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SUBJECT: Provides addl info re proposed license amends re moderator temp coefficient surveillance requirements."

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FPL

FEBRUARY 2 6 1990

L-90-69
10 CFR 50.90

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D. C. 20555

Gentlemen:

Re: St. Lucie Units 1 and 2
Docket Nos. 50-335 and 50-389
Additional Information on Proposed License Amendments
Moderator Temperature Coefficient Surveillance Requirements
(TAC Nos. 66854 and 66855)

On October 26, 1989, a conference call was held between Florida Power & Light Company (FPL) and the NRC to discuss questions the NRC Staff reviewer had pertaining to the St. Lucie Unit 1 and St. Lucie Unit 2 proposed license amendments entitled, "Moderator Temperature Coefficient Surveillance Requirements." Additionally, on January 9, 1990, further discussions were held between FPL and the NRC concerning these questions. Attached is FPL's response to all of the questions which have been raised during these discussions.

Should you have additional questions, please contact us.

Very truly yours,

D A Sager

D. A. Sager
Vice President
St. Lucie Plant

DAS/MSD/gp

Attachments

cc: Stewart D. Ebneter, Regional Administrator, Region II, USNRC
Senior Resident Inspector, USNRC, St. Lucie Plant

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ATTACHMENT

RESPONSE TO CONFERENCE CALL QUESTIONS

1. **What MTC value is assumed in the Main Steam Line Break (MSLB) analysis for St. Lucie Unit 1?**

   The St. Lucie Unit 1 Technical Specifications state that the MTC shall be less negative than -28 pcm/degree F at rated thermal power. This is used as the MTC value in the MSLB analysis for St. Lucie Unit 1.

2. **Are the MTC values stated in the St. Lucie Unit 1 and Unit 2 Technical Specifications given as "ALL RODS OUT" values at Rated Thermal Power?**

   The MTC limits given in the St. Lucie Unit 1 and Unit 2 Technical Specifications are given as Limiting Conditions for Operation. These MTC limits apply at any rod position.

3. **Provide a comparison of predicted and measured MTC values for St. Lucie Unit 1 and Unit 2 at or near 300 ppm, as well as, the most negative predicted MTC values at Hot Full Power, All Rods Out for as many cycles as possible.**

   A comparison between predicted and measured MTC values is given in Table 1 for St. Lucie Unit 1 and Unit 2. The predicted end of cycle (EOC) MTC values are also included in Table 1 for each unit.

4. **Briefly describe the technique used to determine the MTC at St. Lucie Unit 1 and Unit 2.**

   The following is a brief description of the technique used to determine the MTC at both St. Lucie Unit 1 and Unit 2.

   Prerequisite

   The lead control rod assembly (CEA) bank is slowly diluted into the core (approximately 20% inserted) so as not to induce large axial offset disturbances and to allow xenon to reach equilibrium.

Method

The MTC is determined in two parts, utilizing a reactor coolant system (RCS) cooldown and a RCS heatup.

RCS average temperature cooldown

The electrical generation output is increased by approximately 50 MW to affect a RCS average temperature cooldown of approximately 5 degrees F. Core thermal power is maintained constant by inserting either one CEA out of the lead CEA bank for Unit 1 or the lead CEA bank for Unit 2. Reactor power and RCS average temperature are then stabilized using the electrical generation output and either the single CEA or the lead CEA bank, depending on the unit.

RCS average temperature heatup

The electrical generation output is reduced by approximately 50 MW to return the RCS average temperature to approximately its original value (prior to the RCS cooldown). The CEA(s) inserted in the RCS cooldown is withdrawn to maintain thermal power constant. The reactor power and RCS average temperature are stabilized using the electrical generation output and either the single CEA or the lead CEA bank, depending on the unit.

The MTC is determined for each heatup and cooldown cycle by dividing the reactivity withdrawn/inserted by the CEA to maintain constant power by the change in the RCS average temperature over several RCS heatup/cooldown cycles. The MTC values for each heatup and cooldown cycle are then averaged and corrected for power drift.

5. **Assume that during normal end of cycle (EOC) plant operation, plant conditions such as core average temperature, rod position, reactor coolant pressure, critical boron concentrations, etc., vary so as to change the MTC. Can these plant parameters vary within technical specification limits such that the MTC is more negative than the limit stated in the St. Lucie Technical Specifications?**

The analysis in response to this question required three dimensional SIMULATE3 modeling of the St. Lucie Unit 1 and Unit 2 cores. The St. Lucie Unit 1 analysis consisted of full core modeling while that of Unit 2 consisted of quarter core modeling. Both predict the MTC adequately. St. Lucie Unit 1 Cycle 9 and Unit 2 Cycle 5 EOC conditions were modeled. It should be noted that MTC values predicted by SIMULATE3 are: 1.) more negative at EOC than those that have been measured in past operating cycles at both St. Lucie Unit 1 and Unit 2, and 2.) SIMULATE3 MTC values are not biased.

The methodology used to analyze this question was to vary plant conditions about their nominal EOC values, beyond technical specification limits. The data was then examined to determine if any off-nominal operating conditions could exist within the bounds defined by the technical specifications such as to adversely affect the MTC (create a more negative MTC than that allowed in the technical specifications at EOC). The plant conditions investigated were:

1. Reactor coolant average temperature

2. RCS pressure

3. Core thermal power

4. Boron concentration

5. CEA position

6. Axial Shape Index (ASI)

Each parameter was varied about its nominal value (and in some cases outside the technical specification limits) while holding all other parameters constant. It should be noted that when varying the core thermal power, the core average temperature also varied. It should also be noted that the ASI could not be held constant while varying other operating parameters. All other parameters were held constant. In actual plant operation these parameters will be coupled in that changing one parameter about its nominal value will cause another to change about its nominal value.

