Alabama Power Company
600 North 18th Street
Post Office Box 2641
Birmingham, Alabama 35291
Telephone 205 250-1000

Alabama Power

the southern electric system

September 2, 1982

OG-78

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Denton:

RE: WESTINGHOUSE OWNERS GROUP ACTIVITIES RELATED TO PRESSURIZED THERMAL SHOCK

On July 31 and again on August 11, 1982, Westinghouse representatives and members of the Westinghouse Owners Group (WOG) met with members of your staff to continue our dialogue on the subject of Pressurized Thermal Shock (PTS). The following attachments are being provided as a result of those meetings:

Attachment 1 -- Copies of all WOG presentation slides from the August 11 meeting.

Attachment 2 -- A summary evaluation of the basis for WOG estimate of the probability of small LOCA's (1.5"<LOCA< 6.0"). This was previously telecopied to NRC on August 6.

Attachment 3 -- Details of the W interpretation of the CREARE mixing tests, and the application of that data to a W PWR. This material was previously telecopied to the NRC on August 6.

Attachment 4 -- Equations and assumptions used in the application of the CREARE data for small LOCA's on a W PWR. This material was previously transmitted to the NRC on August 13, 1982.

Attachment 5 -- W supplementary material that shows consistency between W operating experience and the W PRA studies. (Submitted in response to the NRC observation to the contrary)

A049

In addition to this information, we would like to note that the NRC staff position presented at the August 11 meeting is consistent with the WOG approach to PTS, and that we are substantially in agreement with the methods, techniques and assumptions presented by the staff. Furthermore, our recommendations presented at the June 22 meeting, and in our July 15 letter (OG-73) are consistent with the proposed staff position. We are of the opinion that the NRC staff's "screening values" for RT_{ndt} (270°F longitudinal flaw, and approximately 300°F for circumferential) are conservative, and that higher values may be defendable. We believe that upon completion of future activities (i.e., research and analytic programs), there will be additional bases for these values to be adjusted upward.

In closing, we strongly recommend that the staff position discussed on August 11 be finalized in the near term so that the establishment of criteria for plant specific assessments may be developed, and final resolution of this issued realized. We further recommend that the WOG be invited to review your final documented position as soon as possible and request your response to this recommendation. Please contact me if you wish any additional information and apprise me of your decision to obtain WOG comments on your documented position.

Very truly yours,

O. D. Kingsley, Jr., Chairman
Westinghouse Owners Group

/mw

Attachments

ATTACHMENT 1

BASIS FOR MEDIUM LOCA FREQUENCIES

- VALUE USED IN MAY 28 SUBMITTAL

- BASIS FOR LOWER FREQUENCY

FREQUENCY IN MAY 28 SUBMITTAL

- BREAK RANGE IS 1.5" TO 6"

- COMPONENT FOR PASSIVE BREAKS BASED ON WASH-1400 ESTIMATES

  6.1×10^{-4}

- EVENT TREE RESULTS REPORTED SHOWED CONSEQUENTIAL FAILURES FOR VALVES TO BE

  1.8×10^{-5}

- WASH-1400 ESTIMATES RESULTED FROM TOTAL NUCLEAR PLANT EXPERIENCE REDUCED BY FACTOR OF 10 FOR LOCA SENSITIVE PIPING

BASIS FOR LOWER FREQUENCY OF PASSIVE BREAKS

- FRACTION OF PLANT PIPING WHICH IS LOCA SENSITIVE IS MUCH LESS THAN 10%.
- LOCA PIPING IS OF A HIGHER GRADE (MARSHALL REPORT USES A FACTOR OF TEN FOR NUCLEAR VERSUS NON-NUCLEAR VESSELS).
- LOCA SENSITIVE PIPING IS MINIMIZED BY CHECK VALVES NEAR MAIN LOOP PIPING ON INCOMING LINES (SI, CHARGING, AND RHR).
- SMALL LINES HAVE FLOW LIMITING ORIFICES BELOW MEDIUM LOCA RANGE (SAMPLE LINES, RTD MANIFOLDS).
- LAWRENCE-LIVERMORE RESULTS AT LEAST TWO ORDERS OF MAGNITUDE BELOW WASH-1400.

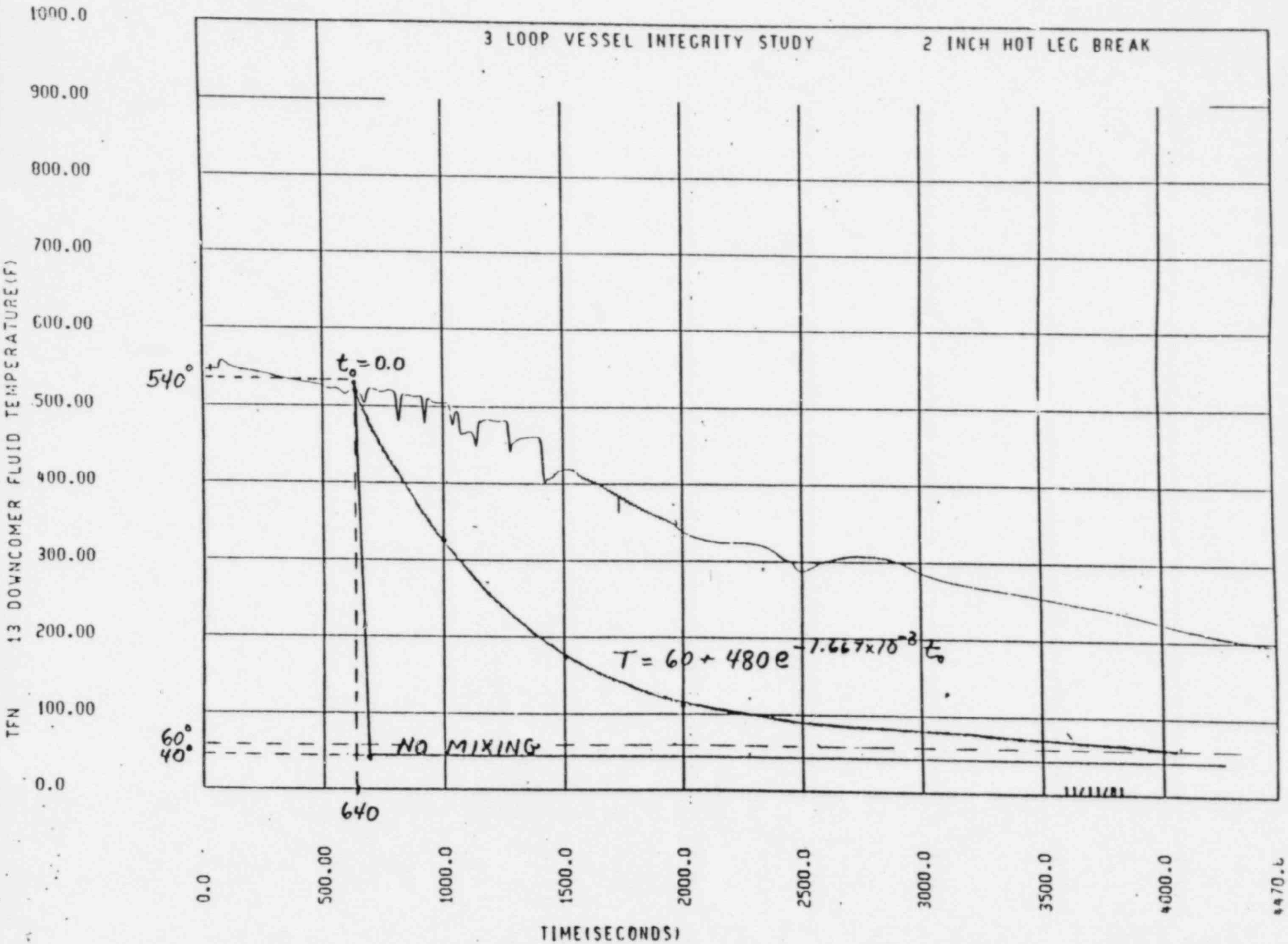
COMBINED MEDIUM LOCA FREQUENCY

- ACTIVE FAILURES - 1.8 X 10^{-5}

- SUPPORTABLE PASSIVE FAILURE RATE - 10^{-5} RANGE

CONCLUSION

- LOWER LIMIT ON COMBINED MEDIUM LOCA FREQUENCY IS 5 X 10^{-5}



3 LOOP VESSEL INTEGRITY STUDY
2 INCH HOT LEG BREAK
TFN 13 DOWNCOMER FLUID TEMPERATURE(F)
1000.0
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.0
540°
60°
40°
$t_o = 0.0$
$T = 60 + 480e^{-7.667\times10^{-3}t_o}$
NO MIXING
640
0.0
500.00
1000.0
1500.0
2000.0
2500.0
3000.0
3500.0
4000.0
4470.6
TIME(SECONDS)
11/11/81

