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THREE MILE ISLAND NUCLEAR STATION

UNIT #2 OPERATING PROCEDURE 2102-2.1

POWER OPERATIONS

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THREE MILE ISLAND NUCLEAR STATION

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THREE MILE ISLAND NUCLEAR STATION

UNIT #2 OPERATING PROCEDURE 2102-2.1

POWER OPERATIONS

1.0 REFERENCES

1.1 Drawings Applicable for Operation

1.1.1 Reactor Coolant Makeup & Purification 2024

1.2 Operating Procedures Applicable for Operation

1.2.1 2101-1.1 Nuclear Plant Limits and Precautions

1.2.2 2102-2.1 Nuclear Plant Setpoints

1.2.3 2102-1(series) Unit Startup Procedures

1.2.4 2103-1.2, Soluble Poison Concentration Control

1.2.5 2103-1.9, Reactivity Balance Calculation

1.2.6 2104-1.2, Makeup and Purification

1.2.7 2105-1.4, Integrated Control System

1.2.8 2105-1.9, Control Rod Drives

1.3 Manufacturers' Instruction Manuals

1.3.1 None

1.4 Applicable System Descriptions

1.4.1 TMI Unit 2, Technical Specifications (TS)

1.5 Curves, Figures, Tables, etc.

1.5.1 Curves.

Figure 1 - Core Pressure/Temperature Safety Limits.

Figure 2 - Operational Power Imbalance Envelope (0-200 EFPD)

Figure 3 - Control Rod Group Withdrawal Limits for 4 Pump Operation (0-200 EFPD).

Figure 4 - Control Rod Group Withdrawal Limits for 3 Pump Operation (0-200 EFPD).

Figure 5 - Control Rod Group Withdrawal Limits for 3 Pump Operation (0-200 EFPD).

Figure 6 - Control Rod Group Designation and Core Position.

Figure 7 - Reactor Coolant System Pressure/Temperature Limits for Heatup and Cooldown and Core Criticality.

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Figure 9A - Core Power Vs Rod Position Bands, 4 Pump Operation (0-200 EFPD).

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Figure 10 - Borate/Deborate ± 10% Rod Position (BOL-140 EFPD).

Figure 11 - RC Boron Change Needed to Reposition Rods in Bands.

Figure 12 - Minimum Feed and Bleed Flow Rate per Load Change vs. RCS Boron Concentration.

Figure 13 - Pressurizer Level vs. T-ave.

1.5.2 Tables

Table 1 - Quadrant Power Tilt Limits.

Table 2 - DNB Margin.

2.0 LIMITS AND PRECAUTIONS

2.1 If any Safety Limit (defined in Technical Specification 2.1 and 2.2) is exceeded, the Shift Supervisor shall notify the Station/Unit Superintendent. The reactor shall be placed in Hot Standby within one hour. The licensee shall notify the Commission, review the matter and record the results of the review, including the cause of the condition and the basis for corrective action taken to preclude reoccurrence. Operation shall not be resumed until authorized by the Commission.

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2.2 If, during operation, the automatic safety system does not function as required, the Station/Unit Superintendent shall be notified. The Shift Supervisor shall take appropriate action as outlined in the Tech. Specs. The reporting requirements of T.S. 6.9 shall be followed. Note that this appropriate action may include shutting down the reactor.

2.3 When a Limiting Condition for Operation (LCO) (defined in Section 3 of the Technical Specifications) is not met, the Shift Supervisor shall notify the Station/Unit Superintendent. The reactor shall be placed in at least HOT STANDBY within 1 hour and in COLD SHUTDOWN within the following 30 hours unless corrective measures are completed that permit operation under the permissible ACTION statements for the specified time interval as measured from initial discovery. The reporting requirements of T.S. 6.9 shall be followed.

2.4 The combination of the reactor coolant core outlet pressure and outlet temperature shall not exceed the safety limit shown in Figure 1.

2.5 The combination of reactor THERMAL POWER and AXIAL POWER IMBALANCE shall not exceed the safety limit shown in Figure 2 for the various combinations of three and four reactor coolant pump operation.

2.6 The Reactor Coolant System pressure should be maintained at 2155 $\pm$ 50 psig during Steady State Operation.

2.7 Reactor Core power shall not exceed 2772 MWt.

2.8 Reactor Protective System trip setpoints will be verified changed within 4 hours after switching pump combinations. Surveillance Procedure (SP 2311-6) (T.S. 4.4.1a).

2.9 The SHUTDOWN MARGIN shall be $\geq$ 2% $\Delta k/k$ (TS 3.1.1.1).

2.10 The flow rate of reactor coolant through the Reactor Coolant System shall be $\geq$ 2800 gpm whenever a reduction in Reactor Coolant System boron concentration is being made (TS 3.1.1.2).

2.11 All control (safety and regulating) rods shall be OPERABLE and positioned within $\pm$ 6.5% (indicated position) of their group average height. (TS 3.1.3.1).

2.12 All axial power shaping rods (APSR) shall be OPERABLE, and unless fully withdrawn, shall be positioned within $\pm$ 6.5% (indicated position) of their group average height. (TS 3.1.3.2).

2.13 All safety, regulating, and axial power shaping control rod reed switch position indicator channels and pulse stepping position indicator channels shall be OPERABLE and capable of determining the control rod positions within $\pm$ 6.5%. (TS 3.1.3.3).

2.14 All safety rods shall be fully withdrawn. (TS 3.1.3.6).

2.15 The individual safety and regulating rod drop time from the fully withdrawn position shall be $\leq$ 1.66 seconds from power interruption at the control rod drive breakers to 3/4 insercion with:

Tavg $\geq$ 525^{o}F and

All reactor coolant pumps operating. (TS 3.1.3.5).

2.16 The regulating rod groups shall be limited in physical insertion as shown on Figures 3, 4, & 5 with a rod group overlap of 25 $\pm$ 5% between sequential withdrawn groups 5 and 6/7. (TS 3.1.3.7).

If the rod group overlap limits are exceeded or inserted beyond the LOCA limit proceed with T.S. Action Statement 3.1.3.7. If the regulating rod groups are inserted beyond the Shutdown Margin limit proceed with T.S. Action Statement 3.1.1.1.

2.17 Each control rod (safety, regulating, and APSR) shall be programmed to operate in the core position and rod group specified in Figure 6. (TS 3.1.3.8).

2.18 THERMAL POWER shall not be increased above the power level cutoff specified in Figure 3 unless one of the following conditions is satisfied:

Xenon reactivity is within 10 percent of the equilibrium value for RATED THERMAL POWER and is approaching stability, or

THERMAL POWER has been within a range of (87-92%) RATED THERMAL POWER for a period exceeding 2 hours in the soluble poison control mode, excluding xenon free startups. (TS 3.1.3.9).

NOTE: Determine Xenon reactivity using either SP 2311-(4) or computer program ROBAL.

2.19 AXIAL POWER IMBALANCE shall be maintained within the limits shown on Figure 2 when above 40% of RATED THERMAL POWER except for physics test. (TS 3.2.1).

2.20 NUCLEAR HEAT FLUX HOT CHANNEL FACTOR - F_Q shall be limited by the following:

$$F_Q \leq \frac{(2.85)}{P}$$

where $P = \frac{\text{THERMAL POWER}}{\text{RATED THERMAL POWER}}$ and $P \leq 1.0$ (TS 3.2.2)

2.21 NUCLEAR ENTHALPY RISE HOT CHANNEL FACTOR - $F^N_{\Delta H}$ shall be limited by the following:

$$F^N_{\Delta H} \leq (1.78)\{1 + 0.6\,(1-P)\}$$

where $P = \frac{\text{THERMAL POWER}}{\text{RATED THERMAL POWER}}$

AND $P \leq 1.0$ (TS 3.2.3)

2.22 THE QUADRANT POWER TILT shall not exceed the Steady State Limit of Table 1 when above 15% of RATED THERMAL POWER, except for physics tests. (TS 3.2.4).

2.23 The following DNB related parameters shall be maintained within the limits shown on Table 2.

Reactor Coolant Hot Leg Temperature

Reactor Coolant Pressure

Reactor Coolant Flow Rate (TS 3.2.5)

2.24 The moderator temperature coefficient (MTC) shall be:

Less positive than 0.9×10^{-4} $\Delta k/k/^{o}F$ whenever THERMAL POWER is < 95% of RATED THERMAL POWER.

Less positive than 0.0×10^{-4} $\Delta k/k/^{o}F$ whenever THERMAL POWER is $\geq$ 95% of RATED THERMAL POWER.

Less negative than -3.0×10^{-4} $\Delta k/k/^{o}F$ at RATED THERMAL POWER (TS 3.1.1.3)

2.25 Reactor Coolant System leakage shall be limited to:

No PRESSURE BOUNDARY LEAKAGE

1 GPM UNIDENTIFIED LEAKAGE

1 GPM total primary-to-secondary leakage through steam generators and 0.5 GPM through any steam generator.

10 GPM IDENTIFIED LEAKAGE from the Reactor Coolant System

8 GPM CONTROLLED LEAKAGE at a Reactor Coolant System pressure of 2155 $\pm$ 50 psig.

2.26 The Reactor Coolant System chemistry shall be maintained within the following limits:

PARAMETER	STEADY STATE LIMIT	TRANSIENT LIMIT
DISSOLVED OXYGEN*	$\leq$ 0.10 ppm	$\leq$ 1.00 ppm
CHLORIDE	$\leq$ 0.15 ppm	$\leq$ 1.50 ppm
FLUORIDE	$\leq$ 0.15 ppm	$\leq$ 1.50 ppm

*Limit not applicable with Tavg $\leq$ $250^{o}F$ (TS 3.4.7).

2.27 The specific activity of the primary coolant shall be limited to:

$\leq$ 1.0 μCi/gram DOSE EQUIVALENT I-131, and

$\leq 100/\overline{E}$ μCi/gram (TS 3.4.8)

2.28 The Reactor Coolant System (except the pressurizer) temperature and pressure shall be limited in accordance with the limit lines shown on Figure 7 during heatup, cooldown and criticality with:

A maximum heatup of 100°F in any one hour period

A maximum cooldown of 100°F in any one hour period (TS 3.4.9.1)

2.29 The pressurizer temperature shall be limited to:

A maximum heatup and cooldown of 100°F in any one hour period

A maximum spray water temperature differential of 410°F. (TS 3.4.9.2)

2.30 The maximum RATE OF LOAD CHANGE shall be:

10%/min between 20-90% increasing and decreasing

10%/min between 90-100% decreasing

5%/min between 90-100% increasing

5%/min between 0-20% increasing and decreasing

2.31 The specific activity of the secondary coolant system shall be $\leq$ 0.1 μCi/gram DOSE EQUIVALENT I-131. (TS 3.7.1.4)

2.32 During normal steady state operation, the maximum linear power density occurring in fuel shall not exceed 18 kw/ft. No central melting of the fuel shall occur during transient operation.

2.33 The DNBR during normal steady state operation shall not be below 1.30 as determined by the B&W-2 heat transfer correlation assuming maximum design mechanical and nuclear considerations set forth in the FSAR.

2.34 The fuel assemblies shall be operated such that peak pellet burnup of any fuel assembly does not exceed 55000 MWD/MTU.

2.35 The level of reactor coolant shall keep the core covered during operation once the fuel has been irradiated.

2.36 The maximum SUR during rod withdrawal is 1.5 DPM.

2.37 The maximum SUR without rod motion is 1.0 DPM.

2.38 In the event of an unplanned or unexpected power reduction, the Shift Supervisor may return to the initial power level if the cause of the reduction is understood and appropriate steps have been taken to preclude a reoccurrance. If the cause of the reduction is not known or has not been precluded from recurring, the Station/Unit Superintendent must authorize the return to higher power levels.

2.39 As a condition to the operating license, operation in modes 1 and 2 with less than three RC pumps is not permitted.

2.40 Insure the breakers T-56-2, 2A-32 (2B-32) and 2A-42 (2B-42) are in PULL-TO-LOCK prior to exceeding 30% power. This insures adequate voltage levels at the 480V ESF busses upon loss of an Aux. transformer.