The results of this analysis are presented in Tables 2 through 4 and Figures 1 through 5. The technical specification limits for a given operating parameter are included on each figure where applicable.

The results show that the EOC MTC is strongly dependent on the steady state coolant average temperature when all other parameters are held constant. Figure 1 shows this dependency. The dependency was found to be -0.29 pcm/degree F per degree F for Unit 1 and -0.28 pcm/degree F per degree F for Unit 2. For example, a 10 degree F increase in the average coolant temperature will lead to a 2.9 pcm/degree F decrease in the EOC MTC for Unit 1 and a 2.8 pcm/degree F decrease in the EOC MTC for Unit 2.

Figure 2 shows that the MTC appears to be dependent on the core thermal power. As was stated before, a change in the steady state core operating power will cause a change in the coolant average temperature. Table 3 and Figure 3 demonstrate the EOC MTC dependency when the core average temperature is corrected to the nominal core average temperature as the power is varied. The dependency of the EOC MTC on core power was found to be approximately -0.015 pcm/degree F per percent power change for both Unit 1 and Unit 2. The dependency of the EOC MTC is not significantly dependent on the core power, but rather on the change in the average coolant temperature that results from a change in the core power. The high power trip limits are 107% for Unit 1 and 112% for Unit 2. If power were to increase to the high power trip setpoints (assuming that the average coolant temperature remains constant), the EOC MTC would decrease by 0.18 pcm/degree F for Unit 1 and 0.105 pcm/degree F for Unit 2.

It can be seen in Table 2 and Figure 4 that varying the boron concentration about the nominal EOC value (41 ppm for Unit 1 and 21 ppm for Unit 2) will affect the EOC MTC. As the boron concentration decreases (with all other parameters held constant), the MTC becomes more negative. The dependency of the MTC on the boron concentration was found to be 0.022 pcm/degree F per ppm for Unit 1 and 0.019 pcm/degree F per ppm for Unit 2. For example, a 100 ppm decrease in the boron concentration would lead to a 2.2 pcm/degree F decrease in the EOC MTC for Unit 1 and a 1.9 pcm/degree F decrease in the EOC MTC for Unit 2.

Table 2 and Figure 5 show that the EOC MTC is dependent on the RCS pressure. A change in the RCS pressure causes a change in the coolant density (both water and boron). A change in the RCS pressure also leads to a change in the average coolant temperature in order to maintain critical operations at a new pressure. A temperature change also leads to a change in the coolant density (both water and boron). For a given change in RCS pressure, these two effects are coupled and tend to cancel out, leading to small changes in the EOC MTC. For example, as RCS pressure increases, the coolant density increases (positive MTC trend). However, the average coolant temperature will also increase (to maintain critical operation at a new pressure) causing a decrease in the coolant density (negative MTC trend). The EOC MTC remains essentially unchanged.

At EOC, the MTC is most negative with respect to the steady state operating pressure when the RCS pressure is between approximately 90% to 95% of its nominal operating value (2250 psia). It can be seen that at its most negative condition with respect to pressure, the EOC MTC is not significantly more negative than its nominal value (0.3% less for Unit 1 and 0.5% less for Unit 2). A change in the RCS pressure does not adversely affect the EOC MTC (create a more negative EOC MTC).

Table 4 demonstrates that the MTC is dependent on the ASI. Shifts in the ASI cause the power and therefore, the temperature distributions within the core to deviate from their nominal EOC profiles. Changes in the temperature distribution about the nominal EOC profile will lead to changes in the global EOC MTC. The St. Lucie steady state power operating procedures limit the ASI to a band of plus or minus 0.05 units about the nominal value. The EOC MTC dependence on ASI is -2.9 pcm/degree F per unit ASI for Unit 1 and -2.3 pcm/degree F per unit ASI for Unit 2. An ASI unit is very large when compared to the operating band width of 0.1 ASI units about the nominal value. These values correspond to at the worst case steady state EOC ASI (0.05 units about the nominal value), a 0.6% decrease in the EOC MTC for Unit 1 and a 0.4% decrease in the EOC MTC for Unit 2. It should be noted that as operating parameters vary about their nominal EOC values, the ASI will also vary about its nominal value. However, the dependency of the EOC MTC on the ASI is small and can be ignored.

Table 2 shows that the EOC MTC is not significantly dependent on whether CEAs are partially inserted or fully withdrawn when all other plant parameters are held constant. Table 2 shows that the EOC MTC is 1.1% less negative when CEAs are inserted for Unit 1 and Unit 2. This analysis was performed assuming that the boron concentration was constant at the nominal EOC value (41 ppm for Unit 1 and 21 ppm for Unit 2) while the CEAs were inserted into the core. However, in actual operation, as CEAs are partially inserted, the boron concentration would have to be reduced to maintain critical operation. This would cause the EOC MTC to decrease due to the decrease in the boron concentration, as is shown in Figure 4.

The above results show that the EOC MTC is primarily dependent on the average coolant temperature and the boron concentration. However, it is not possible to vary these parameters within technical specification limits during normal plant operation so as to cause the EOC MTC to become more negative than that allowed in the technical specifications.