IMPROVED PREDICTION OF DOWNCOMER FLUID TEMPERATURE RESPONSE

- Evaluation of CREARE Data to Determine Mixing Volumes

- Incorporation of Metal Heat
    - Area consistent with Mixing Volume
    - Fracture Mechanics Downcomer Heat Flux

MIXING CUP CONTROL VOLUME ANALYSIS

PRINCIPLE: TRANSIENT 1st LAW ENERGY BALANCE

ASSUMPTIONS:

CONSTANT MASS CONTROL VOLUME

CONSTANT C_p

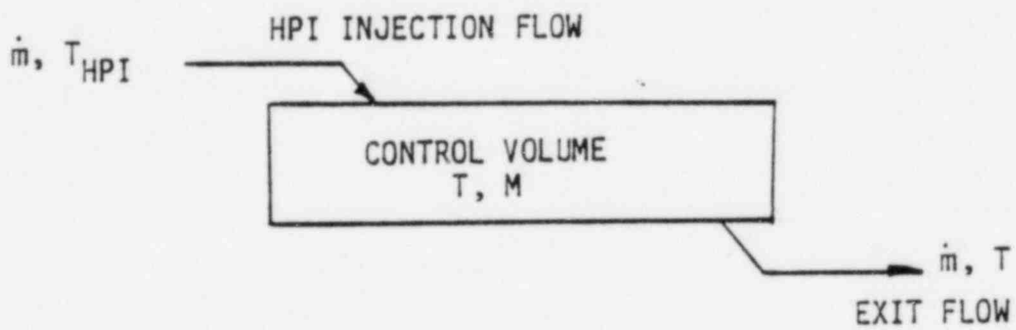
CONSTANT HPI TEMPERATURE

UNIFORM TEMPERATURE THROUGHOUT THE CONTROL VOLUME

NO HEAT TRANSFER ACROSS CONTROL VOLUME BOUNDARIES

MASS FLUX ACROSS CONTROL VOLUME BOUNDARIES DUE TO HPI ONLY (i.e. STAGNANT COLD LEG).

CONTROL VOLUME SCHEMATIC:



MIXING CUP CONTROL VOLUME ANALYSIS

SYSTEM DIFFERENTIAL EQUATION:

$$MC_p \frac{dT}{dt} = \dot{m}Cp \left(T_{HPI} - T\right)$$

SOLUTION:

$$T = \left(T_o - T_{HPI}\right)e^{-\beta t} + T_{HPI} \qquad \beta = \dot{m}/_M$$

NOMENCLATURE:

C_p = SPECIFIC HEAT AT A CONSTANT PRESSURE

M = MASS OF FLUID IN CONTROL VOLUME (CONSTANT) (lbm)

$\dot{m}$ = MASS FLOW RATE OF HPI FLOW (lbm/sec.)

T = CONTROL VOLUME MIXTURE TEMPERATURE AND EXIT FLOW TEMPERATURE (°F)

T_o = CONTROL VOLUME MIXTURE TEMPERATURE AT $t = 0$ SEC. (°F)

T_{HPI} = HPI TEMPERAUTRE (°F)

t = TIME (SEC)

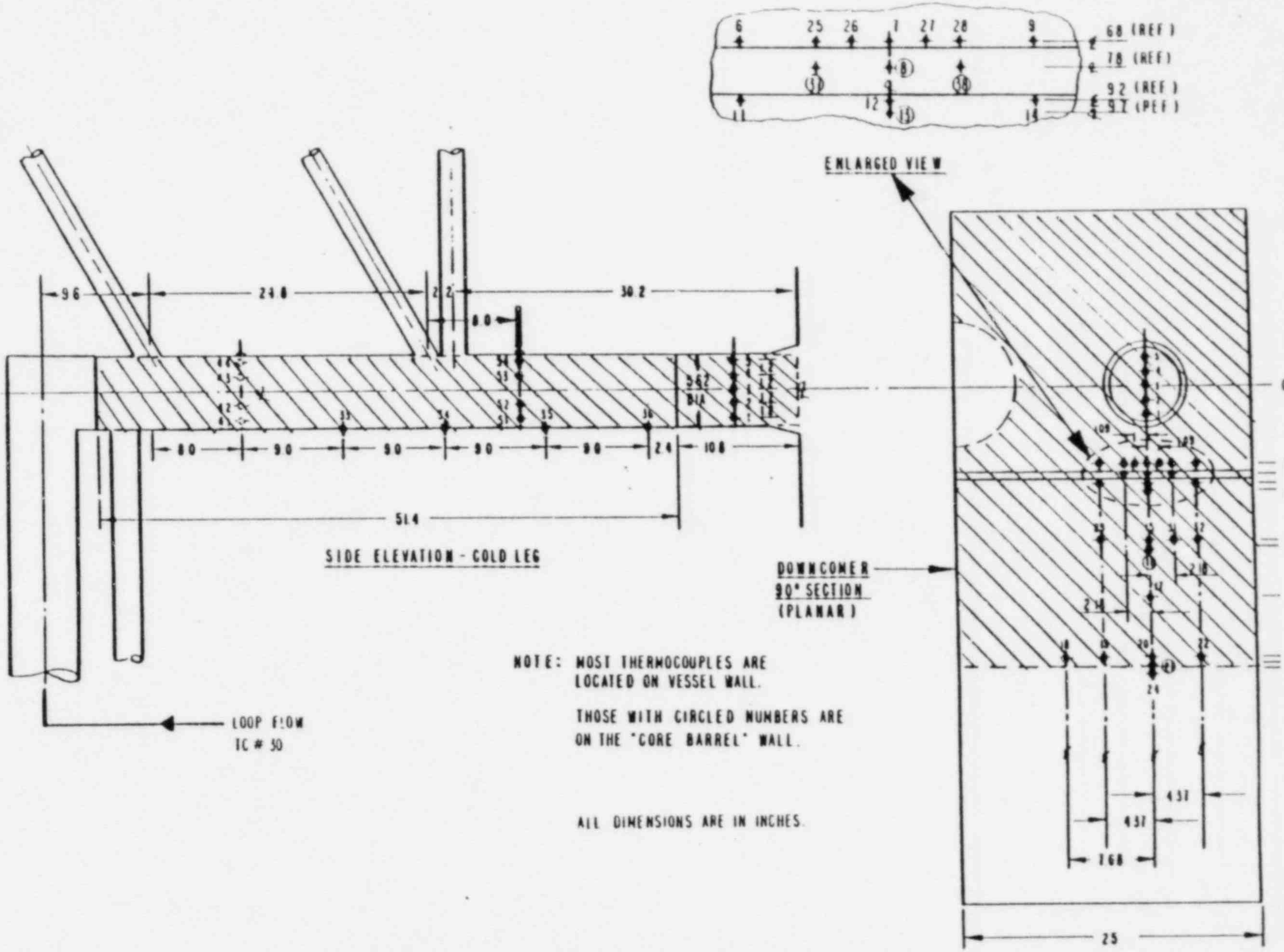


Figure 2-3. Mix Rig Thermocouple Locations, Phase II

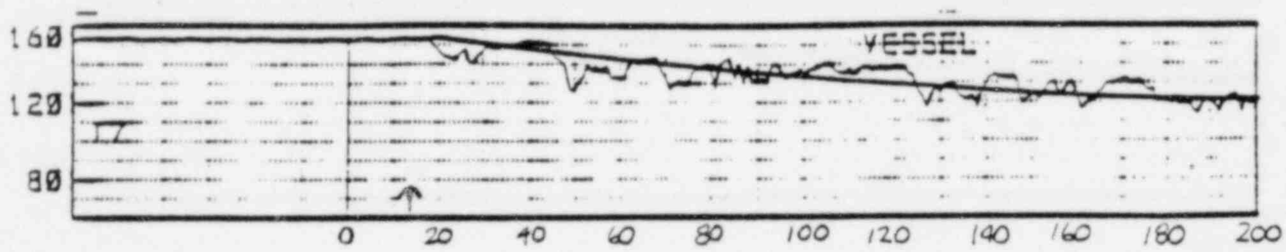
Control Volume Configuration #2b, $V_{2b} = 1.8896\ ft^3$

