disc) w/ 5% water in brake fluid.				

Notes: "S" denotes sample did not leak.

*indicates switch was loaded through Ford clutch assembly.

Data

Summary:	Temperature:	135°C
	Pressure (low):	2 psi
	Pressure (high):	1450 psi
	Frequency:	2 Hz

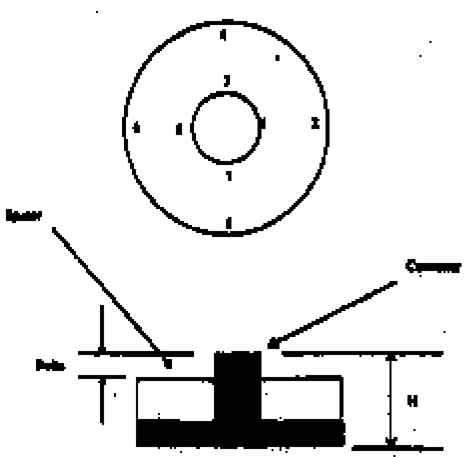
Table 1, above shows the number of cycles to failure for each group. The table is incomplete as tests are ongoing.

Results

Weibull analysis: Weibull analyses were performed on the data obtained from Groups 2 and 4. The results are shown on Figures 1 and 2, respectively.
For each set of data entered into a Weibull Analysis, the set of parameters α, β and R^2 are determined. Values for the data used in this test may be seen in Figure 2.
α is the Characteristic Life which determines the spread of the distribution. The higher the number, the greater the spread.
β is the Shape Factor which determines the shape of the distribution curve.
R^2 is the Coefficient of Determination.

Leak analysis: As seen in Table 1, (10) leaks occurred in Group 4 well before any leaks occurred in the (3) other groups. An investigation was conducted to explain this unexpected result. It is suspected that premature leaks in Group 4 may be attributed to excessive stresses on the diaphragms of Group 4. Excess stress may be caused by height differences between the converter and spacer (see Figure 3, below). Measurements were made to compare the converter to spacer height differential of 77PSL2-1 switches to those of 77PSL4-1 switches.

Figure 3.



Co

Th ... :
(3)
(3)
(4) ... s report.

Th ... is placed on its
res ... is applied to the
spe ... as used to measure
the ... ure 3 above). (8)
me ... : the locations
sh ... ter/converter
co ... eparated and

randomly put back together between measurements. Raw data and further discussion are presented in Appendix A. The results are presented in Table 2, below.

Table 2.

	Delta	Standard Deviation
77PSL4-1 LEAKY SWITCHES		
322	0.0019	0.0006
336	0.0019	0.0006
348	0.0012	0.0004
380-3	0.0023	0.0004
77PSL4-1 FROM PRODUCTION LINE		
Sample 1	0.0018	0.0006
Sample 2	0.0014	0.0006
Sample 3	0.0020	0.0004
77PSL2-1 FROM THE LINE		
Sample 1	0.0031	0.0007
Sample 2	0.0033	0.0006
Sample 3	0.0026	0.0006

Delta is the distance the converter protrudes above the spacer (see Figure 3, above).
(Delta = Converter height – the average of all spacer heights measured for that sample).
Standard Deviation is the standard deviation of all spacer heights measured for that sample.

Conclusion

All 77PSL2-1 switches tested, (24), completed over 1,000,000 cycles without a leak when cycled with either pure brake fluid or with a brake fluid/ 5% water mix.

All 77PSL4-1 switches tested with pure brake fluid, completed over 1,000,000 cycles without a leak.

(10) 77PSL4-1 switches leaked before 400,000 cycles when tested with a brake fluid/ 5% water mix. It is suspected that these switches may have a less than optimum converter to spacer height that puts an excessive strain on the diaphragm. Measurements have been made that tend to support this theory. Analysis of these switches and 77PSL2-1 switches (see Table 2 above) has shown that the converter on 77PSL2-1 switches protrudes above the spacer roughly 1/1000 to1.5/1000 of an inch more then on 77PSL4-1 switches. This difference may be enough to cause premature leaks. There seems to be no significant difference between 77PSL4-1 switches that have been life tested and those that are pulled from the production line.
There is a rather high standard deviation for measurements made on the converters and spacers. This may be attributed to variations in spacer and converter thickness[1] as well as measurement error. However, there is enough evidence to warrant further investigation.

Report Authored by Sean Mulligan

Figure 1.

2 and 3 parameter WEIBULL FAILURE ANALYSIS

CLICK here to recalculate if failure data or "Minimum life" input value is altered

○ Exponential
○ Lognormal
◉ Weibull

Time to failure	Suspended
289000	
312000	
335000	
335000	
345000	
379000	
385000	
385000	
390000	
387000	
387000	1
387000	1

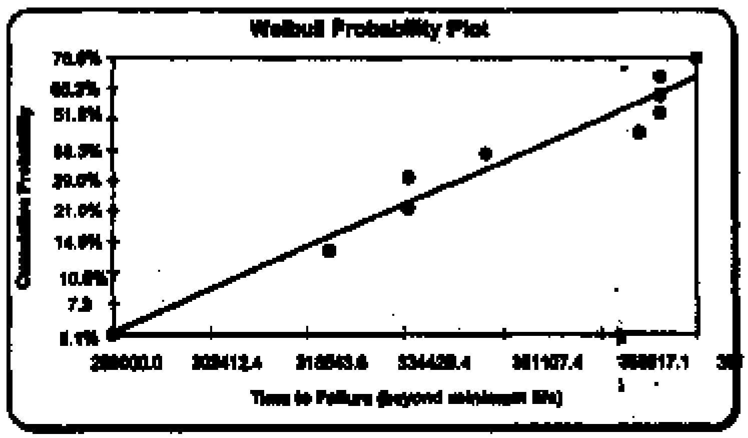
Minimum life
0

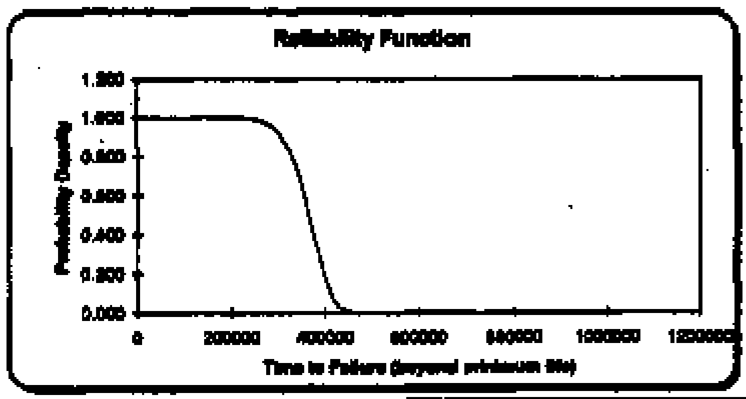
Time (cycle)	Reliability %
1000000	0%

Reliability %	Time (cycle)
99 %	287742.0015

Calculated Outputs

α = 360036.913
β = 10.676
R^2 = 0.965





NOTES: Group 4: 77PSL4-1 w/ 5% water in brake fluid

TI-NHTSA 012524

Appendix A

Leak analysis: The following is an explanation of measurements made on converter and spacers heights of 77PS switches. (Refer to (4) spreadsheet pages included).

Explanation of Data pages. The first (2) pages of the spreadsheet that follows are the data pages.

Column 1: "switch #" is the name of the switch that was analyzed. (a number refers to number of cycles in thousands i.e. 322 = switch that leaked at 322,00 cycles)

Column 2: "H" is the converter height measurement.

Columns 3 – 10: are the locations where measurements were made on the spacer.

As you read down each column, the (3) sets of measurements made on each device is presented followed by an average for the three measurements and the standard deviation ("stdev.").

Explanation of Analysis pages. The last (2) pages of the spreadsheet that follows are the analysis pages.

Column 1: "AVE IN" is the average of the (4) inner measurements made on the spacer (locations 1, 3, 5, and 7).

Column 2: "stdev" is the standard deviation for the (4) inner measurements.

Column 3: "AVE OUT" is the average of the (4) outer measurements made on the spacer (locations 2, 4, 6, and 8).

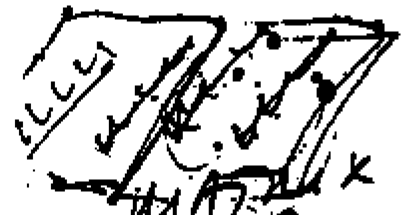
Column 4: "stdev" is the standard deviation for the (4) outer measurements .

Column 5: "AVE TOT." is the average of all (8) measurements made on the spacer.

Column 6: "stdev" is the standard deviation for the (8) measurements made on the spacer.

Column 7: "Delta" is the converter height, H, minus the average height of all measurements made on the spacer, shown in bold in the "AVE TOT" column.

Column 8: "stdev." is the standard deviation of the "Delta" column



✓ TEST ^PROFILES UPDATE - AZIZ

✓ RESOLVE DOE PLANS - STEVE

- DISPOSITION - Q-H_2O
  - NEW ONES
  - H_2O

- PLASTIC PRODUCTS UPDATE - DAVE BRYAN
  - ✓ HIGHER TEMP - RAN
  - = FORD SPECS

- SALT VS OTHER IONS - STEVE/AZ
  - SALT - WHAT IS OXYLIC ? ACID

- BRAKE FLUID INHIBITORS - ?
  - GIVE US OLD FLUID - 92 ERA [illegible]

- PRESENTATION WEDS - [illegible]
  - COIL ISSUE (IV)
  - LAYMENS EXPLAIN

- TEST / IGNITION PRODUCTS - STEVE
  - VIDEO TAPE ✓
  - FLEW THINGS ✓

~~- 93 P/S -~~

- SAYS FAILED... WHY PROCESSING ?
- ALT [illegible] - [illegible] →
- SWITCH - GOLD PLATE

ACTIONS _SW _?
- GO TO SANCING - TASEA
- REVIEW KAHUN WITH C.L.

- GET CONNECTIONS ON ALL P/S TESTS!