The manners in which to increase the average coolant temperature (and reduce the EOC MTC) are: 1. increase reactor power, and/or 2. increase the inlet temperature, and/or 3. decrease the coolant flow rate. The variability of these parameters within technical specification limits is listed below.

TECHNICAL SPECIFICATION LIMITS ON THE VARIABILITY OF PLANT PARAMETERS

Inlet Temp.	535 deg. F (Unit 2 only) ≤ Tin ≤ 549 deg. F
Pressure	2225 psia ≤ Pres ≤ 2350 psia (Unit 2 only)
Coolant Flow	Flow ≥ 37,000 gpm (Unit 1) ≥ 36,300 gpm (Unit 2)
Power	Power ≤ 100%

The above limits on the inlet temperature (549 deg. F), coolant flow rate, and reactor power are the nominal operating values for these parameters. None of these three parameters can be varied so as to raise the average coolant temperature above its nominal value. Therefore, the EOC MTC can not become more negative than the technical specification limit as a result of a change in the average coolant temperature.

The boron concentration can be reduced (and the EOC MTC reduced) while maintaining critical operation by either raising the average coolant temperature or inserting CEAs. Since the average coolant temperature can not be increased above its nominal value, the boron concentration can not be reduced due to a change in the average coolant temperature. It can be seen in Figure 4 that a change in the boron concentration alone (critical operations with CEAs inserted) will not cause the EOC MTC to become more negative than the technical specification limits.

In summary, plant parameters exist, primarily the average coolant temperature and the boron concentration, that affect the EOC MTC. However, these parameters can not vary about their nominal values within technical specification limits so as to cause an EOC MTC more negative that the limits given in the technical specifications.

Table 1
St. Lucie 300 ppm MTC Surveillance Requirement

Comparison of Measured
And Predicted MTC Values

		BOC HZP	800 ppm HFP	300 ppm HFP	EOC HFP
UNIT 1					
Cycle 6	measured	4.20	-3.60	-12.10	
	predicted	4.90	-1.50	-15.00	-22.60
Cycle 7	measured	4.70	-2.00	-12.90	
	predicted	4.50	-1.80	-15.00	-21.06
Cycle 8	measured	4.40	-1.60	-12.00	
	predicted	5.60	-1.40	-15.50	-21.44
Cycle 9	measured	4.10	-3.60	-12.06	
	predicted	4.50	-2.70	-12.97	-18.26
UNIT 2					
Cycle 2	measured	4.10	-3.11	-16.20	
	predicted	3.41	-5.14	-14.82	-22.14
Cycle 3	measured	2.71	-6.05	-13.82	
	predicted	2.49	-8.30	-16.75	-24.20
Cycle 4	measured	2.45	-6.68	-15.69	
	predicted	2.69	-8.78	-16.64	-23.81
Cycle 5	measured	3.65	-7.75	NA	
	predicted	3.37	-9.56	-16.80	-25.00

NA -- 300 ppm MTC measurement not yet performed for Unit 2 Cycle 5

Table 2

St. Lucie 300 ppm MTC Surveillance Requirement

Condition	Unit 1 MTC (pcm/deg. F)	Unit 1 Job #	Unit 2 MTC (pcm/deg. F)	Unit 2 Job #	Comments
		Change in RCS temperatures			
					EOC MTC is strongly dependent on the steady state core average temperature. Note that a 1% increase in Tin corresponds to a 1% increase in Tavg.
* 101% nom. Tin	-24.89	358	-27.09	1465	
* 100.5% nom. Tin	-24.18	366	-26.35	1478	
100% nom. Tin	-23.34	5463	-25.50	5356	
99.5% nom. Tin	-22.56	378	-24.67	1486	
99% nom. Tin	-21.82	386	-23.87	1490	UNIT 1 UNIT 2
					-0.29 -0.28 (pcm/Deg. F)/Deg. F
		Change in RCS Pressure			
* 110% nom. Pressure	-22.60	1329	-24.69	1492	Maximum decrease in MTC is approximately 0.3% for Unit 1 and 0.5% for Unit 2. EOC MTC is not adversely affected by the RCS pressure.
* 105% nom. Pressure	-23.09	1343	-25.23	1498	
100% nom. Pressure	-23.34	5463	-25.50	5356	
* 95% nom. Pressure	-23.37	1353	-25.62	1506	
* 90% nom. Pressure	-23.41	1360	-25.54	1513	
* 80% nom. Pressure	-23.10	2626	-25.09	2613	
		Change in Thermal Power			
* 115% nom. Power	-24.79	2631	-26.92	2620	A change in the thermal power results in a change in the core average temperature. The MTC dependency on the power is primarily dependent on the core average temperature. (See Table 3 for temp. correction)
* 110% nom. Power	-24.34	1368	-26.47	1517	
105% nom. Power	-23.86	1374	-26.00	1527	
100% nom. Power	-23.34	5463	-25.50	5356	
95% nom. Power	-22.80	1379	-24.95	1537	
90% nom. Power	-22.29	1389	-24.41	1539	

Change in Boron Concentration

Condition	Unit 1 Boron	Unit 1 MTC	Unit 1 Job #	Unit 2 Boron	Unit 2 MTC	Unit 2 Job #	Comments
0% nom. boron	0 ppm	-24.2	92	0 ppm	-25.91	1575	MTC dependent on boron concentration.
50% nom. boron	20 ppm	-23.8	102	10 ppm	-25.63	1581	
100% nom. boron	41 ppm	-23.3	5463	21 ppm	-25.50	5356	
150% nom. boron	60 ppm	-22.9	115	30 ppm	-25.33	1591	UNIT 1 UNIT 2
200% nom. boron	80 ppm	-22.5	128	40 ppm	-25.12	1600	-0.022 -0.019 (pcm/Deg. F)/ppm

