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June 4 , 1980
TLL 266

TMI Program Office
Attn: J. T. Collins, Deputy Program Director
U. S. Nuclear Regulatory Commission
c/o Three Mile Island Nuclear Station
Middletown, Pa. 17057

Dear Sir:

Three Mile Island Nuclear Station, Unit II (TMI-2)
Operating License No. DPR-73
Docket No. 50-320
Analysis of MDHR System Startup and
Operation Effects on RCS Boron Concentration

On May 9, 1980, during a meeting with the on-site NRC staff, the question of the effect of MDHR system startup and operation on RCS boron concentration was raised. We committed, at that time, to provide a detailed analysis of the transient and steady state effects on boron concentration throughout the reactor core region that could be anticipated as a result of putting the MDHR system into operation.

The enclosed Technical Data Report (TDR-155) provides the results of the analysis that has been performed. The analysis methodology defines eighteen (18) finite elements that make up the RCS, the reactor core region and the MDHR system. Calculations were performed, using these finite elements, that show that RCS boron concentration does not go below the minimum required value of 3000 ppm in either the transient case (startup) or the steady state case.

We anticipate that the submission of this Technical Data Report is responsive to your concerns.

Sincerely,

/s/ G. K. Hovey

G. K. Hovey
Director, TMI-II

GKH:LJL:nah

Enclosure

cc: [redacted]

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TECHNICAL DATA REPORT

TDR NO. 155	REVISION NO. 0
PROJECT NO. 3792?	PAGE 1 OF 15
PROJECT: TMI-2	DEPARTMENT/SECTION Engineering Mechanics Sec.
	RELEASE DATE 5-23-80 REVISION DATE -

DOCUMENT TITLE: Transient Boron Concentration Analysis in TMI-2 Mini Decay Heat Removal System (MDHRS)

ORIGINATOR SIGNATURE	DATE	APPROVAL(S) SIGNATURE	DATE
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K. M. Jasani [signature]	5-23-80		
		APPROVAL FOR EXTERNAL DISTRIBUTION	DATE
		[signature]	5-23-80

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ABSTRACT:

1. Brief Statement of Problem

To switch from the natural convection cooling mode of the TMI-2 reactor coolant system to the forced circulation for decay heat removal, the Mini Decay Heat Removal System (MDHRS) will be used until the reactor has been completely defueled.

As a result of this situation, an analysis was performed to ensure that the boron concentration everywhere in the reactor vessel, especially in the core, is higher than 3000 ppm (technical specification requirement) all the time during the transient and steady state operation of MDHRS. The effect of flow rate on boron concentration was also studied.

2. Summary of Key Results

Conservation equations of energy and mass were applied to 18 volume elements comprising the MDHRS. Core heat generation during April, 1980 was 5.5×10^5 Btu/hr, and cold leg temperature was assumed to be 100°F. Flow rates of 10, 20, 50 and 120 GPM in the system were considered. Significant findings are listed below.

1. The minimum boron concentration in the reactor vessel is approximately 3575 ppm for all flow rates between 10 and 120 gpm. Obviously, the technical specification requirement of 3000 ppm has been satisfied.

2. The steady state boron concentration is 3705 ppm for all flow rates that were considered.

3. The time needed to achieve steady state (uniform boron concentration in the entire MDHRS) are depicted below.

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ABSTRACT: (continued)

Flow Rate, GPM	Time to Achieve Steady State, Hrs.
10	94
20	44
50	18
120	8

3. Conclusions

The results of this analysis has generated the following conclusions:

1. The hot leg temperature decreases with the increasing flow rate for a fixed cold leg temperature.

2. The minimum boron concentration in the reactor vessel during transient and steady state operation of the MDHRS is independent of flow rate and is always greater than 3000 ppm which is the technical specification requirement. This valve is insensitive to the number of volume elements that were utilized to model the reactor core.
3. The steady state boron concentration is independent of the flow rate.

4. Time required to achieve steady state in the MDHRS varies inversely with the system flow rate.

4. Recommendation

It is recommended that a moderate flow rate of 50 gpm be utilized during start up of the MDHRS to afford reasonable and sufficient time to assess any unusual trends that may occur in the reactor vessel during the transient phase of the operation.

TRANSIENT BORON CONCENTRATION ANALYSIS IN TMI-2 MINI DECAY HEAT REMOVAL SYSTEM (MDHRS)

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I. PURPOSE AND SUMMARY

To switch from the natural convection cooling mode of the TMI-2 reactor coolant system to the forced circulation mode of decay heat removal, the Mini Decay Heat Removal System (MDHRS), with flow path shown in Figure 1, will be utilized until the reactor has been completely defueled. As shown in Figure 1, some of the flow path volume have low boron concentration which can potentially lower the boron concentration in the reactor vessel.

Conservation equations of energy and mass were utilized in analyzing density changes and variation of boron concentration during transient and steady state operation of MDHRS (Reference 5). The minimum required boron concentration of 3000 ppm in the reactor vessel per TMI-2 technical specification will be checked to make sure that this has not been violated any time during the operation of the MDHRS. The effect of flow rates on the transient and steady state variation of boron concentration were also considered in the study.

Methods of analysis, results, conclusions, recommendations and reference will be highlighted in the following sections of this Technical Data Report (TDR).

II. METHODS

The following methods were employed to analyze the operating MDHRS with different flow rates.

1. The MDHRS was divided into a finite number of volume elements. Figure 2 depicts 18 volume elements. The reactor vessel core has 6 elements.

2. Energy equation was applied to each element to determine the temperature and density distributions of reactor coolant in the MDHRS.

3. Mass balance, with a consideration of density variation of reactor coolant, was used for each element to determine the distribution of boron concentration during transient and steady state operation of the MDHRS.

