EPA-AA-EOD-88/2

Temperature Achiever Project Report

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May 1988

Executive Summary

Federal regulations require that automobile manufacturers limit the evaporative hydrocarbon emissions given off by gasoline-fueled motor vehicles. To ensure that the manufacturers meet this standard, the Motor Vehicle Emission Laboratory (MVEL) Vehicle Acquisition and Testing (VA&T) Group perform fuel tank diurnal heat builds as part of the Code of Federal Regulations (CFR) Federal Test Procedure (FTP), Section 86.133-78 "Diurnal breathing loss test." These heat builds simulate the temperature rise a vehicle sees during a day.

The device used to control an electric heat blanket placed on a vehicle fuel tank to effect these heat builds is called a temperature achiever. This report summarizes the project which introduced new temperature achievers for official testing at MVEL between July 1987 and December 1987.

The prototype was designed by the Electronic Support Team (EST) and evaluated by the Laboratory Projects Group (LPG) prior to introduction into VA&T. Eleven units were CFR compliance tested before they were approved for use. A total of twelve units, including the prototype, were introduced.

Data, from compliance tests of the units, indicate that all the new temperature achievers are capable of performing CFR heat builds in automatic mode with a comparable repeatability of one degree on 40 CFR 86.133-78 "Diurnal breathing loss test" heat builds for both 13 and 18 gallon fuel tank vehicles. This performance is anticipated on 93 percent of the vehicles tested at MVEL.

Background

Federal regulations require that automobile manufacturers limit the evaporative hydrocarbon emissions given off by gasoline fueled motor vehicles. To ensure that the manufacturers meet this standard, the Motor Vehicle Emission Laboratory (MVEL) Engineering Operations Division (EOD) Vehicle Acquisition and Testing (VA&T) Group performs fuel tank diurnal heat builds as part of the Code of Federal Regulations (CFR) Federal Test Procedure (FTP). These heat builds simulate the temperature rise a vehicle sees during a day.

40 CFR 86.133-78 contains the specific details of the required "Diurnal breathing loss test." The test consists of artificially heating a vehicle fuel tank in such a way that its temperature change conforms to the following function within ± 3°F:

$$F=T+0.4t$$

where:
F=fuel temperature, °F
t=time since beginning of test, minutes.
T=initial temperature(60°F)

After 60±2 minutes of heating, the fuel temperature rise shall be 24±1°F.

The device used to control an electric heat blanket placed on a vehicle fuel tank to effect these heat builds is called a temperature achiever. This report summarizes the project which introduced new temperature achievers used for official testing at MVEL between July 1987 and December 1987.

The new temperature achievers use a microprocessor to monitor fuel tank temperatures and control the fuel temperature rise with time. The microprocessor compares the fuel tank temperature against time and supplies a control signal to maintain the above fuel temperature rise ramp.

The new units were introduced both to phase out the older, obsolete units with more up-to-date electronics and to increase the number of achievers available for increasing testing demands.

Work Performed

The temperature achievers were designed and manufactured by the EOD Electronic Support Team (EST). The units have LFE Corporation microprocessors as the heart of their operation. The microprocessors perform the monitor and control functions of the heat builds. Power output, to an electric heat blanket on a vehicle fuel tank, is controlled by an Athena proportional control relay (SCR). This varies the power output to the heat blanket as dictated by the microprocessor. The amount of power supplied to the heat blanket is displayed in percent on the front of the LFE (see Appendix A-5). The temperature achievers have an indicator lamp, under the LFE front panel (Appendix A-5) which increases in brightness as power to the heat blanket increases. For safety, the units also contain an overtemperature shutoff set to kill blanket power when fuel temperature reaches 90°F. An electrical schematic and bill of materials for the temperature achiever are contained in Appendices A-2 and B respectively.

The LFE is programmed with a temperature rise ramp corresponding to the time and temperature rise equation stated in the CFR (see Appendix A-3). Fuel temperature from a type J thermocouple, located in a vehicle fuel tank, and elapsed time are then compared, internally in the LFE, to the eight ideal set points versus time programmed into the LFE. The fuel tank thermocouple is simultaneously connected to a temperature recorder as a permanent record of the "Diurnal breathing loss test" temperature rise.

In the automatic mode, if the thermocouple signal is lagging behind the temperature ramp, the LFE will increase the power output to the fuel tank heat blanket. If the fuel temperature signal is ahead of the CFR temperature ramp, power to the blanket is decreased or held at zero. At any time, the temperature achiever can be put into manual mode to allow a technician to apply or hold off power to the heat blanket. When the temperature achiever is placed back in automatic the achiever will continue with the heat build temperature set points, maintaining contiguity with the original start time.

Once the temperature achiever prototype was manufactured, VA&T began its evaluation under actual test conditions. Heat builds on two different-sized fuel tanks were performed to establish a volume range, on which the new temperature achiever's automatic mode could be expected to satisfactorily perform heat builds. A year's worth of VA&T test data were reviewed and reduced to histograms of test vehicle fuel tank sizes to select the two test volumes. The histograms revealed that using 13 gallons as low volume and 18 gallons as high volume would produce test data which would bracket 70 percent of the heat builds performed in VA&T. 40 CFR 86.078-2 defines the "tank fuel volume," used for the heat builds, as "determined by taking the manufacturer's nominal tank(s) capacity and multiplying by 0.40." For these tests 5.2 and 7.2 gallons were used, corresponding to 13 and 18 gallons respectively. In addition, the achievers had never approached using continual 100% power output when EST had experimented with them. So we felt there would be no control problems on large volume fuel tanks. This would leave only 7 percent of the heat builds performed in VA&T (actual fuel volumes of less than 5.2 gallons) which might require the heat builds run primarily in manual mode (Appendix A-8).

