EA02-025

TEXAS INSTRUMENTS, INC.'S

9/10/03

REQUEST NO. 7

BOX 9

PART A – R

PART J

TEXAS INSTRUMENTS

, 1999

FACSIMILE TRANSMITTAL

TO: Name: Sally
Location:
Mail Station:
Phone Number:
FAX Number:

FROM: Andy McQuirk

TEXAS INSTRUMENTS MS 23-07
Phone Number: (508) 236-
FAX Number: (508) 236-2430

Total number of pages (including header page): 11

COMMENTS:

TI-NHTSA 014201

4.5 IMPULSE

4.5.1 PROCEDURES:
Per the engineering specification.

4.5.2 EQUIPMENT:
- Thermotron environmental chamber, model S - 4.
- Twenty-four station manifold.
- Mating electrical connectors.
- Trygon Electronics Dual Power Supply, DL40-1A for the loads.
- Acopian power supply, 5E25D-D15E03 for Sensotec transducer.
- Customized designed and built pressure cycler.
- Enerpac hydraulic pump.
- TI 315 Programmable Logic Controller.
- Moog servo valve, 760-552-A.
- Moog controller, MA-X-50.
- Simpson signal generator.
- Sensotec transducer, TJE-744-03, 0-2,500 psig, calibrated semi-annually.
- Nicolet oscilloscope, 310, calibrated semi-annually.

4.5.3 REQUIREMENTS:
At the completion of this test all switches shall meet the Voltage Drop, Current Leakage, and Creep Time requirements outline in the engineering specification (See Appendix 5.1). Additionally, the post-impulse calibration requirements are not define; results of this test will be used to set this requirement.

4.5.4 RESULTS:
All switches met the requirements outlined in the engineering specification. Data is presented in Appendix 5.4.2.

TEST LOT NO.	TEST	DEVICE
TESTED BY		
APPROVED BY	TEXAS INSTRUMENTS — MATERIALS & CONTROLS GROUP, ATTLEBORO, MA 02703	DOC.
DATE 7/16/93		PAGE

FORM 5293

508236:590 PAGE.

JUN 28 '99 16:45

3.9 IMPULSE

3.9.1 Devices tested: 207-15-1 thru -24.

3.9.2 Procedure: Performed per the ES.

3.9.3 Equipment: Same as 3.8.3.

3.9.4 Results/Discussion: Four devices (#207-15-1,-5,-9,-11) were found to have a slightly elevated release transfer time (Creep Check, ES frame 9 of 13, section III. M.). Note that other Ford Engineering Specifications which cover hydraulic pressure switches produced by Texas Instruments, specifically ES-E53C-3N824-AA, allow up to 30 milliseconds for transfer time after the Impulse test. The four devices noted fell well within 30 msec. This issue will be addressed by communication with the responsible engineering office at Ford, to determine if a slight increase in transfer time at the end of life should be included in the ES.

92005 [signature] 4/12/99 E75C 3N824AA

TEST LOT NO.	TEST	DEVICE
TESTED BY		
APPROVED BY	TEXAS INSTRUMENTS — MATERIALS & CONTROLS GROUP, ATTLEBORO, MA 02703	DWG.
DATE		PAGE 14

FORM

JUN 29 '99 10:49 5082361588 PAGE.003

TI-NHTSA 014203

3.10 IMPULSE

3.10.1 Devices tested: 156-15-81 thru -104.

3.10.2 Procedure: 24 virgin devices were run as opposed to 12 virgins and 12 from Fluid Resistance. This is discussed in detail in section 3.0. The parameters given in the ES (frame 7 of 18, section III. E. 1.) are followed explicitly.

3.10.3 Equipment: same as 3.8.2 with the addition of a 12-station inductive load bank, per the schematic found in the ES (frame 18 of 18; figure 4.) used in the last 25K cycles.

3.10.4 Results/Discussion: Pre-characterization was not performed. After completion of the 500K cycles, all 24 devices passed the acceptance criteria found in the ES (frame 7 of 18, section III. E. 2).

This test may be regarded as the one of the most rigorous. This test is run at elevated temperature (135 C fluid), elevated pressure (1450 psig, 2 Hz), and total cycles (applying brakes 5 times per mile for 100,000 miles) which exceed conditions typically found in actual motor vehicles.

TEST LOT NO.	TEST	DEVICE
TESTED BY		
APPROVED BY	TEXAS INSTRUMENTS — MATERIALS & CONTROLS GROUP, ATTLEBORO, MA 02703	DOC.
DATE [illegible]		PAGE 14

FORM [illegible]

3.6 IMPULSE

3.6.1 Devices tested: 172-15-01 thru -24
173-15-01 thru -24.

3.6.2 Procedure: 172-15-13 thru -24 and 173-15-13 thru -24 were run together on the Impulse test per the ES. Devices 172-15-01 thru -12 and 173-15-01 thru -12 were subject to the Fluid resistance test first, then run together on the Impulse test.

3.6.3 Equipment: Thermotron model S-4 Mini-Max environmental chamber capable of -55 C to +200 C, humidity uncontrolled. Custom TI designed and built cycler, utilizing Enerpak integrated hydraulic pressure source, TI315 Programmable Logic Controller, Moog servovalve and controller, Simpson signal generator, and opposing-piston fluid isolators, to produce a hydraulic-fluid flow-type primary with a brake-fluid dead-end-type secondary terminated with a 24-station manifold equipped with internal heaters. Capability to 5 Hz at 0-1450 psig cycle. Custom TI designed and built 24 station Switch Monitor Circuit which automatically stops the cycler in the event of abnormal switch action, defined as continuity change which does not track the signal from the signal generator. Thermocouple readouts calibrated quarterly. 12-station inductive load bank, per the schematic found in the ES (frame 18 of 18; figure 4.) used in the last 25K cycles.

3.6.4 Results: All devices passed.

TEST LOT NO.	TEST	DEVICE
TESTED BY		
APPROVED BY	TEXAS INSTRUMENTS MATERIALS & CONTROLS GROUP ATTLEBORO, MA 02703	DWG.
DATE		PAGE

FORM 0286

3.10 IMPULSE

3.10.1 Devices tested: 86-15-01 thru 86-15-12 from Fluid Resistance test 3.9 and 86-15-63 thru 86-15-74 virgin devices.

3.10.2 Procedure: All 24 devices actually ran 525,000 pressure cycles. The first 475,000 is done unpowered, with the Switch Monitor Circuit functioning. From 475,000 thru 500,000 cycles one-half of the 24 devices are powered. This is due to the fact that the Load Bank only has 12 stations for cost, size, and weight considerations. From 500,001 thru 525,000 cycles the other half are powered.

3.10.3 Equipment: same as 3.8.2 with the addition of a 12-station inductive load bank, per the schematic found in the ES (frame 18 of 18, figure 4.) used in the last 25K cycles.

3.10.4 Results/Discussion: All twenty-four devices passed the acceptance criteria found in the ES (frame 7 of 18, section III. E. 2.).

This test may be regarded as the one of the most rigorous. This test is run at elevated temperature (135 C fluid), elevated pressure (1450 psig, 2 Hz), and total cycles (applying brakes 5 times per mile for 100,000 miles) which exceed conditions typically found in actual motor vehicles.

TEST LOT NO.	TEST	DEVICE
TESTED BY		
APPROVED BY	TEXAS INSTRUMENTS MATERIALS & CONTROLS GROUP ATTLEBORO, MA	DWG.
DATE 10-11-85		PAGE 15

FORM

3.10 IMPULSE

3.10.1 Devices tested: 157-15-01 thru -12 from Fluid Resistance test 3.9 and 157-15-67, -69 thru -74, -76 thru -80 virgin devices.

3.10.2 Procedure: Virgin devices were run separately, before the Fluid Resistance devices. In each case, the procedure given in the ES (frame 7 of 18, section III. E. 1.) was followed explicitly.

3.10.3 Equipment: same as 3.8.2 with the addition of a 12-station inductive load bank, per the schematic found in the ES (frame 18 of 18; figure 4.) used in the last 25K cycles.

3.10.4 Results/Discussion: All twenty-four devices passed the acceptance criteria found in the ES (frame 7 of 18; section III. E. 2.).

This test may be regarded as the one of the most rigorous. This test is run at elevated temperature (135 C fluid), elevated pressure (1450 psig, 2 Hz), and total cycles (applying brakes 5 times per mile for 100,000 miles) which exceed conditions typically found in actual motor vehicles.

Fred,

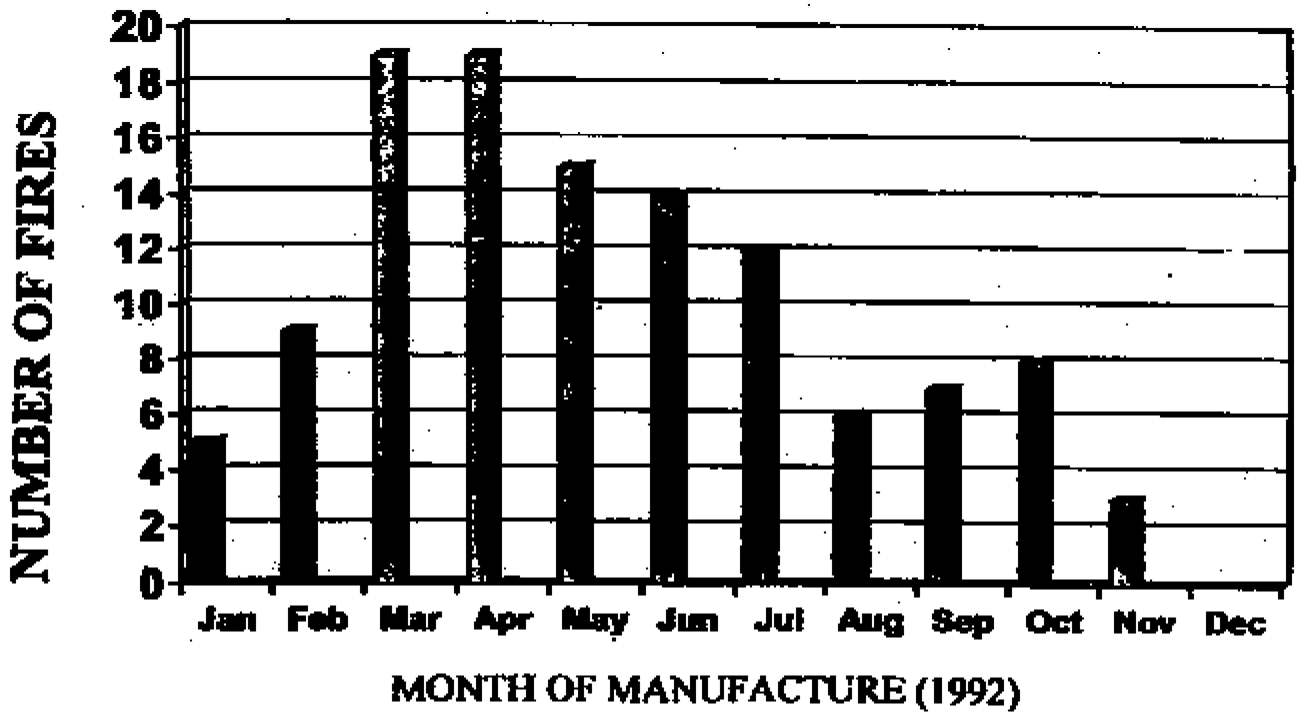
The following represents a rough usage matrix over time:

MY92	MY93	MY94	MY95	F MY96	MY97	MY98
Econoline	Econoline	Econoline	Econoline	Econoline	Econoline	Econoline
Club Wagon	Club Wagon	Club Wagon	Club Wagon	Club Wagon	Club Wagon	Club Wagon
Town Car	Town Car	Town Car	Town Car	Town Car --	Town Car	
Crown Vic	Crown Vic	Crown Vic	Crown Vic	Crown Vic	Crown Vic	
Grand Marquis	Grand Marquis	Grand Marquis	Grand Marquis	Grand Marquis	Grand Marquis	
	F Series	F Series	F Series	F Series	F Series	F Series
	Bronco	Bronco	Bronco	Bronco		
	SHO Taurus	SHO Taurus	SHO Taurus??			
		Capri	Capri	Capri??		
		Win88	Win88	Win88	Win88	Win88
			Falcon	Falcon	Falcon	Falcon
				Explorer??	Explorer	Explorer
				Ranger??	Ranger	Ranger
					Expedition	Expedition
						Navigator

TEXAS INSTRUMENTS

Brake Pressure Switch
Potential Thermal Event Theory Profile 4/21/99

FORD TOWN CAR ISSUES

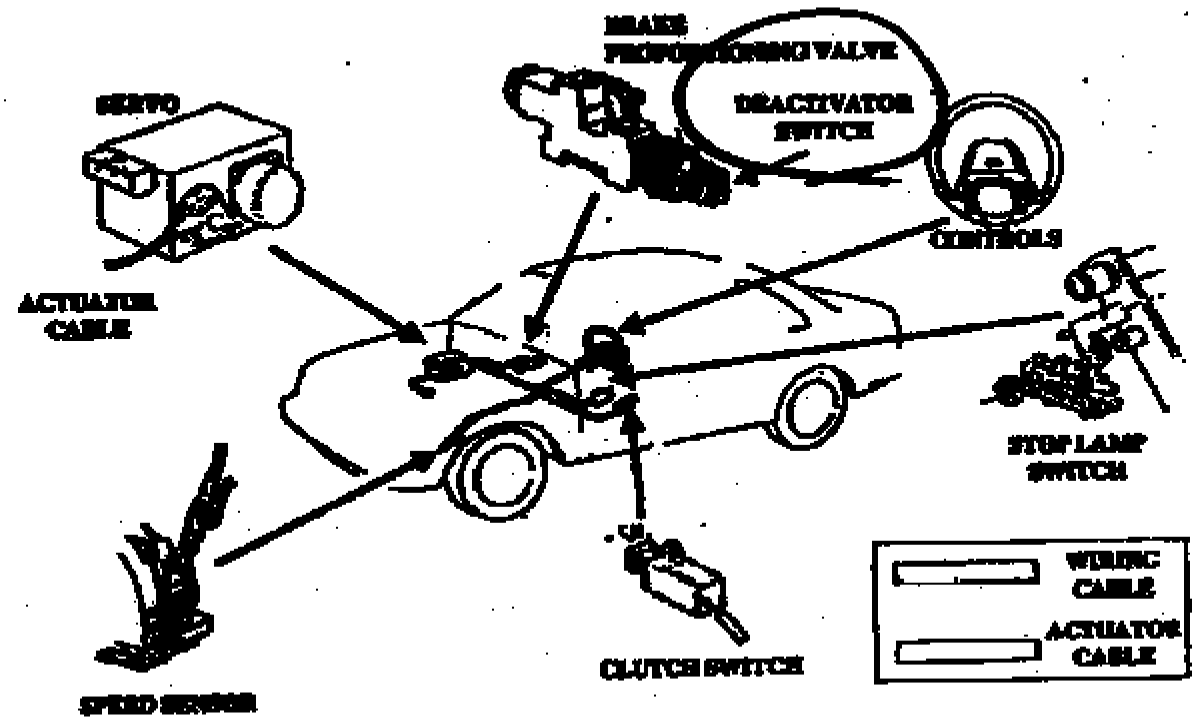


NOTES: Ford data as of 4/14/99

TEXAS INSTRUMENTS

Brake Pressure Switch
Potential Thermal Event Theory Profile 3/15/99

1991 Next Generation Speed Control System



Attachment

Sample	Condition	Hexport, Washer, Connector, and Spacer	Seals	Cup	Base/Switch Cavity/Terminals
Reddick ([illegible] 2, 1998 Town Car)	Partially burned	Black residue containing glycol based material (probably brake fluid) and a metal oxide. Indicates presence of brake fluid on fluid and switch sides of seals.	Environmental seal and gasket intact and appear to have lost good coating. All three Kapton seals are [illegible] and exhibit brittle cracks which most likely formed leak path. Damage appears to have initiated in seal closest to washer. Damaged Kapton [illegible] and [illegible] by unknown mechanism.	Green Deposits on face of cup contain elements from brass contacts indicating transfer of contact material to cup probably as oxide, sulfide, or corrosion product. Glycol based material (probably brake fluid) also detected in this area.	Base separated below crimp ring. Transfer pin and movable contact missing. Stationary contact exhibits loss of material due to corrosion, evidence of dezincification, stress corrosion cracking. Base of movable contact melted [illegible] bridged between switch and terminal cavities. Appears to have occurred in later stages of event. Evidence of terminals covered with black and green deposits which appear to be sulfur compounds of the [illegible] materials.
A (1993 Town Car, Houston)	Burned	Elements from contact material detected at fitting end of hexport. Indicate possible flow of fluid back through seals.	Gasket and environmental seal missing. Charred fragments Kapton seals remain.	Deposits on face of cup contain elements from brass contacts indicating transfer of contact material to cup probably as oxide, sulfide, or corrosion product.	Base, stationary contact, movable contact, and terminals missing.
B (1992 Town Car, Houston)	Burned	Elements from contact material detected at fitting end of hexport. Indicate possible flow of fluid back through seals.	Not permitted to disassemble switch.	Deposits on face of cup contain elements from brass contacts indicating transfer of contact material to cup probably as oxide, sulfide, or corrosion product.	Transfer pin and movable contact missing. Stationary contact exhibits crack at similar location as that in Reddick sample.
C (1992 Town Car, Houston)	Burned	Elements from contact material detected at fitting end of hexport. Indicate possible flow of fluid back through seals. Black deposit in cavity currently being analyzed (possibly charred gasket).	Gasket appears charred. Environmental seal missing. Damage to Kapton seals currently being evaluated.	Deposits on face of cup contain elements from brass contacts indicating transfer of contact material to cup probably as oxide, sulfide, or corrosion product.	Base, stationary contact, movable contact, and terminals missing.
D (1997 Crown Victoria)	Apparent leakage.	Black residue containing glycol based material (probably brake fluid) and a metal oxide. Indicating presence of brake fluid on fluid and switch sides of seals.	Environmental seal and gasket intact and appear to have lost good coating. Kapton seals exhibit damage similar to that found in Reddick sample. All three exhibit brittle cracks which most likely formed a leak path.	Dark green deposits on face of cup contain elements from brass contacts indicating transfer of contact material to cup probably as oxide, sulfide, or corrosion product. Liquid in interior and on face of cup is glycol based (probably brake fluid).	Switch cavity and terminal cavity contain glycol based material (probably brake fluid). Contacts appear intact. Dark green deposits on movable and stationary contacts contain elements from brass contact material. Terminals appear clean (no apparent deposits or corrosion).
E ([illegible] from survey)	No leaks or other apparent problems.	Black residue containing glycol based material (probably brake fluid) and a metal oxide. Indicative presence of brake fluid on fluid and switch sides of seals.	Environmental seal and gasket intact and appear to have lost good coating. Kapton seals exhibit deformation and buckling similar to that found in Reddick sample. Coating on surfaces suggest [illegible] damage is occurring.	Face of cup appears clean and dry.	Switch cavity and terminal cavity appear clean and dry. No apparent deposits or corrosion.
F	Apparent leakage	Black residue containing glycol based material (probably brake fluid) and a metal oxide. Indicative presence of brake fluid on fluid and switch sides of seals.	Environmental seal and gasket intact and appear to have lost good coating. Kapton seals exhibit damage similar to that found in Reddick sample. All three exhibit brittle cracks which most likely formed a leak path.	Dark green deposits on face of cup contain elements from brass contacts indicating transfer of contact material to cup probably as oxide, sulfide, or corrosion product. Liquid in interior and on face of cup is glycol based (probably brake fluid).	Switch cavity and terminal cavity contain glycol based material (probably brake fluid). Stationary contact is intact, but does show stress corrosion cracking in progress at bridge area (same location as in Reddick switch). Movable contact appears to have separated as a result of loss of material (~50% of thickness) due to corrosion. No evidence of heating or arc damage. Dark green deposits on movable and stationary contacts contain elements from brass contact material, as well as sulfur. Terminals exhibit green deposits (currently being analyzed). Deposits extend [illegible] from both sides of bulkhead between switch and terminal cavities, but do not meet.