3.0 PREREQUISITES

_____3.1 The Unit Startup in accordance with 2102-1.3 is complete and the Unit is in operation at between 5% and 100% load. (Mode 1)

_____3.1.1 The Reactor Coolant System lowest loop termperature (Tavg) shall be $\geq$ 525^{o}F. (TS 3.1.1.4)

3.2 Boron Concentration Control

3.2.1 The following boron injection flow paths shall be OPERABLE:

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_____3.2.1.1 A flow path from the concentrated boric acid storage system via a boric acid pump and makeup or decay heat removal (DHR) pump to the Reactor Coolant System.

_____3.2.1.2 A flow path from the borated water storage tank via makeup or DHR pump to the Reactor Coolant System. (TS 3.1.2.2)

_____3.2.2 At least one boric acid pump in the boron injection flow path required by 3.2.1.1 shall be OPERABLE if the flow path through the boric acid pump in 3.2.1.1 is OPERABLE. (TS 3.1.2.7)

3.2.3 The following borated water sources shall be OPERABLE:

_____3.2.3.1 The concentrated boric acid storage system and associated heat tracing with:

_____3.2.3.1a A minimum contained borated water volume in accordance with Figure 8.

_____3.2.3.1b Between 7875 and 13,125 ppm of boron.
A minimum solution temperature of 105°F.

3.2.3.2 The borated water storage tank (BWST) with:

_____3.2.3.2a A contained borated water volume of between 445,620 and 458,722 gallons, and level between 53 ft 6 in. and 56 ft.

_____3.2.3.2b Between 2270 and 2370 ppm of boron.

_____3.2.3.2c A minimum solution temperature of 40°F. (TS 3.1.2.9)

NOTE: Reactor Coolant flow rate shall be ≥ 2800 gpm whenever reactor coolant system boron concentration is being reduced (TS 3.1.1.2)

_____3.3 At least two makeup pumps shall be OPERABLE. (TS 3.1.2.4)

_____3.4 All pressurizer code safety valves shall be OPERABLE with a lift setting of (2435) PSIG ± 1%. (TS 3.4.3)

3.5 The pressurizer shall be OPERABLE with:

_____3.5.1 A steam bubble

_____3.5.2 A water level between 200 and 260 inches.

_____3.6 The steam generators shall be OPERABLE with a water level between 18" and 390".

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NOTE: Maximum operating water level is 82.5 percent of operating range during power operation.

_____3.7 The Engineered Safety Feature Actuation System (ESFAS) Instrumentation Channels shall be OPERABLE with their trip setpoints and response times consistent with the values shown in the applicable tables of reference 1.4.1, (TS 3.3.2.1).

_____3.8 The Reactor Protection System Instrumentation Channels and Bypasses shall be OPERABLE with response times and trip setpoints as shown in Tables 3.3-1 and 2.2.1 respectively. (TS 3.3.1.1)

_____3.9 Secondary water chemistry is within the limits of the applicable table of (LATER).

_____3.10 Each main steam line isolation valve shall be OPERABLE. (TS 3.7.1.5)

_____3.11 The condensate storage tanks (CSTs) shall be OPERABLE with a minimum contained volume of 220,000 gallons of water total (TS 3.7.1.3).

3.12 Three independent steam generator auxiliary feedwater pumps and associated flow paths shall be OPERABLE with:

_____a. Two auxiliary feedwater pumps, each capable of being powered from an OPERABLE emergency bus, and

_____b. One auxiliary feedwater pump capable of being powered from an OPERABLE steam supply system. (TS 3.7.1.2)

_____3.13 All main steam line code safety valves shall be OPERABLE with lift settings as specified in TS 3.7.1.1. With one or more main steam line code safety valves inoperable, operation may proceed provided that within 4 hours either the inoperable valve is restored to OPERABLE status or the Nuclear Overpower Trip Setpoint is reduced per TS 3.7.1.1.

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4.0 PROCEDURE

____4.1 Do not exceed 2772 MT_t (Core Thermal Power)

____4.2 Maintain power below the power level cutoff (See Figures 3 and 4) until the xenon reactivity is within 10 percent of the equilibrium value for operation at rated power and approaching stability or THERMAL POWER has been within a range of (87) to (92) percent of RATED THERMAL POWER for a period exceeding 2 hours in the soluble poison control mode, excluding xenon free start-ups.

NOTE: Determine Xenon reactivity using either SP 2311-4 or computer program ROBAL.

CAUTION: Prior to exceeding (45%) power, verify at least 3 reactor coolant pumps are in operation.

CAUTION: Prior to exceeding 75% power, verify 4 reactor coolant pumps are in operation.

CAUTION: Do not exceed (55%) power unless both feed pumps and 2 condensate/condensate booster pump pairs are in operation.

____4.3 Monitor core power distribution with in-core detectors and the on-line computer as follows:

During steady-state operating, a 3-D Power Map (Group 34) and a worst case Thermal Condition (Group 20) data dump should be taken every EFPD. The reactor power level, boron concentration, and core burnup should also be recorded. This data should be collected each day at midnight along with the Station Daily

Log Sheet, Heat Balance (Group 32), Reactivity Balance (Group 22) and Periodic Typewriter Log Daily Summary for delivery to the Station Nuclear Engineer.

_____4.4 Following a significant one-step load change (> 10% rated power) above 50% rated power or significant control rod motion (> 10% insertion or withdrawal) a Worst Case Thermal Condition should be taken within one hour after the change and then every 4 to 8 hours for a period of 24 to 36 hours, or longer if evidence of a power distribution transient exists. A 3-D Power Map should be taken about 1 hour after reaching steady-state conditions. These data printouts are not necessary on the way up to full power if the Operating Management Recommendations are followed. However, the data from Groups 20 and 34 should be called out one hour after the power hold level is reached.

_____4.5 Obtain a 3-D power map whenever a large imbalance or any other core flux abnormality exists.

_____4.6 Except for physics tests, quadrant power tilt may not exceed the limit of 2.30% on the Symetrical Incore Detector System when operating in Mode 1 above 15% of Rated Thermal power per Table 1. (TS 3.2.4). If the symetrical Indore Detector system is not available, calculate tilt per 2103-1.11.

_____4.7 During Power Operation above 40% of Rated Thermal Power maintain power imbalance within the limits of Figure 2. (TS 3.2.1) Monitor core imbalance on a minimum frequency of once every 12 hours during power operation above 40 percent of rated power.

NOTE: The power-imbalance envelope defined in Figure 2 is based on LOCA analysis which have defined the maximum linear heat rate such that the maximum clad temperature will not exceed the final Acceptance Criteria (2200°F). Operation within the limits of Figure 2 assures us that if the control rods are at the withdrawal/insertion limits as defined by Figures 3, 4 & 5 and if a 4% quadrant power tilt exists, the final Acceptance Criteria will not be exceeded. Additional conservatism is introduced by application of:

Nuclear Uncertainty Factors

Thermal Calibration Uncertainty

Fuel Densification Effects

Hot Rod Manufacturing Tolerance Factors

Fuel Rod Bow

____4.7.1 When an Axial Power Imbalance monitor is inoperable, calculate axial power imbalance at least once per hour per 2103-1.11.

____4.8 When operating from 50 to 100% rated power with 4 RC pumps running, maintain cold leg differential temperatures less than 5°F.

During load transient near rated power maintain cold leg differential less than 10°F.

NOTE: With less than 4 RC pumps running the cold leg temperature may exceed these limits but not over 20°F.

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____4.9 Maintain all control rods and axial power shaping rods within ± 6.5% (indicated position) of their group average height. (TS 3.1.3.1)

____4.10 Except for physics tests or exercising control rods, the control rod insertion/withdrawal limits are specified on Figure 3 (for up to (200) full power days of operation), for four pump operation, Figure 4 for two pump operation and Figure 5 for three pump operation. If the control rod position LOCA limits are exceeded, proceed with T.S. Action Statement 3.1.3.7. If the control rod position Shutdown Margin limits are exceeded proceed with T.S. Action Statement 3.1.1.1.

____4.11 Conduct surveillance testing as listed on the surveillance test schedule in accordance with Administrative Procedure 1010.

____4.12 Maintain shift logs in accordance with Administrative Procedure 1012.

____4.13 Verify Reactor Protective System trip setpoints changed within 4 hours after switching pump combinations. (T.S. 4.4.1a Surveillance Procedure 2311-6).

4.14 Power Maneuvers

Core power is controlled by movement of control rods and adjustment of boron concentration. Figure 9A, 9B, and 9C Core Power vs. Rod Position illustrate the normal control rod operating bands. Control rods should be maintained within the steady-state operating rod position band whenever steady load conditions exist for greater than 1-2 hours or for load changes less than 0.5% per minute. The transient

rod position band is used for all transients greater than 0.5% per minute and during the period of operation when power changes are expected. The Rod Position Bands were developed assuming initial conditions of 100% core power, 100% equilibrium xenon with Group 6/7 positioned at 90 to 100% withdrawn.

NOTE: Following any thermal power change of more than 15% of rated thermal power within a 1 hour period, notify Health Physics/Chemistry that primary coolant must be sampled and analyzed for Iodine (including I-131, I-133 and I-135) between 2 and 6 hours following the change per 2304-3D2. Isotopic Analysis for Iodine (including I-131, I-133 and I-135) of the primary coolant shall continue at 4 hour intervals until the specific activity drops below 1.0 μCi/gm dose equivalent I-131 or 100/$\bar{E}$ μCi/gram (T.S. 4.4.8).

4.14.1 Steady-State Operation (Transient < 0.5% per minute)

4.14.1.1 During steady-state operation with equilibrium Xenon, control rods will slowly drift out of the core with burnup. As rods approach the top of the control band, they should be deborated back into the lower half of the band. The exact point at which to deborate can be at the convenience of the plant operators.

4.14.1.2 During steady-state operation with Xenon oscillations due to a recent transient, Xenon will push control rods out of the band first in one direction, then in the other, for several hours following the transient. This action is dependent on the transient performed but is applicable to both control rod bands. The operator should:

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____4.14.1.2a Determine the change in B^{10} necessary to drive the rods from the top of the band to the bottom of the band from Figure 10 (Note that the same change in B^{10} will go from bottom to top of band also).

____4.14.1.2b Convert the change in B^{10} to a batch volume of DI water necessary to drive rods from the top of the band to the bottom or a volume of boric acid to go from bottom to top of the band. Per Soluble Poison Concentration Control 2103-1.2.

____4.14.1.2c As rods approach the top (bottom) of the band due to known transients, add the volume of DI water (boric acid) calculated above.

____4.14.1.3 Power may be increased at a rate of $\leq$ 0.5% FP/min with rods maintained in the steady-state band, by deborating to maintain rods in the core.

____4.14.1.3a Determine the change in B^{10} necessary to move the rods from 100% wd to 90% wd from Figure 10 and convert this to a batch volume of DI water as per the Soluble Poison Concentration Control Procedure.

____4.14.1.3b As the control rods approach 100% wd, batch in the volume of DI water calculated above.

____4.14.1.3c Each time the rods approach 100% wd, batch in another equal volume of DI water, until the transient is complete.

NOTE: Power may be decreased at any time by driving in control rods. Design rates of decrease can be obtained with rods starting in either band if rod insertion limits will not be exceeded.

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Upon reduction in power, APSR's should be used to minimize imbalance while control rods are withdrawn with Xenon buildup. If return to power will be at $\leq$ 0.5% FP/min., control rods should be allowed to follow Xenon until they reach the steady-state band.

4.14.2 Transient Operation (Transients > 0.5% per minute)

____4.14.2.1 During transient operation the reactor coolant system will follow step or ramp load changes under automatic control without relief valve or turbine bypass valve action as follows:

____4.14.2.1a Step Load Changes will be defined as - increasing load steps of 10% of full power in the range between 20% and 90% full power and decreasing load steps of 10% of full power between 100% and 20% full power.

____4.14.2.1b Ramp Load Changes will be defined as - increasing load ramps of 10% per minute in the range between 20% and 90% full power are acceptable, or decreasing load ramps of 10% per minute from 100% to 20% full power. From 15% to 20% and from 90% to 100% full power, increasing ramp load changes of 5% per minute are acceptable. Decreasing ramp load changes of 5% per minute are acceptable from 20% to 15% full power.