Five diurnal breathing loss tests were performed on 5.2 gallons and five on 7.2 gallons to allow the generation of confidence intervals representing achiever operation on 93 percent of all vehicles tested in VA&T. All temperature recordings were reduced to CFR temperature ramp target difference from the actual temperature ramp value [Diff=T(actual)-T (CFR)] at each 5 minute interval from t=0 to t=60. The means, standard deviations, and 95 percent confidence intervals of the individual CFR temperature ramp targets' differences from actual test temperature ramp values for the first set of prototype evaluations by LPG are below:

Table 1

Time	NOVA (7.2 gal.) Diff	N	Std.Dev.	95% Cl	Pinto (5.2 gal.) Diff	N	Std.Dev.	95% Cl
0								
5	1.14	5	0.79	(0.16,2.12)	1.22	6	0.44	(0.76,1.68)
10	1.64	5	0.88	(0.55,2.73)	1.42	6	0.72	(0.66,2.18)
15	1.60	5	1.12	(0.21,2.99)	1.12	6	0.82	(0.26,1.98)
20	1.72	5	0.92	(0.58,2.86)	1.43	6	0.84	(0.55,2.31)
25	1.52	5	0.99	(0.29,2.75)	1.37	6	0.72	(0.61,2.13)
30	1.50	5	0.87	(0.42,2.58)	1.25	6	0.84	(0.37,2.13)
35	1.24	5	0.86	(0.17,2.31)	1.00	6	0.52	(0.45,1.55)
40	1.22	5	0.97	(0.01,2.43)	0.65	6	0.82	(-0.21,1.51)
45	1.12	5	0.89	(0.01,2.23)	1.15	6	0.71	(0.41,1.89)
50	0.94	5	0.93	(-0.22,2.10)	0.78	6	0.52	(0.23,1.33)
55	0.68	5	0.83	(-0.35,1.71)	0.53	6	0.59	(-0.09,1.15)
58	0.46	5	0.73	(-0.44,1.37)	0.70	6	0.81	(-0.15,1.55)
60	0.52	5	0.64	(-0.28,1.32)	0.33	6	0.60	(-0.30,0.96)
62	1.10	2	0.14		0.25	4	0.66	(-0.80,1.30)

Time	Diff	Both N	Std.Dev.	95% Cl
0				
5	1.18	11	0.59	(0.78,1.58)
10	0.72	11	1.52	(-0.30,1.74)
15	1.44	11	0.93	(0.81,2.07)
20	1.56	11	0.85	(0.99,2.13)
25	1.44	11	0.81	(0.90,1.98)
30	1.36	11	0.82	(0.80,1.91)
35	1.11	11	0.67	(0.66,1.56)
40	0.91	11	0.90	(0.30,1.52)
45	1.14	11	0.75	(0.63,1.64)
50	0.85	11	0.69	(0.39,1.31)
55	0.60	11	0.68	(0.14,1.06)
58	0.59	11	0.74	(0.09,1.09)
60	0.42	11	0.60	(0.02,0.82)
62	0.53	6	0.68	(-0.18,1.24)

The above data were generated on automatic control using various wattage blankets to heat and type J thermocouples to measure fuel tank temperatures on the different tests. Fuel tank temperatures were recorded on VA&T temperature recorders which were calibrated independently of the temperature achiever. All tests satisfied 40 CFR 86.133-78 requirements.

After review of the initial prototype data (Table 1), two questions were raised:

1. Can the microprocessor temperature control confidence intervals be narrowed down by changing its internal control (tune) parameters?

2. Do the confidence intervals indicate that use of the temperature achievers will result in temperature traces with positive temperature rise bias from the CFR equation?

The first question was answered by an LFE Corporation design engineer (Appendix A-8). Under our test conditions, the one- to two-degree spread seen in the confidence intervals in Table 1 is the best the microprocessors might be expected to perform. The answer to the second question lies in how the achievers will be used in actual testing. The heat builds will be monitored by technicians. The technician will adjust the achievers manually to return them to the CFR targets, if necessary. The technician control will ensure no change in the stringency of the test, because historically all the "Diurnal breathing loss tests" have been controlled by the test technicians (Appendix A-12).

As a verification that the units could perform diurnal breathing loss tests in automatic, exactly as specified in the CFR, new data were generated using the same temperature achiever as before. The achiever and a recorder were calibrated at the same time to ensure they agreed. The tests were performed on automatic with the same recorder, thermocouple, heat blanket, and a fuel volume of 6.6 gallons (mean gasoline volume of tests performed in VA&T). The mean, standard deviations and confidence intervals for each of the 5-minute intervals are presented below:

Table 2

Time	Diff	N	Std.Dev.	95% Cl
0				
5	0.04	5	0.30	(-0.38,0.46)
10	-0.04	5	0.26	(-0.41,0.33)
15	0.00	5	0.37	(-0.53,0.53)
20	-0.08	5	0.50	(-0.79,0.63)
25	0.00	5	0.49	(-0.70,0.70)
30	-0.04	5	0.33	(-0.51,0.43)
35	-0.28	5	0.39	(-0.83,0.27)
40	-0.60	5	0.40	(-1.17,-0.03)
45	-0.60	5	0.47	(-1.27,0.07)
50	-0.72	5	0.36	(-1.24,-0.20)
55	-0.88	5	0.30	(-1.31,-0.45)
58	-1.04	5	0.26	(-1.41,-0.67)
60	-1.20	5	0.32	(-1.65,-0.75)
62	-1.32	5	0.23	(-1.64,-1.00

The manufacture and compliance testing of eleven LFE temperature achievers (in addition to the prototype) took place from July 1987 through December 1987. Once an achiever satisfied the CFR Compliance Test Procedure (Appendix A-10), it was placed in use. The compliance tests verified that each unit's high temperature cutoff functioned and established that each achiever could perform an automatic heat build on both a 5.2 gallon and a 7.2 gallon volume of fuel. For acceptance, both fuel temperature traces had to be within ± 2°F of the CFR ideal temperature rise ramp, all achievers met this criterion. The summary statistics are presented below for all successful compliance tests.

Table 3

(11 Temperature Achievers Tested)

Time	Diff	N	Std.Dev.	95% Cl
0				
5	1.2	24	0.91	(0.91,1.67)
10	1.38	24	0.77	(1.05,1.70)
15	1.04	24	0.75	(0.72,1.36)
20	0.67	24	0.92	(0.28,1.05)
25	0.58	24	0.97	(0.17,0.99)
30	0.46	24	0.83	(0.11,0.81)
35	0.50	24	0.98	(0.09,0.91)
40	0.54	24	0.93	(0.15,0.94)
45	0.63	24	0.82	(0.28,0.97)
50	0.33	24	0.64	(0.06,0.60)
55	0.33	24	0.82	(-0.01,0.68)
60	0.25	24	0.68	(-0.04,0.54)

Conclusions

1. When the temperature achievers are calibrated with the specific recorders used for the heat builds and care is taken to match heat blanket wattage to fuel volume, the performance of the temperature achiever in automatic mode improves (Table 2).