* - Beyond Limit given in Technical Specifications

Table 2
St. Lucie 300 ppm MTC Surveillance Requirement

	Unit 1		Unit 2		
Condition	MTC (pcm/deg. F)	Job #	MTC (pcm/deg. F)	Job #	Comments
Insertion of Lead CEA Bank					
100% withdrawn	-23.34	5463	-25.50	5356	The dependence of the MTC
95% withdrawn	-23.57	7831	-25.78	7804	on CEA insertion is minimal.
90% withdrawn	-23.60	7834	-25.76	7809	1.1% decrease for Unit 1
85% withdrawn	-23.56	7838	-25.60	7811	1.1% decrease for Unit 2
80% withdrawn	-23.54	7842	-25.56	7815	
75% withdrawn	-23.56	7848	-25.72	7817	

NOTE: In all cases ASI changes, however, effect on MTC is negligible

Unit 1	Unit 2
Depletion given in Job # 5049	Depletion given in Job # 9696
Depleted to 16.5 GWd/MTHM = 11,870 EFPH	Depleted to 15.2 GWd/MTHM = 11,193 EFPH
Boron Concentration = 41 ppm	Boron Concentration = 21 ppm
Nom. Pressure = 2250 psi	Nom. Pressure = 2250 psi
Nom. Tavg = 575.1	Nom. Tavg = 574.7
Nom. Tin = 548 degrees F.	Nom. Tin = 548 degrees F.
Nom. Power = 2700 MW	Nom. Power = 2700 MW

Table 3

St. Lucie 300 ppm MTC Surveillance Requirement
EOC MTC Power Dependency Correction

	Unit 1			Unit 2		
% Power	Tavg (deg. F)	Raw MTC (pcm/deg. F)	Corrected MTC (pcm/deg. F)	Tavg (deg. F)	Raw MTC MTC (pcm/deg. F)	Corrected MTC (pcm/deg. F)
* 115	579.6	-24.79	-23.49	579.3	-26.92	-25.63
* 110	578.1	-24.34	-23.47	577.8	-26.47	-25.60
* 105	576.6	-23.86	-23.43	576.2	-26.00	-25.58
100	575.1	-23.34	-23.34	574.7	-25.50	-25.50
95	573.7	-22.80	-23.21	573.2	-24.95	-25.37
90	572.2	-22.29	-23.13	571.7	-24.41	-25.25

* Beyond limits given in Technical Specifications

MTC Tavg Dependency pcm/deg. F. per Deg. F (Unit 1)	MTC Tavg Dependency pcm/deg. F. per Deg. F (Unit 2)
-0.29	-0.28

The EOC MTC dependency on power is actually a dependency on the average coolant temperature associated with a given power level. SIMULATE3 cannot hold average coolant temperature constant while changing power. The temperature affect can be corrected out by the following relation:

Corrected MTC = Raw MTC - Tavg dependency * [Tavg(P) - Tavg(P=100%)]

WHERE

Tavg(p) -- the coolant average temperature for a given power level

Tavg(P=100%) -- the nominal average coolant temperature

Raw MTC -- the MTC output by SIMULATE3 for given power level and associated average coolant temperature

Tavg dependency -- the dependency of the EOC MTC on Tavg

Power dependency for constant temperature = -0.015 pcm/degree F per % power change

Table 4
St. Lucie 300 ppm MTC Surveillance Requirement

Dependence on Axial Shape Index (ASI)

Unit 1 -- Job 1993 Unit 2 -- Job 7824

Table 4
St. Lucie 300 ppm MTC Surveillance Requirement

Dependence on Axial Shape Index (ASI)

Unit 1 -- Job 1993 Unit 2 -- Job 7824

ASI	MTC	ASI	MTC
0.066	-23.55	0.069	-25.73
0.040	-23.60	0.049	-25.76
0.012	-23.67	0.025	-25.80
-0.015	-23.75	0.000	-25.86
-0.041	-23.81	-0.027	-25.90
-0.080	-23.96	-0.072	-26.01
-0.091	-23.99	-0.089	-26.07
-0.095	-24.01	-0.099	-26.10
		-0.102	-26.12
		-0.101	-26.12

Unit 1 MTC = -2.9 (pcm/Deg. F)/(Unit ASI)
Unit 2 MTC = -2.3 (pcm/Deg. F)/(Unit ASI)

NOTE: ASI unit is large, change in ASI is small

The ASI change was generating by inducing a xenon transient and determining the MTC at various times within the transient.

ASI = (Pbottom - Ptop)/(Pbottom + Ptop)

-ASI -- power in top half of core

+ASI -- power in bottom half of core

The ASI band from the Operating Procedures is plus or minus 0.05 ASI units from the nominal value. Thus, the corresponding MTC band is plus or minus 0.145 pcm/deg. F for Unit 1 and 0.115 pcm/deg. F for Unit 2. This corresponds to 0.6% decrease in the EOC MTC for Unit 1 and a 0.4% decrease in EOC MTC for Unit 2.

