Met-Ed / GPU

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Writer's Direct Dial Number

January 4, 1980
GQL 1575
TLL 003

TMI Support
Attn: J. T. Collins Deputy 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)
License No. DPR-73
Docket No. 50-320
Natural Circulation

Enclosed please find the response to your letter of November 5, 1979, concerning Natural Circulation, which discusses the changes in the Reactor Coolant System operating parameters which occurred in mid-October.

Sincerely,

R. F. Wilson

R. F. Wilson
Director - TMI-II

RFW:LWH:hah

Enclosures

cc: R. Vollmer

A041
S 1/1

P 8001240 398

ITEM 1 Provide the best estimate of steam generator water level over the last 6 months.

RESPONSE **Steam Generator Level**

Shortly after the accident it was recognized that steam generator secondary side level instrumentation located external to the Reactor Building would have to be installed. Procedure Z-73 was developed to do this, and the instrumentation was installed and calibrated according to that procedure in early April. The method used existing taps on the main steam lines and main feedwater lines. Calibration of the dp cell utilized the then still functional steam generator "operate" range instrumentation. Following loss of the in containment instrumentation, the steam line to feed line Δ P was used for setting steam generator "A" secondary line.

On October 9, 1979, diverging "A" loop Δ T and oscillatory behavior of the temperature in that loop alerted the operating staff to the potential for breakdown of natural circulation. GPUSC Technical Support engineers investigating the circumstances surrounding the sudden change believed that condensate collecting in low points of the main steam lines was causing partial blockage of steam flow to the condenser. Since the steam generator level pressure tap on the steam line would be adversely affected by this phenomenon also, a cross check method of measuring Steam Generator level using a manometer was devised. This cross check showed that at that time (October 12) the actual "A" steam generator level was approximately 80" to 100" higher than previously thought. Whether this condition had existed since shortly after the calibration, whether the original calibration was in error, or whether the error occurred over a short 2 or 3 day term just before the departure of "A" loop temperature from steady values, is open for conjecture. No supportive logs, instrumentation graphs, or the like for directly placing a time of occurrence exist to our knowledge. However it is, we believe, reasonable to assume that this error occurred gradually over a short time just prior to October 9.

On Sunday, October 6, the Turbine Bypass valve was closed slightly to hold Reactor Coolant "A" loop hot leg temperature in the 160° - 180° range, this is in accordance with operating procedure Z-39 for natural circulation. At approximately this same time, TMI was experiencing it's first cold weather of the year; dropping temperatures in the annulus around the Reactor Building would have caused, accelerated, or exacerbated the condensation problem in the steam lines. The resulting bias in the steam generator level measurement would then have led to the over fill problem. Overfeeding would in turn have made the condensate collection in the steam lines worse due to liquid spill over (for real secondary water levels greater than 423"), and would have masked the fact that too little steam was being vented to the condenser. Assuming this scenario, the probable range of OTSG "A" secondary side water level is shown in Figure A. (Attachment 1 contains more details of the events and actions.)

ITEM 2 Correlate steam generator water level to loop flow.

RESPONSE Steam Generator Water Level to Loop Flow Correlation

Increasing the secondary side water level in a Babcock & Wilcox O.T.S.G. will increase the driving head available for promoting natural circulation. A simplified method for calculating the driving head for a given steam generator water level is detailed in the Babcock & Wilcox report "Natural Circulation Stability of TMI-II (BAW-1562)" copies of which have been sent to NRC. Using this method and inputting values for reactor coolant temperature and flow prior to October 9, then correcting for possible changes in steam generator secondary side inventory, does not predict the flow and temperature currently existing. This suggests then a change in flow patterns from those assumed in the original Babcock & Wilcox simplified model.

Babcock & Wilcox has reviewed the operating data and has offered hypotheses on the changed flow patterns now occurring in the "A" loop. Their conclusions are written up in the attached letter (See Attachment 2). We agree with their analysis and conclusions but caution that the existing reactor coolant instrumentation (though sufficient is a basis for safe operation of the plant) is not suited to the task of proving the hypotheses in a detailed, conclusive manner. It should also be noted that while the bulk of the discussion concerns the anomalous behavior of the temperatures, the data clearly shows that natural circulation cooling of the core continues to provide acceptable cooling. This is exemplified by the Incore Thermocouple Data which show the historically highest temperature readings falling off with the decrease in core decay heat. Attachment 3 is a graph of Incore Thermocouple 8-H over the period August 1979 thru the present. Incore Thermocouple 8-H is located in the center of the core pattern and has consistently given the highest temperature readings.

ITEM 3 Revise EP-34 to reflect higher allowable loop ΔT (lower flow).

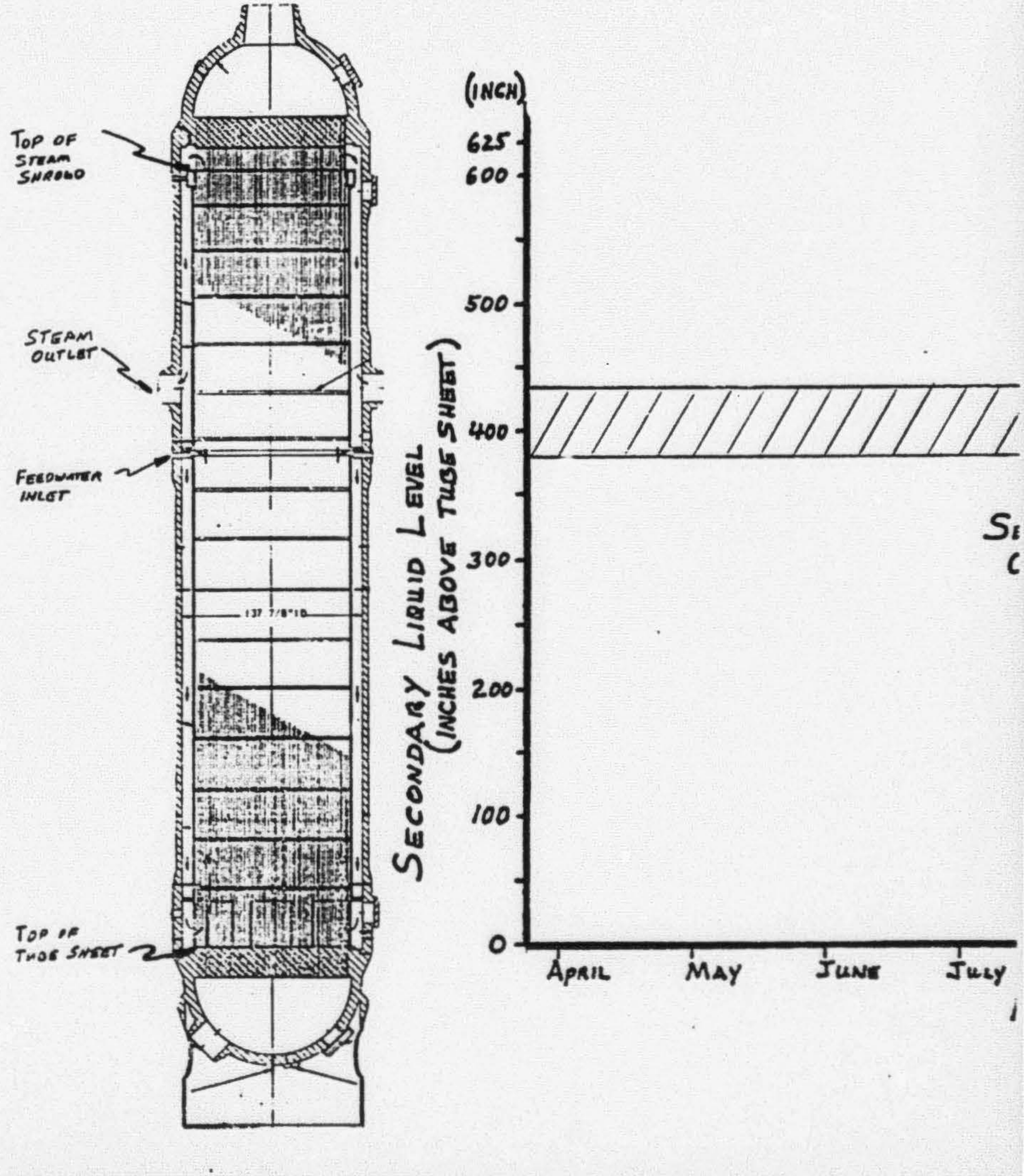
RESPONSE EP-34 Revision

Revisions to the Loss of Natural Circulation Procedure EP-34 have been prepared and are currently in the review process. Deletion of the administrative alarm loop ΔT 20°F or greater indicating loss of natural circulation is included in this proposed revision. Continued monitoring of this important parameter will obviously be required.

