APPENDIX A

TEST SPECIFICATION, TS-51-5A008

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Specification For

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TRANSIENT NATURAL CIRCULATION TEST

Hanford Engineering Development Laboratory

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Note: All changes to this test specification must be approved by DOE.

INITIAL RELEASE AND CHANGE CONTROL RECORD

Hanford Engineering Development Laboratory — Westinghouse Hanford Company, A subsidiary of Westinghouse Electric Corporation, P.O. Box 1970, Richland, Wa. 99352	IDENTIFICATION NO. TS-51-5A008
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B		3/77	Revised by HEDL and issued for FFTFPO approval		
C		9/77	Reissue for approval following incorporation of DTRF A-2264 comments. Additional comments from the design review of natural circulation acceptance testing were also incorporated		
0		12/77	Initial Release for Project use. Approved per DoE letter, FTF:GDB:E036, 11/8/77; and released per ERO FTP-1289, dated 12/8/77.	WL Knecht 12/8/77	RR Derusseau 12/8/77
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D		7/79	Re-issue for approval by ECN A-12265. Major rewrite including the addition of a test at 35%.		
2		9/79	Release per ECN A-12265.	WL Knecht 9/26/79	F Edwards 9/27/79
3		9/80	Released per ECN A-15134	WL Knecht 9/10/80	
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1.0 PURPOSE

o demonstrate that the reactor plant with the HTS pump pony motors not operating will undergo a satisfactory transition to a natural circulation decay heat removal condition following scram, this test simulates the plant response to the design basis condition consisting of a total loss of off-site and on-site electrical power during normal reactor operation.

This test consists of four separate sub-tests with increasing decay heat culminating in the 100% power test. The first test at 5% power and 75% flow is conducted prior to operation of the reactor at full power and has the secondary HTS pump pony in operation throughout. The purpose of this low-power test is to demonstrate the existence of sufficient decay heat removal capability to allow the performance of the 35% power 75% flow test. Tests at 35% power 75% flow, and at 75% power and flow are included to provide additional assurance of the safety of the full power tests. The four subtests are summarized in the following table:

Test Identification	Initial Conditions		Remarks
	Power % of 400 MW	Flow % of full flow	
A	5	75	Conducted prior to 2 day full power test
B	35	75	After successful completion of Test A
C	75	75	After successful completion of Test B
D	100	100	After successful completion of Test C

2.0 TEST REQUIREMENTS

Test A will be performed before the two-day full power demonstration, Test B will be performed after initial operation at 35% power, and Tests C and D will be performed after the full power run. Test B must be performed before Test C, and Test C must be performed before Test D. As specified in Section 3.2, approval by the Test Results Review Team (TRRT) is required to perform Test C and Test D.

The test schedule should provide at least one month between Test B and Test C to provide for data review, and one week between Test C and Test D for data review. Successful completion of Test A will be sufficient to proceed directly to Test B as discussed in Section 5.

A. Test from 5% power and 75% flow

During this test, the reactor and HTS will be scrammed from a condition of 5% power and 75% flow with all three primary HTS pump pony motors stopped, but the three secondary HTS pony motors operating after scram. The plant will be permitted to undergo a transition to a natural circulation decay heat removal condition.

The test will be conducted as follows:

1. Using Operating Procedure PN-2 bring the reactor plant to the power standby condition of

   . Primary loop flow - 75% ± 1% of 13443 gpm

   . Secondary loop flow - 75% ± 1% of 13200 gpm

   . Power - 5% ± 1% of 400 MW

   . Secondary loops cold leg temperatures - 592 ± 10°F

   . Decay power - this test is to be performed after 3 to 7 hours at 2% power followed by 1-16 hours at 5% power (see Section 3).

2. Maintain power and flows at the power standby conditions, and adjust the heat rejection (DHX's) to establish steady-state conditions with all three primary cold leg temperatures at

   . 59?°F ± 5°F

   and the three primary cold leg temperatures as close together as possible. This should produce primary hot leg temperatures of 613° ± 10°F.

3. Maintain 5% power for a minimum of one hour, but not more than 16 hours prior to initiating the scram. [If more than 16 hours is needed, obtain sign-off from Engineering.]

4. Record the Row 2 and Row 6 FOTA temperatures required for a decision to abort the test (see Step 9) and identify all those which are reading in the normal range, i.e., not more than 40°F above the average primary cold leg temperature. The FOTA temperature readings to be used to make the abort decision are: Row 2 - TX1016, TX1012, TX1008, TX1009 (midplane); Row 6 - TX9026, TX9018, TX9009, TX9039 (midplane). At least 5 of these must be in the normal range in steady state for the test to proceed. Of the five, at least one must be a midplane temperature and at least 2 must be Row 2 top of the fuel.

5. Confirm that the DDH&DS is operational as specified in Section 3.1.D.

6. De-energize the three primary HTS pony motors, shut-off the primary sodium sampling system, and divert the return of the reactor overflow makeup pumps to T-42.

7. Scram the reactor and simultaneously de-energize the lube oil circulating pumps for the primary HTS pumps. Continuously monitor the peak FOTA temperatures as indicated by the eight temperature channels (4 each for the row 2 and row 6 FOTA's) displayed in the control room. These temperatures are predicted to reach a peak at ∿ 4 minutes after scram and then decrease. The predicted peak temperatures are shown in Figures 4-11.

8. Place the DHX's in manual control 30 to 60 sec after scram, and maintain secondary cold leg temperature under manual control.

9. Abort the test if any one of the FOTA temperatures displayed in the control room and identified in Step 4 as reading normally exceed the limit:

Row 2 FOTA (HF011)	825°F(1)
Row 6 FOTA (HF012)	825°F(1)

The abort procedure for this test consists of:

. Start the primary HTS pump pony motors (See note)

A procedure has been prepared to restart the pony motors within less than 30 seconds which is consistent with the basis for the above abort limits.

NOTE: The pony motors shall not be started prior to the startup of the lube oil lift pumps to prevent tripping of the pony motor circuit breaker in order to eliminate the additional time to reset the tripped circuit breaker. As an aid to rapid response to an abort, the lube oil lift and circulating pumps shall be restarted immediately after the main sodium pumps cease to turn. After 10 minutes the lift pumps may be secured if the chief operator is satisfied that the peak temperature is passed and the plant is operating normally.

10. This test is complete 20 minutes after scram with the concurrence of the representative from Engineering.

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(1) The basis for these limits and the acceptance criteria are provided in Section 5.

11. Restart the primary pump pony motors, the reactor overflow makeup system, and the primary sodium sampling system.

Caution: A normal conclusion of this test is not expected to produce any limiting thermal differentials. However, the following thermal differntial limitations should be observed for restart of each subsystem:

- Primary Pony Motor - $|T_{Hot\ Leg} - T_{Cold\ Leg}| < 100°F$
- Overflow Makeup System - $|T_{T42} - T_{Outlet\ Plenum}| < 100°F$
- Sodium Sampling System - $|T_{Na\ Sample} - T_{Outlet\ Plenum}| < 100°F$

12. Continue with the test program according to T-OC-5A020, "Power ascension and Operation".

B. Test from 35% Power and 75% Flow

This test is similar to Test A except it is conducted with two of the three secondary HTS pump pony motors off and the power level at the time of the SCRAM is 35%. Having one of the secondary HTS pump pony motors on provides data on unbalanced loop performance with minimal impact on the natural circulation in the reactor and the remaining secondary loops. The peak core temperature is predicted to be approximately 10°F lower with the one pony motor on than it would be with all pony motors off. The unbalanced loop data is required to verify the modeling of a tornado event. The test will be conducted as follows:

1. Using operating procedure PN-3, establish steady-state conditions at the following nominal conditions:
   - Power - 35% ± 1% of 400 MW
   - Primary loop flow - 75% ± 1% of 13443 GPM
   - Primary co'd leg tempera cure - 630° ± 5°F
   - Secondary loop flow 75% ± 1% of 13200 GPM
2. Maintain the operating conditions specified in 1. for a minimum of 5 hours but no' longer than 56 hours. If this time range must be altered, obtain sign-off from Engineering.
3. Record the Row 2 and Row 6 FOTA temperatures required for a decision to abort the test and identify all of those which are reading in the normal range; i.e., 753 °F - 841 °F for the Row 2 FOTA at the top of FOTA, 751 °F - 810 °F for the Row 6 FOTA at the top of the fuel, 710 °F - 752 °F for the mid plane Row 2, and 701 °F - 739 °F for the midplane Row 6. The FOTA temperature readings to be used to make the abort decision are: Row 2 - TX 1016, TX 1012, TX 1008, TX 1009 (midplane); Row 6 - TX 9026, TX 9018, TX 9009, TX 9039 (midplane). At least five of these must be in the normal range in steady state for the test to proceed. Of the five, at least one must be a midplane temperature and at least two must be Row 2 top of the fue' T/C locations are illustrated in Figures 1 and 2.
4. Confirm that the DDH & DS is operational as specifi n Section 3.1.D.
5. De-energize all three primary HTS pony motors and two of the three secondary pony motors, retaining the secondary pony motor operational in the hardened loop (Loop 1 - East). Secure and valve off the primary sodium sampling system, divert the reactor overflow make-up pumps output to T-42, and secure the secondary sodium processing systems on Loops 2-3. This will result in primary cold traps remaining in operation without returning flow to the main HTS.
6. Scram the reactor and simultaneously de-energize the lube oil circulating pumps of the five pumps with the pony motors turned off. Do not turn off the lube oil pump for the secondary pump of Loop 1 - East. Continuously monitor the peak FOTA temperatures as indicated by the eight temperature channels identified in Step 3 above, displayed in the control room. These temperatures are predicted to reach a peak at ~ 3 minutes after SCRAM and then decrease.

7. Control the DHX outlet temperature in the East Loop (Loop 1), in which the secondary pony motor is operating in accordance with procedure PR-2. In the South Loop and the West Loop, transfer the DHX control to manual as the DHX outlet temperatures recover to the normal setpoint value (approximately 592°F) and control in accordance with Procedure SN-90-8. The recovery of the DHX outlet temperature is estimated to require approximately 10 minutes.

8. Abort the test if any one of the FOTA temperatures displayed in the control room and identified as reading ormally in Step 3 exceeds the limits:

   Row 2 FOTA (HF011) 980°F(1)
   Tow 6 FOTA (HF012) 980°F(1)

   The abort procedure for Test B consists of these sequential steps:

   . Start the primary HTS pump pony motors
   . Start the secondary HTS pump pony motors

   NOTE: The pony motors shall not be started prior to the startup of the lube oil lift pumps to prevent tripping of the pon motor circuit breaker in order to eliminate the additional time to reset the tripped circuit breaker. As an aid to rapid response to an abort, the lube oil lift and circulating pumps shall be restarted immediately after the main sodium pumps cease to turn. After 10 minutes the lift pumps may be secured if the chief operator is satisfied that the peak temperature is passed and the plant is operating normally.

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(1) The test shall not be aborted with actual temperatures below the abort limits, since testing over the full temperature range may be required to provide a definitive result. The abort temperatures have been conservatively specified, recognizing that the time required to start the pony motors will result in actual temperatures exceeding the abort limits. The bases for these limits are provided in Section 5.

9. This test is complete 20 minutes after scram with the concurrence of the representative from Engineering.

10. Restore the reactor overflow makeup pumps output to the pretest operating condition (into the reactor vessel), and turn on the primary sodium sampling system. Restore the secondary sodium processing system to normal operation.

11. Restart the shutdown secondary pony motors (Loop 2, Loop 3), and restart all the primary loop pony motors. The pony motor restart should be delayed until the hot leg to cold leg differential in the loop (loop ΔT on C126) is less than 100°F. Plan to start all three primary pony motors approximately simultaneously.

12. Continue with the test program according to T-00-5A020, "Power Ascension and Operation".

C. <u>Test From 75% Power and Flow</u>

This test is essentially similar to Test B except that the initial conditions are 75% power. The test will be conducted as follows:

1. Using Operating Procedure PN-3, establish steady-state conditions at the following nominal operating conditions:

   . Power - 75% ± 1% of 400 MW

   . Primary loop flow - 75% ± 1% 13443 GPM

   . Primary cold leg temperature - 662 ± 5°F

   . Primary hot leg temperature - 920 ± 5°F

   . Secondary cold leg temperature - 602°F

   . Secondary loop flow - 75% ± 1% of 13200 GPM

   . Calculated decay power - 3 to 3.5% of 400 MW

2. Confirm that the DDH&DS is operational as specified in Section 3.1.D.

3. De-energize all six HTS pony motors and shut-off in the indicated order the primary sodium sampling system, the reactor overflow makeup pumps and the secondary sodium processing systems.

4. Scram the reactor and simultaneously de-energize the lube oil circulating pumps. Continuously monitor the peak FOTA temperatures as indicated by the eight temperature channels (4 each for the row 2 and row 6 FOTA's) displayed in the control room. These temperatures are predicted to reach a peak ~2 minutes after scram and then decrease. The predicted peak temperatures are shown in Table 1. Abort the test if any two of the FOTA temperatures displayed in the control room exceed the limits:

   Row 2 FOTA (HF011) 1090°F[(1)]

   Row 6 FOTA (HF012) 1042°F[(1)]

   The above procedure is specified by Step 4 of Test B.

5. Perform Steps 5, 6 and 7 of Test B. The expected time to reach the condition for pony motor restart is less than 4 hours for this test.

D. Test from 100% Power and Flow

This test is essentially similar to Test B except that the initial conditions are 100% power and flow. The test will be conducted as follows:

1. Using Operation Procedure PN-3, establish steady-state conditions at the following nominal operating conditions:

   . Power - 100% ± 1% of 400 MW

   . Primary loop flow - 100% ± 1% of 13443 GPM

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(1) These limits will be updated per actual full power test data. The row 2 FOTA limits is derived as follows: 1090°F = 670°F + 0.934* (1133°F - 680°F) where 1133°F is the peak temperature at full power and 680°F is core inlet temperature. The test shall not be aborted with actual temperatures below the abort limits, since testing over the full temperature range is required to provide a definitive result. The abort temperatures have been conservatively specified, recognizing that the time required to start pony motors will result in actual temperature exceeding the abort limits.

. Primary cold leg temperature - 680 ± 5°F

. Primary hot leg temperature - 938 ± 5°F

. Secondary cold leg temperature - 602°F

. Secondary loop flow - 100% ± 1% of 13200 GPM

. Calculated decay power - 4 to 4.5% of 400 MW

2. Confirm that the DDH&DS is operational as specified in Section 3.1.D.

3. De-energize all six HTS pony motors and shutoff in the indicated order the primary sodium sampling system, the reactor overflow makeup pumps and the secondary sodium processing systems.

4. Scram the reactor and simultaneously de-energize the lube oil circulating pumps. Continuously monitor the peak FOTA temperatures as indicated by the eight temperature channels (4 each for the row 2 and row 6 FOTA's) displayed in the control room. These temperatures are predicted to reach a peak at approximately 2 minutes after scram and then decrease. The predicted peak temperatures are shown in Table 1.

   Abort the test if any two of the FOTA temperatures displayed in the control room exceed the limits:

Row 2 FOTA (HF011)	1133°F(1)
Row 6 FOTA (HF012)	1099°F(1)

   The abort procedure is specified by Step 4 of Test B.

5. Utilize PI-07, to cool the plant to a secondary cold leg temperature of 450°F. Utilize emergency control panels C-181A and C-181B to control the DHX fine dampers.

6. Perform Steps 6 and 7 of Test A. The expected time to reach the condition for pony motor restart is less than 4 hours for this test.

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(1) These limits will be updated per actual full power test data. The test shall not be aborted with actual temperatures below the abort limits, since testing over the full temperature range is required to provide a definitive result. The abort temperatures have been conservatively specified recognizing that the time required to start the pony motors will result in actual temperatures exceeding the abort limits (about 100°F in 30 seconds).

3.0 PLANT CONDITIONS

3.1 Prerequisites for All Tests

A. Acceptance Test T-51-3A018 Parts 1 and 2 have been satisfactorily completed within the specified acceptance criteria; and if required, the test predictions for this test have been updated on the basis of the results from the previous tests.

B. Prior to the performance of Tests C and D (scrams from 75% and 100% power) the plant must have 1) been operated at full power and flow conditions, 2) successfully scrammed from full ΔT conditions, and 3) subsequently operated at post-scram conditions with pony motors operating normally. Also, evaluation of the normal scram tests (5A019) has confirmed that no unacceptable uncertainty or risk is implied by the performance of this test.

C. The coastdown times of all HTS pumps during Acceptance Test T-51-3A023, T-51-3A026, T-51-5A020, and T-00-5A019 have met the acceptance criteria.

D. The DDH&DS including the expansion system and the equipment to provide all specified data recording and display requirements must be operational throughout each test. Any test shall be repeated in the event of the failure of this equipment during the test.

E. One operator should be stationed at the lube oil skid of each HTS pump for the duration of the test to permit rapid startup of the lube oil circulating pumps and the pump and motor bearing oil lift pumps in the event the pony motor must be restarted to abort the test. The operator should be in continuous voice contact with the control room.

F. Two fully instrument FOTA assemblies (rows 2 and 6) shall be installed in the core prior to this test. The instrumentation associated with each FOTA shall be displayed/recorded as specified in Section 3.1.I and 6.B. The accuracy of the recorded/displayed FOTA temperature shall be ±2% of reading with a 5 second maximum time constant. The accuracy of the recorded/displayed FOTA flow rates shall be ±1 GPM.

G. One VOTA assembly[1] shall be installed in row 6 of the core prior to this test. The associated instrumentation, specifically three exit T/C's and eddy current flowmeter, shall be recorded on magnetic tape or similar medium for use during post test data analysis.

H. The calculated decay power is a function of the actual power-time history during each test and of the power-time history prior to each test. Table 5 outlines the assumed power history for each test and the resulting calculated decay power at the time of scram. An allowance is included in each case for the best estimate of the power-time history prior to the test.

I. Two special DDH&DS CRT displays shall be prepared to show the key data required to assess natural circulation performance. These displays shall include the following parameters:

DISPLAY 1 - TEMPERATURES

- The fuel assembly exit temperature measurements for core locations 2101, 1201, 1501, 3508
- The HTS primary hot leg temperature in all three loops
- The temperature channel of the flowmeter for the row 2 FOTA (HF011)
- The temperature (T/C's) for the row 2 FOTA FTRIA

DISPLAY 2 - FLOWS

- The HTS primary flow rate in all three loops
- The flow readings from the 11 PSD calibrated flowmeters (1201, 1202, 1703, 2101, 2201, 2202, 2610, 3508, 3606, 3610, 3707)

Additional output devices shall provide a real time pictorial display of the four row 2 (Figure 1) and four row 6 (Figure 2) FOTA temperatures with a resolution of 10°F or better. The time delay between plotted points and the actual temperature sensed shall be five seconds or less.

(1) The AOTA may be installed but it is not a requisite item for Test A or Test B.

The display scale range shall be fixed at 400°F with the ability to change the base temperature available in the control room.

J. A procedure has been prepared and an actual restart of one HTS pony motor at refueling conditions has been performed to confirm that using this procedure it can be performed in less than 30 seconds. The specified abort temperatures in Section 2.0 include a margin based on a maximum 30 second delay in the restart of the pony motors.

3.2 Additional Prerequisites for Tests C and D

A. The test specified by Test Specifications TS-51-4A009 have been satisfactorily completed within the specified acceptance criteria.

B. Prior to each of the tests, a Test Results Review Team, TRRT, must present a review of the prior tests and an updated prediction of the next test. Approval by the TRRT is mandatory for tests C and D.

The specific, but not all inclusive, items to be reviewed by the TRRT are comparison of the measured and predicted values of:

. decay power, as a function of time calculated by Core Physics compared with the measurement of power history

. coolant flow in the primary and secondary systems

. flow and temperature measurements from the eight thermocouples in the two FOTA;s and from selected thermocouples in the VOTA

. data from the steady state natural circulation test, TS-51-4A009

. coolant temperature and flow data from selected driver positions

Also to be reviewed by TRRT is the prediction by Core Physics of the decay power as a function of time for the subsequent natural circulation test.