2. The 95 percent confidence intervals of individual temperature achiever CFR Compliance Tests indicate that the new temperature achievers are capable of performing CFR heat builds in automatic mode with a comparable repeatability of one degree on "Diurnal breathing loss test" heat builds (per 40 CFR 86.133-78) performed on 13 and 18 gallon fuel tanks (Table 3). This performance is anticipated on 93 percent of the vehicles tested at MVEL (Appendix A-8)

Recommendations

1. Calibrate and maintain the temperature achievers in pairs with the recorders with which they are used in conjunction.

2. Care should be taken to match heat blanket wattage to fuel volume. (Technician judgement will be required until a study is made to develop a specific guideline.)

3. Technicians should monitor the temperature achiever operation during the diurnal breathing loss tests run on automatic.

4. Technicians should take special care with actual fuel volumes of 5.2 gallons or less. Diurnal breathing loss tests on these smaller volumes may require being run entirely in manual mode.

0941e

EQUIPMENT/PROCEDURE CHANGE NOTICE

EPCN NO. 69 | DATE ENTERED 09 / 22/ 86 | PAGE 1 OF 1

1. ORIGINATOR Carl M. Paulina
2. PHONE EXT. 421
3. REVIEW DUE DATE: N/A — ENTER "FYI" AS APPLICABLE
4. DIVISION CLEARANCE
5. TYPE OF CHANGE: ☐ FED. REGISTER ☒ EQUIPMENT ☐ A/C ☐ MSAPC PROCEDURE ☐ FORM ☐ OTHER
6. REFERENCE DOCUMENTS (List Attachments, Forms, Procedures, FR's, etc.)
   40 CFR 86.107-78, 40 CFR 86.133-78, EPA TP 704A, EPA TP 705B
7. DESCRIPTION OF CHANGE (Attach details, specifications, drawings, and implementation plan).

Description - This EPCN authorizes the use of a new model temperature achiever, controlled by an LFE Corporation model 2010/2011 process microprocessor and an Athena model PC proportional SCR. The heat blankets and thermocouples used for CFR gasoline tank heat builds will remain unchanged.

Implementation - As each new unit is completed, it will be tested for safety and compliance with the requirements of 40 CFR Section 86 subpart B. After a unit successfully completes the compliance test, it will be approved for use. Full implementation of the 12 new units is expected to be complete two months following EPCN approval.

Documentation - Prototype functional test data, system schematics, compliance test procedures and results, and operational procedures will be retained in QC Group files.

8. PURPOSE OF CHANGE (Why is this change being proposed?)

Implementation of new electronic control system to replace obsolete units.

9. PROPOSED EFFECTIVITY (Date, MY, etc.) August 3, 1987
10. DURATION OR EXTENT OF USE ☒ PERMANENT ☐ TEMPORARY
11. AREAS OF MSAPC AFFECTED BY THIS CHANGE

☒ LDT ☐ E & D ☒ INST. SERV. ☐ CHEM LAB. ☒ QC/QA ☐ ECTD
☐ HDT ☐ C & M ☐ RTS HDWR. ☐ TEST VALID. ☐ DATA BR. ☐ CSD
☒ OTHER TP 704A and TP 705B (see attached)

12. REVIEWS AND APPROVALS

REVIEWED BY	INIT.	DATE	CONCURRENCE	COMMENTS
A. James D. Carpenter, Ch Facility Support Branch	DWT for JDC	7/22/87	☒ YES ☐ NO	
B. John T. White, Ch Testing Programs Branch	JTW	7/22/87	☒ YES ☐ NO	
C. C. Don Paulsell, Ch Engineering Staff, EOD	CDP	7/22/87	☒ YES ☐ NO	

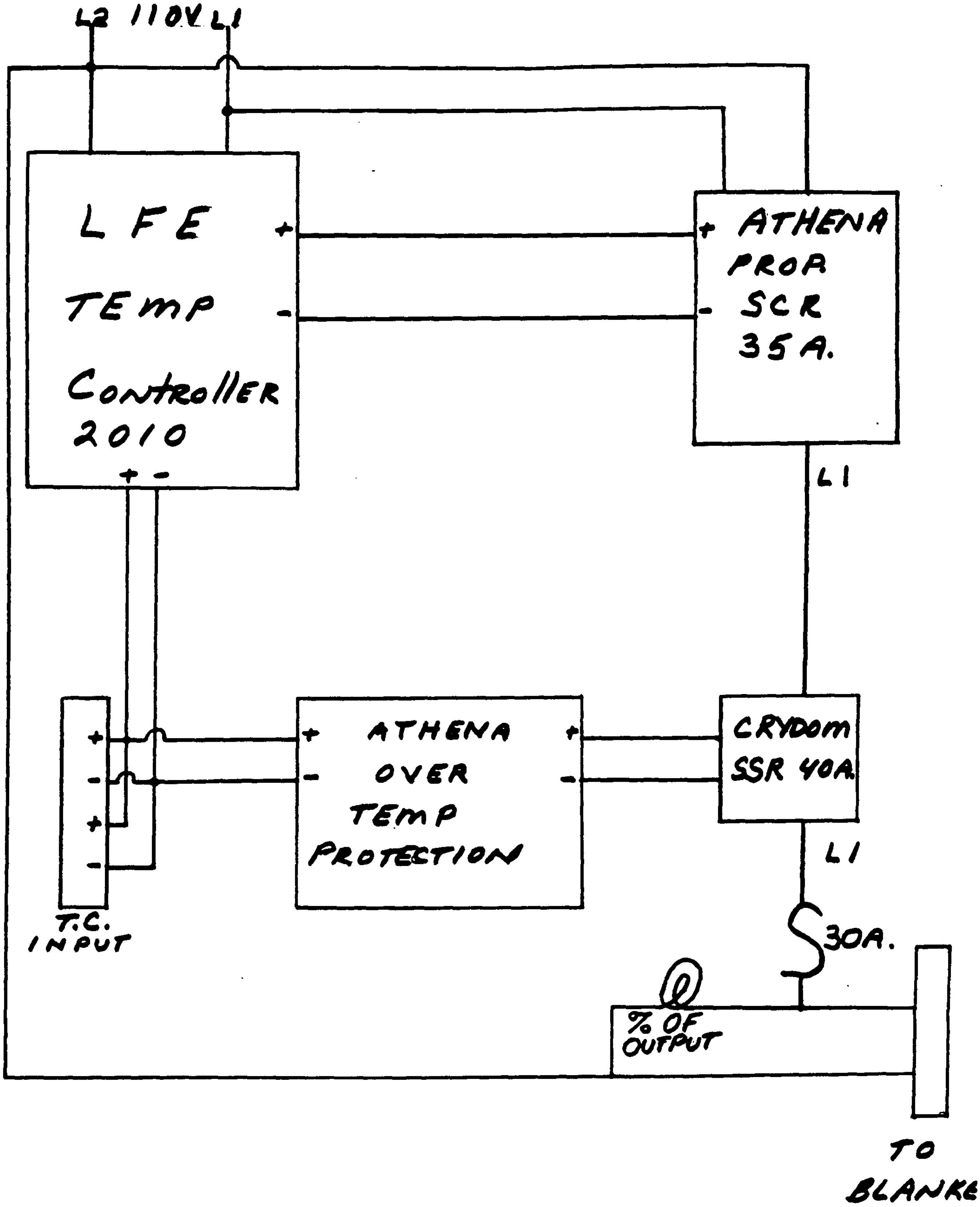
13. DIVISION RESPONSE (QC) — Signature: Donald D. Dowdy — DATE: 7/22/87
RECOMMENDED ACTION: APPROVE ☐ DISAPPROVE ☐ CONDITIONAL APPROVAL ☐ (Comments) REQUEST TO REVIEW REDRAFTS ☐