III. EVALUATION

A. Hot Leg Temperature

This evaluation assumes a cold leg temperature of 100°F and utilizes the following assumptions:

1. Heat loss through the reactor vessel and piping insulation is negligible with respect to the heat generated in the reactor core.

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SUBJECT Boron Concentration Analysis in TMI-2 MDHRS

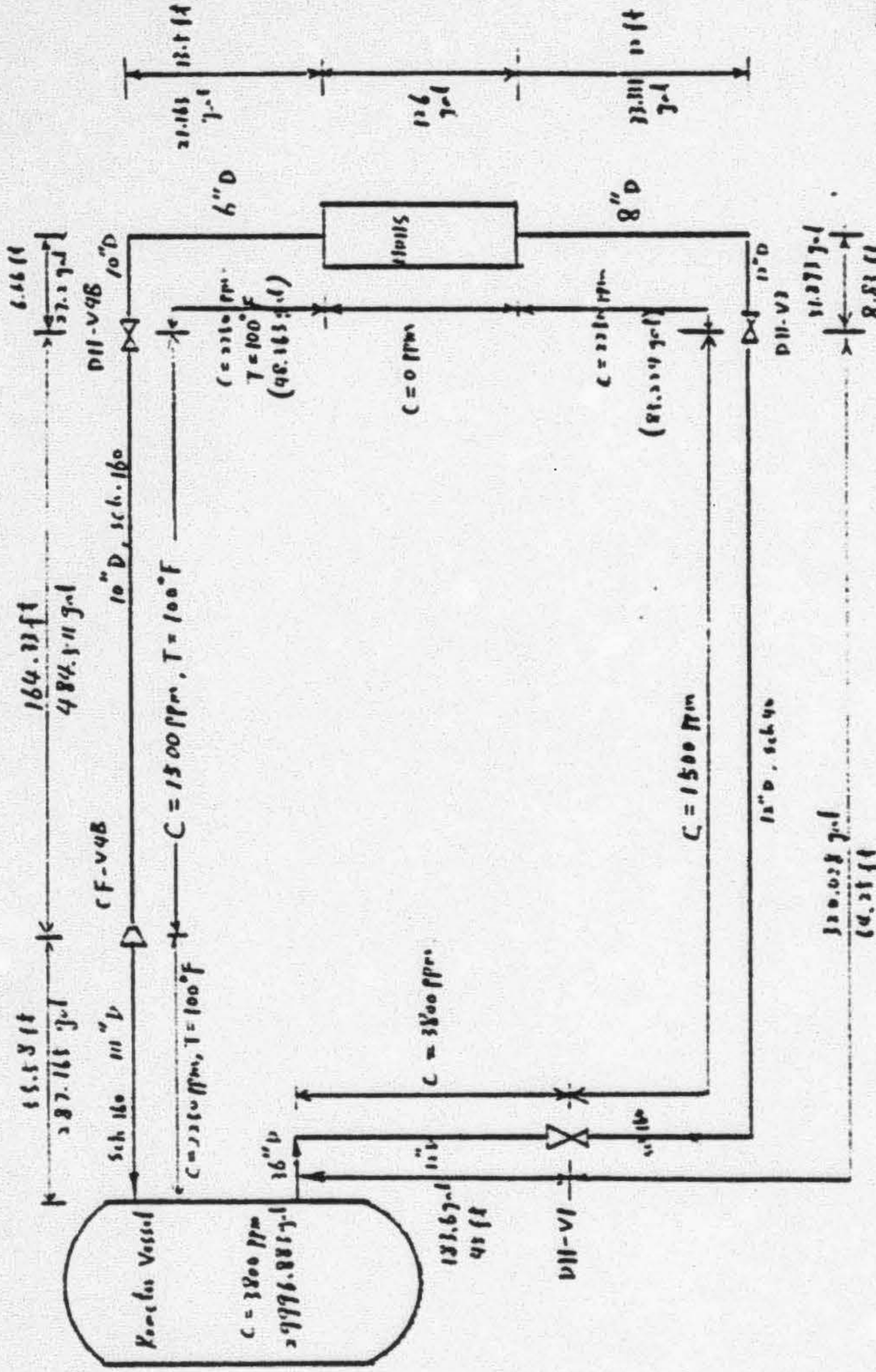

Figure 1: Initial Conditions of Boron Concentration for Different Volume Elements of TMI-2 Mini Decay Heat Removal System (References 1 to 4).