The TRRT will consist of the manager or their designee(s) of the following groups:

. System Dynamics and Thermal Analysis

- Core Engineering
- Fuels Development
- Safety
- Test Engineering
- Fluid Systems Engineering
- Operations
- Fuels and Control

Sufficient time shall be provided between all tests to complete the required analysis and reviews.

C. One AOTA assembly shall be installed in row 6 of the core prior to these tests. The associated instrumentation, T/C's and eddy current flowmeters (high and low flow), shall be recorded on magnetic tape or similar medium for use during post test data analysis.

4.0 SPECIAL EQUIPMENT

A. Equipment to display/record the instrumentation associated with the two installed FOTA assemblies to meet the requirements described in Section 3.1.F.

B. Equipment to record the instrumentation associated with the AOTA an VOTA assemblies as specified in Section 3.1.G and 3.2.C.

C. Special electronics to provide a channel of PSD low flow information (in addition to the standard flow channel) for the eddy current flowmeters in the AOTA, and two FOTA assemblies.

5.0 TEST PREDICTIONS AND ACCEPTANCE CRITERIA

Test result predictions for Tests C and D are detailed in Reference (1). Final test predictions for the 5% test (Test A) are provided in Reference (3), and for the 35% test (Test B) the predictions are provided in Reference (4).

A. Test A Acceptance Criteria

The acceptance criterion for the 5% power, 75% flow scram to natural circulation test (Test A) is that the test results provide adequate predictive capability to assure that the 35% power, 75% flow scram to natural circulation test (Test B) can be performed without unacceptable risk.

Using the data from previous tests, the computer codes IANUS and CORA have been used to provide predictions of the outcome of Test A. These results are documented in Reference (3). The important data will come from the FOTA in row 2 of the core, and from the FOTA in row 6. Four representative temperatures from each FOTA will provide the crucial data. In each FOTA, three of these temperature measurements are at the top of the fuel region of the fuel pins. It is here that the peak temperatures are expected to occur. One of the four measurements in each FOTA will be at the core midplane. This measurement is to cover the unanticipated occurrence of extended flow stagnation or reversal. Figures 1 and 2 show the location of these four measurements in the row 2 and row 6 FOTA's. Figures 3 through 11 are the Test A predictions as given in Reference 3. Figure 3 is the predicted row 2 FOTA flow versus time, Figures 4 through 11 are the predicted T/C readings as a function of time. The important sensitive parameters on these temperature plots are the peak temperature and the time at which the peak occurs.

Test A is very difficult to predict with any confidence because the low power makes the measurements imprecise. The power measurement uncertainty (at this stage in the ascent to power) is ±20% during the steady-state operation preceeding scram. Hence, the decay power is uncertain by that amount combined with the uncertainty in the decay heat curve. The temperature rise measurement will be uncertain by the combined effect of the total decay power uncertainty, the instrumentation uncertainty, and other factors such as flow redistribution.

Conversely, the power level is so low that, with the plant data available to date, there appears to be essentially no risk associated with the test. That is, the predicted nominal case peak core temperature rise is 53°F, which is of the order of 10% of the peak core temperature rise at steady-state full power operation (~500°F). This more than compensates for the measurement difficulties.

The known phenomena of significance which can cause variations in the measured peak ΔT and the time of the peak ΔT can all be reasonably approximated by equivalent variation in either the decay heat, Q_D, or the primary system pressure drop, ΔP. These two gross parameter variations can be cross plotted on a graph of the resulting peak core temperature rise, ΔT_p, versus the corresponding time of the peak. This has been done in Figure 12, utilizing the results of sensitivity analyses of the nominal case. Figure 12 is based on nominal data with five hours at 2% power followed by one hour at 5% power.

The measured ΔT peak and corresponding time will be plotted on the grid of Figure 12. The measured data will then be adjusted for the uncertainties (see Table 1). This will produce an estimate of the worst case values for the effective decay power and primary pressure drop. These values could then be utilized in a recomputation of the results of Test B to ascertain the acceptability of proceeding based on the new data. This last computation has already been performed in a slightly different manner. The extreme values of Q_D and ΔP, which could cause Test B to result in temperatures above the peak 100% power steady state clad or fuel temperature, have been determined. Over the region of interest, when these Q_D and ΔP results are plotted onto the Test A grid (Figure 12), after substracting measurement errors, the result is a limit of 720°F peak temperature as measured in the row 2 FOTA. Any measured result less than this will yield predictions of Test B within acceptable limits.

A period at 5% power exceeding 1 hour will result in increased decay power, hence increased acceptable temperatures. This has been precalculated and the limiting acceptable measured temperatures plotted versus operating time at 5% power prior to scram in Figure 13.

Therefore, the Test A acceptance criterion is a measured peak core temperature below the limit curve of Figure 13 when plotted at the value of hours at 5% power used in the real test.

This acceptance criterion allows a rapid determination of the success of Test A, permitting Test B to be undertaken within a week of the successful completion of Test A. This criterion is conservative but, because of the low level of the test, the acceptance limit core temperature rise is more than double the predicted value.

The detailed test data from Test A will be used in conjunction with that from Test B to refine the modeling and analysis prior to Tests C and D. The results will not be used to provide multipliers <1 in the IANUS safety analyses.

B. Test A Abort Criteria

The maximum temperature allowed in this natural circulation test is 1133°F which just preserves full power fuel data. Safety limits are well above this value. Since the predicted peak core temperature is only 653°F and the success criteria is in the range 720°F to 760°F there is no reason for letting the reactor temperature get anywhere near the maximum allowed. A value of 825°F has been chosen as a reasonable level at which to abort Test A. This temperature is in no way a real limit but is sufficiently far above the predicted level to indicate some gross discrepancy between the predicted and the actual behavior.

Test A should be aborted in the extremely unlikely event that any one of the specially monitored T/C readouts from the Row 2 and Row 6 FOTA's goes above 825°F.

C. Test B Acceptance Test Criteria

The results of Test B will be used for two different purposes. In the short term, Test B will confirm that, during the planned power demonstration, safety is assured in the unlikely event of an unintentional scram to natural circulation. The power demonstration is a part of the same test sequence as Test B and a quantitative criteria which can be immediately applied has been developed.

Using the data from previous tests and the computer code IANUS, the CORA code has been used to provide predictions of the outcome of Test B. These results are documented in Reference (4). The data required to monitor the core performance during the test will come from the FOTA in Row 2 of the core, and from the FOTA in Row 6. Four representative temperatures from each FOTA will provide the data in the control room. In each FOTA, three of these temperature measurements are at the top of the fuel region of the fuel pins where the peak temperatures are expected to occur. One of the four measurements in eahc FOTA will be at the core midplane. This measurement is to cover the unanticipated occurrence of extended flow stagnation. Figures 1 and 2 show the location of these four measurements in the Row 2 and Row 6 FOTA's. Figures 14 through 22 are the Test B predictions as given in Reference 4. Figure 14 is the predicted Row 2 FOTA flow versus time, 14a is the predicted Row 2 FOTA flow, Figures 15 through 22 are the predicted T/C readings as a function of time. The important predicted values of these temperature plots are the peak temperature and the time at which the peak occurs.

The final acceptance criteria for Test B are expressed in terms of measured peak temperatures in the Row 2 FOTA assembly. The development of the criteria is defined in terms of temperature rise (ΔT), which is the temperature at the exit of the fueled section of the FOTA minus the inlet temperature. For this test the inlet temperature is essentially constant at 630°F (±5°F).

The known phenomena of significance which can impact the measured peak ΔT and the time of the peak ΔT can all be reasonably approximated by equivalent variation in the decay heat, Q_D, and/or the primary system pressure drop ΔP. These two gross parameter variations can be cross plotted on a graph of the resulting peak core temperature rise, ΔT, versus the corresponding time of the peak. This has been done in Figure 23, utilizing the results of sensitivity analyses of the nominal case. Figure 23 is based on nominal data with a normal ascent to 35% power followed by 56 hours at 35% power.

The measured ΔT peak and corresponding time can be plotted on the grid of Figure 23. The measured data can then be adjusted for the uncertainties. Known model uncertainties potentially influencing extrapolation to the design case have been identified and quantified for this purpose in a manner which assures that an overall conservative determination of power demonstration acceptability is made.

(See Table 4.) This adjustment will produce an estimate of the worst case values for the effective decay power and primary pressure drop from the test. These values with the established safety model margins incorporated could then be utilized in a recompuation of the results of a design basis loss of electric power during the succeeding power operation cycle to ascertain the acceptability of proceeding based on a model conservatively calibrated to the new test data. This last computation has already been performed for a spectrum of assumed test results to establish an acceptance threshold, in advance, of the extreme values of Q_D and ΔP which could cause the core safety limit to be approached for event E-5 (loss of normal and emergency power). This set of limiting values is defined by a peak ΔT temperature limit curve in Row 2 FOTA T/C readings from the top-of-the fuel T/C's. The Test B grid (Figure 23) has a dashed curve showing this limiting value as calculated. The solid acceptance curve below it has the uncertainty (Table 4) substracted, so that it can be compared to the raw measured values directly.

The time at 35% power has a sufficiently strong influence that it is necessary to adjust for this experimental condition. Figure 24 is a plot of the acceptance temperature (actual temperature, not ΔT) limits for proceeding to the remainder of the power demonstration run using as a parameter the time at 35% power prior to scram. The lines on Figure 24 are the calculated limits with the uncertainties (Table 4) subtracted and can be compared directly to the measured peak T/C value from the Row 2 FOTA. The uncertainty in primary cold leg temperature is included in these limits.

The analysis to determine the limiting values of Q_D and ΔP used the following conservative assumptions:

. IANUS Safety Model including 25% increase in decay power and 20% increase in core pressure drop.

. Decay Heat Corresponding to 2 days of full power (this assumption will be revised and a new limit computed if the power demonstration plan is significantly altered).

. Event occurs at design case power/flow condition (100%/100%).

An additional check will be performed to verify the modeling basis and understanding of the reactor behavior before proceeding with the planned power demonstration. The codes predict that a fuel assembly in a high power region of the core with higher full power operating temperatures will always exhibit a higher peak temperature during natural circulation than a fuel assembly in a lower power (hence lower decay power) region of the core with lower full power operating temperatures. Thus, the peak temperature in the Row 2 FOTA should be greater than the peak temperature in the Row 6 FOTA.

Therefore, the Test B acceptance criteria for proceeding to the planned full power test run are that:

. The measured peak core temperature rise values with uncertainties do not exceed the appropriate limit from Figure 24.

. The Row 6 FOTA temperature peak (-5°F) is not greater than the Row 2 FOTA temperature peak (+5°F).

The ±5°F allowances cover the relative uncertainties in the two separate measurements.

It is necessary to recognize that the test conditions cannot practically be controlled to exactly match the conditions assumed in developing the predictions. As a result, the current predictions cannot be expected to match the test results exactly. A major contributor to differences between the current predictions and the test results will be the power/time history prior to scram. The selection of a minimum of 5 hours of steady state operation was made to limit the impact of the power-time history. Other test factors which may cause the results to differ from predictions are the pump coastdown times and the ambient temperatures. As a consequence of these test condition variables it may become necessary to recalculate the predictions with boundary conditions matching those of the real test.

The longer term objective of Test B is to confirm that Tests C and D can be performed with a high confidence of success. Since Tests C and D are deliberately induced scrams from 75% and 100% power to natural circulation, the acceptable limits for performing the tests are not the safety limits for the E-5 event, but are the temperature levels at which long term fuel data might be lost. These are the steady-state full power clad and fuel temperatures. A further important difference between the full power demonstration run criteria in the short term and the acceptability of the natural circulation Tests C and D is that Tests C and D are deliberate tests of natural circulation which can be aborted and forced flow restored at any time.

The predicted results of Tests C and D will be much closer to the fuel data limits applicable for those tests than the safety anaysis predictions, discussed under the short term objective above, are to safety limits. Fortunately, the extrapolation from the 35% test results to the expected 75% test result involves relatively few uncertainties because the tests are very similar in character. This contrasts with the 5% test in which the predicted minimum flow and time response are significantly different than for the higher power tests. The appropriate grid will be used to recalibrate the model decay power and pressure drop, and the resulting model will be used to predict the result of the 75% power scram (Test C). This result should fall below the abort criterion for Test C. These results will then be reviewed by the Test Results Review Team.

The second Test B acceptance criterion will be a recommendation from the Test Review Team that Tests C and D can be performed with a high confidence of satisfactory result. This acceptance criterion impacts only Tests C and D, not the short term full power demonstration scheduled after Test B and before Test C.

D. Test B Abort Criteria

The maximum temperature allowed in any of the natural criculation tests is 1133°F which just preserves full power fuel data. Safety limits are well above this value. Since the nominal case predicted peak core is below 825°F, there is no reason for letting the reactor temperature get anywhere near the maximum allowed. A value of 980°F has been chosen as a reasonable level at which to abort Test B while assuring a definitive result relative to the acceptance limits in Figure 24. This temperature is not a real limit since no analysis suggests that exceeding this limit would produce damage, shorten component life-times or impair future evaluation of fuel performance. It is, however, sufficiently far above the predicted level to indicate some gross discrepancy between the predicted and the actual behavior, and still 153°F below the fuel data limit which allows adequate time to stop the temperature rise by turning on the pony motor.

Test B should be aborted in the extremely unlikely event that any one of the specially monitored T/C readouts from the Row 2 and Row 6 FOTA's goes above 980°F.

E. Tests C and D Acceptance Criteria

Acceptance criteria for Tests C and D are expressed in terms of FOTA peak δT's. The upper acceptance limits for these three tests are listed in Table 2. These limits were established on a conservative basis to assure protection of fuel lifetime and to demonstrate adequate decay heat removal capability. Exceeding the test acceptance criteria does not, therefore, necessarily imply inadequacy in the plant decay heat removal. Such a result would necessitate further evaluation and resolution of the uncertainty with respect to the adequacy of the decay heat removal capability of the plant. The predicted values of the FOTA peak temperatues are given in Table 3.

6.0 DATA REQUIRED

Data compression for data recorded by magnetic tape or similar medium should be set to minimum but not to exceed 0.1% of full scale.

A. The data to be acquired by the DDH&DS for the duration of each test is specified in Appendix A. The required scan interval for each parameter is specified following the parameter.

B. The thermocouples for the two FOTA assemblies shall be recorded continuously on magnetic tape or similar medium at a maximum compression window of 2°F during the test.

C. The instrumentation for the AOTA (when available) and VOTA assemblies shall be recorded continuously on magnetic tape similar medium at a maximum scan interval of 10 seconds during the test. The channels to be recorded include the inlet and exit T/C's, AOTA eddy current flowmeter specified in Section 4.C, and the self-powered neutron detectors in the VOTA.

D. Pump coastdown time for each pump.

E. Data recording shall be continued byond the completion of the test for a minimum of 1 hour or until near isothermal conditions are achieved with all pony motors on to verify the instrument status.

7.0 REFERENCES

1. Letter, T. A. Mangelsdorf to Directio FFTFPO, "Natural Circulation Acceptance Test Predictions for Test 5A008 (Specifications TS-51-4A009 and TS-51-5A008)," dated May 27, 1977, W/FFTF 7752:35.

2. W. T. Nutt, S. L. Additon and G. D. Bouchey, "FFTF Primary System Transition to Natural Circulation from Low Reactor Power," HEDL-SA-1919FP.

3. H. G. Johnson, "Pretest Predictions of the Thermal and Hydraulic Responses of the Fueled Open Test Assemblies to the 5 percent Power Natural Circulation FFTF Plant Startup Test," HEDL-TC-1778.

4. H. G. Johnson, "Pretest Predictions of the Thermal and Hydraulic Responses of the Fueled Open Test Assemblies to the 35 Percent Power Natural Circulation FFTF Plant Startup Test," HEDL-TC-1799.

Table I

Uncertainty Summary for 5% Transient Natural Circulation Test

Measurement	Uncertainty[2]	Anticipated Model Uncertainties[1]							Subtotal[6] Prediction Uncertainty	Total[7] Prediction Uncertainty
		Q(t)	M_{us}	Duct	Q_o	M(z)	Hot Channel[3] Statistical Factor	Other[4]		
<u>Transient</u>										
ΔT_{HFO11} (°C)	±3	0	±0.2	[illegible]	±3.4	±1.4	±1.6	±2	±5.4	±6.5
t_{max} (sec)	0	0	±1.5	±2.6	±16.5	0	±4.4	±10	±20	±24
T_{1-2} (°C)	±1	0	0	±0.1	±1.4	0	±0.6	0	±1.8	±2.1
W_{Loop} (%)[5]	±0.05	0	0	0	±0.08	0	±0.01	0	±0.09	±0.09
W_{HFO11} (%)	±0.18	0	0	0	±0.08	0	±0.02	0	±0.2	±0.21
<u>Steady-State</u>										
ΔT_{HFO11} (°C)	±3	±0.6	±0.06	±0.02	±1.1	0	±0.06	0	±3.3	±3.7
W_{Loop} (%)	±0.05	0	±0.01	0	±0.09	0	±0.01	0	±0.1	±0.11
W_{HFO11} (%)	±0.18	±0.01	±0.01	0	±0.09	0	±0.02	0	±0.2	±0.21

1. These estimates are based on the assumption that $\Delta Q(t) = \pm 6\%$, $\Delta M_{us} = \pm 0.2$, $\Delta Duct = \pm 0.1$, $\Delta Q = \pm 1\%$ and $\Delta M(z) = \pm 0.5$.
2. Represents 3σ values on the data acquisition.
3. Statistical factors due to inlet flow maldistribution, rod bowing, and power distribution.
4. Estimated uncertainty due to radial heat transfer, upper plenum modelling and sub-assembly cross-flows.
5. All flows are expressed as percent of design flow.
6. This is the root-mean-square of all the uncertainties relevant to the calculation of Q_d and ΔP.
7. Uncertainties of 0.4 in ΔP and 0.12 in Q_d are included.

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TABLE 2

FOTA TEMPERATURE ACCEPTANCE LIMITS

		FOTA Row 2	FOTA Row 6
100% Power (T_{in} = 680°F)	(Test D)	1207°F	1198°F
75% Power (T_{in} = 662°F)	(Test C)	1019°F	1013°F
35% Power (T_{in} = 630°F)	(Test B)	TBD-1	TBD-1
5% Power (T_{in} = 599°F)	(Test A)	See Tables 4a-4c and Page 17	(1 hr. @ 5%) 660°F (2 hrs. @ 5%) 666°F (8 hrs. @ 5%) 6[illegible]1°F

[TABLE # 3]

MAXIMUM FOTA PEAK TEMPERATURES

	Time at Power Before Scram	FOTA Row 2	FOTA Row 6
100% Power (T_{in} = 680°F) (Test D)	1 hour (4% Decay Power*)	1014°F	1005°F
	25 hours (4.5% Decay Power*)	1048°F	1040°F
75% Power (T_{in} = 662°F) (Test C)	1 hour (3% Decay Power*)	932°F	925°F
	25 hours (3.5% Decay Power*)	957°F	950°F
35% Power (T_{in} = 630°F) (Test B)	1 hour (1.4% Decay Power*)	TBD-1	TBD-1
	25 hour (1.7% Decay Power*)	TBD-1	TBD-1
5% Power (T_{in} = 599°F) (Test A)	1 hour (0.216% Decay Power*)	648°F	<648°F
	2 hours (0.224% Decay Power*)	654°F	<654°F
	8 hours (0.234% Decay Power*)	659°F	<659°F

* Predicted decay power as a percentage of 400 MW

TABLE 4

UNCERTAINTY SUMMARY FOR 35% TRANSIENT NATURAL CIRCULATION TEST
ANTICIPATED MODEL UNCERTAINTIES (1)

Quantity	Measurement	$Q_{(t)}$	M_{us}	Duct	Q_o	$M_{(z)}$	Hot Channel Statistical Factors	Other(2)	Subtotal Prediction Uncertainties	Total(3) Prediction Uncertainties
TRANSIENT										
ΔT_{HF011} (°F)	±5	0	±10	0	±6	0	±14	±18	±26	±34
t_{max} (sec)	0	0	± 1.3	0	±1.3	0	0	±17	±17	±18
W_{Loop} (GPM)	±30	0	±32.0	0	±44	0	0	±29	±69	±70
STEADY STATE (10 MINUTES)										
ΔT_{HF011} (°F)	± 5	4.4	± 3.8	0	± 3.5	0	± 8	± 5	±13	±20
W_{Loop} (GPM)	±30	±2.3	±18	0	±24	0	0	±21	±47	±50

(1) These estimates are based on the assumption that $\Delta Q_{(t)}$ = ±6%, ΔM_{us} = ±0.2, ΔDuct = 0, ΔQ_o= 2.6 Mw and $\Delta M_{(z)}$= 0.