THE REVIEWS AND RESPONSES NOTED HAVE BEEN RECEIVED AND DOCUMENTED. DATE
14. EPCN CONTROLLER
REDRAFT REQUIRED ☐ RELEASED FOR IMPLEMENTATION ☒

THE PROVISIONS OF THIS EPCN ARE HEREBY AUTHORIZED FOR IMPLEMENTATION.
15. AUTHORIZED BY: — DATE 7-22-87

MSAPC FORM 7.5 REVISED: 7/1/75 — DISTRIBUTION: ORIGINAL (White) - EPCN LOG; COPY 1 (Yel'; COPY 2 (Blue) - EPCN INTERIM LOG; COPY 3 (Pink) - RETAINED BY ORIGINATOR

TEMP ACHIEVER



Temperature Controller Set Points

The following are the entries necessary to program an LFE programable controller to perform FR gasoline heat builds. The entries are made in conjunction with section III of LFE model 2010/2011 instalation and operation manual. (955-239 rev. A 3484)

Controller Response	Entry
Set point 0	60 JF
Alarm 1	4 JF
Alarm 2	-4 JF
PR Band 1	3 %
Reset 1	0.10 R/M
Rate 1	0.77 M
Aux SP	13 JF
Aux DB	1.00 %
Ramp and Soak?	YES
Set Point 0	60 JF
Time 1	7:31
Set Point 1	63 JF
Time 2	7:30
Set Point 2	66 JF
Time 3	7:30
Set Point 3	69 JF
Time 4	7:30
Set Point 4	72 JF
Time 5	7:30
Set Point 5	75 JF
Time 6	7:30
Set Point 6	78 JF
Time 7	7:30
Set Point 7	81 JF
Time 8	7:30
Set Point 8	84 JF
Cycles	1
Assured Soak ?	NO
End of Tune	

The above sequence ends the programing necessary for the LFE to perform a Federal Register gasoline tank diurnal heat builds. These settings were used for all heat builds performed to evaluate Temperature Achiever proto-type F.R. compliance up to 3/10/87.

The following are the calibration entries. The units can be ordered with these entries.

PN	D0 52 00 34 00
UNITS	JF
TIME	M:S
LO SPAN	60 JF
HI SPAN	86 JF

CAL COMPLETE

LFE Corp. Temperature Achievers'
Operational Procedure

SET-UP:

1. If the display reads OPEN INPUT, plug in a type J thermocouple (TC) to a TC jack on rear of unit. Allow a 3 to 5 minute warm-up with a TC plugged in.
2. Connect the second TC jack on the rear of the temperature achiever to the temperature recorder.
3. Press DISPLAY button (Item F figure 1)until the display reads the same as figure 1.
4. If the temperature displayed on the achiever does not agree with the temperature recorder within ±2°F after a 3-5 minute warm-up, return the heat build cart to EST for calibration.
5. If a TC other than the test vehicle fuel tank TC (i.e. ambient) is plugged into the jack at rear of achiever, switch it with the fuel tank TC.
6. The green MAN light (Item B figure 1) should be flashing. [Achiever is on hold. If not push START/STOP (Item I figure 1)]
7. Plug the vehicle heat blanket into the 120 volt AC jack on back of the temperature achiever.

PRE-HEAT BUILD:

1. Push START/STOP (Item I figure 1) button [Flashing green MAN light (Item B figure 1) will go out or remain on continually]. The temperature achiever has now begun a heat build cycle.
2. If the green MAN light (Item B figue 1) is not on continually, push the AUTO/MANUAL button (Item E figure 1).
3. When the green MAN light (Item B figure 1) is on, the unit is in a heat build cycle manual mode. The YES(↑) and NO(↓) buttons (Items G & H figure 1) control the amount of power to the heat blanket. The rate of the gasoline temperature rise will will be proportional to the percent power output. (Item C figure 1) The fuel temperature rise preceding the heat build should not exceed 1°F per minute.(TP705)
4. When the gasoline temperature approaches the point at which the heat build will begin, press AUTO/MANUAL button (Item E figure 1) and IMMEDIATELY press START/STOP (Item I figure 1). The MAN light (Item B figure 1) should be flashing. (Achiever is on hold)

AUTOMATIC HEAT BUILD CYCLE:

1. When ready to begin (60 ± 2°F), push START/STOP (Item I figure 1). Flashing green MAN light (Item B figure 1) should go out.(If not, see Pre-Heat Build #2) The achiever is now performing a heat build.
2. Monitor the heat build temperature rise. If the gasoline temperature is running behind or ahead of target, use AUTO/MANUAL button (Item E figure 1) and set the desired power output. You can return to the automatic mode whenever you wish by pressing AUTO/MANUAL button(Item B figure 1), the achiever should resume the proper heat build ramp. The test may be finished in manual mode, if desired.
3. The temperature achiever will automatically shut-off at the end of the 60 minute heat build cycle.(Manual or Automatic Modes) If you wish to continue applying heat see PRE-HEAT BUILD.