ITEM 4 Place NRC on distribution for regularly recorded Control Room data.

RESPONSE Documentation of Plant Operating Data

The official vehicle for documenting the TMI-II plant operating data is through your Mr. E. Kevin Cornell, Deputy Executive, Director for Operations. He receives microfilmed copies of all data. Due to the processing time, some time lag exists. However, microfilm covering all operating data through November 26, 1979 has been sent.


Top of Steam Shroud
Steam Outlet
Feedwater Inlet
Top of Tube Sheet
137 7/8" ID
(INCH)
625
600
500
400
300
200
100
0
Secondary Liquid Level (Inches above Tube Sheet)
April
May
June
July
Se
(

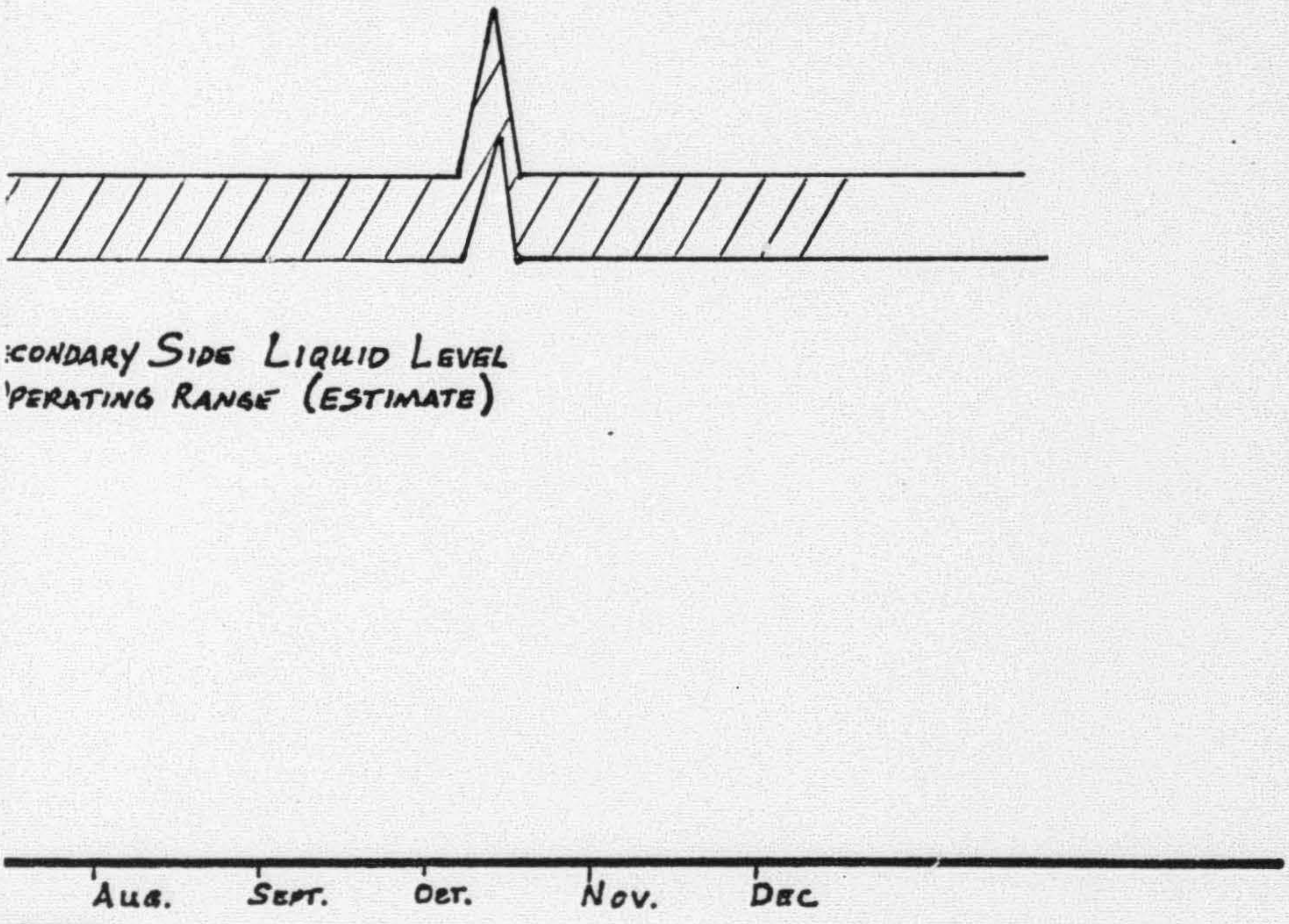

CONDARY SIDE LIQUID LEVEL
PERATING RANGE (ESTIMATE)
AUG.
SEPT.
OCT.
NOV.
DEC
979

FIGURE A

Historical review of events surrounding the loss of
Steam Generator "A" level 10/12/79

Attachment 1
TLL 003

On Tuesday, October 9 the cold leg on Steam Generator "A" began to oscillate about ± 4° in one hour cycles. Also the hot leg temperature started increasing at an average rate of 0.1° per hour. The following is a report of what was found during the investigation to determine the cause and remedies for this behavior.

I. Investigation of potential items that caused temperature abnormalities

A. The increase in the hot leg temperature (T_h) indicates that the resistance to flow from the steam generator to the condenser was increasing.

1. The turbine bypass valve controlling this flow had been reduced from 16% flow to 14% flow Saturday, 10/6/79.
2. Review of the Main Steam Line Drain process indicated that the steam lines were not being drained. The drain line were opened daily for five minutes during the past few months, however, a no flow condition was indicated by the drain lines being cold during this operation.
3. The drain line connection into the condenser was disassembled and found to be pluged with rust particles. The line was cleared and flow was established.
4. It was found from water level indicators installed [illegible] steam lines that both lines were filled [illegible] water [illegible] the [illegible] the Steam Generator to the Condenser.
5. It was also noted that the air temperature around the steam lines had reduced significantly. This drop in temperature would increase the heat loss from the Main Steam Line and increase condensation in the line.

B. The rapid increase of condensed water in the steam lines indicated that sources other then condensation may be contributing to the accumulation. Possibility of leakage through the steam generator shroud instrumentation opening was then investigated. Should the actual level be above 423 inches in the Steam Generator the leakage would flow directly into the steam line.

1. The differential pressure gauge used to measure the Steam Generator water level is connected to the Turbine Bypass line downstream of the Main Steam Line. With the steam line blocked the instrumentation would indicate a reference Steam Generator overpressure less then what would actually exist. The amount of this error was estimated to be as much as 3.0 Psi. I.E., the measured temperature of the bypass line was 120°F with a Psat of 1.69 psia and the highest expected pressure in the Steam Generator would be TH = 160o with Psat = 4.74 Psia.

2. The tubing from the steam line to the differential pressure gauge was found to have a vertical drop of about 10 feet. This length of tube will collect steam condensation and cause the differential pressure gauge to indicate a pressure of 5.0 psia greater then actually exists. When this tubing was cleared by allowing atmosphere air pressure to draw the condensed water into the steam line, the steam generator level indicator in the Control Room pegged at its upper limit of 480". Actual estimatedlevel was assumed to be approximately 500" when accounting for the two compensating errors.

3. Makeup water was being continually added to the Steam Generator at an unknown rate. The valving arrangement was manually opened to adjust the flow. Without Steam Generator level indication the amount of flow could not be detected.

II. Remedial actions required to prevent temperature fluctuations

A. The accumulation of water in the steam line prevents direct communication of pressure conditions from the Turbine Bypass Valve to the Steam Generator.

1. When the steam lines are completely full the [illegible] into the [illegible] [illegible] that exists when the steam line is empty or partially filled. For this reason the draining of the Main Steam Lines should be constantly pursued to insure a stable flow conditions.

2. The exact measurement of Steam Generator water level is necessary to maintain a constant driving force for primary circulation. Currently an interim method of measurement is being used for this measurement. This

interim system uses the Steam Generator sample drains to determine the hydraulic water pressure. It is corrected by using a pressure calculated from the primary T hot temperature. Although this method provides a consistant measurement scheme it is not exact and could indicate as much as 60 inches higher then actually exists if T cold was used. Another concern with this instrumentation is that the hydraulic pressure measurement system could be as much as ± 15 inches off as a result of the physical readings from the chart being used.