(2) This takes into account the effects of plenum modeling and mixing.

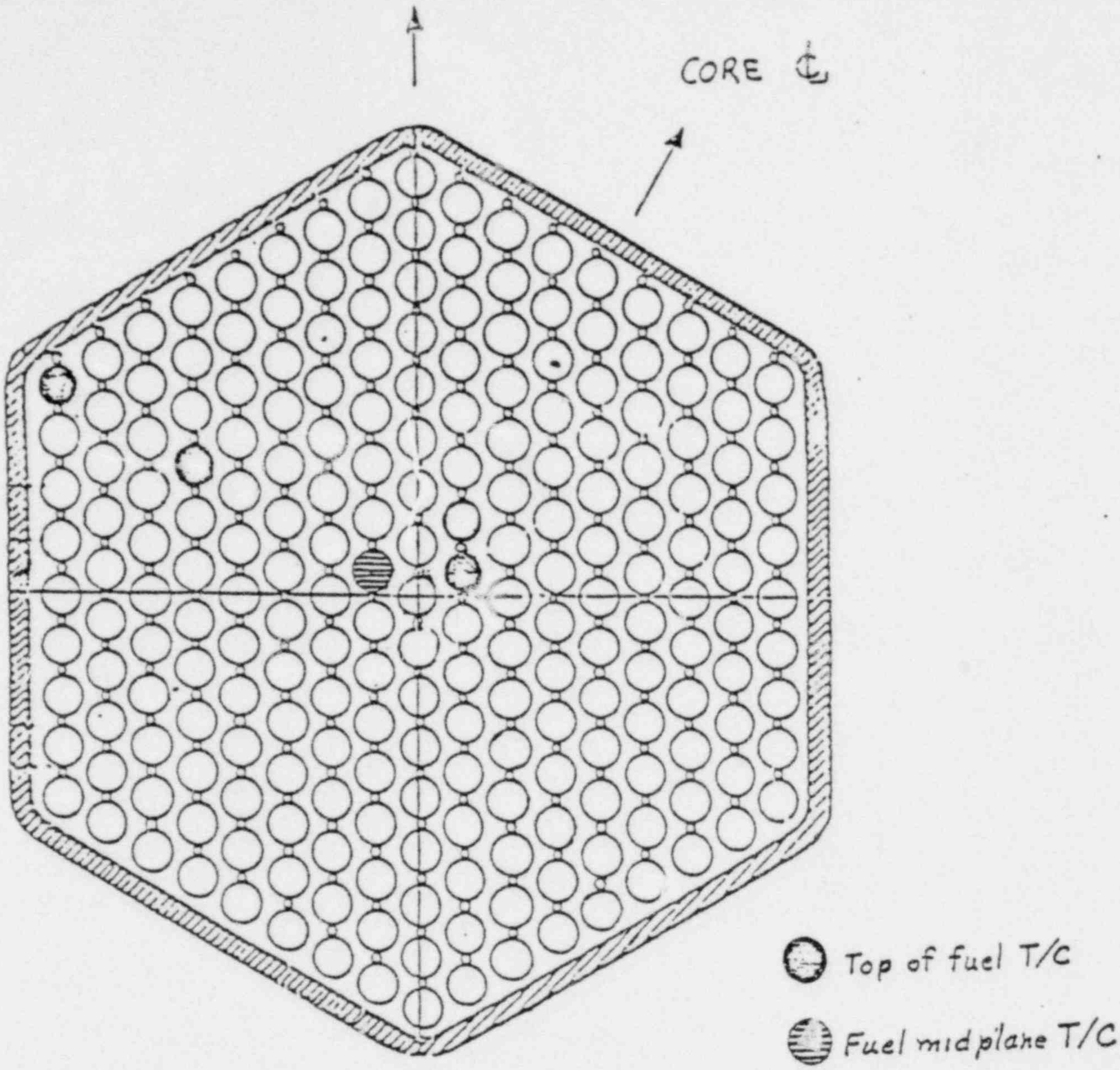
(3) Includes uncertainties of 0.4 in ΔP and 0.12 in Q .

$Q_{(t)}$ = Decay power time dependence (for transient, in total but not subtotal value, see Note (3))
M_{us} = Top reflector/pin mass above active zone
Duct = Duct wall effect (negligible for inner pins)
Q_o = Initial power level
$M_{(z)}$ = Axial dependence of top reflector mass

TABLE 5

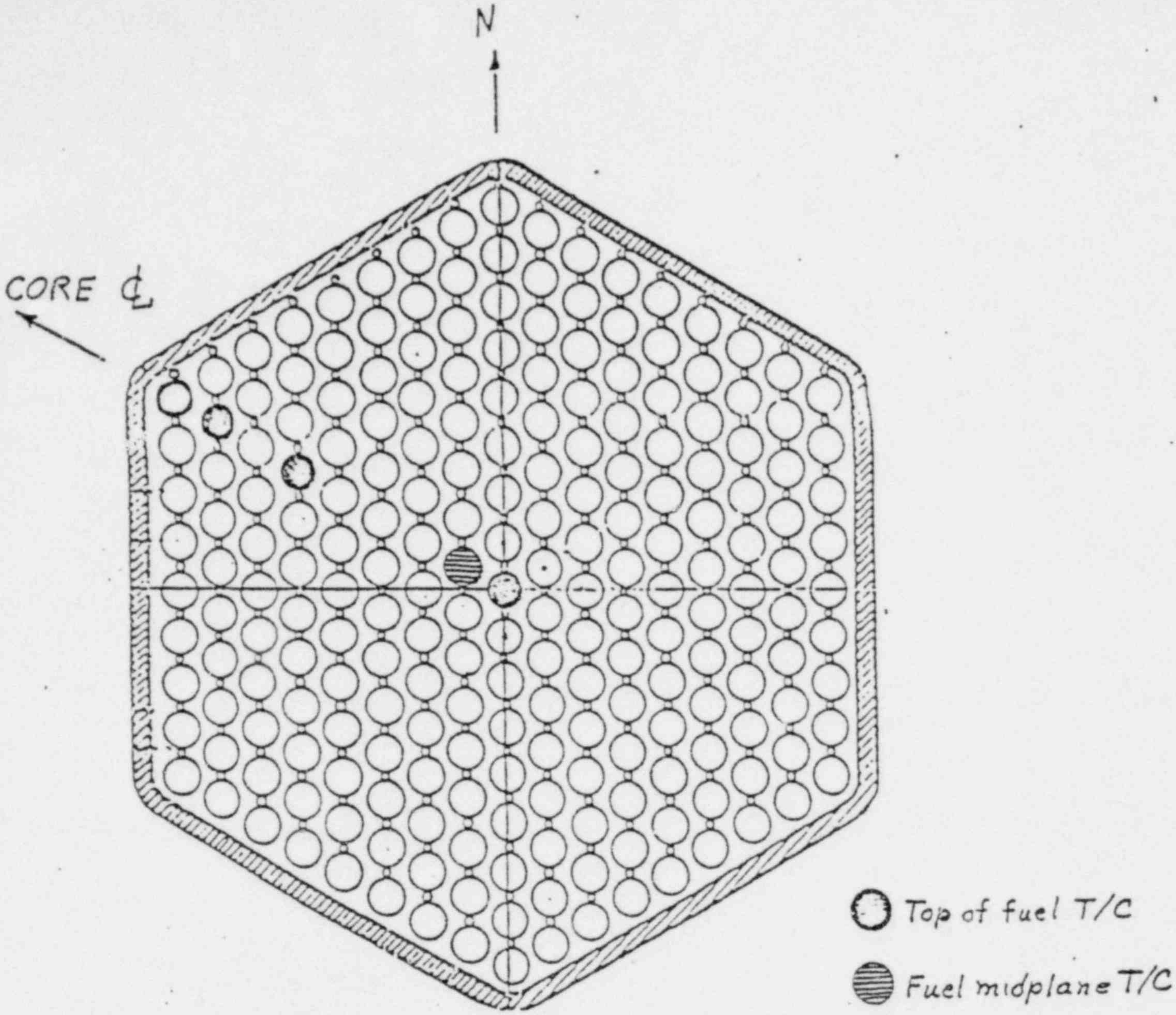
TEST	PREPOWER OPERATION	STEADY STATE POWER	STEADY STATE TIME	CALCULATED DECAY POWER AT SCRAM (% of 400 MW)
A	2% Power (8MW) 3-7 hrs.	5% 20 MW	1-16 hrs	0.216-0.234% (1)
B.	Normal Ascent to 35% Power 3-16 hrs.	35% 140 MW	5-56 hrs	1.68 - 1.75% (1)
C.	Normal Ascent to 75% Power 5-10 hrs.	75% 300 MW	1 hrs	3.0 - 3.5% (1)
D	Normal Ascent to 100% Power 7-12 hrs	100% 400 MW	25 hrs	4.0 - 4.5% (1)

(1) These values include estimates of the residual power from operations prior to the test operation cycle.



CORE LOCATION 1202
VIEW FROM TOP
FOUR TEMPERATURES 1" ABOVE FUEL

FIGURE 1. ROW 2 FOTA TEMPERATURES DISPLAYED IN CONTROL ROOM



CORE LOCATION 3610
VIEW FROM TOP
FOUR TEMPERATURES 1" ABOVE FUEL

FIGURE 2. ROW 6 FOTA TEMPERATURES DISPLAYED IN CONTROL ROOM

FIGURE 3. CALCULATED ROW 2 FOTA NORMALIZED ASSEMBLY COOLANT FLOW RATES.
INITIAL FLOW RATE IS 43.99 LB/SEC.

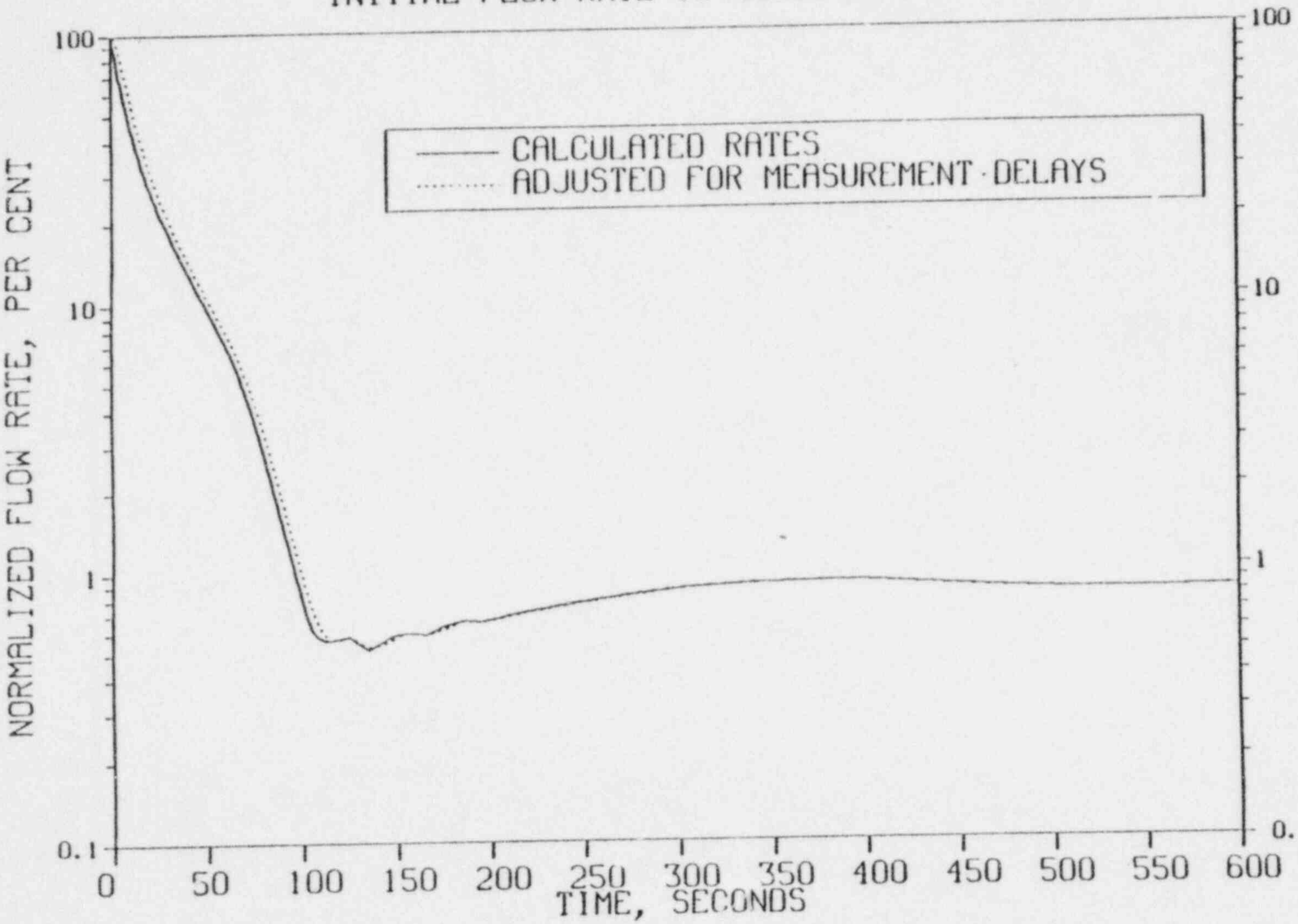


FIGURE 4. CALCULATED ROW 2 FOTA TOP OF FUEL COOLANT TEMPERATURES FOR T/C TX1016 ON PIN 8,8.

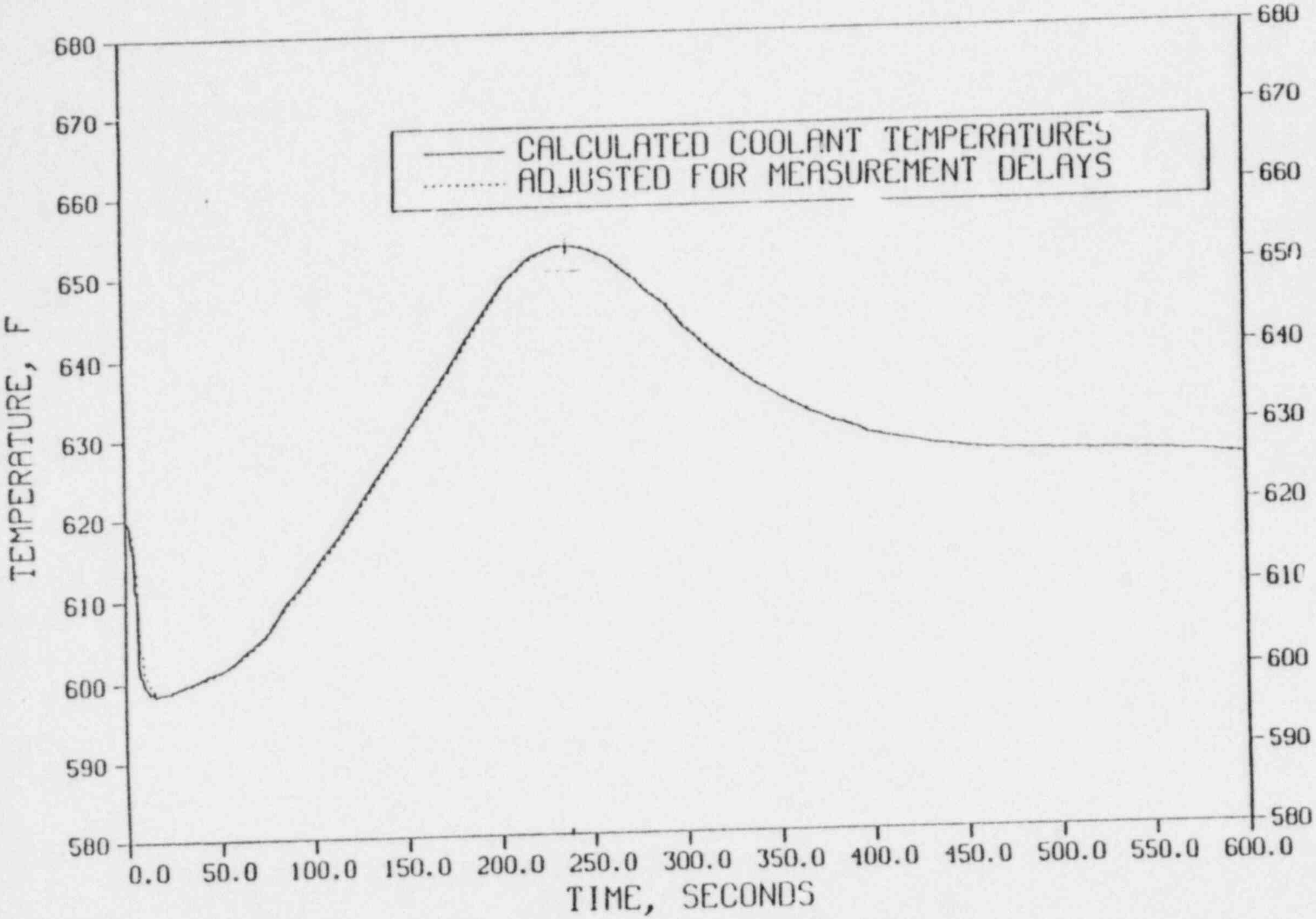


FIGURE 5. CALCULATED ROW 2 FOTH TOP OF FUEL COOLANT TEMPERATURES FOR T/C TX1012 ON PIN 9,14.

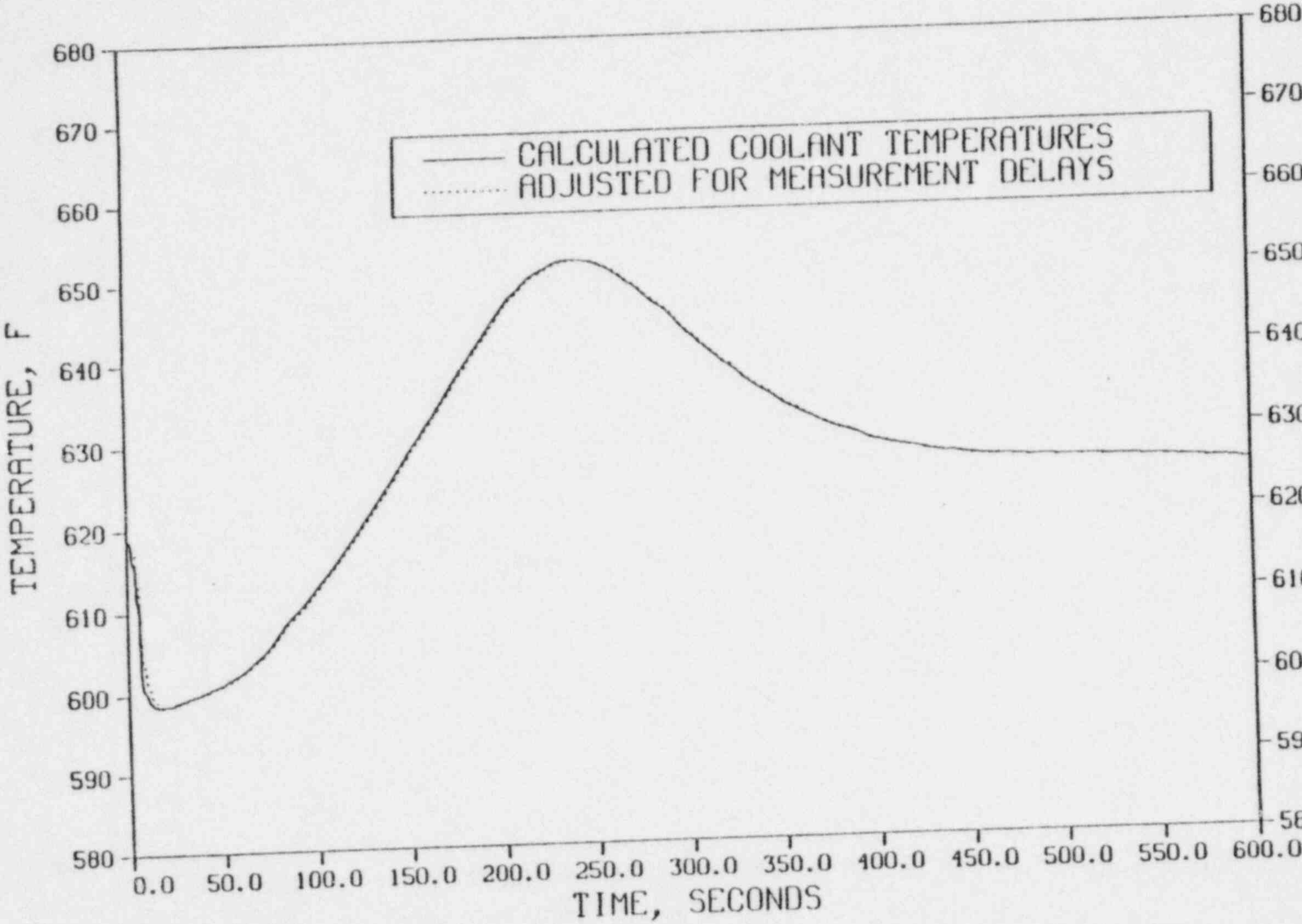


FIGURE 6. CALCULATED ROW 2 FOTA TOP OF FUEL COOLANT TEMPERATURES FOR T/C TX1008 ON PIN 9,17.