____4.14.2.1c The combined actions of the control system and the turbine bypass system permit a 25% load rejection (10% to the system and 15% to the condenser) without safety valve action. The combined actions of the control system, the

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turbine bypass valves, and the main steam safety valves are designed to accept separation of the generator from the transmission system without reactor trip.

____4.14.2.2 If power increases at > 0.5% FP/min are desired, control rods must be placed in the transient band prior to initiating the transient. Assuming the rods were in the steady-state band, proceed as follows:

____4.14.2.2a Determine the change in B^{10} necessary to move the rods from the steady-state band to the transient band from Figure 11 and convert this to a feed and bleed volume of DI water as per the Soluble Poison Control Procedure, 2103-1.2.

____4.14.2.2b Calculate the time required to make the above change.

$$t = \frac{\text{Volume of DI to add}}{\text{F\&B Flow Rate}} + \frac{\text{Water Volume of MU Tank}}{\text{F\&B Flow Rate}} \times 4$$

NOTE: This amounts to the advance notice required prior to performing transients in excess of 15% FP, changes at greater than 0.5% FP/min. This time can vary from 3 hours for smaller transients at beginning of cycle to 7 hours for longer transients near end of cycle.

A 15% load change can be accomplished any time without dilution.

____4.14.2.2c Commence feed and bleed of the DI water as calculated above. When control rods reach the transient band, power may be increased by pulling rods.

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_____4.14.2.3 If power decreases at > 0.5% FP/min are desired:

_____4.14.2.3a Drive rods inward to reduce power at the desired ramp rate. During the power decrease rods must be maintained within the limits of Figures 3, 4 & 5 (TS 3.1.3.1). At the conclusion of the Transient Borate/Deborate as necessary to place rods in the Steady-State or Transient Band as appropriate for anticipated operation.

_____4.14.2.3b Continue operation using 4.14.2.4, 4.14.2.5, or 4.14.2.6, as appropriate.

4.14.2.4 Unplanned Power Return at Nominal Rates

_____4.14.2.4a Maintain rods within the transient position band to preserve return to power capability at nominal ramp rates, using Figure 9A, 9B, or 9C.

NOTE: By keeping the control rods within the transient position band, nominal ramp rates over the entire load range can be obtained. Maintaining rods near the top of the transient band will minimize the power imbalance and resulting loss of rod worth, thereby, maximizing the power return capability at nominal ramp rates.

_____4.14.2.4b Use Figure 12 to determine if the maneuver is possible.

NOTE: Figure 12 is a plot of minimum feed and bleed dilution rate vs. RCS boron concentration for various load changes. Points that lie above and to the left of the desired load change curve indicate that the desired load change is possible at that feed and bleed flow rate and

RC boron concentration, with the ability to return to power at nominal ramp rates.

____4.14.2.4c Deborate and insert rods to the bottom of the control band just before the power return. Use Figure 10 and the rod position at top of transient band to determine boron concentration change.

____4.14.2.4d When return to power is desired, determine the batch volume of boric acid required to increase RCS concentration by 20 ppm.

____4.14.2.4e Commence power increase by pulling rods, batch in volume calculated above to compensate for Xenon burnout (letdown flow should be at maximum). Continue adding batches of the same size, at an effective flow rate of 10 gpm, until control rods have stopped inserting on Xenon burnout.

____4.14.2.4f When Xenon burnout is complete, control rods shall be maintained in the transient band per Figure 9A, 9B, or 9C, or allowed to follow Xenon to the Steady-State Band.

4.14.2.5 Planned Power Return at Nominal Rates

____4.14.2.5a Allow Xenon to put rods in the steady-state operating band. Maintain rods in the steady-state band using Figure 10.

____4.14.2.5b Determine the change in B^{10} necessary to move the rods from the steady-state band to the transient band from Figure 11 and convert this to a feed and bleed volume of DI water as per the Soluble Poison Control Procedure, 2103-1.2.

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____4.14.2.5c Calculate the time required to make the above change.

$$t = \frac{\text{Volume of DI to add}}{\text{F\&B Flow Rate}} + \frac{\text{Water Volume of MU Tank}}{\text{F\&B Flow Rate}} \times 4$$

NOTE: This amounts to the advance notice required prior to performing transients in excess of 15% FP changes at greater than 0.5% FP/min. This time can vary from 3 hours for smaller transients at beginning of cycle to 7 hours for longer transients near end of cycle.

____4.14.2.5d Commence feed and bleed of the DI water as calculated above. When control rods reach the transient band, power may be increased by pulling rods.

____4.14.2.5e Determine the batch volume of boric acid required to increase RCS concentration by 20 ppm. (Present concentration may have to be calculated based on total DI water added in step 4.14.2.5b because previous additions may not be fully mixed. The change of 20 ppmb is used to give the operator a head start on Xenon burnout.

____4.14.2.5f While increasing power at nominal ramp rates, initiate batch boration at 20 gpm intermittantly to average 10 gpm over the duration of the transient. Observe control rod insertion and withdrawal limits.

____4.14.2.5g Continue with successive operations of re-entering the same batch size of step 4.14.2.5e at 20 gpm at an effective flow rate of 10 gpm, until control rods have initially stopped inserting on Xenon burnout.

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CAUTION: Do not allow control rods to approach the control rod low insertion limit. Correct the situation by increasing the batch effective flow rate as necessary.

_____4.14.2.5h Continue to borate until minimum Xenon undershoot has occurred. (Rods have stopped moving in due to Xenon burnout).

_____4.14.2.5i Allow Xenon to put rods in the steady-state operating band and continue operation per Steady-State operation.

4.14.2.6 Peak Xenon Recovery Capability

The limiting power maneuver for the reactor system is a load decrease from rated full power down to 15% power at nominal ramp rates followed by a return to full rated power during the subsequent Xenon peak.

Maneuvers of this magnitude are usually seen during physics testing and are seldom seen in normal operation. Normal power changes are well below the design load changes.

The peak xenon recovery at nominal ramp rates capability of the system can be determined by observing on Figure 12 the intersection of a given flow rate with the boron concentration of the RCS at the appropriate load change curve. RCS boron concentrations that lie to the left of the above intersection (greater ppm boron) indicate that the desired maneuver can be accomplished at the flow rate with the capability of returning to power at nominal ramp rates at peak xenon. RCS boron concentrations that lie to the right of the above intersection indicate the incapability of the system to accommodate at that

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flow rate the return to power at nominal ramp rates at peak xenon.

A 15% load reduction followed by a return to power at peak xenon can be accomplished at any time without need for RCS boron dilution. This assumes a nominal rod position within the transient control rod band before the initial load reduction. Rod positions greater than nominal will shift the curves of Figure 12 to the left while rod positions less than nominal will shift the curves to the right.

The Peak Xenon Recovery capability basic guidelines are:

_____4.14.2.6a Use Figure 12 to determine if the maneuver is possible.

_____4.14.2.6b Decrease power at nominal ramp rates by driving rods inward.

_____4.14.2.6c Refer to 4.14.2.4 Planned Power Return of Nominal Rates for return to power.

195 216

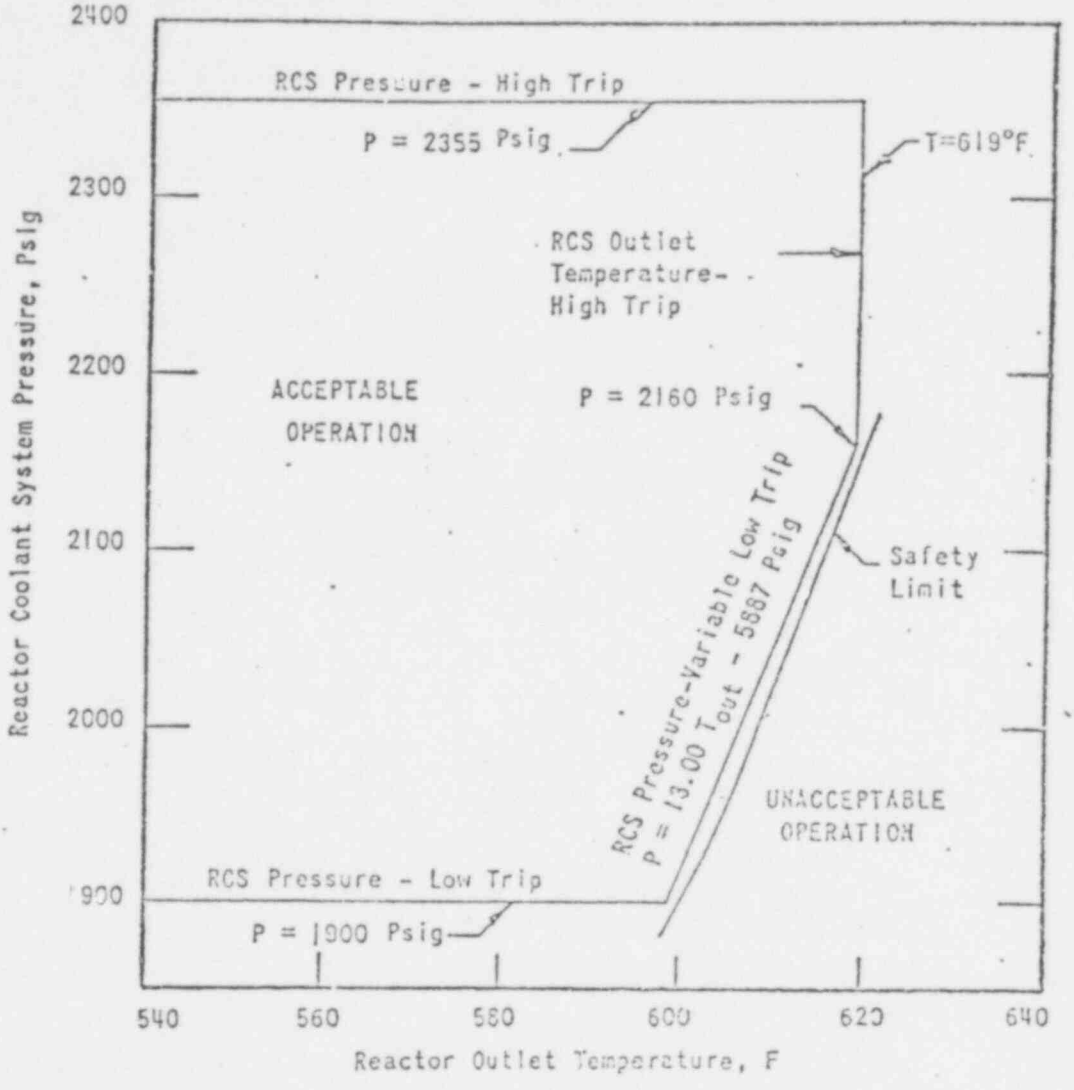
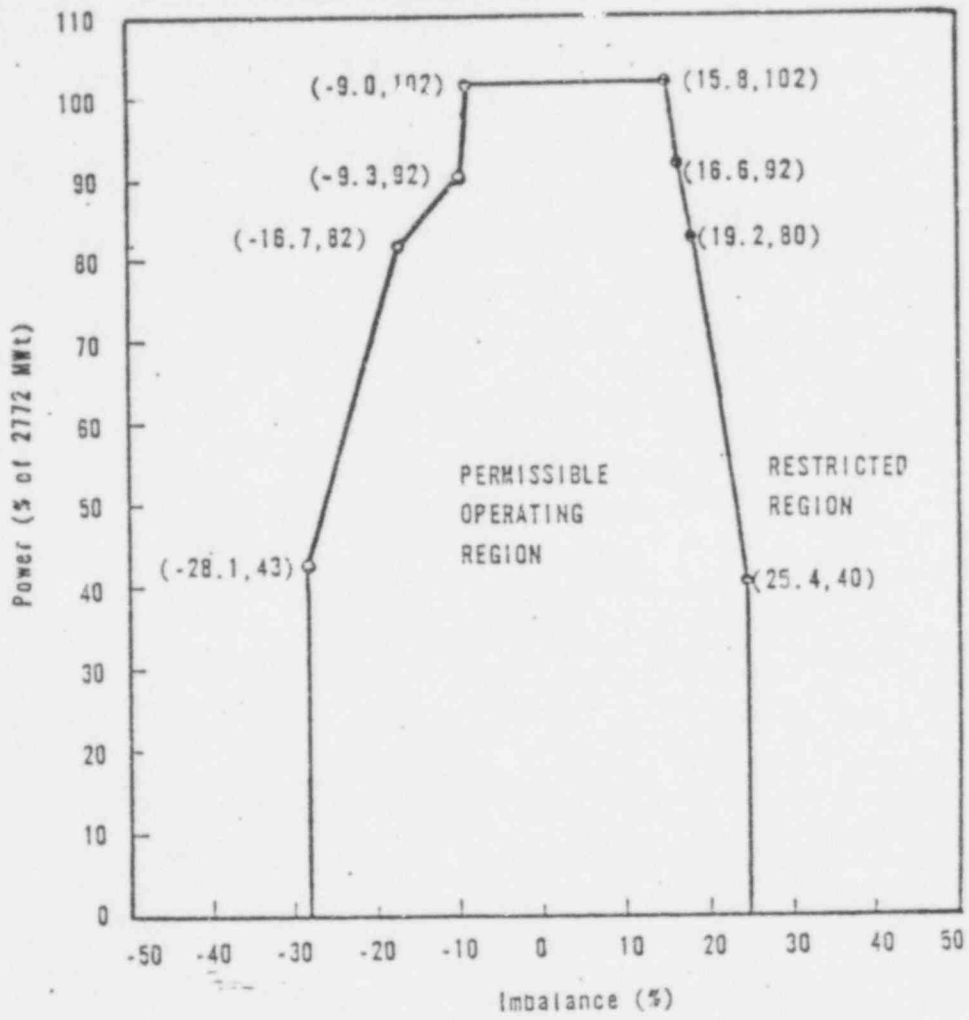


