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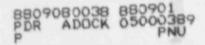
ST. LUCIE UNIT 2

Boric Acid Concentration Reduction

Report CEN - 365 (L)

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BORIC ACID CONCENTRATION REDUCTION EFFORT CEN - 365 (L)

> TECHNICAL BASES AND OPERATIONAL ANALYSIS

14.

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Boric Acid Concentration Reduction Effort Technical Bases and Operational Analysis CEN - 365 (L)

1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

This report defines the methodology and outlines the technical bases which allows a reduction in the boric acid makeup tank (BAMT) concentration to the point where heat tracing of the boric acid makeup system is no longer required in order to prevent boric acid precipitation. The basic methodology or procedure used to set the minimum BAMT concentration and level for Modes 1, 2, 3, and 4 is derived from the safe shutdown requirements of NUREG 0800 Branch Technical Position RSB 5-1, "Design Requirements for the Residual Heat Removal System", (BTP 5-1). The St. Lucie Unit 2 plant has been classified as a Class 2 plant. Two independent boration sources are provided to compensate for reactivity changes and all expected transients throughout core life. These sources are the boric acid makeup tanks (BAMT) and the refueling water tank (RWT). This report reexamines the design basis used to establish BAMT boron concentration and volume requirements. In addition, the minimum RWT volume requirements are recalculated. Specifically, sufficient dissolved boric acid is maintained in these tanks in order to provide the required shutdown margin of Technical Specification 3.1.1.1 for a cooldown from het standby to cold shutdown conditions. In addition, the minimum BAMT concentration and level for Modes 5 and 6 are based upon the ability to maintain the required shutdown margin in Technical Specification 3.1.1.2 following xenon decay and cooldown from 200 degrees to 135 degrees.

The work detailed in this report was performed specifically for the St. Lucie Unit 2 plant. The calculation performed herein and the values obtained should be applicable to future cycles. (See Section 2.2.3 below). The physics parameters used in this analysis were conservatively selected to bound core physics parameters for the remainder of plant life. Future cycle core physics parameters will be compared to the data in Appendix 5 to ensure that this calculation is bounding. The curve in Figure 3.1-1 of Technical Specification 3.1.2.8 and the values in 3.1.2.7 may change slightly; however, there should not be a need to heat trace the majority of the boric acid system for the remainder of plant life.

1.2 REPORT ORGANIZATION

This report has been organized into three general sections: Introduction, Technical Bases, and Operational Analysis. The Technical Bases Section 2.0, outlines the methodology which allows a significant reduction in boric acid makeup tank concentration and presents the results of the detailed calculations performed in support of the Technical Specifications. Separate calculations were performed for Specification 3.1.2.7 (Borated Water Source - Shutdown). Specification 3.1.2.8 (Borated Water Source - Operating), and Specification B3/4.1.2 (Boration Systems Bases). For completeness, the volume requirements for the RWI have been recalculated to demonstrate that the boration requirements for reactivity control in Modes 1, 2, 3 and 4 are much less than the emergency core cooling requirements. Also included in Section 2.0 are the technical responses to typical questions asked by the NRC during review of similar submittals by other nuclear facilities. The Operational Analysis Section, Section 3.0, outlines the impact on normal operations of a reduced boric acid makeup tank concentration. The types of operations evaluated in Section 3.0 include feed-and-bleed, blended makeup, shutdown to refueling, and shutdown to cold shutdown. All tables and figures are contained at the end of each section for easy reference.

1.3 PAST vs. PRESENT METHODOLOGY OF SETTING BAMT CONCENTRATION

Prior to the development of the new methodology for setting BAMT concentration and leve? described in this report, the level and concentration specified in the plant Technical Specifications for Modes 1, 2, 3, and 4 were based upon the ability to perform a cooldown to cold shutdown in the absence of letdown. (Safe Shutdown requirements of NUREG-0800 BTP 5-1 event). The RCS was borated to the boric acid concentration required to provide a shutdown margin of 5000 pcm at 200 degrees prior to commencing plant cooldown. In the limiting situation where letdown was not available, this boration was accomplished by charging to the RCS while simultaneously filling the pressurizer. Since boron concentration typically had to be increased by 800 ppm or more prior to commencing cooldown, highly concentrated boric acid solutions were required due to the limited space that was available in the pressurizer.

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Relatively recent advances have made it possible to develop new methodolcaies for setting BAMT concentration and levels. The methodology for setting concentration and level of Modes 1, 2, 3, and 4 described in this report differs from previous methodologies in that boration of the reactor coolant system is performed concurrently with plant cooldown, i.e., concentrated boric acid is added concurrently with cooldown as part of normal inventory makeup due to coolant contraction. By knowing the exact boron cc contration required to maintain proper shutdown margin at each temperature during a plant cooldown, BAMT concentration can be decoupled from pressurizer volume. As a result, the concentration of boric acid required to be maintained in the boric acid makeup tanks in order to perform a cooldown without letdown to cold shutdown conditions can be lowered to a range of 2.5 to 3.5 wt", where heat tracing of the boric acid system is no longer required, i.e., the ambient temperatures that normally exist in the plant's auxiliary building are sufficient to prevent boric acid precipitation.

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Similarly, a new methodology was developed for setting the minimum concentration and level of the boration source required to be operational in Modes 5 and 6. Since letdown is available in Mode 5 and 6 cooldown scenarios, a feed and bleed can be conducted to increase RCS moron concentration. Additionally boration can be conducted concurrently with cooldown as part of normal system makeup. By insuring that the boron concentration is maintained greater than that required for proper shutdown margin at each temperature, the boric acid makeup tank concentration for Modes 5 and 6 can be lowered to 2.5 weight percent.

2.0 TECHNICAL BASES FOR REDUCING BAMT CONCENTRATION

2.1 BORIC ACID SOLUBILITY

Figure 2-1 is a plot showing the solubility of boric acid in water for temperatures ranging from 32 to 160 degrees. (Data for Figure 2-1 was obtained from Reference 4.1 and is reprinted in Table 2-1.) Note that the solubility of boric acid at 32 degrees is 2.52 weight percent and at 50 degrees is 3.49 weight percent. At or below a concentration of 3.5 weight percent boric acid, the ambient temperature that normally exists in the auxiliary building will be sufficient to prevent precipitation within the boric acid makeup system.

2.2 METHOD OF ANALYSIS AND ASSUMPTIONS

2.2.1 RCS Boron Concentration vs. Temperature

2.2.1.1 Operating Modes 1, 2, 3 and 4

As stated in Section 1.3 above, the methodology developed to allow a significant reduction in the boric acid concentration required to be maintained in the BAMTs in Modes 1, 2, 3, and 4 differs from the previous methodology in that boration of the reactor coolant system is performed concurrently with cooldown in order to insure proper shutdown margin, i.e., concentrated boron is added as part of normal system makeup during the cooldown process. To employ a methodology allowing boration concurrent with cooldown, the exact boron concentration required to be present in the reactor coolant system must be known at any temperature during the cooldown process. In addition, in order to insure applicability for an entire cycle, a cooldown scenario must be developed which is conservative in that it places the greatest burden on an operator's ability to control reactivity, i.e., this scenario must define the boration requirements for the most limiting time in core cycle. Such a limiting scenario is as follows:

2-1

- Conservative core physics parameters were used to determine the 1. required boron concentration and the required Boric Acid Makeup Tank volumes to be added during plant cooldown. End-of-cycle initial boron concentration is assumed to be zero. End-of-cycle moderator cooldown effects are used to maximize the reactivity change during the plant cooldown. End-of-cycle (EOC) inverse boron worth data was used in combination with EOC reactivity insertion rates normalized to the most Negative Technical Specification Moderator Temperature Coefficient (MTC) limit since it was known that this yields results that are more limiting than the combination of actual MTC and actua? IBW values at all periods through the fuel cycle prior to end-of-cycle. These assumptions assure that the required boron concentration and the Boric Acid Makeup Tank minimum volume requirements conservatively bound all plant cooldowns during core life.
- 2. The most reactive and is stuck in the full out position.
- Prior to time zero, the plant is operating at 100% power with 100% equilibrium xeron. Zero RCS leakage.
- 4. At time zero, the plant is shutdown and held at hot zero power conditions for 25.5 hours. (The xenon peak after shutdown will have decayed back to the 100% power equilibrium xenon level. Further xenon decay will add positive reactivity to the core during the plant cooldown.) No credit was taken for the negative reactivity effects of the xenon concentration peak following the reactor shutdown.
- 5. At 25.5 hours, offsite power is lost and the plant goes into natural circulation. All non-safety grade plant equipment and components are lost. Ouring the natural circulation the RCS average temperature rises 25°F due to decay heat in the core. The initial temperature at the start of the cooldown is 557°F.

 Approximately 0.5 hours later, at 26 hours, the operators commence a cooldown to cold shutdown.

The scenario outlined above was used to generate the boration requirements for Modes 1, 2, 3, and 4 (Specification 3.1.2.8). It produces a situation where positive reactivity will be added to the reactor coolant system simultaneously from two sources at the time that a plant cooldown from hot shutdown is commenced. These two reactivity sources result from a temperature effect due to an overall negative isothermal temperature coefficient of reactivity, and a poison effect as the xenon-135 level in the core starts to decay below its equilibrium value at 100% power. This scenario, therefore, represents the greatest challenge to an operators ability to borate the reactor coolant system and maintain the required Technical Specification shutdown margin while cooling the plant from hot standby to cold shutdown conditions.

2.2.1.2 Operating Modes 5 and 6

The methodology developed for Modes 5 and 6 differs from the method used in previous refile. If cycles to determine boration requirements. In this new methodology boration of the reactor coolant system is performed concurrently with cooldown. Concentrated boric acid is added as part of normal system makeup during the cooldown process. To employ a methodology allowing boration concurrent with cooldown, the exact boron concentration required to be present in the reactor coolant system must be known at any temperature during the cooldown process. The following scenario was developed to identify the most limiting cooldown transient for Modes 5 and 6.

 End-of-cycle conditions with the initial RCS boron concentration necessary to provide shutdown margins of 3000 pcm at 200 degrees and xenon free core. EOC moderator cooldown effects are used to maximize the reactivity change during the plant cooldown. End-of-cycle (EOC) inverse boron worth data was used in combination with EOC reactivity insertion rates normalized to the Most Negative Technical Specification Moderator Temperature Coefficient (MTC) limit since it was known that this yields results that are more limiting than the combination of actual MTC and actual IBW values at all periods through the fuel cycle prior to end-of-cycle.

- 2. Most reactive rod is stuck in the full out position.
- 3. Zero PCS leakage.
- 4. RCS feed-and-bleed can be used to increase boron concentration.
- RCS makeup is supplied either from the RWT alone or a combination of makeup from the BAMT and RWT.
- 5. The most limiting scenario for boration in Mode 5 requires that a 3000 pcm shutdown be maintained during the cooldown from 200°F to 135°F. The boration requirements for Mode 6 only address maintaining a previously established shutdown margin. If the required shutdown margin for Mode 6 is not maintained, Technical Specification 3.9.1 requires that the RCS be borated at 40 gallons per minute from source of water ≥ 1720 ppm bc.on. Technical Specification 3.1.2.7 provides three alternative sources to meet this requirement, either BAMT or the RWT.

The scenario outlined above was used to determine the boration requirements for Modes 5 and 6 (Specification 3.1.2.7). It produces a situation where positive reactivity will be added to the reactor coolant system due to the overall negative isothermal temperature coefficient of reactivity. Since the core is already assumed to be xunon free there is no contribution to core reactivity due to xenon decay.

2.2.2 Impact of Various Cooldown Rates

As discussed in the previous Section, a conservative cooldown scenario was selected for use in determining RCS boron concentration levels. These concentration results were then used to define the minimum Technical Specification boric acid makeup tank inventory requirements. In the scenario for Modes 1, 2, 3, and 4, positive reactivity was added simultaneously from two sources at the time that the plant cooldown from hot standby was commenced. The component resulting from an overall negative isothermal temperature coefficient of reactivity is independent of time, but it is directly dependent upon the amount that the system has been cooled. In contrast, the component that results from the decay of xenon-135 below its equilibrium value at 100% power is independent of temperature, but directly dependent upon time. As a result, a slow cuoldown rate will require more boron to be added to the reactor coolant system than a fast cooldown rate for a given temperature decrease since more positive reactivity must be accounted for due to xenon decay. This effect is illustrated in Figure 2-2 and is applicable to the Modes 1, 2, 3. and 4 analysis. Note that the bases for Technical Specification 3.1.2.7 require a cocldown following xenon decay. As a result, boration requirements are independent of cooldown rate for the Modes 5 and 6 analysis.

For the purpose of setting the minimum Technical Specification boric acid makeup tank inventory requirements in Modes 1, 2, 3, and 4, reactor coolant system boron concentration data was used that was based upon an overall cooldown rate of 12.5 degree per hour. This slow cooldown rate was chosen in order to be consistent with the time frames specified in Section 5.2 of Reference 4.3 (natural circulation cooldown in CE NSSS) for reactor vessel upper head cooldown. Specifically, 23.07 hours was required in order to take the plant from hot standby conditions to cold shutdown as shown in Table 2-2. For additional conservatism, 5.73 hours was added to this number to arrive at a final total of 28.8 hours. An overall cooldown rate, therefore, of 12.5 degrees per hour was required

2-5

to cool the plant from an average coolant temperature of 557 degrees to an average coolant temperature of 200 degrees in 28.8 hours. This cooldown scenario will conservatively bound cooldowns that occur sooner and/or at a higher cooldown rate. The above scenario bounds the reactivity affects of a BTP 5-1 cooldown. It is assumed in the BTP 5-1 scenario that the RHR will be capable of bringing the RCS to cold shutdown conditions within 36 hours. With respect to Xenon reactivity affects the scenario used in this report bounds the 36 your cooldown time frame of BTP 5-1 (26 hours to let Xenon return to 100% equilibrium level and 28 hours for a slow cooldown).

2.2.3 Applicability to Future Reload Cycles

To ensure that the current analysis would be valid for future cycles, data from St. Lucie Unit 2 Cycle 3 was conservatively bounded. Cycle 3 Physics data was used because Unit 2 was in that operating cycle at the start of the Boric Acid Concentration Reduction Effort. The physics data used in this analysis should bound future fuel cycles of similar reload cores. The physics data used in the calculation does bound the physics data for St. Lucie 2 Cycle 4. Appendix 5 contains bounding physics assumptions that were used to produce the required boron concentration values. As long as these inputs are more conservative than the reload cycle physics parameters, the values produced in this analysis will bound the boron concentration values for the future reload cycles.

2.2.4 Boron Mixing in the RCS and in the Pressurizer

Throughout the plant cooldowns performed in Section 2.3 and Section 2.4 below, a constant pressurizer level was always assumed, i.e., plant operators charged to the RCS only as necessary to makeup for coolant contraction. The driving force is small, in this situation, for the mixing of fluid between the reactor coolant system and the pressurizer. As a conservatism, however, complete and instantaneous mixing was assumed between all makeup fluid added to the reactor coolant system through the loop charging nozzles and the pressurizer. Further, various pressure reductions were performed during the plant cooldown process as indicated in Section 2.4. These pressure reductions are necessary since the shutdown cooling system is a low pressure rystem and is normally aligned at or below an RCS pressure of 275 psia. Typically, such depressurizations are performed using the auxiliary pressurizer spray system under conditions where the reactor coolant pumps are not running. As an added conservatism in the Modes 1, 2, 3, and 4 analysis, any boron added to the pressurizer via the spray system was assumed to stay in the pressurizer and <u>not</u> be available for mixing with the fluid in the remainder of the RCS.

2.3 BORATED WATER SOURCES - SHUTDOWN (MODES 5 AND 6)

2.3.1 Boration Requirements for Modes 5 and 6

As stated in the plant Technical Specifications, the boration capacity required below a reactor coolant system average temperature of 200 degrees is based upon providing a shutdown margin of 3000 pcm following xenon decay and a plant cooldown from 200 degrees to 135 degrees. From this basis the required RCS boron concentrations were determined using conservative core physics data. The results of these calculations are contained in Table 2-3. The results contained in Table 2-3 are plotted as the required shutdown curve in Figure 2-3. Note that a total boron concentration increase of 46.0 ppm for St. Lucie 2 was required for the cooldown.

2.3.2 Assumptions Used in the Modes 5 and 6 Analysis

A complete list of assumptions and initial conditions used in calculating the minimum boric acid makeup tank inventory requirements for Modes 5 and 6 is contained in Table 2-4. In the process of taking the plant from hot standby to cold shutdown, the shutdown cooling system (SDCS) will normally be aligned when the RCS temperature and pressure have been lowered to approximately 325 degrees and 275 psia for St. Lucie 2. As shown in the next Section, the total system volume, i.e., RCS volume plus PZR volume plus SDCS volume, is required to be known for the Modes 5 and 6 analysis. The exact volumes of the reactor coolant system and the pressurizer are known. The exact volume of the shutdown cooling system, however, is not known. (Best estimate calculations for this volume have yielded values from approximately 2500 ft³ to approximately 3000 ft³). For the purpose of the analysis in the following Section, the volume of the shutdown cooling system will be chosen conservatively large, equal to the RCS volume, so as to yield conservative results with respect to minimum boric acid makeup tank inventory requirements.

The exact system volume used in the Modes 5 and 6 calculation is as follows:

2 x (RCS volume) + (PZR volume at 0% power).

or

$$2(9398 \text{ ft}^3) + (450 \text{ ft}^3) = \underline{19,246 \text{ ft}}^3$$

2.3.3 Modes 5 and 6 Analysis Results

As stated in Section 2.3.1, the boration capacity required below a reactor coolant system average temperature of 200 degrees is based upon providing shutdown margins of 3000 pcm for St. Lucie 2 following xenon decay and a plant cooldown from 200 degrees to 135 degrees. The operating scenario that will be employed for the purpose of determining reactor coolant system boron concentration and ensuring that proper shutdown margin will be maintained is as follows:

Option 1: Provide RCS Makeup From BAMT

- A. The systems are initially at 200 degrees and 275 psia. Initial concentration in the reactor coolant system, pressurizer, and in the shutdown cooling system is 570.3 ppm boron. (See Table 2-4 for a complete list of assumptions).
- B. Perform a plant cooldown from an average temperature of 200 degrees to an average temperature of 135 degrees using makeup water from the BAMT (2.5 weight % boric acid solution at 70 degrees). Charge only as necessary to makeup for coolant contraction.

From Equation 2.0 of Appendix 3 and the conversion factor that is derived in Appendix 4, the initial boric acid mass in the system can be calculated as follows:

$$\frac{570.3 \text{ ppm}}{1748.34 \text{ ppm/wt. } 18,796 \text{ ft}^3 + 450 \text{ ft}^3}$$

or

mba = 3779.5 1bm boric acid

Knowing the initial mass of boron in the system, the exact concentration and makeup requirements can be calculated for each 10 degrees of a cooldown from 200 degrees to 135 degrees. These values are contained in Table 2-6. Equations used to obtain the values shown in Table 2-6 are as follows:

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Shrinkage Mass		$18,796 (1/v_{e} - 1/v_{e})$
Water Vol.	*	(Shrinkage Mass) / (8.329 1bm/gallon)(1)
Boric Acid Added	*	(Water Vol.) x (0.21356 lbm/gallon) (2)
		(Initial Boric Acid) + (Boric Acid Added)
		(Total initial Mass) + (Shrinkage Mass) + (Boric Acid Added)
Final Conc.		(Total Boric Acid)(100)(1748.34) ⁽³⁾ (Total System Mass)

Note that the initial total system mass of 1,158,674.2 lbm in Table 2-6 was obtained as follows:

(Initial Boric Acid) + (Initial System Water Mass) + (Pressurizer Water Mass)

- = 3779.5 lbm + (18,976 ft³ / 0.01662 ft³/lbm) + $(450 ft^3 / 0.018775 ft^3/lbm)$
- = 1,158,674.2 1bm

(1) Water density at 70 degrees.

to set \$

- (2) See Appendix 3 for values of dissolved boric acid in water.
- (3) See Appendix 4 for the conversion factor between wt. % and ppm.

The boration results from the system cooldown from 200 to 135 degrees are plotted as the actual concentration curve in Figure 2-4. As can be seen from this figure, a shutdown margin of greater than the required 3000 pcm was maintained throughout the evaluation. A minimum concentration of 2.5 weight % boric acid was therefore specified in the plant Technical Specification 3.1.2.7. The minimum volume that should be specified in the Technical Specification is 3550 gallons. This volume was determined as follows:

Makeup volume (4)	3049.0 ga	llons
Arbitrary amount	500.0 ga	llons
for conservatism		

Total Round up to nearest 50 gallons

3549.0	gallons
3550	gallons

(4) Total of values in Water Vol. column of Table 2-6.

OPTION 2: Feed and Bleed then Cooldown from RWT

The RWT will not provide enough boric acid to compensate for the reactivity inserted during the cooldown if charging is restricted to makeup for coolant contraction only. A system feed-and-bleed must be performed to raise the RCS concentration before the cooldown is commenced. The initial feed-and-bleed ensures that the actual RCS boron concentration is maintained above the required boron concentration for a 3000 pcm shutdown margin while the plant is cooled down from 200 degrees to 135 degrees.

For St. Lucie 2, in order to calculate the initial increase in boron concentration during the 3200 gallon system feed-and-bleed, Equation 9.0 of Appendix 1 will be used with values as follows:

 $T = \frac{(18,976 \text{ ft}^3/\ 0.01662 \text{ ft}^3/1\text{bm})^{(5)} + (450 \text{ ft}^3/\ 0.018775 \text{ ft}^3/1\text{bm})^{(6)}}{40 \frac{\text{gallons}}{\text{min}} \times 8.343^{(7)} \frac{1\text{bm}}{\text{gallon}}}$

T = 3,493.1 min.

(5) Specific volume of compressed water at 200°F and 275 psia

(6) Specific volume of saturated water at 275 psia

(7) Density of water at 50°F

If one charging pump at 40 gpm (as assumed in calculating the value of T above) is used to conduct the system feed-and-bleed, 80 minutes are required (3200 gal/40 gpm = 80 min). Concentrations vs time for the feed-and-bleed from equation 9.0 of Appendix D is therefore:

Time	Conc
0	570.3
20	577.0
40	583.5
60	590.1
80	596.6

The feed-and-bleed portion of the cooldown process is indicated on Figure 2-4 as the vertical line. As shown, concentration was increased from 570.3 ppm to 596.6 ppm following the 3200 gallon feed-and-bleed.

From Equation 2.0 of Appendix 3 and the conversion .actor derived in Appendix 4, the mass of boric acid in the system corresponding to concentrations of 596.6 ppm can be calculated as follows:

2-13

$$M_{ba} = \frac{CM_{W}}{100 - C}$$

= [(596.6 ppm)/(1748.34ppm/wt.%)] (18,976ft³/0.01662ft³/1bm+450ft³/0.018775ft³/1bm) 100 - (596.6ppm)/(1748.34ppm/wt.%)

= 3954.2 1bm boric acid

Knowing the masses of boric acid in the system following the feed-and-bleed, the exact concentrations and makeup requirements can be calculated for each 10 degrees of cooldowns from 200° F to 135° F. These values are contained in Table 2-7. The cooldown assumes a constant pressurizer volume of 450 ft³ and a constant pressure of 275 psia. In addition, complete mixing between the RCS and the PZR is assumed as discussed in Section 2.2.4 above. Equations used to obtain the values contained in Table 2-7 are as follows:

Shrinkage mass = $18,976 (1/v_{e} - 1/v_{i})$

Water Vol. = (Shrinkage mass) / (8.343 lbm/gallon)

Boric acid added = (water vol.) (0.08289 lbm/gallon)

Total boric acid = initial boric acid + boric acid added

Total System mass = Total initial mass + shrinkage mass + boric acid added

Final concentration = (Total Boric Acid) (100) (1748.34) Total System Mass The results of the initial system feed-and-bleed plus the plant cooldown are plotted as Curve II in Figure 2-4. Note that throughout the evaluation, a shutdown margin greater than 3000 pcm was maintained as required.

The initial total system mass in Table 2-7 was obtained as follows:

Initial boric acid mass + initial system water mass + initial PZR water mass = $3954.2 \text{ lbm} + (18.976 \text{ ft}^3) / (0.01662 \text{ it}^3/\text{lbm}) + (450 \text{ ft}^3) / (0.018775 \text{ ft}^3/\text{lbm})$ = 1,158,730.2 lbm

RWT concentrations of 1720 ppm will therefore be specified in Technical Specification 3.1.2.7 since the proper shutdown margin could be maintained. The minimum volume will be specified as follows for the RWT cooldown:

Feed-and-Bleed Volume	3200.0	gallons
Makeup Volume	3043.1	gallons

Total

1

0

6243.1

Round up to nearest 6750 gallons 50 + 500 gallons

With 60,000 gallons of the RWT unusable, the actual required volumes in the RWT at 1720 ppm is 66,750 gallons for St. Lucie 2.

2.4 BORATED WATER SOURCES - OPERATING (MODES 1, 2, 3, and 4)

2.4.1 Boration Requirements for Modes 1, 2, 3, and 4

For this analysis a shutdown margin of 5000 pcm is provided at all temperatures above a reactor coolant system average temperature of 200 degrees. For temperatures at or below 200 degrees, a shutdown margin of 3000 pcm is provided after xenon decay and cooldown to 200 degrees. From this basis, the required RCS boron concentrations were determined using conservative core physics parameters and the limiting cooldown scenario outlined in Section 2.2.1 above. The results are plotted as the shutdown curve in Figure 2-5.

2.4.2 Assumptions Used in the Modes 1, 2, 3, and 4 Analysis

A complete list of assumptions and initial conditions used in calculating the minimum boric acid makeup tank inventory requirements for Modes 1, 2, 3, and 4 are contained in Table 2-5. Note that complete and instantaneous mixing between the reactor coolant system and the pressurizer was assumed as stated in Section 2.2.4 for all fluid added to the reactor coolant system via the loop charging nozzles. The mechanism used to implement this assumption in the analysis was to include the pressurizer water mass as part of the total system mass for the purpose of calculating boron concentration. Specifically, boron concentration in terms of weight fraction is defined as follows: (

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(boron conc.) = (mass of boron in system) (total system mass)

6

0

9

2-16

where, if complete mixing is assumed between the RCS and the pressurizer, the total system mass is the sum of the boron mass in the system, the reactor coolant system wat a mass, and the pressurizer water mass.

Therefore, the initial total system mass of 458,238.7 lbm in Table 2-8 through Table 2-32 for St. Lucie 2 was calculated as follows:

Initial boron mass + Initial RCS water mass + Initial PZR water mass, or

 $0 + \frac{9398 \text{ ft}^3}{0.021567 \text{ ft}^3/1\text{bm}} + \frac{600 \text{ ft}^3}{0.02669 \text{ ft}^3/1\text{bm}}$ (9)

2.4.3 Modes 1, 2, 3, and 4 Analysis Results

As stated in Section 2.4.1, the boration capacity required below a reactor coolant system average temperature of 200 degrees is based upon providing a 3000 pcm shutdown margin after xenon decay and a plant cooldown to 200 degrees from expected operating conditions. In addition, for this analysis a shutdown margin of 5000 pcm is provided at all temperatures above a reactor coolant system average temperature of 200 degrees. In order to perform a plant cooldown from hot standby conditions to cold shutdown and maintain the above shutdown margin at each temperature above 200 degrees, the following operating scenario will be employed:

(8) Specific volume of compressed water at 557 degrees and 2200 psia.

(9) Specific volume of saturated water at 2200 psia.

2-17

- A. Assuming the initial conditions outlined in Table 2-5, perform a plant cooldown starting from an initial RCS average temperature of 557 degrees to a final average system temperature of 200 degrees.
- B. Charge to the RCS only as necessary to makeup for coolant contraction. Charge from the BAMT initially until BAMT is drained, then switch to the RWT for the remainder of the cooldown.

The exact reactor coolant system boron concentrations versus temperature for plant cooldowns and depressurizations from 557 degrees and 2200 psia to 200 degrees and 275 psia with a boric acid makeup tank concentration of 3.50 weight percent and a refueling water tank concentration of 1720 ppm boron is contained in Table 2-8. These results are plotted as the actual concentration curve in Figure 2-5. (The exact temperature at which charging pump suction was switched from the BAMTs to the refueling water tank was determined via an iterative process. In this process, the smallest boric acid makeup tank volume necessary to maintain the required shutdown margin was calculated for the given set of tank concentrations). Note that at each temperature during the cooldown process, RCS boron concentration is greater than that required for the shutdown margin of 5000 pcm. Also note in Figure 2-5 that the shutdown margin drops from 5000 pcm to 3000 pcm at an average coolant temperature of 200 degrees. Following xenon decay the final concentration required to be present in the system at the most limiting time in core cycle is 570.3 ppm boron. Using the scenario outlined on the previous page, the final system concentrations will always be at least 64.6 ppm greater than these amounts.

A detailed parametric analysis was performed for the modes 1, 2, 3, and 4 Technical Specification (Specification 3.1.2.8). In this study, BAMT concentration was varied from 3.5 weight percent boric acid to 2.5 weight percent boric acid. Although St. Lucie Unit 2 Technical Specifications allow only a maximum RWT concentration of 2100 ppm boron, this report provides analysis for the RWT concentration range from 1720 ppm boron to 2300 ppm boron. This was done to be consistent with the Boric Acid Concentration Reduction Reports provided to other units. The results are contained in Table 2-9 through Table 2-32. Equations used to obtain the values in these tables as well as Table 2-8 are as follows:

Shrinkage Mass = 9398 $(1/v_f - 1/v_i)$ BAMT Vol. = (Shrinkage Mass) / (8.3290 lbm/gallon)⁽¹⁰⁾ RWT Vol. = (Shrinkage Mass) / (8.343 lbm/gallon)⁽¹¹⁾ Boric Acid Added = (BAMT Vol.) x (mass of boric acid/gallon)⁽¹²⁾ or = (RWT Vol.) x (mass of boric acid/gallon)⁽¹²⁾ Total Boric Acid = (Initial Boric Acid) + (Boric Acid Added) Total System Mass = (RCS water mass) + (PZR water mass)⁽¹³⁾ + (Total boric acid) Final Conc. = (Total Boric Acid)(100)(1748.34)⁽¹⁴⁾ (Total System Mass)

(10) Density of water at assumed tank temperature 70°F. (11) Density of water at assumed tank temperature 50°F. (12) See Appendix 3 for values of dissolved boric acid in water. (13) PZR water mass = $(600 \text{ ft}^3) / (\text{specific volume at indicated P}_{sat})$. (14) See Appendix 4 for the conversion factor between wt. % and ppm. Note that the value of the total system mass at any temperature and pressure in Table 2-8 through Table 2-32 can be obtained as follows:

RCS water mass + PZR water mass + total boric acid mass = total system mass.

As an example, the value of the total system mass at 200 degrees and 275 psia in Table 2-8 was obtained as follows:

 $\frac{9,398 \text{ ft}^3}{0.01662 \text{ ft}/10\text{ m}} + \frac{600 \text{ ft}^3}{0.018775 \text{ ft}/10\text{ m}} + 2350.7 \text{ 10\text{ m}}$

= 599,771.4 1bm.

In a similar manner as in the results of Table 2-8, the concentration results of Table 2-9 through Table 2-32 were compared to the required concentrations at each temperature for a plant cooldown from 557 degrees to 200 degrees which are contained in Table 2-33. In each case, the actual system boron concentrations were greater than that necessary for the required shutdown margin as indicated in Figure 2-5. To set the minimum Technical Specification boric acid makeup tank volume corresponding to the various BAMT and RWT concentrations, the

- (15) Specific volume of compressed water at 200 degrees and 275 psia.
- (16) Specific volume of saturated water as 275 psia.

makeup tank volumes from Table 2-8 through Table 2-32 were compiled into Table 2-34. The volumes contained in Table 2-34 are the minimum BAMT volumes needed to borate the RCS to the required shutdown margin. These volumes must be contained in the region of the BAMT above zero percent indicated level. These volumes are rounded up to the next 50 gallons and 500 gallons are added to provide conservatism. The resulting volumes after adjustment are contained in Table 2-35. These values are plotted in Figure 2-6. The cooldown scenario used assumes that V-2504 is opened remotely or manually and depressurization of the RCS is achieved by auxiliary spray from the RWT.

In a similar manner, the values at 1720 ppm in the RWT from Table 2-35 are plotted in Figure 3.1-1 of the St. Lucie 2 Technical Specifications. This figure replaces the existing lechnical Specification Figure 3.1-1.

2.4.4 Simplification Used Following Shutdown Cooling Initiation

In the cooldown and depressurization process assumed in Table 2-8 through Table 2-32, the plant operators must physically align the shutdown cooling systems an RCS temperature and pressure of approximately 325 degrees and 275 psia. Following this alignment, the volume and mass of the system that the operator must contend with during any subsequent cooldown will obviously increase by the volume and mass associated with the shutdown cooling system. Further, the total boron mass in the system that the operator is now dealing with will also have increased by the amount of boron in the SDCS prior to alignment. In Table 2-8 through 2-32, as a simplification, no attempt was made to factor into the equations the higher total volume and total boron mass that would result when the shutdown cooling system is placed in service. The use of these simplifications in the Modes 1, 2, 3, and 4 calculations can be justified as follows:

- 1. At the time that the shutdown cooling system is aligned, makeup is being supplied from the refueling water tank. Therefore, additional makeup that would be required during the cooldown from 325 degrees to 200 degrees due to a larger system volume will not affect the total BAMT volume requirements. This assumption would affect the minimum volume requirement of the RWT in Modes 1, 2, 3, and 4. Since the RWT requirements for emergency core cooling are much greater than the requirements for this cooldown scenario, this simplification does not impact RWT sizing requirements.
- 2. In a cooldown process where an operator is charging only as necessary to makeup for coolant contraction, the change in boron concentration within the system is independent of the total system volume, i.e., the final system boron concentration is not a function of total system volume. (A proof of this statement is contained in Appendix 2).
- 3. As stated in Table 2-5 boron concentration in the SOCS is assumed to be equal to reactor coolant system concentration at the time of shutdown cooling initiation. This assumption is in fact a conservatism since the concentration in that system in most situations will be closer to refueling water tank concentration at the time of initiation.

2.4.5 Refueling Water Tank Boration Requirements-Modes 1,2,3 and 4

The refueling water tank provides an independent source of borated water that can be used to compensate for core reactivity changes and expected transients throughout core life. It should be noted that in Modes 1, 2, 3 and 4 the minimum RWT water volume is 417,100 gallons as required by emergency core cooling considerations. The purpose of this section is to demonstrate that the RWT minimum inventory requirements in modes 1, 2, 3 and 4 to compensate for these reactivity changes during a shutdown are much less than the emergency core cooling requirements.

This calculation derives the minimum quantity of RWT water necessary to bring the plant from hot standby to cold shotdown while maintaining the plant at a 5000 pcm shutdown margin. All RCS makeup is supplied from the RWT at a boron concentration of 1720 ppm. This cooldown is performed as described below.

- A. Perform a RCS feed-and-bleed to raise RCS boron concentration from 0 ppm to 388.9 ppm boron. This is a 110 minute feed and bleed using 3 charging pumps.
- B. Perform a plant cooldown from an initial RCS temperature and pressure of 557 degrees and 2200 psia to 325 degrees and 275 psig. Charge only as required to makeup for coolant contraction.
- C. Align the shutdown cooling system (SDCS) to the RCS. Assume that the SDCS volume is 9398 ft³. Assume that the concentration of the SDCS is equal to that of the RCS at the time of shutdown cooling initiation.
- D. Continue cooldown from 325 degrees and 275 psia to a final RCS condition of 200 degrees and 275 psia. Charge only as necessary to makeup for coolant contraction.

Table 2-38 contains the results of the calculated volumes in steps A through D. The RWT boration requirement for Modes 1, 2, 3 and 4 has been rounded_up to 35,000 gallons. Figure 2-11 shows the RCS boron concentration as the plant cooldown progresses. As expected the boration requirements imposed a RWT sizing are much smaller than the minimum volume requirements placed on the RWT by emergency core cooling requirements (417,100 gallons).

2.5 BORATION SYSTEMS - BASES

The BASES section of the technical specifications was developed to demonstrate the boration system capability to maintain adequate shutdown margin from all operating conditions. Section 3/4.1.2 of the plant Technical Specifications will be changed to state the following:

"The boration capability of either system is sufficient to provide a SHUTDOWN MARGIN from all operating conditions of 3.5% delta k/k after xenon decay and cooldown to 200°F. The maximum boration capability requirement occurs at EOL from full power equilibrium xeron conditions. This requirement can be met for a range of boric acid concentrations in the BAMT and RWT. This range is bounded by 5350.0 gallons of 3.5 weight % boric acid from the BAMT and 16,000 gallons of 1720 ppm borated water from the RWT to 8650.0 gallons of 2.5 weight % boric acid from the BAMT and 12,000 gallons of 1720 ppm borated water from the RWT. A minimum of 35,000 gallons of 1720 ppm boron is required from the RWT if it is to be used to borate the RCS alone."

The 16,000 gallon RWT volume for St. Lucie 2 in Section 3/4.1.2 of the plant Technical Specifications was obtained by assuming RCS makeup was provided from the BAMT and the RWT. Total RCS makeup due to the coolant contraction during cooldown is calculated as described in A, B and C below. This yielded a contraction volume of 20,516.1 gallons. From this volume the minimum BAMT volume for the RWT at 1720 ppm boron from Table 2-35, 5350.0 gallons was subtracted yielding 15,166.1 gallons, which was rounded up to 16,000 gallons. As a result of the addition of 3.5 weight % boric acid from the BAMT, a feed-and-bleed is not required to maintain the shutdown margin of 3.5% delta k/k. Table 2-36 shows how this RWT volume was calculated.