Subject: Boron Concentration Analysis in TMI-2 MDHRS

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6. Calculations

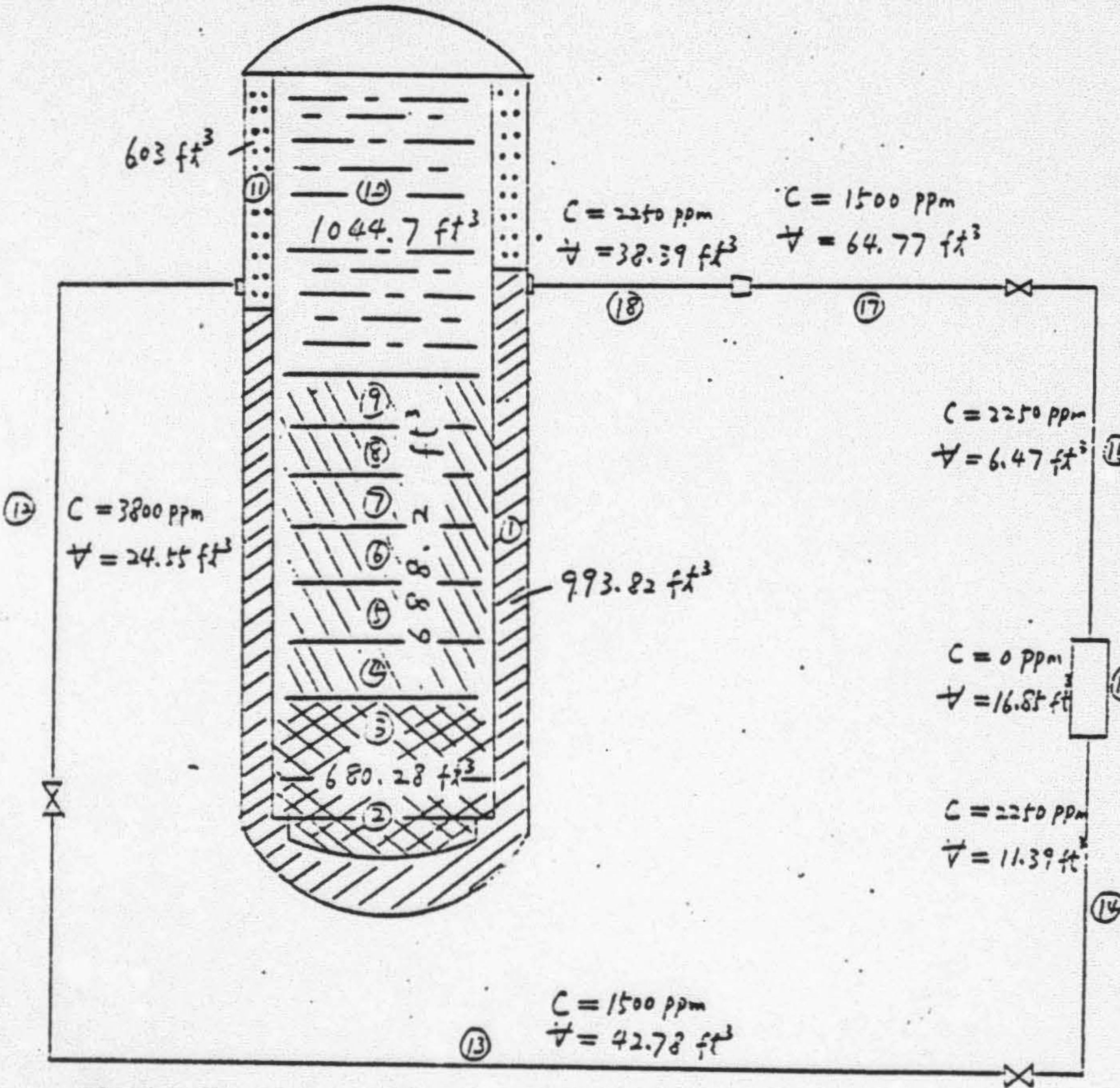

Figure 2 - Volume Elements of TMI-2 MDHRS.

2. Once the MDHRS is in operation, coolant flow will be in steady state, and heat extracted from the MDHRS heat exchanger is equal to the heat produced in the core. Consequently, the coolant temparature and density are uniform within the element during the transient operation of the MDHRS.

The first law of thermodynamics was applied to each element. Consequently, the increase in enthalpy or temperature can be evaluated as a result of heat addition to each element. The energy balance in each element is expressed as follows:

$$\dot{q} = \dot{m}\,(h_{i,\ i+1} - h_{i-1,\ i}) \qquad (1)$$

Where: $\dot{q}$ = heat addition to each element, Btu/Sec.

$\dot{m}$ = mass flow rate of reactor coolant, lbm/Sec.

$h_{i-1,i}$ = Coolant enthalpy at the lower boundary of i^{th} element

$h_{i,\ i-1}$ = Coolant enthalpy at the upper boundary of i^{th} element.

The coolant density for each element was determined from steam tables considering the coolant pressure and temperature. These are consequently used in the mass balance of boron for each element.

B. Boron Concentration:

This evaluation is based on the assumption that mass concentration of boron is uniform in each volume element. Forced convection due to pump action and natural convection due to heat generation in the reactor vessel core can provide a good mixing of boron for each element, which consequently make this a realistic assumption.

The transient variation of boron concentration in each element depends on mass flow rate, difference of boron concentration between inlet and outlet of each element, and total mass in each element

Conservation of boron at each element can be expressed by the folllowing differential equation:

$$\frac{dC_i}{dt} = \frac{\dot{m}}{\rho_i V_i}\,(C_{i-1} - C_i) \qquad (2)$$

With the initial condition, $C_i = C_i^{\,o}$

Where: C_i = time dependent boron concentration in element i, lbm boron/lbm coolant

C_{i-1} = time dependent boron concentration in element i-1, lbm boron/lbm coolant.

t = time, sec.

$\dot{m}$ = Mass flow rate of coolant, lbm/sec.

ρ_i = Coolant density in element i

V_i = Coolant volume in element i

C_i^o = Initial boron concentration

When steady state is reached, the unsteady term, $\frac{dC_i}{dt}$, becomes zero and consequently $C_{i-1} = C_i$. This implies that during steady state, boron concentrations for the whole MDHRS converge to a single value which is independent of mass flow rate.