Brake Pressure Switch Test Log, Updated 6/30/99

Category	Test	Location	Test Parameters	Results Update
Lab Simulation of Potential Ignition in Switch	1	TI	Vary water concentrations in 'new' Brake Fluid 14Vdc to one terminal, hexport grounded Water Conc: 4%, 8%, 16%, 75%	250+ hours, Current draw in the 0.5mA to 5mA range Fluid has discolored. No Significant Temperature Rise. Test Suspended Internal Analysis suspended.
	2	TI	New Brake Fluid 1 Amp through switch terminals 14Vdc to one terminal, hexport grounded	250+ hours. Constant temperature. No significant temperature rise with time Test Suspended.
	3	AVT	new' Brake Fluid in Switch, 24 VDC to one terminal. Hexport Grounded	> 300 hours into test, max current 7mA No significant change with time. Test suspended
	4	AVT	new' Brake Fluid in Switch, 24 VDC to one terminal. Hexport Grounded, Ambient at 100 C	16 hours into test max current 5mA No significant temperature rise with time. Test suspended.
	5	AVT	new' Brake Fluid in Switch, 16 Amps Through switch terminals	Temperature rise of 20 C above room temp Delta T reached steady state at 20 C. Test suspended.
	5a	AVT	new' Brake Fluid in Switch approx. 50 Amps through Switch Terminals	Temperature rose to approx. 270 F. No smoke. No ignition. Test suspended.
	6	TI	Build heater elements into Switch. Heat till failure, include sparking. (1) w/ solution of Brake Fluid and 6 wt. % H_2O	3 tested. Smoke observed, ignition observed on part wheeler See attachment Test complete Brake fluid in cavity slows down heat build-up Smoke observed at 575 F, Base melts and falls off at 800 F
	6a	TI	Create heater by corroding spring arm Salt water solution, 14V between spring and hexport	One out of 15 devices increased resistance to 5 ohms. Others either very low resistance or megaohms It took about 100 hours to reach the 5 ohm stage. The 5 ohm device ignited under conditions similar to test 6.
	6b	TI	Re-run ignition test to understand repeatability and current path.	Switch ignition with repeated 5% water solution into switch Current path is through hexport. See plots and video. Additional test include tap water, old BF, new BF and other.
	6c	TI	Pure 'new' brake fluid with metal shavings	Metal shavings do not contribute significantly to brake fluid

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Brake Pressure Switch Test Log, Updated 6/30/99

				conductivity
Life Cycle Reliability	7	TI	0-1400 psig pressure pulses at 135C	First leak observed at 726,000 cycles.
of Pressure Switch			per EB	Test Completed. See attached Weibull Chart.
Diaphragm Wear	8	TI	0-1400 psig pressure pulses at 135C.	Parts withdrawn every 200k cycles, characterized for wear
Field vs Lab Correlation	9	Central Labs	Field returns, from dealer lots, junkyards	Parts in Central Labs, see Ford spreadsheet
Design Of Experiments (1)	10	TI	Vary water concentrations in 'new' Brake Fluid	Test Report being written investigation continues.
Evaluating Factors			12 snap + 12 quiet switches w/ 0 % water in BF	Suspended at 1.3 million cycles with no leaks observed.
Effecting Diaphragm Wear			12 snap + 12 quiet switches w/ 5 % water in BF	Snap samples suspended at 1.3 million cycles with 2 leaks
Impulse test				observed at 1.3M. Quiet samples suspended at 500k cycles to
				assess fixturing anomalies.
On-Vehicle Characterization	11	AVT	Monitor Pressure and Temperature	Test at AVT.....see Ford charts...>500k in car?
of Pressure & Temperature			at Switch Location for ABS and non-ABS	
Profile in Town Car			braking events.	
Brake fluid analysis	11a	TI	Analyze used brake fluid at the master cylinder	Test complete.
Used fluid at master cylinder.			(UMC), used brake fluid at the caliper (UCA)	UMC: Cu = 416 (ug/ml), Fe = 5.6 (ug/ml), Cr = 0.80 (ug/ml), 1.1 %H2O.
			and new brake fluid (NEW) for metal and water	UCA: Cu = 582 (ug/ml), Fe = 5.5 (ug/ml), Cr = 1.9 (ug/ml), 1.1 %H2O.
			content.	NEW: Cu = <0.01 (ug/ml), Fe = 0.02 (ug/ml), Cr = <.01 (ug/ml), 0.3 %H2O.
Spark /Arc Study	12	Central Labs	Determine if arc/spark forms in switch	Equipment set-up in progress at Central Labs.
			using clutch loads and high speed video.	TI Experimented with no 'significant' sparks observed
			Use dry switches as well as switches with	
			various brake fluid water mixes.	
Characterization of	13	Central Labs	Characterize electrical, mechanical	Data log and analysis procedure set up complete.
switches retrieved from field			and chemical aspects of returned switches	Analysis of switches in progress.
junkyards & other sources				
Fluid Ingress Tests	13a	TI	Repeat ignition simulation with different fluids.	Test complete.
			(3) hour tests:	5% NaCl sample resulted in an ignition.
			5% NaCl in tap water	All brake fluid samples draw less than 3 mAmps. No corrosion
			rain water	visible on brake fluid samples.
			(24) hour tests:	Rain water and tap water samples draw <15 mAmps and showed
			tap water	some signs of corrosion.

TI-NHTSA 014213

Brake Pressure Switch Test Log, Updated 8/30/99

			used brake fluid	Chemical anlysis in process.
			used brake fluid w/ 5% H_2O	
			new brake fluid	
			new brake fluid w/ 5% H_2O	
Design Of Experiments (2)	13b	TI	Vary water concentrations in 'new' Brake Fluid	Test suspended. Analysis in process to assess test failures.
Repeat of test 10			10 snap + 20 quiet switches w/ 0 % water in BF	
			10 snap + 20 quiet switches w/ 5 % water in BF	
Compatibility of Kapton	14	Dupont	Characterize change in properties of Kapton	Test in progress (100) hours completed. Oxalic acid shows
with Oxalic Acid			with various % oxalic acid in brake fluid.	similar effects that water has on Kapton properties.
Evaluation of Plastic	15	TI	Assess properties and moldability of different	Test suspended.
Materials with Improved			grades of plastic resin with additives	Celanese and Noryl ignited 3/5 and 2/5 trials
Parameters			to improve plastic part performance	ZYTEL samples tested 1/5 ignitions
Long duration brake fluid	16a	TI	(4) samples with new brake fluid	Test suspended (500) hours completed.
ingress test.			(2) samples with used brake fluid	Used brake fluid current dropped off to <1/10 mAmp.
				New BF leakport current was increases w/ time under cont. power.
Evaluation of Switch	16b	TI	Assess ignition sensitivity to switch orientation.	Test complete. Ignition is independent of switch orientation.
Orientation			Test vertical verses 45 degree.	simulated switch ignition can occur in vertical or 45 degree angle.
			Test rotational sensitivity in 45 deg. orientation.	Ignition appears not sensitive to switch rotational alignment.
Relay Circuit	16	TI	Repeat test 13a in Ford relay circuit for (48) hrs.	Test complete. No ignition. Corrosion rate drastically reduced.
Test			Bring switch to impending ignition in (15) Amp	Insufficient power in circuit to create or move toward ignition in lab
			circuit then place in relay circuit for (16) hrs.	Heater element was warm to the touch.
			Input relay circuit power into heater on switch.	
Long duration brake fluid	17	TI	(60) samples filled with new brake fluid	Test suspended. (812) hours completed.
ingress test number 2.			(1) hour of vibration per day	Average leakport current is 1.9 mAmp (stdeviation = 1.8 mAmps)
			(1) hour soak at 100 deg C per day	

TI-NHTSA 014214

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.

TI-NHTSA 014215

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.

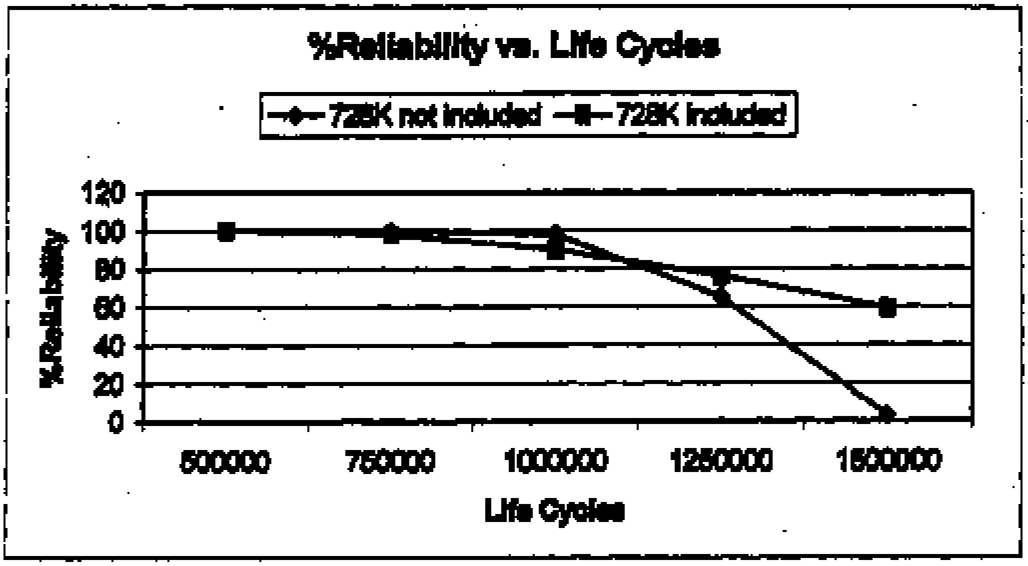
Weibull Failure Analyses were performed on the data.
Figure 1 (page 4 of this report) shows the results where the 728K data point was included in the analysis. It shows a 90% Reliability at 1,000,000 cycles.
Figure 2 (page 5 of this report) shows the results where the 728K data point was excluded in 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

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.

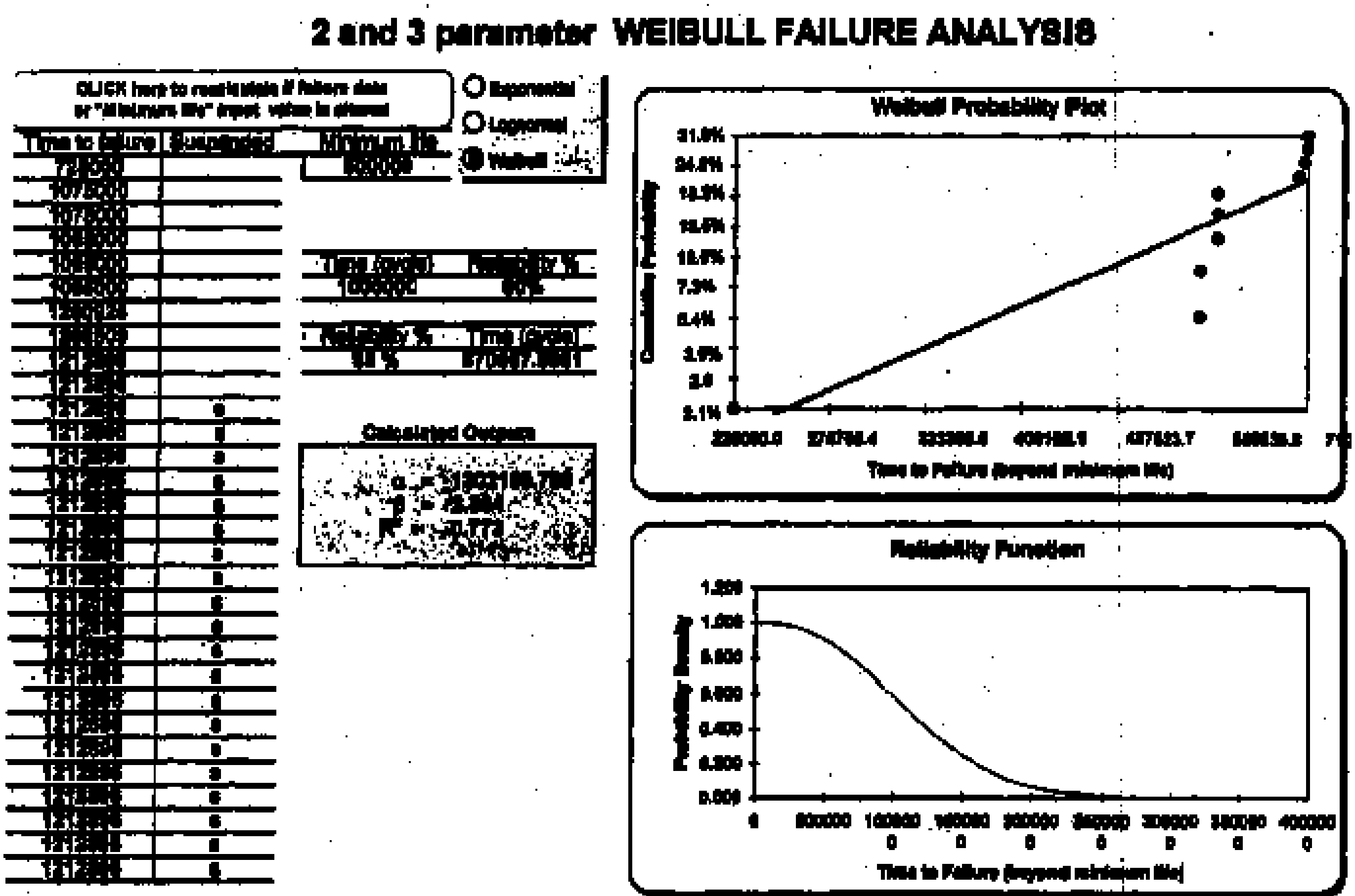
R^2 is the Coefficient of Determination

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 Mulligan

Figure 1.



NOTES: 77PS 725K cycle data point included in analysis

Figure 2.

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
1075000	
1075000	
1089000	
1089000	
1094000	
1200000	
1205000	
1212000	
1212095	
1212095	s
1212095	s
1212095	s
[illegible]	s
[illegible]	s
[illegible]	s
[illegible]	s
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Minimum life
600000

Time (cycle)	Reliability %
1000000	[illegible]%

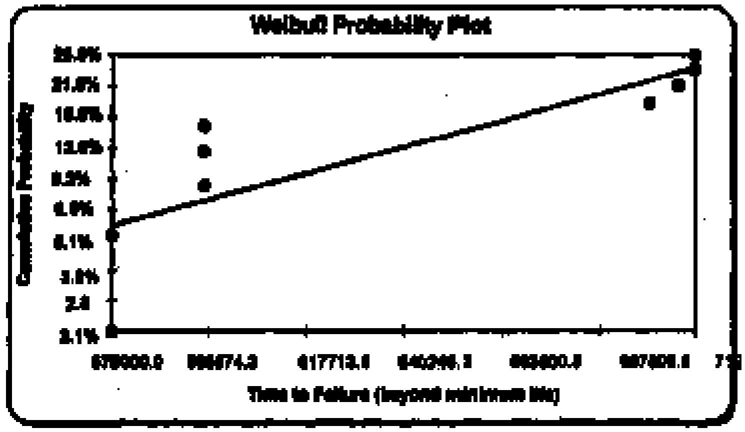
Reliability %	Time (cycle)
[illegible] %	1062142.1[illegible]

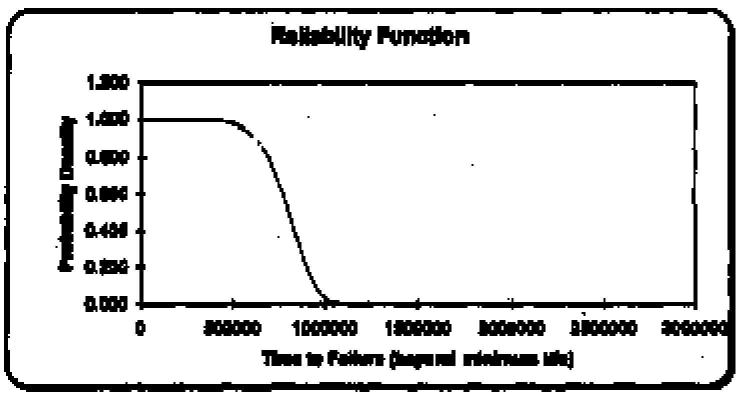
Calculated Outputs

α = 641856.762

β = 7.365

R^2 = 0.675



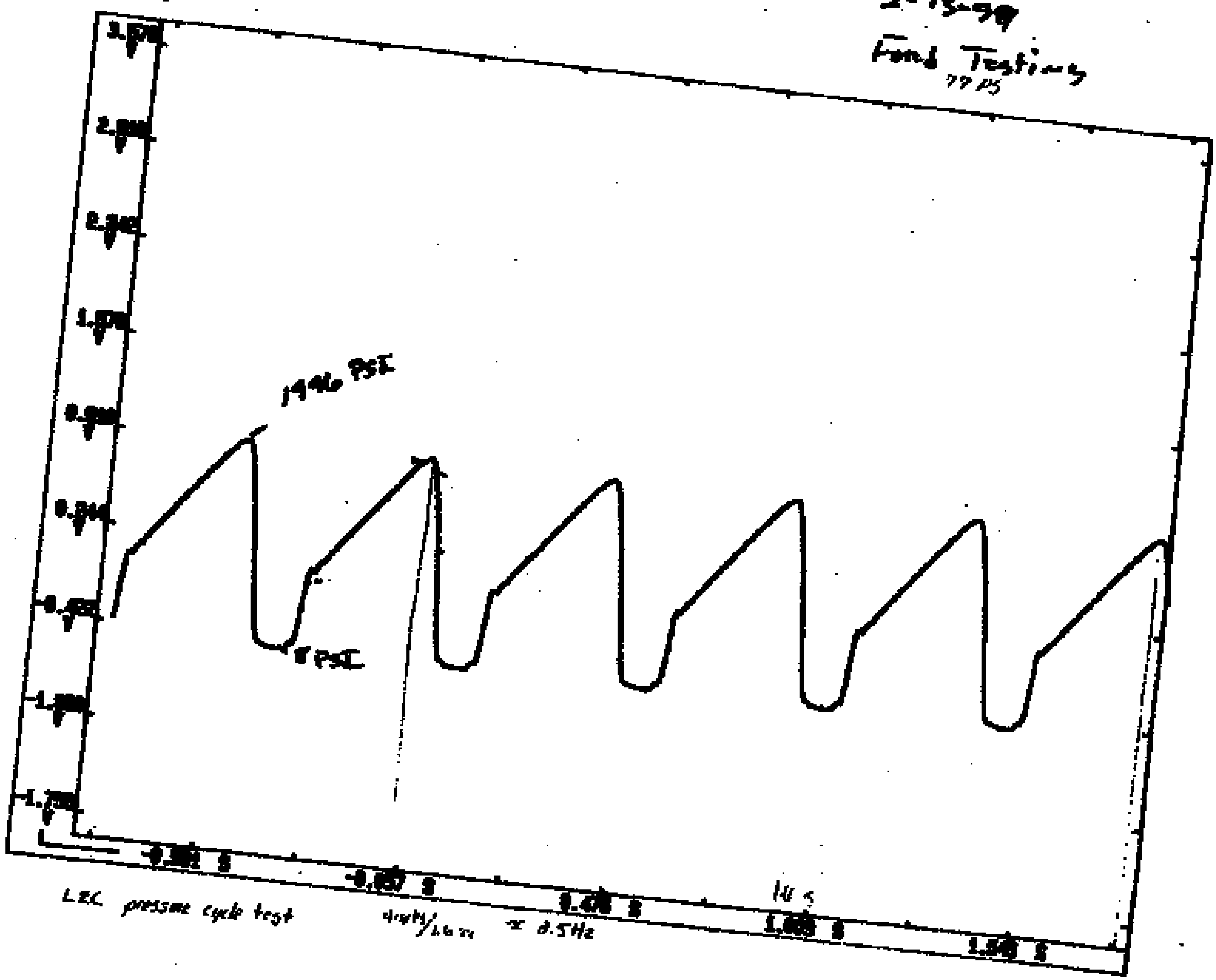


NOTES: 77PS 725K cycle data point not included in analysis

TI-NHTSA 014219

Oven = 135°C

2-13-99
Ford Testing



3/30/99

DOE 2

Group	Switch	% Water Fluid
G1	77PSL2-1	0
G2	77PSL3-1	0
G3	77PSL4-1	0
G4	77PSL2-1	5
G5	77PSL3-1	5
G6	77PSL4-1	5

3/30/99

measured [illegible] @ manifold

DOE 2

GROUP: G1

DESCRIPTION: 77PSL2-1 w/ 0% water in brake fluid

DEVICE #	CYCLES (K)	FORD LOAD APPLIED (Y/N)	LEAKAGE MODE
G1-	1027		[illegible]
G1-	1027		[illegible]
G1-	1027		[illegible]
G1-	1027		[illegible]
G1-	1027		[illegible]
G1-	1027		[illegible]
G1-	1027		[illegible]
G1-	1027		[illegible]
G1-	1027		[illegible]
G1-	1027		[illegible]

GROUP: G2

DESCRIPTION: 77PSL3-1 w/ 0% water in brake fluid

DEVICE #	CYCLES (K)	FORD LOAD APPLIED (Y/N)	LEAKAGE MODE
G2-	861		
G2-	1027		[illegible]
G2-	1027		[illegible]
G2-	1027		[illegible]
G2-	1027		[illegible]
G2-	1027		[illegible]
G2-	1027		[illegible]
G2-	1027		[illegible]
G2-	1027		[illegible]
G2-	1027		[illegible]

GROUP: G3

DESCRIPTION: 77PSL4-1 w/ 0% water in brake fluid

DEVICE #	CYCLES (K)	FORD LOAD APPLIED (Y/N)	LEAKAGE MODE
G3-	461		
G3-	710		
G3-	737.6		
G3-	766.1		
G3-	804.1		
G3-	909		
G3-	919		[illegible]
G3-	919		[illegible]
G3-	919		[illegible]
G3-	919		[illegible]

3/30/99

DOE 2

GROUP: G4

DESCRIPTION: 77PSL2-1 w/ 5% water in brake fluid

DEVICE #	CYCLES (K)	FORD LOAD APPLIED (Y/N)	LEAKAGE MODE
G4-	432.6		
G4-	436.1		
G4-	478		
G4-	491.8		
G4-	497.8		
G4-	518.8		
G4-	518.8		s
G4-	518.8		s
G4-	518.8		s
G4-	518.8		s

GROUP: G5

DESCRIPTION: 77PSL3-1 w/ 5% water in brake fluid

DEVICE #	CYCLES (K)	FORD LOAD APPLIED (Y/N)	LEAKAGE MODE
G5-	297		
G5-	297		
G5-	305		
G5-	337		
G5-	347.5		
G5-	374.5		
G5-	389		
G5-	409.5		
G5-	412		
G5-	518.8		s

GROUP: G6

DESCRIPTION: 77PSL4-1 w/ 5% water in brake fluid

DEVICE #	CYCLES (K)	FORD LOAD APPLIED (Y/N)	LEAKAGE MODE
G6-	243		
G6-	281		
G6-	297		
G6-	297		
G6-	305.2		
G6-	324.7		
G6-	337.2		
G6-	337.2		
G6-	337.2		s
G6-	337.2		s

Figure 2.

2 and 3 parameter WEIBULL FAILURE ANALYSIS

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

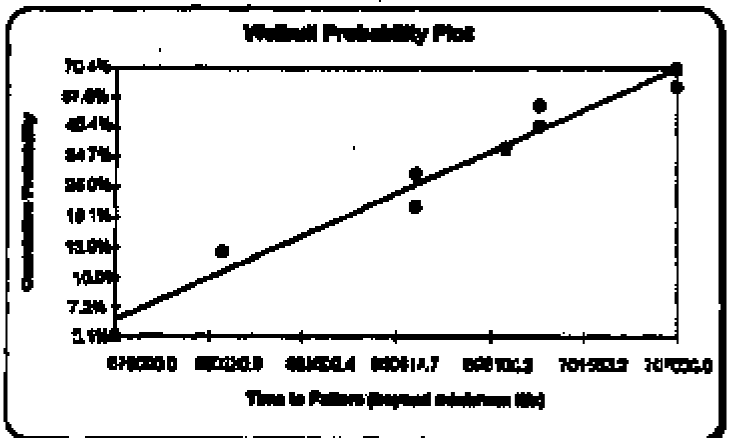
1170000	
1181000	
1182000	
1192000	
1197000	
1198000	
1199000	
1307000	
1307000	
1324000	6
1324000	6
1324000	6

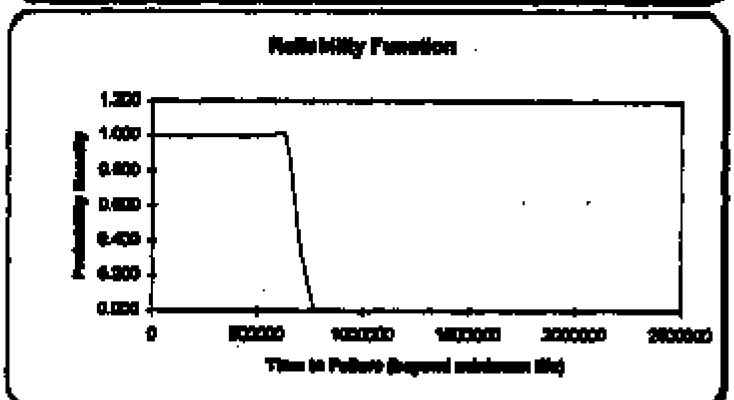
500000

1000000	100%

90 %	1160355.7[illegible]

Calculated Outputs





NOTES: DOE 1 Group 2: 77PSL4-1 (no snap) w/ 0% water in brake fluid.