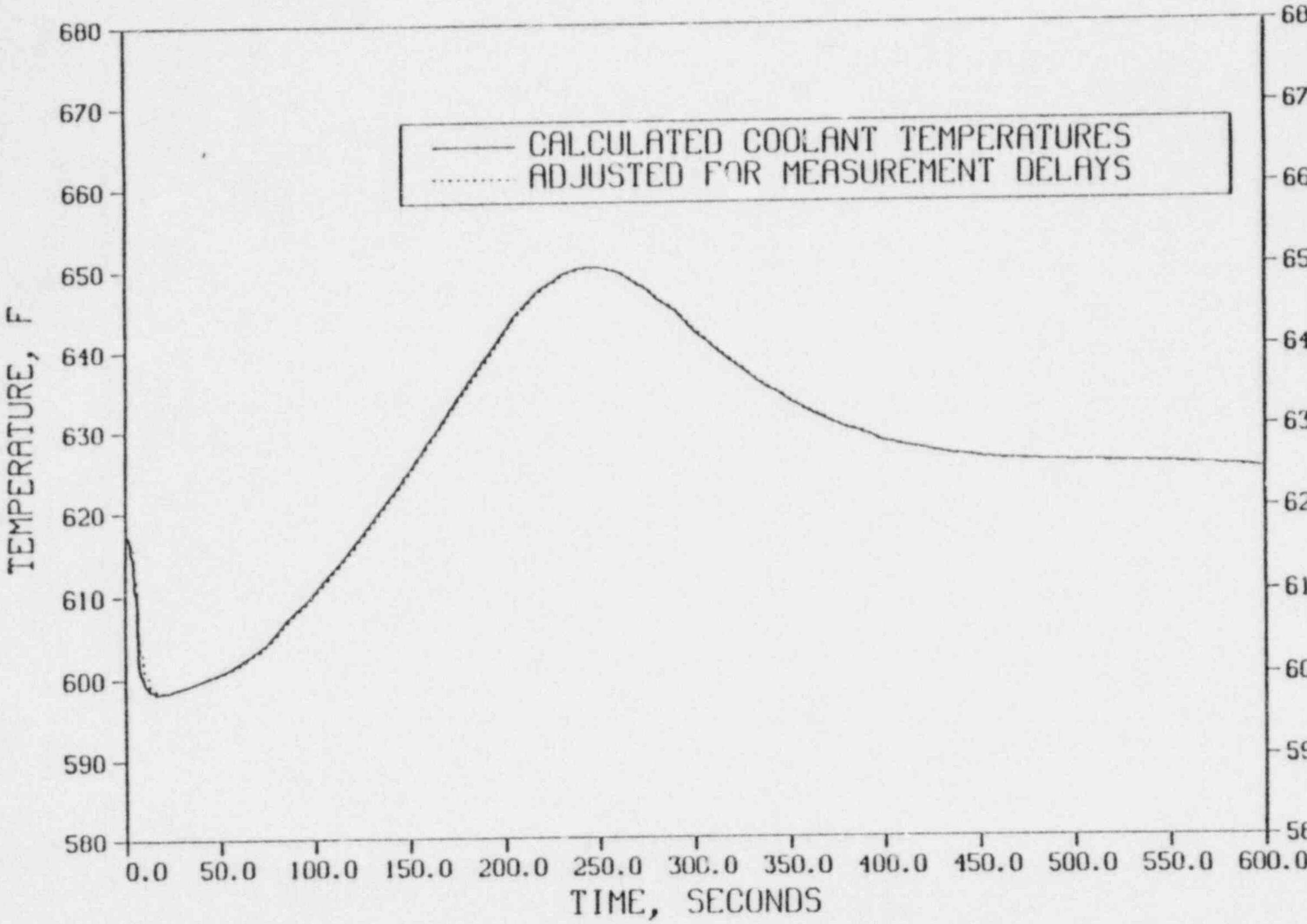


FIGURE 7. CALCULATED ROW 2 FOTA CORE MIDPLANE COOLANT TEMPERATURES FOR T/C TX1009 ON PIN 9,10.

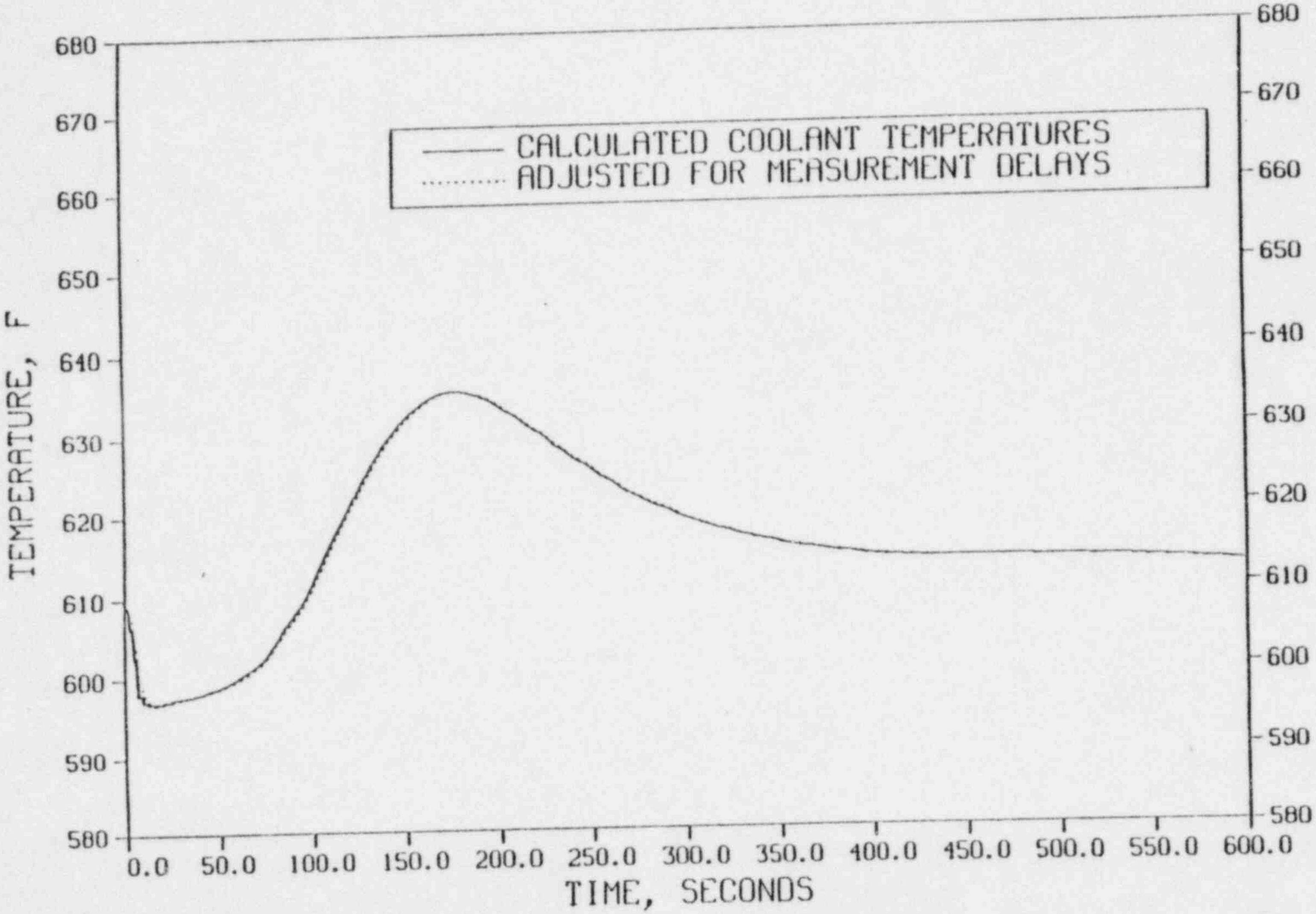


FIGURE 8 CALCULATED ROW 6 FOTA TOP OF FUEL COOLANT TEMPERATURES FOR T/C TX9026 ON PIN 2,2.

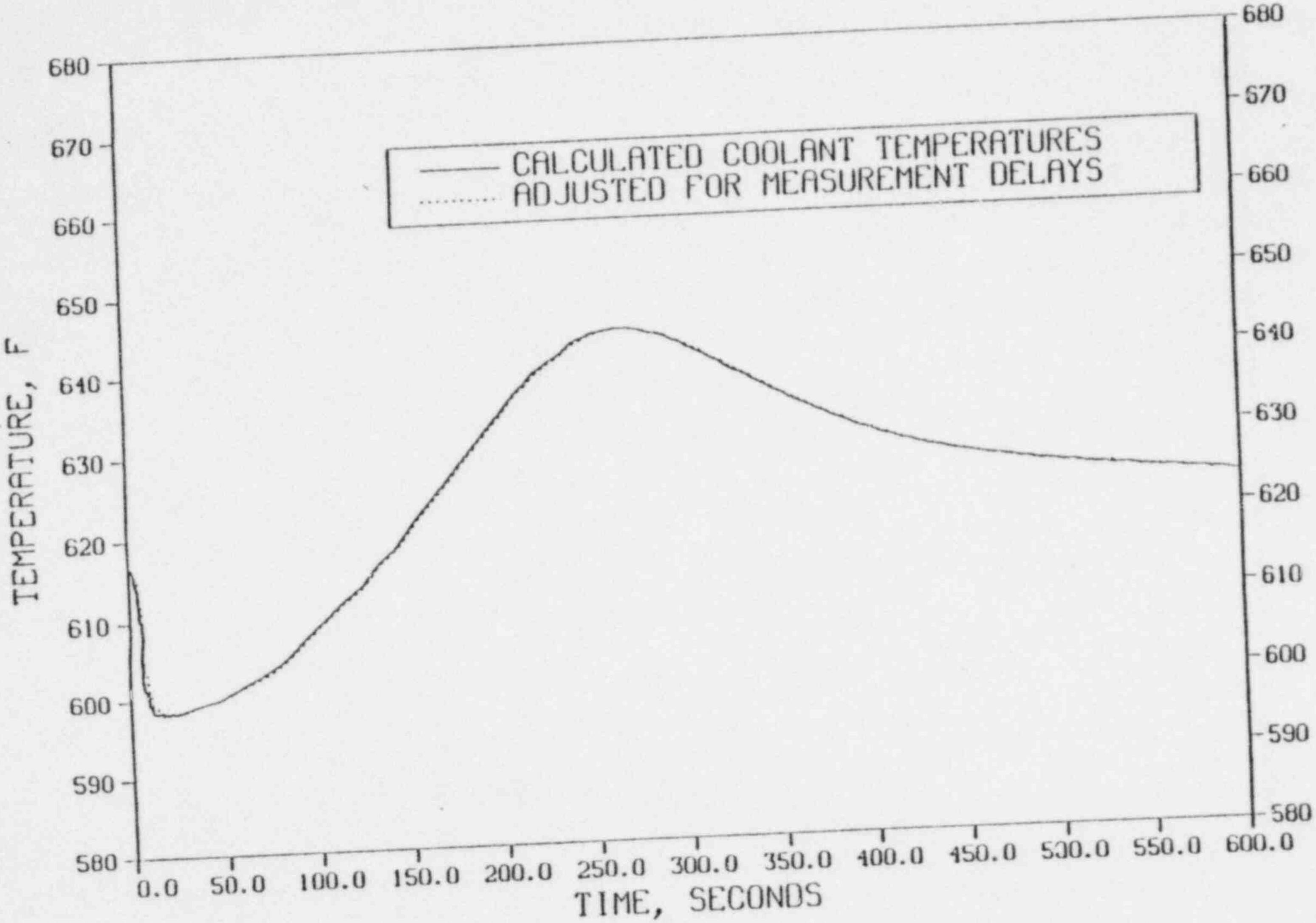


FIGURE 9 CALCULATED ROW 6 FOTA TOP OF FUEL COOLANT TEMPERATURES FOR T/C TX9018 ON PIN 4,4.

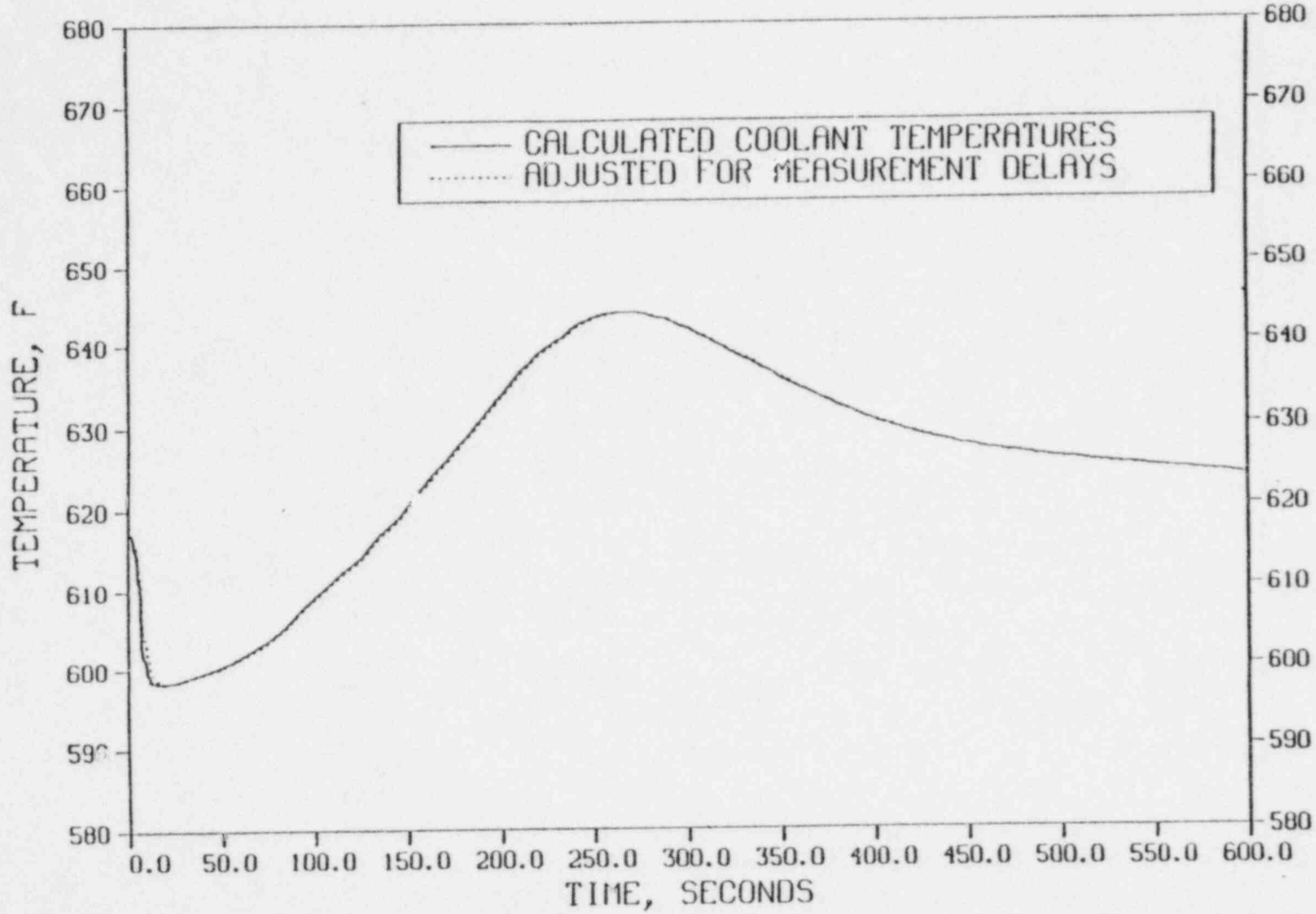


FIGURE 10 CALCULATED ROW 6 FOTA TOP OF FUEL COOLANT TEMPERATURES FOR T/C TX9009 ON PIN 9,9.