Figure 1

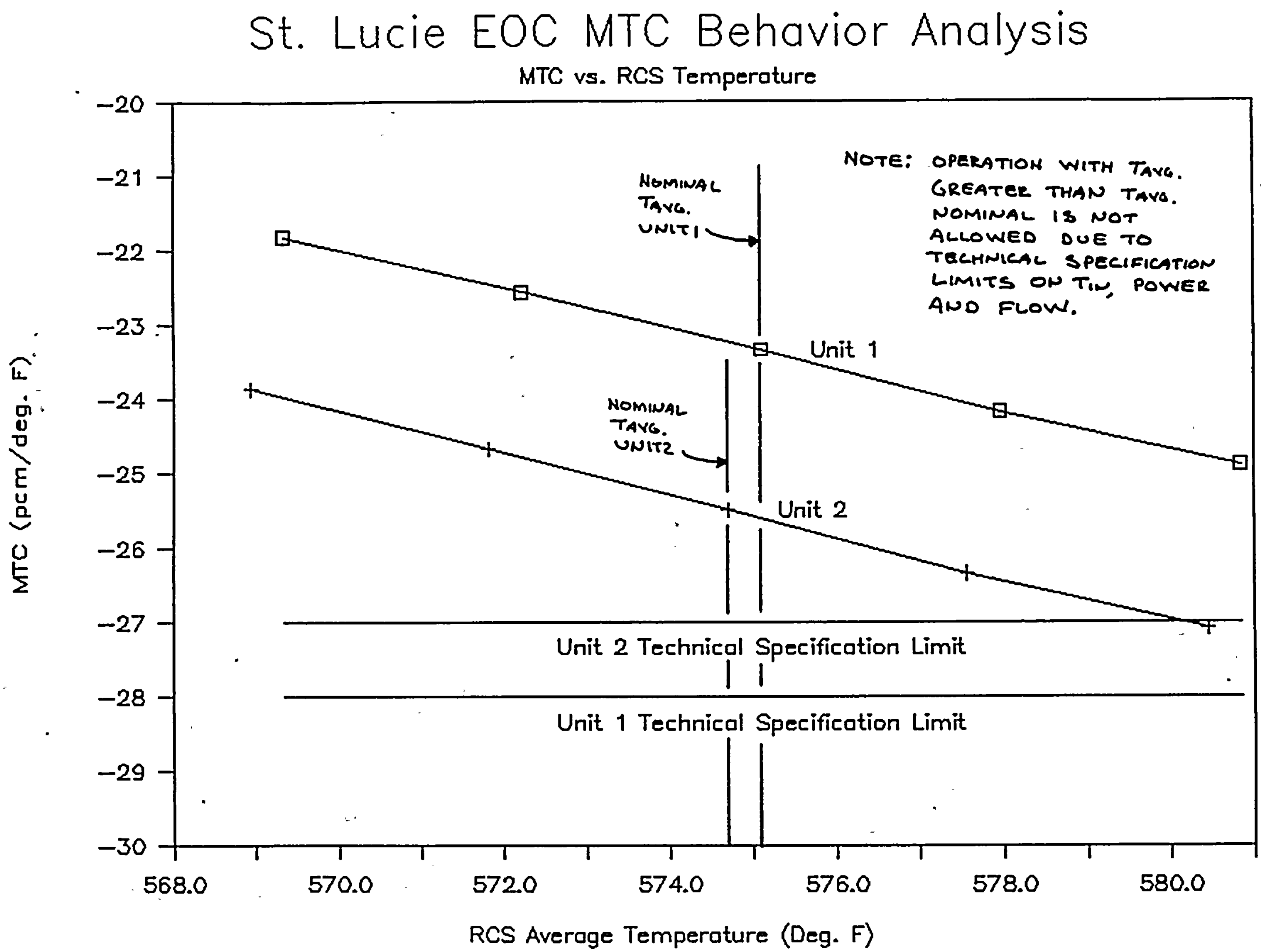

St. Lucie EOC MTC Behavior Analysis
MTC vs. RCS Temperature
NOTE: OPERATION WITH TAVG. GREATER THAN TAVG. NOMINAL IS NOT ALLOWED DUE TO TECHNICAL SPECIFICATION LIMITS ON TIN, POWER AND FLOW.
NOMINAL TAVG. UNIT1
NOMINAL TAVG. UNIT2
Unit 1
Unit 2
Unit 2 Technical Specification Limit
Unit 1 Technical Specification Limit
MTC (pcm/deg. F)
RCS Average Temperature (Deg. F)
−20
−21
−22
−23
−24
−25
−26
−27
−28
−29
−30
568.0
570.0
572.0
574.0
576.0
578.0
580.0