TI-NHTSA 014224

Figure 2.

2 and 3 parameter WEIBULL FAILURE ANALYSIS

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

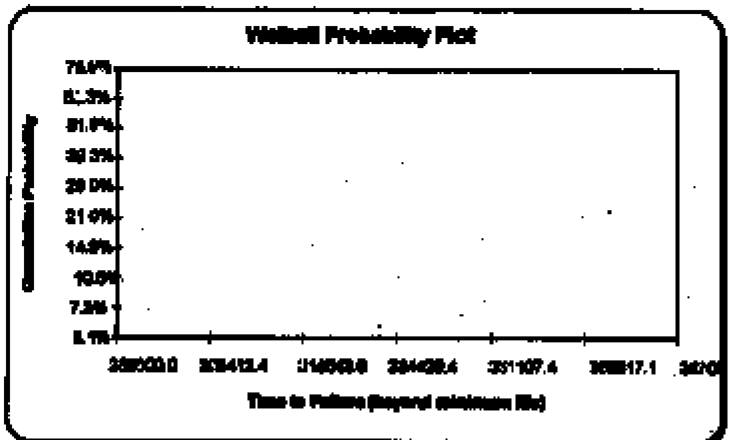
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

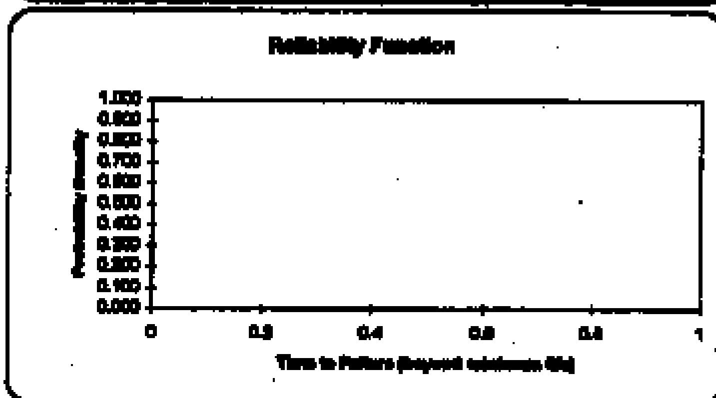
[illegible]

[illegible]	#NUM!

[illegible] %	#NUM!

Calculated Outputs



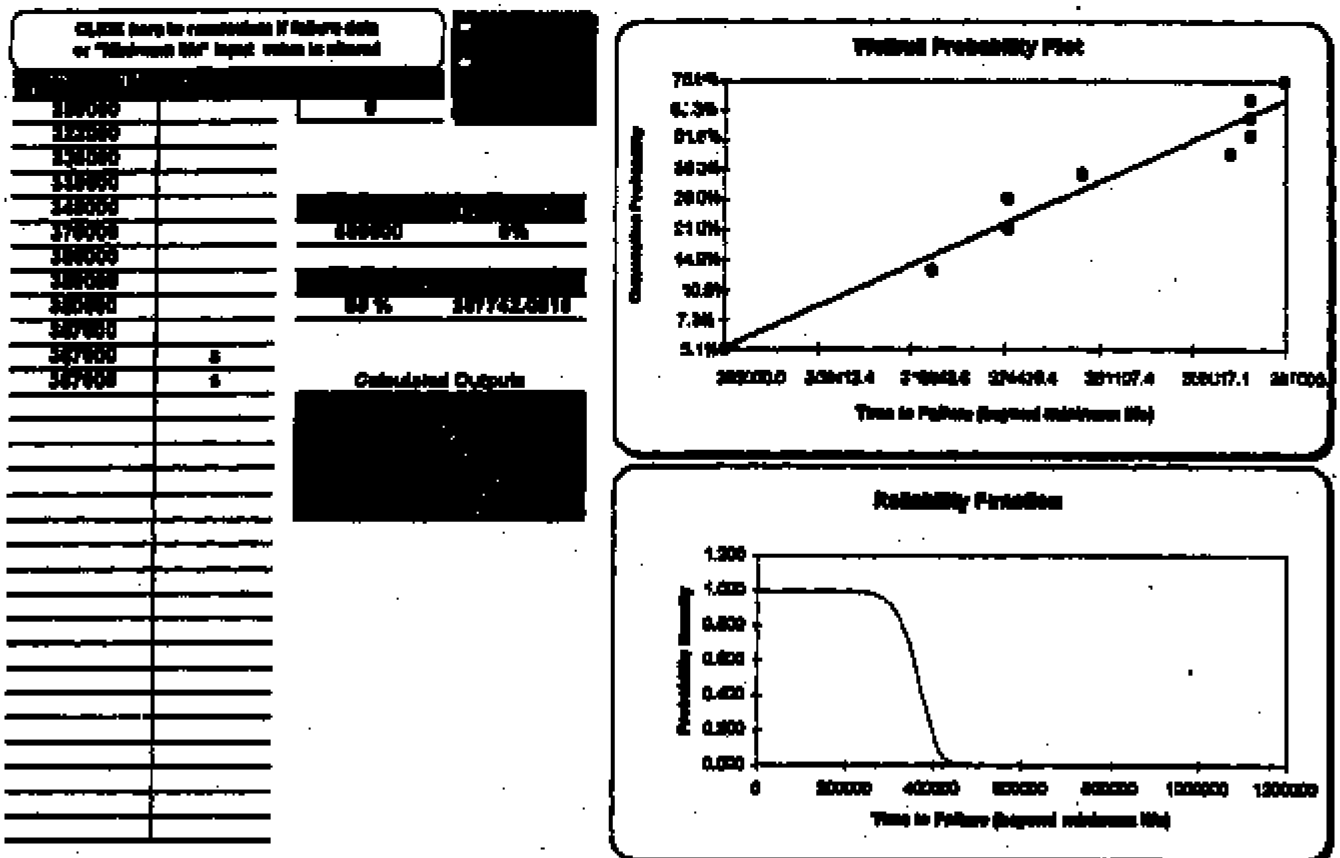


NOTES: DOE 1 Group 1: 77PSL2-1 (w/ wrap) w/ 0% water in brake fluid.

TI-NHTSA 014226

Figure 2.

2 and 3 parameter WEIBULL FAILURE ANALYSIS



NOTES: DOE 1 Group 4: 77PSL4-1 (no snap) w/ 6% water in brake fluid.

TI-NHTSA 014226

Figure 2.

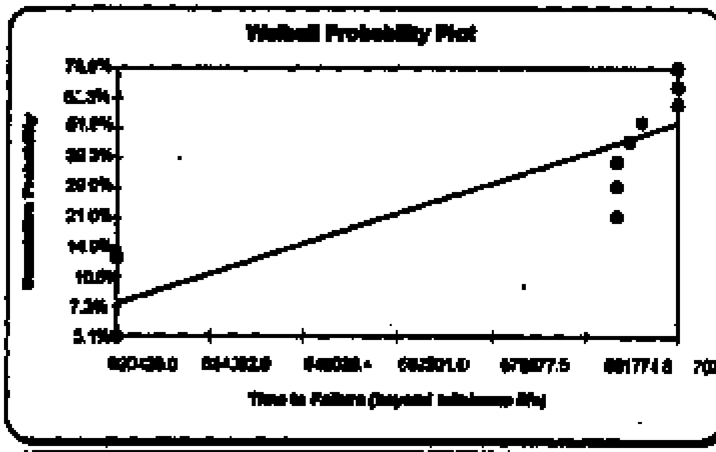
2 and 3 parameter WEIBULL FAILURE ANALYSIS

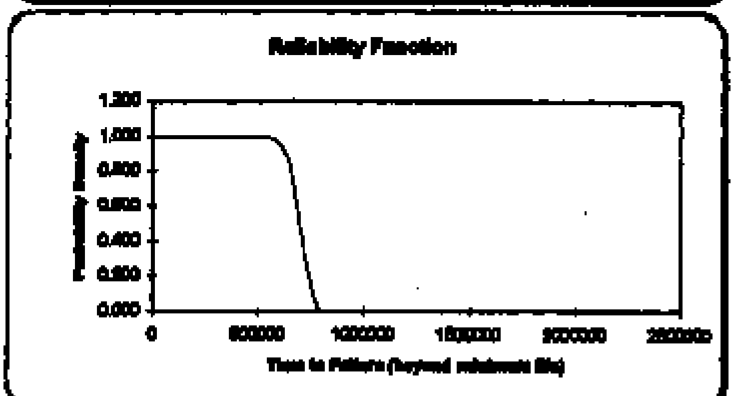
CLICK [illegible]

[illegible]		[illegible]	
1195430			
1195430			
1197000			
1197000			
1197000		[illegible]	[illegible]
1199000		1050000	100%
1201000			
1207000		[illegible]	[illegible]
1207000		90 %	1108221.861
1207000			
1207000	0		
1207000	0		

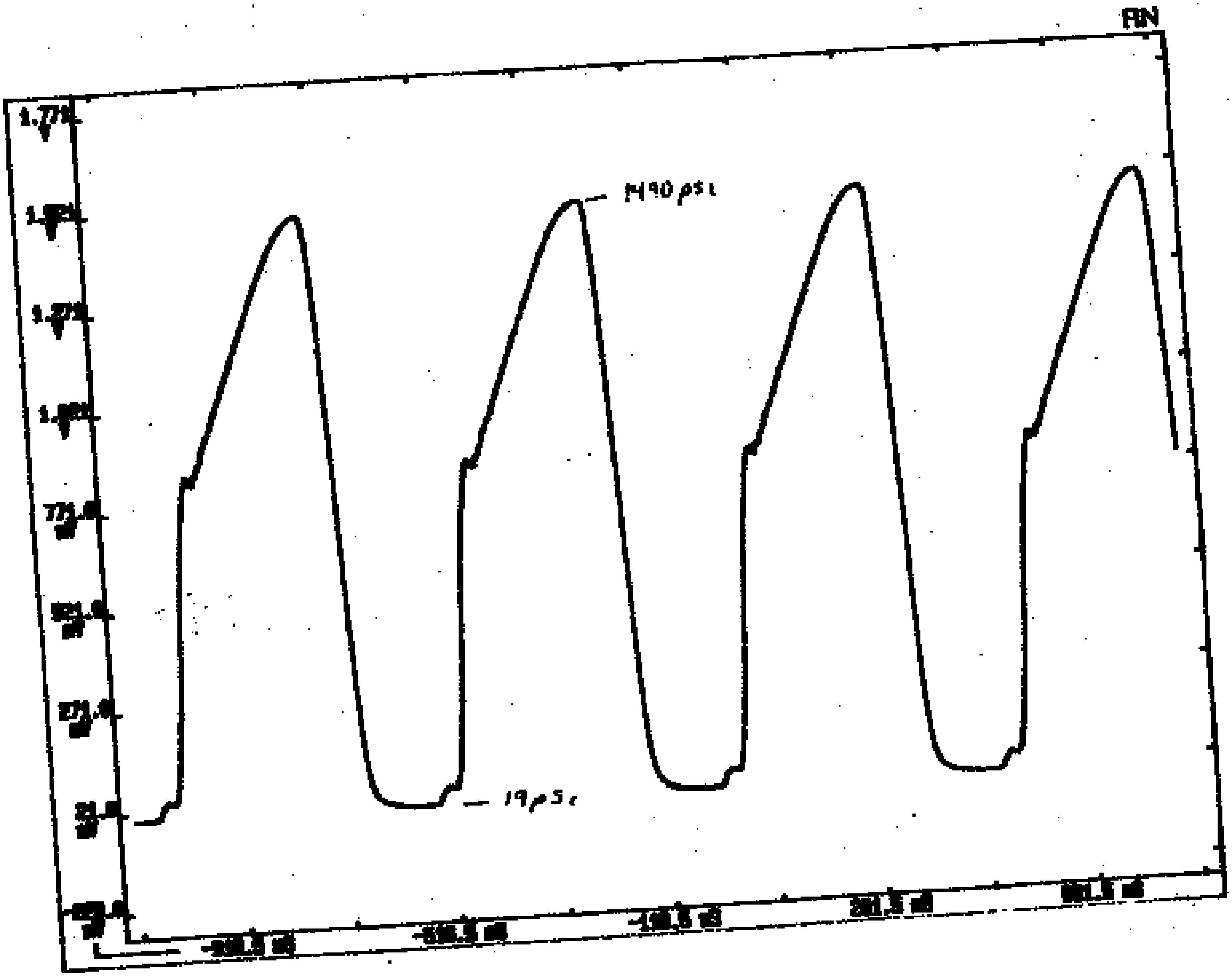
Calculated Outputs

[illegible]



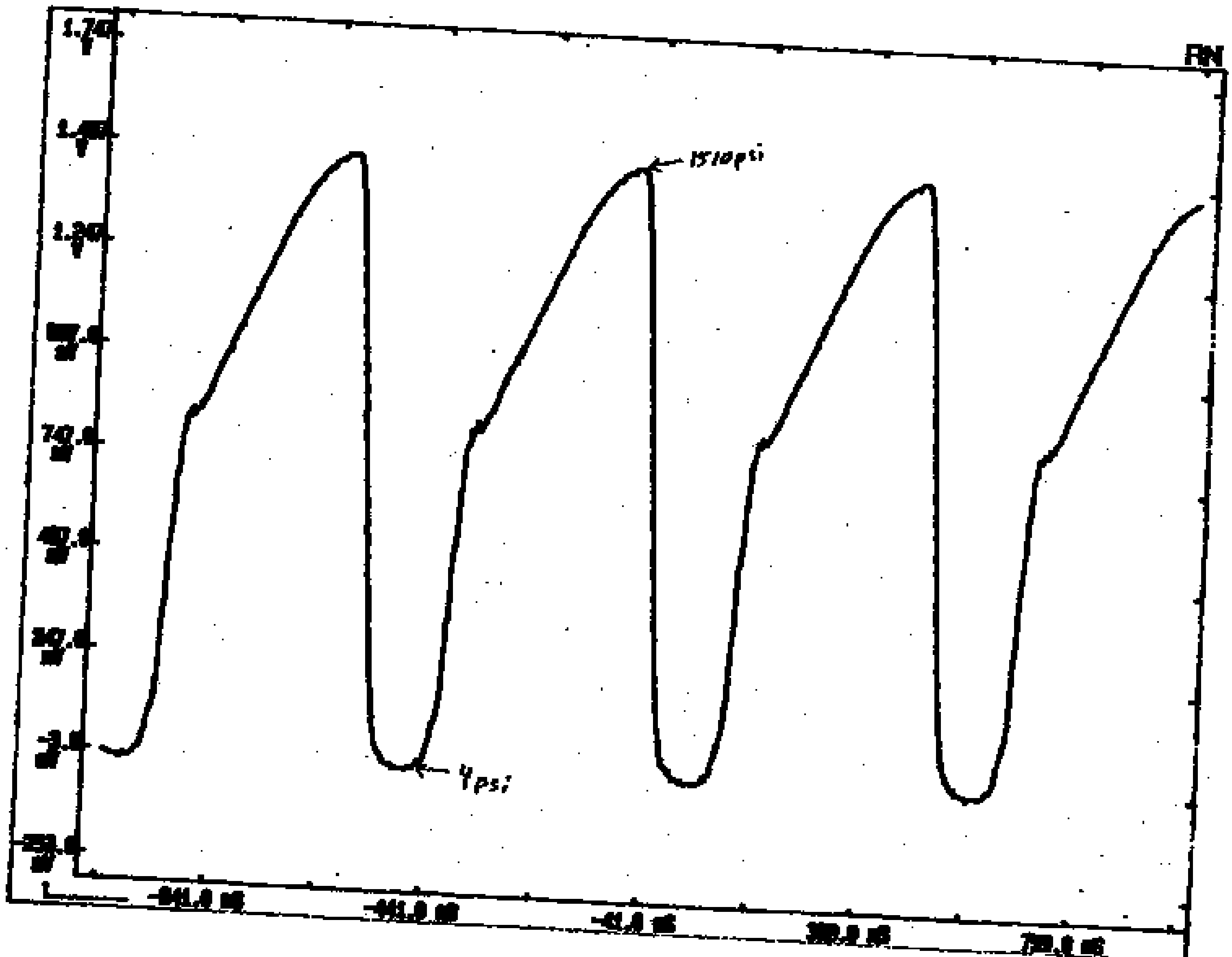


NOTES: DOE 1 Group 3: 77PSL2-1 (w/ wrap) w/ 6% water in brake fluid.