The 12,000 gallon RWT volume was obtained in a similar manner. The total makeup is the same. From this volume, the maximum BAMT volume for the RWT at 1720 ppm boron from Table 2-35, 8650.0 gallons was subtracted

yielding 11,866.1 gallons, which was rounded up to 12,000 gallons. As a result of the addition of 2.5 weight % boric acid from the BAMT, a feed-and-bleed is not required to maintain the shutdown margin of 3.5% delta k/k. Table 2-37 shows how this RWT volume was calculated.

A plant cooldown using water from the RWT alone is discussed in Section 2.4.5 of this report. This cooldown scenario provides the minimum RWT water volume requirement for plant cooldown considerations of 35,000 gallons. This number is contained in Technical Specification Bases 3/4.1.2.

2.6 RESPONSE TO REVIEW QUESTIONS

This Section of the report details the responses to the typical questions asked during the review of the Technical Specifications.

Question 1: What are the uncertainties and conservatism associated with the two curves shown in Figure 2-5 of this report?

Response to Question 1:

The lower curve in Figure 2-5 of this report represents an upper bound on the minimum concentrations required to be present in the reactor coolant system for a required shutdown margin at the indicated temperatures. In the computer analyses that were performed to generate these curves, appropriate analytical and measurement uncertainties as well as appropriate conservation were included to ensure that an upper bounding curve was obtained. The major uncertainties and conservatism that were factored into the required shutdown curve of Figure 2-5 was as follows:

 Initial scram is assumed to take place from the hot full power PDIL (power dependent insertion limit) to all rods in, with the worst case rod stuck is the full out position.

- A bias of -9% and uncertainty of 13% was applied to the scram worth for the Unit 2 data.
- A combined bias and uncertainty of 10% was applied to the moderator data.
- A bias of 15% and an uncertainty of 15% was applied to the Doppler data.
- 5. The assumption that the cooldown begins at 26 hours is conservative in relation to the buildup and decay of Xenon.

Since appropriate analytical and measurement uncertainties as well as appropriate conservatism associated with the analysis were factored into the lower curve in Figure 2-5, it is not necessary to factor any additional uncertainties or conservatism directly into the upper curve shown in that figure. Although no additional uncertainties were included in the upper curve, the cooldown scenario followed by the operator was specifically chosen to be conservative such that the actual concentration curve in Figure 2-5 in effect represents a lower bound on the boron concentration that can be achieved by an operator given a certain boric acid makeup tank (BAMT) level and boron content. Specifically, conservatism in the cooldown scenario was insured in two ways. First, the cooldown was conducted assuming a constant pressurizer level, i.e., plant operators charged to the reactor coolant system only as necessary to makeup for coolant contraction. As a result, boron concentration in the reactor coolant system can be increased above the upper curve in Figure 2-5 by over-charging during the cooldown process, i.e., charge in excess of the makeup required for coolant contraction by allowing pressurizer level to increase. Second, the BAMT volumes obtained in Table 2-8 through Table 2-32 of this report were rounded up to the nearest 50 gallons and 500 gallons were added in order to give the final results that appear in Figure 2-6. Boron concentration in the reactor

coolant system, therefore, can be increased further since more inventory is available in the BAMTs than that used to generate the actual concentration curve in Figure 2-3.

Question 2: What are the implications of a reduction in boric acid makeup tank concentrations with respect to plant emergency procedures and Combustion Engineering's Emergency Procedure Guidelines?

Response to Question 2:

As stated in Section 3.2 of this report credit is not taken for boron addition to the reactor coolant system from the boric acid makeup tanks for the purpose of reactivity control in the accidents analyzed in Chapter 15 of the plant's Final Safety Analysis Report. The response of an operator, therefore, to such events as steam line break, overcooling, boron dilution, etc., will not be affected by a reduction in BAMT concentration. In particular, the action statements associated with Technical Specification 3.1.1.2 require that boration be commenced at greater than 40 gallons per minute using a solution of at least 1720 ppm boron in the event that shutdown margin is lost. Such statements are conservatively based upon the refueling water tank concentration and are therefore independent of the amount of boron in the BAMTs.

Similar to the Technical Specification action steps in the event of a loss of shutdown margin, the operator guidance in Combustion Engineering's Emergency Procedure Guidelines (EPGs), CEN-152, Rev. 2, are also independent of specific boron concentrations within the boric acid makeup_tanks. Specifically, the acceptance criteria developed for the reactivity control section of the Functional Recovery Guidelines of CEN-152 are based upon a boron addition rate from the chemical and volume control system of 40 gallons per minute without reference to a particular boration concentration. The reduction in boron concentration within the boric acid makeup tanks therefore has no impact on, and does not change, the guidance contained in the EPGs.

Question 3: Under natural circulation conditions, show that boron mixing in the reactor coolant system is rapid enough to ensure that proper shutdown margin is maintained during a safe shutdown. What is the effect of various cooldown rates on the mixing process? If an operator charges only as necessary to makeup for coolant contraction, what is the impact of pressurizer level instrument errors on boron concentration?

Response to Question 3:

As discussed in Section 1.1 of this report the basic methodology or procedure used to set the minimum boric acid makeup tank (BAMT) level and concentration for Modes 1, 2, 3, and 4 is derived from the safe shutdown requirements of Branch Technical Position (RSB) 5-1. Specifically, sufficient dissolved boric acid is maintained in these tanks in order to provide the required shutdown margin of Technical Specification 3.1.1.1 for a cooldown from hot standby to cold shutdown conditions. Further, the methodology outlined in Section 2.0 of the report for Modes 1, 2, 3, and 4 was developed by incorporating appropriate conservatism to insure that the shutdown margin of 5.0% delta k/k would indeed be satisfied at each temperature during the cooldown process.

The conservatism includes a cooldown scenario that maximized the boration requirements due to xenon decay. In Section 2.0 the cooldown was not commenced until twenty-six hours after the reactor trip. This time interval allowed the post trip xenon to peak and decay back to the pre-trip steady state value. Selecting the low cooldown rate of 12.5

degrees per hour maximized the xenon contribution to the boration requirement by allowing more xenon decay during the cooldown than would have occurred if a more rapid cooldown had been conducted.

Boron mixing affects were evaluated for natural circulation cooldown conditions specified in the safe shutdown requirements of Reference 4.4. Just prior to event initiation, the plant is operating at 100% of rated thermal power. Previous operating history is such as to develop the maximum core decay heat load. At time zero, event initiation occurs and offsite power is lost. The reactor coolant pumps deenergize causing a reactor trip, and the plant goes into natural circulation. All non-safety grade equipment is lost, including letdown, and one diesel generator fails to start. The plant is held at these conditions in hot standby for four hours, at which time a cooldown to cold shutdown is commenced. (Section 5.4 of CEN-201(S), Supplement No. 1, contains a computer simulation of the safe shutdown scenario of Reference 4.3 and shows these events).

The exact boration requirements that give a 5.0% shutdown margin for these scenarios are shown in Figure 2-7. (These curves were obtained using conservative core physics parameters. Note that the above shutdown curves in these figures are based upon a 100 degree per hour cooldown rate. A cooldown rate of 100 degrees per hour was selected for the following reasons: First, a fast cooldown rate is more limiting than a slow cooldown with respect to boron mixing since the slope of the required boration curve is greater. The effect of the assumed mixing time (less than thirty minutes) would be more adverse than a cooldown at a slower cooldown rate (see Figure 2-7). Second, a 100 degrees per hour cooldown_rate is the maximum allowabls. For an added conservatism the actual RCS boron concentration was derived by using BAMT concentrations of 2.5 weight percent. (BAMT concentrations of 2.5 weight % was selected since these are the lowest values that will be allowed by Technical Specification 3.1.2.8 and since it yields the slowest increases in reactor coolant system concertrations during the cooldown process). The actual concentration curves were obtained using the methodology outlined in Section 2.4 of this report and includes the following assumptions and conservatism:

- No boron addition is credited prior to commencing plant cooldown. (Note that one charging pump will operate immediately following plant trip in response to pressurizer level shrink as indicated in Section 5.4 of CEN-201(S), Supplement No. 1. Credit for boron addition, however, during this period will not be taken).
- 2. Pressurizer volume at the start of plant cooldown equals 450 ft³.
- 3. Charging will be secured at the start of the plant cooldown and will remain secured until pressurizer level has decreased by 10%. (In the methodology outlined in this report operators were assumed to charge as necessary to maintain a constant pressurizer level. Note that the error associated with pressurizer level is typically ± 2 percent, therefore allowing a 10 percent decrease in level before initiating charging is conservative).
- 4. Following the initial 10% decrease in pressurizer level, charging will be initiated and maintained as necessary to keep pressurizer lovels constant for the remainder of the plant cooldown.
- 5. Complete and instantaneous mixing with all fluid added via the charging nozzles with the contents of the RCS and the pressurizer is assumed. (Note that this assumption in relation to a delay in boron mixing will be discussed below).

The concentration curve that was obtained using these assumptions is shown in Figure 2-7. In order to account for the effect of a delay in the boron mixing process under natural circulation conditions, the actual

concentration curve in Figure 2-7 will be shifted to the right by 0.5 hours. (Note that 30 minutes is consistent with the boron mixing time that was determined in CEN-259 and, in addition, is conservative since CEN-259 also indicates that significant mixing of added boron does occur prior to 30 minutes). The shift is shown in Figure 2-8. The relationship between the shifted curve and the required concentration curve is shown in greater detail in Figure 2-9 and Figure 2-10. As can be seen in Figure 2-8 to Figure 2-10, the concentrations within the reactor coolant system for the 0.5 hour shift curves are above the required shutdown curve at each temperature during the cooldown.

Question 4: LP&L included boron measurement uncertainties in their report. FP&L did not include them. Why?

Response to Question 4:

A boron measurement uncertainty was included in the LP&L physics data when the natural circulation scenario assumed that the boronometer would be used to verify RCS boron concentration. A very conservative boronometer measurement uncertainty (50 ppm) was added to the RCS boron requirements. A review of the cooldown scenario shows that the addition of boronometer measurement uncertainty to the RC3 boron requirements is unnecessary. The cooldown scenario in CEN-365(L) identifies the minimum volume of BAMT water that must be added to maintain the desired shutdown margin throughout the cooldown. Delivery of this quantity of BAMT water will ensure that the RCS is adequately borated. The boronometer readings will not be used during the cooldown as a criteria to reduce the amount of BAMT water delivered to the RCS during this cooldown. In conclusion, boronometer measurement uncertainties need not be included in the boration requirement curves for either plant.

Question 5: Explain the uncertainties and conservatism for the Scram Worth, Moderator Temperature Coefficient (MTC) and the Doppler Coefficient used in the FP&L boric acid makeup tank report.

Response to Question 5:

A bias of -9% and an uncertainty of 13% was applied to the Scram Worth data. No conservative correction was needed to the MTC curve since it was already consistent with the Most Negative Technical Specification MTC limit. A combined bias and uncertainty of 10% was applied to the moderator data. The application of bias of 15% and an uncertainty of 15% to the Doppler data is consistent with the licensing methodology used at other plants.

Question 6: Why is there a substantial difference between the boric acid requirements specified for St. Lucie Unit i and Unit 2?

Response to Question 6:

The substantial difference is due to the fact that the fuel vendors for the two units are different. C-E is the fuel vendor for Unit 2 and C-E provides the Reload Safety Analysis. C-E had all the physics data required to determine the boration requirements, particularly the Inverse Boron Worth and the Cooldown Curve.

In the case of St. Lucie Unit 1, ANF is the fuel vendor and provides the Reload Safety Analysis. To perform the Unit 1 work FP&L, through ANF, provided the physics data inputs to C-E. In the analysis, it was noted that the ANF Inverse Boron Worth (IBW) values were significantly different than those that would be provided with C-E methodology. The ANF IBW values were conservative (i.e. the boron requirements were greater than similar data C-E would generate). C-E also analyzed the Moderator Temperature Coefficient (MTC) curve provided by ANF and found it necessary to normalize the curve provided to the Most Negative Technical Specification MTC limit. This normalization was done in a very conservative manner, and it probably shows a much greater reactivity insertion due to cooldown than if the fuel vendor had done the evaluation. The normalized MTC values were conservative.

Question 7: What shutdown margin was used to generate the boron concentration requirements for Modes 5 and 6?

Response to Question 7:

Although the Technical Specifications only required a shutdown margin of 3000 pcm in Modes 5 and 6, a shutdown margin of 3500 pcm was used in the calculations to generate the boron concentration requirements. The only effect is that the use of 3500 pcm changes both the initial and final concentration requirements by a constant amount. Since the difference between the initial and final requirements is due only to the moderator temperature coefficient, the use of 3500 pcm does not change the difference between the requirements. The requirements are conservative.

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Boric Acid Solubil	lity in Water(1)
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Temperature	
(Degrees F)	wt. % H ₃ BO ₃
32.0	2.52
41.0	2.98
50.0	3.49
59.0	4.08
68.0	4.72
77.0	5.46
86.0	6.23
95.0	7.12
104.0	8.08
113.0	9.12
122.0	10.27
131.0	11.55
140.0	12.97
149.0	14.42
158.0	15.75
167.0	17.91
176.0	19.10

 Solubility from Technical Data Sheet IC-11, US Borax & Chemical Corporation, 3-83-J.W.

1

Time Frames for Determining an Overall RCS Cooldown Rate

Initial Hot Standby hold period (*)	4.0 hours
Plant cooldown from 557 to 325 degrees (#)	2.32 hours
Hold period for cooling the reactor vessel upper head	15.5 hours
Plant cooldown from 325 to 200 degrees (#)	1.25 hours
Additional con* vatism	5.73 hours
Total	28.8 hours

(*) Per the requirements of Branch Technical Position (RSB) 5-1.

(#) Assume an average cooldown rate of 100 degrees per hour.

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Required Boron Concentration for a Cooldown from 200 Degrees to 135 Degrees

Temperature (Degrees F)	Concentration (@) (ppm boron)
200	570.3
190	577.4
180	584.5
170	591.6
160	598.5
150	605.7
140	612.8
135 -	616.3

(@) Based upon a 3000 pcm shutdown margin after xenon decay.

Initial Conditions and Assumptions Used in the Modes 5 and 6 Calculation

- a. Reactor coolant system volume = 9,398 ft³.
- b. Reactor coolant system pressure = 275 psia.
- c. Pressurizer volume = 450 ft³.
- d. Pressurizer is saturated.

- e. Zero reactor coolant system leakage.
- f. Boration source concentration = 2.5 weight % boron.
- g. Boration source temperature = 70 degrees.
- h. Initial reactor coolant system concentration = 570.3 ppm
- i. Initial pressurizer concentration = 570.3 ppm boron.
- Complete and instantaneous mixing between the pressurizer and the reactor coolant system. (Refer to discussion on Section 2.2.4 above).
- k. Constant pressurizer level maintained during the plant cooldown, i.e., charge only as necessary to makeup for coolant contraction.
- Total system volume (RCS + SDCS + PZR) = 19,246 ft³. (See discussion in Section 2.3.2).

Table 2-5 Initial Conditions and Assumptions Used in the Modes 1, 2, 3, and 4 Calculation

- a. Reactor coolant system volume = 9,398 ft³.
- b. Initial reactor coolant system pressure = 2200 psia.
- c. Pressurizer volume = 600 ft³ (40% level).
- d. Pressurizer is saturated.
- Reactor coolant system depressurization performed as shown in Table 2-8 through Table 2-32.
- f. Zero reactor coolant system Technical Specification leakage.
- g. Initial reactor coolant system concentration = 0 ppm.
- h. Initial pressurizer concentration = 0 ppm boron.
- Complete and instantaneous mixing between the pressurizer and the reactor coolant system. (Refer to discussion on Section 2.2.4 above).
- j. Constant pressurizer level maintained during the plant cooldown, i.e., charge only as necessary to makeup flant contraction.
- k. Boron concentration in the SDCG ages a the boron concentration in the reactor coolant system at the star shutdown cooling initiation.
- 1. Letdown is not available.

Sec. 2

- m. RWT temperature = 50 degrees.
- n. BAMT temperature = 70 degrees.

200 200 275 1.00000 1.00000 1.00000 0.0	8/A ABOFS TOTAL 827 (11as) (11as)	(ita) (ita)	Fiest COMC (ppm borten)
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170 275 0.01650 0.01644 4,157.5 409.2 160 275 0.01644 0.01636 4,157.5 409.2 150 275 0.01644 0.01633 5,513.5 407.5 150 275 0.01643 0.01633 5,513.5 4,21.6 150 275 0.01633 0.01633 5,513.5 4,21.6 151 275 0.01633 0.01633 1,515.0 4,24.4 155 275 0.01626 0.01626 1,775.7 213.2			
160 275 0.01644 0.01636 4, 187.9 502.6 150 275 0.01639 0.01633 5,513.5 421.6 140 275 0.01639 0.01633 5,513.5 424.4 140 275 0.01633 0.01635 3,515.0 424.4 141 275 0.01626 0.01626 1,775.7 213.2			9-14C
150 275 0.01636 0.01633 3,513.5 421.6 140 275 0.01633 0.01638 3,535.0 424.4 135 275 0.01626 0.01626 1,775.7 213.2	107.4 4.20		10.2
140 275 9.01433 9.01428 3,535.0 424.4 135 275 9.01428 9.01424 1,775.7 215.2		ŝ	64.7
135 275 0.01428 0.01626 1,775.7 213.2	1	1	648.1
		1,430.7 1,184,719.8	623.9

(ppm boron) A T TH FOTAL SYS. MASS FIRML COMC. 60K.6 6.808 5.965.6 6.003 612.6 615.9 5.918 1,158,848.9 1, 167, 155.5 1,171,354.5 1, 162, 967.1 1,175,583.8 1,179,132.2 1,162,762.3 1,164,495.6 (itm) 3,9%4.2 3,9%4.9 4,035.9 4,017.2 4,786.5 4,118.8 4,153.7 Parts. B/A NON 0.0 41.0 1.04 41.3 41.6 35.1 (()) SO F (pail) 0.194 0.0 494.6 5.962 501.8 421.0 9-515 70 F (gal) 0.0 SAMI WA 2 ST. LUCIE WILL 2 PLANT COOLDOAM FROM 200 F 10 135 F, BUT AT 1720 ppm 50808 4,187.9 MASS(ILM) 0.0 4.097.4 4, 127.4 4, 157.5 3,513.5 3,535.0 1.775.1 SHE I MEALE SPECIFIC VOLUME 0.01656 0.01636 0.01433 0.01625 1.00000 0.01650 0.01644 0.01626 (cu.ft./lbm) 34 ŝ 1.00000 0.01656 05510.0 0.01436 0.01633 0.01628 0.01644 ä 55384 NZ4 273 52 52 (mim) 888 170 135 150 AVG. 575. 16MP. * (1) 8 2 982 981 8 170 31 2

FOIAL RUT VOXUME 3043.0 gailons

(ppm boron) TOTAL B/A TOTAL SYS. MASS FINAL COMC. \$35.ó 0.0 10.94 511.5 \$13.8 525.0 545.6 555.1 9.895 572.6 501.7 5.00.4 597.6 8.400 611.9 619.0 \$2.50 632.0 636.6 641.5 0.950.0 9.020 658.6 4.018 661.1 35,950.2 600,032.3 01,006.6 505,700.6 518, 758.9 510,230.7 514,507.3 522,734.1 526, 773.0 530, 377.3 1.424,642 58,235.7 534,488.4 541,865.7 545, 342.3 548,865.5 552,136.8 555,448.7 558,802.1 560,346.3 569,817.3 572,920.1 504, 716.6 591,308.5 597,376.2 1.111.49 (Ibm) 1,647.0 0.0 6.96 462.8 2,007.5 2,040.9 1.572.4 1,518.5 1.563.1 1,686.1 1,725.8 1,766.2 1.801.7 0.040.1 5.000.1 1.975.4 2,056.1 2,056.1 2,006.6 2,202.5 2,267.5 1,606.0 1,874.3 1,943.2 2,327.2 2,350. (Ipm) PLANT COORDOWN FROM 557 F TO 200 F; BANI AT 3.5 WIX BORIC ACID; RWT AT 1720 PH BORON B/A ADDED 42.9 6.98 92.9 46.2 44.6 41.0 39.1 39.7 0.0 4" N 35.5 3.0.8 33.8 34.2 34.7 32.2 32.6 33.0 9.6 0.0 116.0 15.1 30.5 54.8 1.35 23.6 (11) SO F (gel) 0.0 0.0 115.9 556.9 0.0 537.6 517.1 1 567 471.6 479.3 1.184 428.6 1.001 \$07.2 412.6 418.1 308.2 396.0 593.1 182.6 400.0 0.0 366.2 782.3 720.1 284.3 ZO F (gal) 0.0 1,631.5 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 3,210.7 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 ST. LUCIE UNIT 2 0.0 4,485.6 966.7 4,645.9 4,063.9 3,575.6 3,907.5 3,397.2 3,488.5 MASS((bm) 26,741.7 13, 589.2 4,513.8 4,130.5 3,999.2 3,442.4 3,235.1 1,523.0 6,527.0 1.936.1 0.0 11,680.4 6,008.1 SHRINKAGE 3,279.4 3, 320.4 3,072.3 2.371.6 SPEC. "IC VOLUME 0.01828 0.01816 0.01974 0.01970 0.01933 0.01916 0.01855 0.01842 0.02032 0.01870 0.01951 0.01900 0.01885 0.01792 0.01770 0.01754 1.00000 0.01804 0.01781 0.01759 0.01754 0.01744 0.01707 0.01669 0.01687 0.01662 (cu.ft./lbm) 27 . 0.02157 0.02032 0.01970 1.00000 0.01933 0.01870 47910.0 0.01951 0.01916 0.01900 0.01365 0.01855 0.01842 0.01626 0.01816 0.01792 0.01781 0.01770 0.01759 0.01804 0.01754 0.01754 0.01744 0.01707 0.01667 0.01669 4842.2 gallons in PZR PRESS 2200 2200 2200 2200 2200 2200 22000 2200 2200 2200 2200 2200 2200 2200 2200 2200 2200 2200 2200 2200 275 275 275 275 52 (sist) 510 3 3 223 557 3 450 110 927 8 410 8 370 3 350 270 8 3 330 310 22 200 200 235 200 VOLUME. AVG. SYS. TENP. (F) TOTAL JANT 510 29 78 2 3 057 057 557 557 120 110 8 280 370 3 350 340 280 330 310 325 2 200 235 210 2

	- Castron										
(F)		(pata)		SPECIFIC VOLUME (cu.ft./lbm) vi , vf	SHR I NKAGE NASS (I bm)	RAMI VOL 2 70 f (gal)	Rui vox a 50 f (gal)	B/A ADDED (Ibm)	101AL 8/A ((bm)	TOTAL B/A TOTAL SYS. MASS (Ibm) (Ibm)	(ppm boron)
557	557	2200	1.00000	1.00000	0.0	0.0	0.0	0.0	00	C BLC BY7	
155	510		0.02157	-	26,741.7	3,210.7	0.0	808.3	E NON	LAS ATA A	
510	067	2200	0.02032	0.01990	9,761.3	1,172.0	0.0	327.9	1.226.2	100 201	1 07
067	180	2200	0.01990	0.01970	4,794.5	575.6	0.0	161.1	1.367.3	500.923.4	
180	115	2200	0.01970	0.01955	3,709.5	445.4	0.0	124.6	1.511.9	504.757.5	
115	160	2200	0.01955	0.01933	5, 22.0	0.0	6.9.9	53.9	1,565.8	510.233.4	i,
997	450	2200	0.01933	0.01916	4,313.8	0.0	1.112	42.9	1,608.6	514.590.0	546.5
. 450	077	2200	3.01916	0.01900	4,130.5	0.0	1.881	6.12	1.649.7	518.761.6	
140	430	22:30	0.01900	0.01885	3,936.1	0.0	8.174	39.1	1,666.8	522.736.7	
130	120	22000	0.01865	0.01870	3,999.2	0.0	1.19.5	39.7	1.728.5	526.175.1	
120	410	2200	9.01870	0.01855	4,063.9	0.0	4.87.1	7.07	1,768.9	530.679.9	
410	007		0.01855	0.01842	3,575.6	0.0	428.6	35.5	1,804.4	534.491.0	
100	390		0.01842	0.01828	3,907.5	0.0	408.4	36.8	1.643.2	538.437.3	
390	380		0.01824	0.01816	3,397.2	0.0	2.104	33.8	1,877.6	541.866.3	A05.6
380	370		0.01816		3,442.4	0.0	412.6	34.2	1.911.2	545 344 9	
370	360		0.01804		3,486.5	0.0	418.7	34.7	1.945.8	548.846.1	
200	350	-	0.01792		3,239.1	0.0	1.85.	32.2	1.978.0	552.130.4	
350	340	-	0.01781	~	3,279.4	0.0	343.1	32.6	2,010.6	555.451.4	• 44
34.0	330		0.01770	0.01759	3, 320.4	0.0	396.0	33.0	2,043.6	558.804.7	4.9.4
330	325		0.01759	0.01754	1,523.0	0.0	182.6	15.1	2.058.7	560.342.9	
22	310	275	0.01754	0.01754	0.0	0.0	0.0	0.0	2.058.7	569.820.0	
310	300		0.01754		3,072.3	0.0	368.2	30.5	2.009.2	572.922.8	617.6
300	260	-	0.01744	0.01707	11,680.4	0.0	1,400.0	16.0	2.205.3	5.017.02	4 924
260	235	275	0.01707	0.01687	6,527.0	0.0	784.3	84.8	2,270.1	591.311.1	2 11.2
235	210	275	0.01667	0.01669	6,008.1	0.0	720.1	1.92	2,329.8	597.378.9	0
210	200	275	0.01669	0.01662	2 371.6	0.0	2 780	1 10	2 868 4		

Table 2-10

	PLANT LU	OLDOME PRO	14 /CC M	10 200 F;	BANT AT 3.0	WEX BORIC A	CID; RWT AT	1720 ppm BOR	ON		
AVG.SYS.	4	PZR PRESS	SPECIF	IC VOLUME	SHRINKAGE	BANT VOL 2	RWT VOL @	B/A ADDED	TOTAL B/A	TOTAL SYS. MASS	FINAL CONC
Li (F	, ¹¹	(psia)		Vf	MASS(1bm)	70 F (gel)	50 F (gel)	(ltm)	(lbm)	((bs)	(ppm boron
557	557	2200	1.00000	1.00000	0.0	0.0	0.0	0.0	0.0	458,238.7	
557	510	, 2200	0.02157	0.02032	26,741.7	3,210.7	0.0	827.1	827.1		0.0 297.6
510	490	2200	0.02032	0.01990	9,761.3	1,172.0	0.0	301.9	1,129.0		398.1
490	450	2200	0.01990	0.01970	4,794.5	575.6	0.0	148.3	1,277.3	,	445.9
480	4.79	2200	0.01970	0.01951	4,645.9	557.8	0.0	143.7	1,420.9		491.4
470	459	2200	0.01951	0.01931	4,913.5	589.9	0.0	152.0	1,572.9		538.5
459	450	2200	0.01931	0.01916	3,885.8	0.0	465.8	38.6	1,611.5		
- 450	440	2200	0.01916	0.01900	4,130.5	0.0	495.1	41.0	1,652.6		547.5
440	430	2200	0.01900	0.01885	3,936.1	0.0	471.8	39.1	1,691.7		556.9
430	420	2200	0.01885	0.01870	3,999.2	0.0	479.3	39.7	1,731.4	526,778,6	565.8
420	410	2200	0.01870	0.01855	4,063.9	0.0	487.1	40.4	1,771.8		574.6
410	400	2200	0.01855	0.01842	3,575.6	0.0	428.6	35.5	1,807.3	534,493.9	583.5
400	390	2250	0.01842	0.01828	3,907.5	0.0	468.4	38.8	1,846.1	538,440.2	591.2
390	380	2200	0.01828	0.01816	3,397.2	0.0	407.2	33.8	1,879.9	541,871.2	599.4
380	370	2200	0.01816	0.01804	3,442.4	0.0	412.6	34.2	1,914.1	545, 347.8	606.5
370	360	2200	0.01804	0.01792	3,488.5	0.0	618.1	34.7	1,945.7	548,871.0	613.6
360	350	2200	0.01792	0.01781	3,239.1	0.0	388.2	32.2	1,980.9	552, 142.3	620.7
350	340	2200	0.01781	0.01776	3,279.4	0.0	393.1	32.6	2,013.5	555,454.3	627.2
340	330	2200	0.01770	0.01759	3,320.4	0.0	398.0	33.0	2,046.5	558,807.6	633.8
330	325	2200	0.01759	0.01754	1,523.0	0.0	182.6	15.1	2,061.6	530,345.8	640.3
325	310	275	0.01754	0.01754	0.0	0.0	0.0	0.0	2,031.6	569,822.9	643.2
313	300	275	0.01754	0.01744	3,072.3	0.0	368.2	30.5	2,092.1	572,925.7	632.5
300	260	275	6.01744	0.01707	11,680.4	0.0	1,400.0	116.0	2,208.2	584,722.1	638.4
260	235	275	0.01707	0.01687	6,527.0	0.0	782.3	64.8	2,273.0	591,314.0	660.3
235	210	275	0.01687	0.01669	6,008.1	0.0	720.1	59.7	2,332.7		672.1
210	200	275	0.01669	0.01662	2,371.6	0.0	284.3	23.6	2,356.3	597,381.8	682.7
					-,	0.0		c3.0	2,330.3	599,777.0	686.9

Table 2-11

		PLANT CO	OLDOWN FRO	N 557 F 1	10 200 F;	BANT AT 2.7	S with BORIC A	CID; RUT AT	1720 ppm 608	ON		
AV	G. SYS. 1	ENP.	PZR PRESS	SPECIFI	C VOLUME	SHRINKAGE	BANT VOL 2	RWT VOL 2	B/A ADDED	TOTAL B/A	TOTAL SYS. MASS	FINAL CONC
	(F) Ti	nł-	(peia)	(cu.ft Vi	· Vf	MASS(1bm)	70 F (gal)	50 F (gel)	(lbm)	(11m)	(1bm)	(ppm boron
	557	557	2200	1.00000	1.00000	0.0	0.0	0.0	0.0	0.0		••••••
	557	510	2200	0.02157	0.02032	26,741.7		0.0	756.2	756.2		0.0
	510	490			0.01990	9,761.3		0.0	276.0	1,032.2		272.2
	490	480			0.61970	4,794.5		0.0	135.6			364.0
	480	479			0.01951	4,645.9		0.0	131.4	1,167.8		407.8
	470	460			0.01933	4,485.6		0.0	126.8			449.3
	460	450			0.01916	4,313.8		0.0	122.0	1,426.0		488.8
5	450	442			0.01903	3,298.9		0.0	93.3	1,548.0		526.0
	442	430			0.01885	4,767.7		571.5	47.4	1,641.2		554.0
	430	420			0.01870	3,999.2		479.3		1,688.6		564.0
	430	410			0.01855	4,063.9		487.1	39.7	1,72*.3		573.0
	410	400			0.01842	3,575.6			40.4	1,768.7		582.5
	400	390			0.01828	3,907.5		428.6	35.5	1,804.2		590.2
	390	380			0.01816	3,397.2		468.4	38.8	1,843.1	538,437.2	598.5
	380	370		0.01816		3,442.6	0.0	407.2	33.8	1,876.8		605.0
	370	360			0.01792		0.0	412.6	34.2	1,911.0	545,34+.8	612.1
	360	350			0.01781	3,488.5	0.0	418.1	34.7	1,945.7	548,068.0	619.8
	350	340				3,239.1	0.0	388.2	32.2	1,977.9	552, 139.3	626.3
	340	330			0.01770	3,279.4	0.0	393.1	32.6	2,010.4	555,451.2	632.8
	330	325			0.01759	3,320.4	0.0	398.0	33.0	2,043.4	558,804.6	639.3
	325	310		0.01759		1,523.0	0.0	182.6	75.1	2,058.6	560, 342.8	642.3
	310			0.01754		0.0	0.0	0.0	0.0	2,058.6	569,819.8	631.6
		500		0.01754		3,072.3	0.0	368.2	30.5	2,089.1	572,922.6	637.5
	300	260		0.01744		11,680.4	0.0	1,400.0	116.0	2,205.1	584,719.1	659.3
	260	235		0.01707		6,527.0	0.0	782.3	64.8	2,270.0	591, 311.0	671.2
	235	210		0.01687		6,008.1	0.0	720.1	59.7	2,329.7	597, 378.7	681.8
	210	200	275	0.01669	0.01662	2,371.6	0.0	284.3	23.6	2,353 2	599,773.9	686.0

16.5	AVG.STS. TEN	÷-	PZR PRESS		SPECIFIC VOLIME	SHRINKAGE	BANT VOL 2		B/A ADDED	101AL 8/A	TOTAL SYS. MASS	S. MASS	FINAL COMC
-	8	-1	(peie)	(su.f) vi	(cu.ft./:cm) vi vi	MASS(Ibm)	70 f (gal)		((1)	(III)	5	(j	(ppm boron)
	251	557	2200	1.00000	1.00000	0.0	9.0	0.0	00				
	221	510	1 27:55	0.02157	0.02032	26.741.7	3.2	0.0	1 787			1.007.00	0.0
	510	190	2200	0.02032	-	9,761.3	-	0.0	2.12	0 100		0.000,004	246.8
	067	180	2200	0.01990	0.01970	4,794.5		0.0	122.0	1 DKA 0		· >>> 0.10, CA	1.065
	190	470	2290	0.01970	J.01951	4,045.9	\$57.8	0.0	119.1	1.178.0	2.9	1 . CAC ' MO	8.Vot
	24	100	2200	0.01951		4,485.6		0.0	115.0	1.293.0	205	V 000 005	C. 104
	3	450	2200	0.01933		4,313.6		0.0	110.6	1.403.6	15	0 300 7	
	\$20	077	2200	0.01916	-	4,130.5		0.0	105.9	1 500.5	115	3 1CY 8	
	140	430	2200	6.01900		3,936.1		0.0	100.9	1.610.5	25	7 859 2	V.000
	120	418	2200	0.01665		4,806.8		0.0	123.2	1.733.7	25	7 845 2	1 3 743
	118	410	2200	0.01867		3,256.3	0.0	390.3	32.4	1,766.1	530	530.877.1	A 182
		8	22000	SEL10.0		3,575.6	0.0	428.6	35.5	1,601.6	534	4 488 2	1 005
	-	DAG .	22000	0.01842		3,907.5	0.0	1.801	36.6	1,840.4	536	2.44.5	1 Y 105
		200	22000	0.01828		3, 397.2	0.0	407.2	33.8	1,874.2	541	845.5	2 704
	8	2/2	2200	0.01816	-	3.442.4	0.0	412.6	34.2	1,908.4	585	W2.1	
	210	3	22000	0.01804		3,488.5	0.6	418.1	34.7	1,943.0	548	1 865.3	1 3 8 3 4
1	8 5	000	22000	0.01792	0.01781	3,239.1	0.6	366.2	32.2	1,975.2	552	552,136.6	17.50
1	-		20022	0.01/8/	-	3,279.4	0.0	393.1	32.6	2,007.5	\$55	555.448.6	10 0.9
1	110		0077	0//10.0	-	3, 320.4	0.3	396.0	33.0	2,040.5	558	558,801.9	1 2 474
1	XCI	00	0077	95/10.0		1,523.0	0.0	182.6	15.1	2,055.9	560	560, 340.1	1 5 1 79
1	100	0102	e x	10.01/24		0.0	0.0	0.0	0.0	2,055.9	569	569,817.2	630.8
1			SI	ACIU.0	-	3,072.3	0.0	368.2	30.5	2,086.4	572	572.920.0	1 2 92.9
	-	100	5	0.01744		1, 680.4	0.0	1,400.0	116.0	2,202.5	584	584.716.4	I V VSV
. '	8 1	6	S	0.01/07	-	6,527.0	0.0	782.3	6.10	2,261.3	165	591, 508.5	1 7 020
1	6 2	017	SIS	0.01687	0.01669	6,006.1	0.0	720.1	1.92	2,327.0	165	1 376.1	1 0 100
	017	200	512	0.01669	0.01662	2,371.6	0.0	204.3	23.6	2,350.6	599	5.171.992	1 2.200
IAL	16.90	TOTAL BANT VOLING		-									