Figure 2

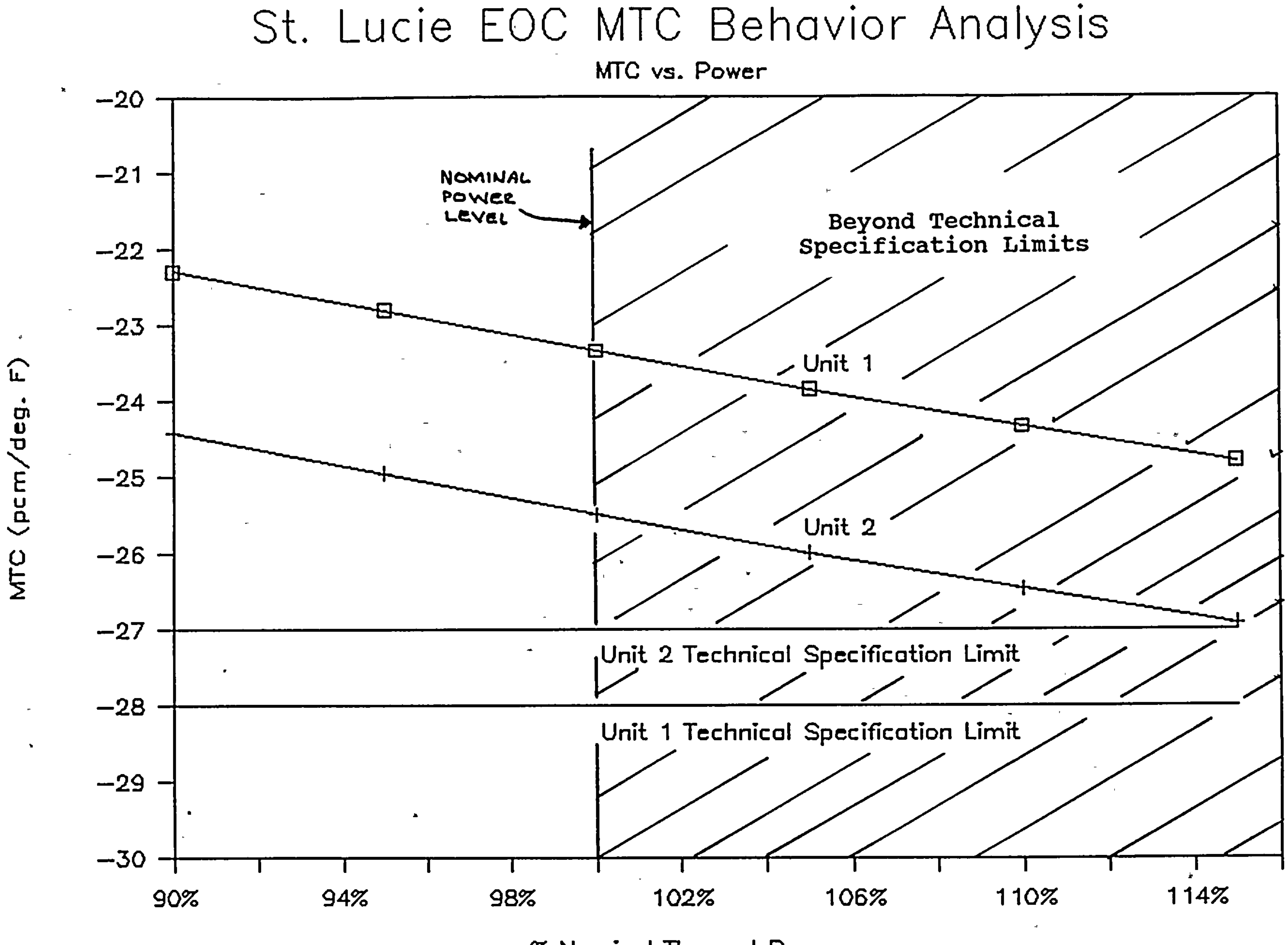

St. Lucie EOC MTC Behavior Analysis
MTC vs. Power
NOMINAL
POWER
LEVEL
Beyond Technical
Specification Limits
Unit 1
Unit 2
Unit 2 Technical Specification Limit
Unit 1 Technical Specification Limit
-20
-21
-22
-23
-24
-25
-26
-27
-28
-29
-30
MTC (pcm/deg. F)
90%
94%
98%
102%
106%
110%
114%
% Nominal Thermal Power