Application of equation(2) to each volume element results in the following set of ordinary differential equations with the consequent initial conditions:

	Initial Conditions	
$\dot{C}_1 = D_1\ (C_{18}-C_1)$	$t = 0,\ C_1 = 3800$ ppm	
$\dot{C}_2 = D_2\ (C_1 - C_2)$	$t = 0,\ C_2 = 3800$ ppm	
$\dot{C}_3 = D_3\ (C_2 - C_3)$	$t = 0,\ C_3 = 3800$ ppm	
$\dot{C}_4 = D_4\ (C_3 - C_4)$	$t = 0,\ C_4 = 3800$ ppm	
$\dot{C}_5 = D_5\ (C_4 - C_5)$	$t = 0,\ C_5 = 3800$ ppm	(3)
$\dot{C}_6 = D_6\ (C_5 - C_6)$	$t = 0,\ C_6 = 3800$ ppm	
$\dot{C}_7 = D_7\ (C_6 - C_7)$	$t = 0,\ C_7 = 3800$ ppm	
$\dot{C}_8 = D_8\ (C_7 - C_8)$	$t = 0,\ C_8 = 3800$ ppm	
$\dot{C}_9 = D_9\ (C_8 - C_9)$	$t = 0,\ C_9 = 3800$ ppm	
$\dot{C}_{10} = D_{10}\ (C_9 - C_{10})$	$t = 0,\ C_{10} = 3800$ ppm	
$\dot{C}_{11} = D_{11}\ (C_{10} - C_{11})$	$t = 0,\ C_{11} = 3800$ ppm	
$\dot{C}_{12} = D_{12}\ (C_{11} - C_{12})$	$t = 0,\ C_{12} = 3800$ ppm	
$\dot{C}_{13} = D_{13}\ (C_{12} - C_{13})$	$t = 0,\ C_{13} = 1500$ ppm	
$\dot{C}_{14} = D_{14}\ (C_{13} - C_{14})$	$t = 0,\ C_{14} = 2250$ ppm	
$\dot{C}_{15} = D_{15}\ (C_{14} - C_{15})$	$t = 0,\ C_{15} = 0$	
$\dot{C}_{16} = D_{16}\ (C_{15} - C_{16})$	$t = 0,\ C_{16} = 2250$ ppm	
$\dot{C}_{17} = D_{17}\ (C_{16} - C_{17})$	$t = 0,\ C_{17} = 1500$ ppm	
$\dot{C}_{18} = D_{18}\ (C_{17} - C_{18})$	$t = 0,\ C_{18} = 2250$ ppm	

Where:

$$C_i = \frac{dC_i}{dt} \qquad (4)$$

$$D_i = \frac{\dot{m}}{\rho_i V_i}$$

Values of D and ρ were calculated for each element at different flow rates. Resulting system of simultaneous differential equations were solved numerically using the computer code depicted in the Appendix I. Sample output is also shown. Flow rates of 10, 20, 50 and 120 gpm in the MDHRS were considered.

IV. RESULTS

A. Hot Leg Temperature

The consequent hot leg temperature for each flow rate are depicted in the table below. These results are based on a coolant temperature of 100°F in the cold leg.

Coolant Mass Flow Rate, GPM	Hot Leg Temperature, °F
10	210.5
20	155.4
50	122.2
120	109.2

B. Boron Concentration

Transient and steady state values of boron concentration for volume elements 2, 3, 4 and 9 inside the reactor vessel are shown in Figure 3, 4, 5 and 6 for volume flow rates of 10, 20, 50, and 120 gpm respectively. Key results are summarized below:

1. The minimum boron concentration in the reactor vessel is approximately 3575 ppm for all flow rates between 10 and 120 gpm. Obviously, the technical specification requirement of 3000 ppm has been satisfied.

2. The steady state value of boron concentration is 3705 ppm in MDHRS for all flow rates.

3. The time needed to achieve steady state, i.e., uniform boron concentration in the entire MDHRS, are tabulated below.

Flow Rate GPM	Time to Achieve Steady State, Hrs.
10	94
20	44
50	18
120	8

V. CONCLUSIONS:

This investigation has come up with the following conclusions:

1. The hot leg temperature decreases with the increasing flow rate for a fixed cold leg temperature.

2. The minimum boron concentration in the reactor vessel during transient and steady state operation of the MDHRS is independent of flow rate, and is always greater than 3000 ppm which is the technical specification requirement. This value is insensitive to the number of volume elements that were utilized to model the reactor vessel core.

3. The steady state boron concentration in the MDHRS is independent of the flow rate.

4. Time required to achieve steady state in the MDHRS varies inversely with the system flow rate.

VI. RECOMMENDATION:

It is recommended that a moderate flow rate of 50 gpm be utilized during start up of the MDHRS to afford reasonable and sufficient time to assess any unusual trends that may occur in the reactor vessel during the transient phase of the operation.

VII. REFERENCES

(1) Calculations for Initial Value of Boron Conentration in the Mini Decay Heat Removal System dated March 13, 1980, R. Skillman to A. P. Rochino.

(2) Three Mile Island Nuclear Station Unit #2, System Description TS-27 by Burns and Roe, Inc., W. O. 3475-35, November 16, 1979.

(3) Docket No. 50-320, Metropolitan Edison Company, Jersey Central Power and Light Company, Pennsylvania Electric Company - Final Safety Analysis Report, Three Mile Island - Unit 2, Volume 5.

(4) B&W Drawing No. 136438E, 103098D, and 136428E.

(5) GPUSC Calculations No. 3792F - 322C - B01, "Boron Concentration Analysis in TMI-2 Mini Decay Heat Removal System" by J. P. Sheu, March 27, 1980.

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SUBJECT: Boron Concentration Analysis in TMI-2 MDHRS

