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- EM
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July 27, 1983

Docket No. 50-289

MEMORANDUM FOR: H. Denton, J. Carter, D. Eisenhut, R. Purple, T. Novak, G. Lainas, F. Miraglia, T. Speis, R. Vollmer, R. Mattson, H. Thompson, J. Sniezek, T. Ippolito, E. Case, S. Varga, D. Vassallo, R. Clark, D. Crutchfield, C. Heltemes

THRU: John F. Stolz, Chief, Operating Reactors Branch #4, Division of Licensing

FROM: James Van Vliet, Project Manager
Operating Reactors Branch #4, Division of Licensing

SUBJECT: DAILY HIGHLIGHT

TMI-1 Steam Generator Repair Program

GPU Nuclear has recently completed an analysis predicting that steam generator tube thermally induced tensile loads tend to be smaller than previous analyses have indicated. In addition, GPU Nuclear has also observed a loss of initial tensile prestress in a few hundred tubes during the course of the kinetic expansion in adjacent tubes as a result of separation in the defective area of these tubes within the upper part of the tubesheet. These tubes were subsequently kinetically sealed to the tubesheet below the defective area to restore tube integrity.

GPU Nuclear is evaluating the effects of reduced tube tension and loss of prestress on through-wall crack leakage monitoring sensitivity. GPU Nuclear presently expects to submit its evaluation and findings the week of August 8, 1983. This new information will need to be evaluated as part of the staff's Safety Evaluation and will likely delay its issuance by about three weeks.

James Van Vliet, Project Manager
Operating Reactors Branch #4, DL

cc:
JStolz
JVan Vliet
ORB#4 File

SAPC # 152

Inter-Office Memorandum

Date August 3, 1983

GPU Nuclear

Subject Technical Review of Calc. 1101X-5450-014

To N. G. Trikouros, Location
Manager - Safety Analysis & Plant Control

A technical review has been performed on the subject calculation. The governing equations are given in the calculation and also in a prior calculation 1101X-5450-010. The equations were digitally simulated using CSMP and are given in data sets N1564.ADV4.DATA and N1564.ADV.DATA.

A review of the equations and assumptions given in the subject calculation indicates that they are reasonable. The prior calculation, 1101X-5450-010, has already been reviewed (see Ref 1).

Following are pertinent comments for the two computer programs.

A. N1564.ADV4.DATA

1. A review of this program indicates that the equations are coded as written in the calculations, except as noted in A.4 below. A random check was made on the value of constants, and none were found incorrect.

2. The MACRO HEM is essentially developed from the prior calculation.

3. This program uses a fixed time step. To check if this time step is sufficiently small, the reviewer halved the step size. The resulting integrated mass flow rate through the ADV was within 1% at the end of the run (10,000 sec); TAVG was within 3%; the reactor system pressure was within 4%; and the pressures of the secondary side were within 13%.

4. The algorithm for controlling the ADV (page 7 of subject calculation) is, in practice, impractical since it may occur too often for an operator to handle. Further, the code logic states the switching algorithm is not to be performed if TAVE is greater than 550°F; this is not stated in the calculations.

   Changing the time step in A.3 above changed the switching times, and was the primary cause for the different results. Nonetheless, the algorithm appears to be adequate for this study in determining the cooldown rate and integrated mass flow rate.

[1] Schuler, E. J., Letter to N.G.T., Subject: 'QA of Calculation

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B. N1564.ADV.DATA

1. A review indicates that the equations are coded as written in the calculation. All constants were checked; small variances were found, and they were less than 4%.

2. The fixed time step was replaced by a variable time step for a check. A comparison of results indicate that they are almost identical.

C. Functions and Subroutines Appended to Above Two Programs.

Both programs use FORTRAN functions and subroutines; these are appended to the main program. Most of them are used to calculate water and steam properties.

These functions and subroutines have not been reviewed by the undersigned.

E. J. Schuler,
Engineer - SAPC

EJS/ar

cc: T. G. Broughton, Director - Systems Engineering
L. C. Pwu, Engineer - SAPC

Problem Statement:

During a steam generator tube rupture (SGTR) event, ~~with loss of offsite power (LOOP)~~, concern is the method of cooldown and the associated dose release. Procedure guideline requires isolation ~~of the affected~~ OTSG's and control the cooldown rate by the Atmospheric Dump Valves (ADV) and/or Turbine bypass valves (TBV).
A calculation is presented below on the rate of cooldown and integrated steam ~~loss~~ relief to the atmosphere by using one ADV valve.

Method.

A Four-node, 2 loop CSMP model is presented in Figure 1, The steam generator secondary in either side is modeled as a saturated two-phase volume which is