CREARE STAGNANT FLOW CASES

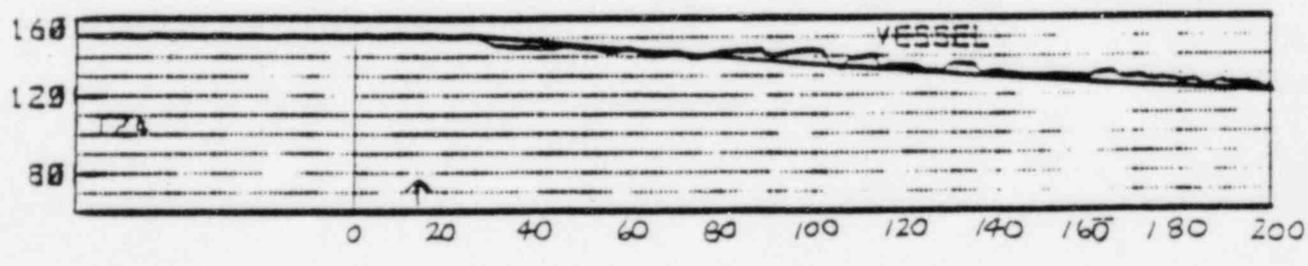
TEST #	T_{HPI} (°F)	T_0 (°F)	Q_{HPI} (gpm)	Fr	β_{2a} (min^{-1})	β_{2b} (min^{-1})	β_3 (min^{-1})
49	64	147.13	0.57	0.014	0.0480	0.042	0.036
61	62	148.7	0.62	0.015	0.048	0.0447	0.0416
57	62	149.16	2.04	0.052	0.156	0.150	0.138
45	65	152.86	2.14	0.054	0.1680	0.156	0.144
50	64	149.39	4.0	0.106	0.3120	0.2880	0.2700
64	58	149.14	4.10	0.032			

TEST #45

THERMOCOUPLE #7

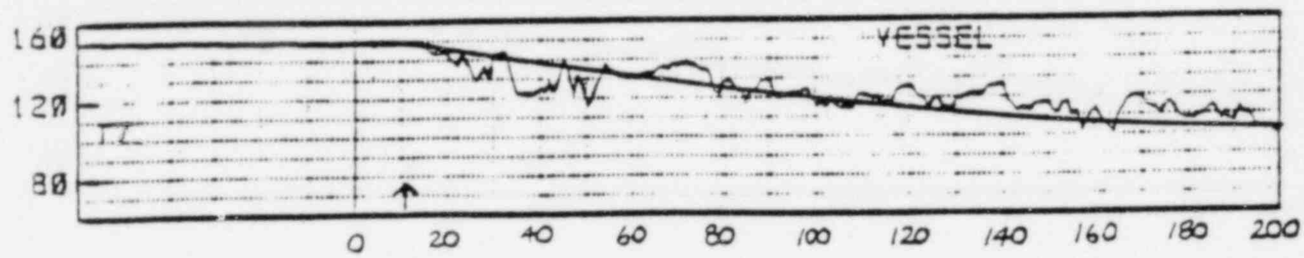


THERMOCOUPLE #24

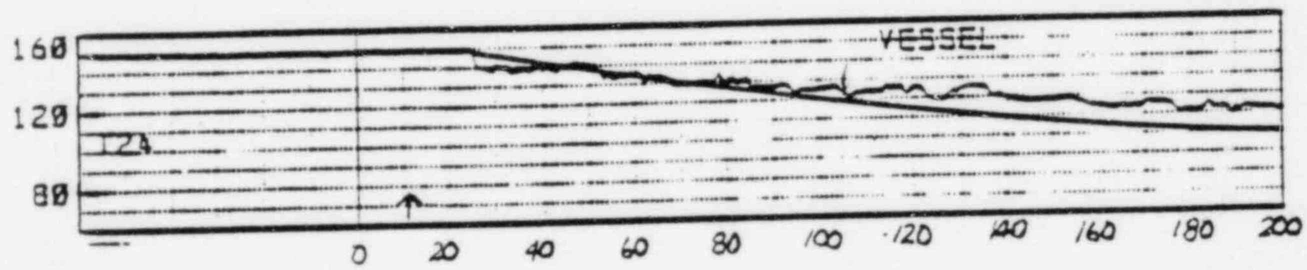


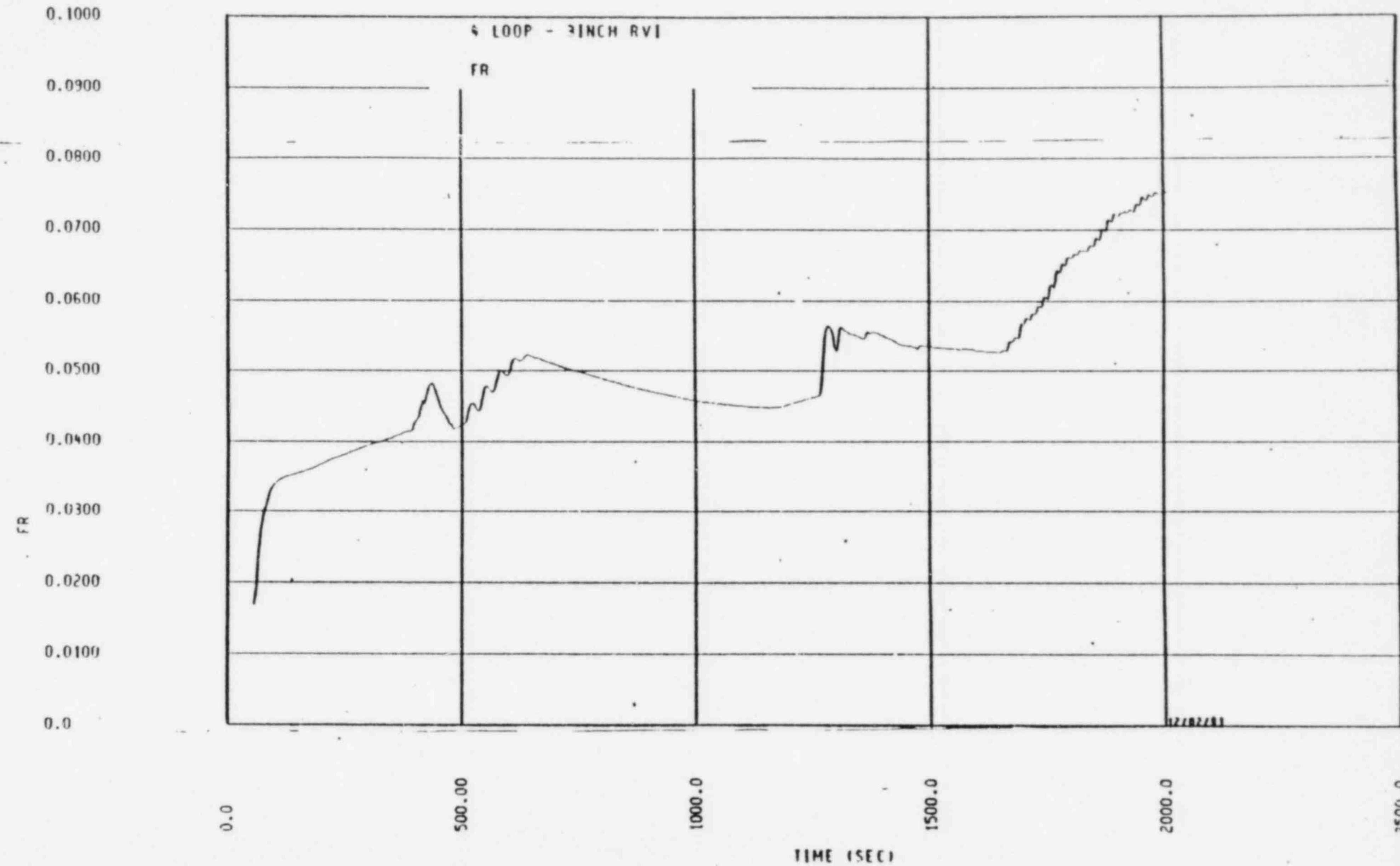
TEST #50

THERMOCOUPLE #7



THERMOCOUPLE #24





4 LOOP - 3INCH RVI
FR
0.1000
0.0900
0.0800
0.0700
0.0600
0.0500
0.0400
0.0300
0.0200
0.0100
0.0
FR
0.0
500.00
1000.0
1500.0
2000.0
2500.0
TIME (SEC)

CONCLUSIONS

- AGREEMENT BETWEEN MIXING CUP ANALYSIS AND CREARE EXPERIMENTAL DATA IS GOOD FOR SPECIFIED CONTROL VOLUMES.