- RESOLVE KAPTON ISSUES

- EXTRAS 8D - WHAT IS 14D?
- LIST OF ISSUES
- C/B
- PHEONICS

TI-NHTSA 012529

3/10

"ANDY'S INTERACTIONS OF QUALITY CONTROL TEAM DIRECTION"

- RE-BUILD HISTORY OF ISSUES WITH QUAN BOLTS
- DEVELOP IS / IS NOT ..... VEHICLE OPTIONS - GM/CV
  - TAXI
  ..... NHTSA FILES
- INTERVIEWS PROMPTED
- DISPOSITION PROMPTED

3/10/99

FORD CORE MEETING

- AT 3/8/99 EXECUTIVE REVIEW, MNGT "SUGGESTED" QUALITY CONTROL "HELP"
  + FRED PORTER & CORE TEAM ARE CONSIDERING USE OF "HELP"
  + QUALITY CONTROL HELD SOMEWHERE INVENTION MEETING.... MANY IDEAS

- AT 3/10 CORE MEETING, CORE TEAM HEARD FROM QUALITY CONTROL
  + 13/15 NOT
  + PARTIES
  + GO GETS

- PROBABLE 3 TEAMS.... ANDY'S "PROTECTION"
  - QUALITY CONTROL - WARRANTY - SVC < PEAT
  - CORE TEAM - FRED ET AL
  - FIELD TEAM....

TI-NHTSA 012531

→ Ford – [illegible] stakes – (Ariz)

→ 14 D ... (Andy)

→ ED ..... Switch ... (Andy)

→ Attachments ... Write out ← (BW)

⇒ Success testing results
Spec testing
Life

⇒ Water BF –

→ Check the lot numbers/parts for test (TW)

⇒ Armada Spec...

⇒ BF does not ~~[illegible]~~ cause fires .... [illegible]

Delivered to Andy M. 3/10/99 by Fred

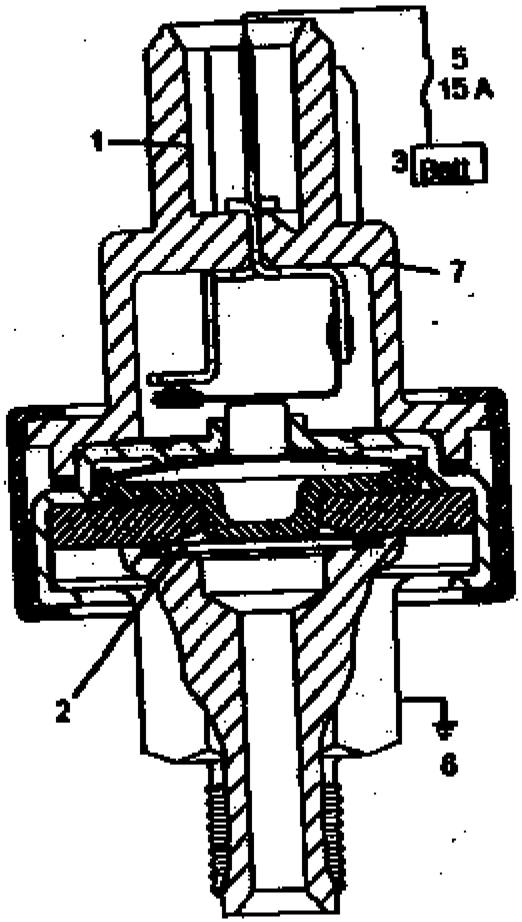
Potential Actions

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

■ = fixed
□ = improved

Delivered to Andy M. 3/11/99 by Fred.

Contributing Factors



1. Connector Seal
2. Kapton Life
3. Continuous Power
4. Switch Orientation
5. Current Capability
6. Grounded Hex-Port
7. Plastic Parameters

TI-NHTSA 012834

77PS Life Cycle DOE Test to Leakage

Abstract

The purpose of this life cycle test was to quantify the life expectancy of 77PSL2-1 (snap disc) and 77PSL4-1 (quiet disc) hydraulic pressure switches. (12) 77PSL2-1 and (12) 77PSL4-1 switches were pressure cycled to leakage with pure brake fluid. (12) 77PSL2-1 and (12) 77PSL4-1 switches were pressure cycled to leakage with brake fluid combined with 5% water. Upon leakage, the suspect switches were removed and the number of cycles recorded. Weibull Analyses were then performed on the data.
Due to results obtained in this test, an investigation was conducted to determine why (1) group of switches failed before the (3) other groups. The results of the investigation are also presented in this report.

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(48) 77PS switches were used as a test sample. There were (4) groups of switches as outlined at the bottom of Table 1, below. (2) switches from each group were loaded through clutch assemblies provided by Ford. All switches were placed in an oven where a temperature of 135°C was maintained. The switches were cycled from 2 psi to 1450 psi at a frequency of 2 Hz. When a leaky switch was detected, the test was suspended and the switches were allowed to cool to ambient temperature. Leaky switches were removed and the number of cycles noted. The remaining switches were brought back up to 135°C and testing resumed.

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4	S	1192	S	338
5	S	1197	S	348
6	S	1235	S	378
7	S	S	S	387*
8	S	S	S	387*
9	S	S	S	380
10	S	S	S	387
11	S	S	S	387*
12	S	S	S	387*

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

Note: "S" denotes sample did not leak.
*Indicates switch was loaded through Ford clutch assembly.

Data

Summary:	Temperature:	135°C
	Pressure (low):	2 psi
	Pressure (high):	1450 psi
	Frequency:	2 Hz

Table 1, above shows the number of cycles to failure for each group. The table is incomplete as tests are ongoing.

Results

Weibull analysis: Weibull analyses were performed on the data obtained from Groups 2 and 4. The results are shown on Figures 1 and 2, respectively.
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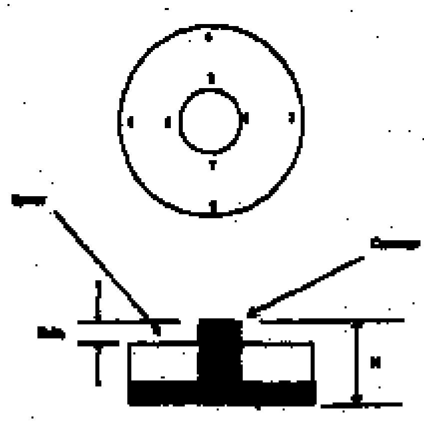
Figure 3.



Converter to spacer height measurement Procedure:

The following samples were de-crimped and collected for measurement:
(3) 77PSL2-1 switches from the production line
(3) 77PSL4-1 switches from the production line
(4) 77PSL4-1 switches that leaked from Group 4 of the cycle test in this report.

The converter and spacer of each sample was removed. Each spacer was placed on its respective converter and placed on a level surface. A small pressure was applied to the spacer to keep it in good contact with the converter. A dial indicator was used to measure the height of the converter relative to the level surface. (See "H" in Figure 3 above). (8) measurements were made of the height of the spacer on the converter at the locations shown in Figure 3. Because test repeatability was a concern, each spacer/converter combination was measured (3) times. The spacer and converter were separated and randomly put back together between measurements. Raw data and further discussion are presented in Appendix A. The results are presented in Table 2, below.

Table 2,

	Delta	Standard Deviation
77PSL4-1 LEAKY SWITCHES		
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
77PSL4-1 FROM PRODUCTION LINE		
Sample 1	[illegible]	[illegible]
Sample 2	[illegible]	[illegible]
Sample 3	[illegible]	[illegible]
77PSL2-1 FROM THE LINE		
Sample 1	[illegible]	[illegible]
Sample 2	[illegible]	[illegible]
Sample 3	[illegible]	[illegible]

Delta is the distance the converter protrudes above the spacer (see Figure 3, above).
(Delta = Converter height – the average of all spacer heights measured for that sample).
Standard Deviation is the standard deviation of all spacer heights measured for that sample.

Conclusion

All 77PSL2-1 switches tested, (24), completed over 1,000,000 cycles without a leak when cycled with either pure brake fluid or with a brake fluid/ 5% water mix.

All 77PSL4-1 switches tested with pure brake fluid, completed over 1,000,000 cycles without a leak.

(10) 77PSL4-1 switches leaked before 400,000 cycles when tested with a brake fluid/ 5% water mix. It is suspected that these switches may have a less than optimum converter to

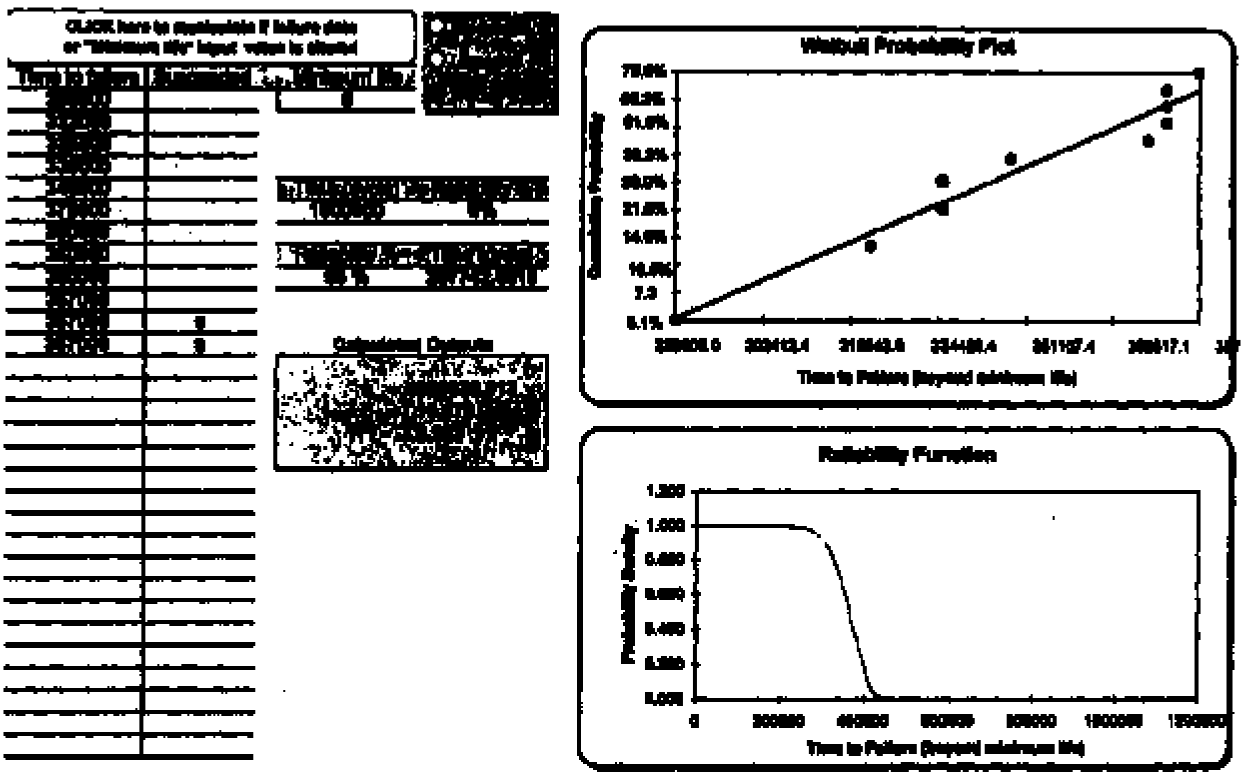
spacer height that puts an excessive strain on the diaphragm. Measurements have been made that tend to support this theory. Analysis of these switches and 77PSL2-1 switches (see Table 2 above) has shown that the converter on 77PSL2-1 switches protrudes above the spacer roughly 1/1000 to1.5/1000 of an inch more than on 77PSL4-1 switches. This difference may be enough to cause premature leaks. There seems to be no significant difference between 77PSL4-1 switches that have been life tested and those that are pulled from the production line.