FIGURE 1:

THI - UNIT 2
REACTOR CORE SAFETY LIMIT

(Tec Spec. Figure 2.1-1)

195 217



CORE IMBALANCE VS POWER LEVEL
(0-200 ± 10 EFPD'S)

Figure 2

195 218

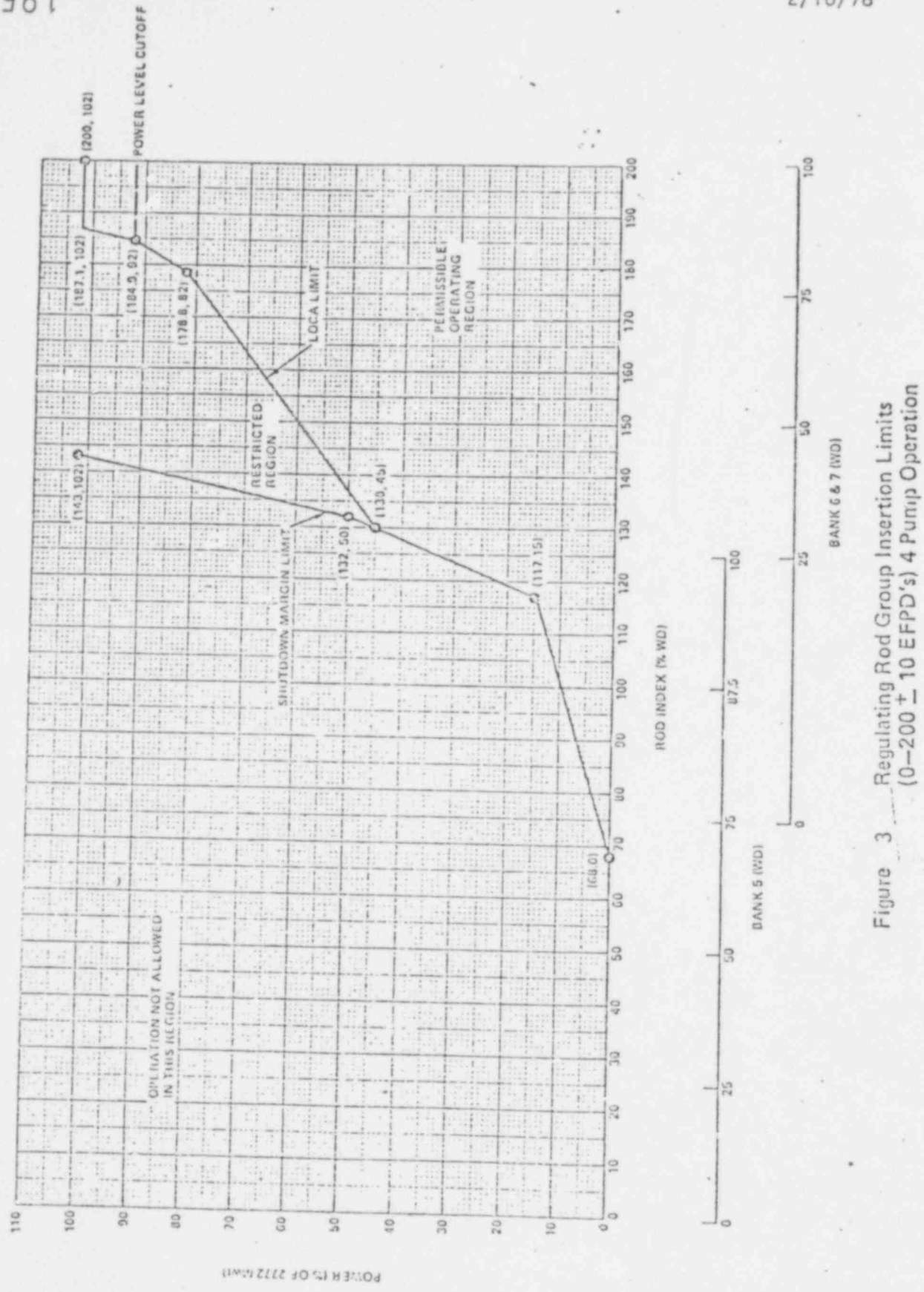
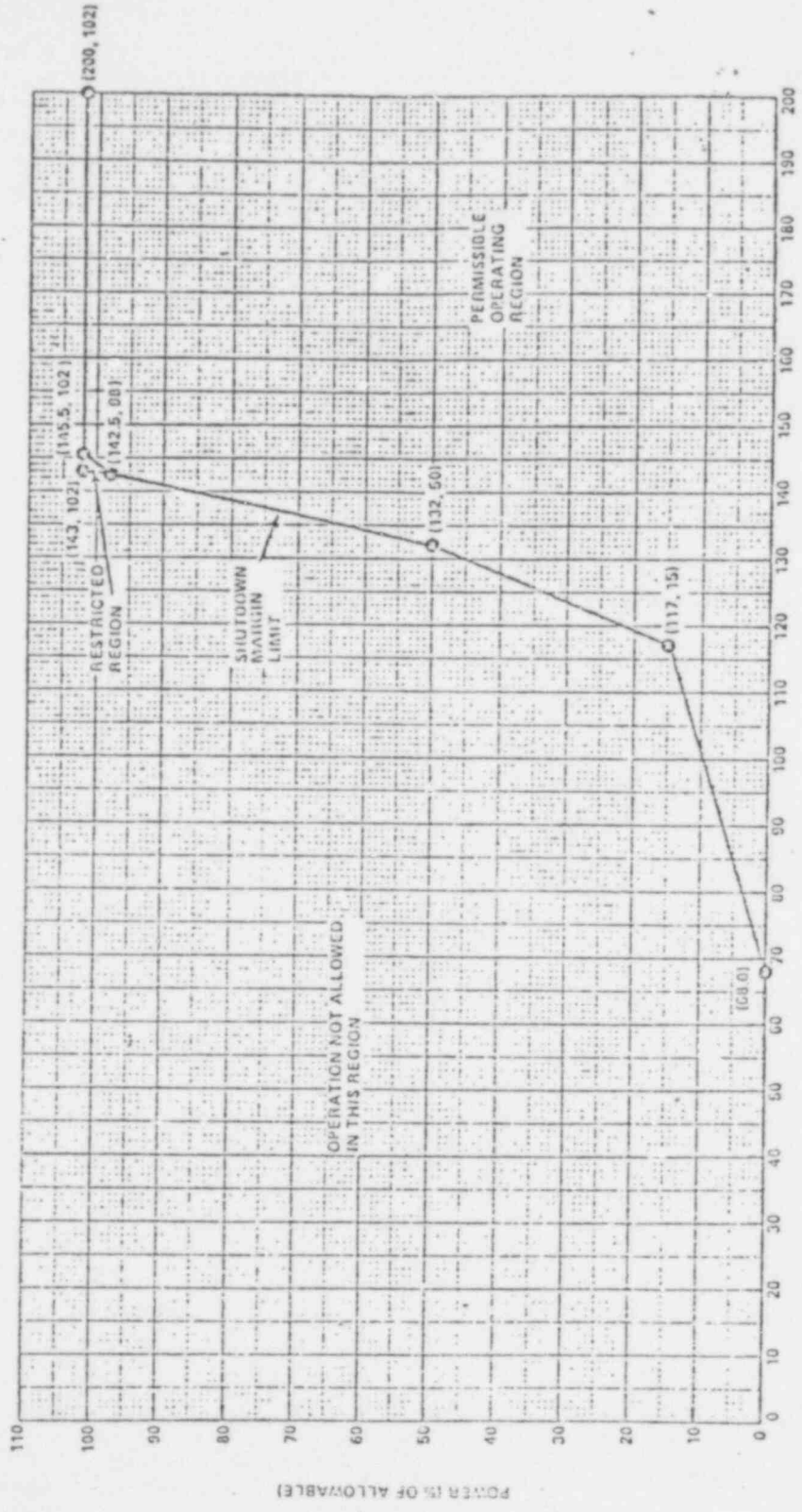
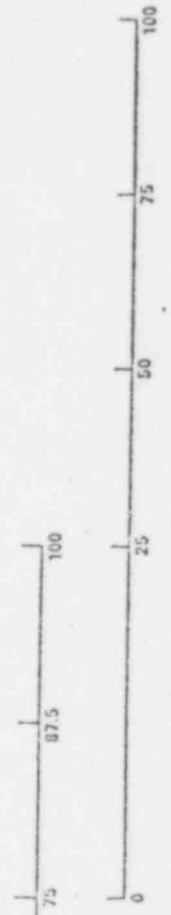


Figure 3 Regulating Rod Group Insertion Limits
(0–200 ± 10 EFPD's) 4 Pump Operation

195 220





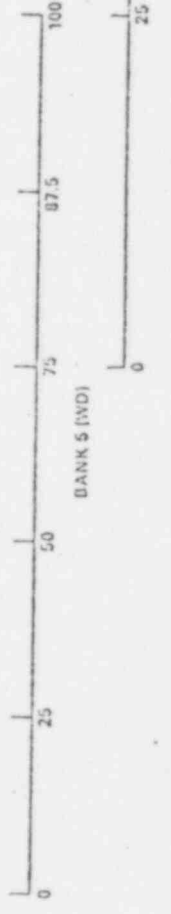


Figure 4 Regulating Rod Group Insertion Limits (0–200 ± 10 EFPD's) 2 Pump Operation