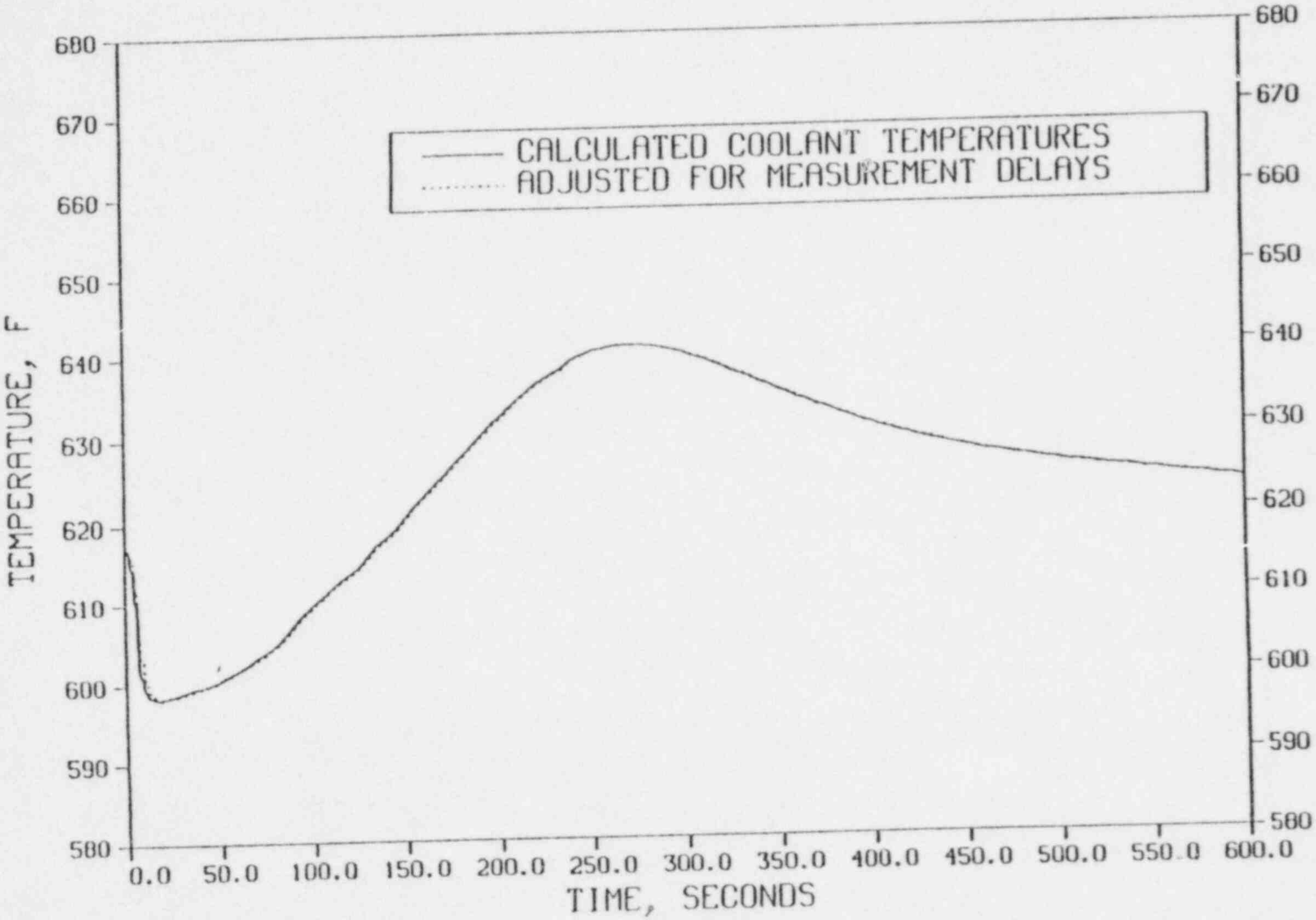
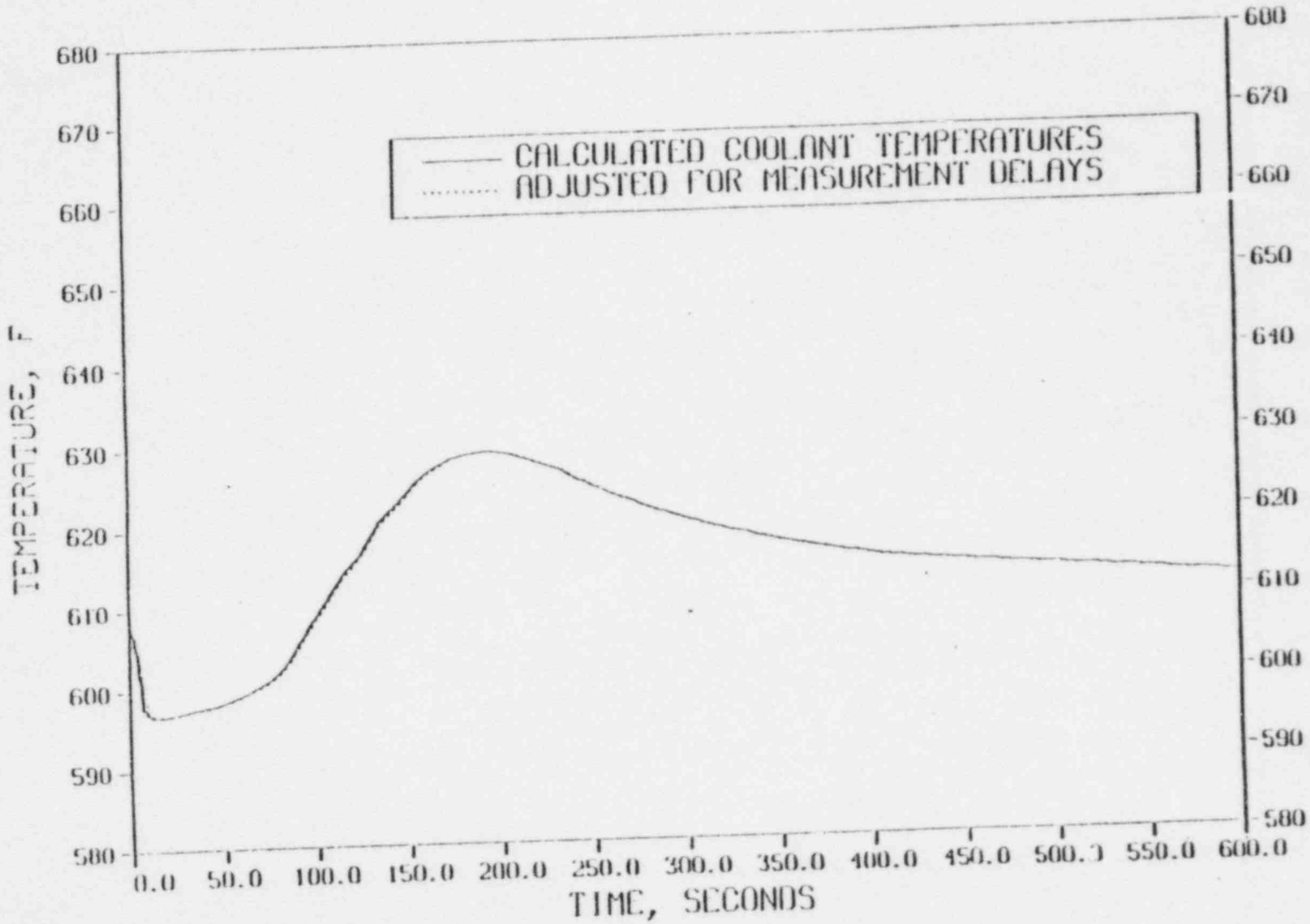


Figure 11 Calculated Row 6 FOTA Core Midplant Coolant Temperatures for T/C TX9039 on Pin 8,8



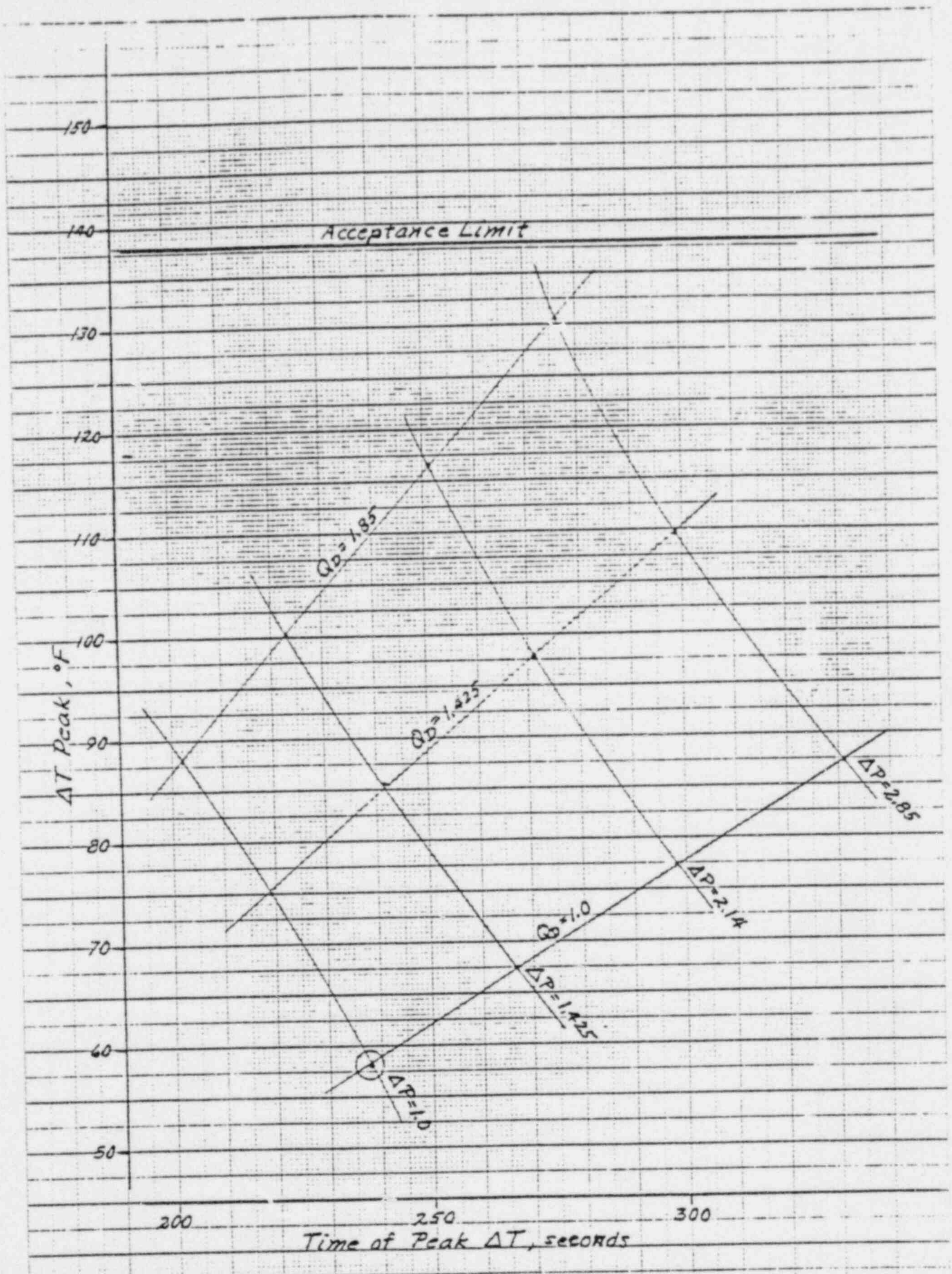


Figure 12 – Test A Acceptance Grid

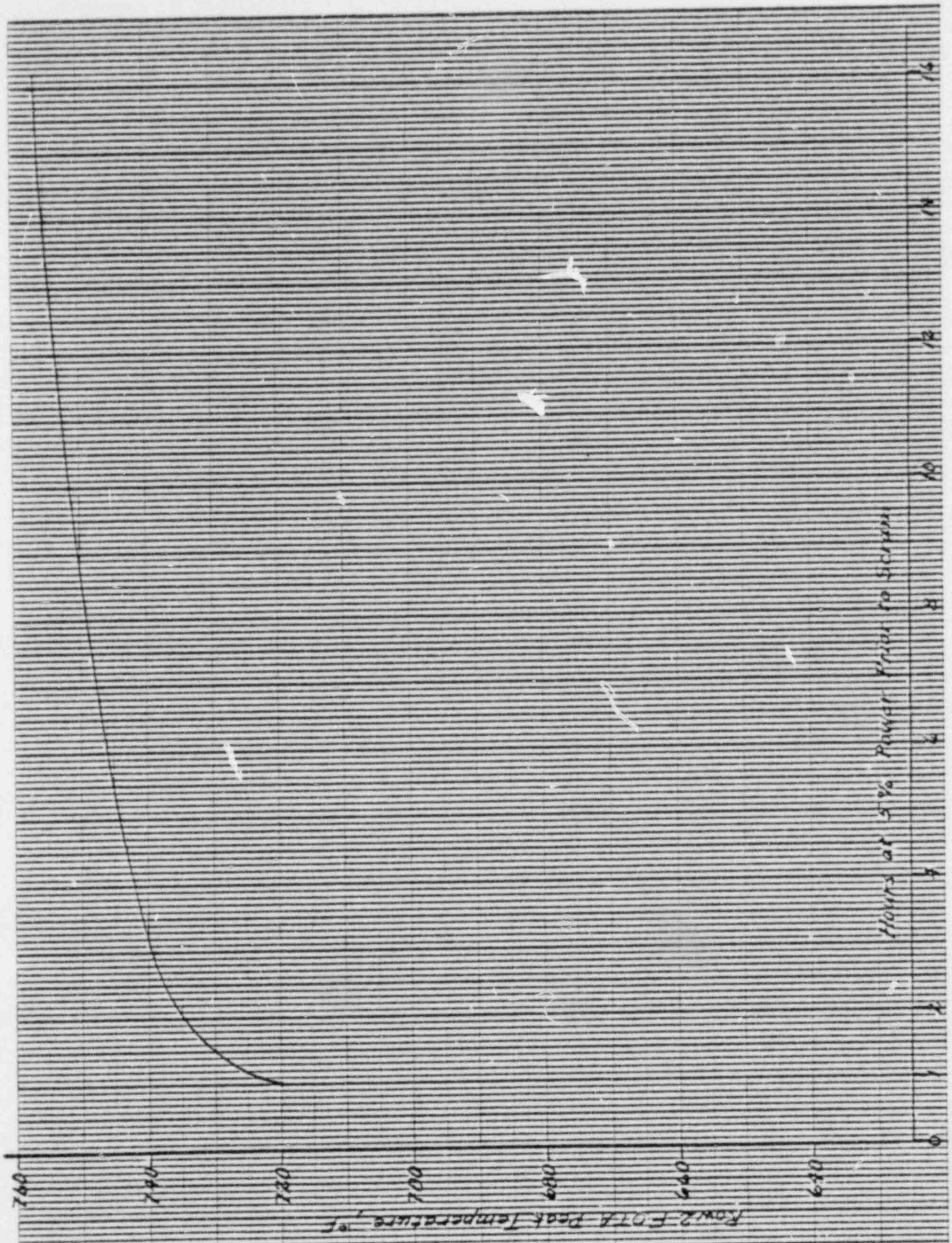
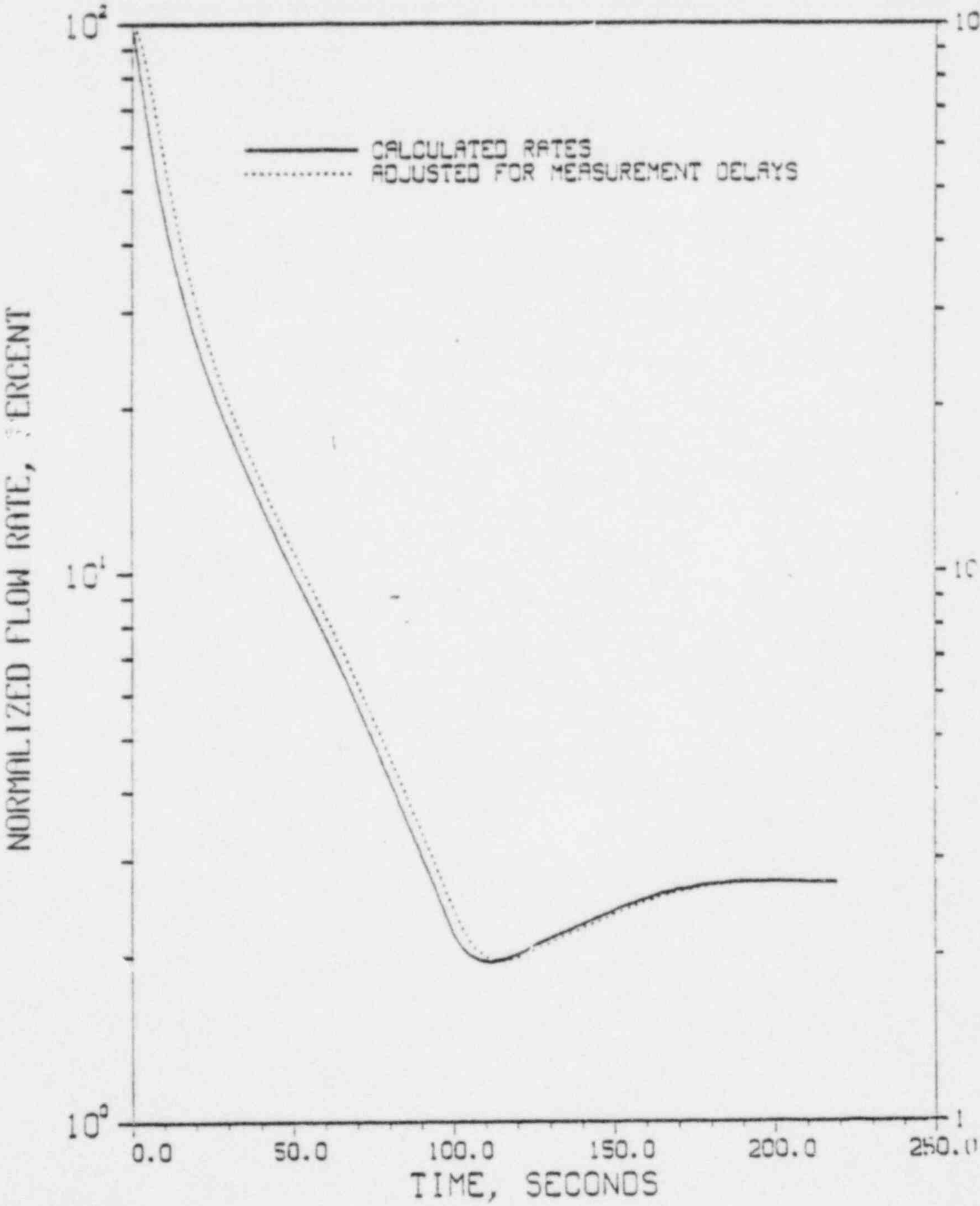


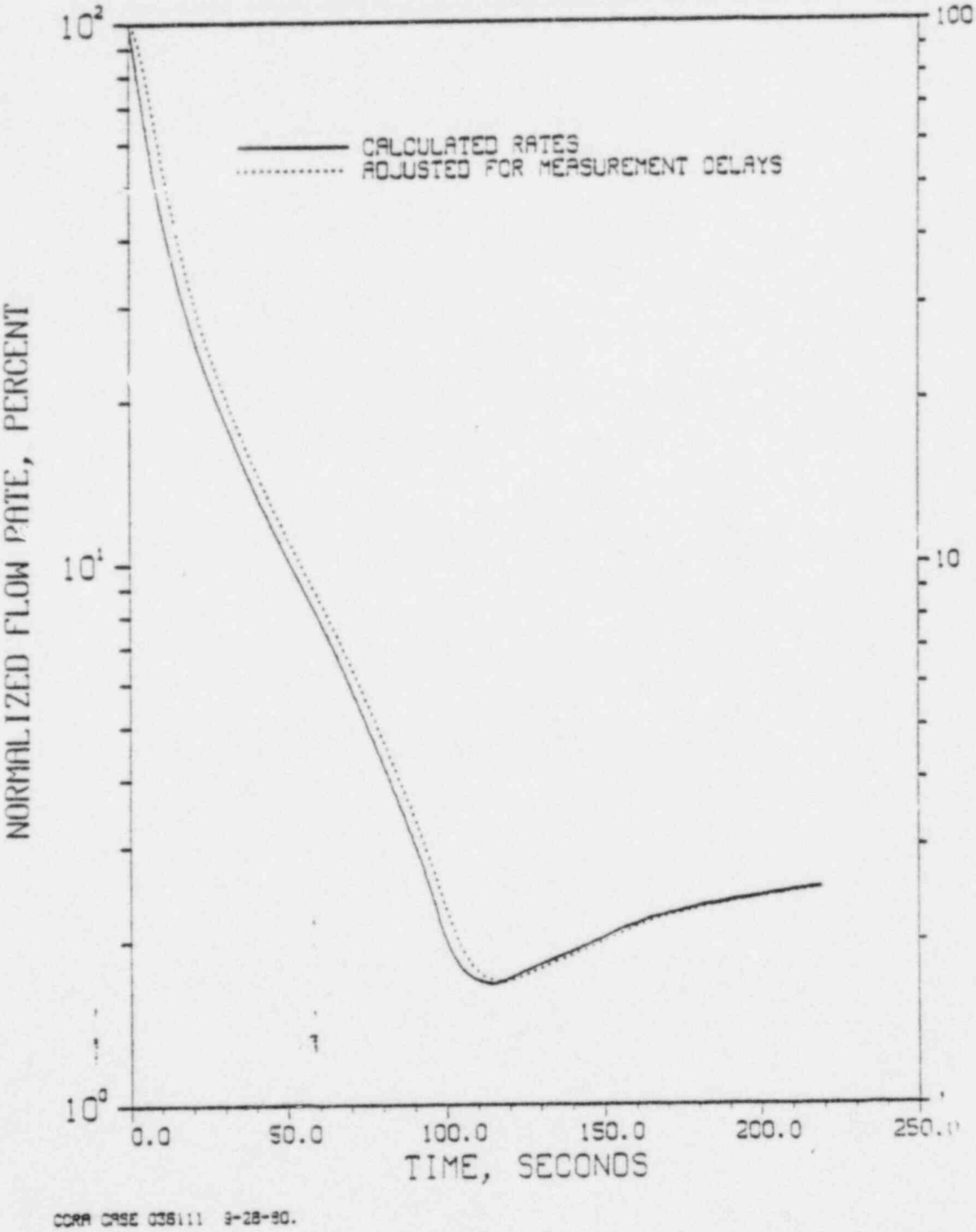
Figure 13 - Test A Acceptance Criterion

FIG. 14 CALCULATED ROW 2 FOTA NORMALIZED ASSEMBLY COOLANT FLOW RATES. 35 PERCENT POWER NATURAL CIRCULATION TEST. INITIAL RATE IS 43.95 LB/SEC.