There is a rather high standard deviation for measurements made on the converters and spacers. This may be attributed to variations in spacer and converter thickness' as well as measurement error. However, there is enough evidence to warrant further investigation.

Report Authored by Sean Mulligan

Figure 1.

2 and 3 parameter WEIBULL FAILURE ANALYSIS

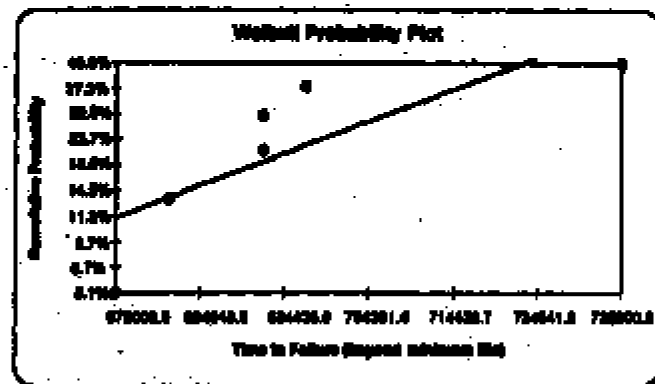


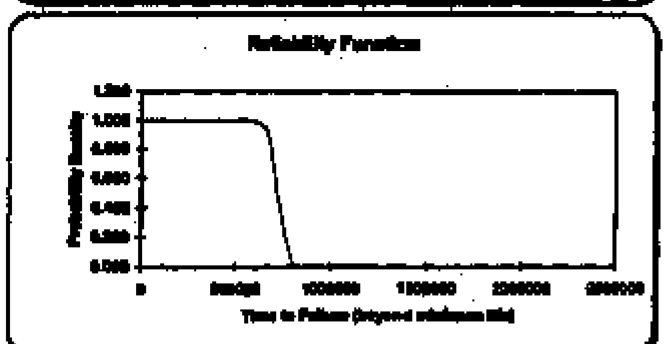
NOTES: Group 4: 77PSL4-1 w/ 5% water in brake fluid

Figure 2.

2 and 3 parameter WEIBULL FAILURE ANALYSIS

Calculated Outputs





NOTES: Group 2: 77PSL4-1 (no snap) w/ 0% water

Appendix A

Leak analysis: The following is an explanation of measurements made on converter and spacers heights of 77PS switches. (Refer to (4) spreadsheet pages included).

Explanation of Data pages. The first (2) pages of the spreadsheet that follows are the data pages.

Column 1: "switch #" is the name of the switch that was analyzed. (a number refers to number of cycles in thousands i.e. 322 = switch that leaked at 322,00 cycles)

Column 2: "H" is the converter height measurement.

Columns 3 – 10: are the locations where measurements were made on the spacer.

As you read down each column, the (3) sets of measurements made on each device is presented followed by an average for the three measurements and the standard deviation ("stdev.").

Explanation of Analysis pages. The last (2) pages of the spreadsheet that follows are the analysis pages.

Column 1: "AVE IN" is the average of the (4) inner measurements made on the spacer (locations 1, 3, 5, and 7).

Column 2: "stdev" is the standard deviation for the (4) inner measurements.

Column 3: "AVE OUT" is the average of the (4) outer measurements made on the spacer (locations 2, 4, 6, and 8).

Column 4: "stdev" is the standard deviation for the (4) outer measurements .

Column 5: "AVE TOT." is the average of all (8) measurements made on the spacer.

Column 6: "stdev" is the standard deviation for the (8) measurements made on the spacer.

Column 7: "Delta" is the converter height, H, minus the average height of all measurements made on the spacer, shown in bold in the "AVE TOT" column.

Column 8: "stdev." is the standard deviation of the "Delta" column

77PSL4-1 LEAKY SWITCHES

Measurement location

switch #	H	1	2	3	4	5	6	7	8
322	0.1846	0.1822	0.183	0.1827	0.1834	0.1824	0.1833	0.1821	0.183
	0.1846	0.1826	0.1836	0.1822	0.1828	0.1819	0.1824	0.1823	0.1828
	0.1846	0.1823	0.1832	0.1826	0.1832	0.1822	0.1821	0.183	0.1829
Average	0.1846	0.1824	0.1833	0.1825	0.1831	0.1822	0.1826	0.1825	0.1829
stdev.	0.0001	0.0002	0.0004	0.0003	0.0003	0.0003	0.0006	0.0005	0.0001
336	0.1846	0.1827	0.1822	0.1826	0.1819	0.1834	0.1836	0.1832	0.1833
	0.1847	0.1831	0.1829	0.1823	0.1816	0.1833	0.1831	0.1834	0.1836
	0.1846	0.1833	0.1831	0.1824	0.1816	0.1832	0.1831	0.1834	0.1836
Average	0.1846	0.1830	0.1827	0.1824	0.1816	0.1833	0.1833	0.1833	0.1835
stdev.	0.0001	0.0003	0.0006	0.0002	0.0002	0.0001	0.0004	0.0001	0.0002
346	0.1845	0.1831	0.1836	0.1831	0.1837	0.183	0.1838	0.183	0.1834
	0.1846	0.183	0.1836	0.1833	0.1839	0.1833	0.1841	0.1829	0.1833
	0.1845	0.1831	0.1837	0.1829	0.1834	0.183	0.1832	0.1832	0.1839
Average	0.1845	0.1831	0.1836	0.1831	0.1837	0.1831	0.1837	0.1830	0.1835
stdev.	0.0001	0.0001	0.0001	0.0003	0.0003	0.0002	0.0005	0.0002	0.0003
350-3	0.185	0.1828	0.1831	0.1826	0.1826	0.1824	0.1824	0.1828	0.1834
	0.185	0.1827	0.1836	0.1826	0.1829	0.1822	0.1823	0.1826	0.1832
	0.185	0.1827	0.1833	0.183	0.1836	0.1824	0.1824	0.1822	0.1826
Average	0.1850	0.1827	0.1834	0.1828	0.1831	0.1823	0.1824	0.1824	0.1829
stdev.	0.0000	0.0001	0.0002	0.0002	0.0005	0.0001	0.0001	0.0003	0.0004

77PSL4-1 FROM PRODUCTION LINE

Measurement location

	H	1	2	3	4	5	6	7	8
sample 1	0.1857	0.1838	0.1853	0.1838	0.1838	0.1836	0.1839	0.1841	0.1847
	0.1856	0.1841	0.1852	0.1837	0.1846	0.1836	0.1838	0.1838	0.184
	0.1856	0.1836	0.1847	0.1842	0.1849	0.1837	0.184	0.1836	0.1841
Average	0.1856	0.1838	0.1851	0.1839	0.1844	0.1836	0.1839	0.1838	0.1843
stdev.	0.0001	0.0003	0.0003	0.0004	0.0006	0.0001	0.0001	0.0003	0.0004
sample 2	0.1856	0.184	0.1842	0.1838	0.1842	0.1838	0.1842	0.1841	0.1845
	0.1854	0.1841	0.185	0.184	0.1846	0.1843	0.1846	0.1838	0.1844
	0.1854	0.1838	0.1849	0.1834	0.1839	0.1834	0.1838	0.1832	0.1838
Average	0.1854	0.1840	0.1847	0.1837	0.1843	0.1838	0.1843	0.1837	0.1842
stdev.	0.0001	0.0002	0.0004	0.0003	0.0003	0.0005	0.0005	0.0005	0.0005
sample 3	0.185	0.1829	0.1832	0.1829	0.1827	0.1831	0.1836	0.1836	0.1839
	0.185	0.1829	0.1834	0.1825	0.1824	0.1827	0.1832	0.183	0.1831
	0.185	0.1827	0.183	0.1826	0.1822	0.1828	0.1832	0.183	0.1832
Average	0.1850	0.1828	0.1832	0.1827	0.1824	0.1829	0.1834	0.1832	0.1834
stdev.	0.0000	0.0001	0.0002	0.0002	0.0003	0.0002	0.0004	0.0003	0.0004