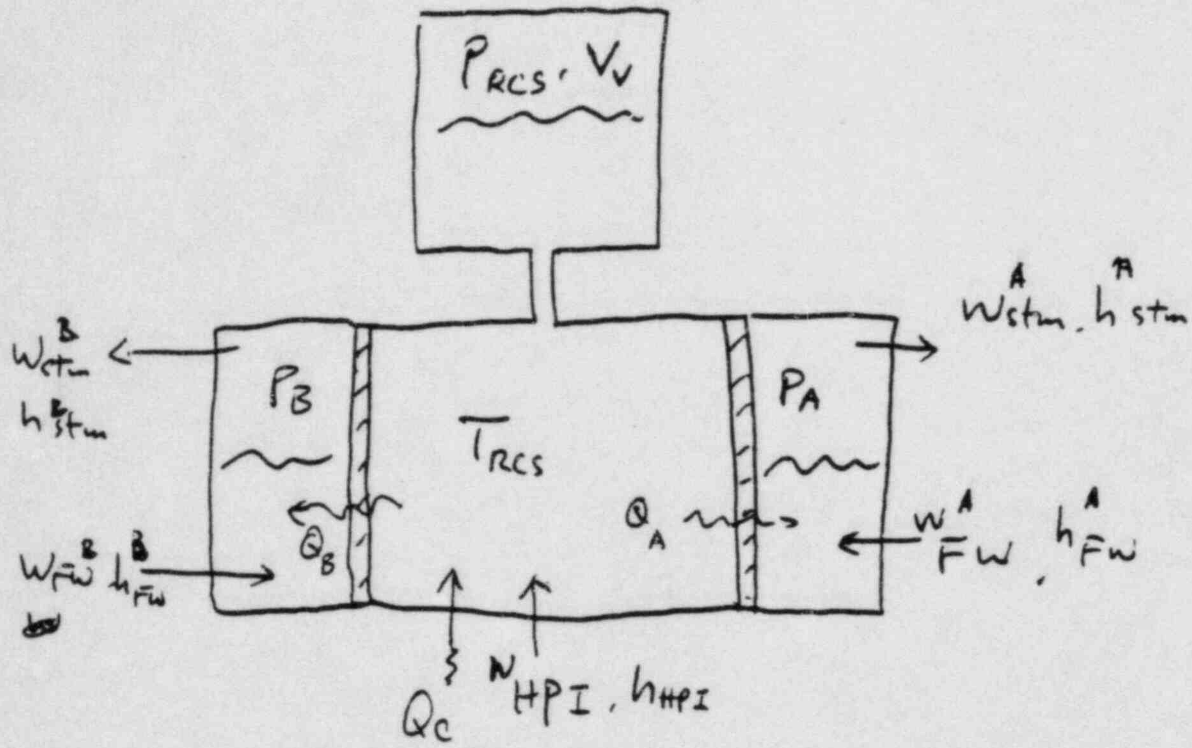

Figure 1 Two-Loop Four Node CSMP model

GPU Nuclear

SUBJECT ....

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similar to the pressurizer model of a calc# 110/X-5430-01

Since it is repeatedly used in both ~~sets~~ of the OTSG's, a MACRO in CSMP language is set up in the following ~~format~~ :

DXDT, DPDT, LSG, ALFA = HEM (X, P, WFW, HFW, WST, HST, QT, V)

where

$DXDT = \frac{dx}{dt}$ = rate of quality change in OTSG

$DPDT = \frac{dP}{dt}$ = " pressure " "

LSG = steam generator level

ALFA = α = void fraction in the OTSG

x = steam quality

P = pressure

WFW = w_{FW} = Feedwater flowrate

HFW = h_{FW} = enthalpy of feedwater

WST = steam flowrate

HST = h_{st} = ~~hg~~ steam ~~flow rate~~ enthalpy
(hg, i.e., specific enthalpy of saturated steam was used)

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Q_T = heat removal by the OTSG

$= UA\Delta T$

$= UA\cdot(T_{RCS} - T_{SG})$

V = total volume of one OTSG

$= 3307\ ft^3$.

At a given time the system's ~~condition~~ status, x and P plus boundary conditions W_{FW}, h_{FW}, W_{ST}, h_{ST} and Q_T are given to calculate the rate of change $\dot{x}$ and $\dot{P}$. then CSMP is used to solve x and P at the next time step.

Also, α, L_{SG} and x are interrelated by

$$M_T = \frac{V}{x\cdot v_g + (1-x)\,v_f} = \text{Total mass in OTSG}$$

$$M_F = M_T\cdot(1-x) = \text{fluid mass in OTSG}$$

$$\alpha = \frac{x\,v_g}{x v_g + (1-x) v_f}$$

$$L_{SG} = \frac{M_f\cdot v_f}{\text{S.G cross section area}}\cdot 12 - 6$$ (in inches there is a 6" section has no heat transf)

where S.G x-s Area = 88.9 ft^2 (each)

On the primary side, the steam bubble and the liquid phase are treated separately.

Since in the depressurization process the steam bubble behaves very much ~~as an~~ adiabatically, the adiabatic expansion law is used, i.e.

$$P_{RCS} V_v^{1.3} = \text{constant}$$

The liquid phase then expand or contract by the net heat input.

$$M_R C_p \frac{dT_{RCS}}{dt} = Q_c + Q_{RCP} - Q_T^A - Q_T^B$$

where

M_R = total liquid mass in RCS $= M_R(0) + \int_0^t w$

C_p = heat capacity of water

T_{RCS} = RCS temp.

Q_C = core heat (ANS Table is used)

Q_{RCP} = RC pump heat input

then

$$V_v = V_T - M_R \cdot V_L(T_{RCS}, P)$$

where V_T = total RCS volume (incl. PRZR)

= 11500 ft^3 (constant).

If there is RCP heat input. T_H and T_C is given ~~on~~ in the following manner.

$$T_H = T_{RCS} + Q_T/2W_{RC}C_p$$

$$T_C = T_{RCS} - Q_T/2W_{RC}C_p$$

If the RCP are tripped, the RCS will be stagnated (no N.C. assumed) then an infinite W_{RC} should be input by the user (rather than zero) to result in $T_{RC} = T_H = T_C$.

Several Lag functions have to be introduced in the CSMP program to avoid ~~[illegible]~~ infinite loops in the iteration. The results will be off by the lag time (3 second was chosen), but does not affect the general correctness.

HPI is assumed to be initiated at 1615 psia RCS pressure and throttled back at Subcooling margin exceeding 120°F. (overcooling criteria SCM = 100°F)

GPU Nuclear

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COMP. BY/DATE ZCP
CHK'D. BY/DATE 3 AUG-83

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ADV Discharge rate was chosen to be 93 lb/sec (~5%) at set opening pressure (1050 psia) and decrease according to the square root of the OTSG pressure.

Controlling the ADV is an operator action and here is assumed that ~~at~~ any time the cooldown rate ~~should be less~~ becomes greater than 50°F/hr the operator shall throttle the ADV area to 1/2.

Calculation

the run attached using the following initial and boundary condition.

Power = 2568 MWt.

Tavg = 579°F

No RCP.

LSG (t) = 120". following trip OTSG A controlled at 200" using EFW. maximum flow rate ~~133 gpm~~ = 133 lb/sec (950 gpm).

B is controlled at 30", TBV set at 1025 psia. TBV flow = 280 lb/sec

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Program ADV.4.DATA is attached.

For long term cooling, a single volume CSMP program is sufficient ($t > 10{,}000$ sec) since the ADV is full open (not throttled)

program AN.DATA shall restart ADV4.DATA at 10,000 sec. the OTSG pressure is 1346 psia. the integrated steam loss to atmosphere is 4.412×10^5 lbm. Primary to secondary ΔT is approximately zero. the secondary ADV discharge rate is proportional to the square root of OTSG pressure. i.e.

$$M C_p \frac{dT}{dt} = Q_c(t) - W_{st} \cdot (h_g(P) - h_{EFW})$$

where M = RCS mass

T = RCS temp $\simeq$ OTSG Temp.

$P = T_{sat}$.

The result is T cooled to 275°F in another 10,000 second.