- FOR AN HPI FROUDE NO. OF 0.054 THE MIXING CUP ANALYSIS INDICATES A β OF APPROXIMATELY 0.16 MIN^{-1}

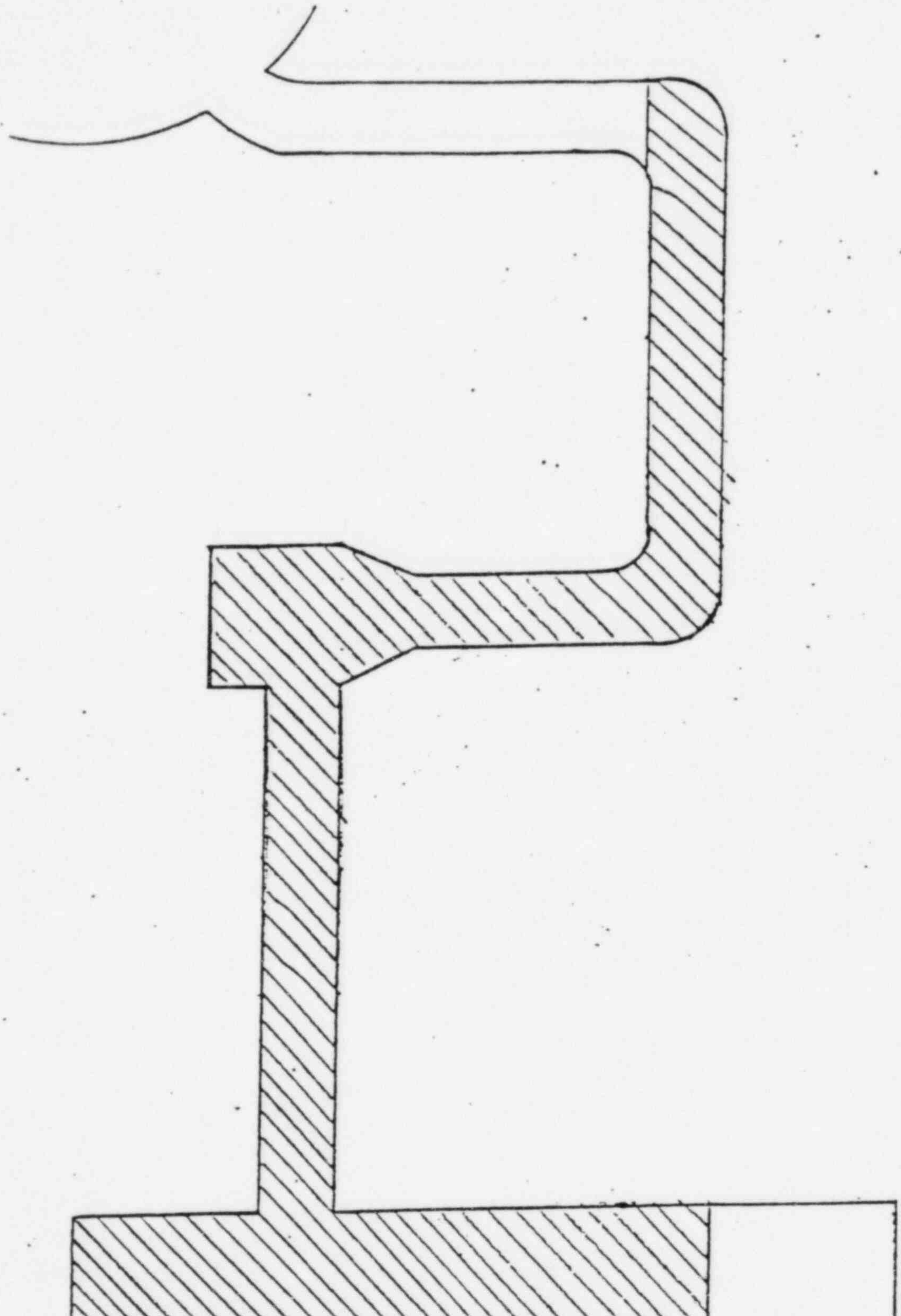
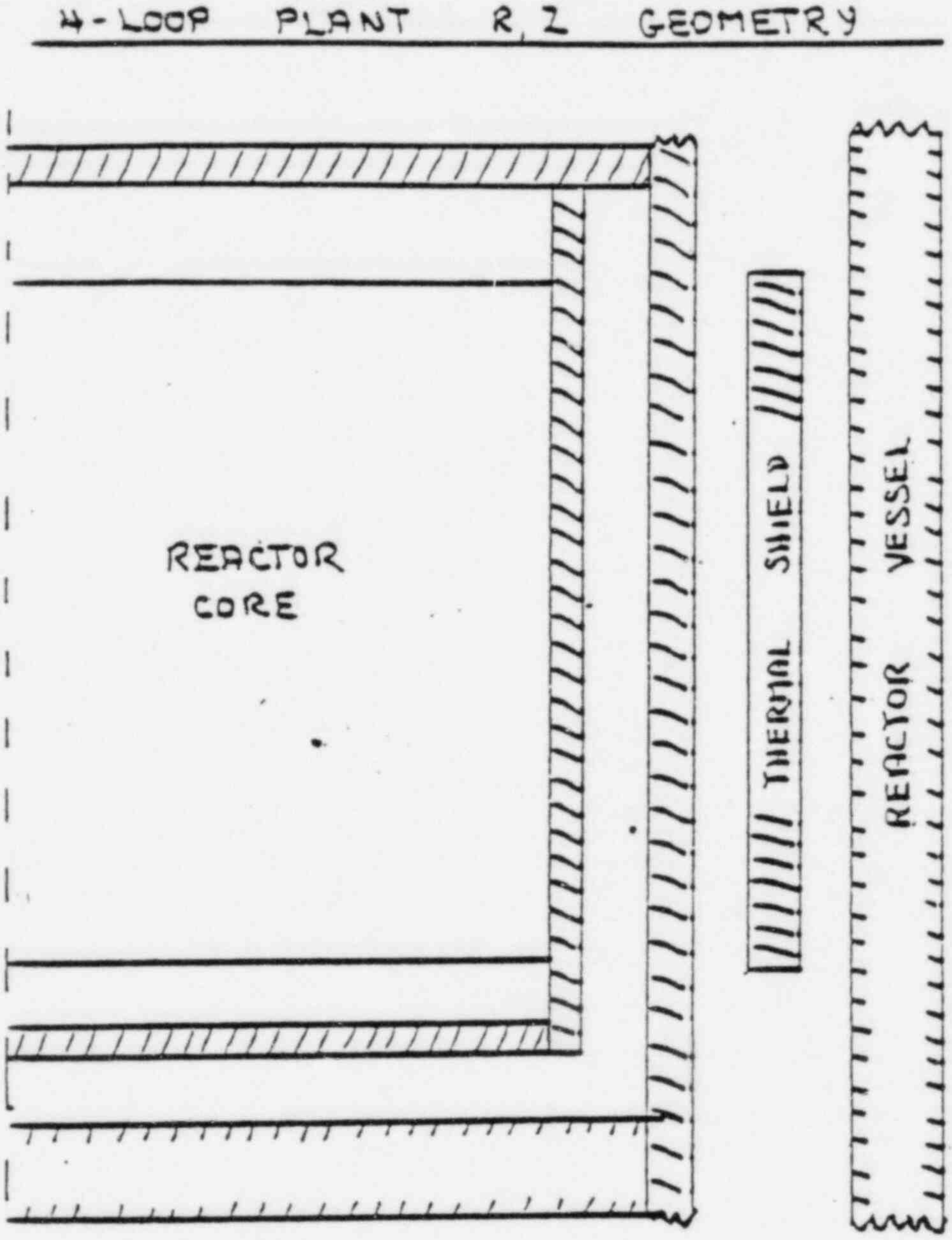
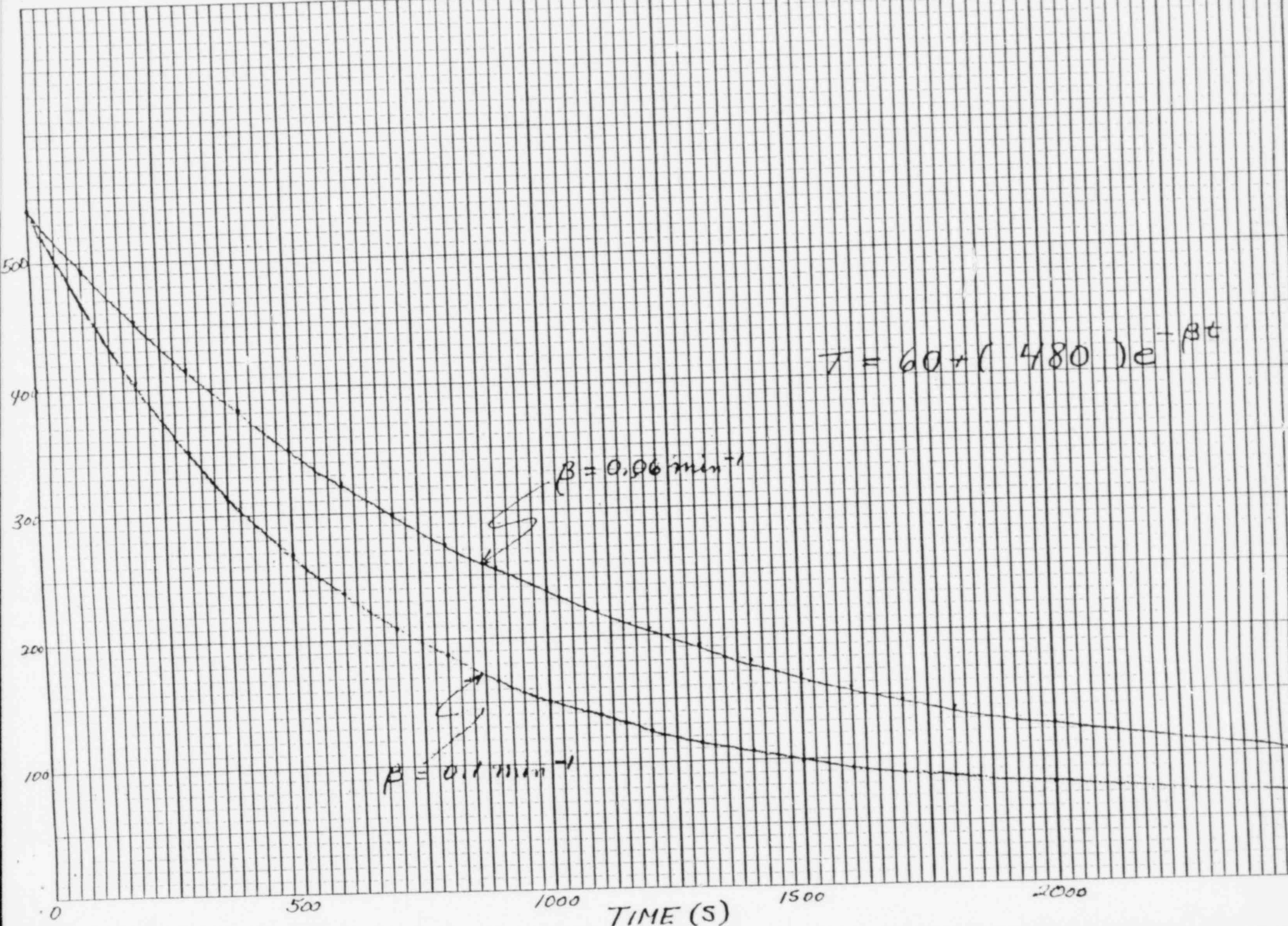
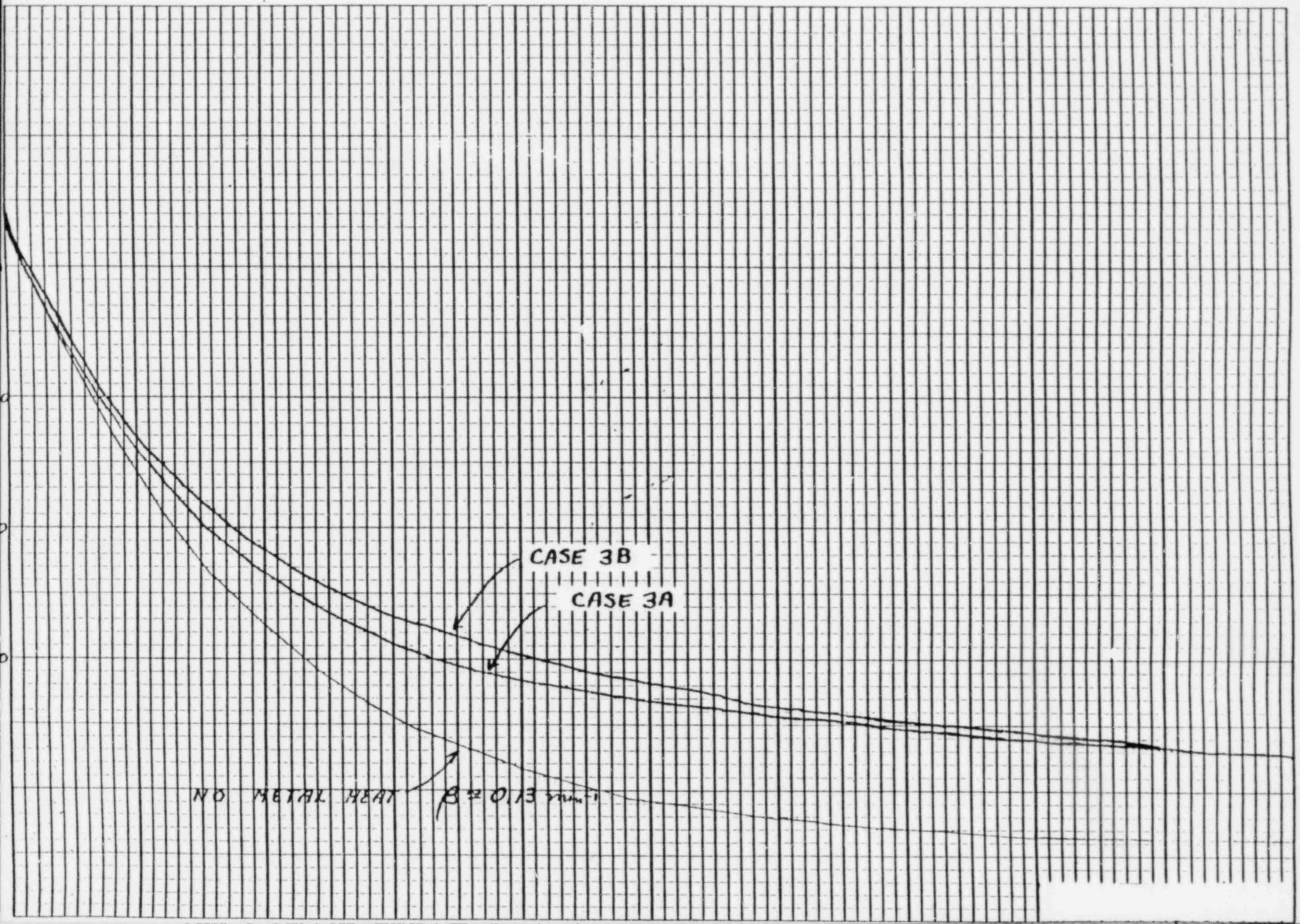