3. Pressure communication from the turbine bypass line to the Steam Generator will result in exact pressure readings with corrections for steam head and flow losses. A pressure reading at this location should be used in conjunction with the sample line hydraulic pressure to determine the exact steaming levels. Caution should be taken to assure that any instrumentation tubing taken from the top of the Turbine Bypass Line has a direct upward slope to the pressure measuring transducer. (i.e., no loop seals to accumulate condensed steam).

4. The flow rate into the Steam Generator would provide a limiting control of water level. A flow detector and metering device on the feed line would provide assurance of water level control should the level instrumentation temporarily malfunction. This flow device would also allow a method for determining the heat rejection from steaming of the generator.

A. PROBLEM

Further evaluation and explanation of the variation in natural circulation behavior which occurred starting 10/9/79, and has since become the norm.

B. REFERENCES

1. Telecopy from S. J. Engel to L. C. Rogers on 10/17/79, Explanation of Deviant Flow Behavior, 03-05-008.
2. Natural Circulation Stability Report by S. H. Esleeck and J. E. Lemon, June 29, 1979, BAW-1562.
3. Memo from L. C, Rogers to B. Elam, LRC-084, "Review of "A" OTSG Steaming Test Data," September 12, 1979.

C. DISCUSSION

CAUSE OF THE DEVIANT BEHAVIOR

The cause of the deviant behavior which started on 10/9/79 is not attributed to any one factor but is due to many factors. The factors that contributed to the deviant behavior are indicated below:

1. The TBV setting was reduced from 15% to 13% on 10/7/79 causing a slight imbalance between heat generated and heat removed. The result was a gradual increase in the temperature of the "A" loop reactor coolant system of approximately 1.5 F from 155 F on 10/7/79 to 156.5 F on 10/8/79 (See Figure 2). This upset in the equilibrium between decay heat generated and removed continued until 10/14/79 with the "A" loop average primary temperature increasing another 4 F to 160.5 (Figure 3). The gradual temperature increase was finally halted on 10/14/79 as the TBV setting was increased to 17%; this allowed an adequate increase in steam flow rate to more than remove decay heat as the "A" loop temperature started an immediate decrease (Figure 3).
2. A cold weather front came into the Harrisburg area on approximately 10/9/79. This had the effect of reducing make-up tank temperature

from approximately 130 F on 10/8/79 to 124 F on 10/12 to 117 on 10/10. Similarly the feedwater temperature was reduced from approximately 75 F on 10/8 to 66 F on 10/11; it was subsequently increased to about 70 F on 10/16/79. The condensor vacuum may have also changed slightly though there has been no indication on the instrumentation; the reading remained uniform at about 28½-29" Hg.

3. When the "B" loop burps it causes temperature oscillation in the "A" loop. These were very mild prior to 10/2/79 but the 10/2/79 and 10/6 "B" loop burps showed significant temperature oscillations (See Figure 1). Following the 10/2 and 10/6 burps the "A" loop temperature oscillations were dampened out after about 12 hours since the system was in steady state equilibrium <u>except</u> for the "B" loop burp perturbations. However, following the "B" loop burp of 10/9 with the addition of the perturbations due to the 13% TBV position and the temperature changes due to the cold front, the system was unable to dampen out the initial "A" loop temperature oscillations (Figure 2). In fact, the "A" loop temperature oscillations got stronger particularly between the "A" loop cold legs, which suggests some form of unstable fluid flow interaction between the cold legs. This fluid flow interaction increases the cold leg "riser" ΔP and therefore reduces the driving head for natural circulation. Since the driving head is reduced the flowrate is also reduced. This results in an increase in the "A" loop equilibrium ΔT from approximately 8 F on 10/8/ to 12 F on 10/11. With the reduction in driving head the system is even more susceptible to "B" loop burp perturbation than it was on 10/9. For example, the system burped only 2 days later on 10/11 (versus the normal 3-4 day period). This burp triggered a similar decrease in driving head as did the 10/9 burp, and a new equilibrium ΔT of 17 F was established. The 10/13 burp resulted in a third flow reduction and a ΔT increase to about 22 F before the TBV setting was increased (Figure 3).
4. There are two other factors in addition to the cold leg fluid flow interactions which reduce the driving head for natural circulation:

(1) As the flow rate decreases the "A" loop cold leg temperatures decrease even further since they are transferring essentially the same amount of heat to the reactor building water; i.e., as $\dot{m}$ decreases ΔT increases.

(2) As the system temprature increased from 155 F on 10/7 to 160.5 F on 10/14 the ambient heat loss is increasesed and this tends to further decrease the driving head for natural circulation. Natural circulation is best supported by having as much of the decay heat removed in the OTSG as possible.

5. Since there has been uncertainty about the OTSG water inventory during this period, this may also have been a factor since changes in OTSG level can also affect the driving head for natural circulation. A reduction in water level in the OTSG changes the temperature gradient on the primary side such that there is a reduction in the average density of the primary coolant in the OTSG. This reduces the ΔP of the OTSG (which is a downcomer in the natural circulation system) and therefore reduces the driving head for natural circulation. For example, a change in OTSG level from 430" to 330" would cause a reduction in the OTSG downcomer ΔP of .0065 psi. An identical reduction in natural circulation driving head would also occur. If it is assumed that an OTSG wtih a 430" level had a driving head of .0200 psi (Reference 2) and a resultant flow of 375 gpm and an "A" loop ΔT of 8 F, a reduction in the OTSG level to 330" would result in a driving head of .0135 psi, a flow rate of approximately 300 gpm and an "A" loop ΔT of about 10 F.

EVALUATION OF THE FLUID FLOW INTERACTION PHENOMENON

Reactor residual heat generation continues to decay (Figure 4) and the percent of this heat removed in the generator decreases as the ambient losses and heat removed by the makeup flow continue at constant level. For example, on August 29, 1979 the heat removed by the OTSG was estimated to be a maximum of 72% of the decay heat generated (1.9×10^6 Btu/hr) as per Reference 3. This results in ambient and makeup losses of approximately 0.53 x 10^6 Btu/hr (28%). On November 15, 1979 the decay heat level was about 1.25 x 10^6 Btu/hr (Figure 4). Assuming no change in ambient and makeup losses, the OTSG is transferring only 57% of the decay heat generated. This reduction in the percentage of heat transferred by the OTSG reduces the driving head for natural circulation since the heat loss (43%) may not be occurring in a downcomer. Heat loss in a downcomer promotes natural circulation where heat loss in a riser impedes natural circulation. The best example of this is the heat loss to the reactor building water due to a portion of the pump inlet piping being submerged in the water. The two parallel pipes are cooling "risers" in a complex natural circulation configuration. Anytime a cooling "riser" occurs in a natural circulation system the stability of natural circulation is challenged. The fact that the cooling risers are in parallel further complicates natural circulation of the system.

In order to evaluate and explain what is happening during the fluid flow interaction phenomenon it was decided to obtain detailed accounts of "A" loop inlet and outlet primary temperatures during three different periods of time. The method of obtaining this information was to borrow the "reactimeter" computer tapes from the site and obtain the hard copy computer printout and a computer plot of the "A" loop temperatures versus time. The reactimeter tapes record the measured variable every 10 seconds. The computer plots for the three different time periods are shown in Appendix A.

The first time period selected was from 0000-1000 on 10/16/79 (Figure 5). This period was selected since it represents a "steady state" period following the "B" loop burp on 10/13/79 even though there are very large fluctuations in the "A" loop cold leg temperatures every two hours. The "TT2" leg temperature fluctuations are greater than the "TT4" leg temperature fluctuations. The second time period selected was from 0000-1000 on 10/17/79. This time period represents the time before and immediately following the "B" loop burp which occurred at approximately 0330 on 10/17/79. Again, very large fluctuations were observed in the "A" loop cold legs during this period. The third period selected was from 1400-2400 on 10/17/79. This period showed very regular fluctuations of cold leg temperatures similar to a sawtooth pattern, with much smaller temperature changes than in the first two time periods.

The following conclusions have been made regarding the fluid flow interaction phenomenon which started on 10/9/79 and is now the norm after reviewing and evaluating the temperature plots in Appendix A:

1. The fluid flow interaction between the pump cold legs is actually a "burping" of the "A" loop "TT2" cold leg. The flow in this leg actually slows down, stops, and reverses for a short period of time resulting in a decrease in the total flow to the reactor coming from the TT4 "A" loop cold leg. During this phase of the burp cycle, the TT2 cold leg is slowing down because it is cooling off more rapidly than the TT4 cold leg. Its density increases until the leg is heavy enough to cause reverse flow. The reverse flow is only momentary, though, as higher temperature coolant is pulled from the reactor vessel into the TT2 cold leg (See Figure 6). This low density fluid causes the flow to reverse again with both legs now flowing in the same direction until the next cycle occurs.