3/30/99

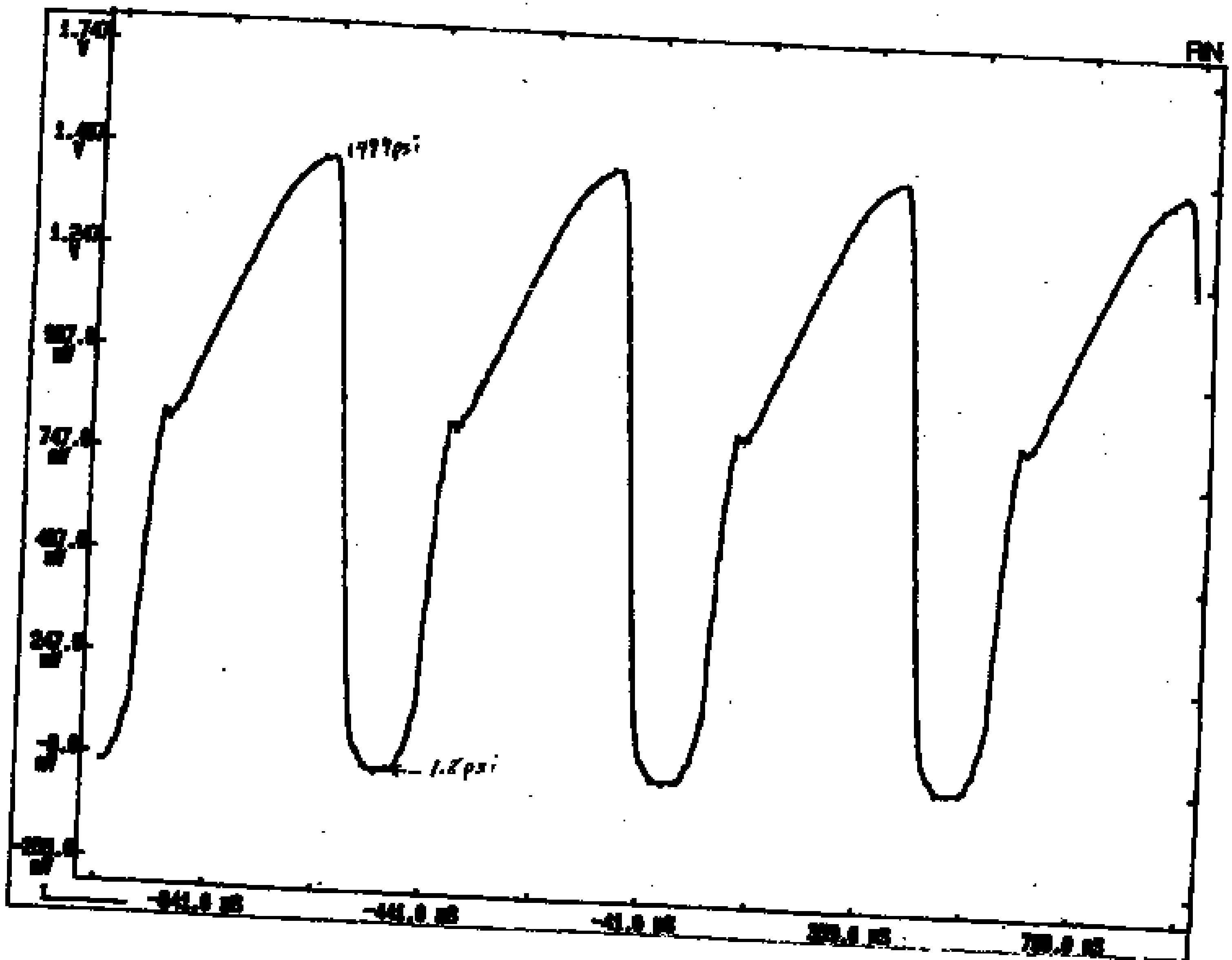
1mV = 1psi



75% brake fluid solution
5% Tap H_2O

2/19/99
0950 HRS

T-NHTSA 014229

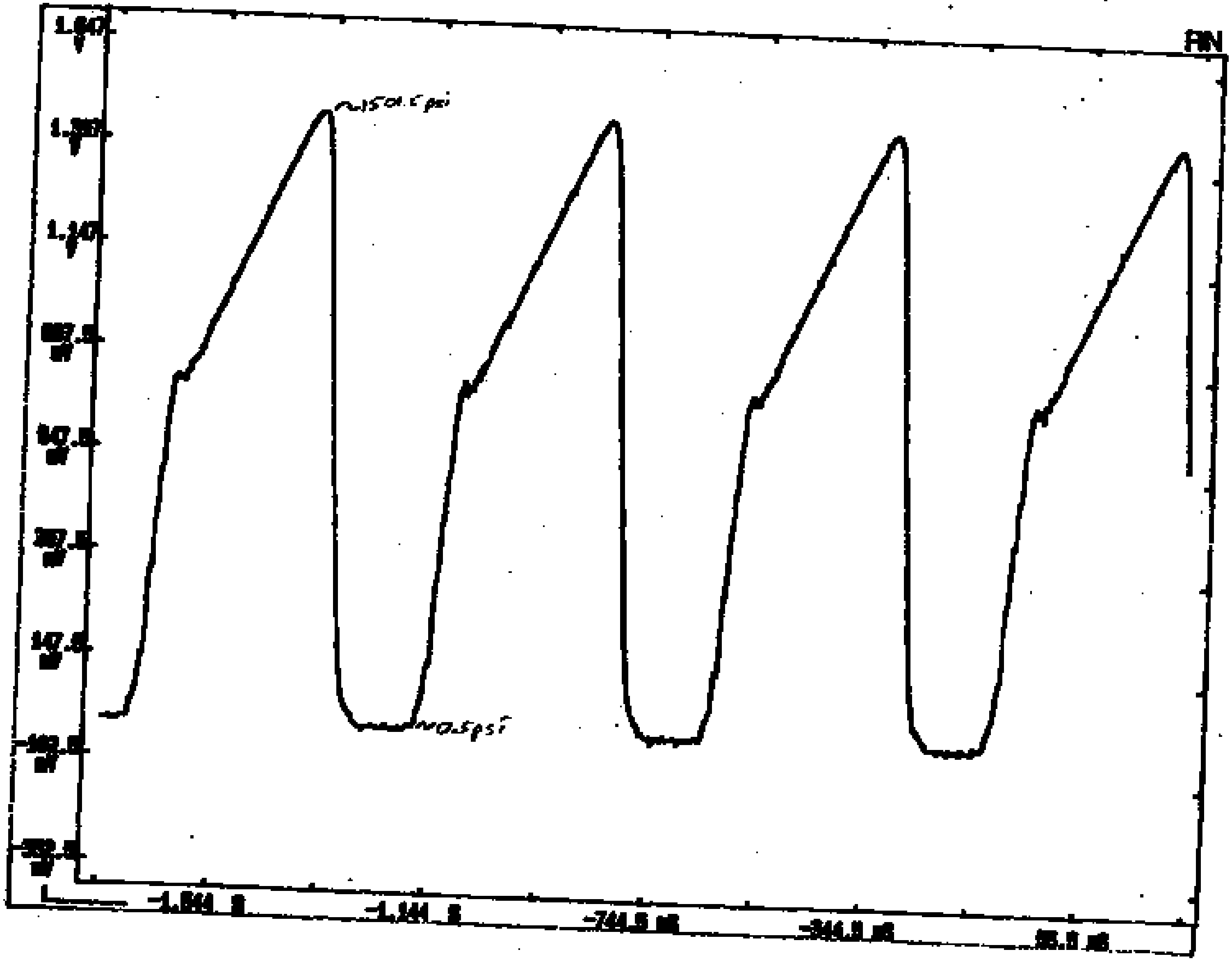


1mV=1psi

3/18/99
0945 HRS

100% brake fluid

1mV=1psi

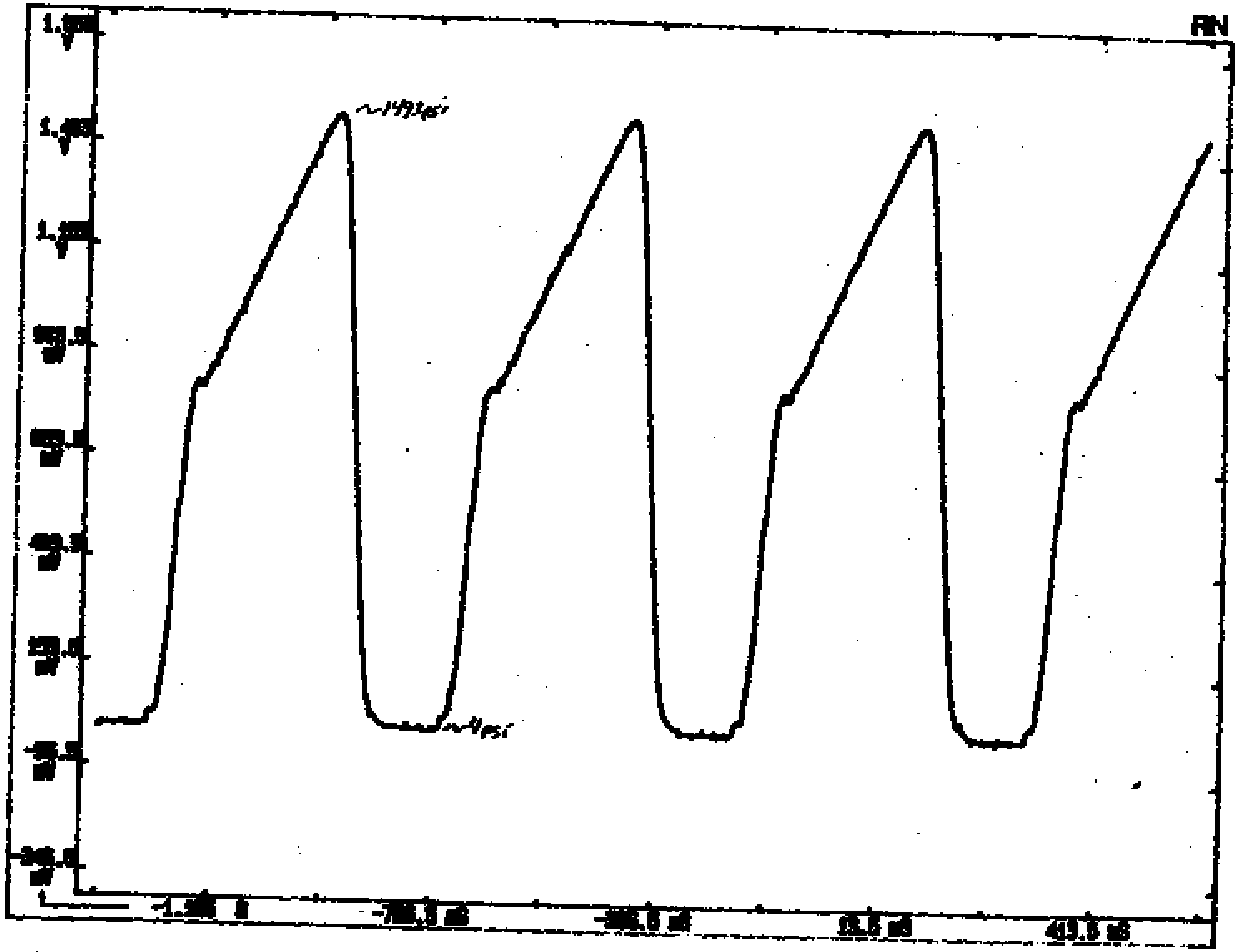


TI-NHTSA 014231

3/15/99
Time 0905

10% Brake

1 mV = 1 psi



TI-NHT78A 014232

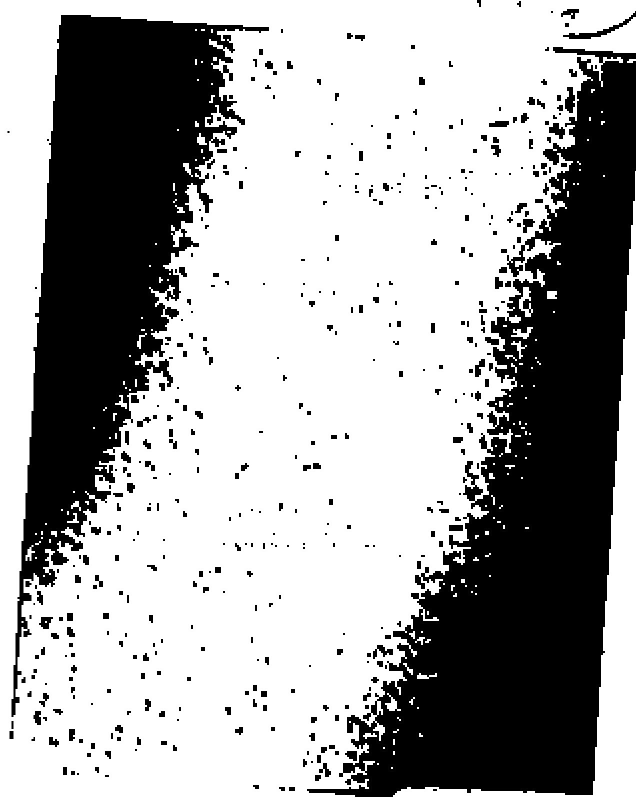
3/18/99
Time 0915

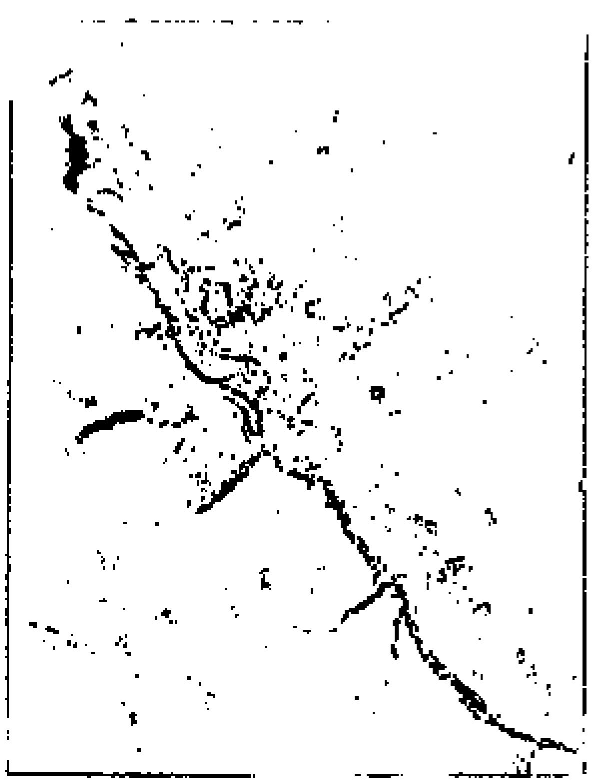
5% H_2O (tap)
95% brake fluid

1-1

2-1 (10X)

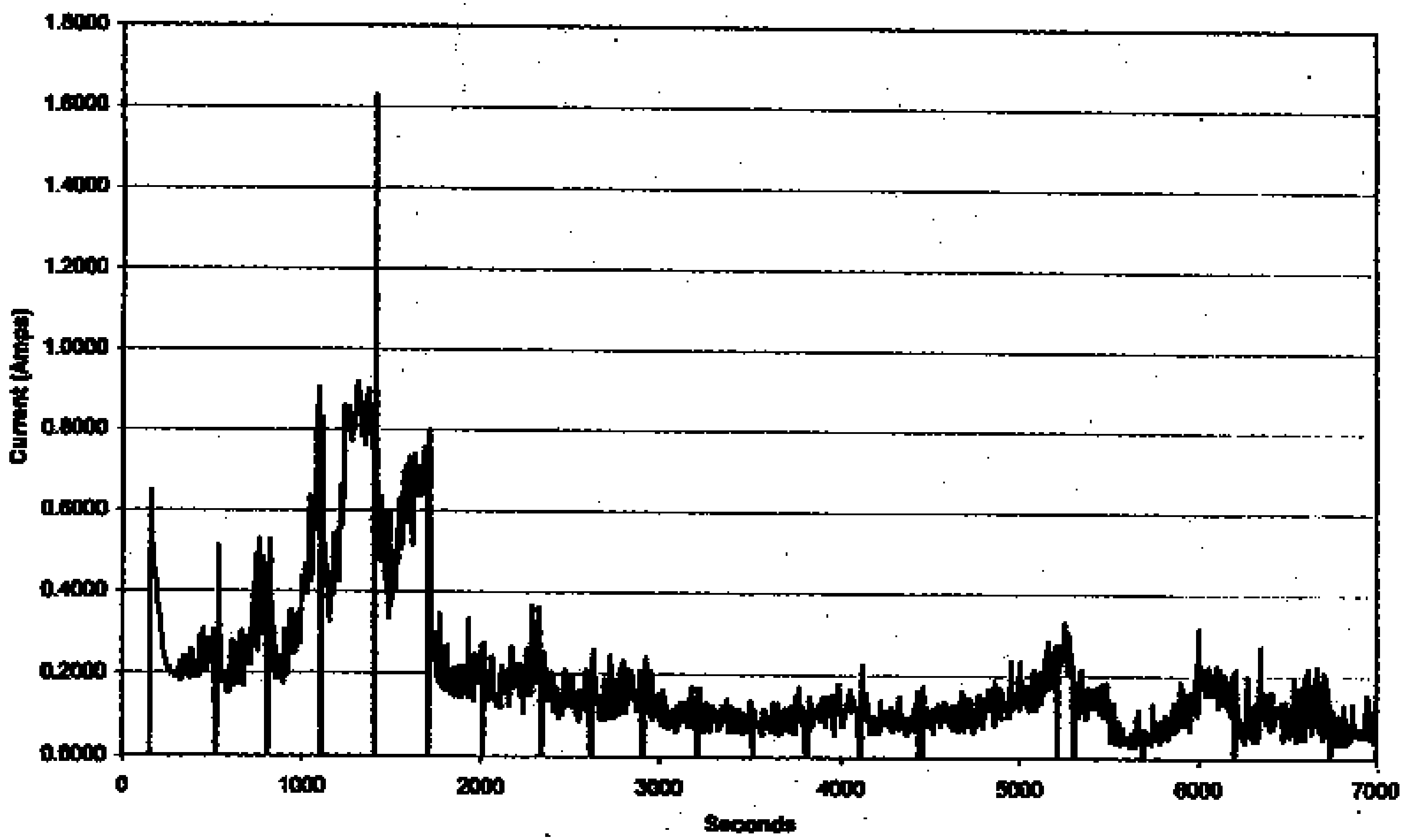
1-1





TI-NHTSA 014234

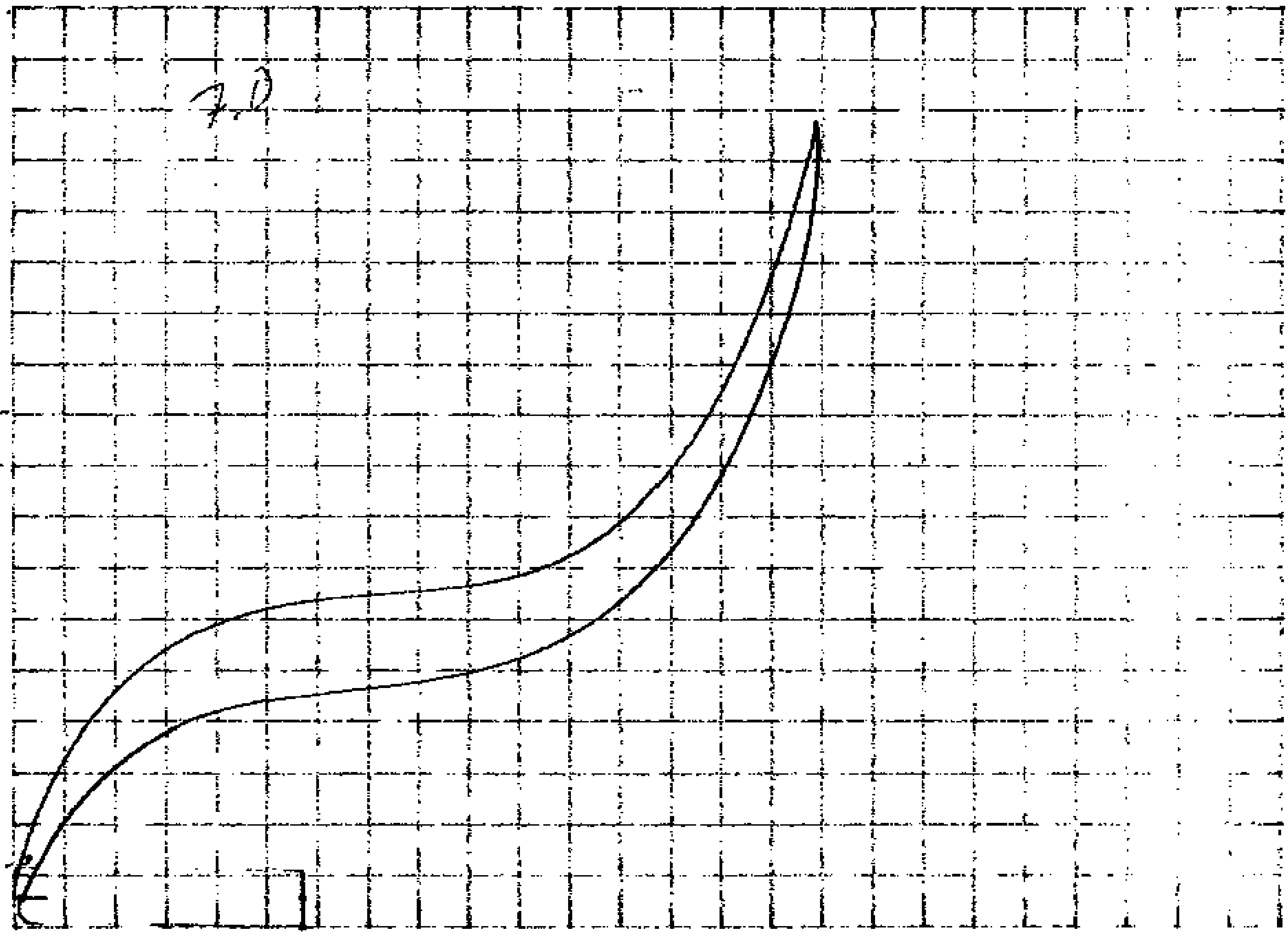
Hexport Current vs. Time
Noryl BASE_1 5% Salt Water Ingress Experiment