77P8L2-1 FROM THE LINE

Measurement location

	H	1	2	3	4	5	6	7	8
sample 1	0.1855	0.1846	0.1847	0.1857	0.1859	0.186	0.1857	0.1846	0.185
	0.1854	0.1846	0.186	0.1842	0.1863	0.185	0.1864	0.1852	0.1852
	0.1853	0.1849	0.1869	0.1854	0.1862	0.1854	0.1859	0.1845	0.1851
Average	0.1854	0.1846	0.1859	0.1851	0.1860	0.1851	0.1858	0.1847	0.1854
stdev.	0.0001	0.0002	0.0011	0.0008	0.0007	0.0002	0.0002	0.0004	0.0007
sample 2	0.186	0.1853	0.1849	0.1854	0.1863	0.1852	0.1856	0.1852	0.1855
	0.186	0.1855	0.1847	0.1851	0.1864	0.1857	0.1856	0.1852	0.1852
	0.186	0.1853	0.1856	0.1856	0.1856	0.1853	0.1861	0.1859	0.1852
Average	0.1860	0.1854	0.1851	0.1854	0.1858	0.1855	0.1857	0.1851	0.1853
stdev.	0.0000	0.0002	0.0005	0.0004	0.0003	0.0003	0.0003	0.0002	0.0002
sample 3	0.186	0.1857	0.186	0.1852	0.1879	0.1859	0.1857	[illegible]	0.1857
	0.186	0.1862	0.1856	0.1852	0.1877	0.1858	0.1853	0.186	0.1864
	0.1859	0.1859	0.1864	0.1855	0.1867	0.1859	0.1854	0.1853	0.1872
Average	0.1860	0.1859	0.1863	0.1851	0.1874	0.1859	0.1855	0.1860	0.1859
stdev.	0.0001	0.0003	0.0005	0.0002	0.0006	0.0001	0.0002	0.0005	0.0004

77PSL4-1 LEAKY SWITCHES

AVE IN	stdev.	AVE OUT	stdev.	AVE TOT.	stdev	Delta	stdev.
0.1824	0.0003	0.1832	0.0002	0.1829	0.0005	0.0018	0.0006
0.1823	0.0003	0.1830	0.0002	0.1826	0.0006		
0.1825	0.0004	0.1829	0.0001	0.1827	0.0004		
0.1824	0.0003	0.1830	0.0005	0.1827			
				0.0005			
0.1830	0.0004	0.1829	0.0003	0.1829	0.0005	0.0019	[illegible]
0.1830	0.0005	0.1829	0.0005	0.1829	0.0007		
0.1831	0.0005	0.1828	0.0004	0.1830	0.0007		
0.1830	0.0004	0.1829	0.0006	0.1829			
				0.0006			
0.1831	0.0001	0.1836	0.0000	0.1833	0.0003	0.0012	0.0004
0.1831	0.0002	0.1837	0.0002	0.1834	0.0004		
0.1830	0.0002	0.1836	0.0003	0.1833	0.0004		
0.1831	0.0001	0.1836	0.0003	0.1834			
				0.0004			
0.1827	0.0002	0.1829	0.0002	0.1828	0.0003	0.0023	0.0004
0.1825	0.0002	0.1828	0.0002	0.1827	0.0004		
0.1829	0.0003	0.1830	0.0003	0.1828	0.0006		
0.1826	0.0002	0.1829	0.0005	0.1828			
				0.0004			

77PSL4-1 FROM PRODUCTION LINE

AVE IN	stdev.	AVE OUT	stdev.	AVE TOT.	stdev	Delta	stdev.
0.1836	0.0003	0.1844	0.0005	0.1841	0.0006	0.0018	0.0006
0.1837	0.0003	0.1844	0.0001	0.1841	0.0005		
0.1835	0.0003	0.1844	0.0002	0.1841	0.0006		
0.1836	0.0002	0.1844	0.0005	0.1841			
				0.0006			
0.1839	0.0002	0.1843	0.0002	0.1841	0.0003	0.0014	[illegible]
0.1841	0.0002	0.1846	0.0002	0.1844	0.0004		
0.1835	0.0003	0.1841	0.0001	0.1838	0.0005		
0.1838	0.0003	0.1844	0.0005	0.1841			
				0.0005			
0.1831	0.0003	0.1834	0.0003	0.1833	0.0005	0.0030	0.0004
0.1826	0.0002	0.1830	0.0002	0.1828	0.0003		
0.1828	0.0002	0.1829	0.0002	0.1828	0.0003		
0.1828	0.0003	0.1831	0.0005	0.1830			
				0.0004			

77PSL2-1 FROM THE LINE

AVE IN	stdev.	AVE OUT	stdev.	ave tot	stdev	Delta	stdev.
0.1550	0.0006	0.1556	0.0006	0.1553	0.0007	0.0031	0.0007
0.1546	0.0004	0.1557	0.0004	0.1552	0.0007		
0.1551	0.0004	0.1550	0.0004	0.1555	0.0006		
0.1549	0.0004	0.1557	0.0007	0.1553			
				0.0007			
0.1555	0.0005	0.1556	0.0004	0.1556	0.0005	[illegible]	[illegible]
0.1557	0.0005	0.1556	0.0004	0.1556	0.0005		
0.1557	0.0003	0.1552	0.0001	0.1556	0.0005		
0.1556	0.0004	0.1557	0.0006	0.1557			
				0.0005			
0.1559	0.0002	0.1556	0.0002	0.1564	0.0007	[illegible]	[illegible]
0.1561	0.0002	0.1567	0.0008	0.1564	0.0006		
0.1560	0.0002	0.1567	0.0002	0.1563	0.0006		
0.1560	0.0002	0.1557	0.0006	0.1564			
				0.0006			

PS/99/07

77PS Life Cycle Test to Leakage

Abstract

The purpose of this life cycle test was to quantify the life expectancy of 77PS hydraulic pressure switches. A sample of switches was cycled under specified conditions until leakage occurred. Upon leakage, the suspect switch was removed and the number of cycles recorded. Weibull Failure Analyses were then performed on the data.

Procedure

(36) 77PS switches were used as a test sample. The switches were placed in an oven where a temperature of 135°C was maintained. The switches were cycled from 8 psi to 1500 psi at a frequency of 2 Hz. When a leaky switch was detected, the test was suspended and the switches were allowed to cool to ambient temperature. The leaky switch was removed and the number of cycles noted. The remaining switches were brought back up to 135°C and testing resumed.

Data

Summary:		
	Temperature:	135°C
	Pressure (low):	8 psi
	Pressure (high):	1500 psi
	Frequency:	2 Hz

Table 1. below, shows the raw data obtained.

Table 1.

Quantity of samples	Cycles to Leakage (*indicates switches did not leak to specified cycles)
1	728000
2	1075000
3	1095000
1	1200925
1	1208509
2	1212896
26	1212896*

Note: Some switches leaked at the same time; this is reflected in the above table where there are multiple quantities for the same cycles to leakage.

Results

All (36) switches passed the specified 500,000 cycle requirement. Only (1) leakage occurred below 1,000,000 cycles.

The leakage mode of the switch at 728K (K = 1000) cycles, appears to be unrelated to the leakage modes of switches above 1000K cycles. An investigation is ongoing to gain an understanding. It is unclear at this time whether it is valid to use this data point as part of the analysis. Therefore, two separate analyses were performed; one including the 728K data point and one excluding the 728K data point.

Weibull Failure Analyses were performed on the data.
Figure 1 (page 4 of this report) shows the results where the 728K data point was included in the analysis. It shows a 90% Reliability at 1,000,000 cycles.
Figure 2 (page 5 of this report) shows the results where the 728K data point was excluded in the analysis. It shows a 98% Reliability at 1,000,000 cycles.
(Note: Due to software constraints, only (30) data points were used to perform the Weibull analysis instead of the (36) available).

Table 2, below, was constructed using the Weibull Failure Analyses of Figures 1 and 2. Percent reliability was obtained as a function of life cycles. The results are displayed graphically in Figure 3 below.

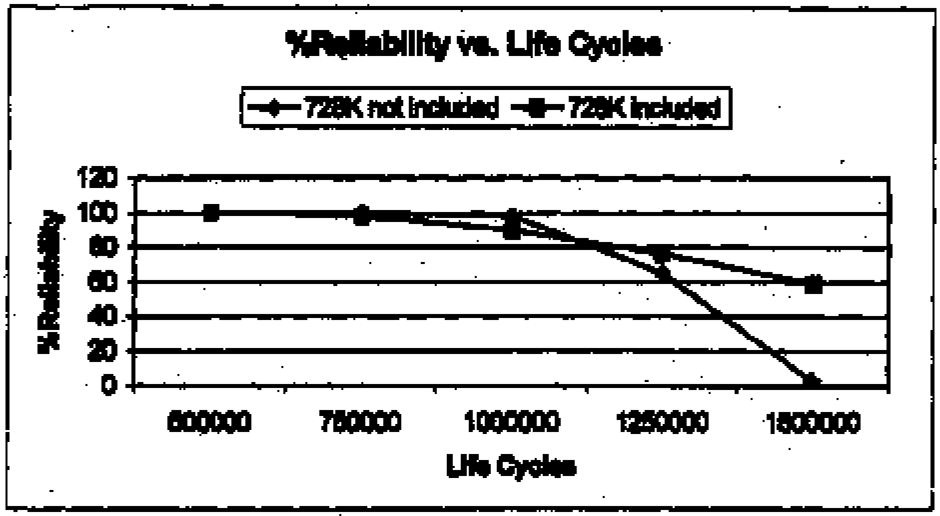
Table 2.
% Reliability vs. Life Cycles

728K point included in analysis			728K point not included in analysis	
Life Cycles	% Reliability		Life Cycles	% Reliability
500000	100		500000	100
750000	98		750000	100
1000000	90		1000000	98
1250000	76		1250000	65
1500000	59		1500000	3

TI-004037

TI-NHTSA 012548

Figure 3.



Discussion of Weibull Failure Analysis

For each set of data entered into a Weibull Analysis, the set of parameters α, β and R^2 are determined. Values for the data used in this test may be seen in Figure 1 and Figure 2.

α is the Characteristic Life which determines the spread of the distribution. The higher the number, the greater the spread.
For example, Figure 1 shows a calculated α = 1,302,169 while Figure 2 shows a value of 841,858. In Figure 1, the 728K point is included in the analysis and causes a greater spread of the distribution than that of Figure 2, where the 728K point is not included in the analysis.

β is the Shape Factor which determines the shape of the distribution curve.