2. The "A" loop TT2 cold leg burping (or reverse flow) occurs independently of the B loop burps; the cycle time is approximately 3½ hours. Inspection of the temperatures plotted every 2 hours (Figure 5) appears to show a different type of behavior between the period of 0000-1000 on 10/16 and 1400-2400 on 10/17. The large irregular temperature changes of the "A" loop cold legs in the first period conflict with the small regular sawtooth pattern temperature changes in the third period. However, examination of the reactimeter tape plots in Appendix A shows that the temperature behavior for the 2 periods is quite similar but appears different in Figure 5 because the 2 hour plotting interval is so

long that it may miss the large temperature fluctuation in the TT2 cold leg and becasue the "A" loop TT2 cold leg burps occur approximately once for every two (2) hour readings; i.e., they are in phase.

3. The "A" loop TT2 cold leg burping results in a variable primary flow as the ΔP in the cold leg changes throughout the flow cycle. The variable flow rate results in the primary temperature fluctuations observed and <u>is the cause</u> of the steam temperature variations also. This is verified since the incore T_{ave} is leading the "A" loop steam temperature by approximately 2 hours (See Figure 7). This means that <u>the "A" loop "TT2" cold leg burping is the primary cause of the cyclic primary temperatures, primary flow and steam temperatures observed since 10/9/79</u>.

PROJECTIONS OF EXPECTED BEHAVIOR

As the decay heat level continues to decay over the next few months (Figure 4) and if the TBV setting remains at 17%, it is expected that "B" loop burps will continue to occur every 3-4 days and "A" loop "TT2" cold leg burps will continue approximately every 3-4 hours. The "A" loop "TT2" cold leg burps will continue to be independent of the "B" loop burps and will result in similar "A" loop cyclic primary flows, primary temperatures, and steam temperatures that have been observed in the past. It is anticipated that the reduction in decay heat level over the next few months will result in reduced "A" loop primary system temperatures and a slight reduction in the "A" loop ΔT as the TBV setting remains at 17%.

A gradual reduction in primary system temperature will be required to maintain natural circulation in the future. Ambient and makeup losses at the present rate of approximately 500,000 Btu/hr are too high to support natural circulation when the decay heat level gets much below 1.0×10^6 Btu/hr. It is possible, though not anticipated, that the ambient and makeup losses will continue at about 500,000 Btu/hr level due to the possibility of: (1) primary system temperature not decreasing or (2) the lower cooling water and the reactor building sump and containment temperatures that will probably occur in the near future when the winter weather is here for good. Should this occur, natural circulation performance will be reduced with a resultant increase in the "A" loop primary system temperatures. However, stable natural circulation performance can be maintained by monitoring the temperature variables and taking corrective action, if required, in accordance with the Loss of Natural Circulation Procedure (EP-34).

D. CONCLUSIONS

The "A" loop TT2 cold leg burping is the primary cause of the cyclic primary temperatures, primary flow and steam temperatures observed since 10/9/79.

There is no concern with respect to core cooling now or in the next few months with continued operation of steaming in the "A" OTSG and the accompanying cyclical "B" loop burps and "A" loop "TT2" cold leg burps.

In order to maintain stable natural circulation over the next few months the thermal level of the system ("A" loop average temperature) must be reduced. This may require further opening of the "A" loop turbine bypass valve(s).

B&W recommends that the TBV setting be maintained at its present position of 17% open and that the temperature variables be monitored in accordance with EP-34 to ensure that stable natural circulation to remove decay heat continues.