CALC. NO. 3790F-322C-B..
SHEET NO. 4 OF 62
DATE 3/27/80
COMP. BY/DATE J.P. Shen
CHK'D. BY/DATE K.I.L. Yanai

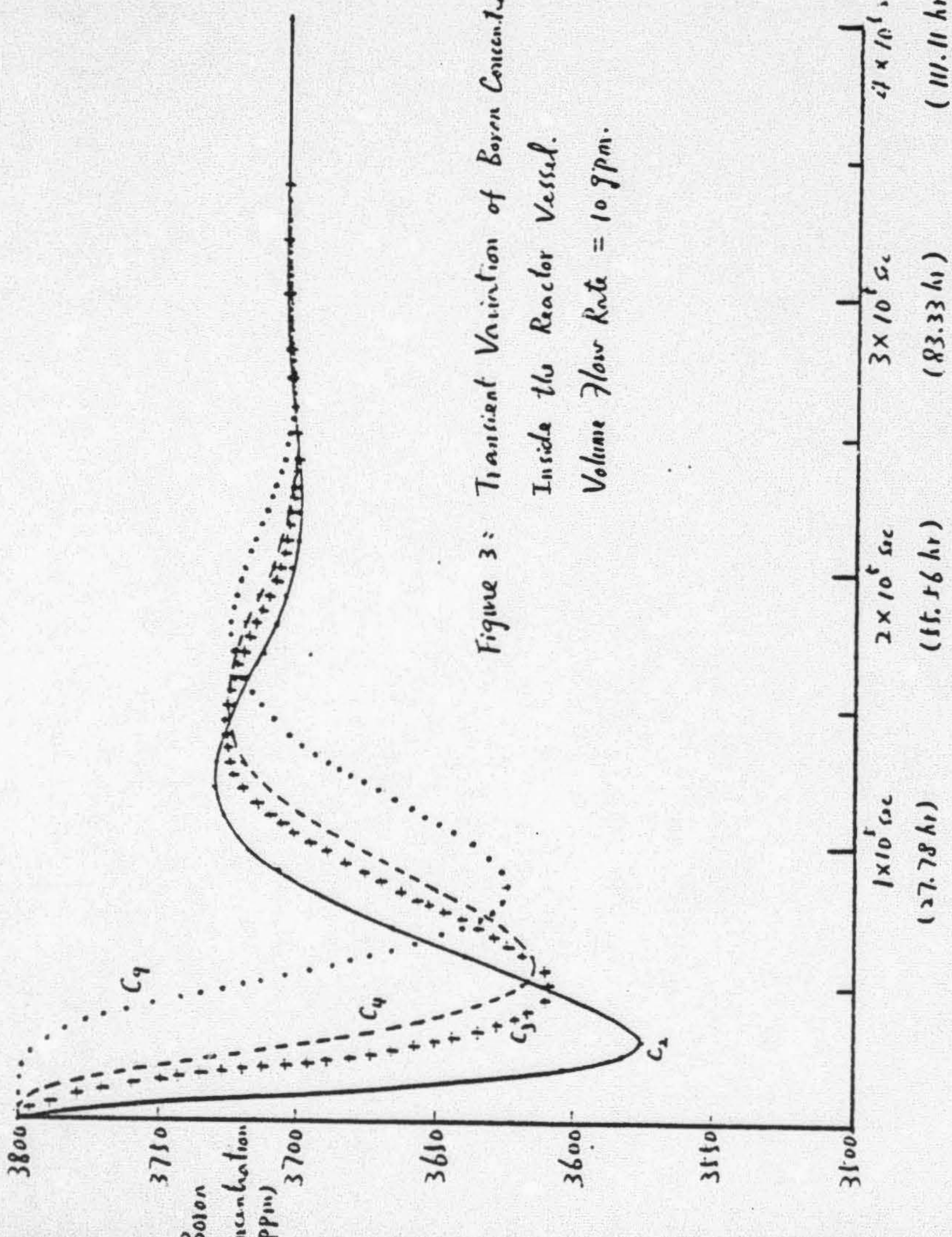

Figure 3: Transient Variation of Boron Concentration Inside the Reactor Vessel. Volume Flow Rate = 10 gpm.

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SUBJECT Boron Concentration Analysis in TMI-2 MIDHRS

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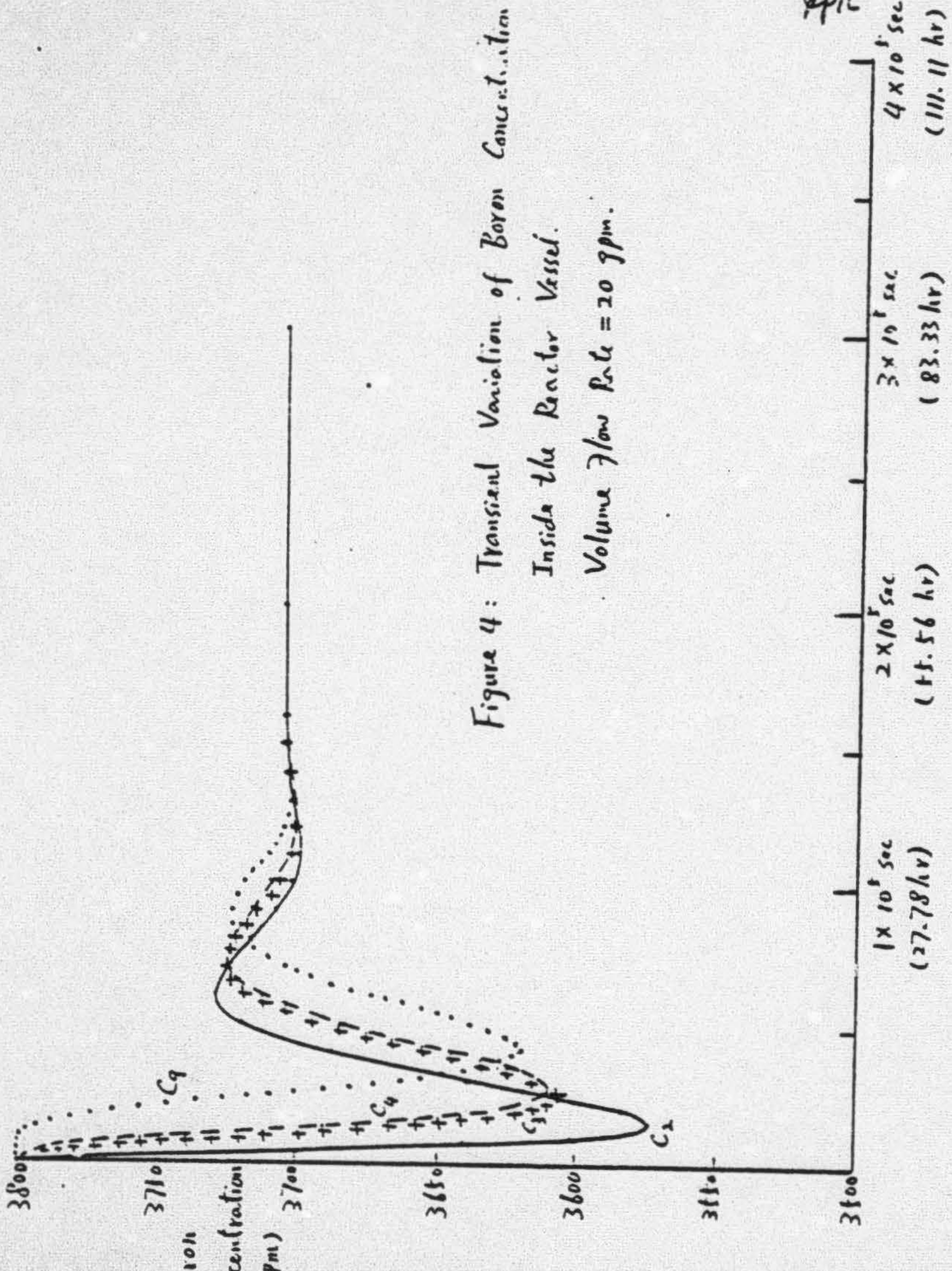