R^2 is the Coefficient of Determination

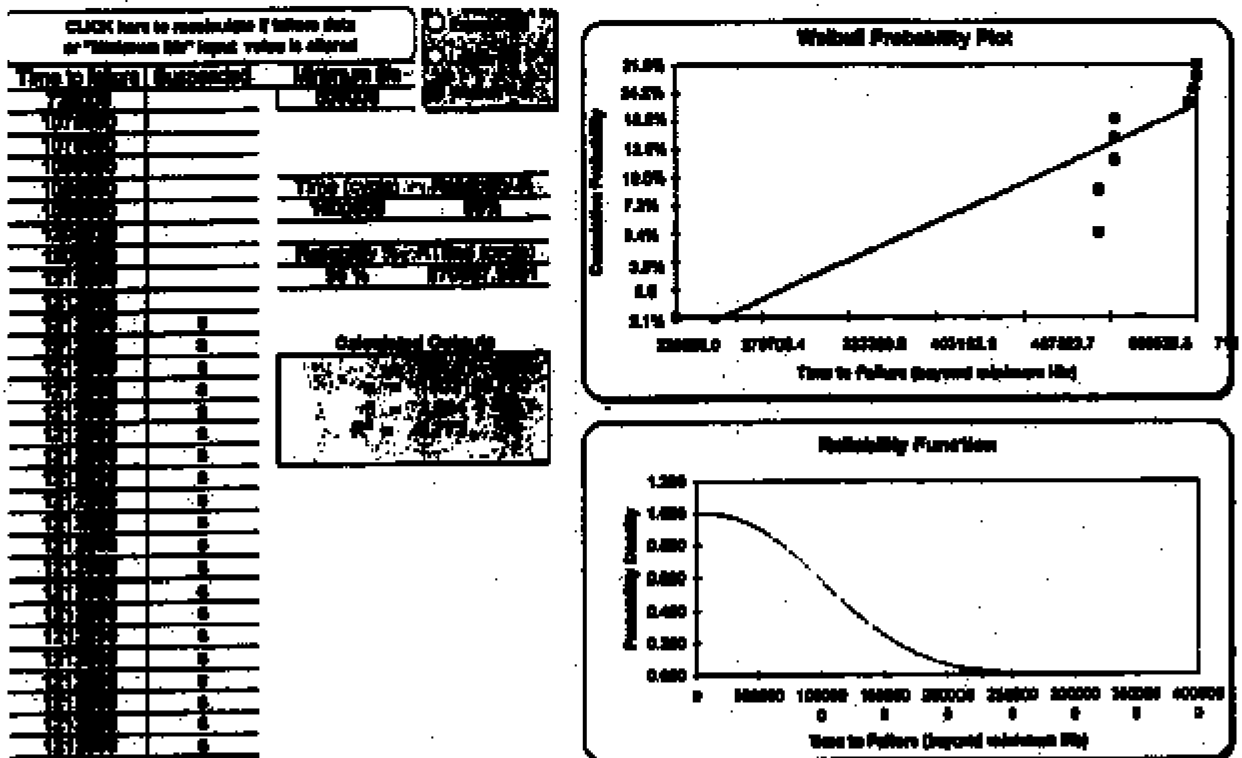
Conclusion

Reliability of PS77 switches to 500,000 cycles is 100%.
Reliability of PS77 switches to 1,000,000 cycles is at least 90%. Reliability is as high as 98% when (1) separate leakage mode at 728,000 cycles is not included in the analysis.

Report Authored by Sean Milligan

Figure 1.

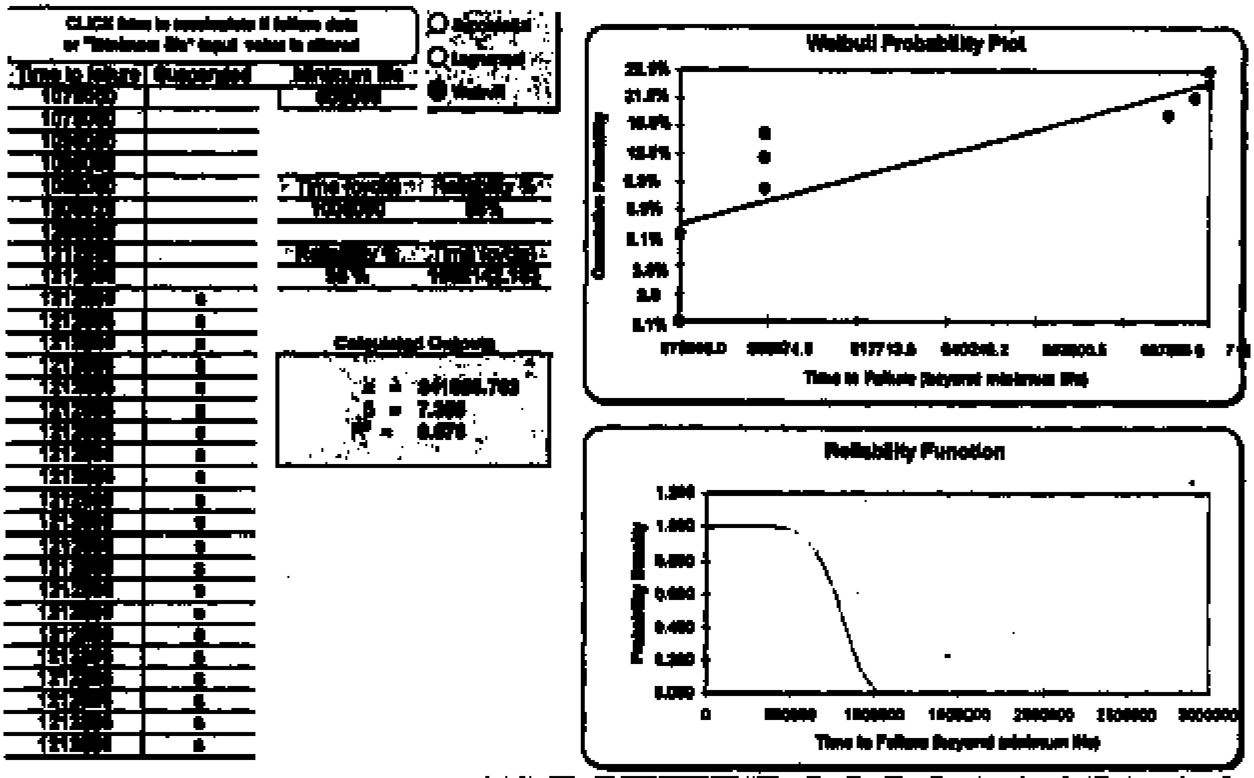
2 and 3 parameter WEIBULL FAILURE ANALYSIS



NOTES: 77P5 726K cycle data point included in analysis

Figure 2.

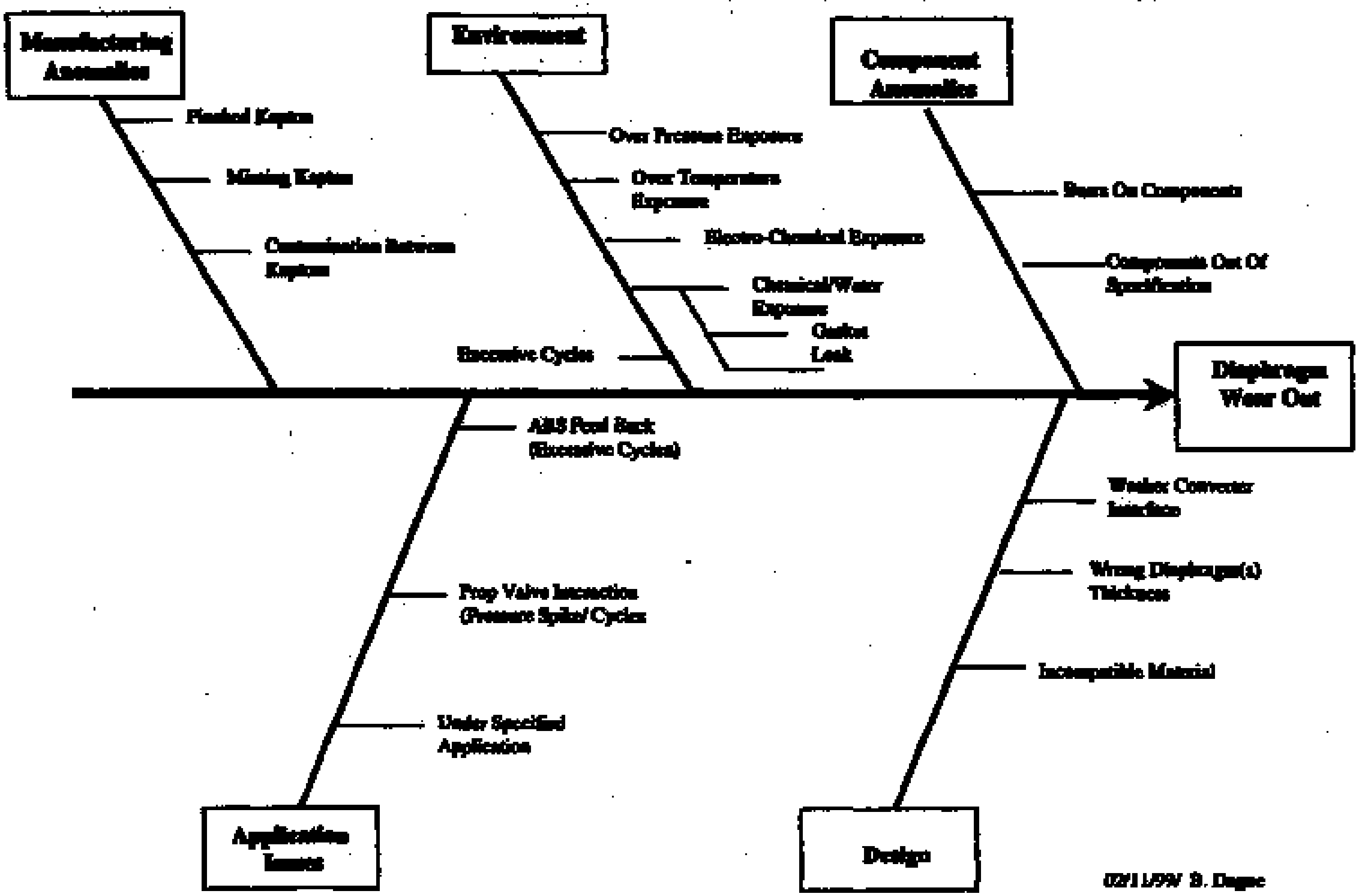
2 and 3 parameter WEIBULL FAILURE ANALYSIS



NOTES: 77F8 728K cycle data point not included in analysis

Texas Instruments

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



02/11/99 B. Dague

TI-NHTSA 012852

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Proprietary Information: Attorney-Client Privilege Invoked
PS/99/08
3/2/99

77 PS Heated Device Testing

Abstract

The purpose of this test was to investigate possible ignition caused by excessive heat generated in the contact cavity of 77PS switches. Several methods were used to artificially generate electrical heat in the switches. Power input and temperature were recorded as well as observations.