(ppm boron) TOTAL B/A TOTAL SYS. MASS FINAL CONC. 0.0 149.0 4.83.4 1.265 505.3 517.3 528.6 5:5.2 5.9.2 559.2 569.1 577.8 587.1 1.595 603.1 611.2 618.5 6.25.9 633.2 636.6 626.0 632.6 657.2 670.5 662.5 1.188 6.140,000 505,643.5 1.862,86.1 35,950.2 41,545.6 510, 177.0 514,536.9 518,711.6 522,689.8 526, 731.8 534,452.9 545,315.0 552,114.6 530, 839.1 536,402.2 541,835.8 9.048,840.9 1.954,858 558, 785.0 560, 324.3 569,801.3 572,906.5 Sek, 711.8 91,306.6 0.155,793 0.877.99 (11) 0.0 6.999 375.8 1,411.8 1,766.3 1,808.1 1,844.4 1,918.6 2,072.9 4.164.1 1.509.4 1,555.6 1,641.8 1,684.6 1,728.1 1,953.2 1.992.1 1,966.5 2,023.8 2,040.1 2,040.1 2.197.9 9.155,5 2,261.7 2,357.3 (Ithm) PLANT COOKDOAM FROM 557 F TO 200 F; BANI AI 3.5 MTX BORIC ACID; RWI AI 1850 PLAN BOROM B/A ADDED 6.96 0.9 35.8 36.0 1.94 48.0 46.1 2.44 42.1 \$2.8 13.5 41.8 36.3 34.8 37.3 34.6 35.1 35.5 16.3 0.0 32.9 24.9 8.93 5.4 (11) Rui wou a 50 f (gal) 0.0 0.0 0.0 556.9 537.6 517.1 1.83 471.8 170.3 487.1 428.6 1.801 4.07.2 412.6 418.1 346.2 1.268 396.0 182.6 0.0 346.2 0.004, 782.3 403. 720.1 284.3 RAMM VOL 2 70 f (gal) ST. LUCIE UNIT 2 0.0 0.0 3,210.7 0.0 0.0 0.0 0.0 0.0 0.3 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1,343.4 0.0 0.0 0.0 0.0 ł 4.645.9 11,189.5 4,485.6 4,130.5 MASS(Ibm) 26,741.7 3,366.3 4,313.8 3,936.1 3,907.5 5, 397.2 3,488.5 3,239.1 6,527.0 0.0 3,999.2 3,575.6 3,442.4 3,279.4 6,006.1 SHR I WKAGE 4.063.9 3, 320.4 0.0 1,523.0 3,072.3 11,600.4 2,371.6 SPECIFIC VOLUME 0.01842 0.01828 0.01816 1.00000 C.02032 0.01970 0.01916 0.01855 0.01984 0.01951 0.01933 0.01900 0.01870 0.01792 0.01665 0.01804 0.01770 0.01759 69. 00 0.01781 0.01754 0.01707 0.01687 0.01754 0.01744 0.01662 (cu.ft./ltm). ž 1.00000 0.02157 0.01842 vi , 0.02032 0.01916 0.01900 0.01870 0.01855 0.01816 0.01984 0.01970 0.01951 0.01933 0.01385 0.01828 0.01770 0.01759 0.01754 0.01707 0.01669 0.01792 0.01781 0.01687 0.01804 0.01754 0.01744 4554.1 gallons PZR PRESS 22000 2200 2200 2200 2200 2200 2200 2200 2200 2200 2200 2200 2200 2200 2200 2200 2200 2200 2200 2200 575 513 275 275 512 513 (paia) 557 191 3 450 130 27 410 8 28 370 330 325 310 200 560 235 210 TOTAL BANT VOLUME 11.1 AVG. SYS. TENP. (1) 510 181 120 3 \$50 1071 557 557 (30 120 410 8 8 200 220 2 130 22 310 235 11

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AVG. 313.	IEw.	PZR PRESS		SPTICIFIC VOLUME	SHR I MCAGE	BANT VOX 3	6 UT UN 2	B/A ADDED				
ы н С		(mim)	(cu.f . vi .	(cu.ft./(lbm) vi . vf	MASS(Itam)	70 f (gal)		((1)	(item)	((fai)	((fbm)	(ppm borran)
557	155		1.00000	1.00000	0.0	0.0		0.0	0.0	657	2 102 10	
155	510			0.02032	26,741.7	3,210.7	7 0.0	396	898.3	1997	AN 878 6	C. 101
510	067		-	0.01990	9,761.3	1,172.0		327.9	1.226.2	567	0 190 501	1.01
84	478		1.00	0.01966	5,716.5	004.3		102.3	1,418.2	501	\$ 91.876.4	1 707
82.5	720			-	3,723.9	0.0	3	5. OF	1,456.1	505	505,640.1	504.2
1/0	100			0.01933	4.253.4	0.0	u 537.6	0.34	1,506.1	510	510.173.7	516.1
3	450			-	4,313.8	0.0	0 517.1	1.97	1,552.2	514	514,533.6	527.4
420	110		- in .	-	4,150.5	0.0	1.293 0	44.2	1,596.4	518	518,708.3	538.1
110	430			~	3,936.1	0.0		42.1	1,638.5	522	522,686.4	548.1
130	027			~	3,999.2	0.0	J	42.8	1,661.2	526	526,728.4	\$58.0
27	410			0.01855	4,065.9	0.0		43.5	1.724.1	530	830.835.8	200.005
410	100			Ξ.	3.5 7.6	0.0	0 428.6	38.2	1,762.9	534	534,449.6	576.7
8	390			0.01628	3,907.5	0.0		41.8	1,804.7	536	536.396.6	500.0
390	380			0.01816	3,397.2	0.0		36.5	1,841.1	195	41.832.4	504.1
200	370			- T	3,442.4	0.0		34.8	1,877.9	545	\$45.311.6	1 209
370	Xeo			-	3,488.5	0.0		37.3	1,915.2	548	548.037.5	610.1
2	350			-	3,239.1	0.0		34.6	1.949.8	552	552 111.2	417.4
350	340			-	3,279.4	0.0		35.1	1,964.9	555	555.46.7	8.909
340	330		0.01770	~	3, 320.4	0.0		35.5	2,020.4	558	558.781.6	612.2
330	325	~	0.01759	0.01754	1,523.0	0.0	162.6	16.3	2.036.7	2660	0 021 095	\$ \$19
325	310		0.01754	-	0.0	0.0		0.0	2.036.7	560	0.007.005	0 707
310	300	215	0.01754	-	3,072.3	0.0	1 348.2	32.9	2,069.6	572.	572.943.1	631.6
300	260	275	0.01744	0.01707	11,680.4	0.0	1,400.0	124.9	2.194.5	584	584 708 4	C 959
260	235	275	0.01707	0.01687	6,527.0	0.0		69.8	2,264.3	165	1 202 1 90	2 000
235	210	275	0.01687	-	6,008.1	0.0	1	64.3	2.328.6	202	597.377.6	5 189
210	200	275	0.01669	0.01662	2,371.6	0.0	204.3	2.4	2.353.9	2005	Y 711 005	C 101

Table 2-15

TEMP.) 1 1 55 51 49 48 46 46 46 46 46 46 46 46 46 46		2200 2200 2200 2200 2200 2200 2200 220	(cu. ft Vi 1.00000 0.62157 0.02032 0.01990 0.01970 0.01970 0.01944 0.01953 0.01916 0.01900	0.01970 0.01944 0.01933 0.01916 0.01900		70 F (gal) 0.0 3,210.7 1,172.0 575.6	RWT VOL 2 50 F (gal) 0.0 0.0 0.0 0.0 0.0 0.0 323.8	B/A ADDEG (1bm) 0.0 827.1 301.9 148.3 198.9	10fAL B/A (1bm) 0.0 827.1 1,129.0 1,277.3 1,476.1	485,807.4 495,870.6 500,813.4	(ppm boran 0.0 297.6 398.1 445.9
51 49 48 46 46 45 46 45 45 45 45 45 45 45 45 45 45 45 45 45		2200 2200 2200 2200 2200 2200 2200 220	0.62157 0.02032 0.01990 0.01970 0.01970 0.01953 0.01916 0.01900	0.02032 0.01990 0.01970 0.01944 0.01933 0.01916 0.01900	26,741.7 9,761.3 4,794.5 6,430.1 2,701.3 4,313.8	3,210.7 1,172.0 575.6 772.0 0.0	0.0 C.0 0.0 0.0	827.1 301.9 148.3	827.1 1,129.0 1,277.3	485,807.4 495,870.6 500,813.4	297.6 398.1 445.9
49 48 46 45 45 43 43		2200 2200 2200 2200 2200 2200 2200 220	0.02032 0.01990 0.01970 0.01944 0.01933 0.01916 0.01900	0.01990 0.01970 0.01944 0.01933 0.01916 0.01900	9,761.3 4,794.5 6,430.1 2,701.3 4,313.8	3,210.7 1,172.0 575.6 772.0 0.0	0.0 C.0 0.0 0.0	827.1 301.9 148.3	827.1 1,129.0 1,277.3	485,807.4 495,870.6 500,813.4	297.6 398.1 445.9
48 46 45 45 43 43		2200 2200 2200 2200 2200 2200 2200	0.01990 0.01970 0.01944 0.01933 0.01916 0.01900	0.01970 0.01944 0.01933 0.01916 0.01900	4,794.5 6,430.1 2,701.3 4,313.8	1,172.0 575.6 772.0 0.0	0.0 0.0	301.9 148.3	1,129.0 1,277.3	495,870.6 500,813.4	398.1 445.9
46 46 45 45 45 45 45		2200 2200 2200 2200 2200 2200	0.01970 0.01944 0.01933 0.01916 0.01900	0.01944 0.01933 0.01916 0.01900	4,794.5 6,430.1 2,701.3 4,313.8	575.6 772.0 0.0	0.0 0.0	148.3	1,277.3	500,813.4	445.9
46 45 44 43 42		2200 2200 2200 2200	0.01944 0.01933 0.01916 0.01900	0.01933 0.01916 0.01900	2,701.3 4,313.8	772.0 0.0	0.0				
45 44 43 42		2200 2200 2200	0.01933 0.01916 0.01900	0.01916 0.01900	4,313.8	0.0		170.7	1,4/0.1		
44		2200 2200	0.01916 0.01900	0.01900	4,313.8			28.9	1,505.0		508.0
- 43 42		2200	0.01900			U.U.	517.1	46.1			515.0
42						0.0	495.1	44.2	1,551.2		527.1
		2200		0.01885	3,936.1	0.0	471.8	42.1	1,595.3		537.
410			0.01885	0.01870	3,999.2	0.0	479.3	42.8	1,637.4		547.
		2200	0.01870	0.01855	4,063.9	0.0	487.1	43.5	1,680.2		557.
404		2200	0.01855	0.01842	3,575.6	0.0	428.6	38.2			567.
39		2200	0.01842	0.01828	3,907.5	0.0	468.4	41.8	1,761.9	534,468.5	576.4
38			0.01828		3, 397.2	0.0	407.2	36.3	1,803.7	538, 397.8	585.7
370			0.01816		3,442.4	0.0			1,840.0	541,831.4	593.7
364											601.1
350											609.1
340											617.1
330											624.5
325											631.8
310											635.2
300											624.6
260											631.3
235					-						655.9
210									and the second sec		669.2
200					2,371.6	0.0	284.3	25.4			681.2 685.9
	350 340 330 325 310 300 260 235 210 200	360 350 340 330 325 310 300 260 235 210 200	360 2200 350 2200 340 2200 330 2200 325 2200 310 275 300 275 260 275 260 275 210 275 200 275 200 275 200 275 200 275	360 2200 0.01804 350 2200 0.01792 340 2200 0.01781 330 2200 0.01770 325 2200 0.01759 310 275 0.01754 300 275 0.01754 260 275 0.01764 235 275 0.01707 210 275 0.01667 200 275 0.01667	360 2200 0.01804 0.01792 350 2200 0.01792 0.01781 340 2200 0.01781 0.01770 330 2200 0.01770 0.01759 325 2200 0.01759 0.01754 310 275 0.01754 0.01754 300 275 0.01754 0.01764 300 275 0.01754 0.01764 260 275 0.01764 0.01707 235 275 0.01767 0.01687 210 275 0.01667 0.01669 200 275 0.01667 0.01662	360 2200 0.01804 0.01792 3,462.5 350 2200 0.01792 0.01781 3,229.1 340 2200 0.01781 0.01770 3,279.4 330 2200 0.01770 0.01759 3,320.4 325 2200 0.01759 0.01754 1,523.0 310 275 0.01754 0.01754 0.0 300 275 0.01754 0.01764 3,072.3 260 275 0.01707 0.01687 6,527.0 210 275 0.01687 0.01669 6,008.1 200 275 0.01667 0.01662 2,371.6	360 2200 0.01804 0.01792 3,462.5 0.0 350 2200 0.01792 0.01781 3,239.1 0.0 340 2200 0.01781 0.01770 3,279.4 0.0 330 2200 0.01770 0.01759 3,320.4 0.0 330 2200 0.01759 0.01754 1,523.0 0.0 310 275 0.01754 0.01754 0.0 0.0 300 275 0.01754 0.01764 0.0 0.0 300 275 0.01754 0.01764 0.0 0.0 300 275 0.01754 0.01767 11,680.4 0.0 260 275 0.01707 0.01687 6,527.0 0.0 210 275 0.01687 0.01669 6,008.1 0.0 200 275 0.01662 2,371.6 0.0	360 2200 0.01804 0.01792 3,462.5 0.0 418.1 350 2200 0.01792 0.01781 3,239.1 0.0 368.2 340 2200 0.01781 0.01770 3,279.4 0.0 393.1 330 2200 0.01770 0.01759 3,320.4 0.0 396.0 325 2200 0.01759 0.01754 1,523.0 0.0 182.6 310 275 0.01754 0.01754 0.0 0.0 0.0 325 2200 0.01754 0.01754 0.0 0.0 182.6 310 275 0.01754 0.01754 0.0 0.0 0.0 300 275 0.01754 0.01764 3,072.3 0.0 368.2 260 275 0.01707 0.1687 6,527.0 0.0 5 210 275 0.01687 0.01669 6,008.1 0.0 720.1 200 275 0.01667	360 2200 0.01804 0.01792 $3,462.5$ 0.0 418.1 37.3 350 2200 0.01792 0.01781 $3,239.1$ 0.0 388.2 34.6 340 2200 0.01781 0.01770 $3,279.4$ 0.0 393.1 35.1 330 2200 0.01770 0.01759 $3,320.4$ 0.0 396.0 35.5 325 2200 0.01759 0.01754 $1,523.0$ 0.0 182.6 16.3 310 275 0.01754 0.01754 0.0 0.0 0.0 0.0 300 275 0.01754 0.01764 $3,072.3$ 0.0 368.2 32.9 260 275 0.01754 0.01767 $11,680.4$ 0.0 $1,4^{en}0.0$ 124.9 235 275 0.01707 0.01687 $6,527.0$ 0.0 5 69.8 210 275 0.01687 0.01669 $6,008.1$ 0.0 720.1 64.3 200 275 0.01667 0.01662 $2,371.6$ 0.0 254.3 25.4	360 2200 0.01804 0.01792 3,482.5 0.0 418.1 37.3 1,914.2 350 2200 0.01792 0.01781 3,229.1 0.0 388.2 34.6 1,948.8 340 2200 0.01781 0.01770 3,279.4 0.0 393.1 35.1 1,983.9 330 2200 0.01770 0.01754 1,523.0 0.0 182.6 16.3 2,035.7 310 275 0.01754 0.523.0 0.0 182.6 16.3 2,035.7 310 275 0.01754 0.523.0 0.0 182.6 16.3 2,035.7 310 275 0.01754 0.072.3 0.0 368.2 32.9 2,068.5 260 275 0.01764 0.01707 11,680.4 0.0 1,4°0.0 124.9 2,193.5 215 275 0.01707 0.01687 6,527.0 0.0 4.3 69.8 2,263.3 210 275 0.01	360 2200 0.01804 0.01792 3,462.5 0.0 418.1 37.3 1,914.2 548,836.5 350 2200 0.01792 0.01781 3,229.1 0.0 388.2 34.6 1,948.8 552,110.2 340 2200 0.01781 0.01770 3,279.4 0.0 393.1 35.1 1,983.9 555,424.7 330 2200 0.01770 0.01754 1,523.0 0.0 182.6 16.3 2,035.7 560,319.9 310 275 0.01754 0.02754 0.0 0.0 182.6 16.3 2,035.7 569,796.9 300 275 0.01754 0.072.3 0.0 368.2 32.9 2,068.5 572,902.1 260 275 0.01764 0.01707 11,680.4 0.0 1,4°0.0 124.9 2,193.5 584,707.4 210 275 0.01687 6,527.0 0.0 .4.3 69.8 2,263.3 591,304.2 210 275 0.01667 0.01669 6,008.1 0.0 284.3 25.4 2,352.9

Table 2-16

AVG.S	SYS. 1	ENP.	PZR PRES	SPECIF	IC VOLUME	SHRINKAGE	BANT VOL 2	RUT VOL 2	8/A ADDED	TOTAL BUS		
	(F)	. 6	(psia)	(cu.f	t./lbm)		70 F (gel)	50 F (gal)	(lbm)	(ibm)	TOTAL SYS. MASS	
E1		5 9		Vi	• Vf					((15m)	(ppm boron)
	557	557	2200	1.00000	1.00000	0.0	0.0	0.0	0.0	0.0		
	557	510	, 2200	6.02157	0.02032	26,741.7	3,210,7	0.0	756.2	756.2		0.0
	510	490	2200	0.02032	0.01990	9,761.3	- Barrene -	0.0	276.0	1,032.2		272.2
	490	480	2200	0.01990	6.01970	4,794.5	575.6	0.0	135.6	1,167.8		364.0
	480	470	2200	0.01970	0.01951	4,645.9	557.8	0.0	131.4	1,299.1		407.8
	470	450	2200	0.01951	0.01933	4,485.6	538.5	0.0	126.8			449.3
	460	450	2290	0.01933	0.01916	4,313.8	517.9	0.0	122.0	1,426.0		488.8
	450	460	2200	0.01916	0.01900	4,130.5	0.0	495.1	44.2	1,548.0		526.0
	440	430	2200	0.01900	0.01885	3,936.1	0.0	471.8	42.1	1,634.2		536.6
	430	420	2200	0.01885	0.01870	3,999.2	0.0	479.3	42.8	1,677.0	522,682.2	546.6
	420	410	2200	0.01870	0.01855	4,063.9	0.0	487.1	43.5	1,720.5	526,724.2	556.6
	410	400	2200	0.01855	0.01842	3,575.6	0.0	428.6	38.2	1,758.7	530,831.5	566.7
	400	390	2200	0.01842	0.01828	3,907.5	0.0	468.4	41.8	1,800.5	534,445.3	575.3
1	390	380	2200	0.01828	0.01816	3, 397.2	0.0	407.2	36.3	1,836.8	538, 394.6	584.7
-	380	370	2200	0.01816	0.01804	3,442.4	0.0	412.6	36.8	1,873.7	541,828.2	592.7
3	370	360	2200	0.01804	0.01792	3,488.5	0.0	418.1	37.3	1,911.0	545,307.4	600.7
- 3	360	350	2200	0.01792	0.01781	3,239.1	0.0	388.2	34.6	1,945.6	548,833.3	608.8
3	550	340	2200	0.01781	0.01770	3,279.4	0.0	393.1	35.1		552,107.0	616.1
3	540	330	2200	0.01770	0.01759	3,320.4	0.0	398.0	35.5	1,980.7	555,421.5	623.5
3	\$30	325	2200	0.01759	0.01754	1,523.0	0.0	182.6	16.3	2,016.2	558,777.4	630.8
3	325	310	275	0.01754	0.01754	0.0	0.0	0.0		2,032.5	560, 316.7	634.2
3	\$10	300		0.01754		3,072.3	0.0	368.2	0.0	2,032.5	569,793.8	623.6
3	001	260		0.01744		11,680.4	0.0	1,400.0	32.9	2,065.3	572,898.9	630.3
2	660	235		0.01707		6,527.0	0.0	782.3	124.9	2,190.3	584,704.2	654.9
2	35	210		0.01687	0.01669	6,008.1	0.0	720.1	69.8	2,260.1	591,301.0	668.3
2	10	200		0.01669		2,371.6	0.0		64.3	2,324.3	597, 373.4	680.3
						-,	0.0	284.3	8.4	2,349.7	599,770.4	684.9

AVG.	AVG.STS. TEND	IEN.	PZR PRESS		CIFIC	SPECIFIC VOLUME	SHR I NKAGE	BANT	BANT VOL 2	RUT VOL 2	B/A ADDED	TOTAL B/A	TOTAL	TOTAL STS. MASS	FINAL COMC.
-	. 6	-1	(peis)		(cu.ft./lba) Vi Vi	(Ita) vi	MASS(Ibm)	70 F	70 f (gel)	50 F (gal)	(Ibm)			(P)	(ppm boron)
	557	552		1	1	1.00000	0.0		0.0	0.0	0.0	0.0		2 87 8 2	
	2557	510	-			0.02032	26,741.7		5,210.7	0.0	685.7	1 2800		ANA ANA D	a.v
	510	067		0.02032	-	0.01999	9,761.3		1,172.0	6.0	250.3	936.0		A 17 A	1.011
	889	180		-	Ξ.	0.01970	4,794.5		575.6	0.0	122.9	1.058.9		1 305 005	A ON
	180	470		0.01970		0.01951	4,615.9		\$57.8	0.0	1.911	1,178.0		505. 360.0	\$ 167
	170	(99)	220			0.01933	4,485.6		538.5	0.0	115.0	1,293.0	~	509.960.6	1.1.5
	100	151	220	0.0	2	0.01916	4,313.8		\$17.9	0.0	110.6	1,403.6	~	514, 365.0	1.112
	450	077	220	0.0	1916	0.01900	4,130.5		6.593	0.0	105.9	1,509.5	~	518,621.5	506.9
	110	426	220			0.01879	5,528.5		663.7	0.0	1.1.21	1,651.3	~	524,291.3	550.6
	3	27	220			0.01870	2.407.2		0.0	200.5	2.2	1,677.0	s	526.724.2	556.7
	97,	410	220		1	0.01855	4,063.9		0.0	1.184	43.5	1,720.5	~	530,831.6	566.7
	410	607	220		-	0.01842	3,575.6		0.0	428.6	3.8.2	1,750.1	~	\$.244,462.4	57.3
	8	390	220		~	0.01828	3,907.5		0.0	1.801	41.8	1,800.5	~	538, 394.6	564.7
	340	100	220			0.01816	3, 397.2		0.0	407.2	36.5	1,836.9	Ŷ	541.828.2	592.1
	8	370	220			0.01504	3,442.4		0.0	412.6	3.6.8	1,873.1	s	4.102.242	600.7
	370	360	220		1	0.01792	3,488.5		0.0	418.1	37.3	1,911.0	~	48.833.3	608.8
	3	350	220			0.01781	3,239.1		0.0	3.846.2	34.6	1,945.6	5	52.107.0	616.1
	330	340	2200	0 0.01781		0.01770	3,279.4		0.0	393.1	35.1	1,980.7	~	555,421.5	623.5
	2	330	220		-	0.01759	3, 320.4		0.0	396.0	35.5	2,016.2	s	\$0,777.4	630.8
	200	0	220		-	0.01754	1,523.0		0.0	182.0	16.3	2,032.5	~	560,316.7	634.2
	2	510	52	5 0.01754	- C.	0.01754	0.0		0.0	0.0	0.0	2,032.5	~	569, 793.8	623.6
	210	300	215		÷.	0.01744	3,072.5		0.0	368.2	32.9	2,065.4	2	572,898.9	630.3
	8	260	215		÷.,	0.01707	11,660.4		0.0	1,400.0	124.9	2, 190.3	8	5.404.2	634.9
	700	235	275		-	0.01687	6,527.0		0.0	782.3	69.8	2,260.1	S	1.105,198	668.3
	8	210	275	Ξ.	~	0.01669	6,008.1		0.0	720.1	64.3	2,324.4	S	\$17.373.4	6.00.3
	210	200	27.		•	0.01662	2,371.6		0.0	254.3	3.4	7.945.2	5	7.011.005	0 707

Table 2-18

									ID; RWT AT 20				
AVG.S			PZR PRESS	SPECIF	IC VOLUME	SHRINKSSE	BANT V	OL a	RWT VOL 2	B/A ADDED	TOTAL B/A	TOTAL SYS. MASS	FINAL CONC
Ťi	(F)	i.	(psie)	(cu.f	t./lbm) Vf	MASS(ibm;	70 F (gal)	50 F (gal)	(lbm)	(itm)	(lbm)	(ppm boron
	557	557	2200	1. 90000	1.00000	0.0		0.0	0.0	0.0	0.0	458,238.7	0.0
	557	510		9.02157	0.02032	26,741.7	3,	210.7	0.0	969.9	969.9		342.0
	510	494	2200	0.02032	0.01998	7,776.2		933.6	0.0	282.0	1,252.0	494,008.5	443.1
	494	480	2200	0.01998	0.01970	6,779.6		0.0	812.6	78.4	1,330.4	500,866.6	464.4
	480	470	2200	0.01970	0.01951	4,645.9		0.0	556.9	53.8	1,384.2	505,566.2	478.7
1.1	470	460	2200	0.01951	0.01933	4,485.6		0.0	537.6	51.9	1,636.1	510, 103.7	492.2
. •	460	450	2200	0.01933	0.01916	4,313.8		0.0	517.1	49.9	1,486.0		505.0
1	450	440	2200	0.01916	0.01900	4,130.5		6.0	495.1	47.8	1,533.8	518,645.7	517.0
	440	430	2200	0.01900	0.01885	3,936.1		0.0	471.0	45.5	1,579.3	522,627.3	528.3
	430	420	2200	0.01885	0.01870	3,999.2		0.0	479.3	46.3	1,625.6	526,672.8	539.6
	420	410	2200	0.01870	0.01855	4,063.9		0.0	487.1	47.0	1.672.6	530,783.7	550.9
	410	400	2200	0.01855	0.01842	3,575.6		0.0	428.6	41.4	1,714.0	534,400.6	560.7
	400	390	2200	0.01842	0.01828	3,907.5		0.0	468.4	45.2	1,759.2	538,353.3	571.3
3	390	380	2200	0.01828	0.01816	3,397.2		0.0	407.2	39.3	1,798.5	541,789.9	580.4
3	580	370	2200	0.01816	0.01804	3,442.4		0.0	412.6	39.8	1,838.4	545,272.1	589.4
. 3	\$70	360	2200	0.01804	0.01792	3,488.5		0.0	418.1	40.4	1,878.7	548,801.0	598.5
3	560	350	2200	0.01792	0.01781	3,239.1		0.0	368.2	37.5	1,916.2	552,077.6	606.8
3	\$50	340	2200	0.01781	0.01770	3,279.4		0.0	393.1	37.9	1,954.2	555, 394.9	615.2
3	540	330	2200	0.01770	0.01759	3,320.4		0.0	398.0	38.4	1,992.6	558,753.7	623.5
3	530	325	2206	0.01759	0.01754	1,523.0		0.0	182.6	17.6	2,010.2	560, 294, 4	627.3
3	325	310	275	0.01754	0.01754	0.0		0.0	0.0	0.0	2,010.2	569,771.5	616.8
3	510	300	275	0.01754	0.01744	3,072.3		0.0	368.2	35.6	2,045.7	572,879.3	624.3
3	000	260	275	0.01744	0.01707	11,680.4		0.0	1,400.0	135.2	2,180.9	584,694.8	652.1
2	260	235	275	0.01707	0.01687	6,527.0		0.0	782.3	75.5	2,256.4	591,297.4	667.2
2	235	210	275	0.01687	0.01669	6,008.1		0.0	720.1	69.5	2,326.0	597,375.0	680.7
2	210	200	275	0.01669	0.01362	2,379.6		0.0	284.3	27.4	2,353.4	599,774.1	686.0

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NG.	AVG. SYS. I	IEW.	PZR PRESS		SPECIFIC VOLUME	SHRIMKAGE	BANT	BANT VOL 2	RUT VOL 2	B/A ADDED	TOTAL B/A 1	TOTAL	TOTAL SYS. MASS	FINAL COMC.
-	÷.		(beia)	(cu fi	(cu ft./lbm) vi · vi	MASS(Ibm)	1 92	70 F (gal)	()eff; 3 05	(II)			(1)	(ppm boron)
1	557	552	2200	1.00000	1.00000	0.0		0.0	0.0	0.0	0.0		1.987	0.0
	257	510	2200	0.02157	0.02032	26,741.7		3,210.7	0.0	898.3	898.3	1	485,878.6	323.2
	510	494	2200	0.02032		9,761.3		1,172.0	0.0	327.9	1,226.2	1	6.189,861	632.3
	790	181	2200	0.01990		2,385.2		286.4	0.0	80.1	1,306.3		1.557,867	458.2
	182	470	2200	0.01960	-	7,055.2		0.0	845.6	81.6	1,366.0		505,570.0	0.064
	470	100	2200	0.01951		4,485.6		0.0	537.6	51.9	1,439.9		510, 107.5	\$.593.5
	100	450	2700	0.91933	-	4,313.8		0.0	517.1	6.94	1,489.8		5.174,412	506.3
	450	110	2200	0.01915		4,130.5		0.0	1.263	47.8	1,537.6		518,649.5	518.3
	110	130	2200	0.01900	-	1.986.1		0.0	8.11.8	45.5	1,563.1		522,631.1	5.958
	430	120	2200	0.01885		3,999.2		0.0	19.3	46.3	1.020.1	Ĩ	526,676.6	549.9
	120	410	2200	0.01870	-	4,043.9		0.0	4.87.1	0.74	1,716.4		530,787.5	552.2
	410	8	12200	0.01855		3,575.6		0.0	428.6	41.4	1,71.6		534,404.4	562.0
	8,	390	2200	0.01842		3,907.5		0.0	1.801	45.2	1,763.0	Ĩ	536,357.1	572.6
	390	200	2200	0.01828		3, 397.2		0.0	407.2	39.3	1,802.3		541,793.7	581.6
	200	370	2200	0.01816		3,442.4		0.0	412.6	39.8	1,842.2		9.275.248	590.7
	370	No	2200	0.01804	~	3,488.5		0.0	418.1	101	1,862.5		548,804.8	2.992
	200	350	2200	0.01792	~	3,239.1		0.0	388.2	37.5	1,920.0		\$52,001.4	603.0
	350	34.0	2200	0.01781	~	3,279.4		0.0	393.1	37.9	1,958.0		555, 398.8	616.3
	340	333	2200	0.01770	~	3, 320.4		0.0	396.0	3.8.4	1,996.4	*	558, 757.6	624.7
	330	325	2200	0.01759	~	1,523.0		0.0	162.6	17.6	2,014.0	*	5.96.09	628.4
	325	310	275	0.01754	~	0.0		0.0	0.0	0.0	2,014.0	~	569, 775.3	618.0
	310	300	275	0.01754	~	3,072.3		0.0	366.2	35.6	2,049.6	s	572,063.1	625.5
	300	260	275	0.01744	0.01707	11,660.4		0.0	1,400.0	135.2	2,184.7	~	64,698.6	653.3
	260	235	52	0.01707	~	6,527.0		0.0	782.3	75.5	2,260.3	°.	5.105.192	668.3
	235	210	5.2	0.01687	-	6,008.1		0.0	720.1	69.5	2,329.6	Ŷ	597,378.8	6.1.9
	210	200	213	0.01669	0.01662	2,371.6		0.0	284.3	27.6	2,357.2	\$	6.111.998	

AVG.SYS.	IGW.	PLR PRESS	SPE	CIFIC VOLUME	SHRINKAGE	BANT VOL 2	RUT VOL 2	B/A ADDED	TOTAL B/A	TOTAL CVC MACC	MACC	CINAL COMP
(1)	=	(paia)	(cu.f	(ce.ft./ltm) vi vi	MASS((bm)	70 F (gal)	50 F (gel)	(1)		(1)	((1))	(ppm borron)
155	557	0000	1.00000	1.00900	0.0	0.0	0.0	0.0	0.0			
155	510	0022 4	0.02	0.02032	26,741.7	3.21	0 0	1 108	1 7 4	Set.	1.003,004	0.0
510	067		0.02032	0.01990	9,761.3			301.0	1 120 0	201	Y ULA YOT	1001
867	180		0.01	0.01970	4,794.5			148.3	1 277 1	003	7 218 003	1.011
180	173		0.01970	0.01957	3,242.6			100.3	1.377.5	20x	1 154 1	1.00
513	100			0.01933	5,888.8	0.0	705.8	68.1	1.605.7	510	510.113.3	5 567
100	450		0.01933		4,313.8	0.0	517.1	6.94	1,495.6	514	514.477.0	5.002
450	011		1.1	~	4,130.5	0.0	1.293	8.72	1,543.4	518	518.655.3	1 025
077	430				3,936.1	0.0	8.172	45.5	1,568.9	522	522,636.9	531.5
2	027	2200		-	3,999.2	0.0	1.9.3	46.3	1,635.2	526	526.002.4	542.5
120	410				4,063.9	0.0	487.1	0.74	1,662.2	530	530.795.3	1.45
110	007		0.01855	π.	3,575.6	0.0	428.6	41.4	1,725.6	534	534.410.2	0 195
89	390		0.01842	~	3,907.5	0.0	1.661	45.2	1,768.8	536	536.362.9	574.4
2	200		0.01828		3, 397.2	0.0	407.2	39.3	1,806.1	541	541,799.5	543.5
	270		0.01816		3,442.4	0.0	412.6	39.8	1,648.0	545	545,281.7	592.5
2/1	38				3,488.5	0.0	418.1	1.01	1,866.3	548	548,810.6	\$41.6
3	965			~	3,239.1	0.0	368.2	37.5	1,925.8	552	552.067.2	6.009
945	340		0.01/81	-	3,279.4	0.0	393.1	37.9	1,963.8	555	555,404.6	618.2
			0.01170	-	3, 320.4	0.0	396.0	3.8.4	2,002.2	558	\$58,763.4	626.5
NCC .	2	~	0.01759	~	1,523.0	0.0	162.6	17.6	2,019.8	560	560, 304.0	630.3
9	510		0.01754	~	0.0	0.0	0.0	0.0	2,019.6	560	1.181.9	619.9
010	nor i		0.01/54	~	3,072.3	0.0	1.80.2	35.6	2,055.4	572	\$72,666.9	627.3
200	200	27	0.01744	0.01707	11,680.4	0.0	1,400.0	135.2	2,190.5	Sek.	Sek, 704.4	655.0
100	6	52	0.01707	0.01667	6,527.0	0.0	782.3	75.5	2,266.1	165	591, 307.0	670.0
6	210	212	0.01687	0.01069	6,008.1	0.0	720.1	69.5	2,335.6	265	597, 384.6	663.5
017	200	215	0.01669	0.01662	2,371.6		204.3	27.4	2,363.0	599	1.281.992	666.6