The results of the CSMP runs ADV4.DATA and restart ADV.DATA for cooldown and ADV discharge are

Time (hr)	Tavg (°F)	Integrated Steam Discharge (lbm)
0	579	0
1	444	2.2×10^5
2	367	3.6×10^5
3	331	4.5×10^5
6	285	6.3×10^5
16	225	1.3×10^6

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TITLE PROGRAM TO STUDY TMI-1 COOLDOWN USING ONE ADV       ...
ADV4.DATA    CREATED FROM ADV2.A.DATA ON 6-3-83
* THROTTLED ADV TO COOLDOWN RATE OF 50 F/HR AT TEMP BELOW 550 F
* CLDN = COOLDOWN RATE (F/HR), ADV AREA WILL BE HALF IF EXEEDING THIS
* TAVG-TSG FOR OTSG HEAT TRANSFER DURING TRANSIENT(NO LOG MEAN)
* TWO LOOP MODEL
* STEAMING A OTSG, B OTSG CONTROLLED AT 1025 PSIA AND 30 IN LEVEL
* A OTSG ADV STUCK OPEN, FLOW = 93 LB/SEC AT 1050 PSIA, SQRT(PRESS) DEP
* ADIABATIC PRZR MODEL
* VERY LARGE RCS LOOP FLOW = 1.E8(LB/SEC) ASSUMED (ALL RCP'S OFF)
* TO EQUATE TH AND TC: PUMP HEAT = 0
* USE MACRO TO CALCULATE DYNAMIC VARIABLES
* S.G. CROSS SECTION AREA = 88.9  FT**2(PER OTSG)
* SIMPLE HOMOGENEOUS STEAM GENERATOR MODEL TO STUDY HEAT REMOVAL
* DECAY(TIME) = ANS DECAY HEAT TABLE
* ASME STEAM TABLE USED
*
MACRO DXDT,DPDT,LSG,ALFA= HEM(X,P,WFW,HFW,WST,HST,QT,V)
      VG=VGAS(P)
      VF=VFLD(P)
      HG=HVAP(P)
      HF=HLIQ(P)
      HGP=(HVAP(P+10.)-HVAP(P-10.))/20.
      VGP=(VGAS(P+10.)-VGAS(P-10.))/20.
      HFP=(HLIQ(P+10.)-HLIQ(P-10.))/20.
      VFP=(VFLD(P+10.)-VFLD(P-10.))/20.
      MT=V/(X*VG+(1.-X)*VF)
      MF=MT*(1-X)
      HM=X*HG+(1-X)*HF
      ALFA=X*VG/(X*VG+(1-X)*VF)
      LSG=MF*VF/88.9*12-6
      A=MT*(VG-VF)
      B=MT*(X*VGP+(1.0-X)*VFP)
      C=(WST-WFW)*(X*VG+(1-X)*VF)
      D=HG-HF
      F=(WFW*(HFW-HM)-WST*(HST-HM)+QT)/MT
      E=X*HGP+(1.-X)*HFP-.185*(X*VG+(1-X)*VF)
      DXDT=(C*E-B*F)/(A*E-B*D)
      DPDT=(A*F-C*D)/(A*E-B*D)
ENDMAC
CONSTANT VRCS=10800., A0=1.32E5, POWER=2568. , WRCS=1.E8,CLDN= 50
CONSTANT RCP=0., V =3307.,  HMFW=400.,HEFW=60., WMFW=1458.,WEFW=133.
      IVPRZ=900.
      VPRZ=IVPRZ
      P=930.
      CDPS=-CLDN/3600
      IP=P