Procedure

A heater wire coil was installed in each switch base where the contacts and arm assembly normally occupy. The heater was attached to the terminals by removing the contact arm, and grinding away the rivet. The stationary contact was drilled and crimping with a small wire cutter. The heater element measured a total resistance of 0.5 ohms.
A small hole was drilled into the terminal cavity to facilitate use of a K-type thermocouple wire to monitor cavity temperature.

A variable output DC power supply was used to power the heating element through the mating connector leads. The devices were placed in a fire-proof oven and allowed to stabilize to room temperature, 70°F. Voltage, current and temperature were recorded.

Three devices were tested: Device 1 had a brake fluid and 6% water mix injected in the contact cavity. Devices 2 and 3 were dry. Provisions were made for an external source of ignition by drilling a .040 hole on a 45° angle through each base and inserting a .042 Torrington pin. A hy-pot tester was used to generate a spark.

Data

The data obtained on device 1 is shown in Table 1. below.

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

Voltage (Volts)	Heater Current (Amps)	Internal Temperature (°F)
.27	1.0	100
.30	2.0	175
.80	2.9	220
.90	3.0	246
.98	3.2	349
1.6	2.0	300
.97	3.1	340
1.1	3.6	460
1.2	3.8	462
1.1	3.8	488
1.3	4.0	531
1.1	3.6	571
1.4	4.1	647
1.4	4.0	660

Notes on Table 1:

Out-gassing of fluids began at 220 °F and a noticeable hissing sound was present. Smoke was visible and the base was venting from the side at a temperature of 246 °F. Smoke vented until failure of the base at 660 °F. At this point power to heater was shut down and spark was generated using the hy-pot. Ignition of gases occurred at this point and the fire was extinguished.

The data obtained on device 2 is shown in Table 2, below.

Table 2.
Test 2 (dry device with spark)

Voltage (Volts)	Heater Current (Amps)	Internal Temperature (°F)	Notes
1.0	3.1	501	
1.09	3.0	743	
Connection failed. Test interrupted.			
1.06	3.02	596	
1.06	3.09	626*	Smoke became visible from terminal area.
1.12	3.15	650	
1.13	3.08	681	
1.13	3.26	692	A small burn through area in the base. Smoke began venting from burn through area.
1.13	3.18	707	
1.13	3.36	722	
1.20	3.52	758	
1.36	3.95	806	Base flopped over
1.36	4.00	875	

*Light smoke became visible from terminal area
** A small burn

Notes on Table 2:

Power was left on at the end of the test and spark was generated. The fumes ignited and extinguished rapidly. The upper portion of the switch did not ignite despite 1230 °F temperatures .

TI-NHTSA 012556

Data obtained on Device 3 is shown in Table 3, below.

Table 3.
Test 3 (rapid temp. rise)

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

Notes on Table 3:

Readings for this test were made at approximately 20 second intervals. This was a fast happening event, where the internal temperature rise was very rapid. Smoke emitted at 300 °F. The device vented at the side of the base at 643 °F and the base did not fall until 1436 °F was achieved. A spark was applied at 1436 °F and fumes ignited . The heater instantly burned out and the fire was extinguished ..

Conclusions

Heat generated in the contact cavity of switches is not sufficient to initiate a thermal event. Vapors from base plastic melting and a catalyst such as a spark are necessary for ignition. In order to sustain an ignition, devices must be open to the atmosphere for a supply of Oxygen.

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Potential Actions

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

■ = fixed
□ = improved

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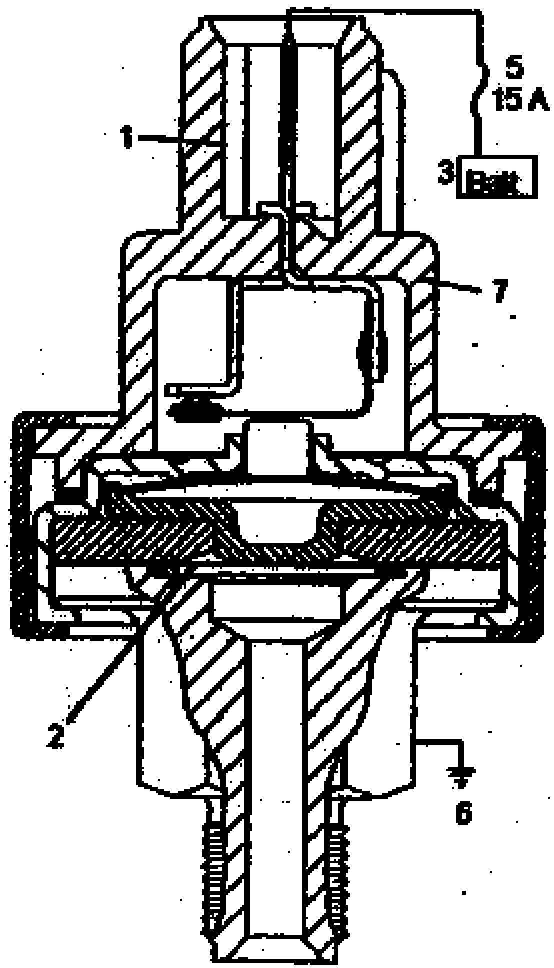
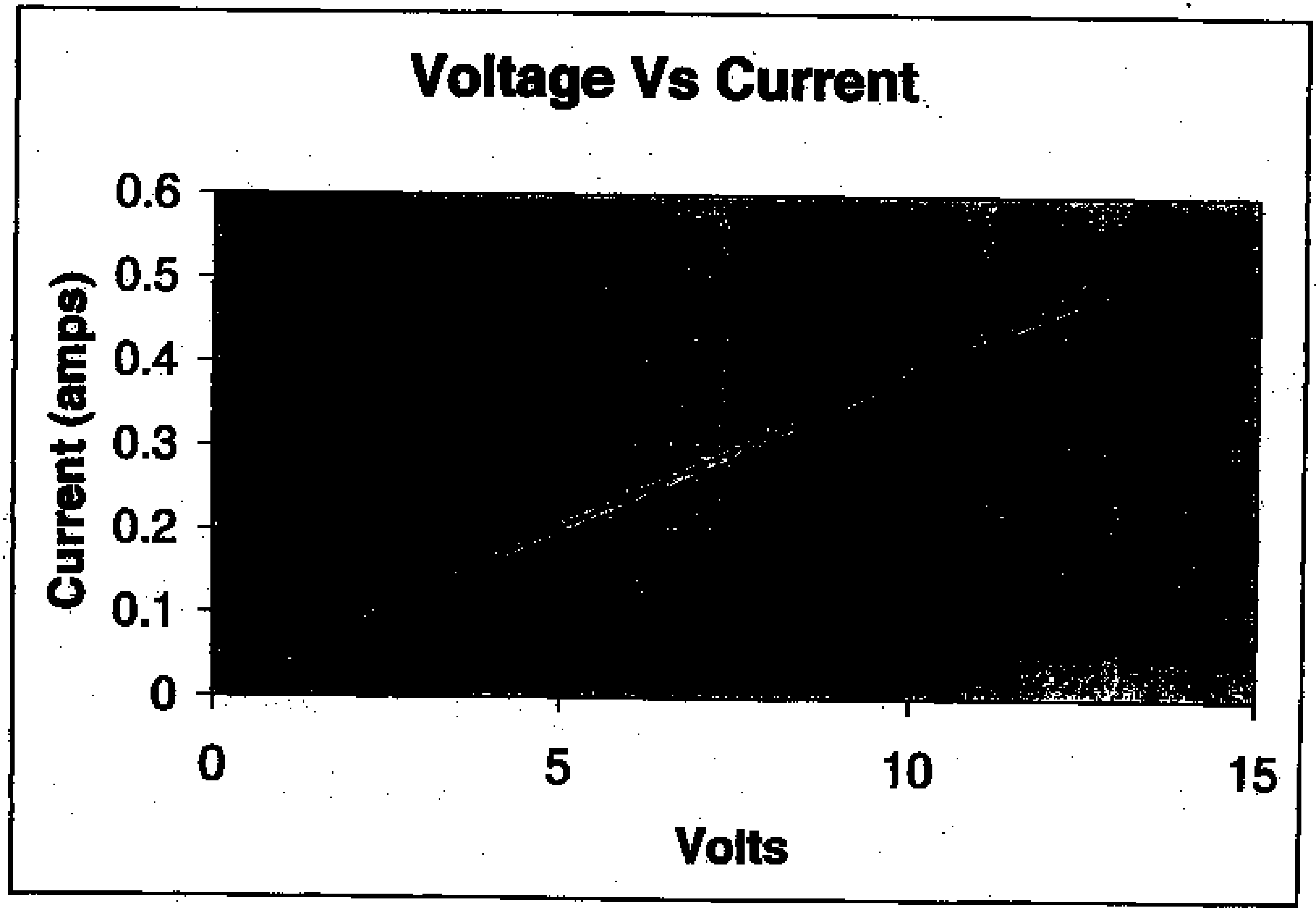
Contributing Factors



1. Connector Seal
2. Kapton Life
3. Continuous Power
4. Switch Orientation
5. Current Capability
6. Grounded Hex-Port
7. Plastic Parameters


Voltage Vs Current
Current (amps)
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
Volts

PRODUCT DATA SHEET

Product Support
General Electric Company
One Plastics Avenue, Pittsfield, MA 01201
[illegible]

NORYL: SE1GFN2 EUROPE: COMMERCIAL
AVAILABILITY: Europe, USA USA : COMMERCIAL

GR 20%. 270F (132C) DTUL. UL94 V-1 rated. Halogen free flame retardant. For electrical construction applications.