Figure II.2-3


4-LOOP PLANT R, Z GEOMETRY
REACTOR CORE
THERMAL SHIELD
REACTOR VESSEL



$T = 60 + (480)e^{-\beta t}$
$\beta = 0.06\ min^{-1}$
$\beta = 0.1\ min^{-1}$
500
400
300
200
100
0
500
1000
1500
2000
TIME (S)



CASE 3B
CASE 3A
NO METAL HEAT
$\beta = 0.13\ min^{-1}$

CONCLUSION:

1. METAL HEAT IS VERY IMPORTANT AND CAUSES THE FLUID TEMPERATURE TO FLATTEN OUT AT A HIGHER VALUE THAN THE HPI INJECTION TEMPERATURE ($125^{o}F$)

2. CASE 3 IS BELIEVED TO BE MOST REALISTIC BECAUSE OF THE HPI FLOW SPLIT WHICH WILL YIELD A LARGER VOLUME FOR MIXING AS WELL AS MORE SURFACE AREA FOR METAL HEAT RELEASE

QUANTIFICATION OF DIFFERENCES IN NRC/WOG FRACTURE MECHANICS RESULTS FOR THE SMALL BREAK LOCA EVENT

ASSUMPTIONS:

- TRANSIENT TEMPERATURE - T_i = 540°F, T_f = 60°F, β = 0.10/MIN
- TRANSIENT PRESSURE - P = 1,000 PSI
- VESSEL THICKNESS = 8.625".
- GUTHRIE IRRADIATION DAMAGE TREND CURVE WITH dPa EFFECT INCLUDED
- CONTINUOUS FLAW SHAPE FOR CRACK ARREST

RT_{NDT} RESULTS USING WARM PRESTRESSING:

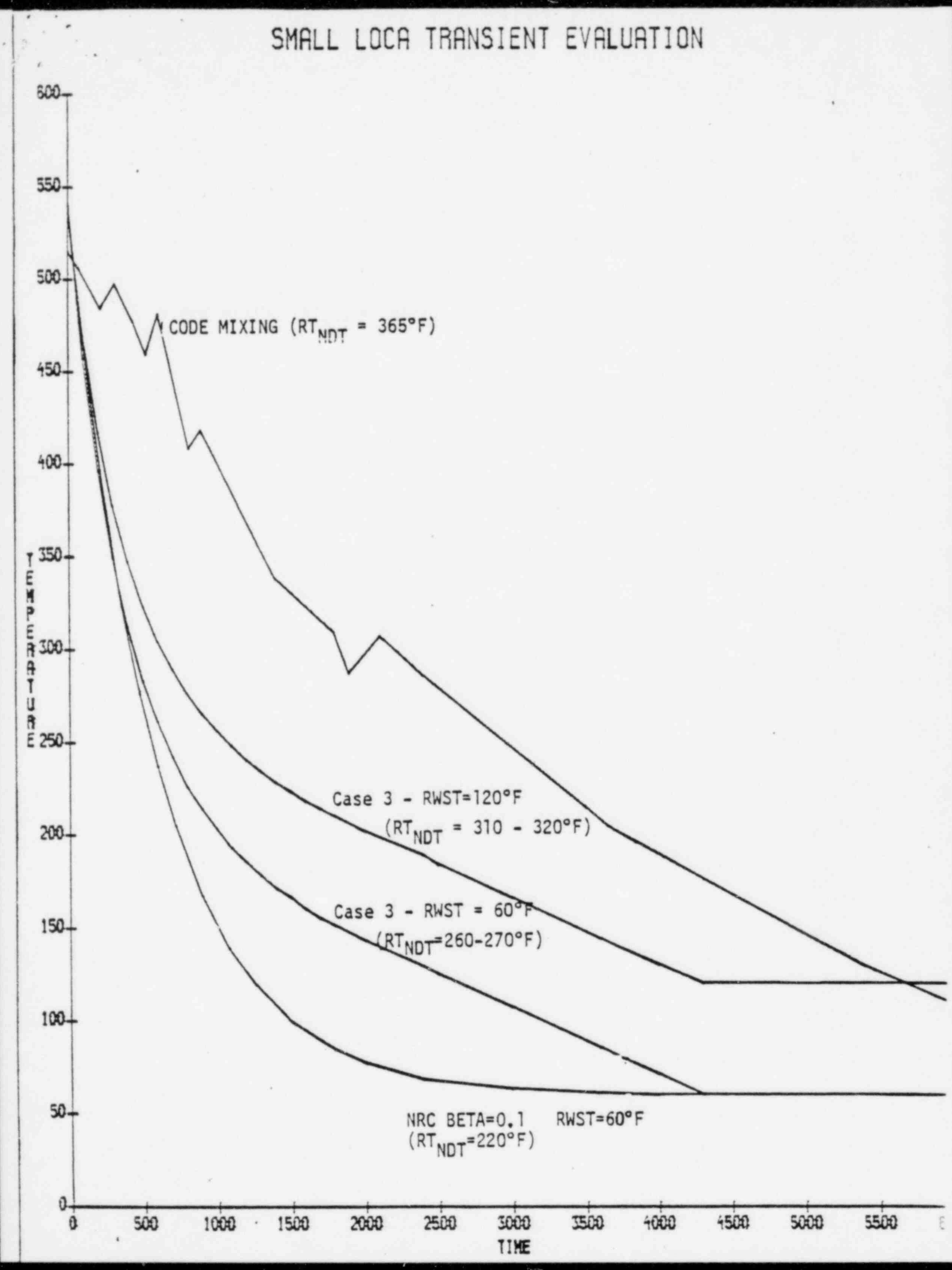
NRC - 175°F LONGITUDINAL FLAW (CRACK INITIATION W/O ARREST)
$>$300°F CIRCUMFERENTIAL FLAW (CRACK ARREST)

WOG - 220°F LONGITUDINAL FLAW (CRACK INITIATION W/O ARREST)
360°F CIRCUMFERENTIAL FLAW (CRACK ARREST)

CALCULATIONAL DIFFERENCES

LONGITUDINAL FLAW (Δ = 45°F):

	NRC		WOG	Δ
•	CLAD STRESS EFFECT	VS.	NO STRESS EFFECT	10°F
•	CONTINUOUS FLAW FOR INITIATION	VS.	FINITE FLAW FOR INITIATION	20°F
•	$\bar{h}$ = 300 BTU/HR-FT^2-°F	VS.	$\bar{h}$ FROM FREE CONVECTION CORRELATION	15°F


SMALL LOCA TRANSIENT EVALUATION
TEMPERATURE
TIME
600
550
500
450
400
350
300
250
200
150
100
50
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
CODE MIXING (RT_{NDT} = 365°F)
Case 3 - RWST=120°F
(RT_{NDT} = 310 - 320°F)
Case 3 - RWST = 60°F
(RT_{NDT}=260-270°F)
NRC BETA=0.1 RWST=60°F
(RT_{NDT}=220°F)

ATTACHMENT 2

DO NOT STAPLE

USE BLACK PEN

PROVIDE ALL INFORMATION REQUESTED

FACSIMILE USE REQUEST

DATE: AUGUST 6, 1982

TO: Messrs. T. Spies/S. Hanuaer

FROM: R.J. Sero

COMPANY: NUCLEAR REGULATORY COMM.

DEPT/DIV: WESTINGHOUSE ELECTRIC CORPORATION
NTD, MNC 459

CONTROL AND BUDGET NUMBER: 86261

TELEPHONE EXTENSION: 373-4189

NUMBER OF PAGES BEING SENT: 4
(Include this page)

Phone Number of Receiving Equipment: 301-492-7617

Type of Machine:

Automatic: X

Manual

Verification Number: 301-492-7371

WESTINGHOUSE AUTOMATIC FACSIMILE EQUIPMENT NUMBERS:

	Dex 4200	Xerox 485	Rapifax 100	Verification
☐ M NUCLEAR CENTER	373-5744	373-5512	373-5738	373-4930
☐ MALL OFFICE BLDG	374-2452	374-2450	374-2459	374-2448
☐ PENN CENTER	273-7883	273-7882	NA	273-7885
☐ 701	256-3059	256-5874	NA	256-4013
☐ FOREST HILLS	NA	NA	244-3401	NA
☐ GM 286	327-6235 (Model 1100)	NA	NA	327-6235

PLEASE RETURN ORIGINAL TO: R.J. SERO
(Please Include Location and Bay Number) MNC 459

BASIS FOR MEDIUM LOCA (1.5" - 6") FREQUENCIES

The basis for the medium LOCA pipe break frequency (excluding active failures such as valves) utilized in the May 28 Pressurized Thermal Shock (PTS) submittal is essentially that used in WASH-1400 adjusted by a Bayesian update to account for U.S. PWR operating experience (zero occurrences in 213 reactor years). The Bayesian effect is only significant for the portion of the WASH-1400 distribution or any other estimated distribution that is within the range of meaning with respect to the operating experience. For example, sufficient data exist so that a valid judgement can be made as to the posterior likelihood of a 10^{-2} per year failure rate. Values several orders of magnitude lower are beyond the range within which operating experience has significant influence. Therefore, the most significant variable for the point estimate used is the prior distribution. Table 1 shows two other distributions which were evaluated as priors.

Case 1 in Table 1 is the WASH-1400 result reduced by an order of magnitude. The value used in WASH-1400 was the result of reducing the total plant experience for nuclear installations by a factor of ten to reflect the fraction of total plant piping which is LOCA sensitive. A further reduction in the LOCA frequency can be supported by the fact that the LOCA sensitive piping is of a much higher grade, better supported, and inherently shorter than the remaining piping in a nuclear plant. In the same sense that piping grade affects frequency, the Marshall report(1) concluded that disruptive failure frequencies of reactor vessels should be a factor of ten or more below non-nuclear grade vessels. In addition, all incoming medium piping (>2") such as safety injection, charging, and RHR lines have check valves very close to the injection nozzles on the main coolant loops, which reduces the amount of medium LOCA sensitive piping. Also, all sample lines, RTD manifold lines, and other small pipes have flow limiting orifices whose throat diameter is well below the medium LOCA range.

The Lawrence-Livermore results (NUREG/CR-2189) for deterministic fracture mechanics support a frequency of passive pipe breaks at least two orders of magnitude below WASH-1400 (see Case 2 in Table 1), which provides further basis for reducing the WASH-1400 estimate. An inherent lower bound to the frequency of a medium LOCA is provided by the estimate of active component failures for pressurizer safeties, PORVs, RCP seals, etc., which was included in the results of the May 28 submittal for medium LOCAs. The frequency of active component failures in the range of 1.5" to 6" is 1.8×10^{-5} as shown in Table 1.

In conclusion, the lower limit on a value for a medium LOCA frequency which covers active and passive failures if 5×10^{-5}.

---

(1) Dr. W. Marshall, UKAEA, "An Assessment of the Integrity of PWR Pressure Vessels", 1 October 1976.

TABLE 1

MEDIUM LOCA FREQUENCIES (1.5" - 6")

Prior	Prior Mean	Post Mean
WASH-1400	8.0×10^{-4}	5.2×10^{-4}*
Case 1 (WASH-1400 Adjusted)	8.0×10^{-5}	7.4×10^{-5}
Case 2 (Lawrence-Livermore)	2.7×10^{-6}	2.6×10^{-6}

Active Failures (Single Safety Valves, Double PORVs, etc.)	1.8×10^{-5}

* The submittal contained a value of 6.1×10^{-4} based on a more conservative expansion of the WASH-1400 prior distribution.