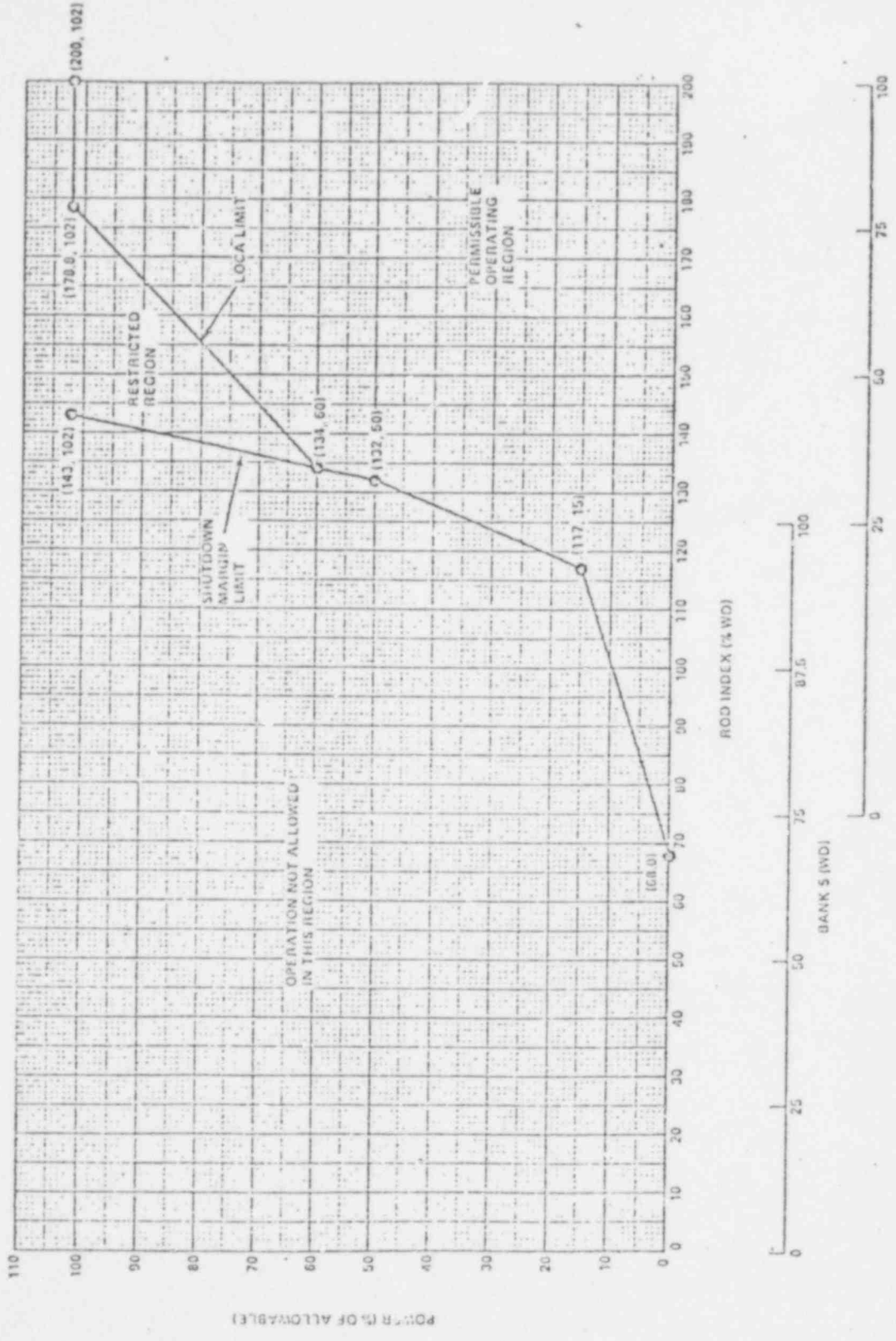


Figure 5 Regulating Rod Group Insertion Limit. (0–200 ± 10 EFPD's) 3 Pump Operation

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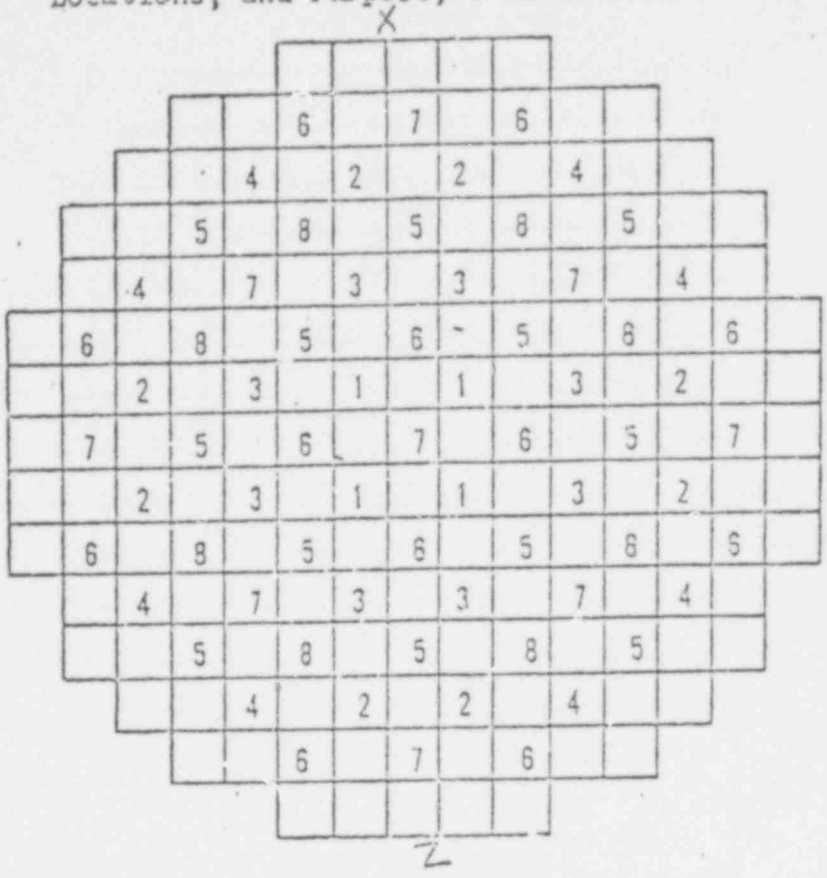
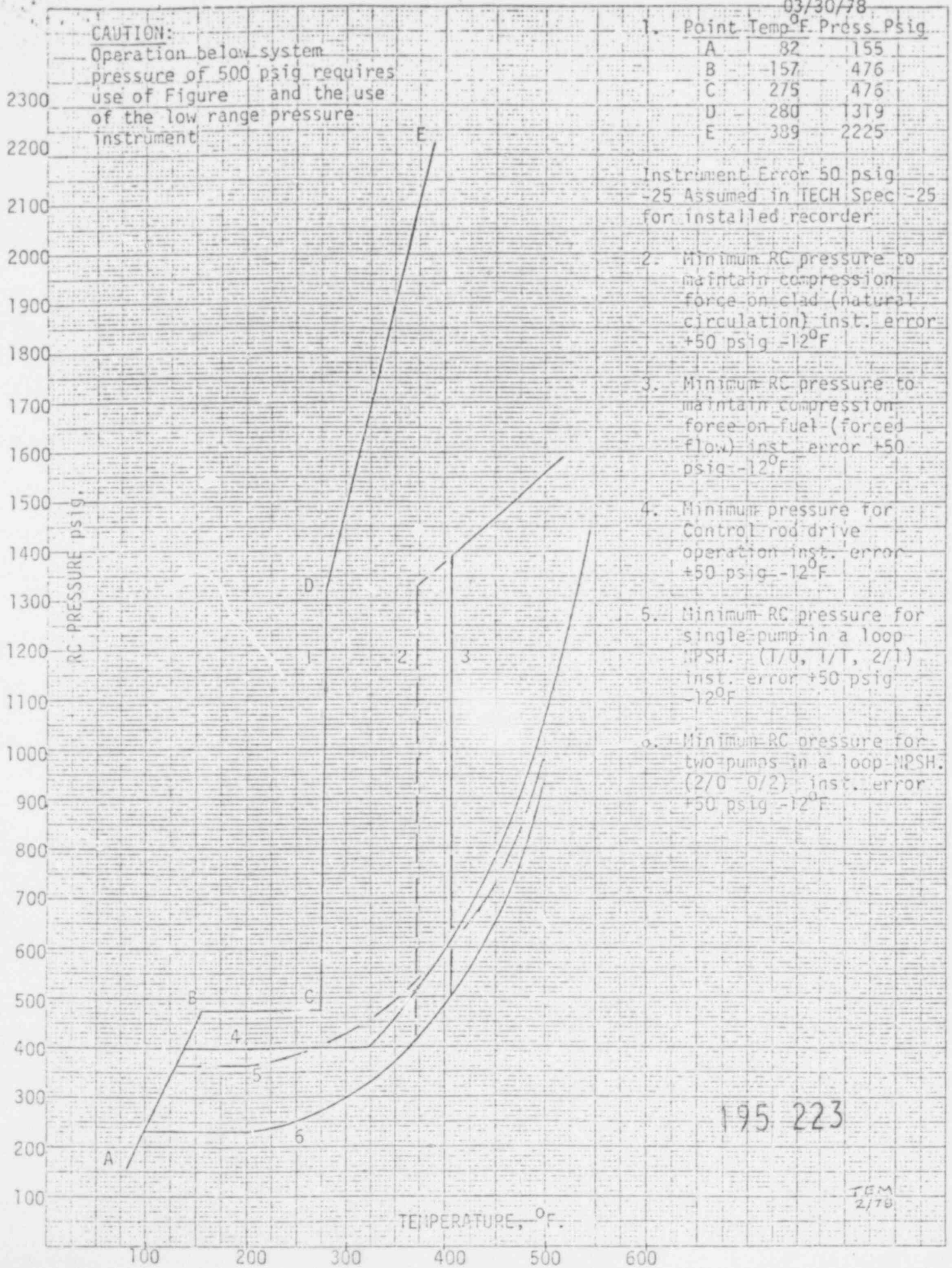
Control Rod Group Designations, Locations, and Purpose, 0 to 200 FPD



Rod Group	No. CRAs	Purpose
1	4	Safety
2	8	Safety
3	8	Safety
4	8	Safety
5	12	Regulating
6	12	Regulating
7	9	Regulating
8	8	APSR
	69	

HEAT UP/COOLDOWN CURVE



1. Point Temp °F Press Psig

Point	Temp °F	Press Psig
A	82	155
B	157	476
C	275	476
D	280	1379
E	389	2225

Instrument Error 50 psig -25 Assumed in TECH Spec -25 for installed recorder

2. Minimum RC pressure to maintain compression force on clad (natural circulation) inst. error +50 psig -12°F

3. Minimum RC pressure to maintain compression force on fuel (forced flow) inst. error +50 psig -12°F

4. Minimum pressure for Control rod drive operation inst. error +50 psig -12°F

5. Minimum RC pressure for single pump in a loop NPSH. (1/0, 1/1, 2/1) inst. error +50 psig -12°F

6. Minimum RC pressure for two pumps in a loop NPSH. (2/0 0/2) inst. error +50 psig -12°F

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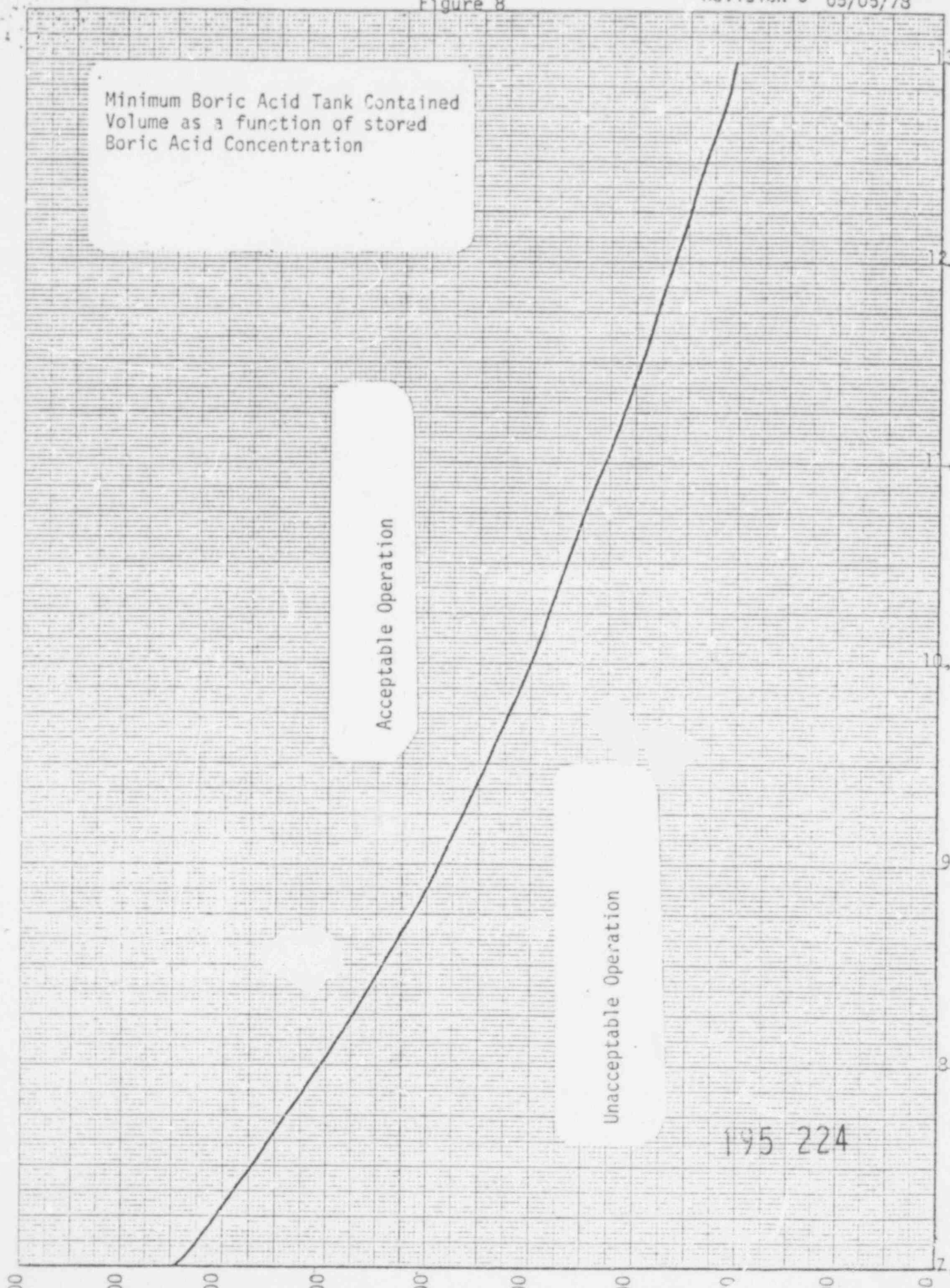
TEM 2/78