Figure 3

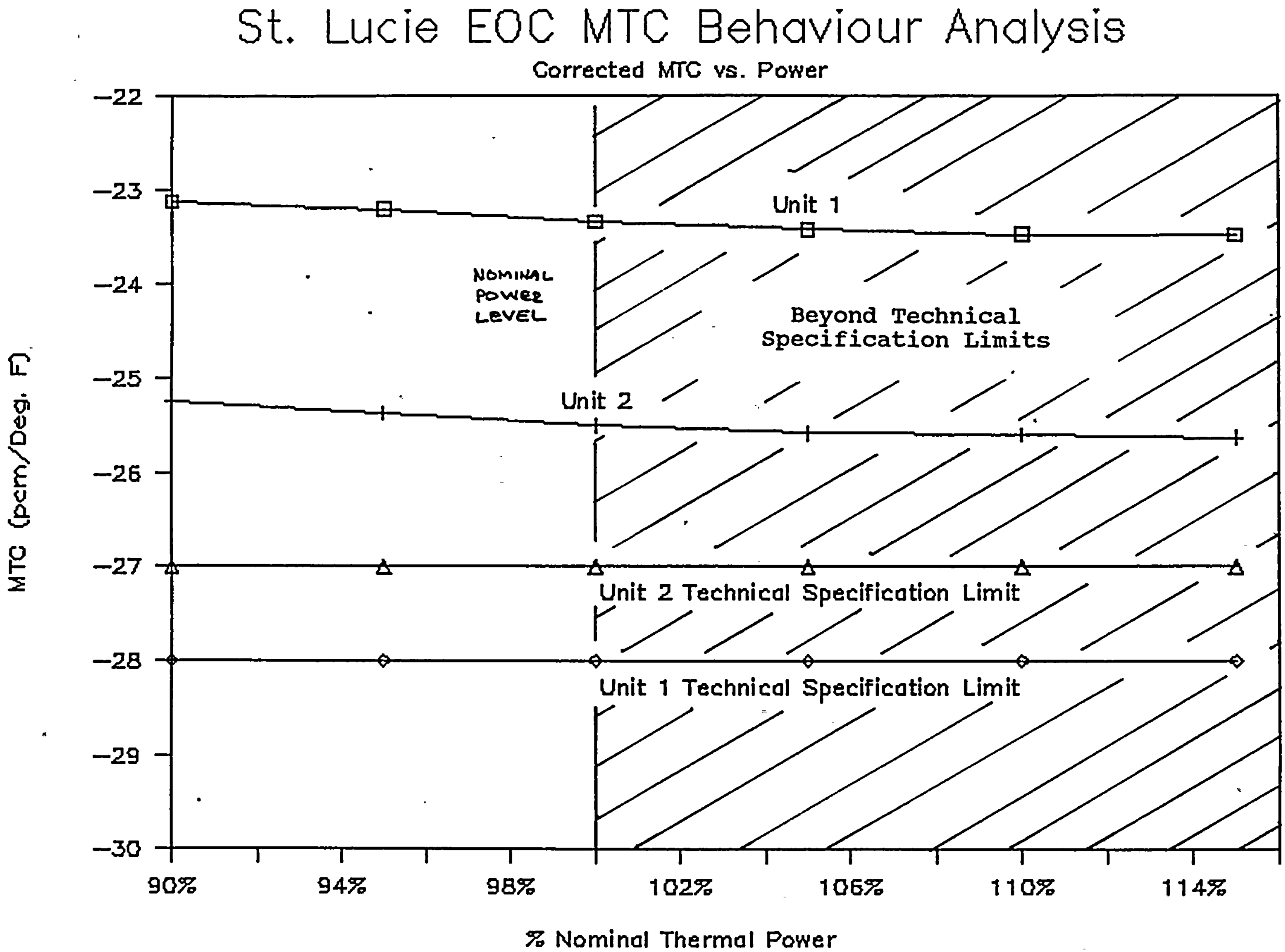

St. Lucie EOC MTC Behaviour Analysis
Corrected MTC vs. Power
-22
-23
-24
-25
-26
-27
-28
-29
-30
MTC (pcm/Deg. F)
Unit 1
NOMINAL
POWER
LEVEL
Beyond Technical
Specification Limits
Unit 2
Unit 2 Technical Specification Limit
Unit 1 Technical Specification Limit
90%
94%
98%
102%
106%
110%
114%
% Nominal Thermal Power