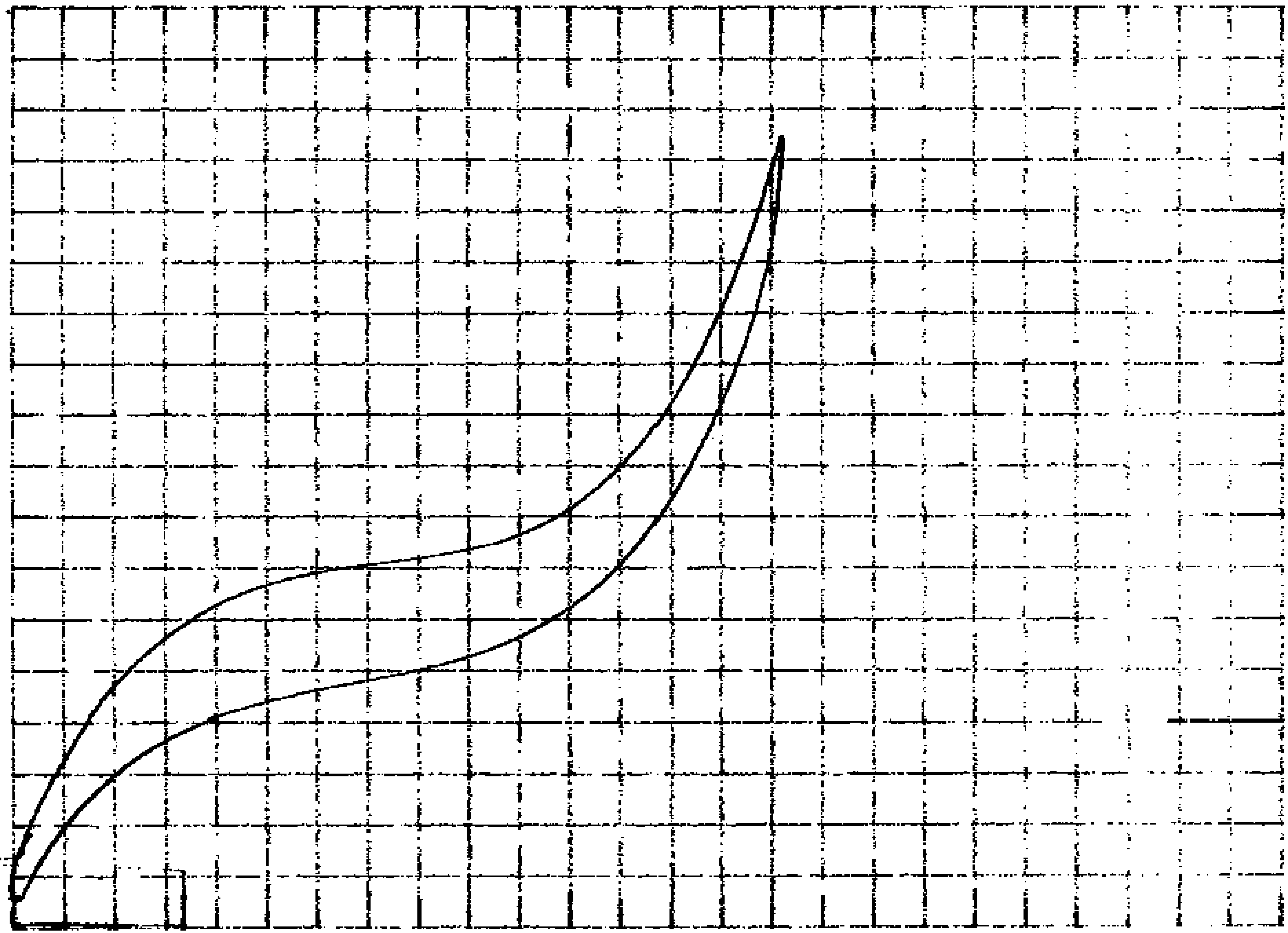
TI-NHTSA 014235

DRAWINGS AVAILABLE UPON REQUEST

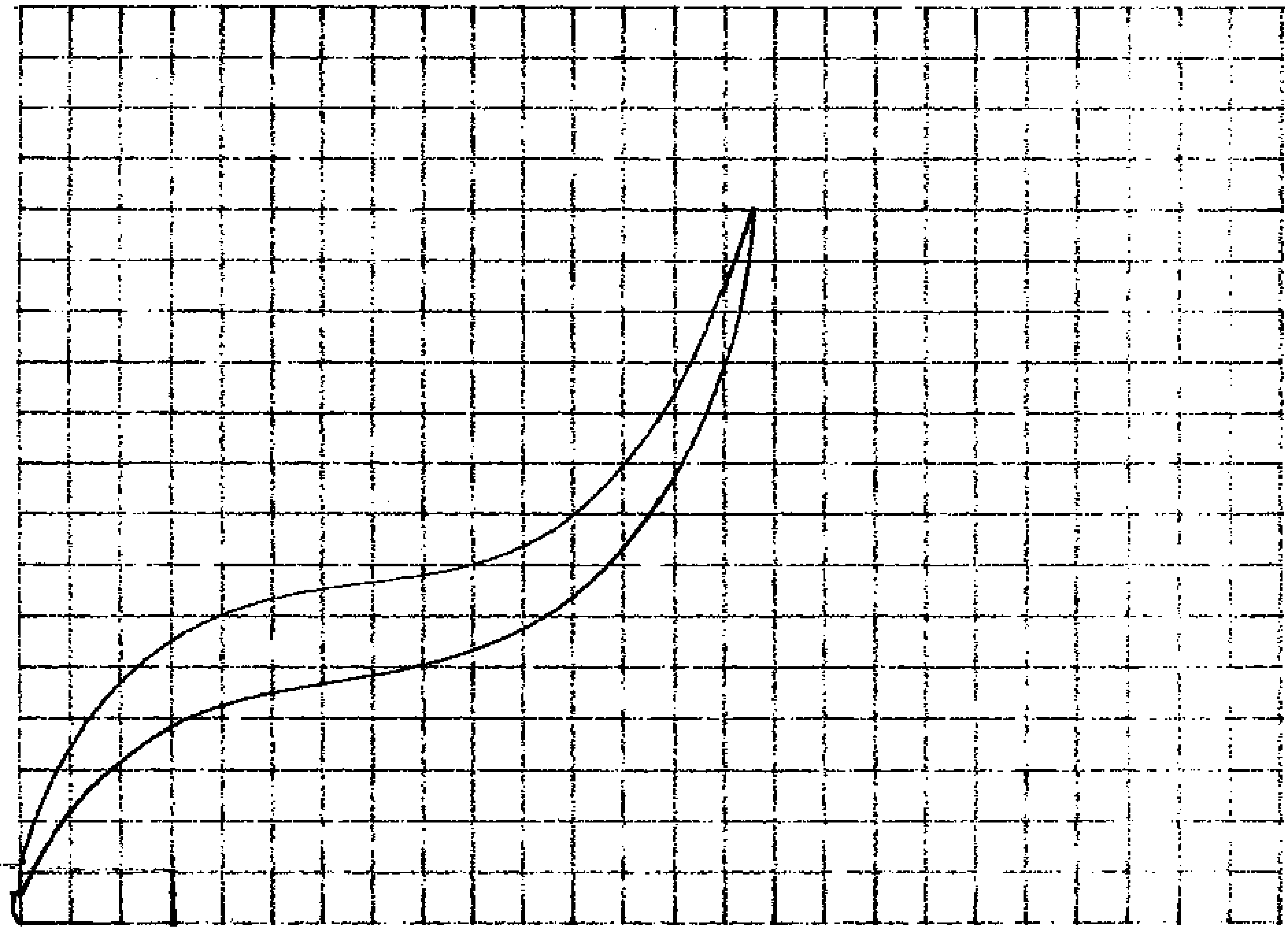
7-19-99 LF 1



7-19-99 LF2

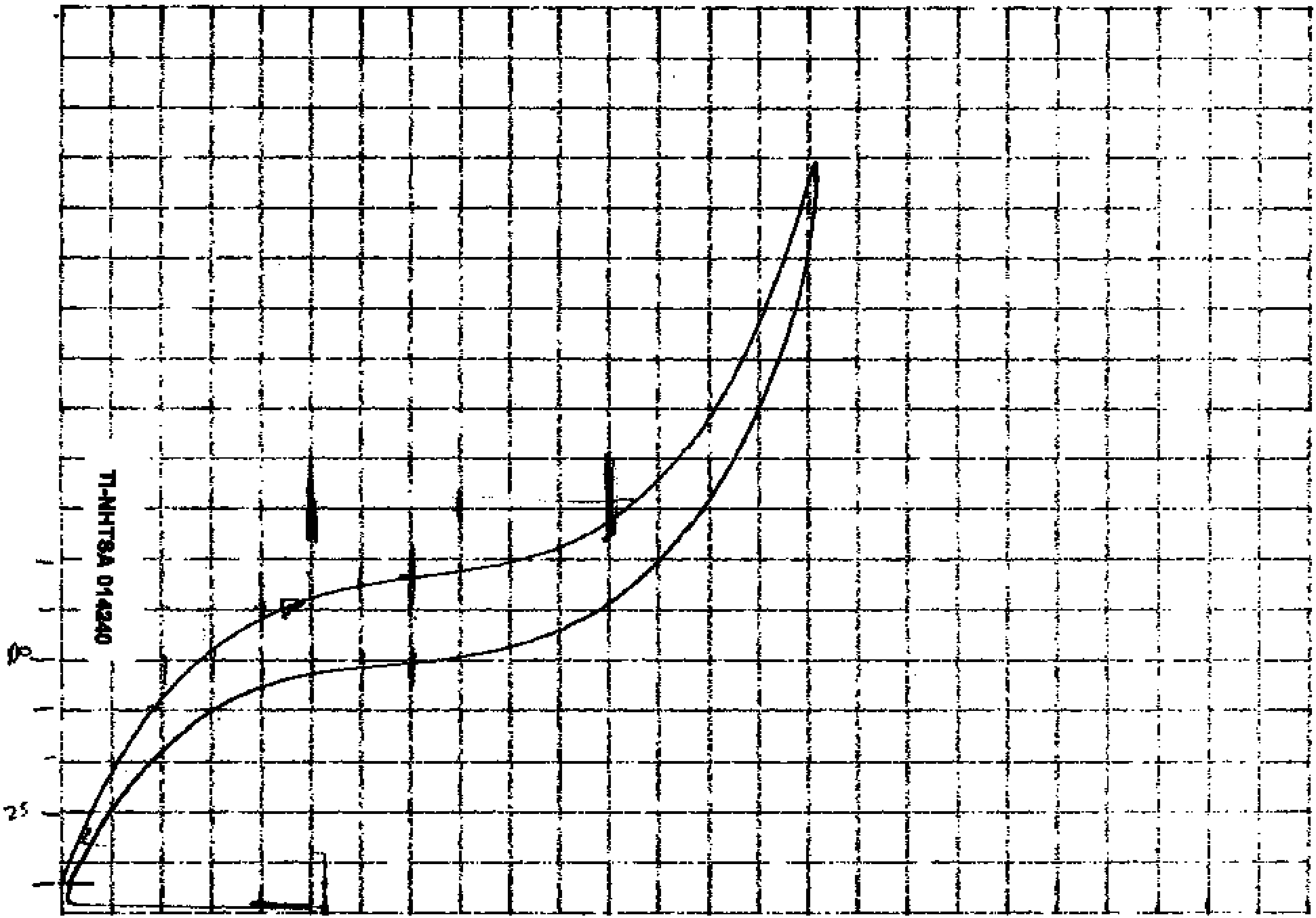


LF3



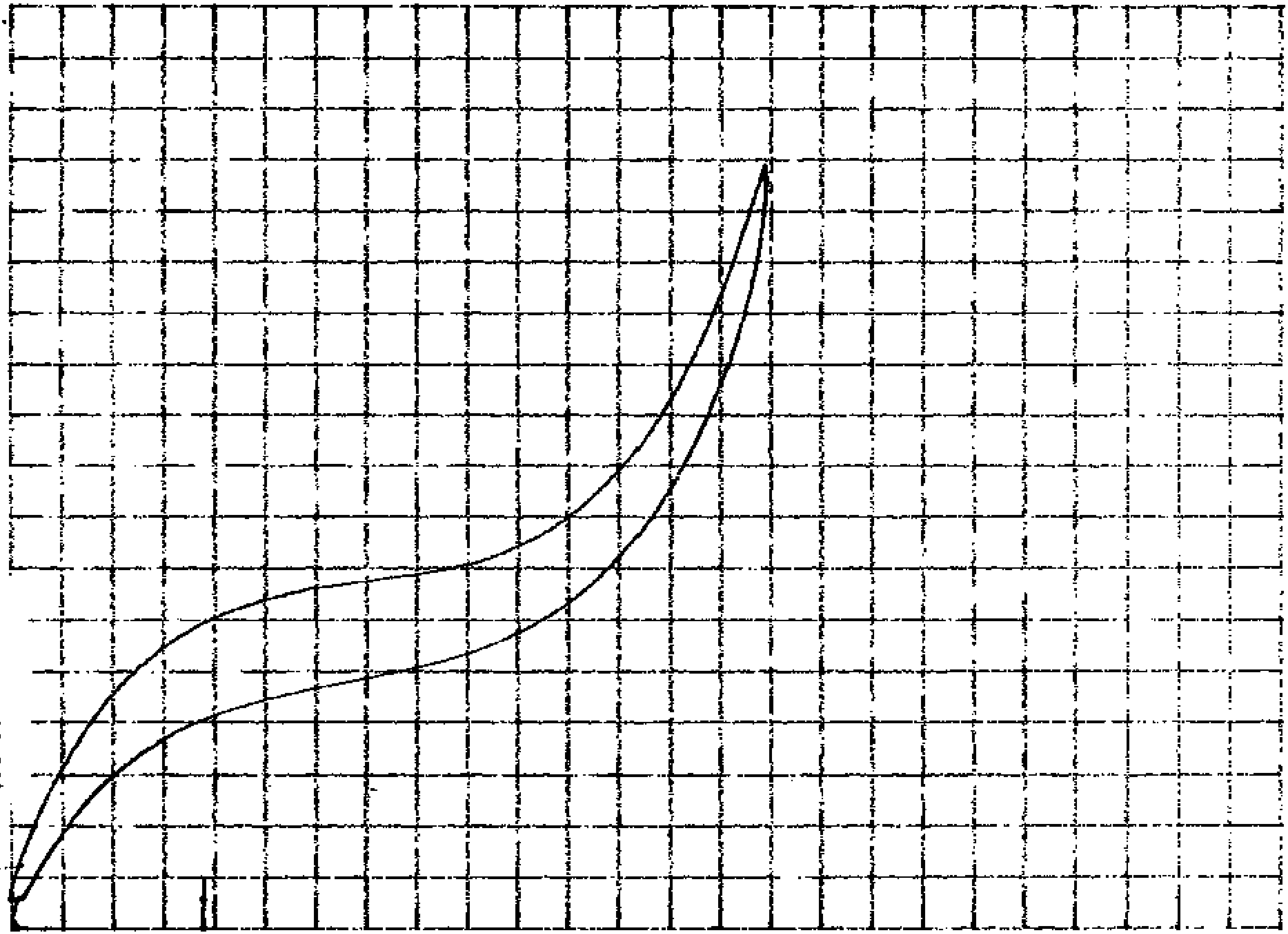
7-14-99

LF 4



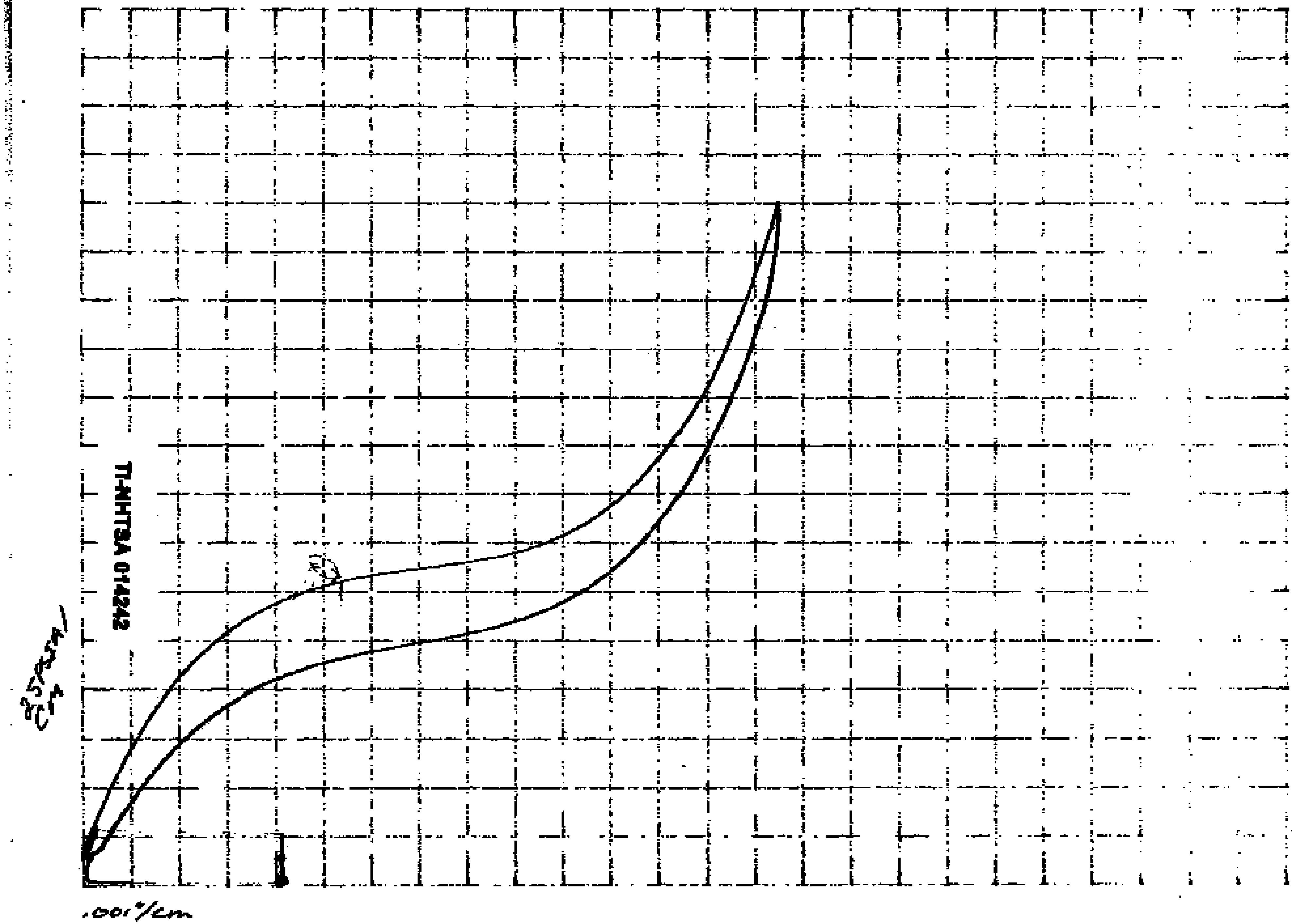
7-19-99

LF5

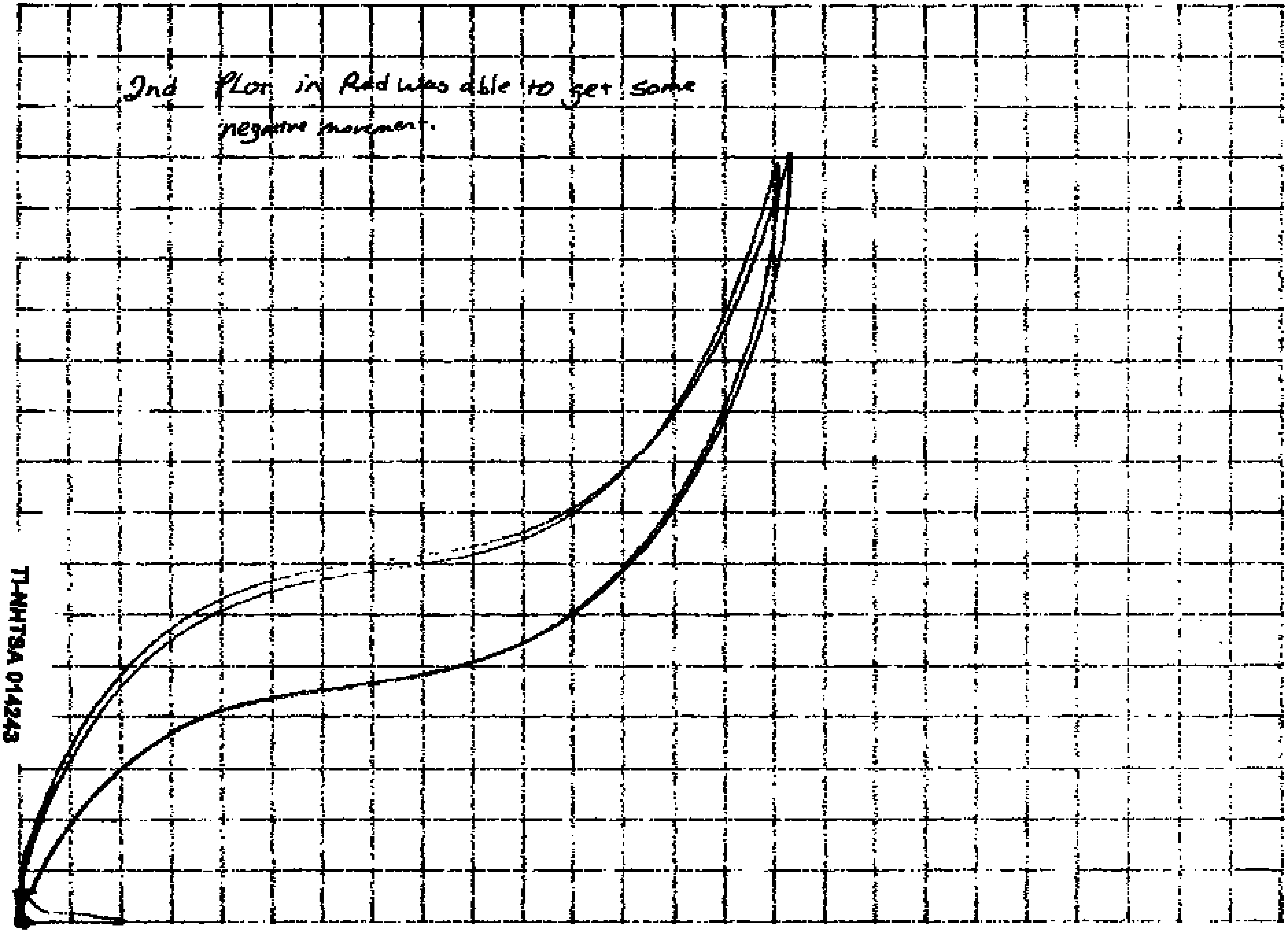


7-16-99

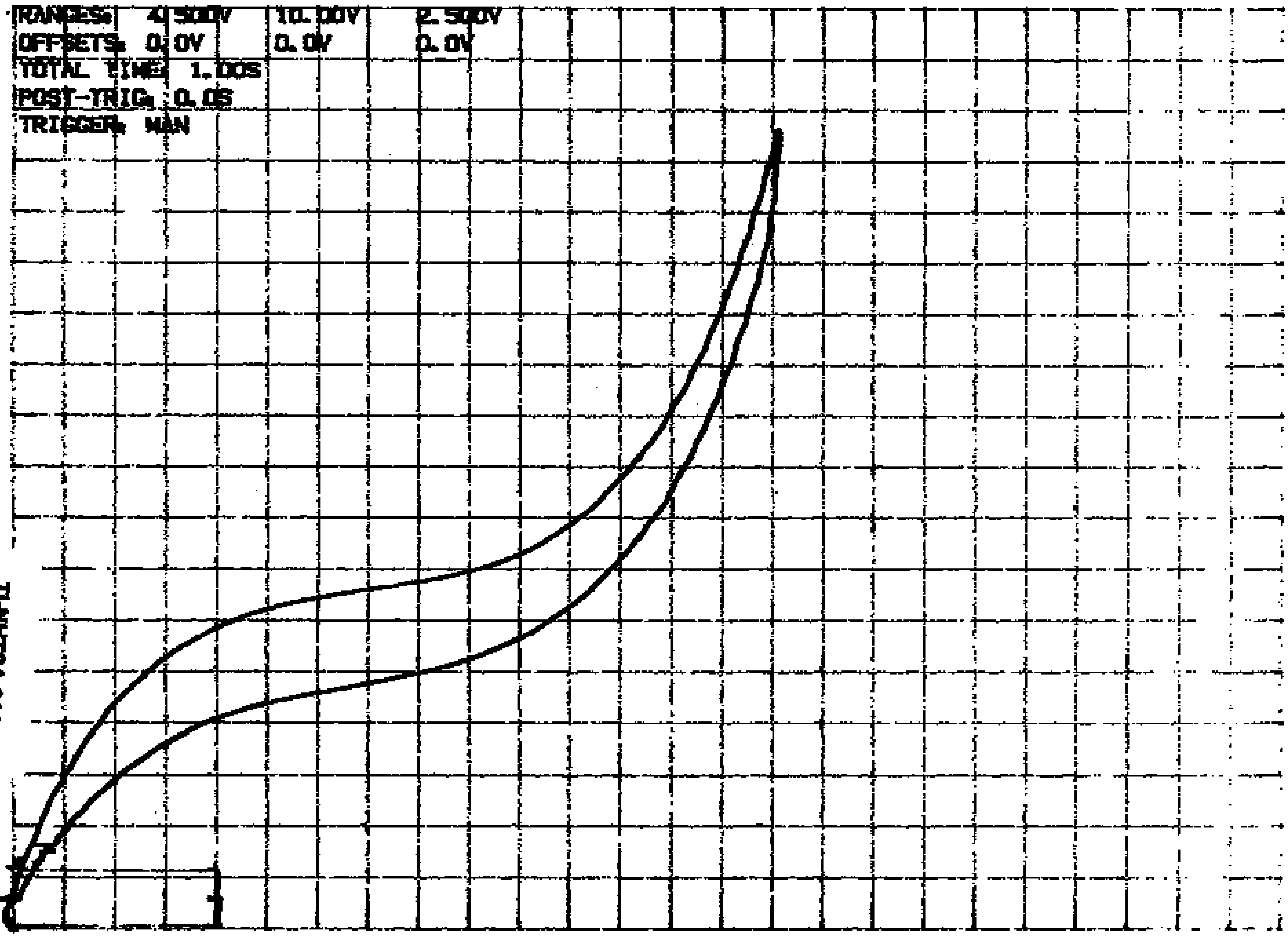
LF #6



LF7

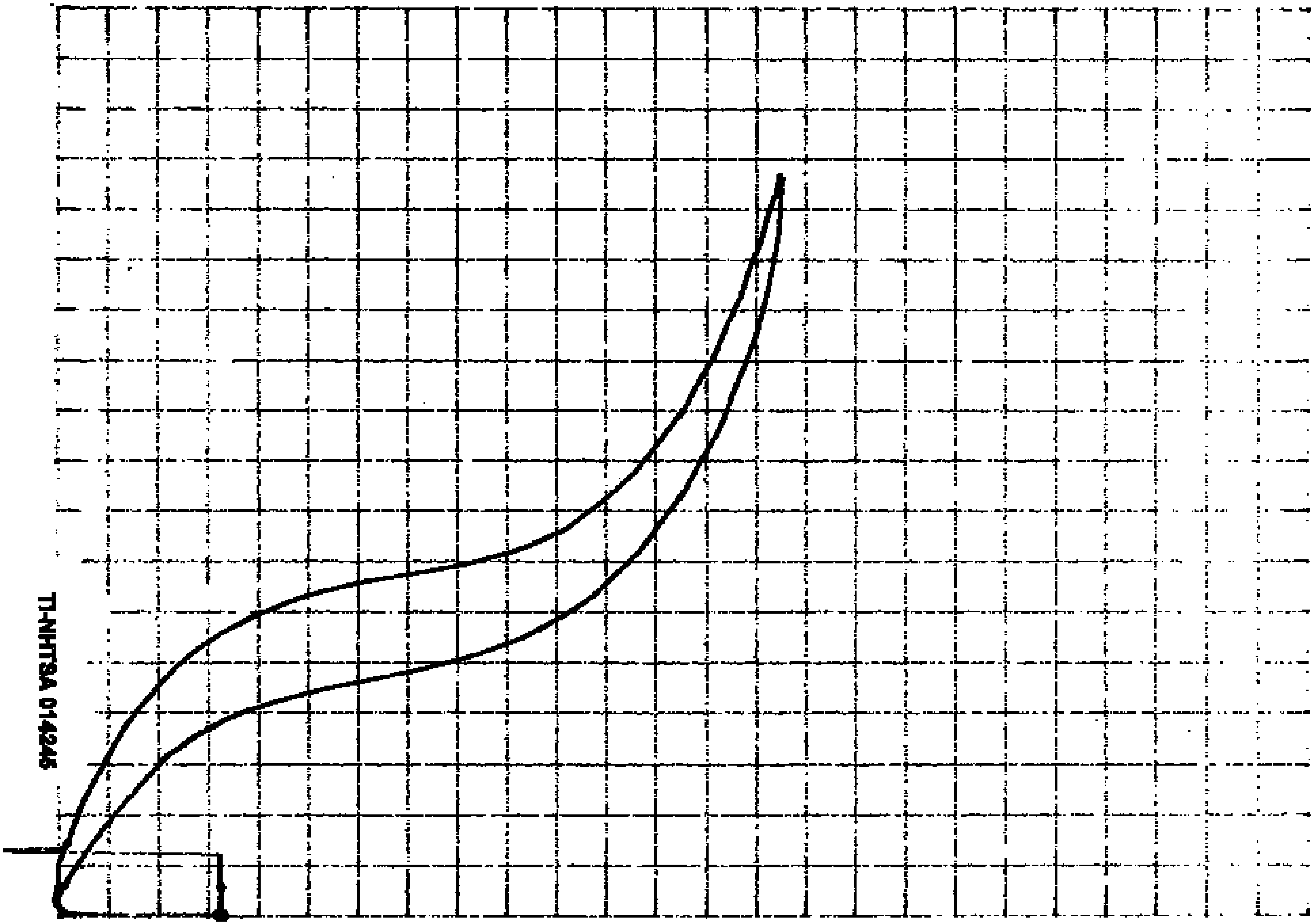


LF8

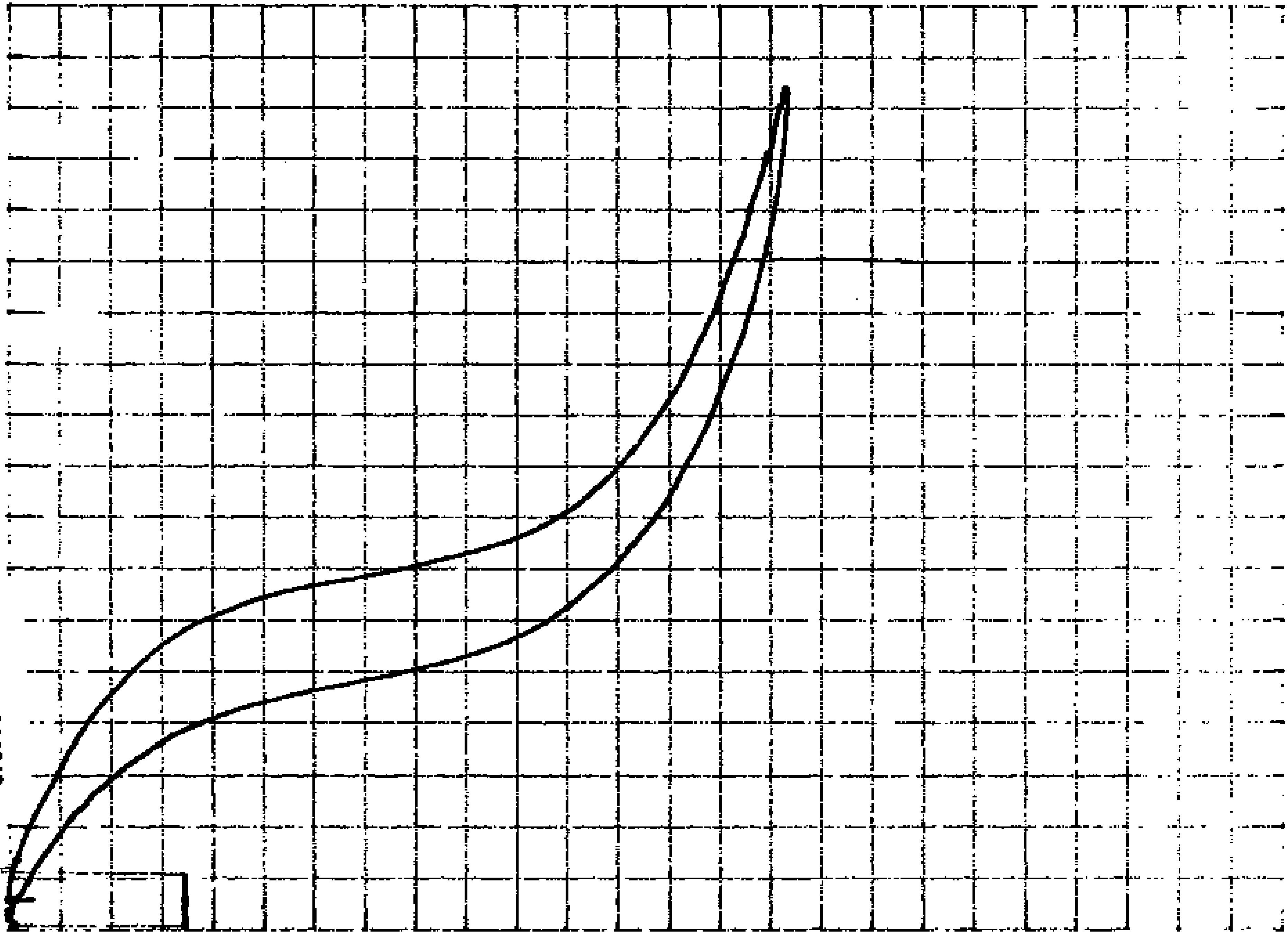


TI-NHT9A 014244

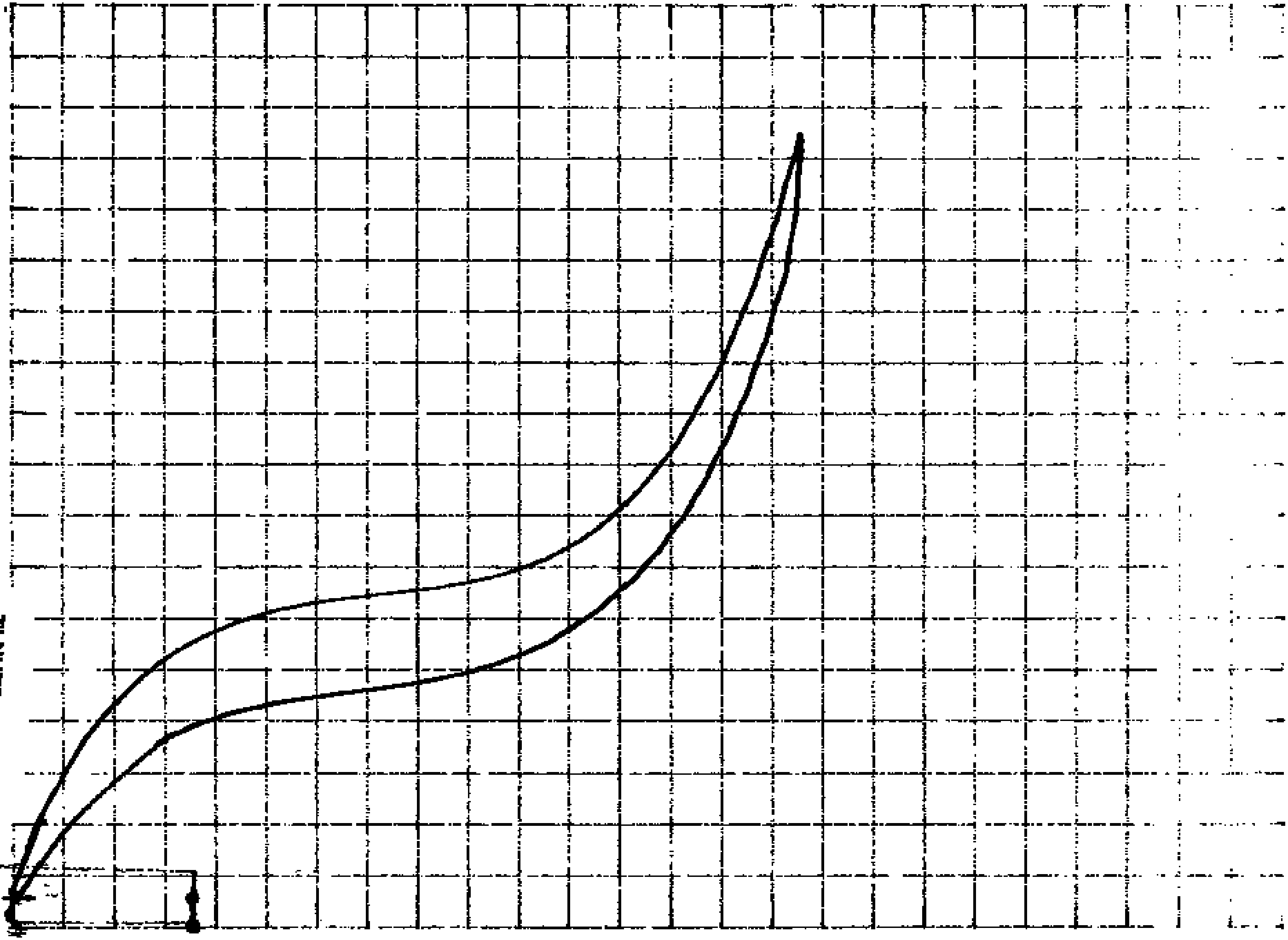
647



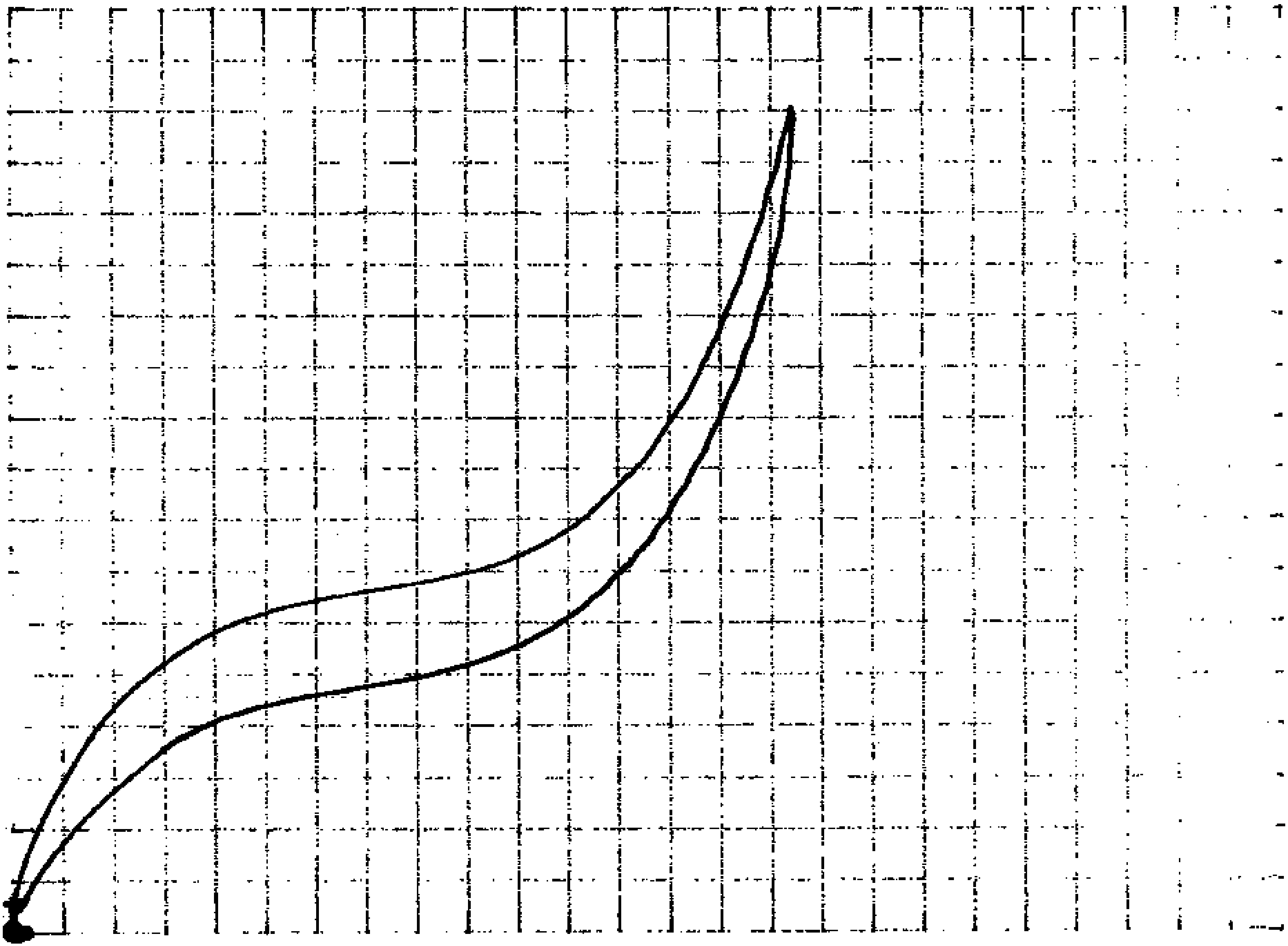
LF 10



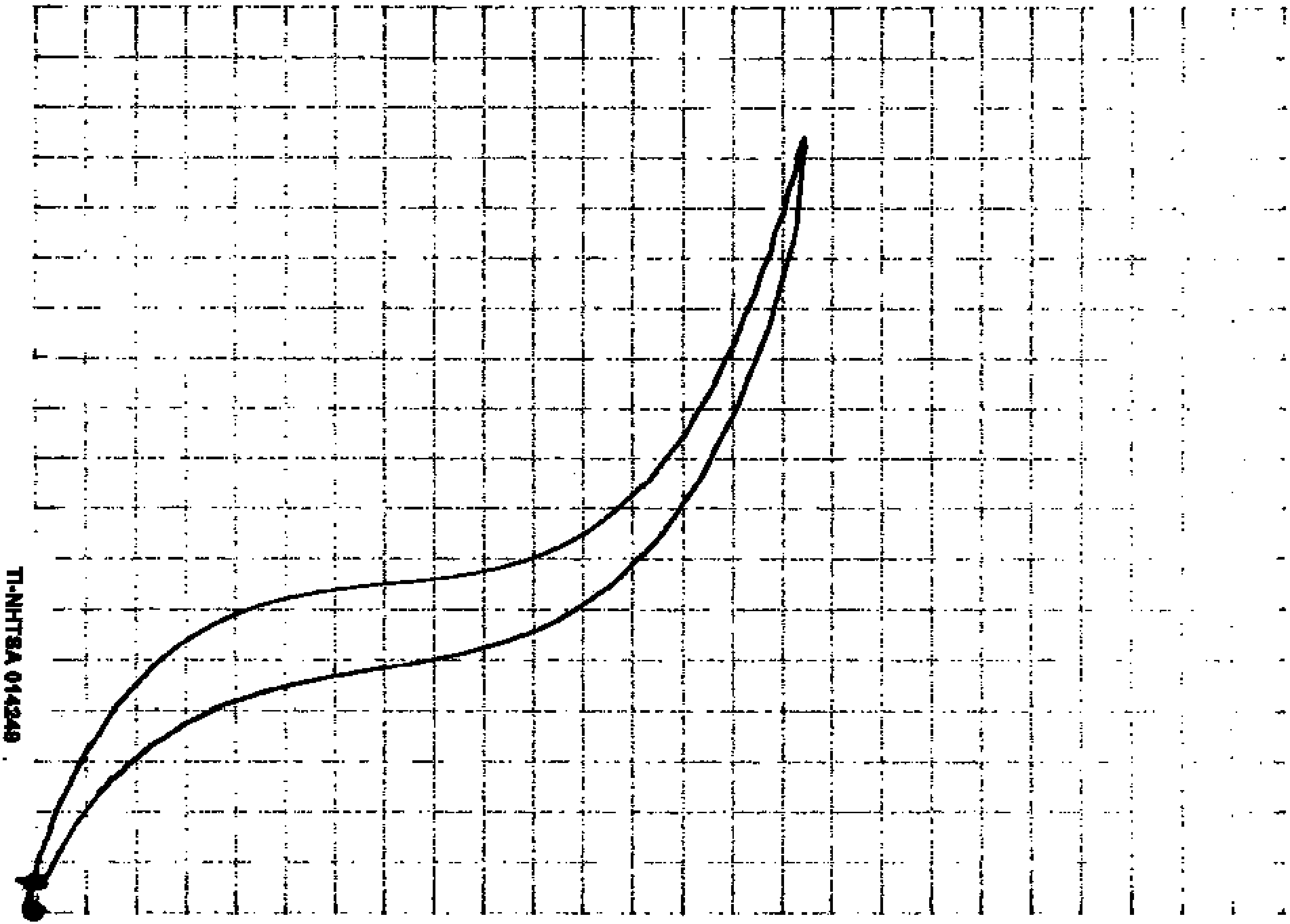
LF 11



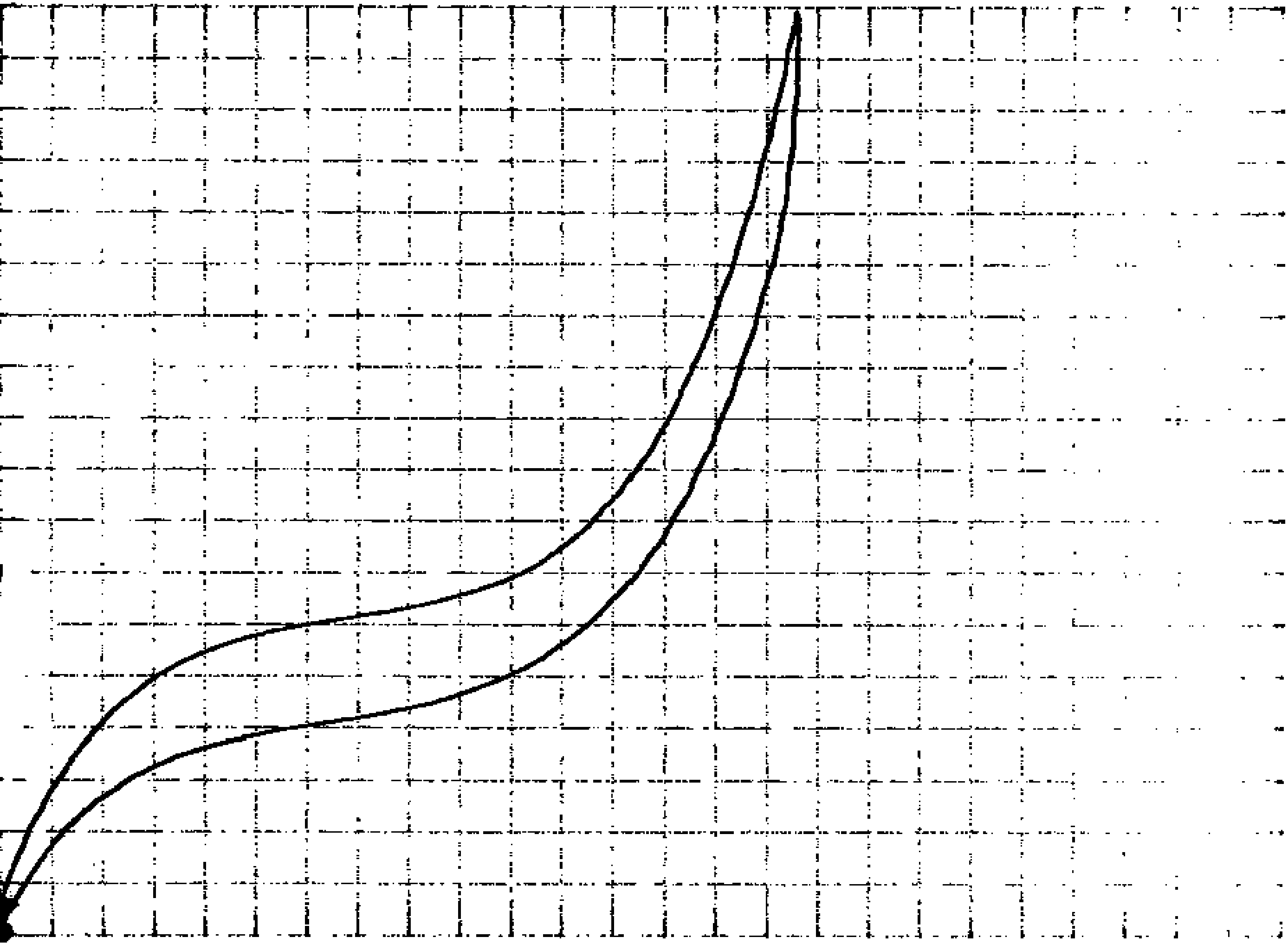
LF12



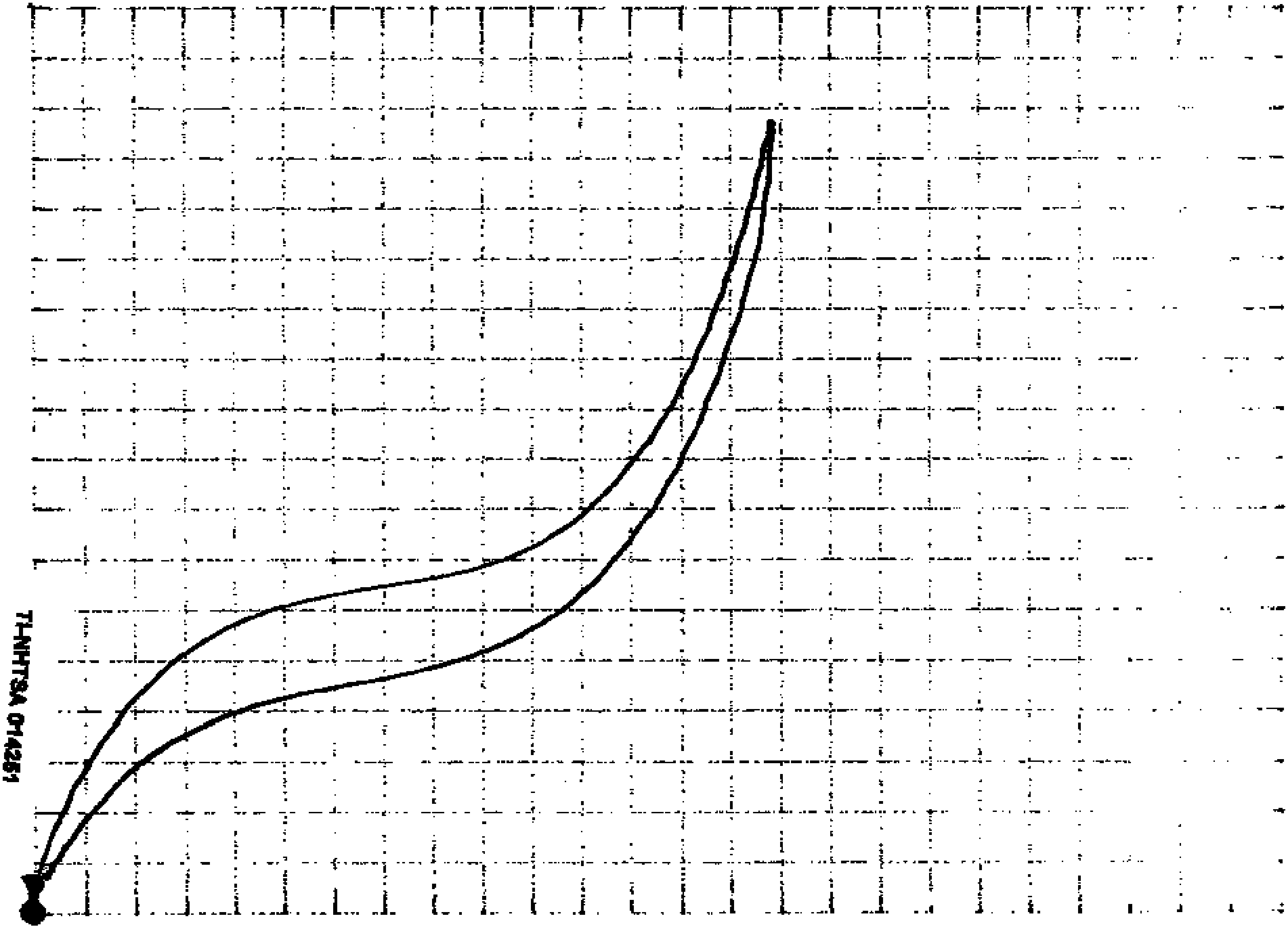
LF 13



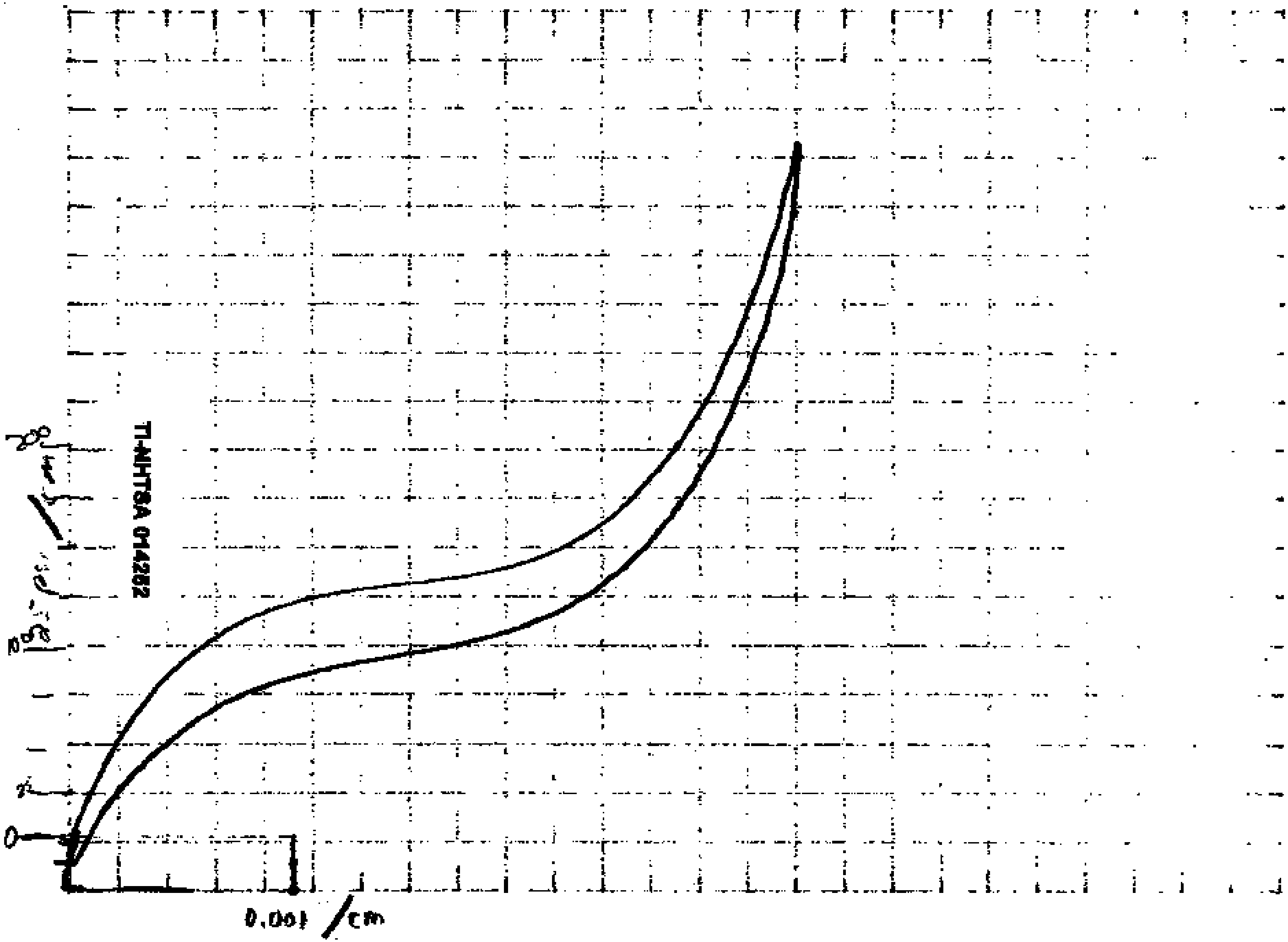
LF 14



LF15



LF16



TI 77PS Test Synopsis Draft 7/22/99

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:

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

Refer to <u>Brake Pressure Switch Test Log.</u>

Level 1 Objective: Determine if a switch ignition can be created in the laboratory.

- Test 1

Objective: Determine if switch ignition can occur under the following laboratory conditions:

Switch contact cavity 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.

Results: (8) samples were tested total:
(2) with 4% H_2O in brake fluid.
(2) with 6% H_2O in brake fluid.
(2) with 10% H_2O in brake fluid.
(2) with 75% H_2O in brake fluid.

No ignition occurred. No significant temperature rise observed in all samples. Current draw ranged from 0.5 mAmps to 5 mAmps over a period greater than (250) hours.

- Test 2

Objective: Determine if switch ignition can occur under the following laboratory conditions:

Switch contact flooded with brake fluid.
14 volts applied to one terminal, second terminal connected to a 14 Ω resistor which is tied to ground. (1 Amp load across switch terminals).
Switch hexport electrically grounded.

Results: (2) samples were tested. No ignition occurred. No significant temperature rise observed for a period over (250) hours.

Conclusion: A (1) Amp load through switch terminals cannot ignite brake fluid in the contact cavity of switches.

- Test 6

Objective: Determine if switch ignition can occur under the following laboratory conditions:

Heater element installed in contact cavity of the switch.
Power applied to the heater element until plastic base melts.
Spark generated in contact cavity of switch.
Brake fluid present in the contact cavity (wet device) and absent in the contact cavity (dry device).

Results: (2) dry devices were tested and (1) wet device was tested. Ignition occurred in all 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 applied spark ignited the fumes in the contact cavity of the switch and engulfed the base material of the switch.
Dry device: The internal temperature of a dry switch reached over 1000°F. The switch base flopped over. The applied spark ignited the fumes in the contact cavity of the switch and engulfed the base material of the switch.

Conclusion: A switch ignition can occur under the following laboratory conditions:

Heater element installed in the switch contact cavity.
5 watts of power dissipated in heating element.
Spark generated in the contact cavity of the switch.

Brake fluid did not contribute to the ignition process.

Level 2: Objective: Determine if a laboratory 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.

Results: (1) out of (15) samples tested increased resistance to 5 Ωs. A solution of 5 wt. % NaCl in H_2O can corrode the electrical components of the switch and cause an increase in electrical resistance. Repeated injections of the solution of 5 wt. % NaCl in H_2O into the contact cavity of a switch, with the switch continuously powered at 14 Volts, can cause an ignition.

Conclusion: A switch ignition can occur under the following laboratory conditions:

A solution of 5% NaCl in H_2O is injected into contact cavity of a switch.
Continuous 14 Volt power applied to the switch.