CORA CASE 022032 9-13-80.

FIG. 14A CALCULATED ROW 6 FOTA NORMALIZED ASSEMBLY COOLANT FLOW RATES.
35 PERCENT POWER NATURAL CIRCULATION TEST.
INITIAL RATE IS 35.81 LB/SEC.



CORA CASE 038111 9-28-80.

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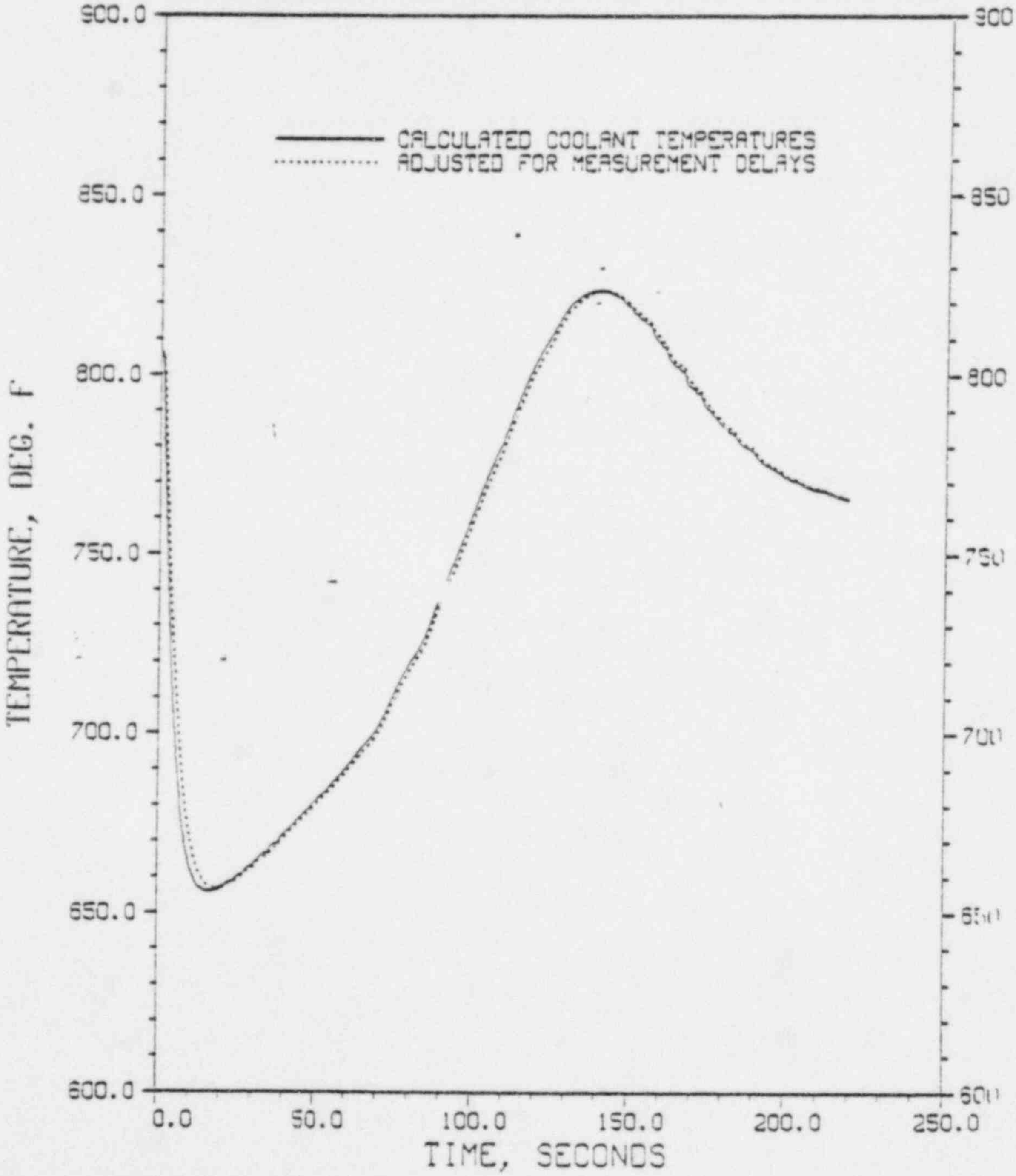
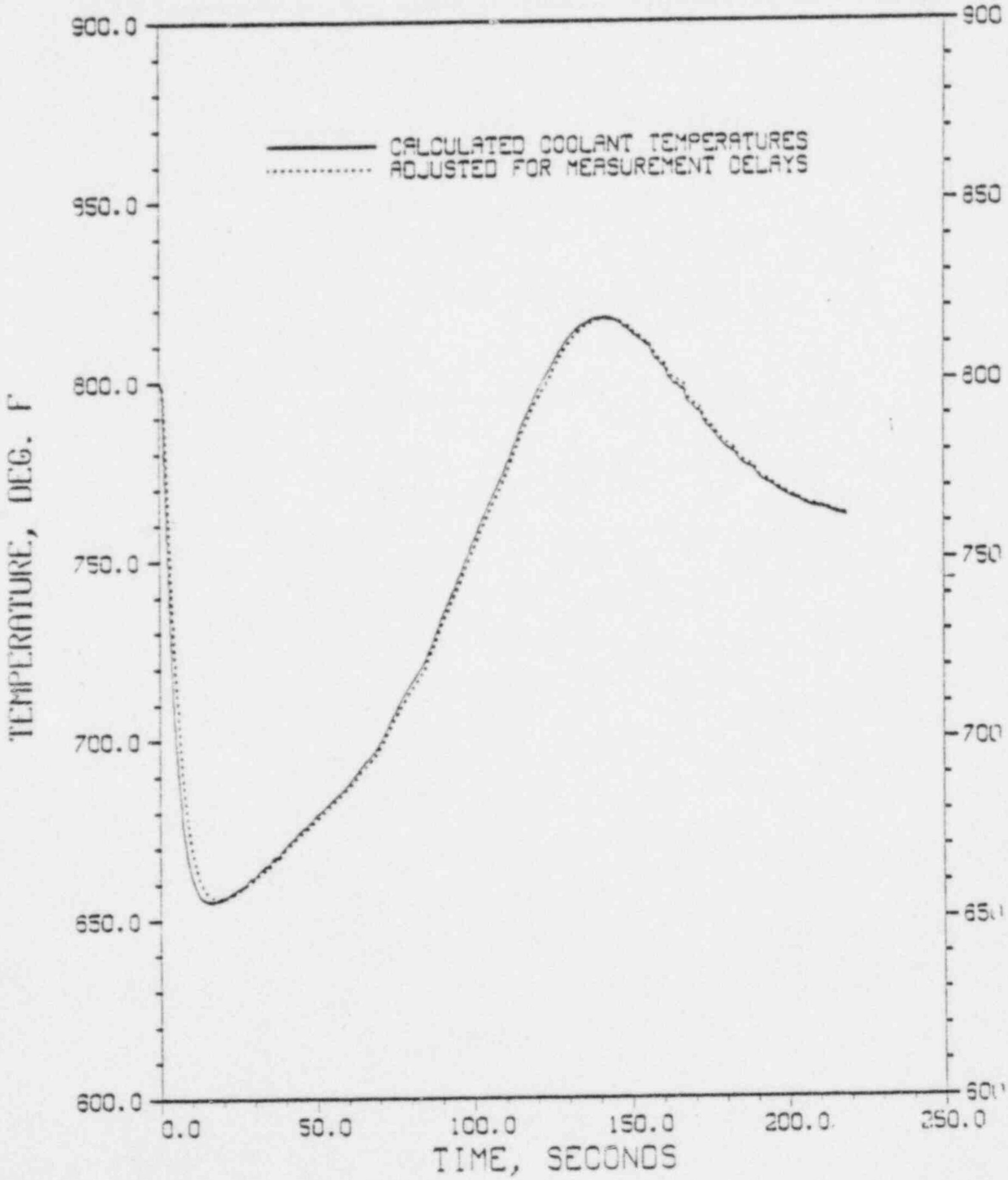
FIG. 15 CALCULATED ROW 2 FCTA TOP OF FUEL COOLANT TEMPERATURES FOR T/C TX1016 ON PIN 8,6. 35 PERCENT POWER NATURAL CIRCULATION TEST.



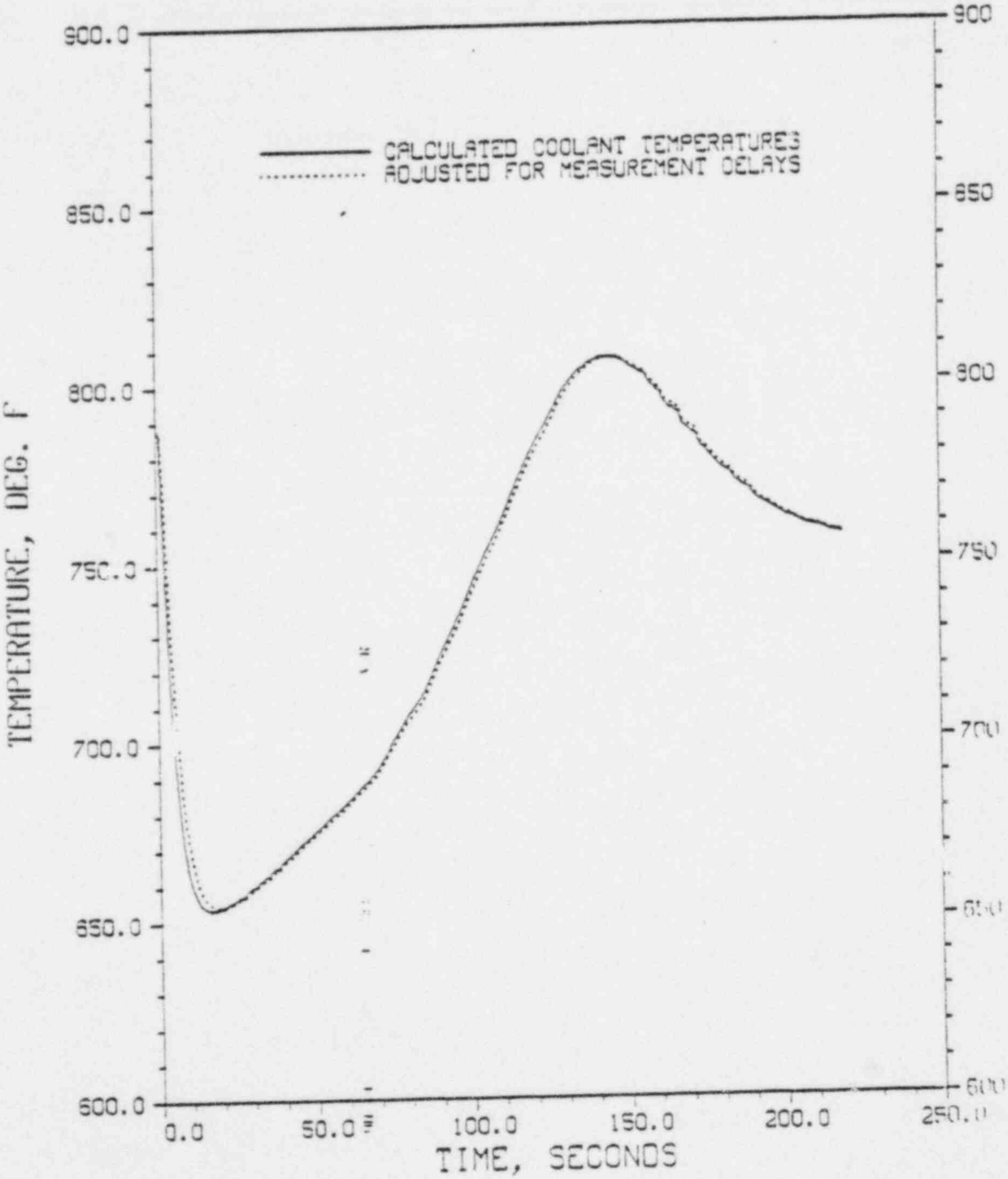
CORA CASE 022032 9-13-80.

FIG. 16 CALCULATED ROW 2 FOTA TOP OF FUEL COOLANT TEMPERATURES FOR T/C TX1012 ON PIN 9,14. 35 PERCENT POWER NATURAL CIRCULATION TEST.



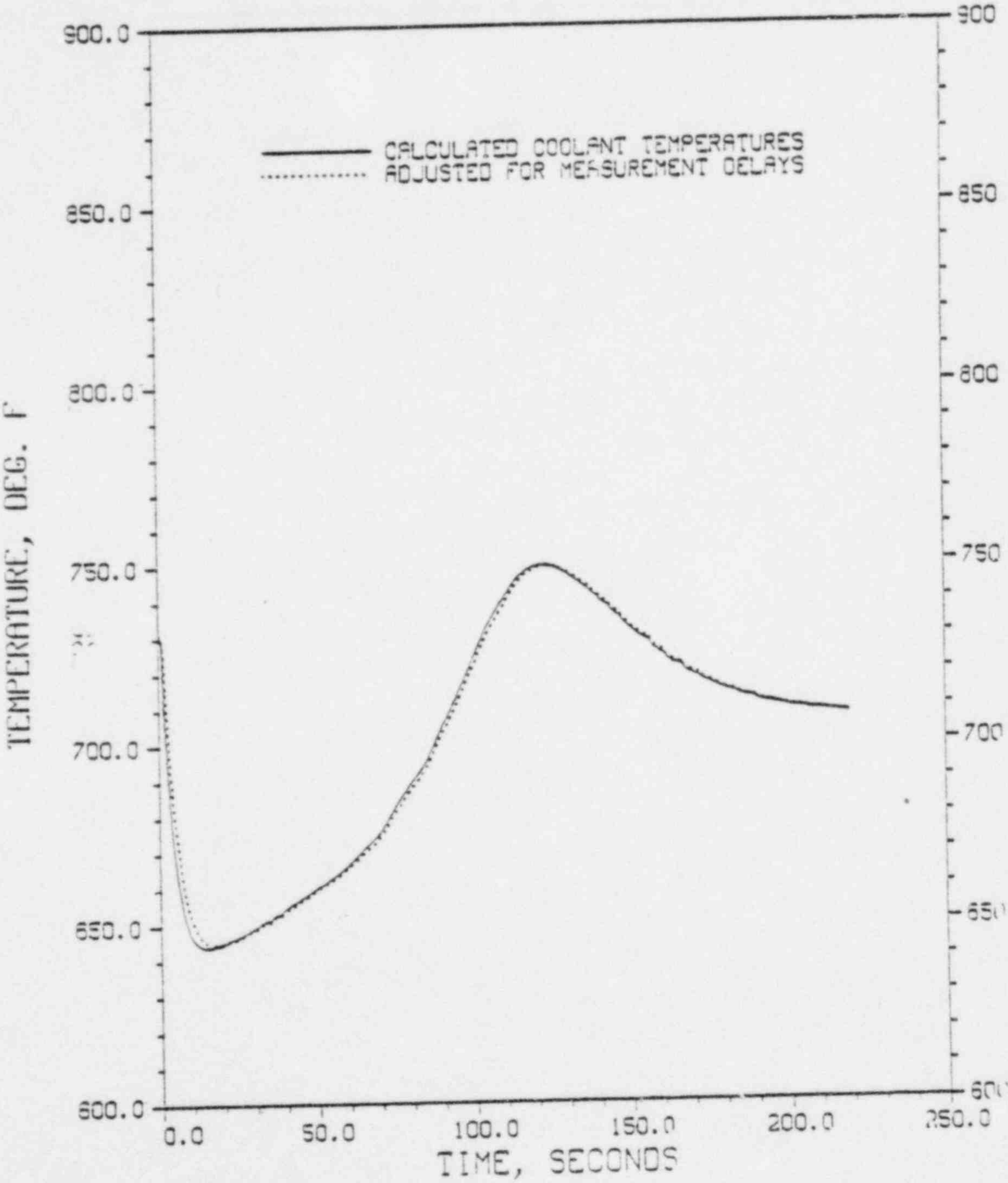
CORA CASE 022032 9-13-80.

FIG. 17 CALCULATED ROW 2 FOTA TOP OF FUEL COOLANT TEMPERATURES FOR T/C TX1008 ON PIN 9,17. 35 PERCENT POWER NATURAL CIRCULATION TEST.



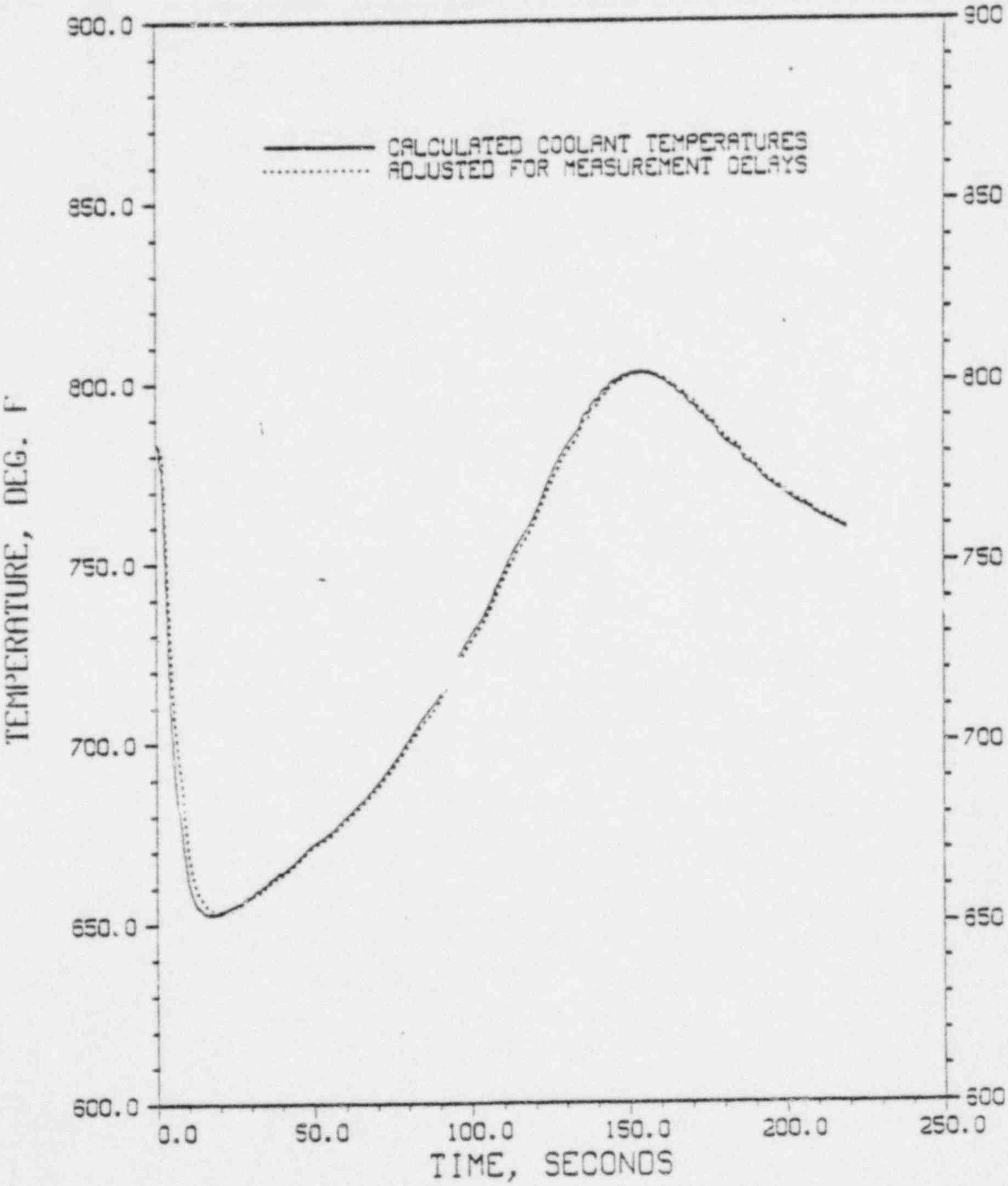
CORA CASE 022032 9-13-80.