SLANT COOLDOWN FROM 557 F TO 200 F; BANI AT 2.75 w1X BORIC ACID; RUI AT 2000 ppm 5050M ST. LUCIE UNIT 2

357 357 250 100000 100000 100000 100000 2001 <	(£)	AVG. STS. IEW.	(paia)		SPECIFIC VOLUME (cu.ft./lbm) vi ui	SHRIMKAGE NASS(Ibm)	ZO F (gel)		50 F	SO F (gal)	F/A ADDED (11m)	TOTAL B/A TO:AL SYS. MASS (itam) (itam)	10:41	SYS. MASS ((thm)	(ppm borron)	
Zood Lummod Lummod <thlumod< th=""> <thlumod< th=""> Lumod</thlumod<></thlumod<>	1												*****	*******		
2000 0.428757 0.400577 0.400577 0.400577 0.400577 0.400577 0.400577 0.400577 0.400577 0.400577 0.4005777 0.4005777 0.4005777 0.4005777 0.4005777 0.4005777 0.4005777 0.4005777 0.4005777 0.400777 0.400777 0.4007777 0.4007777 0.4007777 0.4007777 0.4007777 0.4007777 0.4007777 0.4007777 0.40077777 0.4007	100	100	0027	1.00000	1.00000	0.0		0.0		0.0	0.0	0.0		458,238.7	0.0	1
2000 0.040033 0.010900 0.761.3 1,172.3 0.0 7/6.0 1,032.2 469,713.4 2200 0.010901 0.01951 4,645.9 557.3 0.0 133.6 1,047.8 500,703.9 2200 0.01091 0.01951 4,645.9 557.3 0.0 133.6 1,067.1 500,703.9 2200 0.01091 0.01901 5,065.3 500 455.9 1,500.1 510,531.5 510,531.5 2200 0.01091 0.01903 5,065.3 0.0 465.1 47.3 1,530.3 510,542.6 510,543.6 510,542.6 2200 0.01080 0.01803 5,965.3 0.0 465.4 45.5 1,550.4 520,544.6 520,544.6 520,546.6 520,546.6 520,546.6 520,546.6 520,546.6 520,546.6 520,546.6 520,546.6 520,546.6 520,546.6 520,546.6 520,546.6 520,546.6 520,546.6 520,546.6 520,546.6 520,546.6 520,566.6 520,566.6 520,566.6 520,	222	510	2200	0.02157	0.02032	26,741.7	~	210.7		0.0	7.2	756.2		485, 736.5	212.2	-
Z000 0.01090 0.31970 4,7N4.5 575.6 0.0 135.6 1,167.6 500,703.9 Z000 0.01091 0.01091 4,013.5 500.9 0.0 135.6 1,167.6 500,701.9 Z000 0.01991 0.01931 4,013.5 500.9 0.0 145.1 510,533.6 Z000 0.01991 0.01906 4,190.5 0.0 465.1 4.5.3 1,500.1 510,642.6 Z000 0.01960 0.01905 5,905.2 0.0 4.67.1 4.5.3 1,650.7 530,640.1 Z000 0.01963 0.01863 5,905.2 0.0 4.67.1 4.5.3 1,660.7 530,740.1 Z000 0.01963 0.01863 5,907.2 0.0 4.67.1 1,701.1 534,76.6 Z000 0.01863 0.01863 5,907.2 0.0 4.67.1 1,701.1 534,76.7 Z000 0.01863 0.01863 5,907.2 0.0 4.66.1 1,700.1 536,760.6 <td< td=""><td>510</td><td>667</td><td>2200</td><td>0.02032</td><td>0.01990</td><td>9,761.3</td><td>-</td><td>172.0</td><td></td><td>0.0</td><td>176.0</td><td>1,032.2</td><td></td><td>495, 173.8</td><td>364.0</td><td>-</td></td<>	510	667	2200	0.02032	0.01990	9,761.3	-	172.0		0.0	176.0	1,032.2		495, 173.8	364.0	-
Z200 0.01970 0.01951 4,645.9 557.8 0.0 131.4 1,290.1 500,401.2 Z200 0.01991 0.01991 4,913.5 580.9 0.0 136.9 1,458.1 510,533.6 Z200 0.01991 0.01906 3,855.3 0.0 457.1 1,453.1 510,543.6 Z200 0.01990 0.01960 3,855.3 0.0 457.1 47.3 1,526.4 510,533.6 Z200 0.01960 0.01860 3,956.1 0.0 477.3 4.53 1,570.4 526,564.9 Z200 0.01960 0.01860 3,967.5 0.0 477.3 4.53 1,670.1 547,464.4 Z200 0.01960 4,043.9 0.0 477.3 4.63 1,690.7 500,580.6 Z200 0.01960 3,967.5 0.0 428.6 4.14 1,711.1 54,496.7 Z200 0.01861 3,967.5 0.0 466.4 457.2 1,660.7 546.690.9 Z200	8	181	2200	0.01990	0/616-0	4,794.5		575.6		0.0	135.6	1,167.8		\$00, 703.9	407.8	
Z200 0.01951 0.01951 0.913.5 560.9 0.0 158.0 1.458.1 510,533.6 Z200 0.01991 0.01906 3,855.4 0.0 455.1 47.3 1,503.8 510,64.4 Z200 0.01906 0.01960 4,190.5 0.0 455.1 47.3 1,506.4 532,64.4 Z200 0.01960 0.01850 3,956.1 0.0 477.3 46.3 1,506.4 532,64.4 Z200 0.01850 3,967.5 0.0 477.3 46.3 1,506.7 530,600.8 Z200 0.01850 3,967.5 0.0 477.3 47.3 1,602.7 530,760.8 Z200 0.01861 3,975.6 0.0 467.1 47.1 1,711.1 544,967.7 Z200 0.01861 3,975.6 0.0 466.4 45.2 1,602.7 50,530,60.9 Z200 0.01861 3,975.6 467.1 47.1 1,711.1 544,96.9 Z200 0.01861 3,977.2	199	674	2200	0.01970	0.01951	4,645.9		557.8		0.0	131.4	1,200.1		505,481.2	1 2.934	
Z200 0.01931 0.01916 3,465.0 0.0 455.1 1,461.1 514,464.4 Z200 0.019916 0.01900 4,130.5 0.0 455.1 4.5.3 1,530.6 519,462.6 Z200 0.01900 0.01900 3,985.1 0.0 457.1 4.5.3 1,530.6 519,462.6 Z200 0.01900 0.01905 3,995.1 0.0 4.71.1 4.5.3 1,530.6 519,462.6 Z200 0.01853 0.01853 5,063.3 3,955.6 0.0 4.87.1 4.6.3 1,622.7 52,654.4 Z200 0.01853 0.01853 5,063.3 5,063.3 56,069.3 56,069.3 Z200 0.01853 0.01864 3,487.5 0.0 4.87.1 47.0 1,711.1 59,496.3 Z200 0.01853 0.01864 3,486.5 0.0 4.66.4 4.1.4 1,711.1 59,496.2 Z200 0.01861 3,497.5 0.0 4.66.4 45.2 4.6.3 54,676.4	027	459	2200	0.01951	0.01931	4,913.5		580.9		0.0	136.9	1,438.1		510,533.6	492.5	
Z200 0.01916 0.01906 4,130.5 0.0 49.1 4.7.8 1,530.8 519,442.8 Z200 0.01906 0.01805 3,936.1 0.0 471.1 45.5 1,576.4 522,624.4 Z200 0.01805 0.01805 3,996.2 0.0 477.1 47.0 1,622.7 52,654.4 Z200 0.01805 0.01865 5,907.5 0.0 47.1 47.0 1,711.1 53,756.6 Z200 0.01865 0.01864 3,907.5 0.0 407.1 47.0 1,711.1 53,756.6 Z200 0.01864 0.01864 5,907.5 0.0 407.2 39.3 54,776.3 53,950.4 Z200 0.01864 0.01864 5,442.4 0.0 4,164.1 1,711.1 53,496.0 Z200 0.01864 0.01864 5,442.4 0.0 4,047.2 54,776.1 Z200 0.01864 0.01771 5,229.1 54,786.1 55,764.4 55,764.4 Z200 0.0177	426	450	2200	0.01931	0.01916	3,885.8		0.0		\$405.8	45.0	1,483.1		514,464.4	504.0	
Z200 0.01960 0.01605 3,956.1 0.0 471.6 5.5 1,576.4 522,624.4 Z200 0.01860 0.01870 3,999.2 0.0 467.1 47.0 1,660.7 536,600.8 Z200 0.01870 0.01865 4,083.9 0.0 467.1 47.0 1,660.7 536,500.8 Z200 0.01855 0.01842 3,575.6 0.0 467.1 47.2 1,711.1 54,367.7 Z200 0.01852 0.01842 3,575.6 0.0 467.1 47.2 34,751 536,500.8 Z200 0.01854 0.01864 0.01826 3,997.2 0.0 467.2 1,711.1 54,367.7 Z200 0.01864 0.01864 0.0 40.2 376.6 541,766.9 544,766.9 Z200 0.01864 3,442.4 0.0 40.2 1,013.3 544,766.9 544,766.9 Z200 0.01761 3,239.1 0.0 406.2 376.6 544,766.9 544,766.9 546	450	077	2200	0.01916	0.01900	4,130.5		0.0		1.241	67.8	1,530.8		518,642.8	516.0	
Z200 0.01607 0.01670 3,999.2 0.0 47.0 1,62.7 526,660.6 Z200 0.01607 0.01655 4,063.9 0.0 467.1 47.0 1,60.7 530,780.6 Z200 0.01655 0.01655 4,063.9 0.0 467.1 47.0 1,60.7 530,780.6 Z200 0.01655 0.01662 3,575.6 0.0 467.1 47.0 1,711.1 54,967.7 Z200 0.01664 0.01664 5,575.6 0.0 467.1 47.0 1,711.1 54,967.7 Z200 0.01664 0.0164 3,497.2 0.0 416.1 40.7 1,711.1 54,766.9 Z200 0.01664 0.01791 3,442.4 0.0 416.1 40.4 1,615.4 546,767.9 Z200 0.01792 0.01791 3,239.1 0.0 407.2 393.5 546,766.9 Z200 0.01792 0.01791 3,442.4 0.0 416.1 40.4 1,615.4 546,76.9	140	430	2200	0.01900	0.01885	3,936.1		0.0		\$71.8	45.5	1,576.4		522,624.4	527.4	
Z200 0.016/70 0.0165/5 4,064.9 0.0 467.1 47.0 1,660.7 530,780.8 Z200 0.0166/2 3,575.6 0.0 428.6 41.4 1,711.1 514,307.7 Z200 0.0166/2 3,575.6 0.0 428.6 41.4 1,711.1 514,307.7 Z200 0.0166/2 3,575.6 0.0 468.4 5.2 1,764.3 530,350.4 Z200 0.0166/6 0.0160/6 3,907.2 0.0 407.2 39.3 544,766.9 541,766.9 542,769.7 542,769.7 542,769.7 542,769.7 542,769.7 542,769.7 542,769.7 542,769.7 542,769.7 542,769.7 542,779.7	5	120	2200	0.01885	0.01870	3,999.2		0.0		479.3	46.3	1,622.7		526,669.8	536.7	
Z200 0.01655 0.01642 3,575.6 0.0 428.6 41.4 1,711.1 584,397.7 Z200 0.01642 0.01640 3,907.5 0.0 466.4 45.2 1,756.3 530,350.4 Z200 0.01646 0.01616 3,397.2 0.0 467.2 39.3 1,795.6 541,786.9 Z200 0.01616 0.01616 3,397.2 0.0 407.2 39.3 1,913.3 530,350.4 Z200 0.01782 0.01782 3,466.5 6.0 418.1 40.4 1,675.4 540,796.3 530,350.4 Z200 0.01782 0.01782 3,290.1 0.0 408.2 37.5 1,913.3 552,074.7 Z200 0.01781 0.01792 3,2794.4 0.0 366.2 37.6 540,796.3 552,074.7 Z200 0.01762 0.01754 1,273.4 0.0 366.2 552,074.7 552,074.7 Z200 0.01754 1,270.4 0.0 366.2 356.6 56	927	410	2200	0.01870	0.01855	4,063.9		0.0		1.184	47.0	1,669.7		530,780.8	550.0	
Z200 0.0154/2 0.0184/2 3,907.5 0.0 466.4 45.2 1,756.3 539,350.4 Z200 0.01816 3,907.2 0.0 407.2 39.3 1,776.3 539,350.4 Z200 0.01816 0.01816 3,997.2 0.0 407.2 39.3 1,815.4 545,200.2 Z200 0.01816 0.01811 3,239.1 0.0 416.1 40.4 1,815.4 545,200.2 Z200 0.01792 3,486.5 0.0 346.2 1,913.3 546,706.1 545,200.2 Z200 0.01792 3,239.1 0.0 393.1 317.9 1,913.3 546,706.1 Z200 0.01774 3,239.1 0.0 393.1 317.9 1,913.3 546,706.1 Z200 0.01774 3,239.1 0.0 393.1 37.9 1,913.3 546,706.1 Z200 0.01774 3,237.4 0.0 396.0 386.2 356,701.7 546,701.6 546,701.6 546,701.7 546,701.6	410	007	2200	0.01855	0.01842	3,575.6		0.0		428.6	4.1.4	1,117,1		534,397.7	\$59.8	
Z200 0.01626 3,997.2 0.0 407.2 39.3 1,795.6 541,766.9 Z200 0.01616 0.01604 3,442.4 0.0 412.6 39.6 1,615.4 545,266.2 Z200 0.01666 0.01792 3,442.4 0.0 416.1 40.4 1,615.6 546,766.1 Z200 0.01792 0.01792 3,442.4 0.0 393.1 37.5 1,913.3 552,074.7 Z200 0.01781 0.01792 3,279.4 0.0 393.1 37.5 1,913.3 552,074.7 Z200 0.01754 0.01754 0.01754 0.01754 575,95.3 556,750.8 Z200 0.01754 0.01754 0.01754 0.0 393.1 37.5 1,913.3 550,750.8 Z200 0.01754 0.01754 1,523.0 0.0 182.6 17.6 2,007.3 560,790.8 Z200 0.01754 1,523.0 0.0 182.6 17.6 2,007.3 560,700.8 Z200 0.01754 1,025.1 1,260.2 356,700.3 560,701.3 560,701.5	8	390	2200	0.01542	0.01828	3,907.5		0.0		1.801	45.2	1,756.3		530,350.4	570.4	
Z200 0.01816 0.01804 3,442.4 0.0 412.6 39.8 1,615.4 545,200.2 Z200 0.01792 0.01792 3,486.5 0.0 416.1 40.4 1,615.6 546,796.1 Z200 0.01792 0.01792 3,486.5 0.0 303.1 37.5 1,913.3 552,074.7 Z200 0.01792 0.01770 5,279.4 0.0 303.1 37.5 1,913.3 552,074.7 Z200 0.01784 0.01770 3,279.4 0.0 393.1 37.5 1,913.3 550,750.8 Z200 0.01754 0.01754 1,523.0 0.0 393.1 37.5 560,750.8 Z200 0.01754 0.01754 1,523.0 0.0 366.0 560,750.8 Z200 0.01754 0.01754 1,523.0 0.0 366.2 560,70.3 560,750.8 Z17 2.01754 0.01764 1,523.0 0.0 2,007.3 560,70.3 560,70.6 Z17 0.01774 <td>38</td> <td>380</td> <td>2200</td> <td>0.01828</td> <td>0.01816</td> <td>3,397.2</td> <td></td> <td>0.0</td> <td></td> <td>2.704</td> <td>39.3</td> <td>1,795.6</td> <td></td> <td>541,786.9</td> <td>579.4</td> <td></td>	38	380	2200	0.01828	0.01816	3,397.2		0.0		2.704	39.3	1,795.6		541,786.9	579.4	
Z200 0.01664 0.01792 3,486.5 0.0 416.1 40.4 1,675.6 546,796.1 Z200 0.01792 0.01770 3,239.1 0.0 393.1 37.5 1,913.3 532,074.7 Z200 0.01781 3,279.4 0.0 393.1 37.9 1,913.3 532,074.7 Z200 0.01781 0.01770 3,279.4 0.0 393.1 37.9 1,913.3 532,074.7 Z200 0.01781 0.01759 3,320.4 0.0 393.1 37.9 1,913.3 532,792.0 Z200 0.01784 0.01759 3,320.4 0.0 393.1 37.9 1,913.3 532,792.0 Z200 0.01784 1,523.0 0.0 162.6 17.6 2,007.3 540,290.6 Z200 0.01764 1,523.0 0.0 0.0 2,007.3 540,291.5 Z75 0.01764 0.1707 11,626.4 17.6 2,007.3 540,291.5 Z75 0.01764 0.1707 11,626.4 0.0 0.0 2,007.3 540,291.5 Z75	200	370	2200	0.01816	0.01804	3,442.4		0.0		412.6	39.8	1,835.4		545,269.2	500.5	_
Z200 0.01792 0.01781 3,239.1 0.0 306.2 37.5 1,913.3 552,074.7 Z200 0.01781 0.01770 3,279.4 0.0 393.1 37.9 1,913.3 555,392.0 Z200 6.01770 3,370.4 0.0 393.1 37.9 1,913.3 555,392.0 Z200 6.01770 3,370.4 0.0 393.1 37.9 1,913.3 555,392.0 Z200 6.01779 0.01759 3,320.4 0.0 393.1 36.7 556,750.8 Z200 6.01774 1,523.0 0.0 0.0 182.6 17.6 2,007.3 560,790.5 Z200 6.01774 0.1754 0.0 0.0 0.0 2,007.3 560,790.5 Z75 0.01754 0.01764 1,523.0 0.0 0.0 2,007.3 560,790.5 Z75 0.01764 0.07 1,020.2 176.0 2,007.3 560,790.5 Z75 0.01764 1,072.3 0.0 0.0 2,007.3 560,790.5 Z75 0.01744 0.1707 11,	370	Soo	2200	0.01804	0.01792	3,488.5		0.0		418.1	40.4	1,875.8		548,798.1	597.6	
Z200 0.01781 0.01770 3,279.4 0.0 393.1 37.9 1,951.2 555,392.0 Z200 6.01779 0.01759 3,320.4 0.0 396.0 36.17 556,750.6 Z200 0.01759 1,523.0 0.0 162.6 17.6 2,007.3 560,790.5 Z200 0.01754 0.01754 0.0 0.0 182.6 17.6 2,007.3 560,790.5 Z75 0.01754 0.01754 0.0 0.0 182.6 17.6 2,007.3 560,790.5 Z75 0.01754 0.01764 3,072.3 0.0 0.0 2,007.3 560,790.5 Z75 0.01754 0.01707 11,660.4 0.0 182.6 2,007.3 560,790.5 Z75 0.01707 11,660.4 0.0 760.2 35.6 2,007.3 560,780.5 Z75 0.01707 11,660.4 0.0 76.2 35.6 2,042.8 560,780.5 Z75 0.01667 6,527.0 0.0 782.3 75.5 2,942.8 591,594.5 Z75 0.01	3	350	2200	0.01792	0.01781	3,239.1		0.0		3.86.2	37.5	1,913.3		1. 10. 255	602.9	
2200 6.01770 0.01759 3,120.4 0.0 596.0 36.4 1,969.6 556,750.6 2200 0.01754 1,523.0 0.0 162.6 17.6 2,007.3 560,291.5 275 0.01754 1,523.0 0.0 0.0 2,007.3 560,750.6 560,750.6 275 0.01754 1,523.0 0.0 0.0 9.0 0.0 2,007.3 560,750.5 275 0.01754 0.01707 11,680.4 0.0 9.0 9.0 2,007.3 560,750.5 275 0.01764 0.1707 11,680.4 0.0 762.3 75.5 2,178.0 560,790.5 275 0.01667 0.01661 1,660.0 1,600.0 135.2 2,178.0 560,794.5 275 0.01667 6,008.1 0.0 270.1 69.5 2,233.5 591,372.1 275 0.01666 6,008.1 0.0 760.1 69.5 2,323.0 591,372.1 275 0.01666 0.016661 6,008.1 0.0 760.1 27.4 2,350.5 59	350	340	2200	0.01781	0.01770	3,279.4		0.0		393.1	37.9	1,951.2		555,392.0	614.2	
2200 0.01759 0.01754 1,523.0 0.0 182.6 17.6 2,007.3 560,291.5 275 0.01754 0.01754 0.0 0.0 0.0 2,007.3 560,780.5 275 0.01754 0.01754 0.0 0.0 0.0 2,007.3 560,780.5 275 0.01754 0.01707 11,680.4 0.0 1,400.0 135.2 2,178.0 564,691.9 275 0.01707 0.11687 6,527.0 0.0 782.3 75.5 2,042.8 591,294.5 275 0.01687 6,527.0 0.0 782.3 75.5 2,178.0 591,294.5 275 0.01669 0.01667 6,006.1 0.0 782.3 27.4 2,350.5 591,372.1 275 0.01669 0.016667 6,006.1 0.0 264.3 27.4 2,350.5 591,372.1 275 0.01669 0.016662 5,006.1 0.0 264.3 27.4 2,350.5 591,372.1 275 0.01669 0.016662 2,371.6 0.0 264.3 27.4 <td< td=""><td>340</td><td>330</td><td>2200</td><td>6.01770</td><td>0.01759</td><td>3, 320.4</td><td></td><td>0.0</td><td></td><td>396.0</td><td>38.4</td><td>1,989.6</td><td></td><td>556,750.8</td><td>622.6</td><td>_</td></td<>	340	330	2200	6.01770	0.01759	3, 320.4		0.0		396.0	38.4	1,989.6		556,750.8	622.6	_
275 0.01754 0.0 0.0 0.0 2,007.3 569,766.5 275 0.01754 0.01744 3,072.3 0.0 3,66 572,676.4 275 0.01754 0.01707 11,666.4 0.0 1,600.0 135.2 2,178.0 564,691.9 275 0.01707 0.01687 6,527.0 0.0 1,600.0 135.2 2,178.0 564,691.9 275 0.01707 0.01687 6,527.0 0.0 782.3 75.5 2,253.5 591,294.5 275 0.01687 0.01660 6,006.1 0.0 264.3 27.4 2,350.5 591,294.5 275 0.016687 0.016621 0.0 264.3 27.4 2,350.5 591,294.5 275 0.016687 0.016621 0.0 264.3 27.4 2,350.5 591,294.5 275 0.01669 0.016621 2,642.6 5,97,372.1 591,290.5 591,712.2 275 0.01669 0.016622 2,371.6 0.0 264.3 2,74 2,350.5 599,771.2 6106.0 0	330	575	2200	0.01759	0.01754	1,523.0		0.0		182.6	17.6	2,007.3		5.105.002	626.3 1	
275 0.01754 0.01744 3,072.3 0.0 368.2 35.6 2,042.8 572,676.4 275 0.01744 0.01707 11,666.4 0.0 1,4600.0 135.2 2,178.0 564,691.9 275 0.01707 0.10687 6,527.0 0.0 782.3 75.5 2,733.5 591,294.5 275 0.01667 6,006.1 0.0 782.3 75.5 2,733.0 591,294.5 275 0.01667 6,006.1 0.0 782.3 75.5 2,333.0 591,294.5 275 0.01667 6,006.1 0.0 782.3 75.5 2,353.0 597,372.1 275 0.01669 6,006.1 0.0 284.3 27.4 2,350.5 599,771.2 6106.0 gallocas 2,371.6 0.0 284.3 27.4 2,350.5 599,771.2	323	310	275	01754	0.01754	0.0		0.0		0.0	0.0	2,007.3		569,768.5	615.9	
275 0.01744 0.01707 11,686.4 0.0 1,400.0 135.2 2,178.0 584,691.9 275 0.01707 0.01687 6,527.0 0.0 782.3 75.5 2,253.5 591,294.5 1 275 0.01667 6,527.0 0.0 782.3 75.5 2,253.5 591,294.5 1 275 0.01667 6,008.1 0.0 782.3 75.5 2,323.0 591,372.1 1 275 0.01669 6,008.1 0.0 720.1 69.5 2,323.0 597,372.1 1 275 0.01669 0.01662 2,371.6 0.0 264.3 27.4 2,350.5 599,771.2 1 276.0 galtoma 27.4 2,350.5 599,771.2	310	300	215	0.01754	97110.0	3,072.3		0.0		368.2	35.6	2,042.8		\$72,876.4	623.4	
275 0.01707 0.01667 6,527.0 0.0 782.3 75.5 2,253.5 591,294.5 1 275 0.01667 0.01660 6,006.1 0.0 720.1 69.5 2,323.0 591,372.1 1 275 0.01669 0.01660 6,006.1 0.0 720.1 69.5 2,323.0 597,372.1 1 275 0.01669 0.01662 2,371.6 0.0 264.3 27.4 2,350.5 599,771.2 6106.0 gallora 6106.0 gallora 0.0 264.3 27.4 2,350.5 599,771.2	20	260	275	0.01744	0.01707	11,680.4		0.0	-	400.0	135.2	2,178.0		9.198,482	651.3 1	
0 275 0.01667 0.01669 6,006.1 0.0 720.1 69.5 2,325.0 597,372.1 275 0.01669 0.01662 2,371.6 0.0 264.3 27.4 2,550.5 599,771.2 6106.0 gaitors	200	235	275	0.01707	0.01687	6,527.0		0.0		782.3	7.5	2,253.5		591,294.5	000.3	
0 275 0.01669 0.01662 2,371.6 0.0 264.3 27.4 2,350.5 599,771.2 6106.0 gailons	235	210	275	0.01687	0.01669	6,008.1		0.0		720.1	69.5	2,323.0		1.272.192	679.9	
6106.0 gal	210	200	275	0.01669	0.01662	2,371.6		0.0		284.3	37.4	2,350.5		2.111.998	685.2	
	3	IT VOLUME	6106.0	gallons												

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ST. LUCLE UNIT 2

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	AVG.SYS. 16		PZR PRESS	345	CIFIC VOLUNE	SHR I NKAGE	BAKT VOL 2	BUT VOL 2	8/A ADDED	TAN BIA TOTAL SYS. MASS	TOTAL SYS.	NASS	FINAL CONC.
-	(1)	÷	(pais)	(cu.ft	(cu.ft./ibm) Vi · Vf	MASS(ILm)	70 F (gal)		(([])	(Ita)	(ithm)	2	(ppm boron)
		****		2 2 2 2 2 2 2 2 2 2 2	*****				小子子 医法耳氏 医法治学				
	255	557	j.	1.00000	1.00000	0.0			0.0	0.0	458.	1.58,238.7	0.0
	155	510	2200	0.02157	-	26,741.7	~		1.580	1.289	485.	666.0	246.8
	510	667		0.02032	0.01990	9,761.5			250.3	936.0	195.	6.77.6	330.1
	887	180		0.01990	_	4,744.5			122.9	1,058.9	500.	595.1	369.8
	190	470	2200	6.01979	0.01951	4,045.9			119.1	1, 178.0	505.	340.0	407.5
	170	160	2200	0.01951	0.01933	4,485.6	538.5		115.0	1, 293.0	509.	9.094	413.3
	100	450		0.01933	0.01916	4,313.8			110.6	1,403.6	514.	385.0	1.114
	450	436	2200	0.01916	0.01894	5.697.5			1.6.1	1.949.1	520.	228.6	520.8
	134	430		0.01894	~	2,369.1			27.4	1.57.1	522,	625.1	527.6
	130	420		0.01875	0.01870	3,999.2		į	46.3	1,623.4	526.	6.016	536.9
	120	410	2200	0.01870		4,063.9	0.0	487.1	47.0	1,670.4	530.	781.5	\$50.2
	410	100	2200	0.01855		3,575.6	0.0	128.6	41.4	1,711.8	534.	396.4	560.0
	8	390	2200	0.01842		3,907.5		1.801	45.2	1,757.0	538.	351.1	570.6
	38	260	2200	0.01828		3, 397.2	0.0	437.2	39.3	1,746.3	541,	1.181	579.7
10	260	370	2290	0.01816		3,442.4	0.0	412.6	39.3	1,836.2	545.	566.9	588.7
1	370	Xeo	2200	0.01804		3,488.5	0.0	414.1	1.01	1,876.5	548.	796.6	\$97.8
	200	350	2200	0.01792		3,239.1	0.0	366.2	37.5	1,914.0	552.	1.510	606.1
-	350	34.0	2200	0.01781	0.01770	3,279.4		395.1	37.9	1,952.0	555.	555, 392.7	614.5
-	240	330	2200	0.41770		3,320.4	0.0	398.0	3.8.4	1,990.4	558.	51.6	622.8
	330	325	2200	0.01759		1,523.0	0.0	182.6	17.6	2,006.0	560.	2.262	626.6
-	323	310	275	0.01754		0.0	0.0	0.0	0.0	2,006.0	569.	769.3	616.2
	310	300	275	9.01754		3,072.3		366.2	35.4	9 - 10 C	512,	877.1	623.7
-	X00	21.3	275	0.01744		11,680.4			2.000	2,178.7	584.	692.6	651.5
	260	235	275	0.01707		6,527.0	B	782.3	1:5	2.254.2	165	591,295.2	6.666.5
	535	210	275	0.01687	0.01669	6,008.1		7.00.1	6.90	2,323.6	597.	597,372.8	680.1
-	510	200	275	0.01669	0.01662	2,371.	0.0	284.3	27.4	2, 351.2	500	6.111.99	4.200
ITAL	INVE	TOTAL BANT VOLUME	7256.6 getlons	pat lons									

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ST. LUCIE UNIT 2

FINAL CONC. (ppm boren) 0.948 6.104 438.0 124.0 1.994 1.83.4 522.1 0.0 \$ 96.8 500.5 1.425 545.7 557.5 567.6 1.112 9.185 2.102 615.8 606.5 620.0 1.909 618.0 1.940 6.530 661.0 6.000 TOTAL SYS. MASS 1.58,238.7 485,950.2 6.944,064 500, 790.8 505,494.6 510,036.1 \$14,403.6 518,585.6 522,570.7 526,619.8 5.417,082 536, 510.6 5.235.228 5.107.845 552,047.0 555,367.2 0.027,828 0.175.062 534,354.4 541,750.2 569,743.1 572,858.6 0.480,480 01, 293.0 97,375.9 1.111.99 (IDm) 6.969 1.121.1 1,312.6 1,348.5 1,422.2 1.473.7 \$22.8 1.572.6 1,623.2 1,667.8 1,716.5 1,756.8 1,801.7 1,845.2 1,865.6 TOTAL 8/A 0.0 1.926.4 1,967.8 1,966.8 1,966.8 2,025.1 2,170.6 2,252.0 2,326.9 2,356. (10) PLANT COCKDONN FROM 557 F 10 260 F; BANT AT 3.5 WIX BORIC AC10; RUT AT 2150 ppm BORON B/K ADDED 6.999 \$1.9 \$5.9 53.8 51.5 157.5 127.3 1.03 8.94 50.6 42.9 0.0 44.6 1.07 42.3 4.04 43.5 41.4 19.0 3.0.3 145.6 81.3 9.42 0.0 (Ilba) RUT VOL 8 0.0 0.0 0.0 1,224.2 \$56.9 537.6 517.1 1.534 471.8 479.3 487.1 428.6 1.83 407.2 412.6 418.1 348.2 1.293.1 396.0 0.0 182.6 366.2 400.0 782.3 1.057 0.0 0.0 70 F (gal) 3,210.7 521.3 0.0 6.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 BANT VOL 2 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 4,313.8 4,130.5 0.0 10,213.7 4.485.6 3,936.1 3,979.2 3,575.6 3,907.5 6,527.0 MASS([bm) 26,741.7 4,342.2 4.645.9 4.560.3 3, 397.2 1,523.0 3,442.4 3,488.5 3,072.3 3,239.1 3,279.4 3, 320.4 0.0 SHR I NICAGE 11,680.4 6,008.1 2,371.6 0.01951 0.01870 SPECIFIC VOLUME 0.01900 0.01842 0.01828 1.00000 0.02032 0.02013 0.01970 0.01933 0.01916 0.01885 0.01855 0.01816 0.01792 0.01781 0.7170.0 0.01759 0.01754 0.01754 0.01744 0.01687 0.01804 0.01707 0.01669 0.01662 (cu.ft./lbm) -0.01951 0.02157 6.02032 0.02013 0.01970 0.01933 1.00000 0.01916 U. unitaria 0.01885 0.01870 0.01855 0.01842 0.01828 0.01770 0.01816 0.01804 0.01792 0.01781 0.01759 0.01754 0.01754 0.01707 0.01669 0.01744 0.01657 gallons ----PIR PRESS 2200 2200 2200 2200 2200 2200 2200 2200 22000 2200 2200 2200 2200 2200 2200 2200 2200 2200 2200 2200 (pata) 275 3732.0 275 512 52 52 52 510 557 201 3 170 450 3 93 150 23 410 8 8 3 370 3 350 240 330 22 310 2550 210 VOLUME -1 AVG. STS. TERO. (1) TOTAL BANT 557 557 510 3 170 3 450 201 110 130 027 410 89 8 3 370 3 350 29 23 310 200 235 210