DO NOT LEAVE TEMPERATURE ACHIEVER UNATTENDED
IN EITHER MANUAL OR AUTOMATIC MODE

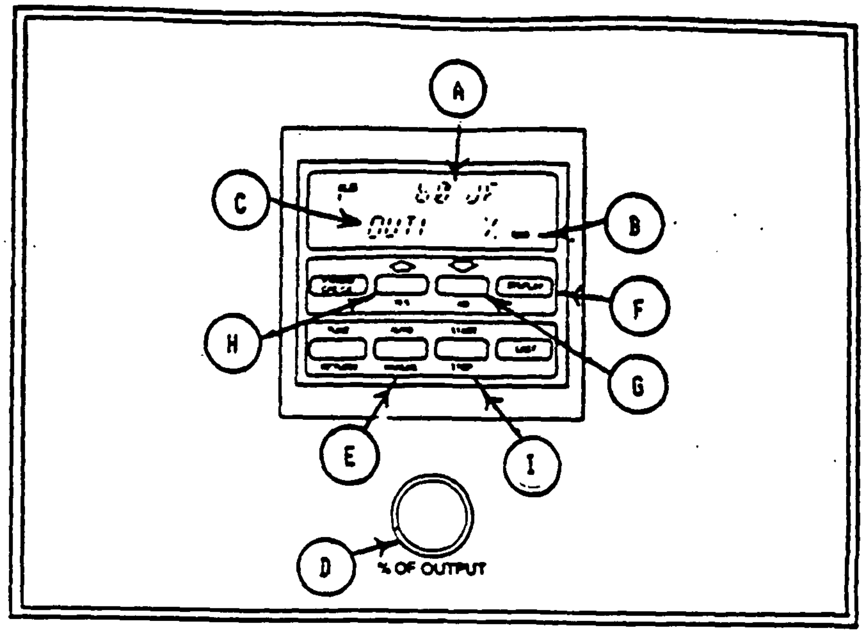
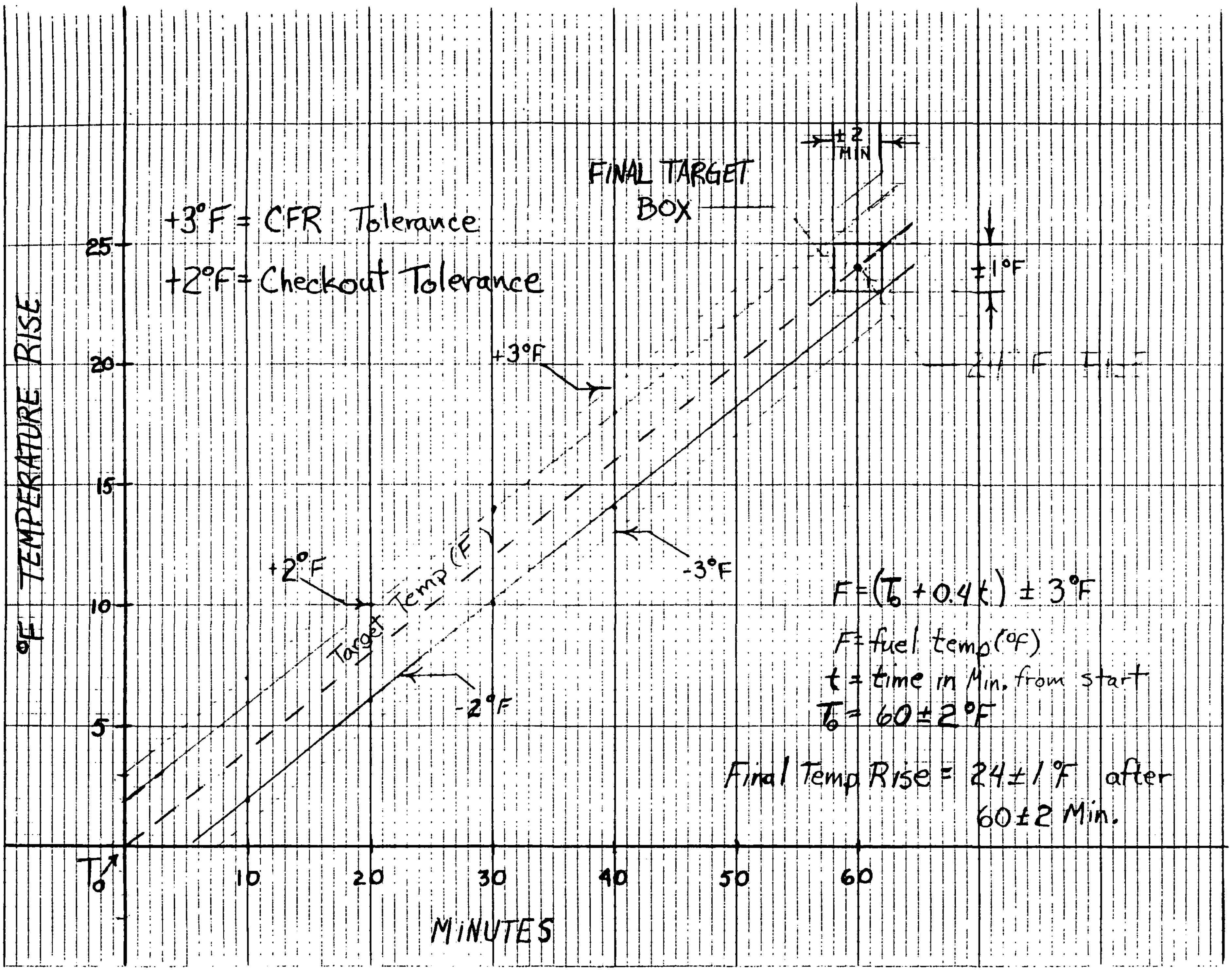


FIGURE 1

	DESCRIPTION	FUNCTION
(A)	60 JF	DISPLAYS FUEL TEMPERATURE(60°F,TYPE J THERMOCOUPLE)
(B)	MAN	DISPLAYS OPERATIONAL MODE – BLINKING: ON HOLD OFF : HEAT BUILD CYCLE (AUTOMATIC) ON : HEAT BUILD CYCLE (MANUAL)
(C)	OUT1 %	DISPLAYS PERCENTAGE POWER OUTPUT TO BLANKET
(D)	% OF OUTPUT	LAMP BRIGHTNESS INCREASES WITH POWER OUTPUT TO HEAT BLANKET
(E)	AUTO/MANUAL	PRESS TO SWITCH UNIT BETWEEN AUTOMATIC AND MANUAL MODES (DOES NOT INTERUPT 60 MIN. HEAT BUILD CYCLE)
(F)	DISPLAY	PRESS TO CHANGE PARAMETERS DISPLAYED IN READOUT. (PRESS UNTIL DISPLAY IS SAME AS FIGURE 1)
(G)	NO(↓)	PRESS TO DECREASE POWER OUTPUT TO HEAT BLANKET. (MANUAL MODE ONLY)
(H)	YES(↑)	PRESS TO INCREASE POWER OUTPUT TO HEAT BLANKET. (MANUAL MODE ONLY)
(I)	START/STOP	PRESS TO BEGIN OR END HEAT BUILD CYCLE (RESETS TO TIME=0 ON STOP)