      Q=(RCP+POWER)*3.413E6/3600.
     LSG=120.
      DTLM=ITAVG-ITSG
     DT=Q/1.34/WRCS
     ITAVG=579.
     U=Q/2/AREA/DTLM
     AREA=(LSG+6.)/12./52.*A0
     ITC=ITAVG-DT/2
     ITH=ITAVG+DT/2
     TSG=ITSG
     ITSG=535.85
      IPRCS=2160.
     VR=VL(ITAVG,IPRCS)
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      ALFA=1-MF*VF/V
      VG=VGAS(P)
      IX=ALFA/VG/(ALFA/VG+(1.-  ALFA)/VF)
      TAVG=ITAVG
     MP=IMR
     X1=IX
     X2=IX
     P1=P
     P2=P
*
 DYNAMIC
*
      QRCS=(POWER*DECAY(TIME)+RCP)*3.413E6/3600.
 PROCEDURE WHPI=HPI(PRCS)
      IF(PRCS.LT.1615.) GO TO 78
      WHPI=0.
      GO TO 79
   78 WHPI=PUMP(PRCS)*2
      IF(SCM.GT.120.) WHPI=0.
   79 CONTINUE
 ENDPRO
      HST=HVAP(P)
      QT1= U*AREA1*DT1
      QT2= U*AREA2*DT2
      CP=SPHT(TAVG,PRCS)
      THP=TAVG+QT/WRCS/CP/2.
      TC1P=TAVG-QT1/WRCS/CP
      TC2P=TAVG-QT2/WRCS/CP
      TH=REALPL(ITH,3.,THP)
      TC1=REALPL(ITC,3.,TC1P)
      TC2=REALPL(ITC,3.,TC2P)
     VP=VL(TAVG,PRCS)
      DT1=(TH+TC1)/2-TSG1
      DT2=(TH+TC2)/2-TSG2
      QT=QT1+QT2
      DTDT=(QRCS-QT)/MR/CP
      AREA1=(LSG1+6)/12*A0/52
      AREA2=(LSG2+6)/12*A0/52
      WST=93*SQRT(P1/1050)
 PROCEDURE WFW1,HFW1,WST1 =EFW1(LSG1,TAVG,DTDT)
      IF (TAVG.GT.550) GO TO 30
      IF (DTDT.LT.CDPS) GO TO 40
   30 WST1=WST
      GO TO 50
   40 WST1=WST/2.
   50 CONTINUE
      HFW1=HEFW
      IF (LSG1.GT.200.) GO TO 77
      WFW1=WEFW
      GO TO 76
   77 WFW1=0.
   76 CONTINUE
 ENDPRO
*
 PROCEDURE WFW2,HFW2,WST2 = EFW2(P2,LSG2)
      IF(P2.GT.1025) GO TO 15
      WST2=0.
      GO TO 16
   15 WST2=280.
   16 IF(LSG2.GT.30.) GO TO 17
      WFW=WEFW
      GO TO 18
   17 WFW=0.
   18 CONTINUE
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ENDPRO
      VPRZ=MR*VR-10000.
      PP=IPRCS*(700/(11500.-MR*VR))**1.3
     SCM=TSS-TH
* DUMMY VARIABLE TO AVOID VF BEING WIPED OUT BY TSS
      TSS1=TSS
      PRCS=REALPL(IPRCS,3.0,PP)
     DXDT1,DPDT1,LSG1,ALFA1=HEM(X1,P1,WFW1,HFW1,WST1,HST,QT1,V)