SI. LUCIE UNIT 2 PLANT COORDOMM FROM 557 F 10 200 F; SANT AT 3.25 MTX BORIC ACID; RWT AT 2150 ppm BOROM

517 2200 1.00000 1.0000 0.0 <th< th=""><th>1.00000 0.02052 0.01951 0.01951 0.01951 0.019900 0.01900 0.01900 0.01800 0.01800 0.01800 0.01800</th><th></th><th></th><th></th><th>(ppm boron)</th></th<>	1.00000 0.02052 0.01951 0.01951 0.01951 0.019900 0.01900 0.01900 0.01800 0.01800 0.01800 0.01800				(ppm boron)
2000 0.42137 0.20032 50,71,1 3,210.7 0.0 277.4 1,15.2 606,3 606,4 700 700,4	520200 0.019970 0.019970 0.019970 0.01900 0.01900 0.01900 0.01900 0.01900 0.01900 0.01000		0.0	458.238.7	0.0
Z000 0.40012 0.10706 0.270.9 0.01 73.3 78.3 1,76.2 646,427.4 Z000 0.10790 0.01991 6.286.9 0.0 753.3 78.3 1,76.45 500,700.6 Z000 0.10791 0.01993 4,465.4 0.0 535.4 70.1 1,754.5 500,700.6 Z000 0.10791 0.10793 4,465.4 0.0 517.1 513.1 513.1 514.014.4 Z200 0.10791 6,173.3 0.0 717.1 513.6 1,403.4 514.014.4 Z200 0.01790 6,130.3 0.0 471.0 91.1 1,272.0 514.014.4 Z200 0.01895 5,963.7 0.0 471.1 50.6 1,403.1 514.014.4 Z200 0.01895 5,963.7 0.0 471.1 50.6 1,403.4 514.014.4 Z200 0.01895 5,963.7 0.0 471.1 50.6 1,403.4 514.014.4 Z200 0.01895	0.01900 07010.0 07010.0 0.01910.0 0.01910.0 0.01910.0 0.01810.0 0.01810.0		898.3	485,878.6	323.21
Z000 0.019700 0.2364.9 0.0 753.3 78.3 1,254.5 500,700.6 Z000 0.01970 0.01931 4,465.4 0.0 554.9 57.9 1,172.4 500,700.6 Z000 0.01931 0.01931 4,465.4 0.0 517.1 513.6 519.015.9 Z000 0.01931 0.01931 4,413.45 0.0 517.1 513.6 519.60.14 Z000 0.01931 0.01935 4,413.45 0.0 477.1 513.6 519.60.7 Z000 0.01935 0.01635 4,063.9 0.0 477.1 513.6 519.61.1 Z000 0.01935 0.01642 3,995.1 0.0 477.1 513.6 519.61.6 Z000 0.01862 3,995.1 0.0 477.1 50.6 54.557575 519.565.4 Z000 0.01862 3,995.1 0.0 477.1 50.6 54.557575 519.565.4 Z000 0.01862 3,997.5 0.0 477.1	0.01970 0.01970 0.01910 0.01910 0.01910 0.01910 0.01810 0.01810 0.01810 0.01810 0.01810		1,176.2	194,427.4	415.91
Z200 0.01970 0.01970 4.465.9 0.0 556.9 57.9 1,112.4 506,404.4 Z200 0.01931 0.01933 4,465.6 0.0 537.6 55.9 1,463.3 510,015.9 Z200 0.01931 0.01933 4,465.6 0.0 517.1 53.8 1,422.0 514,401.4 Z200 0.01900 0.01903 5,0193.9 0.01803 5,936.1 53.5 515,505.4 515,505.4 Z200 0.01900 0.01803 5,018.3 5,936.1 53.5 515,505.4 53.5,505.4 Z200 0.01960 5,018.5 5,935.4 6.0 1,577.4 50,505.4 Z200 0.01863 5,905.1 53.5 50.751.6 53.750.5 Z200 0.01864 5,907.5 0.0 4.6.1 1,76.3 50.794.1 Z200 0.01865 5,907.5 0.0 4.6.1 1,67.3 53.796.2 Z200 0.01865 5,907.5 0.0 4.6.2 1,76.3 <	1.2010.0 2.01910.0 200010.0 200010.0 200010.0 200010.0 200010.0		1,24.5	500,790.6	438.0
Z200 0.01991 0.01931 4,465.6 0.0 517.1 53.9 1,422.0 510,015.9 Z200 0.01931 0.01936 4,313.8 0.0 517.1 53.6 1,422.0 514,403.4 Z200 0.01906 4,130.5 0.0 471.8 0.01 4,735.5 510,505.4 Z200 0.01906 0.01805 3,906.1 0.0 477.8 515.5 525.570.5 Z200 0.01805 0.01855 4,603.9 0.0 477.4 526.019.6 Z200 0.01805 3,907.5 0.0 477.4 50.6 1,473.0 50.79.1 Z200 0.01805 3,907.5 0.0 407.1 50.6 1,473.0 50.79.1 Z200 0.01805 3,907.5 0.0 407.1 50.6 1,473.0 50.79.1 Z200 0.01805 3,907.5 0.0 406.1 1,667.6 53.57.5 53.57.53.5 Z200 0.0186 3,907.5 0.0 406.1	0.01913 51910-0 20610-0 20610-0 27310-0 27310-0 27310-0		1,312.4	505,494.4	1 6:23.9 1
Z200 0.01933 0.01915 4,313.1 0.0 517.1 53.8 1,422.0 514,403.4 Z200 0.01916 0.01900 4,130.5 0.0 495.1 51.5 1,473.5 519,565.4 Z200 0.01900 0.01805 3,956.1 0.0 471.0 40.1 1,522.4 525,570.5 Z200 0.01805 0.01835 4,003.9 0.0 471.1 50.6 1,577.4 526,610.6 Z200 0.01805 0.01842 3,575.6 0.0 487.1 50.6 1,577.4 526,610.6 Z200 0.01842 0.01842 3,575.6 0.0 407.1 50.6 1,667.5 536,750.6 Z200 0.01842 0.01842 3,575.6 0.0 407.2 44.7 1,716.3 536,750.6 Z200 0.01846 3,197.2 0.0 407.2 44.7 1,776.5 541,750.0 Z200 0.01846 3,472.4 0.0 407.2 44.27 1,776.5 545,750.0 <td>0.01910.0 000910.0 07310.0 023810.0 0.03810.0</td> <td></td> <td>1,368.3</td> <td>510,035.9</td> <td>1 0.934</td>	0.01910.0 000910.0 07310.0 023810.0 0.03810.0		1,368.3	510,035.9	1 0.934
Z200 0.01904 0.01900 4,130.5 0.0 49.1 51.5 1,473.5 516,565.4 Z200 0.01900 0.01605 3,936.1 0.0 471.6 40.1 1,522.6 525,570.5 Z200 0.01805 3,996.1 0.0 471.6 40.1 1,522.6 525,570.5 Z200 0.01805 4,063.9 0.0 477.1 50.619.6 536,754.1 Z200 0.01805 3,597.6 0.0 471.1 50.6 1,677.4 526,570.5 Z200 0.01805 3,597.5 0.0 471.1 50.6 1,677.4 536,754.1 Z200 0.01805 3,597.5 0.0 468.7 46.7 1,716.3 536,754.1 Z200 0.01804 3,597.5 0.0 472.6 42.2 1,776.5 536,754.3 Z200 0.01702 3,442.4 0.0 418.1 44.7 1,716.3 536,750.0 Z200 0.01701 0.01701 3,542.2 0.0	0.01900 0.01865 0.01855 0.01855		1,422.0	514,403.4	403.3 1
Z200 0.01000 0.01005 5,936.1 0.0 471.8 40.1 1,522.6 522,570.5 Z200 0.01805 0.01770 3,996.2 0.0 497.1 50.6 1,577.4 526,619.6 Z200 0.01805 0.01855 4,063.9 0.0 497.1 50.6 1,577.4 526,619.6 Z200 0.01865 0.01862 3,575.6 0.0 487.1 50.6 1,577.4 526,570.5 Z200 0.01862 3,575.6 0.0 487.1 50.6 1,577.4 526,570.5 Z200 0.01862 3,977.2 0.0 487.1 1,716.3 536,310.4 Z200 0.01864 3,597.2 0.0 412.1 48.7 1,716.3 536,310.4 Z200 0.01864 0.01702 3,442.4 0.0 412.1 45.2 545,57.3 Z200 0.01702 3,442.4 0.0 418.1 45.6 541,750.0 Z200 0.01702 0.0181 3,529.1	0.01805 0.01770 0.01855		1,473.5	518,585.4	1 9.90
Z200 0.01805 0.01875 4,003.9 0.0 479.3 49.8 1,577.4 520,619.6 Z200 0.01807 0.01855 4,003.9 0.0 487.1 50.6 1,423.0 530,794.1 Z200 0.01855 0.01865 4,003.9 0.0 487.1 1,764.6 534,354.2 Z200 0.01842 3,575.6 0.0 466.4 46.7 1,764.6 544,354.2 Z200 0.01842 0.01846 3,997.2 0.0 407.2 42.3 1,764.6 541,750.0 Z200 0.01846 0.01846 3,442.4 0.0 418.1 1,176.3 538,110.4 Z200 0.01846 0.01846 3,442.4 0.0 418.1 418.1 1,776.6 541,750.0 Z200 0.01846 0.01702 3,442.4 0.0 235.6 542.758.6 545,753.3 Z200 0.01770 0.01770 3,770.4 0.0 540.4 552,666.7 552,666.7 Z200 0.0	0.01770		1,522.6	522,570.5	1 7.605
Z200 0.016/0 0.016/0 4,043.9 0.0 46/.1 50.6 1,423.0 534,354.2 Z200 0.01642 3,575.6 0.0 428.6 44.6 1,447.5 534,354.2 Z200 0.01642 3,575.6 0.0 428.6 44.6 1,447.6 544.56.5 Z200 0.01642 3,597.2 0.0 406.4 48.7 1,716.3 539,310.4 Z200 0.01642 3,597.2 0.0 407.2 42.3 1,756.6 541,750.0 Z200 0.01792 0.01804 3,442.4 0.0 418.1 43.5 543.53.3 Z200 0.01792 0.01702 3,448.5 0.0 418.1 43.5 543.53.3 Z200 0.01794 0.01703 3,448.5 0.0 418.1 43.5 543.730.0 Z200 0.01774 0.01770 3,448.5 0.0 418.1 44.5 543.730.0 Z200 0.01774 0.01770 3,448.5 0.0 20	0.01855		1,573.4	526,619.6	522.01
Z200 0.01865 0.01642 3,575.6 0.0 428.6 44.6 1,647.6 534,354.2 Z200 0.018642 0.018643 3,907.5 0.0 468.4 48.7 1,716.3 536,310.4 Z200 0.018642 0.018643 3,907.2 0.0 468.4 48.7 1,716.3 536,310.4 Z200 0.01864 0.01864 3,442.4 0.0 407.2 4.2.9 1,901.5 544,750.0 Z200 0.01792 0.01864 3,442.4 0.0 0.0 418.1 4.8.7 1,764.5 546,773 Z200 0.01792 0.01792 3,468.5 0.0 418.1 4.8.7 1,764.5 546,773 Z200 0.01792 0.01792 3,2794.1 0.0 418.1 4.8.7 1,865.0 546,773 Z200 0.01770 3,2794.1 0.0 393.1 40.9 1,965.6 556,776.0 Z200 0.01770 3,2794.1 0.0 393.2 40.4 1,865.0	A 1940.0		1,023.0	530,734.1	54.71
Z200 0.01642 0.01663 3,907.5 0.0 466.4 48.7 1,716.3 536,510.4 Z200 0.016816 3,907.2 0.0 407.2 42.3 1,756.6 541,750.0 Z200 0.01816 0.01804 3,442.4 0.0 407.2 42.3 1,756.6 541,750.0 Z200 0.01804 3,442.4 0.0 418.1 43.5 1,801.5 543,25.3 Z200 0.01804 0.01782 3,442.4 0.0 418.1 43.5 546.0 543,751.3 Z200 0.01781 3,279.4 0.0 20.0 400.4 1,60.5 1,60.5 543,751.3 Z200 0.01770 0.01784 3,279.4 0.0 500.1 1,905.6 556,757.0 Z200 0.01754 0.01754 1,523.0 0.0 192.6 1,966.6 556,757.0 Z200 0.01754 0.01754 1,523.0 0.0 192.6 556,756.7 556,756.7 Z200 0.01754	0.01042		1,667.6	534,354.2	545.61
Z200 0.01626 0.01616 3,397.2 0.0 407.2 42.3 1,756.6 541,750.0 Z200 0.01816 0.01804 3,442.4 0.0 418.1 43.5 1,801.5 545,235.3 Z200 0.01804 0.01702 3,466.5 0.0 418.1 43.5 1,801.5 545,753.3 Z200 0.01702 3,466.5 0.0 418.1 43.5 1,805.6 545,753.3 Z200 0.01702 3,279.4 0.0 393.1 43.5 556,758.6 546,753.3 Z200 0.01770 0.01770 3,279.4 0.0 393.1 40.4 1,865.6 556,728.6 Z200 0.01770 0.01754 1,525.0 0.0 199.0 1,966.6 556,778.6 Z200 0.01754 0.01754 1,525.0 0.0 1,962.6 556,778.6 556,778.6 Z200 0.01754 0.01754 1,525.0 0.0 1,962.6 556,778.6 556,778.6 Z200 0	0.01828		1,716.3	538, 510.4	1 4.182
Z200 0.01916 0.01804 3,442.4 0.0 412.6 42.9 1,001.5 545,253.3 Z200 0.01804 0.01792 3,442.4 0.0 418.1 43.5 1,001.5 549,767.3 Z200 0.01792 3,440.5 0.0 418.1 43.5 1,005.0 549,767.3 Z200 0.01792 3,239.1 0.0 393.1 40.4 1,005.4 559,767.0 Z200 0.01770 0.01779 3,239.4 0.0 393.1 40.9 1,926.2 559,758.6 Z200 0.01779 0.01754 1,523.0 0.0 182.6 19.0 1,906.6 569,778.6 Z200 0.01754 0.01754 1,523.0 0.0 102.0 1,906.6 569,747.9 Z200 0.01754 0.01754 1,523.0 0.0 10.0 1,906.6 569,747.9 Z200 0.01754 0.1754 3,072.3 0.0 1,906.6 569,747.9 Z750 0.01754 0.01754 <td>0.01816</td> <td></td> <td>1,758.6</td> <td>541,750.0</td> <td>567.5</td>	0.01816		1,758.6	541,750.0	567.5
Z200 0.01502 3,466.5 0.0 416.1 43.5 1,645.0 543,767.3 Z200 0.01792 0.01770 3,239.1 0.0 365.2 40.4 1,865.4 552,046.0 Z200 0.01770 0.01770 3,279.4 0.0 369.1 40.4 1,865.4 552,046.0 Z200 0.01770 0.01770 3,279.4 0.0 399.1 40.4 1,865.4 552,046.0 Z200 0.01779 0.01779 3,320.4 0.0 399.0 41.4 1,926.2 559,726.0 Z200 0.01779 0.01754 1,523.0 0.0 162.6 19.0 1,966.6 560,270.6 Z200 0.01754 0.01754 1,523.0 0.0 0.0 1,966.6 560,270.6 Z200 0.01754 0.1754 1,523.0 0.0 1,966.6 560,270.6 Z200 0.01754 0.01754 1,523.0 0.0 0.0 1,966.6 560,770.9 Z75 0.01744	0.01804		1,801.5	545,235.3	577.7
Z200 0.01792 0.01781 3,239.1 0.0 366.2 40.4 1,665.4 552,046.6 Z200 0.01770 3,279.4 0.0 393.1 40.4 1,926.2 555,357.0 Z200 0.01770 3,279.4 0.0 393.1 40.9 1,926.2 555,756.6 Z200 0.01779 0.01759 3,320.4 0.0 360.0 1906.0 1,926.2 555,756.6 Z200 0.01754 0.1759 3,320.4 0.0 0.0 1906.0 1,926.5 550,770.6 Z75 0.01754 0.1754 1,523.0 0.0 182.6 19.0 1,966.6 560,747.9 Z75 0.01754 0.01764 3,072.3 0.0 0.0 1,966.6 540,71.9 Z75 0.01764 0.1707 11,660.4 0.0 1,460.0 1,966.6 540,71.9 Z75 0.01764 0.11764 3,072.3 0.0 76.3 2,170.4 584,666.4 Z75 0.01764	0.01792		1,045.0	548,767.3	587.6 1
Z200 0.01781 0.01770 3,279.4 0.0 393.1 40.9 1,926.2 555,367.0 Z200 0.01770 0.01759 3,320.4 0.0 396.0 41.4 1,947.6 559,728.8 Z200 0.01759 3,320.4 0.0 396.0 41.4 1,946.6 569,728.8 Z200 0.01754 0.01754 1,523.0 0.0 162.6 19.0 1,966.6 569,770.8 Z75 0.01754 0.01754 1,523.0 0.0 0.0 1,966.6 569,770.8 Z75 0.01754 0.01764 3,072.3 0.0 0.0 1,966.6 569,747.9 Z75 0.01764 0.01707 11,660.4 0.0 76.0 165.6 517.0 Z75 0.01707 0.11667 6,527.0 0.0 760.0 165.6 5170.4 584,664.4 Z75 0.01707 11,660.4 0.0 760.0 165.6 5170.4 584,664.4 Z75 0.01707 1	0.01781		1, 285.4	552,046.8	1 1.792
Z200 0.01770 0.01759 5,320.4 0.0 396.0 41.4 1,967.6 556,728.6 Z200 0.01754 0.01754 1,523.0 0.0 122.6 19.0 1,966.6 560,270.8 Z200 0.01754 0.01754 1,523.0 0.0 122.6 19.0 1,966.6 560,770.8 Z75 0.01754 0.01754 1,523.0 0.0 0.0 1,966.6 560,747.9 Z75 0.01754 0.01764 3,072.3 0.0 1,460.0 1,966.6 560,747.9 Z75 0.01707 0.11764 3,072.3 0.0 1,460.0 1,55.6 5170.4 564,664.4 Z75 0.01707 0.11660.4 0.0 1,460.0 1,45.6 2,170.4 564,664.4 Z75 0.01707 0.11660.4 0.0 762.3 61.3 2,251.6 591,292.7 Z75 0.01667 6,006.1 0.0 76.9 2,756.6 591,392.7 Z75 0.016662 2,371.6	0.01770		1,926.2	555,367.0	606.4 1
2200 0.01759 0.01754 1,525.0 0.0 162.6 19.0 1,966.6 560,270.8 275 0.01754 0.01754 0.01754 0.01754 0.01754 572,858.4 275 0.01754 0.01774 3,072.3 0.0 0.0 1,966.6 569,747.9 275 0.01754 0.01744 3,072.3 0.0 1,460.0 145.6 5,024.9 572,858.4 275 0.01707 0.01707 11,660.4 0.0 1,400.0 145.6 2,170.4 564,666.4 275 0.01707 0.01607 11,660.4 0.0 782.3 61.3 2,251.6 591,292.7 275 0.01667 6,006.1 0.0 780.1 74.9 2,126.6 591,392.7 275 0.016687 6,006.1 0.0 264.3 2,96.7 591,392.7 275 0.016682 2,377.6 0.0 264.3 2,95.6 591,392.7 275 0.016682 2,377.6 0.0 264.3 2,96.7 591,392.7 275 0.016662 2,971.6 2	0.01759		1,967.6	558,728.8	615.7 8
ZP5 0.01754 0.0 0.0 0.0 0.0 1,966.6 569,747.9 ZP5 0.01754 0.01744 3,072.3 0.0 0.0 1,966.6 569,747.9 ZP5 0.01754 0.01707 11,660.4 0.0 1,400.0 145.6 2,170.4 584,664.4 ZP5 0.01707 0.01607 11,660.4 0.0 1,400.0 145.6 2,170.4 584,664.4 ZP5 0.01707 0.01607 11,660.4 0.0 782.3 61.3 2,251.6 591,292.7 ZP5 0.01607 0.016661 0.0 782.3 61.3 2,251.6 591,292.7 ZP5 0.01662 2,371.6 0.0 264.3 2,156.6 591,392.7 ZP5 0.016662 0.016662 2,371.6 0.0 264.3 2,156.6 591,392.7	0.01754		1,966.6	560,270.8	619.91
275 0.01754 0.01744 3,072.3 0.0 368.2 36.3 2,024.9 572,658.4 275 6.01744 0.01707 11,660.4 0.0 1,400.0 165.6 2,170.4 584,664.4 275 6.01707 0.01607 6,527.0 0.0 7,400.0 165.6 2,170.4 584,664.4 275 0.01707 0.01607 6,527.0 0.0 762.3 81.3 2,251.8 591,292.7 275 0.01687 6,527.0 0.0 782.3 81.3 2,251.8 591,292.7 275 0.01687 6,908.1 0.0 720.1 74.9 2,326.6 591,392.7 275 0.016682 2,371.6 0.0 264.3 29.6 591,375.7	0.01754		1,966.6	569,747.9	000.61
275 0.01744 0.01707 11,660.4 0.0 1,400.0 145.6 2,170.4 564,664.4 275 0.01707 0.01667 6,527.0 0.0 782.5 61.3 2,251.8 591,292.7 275 0.01667 6,527.0 0.0 782.5 61.3 2,251.8 591,292.7 275 0.01667 6,906.1 0.0 720.1 74.9 2,326.6 591,375.7 275 0.01669 0.016642 2,371.6 0.0 264.3 29.6 597,375.7	0.01744		2,024.9	\$72,858.4	618.0 1
275 0.01707 0.01667 6,527.0 0.0 782.3 81.3 2,251.6 591,292.7 275 0.01667 0.01669 6,006.1 0.0 720.1 74.9 2,326.6 591,375.7 275 0.01669 0.01661 0.0 20.0 720.1 74.9 2,326.6 591,375.7 275 0.01669 0.01662 2,371.6 0.0 204.3 29.6 2,356.2 500 776.0	0.01707	-	2,170.4	5.84,684.4	0.920
275 0.01667 0.01669 6,006.1 0.0 720.1 74.9 2,326.6 597,375.7 275 0.01669 0.01662 2,371.6 0.0 284.3 29.6 2.356.2 500 776.0	0.01687		2,251.8	591,292.7	665.8 1
275 0.01669 0.01662 2,371.6 0.0 264.3 29.6 2.356.2 500 776.0	0.01069		2,326.6	597.375.7	1 0.009
	0.01662		2.356.2	599.776.9	000.01

(ppm boron) FINAL CONC. 91.6 1.965 431.5 \$52.5 1.100 482.0 1.201 1.808 520.7 0.0 513.4 566.3 576.4 5.986.5 8. 242 1.209 614.5 4.800 618.7 616.8 647.8 0.400 679.8 1.585 TOTAL 8/A TOTAL SYS. MASS 4.700,25 9.018, 291 99,320.1 9.180,013 58,238.7 7.067, 202 \$22,566.6 \$14,399.4 518,581.4 526,615.6 530, FE0. 1 541,746.0 534,350.2 538,306.4 545,231.3 548,763.3 552,042.8 555,363.0 558,724.8 560,266.8 569,743.9 572,854.4 1.080, 488 91,266.8 1.112,191 97,112.9 (Ithm) 827.3 1,129.0 0.0 1,308.4 1,418.1 1,469.5 1,518.6 1,568.4 1,922.5 1.344.3 1.619.1 0.500,1 1,712.5 1.451.1 1,797.6 1,841.0 1,661.4 1,982.6 1,962.6 2,020.9 2,247.8 2,322.7 2,106.5 2,352. (1150) PLANT COOLDOWN FROM 557 5 19 200 F; BANT AT 3.00 WCK 9081C ACID; RWT AT 2150 ppm BORON B/A ADDED 0.0 827.1 901.9 75.9 55.9 53.8 51.5 1.92 8.93 50.6 42.3 42.9 43.5 40.9 40.9 40.9 10.91 0.0 36.3 45.6 61.3 20.65 (1110) Rui voi a 50 f (gal) 0.0 0.0 0.0 0.0 730.5 537.6 517.1 1.241 8.114 10.3 487.1 1.801 407.2 412.6 418.1 346.2 393.1 398.0 182.6 0.0 546.2 782.3 120.1 0.0 0.0 0.0 0.0 3,210.7 1,172.0 70 F (gai) 1.103 0.0 9.9 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 BANT VOL 2 0.0 0.0 0.0 0.0 0.0 ST. LUCIE 'MIT 2 6.094.4 0.0 3,346.0 4,485.6 4,313.8 4,063.9 3,575.6 3,907.5 9,761.3 4,130.5 3,936.1 3,999.2 3, 397.2 3,488.5 3,239.1 3,072.3 MASS(Ibm) 26,741.7 3,442.4 1,523.0 6.527.0 3.279.4 0.0 11,680.4 SHR I NKAGE 3,320.4 6,008.1 2,371.6 0.01828 0.01759 SPECIFIC VOLUME 1.00000 0.02032 0.01990 0.01900 0.01885 0.01976 0.01951 0.01933 0.01916 0.01870 0.01842 0.01816 0.01754 0.01855 0.01804 0.01792 0.01781 0.01770 0.01744 0.01754 0.01707 0.01687 0.01669 0.31661 (cu.ft./(bm) 1 1.00000 0.02157 0.02032 0.01990 0.01976 0.01951 0.01933 0.01916 0.01900 0.01865 0.01870 3.01855 0.01842 0.01828 0//10.0 0.01816 0.01759 0.01804 0.01792 0.01754 0.01781 0.01754 . 18 47/10.0 0.01707 0.01667 0.01669 4784.4 gallons PZR PRESS 22000 2200 2200 2200 2200 2200 2200 2200 2200 2200 2200 2200 22900 2200 2200 2200 22200 2200 2200 275 52 52 522 275 (paia) 52 077 410 \$000 \$1000 \$ 510 2800 2810 2710 WOR LINE H, HO AVG. 515. 16HP. TOTAL BANT 557 510 557 887 183 2 3 3 3 9 8 7 110 3 22 28 22 22 510 510 510 510 510 510 510 510 510 8 510 2

(ppm boron) 54Y.0 FINAL CONC. 0.0 272.4 8.704 453.3 6.001 191.2 507.3 520.0 1.161 532.6 543.6 \$65.6 \$155.4 575.7 585.8 613.8 618.0 604.5 1.109 616.1 5.7.40 0.400 1.019 28 TOTAL S/A TOTAL SYS. MASS 522,564.3 1.58,238.7 136.5 9. 277. 201 9.201,003 05,938.6 510,029.7 514,317.2 518,579.2 \$26.613.4 530, 727.9 0.848.420 5.30, 304.2 541,743.8 1.955,228 1.101.84 552,040.6 555,360.8 558, 722.6 560,264.6 1.1.1. 695 572,852.2 5.810,48 91,286.6 97,369.5 1.011.99 ((100) 0.0 7.957 1,616.8 1.920.0 1.940.1 1.980.1 1,755.5 1,032.2 1,167.8 1.311.7 1.382.1 1,415.8 1,467.3 1,516.4 1,879.2 2,018.7 2,350.5 2.164.2 2.245.6 (11) PLANT COOKDOMM FROM 557 F TO 200 F; BANT AT 2.75 LET BORIC AT 07 PLAT AT 2150 ppm BOROM 276.0 135.6 6.54 53.8 S/A ADDED 0.0 7.6.2 8.94 \$0.6 9.44 1.84 42.3 42.9 43.5 40.9 \$.02 19.0 0.0 41.4 36.3 45.6 81.3 14.9 (Ithm) SU F (gal) 0.0 0.0 0.0 0.0 0.6 104.3 517.1 1.81 8.174 428.6 412.6 396.0 179.3 4.884 407.2 418.1 393.1 182.6 0.0 346.2 400.0 1.184 782.3 720.1 EAMIT WOL 2 70 5 (gml) 3,210.7 1,172.0 0.0 0.0 0.0 0.0 0.0 0.0 575.6 611.2 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 LUCLE UNIT 2 MASS(10m) 0.0 9,761.3 4.744.5 4,130.5 4,063.9 3,575.6 3,907.5 3,907.2 26.741.7 5,090.7 4,040.8 4,313.8 SHR I NKAGE 3,999.2 3,936.1 3.442.4 3,488.5 3,279.4 1,523.0 3,072.3 11,680.4 6.527.0 3,239.1 3, 320.4 0.0 6,008.1 SI. 1.00000 0.01842 0.01770 SPECIFIC VOLUME 0.01990 0.91970 0.01949 22610.0 0.01900 0.01885 0.01870 0.01855 0.01216 0.01759 0.01804 0.01707 0.01915 0.01792 0.01781 42110.0 0.01744 0.01687 0.01669 0.01662 0.01754 (cu.ft./lbm) 12 0.01916 vi . 1.00000 0.02157 0.02032 0.01990 0.91970 0.01949 0.01933 0.01900 20010.0 0.01870 0.01855 0.01526 0.01770 0.01759 0.01842 0.01816 0.01804 0.01792 0.01754 0.01781 20.01754 0.01744 0.01707 0.01667 0.01009 5569.5 gallons PZK PRESS 22000 2200 22000 22000 2200 22000 2200 22000 2200 2200 22200 2200 2200 22000 2200 2200 2200 2200 2200 22000 275 575 (pais) 275 275 52 275 557 8 3 3 3 120 110 130 27 410 3 8 8 3 370 350 350 323 310 20 260 235 200 TOTAL BANT VOLUME in. AVG. SYS. ICH. (#) 510 557 557 8 33 100 130 120 10 8 200 370 3 2 R 330 0012 2852 210 2 2

ST. LUCIE UNIT 2 PLANT COOLDOWN FROM 557 F TO 200 F; BANI AT 2.5 WEB BORIC ACID; BUT AT 2150 ppm BORD

S FRIML COMC.			6 330.1																								
FILM)	456,238.	435,666.0	475,617.6	500,595.	505,360.0	509,960.1	515,648.	518,583.	522,568.	526,617.4	5.167,082	514, 352.	538, 308.	541,747.1	545,233.1	548, 765.1	552,044.0	555, 364.5	558, 726.4	560,268.0	569,745.1	572,856.3	584,682.2	591,290.6	5.678, 392.5	1.111,992	
1014									i.			1		i.	ŝ	1	i.		ļ		ł	i.					
TOTAL B/A TOTAL (Ubra)	0.0	685.7	936.0	1,058.9	1,178.0	1,293.0	1,435.2	1,471.3	1,520.4	1,570.2	1,620.9	1,665.4	1,714.1	1,736.5	1,799.4	1,842.8	1,863.2	1,924.1	1,965.4	1,964.4	1,984.4	2,022.7	2,168.3	2,249.6	2,324.5	2,354.0	
8/A 40060 ((tm)	6.0	1.500	250.3	122.9	119.1	115.0	142.2	36.1	1.92	3.94	50.6	5.42	1.8.1	42.3	42.9	43.5	7.07	6.04	1.12	19.0	0.0	5.8.5	145.6	81.3	14.9	29.62	
SO F (gel)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	347.4	\$71.8	479.3	4.87.1	428.6	1.681	407.2	412.6	418.1	3488.2	1.293.1	396.0	182.6	0.0	348.2	1,400.0	782.3	720.1	284.3	
TO F (gail)	0.0	,210.7	1,172.0	575.6	\$57.8	538.5	8.200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1.07		***	-																								
SHR INKAGE HASS(I Em)	0.0	26,741.7	9,761.3	4,744.5	4,645.9	4,485.6	5,545.7	2,898.6	3,936.1	3,999.2	4,063.9	3,575.6	3,907.5	3, 397.2	3.442.4	3,488.5	3,239.1	3,279.4	5,320.4	1,523.0	0.0	3,072.3	11,680.4	6,527.0	6,008.1	2,371.6	
CIFIC VOLUME	1.00000	0.02032	0.01990	0.01970	0.01951	0.01933	0.01911	0.01900	0.01865	0.01370	0.01855	0.01642	0.01825	0.01816	0.01804	0.01792	0.01781	0.01770	0.01759	0.01754	0.01754	0.01744	0.01707	0.01687	0.01669	0.01662	
Genetic vocu (cu.ft./fbm) vi ' vf	1.00000	0.02157	a.02032	0.01990	0.01970	0.01951	0.01933	0.01911	0.01900	0.01885	0.01870	0.01855	0.01842	0.01828	0.01816	0.01804	20/10.0	0.01781	0.01770	0.01759	0.01754	0.01754	0.01744	0.01707	0.01487	0.01669	and Lone
(pais)	2200	2200	2200	2200	0622	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	275	215	275	275	215	275	11mp 7 0224
·'=	557	510	067	181	170	993	177	077	130	120	410	89	390	20	370	360	350	34.0	330	325	310	300	260	235	210	200	NORLINE
0.515. 18 (1) 11	557	155	510	887	187	170	100	173	110	130	120	410	100	390	200	370	No	350	340	330	325	310	300	260	235	210	TOTAL BANT VOLINE
<u></u>	1 -	-	-			_	-	-			_	_	-			-	-	-	-		-	-	-	-	-	_	1

TOTAL B/A TOTAL SYS. MASS FINAL COMC. (ppm borow) 395.6 0.0 1.061 431.6 1.8.3 10.101 8.874 1.265 506.7 520.6 532.6 545.6 556.8 \$67.9 5.992 1.472 5.99.3 8.908 614.5 604.2 613.4 647.6 1.999 1.000 186,942.9 195.363.6 526,573.1 534,314.4 1.98,238.7 6.051,202 500, 722.1 509,975.2 514,346.5 522,520.6 518,532.1 530,691.2 541,716.5 545,204.8 9.9ET.842 552,022.1 555, 345.2 9.907.825 5.855.000 1.067,988 5.2,843.5 584,679.6 ((())) 01,293.6 97,381.8 0.281,993 1,526.0 0.0 1.004.1 1,122.0 1,185.9 1,307.6 1,247.8 1.365.1 1.560.1 1,627.8 1,679.9 1,755.2 1.171.1 1,948.1 1,817.6 1.000.1 1.904.4 1,969.0 2,910.0 2,165.7 2,252.7 2,332.7 (11) PLANT COOKDOAM FROM 557 F TO 200 F; BANT AT 3.5 wIX BORIC ACID; RWI AT 2300 ppm BOROM B/A ADDED 0.0 63.9 61.9 5.12 0.04.7 117.3 55.1 \$2.5 53.3 54.2 1.14 52.1 45.3 45.9 66.5 43.2 43.7 20.3 0.0 41.0 87.0 55.7 31.6 (Itas) 50 f (gel) 0.0 0.0 574.7 1,055.2 537.6 517.1 1.541 8.114 10.3 1.784 428.6 1.841 407.2 412.6 418.1 396.0 RUT VOL 2 346.2 393.1 122.6 0.0 346.2 400.0 782.3 120.1 TO F (gal) ST. LUCIE UNIT 2 0.0 0.0 1.35.1 0.0 27,699.6 0.0 RASS(1bm) 8,803.4 4,744.5 4,130.5 SHRINKAGE 3,936.1 3,999.2 4,063.9 3,907.5 4.645.9 4.485.6 4,313.8 3,575.6 3,279.4 3, 320.4 3,072.3 6,527.0 3, 397.2 3.442.4 3,488.5 3,239.1 1,523.0 0.0 11,680.4 6,008.1 2,371.6 SPECIFIC VOLUME 0.01916 0.02028 0.01670 0.01855 0.01842 0.01828 1.00000 0.01990 0.01951 0.01933 0.01900 0.01385 0.01759 0.01970 0.01816 0.01804 0.01770 0.01792 47210.0 0.01781 0.01707 0.0168/ 0.01754 0.01754 (cu.ft./ibm) 0.01669 0.01662 vi , 1.00000 0.02157 9.92028 0.01990 0.01970 0.01951 0.01933 0.01916 0.01900 0.01670 0.01855 0.01804 0.01885 0.01842 0.01828 0.01816 0.01792 0.05781 0.01770 0.01759 0.01754 0.01707 0.01754 0.01744 0.01687 0.01669 3325 7 gallons PZR PRESS 5200 2200 22000 2200 22000 2200 22000 2200 2200 2200 2200 2200 2200 2200 22000 2200 2200 2200 22000 2200 (pais) 52 275 275 275 512 SZ 255 8 3 27 3 150 110 130 120 8 390 220 410 350 330 2 310 8 992 52 210 TOTAL BANT VOLUME AVG. STS. TEMP. 1 (1) 557 8 8 89 23 3 659 10 557 130 23 (10 8 8 8 22 3 330 310 210 200 22 -

AVG. STS.	IEW.	P28 PRESS	5	CIFIC VOLDE	SWBISKAGE	BANT VOL 2		B/A ADDED	TOTAL BIA	TOTAL OVE MACC	1.1	Tuat Pres
11 (1)	'z	(pais)	o) Ni	(cu.ft./illa) vi vi	(md1)sse	70 F (gal)	50 F (pat)	(1)		(m)		(the porter)
155	555	2200	1.00000	1.00000	0.0			0.0	0.0	458.2	1.5	0.0
557	510	2200	0.02157	0.02032	26,741.7	3.	0.0	896.3	898.3	182,85	8.6	323.2
510	201		0.02032	0.02013	4,342.2			145.9	1,044.2	¥.064	1.8	372.3
201	181		0.02015	0.01970	10,213.7			136.1	1,160.3	500,71	16.5	412.1
1007	470		0.012/0	0.31951	4,645.9	0.0	556.9	61.9	1,242.3	. 505.41	1.3	1.023
227	464	1	0.01951	0.01933	4,485.6	0.0	537.6	59.8	1, 302.0	509.94	2.9	416.4
999	450		0.01933	0.01916	4,313.8	0.0	517.1	51.5	1,359.5	514,34	6.0	402.1
959	111		0.01916	0.01900	4,130.5	0.0	1.293	55.1	1,414.6	518,52	10.5	477.0
110	430		0.01900	0.01665	3,936.1	0.0	8.174	\$2.5	1,467.1	522.51	15.0	6.064
*50	121		0.01885	0.01870	3,999.2	0.0	10.3	53.5	1,520.4	526,56	9.1	504.8
120	410		0.01870	0.01855	4,063.9	0.0	4.87.1	54.2	1,574.5	530,64	9.6	518.7
410	107		0.01055	0.01842	3,575.6	0.0	428.6	1.13	1,622.2	534,30	8.8	530.0
89	396		0.01842	0.01828	3,907.5	0.0	1.800	52.1	1,674.3	538,24	9.6	543.8
390	J BL		0.01828	0.01816	3, 397.2	0.0	\$07.2	45.3	1,719.6	11,112	6.0	\$55.0
260	SN		0.01816	0.01804	3,642.4	0.0	412.6	45.9	1,765.5	545,15	5.0	566.1
370	200	2200	0.01804	0.01792	3,488.5	0.0	418.1	6.5	1,612.0	548.77	5.4	577.3
36	354		0.01792	0.01781	3,239.1			43.2	1,855.1	552,01	0.0	587.0
350	340		0.01/31	0.01770	3,279.4			13.7	1,898.9	555, 31	9.6	\$. 192
340	334		0.01170	0.01759	3,320.4	0.0		5.43	1.943.1	556,70	-	608.1
330	22	~	0.01759	0.01754	1,523.0			20.3	1,963.4	560,24	3.6	612.7
325	310	5	0.01754	0.01754	0.0			0.0	1,963.4	569.72	1.4	602.5
310	300	512	9.01754	0.01744	3,072.3			41.0	2,004.4	572,63	6.1	611.7
300	264	j	0.01744	0.01707	11,680.4			1.551	2,160.1	584.61	0.4	645.9
260	235	2	0.01707	0.01487	6,527.0		782.3	87.0	2,247.1	591,28	0.6	4.400
235	210		0.01667	0.01660	5,006.1	0.0		80.1	2,327.2	597.31	6.2	1.100
210	200		0.01669	0.01662	2,371.6			31.6	2,358.8	5.017,092	9.5	6.7.60