Hexport is grounded.
Current is limited at 15 Amps.

- Test 6c

Objective: Determine if brake fluid with metal shavings is conductive enough to create an ignition.

Results: (3) devices with various size metal particles were tested. No significant current increase detected.

Conclusion: Metal shavings did not significantly increase conductivity brake fluid. Current levels measured were well below levels necessary to create an ignition.

- Test 7

Objective: Determine if switch meets cycle life specification.

Results: Tests conducted during the first quarter of 1999 show that switches exceed cycle life specification.
In the first quarter of 1999, a total of (42) 77PSL2-1 snap switches were impulse tested to over 1,000,000 cycles with only (1) leak below 1,000,000 cycles, which

occurred at 728,000 cycles. A Weibull analysis showed 99.9% reliability at 500,000 cycles at 95% confidence level.

Conclusions: Switches meet cycle life specification. First quarter, 1999 tests confirm impulse test findings made during the period between 1991 and 1992. During that period, (6) impulse tests on 144 devices of 57PS and 77PS construction, had no leaks when tested to 500,000 cycles. A Weibull analysis of first quarter, 1999 tests, showed 99.9% reliability at 500,000 cycles at 95% confidence level.

- Test 15a

Objective: Determine the long term corrosive effects of brake fluid on the electrical components of switches which are continuously powered at 14 Volts.

Results: Test was suspended after 550 hours of testing. (6) samples were tested with continuous 14 Volts power. The contact cavity of (4) switches contained new brake fluid and (2) switches contained old brake fluid. Switches with old brake fluid drew very little hexport current and showed a decrease in hexport current over time to less than 1/10 mAmp. Samples with new brake fluid showed an increase in hexport current to over 20 mAmps toward the end of the 550 hours of testing. Analyses of (1) sample with new brake fluid and (1) sample with old brake fluid revealed electrolytic corrosion of the contact arm of both switches. There was a much lower level of corrosion in the sample with used brake fluid than the sample with new brake fluid.

Conclusion: Brake fluid in the contact cavity of switches, which are at 14 Volts continuous power for over 500 hours, can cause electrolytic corrosion of the switch contact arm. It is unknown if this corrosion, under continuous power conditions, can eventually lead to sufficient current draw to drive an ignition.

- Test 17

Objective: Quantify the long term corrosive effects of new brake fluid on the electrical components of switches under the following laboratory conditions:

Contact cavity of switch flooded with new brake fluid.
Switches at continuous 14 Volts power.
Switches subjected to vibration for (1) hour per day.
Switches subjected to 100°C for (1) hour per day.

Results: Test suspended after (312) hours. (50) samples tested. The average hexport current draw after (312) hours is 1.9 mAmps with a standard deviation of 1.8 mAmps. There has been no increase in hexport current. These results are consistent with results previously found in Test 15a.

Conclusion: New brake fluid in the contact cavity of switches. has not caused an increase in hexport current after (312) hours at continuous 14 Volts power

Level 3: Objective: Understand the laboratory ignition process, determine the current path and establish a repeatable ignition method.

- **Test 6b**

Objective: Understand the ignition process, determine the current path and establish a repeatable ignition method.

Results: Multiple attempts at laboratory ignition, via injection of a solution of 5 wt. % NaCl in H_20 into the contact cavity of switches, has resulted in a repeatability rate of approximately 50%. Plots of hexport current verses time show an increase in current until the point of ignition.

Conclusion: A repeatable laboratory method for switch ignition was established. Based on hexport current measurements, the current path is from switch terminals to hexport body.