ATTACHMENT 3

DO NOT STAPLE

USE BLACK PEN

PROVIDE ALL INFORMATION REQUESTED

FACSIMILE USE REQUEST

DATE: 8-6-82

TO: B. Sheron
T. Spies
S. Hanauer
N. Lauben

FROM: Ray Sero
MNC-455
X4189

COMPANY: NRC

NUMBER OF PAGES BEING SENT: 7
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Type of Machine:

Automatic:

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WESTINGHOUSE AUTOMATIC FACSIMILE EQUIPMENT NUMBERS:

	Dex 4200	Xerox 485	Rapifax 100	Verification
M NUCLEAR CENTER	373-5744	373-5512	373-5738	373-4930
MALL OFFICE BLDG	374-2452	374-2450	374-2459	374-2448
PENN CENTER	273-7883	273-7882	NA	273-7885
FOREST HILLS			244-3401	
GM 286	327-6235 (Model 1100)	NA	NA	327-6235

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Ray Sero
MNC-455

VESSEL MIXING CALCULATIONS

The Creare 1/5 scale mixing data was examined to find an appropriate mixing volume to use which resulted in a reasonable agreement with the stagnant flow data. It appears that using the cold leg volume and the full downcomer gives reasonable agreement with the test data we have analyzed.

For the PWR case, a series of best estimate mixing cases were performed using the surface area for metal heat release which was consistant with the mixing volume assumed. The metal heat release was calculated from a one-dimensional heat conduction computer code which used as a surface boundary condition the free convection heat transfer coefficient from WCAP 10019. The stainless clad was modelled as well as the carbon steel for the reactor vessel wall. The heat flux from the conduction calculation was obtained for a Beta = 0.1 and Beta = 0.06. The surface heat flux was applied to the metal surface area enclosed by the mixing volume.

Assumptions:

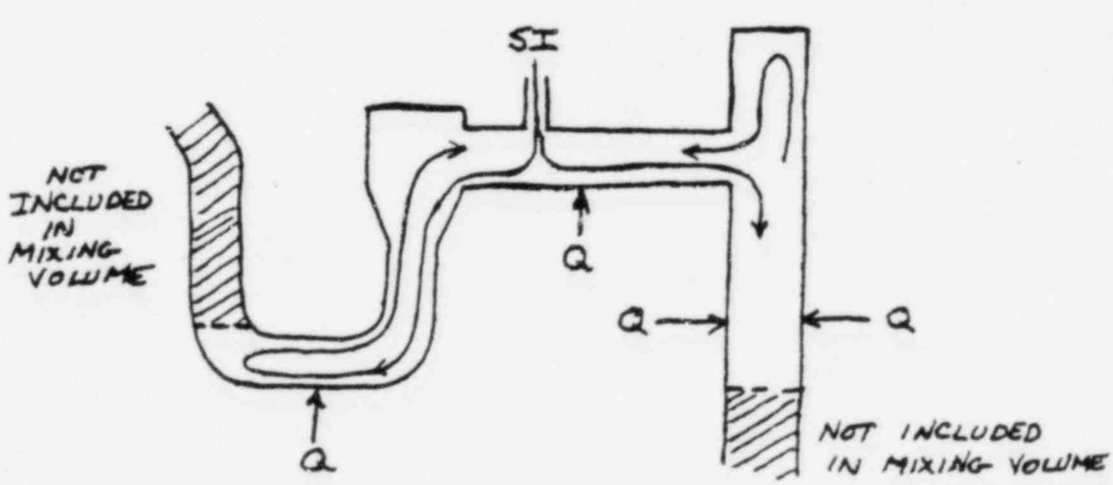
- Best Estimate HPI flow at 1000 psia
- 90° injection angle, therefore mixing in full cold leg.
- Metal heat release calculated form one-dimensional conduction solution.

Cases:

1.) The downcomer down to the core mid-plane and full cold leg were used as the mixing volume and the metal heat release heat flux was applied to the cold leg, vessel, and barrel. The heat release from the thermal shield was ignored since these values were not available. The transient curves are shown in Figure 1. The difference between case 1a and 1b is the metal heat release which was previously calculated assuming a Beta of either 0.1 or 0.06. The figure show that the temperature is 125°F at 2500 seconds. The no metal heat release case is also shown.

2.) Case 2 is the same as case (1) except that the metal heat release from the cold leg is reduced to reflect the thinner wall of the cold leg relative to the reactor vessel. The final temperature for this case if 110°F at 2500 seconds. Again the heat release from the thermal shield is ignored.

3.) Case 3 is the same as Case 2 except that mixing of the HPI water with the hot water in the loop seal was aasumed. The justification for this assumption is that with the 90° injection nozzle, into a stagnant cold leg, the HPI flow is expected to split with some (half) of the HPI water to flow backward toward the loop seal. The colder, dense, HPI is postulated to displace the hot loop seal water and set up a convection pattern which return the loop seal water to the downcomer. See the sketch below.



For our calculation, this implies a larger hot water mixing volume which includes the horizontal portion of the loop seal as well as the vertical leg of the loop seal next to the HPI injection line. In addition to the larger, additional metal heat release was calculated for the increased loop seal surface area. The results for this case are shown in Figure 3 which yields a 125°F temperature at 2500 seconds. The initial portion of the transient for this case is not as steep as the other two cases because of the larger mixing volume. Again, the metal heat from the thermal shield was ignored.

Conclusion:

1.) Metal heat is very important and causes the fluid temperature to flatten out at a higher value than the HPI injection temperature (~125°F)

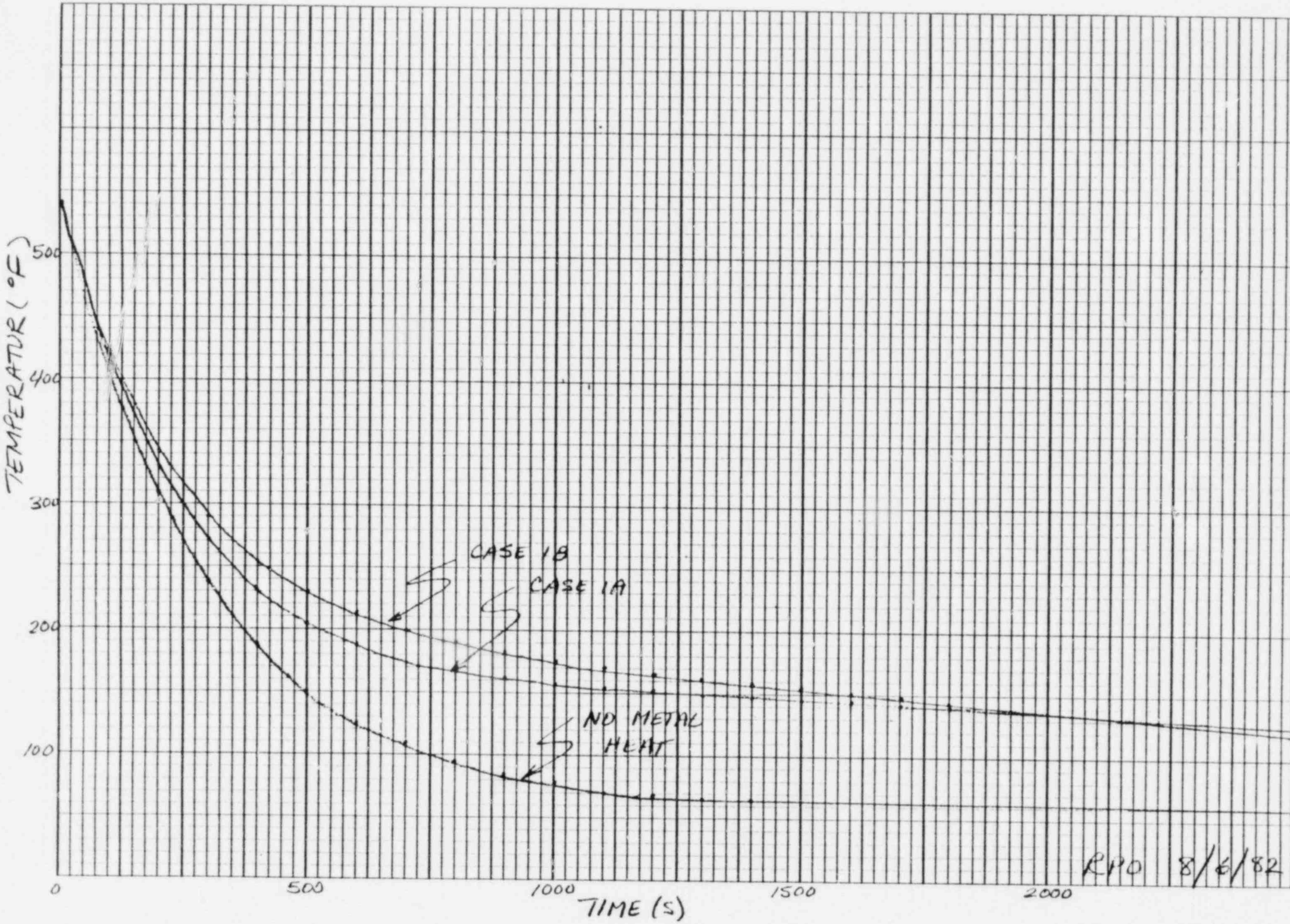
2.) Case 3 is believed to be most realistic because of the HPI flow split which will yield a larger volume for mixing as well as more surface area for metal heat release.