Figure 4: Transient Variation of Boron Concentration Inside the Reactor Vessel.
Volume Flow Rate = 20 gpm.

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SUBJECT Boron Concentration Analysis in TMI-2 MDHRS

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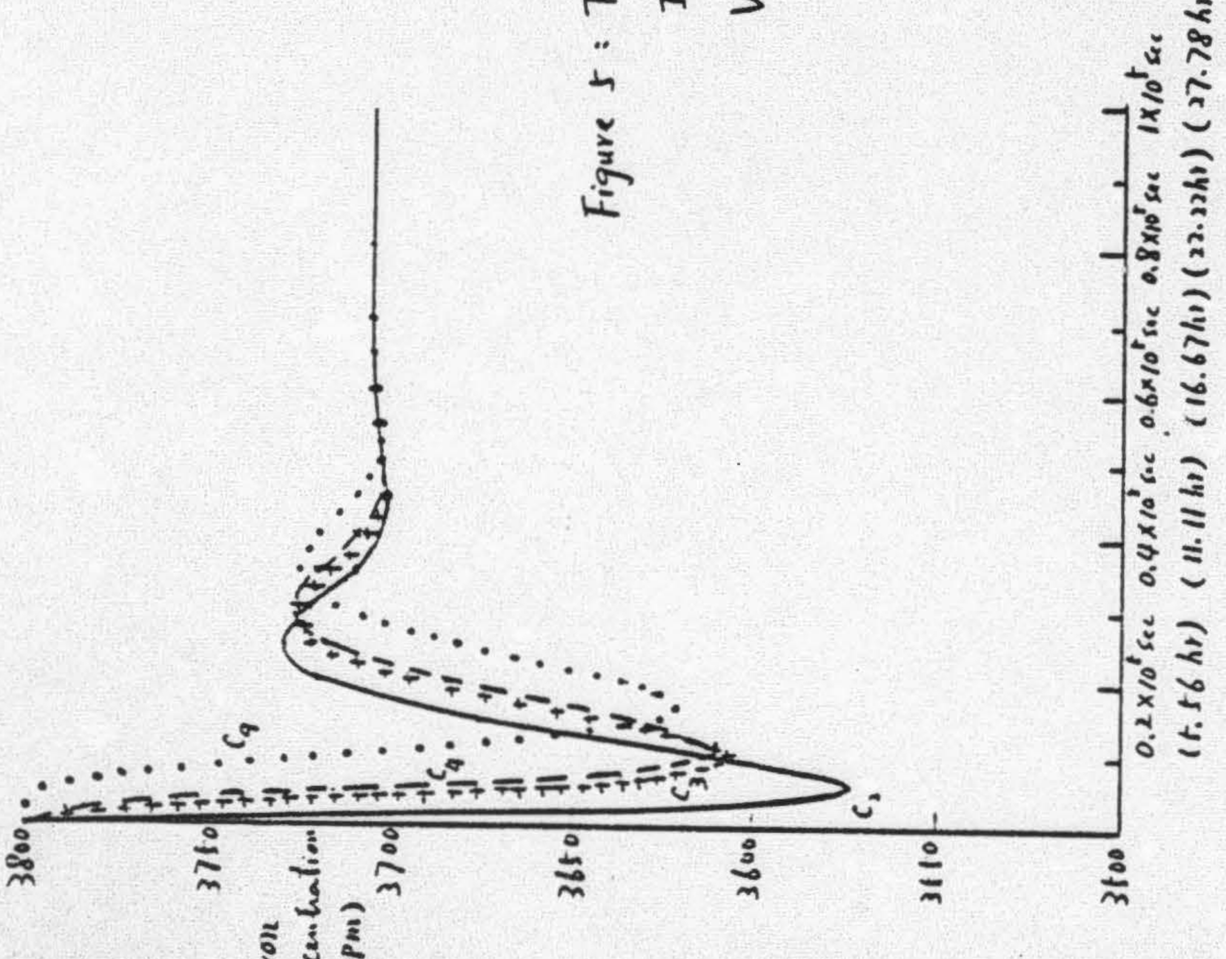
Figure 5 : Transient Variation of Boron Concentration Inside the Reactor Vessel.