Figure 8



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195 224

CORE POWER

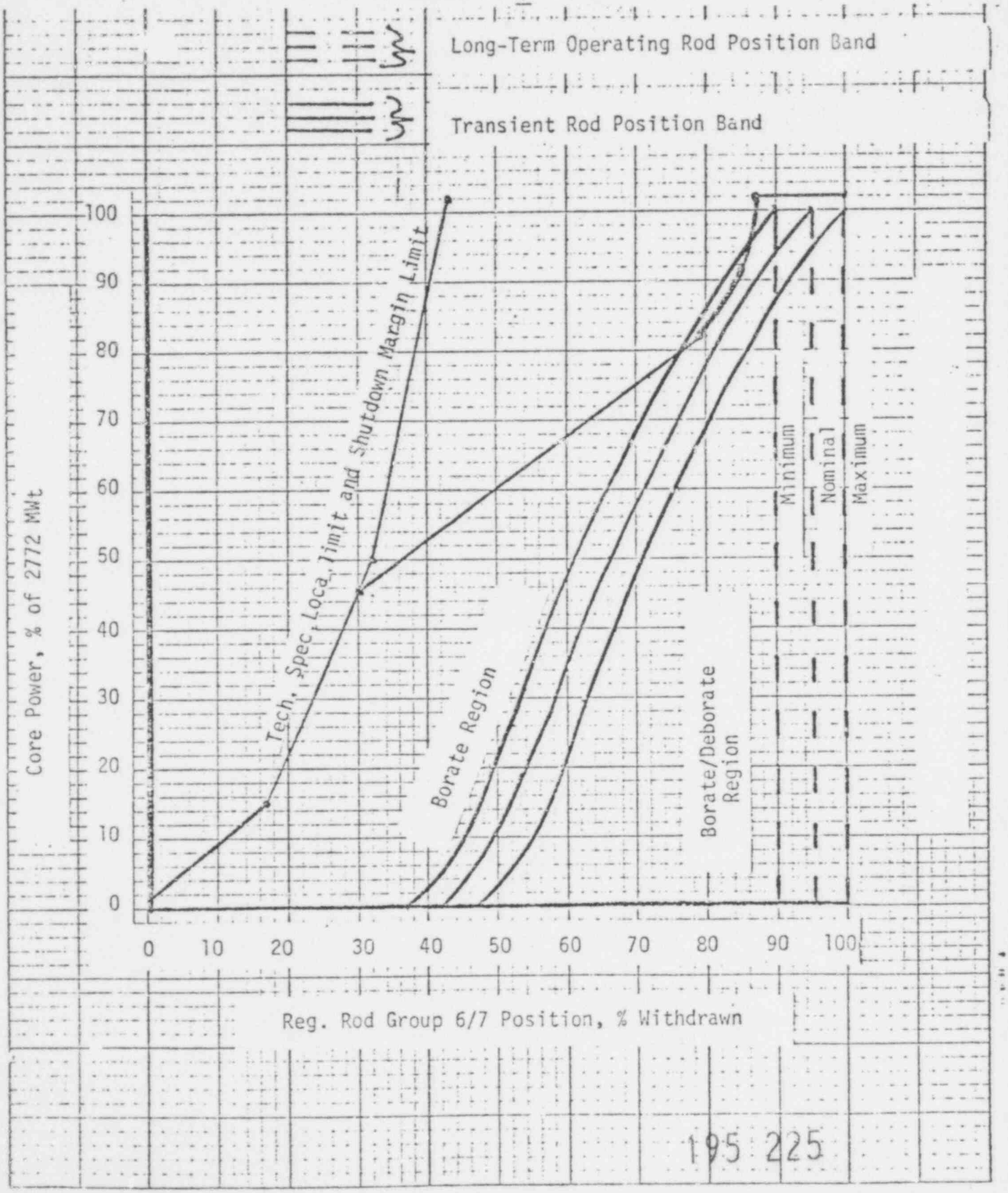
VS.

2102-2.1
Revision 5
04/18/78

LONG-TERM OPERATING AND TRANSIENT ROD POSITION BANDS

TMI 2 CYCLE 1 (0-200 ± 10 EFPD's) 4 PUMP OPERATION

FIGURE 9A



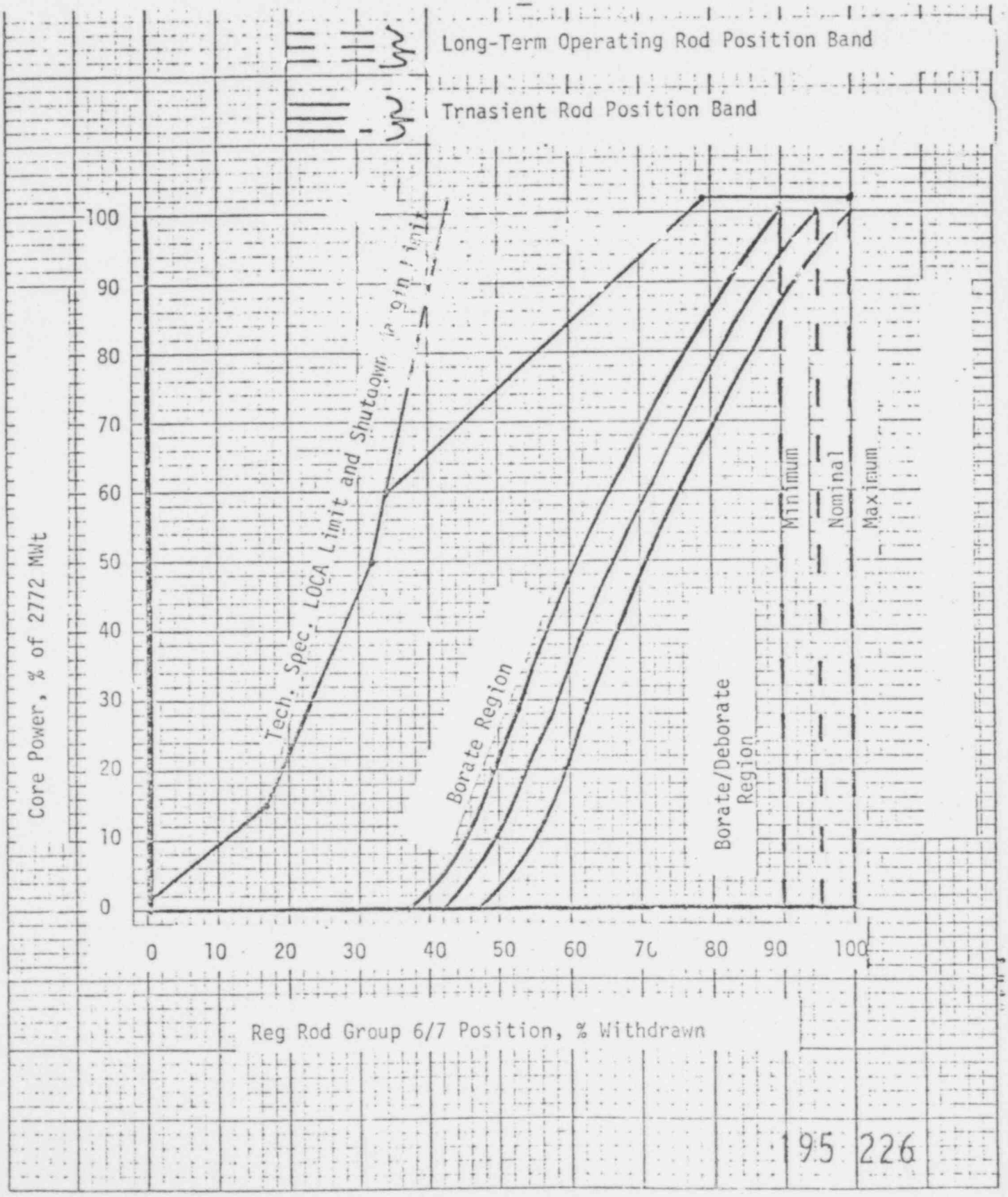
195 225

VS.

LONG-TERM OPERATING AND TRANSIENT ROD POSITION BANDS

TMI 2 CYCLE 1 (0-200 ± 10 EFPD's) 3 PUMP OPERATION

FIGURE 9B



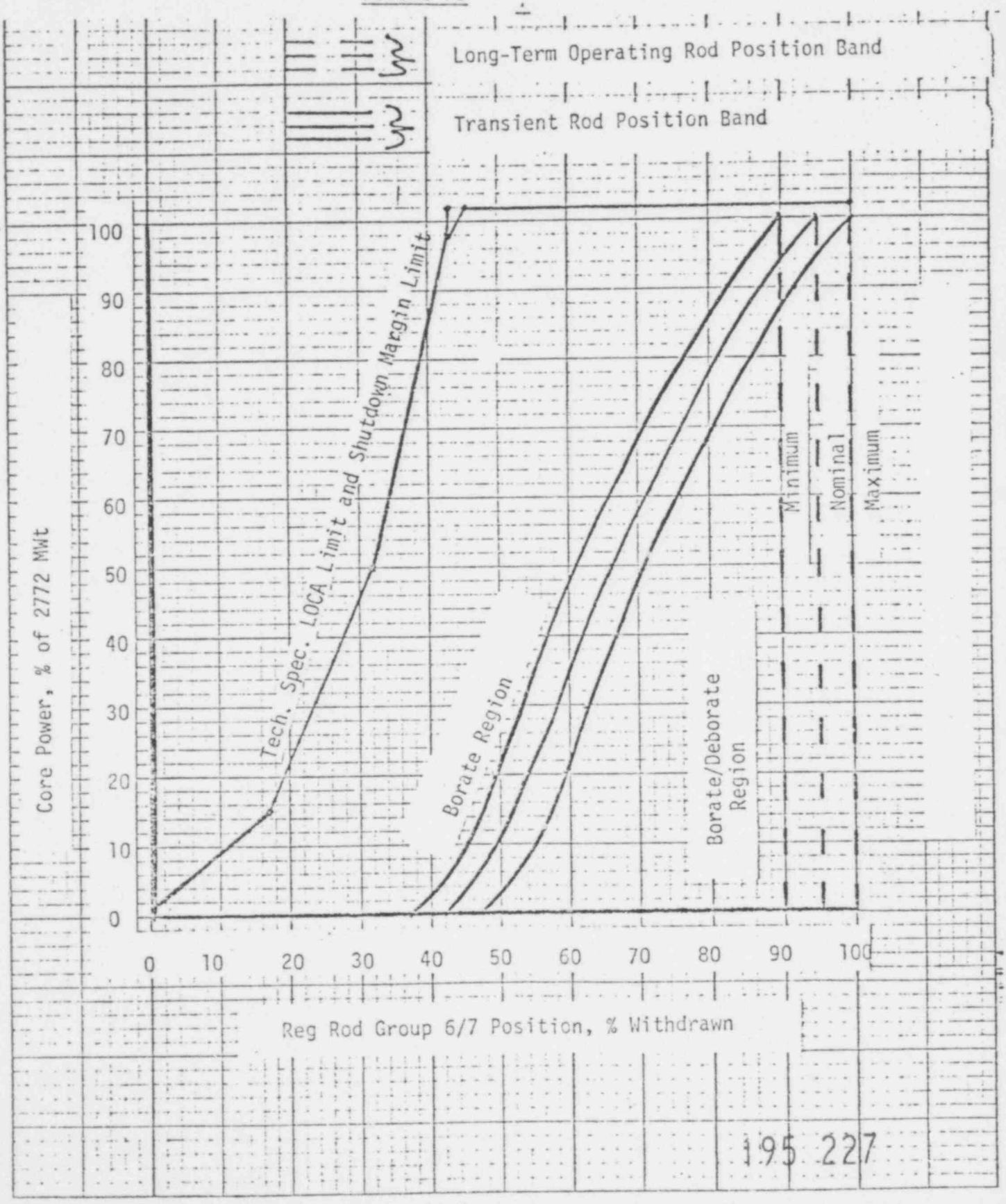
CORE POWER

VS.