When a solution of 5 wt. % NaCl in H_20 is repeatedly injected into the contact cavity of powered switches, electrolytic corrosion of the switch terminal results in an increase in terminal resistance. When sufficient power is drawn through the corrosive resistance, switch elements heat up and begin to glow red hot. A hole burns through the switch base and ignition occurs. There is arcing visible throughout the corrosion process which may provide the spark necessary for ignition.

Level 4: Objective: Compare and contrast variables influencing ignition using the established laboratory ignition method.

- **Test 13a**

Objective: Compare various fluids in the established ignition method.

Results: The following fluids were tested.
(1) NaCl in H_20.
(1) tap water
(1) rain water
(1) used brake fluid
(1) used brake fluid with 5 wt. % H_20
(1) new brake fluid
(1) new brake fluid with 5 wt. % H_20
The switch filled with 5 wt. % NaCl in H_20 resulted in an ignition when average hexport current exceeded 2.5 Amps. Switches that were filled with tap water and rain water drew less than 10 mAmps over a (3) hour test and showed little signs of

corrosion. Switches filled with a matrix of new and used brake fluids, with water and without water, all drew less than 3 mAmps hexport current draw and showed no signs of corrosion over the (24) hour test.

Conclusion: Brake fluid is not conductive enough to cause the electrolytic corrosion and necessary current draw to create an ignition. Because of its' significantly higher conductivity, an ionic rich fluid such as NaCl in H_20 is necessary to cause an ignition.

- Test 15

Objective: Compare the ignition characteristics of various plastics as switch base material.

Results: When 5 wt. % NaCl in H_20 was injected into switches with different base materials, the following results were obtained: Celanex 4300 ignited 3 out of 5 attempts. Noryl ignited 2 out of 5 attempts. Zytel ignited 1out of 5 attempts.

Conclusions: All plastics tested can ignite using the established laboratory ignition method.

- Test 15b

Objective: Determine if switch ignition can occur in the vertical position and 45° orientation. Determine if switch ignition can occur and at different rotational angles in the 45° orientation.

Results: Switch ignitions can occur in both the vertical and 45° orientation using the established laboratory ignition method.

Conclusion: Switch ignition does not appear to be sensitive to vertical orientation verses 45° orientation nor to rotational angle in the 45° orientation.

Level 5 Objective:

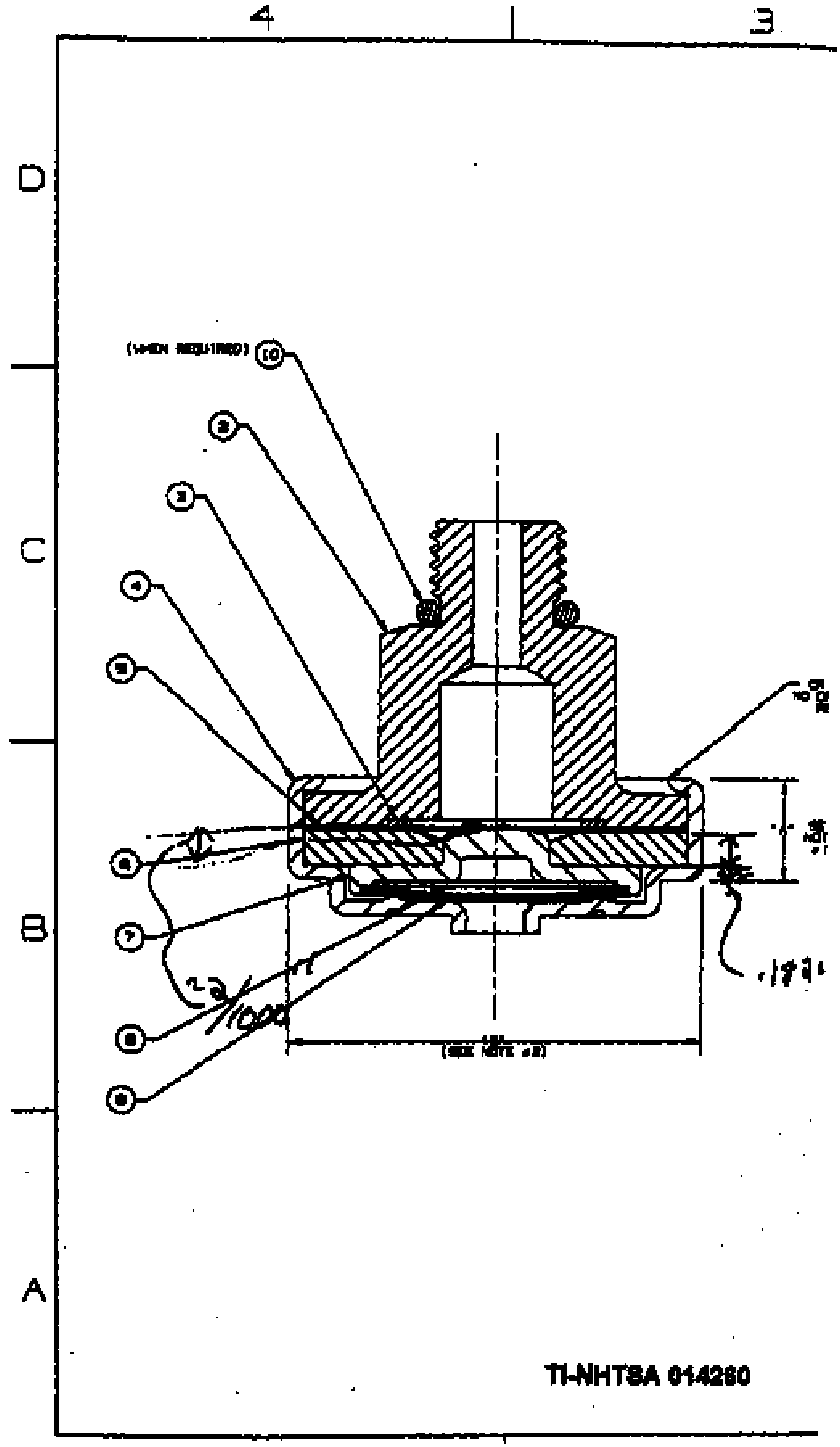
Test 16

- Objective: Test proposed relay circuit.

Results: (1) switch was injected with a solution of 5 wt. % Nacl in H_20 and placed in the proposed current limiting circuit for (48) hours. The current draw remained constant at 180 mAmps throughout the test. There was no activity observed and the contact arm remained mostly intact.
(1) switch was brought to an impending burn condition using the established burn method. An impending burn is a condition where a corrosive resistance has built

up in the switch and an ignition is imminent. The switch was then placed in the proposed relay circuit for(18) hours where it drew 160 mAmps, showed no visible activity and did not result in an ignition.
Because the proposed relay circuit acts as a resistor which limits current to the switch, the maximum power to the switch is limited to .75 Watts. A resistive wire was wrapped around the base of (1) switch and 0.75 Watts of power was dissipated in the wire. The wire became warm to the touch but had no effect on the switch.

Conclusion: 0.75 Watts, the maximum power in the proposed circuit design, is insufficient to cause substantial electrolytic corrosion or significant switch terminal heating, which is necessary to create an ignition. In previous tests, using a resistor as the heating element (see Test 6), approximately 5 Watts of power was necessary to create an ignition. There is not enough power in the proposed circuit to create ignition.