POOR ORIGINAL

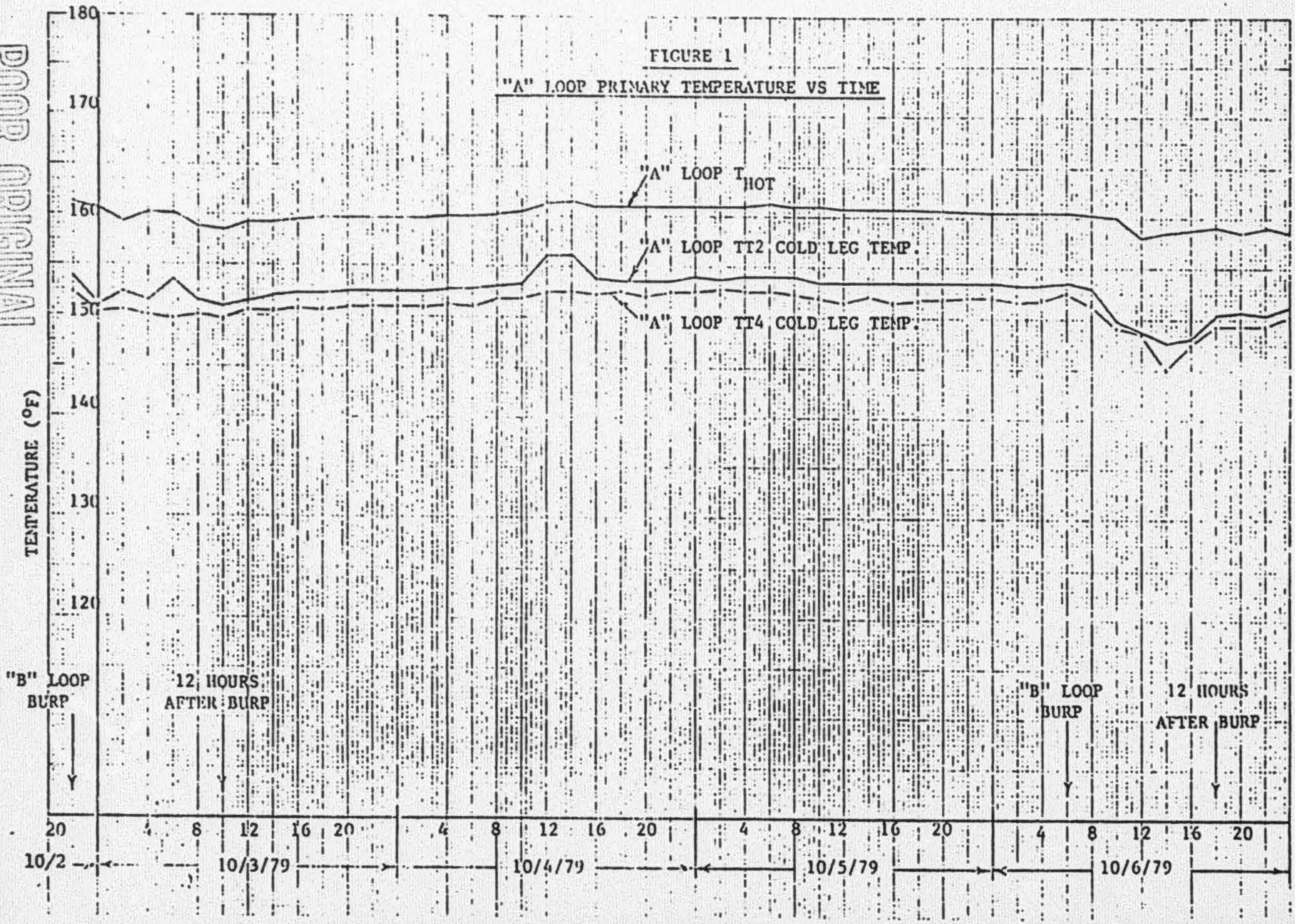


FIGURE 1

"A" LOOP PRIMARY TEMPERATURE VS TIME

46 1510

POOR ORIGINAL

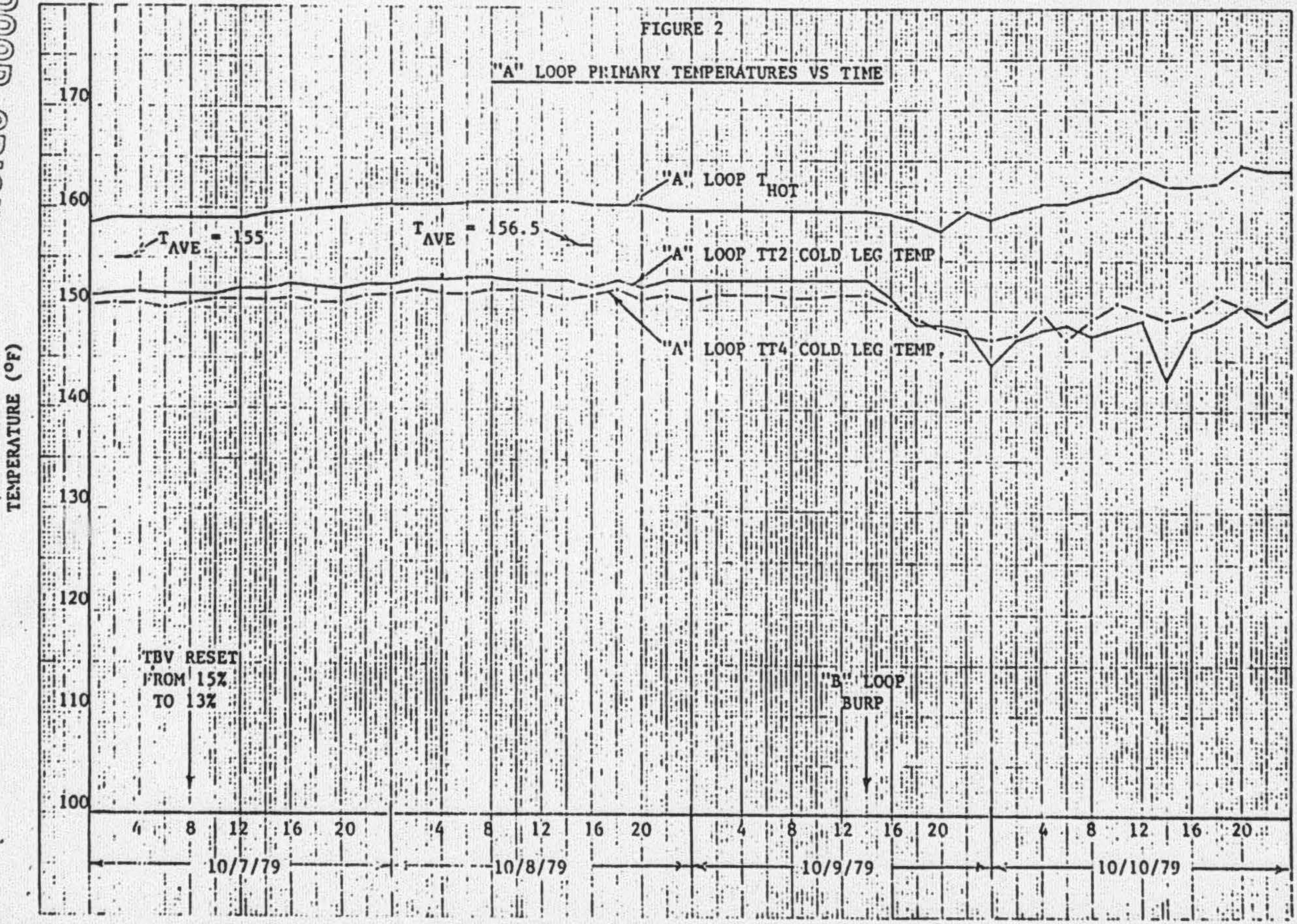


FIGURE 2

"A" LOOP PRIMARY TEMPERATURES VS TIME

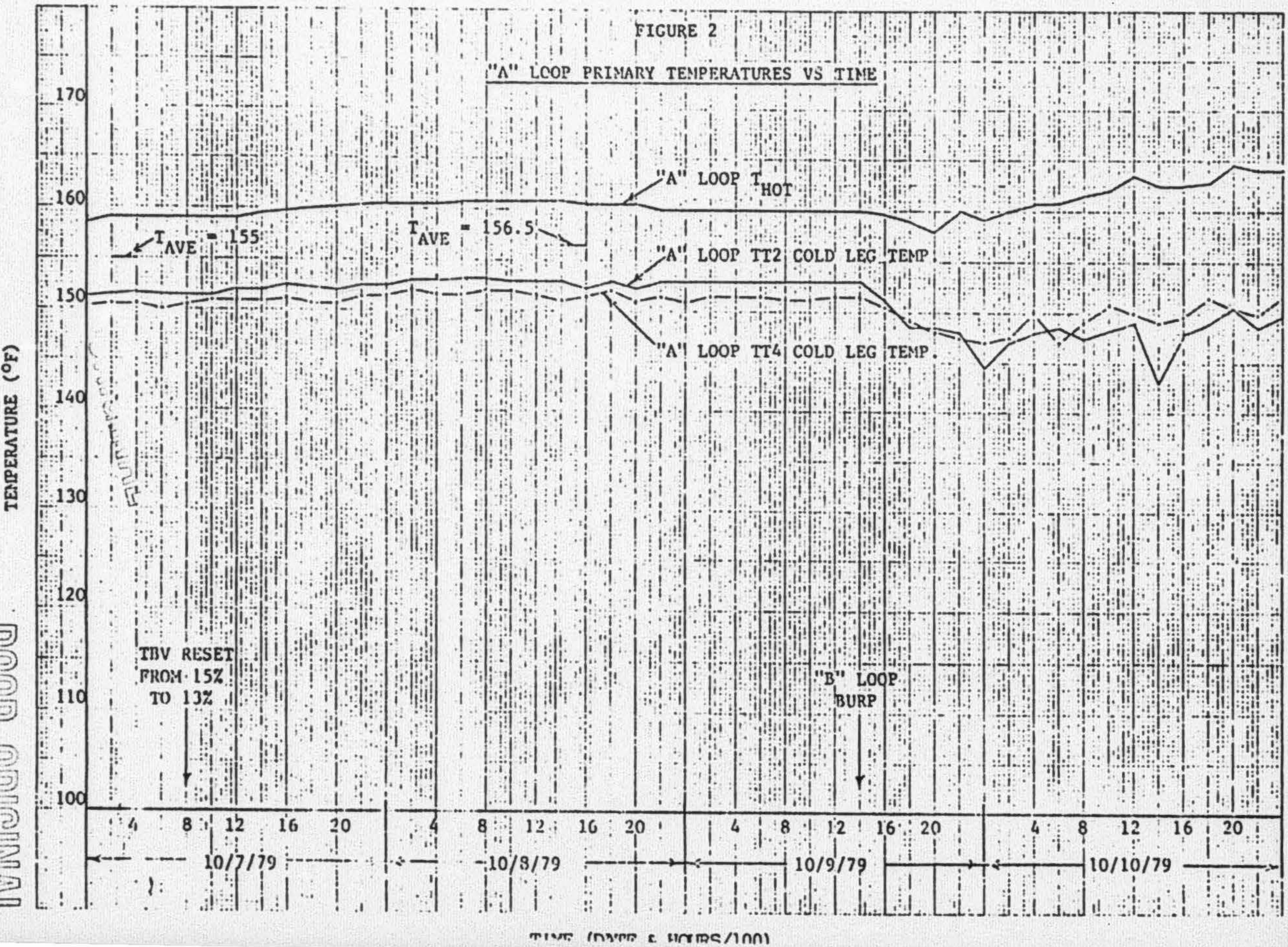


FIGURE 2