ALLOWABLE DEVIATION FROM TARGET TEMP. VS. TIME

TIME(min.)	TARGET TEMP. RISE	CHECKOUT LIMITS (DELTA TEMP. FROM TARGET)	AUTOMATIC VOID REGULATORY LIMITS (DELTA TEMP. FROM TARGET)	VALID TEST END LIMITS (ANY OF 58, 60, OR 62 MIN INTERVALS)
5	2.0	(-2.0,+2.0)	(-3.0,+3.0)	
10	4.0	(-2.0,+2.0)	(-3.0,+3.0)	
15	6.0	(-2.0,+2.0)	(-3.0,+3.0)	
20	8.0	(-2.0,+2.0)	(-3.0,+3.0)	
25	10.0	(-2.0,+2.0)	(-3.0,+3.0)	
30	12.0	(-2.0,+2.0)	(-3.0,+3.0)	
35	14.0	(-2.0,+2.0)	(-3.0,+3.0)	
40	16.0	(-2.0,+2.0)	(-3.0,+3.0)	
45	18.0	(-2.0,+2.0)	(-3.0,+3.0)	
50	20.0	(-2.0,+2.0)	(-3.0,+3.0)	
55	22.0	(-2.0,+2.0)	(-3.0,+3.0)	
58	23.2	(-2.0,+2.0)	(-3.0,+3.0)	(-0.2,+1.8)
60	24.0	(-2.0,+2.0)	(-3.0,+3.0)	(-1.0,+1.0)
62	24.8	(-2.0,+2.0)	(-3.0,+3.0)	(-1.8,+0.2)



+3°F = CFR Tolerance
+2°F = Checkout Tolerance
FINAL TARGET BOX
±2 MIN
±1°F
+3°F
-3°F
+2°F
-2°F
Target Temp (F)
F = (T₀ + 0.4t) ± 3°F
F = fuel temp (°F)
t = time in Min. from start
T₀ = 60 ± 2°F
Final Temp Rise = 24 ± 1°F after 60 ± 2 Min.
°F TEMPERATURE RISE
MINUTES
T₀
25
20
15
10
5
10
20
30
40
50
60

3/5/87

Additional Information/Clarification

1. Set-up parameters used in proto-type. - Attached (supplied by EST)

2. Does Q.C. feel that data from 5.2 and 7.2 gallon nominal tank volume heat builds indicate an operational offset from 0 target that should necessarily be corrected by changing microprcessor tune parameters?

Answer-No. The initial eleven tests were performed with no control on heat blanket size, thermocouple type (intank,stick-on,weighted,etc), temperature recorder agreement with temperature achiever proto-type, or technician familiarity with operation of the units(no attention given to pre-heat build temp. rise and tests performed on full automatic). The tests were performed over approximately two months with no calibration checks on the recorders or proto-type. Q. C. and Mark Alarie (engineer LFE) agree with Project Engineer that the data indicates an ability of the Temperature Achiever proto-type to control temperatures within a 2-2.5 degree F range, Fed. Reg. allows 6 degrees F. The temperature achiever proto-type(set-up parameters same as initial 11 tests) had its temperature read-out re-calibrated(it was 1-2 degrees high). A temperature recorder was calibrated at the same time and all second set tests were performed with the same recorder. All 5 new heat builds were performed with an in tank weighted TC, 6.4 gallons of gasoline(approx. mean of all nominal fuel tank volumes over previous year), 600 watt heat blanket,and all automatic operation.(No technician overides were allowed although it will probably be common in practice.) The summary of the second set of tests is attached. Mark Alarie(engineer for LFE Corp.) went on to say that the units could not be set up to function exactly the same with heat blankets that range from 600 to 2000 watts and varying tank sizes. In Mark's opinion all the tests results sound as if the proto-type is operating about as well as can be expected and "fine tuning" the units is time and labor intensive.

Conclusion : Data does not indicate that all LFEs will have a positive temperature offset from heat build ramp target temps with the set-up parameters established by EST(temp. achiever proto-type developers)

Suggested Areas of Responsibility:
1.Calibration(EST)
2.Blanket to volume sizing(VAT)

3. Other vehicles tried?

Answer : Histograms of 2046 tests in the previous year indicate that only 7% of the vehicles tested in VAT would have nominal tank volumes(40% full) of less than 5.2 gallons. In all the tests performed with the proto-type the unit hasn't even approach maximum power to the blanket over the entire hour heat build. I feel we should have no problems controlling heat builds on higher volumes of gas than those used. If the 7% of test vehicles which would have nominal volumes smaller than the 5.2 gallon tests have too small of thermal capacities for this proto- type combined with our present heat blanket stock, technician overide and/or stocking smaller power heat blankets should minimize problems in this area.

4. Branch Chief needs an explanation of 58 to 62 minute limits.

Answer : If the temperture rise is within any of the acceptance intervals written for 58, 60,or 62 minutes, the heat build can be stopped and the test is valid (if the 3 degree limit has not been violated.)

5. Why not use ATA ramp for heating fuel to starting point?

Answer : Two reasons -

1. VAT technicians require the ability to coax two vehicles to their starting temps at different rates so that vehicles can be started at the same time.

2. Temperature achiever operation will cause 100% power output with present set-up, resulting in overdriving the fuel temperature at test start. Fuel dispensing temperature variability prevent programming a cycle for pre-heat build ramp.

6. Should it stop @ 60 minutes - may want 62 in case its comming up slow?

Answer : Maybe. Lets let VAT & EST decide. It can easily be incorporated. I don't see any reason to hold up manufacturing the units for VAT, inorder to do additional testing.