Volume Flow Rate = 50 gpm.



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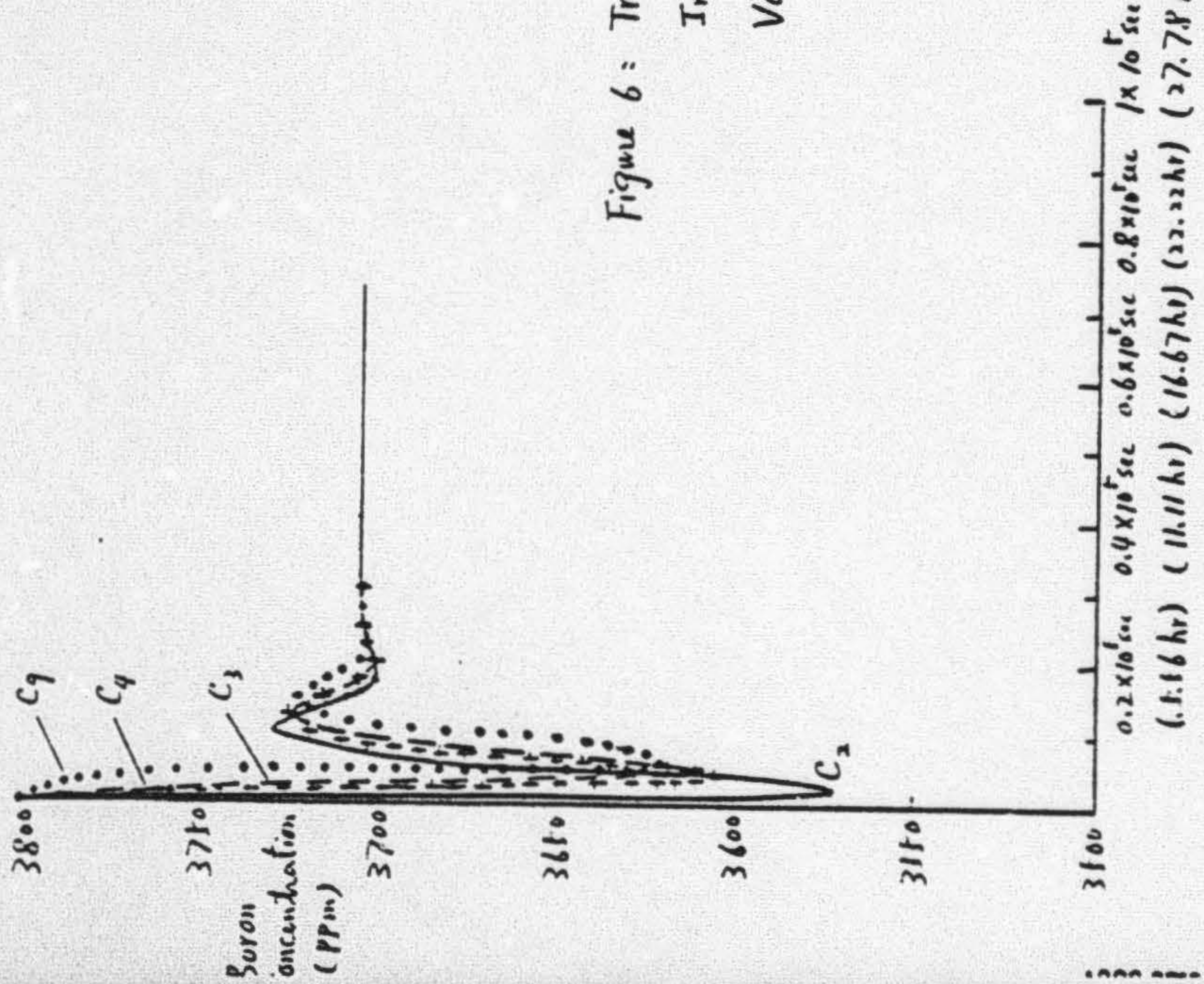
CHK'D. BY/DATE

Figure 6: Transient Variation of Boron Concentration Inside the Reactor Vessel. Volume Flow Rate = 120 gpm.



Subject: Boron Concentration Analysis in TMI-2 MDHRS

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Calc. No. 379DF-33:C-3
Sheet No. 391 of 1U:
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7. Appendix-A.