(11m) (11m) (11m) (11m) (11m) 0.0 0.0 0.0 456,236.7 0.1 0.0 456,236.7 0.1 1,175.4 500,711.5 0.1 1,217.3 500,711.5 0.1 1,217.3 500,711.5 0.1 1,217.3 500,711.5 0.1 1,217.3 500,711.5 0.1 1,217.3 500,711.5 0.1 1,217.3 500,711.5 0.1 1,217.4 500,711.5 0.1 1,217.3 500,711.5 0.1 1,217.3 500,711.5 0.1 1,217.4 510,521.6 0.2.1 1,515.4 522,510.1 0.2.1 1,515.4 520,510.1 0.2.1 1,515.4 520,500.1 0.2.1 1,515.4 520,500.1 0.2.1 1,515.4 520,500.1 0.2.1 1,515.4 520,500.1 0.1 1,600.2 540,703.5 0.1 1,6	6 .	AVG. STS. TENP.	PZR PRESS	3	CIFIC VOLUME	SHR I NICAGE	BANT VOL 2		S/A ADDED	TOTAL B/A TOTAL SYS. MASS	TOTAL SYS	MASS	FINAL COM
7 557 200 1.0000 1.0000 0.00 0.		'z	(pata)	tcu.f	(t./(the)	(mai) (mai)	70 f (gal)	50 F (gal)	(Ita)	(9)	10		(ppm borom)
310 2200 0.0015 0.4015 <th0.4015< th=""></th0.4015<>	557	557	2200	1	1.7	0.0		1	0.0	00	5 7	7 870	
482 2700 0.01094 0.766.7 1,02.5 0.0 277.1 1,175.4 500,7115 480 2700 0.01090 5,780.2 0.0 95.9 77.2 1,175.4 500,7115 480 2700 0.01091 4,465.6 0.0 951.7 1,175.4 500,7115 480 2700 0.01091 4,465.6 0.0 951.7 1,175.4 500,7115 480 2700 0.01991 4,465.6 0.0 951.7 1,175.4 500,7115 440 2700 0.01901 4,465.6 0.0 951.7 1,157.4 500,7115 440 2700 0.01903 4,465.6 0.0 671.1 523.7 1500.7 500,7017 440 2700 0.01903 3,956.1 0.0 671.1 523.7 1500.7 500,7115 440 270 0.01060 3,975.4 0.01070 3,975.4 500,7115 440 270 270 270.7 310,7	2557	510	, 220	-	~	26,741.7	3,2		827.1	827.1	145	NOT 4	A 104
460 2700 0.0190 5,780.2 0.0 0.019 5,780.2 0.0 0.019 5,780.2 0.0 0.019 5,780.2 0.00 5,781.3 50,711.3	210	267	2200	-	~	8,766.7			271.1	1.098.2	107	C 578	100 D
4.00 2200 0.01090 0.01931 4.465.9 0.0 556.9 61.9 1.297.1 509,664.7 4.60 2200 0.01991 0.01933 4.465.6 0.0 517.1 575.3 1.354.6 514.356.0 4.60 2200 0.01991 0.01903 4.405.4 0.0 677.1 575.3 1.462.1 525.300.1 4.60 2200 0.01900 3.995.1 0.0 4.77 1.462.1 525.510.1 4.00 2200 0.01900 3.995.1 0.0 4.77 1.462.1 525.510.1 4.00 2700 0.01803 4.905.3 0.0 4.77 1.462.1 525.510.1 4.00 2700 0.01803 3.997.2 0.0 4.77 1.462.1 525.510.1 4.00 2700 0.01803 3.997.2 0.0 4.77 1.617.3 536.302.1 7.00 2700 0.01803 3.997.2 0.0 4.66.1 5.77.1 5.75.50.1 7.00	767	180	2200	-	Ξ.	5,789.2			11.2	1.13.4	2005	2111.5	10.4
460 2200 0.01951 0.465.6 0.0 517.1 57.5 1,297.1 509, 44.35.6 440 2200 0.019910 0.1190.5 0.1190.5 0.1190.5 0.1190.5 513.1.6 514.15.6 514.356.0 440 2200 0.019910 0.01800 5,956.1 0.0 471.3 25.5 1,460.7 516.251.6 440 2200 0.01990 0.01800 5,956.1 0.0 477.3 52.5 1,460.7 516.251.6 440 2200 0.01800 5,996.2 0.0 477.3 52.5 1,460.7 530,501.1 440 2200 0.01800 5,997.3 0.0 4,77.1 1,607.7 536,525.6 400 2200 0.01802 5,997.3 0.0 4,77.1 1,607.7 546,525.5 500 20080 0.10802 5,997.3 0.0 4,77.4 547.3 546,555.5 500 20080 0.0180 5,997.3 0.00 4,17.4 547.3	8	470	2200	-	Ξ.	4.645.9			61.9	1,237.3	505	419.3	428.0
450 2700 6.01053 6.111.0 0.0 511.1 51.2 1,24.2 51.2 1,24.2 51.2 1,24.2 51.2 1,24.2 51.2 1,24.2 51.2 1,24.2 51.2 1,24.2 51.2 1,24.2 51.2 1,24.2 51.2 1,24.2 51.2 1,24.2 51.2 1,24.2 51.2 1,24.2 51.2 1,24.2 51.2 1,24.2 51.2 1,24.2 51.2 1,24.2 51.2 1,24.2 51.2 1,24.2 52.2 1,24.2	27	100	2200	-	-	4.485.6			59.8	1.797.1	2005	2 198	1 111
440 2200 0.01916 0.01906 4,130.5 0.0 471.0 35.1 1,400.7 516,521.6 410 2200 0.01900 0.01900 3,996.1 0.0 471.0 3.5 1,462.1 525,510.1 410 2200 0.01900 0.01903 4,965.1 0.0 467.1 5.5.5 1,462.1 525,510.1 410 2200 0.01903 0.01903 4,965.9 0.0 467.1 5.5.1 1,515.4 536,562.6 410 2200 0.01903 0.01903 1,907.2 0.0 47.7 1,617.3 534,993.9 90 2200 0.01964 3,907.2 0.0 407.2 65.9 1,714.6 541,796.0 90 2200 0.01970 0.01070 3,442.4 0.0 407.2 65.9 1,714.6 541,796.0 90 2200 0.01970 0.01070 3,442.4 0.0 407.2 65.9 1,714.6 541,796.0 90 2200	3	450	2700		~	4,315.8	0.	0 517.1	57.5	1,354.6	514	336.0	5 097
420 2200 0.01000 0.01005 3.984.1 0.0 471.8 3.5.5 1.442.1 525,710.1 4.10 2200 0.01000 0.01005 3,996.2 0.0 477 1,515.4 530,600.7 4.10 2200 0.01003 0.01003 3,990.2 0.0 477 1,617.3 530,600.7 9.00 2200 0.01003 0.01003 3,972.5 0.0 477 1,617.3 534,901.9 9.00 2200 0.01003 0.01004 3,972.5 0.0 407.2 42.1 54.2 1,500.4 530,600.7 9.00 2200 0.01004 3,472.4 0.0 412.4 52.1 46.1 54.1 54.2	450	110	2200			4,130.5			55.1	1,409.7	518	521.6	123
420 2300 0.01600 0.00600 3,999.2 0.0 4,79.3 53.3 1,515.4 525,502.6 410 2300 0.01600 0.01605 4,065.9 0.0 457.1 54.2 1,500.6 590,600.7 410 2300 0.01605 0.01606 3,575.6 0.0 457.1 52.1 1,601.3 590,600.7 310 2300 0.01655 0.01666 3,575.6 0.0 460.4 52.1 1,601.3 590,500.7 310 2300 0.01666 3,575.6 0.0 460.4 52.1 1,601.3 590,500 310 2300 0.01666 3,597.2 0.0 407.2 65.9 1,714.6 541,700.3 310 2300 0.01666 3,442.4 0.0 418.1 46.5 542,70 546,700.3 310 2300 0.0170 3,239.1 0.0 418.1 46.5 546,703 546,703 310 2300 0.0170 3,239.1	3	130	2200			3,936.1	0	0 471.8	2.5	1,442.1	522	510.1	2.984
410 2200 0.01835 4,063.9 0.0 457.1 54.2 1,500.6 510,103 510,000.7 100 2200 0.01845 0.01842 3,575.4 0.0 466.4 52.1 1,617.3 510,303.6 100 2200 0.01842 0.01842 3,575.4 0.0 466.4 52.1 1,617.3 519,25.5 101 2200 0.01842 0.01846 3,977.2 0.0 466.4 52.1 1,617.4 541,76.0 519,25.5 101 2200 0.01846 0.01864 3,472.4 0.0 412.4 45.9 1,714.6 541,76.0 546,75.3 101 2200 0.01846 0.0170 3,472.4 0.0 413.1 45.17 1,901.9 546,759.3 102 2200 0.0170 0.0170 3,279.1 0.0 393,14.7 43.17 1,912.6 546,759.3 102 2200 0.0176 0.0170 3,279.1 0.0 393.1 43.17 1,91	13	27	2200		Τ.	3,999.2	0	0 479.3	53.3	1,515.4	526	542.6	503.2
400 2200 0.01682 3,575.6 0.0 428.6 47.7 1,617.3 534,935.5 300 2200 0.01682 0.01686 3,977.2 0.0 446.4 52.1 1,647.3 534,935.5 310 2200 0.016816 3,397.2 0.0 446.4 52.1 1,640.3 534,766.0 317 2200 0.01686 0.01702 3,442.4 0.0 446.4 52.1 1,640.3 545,194.3 316 2200 0.01686 0.01702 3,442.4 0.0 418.1 46.5 1,714.6 541,706.0 317 2200 0.01702 0.01702 3,448.5 0.0 418.1 46.5 1,714.6 541,706.0 310 2200 0.01701 0.01702 3,239.1 0.0 418.1 45.5 1,860.2 553,134.7 310 2200 0.01770 3,239.1 0.0 399.1 43.7 1,999.2 556,703.1 310 2200 0.01770	24	410	2200		Ξ.	4,063.9	0.	0 467.1	5.2	1,569.6	530.	1.000.7	517.1
390 2200 0.01642 0.01626 3,907.5 0.0 466.4 32.1 1,704.0 549.55 316 2200 0.016016 3,397.2 0.0 407.2 45.9 1,704.0 541,706.0 317 2200 0.01604 0.01016 3,397.2 0.0 407.2 45.9 1,704.0 541,706.0 316 2200 0.01604 0.01792 3,497.2 0.0 412.4 45.9 1,704.0 545,194.3 310 2200 0.01604 0.01792 3,497.4 0.0 416.1 46.5 1,704.0 546,799.3 310 2200 0.01770 0.01770 3,279.4 0.0 393.1 41.7 1,994.2 546,799.3 310 2200 0.01770 0.01770 3,279.4 0.0 393.1 41.1 1,994.2 546,799.3 310 2700 0.01770 0.01770 3,279.4 0.0 1,994.2 546,72.7 546,72.7 310 270	410	87	2200		Ξ.	3,575.6	.0	0 428.6	1.13	1,617.3	534	303.9	520.2
360 2200 6.01626 0.01616 3,397.2 0.0 407.2 45.3 1,714.6 541,706.0 376 2200 6.01616 0.01064 3,442.4 0.0 412.6 45.9 1,760.5 545,194.3 376 2200 6.01616 0.01702 3,486.5 0.0 418.1 46.5 1,760.5 549,79.3 350 2200 0.01702 0.01701 3,239.1 0.0 418.1 46.5 1,760.5 549,79.3 350 2200 0.01770 0.01770 3,279.4 0.0 393.1 43.2 1,800.2 555,34.7 350 2200 0.01770 0.01770 3,279.4 0.0 393.1 43.2 1,994.2 556,690.3 350 2200 0.01754 0.01754 1,523.0 0.0 1,994.2 556,701.6 350 2200 0.01754 1,523.0 0.0 366.2 20.3 1,994.2 556,703.7 350 2200 0.01754	8	390	2200		~	3,907.5	.0	1.851 0	52.1	1,669.3	536	263.5	542.2
JN Z200 0.01816 0.01804 J,442.4 0.0 412.4 65.9 1,700.5 545,194.3 360 Z200 0.01804 0.01792 J,426.5 0.0 416.1 46.5 1,780.0 546,790.3 350 Z200 0.01792 J,426.5 0.0 416.1 46.5 1,780.0 546,790.3 350 Z200 0.01792 J,279.1 0.0 399.1 416.1 46.5 1,780.2 552,011.6 350 Z200 0.01792 J,279.4 0.0 399.1 413.7 1,994.2 555,334.7 310 Z200 0.01754 0.01754 1,523.0 0.0 160.0 396.0 44.3 1,994.2 556,737.7 310 Z75 0.01754 1,523.0 0.0 160.0 1,994.2 556,734.7 310 Z75 0.01754 1,523.0 0.0 162.4 20.3 1,994.2 556,737.7 310 Z75 0.01754 1,523.0	8	200	2200			3,397.2	.0	2.703 0	45.3	1,714.6	115	706.0	7 855
360 2200 0.01064 0.01792 3,486.5 0.0 416.1 46.5 1,537.0 546,779.3 350 2200 3.01792 0.01781 3,239.1 0.6 366.2 43.2 1,650.2 552,011.6 350 2200 3.01792 0.01770 3,279.4 0.0 393.1 43.7 1,650.2 552,011.6 350 2200 0.01770 3,279.4 0.0 393.1 43.7 1,956.2 553,334.7 350 2200 0.01754 0.01759 3,320.4 0.0 399.1 41.3 1,996.2 556,70.7 310 275 0.01754 1,523.0 0.0 160.0 306.2 20.3 1,996.2 556,710.7 310 275 0.01754 1,523.0 0.0 162.6 20.3 1,996.2 560,710.7 310 275 0.01764 1,523.0 0.0 0.0 0.0 1,996.5 560,710.7 310 275 0.01764	2	376	2200		~	3,442.4	0.	412.6	45.9	1,760.5	545	194.3	204.0
350 2200 a.01702 0.01701 3,239.1 0.0 393.1 43.7 1,650.2 552,011.6 340 2200 0.01770 3,279.4 0.0 393.1 43.7 1,690.2 555,334.7 340 2200 0.01770 3,279.4 0.0 393.1 43.7 1,996.2 555,334.7 310 2200 0.01770 0.01759 3,320.4 0.0 396.0 44.3 1,996.2 556,600.3 310 275 0.01754 0.01754 1,523.0 0.0 162.6 20.3 1,996.2 560,742.7 310 275 0.01754 0.01754 1,523.0 0.0 0.0 0.0 1,996.2 560,742.7 310 275 0.01754 1,523.0 0.0 162.6 20.3 1,996.2 560,742.7 310 275 0.01754 1,523.0 0.0 0.0 0.0 1,996.5 560,742.7 200 275 0.01764 3,072.3 0	370	8	2200		-	3,488.5	l		5.63	1,507.0	548	129.3	1.612
340 2200 0.01770 3,279,4 0.0 393.1 43.7 1,893.9 555,334.7 310 2200 0.01770 0.01759 3,320.4 0.0 396.0 44.3 1,936.2 556,690.3 310 2200 0.01759 0.01759 3,320.4 0.0 162.6 20.3 1,936.2 556,5334.7 310 275 0.01754 0.01754 1,523.0 0.0 162.6 20.3 1,936.2 569,719.7 310 275 0.01754 0.01754 0.0 0.0 0.0 1,956.5 569,719.7 310 275 0.01754 0.01764 3,072.3 0.0 1,956.5 569,719.7 300 275 0.01764 3,072.3 0.0 760.0 155.7 2,155.1 569,719.7 200 275 0.01764 3,072.3 0.0 760.1 569,719.7 201 275 0.01764 5,072.10 0.0 760.0 155.7 2,155.1	2	350	2200	3.01	0.01/81	3,239.1			43.2	1,850.2	552.	011.6	586.0
330 2200 0.01770 0.01759 3,320.4 0.0 366.0 44.3 1,936.2 556,669.3 310 2200 0.01759 0.01754 1,523.0 0.0 162.6 20.3 1,936.2 560,242.7 310 275 0.01754 0.01754 0.01754 0.01754 5.023.3 500,710.7 310 275 0.01754 0.01754 0.01764 3,072.3 0.0 0.0 1,056.5 560,710.7 300 275 0.01754 0.01704 3,072.3 0.0 1,000.0 1,056.1 572,613.0 266 275 0.01704 1,522.10 0.0 1,460.0 155.7 2,155.1 569,719.7 266 275 0.01667 6,527.0 0.0 7,400.0 155.7 2,155.1 591,263.1 210 275 0.01667 6,527.0 0.0 7,600.0 2,357.1 591,263.1 210 275 0.01667 6,527.0 0.0 7,600.0 <t></t>	320	240	2200		0.01/70	3,279.4			13.7	1,893.9	555.	334.7	5.96.3
323 2200 0.01759 0.10754 1,523.0 0.0 182.6 20.3 1,966.5 560,242.7 310 275 0.01754 0.01754 0.01754 0.0 0.0 0.0 1,956.5 569,719.7 310 275 0.01754 0.01754 0.01754 0.01754 0.0 0.0 0.0 1,956.2 569,719.7 300 275 0.01754 0.01704 3,072.3 0.0 0.0 1,956.2 569,719.7 206 275 0.01754 0.01707 11,660.4 0.0 1,600.0 155.7 2,155.1 569,719.7 205 275 0.01764 0.01667 6,527.0 0.0 1,600.0 155.7 2,155.1 599,703.1 210 275 0.01667 6,5066.1 0.0 770.1 501.2 591,263.1 210 275 0.016667 6,006.1 0.0 782.3 597,317.3 210 275 0.016667 6,006.1 0.0 264.3 591,663.1 210 275 0.016667 6,006.1	340	330	2200		0.01759	3,320.4			1.11	1,936.2	558.	699.3	606.5
310 275 0.01754 0.0 0.0 0.0 1,954.5 569,719.7 300 275 0.01754 0.01744 3,072.3 0.0 0.0 0,954.5 569,719.7 300 275 0.01754 0.01704 3,072.3 0.0 1,600.0 155.7 2,155.1 569,719.7 266 275 0.01707 0.11507 11,600.4 0.0 1,600.0 155.7 2,155.1 569,703.1 255 275 0.01667 6,527.0 0.0 782.3 67.0 2,242.1 591,263.1 210 275 0.01667 6,006.1 0.0 720.1 60.1 2,342.1 591,263.1 200 275 0.01669 6,006.1 0.0 720.1 60.1 2,342.1 591,263.1 200 275 0.01669 6,006.1 0.0 720.1 60.1 2,342.1 591,263.1 200 275 0.01669 6,006.1 0.0 720.1 60.1 2,3	330	22	2200		0.01754	1,523.0		1	20.3	1,958.5	560.	242.7	611.2
300 275 0.0174 0.0174 3,072.3 0.0 366.2 41.0 1,999.4 572,813.0 1 266 275 0.01744 0.01707 11,680.4 0.0 1,400.0 155.7 2,155.1 597,669.0 255 275 0.01707 0.10667 6,527.0 0.0 782.3 67.0 2,242.1 597,263.1 210 275 0.01667 6,527.0 0.0 782.3 67.0 2,242.1 597,317.3 210 275 0.01667 6,006.1 0.0 780.1 60.1 2,342.2 597,317.3 210 275 0.01669 6,006.1 0.0 720.1 60.1 2,322.2 597,317.3 200 275 0.016662 2,371.6 0.0 284.3 31.6 2,353.6 599,774.5	2	310	512		0.01754	0.0			0.0	1,958.5	569.	7.917	1 0 109
266 275 0.01744 0.01707 11,660.4 0.0 1,400.0 155.7 2,155.1 564,669.0 1 235 275 0.01667 6,527.0 0.0 782.3 67.0 2,242.1 591,263.1 235 275 0.01667 0.01667 6,527.0 0.0 782.3 67.0 2,242.1 591,263.1 210 275 0.01667 0.01661 0.0 720.1 60.1 2,322.2 597,371.3 200 275 0.01669 6,006.1 0.0 720.1 60.1 2,323.6 597,371.3 200 275 0.01669 0.01662 2,371.6 0.0 284.3 31.6 2,353.6 599,774.5	310	300	215	0.01754	0.01744	3,072.3			41.0	1,999.4	SR.	833.0	610.21
235 275 6.01707 6.527.0 0.0 782.3 67.0 2,242.1 591,263.1 210 275 0.01667 6,006.1 0.0 720.1 60.1 2,322.2 591,263.1 210 275 0.01669 6,006.1 0.0 720.1 60.1 2,322.2 597,317.3 200 275 0.01669 0.01661 0.0 284.3 31.6 2,353.6 599,714.5	2	2002	275	0.01744	0.01707	11,680.4		1	155.7	2,155.1	Sex	0.988	1 1 1 1
210 275 0.01667 0.01669 6,000.1 0.0 720.1 60.1 2,322.2 597,371.3 200 275 0.01669 0.01662 2,371.6 0.0 284.3 31.6 2,353.6 599,774.5	38	235	275	C.01707	0.01667	6,527.0			67.0	2,242.1	145	283.1	0 195
200 275 0.01669 0.01662 2,371.6 0.0 284.3 31.6 2,353.8 599,774.5	235	210	275	0.01667	0.01669	6,006.1			80.1	2,322.2	192	371.5	1 9 0 9
	210	200	275	0.01669	0.01662	2,371.6			31.6	2,353.8	500.	774.5	1.989

ST LUCLE UNIT 2

1.5.1 0. MAK 1.111 2.004 (ppm .voron) 411.9 427.8 199.0 \$02.9 516.9 B/A ADDED TOTAL B/A TOTAL SYS. MASS FINAL COMC. 212.2 529.0 542.0 5.462 57.5 585.8 596.0 6.06.3 0.0 \$53.2 611.0 8.000 610.0 5.440 805.8 1.010 6.65.9 1.56,256.7 485, 736.5 6%, TT3.8 5.111,102 505,418.6 509,964.0 514, 335.3 518,520.8 522,500.6 526,561.9 9.970,052 5.808, 363.2 536,262.7 541,705.3 545, 193.6 552,010.9 555,334.0 558,698.6 560,242.0 569, 719.0 548, 728.6 572,832.2 5.84,668.3 597, 370.6 8.277.992 591,282.4 (Ithe) 1,180.8 1,236.6 1,353.9 1,568.9 1,713.9 0.0 1,032.2 1.296.4 1,408.9 1.461.4 1.514.7 1,616.5 3.868.6 1,759.8 1,806.3 1,849.5 1,937.5 1.957.8 1.957.8 7.6.2 1,893.2 1.998.1 2,353.1 2,241.4 2.154.4 (11) PLANT COOLDOWN FROM 557 F 10 200 F; BANT AT 2.75 wIX BORIC ACID; BUT AT 2500 ppm BOROK 276.0 148.6 59.8 \$7.5 \$5.1 \$2.5 52.3 54.2 41.7 47.9 0.0 7.4.2 55.8 52.1 44.3 \$99 43.2 43.7 5.44 20.3 0.0 41.0 155.7 87.0 80.1 31.6 ((110) (jed) i 05 0.0 0.0 0.0 0.0 537.6 1.534 471.8 1.783 428.6 418.1 398.0 400.0 501.7 517.1 470.3 4.66.4 412.6 346.2 393.1 0.0 5.86 BUT VOL 2 407.2 182.6 782.3 1.027 0.0 0.0 0.0 0.0 3,210.7 0.0 0.0 9.6 0.0 0.0 B JON INGS 70 F (gal) 1,172.0 630.9 0.0 0.9 0.0 0.0 0.6 0.6 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 5,255.1 4,485.6 4,313.8 4,130.5 3,488.5 3,239.1 6,527.0 MASS([bm) 0.0 3,575.6 3,907.5 3, 397.2 3.442.4 1,523.0 26,741.7 9,761.3 3,936.1 3,999.2 3, 320.4 4,185.3 4.063.9 SKR I NKAGE 3.279.4 0.0 3,072.3 11,680.4 6,008.1 2,371.6 SPECIFIC VOLUME 0.01826 0.01816 0.02032 2.01933 0.01885 0.01855 0.01642 0.01804 0.01792 0.01781 0.01759 0.01951 6.01916 0.01870 0.01770 1.00000 0.01990 0.01968 0.01900 0.01754 0.01754 0.01744 0.01707 0.01687 0.01669 0.01662 (cu.ft./lbm) 1 1.00000 * 0.02157 0.02032 0.01870 0.01990 0.01968 0.01951 0.01953 J.01916 0.01900 0.01885 0.01855 0.01842 0.01828 0.01816 0.01770 0.01759 0.0174 0.01707 0.01669 0.01792 0.01781 0.01754 0.01687 0.01804 0.01744 5 5013.6 galions P.28 PRE 26 22000 22000 22000 2200 22000 20022 2200 22000 2200 2200 2200 2200 2200 2200 22000 22000 22000 22000 2200 22000 52 575 275 273 275 27 (paise) 510 557 8 23 27 3 659 640 430 3 410 8 8 3 370 3 350 22 350 22 310 3 22 210 235 2 TOTAL SAMT VOLUME AME.STS. IEMP. 2 (8) 510 83 557 557 23 27 597 450 440 3 120 410 89 8 3 370 3 350 270 330 325 310 200 260 235 210 iii

0

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Tahle 2-32

FINAL COMC. (ppm boron) 459.1 552.1 1.011 \$.104 143.3 6.213 \$01.8 \$15.8 \$27.9 563.3 514.5 0.0 246.8 6.181 6.042 5.864.7 6.900 8.992 0.908 G43.2 661.8 678.5 A55.0 TOTAL B/A TOTAL SYS. MASS 485,666.0 6.1.6.20 505, 340.0 514,331.9 9.101,122 500,595.1 509,960.6 518,517.5 522,506.0 526,558.5 530,676.6 8.995, 422 5.96,259.4 545, 190.2 545, 725.2 522,007.5 \$55, 330.6 558,645.3 560,230.6 1.211,908 572,828.9 84,665.0 1.98,238.7 91,279.0 5.102.190 1011 46 (Ibe) 936.0 1,056.9 1,178.0 1,293.0 1,405.6 1,565.5 1,869.8 0.0 1.500 1,350.5 1,458.1 1,613.2 1,665.3 1,710.6 1.756.4 1,802.9 1.511.4 1.846.1 1.934.1 7.246.1 2,151.1 1.954.4 1.954.4 2,238.1 2,318.1 (Ibe) PLANT COOLDOAM FROM 557 F 10 200 F; BANT AT 2.50 w1% BORIC ACID; BUT AT 2500 ppm BOROM B/A ADDED 115.0 1.585 250.3 119.1 57.5 55.1 52.5 53.3 54.2 1.13 52.1 45.9 46.5 43.2 43.7 20.3 41.0 0.0 55.7 87.6 ((())) Ruf VOL 2 50 f (gel) 0.0 0.0 428.6 407.2 8.11.8 470.3 487.1 412.6 418.1 366.2 517.1 1.81 393.1 398.0 0.0 400.0 782.3 720.1 284.3 182.6 5.862 ST. LUCIE UNIT 2 RAMI VOL 2 70 F (gal) 0.0 3,210.7 1,172.0 575.6 557.8 538.5 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 9,761.3 4.645.9 4,313.8 4,130.5 3,936.1 3,999.2 4,063.9 3, 397.2 11,660.4 MASS(Ibm) 3,442.4 3,486.5 1,523.0 0.0 3,072.3 26,741.7 4. 74K.5 4,485.6 3,239.1 3,279.4 3, 320.4 SHR INKAGE 6,008.1 2,371.4 SPECIFIC VOLUME 0.02032 0.01900 0.01870 0.01842 0.01828 0.01814 0.01792 0.01759 0.01707 0.01990 0.01970 0.01933 0.01916 0.01665 0.01855 1.00000 0.01754 0.01754 0.01744 0.01804 0.01781 0.017/0 6.01687 0.01951 0.01669 0.01662 (cu.ft./lbm) - 14 1.30000 0.02:37 0.02032 0.01990 0.01970 9.01951 0.019 53 91410.0 0.01900 0.01885 0.01870 0.01855 0.01626 0.01816 0.01770 0.01842 0.01759 0.01707 0.01792 0.01781 9.01754 0.0174 0.01504 0.01744 0.01667 0.01669 gallons -PZR PRESS (paia) 2200 22000 2200 2200 2200 2200 2200 2200 2200 2200 2200 22000 2200 22000 2200 2200 22000 2200 2200 22000 275 0.156.0 275 275 512 275 R2 510 557 8 3 027 100 150 110 957 8 410 8 370 3 350 240 530 2 310 992 8 8 8 235 210 TOTAL BANT VOLUME -AVG.STS. IEM. (1) 557 557 510 8 3 027 3 150 977 630 877 410 8 3 350 34.0 330 323 3 370 510 8 235 210 -

Required Boron Concentration for a Cooldown from 557 Degrees to 200 Degrees				
Temperature	Concentration			
(Degrees F)	(ppm boron)			
557	-71.2			
510	133.0			
490	203.0			
480	235.5			
470	262.3			
460	289.8			
450	314.1			
440	338.0			
430	360.6			
420	382.0			
410	403.4			
400	423.9			
390	443.0			
380	461.2			
370	474.5			
360	488.7			
350	500.9			
340	512.6			
330	523.5			
325	528.7			
310	543.6			
300	568.8			
260	589.9			
235	608.7			
. 210	627.6			
200	634.9			
199.9*	539.9			
199.9**	570.3			

Table 2-33 quired Boron Concentration for a Cooldo

*Note: After Shutdown margin change from 5.0% delta k/k to 3.5% delta k/k. **Note: The boracion requirement for a 3.5% shutdown margin and core is xeron free.

Minimum Boric Acid Makeup Tank Boration Volume vs. Stored Boric Acid Concentration for Modes 1, 2, 3, and 4

Minimum Volume (gallons)

BAMT	RWT at	RWT at	RWT at	RWT at	RUT at
Conc	1720ppm	1850 ppm	2000 ppm	<u>2150 ppm</u>	2300 ppm
3.5	4,842.2	4,554.1	4,144.3	3,732.0	3,325.7
3.25	5,403.6	5,069.0	4,669.0	4,203.7	3,732.0
3.0	6,105.0	5,730.3	5,347.6	4,784.4	4,263.2
2.75	6,968.6	6,572.5	6,106.0	5,569.5	5,013.6
2.5	8,118.1	7,732.2	7,256.6	6,720.4	6054.6

Minimum Stored Boric Acid Makeup Tank Volume vs. Stored Boric Acid Concentration for Modes 1, 2, 3, and 4

BAMT Conc	RWT at 1720 ppm	RWT at 1850 ppm	RWT at 2000 ppm	RWT at 2150 ppm	RWT at 2300 ppm
3.5	5,350	5,100	4,650	4,250	3,850
3.25	5,950	5,600	5,200	4,750	4,250
3.0	6,650	6.250	5,850	5,300	4,800
2.75	7,500	7,100	6,650	6,100	5,550
2.50	8,650	8,250	7,800	7,250	6,600

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Minimum Volume (gallons)

Calculation of the 16,030 Gallon Volume In Specification 3/4.1.2

12,281.0 gallons	Cooldown to 325 degrees and 275 psia (Part A)
+8,235.1	Cooldown to 200 degrees on shutdown cooling (Parts B & C)
-5,350.0	Smallest BAMT inventory value for 1720 ppm Boron in the RWT from
15,166.1 gallons	Table 2-35 Total
10 000 0	

16.000.0 gallens

 \mathcal{F}_{i}

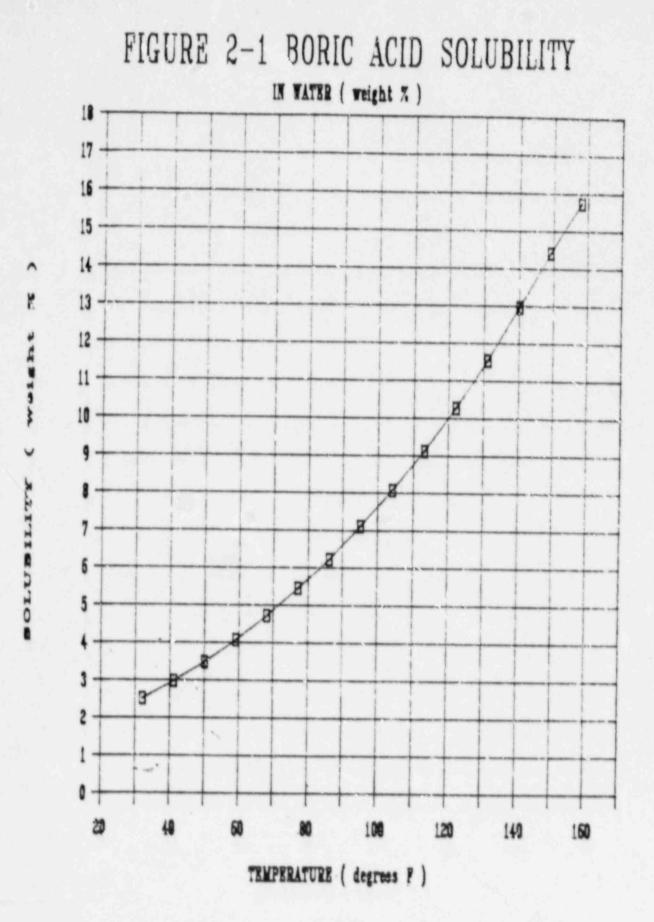
Total rounded up to the nearest 1900 gallons

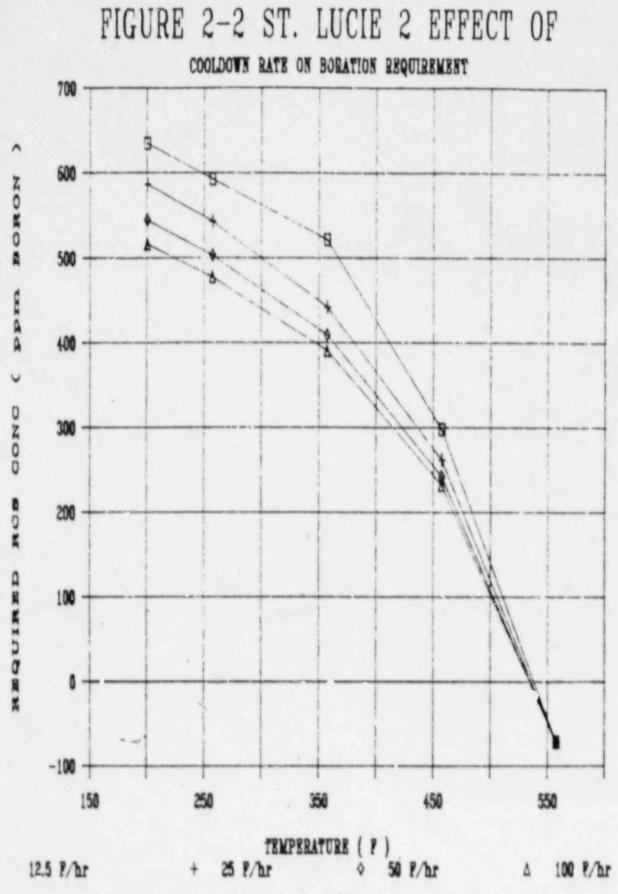
Calculation of the 12,000 Gallon Volume In Specification 3/4.1.2

12,281.0 gallons	Cooldown to 325 degrees and 275 psia (Part A)
+8235.1	Cooldown to 200 degrees on shutdown cooling (Parts B & C)
<u>-8,650</u>	Greatest BAMT inventory value for 1720 ppm Boron in the RWT from Table 2-35
11,866.1 gallons	Total
12,000 gallons	Total rounded up to the nearest 1000 gallons

Calculation of the 35,000 Gallon Volume In Specification 3/4.1.2 for St. Lucie 1

14,080 gallons	System feed-and-bleed prior to couldown
+12,281.0	Cooldown to 325 degrees and 275 psia (Part A)
<u>+ 8,235.1</u>	Cooldown to 200 degrees on shutdown cooling (Parts B & C)
34,615.1 gallons	Total
35,000 gallons	Final volume rounded up to the nearest 1000 gallons.





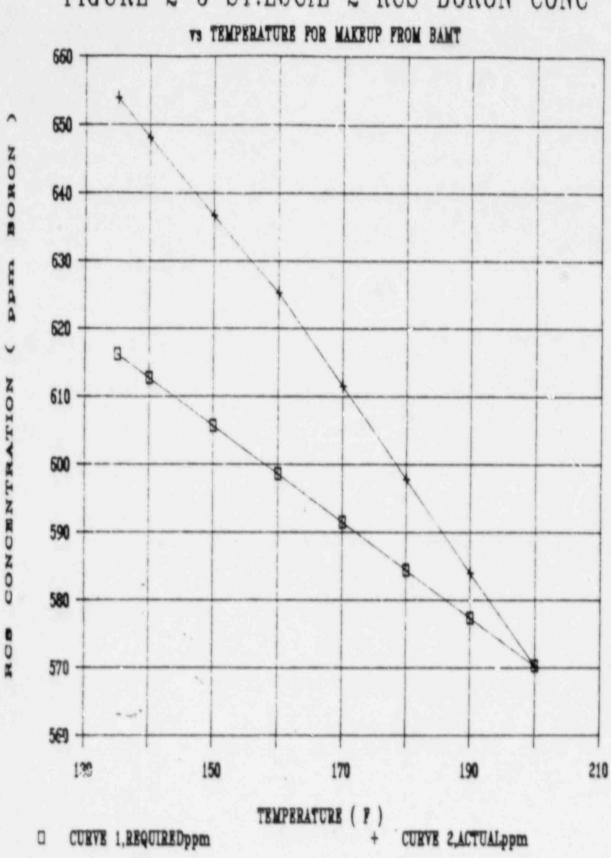
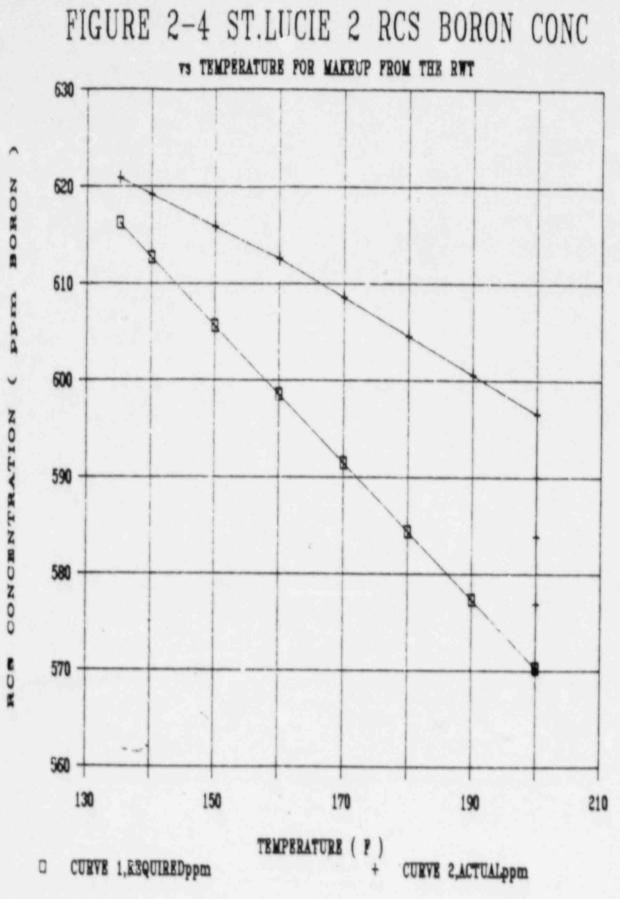
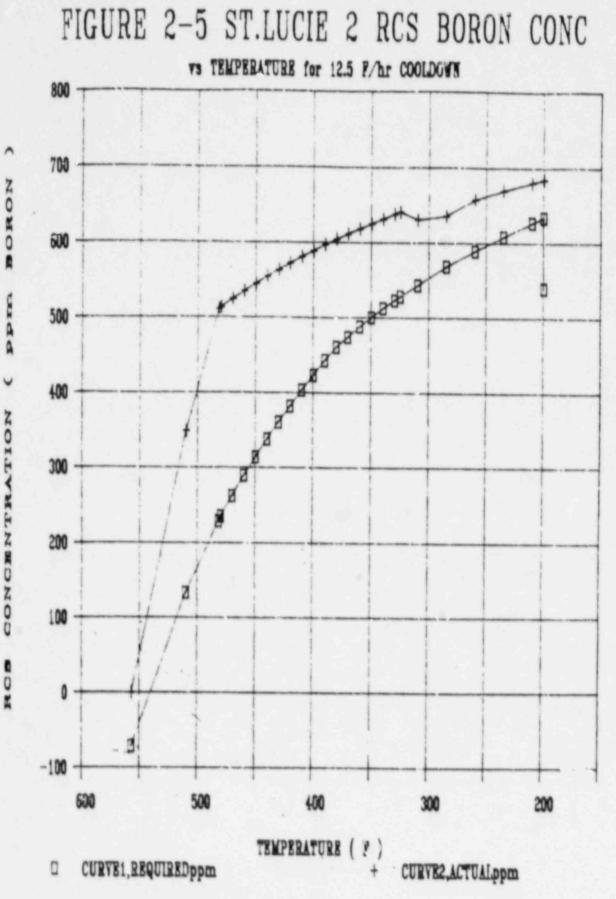
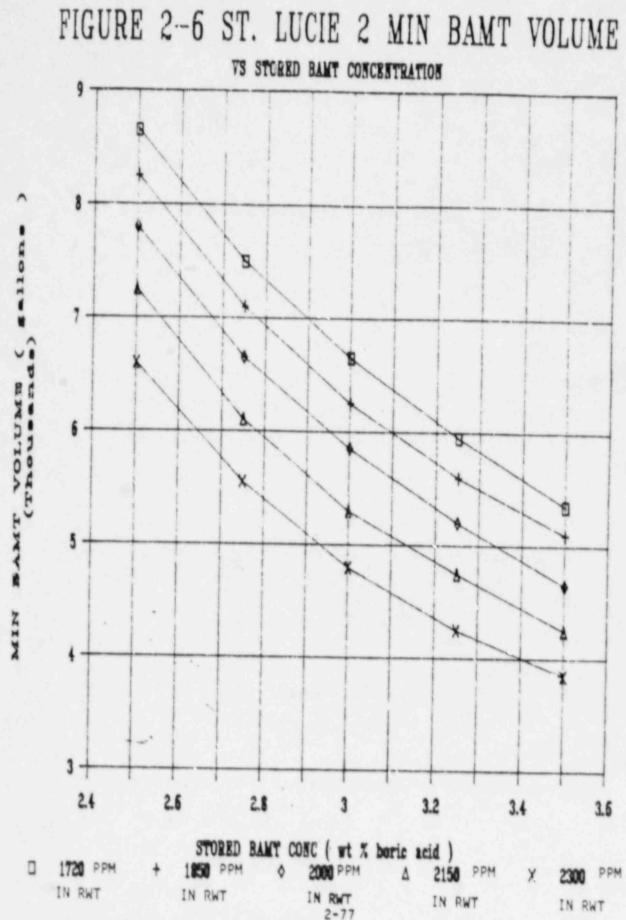
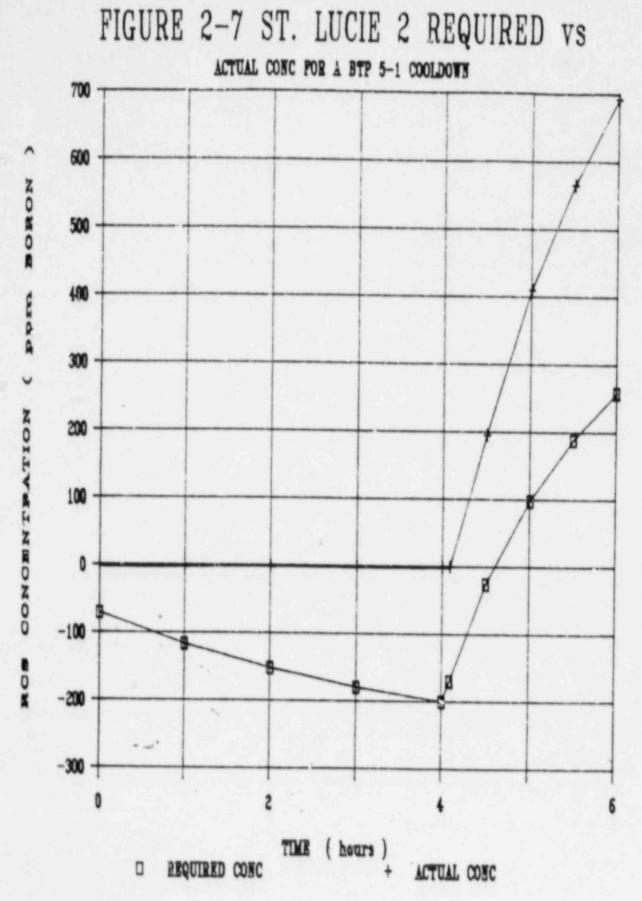