LONG-TERM OPERATING AND TRANSIENT ROD POSITION BANDS

TMI 2 CYCLE 1 (0-200 ± 10 EFPD'S) 2 PUMP OPERATION

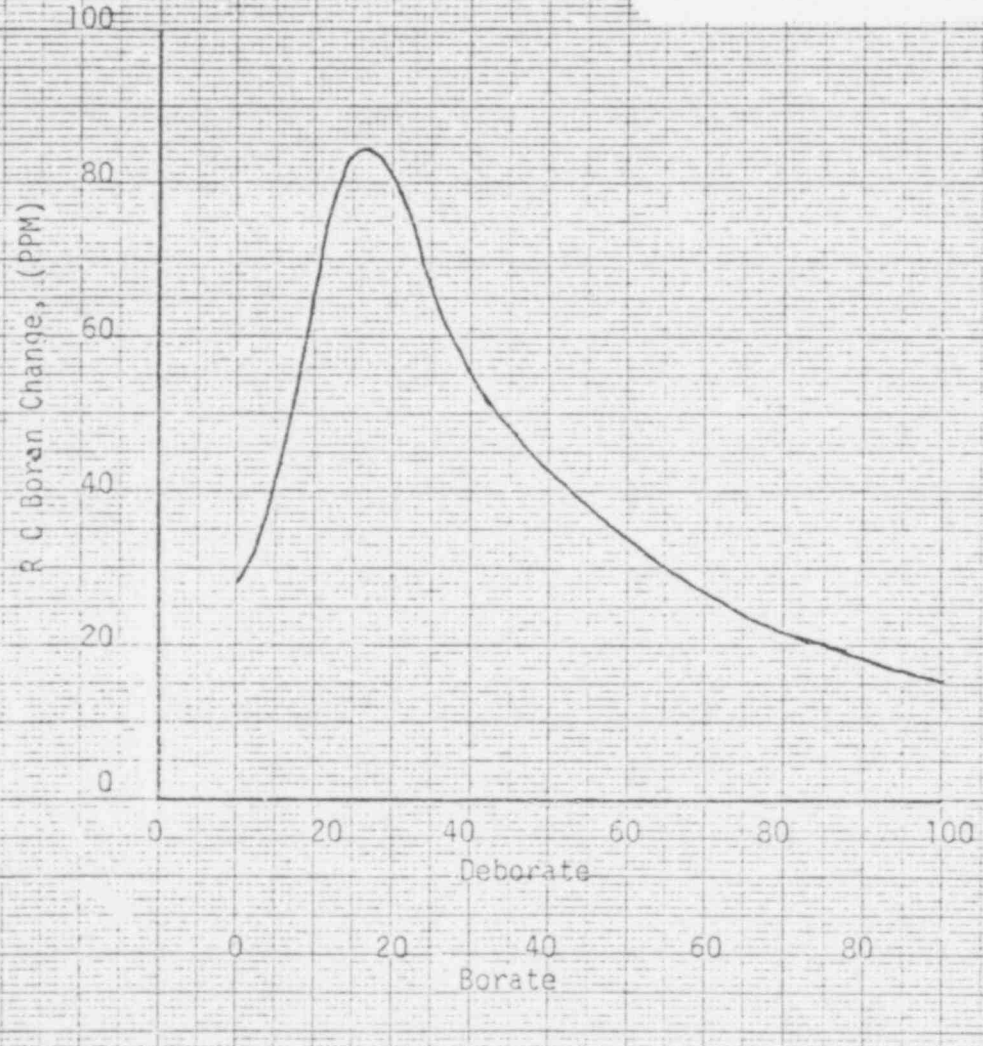
FIGURE 9C



195 227

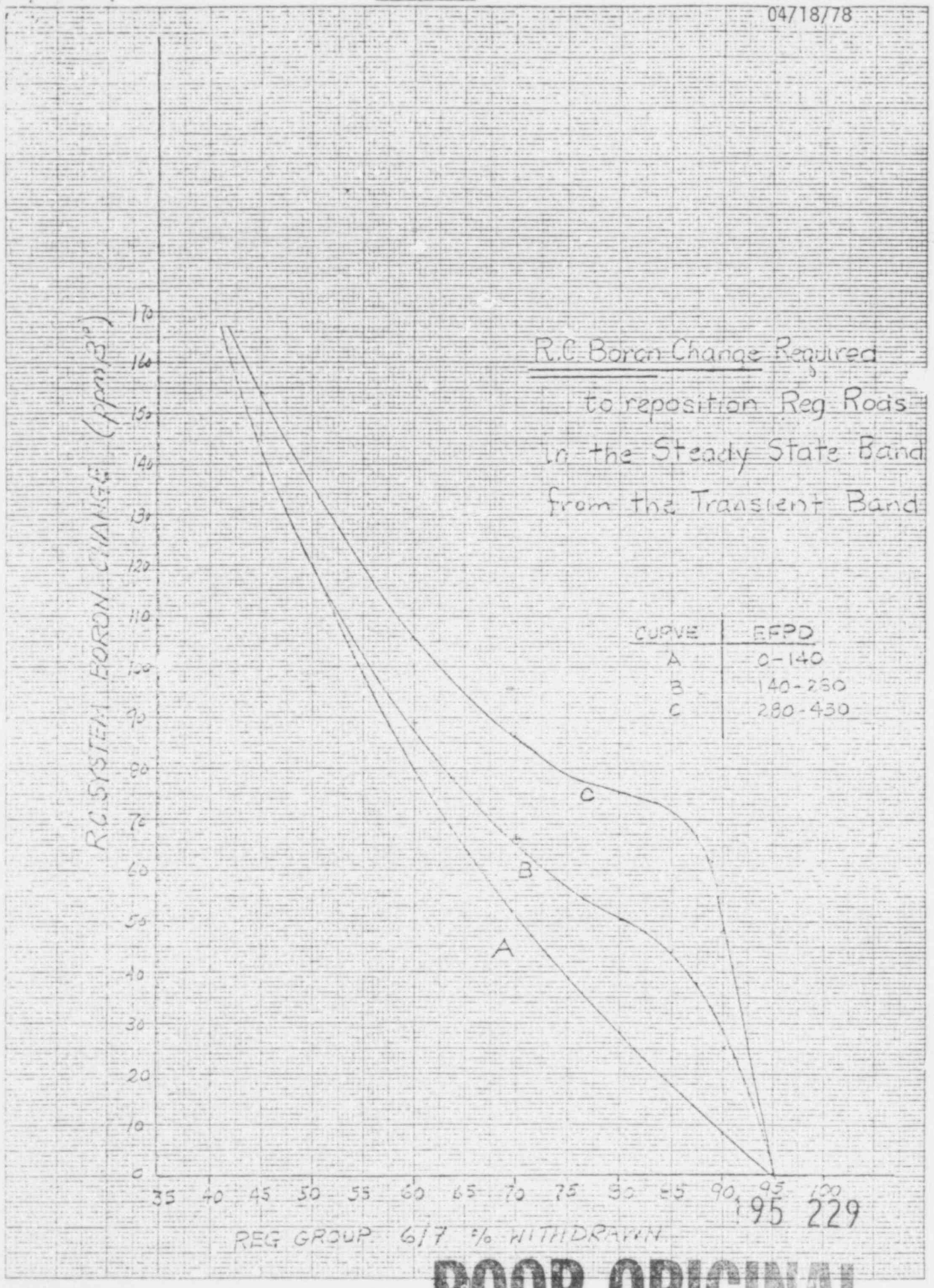
Deborate/Borate
+ 10% Rod Position
BOL - 140 EFPD
First cycle

NOTE: Figure assumes EQ. Reactivity conditions in the core. Transient Xenon effects should be noted.



195 228

FIGURE 11



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POOR ORIGINAL

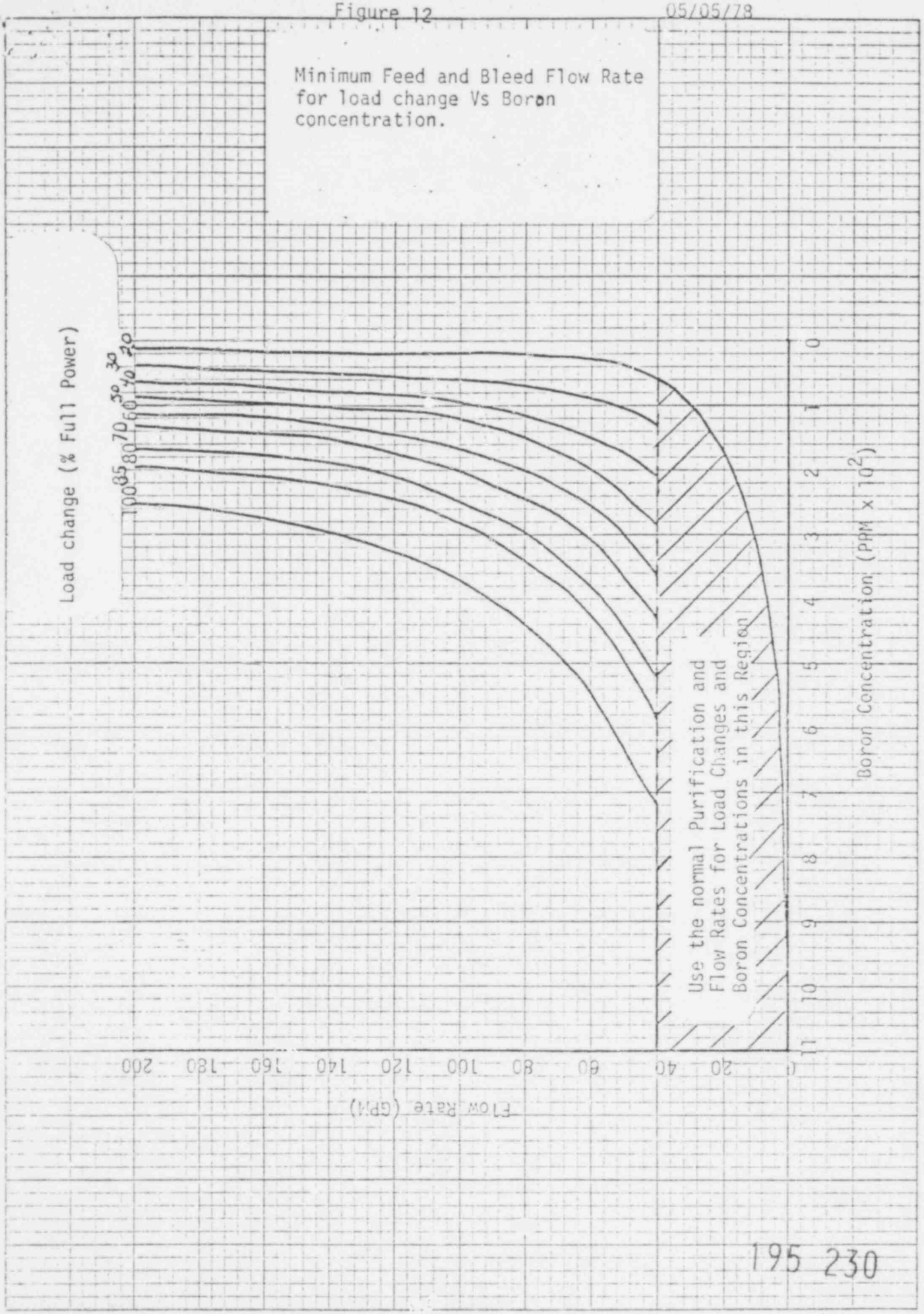
Minimum Feed and Bleed Flow Rate for load change Vs Boron concentration.
Load change (% Full Power)
100 85 80 70 60 50 40 30 20 10
Use the normal Purification and Flow Rates for Load Changes and Boron Concentrations in this Region
Boron Concentration (PPM x 10^2)
0 1 2 3 4 5 6 7 8 9 10 11
Flow Rate (GPM)
0 20 40 60 80 100 120 140 160 180 200