"A" LOOP PRIMARY TEMPERATURES VS TIME

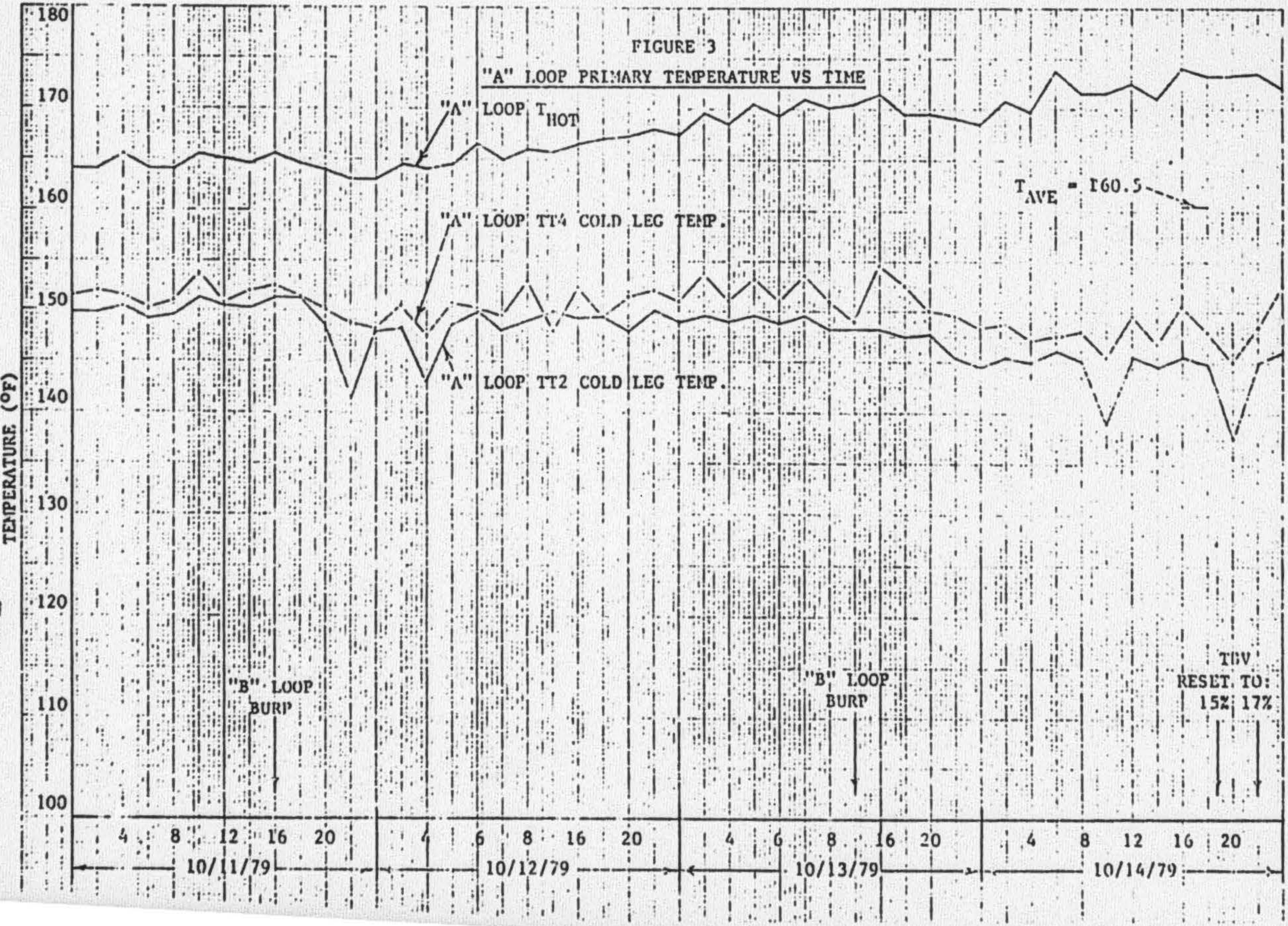
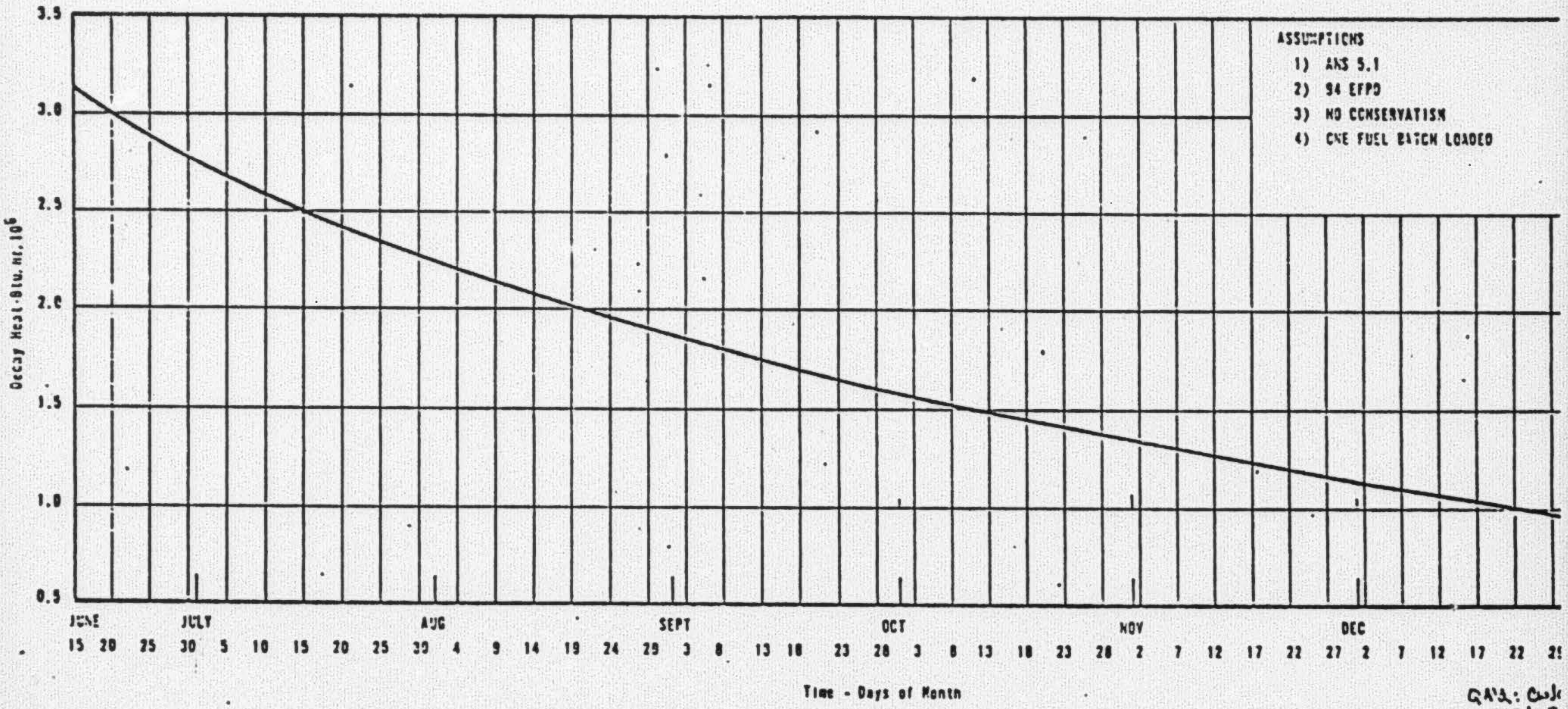


FIGURE 3

"A" LOOP PRIMARY TEMPERATURE VS TIME

FIGURE 4

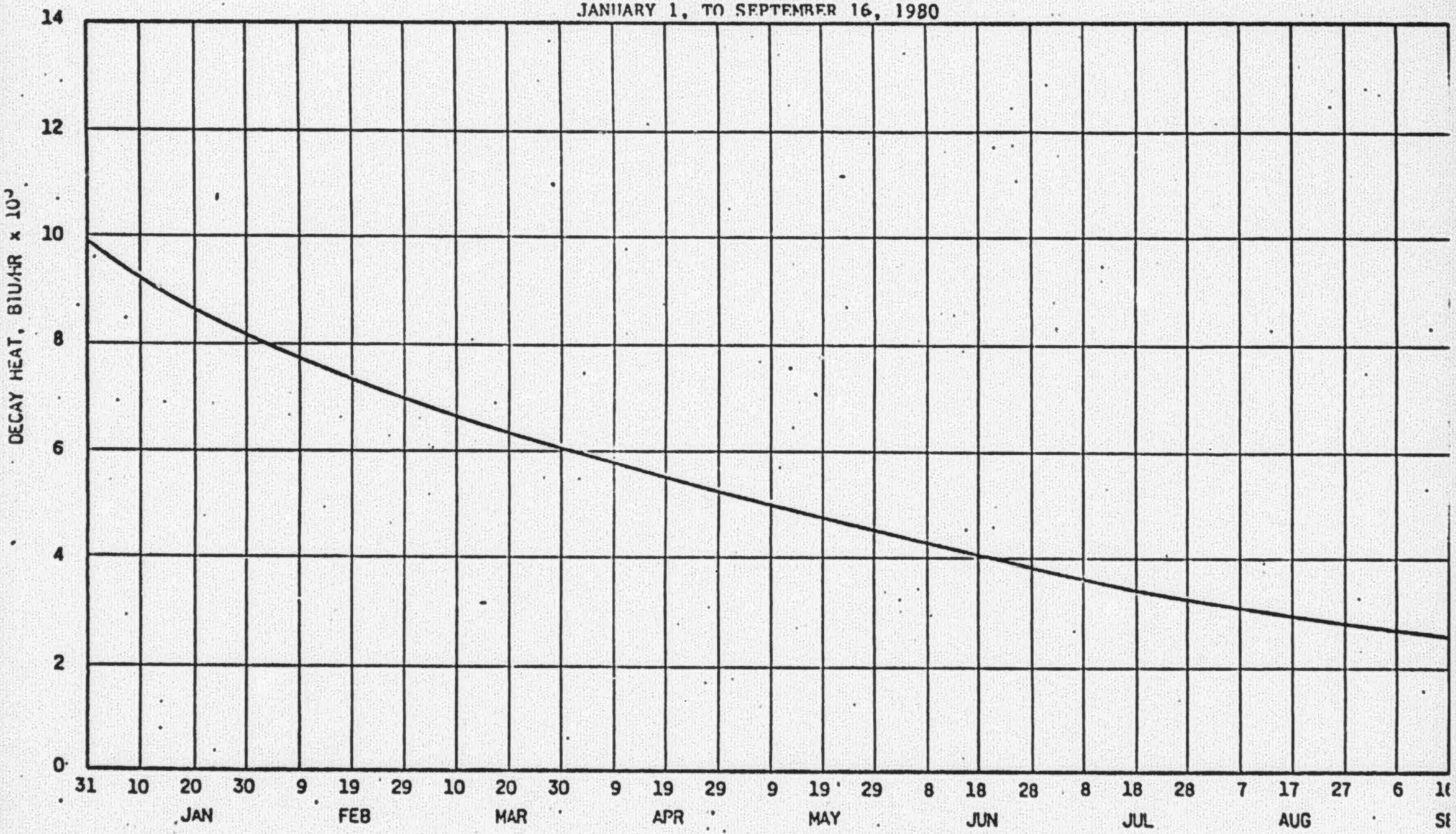
TMI-2 EXPECTED DECAY HEAT LOAD
VS TIME, JUNE 15, TO DECEMBER 31, 1979