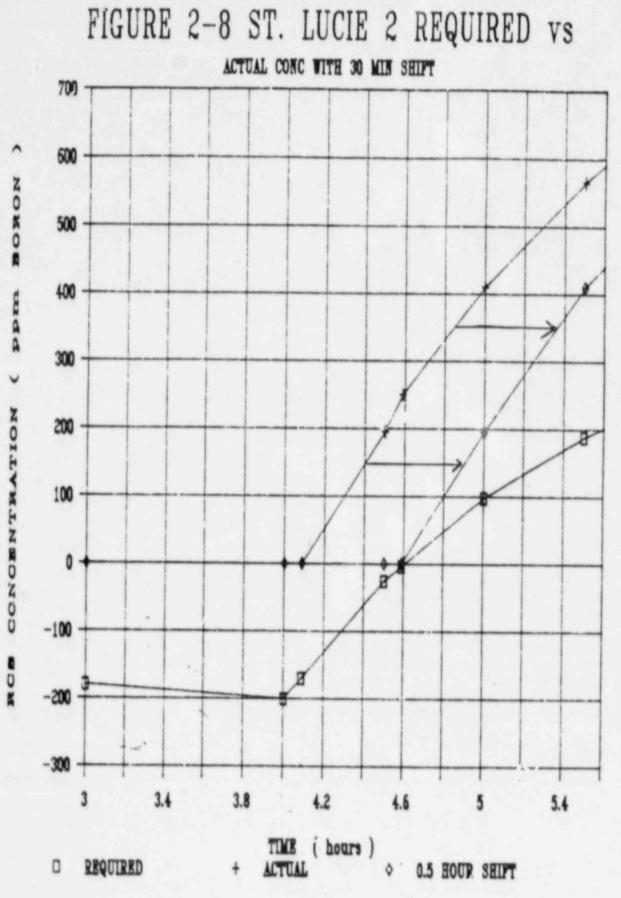
FIGURE 2-3 ST.LUCIE 2 RCS BORON CONC

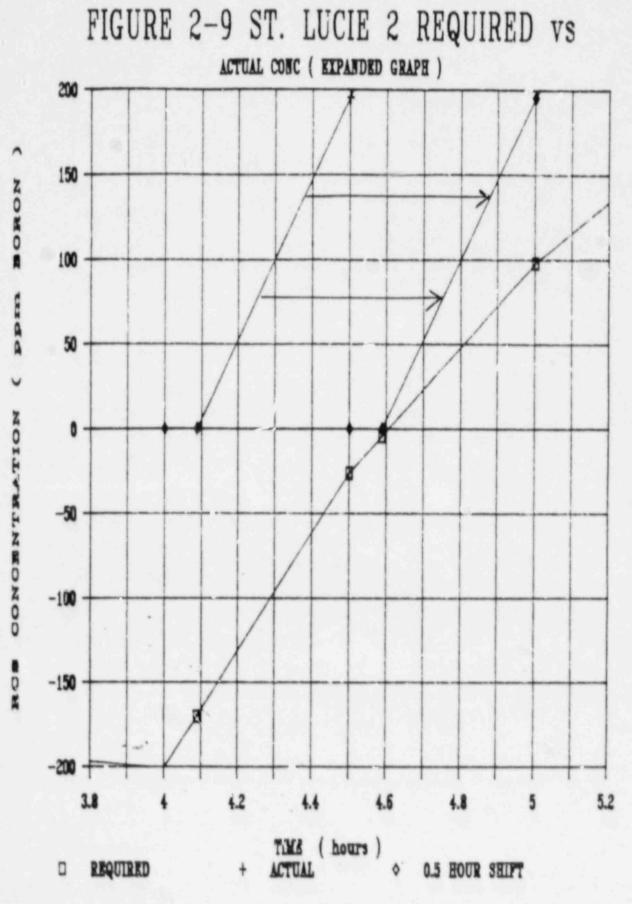


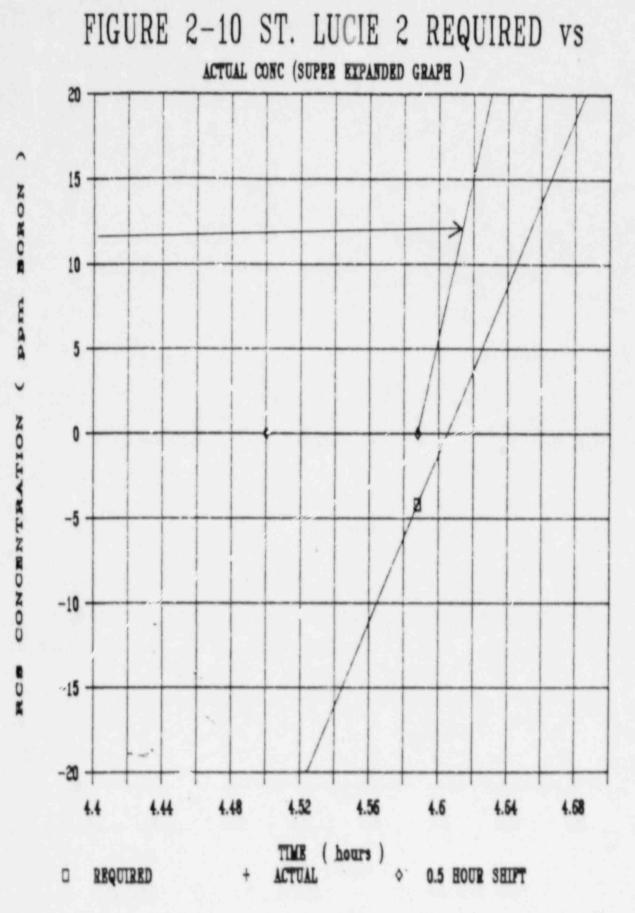












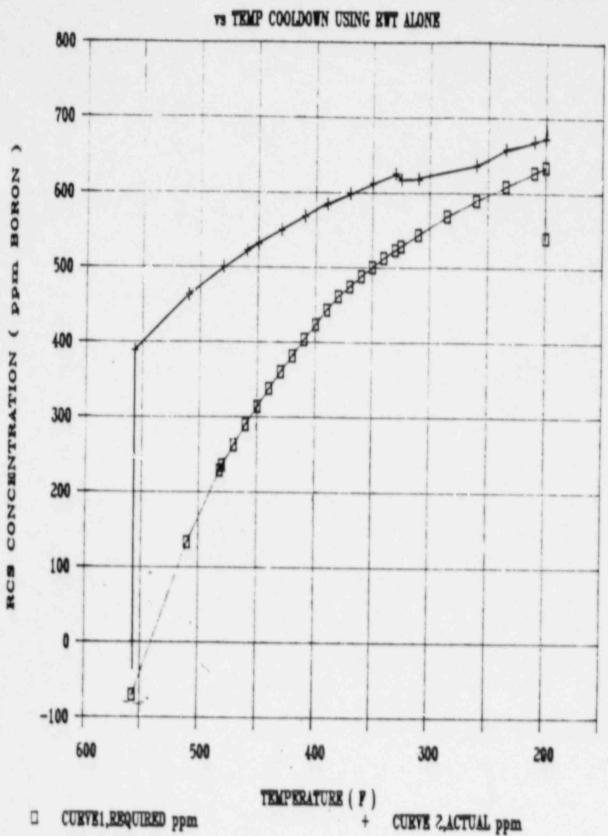


FIGURE 2-11 ST.LUCIE 2 RCS BORON CONC

3.0 OPERATIONAL ANALYSIS

3.1 INTRODUCTION TO THE OPERATIONAL ANALYSIS

The remaining Sections of this report present the results of an evaluation performed in order to demonstrate the general impact on plant operations of a reduction in boric acid makeup tank concentration. The specific areas that will be discussed include operator response to emergency situations, typical plant feed-and-bleed operations, typical plant blended makeup operations, plant shutdown to refueling, and plant shutdown to cold shutdown. Because it is obviously an impossible task to evaluate each of these five areas and consider all possible combinations of plant conditions, initial plant parameters and analysis assumptions that were used in the evaluation were selected, where possible in a conservative manner in order to give worst case type answers. As a consequence, the results, i.e., the volumes and final concentrations that were obtained, should in general be bounding for any event or any set of initial plant conditions.

3.2 RESPONSE TO EMERGENCY SITUATIONS

In general, credit is not taken for boron addition to the reactor coolant system from the boric acid makeup tanks for the purpose of reactivity control in the accidents analyzed in Chapter 15 of the plant's Final Safety Analysis Report. The response of an operator, therefore, to such events as steam line break, overcooling, boron dilution, etc., will not be affected by a reduction in boric acid makeup tank concentration. In particular, the action statements associated with Technical Specification 3.1.1.1- and Technical Specification 3.1.1.2 require that boration be commerced at greater than 40 gallons per minute using a solution of at least 1720 ppm boron in the event that shutdown margin is lost. Such statements are conservatively based upon the refueling water tank concentration and are therefore independent of the amount of boron in the BAMTs. In addition, the acceptance criteria developed for the Reactivity Control Section of the Functional Recovery Guidelines of Reference 4.2 are based upon a boron addition rate of 40 gallons per minute and are also independent of the exact boration source concentration.

3.3 FEED-AND-BLEED OPERATIONS

During a feed-and-bleed operation to increase system boron content, the charging pumps are used to inject concentrated boric acid into the RCS with the excess inventory normally being diverted to the liquid waste system via letdown. The rate of increase in boron concentration is proportional to the difference between the system concentration at any given time and the concentration of the charging fluid. From this basic relationship, an equation describing feed-and-bleed can be derived. (Appendix 1 contains the derivation of the reactor coolant system feed-and-bleed equation). In general, if the concentration within the boric acid makeup tanks is reduced to the point where heat tracing is no longer required, the maximum rate of change of RCS boron cuncentration that an operator can expect to see during feed-and-bleed will be less than currently achievable.

The purpose of the evaluation performed in this section of the report was to show the exact feed-and-bleed rates that can be expected using boric acid makeup tanks having a reduced concentration. The analysis was done assuming hot zero power conditions with other key parameters and conditions shown in Table 3-1. Both a one charging pump and a two charging pump feed-and-bleed were evaluated from two initial system concentrations: zero ppm and 800 ppm. The results are presented in

Table 3-2 to Table 3-5. Equation 9.0 of Appendix 1 was used to generate the results in these tables. The value of the system mass used to obtain the time constant in Equation 9.0 was calculated as follows for St. Lucie 2:

or

$$(m_w) = \frac{9,398 \text{ ft}^3}{0.020854 \text{ ft}.^3/1\text{bm}^{(1)}} + \frac{450 \text{ ft}^3}{0.02669 \text{ ft}^3/1\text{bm}^{(2)}}$$

From this system mass (477,626.2 lbm), the value of the feed-and-bleed time constant for one charging pump is

$$T_{40} = \frac{467,517.2 \text{ lbm}}{40 \text{ gpm x } 8.329 \text{ lbm/gallon (3)}}$$

or

and the value of the feed-and-bleed time constant for two charging pumps is

or

--- T₈₄ = 668.2 min.

(1) Specific volume of compressed water at 532 degrees and 2200 psia.

(2) Specific volume of saturated water at 2200 psia.

(3) Water density at 70 degrees.

Several of the concentration results shown in Table 3-2 through Table 3-5 are plotted in Figures 3-1 and 3-2 for comparison. Note that significant feed-and-bleed rates will be achievable following the reduction in boric acid makeup tank concentration levels.

3.4 BLENDED MAKEUP OPERATIONS

During typical plant blending operations, concentrated boric acid via FCV-2210Y is mixed with demineralized water via FCV-2210X at the blending tee and then added to the volume control tank. Since the ability to blend and add makeup to the reactor coolant system and to other systems is important to plant operations, three different parametric studies were performed in order to demonstrate the effect of a reduction in boric acid makeup tank concentration. The studies performed were as follows:

- Flow through FCV-2210Y is varied between 0.5 gpm and 15.0 gpm while the flow through FCV-2210X is varied to give a total flow out of the blending the of 44 gallons per minute.
- Flow through FCV-2210Y is varied between 0.5 gpm and 15.0 gpm while the flow through FCV-2210X is varied to give a total flow out of the blending tee of 88 gallons per minute.
- Flow through FCV-2210Y is varied between 0.5 gpm and 15.0 gpm while the flow through FCV-2210X is varied to give a total flow out of the blending tee of 132 gallons per minute.

In each of the three studies, the temperature of the boric acid makeup tank and the temperature of the demineralized water supply was assumed to be 70 degrees. The results are shown in Table 3-6 through Table 3-8. The final concentration out of the blending tee in each of these tables was obtained using the following equation:

$$C_{out} = \frac{(F_y \cdot C_y)}{(F_y \cdot C_y) + (F_{out} \cdot D_w)} (100) (1748.34).$$

In this equation, C_{out} is the concentration coming out of the blending tee in ppm boron, F_y is the flowrate coming out of CH-0210Y in gallons per minute, C_y is the concentration of the boric acid makeup tanks in 1bm per gallon, F_{out} is the total flow coming out of the blending tee in gallons per minute, D_w is the density of water at 70 degrees in 1bm per gallon, and 1748.34 is the conversion factor between concentration expressed in terms of weight percent boric acid and concentration expressed in terms of ppm boron. (See Appendix 4 for a derivation of this conversion factor). The data contained in Tables 3-6, 3-7, and 3-8 is plotted in Figure 3-3 through Figure 3-5. Note that following the reduction in BAMT concentration, a full range of flowrates and boron concentrations are available for blended makeup operations.

3.5 SHUTDOWN TO REFUELING - MODES 6

The plant shutdown to the refueling is typically the most limiting evolution that an operator must perform with respect to system boration, i.e., this evolution normally requires the maximum amount of boron to be added to the reactor coolant system. A shutdown to refueling normally occurs at the end of core cycle when the critical boron concentration is low and requires an increase to the refueling boron concentration. In the most limiting case, boron concentration must be raised from zero ppm to the present refueling concentration of 1720 ppm.

This section presents the evaluation results of a plant shutdown to refueling. The evaluation was performed specifically to demonstrate the effect on makeup inventory requirements of a reduction in boric acid storage tank concentration. A list of key parameters and conditions assumed in the analysis is contained in Table 3-9. The evaluation was performed for end-of-cycle conditions in order to maximize the amount of boron that must be added to the reactor coolant system. As a result, the boron concentration within the RCS was required to be increased from zero ppm to the present refueling concentration of 1720 ppm. The shutdown for refueling was assumed to take place as follows:

- The reactor is shutdown via rod insertion to hot zero power conditions.
- Following shutdown, at time zero, operators commence system feed-and-bleeds for both plants using three charging pumps and the boric acid makeup tanks. (BAMT concentration is assumed to be 3.5 weight percent boric acid).
- The feed-and-bleed is conducted for 40 minutes, after which time it is secured.
- 4. A plant cooldown and depressurization is commenced from an average coolent temperature and system pressure of 532 degrees and 2250 psia to an average coolant temperature and system pressure of 325 degrees and 275 psia. An overall cooldown rate of approximately 100 degrees per hour is assumed. Makeup inventory is supplied from the boric acid makeup tanks.
- The shutdown cooling system is placed in operation at 325 degrees and 275 psia. (Prior to initiation, the concentration within the SDCS is assumed to be equal to the concentration in the reactor coolant system).

a set

 The plant cooldowns are continued following shutdown cooling initiation from 325 degrees to 135 degrees at 275 psia. A rate of 100 degrees per hour is assumed over the whole temperature range.

Evaluation results showing the system concentrations as a function of time and total boric acid makeup tank inventory requirements are contained in Table 3-10. Loop average temperature and system boron concentration data from this table is plotted in Figure 3-6. Concentrations during the initial feed-and-bleed operation was calculated using the methodology discussed in Section 3.3 above. Concentrations during the subsequent plant cooldown were calculated in the same manner as the concentrations for the plant cooldowns in Section 2.4. Note that the boron content of the RCS was raised from zero ppm at the start of the evaluation to greater than 1720 ppm by the time the plants had been cooled and depressurized to 135 degrees and 275 psia. A total volume of 23,085.0 gallons of a 3.5 weight percent boric acid solution was required. Of this volume, 5120 gallons were used during the initial forty minute plant feed-and-bleed operation, and 17,965.0 gallons were charged into the system to compensate for shrinkage during the cooldown process.

As can be seen from the results in Table 3-10, the volume of a 3.5 weight percent boric acid solution that is required in order to perform the shutdown to refueling is approximately 2.3 times the capacity or one boric acid makeup tank. Note that this result is conservative or bounding, and therefore, represents the maximum volume that would be required to be available assuming a refueling concentration of 1720 ppm boron and a boric acid makeup tank concentration of 3.5 weight percent boric acid. Since there are only two boric acid makeup tanks in each plant, with the combined capacities of approximately 19,950 gallons, additional provisions or operator actions are required in order to place the plant in Mode 6. These provisions could include some combination of the following:

 The initial plant feed-and-bleed and some portion of the plant cooldown could be performed using the refueling water tank. This would decrease the amount of inventory needed from the boric acid makeup tanks.

- Prior to conducting the evolution, both boric acid makeup tanks are full and available for use.
- During the initial part of the evolution, charge from one boric acid makeup tank until depleted, then transfer to the second RAMT. Concurrent with continued cooldown, replenish inventory in the first tank.

These provisions, or operator actions, would need to be considered only once during core cycle, just prior to conducting a shutdown for refueling. Note that they are relatively simple actions that should be well within the current plant operating procedures. In addition, they can be planned for in advance so as to have no impact on maintenance activities or the plant refueling schedule.

3.6 SHUTDOWN TO COLD SHUTDOWN - MODE 5

As discussed in the previous Section, the shutdown to refueling is the most limiting evolution that an operator must perform with respect to system boration. This evolution is normally performed once during a fuel cycle just prior to refueling. Situations (such as unscheduled plant maintenance, etc.) can occur during a fuel cycle, however, and require that an operator perform a plant shutdown to cold shutdown conditions. Although not limiting with respect to boration requirements, it isimportant for an operator to be able to perform such a shutdown quickly and efficiently.

This section presents the evaluation results of a plant shutdown to cold shutdowp. The analysis was performed specifically to demonstrate the effect on makeup inventory requirements of a reduction in boric acid storage tank concentration. A list of key parameters and conditions assumed in the analysis is contained in Table 3-11. In addition to the parameters in Table 3-11, the evaluation was performed for end-of-cycle conditions assuming a cold shutdown concentration of 800 ppm boron. As a result, boron concentration had to be increased from zero ppm to 800 ppm boron. The operator scenario employed in the shutdown to cold shutdown is as follows:

- The reactor is shutdown to hot zero power conditions via rod insertion.
- 2. A plant cooldown and depressurization is immediately commenced from an average coolant temperature and system pressure of 532 degrees and 2200 psia to an average coolant temperature and system pressure of 325 degrees and 275 psia. An overall cooldown rate of approximately 100 degrees per hour is assumed. Makeup inventory is supplied from the boric acid makeup tanks.
- The shutdown cooling system is placed in operation at 325 degrees and 275 psia.
- The plant cooldown is continued following shutdown cooling initiation from 325 degrees to 135 degrees at 275 psia. Makeup inventory is supplied from the boric acid makeup tanks.

Evaluation results showing the system concentrations as a function of time and total boric acid makeup tank inventory requirements are contained in Table 3-12 and Table 3-13. Note that two cases were analyzed for comparison. In Case I the concentration within the shutdown cooling system was assumed to be equal to the concentration of the reactor coolant system at the time of shutdown cooling initiation. In Case II the concentration within the shutdown cooling system was assumed to be equal to the concentration of the refueling water tank at the time of shutdown cooling initiation. System boron concentration data from these two tables are plotted in Figure 3-7 and Figure 3-8. Concentrations during the plant cooldown were calculated using the methodology discussed in Section 2.4. During those portions of the plant cooldown in which blended makeup was used, data was calculated using the methodology contained in Section 3.4.

A total volume of 10,243.7 gallons of a 3.5 weight percent boric acid solution were required in order to perform the shutdown to cold shutdown for the case in which the concentration of the fluid within the shutdown cooling system was assumed to be equal to that of the reactor coolant system at the time of shutdown cooling initiation. In the case where the concentration within the shutdown cooling system was assumed to equal that of the refueling water tank at the time of shutdown cooling initiation, a total volume of 7248.1 gallons was required. Note that approximately 2995.6 gallons less of the boric acid makeup tank inventories were required to be used in the Case II cooldown. Since the plant operating procedures require that the shutdown cooling system be operated via recirculation within that system will normally be very near that of the RWT any time that the shutdown cooling system is placed in operation.

3.7 LONG TERM COOLING AND CONTAINMENT SUMP pH

The impact of the Boric Acid Reduction Effort on post LOCA long term cooling and containment sump pH control was reviewed. Each analysis is discussed qualitatively below.

Performance of the Emergency Core Cooling System (ECCS) during extended periods of time following a loss-of-coolant accident (LOCA) was analyzed in Section 6.3.3.4 of the St. Lucie 2 FSAR. Long term residual heat removal is accomplished by continuous boil-off of fluid in the reactor vessel. As borated water is delivered to the core region via safety injection and virtually pure water escapes is steam, high levels of boric acid may accumulate in the reactor vessel. As an input to this analysis, boric acid makeup tank (BAMT) boron concentration was assumed to be 12 weight percent. This calculation conservatively bounds the maximum boric acid makeup tank boron concentration of 3.5 weight %.

A detailed calculation will be performed by Florida Power and Light Company to determine the effects of boric acid concentration reduction on the post LOCA sump P^H and containment spray P^H . This evaluation will be conducted to determine if the hydrazine addition rate or total quantity injected by the containment spray system needs to be changed to maintain the sump and containment spray within the P^H ranges specified in the St. Lucie Unit 2 FSAR. Two boundary cases are provided for this review and are listed below:

Minimum BAMT Boric Acid contribution

Maximum BAMT Boric Acid

4,850 gallons of 3.5 weight % boric acid solution

19,950 gallons of 2.5 weight % boric acid solution

Key Plant Parameters and Conditions Assumed in Generating the Feed-and-Bleed Curves

- Reactor coolant system volume = 9,398 ft³. a. Reactor coolant system pressure = 2200 psia. b. Reactor coolant system average temperature = 532 degrees. c. Pressurizer volume = 450 ft³. d. Pressurizer is sacurated. e. Zero reactor coolant system Technical Specification leakage. f. Boric acid makeup tank temperature = 70 degrees. g. Complete and instantaneous mixing between the pressurizer and the h. reactor coolant system. Constant pressurizer lavel maintained during the feed-and-bleed 1.
- j. Letdown flowrate from one charging pump = 40 gpm.

process.

k. Letdown flowrate from two charging pumps = 84 gpm.

Feed-and-Bleed Using One Charging Pump from an

Initial RCS Concentration of 0 ppm Boron

St. Lucie #2

RCS Boron Concentration (ppm boron)

	BAMT at	BAMT at	BAMT at	8AMT at	BAMT at	BAMT at
Time (min)	0.98 wt 1	2.50 wt %	2.75 wt %	3.00 wt %	3.25 wt %	3.50 wt %
10	12.2	31.0	34.1	37.2	40.3	43.4
20	24.3	61.9	68.0	74.2	80.4	86.6
30	36.4	92.5	101.7	110.9	120.2	129.4
40	48.3	122.8	135.1	147.4	159.7	172.0
50	60.2	153.0	168.3	183.6	198.9	214.2
60	72.0	182.9	201.2	219.5	237.8	256.1
70	83.7	212.7	234.0	255.2	276.5	297.7
80	95.3	242.2	266.4	290.6	314.9	339.1
90	106.8	271.5	298.7	325.8	353.0	380.1
100	118.3	300.6	330.7	360.9	390.8	420.9
110	129.7	329.5	362.5	395.4	428.4	461.3
120	141.0	358.2	394.1	429.9	465.7	501.5

Feed-and-Bleed Using Two Charging Pumps from an Initial RCS Concentration of 0 ppm Boron

St. Lucie #2

RCS Boron Concentration (ppm Loron)

*

	BAMT at	BAMT at	BAMT at	BACT at	.al at	BAMT at
Time (min)	0.98 wt 1	2.50 wt 1	2.75 wt %	3.00 wt 1	3.25 wt %	3.50 wt %
20	.5.5	64.9	71.4	77.9	84.4	90.9
20	50.7	128.9	141.8	154.7	167.5	180.4
30	75.5	191.9	211.1	230.3	249.5	268.6
40	99.9	254.0	279.4	304.8	330.2	355.5
50	124.0	315.1	346.6	378.1	409.7	441.2
60	147.7	375.4	412.9	450.4	488.0	525.5
70	171.1	434.7	478.2	521.7	565.1	608.6
80	194.1	493.2	542.5	591.8	641.1	690.4
90	216.7	550.8	605.9	660.9	716.0	771.1
100	239.1	607.6	668.3	729.0	789.8	850.5
110	261.1	663.5	729.8	796.1	862.4	928.8
120	282.7	718.5	790.4	862.2	934.0	1005.9

0

Feed-and-Bleed Using One Chars Pumps from an

Initial RCS Concentration of 800 ppm Boron

St. Lucie #2

RCS Boron Concentration (ppm boron)

	BAMT at					
Time (min)	0.98 wt %	2.50 wt %	2.75 wt %	3.00 wt %	3.25 wt %	3.50 wt %
10	306.5	825.3	828.4	831.5	834.6	837.7
20	813.0	850.6	856.7	862.9	859.1	875.3
30	819.5	875.6	884.8	894.0	903.3	912.5
40	825.8	900.3	912.6	924.9	937.2	949.5
50	832.2	925.0	940.3	955.6	970.9	986.2
60	838.5	949.4	967.7	986.0	1004.3	1022.6
70	844.8	973.8	995.1	1016.3	1037.6	1058.8
80	851.0	997.9	1022.1	1046.3	1070.6	1094.8
90	857.1	1021.8	1049.0	1076.1	1103.3	1130.4
100	863.3	1045.6	1075.7	1105.8	1135.8	1165.9
110	869.4	1069.3	1102.2	1135.1	1168.1	1201.0
120	875.4	1092.6	1128.5	1164.3	1200.1	1201.0
						1235.5

Ferd-and-Bleed Using Two Charging Pumps from an

Initial RCS Concentration of 800 ppm Boron

St. Lucie #2

RCS Boron Concentration (ppm boron)

	BAMT at					
Time (min)	0.98 wt 1	2.50 wt %	2.75 wt %	3.00 wt %	3.25 wt %	3.50 wt %
89 (Berge 197						
10	813.6	853.0	859.5	866.0	872.5	879.0
20	827.1	905.3	918.2	931.1	943.9	956.8
30	840.4	956.9	976.0	995.2	1014.4	1033.5
40	853.4	1007.5	1032.9	1052.3	1083.7	1109.0
50	866.3	1057.4	1088.9	1120.4	1152.0	1183.5
60	879.0	1006.7	1144.2	1181.7	1219.3	1256.8
70	891.5	1155.1	1198.6	1242.1	1285.5	1329.0
80	903.8	1202.9	1252.2	1301.5	1350.8	1400.1
90	915.9	1250.0	1305.1	1360.1	1415.2	1470.3
100	927.9	1296.4	1357.1	1417.8	1478.6	1539.3
110	939.7	1342.1	1408.4	1474.7	1541.0	1607.4
120	951.2	1387.0	1458.9	1530.7	1602.5	1674.4

Typical Blended Makeup Operations at 44 gpm out of Blending Tee

Concentration Out of Tee (ppm boron)

Flow	(gpm)	BAMT at				
FCV-2210Y	FCV-2210X	2.50 wt %	2.75 wt %	3.00 wt %	3.25 wt %	3.50 wt %
0.5	43.5	50.9	56.2	61.4	66.7	72.0
1.0	43.0	101.8	112.3	122.8	133.4	144.0
1.5	42.5	152.7	168.4	184.1	200.0	215.9
2.0	42.0	203.5	224.4	245.4	266.6	287.8
3.0	41.0	305.1	336.4	367.9	399,5	431.3
4.0	40.0	406.6	448.3	490.2	532.3	574.6
5.0	39.0	507.9	560.0	612.3	664.9	717.6
6.0	38.0	609.2	671.6	734.3	797.2	860.4
7.0	37.0	710.3	783.0	856.0	929.4	1003.0
8.0	36.0	811.3	894.3	977.6	1061.3	1145.4
9.0	35.0	912.2	1005.4	1099.1	1193.1	1287.5
10.0	34.0	1012.9	1116.4	1220.3	1324.7	1429.4
15.0	29.0	1515.0	1669.3	1824.2	1979.5	2135.4

Typical Blended Makeup Operations at 88 gpm out of Blending Tee

Concentration Out of Tee (ppm boron)

Flow	(gpm)	BAMT at				
FCV-2210Y	FCV-2210X	2.50 wt %	2.75 wt %	3.00 wt %	3.25 wt %	3.50 wt %
0.5	87.5	25.5	28.1	30.7	33.4	36.0
1.0	87.0	50.9	56.2	61.4	66.7	72.0
1.5	86.5	76.4	84.2	92.1	100.1	108.0
2.0	86.0	101.8	112.3	122.8	133.4	144.0
3.0	85.0	152.7	168.4	184.1	200.0	215.9
4.0	84.0	203.5	224.4	245.4	266.6	287.8
5.0	83.0	254.3	280.4	306.7	333.1	359.6
6.0	82.0	305.1	336.4	367.9	399.5	431.3
7.0	81.0	355.9	392.4	429.1	465.9	503.0
8.0	80.0	406.6	448.3	490.2	532.3	574.6
9.0	79.0	457.3	504.2	551.3	598.6	646.1
10.0	78.0	507.9	560.0	612.3	664.9	717.6
15.0	73.0	760.8	838.7	916.9	995.4	1074.2

.

Typical Blended Makeup Operations at 132 gpm out of Blending Tee

Concentration Out of Tee (ppm boron)

Flow	(gpm)	BAMT at				
FCV-2210Y	FCV-2210X	2.50 wt %	2.75 wt %	3.00 wt %	3.25 wt %	3.50 wt 2
0.5	131.5	17.0	18.7	20.5	22.2	24.0
1.0	131.0	34.0	37.4	41.0	44.5	48.0
2.0	130.0	67.9	74.9	81.9	88.9	96.0
3.0	129.0	101.8	112.3	122.8	133.4	144.0
4.0	128.0	135.7	149.7	163.7	177.8	191.9
. 5.0	127.0	169.6	187.1	204.6	222.2	239.9
6.0	126.0	203.5	224.4	245.4	266.6	287.8
7.0	125.0	237.4	261.8	286.3	310.9	335.6
8.0	124.0	271.3	299.1	327.1	355.2	383.5
9.0	123.0	305.1	336.4	367.9	399.5	431.3
10.0	122.0	339.0	373.7	408.6	443.8	479.1
15.0	117.0	507.9	560.0	612.3	664.9	717.6

Key Plant Parameters and Conditions Assumed in the Shutdown to Refueling Evaluation

а.	Reactor coolant system volume = 9,398 ft ³ .
ь.	Initial RCS average 'oop temperature = 532 degrees.
c.	Pressurizer volume = 450 ft ³ .
d.	Pressurizer is saturated.
e.	Zero reactor coolant system leakage.
f.	Boric acid bakeup tank temperature = 70 degrees.
g.	Complete and instantaneous mixing between the pressurizer and the reactor coolant system.
h.	Constant pressurizer level maintained during the feed-and-bleed process.
1.	Initial RCS concentration = 0 ppm boron.
j.	BAMT concentration = 3.50 weight percent boric acid.
k.	RWT concentration = 1720 ppm boron.
1.	Shutdown cooling system volume = 3000 ft^3 .
m.	Boron concentration in the shutdown cooling system is equal to the boron concentration in the RCS at the time of shutdown cooling initiation.

n. Refueling concentration, Mode 6 = 1720 ppm.

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Evaluation Results for Plant Shutdown to Refueling

Temp (degrees)	Pressure (psia)	Concentration (ppm_boron)	Total BAMT Volume (gal)	
532 532 532 532 532* 532* 500 450	2200 2200 2200 2200 2200 2200 2200	0 138.0 272.8 404.6 533.4 734.6	0 1.280 2.560 3.840 5,120 7,149.7	
400 350 325# 325 300 250 200 150	2200 2200 275 275 275 275 275 275 275 275	985.4 1183.0 1345.9 1359.1 1359.1 1427.3 1547.7 1646.7 1724.3	9,903.8 12,269.6 14,367.7 15,632.8 15,632.8 16,862.8 19,123.5 21,073.9	
135	275	1744.4	22,664.4 23,085.0	

-30

* Initial 40 minute feed-and-bleed complete.
Cooldown stopped for one hour for shutdown cooling system alignment.

Key Plant Parameters and Conditions Assumed in the Shutdown to Cold Shutdown Evaluation

Reactor coolant system volume = 9.398 ft³. a., b. Initial RCS average loop temperature = 532 degrees. Pressurizer volume = 450 ft^3 . c. d. Pressurizer is saturated. Zero reactor coolant system leakage. е. f. Boric acid makeup tank temperature = 70 decrees. Demineralized water supply temperature = 70 degrees. q. h. Complete and instantaneous mixing between the pressurizer and the reactor coolant system. 1. Constant pressurizer level maintained during the plant cooldown. Initial RCS concentration = 0 ppm boron. 1. k. BAMT concentration = 3.50 weight percent boric acid. RWT concentration = 1720 ppm boron. 1. Shutdown cooling system volume = 3000 ft^3 . m. Boron-concentration in the shutdown cooling system is equal to the n. boron concentration in the RCS at the time of shutdown cooling initiation for Case I. Soron concentration in the shutdown cooling system is equal to the 0. boron concentration in the RWT at the time of shutdown cooling initiation for Case II.

in set

Case I Evaluation Results for Plant Shutdown to Cold Shutdown with SDCS Concentration Equal to RCS Concentration at the Time of Shutdown Cooling Initiation

Temp	Blending	Pressure	Concentration	Total BAMT
(degrees)	Ratio(*)	(psia)	(ppm boron)	Volume (gal)
532 500 450 400 350 325 325# 300 250 200	0.85:1 1.53:1 6.89:1 6.89:1 6.9:1	2200 2200 2200 2200 2200 275 275 275 275 275 275	0 221.0 496.6 713.5 799.8 800.0 800.0 800.0 800.0 800.0	0 2,029.7 4,783.8 7,149.6 8,446.5 9,299.9 9,299.9 9,455.7 9,742.3 9,989.2
150	6.9:1	275	800.0	10,190.5
135	6.9:1	275	800.0	10,243.7

* Ratio of pure water to BAMT water at blending tee.

After shutdown cooling system alignment.

Case II Evaluation Results for Plant Shutdown to Cold Shutdown with SDCS Concentration Equal to RWT Concentration at the Time of Shutdown Cooling Initiation

0
2,029.7 4,783.8 5,171.6 5,346.5 6,303.6 6,303.6 6,459.5 6,746.0 6,993.2 7,194.8

* Ratio of pure water to BAMT water at blending tee.

÷.,

a set

After shutdown cooling system is aligned and circulated.