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$$$CONTINUOUS SYSTEM MODELING PROGRAM  III   V1M3   TRANSLATOR OUTPUT$$$
 * VOLUME FLOW RATE=10.GPM IN THE COLD LEG WITH TEMP OF 100 F
 * MASS FLOW RATE=CONSTANT IN THE 18 ELEMENTS OF WHOLE SYSTEM
      CONSTANT Z1=0.0038,Z2=0.0038,Z3=0.0038,Z4=0.0038,Z5=0.0038,...
      Z6=0.0038,Z7=0.0038,Z8=0.0038,Z9=0.0038,Z10=0.0038,Z11=0.0038,...
      Z12=0.0038,Z13=0.0015,Z14=0.00225,Z15=0.0,Z16=0.00225,...
      Z17=0.0015,Z18=0.00225,...
      D1=2.2421565E-5,D2=6.551126E-5,D3=6.551126E-5,D4=1.4091543E-4,...
      D5=1.5550073E-4,D6=1.9658449E-4,D7=1.9771664E-4,...
      D8=1.9900967E-4,D9=2.004627E-4,D10=2.2089921E-5,...
      D11=3.6270081E-5,D12=9.4001309E-4,D13=5.3944228E-4,...
      D14=2.0261054E-3,D15=1.3421098E-3,D16=3.4440494E-3,...
      D17=3.4403273E-4,D18=5.8043761E-4
      DC1=D1*(C18-C1)
      DC2=D2*(C1-C2)
      DC3=D3*(C2-C3)
      DC4=D4*(C3-C4)
      DC5=D5*(C4-C5)
      DC6=D6*(C5-C6)
      DC7=D7*(C6-C7)
      DC8=D8*(C7-C8)
      DC9=D9*(C8-C9)
      DC10=D10*(C9-C10)
      DC11=D11*(C10-C11)
      DC12=D12*(C11-C12)
      DC13=D13*(C12-C13)
      DC14=D14*(C13-C14)
      DC15=D15*(C14-C15)
      DC16=D16*(C15-C16)
      DC17=D17*(C16-C17)
      DC18=D18*(C17-C18)
      C1=INTGRL(Z1,DC1)
      C2=INTGRL(Z2,DC2)
      C3=INTGRL(Z3,DC3)
      C4=INTGRL(Z4,DC4)
      C5=INTGRL(Z5,DC5)
      C6=INTGRL(Z6,DC6)
      C7=INTGRL(Z7,DC7)
      C8=INTGRL(Z8,DC8)
      C9=INTGRL(Z9,DC9)
      C10=INTGRL(Z10,DC10)
      C11=INTGRL(Z11,DC11)
      C12=INTGRL(Z12,DC12)
      C13=INTGRL(Z13,DC13)
      C14=INTGRL(Z14,DC14)
      C15=INTGRL(Z15,DC15)
      C16=INTGRL(Z16,DC16)
      C17=INTGRL(Z17,DC17)
      C18=INTGRL(Z18,DC18)
      PRINT C1,C2,C3,C4,C5,C6,C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,...
      C17,C18
 TITLE SOLVE FOR EIGHTEEN 1ST ORDER SIMUL DIFF EQS IN MDHR BORON SYS
      TIMER FINTIM=500000.,PRDEL=100.
 END
 STOP
```

Subject: Boron Concentration Analysis for TMI-2 MDHRS

Appendix-B

Calc. No 3720F-[illegible]
Sheet No 40 of [illegible]
Date 3/27/80
Comp. By/Date J.R. Shu
Chk'd By/Date [illegible]

SOLVE FOR EIGHTEEN 1ST ORDER SIMUL DIFF EQS IN MORM BORON SYS

TIME	.0	100.00	200.00	300.00	400.00	500.00	600.00	700.00	800.00
C1	3.8000E-03	3.7965E-03	3.7929E-03	3.7892E-03	3.7854E-03	3.7816E-03	3.7777E-03	3.7738E-03	3.7697E-03
C2	3.8000E-03	3.8000E-03	3.8000E-03	3.7999E-03	3.7998E-03	3.7997E-03	3.7996E-03	3.7994E-03	3.7992E-03
C3	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03
C4	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03
C5	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03
C6	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03
C7	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03
C8	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03
C9	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03
C10	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03
C11	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03
C12	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03
C13	1.5000E-03	1.6200E-03	1.7352E-03	1.8437E-03	1.9464E-03	2.0437E-03	2.1360E-03	2.2234E-03	2.3061E-03
C14	2.2500E-03	2.1240E-03	2.0426E-03	1.9966E-03	1.9704E-03	1.9818E-03	2.0020E-03	2.0349E-03	2.0714E-03
C15	.0	2.7348E-04	5.0069E-04	6.9107E-04	8.5361E-04	9.9490E-04	1.1200E-03	1.2320E-03	1.3362E-03
C16	2.2500E-03	1.6379E-03	1.2765E-03	1.0605E-03	9.9261E-04	9.7437E-04	9.9996E-04	1.0526E-03	1.1212E-03
C17	1.5000E-03	1.5141E-03	1.5116E-03	1.4999E-03	1.4840E-03	1.4669E-03	1.4506E-03	1.4362E-03	1.4243E-03
C18	2.2500E-03	2.2082E-03	2.1691E-03	2.1317E-03	2.0956E-03	2.0606E-03	2.0267E-03	1.9938E-03	1.9620E-03

TIME	900.00	1000.0	1100.0	1200.0	1300.0	1400.0	1500.0	1600.0	1700.0
C1	3.7657E-03	3.7615E-03	3.7573E-03	3.7531E-03	3.7488E-03	3.7444E-03	3.7401E-03	3.7356E-03	3.7312E-03
C2	3.7990E-03	3.7988E-03	3.7985E-03	3.7983E-03	3.7980E-03	3.7976E-03	3.7973E-03	3.7969E-03	3.7965E-03
C3	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.7999E-03	3.7999E-03	3.7999E-03	3.7999E-03	3.7999E-03
C4	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03
C5	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03
C6	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03
C7	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03
C8	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03
C9	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03
C10	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03
C11	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03
C12	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03	3.8000E-03
C13	2.3846E-03	2.4569E-03	2.5294E-03	2.5961E-03	2.6573E-03	2.7192E-03	2.7760E-03	2.8297E-03	2.8807E-03
C14	2.1269E-03	2.1812E-03	2.2389E-03	2.2986E-03	2.3592E-03	2.4199E-03	2.4803E-03	2.5396E-03	2.5977E-03
C15	1.4324E-03	1.5230E-03	1.6094E-03	1.6923E-03	1.7723E-03	1.8499E-03	1.9254E-03	1.9989E-03	2.0705E-03
C16	1.1980E-03	1.2809E-03	1.3649E-03	1.4489E-03	1.5322E-03	1.6142E-03	1.6945E-03	1.7732E-03	1.8500E-03
C17	1.4154E-03	1.4095E-03	1.4065E-03	1.4066E-03	1.4094E-03	1.4150E-03	1.4231E-03	1.4336E-03	1.4464E-03
C18	1.9314E-03	1.9021E-03	1.8742E-03	1.8478E-03	1.8230E-03	1.7990E-03	1.7784E-03	1.7586E-03	1.7406E-03