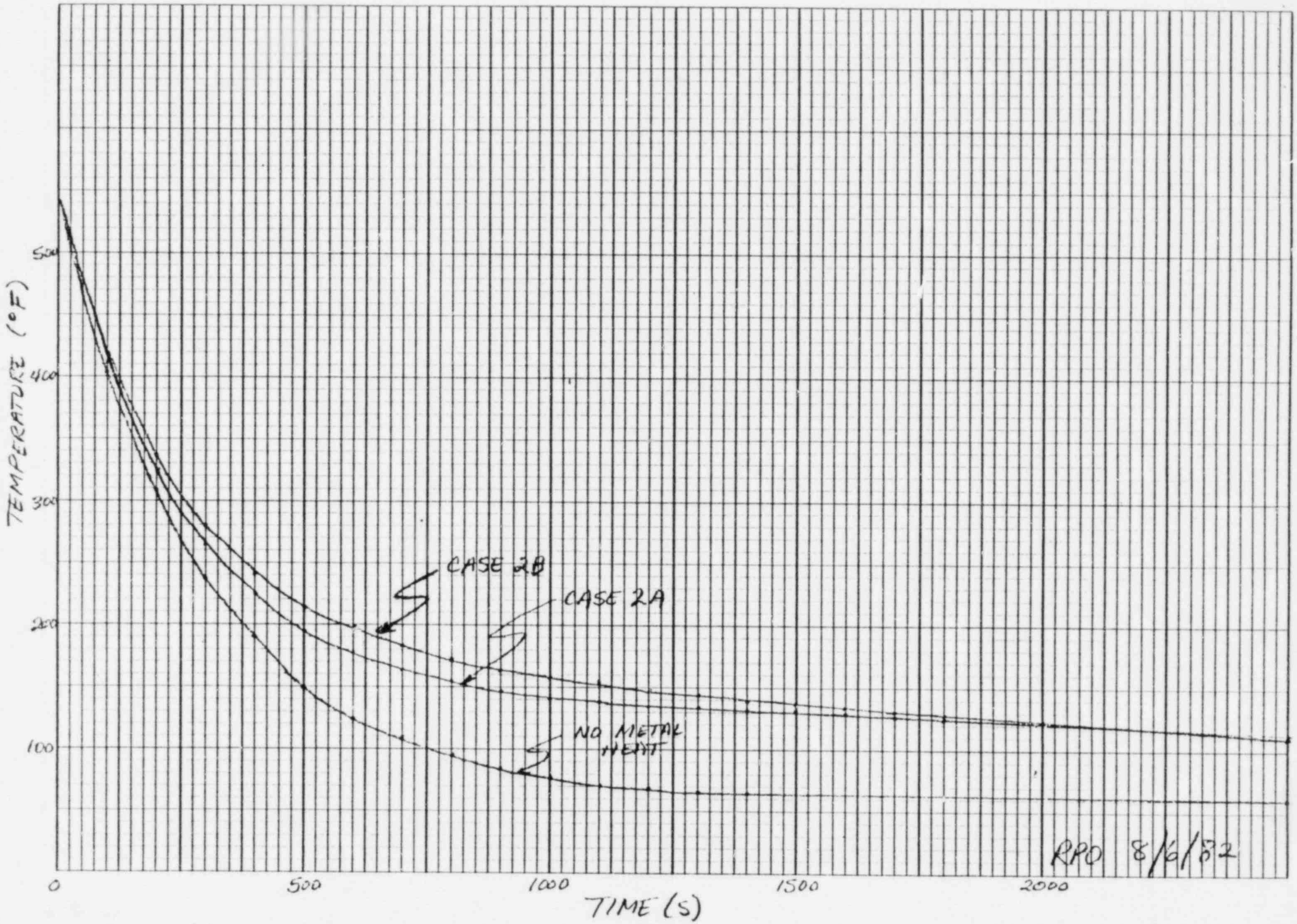
HEAT TRANSFER COEFFICIENTS

	Beta = .1	Beta = .06 T_{min} 120
t	h $\frac{Btu}{hr}$ ft.^{2} - °F	h $\frac{Btu}{hr.}$ ft.^{2} °F
500	492	506
1000	369	433
1500	288	361
2000	240	302
2500	209	258
3000	188	224

K·E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

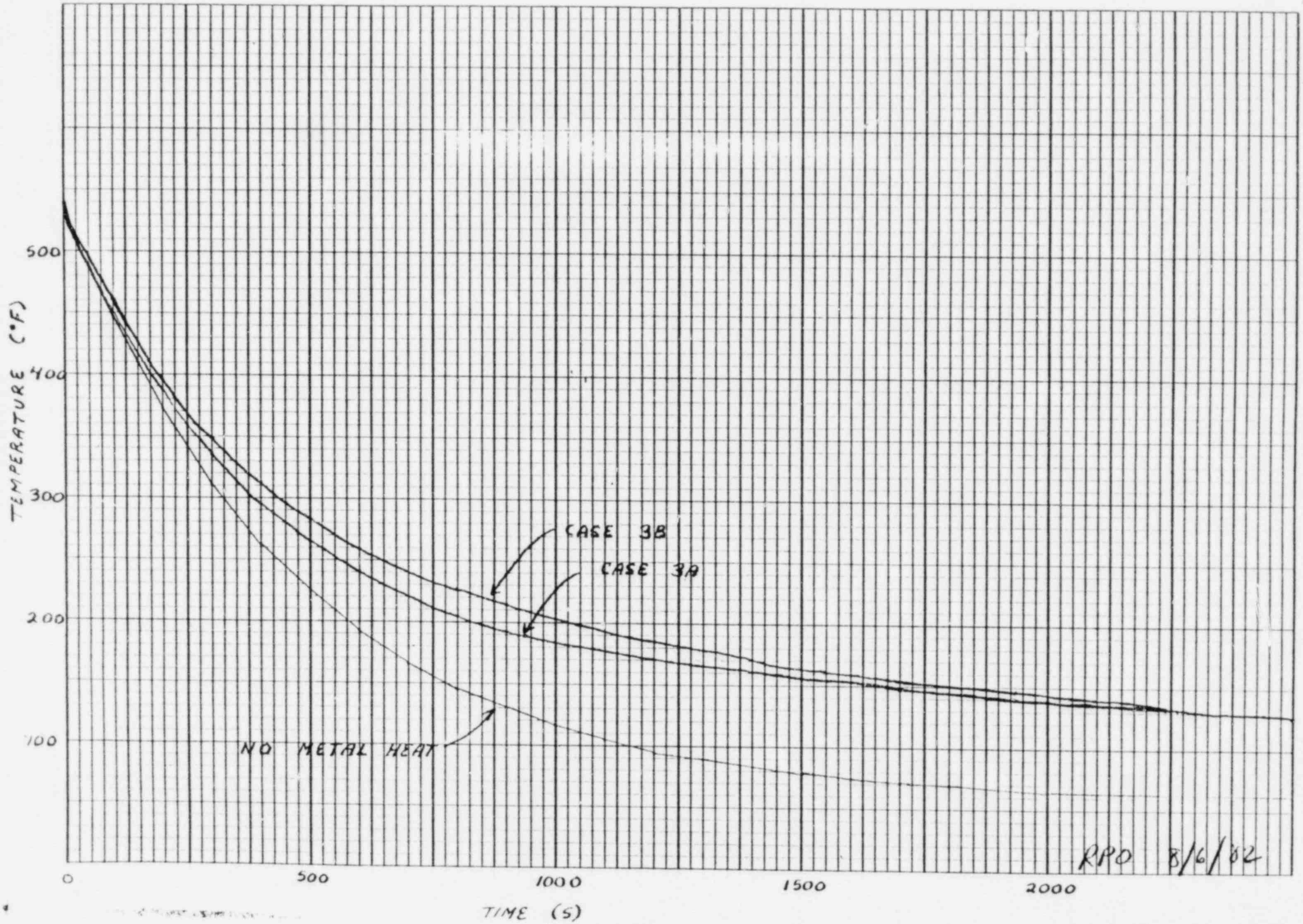
46 0780





TEMPERATURE (°F)
500
400
300
200
100
0
500
1000
1500
2000
TIME (S)
CASE 2B
CASE 2A
NO METAL HEAT
RPO 8/6/82

46 0780


500
400
300
200
100
TEMPERATURE (°F)
0
500
1000
1500
2000
TIME (S)
CASE 3B
CASE 3A
NO METAL HEAT
RPO 8/6/82

ATTACHMENT 4