INJECTION MOLDING

Melt Temperature	560-600	deg F
Nozzle	540-600	deg F
Front	540-600	deg F
Middle	520-570	deg F
Rear	500-560	deg F
Mold Temperature	170-220	deg F
Drying Temperature	220-230	deg F
Drying Time (average)	3-4	h
Drying Time (maximum)	5	h
Moisture Content, Maximum	0.02	%
Back Pressure	50-100	psig
Screw Speed	20-100	rpm
Shot size to Cylinder Size	30-70	%

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ALL DATA SUBJECT TO STANDARD DISCLAIMER

→ HWI 0
HAI 2

GE plastics top 3.
Sounds like the Noryl or Valox would be better than the Cycolac as it is unfilled.

A)

GE Plastics

PRODUCT DATA SHEET

Product Support
General Electric Company
One Plastics Avenue, Pittsfield, MA 01201
[illegible]

NORYL: SE1GFN2
AVAILABILITY: Europe, USA

EUROPE: COMMERCIAL
USA : COMMERCIAL

GR 20%, 270F [132C] DTUL. UL94 V-1 rated. Halogen free flame retardant. For electrical construction applications.

PROPERTY	TYPICAL DATA	UNIT	METHOD
MECHANICAL			
Tensile Strength, yield, Type I, 0.125"	10500	psi	ASTM D 638
Tensile Elongation, break, Type I 0.125"	5.0	%	ASTM D 638
Flexural Strength, yield, 0.250"	22000	psi	ASTM D 790
Flexural Modulus, 0.250"	850000	psi	ASTM D 790
Hardness, Rockwell L	106	-	ASTM D 785
IMPACT			
Izod Impact, notched, 73F	2.0	ft-lb/in	ASTM D 256
Izod Impact, notched, -40F	1.8	ft-lb/in	ASTM D 256
THERMAL			
HDT, 66 psi, 0.250", unannealed	280	deg F	ASTM D 648
HDT, 264 psi, 0.250", unannealed	270	deg F	ASTM D 648
CTE, flow, -40F to 200F	2.0 E-5	in/in-F	ASTM E 831
Thermal Index, Elec Prop	110	deg C	UL 746B
Thermal Index, Mech Prop with impact	105	deg C	UL 746B
Thermal Index, Mech prop without impact	110	deg C	UL 746B
Glass Transition Temperature	135	deg C	-
PHYSICAL			
Specific Gravity, solid	1.23	-	ASTM D 792
Water Absorption, 24 hours @ 73F	0.060	%	ASTM D 570
Mold Shrinkage, flow, 0.125"	2-5	in/in E-3	ASTM D 955
ELECTRICAL			
Dielectric Strength, in oil, 125 mils	600	V/mil	ASTM D 149
Dielectric Constant, 60 Hz	2.95	-	ASTM D 150
Dissipation Factor, 60 Hz	0.0016	-	ASTM D 150
FLAME CHARACTERISTICS			
UL File Number, USA	E121562	-	-
V-1 Rated (tested thickness)	0.060	inch	UL 94
V-0 Rated (tested thickness)	0.240	inch	UL 94
Oxygen Index (LOI)	27.0	%	ASTM D 2863

Source data, print date: 99/03/11, last updated: 96/12/22

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TI-NHTSA 012562

GE Plastics

PRODUCT DATA SHEET

Product Support
General Electric Company
[illegible]
[illegible]

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(TELEPHONE) : AREA: NUMBER: COUNTRY:

SENDER ID: PESR100 NAME: KOCH, ROBERT TEL:

CONTENTS: V166

WOULD NOT SUGGEST FOR UNDERHOOD APPLICATION....
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GE Plastics

PRODUCT DATA SHEET

Product Support
[illegible]

CYCOLAC: V100 EUROPE: OBSOLETE
AVAILABILITY: Europe, USA USA : COMMERCIAL

UL/CSA listed. ABS flame retardant based upon non-PBDE additives. Good properties/toughness. Excellent moldability.

INJECTION MOLDING

Melt Temperature	380-430	deg F
Nozzle Temperature	390-430	deg F
Front Temperature	390-420	deg F
Middle Temperature	380-400	deg F
Rear Temperature	340-360	deg F
Mold Temperature	120-160	deg F
Drying Temperature	180-190	deg F
Drying Time (minimum)	2-4	h
Drying Time (maximum)	6	h
Moisture Content, Maximum	0.10	%
Back Pressure	50-100	psi
Screw Speed	30-60	rpm
Suggested shot size	50-70	%
Vent Depth	.0015-.0020	in

Source Orig. print date: 99/03/11, last updated: 97/03/06

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HWI 0
HAI 0

PRODUCT DATA SHEET

Product Support
General Electric Company
One Plastics Avenue, Pittsfield, MA [illegible]
[illegible] Fx 413 448-[illegible]

CYCOLAC: V100
AVAILABILITY: Europe, USA

EUROPE: OBSOLETE
USA : COMMERCIAL

UL/CSA listed. ABS flame retardant based upon non-PBBE additives. Good properties/toughness. Excellent moldability.

PROPERTY	TYPICAL DATA	UNIT	METHOD
MECHANICAL			
Tensile Strength, yield, Type I, 0.125"	6300	psi	ASTM D 638
Tensile Modulus, Type I, 0.125"	340000	psi	ASTM D 638
Flexural Strength, yield, 0.125"	10600	psi	ASTM D 790
Flexural Modulus, 0.125"	360000	psi	ASTM D 790
Hardness, Rockwell R	104	-	ASTM D 785
IMPACT			
Izod Impact, notched, 73F	3.0	ft-lb/in	ASTM D 256
Gardner Impact, 73F	20	ft-lbs	ASTM D 3029
Instrumented Impact Energy @ peak, 73F	324	in-lbs	ASTM D 3763
Instrumented Impact Energy @ Peak, 73F.	27.0	ft-lbs	ASTM D 3763
THERMAL			
HDT, 264 psi, 0.125", unannealed	162	deg F	ASTM D 648
Thermal Index, Elec Prop	60	deg C	UL 746B
Thermal Index, Mech Prop with impact	60	deg C	UL 746B
Thermal Index, Mech prop without impact	60	deg C	UL 746B
PHYSICAL			
Specific Gravity, solid	1.21	-	ASTM D 792
Mold Shrinkage, flow, 0.125"	5-7	in/in E-3	ASTM D 955
Melt Flow Rate, nom'l, 230C/3.8 kgf (I)	4.9	g/10 min	ASTM D 1238
FLAME CHARACTERISTICS			
UL File Number, USA	E121562	-	-
*V-0 Rated (tested thickness)	0.059	inch	UL 94
5VA Rating (tested thickness)	0.098	inch	UL 94
CSA (See File for complete listing)	LS88480	File No.	CSA LISTED
CSA A06, No. 0.6	0.126	inch	Std 22.2
CSA 0.6V-0	0.061	inch	Std 22.2
Oxygen Index (LOI)	29.0	%	ASTM D 2863

Source GRIS, print date: 99/03/11. last updated: 98/02/20

THESE PROPERTY VALUES ARE NOT INTENDED FOR SPECIFICATION PURPOSES
ALL DATA SUBJECT TO STANDARD DISCLAIMER

TI-NHTSA 012565

GE Plastics

PRODUCT DATA SHEET

Product Support
General Electric Company
One Plastics Avenue, Pittsfield, MA 01201
800 845-0600 Fx: 413 448-7731

The following information was used to request this fax:

FAX NUMBER : AREA: 540 NUMBER: 2363586 COUNTRY:
FAX TO (COMPANY) : TI
FAX FOR (NAME) : ALAN AMORE
(TELEPHONE) : AREA: NUMBER: COUNTRY:

SENDER ID: P65R130 NAME: KOCH, ROBERT TEL:

CONTENTS: 420SE0

WOULD NOT SUGGEST FOR UNDERHOOD APPLICATION....

TI-NHTSA 012566

PRODUCT DATA SHEET

Product Support
General Electric Company
[illegible]
[illegible]

VALOX: 420SE0 EUROPE: COMMERCIAL
AVAILABILITY: Europe, USA USA : COMMERCIAL

30% GR, UL94V-0/5V rated. Numerous applications; edge trimmers, food mixer motor stator and commutator, cooling fan, connectors, bobbins, switches etc

INJECTION MOLDING

GROUP	UNITS	VAL-IN-US
Drying Temperature	deg F	250
Drying Time (basic)	h	3-4
Drying Time (maximum)	h	12
Moisture Content, max	%	0.02
Moisture Content, min	%	-
Melt Temperature	deg F	490-530
Nozzle	deg F	480-520
Front	deg F	490-530
Middle	deg F	480-520
Rear	deg F	470-510
Mold Temperature	deg F	150-190
Back Pressure	psig	50-100
Screw Speed	rpm	50-80
Shot to Cylinder Size	%	40-80
Clamp Tonnage	tons/psi	3-6
Vent Depth	inch	0.0010-0.0015

Source Eric, print date: 99/03/11, last updated: 99/02/26

THESE PROPERTY VALUES ARE NOT INTENDED FOR SPECIFICATION PURPOSES
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HW1 2
HA1 0

TI-NHTSA 012567

GE Plastics

PRODUCT DATA SHEET

Product Support
General Electric Company
One Plastics Avenue, Pittsfield, MA 01201
[illegible]

VALOX: 420SE0
AVAILABILITY: Europe, USA

EUROPE: COMMERCIAL
USA : COMMERCIAL

30% GR, UL94V-0/5V rated. Numerous applications: edge trimmers, food mixer motor stator and commutator, ceiling fan, connectors, bobbins, switches etc