Automatic Temperature Achiever CFR Compliance Test Procedure

1. Safety Temperature and Automatic/Manual Override Tests : Place thermocouple and a thermometer into a beaker of water at less than 60°F. Plug the thermocouple into back of temperature achiever. Plug one hundred ten volt AC lamp into power output plug on back of temperature achiever. Start automatic heat build cycle. One hundred ten volt lamp should light with power output. Push AUTO/MANUAL button. Green MAN light (on front of LFE) should stay on. Push NO (↓) button on temperature achiever front until one hundred ten volt lamp goes out and power output reading on front of temperature achiever goes to 0%. Push YES (↑) button until power output goes to 75%.

Supply a millivoltage equivalent to 90° ± 1°F to the thermocouple jack on the rear of the temperature achiever. The one hundred ten volt and front indicator lamps should go out.

2. Set up temperature achiever/heat blanket with a vehicle containing 7.2 gallons of gasoline.

3. Perform heat build. Temperature trace must satisfy the following conditions:

$$F = T + 0.4\,t$$

where:

F = fuel temperature, °F

t = time since start of test in minutes

T = 60° + 2°F (initial fuel temperature)

After 60 ± 2 minutes of heating, the fuel temperature rise shall be 24° ± 1°F. Save temperature trace with temperature achiever unit #, test date, gasoline amount, chart speed, and heat blanket power rating.

4. Perform steps 2-3 with a vehicle containing 5.2 gallons of gasoline.

5. Test Acceptance Criteria :

A. Achiever stops automatic cycle at 60 minutes.

B. Based on a 60°F start temperature, the temperature trace will meet the following criteria ± 2°F, in the automatic mode.

Automatic Temperature Achiever
temperature vs time

Minutes	Fuel Temperature (°F)
0	60
5	62
10	64
15	66
20	68
25	70
30	72
35	74
40	76
45	78
50	80
55	82

At 60 ± 2 minutes the fuel temperature rise will be 24 ± 1°F. No round offs will be acceptable.

C. Must be able to perform step 1 completely. (manual power increase and decrease, 90°F power output shut off)

If temperature achiever fails to meet the above criteria, return to EST for calibration until unit successfully passes all criteria.

LFE Temperature Achiever Theoretical Rationale On Need for Comparative Data

I feel that we should not run comparitive testing between the new temperature achievers and the old to determine if the new achievers will affect gasoline vehicle evaporative emissions from historical because:

1. The fuel tanks will continue to be heated by the same heat same heat blankets as previously.

2. Fuel tank temperatures will be measured by the same thermocouples.

3. The thermocouple, recorder, temperature achiever, heat blanket/fuel volume match ups all dictate the performance of the temperature achievers fuel temperature heat build on automatic.

   Conclusion: It is not possible to determine a typical configuration to compare.

4. Heat builds will always be performed under technician supervision. The technicians were the controling influence on heat builds in the past, and will continue to be with the new achievers.

   Conclusion: Fully automatic heat build comparison to prevous tests would not be valid and technician supervision of the heat builds will ensure no change in the test stringency.

5. No real baseline of comparison exists. It would require a data search through analog temperature traces to establish what our historical temperature rise confidence intervals are. Do we want to spend considerable resources to establish historical test variability on a test that is primarily technician controlled ? Since the new achievers have technician overide capability, there isn't any reason to assume there will be a difference in the heat build temperature rise values from historical.

TEST #1 STATISTICS

	NOYA				PINTO				TOTAL			
time	X_{ave}	N	σ	95% CI	X_{ave}	N	σ	95% CI	X_{ave}	N	σ	95% CI
0												
5	1.14	5	0.79	(0.16,2.12)	1.22	6	0.44	(0.76,1.68)	1.18	11	0.59	(0.78,1.58)
10	1.64	5	0.88	(0.55,2.73)	1.42	6	0.72	(0.66,2.18)	0.72	11	1.52	(-0.30,1.74
15	1.60	5	1.12	(0.21,2.99)	1.12	6	0.82	(0.26,1.98)	1.44	11	0.93	(0.81,2.07)
20	1.72	5	0.92	(0.58,2.86)	1.43	6	0.84	(0.55,2.31)	1.56	11	0.85	(0.99,2.13)
25	1.52	5	0.99	(0.29,2.75)	1.37	6	0.72	(0.61,2.13)	1.44	11	0.81	(0.90,1.98)
30	1.50	5	0.87	(0.42,2.58)	1.25	6	0.84	(0.37,2.13)	1.36	11	0.82	(0.80,1.91)
35	1.24	5	0.86	(0.17,2.31)	1.00	6	0.52	(0.45,1.55)	1.11	11	0.67	(0.66,1.56)
40	1.22	5	0.97	(0.01,2.43)	0.65	6	0.82	(-0.21,1.51)	0.91	11	0.90	(0.30,1.52)
45	1.12	5	0.89	(0.01,2.23)	1.15	6	0.71	(0.41,1.89)	1.14	11	0.75	(0.63,1.64)
50	0.94	5	0.93	(-0.22,2.10)	0.78	6	0.52	(0.23,1.33)	0.85	11	0.69	(0.39,1.31)
55	0.68	5	0.83	(-0.35,1.71)	0.53	6	0.59	(-0.09,1.15)	0.60	11	0.68	(0.14,1.06)
58	0.46	5	0.73	(-0.44,1.37)	0.70	6	0.81	(-0.15,1.55)	0.59	11	0.74	(0.09,1.09)
60	0.52	5	0.64	(-0.28,1.32)	0.33	6	0.60	(-0.30,0.96)	0.42	11	0.60	(0.02,0.82)
62	1.10	2	0.14		0.25	4	0.66	(-0.80,1.30)	0.53	6	0.68	(-0.18,1.24

TEMPERATURE ACHIEVER EVALUATION

TEST SET #1

(Random temperature achiever, temp. recorder, thermocouple, heat blanket, and fuel tank matchups)