QA'd: Cook
7 Aug 7

FIGURE 4
(Cont'd)

TMI-2 EXPECTED DECAY HEAT LOAD VS TIME
JANUARY 1, TO SEPTEMBER 16, 1980



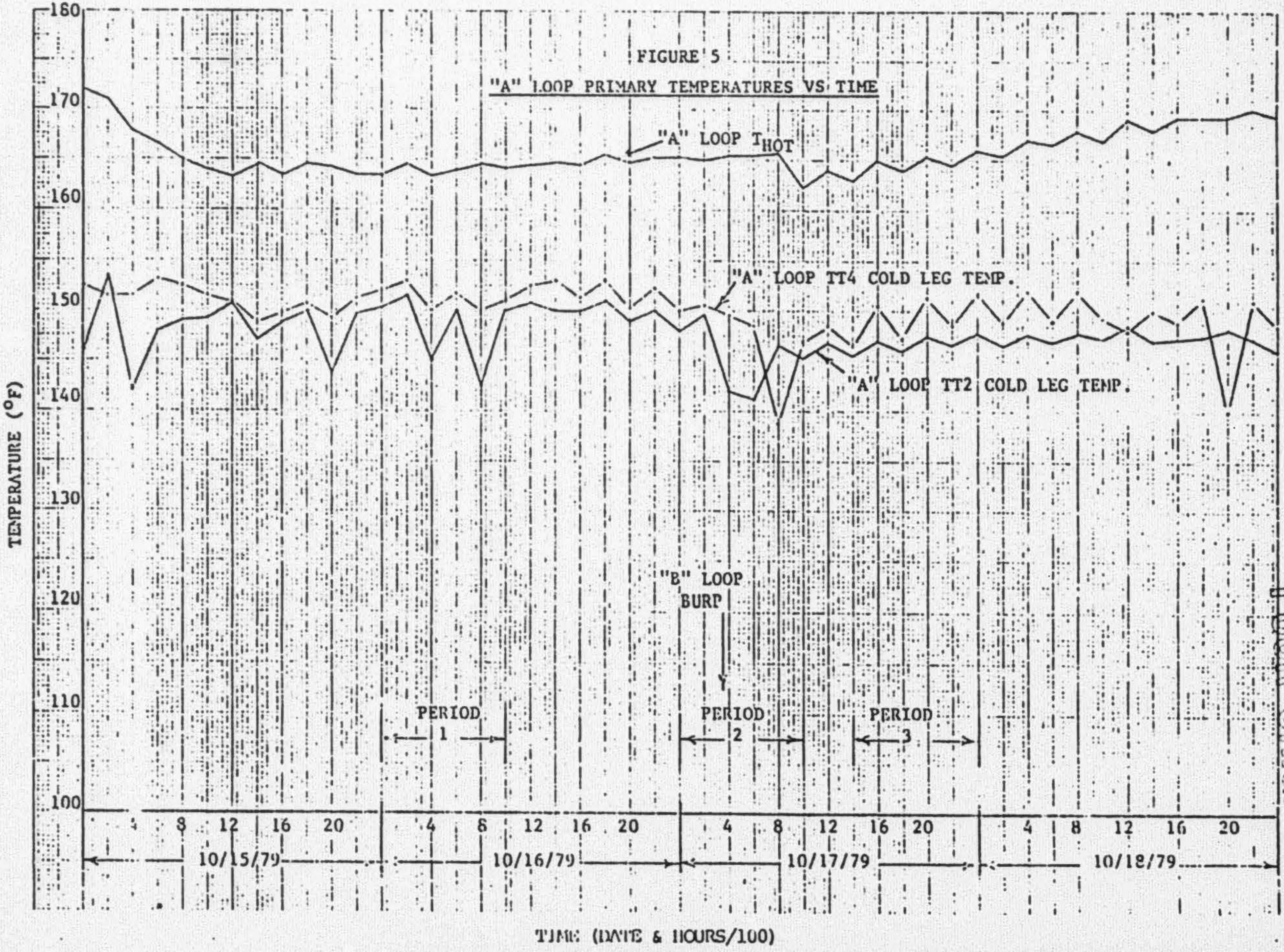


FIGURE 5

"A" LOOP PRIMARY TEMPERATURES VS TIME

FIGURE 6

"A" LOOP TT2 COLD LEG "BURPING" PHENOMENON

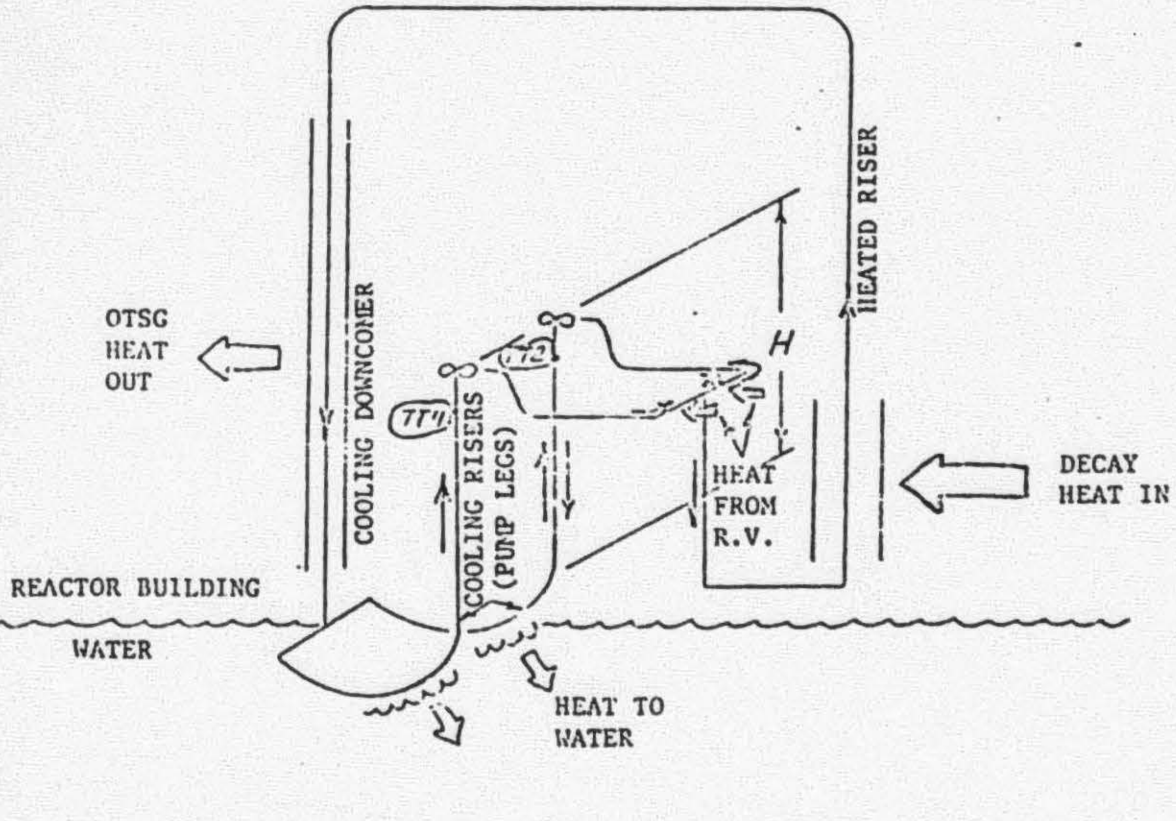
- Each pump leg transfers heat to the reactor building water at approximately the same rate.