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Figure 13

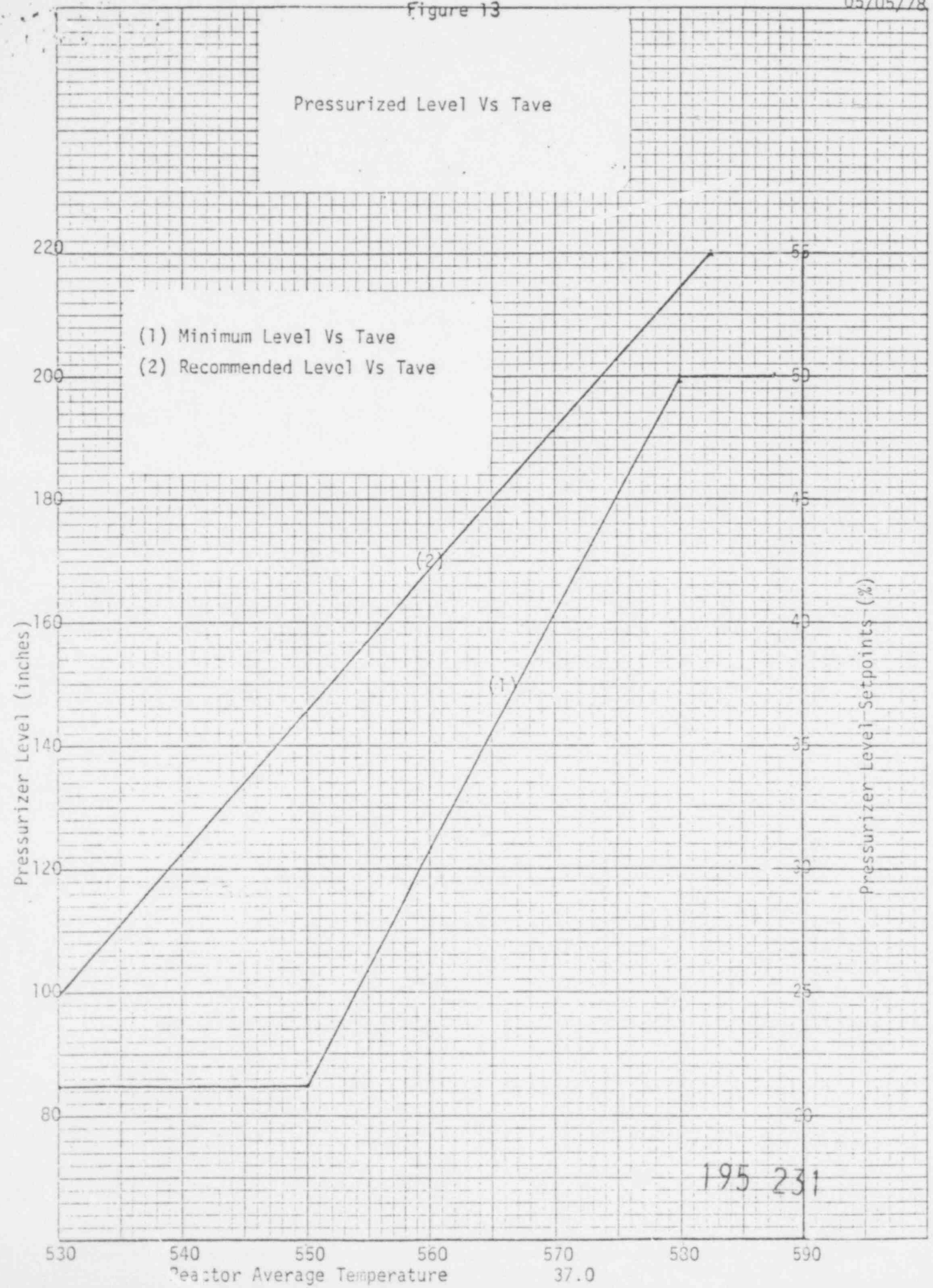

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TABLE 1

QUADRANT POWER TILT LIMITS

	STEADY STATE LIMIT	TRANSIENT LIMIT	MAXIMUM LIMIT
Measurement Independent QUADRANT POWER TILT	(3.69)	(9.74)	(20.0)
QUADRANT POWER TILT as Measured by:			
Symmetrical Incore Detector System	(2.30)	(7.71)	(20.0)
Power Range Channels	(0.96)	(5.88)	(20.0)
Minimum Incore Detector System	(1.72)	(3.71)	(20.0)

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TABLE 2

DNB MARGIN

Parameter		LIMITS		
		Four Reactor Coolant Pumps Operating	Three Reactor Coolant Pumps Operating	One Reactor Coolant Pump Operating in Each Loop
Reactor Coolant Hot Leg Temperature, T_H °F		$\leq$ 609.3	$\leq$ 609.3(1)	$\leq$ 609.3
Reactor Coolant Pressure, psig(2)		$\geq$ 2060.4	$\geq$ 2056.4(1)	$\geq$ 2091.4
Reactor Coolant Flow Rate, gpm	a.	$\geq$ 370,496 with THERMAL POWER $\leq$ 2717 MW_t(3)	$\geq$ 280,400	$\geq$ 182,800
	b.	$\geq$ 373,120 with 2717 MW_t < THERMAL POWER $\leq$ 2744 MW_t.(4)		
	c.	$\geq$ 377,000 with 2744 MW_t < THERMAL POWER $\leq$ 2772 MW_t		

(1) Applicable to the loop with 2 Reactor Coolant Pumps Operating.

(2) Limit not applicable during either a THERMAL POWER ramp increase in excess of 5% of RATED THERMAL POWER per minute or a THERMAL POWER step increase of greater than 10% of RATED THERMAL POWER.

(3) The Nuclear Overpower trip setpoint shall be reduced to $\leq$ 103.5% of RATED THERMAL POWER.

(4) The Nuclear Overpower trip setpoint shall be reduced to $\leq$ 104.5% of RATED THERMAL POWER.

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APPENDIX A

EXAMPLE OF FEED AND BLEED PROCEDURE FOR A 50 PERCENT LOAD CHANGE

Load change from 100 to 50 percent power at 100 EFPD with the initial reactor boron concentration of 1000 ppm.

Example 1: Planned power return in eight hours at nominal ramp rates.

1. When 50% power is reached minimize imbalance with APSR's and allow control rods to follow xenon buildup to the Steady-State operating band.

2. From Figure 10 a deboration of 19 ppm is observed at 90% regulating group 6/7 withdrawal.

3. The volume set in the batch controller is determined from 2103-1.2 using 1000 ppm - 19 ppm = 981 ppm for the final concentration. The demineralized water volume is 1253 gal.

4. At maximum attainable letdown flow rate feed and bleed the calculated volume when the regulating rod group is 90% withdrawn.

5. Monitor the position of the regulating rod group. If the rods approach 100% withdrawn add another of the same batch volume computed above. Repeat as necessary.

6. From Figure 11 determine that the change in RCS boron concentration required to put the rods back in the transient band from the steady-state operating band is 61 ppm (Regulating Group 6/7 nominal position of 66% withdrawn, per Figure 9A).

7. The volume set in the batch controller is determined from 2103-1.2 using 981 ppm - 61 ppm = 920 for the final concentration. The demineralized water volume is approximately 4000 gal.

8. Compute the minimum total lapsed time from the start of the deboration to the time the rods are back at the nominal position and ready for power increase. With a maximum letdown flow of 100 gpm.

   T = (4000 gal/6000 gph) + (3000 gal/6000 gph) x 4 = 2.6 hours

9. At the maximum attainable letdown flow rate, feed and bleed the calculated volume 2.6 hours before the planned return to power.

NOTE: A peak xenon return at nominal ramp rates using this method is only practical until the time in core life when boron concentration decreases to 200 ppm if the letdown flow is 140 gpm.

10. Return to power per Example 2, step 7 below.

Example 2: Unplanned power return in eight hours at nominal ramp rates.

1. When 50% power is reached minimize imbalance with APSR's and note that the nominal position is 66% withdrawn (Figure 9A).

2. From Figure 10, a deboration of 29 ppm is observed.

3. The volume set in the batch controller is determined from 2103-1.2 using 1000 ppm - 29 ppm = 971 ppm for the final concentration. The demineralized water volume is 2057 gal.

4. At maximum attainable letdown flow rate feed and bleed the calculated volume as soon as possible after the load decrease.

5. Continue with successive operations of re-entering the same feed and bleed batch size with maximum flow but at time intervals which yield an effective flow rate per Figure 12 (40 gpm at 1000 ppm).

   The time between start of successive batches = 2057 gal/40 gpm = 51 min.

6. Monitor the position of the regulating group. Attempt to maintain the rods near the top of the band for at least the first four hours of reduced power. Then by continued deboration, insert the rods to the bottom of the control band.

RETURN TO POWER

7. On return to power maintain the APSR's fixed till after boric acid addition has overcome the insertion of rods due to xenon burnout.

8. The volume set in the batch controller is determined from 2103-1.2 using the existing boron concentration 920 ppm + 20 ppm = 940 ppm for the final concentration. The boric acid volume is 257 gal, assuming 6000 ppmb solution.

9. While returning to full power at nominal ramp rates start the batch boration at 20 gpm through the batch controller and at maximum attainable letdown flow rate.

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10. Continue with successive operations of re-entering the same batch size as above but at time intervals which yield an effective flow rate of 10 gpm.

11. While increasing power with Unit Load Demand, monitor the position of the regulating group. After the rods have stopped inserting due to xenon burnout, borate/deborate as necessary per Figure 10 at normal letdown flowrates.

NOTE: If power increase is terminated prior to rods reaching the steady-state band, rods may be allowed to follow xenon to the steady-state band.

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APPENDIX B

MECHANICAL MANEUVERING RECOMMENDATIONS

The following are the recommended maneuvering limits for TMI-II, Cycle 1:

1. The maximum rate of power increase below 20% full pwer shall be 10% per hour.

2. Above 20% power, normal operating procedures (Tech. Spec. Limits) will apply unless the reactor has operated at less than 20% power for more than 48 hours.

3. If the power level has been below 20% full power for greater than forty-eight (48) hours, the maximum rate of power increase above 20% full power shall be 30% per hour with a five (5) hour hold at 20% full power below the power level cutoff and a five (5) hour hold at the power level cutoff. These holds can run concurretnly with holds required by the Technical Specification.

4. During the initial power escalation at cycle startup or immediately following a control rod interchange, the initial escalation above the 75% full power shall be limited to 3% per hour, with a five (5) hour hold at the power level cutoff. These nolds can run concurrently with Technical Specification holds where applicable.

5. With the exception of item 4 above, no restrictions are placed on required physics startup tests.

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