ΔT = DEVIATION FROM DESIRED RAMP, °F

time	1	2	3	4	5	6	7	8	9	10	11
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	1.3	0.0	1.0	2.2	1.2	1.2	0.5	1.8	1.4	1.0	1.4
10	1.4	0.4	1.6	2.8	2.0	0.1	1.4	2.0	2.0	1.2	1.8
15	1.0	0.2	1.6	3.2	2.0	-0.2	1.2	2.0	2.0	1.2	1.6
20	1.2	0.6	1.6	3.0	2.2	0.0	1.0	2.2	2.2	1.4	1.8
25	1.0	0.2	1.6	2.8	2.0	0.3	0.7	2.0	2.0	1.4	1.8
30	0.9	0.4	1.6	2.6	2.0	0.2	0.5	2.0	2.0	0.8	2.0
35	0.8	0.0	1.4	2.2	1.8	0.2	1.0	1.6	1.4	0.6	1.2
40	0.5	0.0	1.4	2.4	1.8	0.2	0.3	1.8	1.4	1.0	1.0
45	0.6	0.0	1.0	2.2	1.8	0.3	0.3	1.8	1.4	1.2	1.9
50	0.7	-0.4	0.8	2.0	1.6	0.1	0.4	1.6	0.8	0.8	1.0
55	0.2	-0.4	0.6	1.6	1.4	0.0	0.0	1.6	0.6	0.6	0.4
58	0.1	-0.6	0.6	1.2	1.0	-0.2	0.0	1.2	0.6	0.2	0.6
60	0.2	0.0	0.0	1.4	1.0	-0.4	0.4	1.4	0.4	0.2	0.0
62				1.2	1.0			1.2	0.2	-0.2	-0.2

1 NOVA Tank Vol. 7.2 Gal.
Large Blanket
No Thermocouple Indicated
7/23/86

2 NOVA Tank Vol. 7.2 Gal.
Crank Strip Blanket
In-Tank Thermocouple
8/28/86

3 NOVA Tank Vol. 7.2 Gal.
Large Blanket
Magnetic Thermocouple
No Date Indicated

4 NOVA Tank Vol. 7.2 Gal.
Medium Blanket
In-Tank Thermocouple
9/12/86

5 NOVA Tank Vol. 7.2 Gal.
Medium Blanket
In-Tank Thermocouple
9/12/86

6 PINTO Tank Vol. 5.2 Gal.
Small Strip Blanket
No Thermocouple Indicated
8/1/86

7 PINTO Tank Vol. 5.2 Gal.
Medium Strip Blanket
No Thermocouple Indicated
8/13/86

8 PINTO Tank Vol. 5.2 Gal.
Strip Blanket
In-Tank Thermocouple
9/17/86

9 PINTO Tank Vol. 5.2 Gal.
Strip Blanket
In-Tank Thermocouple
9/17/86

10 PINTO Tank Vol. 5.2 Gal.
Strip Blanket
In-Tank Thermocouple
9/17/86

11 PINTO Tank Vol. 5.2 Gal.
Strip Blanket
In-Tank Thermocouple
9/17/86

TEST #2 STATISTICS

	NOVA			
time	X_{ave}	N	σ	95% C.I.
0				
5	0.04	5	0.30	(-0.38, 0.46)
10	-0.04	5	0.26	(-0.41, 0.33)
15	0.00	5	0.37	(-0.53, 0.53)
20	-0.08	5	0.50	(-0.79, 0.63)
25	0.00	5	0.49	(-0.70, 0.70)
30	-0.04	5	0.33	(-0.51, 0.43)
35	-0.28	5	0.39	(-0.83, 0.27)
40	-0.60	5	0.40	(-1.17, -0.03)
45	-0.60	5	0.47	(-1.27, 0.07)
50	-0.72	5	0.36	(-1.24, -0.20)
55	-0.88	5	0.30	(-1.31, -0.45)
58	-1.04	5	0.26	(-1.41, -0.67)
60	-1.20	5	0.32	(-1.65, -0.75)
62	-1.32	5	0.23	(-1.64, -1.00)

TEMPERATURE ACHIEVER EVALUATION

TEST SET#2

(Same temperature achiever, temperature recorder, thermocouple, heat blanket and fuel tank volume on all tests. Temperature recorder and achiever temperature values calibrated to exact agreement.)

	ΔT = DEVIATION FROM DESIRED RAMP, °F				
time	1	2	3	4	5
0	0.0	0.0	0.0	0.0	0.0
5	0.2	-0.4	0.4	0.0	0.0
10	0.2	-0.4	0.2	0.0	-0.2
15	0.2	-0.4	0.2	0.4	-0.4
20	0.2	-0.8	0.2	0.4	-0.4
25	0.0	-0.8	0.4	0.4	0.0
30	-0.2	-0.4	0.4	0.2	-0.2
35	-0.4	-0.8	0.0	0.2	-0.4
40	-0.8	-1.0	0.0	-0.4	-0.8
45	-0.8	-1.0	0.2	-0.6	-0.8
50	-0.6	-1.2	-0.2	-0.8	-0.8
55	-1.0	-1.2	-0.4	-0.8	-1.0
58	-1.0	-1.2	-0.6	-1.2	-1.2
60	-1.4	-1.6	-0.8	-1.0	-1.2
62	-1.4	-1.6	-1.0	-1.2	-1.4

1 WHITE NOVA Tank Vol. 6.4 Gal.
Heat Blanket MS-8 600 Watts
No Termocouple Indicated
2-24-87

2 WHITE NOVA Tank Vol. 6.4 Gal.
Heat Blanket MS-8 600 Watts
No Termocouple Indicated
2-25-87

3 WHITE NOVA Tank Vol. 6.4 Gal.
Heat Blanket MS-8 600 Watts
No Termocouple Indicated
2-25-87

4 WHITE NOVA Tank Vol. 6.4 Gal.
Heat Blanket MS-8 600 Watts
No Termocouple Indicated
2-25-87

5 WHITE NOVA Tank Vol. 6.4 Gal.
Heat Blanket MS-8 600 Watts
No Termocouple Indicated
2-25-87

LFE Temperature Achiever
Bill of Materials

1/27/88

Quan.	Part or Manufacturer	Description/Part No.
1	Bud Cabinet	Showcase: finish royal blue textured with white frame/BB-1804-RB
1	Hubbell	3-wire grounding flanged receptacle/5256
1	Buss	Fuse holder/Newark No. 81F2154
1	Littlefuse	Fuse/KLK-30
1	Magnecraft	Relay/W199AX-Y SPDT 120 VAC
1	Sylvania	Lamp/7 watt 125 v c7 7c7
1	Light	Amber lens/ Newark No.: 25F 1578
1	Dialight	Indicator light base/ Newark No.: 45F606
1	Athena	Alarm circuit controller, overtemperature/ 86AB-03F
1	Athena	Power Pack/PC-24-35-0-v
1	LFE	Micro-Processor/Model: 2010 PUP, PN D0 5200 3400
2	Thermo-Electric	T.C. Jacks Part/41806-JX Type J

TRW	Cinch Connectors/6-#141
Belden Wire	9918 BLK, 9918 White, 8916 BIK, 8916 white
Voltrex	Cable Clamps 5/16 Dia./Newark No. 32N1272