     DXDT2,DPDT2,LSG2,ALFA2=HEM(X2,P2,WFW2,HFW2,WST2,HST,QT2,V)
      MR = INTGPL(IMP,WHPI)
      ZX1= INTGRL(IX,DXDT1)
      ZX2= INTGRL(IX,DXDT2)
      ZP1= INTGRL(IP,DPDT1)
      ZP2= INTGRL(IP,DPDT2)
      TAVG=INTGRL(ITAVG,DTDT)
PROCEDURE X1,TSG1,TSS,X2,TSG2=LIMIT(ZX1,ZX2,PRCS)
     IF(ZX1.GE.1.0) ZX1=1.0
     IF(ZP1.LT.15) ZP1=15.
     IF(ZX2.LE.0.0.OR.ZX2.GE.1.) CALL FINISH
     IF(LSG2.GT.300.OR.LSG2.LT..05) CALL FINISH
     X1=ZX1
     X2=ZX2
     P1=ZP1
     P2=ZP2
     CALL TSAT(ZP1,TSGP1)
     CALL TSAT(ZP2,TSGP2)
      TSG1=TSGP1
      TSG2=TSGP2
      CALL TSAT(PRCS,TSS)
      MST=INTGRL(0.,WADV)
      WADV=WST1+WST2
ENDPRO
NOSORT
CALL DEBUG(2,0.)
* WRITE(21,99) TIME,TAVG,PRCS,LSG1,LSG2,WST1,MST,P1,P2
 99 FORMAT(1X,10F8.1)
TERMINAL
METHOD RECT
   TIMER FINTIM=10000,PRDEL=10, DELT=2., OUTDEL=20
  PRINT TAVG,PRCS,VPRZ,P1,P2,LSG1,WST1,WST2,MST
      PAGE XYPLOT
*     OUTPUT TIME , P2(0,1200),P1(0,1200)
*    OUTPUT TIME,WHPI
      OUTPUT TIME,MST
     OUTPUT TIME, PRCS
*    OUTPUT TIME,TH(200.,600.),TC2(200.,600.),TSG2(200.,600.)
*    OUTPUT TIME,TH(200.,600.),TC1(200.,600.),TSG1(200.,600.)
*     OUTPUT TIME,  VPRZ
*    OUTPUT TIME,LSG1(0,300),LSG2(0,300)
     OUTPUT TIME,WST1(0,200),WST2(0,200)
      END
      STOP
C FUNCTION OF HPI HEAD CURVE
      FUNCTION PUMP(P)
      DIMENSION PI(6),PM(6)
      DATA PI/15.,615.,1015.,1515.,2015.,2415./
      DATA PM/69.7,63.5,55.6,51.3,41.9,33.1/
      CALL INTP(PI,PM,6,P,FP)
      PUMP=FP
      RETURN
      END
C FUNCTION TO CALCULATE SUBCOOLED FLUID ENTHALPY
      FUNCTION HFLD(T,P)
      CALL ENTHAP(T,P,HL)
      HFLD=HL
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      END
      FUNCTION SPHT(T,P)
      CALL CSUBPF(T,P,CP)
      SPHT=CP
      RETURN
      END
      FUNCTION TBV(SIG)
      DIMENSION SI(12),WI(12)
      DATA SI/-10.,-8.,-4.,-2.,0.,2.,4.,6.,8.,8.4,8.8,10./
      DATA WI/1371.,1365.,1304.,1265.,1198.,1090.,994.,
     C 663.,208.,88.,54.5,34.5/
      CALL INTP(SI,WI,12,SIG,W)
      TBV=W
      RETURN