Figure 4

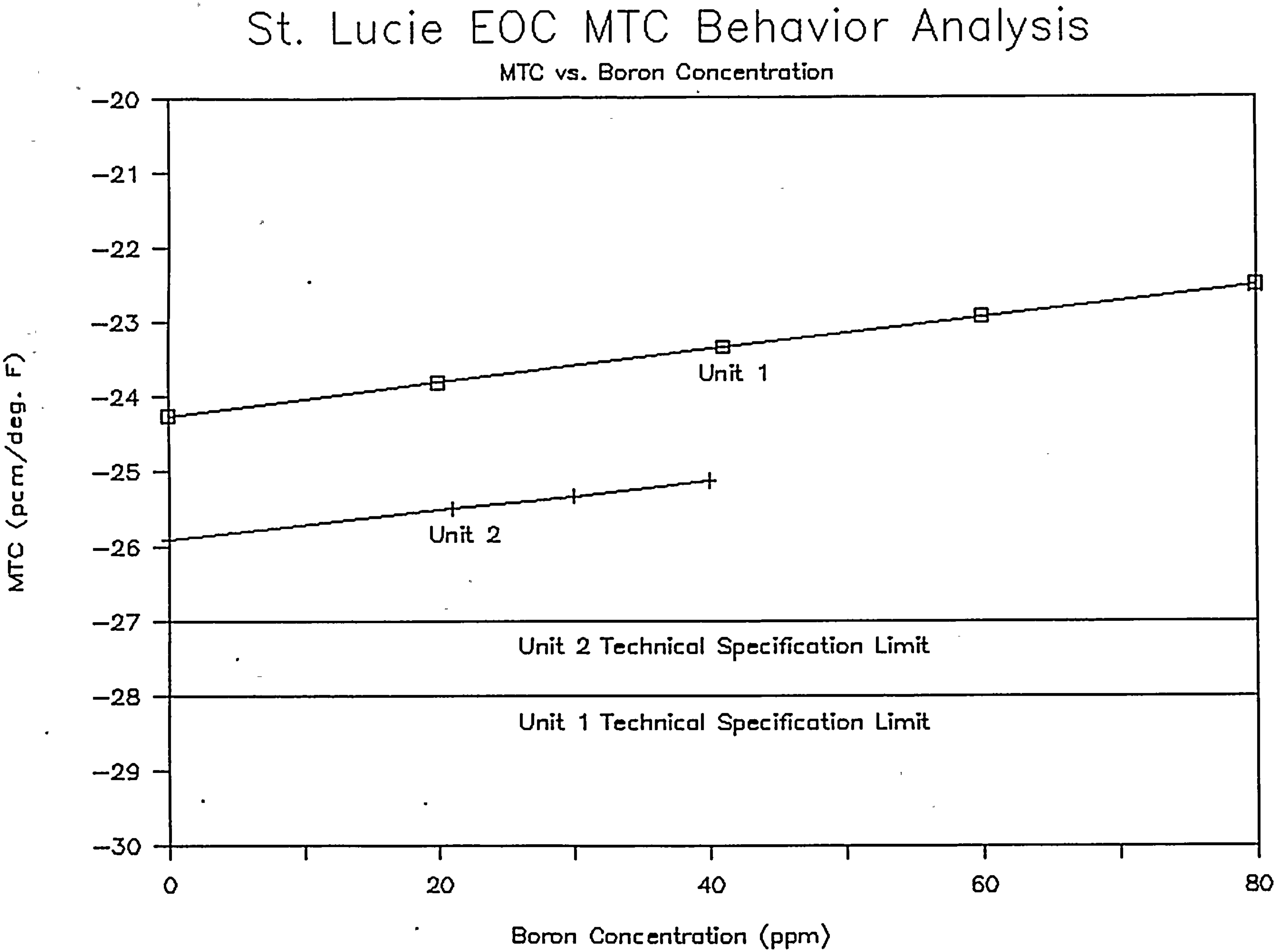
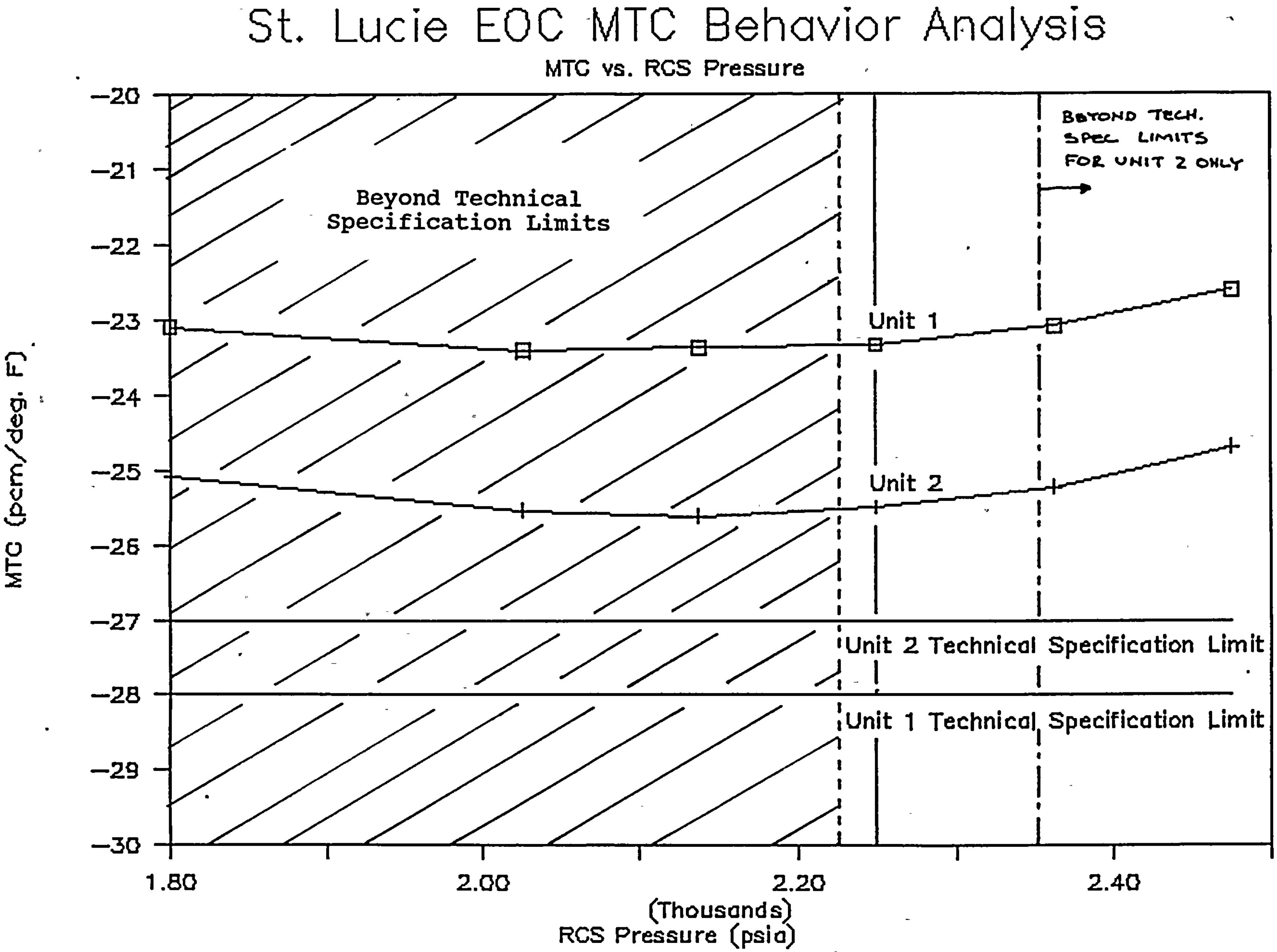

St. Lucie EOC MTC Behavior Analysis
MTC vs. Boron Concentration
-20
-21
-22
-23
-24
-25
-26
-27
-28
-29
-30
MTC (pcm/deg. F)
Unit 1
Unit 2
Unit 2 Technical Specification Limit
Unit 1 Technical Specification Limit
0
20
40
60
80
Boron Concentration (ppm)

Figure 5


St. Lucie EOC MTC Behavior Analysis
MTC vs. RCS Pressure
MTC (pcm/deg. F)
-20
-21
-22
-23
-24
-25
-26
-27
-28
-29
-30
Beyond Technical Specification Limits
BEYOND TECH. SPEC LIMITS FOR UNIT 2 ONLY
Unit 1
Unit 2
Unit 2 Technical Specification Limit
Unit 1 Technical Specification Limit
1.80
2.00
2.20
2.40
(Thousands)
RCS Pressure (psia)