FIG. 18 CALCULATED ROW 2 FOTA CORE MIDPLANE COOLANT TEMPERATURES FOR T/C TX1009 ON PIN 9,10. 35 PERCENT POWER NATURAL CIRCULATION TEST.



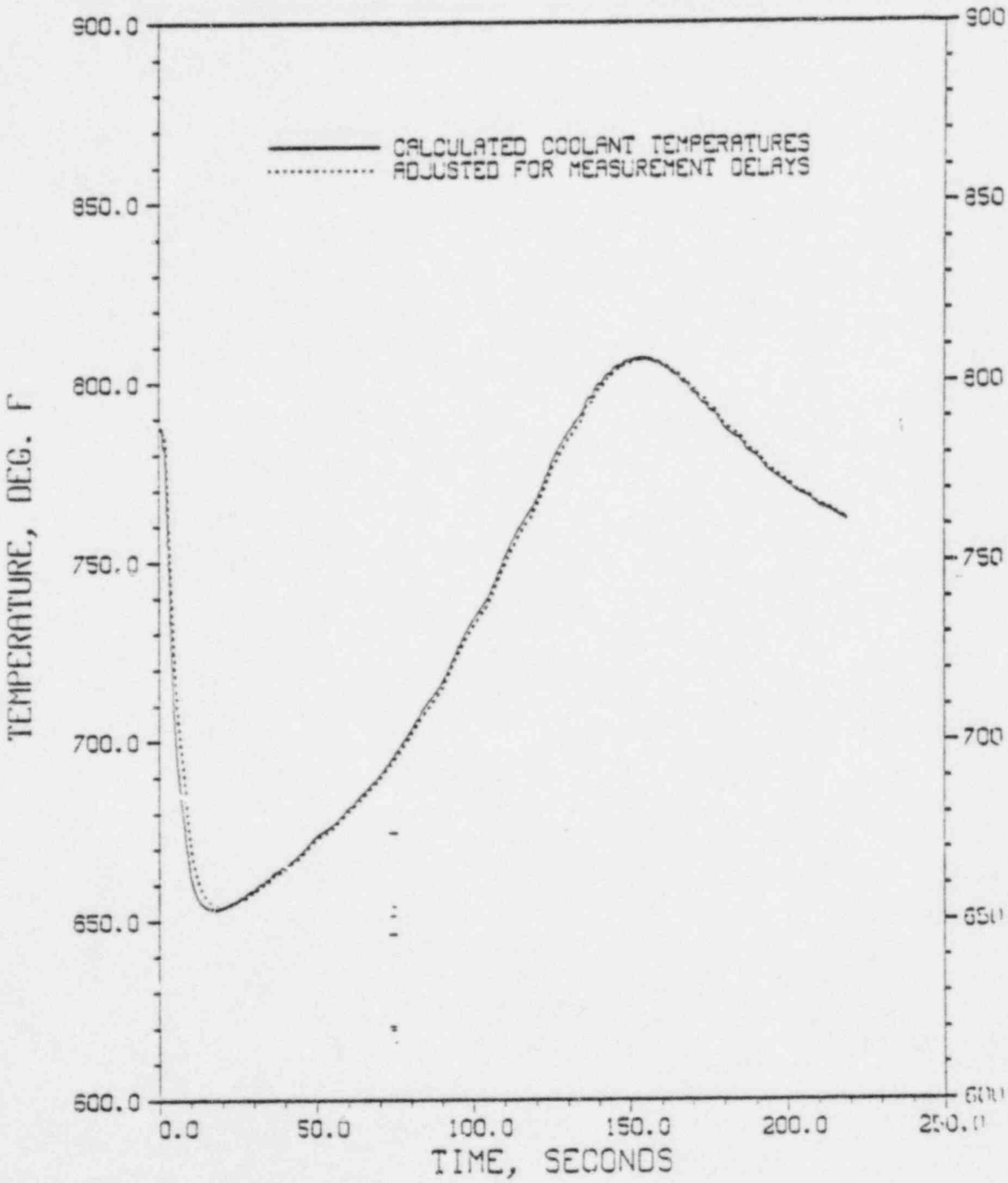
CORA CASE 022032 9-13-80.

FIG. 19 CALCULATED ROW 6 FOTA TOP OF FUEL COOLANT TEMPERATURES FOR T/C TX9026 ON PIN 2,2. 35 PERCENT POWER NATURAL CIRCULATION TEST.



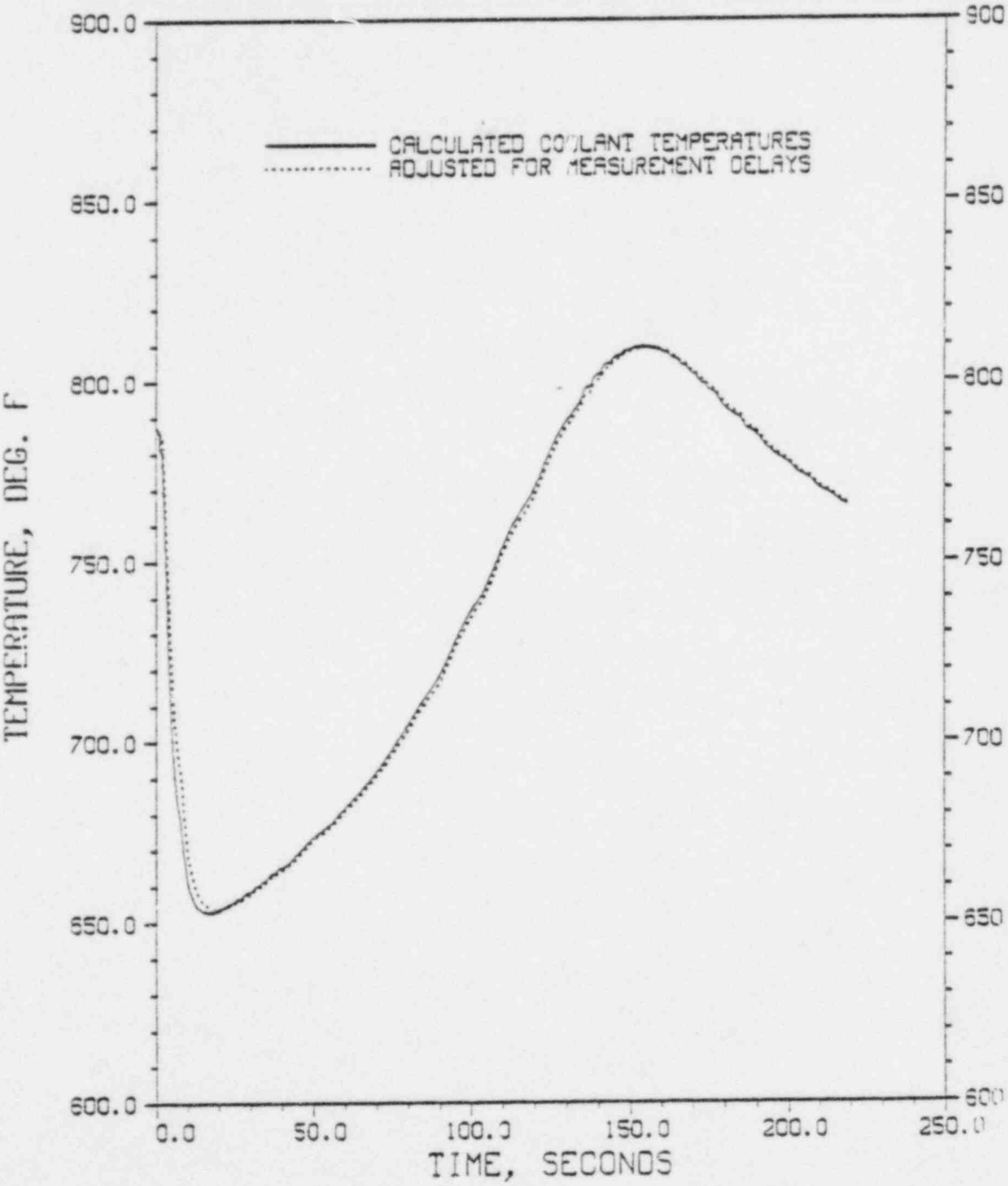
CORA CASE 036111 9-28-80.

FIG. 20 CALCULATED ROW 6 FOTA TOP OF FUEL COOLANT TEMPERATURES FOR T/C TX9018 ON PIN 4,4. 35 PERCENT POWER NATURAL CIRCULATION TEST.



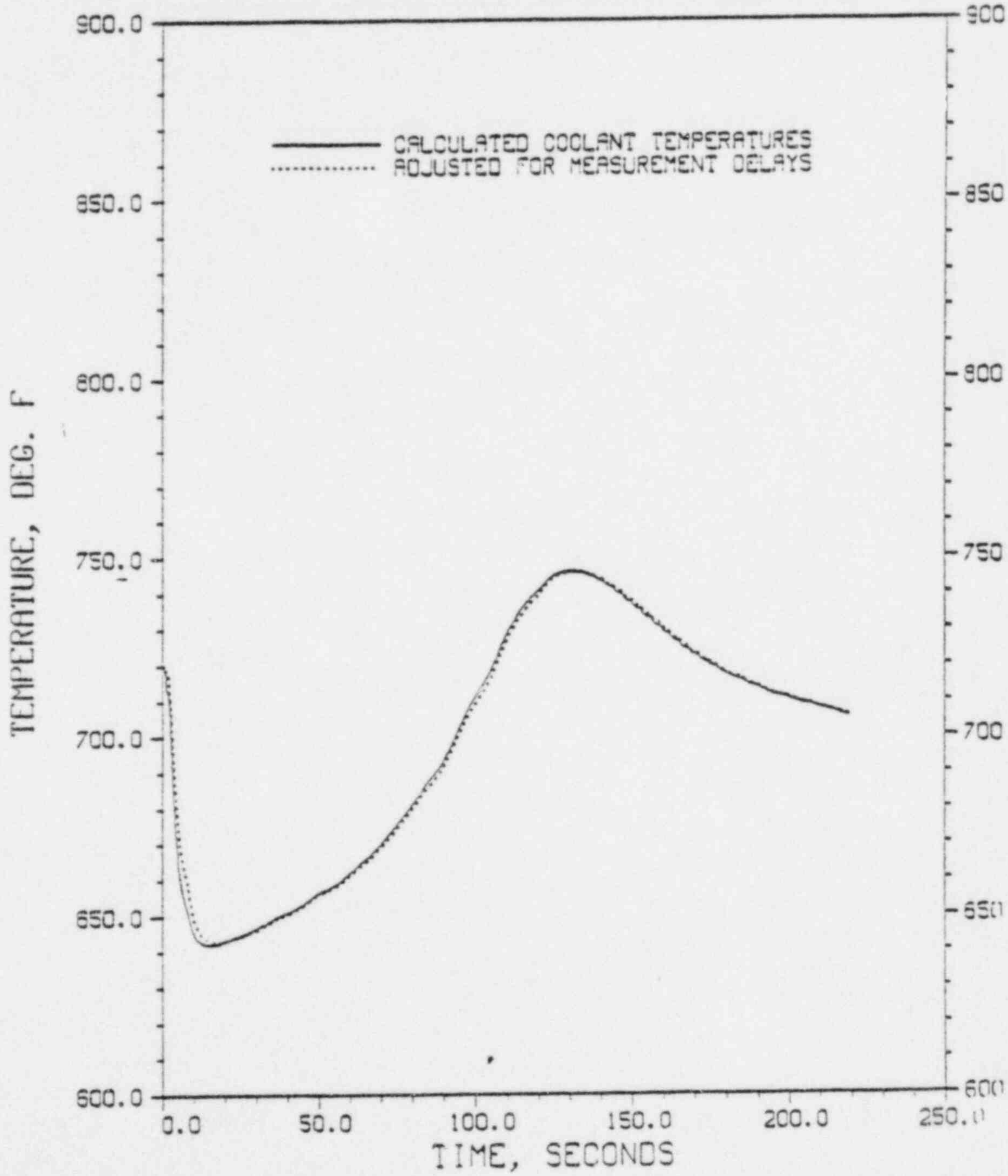
CORA CASE 036111 9-28-80.

FIG. 21 CALCULATED ROW 6 FOTA TOP OF FUEL COOLANT TEMPERATURES FOR T/C TX9009 ON PIN 9,9. 35 PERCENT POWER NATURAL CIRCULATION TEST.



COPA CASE 0C6111 9-28-80.

FIG. 22 CALCULATED ROW 6 FOTA CORE MIDPLANE COOLANT TEMPERATURES FOR T/C TX9039 ON PIN 8,8. 35 PERCENT POWER NATURAL CIRCULATION TEST.



CORA CASE 036111 9-28-90.

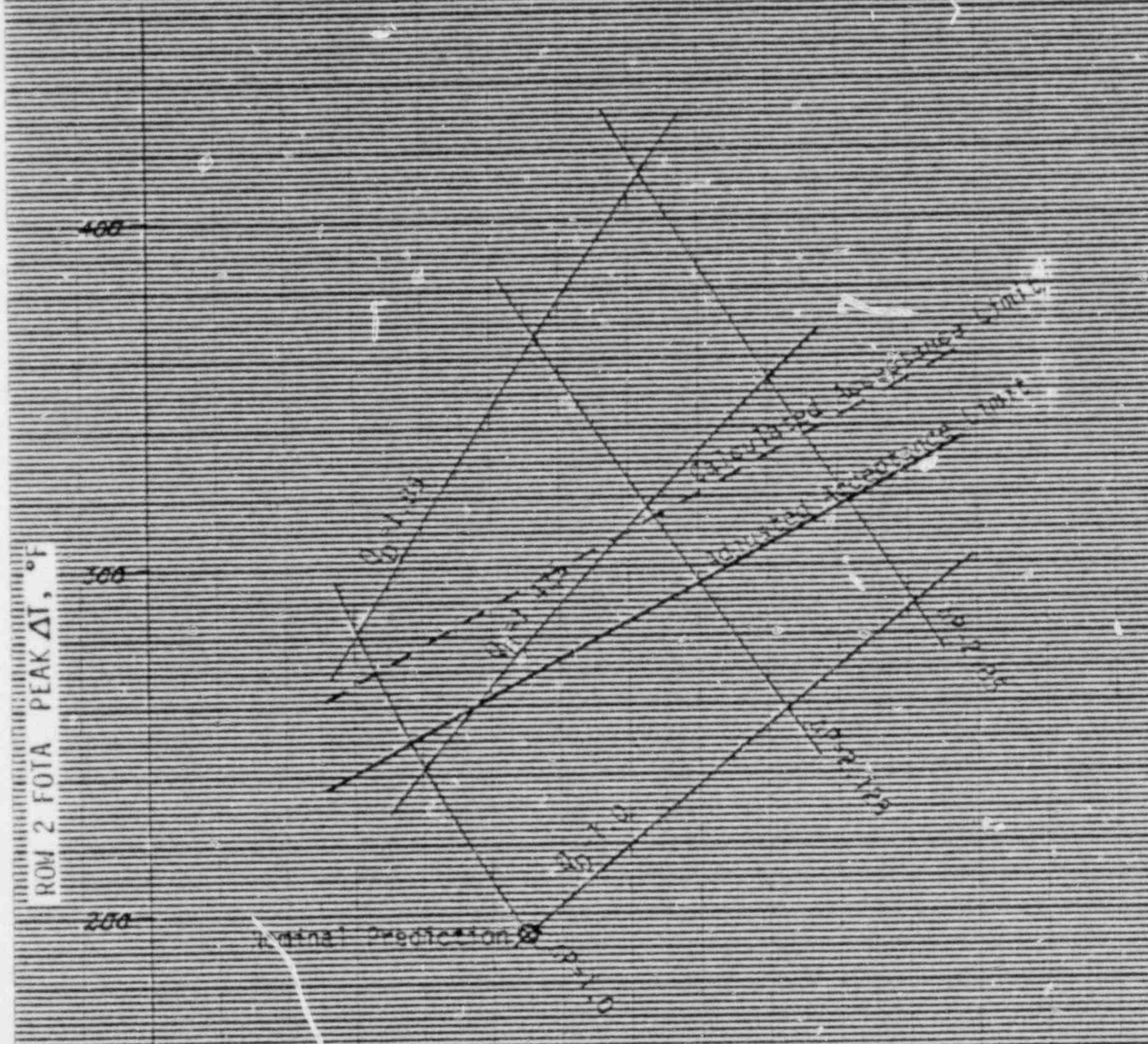


FIGURE 23 - TEST B ACCEPTANCE GRID

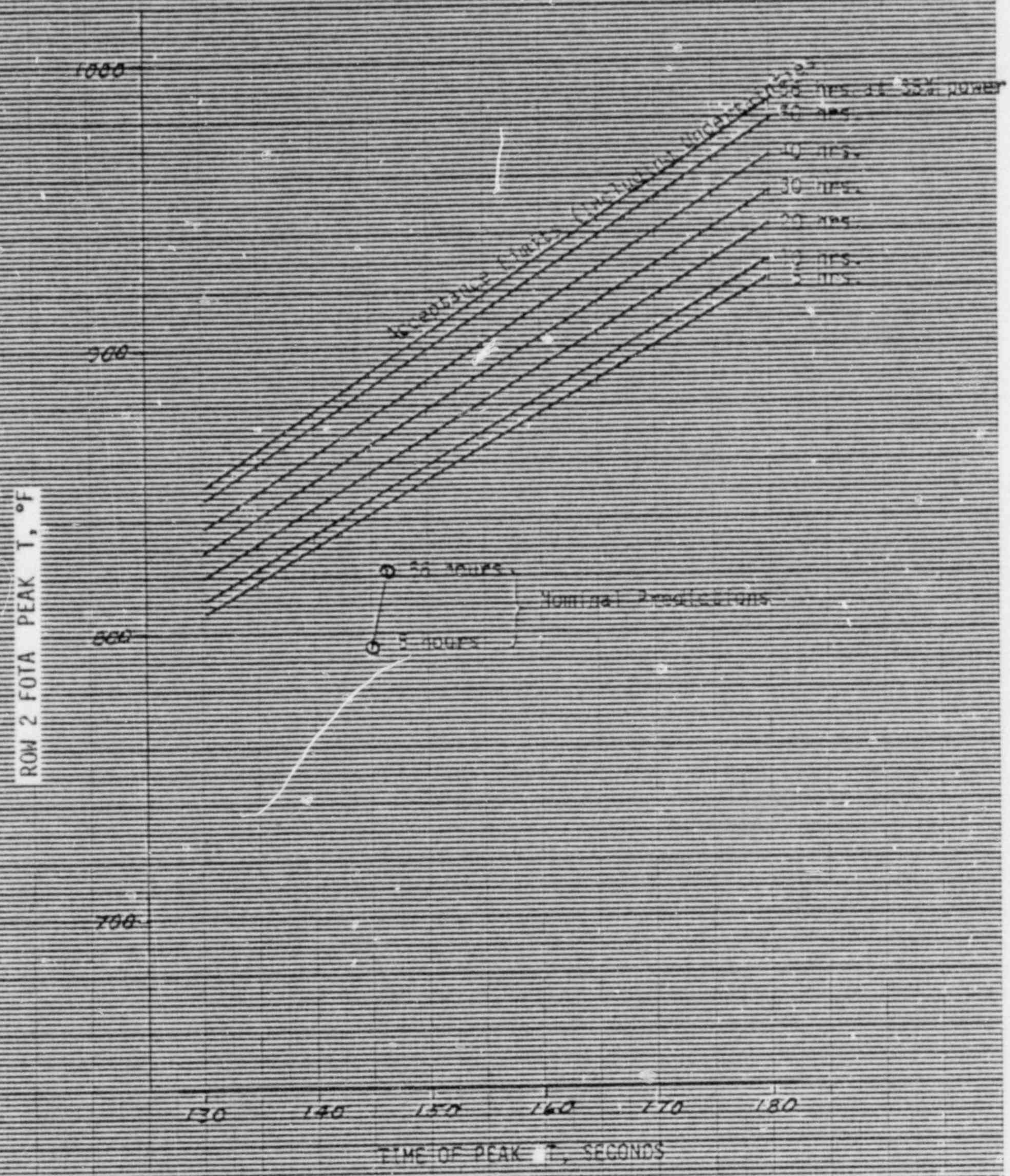


FIGURE 24 - TEST 3 ACCEPTANCE LIMITS

APPENDICES

APPENDIX A

DDH & DS PROGRAMING FOR DATA ACQUISITION

Appendix A

DDH & DS MONITORING REQUIREMENTS

Instrument Number	Description	Scan Interval (Sec)
10001 A, B, C	Driver 2101 Temperature	60
10002 A, B, C	Driver 3201 Temperature	60
10003 A, B, C	Driver 3301 Temperature	60
10004 A, B, C	Driver 3303 Temperature	60
10005 A, B, C	Driver 3304 Temperature	60
10006 A, B, C	Driver 3401 Temperature	60
10007 A, B, C	Driver 3402 Temperature	60
10008 A, B, C	Driver 3403 Temperature	60
10009 A, B, C	Driver 3404 Temperature	60
10010 A, B, C	Driver 3405 Temperature	60
10011 A, B, C	Driver 3501 Temperature	60
10012 A, B, C	Driver 3503 Temperature	60
10013 A, B, C	Driver 3505 Temperature	60
10014 A, B, C	Driver 3506 Temperature	60
10015 A, B, C	Driver 3507 Temperature	60
10016 A, B, C	Driver 3508 Temperature	60
10017 A, B, C	Driver 3601 Temperature	60
10018 A, B, C	Driver 3602 Temperature	60
10019 A, B, C	Driver 3603 Temperature	60
10020 A, B, C	Driver 3604 Temperature	60
10021 A, B, C	Driver 3605 Temperature	60
10022 A, B, C	Driver 3606 Temperature	60

NOTE: All data collection compression windows should be set to minimum, but not to exceed 0.1%.