      END
C*    FUNCTION TO CALCULATE VAPOR ENTHALPY
      FUNCTION HVAP(P)
      CALL TSAT(P,T)
      CALL ENTHAV(T,P,HV)
      HVAP=HV
      RETURN
      END
C     FUNCTION TO CALCULATE LIQUID ENTHALPY
      FUNCTION HLIQ(P)
      CALL TSAT(P,T)
      CALL ENTHAF(T,P,HL)
      HLIQ=HL
      RETURN
      END
C     FUNCTION TO CALCULATE SUBCOOLED SPECIFIC VOLUME
      FUNCTION VL(T,P)
      CALL SPVOLF(T,P,V)
      VL=V
      RETURN
      END
C     FUNCTION TO CALCULATE LIQUID SPECIFIC VOLUME
      FUNCTION VFLD(P)
      CALL TSAT(P,T)
      CALL SPVOLF(T,P,VF)
      VFLD=VF
      RETURN
      END
      SUBROUTINE INTP(XI,YI,ID,X,Y)
      DIMENSION XI(ID),YI(ID)
      J=1
   10 IF(X.GE.XI(J).AND.X.LT.XI(J+1)) GO TO 5
      IF(J.EQ.ID-1) GO TO 15
      J=J+1
      GO TO 10
    5 Y=YI(J)+(YI(J+1)-YI(J))/(XI(J+1)-XI(J))*(X-XI(J))
      RETURN
   15 Y=YI(ID)+(YI(ID)-YI(ID-1))/(XI(ID)-XI(ID-1))*(X-XI(ID))
      RETURN
      END
      FUNCTION VGAS(P)
      CALL TSAT(P,T)
      CALL SPVOLV(T,P,VG)
      VGAS=VG
      RETURN
      END
      REAL FUNCTION MOODY(P,IRK)
      DIMENSION FLQ(13),FGS(13),PRS(13)
      DATA PRS/100.,200.,400.,600.,800.,1000.,1200.,1400.,1600.,
     C1800.,2000.,2200.,2400./
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      DATA POS/200.,400.,800.,1200.,1648.5,2074.,2513.,2965.,3434.,
     C3922.,4435.,4979.,5566./
      IF(IBK.EQ.2)GO TO 20
      CALL INTP(PRS,FLQ,13,P,YP)
      MOODY=YP
      RETURN
   20 CALL INTP(PRS,POS,13,P,YP)
      MOODY=YP
      RETURN
      END
      FUNCTION DECAY(T)
      DIMENSION TI(28),DI(28)
      DATA TI/0.,1.,2.,4.,6.,8.,10.,20.,40.,60.,80.,100.,
     C200.,400.,600.,800.,1000.,2000.,4000.,6000.,8000.,10000.,
     C2.E4,4.E4,6.E4,8.E4,1.E5,2.E5/
      DATA DI/.0675,.0625,.059,.0552,.0533,.0512,.05,
     C.045,.0396,.0365,.0346,.0331,.0275,.0235,.0211,.0196,.0185,.0157,
     C.0128,.0112,.0105,.00965,.00795,.00625,.00566,.00505,.00475,.004/
      CALL INTP(TI,DI,27,T,DY)
      DECAY=DY