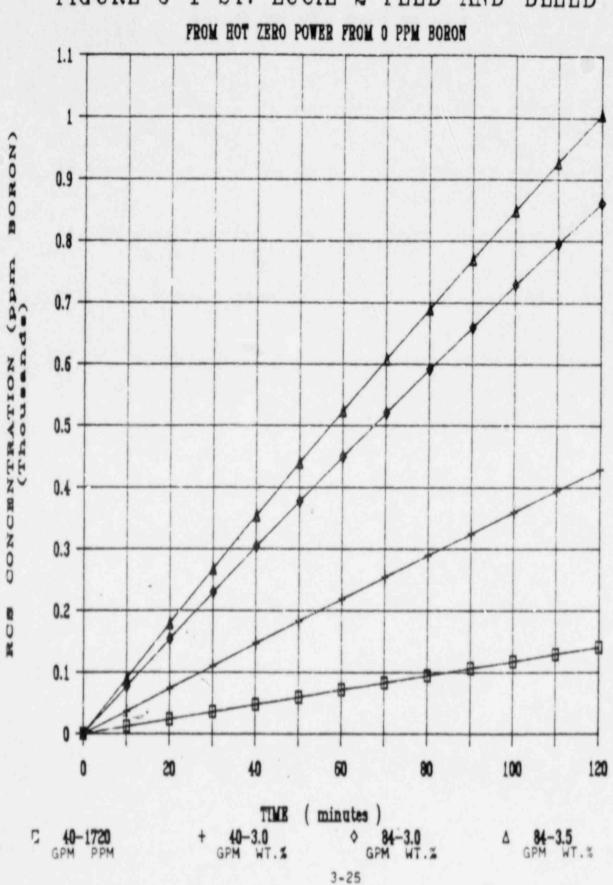
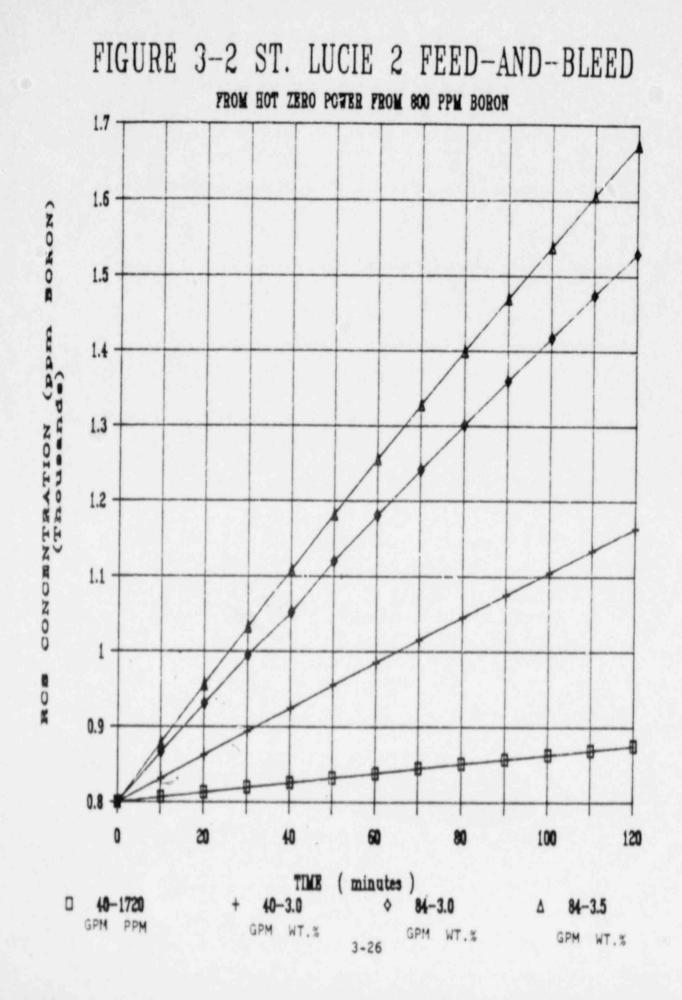
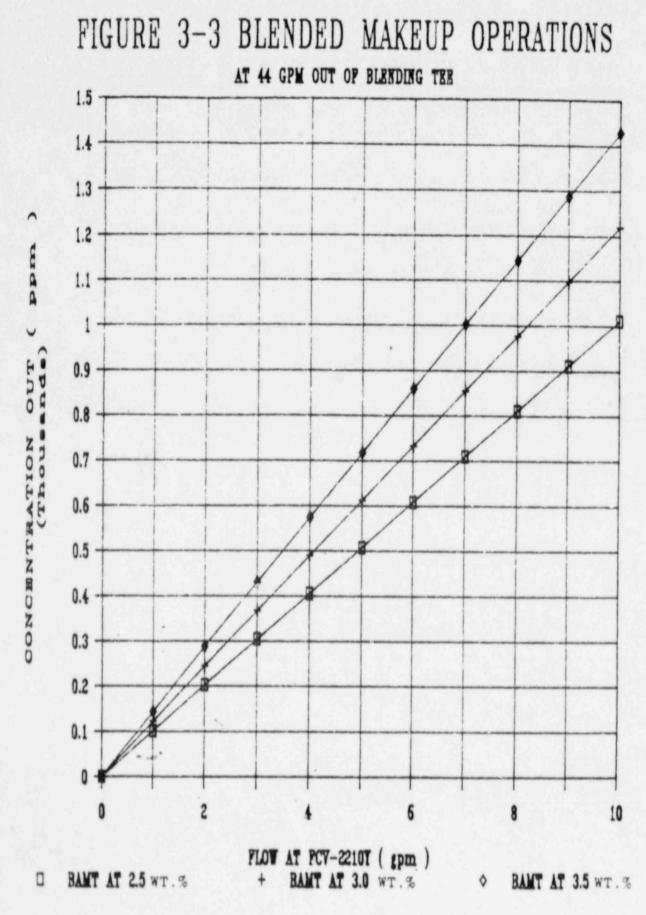
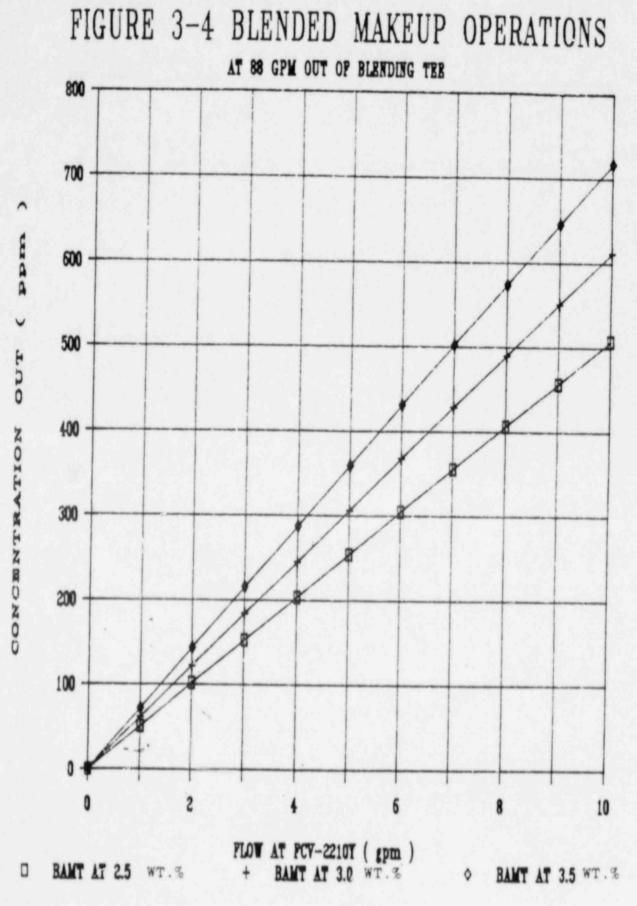
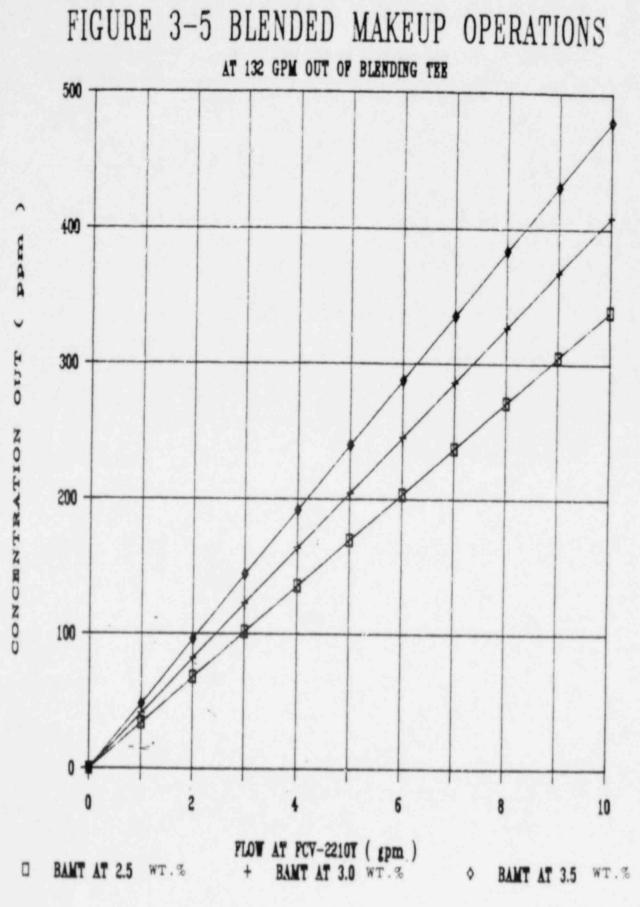


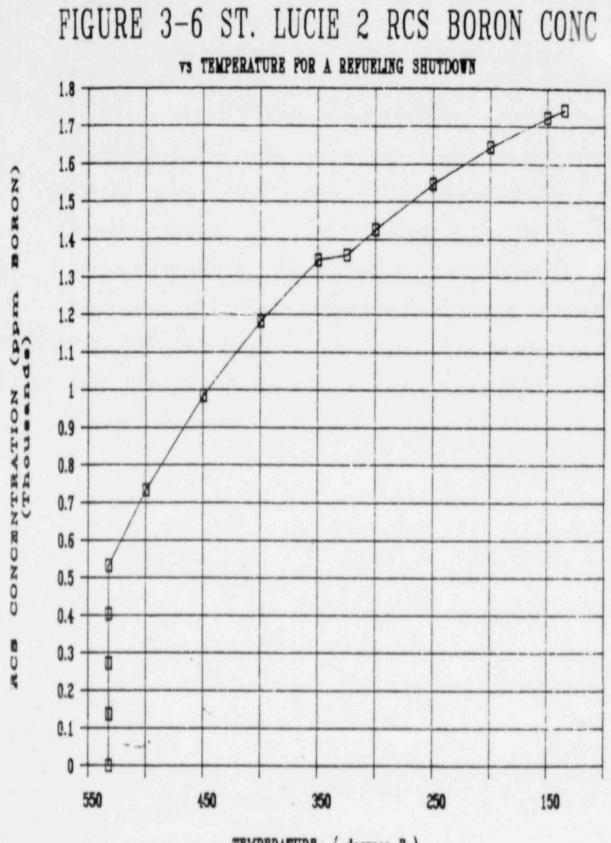
FIGURE 3-1 ST. LUCIE 2 FEED-AND-BLEED



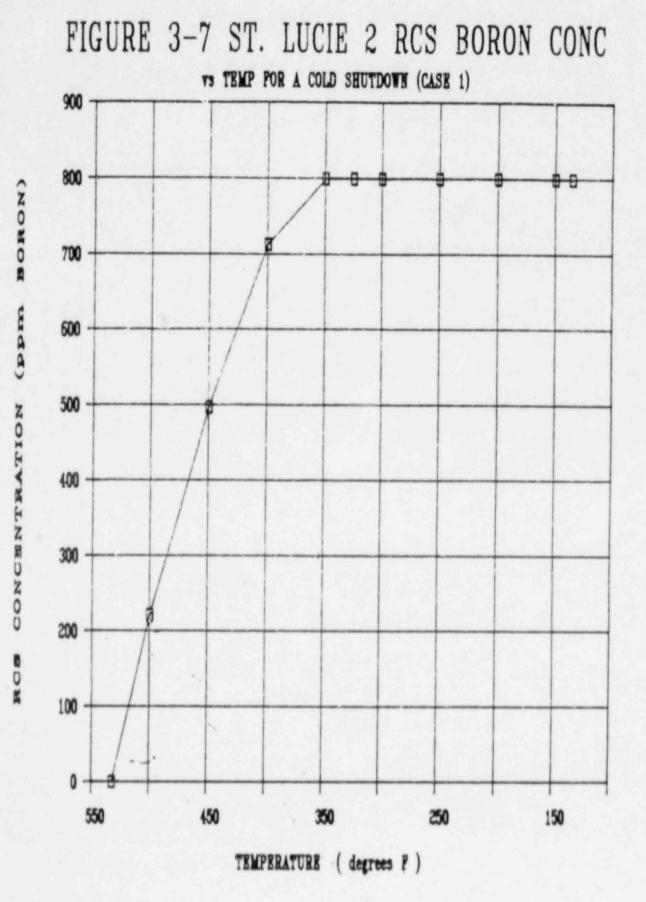


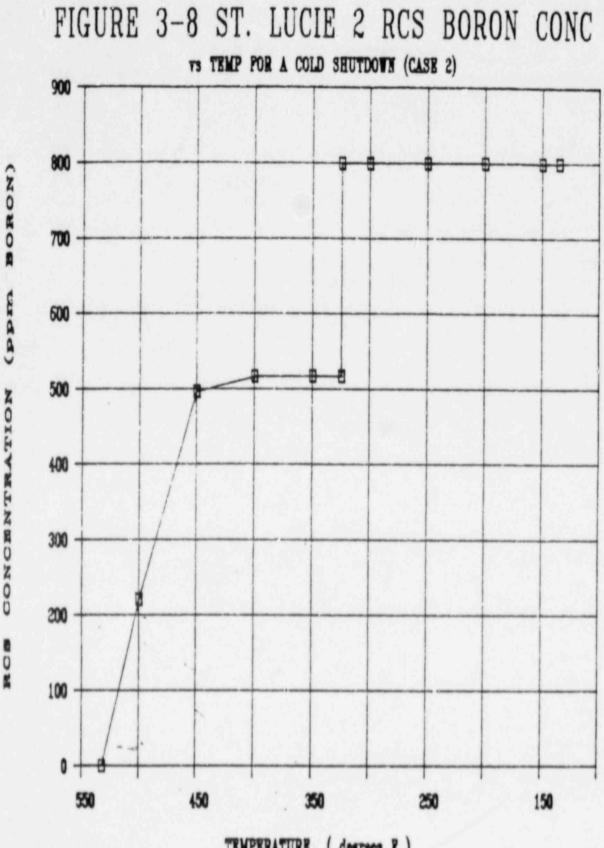






TEMPERATURE (degrees P)





CONCENTRATION

NOW

TEMPERATURE (degrees F)

4.0 REFERENCES

- 4.1 Technical Data Sheet IC-11, US Borax & Chemical Corporation, 3-83-J.W.
- 4.2 Combustion Engineering's Emergency Procedure Guidelines, <u>CEN-152</u>, Revision 2, May, 1984.
- 4.3 An Evaluation on the Natural Circulation Cooldown Test Performed at the San Onofre Nuclear Generating Station, compliance with the Testing Requirements of Branch Technical Position RSB 5-1, <u>CEN-259</u>, Combustion Engineering, January 1984.
- 4.4 U.S. Nuclear Regulatory Commission Standard Review Plan NUREG-0800 Section 5.4.7. "Residual Heat Removal (RHR) System" and Branch Technical Position (RSB) 5-1 "Design Requirements of the Residual Heat Removal System".
- 4.5 C-E Letter F2-CE-R-021, "St. Lucie Unit 2 Cycle 3 Physics Data for FP&L's Non-LOCA Transient Evaluation", E. A. Trapp to J. L. Perryman, dated August 12, 1985.
- 4.6 C-E Letter F2-CE-R-078, "Transmittal of St. Lucie Unit 2 Cycle 3 Startup Test Predictions and Physics Data Book Information", E. A. Trapp to J. L. Perryman, dated May 1, 1986.

Appendix 1

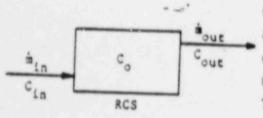
Derivation of the Reactor Coolant System Feed-and-Bleed Equation

Purpose of Definitions

This appendix presents the detailed derivation of an equation which can be used to compute the reactor coolant system (RCS) boron concentration change during a feed-and-bleed operation. For this derivation, the following definitions were used:

min	= mass flowrate into the RCS
mout	
mb	= boron mass flowrate
mw w	= water mass flowrate
mb	= boron mass
mw	= water mass
Cin	= boron concentration going into RCS
	= boron concentration, going out of RCS
C	= initial boron concentration
C(t)	= boron concentration as a function of time
	= RCS boron concentration

Simplifying Assumptions



During a feed-and-bleed operation, the reactor coolant system can be pictured as shown in the figure as a closed container having a certain volume, a certain mass, and an initial boron concentration. Coolant is added at one end via the charging pumps. The rate of addition is dependent on the number of charging pumps that are running with the concentration being determined by the operator. Coolant is removed at the other end via letdown at a rate that is approximately equal to the charging rate and at a concentration determined by fluid mixing within the reactor coolant system. The mass flowrate into the reactor coolant system is given by the following equation:

$$\hat{m}_{in} = (\hat{m}_b + \hat{m}_w)_{in}$$

For typical boron concentrations within the chemical and volume control system, m_w is very much greater than m_b . (For example, a 3.5 weight percent boric acid solution contains only 0.04 lbm of boric acid per lbm of water). Therefore the above equation can be simplified to the following:

$$\hat{m}_{in} = (\hat{m}_{w})$$
(1.0)

In a similar manner, the mass flowrate coming out of the reactor coolant system, given by

$$h_{out} = (h_{b} + h_{w})_{out}$$

can be simplified by again realizing that $\mathbf{m}_{\mathbf{W}}$ is very much greater than $\mathbf{m}_{\mathbf{b}}$ or

 $\mathbf{\hat{m}}_{out} = (\mathbf{\hat{m}}_{w})_{out}.$ (2.0)

For a feed-and-bleed operation with a constant pressurizer level and a constant system temperature, the mass flowrate into the RCS will be equal to the mass flowrate out of the RCS. or

$$h_{in} = h_{out} = (h_{w})_{in} = (h_{w})_{out}$$
 (3.0)

Finally, if it is assumed that the boron which is added to the reactor coolant system mixes completely and instantly with the entire RCS mass, the concentration of the fluid coming out of the system will be equal to the system concentration, or

$$C_{out} = C_{RCS}.$$
 (4.0)

Derivation

The rate of change of boron mass within the reactor coolant system is equal to the mass of boron being charged into the system minus the mass of boron leaving via letdown. In equation form, this becomes

$$\frac{d(m_b)_{RCS}}{dt} = \frac{m_{in}c_{in} - m_{out}c_{out}}{dt}$$

From Equation 3.0,

$$\frac{d(m_b)_{RCS}}{dt} = \frac{m_{in}}{(C_{in} C_{out})^2} (m_w)_{in}(C_{in} C_{out}).$$
(5.0)

The concentration of boron in the reactor coolant system, i.e., the weight fraction of boron, is defined as follows:

$$C_{RCS} = \frac{m_b}{m_b + m_w} RCS$$

Since my mb.

$$C_{RCS} = \frac{m_b}{m_w} RCS$$

3 of 5

Where $(m_w)_{RCS}$ is a constant for a constant system temperature. The rate of change of the RCS concentration is therefore

$$\frac{dC_{RCS}}{dt} = \frac{\frac{d(m_b)_{RCS}}{dt}}{(m_w RCS}$$
(6.0)

Substituting Equation 5.0 into Equation 6.0 yields the following:

$$\frac{dc_{RCS} = (\hat{m}_w)_{in} (C_{in} - C_{out})}{(m_w)_{RCS}},$$

and from Equation 4.0.

$$\frac{dC_{RCS}}{dt} = \frac{(m_w)_{in} (C_{in} - C_{RCS})}{(m_w)_{RCS}}.$$
(7.0)

Solving Equation 7.0 for concentration yields:

$$\frac{dC_{RCS}}{C_{in} - C_{RCS}} = \frac{(m_w)_{in}}{(m_w)_{RCS}} dt'$$

or

$$\int_{C} \frac{dC_{RCS}}{C_{fn} - C_{RCS}} = \frac{(m_{w})_{in}}{(m_{w})_{RCS}} dt.$$

Integrating from Lume initial concentration C_0 to some final concentration C(t) and multiplying through by a minus one gives the following:

$$\ln (C_{RCS} - C_{IN}) \Big|_{C_0}^{C(t)} - \frac{(m_w)_{in}}{(m_w)_{RCS}} t,$$

or

4 of 5

$$\ln \frac{C(t) - C_{\text{in}}}{C_0 - C_{\text{in}}} = -\frac{(\hat{m})}{(m_w)} \frac{1}{\text{RCS}} t .$$

Continuing to solve for C(t), this equation becomes:

$$\frac{C(t) - Cin}{C_0 - C_{in}} = e^{-(m_w)in t/(m_w)RCS},$$

or

$$C(t) = C_{in} + (C_0 - C_{in}) e^{-(m_w) in t / (m_w) RCS}$$
. (8.0)

If we define the time constant T to be as follows:

$$T = \frac{(m_w) RCS}{(m_w) in} ,$$

1.

then Equation 8.0 becomes

. ×

in inch

$$C(t) = C_0 e^{-t/T} + C_{in} (1 - e^{-t/T})$$
. (9.0)

Appendix 2

A Proof that Final System Concentration is Independent of System Volume

Purpose of Definitions

This appendix presents a detailed proof that during a plant cooldown where an operator is charging only as necessary to makeup for coolant contraction, the final system concentration that results using a given boration source concentration will be independent of the total system volume. For this proof, the following definitions were used:

c_i = initial boron concentration Plant 1
mbi = initial boron mass Plant 1
mwi = initial water mass Plant 1
c_f = final boron concentration Plant 1
c_a = boron concentration of makeup solution Plant 1
mba = mass of boron added Plant 1
mwa = mass of water added Plant 1
mbf = final boron mass Plant 1
C_i = initial boron concentration Plant 2
Mbi = initial boron mass Plant 2
Mwi = initial water mass Plant 2
C_f = final boron concentration Plant 2
Mwi = initial boron concentration Plant 2
Mwi = mass of boron added Plant 2
Mwi = mass of boron added Plant 2
Mba = mass of boron added Plant 2
Mwa = mass of boron added Plant 2
Mwa = mass of boron added Plant 2

Proof

For this proof, consider two plants at the same initial temperature, the same initial pressure, and the same initial boron concentration. One plant, Plant 2, has exactly twice the system volume as the other plant,

Plant 1. Initially, boron concentration Plant 1 = boron concentration Plant 2,

ur

$$c_{i} = C_{i} = \frac{m_{bi}}{m_{bi} + m_{wi}} = \frac{M_{bi}}{M_{bi} + M_{wi}}$$
 (1.0)

Since the volume of Plant 2 is twice that of Plant 1, $M_{wi} = 2m_{wi}$. Substituting this relationship into Equation 1.0 and solving yields the following:

$$\frac{m_{bi}}{m_{bi} + m_{wi}} = \frac{M_{bi}}{M_{bi} + 2m_{wi}}$$

$$M_{bi} + 2m_{bi}m_{wi} = m_{bi}M_{bi} + m_{wi}M_{bi},$$

and

m

$$M_{b1} = 2m_{b1}$$
 (2.0)

.

Therefore, the initial boron mass in Plant 2 is exactly twice the initial boron mass in Plant 1.

During the cooldown process for Plant 1, the final boron mass in the system will equal the initial boron mass plus the added boron mass, or

$$m_{bf} = m_{bi} + m_{ba}$$
 (3.0)

If, during this cooldown process, operators charge only as necessary to makeup for coolant contraction, water and boron will be added only as space is made available in the system due to coolant shrinkage. The final boron concentration from Equation 3.0 can therefore be expressed as follows:-

$$m_{bf} = \begin{bmatrix} m_{bi} + m_{ba} + m_{wi} + m_{wa} \end{bmatrix} \begin{bmatrix} m_{bf} \\ \hline m_{bi} + m_{ba} + m_{wi} + m_{wa} \end{bmatrix}$$

If concentration is expressed in terms of weight percent, this last equation becomes

$${}^{m}bf = \begin{bmatrix} {}^{m}bi + {}^{m}ba + {}^{M}wi + {}^{m}wa \end{bmatrix} c_{f}.$$
(4.0)

Similarly, the remaining two components of Equation 3.0 become

$$M_{bi} = \begin{bmatrix} m_{bi} + m_{wi} \end{bmatrix} c_i$$
 (5.0)

and

$$m_{ba} = \left[m_{ba} + m_{wa} \right] c_a \tag{6.0}$$

Substituting Equations 4.0, 5.0, and 6.0 into Equation 3.0 and solving for the final concentration yields the following:

$$c_{f} = \left[\frac{m_{bi} + m_{wi}}{m_{bi} + m_{ba} + m_{wa}} c_{a} \right] (7.0)$$

For Plant 2, Equation 7.0 becomes

$$C_{f} = \left[\frac{M_{bi} + M_{wi}}{M_{bi} + M_{ba}} C_{i} + \left[\frac{M_{ba} + M_{wa}}{M_{wa}} C_{a} \right] \right]$$
(8.0)

During a cooldown, the shrinkage mass, i.e., the mass of fluid that must be added to the system in order to keep pressurizer level constant, is calculated by dividing the system volume by the change in specific volume, or

and

where System Volume Plant 1 = (1/2) System Volume Plant 2.

For a given cooldown, dividing Equation 9.0 by Equation 10.0 gives the following:

$$M_{wa} = 2m_{wa}$$
 (11.0)

In addition, if the charging source for both plants is at the same concentration and temperature,

and

$$f_{ba} = 2m_{ba}$$
 (13.0)

Substituting Equations 2.0, 11.0, 12,0, and 13.0 into Equation 8.0 yields the following:

$$C_{f} = \frac{\left[2m_{bi} + M_{wi}\right]C_{i} + \left[2m_{ba} + 2m_{wa}\right]c_{a}}{2m_{bi} + 2m_{ba} + M_{wi} + 2m_{wa}}$$

Since the initial concentrations are the same, $C_i = c_i$, and since Plant 2 is twice as large as Plant 1, $M_{wi} = 2m_{wi}$,

$$C_{f} = \left[\frac{2m_{b1} + 2m_{1}}{2m_{b1} + 2m_{ba} + 2m_{ba} + 2m_{1}} + \frac{2m_{a}}{2m_{b1} + 2m_{ba} + 2m_{1} + 2m_{a}} \right] = C_{f},$$

or

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0

$$C_{f} = C_{f}$$
 (14.0)

8

Therefore, for a cooldown where pressurizer level is maintained constant, the final boron concentration for Plant 2 is equal to the final boron concentration for Plant 1, i.e., the change in boron concentration is independent of the exact system volume.

Appendix 3

Methodology for Calculating Dissolved Boric Acid per Gallon of Water

Furpose

The purpose of this appendix is to show the methodology used to calculate the mass of boric acid dissolved in each gallon of water for solutions of various boric acid concentrations. Two solution temperatures were used corresponding to the minimum allowable refueling water tank temperature of 5 degrees and a boric acid makeup temperature of 70 degrees in the absence of tank heaters.

Methodology and Results

Boric acid concentration expressed in terms of weight percent is defined as follows:

 $C = \frac{\text{mass of boric acid}}{\text{total solution mass}} \times 100,$

or

$$= \frac{\text{mass of boric acid}}{(\text{mass of boric acid}) + (\text{mass of water})} \times 100. \quad (1.0)$$

If we define m_{ba} to be the mass of boric acid and m_w to be the mass of water, and if we substitute these defined terms into Equation 1.0 and solve for the mass of boric acid we have the following:

$$C = \frac{m_{ba}}{m_{ba} + m_{w}} \times 100 ,$$
$$m = \frac{C \times m_{w}}{m_{ba} + m_{w}} = \frac{100}{m_{ba}} + \frac{100}{m_{ba}}$$

ba 100 - C

(2.0)

1 of 2

or

From Appendix A of the Crane Company Manual (Flow of Fluids Through Valves, Fittings, and Pipe, Crane Co., 1981, Technical Paper No. 410), the density of water at 70 degrees is 8.3290 lbm / gallon and at 50 degrees is 8.343 lbm / gallon. Using these water masses and Equation 2.0 above, ... e mass of boric acid per gallon of solution is as follows:

Mass of acid per gallon

	Concent	ration	of solution at				
source	wt. % boric acid	ppm boron	50 degrees	70 degrees			
RWT	0.98379	1720	0.08289 1bm				
RWT	1.05815	1850	0.08923 1bm				
RWT	1.14394	2000	0.09654 1bm	**			
RWT	1.22974	2150	0.10387 1bm				
RWT	1.31553	2300	0.11121 1tm				
BAMT	2.50	4371		0.21356 1bm			
BAMT	2.75	4808		0.23552 1bm			
BAMT	3.00	5245		0.25760 1bm			
BAMT	3.25	5682		0.27979 1bm			
BAMT	3.50	6119		0.30209 1bm			

Appendix 4

Methodology for Calculating the Conversion Factor Between Weight Percent Boric Acid and Jum Boron

Purpose

The purpose of this appendix is to show the methodology used to derive the conversion factor between concentration in terms of weight percent boric acid and concentration in terms of parts per million (ppm) of naturally occurring boron.

Results

For any species (solute) dissolved in some solvent, a solution having a concentration of exactly 1 ppm can be obtained by dissolving 1 lbm of solute in 999,999 lbm of solvent. An aqueous solution having a concentration of 1 ppm boric acid, therefore, can be obtained by dissolving 1 lbm of boric acid in 999,999 lbm of water, or

1	ppm			1	1bm	bor	ic acid			1 1bm	boric	acid	
		1	1bm	boric	acid	+ 1	999,999	1bm	water	106	1bm	solution	

For any species (solute) dissolved in some solvent, a solution having a concentration of 1 weight parcent (wt. %) can be obtained by dissolving 1 lbm of solute in 99 lbm of solvent. An aqueous solution having a concentration of 1 wt. % boric acid, therefore, can be obtained by dissolving 1 lbm of boric acid in 99 lbm of water, or

1 wt. 5 1 1bm boric &cid 100 1bm boric acid + 99 1bm water 100 1bm solution

Dividing these last two equations yields a ratio of 10⁴, or 1 wt. % boric acid = 10,000 ppm boric acid. (1.0) To convert from ppm boric acid (weight fraction) to ppm boron (weight fraction), multiply Equation 1.0 by the ratio of the molecular weight of boric acid (naturally occurring H_3BO_3) to the atomic weight of naturally occurring boron. From the Handbook of Chemistry and Physics, CRC Press,

1 wt. % boric acid = $(10,000) \frac{10.81}{61.83}$ ppm boron ,

1 wt. % boric acid = 1748.34 ppm boron.

or

Appendix 5 Bounding Physics Data Inputs

The following Physics Data Inputs for St. Lucie Unit 2 are provided to facilitate review of this effort. The conservatism, uncertainties, and biases incorporated in the BAMT Boric Acid Concentration Reduction effort for St. Lucie Unit 2 are contained in Table 1. The St. Lucie Unit 2 EOC Physics Data Inputs are contained in References 4.5 and 4.6. During future cycles, the new core parameters must be compared with these inputs to ensure that they are still bounding.

The purpose of this section is to describe the methodology used to compute the core reactivity during the cooldown. This method has been devised to conservatively bound the reactivity affects of the natural circulation cooldown described in Section 2.2.1.1 of this report. The cooldown scenario and the method used to compute core reactivity are discussed in detail in the following paragraphs.

A description of the core reactivity affects is provided. In addition a brief description is provided to show that these assumptions conservatively bound all similar cooldowns at any time during the fuel cycle.

- Conservative core physics parameters were used to determine the required boron concentration and the required Boric Acid Makeup Tank volumes to be added during plant cooldown.
 - End-of-cycle (EOC) initial boron concentration is assumed to be zero.
 - End-of-cycle moderator cooldown offects are used to maximize the reactivity changes during plant cooldown. End-of-Cycle moderator cooldown effects are used at the most Negative Technical Specification MTC.

Positive reactivity is added to the core as the moderator temperature is lowered during the cooldown. The moderator temperature effects on core reactivity vary over the fuel cycle. The moderator temperature effect at beginning-of-cycle (BOC) is very small while the moderator temperature effect EOC provides the maximum reactivity insertion.

EOC Inverse Boron Worths (Table 2) were extracted from Reference 4.6. End-of-cycle (EOC) inverse boron worth data was used in combination with EOC reactivity insertion rates normalized to the most Negative Technical Specification Moderator Temperature Coefficient (MTC) limit since it was known that this yields results that are more limiting than the combination of actual MTC and actual IBW values at all periods through the fuel cycle prior to end-of-cycle.

2. Scram Worth

A conservative scram worth was used in this calculation. The available scram worth was computed utilizing the hot zero power scram worth for all rods in minus the worst rod stuck full out. From this value the Power Dependent Insertion Limit worth: were subtracted to obtain a net available scram worth. A Bias of -9% and Uncertainty of 13% was subtracted from the available scram worth for added conservitism. This scram worth is further reduced by subtracting an EOC reactivity value associated with the Full Power Defect.

3. Determination of Excess Scram Worth

Excess scram worth was determined by comparing the available scram worth at zero power and subtracting the required technical specification shutdown margin. Required Shutdown Margin:

	Tave		SI	M	
>	200°F	2	5000	pcm	
<	200°F	>	3000	pcm	

It was determined by this method that there was a 0.08 $\Delta k/k$ excess scram worth available for temperatures above 200°F and an excess scram worth of 1.58 $\Delta k/k$ for temperatures below 200°F.

Core Reactivity Effects

A reactivity calculation has been performed to account for positive reactivity insertion due to the decay of xenon and the positive reactivity one to the cooldown of the moderator and fuel. Uncertainties and biases were applied to all reactivity affects. Table 1 delineates the biases and uncertainties used in this calculation.

Xenon Reactivity Effects

As shown in Reference 4.6 of the xenon worth peaks at its most negative reactivity worth around eight hours after the reactor is shutdown. Xenon decay reduces the negative reactivity of the xenon back to its steady state operating value at approximately 26 hours after shutdown. At times after 26 hours the plant must be borated to compensate for the further reduction in xenon concentration. As an added conservatism this calculation never credited the extra negative reactivity inserted by the xenon peak that occurs after shutdown. Instead the plant was maintained at hot standby for 26 hours to allow xenon to return to the 100% steady state value and further xenon decay to add reactivity simultaneously with the plant cooldown effects. Reference 4.6 was used to determine the positive reactivity inserted into the core for times after 26 hours at discreet time intervals. Note that a slow cooldown rate will prolong the time required to reach Mode 5 where the shutdown margin drops from 5.0% Ak/k to 3.5% Ak/k and therefore would require a larger boron concentration to counteract xehon decay during the cooldown. A 12.5 degree per hour cooldown rate has been utilized in this calculation. It should be noted that this method accounts for xenon decay for a full 54 hours which is a much longer time frame than is expected to achieve cold shutdown.

Reactor Cooldown Effects

The affect of the reactor cooldown was calculated by determining the fuel temperature and moderator temperature reactivity effects for each incremental temperature decrease. Data from Reference 4.5 was utilized to determine these effects. It should be noted that these reactivity effects are independent of time and solely dependent on the change in temperature of the core.

Boration Requirements

in and

Having determined the reactivity effects due to xenon, moderator cooldown and fiel temperature cooldown for discreet time intervals after the plant is shutdown, the necessary boron concentration to compensate for this reactivity change is determined. The Inverse Boron Worth values of Reference 4.6 white used to determine the ppm boron necessary in the RCS to compensate for the positive reactivities determined above. All the conservatism, uncertainties and biasons applied to this calculation are included in Table 1.

Table 1

Conservatism, Uncertainties and Biases Incorporated in the BAMT Boric Acid Concentration Reduction Effort for St. Lucie Unit 2

- The initial scram is assumed to proceed from the hot full power PDIL (power dependent insertion limit) to the all rods in, with the worst case rod stuck in the full out position conditions.
- 2. A bias of -9% and uncertainty of 13% was applied to the scram worth data.
- 3. A combined bias and uncertainty of 10% was applied to the moderator data.
- 4. A bias of 15% and an uncertainty of 15% was applied to the Doppler data.
- The assumption that the cooldown begins at 26 hours is conservative in relation to the buildup and decay of Xenon.

the same is

Table 2

Inverse Boron Worth

TEMP	IBN
557.0	80.0
544.5	80.0
532.0	80.0
507.0	80.0
482.0	78.1
457.0	76.3
432.0	74.6
407.0	73.0
382.0	71.4
357.0	70.2
332.0	69.0
307.0	67.8
282.0	66.7
257.0	65.6
232.0	64.5
207.0	63.7
200.0	63.3
200.0	63.3
200.0	63.3
130.0	60.9

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5

4.40

Table 3

Required Boron Concentration for a Cooldown from 557°F to 135°F

Temperatures (Degrees F)	Concentration (ppm boron)
557 510 490 480 470 460 450 440 430 420 410 400 390 380 370 360 350 340 350 340 330 325 310 285 260 235 210 200 199.9* 199.9* 199.9* 190 180 170 160 150 140 135	-71.2 133.0 203.0 235.5 262.3 289.8 314.1 338.0 350.6 382.0 403.4 423.5 443.0 461.2 474.5 488.7 500.9 512.6 523.5 528.7 543.6 568.8 589.9 608.7 627.6 634.9 539.9 570.3 577.4 584.5 591.6 598.6 605.7 612.8 616.3

* After shutdown margin change from 5.0% delta k/k to 3.5% del's k/k

the same at

** The boration requirement for a 3.5% shutdown margin and core is xenon free