Appendix A

DOH & DS MONITORING REQUIREMENTS

Instrument Number	Description	Scan Interval (Sec)
10023 A, B, C	Driver 3607 Temperature	60
10024 A, B, C	Driver 3608 Temperature	60
10025 A, B, C	Driver 3609 Temperature	60
10026 A, B, C	Driver 1201 Temperature	60
10027 A, B, C	Driver 1301 Temperature	60
10028 A, B, C	Driver 1303 Temperature	60
10029 A, B, C	Driver 1304 Temperature	60
10030 A, B, C	Driver 1401 Temperature	60
10031 A, B, C	Driver 1402 Temperature	60
10032 A, B, C	Driver 1403 Temperature	60
10033 A, B, C	Driver 1404 Temperature	60
10034 A, B, C	Driver 1405 Temperature	60
10035 A, B, C	Driver 1501 Temperature	60
10036 A, B, C	Driver 1503 Temperature	60
10037 A, B, C	Driver 1505 Temperature	60
10038 A, B, C	Driver 1506 Temperature	60
10039 A, B, C	Driver 1507 Temperature	60
10040 A, B, C	Driver 1508 Temperature	60
10041 A, B, C	Driver 1601 Temperature	60
10042 A, B, C	Driver 1602 Temperature	60
10043 A, B, C	Driver 1603 Temperature	60
10044 A, B, C	Driver 1604 Temperature	60

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DDH & DS MONITORING REQUIREMENTS

Instrument Number	Description	Scan Interval (Sec)
10045 A, B, C	Driver 1605 Temperature	60
10046 A, B, C	Driver 1606 Temperature	50
10047 A, B, C	Driver 1607 Temperature	50
10048 A, B, C	Driver 1608 Temperature	60
10049 A, B, C	Driver 1609 Temperature	50
10051 A, B, C	Driver 2201 Temperature	60
10052 A, B, C	Driver 2301 Temperature	60
10053 A, B, C	Driver 2303 Temperature	60
10054 A, B, C	Driver 2304 Temperature	60
10055 A, B, C	Driver 2401 Temperature	50
10056 A, B, C	Driver 2402 Temperature	60
10057 A, B, C	Driver 2403 Temperature	60
10058 A, B, C	Driver 2404 Temperature	60
10059 A, B, C	Driver 2405 Temperature	60
10060 A, B, C	Driver 2501 Temperature	60
10061 A, B, C	Driver 2503 Temperature	60
10062 A, B, C	Driver 2505 Temperature	60
10063 A, B, C	Driver 2506 Temperature	60
10064 A, B, C	Driver 2507 Temperature	60
10065 A, B, C	Driver 2508 Temperature	60
10066 A, B, C	Driver 2601 Temperature	60
10067 A, B, C	Driver 2602 Temperature	60
10068 A, B, C	Driver 2603 Temperature	60

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DOH & DS MONITORING REQUIREMENTS

Instrument Number	Description	Scan Interval (Sec)
10069 A, B, C	Driver 2604 Temperature	60
10070 A, B, C	Driver 2605 Temperature	60
10071 A, B, C	Driver 2606 Temperature	60
10072 A, B, C	Driver 2607 Temperature	60
10073 A, B, C	Driver 2608 Temperature	60
10074 A, B, C	Driver 2609 Temperature	60
10076 A, B, C	Refl 3703 Temperature	60
10077 A, B, C	Refl 3705 Temperature	60
10078 A, B, C	Refl 3707 Temperature	60
10079 A, B, C	Refl 3709 Temperature	60
10080 A, B, C	Refl 1703 Temperature	60
10081 A, B, C	Refl 1705 Temperature	60
10082 A, B, C	Refl 1707 Temperature	60
10083 A, B, C	Refl 1709 Temperature	60
10084 A, B, C	Refl 2703 Temperature	60
10085 A, B, C	Refl 2705 Temperature	60
10086 A, B, C	Refl 2707 Temperature	60
10087 A, B, C	Refl 2709 Temperature	60
10101A	PSD Flow 2101 Driver	1
10101	Flow 2101 Driver	1
10102	Flow 3201 Driver	10
10103	Flow 3301 Driver	10
10104	Flow 3303 Driver	10

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DOH & DS MONITORING REQUIREMENTS

Instrument Number	Description	Scan Interval (Sec)
10127	Flow 1301 Driver	10
10128	Flow 1303 Driver	1
10129	Flow 1304 Driver	10
10130	Flow 1401 Driver	10
10131	Flow 1402 Driver	1
10132	Flow 1403 Driver	1
10133	Flow 1404 Driver	10
10134	Flow 1405 Driver	10
10135	Flow 1501 Driver	10
10136	Flow 1503 Driver	1
10137	Flow 1505 Driver	10
10138	Flow 1506 Driver	10
10139	Flow 1507 Driver	10
10140	Flow 1508 Driver	10
10141	Flow 1601 Driver	10
10142	Flow 1602 Driver	10
10143	Flow 1603 Driver	1
10144	Flow 1604 Driver	10
10145	Flow 1605 Driver	10
10146	Flow 1606 Driver	10
10147	Flow 1607 Driver	10
10148	Flow 1608 Driver	10

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DDH & DS MONITORING REQUIREMENTS

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Instrument Number	Description	Scan Interval (Sec)
10105	Flow 3304 Driver	10
10106	Flow 3401 Driver	10
10107	Flow 3402 Driver	10
10108	Flow 3403 Driver	10
10109	Flow 3404 Driver	10
10110	Flow 3405 Driver	10
10111	Flow 3501 Driver	10
10112	Flow 3503 Driver	10
10113	Flow 3505 Driver	10
10114	Flow 3506 Driver	10
10115	Flow 3507 Driver	10
10116	Flow 3508 Driver	1
10116A	PSD Flow 3508 Driver	1
10117	Flow 3601 Driver	10
10118	Flow 3602 Driver	10
10119	Flow 3603 Driver	10
10120	Flow 3604 Driver	10
10121	Flow 3605 Driver	10
10122	Flow 3606 Driver	1
10122A	PSD Flow 3606 Driver	1
10123	Flow 3607 Driver	10
10124	Flow 3608 Driver	10
10125	Flow 3609 Driver	10
10126	Flow 1201 Driver	1
10126A	PSD Flow 1201 Driver	1

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DDH & DS MONITORING REQUIREMENTS

Instrument Number	Description	Scan Interval (Sec)
10149	Flow 1609 Driver	10
10151	Flow 2201 Driver	1
10151A	PSD Flow 2201 Driver	1
10152	Flow 2301 Driver	10
10153	Flow 2303 Driver	1
10154	Flow 2304 Driver	1
10155	Flow 2401 Driver	10
10156	Flow 2402 Driver	10
10157	Flow 2403 Driver	10
10158	Flow 2404 Driver	10
10159	Flow 2405 Driver	1
10160	Flow 2501 Driver	10
10161	Flow 2503 Driver	10
10162	Flow 2505 Driver	10
10163	Flow 2506 Driver	10
10164	Flow 2507 Driver	1
10165	Flow 2508 Driver	10
10166	Flow 2601 Driver	10
10167	Flow 2602 Driver	10
10168	Flow 2603 Driver	10
10169	Flow 2604 Driver	10
10170	Flow 2605 Driver	10
10171	Flow 2606 Driver	10

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DDH & DS MONITORING REQUIREMENTS

Instrument Number	Description	Scan Interval (Sec)
10172	Flow 2607 Driver	10
10173	Flow 2608 Driver	1
10174	Flow 2609 Driver	10
10176	Flow 3703 Reflector	10
10177	Flow 3705 Reflector	10
10178	Flow 3707 Reflector	10
10179	Flow 3709 Reflector	10
10180	Flow 1703 Reflector	1
10180A	PSD Flow 1703 Reflector	1
10181	Flow 1705 Reflector	1
10182	Flow 1707 Reflector	10
10183	Flow 1709 Reflector	10
10184	Flow 2703 Reflector	10
10185	Flow 2705 Reflector	10
10186	Flow 2707 Reflector	10
10187	Flow 2709 Reflector	1
10200 A, B, C	Driver 2202 Temperature	10
10201 A, B, C	OTA 3610 Temp A, B, C	60
10202 A, B, C	OTA 2406 Temp A, B, C	60
10203 A, B, C	OTA 2610 Temp A, B, C	60
10204 A, B, C	OTA 1202 Temp A, B, C	60
10205 A, B, C	OTA 1406 Temp A, B, C	60
10206 A, B, C	OTA 1610 Temp A, B, C	60
10217	FOTA 3610 Flow	1

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DOH & OS MONITORING REQUIREMENTS

Instrument Number	Description	Scan Interval (Sec)
10210	Flow 2202 OTA	1
10210A	PSD Flow 2202 OTA	1
10211	Flow 3610 OTA	1
10211A	PSD Flow 3610 OTA	1
10214	OTA 1202 Flow	1
10213	Flow 2610 OTA	1
10213A	PSD Flow 2610 OTA	1
10214A	PSD Flow 1202 OTA	1
10214B	PSD Temperature 1202 OTA	1
10401 A, B	Safety Rod 3302 Temp.	10
10402 A, B	Contrl Rod 3502 Temp.	10
10403 A, B	Contrl Rod 3504 Temp.	10
10404 A, B	Safety Rod 1302 Temp.	10
10405 A, B	Contrl Rod 1502 Temp.	10
10406 A, B	Contrl Rod 1504 Temp.	10
10407 A, B	Safety Rod 2302 Temp.	10
10408 A, B	Contrl Rod 2502 Temp.	10
10409 A, B	Contrl Rod 2504 Temp.	10
10410 A, B	Periph CR 2702 Temp.	10
10411 A, B	Periph CR 2706 Temp.	10
10412 A, B	Periph CR 2708 Temp.	10
10413 A, B	Periph CR 3702 Temp.	10
10414 A, B	Periph CR 3706 Temp.	10
10415 A, B	Periph CR 3708 Temp.	10
10416 A, B	Periph CR 1702 Temp.	10
10417 A, B	Periph CR 1706 Temp.	10

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DOH & DS MONITORING REQUIREMENTS

Instrument Number	Description	Scan Interval (Sec)
10418 A, B	Periph CR 1708 Temp.	10
10419	Fixed Shim 3704 Temp.	10
10420	Fixed Shim 3711 Temp.	10
10421	Fixed Shim 2704 Temp.	10

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DDH & DS MONITORING REQUIREMENTS

Instrument Number	Description	Scan Interval (Sec)
10422	Fixed Shim 2711 Temp.	10
10423	Fixed Shim 1704 Temp.	10
10424	Fixed Shim 1711 Temp.	10
10425A	Reflector 2712 Temp.	10
10426A	Reflector 3701 Temp.	10
10427A	Reflector 3710 Temp.	10
10428A	Reflector 3712 Temp.	10
10429A	Reflector 1701 Temp.	10
10430A	Reflector 1710 Temp.	10
10431A	Reflector 1712 Temp.	10
10432A	Reflector 2701 Temp.	10
10433A	Reflector 2710 Temp.	10
10451	RX VSSL Coolant OPER LVL	10
10452	RX VSL Full Range Level	10
10453 A, B, C	RX VSL LVL PPS	1
10601 D, E, F	FLUX SRC Level 1	1
10631 A	WD RNG CNT LEVEL A	1
10631 C	WD RNG LG MSV LV A	1
10631 E	WD RNG LN PWR LV A	1
10631 F	WD RNG CNT LEVEL B	1
10631 H	WD RNG LG MSV LV B	1
10631 K	WD RNG LN PWR LV B	1

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DDH & DS MONITORING REQUIREMENTS

Instrument Number	Description	Scan Interval (Sec)
10631 L	WD RNG CNT LEVEL C	1
10631 N	WD RNG LG MSV LV C	1
10631 Q	WD RNG LN PWR LV C	1
21001 A, B, C, D	Pri Hot Leg 1 Temp	10
21003 A, B, C	Pres Pri Loop 1	1
21005 A, B, C, D	Pri Cold Leg 1 Temp	10
21008 A, B, C	IHX Pri Out 1 Temp	10
21011 A, B, C	Flow Pri Loop 1	1
21011 D	Reverse Flow Pri Loop 1	1
21014	P1 DISCHRG Press	1
21014 A	LP1 PRI/SEC DIFF Press	1
21042	LVL PRI Pump P1	1
21047	RPM PRI Pump P1	1
21507	Temp DHX E4 Out	10
21514	Temp DHX E5 Out	10
21521	Temp DHX E6 Out	10
21528	Temp DHX E7 Out	10
21534 A, B, C, D	SEC Hot Leg 1 Temp	10
21536	P4 DISCHRG Press	1
21538	Speed SEC Pump P4	1
21540	Level SEC Pump P4	1
21541	LP1 SEC EXP TK LVL	10

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DDH & DS MONITORING REQUIREMENTS

Instrument Number	Description	Scan Interval (Sec)
21548 A, B, C	Flow SEC Loop 1	1
21550 A, B, C, D	SEC Cold Leg 1 Temp	10
21552 A, B	1F Flow SEC Loop Venturi 2F " " "	1
21603	POS E4 Fine Damper	10
21604	POS E4 CORS Damper	10
21610	Speed E4 Blower	10
21616	POS E4 Vanes	10
21633	POS E5 Fine Damper	10
21634	POS E5 CORS Damper	10
21640	Speed E5 Blower	10
21646	POS E5 Vanes	10
21663	POS E6 Fine Damper	10
21664	POS E6 CORS Damper	10
21670	Speed E6 Blower	10
21676	POS E6 Vanes	10
21803	POS E7 Fine Damper	10
21804	POS E7 CORS Damper	10
21810	Speed E7 Blower	10
21816	POS E7 Vanes	10
22001 A, B, C, D	PRI Hot Leg 2 Temp	10
22003 A, B, C	PRES PRI Loop 2	1
22005 A, B, C, D	PRI Cold Leg 2 Temp	10

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DOH & DS MONITORING REQUIREMENTS

Instrument Number	Description	Scan Interval (Sec)
22008 A, B, C	IHX PRI Out 2 Temp	10
22011 A, B, C, D	Flow PRI Loop 2	1
22014	P2 DISCHRG Press	1
22014 A	LP2 PRI/SEC DIFF Press	1
22042	LVL PRI Pump P2	1
22047	RPM PRI Pump P2	1
22507	Temp DHX E8 Out	10
22514	Temp DHX E9 Out	10
22521	Temp DHX E10 Out	10
22528	Temp DHX E11 Out	10
22534 A, B, C, D	SEC Hot Leg 2 Temp	10
22536	P5 DISCHRG Press	1
22538	Speed SEC Pump P5	1
22540	Level SEC Pump P5	1
22541	LP2 SEC EXP TK LVL	10
22548 A, B, C	Flow SEC Loop 2	1
22550 A, B, C, D	SEC Cold Leg 2 Temp	10
22552 A, B	1F Flow SEC Loop Venturi 2F Flow SEC Loop Venturi	1 1
22603	POS E8 Fine Damper	10
22604	POS E8 CORS Damper	10
22610	Speed E8 Blower	10
22616	POS E8 Vanes	10

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DOH & OS MONITORING REQUIREMENTS

Instrument Number	Description	Scan Interval (Sec)
22633	POS E9 Fine Damper	10
22634	POS E9 CORS Damper	10
22640	Speed E9 Blower	10
22646	POS E9 Vanes	10
22663	POS E10 Fine DMPR	10
[illegible]	POS E10 CORS DMPR	10
22670	Speed E10 Blower	10
22676	POS E10 Vanes	10
22803	POS E11 Fine DMPR	10
22804	POS E11 CORS DMPR	10
22810	Speed E11 Blower	10
22816	POS E11 Vanes	10
23001 A, B, C, D	PRI Hot Leg 3 Temp	10
23003 A, B, C	PRES PRI Loop 3	1
23005 A, B, C, D	PRI Cold Leg 3 Temp	10
23008 A, B, C	IHX PRI Out 3 Temp	10
23011 A, B, C, D	Flow PRI Loop 3	1
23014	P3 DISCHRG Press	1
23014A	LP3 PRI/SEC DIFF Press	1
23042	LVL PRI Pump P3	1
23047	RPM PRI Pump P3	1
23507	T[illegible]X E12 Out	1

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DOH & DS MONITORING REQUIREMENTS

Instrument Number	Description	Scan Interval (Sec)
23514	Temp DHX E13 Out	1
23521	Temp DHX E14 Out	1
23528	Temp DHX E15 Out	1
23534 A, B, C, D	SEC Hot Leg 3 Temp	1
23536	P6 DISCHRG Press	1
23538	Speed SEC Pump P6	1
23540	Level SEC Pump P6	1
23541	LP3 SEC EXP TK LVL	10
23548 A, B, C	Flow SEC Loop 3	1
23550 A, B, C, D	SEC Cold Leg 3 Temp	10
23552A	1F Flow SEC Loop Venturi	1
23552B	2F Flow SEC Loop Venturi	1
23603	POS E12 Fine DMPR	1
23604	POS E12 CORS DMPR	1
23610	Speed E12 Blower	1
23616	POS E12 Vanes	1
23633	POS E13 Fine DMPR	1
23634	POS E13 CORS DMPR	1
23640	Speed E13 Blower	1
23646	POS E13 Vanes	1
23663	POS E14 Fine DMPR	1
23664	POS E14 CORS DMPR	1

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ODH & OS MONITORING REQUIREMENTS

Instrument Number	Description	Scan Interval (Sec)
23670	Speed E14 Blower	1
23676	POS E14 Vanes	1
23803	POS E15 Fine DMPR	1
23804	POS E15 CORS DMPR	1
23810	Speed E15 Blower	1
23816	POS E15 Vanes	1
41002	PRI Overflow VSL T42 LVL	60
41021	P39 Inlet Flow	10
41026	P38 Inlet Flow	10
52041	Rx Cover Gas Pressure	1

APPENDIX B

FFTF PRIMARY SYSTEM TRANSITION
TO NATURAL CIRCULATION FROM LOW
REACTOR POWER, HEDL-SA-1919S
FEBRUARY 1980