      RETURN
      END
       SUBROUTINE PSAT (DEGF, PSIA)
C
C   CALCULATES SATURATION PRESSURE GIVEN TEMPERATURE
C   IN DEGREES F IN RANGE 32 TO 662 DEGREES.
C
C     REF.-   ASME STEAM TABLES - FOURTH EDITION
C             SECT. 5 (P. 17)
C
       REAL*8 DEGF, TREDU, PSIA, THETA, BETA, BETAK
C
C  CONVERT TEMPERATURE TO REDUCED TEMP
C
       THETA = TREDU (DEGF)
C
C  GET REDUCED SATURATION PRESS (BETA(K)= THE K FUNCTION)
C
       BETA = BETAK (THETA)
C
C CONVERT TO ABSOLUTE PRESSURE
C
       PSIA = (BETA*2.212D+7*0.0254D+0**2)/(9.80665D+0*0.45359237D+0)
C
C BOUNDRY CHECKS
C
       CALL BOUNDS ('PSAT    ',DEGF,PSIA,1)
C
       RETURN
       END
C
C
       SUBROUTINE TSAT (PIN, DEGF)
C
C  RETURNS SATURATION TEMPERATURE GIVEN  A PRESSURE
C  IN PSIA IN THE RANGE 0 TO 2398.22.
C
C  USES A SIMPLE BISECTION METHOD TO CONVERGE
C  ON ON TSAT BY CALLING BETA (K).
C
C
      REAL*8  PIN, DEGF, TA, TB, TMID, PRESS, EPSLON, PMIN, PMAX,
     *        BETA, BETAK, TREDU, PREDU
      INTEGER  ITER
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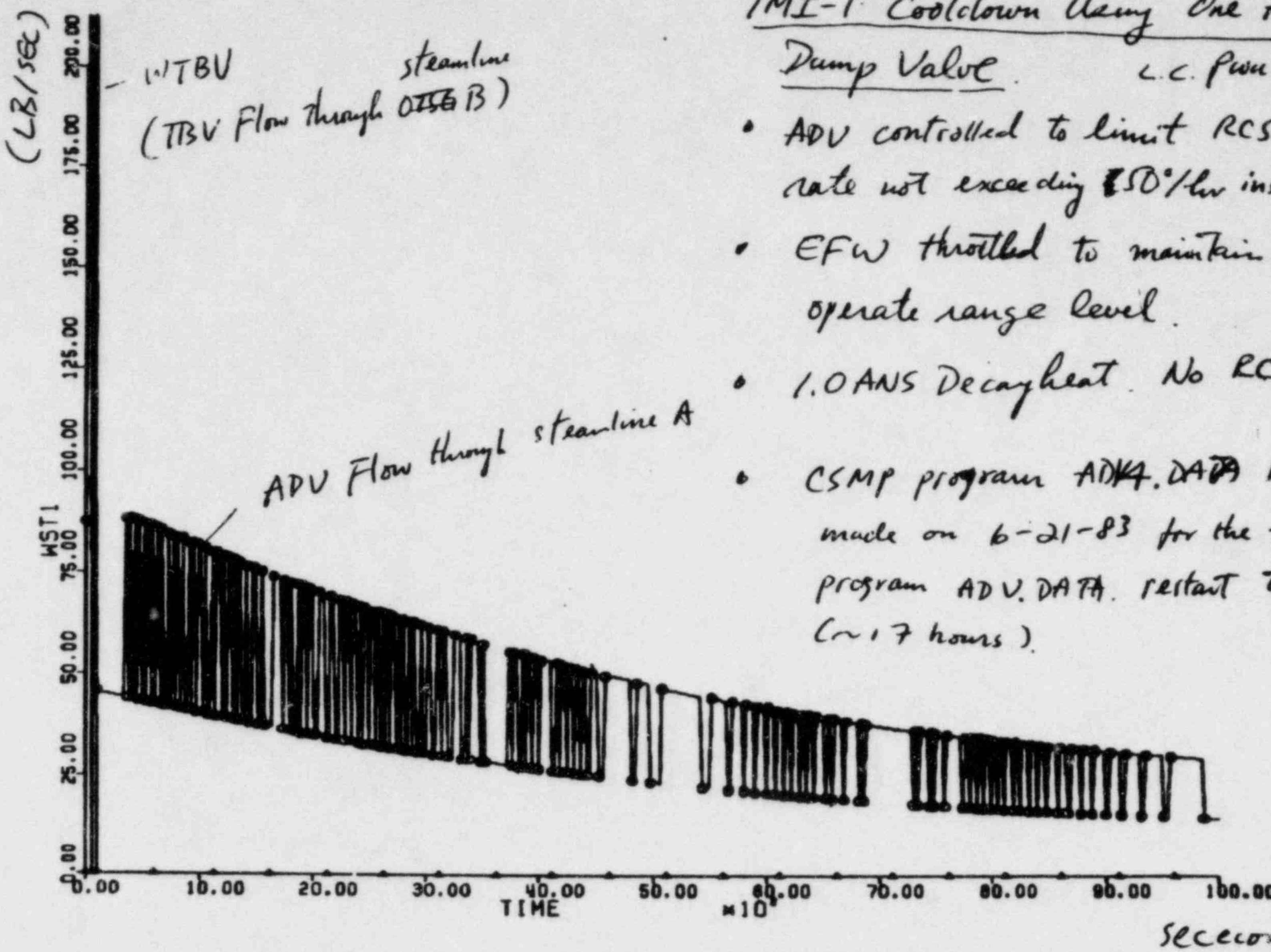
TITLE PROGRAM TO COOLDOWN RATE BY USING ADV AT TMI
ADV.DATA
* CONTINUATION OF TWO LOOP MODEL ADV4.DATA RUN
* AT 10000 SEC TOTAL STEAM LOSS THROUGH TBV AND ADV IS 4.412E5 LBM
CONSTANT POWER = 2568., V= 12000.,DELAY=10000,HEFW=60
      P=134.6
      IP=P
       IT=350
      M=V*50
      CP=1.25
*
DYNAMIC
*
     HST = HVAP(P)
     WST = 93.*SQRT(P/1050)
     Q=DECAY(TIME+DELAY)*POWER*3.413E6/3600.-WST*(HST-HEFW)
     DTDT = Q/M/CP
     ZT= INTGRL(IT,DTDT)
PROCEDURE P,T=LIMIT(ZT)
     ZP=0
     CALL PSAT(ZP,ZT)
     IF(ZP.LT.20) CALL FINISH
     P=ZP
     T=ZT
ENDPRO
     MST=INTGRL(4.4124E5,WST)
*
NOSORT
CALL DEBUG(2,0.)
TERMINAL
METHOD RECT
   TIMER FINTIM=100000, PRDEL=100., DELT=10, OUTDEL=100.
      PRINT TIME,T, WST,Q,P,MST
      PAGE XYPLOT
      LABEL TMI COOLDWON USING ONE ADV
*     OUTPUT TIME,T
*     OUTPUT TIME,P
*    OUTPUT  TIME,WST
*     OUTPUT TIME, Q
      OUTPUT TIME,MST
      END