TI-NHTSA 014260

77PSL4-1 LEAKY SWITCHES ANALYSIS

AVE IN	stdev.	AVE OUT	stdev.	AVE TOT.	stdev	Delta	stdev.
0.1824	0.0003	0.1832	0.0002	0.1828	0.0006	0.0018	0.0008
0.1823	0.0003	0.1830	0.0002	0.1826	0.0006		
0.1825	0.0004	0.1829	0.0003	0.1827	0.0004		
0.1824	0.0003	0.1830	0.0005	0.1827			
				0.0005			
0.1830	0.0004	0.1828	0.0003	0.1829	0.0006	0.0019	[illegible]
0.1830	0.0006	0.1828	0.0006	0.1829	0.0007		
0.1831	0.0006	0.1828	0.0004	0.1830	0.0007		
0.1830	0.0004	0.1828	0.0006	0.1829			
				0.0006			
0.1831	0.0001	0.1836	0.0000	0.1833	0.0006	0.0012	0.0004
0.1831	0.0002	0.1837	0.0002	0.1834	0.0004		
0.1830	0.0002	0.1836	0.0002	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	[illegible]	0.0004
0.1826	0.0002	0.1829	0.0002	0.1827	0.0004		
0.1826	0.0003	0.1830	0.0003	0.1828	0.0006		
0.1826	0.0002	0.1829	0.0006	0.1828			
				0.0004			

77PSL4-1 FROM PRODUCTION LINE ANALYSIS

AVE IN	stdev.	AVE OUT	stdev.	AVE TOT.	stdev	Delta	stdev.
0.1838	0.0003	0.1844	0.0003	0.1841	0.0006	0.0015	0.0006
0.1837	0.0003	0.1844	0.0001	0.1841	0.0006		
0.1838	0.0003	0.1844	0.0002	0.1841	0.0006		
0.1838	0.0002	0.1844	0.0006	0.1841			
				0.0006			
0.1838	0.0002	0.1843	0.0002	0.1841	0.0003	0.0014	[illegible]
0.1841	0.0002	0.1848	0.0002	0.1844	0.0004		
0.1836	0.0003	0.1841	0.0001	0.1838	0.0006		
0.1838	0.0003	0.1844	0.0006	0.1841			
				0.0006			
0.1831	0.0003	0.1834	0.0003	0.1833	0.0006	[illegible]	0.0004
0.1828	0.0002	0.1830	0.0002	0.1829	0.0003		
0.1826	0.0002	0.1829	0.0002	0.1828	0.0003		
0.1829	0.0003	0.1831	0.0006	0.1830			
				0.0004			

77PSL3-1 FROM THE LINE ANALYSIS

AVE IN	stdev.	AVE OUT	stdev.	ave tot	stdev	Delta	stdev.
0.1850	0.0006	0.1856	0.0005	0.1853	0.0007	0.0031	0.0007
0.1848	0.0004	0.1857	0.0004	0.1852	0.0007		
0.1851	0.0004	0.1860	0.0004	0.1855	0.0006		
0.1849	0.0004	0.1857	0.0007	0.1853			
				0.0007			
0.1855	0.0006	0.1856	0.0004	0.1856	0.0005	0.0032	[illegible]
0.1857	0.0005	0.1855	0.0004	0.1856	0.0006		
0.1857	0.0003	0.1862	0.0001	0.1858	0.0006		
0.1856	0.0004	0.1857	0.0006	0.1857			
				0.0006			
0.1859	0.0002	0.1866	0.0002	0.1864	0.0007	[illegible]	[illegible]
0.1861	0.0002	0.1867	0.0002	0.1864	0.0006		
0.1860	0.0002	0.1857	0.0002	0.1863	0.0006		
0.1860	0.0002	0.1867	0.0006	0.1864			
				0.0006			

DOE1   1,120,428
+204,000
1,324,428

GROUP: G1
DESCRIPTION: 77PSL2-1 (w/ snap, 0% water)

DEVICE #	CYCLES (K)	FORD LOAD APPLIED (Y/N)	LEAKAGE MODE
G1-			
G1-			
G1-			
G1-			
G1-			
G1-			
G1-			
G1-			
G1-			
G1-			
G1-			
G1-			

No Leaks

Start 2/24/99

GROUP: G2

DESCRIPTION: 77PSL4-1 (no snap, 0% water)

DEVICE #	CYCLES (K)	FORD LOAD APPLIED (Y/N)	LEAKAGE MODE
G2-	1,155	Yes	
G2-	1,181	Yes	
G2-	1,192		
G2-	1,192		
G2-	1,197		
G2-	1,199		
G2-	1,199		
G2-	1,407	Yes	
G2-	1,407	N	
G2-	1,354		
G2-	1,354		
G2-	1,354		

TI-NHTSA 014264

GROUP: G3
DESCRIPTION: 77PSL2-1 (w/ snap, 5% water)

DEVICE #	CYCLES (K)	FORD LOAD APPLIED (Y/N)	LEAKAGE MODE
G3-	1197	Y	
G3-	1197	–	
G3-	1197	–	
G3-	1199	–	
G3-	1,201	—	
G3-	1,207	Y	
G3-	1,207		
G3-	1,207		
G3-	1,207		
G3-	1,207		
G3-	1207 [illegible]		
G3-	1207 [illegible]		

DOE1 77PSL2-1 AND 77PSL4-1

Sample	ppm H_2O	ppm H_2O	ppm H_2O	Avg	Std Dev	%RSD	Wt % H_2O
Clean	2829	3300		3065			0.31
Caliper	11269	11329	11064	11221	118.76	1.10	1.11
Master	11596	11006	11298	11301	294.01	2.94	1.13
Cylinder #1	7794	7443	7458	7565	190.46	1.99	<u>0.75</u>
Cylinder #2	27102	29503	28785	28797	290.67	3.60	<u>2.8[illegible]</u>
Reference*	4065						0.41

should be same as clean sample (Cylinder #1)

should be 5% (Cylinder #2)

reference contains 0.38 to 0.42 % H_2O

Fluid samples taken at the end of the test

DOE 1

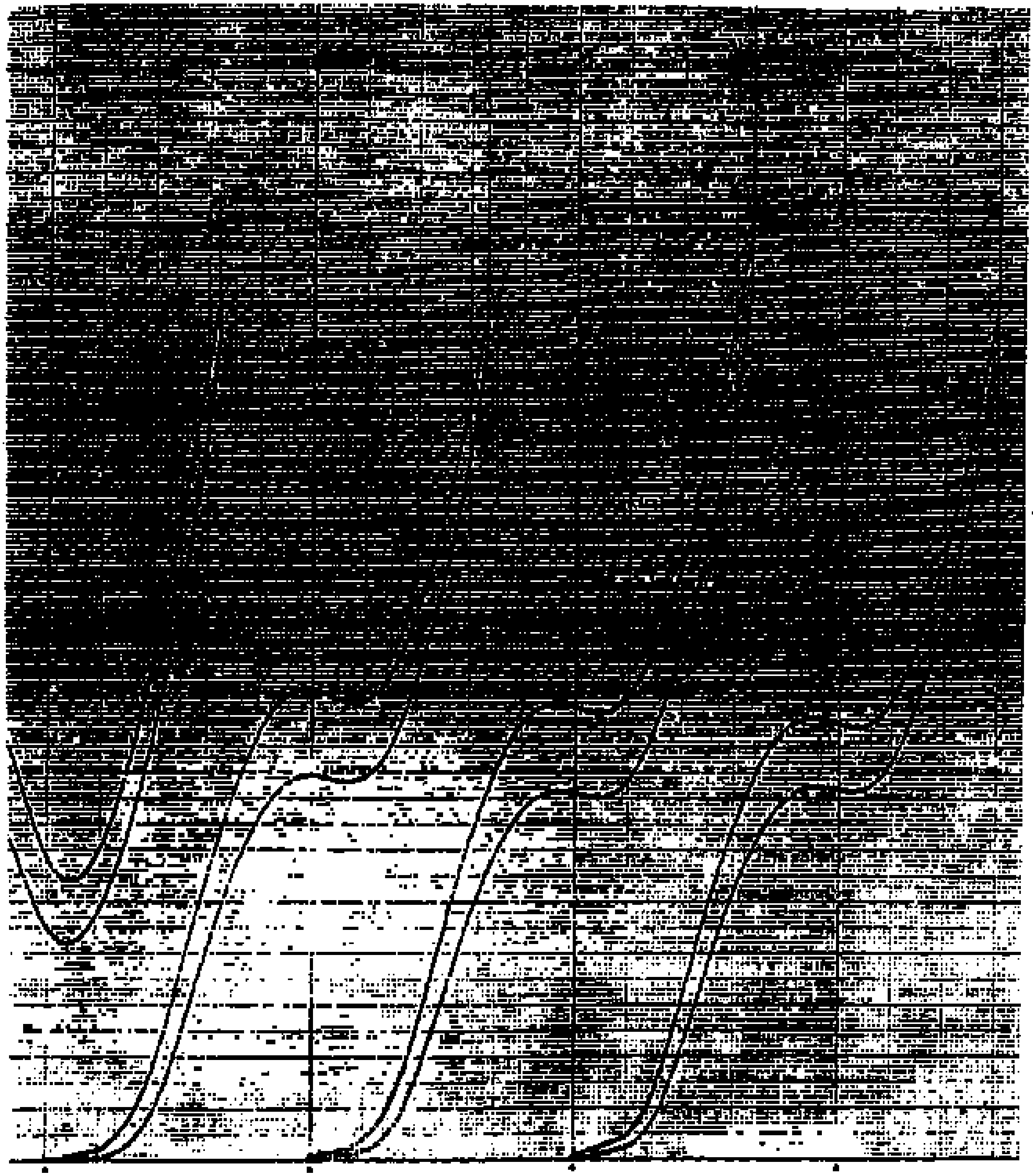
Test Log

Start	2-26		
200k	3-1		
289k	Failure	5%	3-2
326k	Failure	5%	3-2
325k	"	"	"
335k	"	5%	3-2
348	"	"	3-2
376k	"	"	3-3
380k	3 Failures	5%	3-3 (2 Powered Switches)
387k	Failure	5%	3-3
1,175k	Failure	0%	3-8
1,18[illegible]	"	"	3-9
1,192k	2 Failures	"	3-9
1,197k	3 Failures	5%	3-9
	1 Failure	0%	3-9
~~[illegible]~~ 1,199	2 Failures	0%	3-9 @ 5:[illegible]
1,199K	1 failure	5%	
1,201	5% Snap failure		
[illegible]207	4 5% [illegible] 5%		

TI-NHTSA 014267

77PS part differences.

	77PS2-1	77PS3-1	77PS4-1	
description	part number	part number	part number	EFFECT
CUP	27713-1	27713-1	27713-2	Spacer used to bump height 4/1000 larger on -1 than on -2
HEXPORT	30900-1	30900-1	37067	4-1 C'Bore is .330 (.13 deeper than 2-1)
DISC	30688-27	30688-35	30688-35	-35 measured height = .0275 +/- .0005"
(OR)	30688-28	30688-41	30688-41	-41 measured height = .0291 +/- .0003"
				-27 measured height = .0298 +/- .0003"
				-28 measured height = .0310 +/- .0005"
				Crown height on 4-1 are ~ 2/1000 to 4/1000 lower than 2-1 (measured)
Base	46515-2	46515-3	46515-3	
DATE stamp	8289	7184	[illegible]	



TI-NHTSA 014269

Date
CROWN Height | 12/3/99 | Sh

77PS (2-1 : -27, -28 } 36656
" 3-1 : -35, -41
4-1 : -35, -41

Measurements

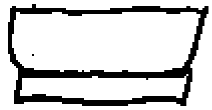
77PS Discs

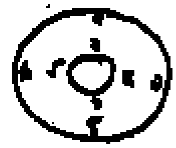
		CROWN	
36656 -27	1	.0297	
	2	.0295	
	3	.0300	1-3/ .27
	4	.0299	
	5	.0299	
-28	1	.0311	
	2	.0308	
	3	.0307	
	4	.0314	
	5	.0311	
-35	1	.0276	
	2	.0277	
	3	.0277	2/1030
	4	.0275	
	5	.0274	
-41	1	.0299	
	2	.0290	
	3	.0291	
	4	.0291	
	5	.0291	

Sample cup

	77PSL2-1	ADE1	09/13/99

Decrimped (3) unused units
→ placed on spacer
→ zeroed on clearance

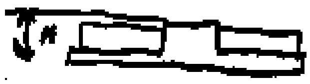


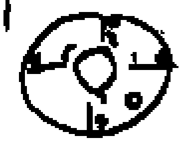


	1	2	3	4	5	6	7	8
S1	-.0030	-.0029	-.0012	-.0030	-.0051	-.0060	-.0037	-.0045
S2								
S3								

77PSL2-1

Slight pressure applied b/c cup wobble on cup





Sample	H	1	2	3	4	5	6	7	8
1st	.1995	.1948	.1947	.1957	.1966	.1950	.1957	.1945	.1950
2nd	.1994	.1946	.1960	.1942	.1962	.1950	.1959	.1952	.1962
3	.1993	.1944	.1961	.1954	.1962	.1959	.1959	.1945	.1951
S2	.1998	.1953	.1949	.1954	.1953	.1962	.1956	.1962	.1965
	.1990	.1956	.1947	.1951	.1959	.1957	.1955	.1962	.1962
	.1990	.1953	.1956	.1958	.1966	.1956	.1961	.1957	.1962
S3	.1990	.1957	.1960	.1962	.1979	.1959	.1967	.1959	.1967
	.1990	.1962	.1965	.1962	.1977	.1958	.1963	.1960	.1964
	.1989	.1959	.1964	.1954	.1967	.1959	.1964	.1963	.1972

77PSL4-1

better condition ... below

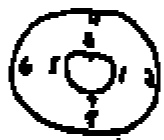
Sample	H	1	2	3	4	5	6	7	8
S1	.1957	.1938	.1953	.1935	.1938	.1936	.1939	.1941	.1947
	.1956	.1941	.1952	.1937	.1945	.1936	.1938	.1935	.1940
	.1956	.1936	.1947	.1942	.1949	.1937	.1940	.1939	.1941
		Av .1938	.1950	.1939	.1945	.1936	.1939	.1938	.1942
S2	.1955	.1940	.1942	.1936	.1942	.1939	.1942	.1941	.1945
	.1954	.1941	.1950	.1940	.1949	.1948	.1944	.1934	.1944
	.1954	.1934	.1949	.1934	.1939	.1934	.1938	.1952	.1936
S3	.1950	.1929	.1932	.1929	.1927	.1931	.1939	.1935	.1920
	.1950	.1929	.1934	.1925	.1924	.1927	.1932	.1930	
	.1950	.1927	.1930	.1926	.1922	.1925	.1930	.1930	

	779SL4-1	DOEI	08/03/99

G4 measurement uncrimped

Converter

washer on



± 3/10,000

Converter measurements

convert K	H	1	2	3	4	5	6	7	8	min	Avg
222	.1846	.0804	.0812	.0809	.0813	.0813	.0812	.0801	.0810	.0807	.0
349	.1844	.0801	.0814	.0805	.0815	.0909	.0815	.0805	.0814	.0905	.0
390-3 (7)	.1951	.0913	.0819	.0807	.0819	.0901	.0817	.0707	.0813	.0907	.0
335	.1944	.0914	.0909	.0919	.0914	.0913	.0817	.0805	.0809		
51 (1) sample	.1892	.0850	.0850	.0850	.0850	.0849	.0849	.0894	.0895		
52	.1874	.0894	.0851	.0844	.0849	.0849	.0849	.0873	.0849		

WASHER ON CONVERTER

washer on converter (7)										inside	out
222	.1946	.1919	.1929	.1922	.1929	.1922	.1934	.1922	.1932	.1921 (+.0002)	[illegible]
349	.1844	.1925	.1934	.1926	.1934	.1929	.1939	.1929	.1939	.1927 (+.0002)	.19565 (+.0005)
380	.1851	.1928	.1923	.1924	.1929	.1922	.1922	.1926	.1927	.1925 (.0002)	[illegible]
335	.1944	.1932	.1931	.1929	.1921	.1923	.1922	.1931	.1930	.1925 (+.0002)	.1931
51	.1882	.1870	.1877	.1862	.1863	.1868	.1867	.1880	.1895	.187 (+.0016)	.1878 (+.001)
52	.1874	.1959	.1957	.1946	.1875	.1971	.1884	.1870	.1977	.1867 (.00075)	.187 (.00)

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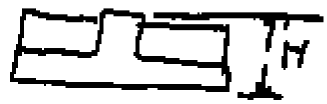
77154-1 Leaks | 0081 | 09/13/99

	H	1	2	3	4	5	6	7	8
322	.1946 .1945 .1946	.1922 .1924 .1923	.1930 .1928 .1932	.1927 .1922 .1936	.1934 .1929 .1932	.1924 .1919 .1927	.1933 .1924 .1929	.1929 .1921 .1923	.1930 .1929 .1929
335	.1944 .1947 .1944	.1927 .1931 .1933	.1922 .1929 .1931	.1926 .1923 .1929	.1919 .1916 .1915	.1934 .1933 .1932	.1938 .1921 .1931	.1932 .1934 .1924	.1933 .1936 .1936
349	.1945 .1946 .1945	.1931 .1930 .1931	.1936 .1936 .1937	.1931 .1933 .1929	.1937 .1939 .1934	.1930 .1933 .1930	.1938 .1941 .1932	.1930 .1929 .1932	.1934 .1933 .1939
380-3	.1950 .1950 .1950	.1928 .1927 .1927	.1931 .1935 .1932	.1926 .1926 .1930	.1926 .1926 .1936	.1924 .1922 .1924	.1924 .1925 .1924	.1928 .1926 .1922	.1934 .1932 .1926

← [illegible]

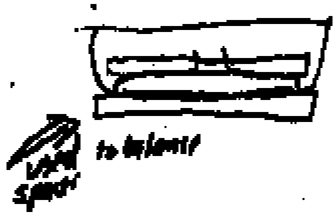
77P5L4-1 10/3/99



POE V

	H	1	2	3	4	5	6	7	8
387	.1952 .1951 .1951	.1932 .1932 .1933	.1942 .1939 .1944	.1931 .1934 .1931	.1938 .1941 .1937	.1934 .1934 .1929	.1944 .1929 .1929	.1930 .1931 .1926	.1934 .1928 .1933

G4 in Cup



322K converter to outside of disc Δ

⊕ → spacer higher
① + 0.0012
② + 0.0005
③ + 0.0001
④ + 0.0003
} repeatable

⊖ → spacer lower
380K ① -.0003
-.0000
-.0005
-.0011
} repeatable ±.0002

349K
① .0029
② .0025
③ .0032
④ .0008
} "

Had trouble duplicating results
∴ abandoned

02/23/99 SM

time 11:30

alt V	PS	V	i	
	1	14.05	~900 mA [illegible]	
2.5%	2	14.07	~750	
	3	14.05	~930	
	4	14.04	~900	
5%	5	14.05	~920	
	6	14.06	>1100	
	7	14.06	1200	supply current limited
10%	8		>1100	
	9			

14Ω

$i = \frac{V}{R}$

02/22/99 SPM

77PS salt + H_2O mix

(3) units w/ 2.5% salt/H_2O mix
(3) units w/ 5% salt/H_2O mix
(5) units w/ 10% salt/H_2O mix

injected w/ mixtures 18:00

02/22/99

cup = 20.51 g

need 56.5 g / 56.5 g of 5% mix = 2.825 g salt

$\frac{2.825}{x} = .025 = 113 g$

113 g measured adding tap water

71.9 g of 5% = 3.595 g salt

$\frac{x \text{ g salt} + 3.595}{(71.9 + x)}$ .1 7.19 + .1 x = x + 3.595

.9x = 7.19 - 3.595

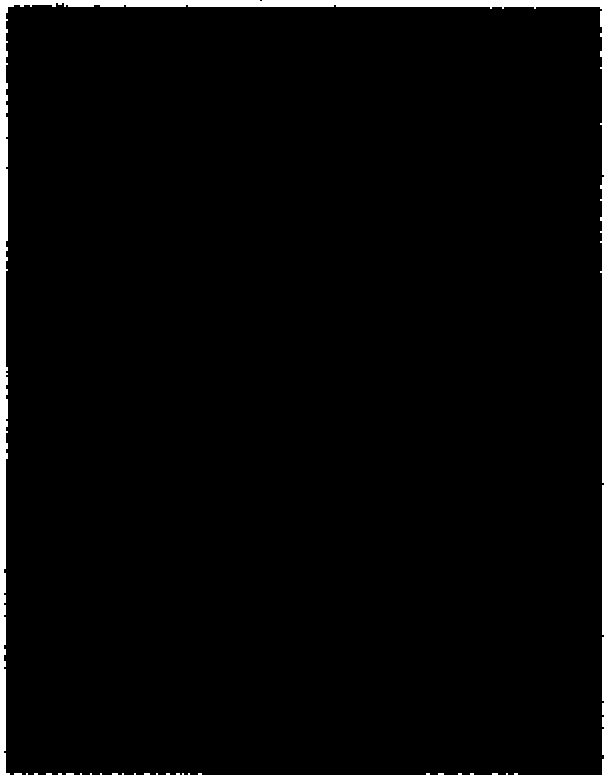
.9x = 3.595

x = 3.99

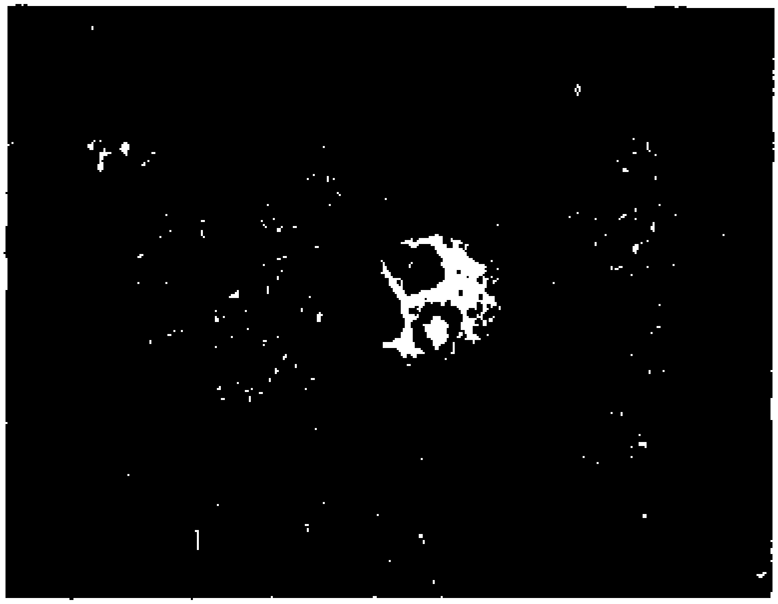
$\frac{3.99 + 3.595}{75.9}$

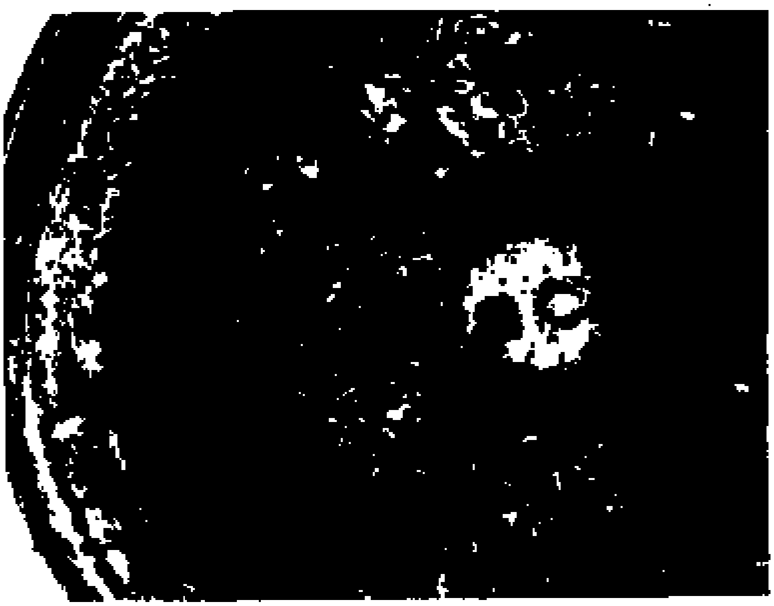
initial reading	% salt	V	i
	2.5%		
	2.5		
	2.5		
	5		
	5		
	5		
	10		
	10		
	10		

TI-NHTSA 014279



Polaroid 3 J81478A10703A





Polaroid 3 J01475A10703A