PROPERTY	TYPICAL DATA	UNIT	METHOD
MECHANICAL			
Tensile Strength, break, Type I, 0.125"	17000	psi	ASTM D 638
Flexural Strength, break, 0.125"	27000	psi	ASTM D 790
Flexural Modulus, 0.125"	1100000	psi	ASTM D 790
Compressive Strength	18000	psi	ASTM D 695
Shear Strength	9000	psi	ASTM D 732
Hardness, Rockwell R	119	-	ASTM D 785
IMPACT			
Izod Impact, unnotched, 73F	12.0	ft-lb/in	ASTM D 4812
Izod Impact, notched, 73F	1.5	ft-lb/in	ASTM D 256
THERMAL			
HDT, 66 psi, 0.125", unannealed	415	deg F	ASTM D 648
HDT, 66 psi, 0.250", unannealed	420	deg F	ASTM D 648
HDT, 264 psi, 0.125", unannealed	375	deg F	ASTM D 648
HDT, 264 psi, 0.250", unannealed	400	deg F	ASTM D 648
CTE, flow, -40F to 100F	1.4 E-5	in/in-F	ASTM E 831
CTE, flow, 140F to 300F	1.4 E-5	in/in-F	ASTM E 831
Thermal Index, Elec Prop	130	deg C	UL 746B
Thermal Index, Mech Prop with impact	130	deg C	UL 746B
Thermal Index, Mech prop without impact	140	deg C	UL 746B
PHYSICAL			
Specific Gravity, solid	1.58	-	ASTM D 792
Specific Volume	17.52	in3/lb	ASTM D 792
Water Absorption, 24 hours @ 73F	0.060	%	ASTM D 570
Mold Shrinkage, flow, 60-125 mil	3-5	in/in E-3	ASTM D 955
Mold Shrinkage, flow, 125-190 mil	5-8	in/in E-3	ASTM D 955
Mold Shrinkage, xflow, 60-125 mil	4-6	in/in E-3	ASTM D 955
Mold Shrinkage, xflow, 125-190 mil	6-9	in/in E-3	ASTM D 955
ELECTRICAL			
Volume Resistivity	>3.4E16	ohm-cm	ASTM D 257
Dielectric Strength, in air, 125 mils	490	V/mil	ASTM D 149
Dielectric Strength, in oil, 62 mils	610	V/mil	ASTM D 149

PRODUCT DATA SHEET

Product Support
General Electric Company
One Plastics Avenue, Pittsfield, MA 01201
800 845-0600 Fax 413 448-7731

VALOX: 420SE0
AVAILABILITY: Europe, USA

EUROPE: COMMERCIAL
USA : COMMERCIAL

PROPERTY	TYPICAL DATA	UNIT	METHOD
Dielectric Constant, 100 Hz	3.50	-	ASTM D 150
Dielectric Constant, 1 MHz	3.70	-	ASTM D 150
Dissipation Factor, 100 Hz	0.0020	-	ASTM D 150
Dissipation Factor, 1 MHz	0.0200	-	ASTM D 150
FLAME CHARACTERISTICS			
UL File Number, USA	E121562	-	-
V-0 Rated (tested thickness)	0.029	inch	UL 94
5VA Rating (tested thickness)	0.071	inch	UL 94
CSA (See File for complete listing)	LS88480	File No.	CSA LISTED
Oxygen Index (LOI)	32.0	%	ASTM D 2863

Source Gric. print date: 99/03/11. last updated: 99/02/26

THESE PROPERTY VALUES ARE NOT INTENDED FOR SPECIFICATION PURPOSES
ALL DATA SUBJECT TO STANDARD DISCLAIMER

TI-NHTSA 012569

Ticona Celanex® 4300 Polyester (PBT), 30% Glass-Fiber

Category: Polymer

Subcategory: Polyester, TP; Thermoplastic; Polybutylene Terephthalate (PBT)

Close Analogs:

Data provided by Ticona.

Key Words: Ticona Celanex 4300 Polyester (PBT), 30% Glass-Fiber; Polybutylene Terephthalate; Hoechst Celanese Corporation;

Composition:

Material Notes: Good impact strength

Click here to see a list of companies that sell this material.

PHYSICAL PROPERTIES	VALUES	COMMENTS	
Density, g/cc	1.53	ASTM D792	See other units
Linear Mold Shrinkage, cm/cm	0.004	Flow Direction	
Water Absorption, %	0.01	ASTM D570	
Hardness, Rockwell R	91	ISO 2039-2	
MECHANICAL PROPERTIES	VALUES	COMMENTS	
Tensile Strength, Ultimate, MPa	130	ISO 527	See other units
Elongation %; break	3	ASTM D638	
Flexural Modulus, GPa	9	ISO 178	See other units
Flexural Yield Strength, MPa	205	ISO 178	See other units
Impact Strength, Izod, in J, J/cm, or J/cm²	1.15	J/cm²; Notched; ISO 180/1A	
THERMAL PROPERTIES	VALUES	COMMENTS	
Deflection Temperature at 0.46 MPa, °C	220	ISO 75	
Deflection Temperature at 1.8 MPa, °C	200	ISO 75	
Maximum Service Temperature, Air, °C	200	Deflection Temperature at 1.8 MPa load	
Flammability, UL94 (5=V-0; 4=V-1; 3=V-2; 1=HB)	1 (HB)	HB At 0.8 mm; UL94	
ELECTRICAL PROPERTIES	VALUES	COMMENTS	
Electrical Resistivity, Ohm-cm	1E+16	Lower Limit; ASTM D257	See other units
Dielectric Constant, Low Frequency	3.8	100 Hz	
Dielectric Strength, kV/mm	22	3.2 mm; 50% RH; ASTM D149	See other units
Dissipation Factor, Low Frequency	0.002	100 Hz	
Comparative Tracking Index, V	500	ASTM D3638	

Ticona Celanex® 3310 Polyester (PBT), 30% Glass-Fiber

Category: Polymer

Subcategory: Polyester, TP; Thermoplastic; Polybutylene Terephthalate (PBT)

Close Analogs:

Data provided by Ticona.

Key Words: Ticona Celanex 3310 Polyester (PBT), 30% Glass-Fiber; Polybutylene Terephthalate; Hoechst Celanese Corporation;

Composition:

Material Notes: Flame retardant

Click here to see a list of companies that sell this material.

PHYSICAL PROPERTIES	VALUES	COMMENTS	
Density, g/cc	1.66	ASTM D792	See other units
Linear Mold Shrinkage, cm/cm	0.004	Flow Direction	
Water Absorption, %	0.07	ASTM D570	
Hardness, Rockwell M	90	ISO 2039-2	
MECHANICAL PROPERTIES	VALUES	COMMENTS	
Tensile Strength, Ultimate, MPa	140	ISO 527	See other units
Elongation %; break	2	ASTM D638	
Flexural Modulus, GPa	10.6	ISO 178	See other units
Flexural Yield Strength, MPa	225	ISO 178	See other units
Impact Strength, Izod, in J, J/cm, or J/cm²	0.84	J/cm²; Notched; ISO 180/1A	
THERMAL PROPERTIES	VALUES	COMMENTS	
Deflection Temperature at 0.46 MPa, °C	222	ISO 75	
Deflection Temperature at 1.8 MPa, °C	205	ISO 75	
Maximum Service Temperature, Air, °C	205	Deflection Temperature at 1.8 MPa load	
Flammability, UL94 (5=V-0; 4=V-1; 3=V-2; 1=HB)	5 (V-0)	V-0 At 0.8 mm; UL94	
ELECTRICAL PROPERTIES	VALUES	COMMENTS	
Electrical Resistivity, Ohm-cm	1E+16	Lower Limit; ASTM D257	See other units
Dielectric Constant, Low Frequency	3.9	100 Hz	
Dielectric Strength, kV/mm	19	3.2 mm; 50% RH; ASTM D149	See other units
Dissipation Factor, Low Frequency	0.006	100 Hz	
Comparative Tracking Index, V	[illegible]	ASTM D3638	

TI-NHTSA 012573

3/12/99 Grounds Fault I

SA missing - BF?

Memphis - LC ➡

Other 2 missing BF

Come to conclusion that BF

is not a contributor

If connector ....

Contaminated thru the connector

Brake fluid

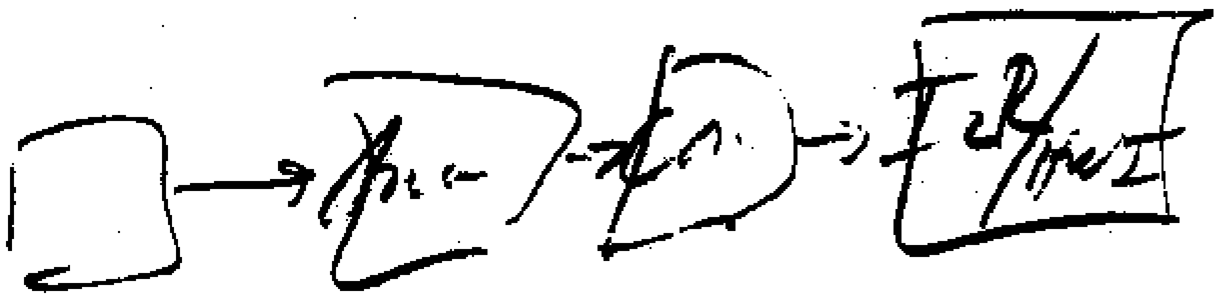
When we offer up a fix — does it cover the issues we are concerned about —
(Cam - Conn, Cover, Posses, RT

Not clear of the cause
— Solutions have to assure they cover both pieces

EVIDENCE
&
LITIGANTS < MEMPHIS
↓
SUC [illegible]
↓
FIRES

BF CORROSION

H_2O CORROSION



IF TC → BPS

IF ALL RAT THEN SWITCH SOLUTION

- Cyclon going [illegible]
- Thermal event -
- No lead / lead
- Kapton -
- Production changeovers - [illegible]

· OVC status - 6 days to [illegible]

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