      STOP
C*    FUNCTION TO CALCULATE VAPOR ENTHALPY
      FUNCTION HVAP(P)
      U=ALOG(P)
      IF(P.LE.450.0)GO TO 2
      IF(P.LE.2190.)GO TO 3
      U=U-7.0
      HVAP=((((0.37170416D01*U-0.91118126D01)*U-0.24447810D02)*U
     C-0.27217176D02)*U-0.44206896D02)*U-0.46351642D02)*U
     C+0.11876082D04
      RETURN
    2 HVAP=((((((-0.36740-04*U-0.5662D-03)*U+0.43507598D-02)*U
     C-0.14535040D-01)*U+0.22775919D-01)*U
     C+0.85550917D0)*U+0.14228318D02)*U+0.11059625D04
      RETURN
    3 HVAP=1.19251E3+6.416805E-2*P-9.9871952E-5*P**2
     C +4.5502391E-8*P**3-9.3721615E-12*P**4
      RETURN
      END
C     FUNCTION TO CALCULATE LIQUID ENTHALPY
```

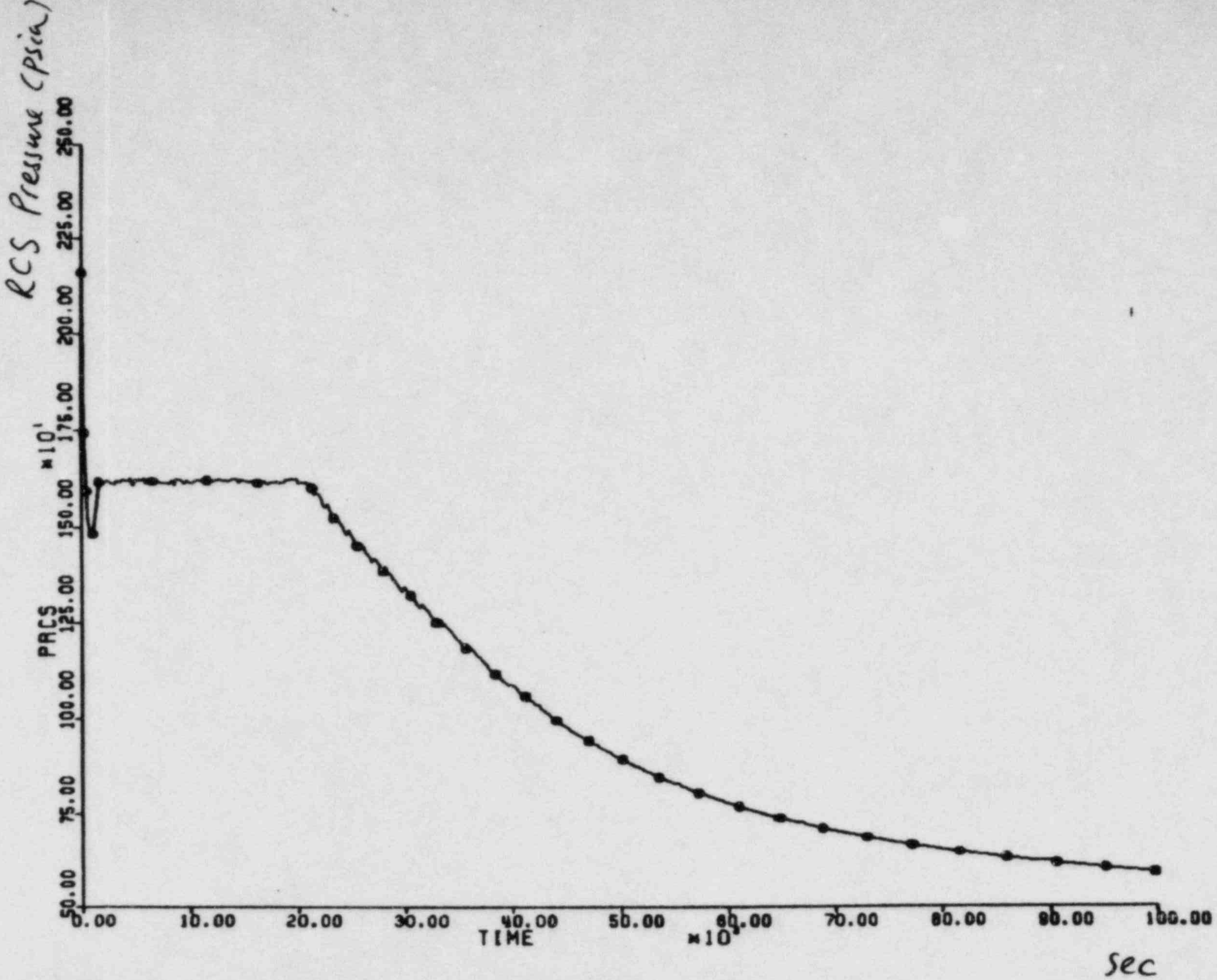
TMI-1 Cooldown Using One Atmospheric Dump Valve. L.C. Pion 6-21-83

- ADV controlled to limit RCS cooldown rate not exceeding 150°/hr instantaneously
- EFW throttled to maintain 50% OTSG operate range level.
- 1.0 ANS Decay heat. No RCP heat input
- CSMP program ADV4.DATA run #[illegible] made on 6-21-83 for the first 10000 sec program ADV.DATA restart to 60000 sec (~17 hours).



Accumulated Steam Loss

Time (hr)	Mass (lbm)	RCS Tavg (°F)
0	0	579
1	2.2×10^5	446
2	3.6×10^5	367
3	4.5×10^5	331
[illegible]	$6.[illegible] \times 10^5$	2[illegible]5



110/X-5250-014
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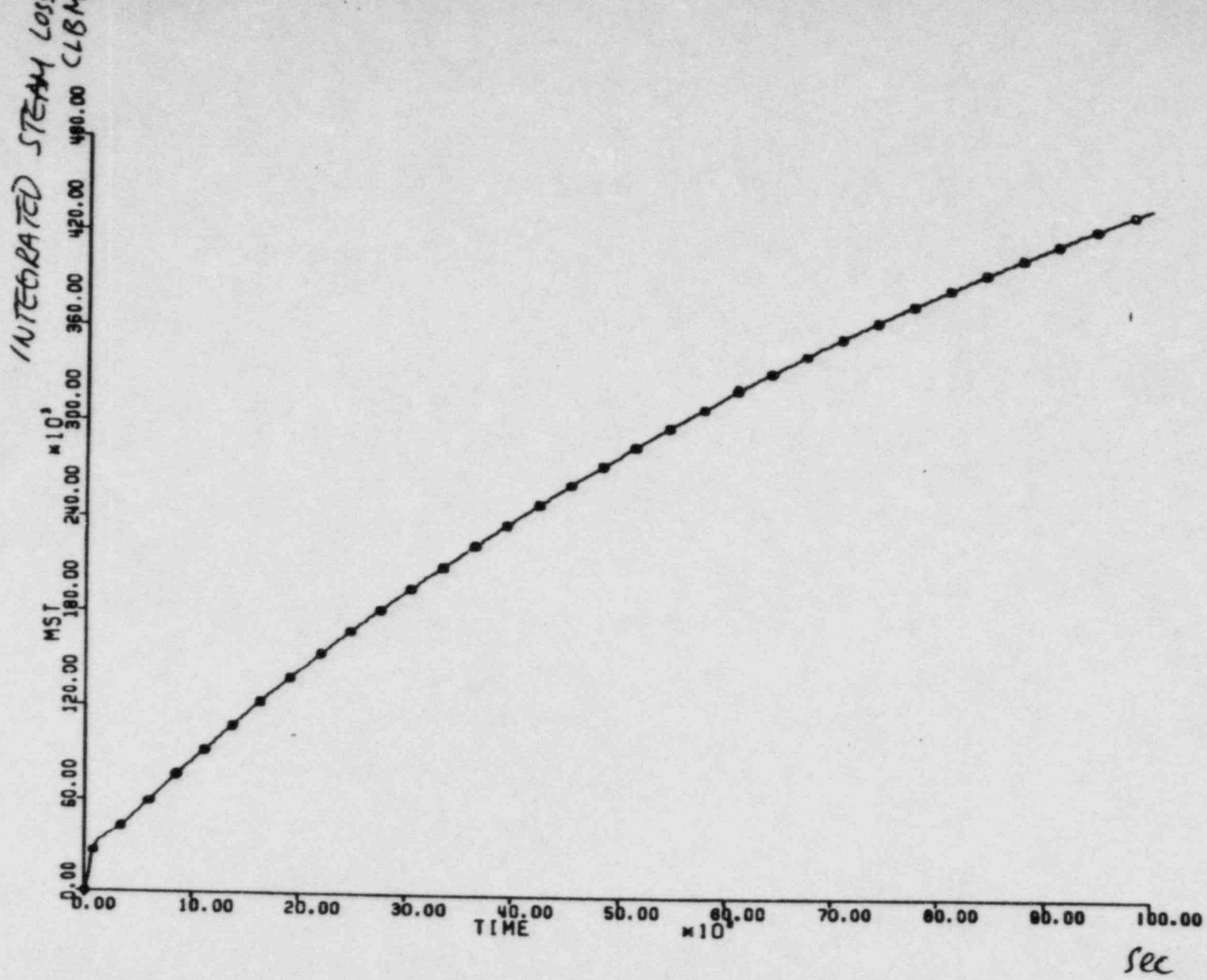
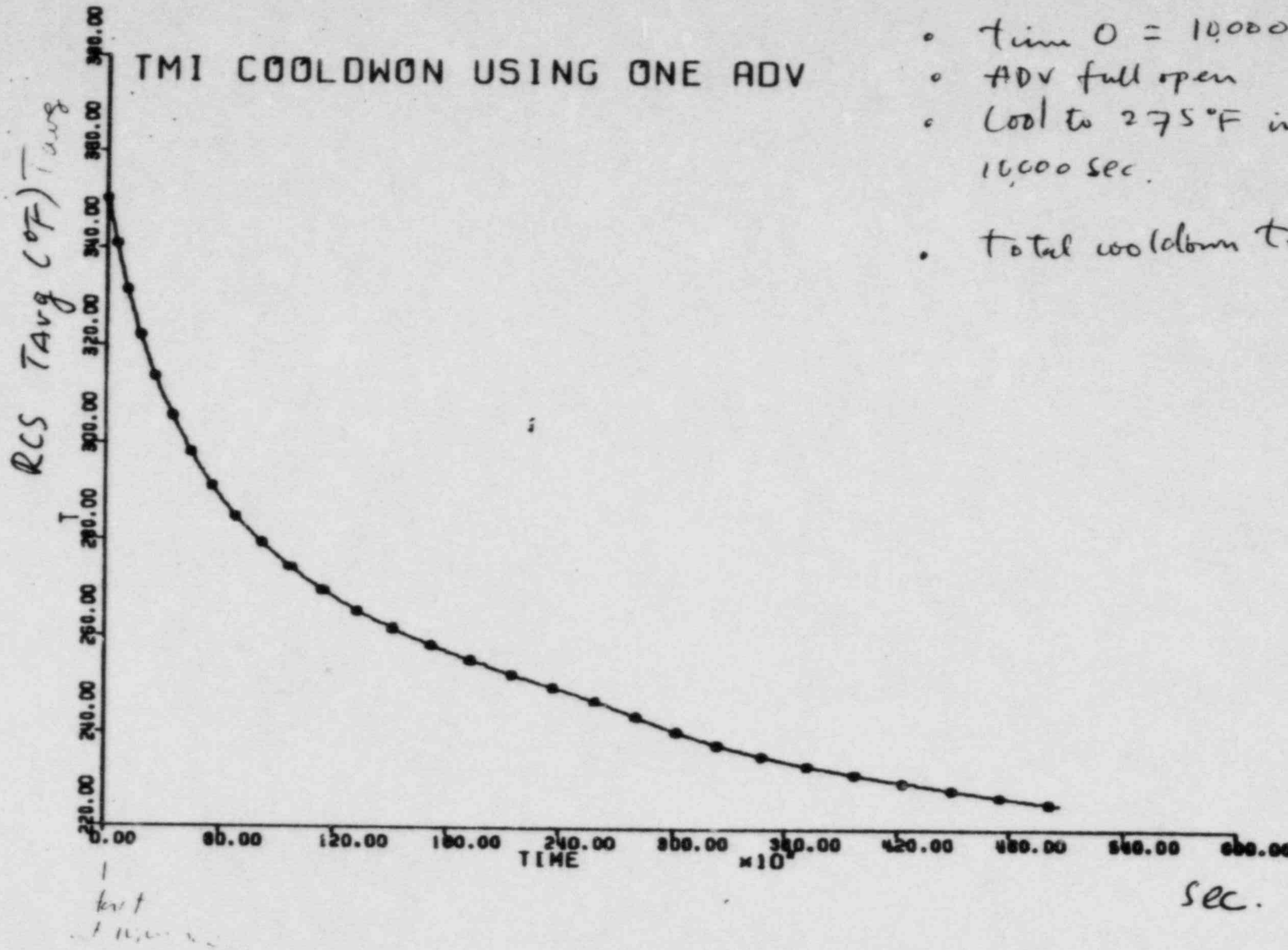

INTEGRATED STEAM LOSS (LBM)
MST
x10³
0.00
60.00
120.00
180.00
240.00
300.00
360.00
420.00
480.00
TIME
x10¹
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
sec

ADV. DATA 6-4-13

- time 0 = 10,000 sec.
- ADV full open
- Cool to 275°F in another 10,000 sec.
- total cooldown time ≃ 6 hr



1101×5250-014
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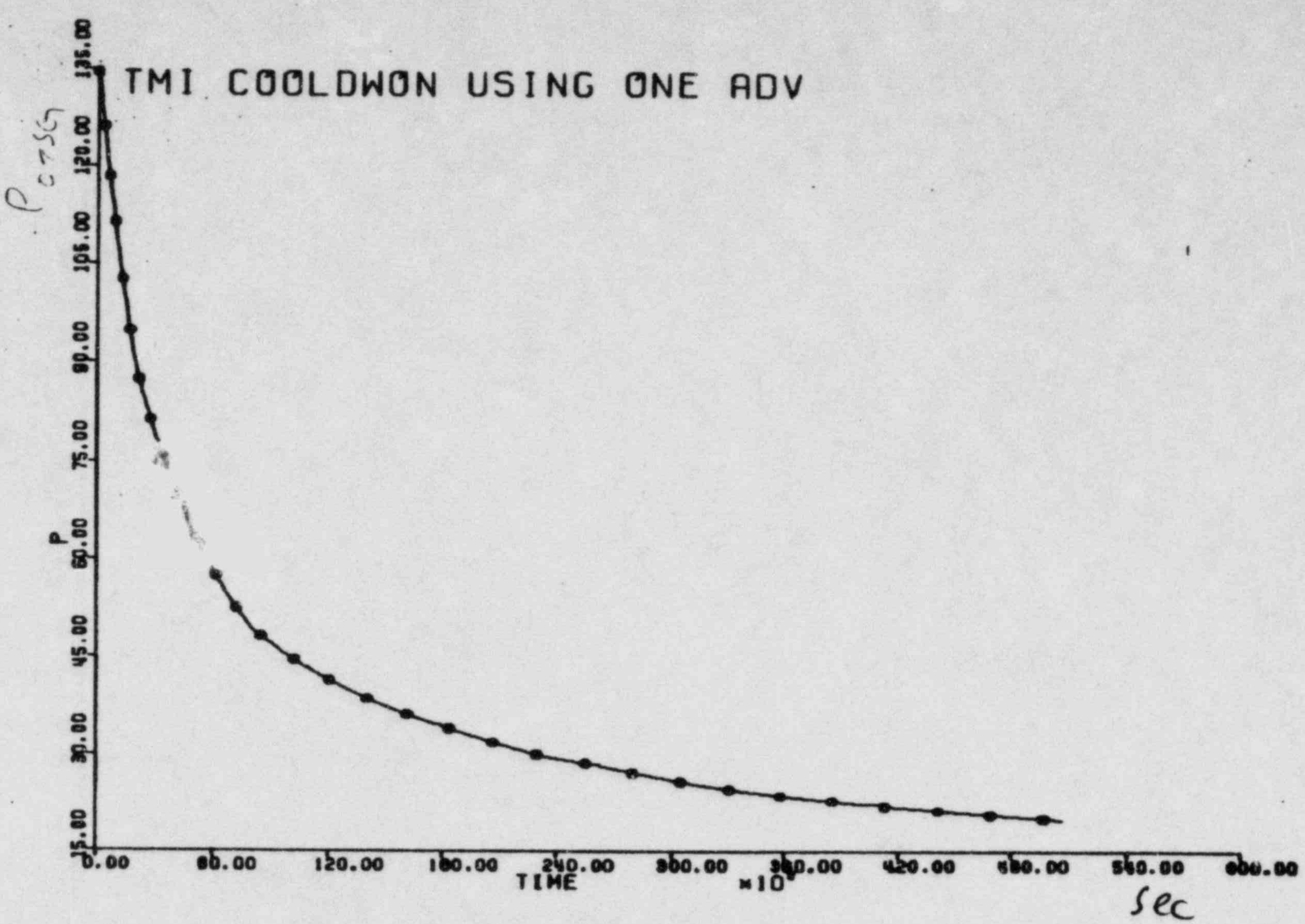
TMI COOLDWON USING ONE ADV
P
135.00
120.00
105.00
90.00
75.00
60.00
45.00
30.00
15.00
0.00
60.00
120.00
180.00
240.00
300.00
360.00
420.00
480.00
540.00
600.00
TIME
×10
sec