- The TT2 pump leg has less flow than the TT4 pump leg (different inherent flow resistance due to position of the stopped pump rotor).

- The pump leg with the least flow (TT2) has a greater rate of temperature decrease as the result of heat loss to the building water.

- The colder pump leg (TT2) acting through height "H" develops a greater head in opposition to available natural circulation head and the flow in this leg slows down and reverses.

- The reverse flow pulls hotter water from the reactor vessel which displaces the colder water in the pump leg making it a "light" riser and re-establishing forward flow, and the cycle begins again.



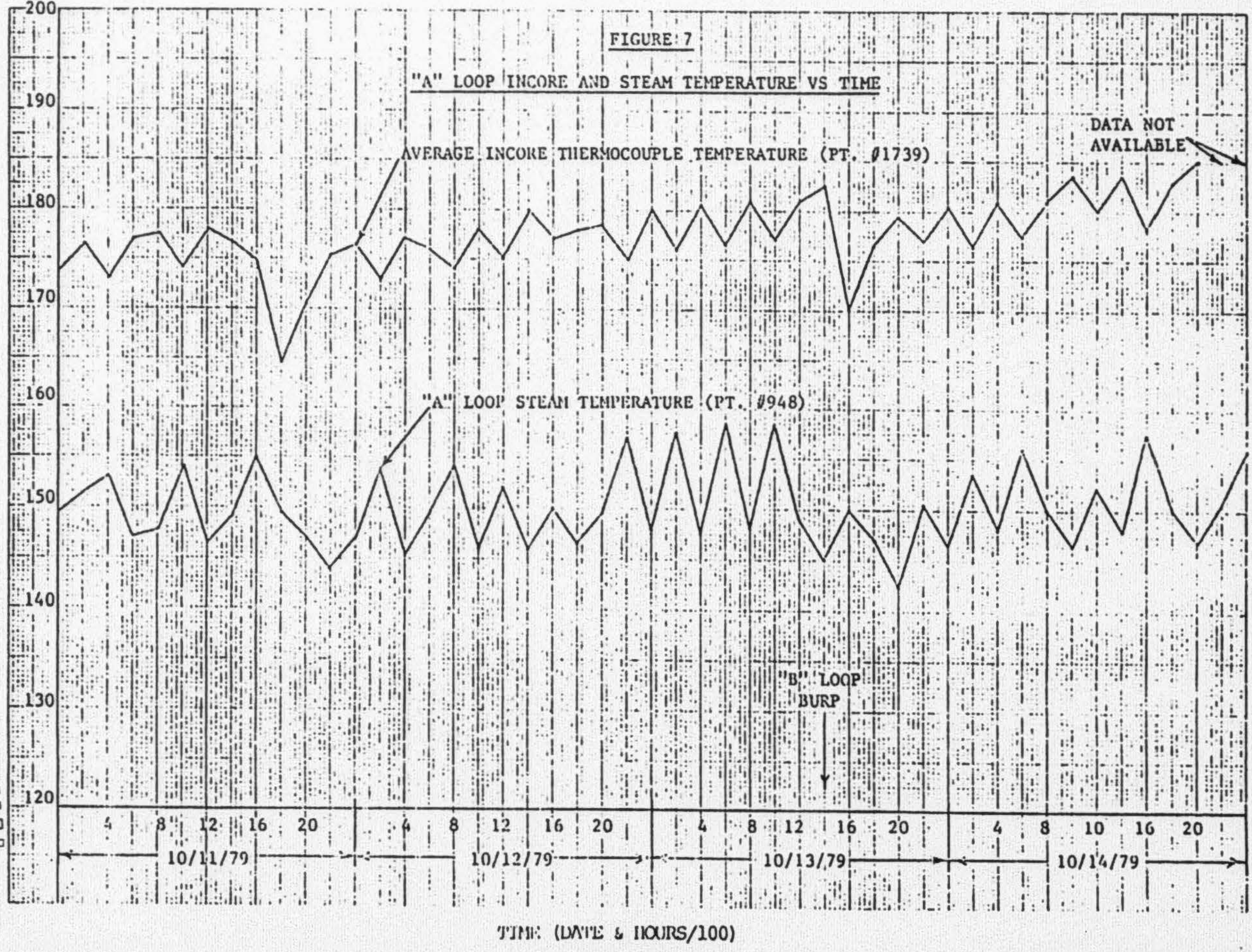
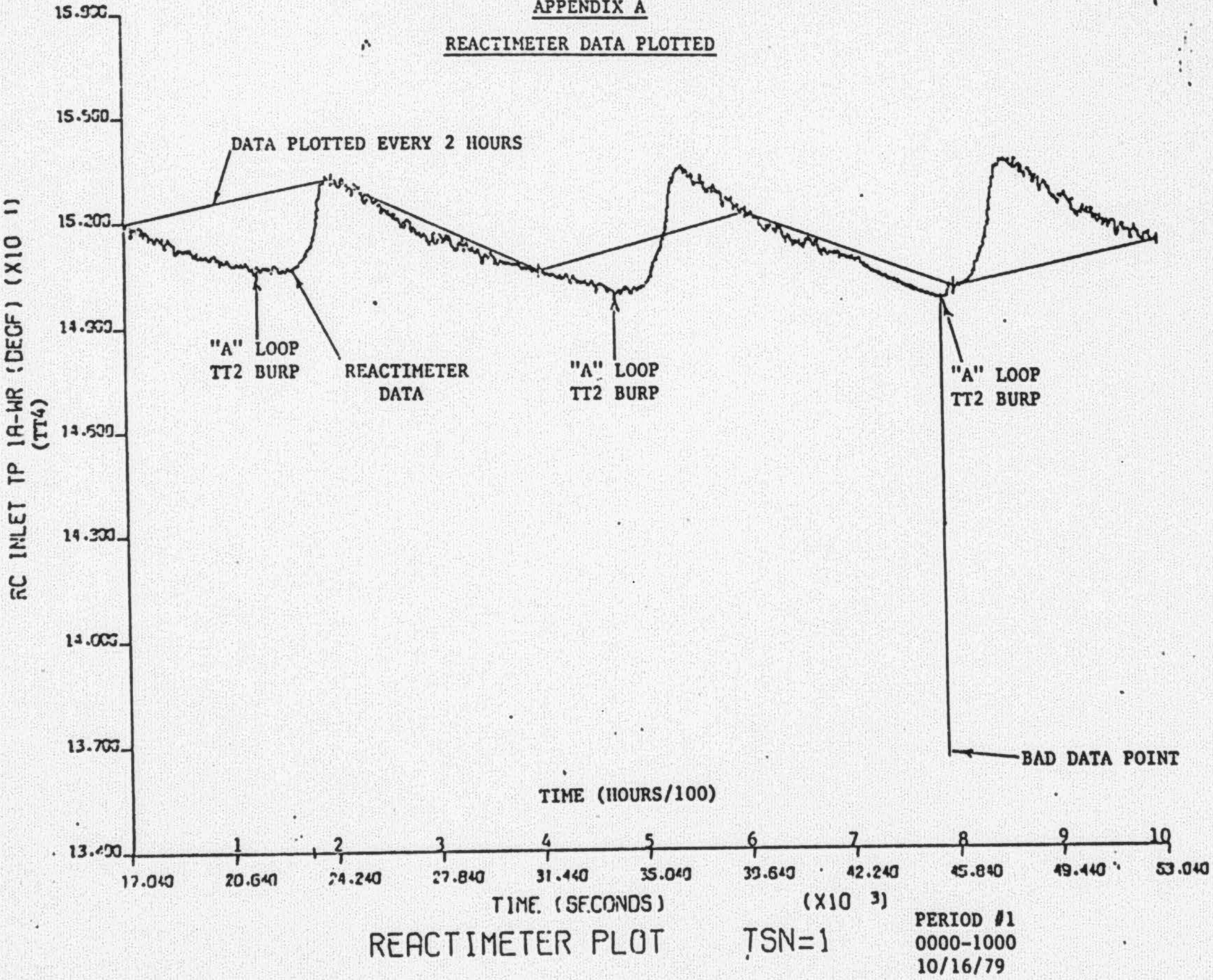


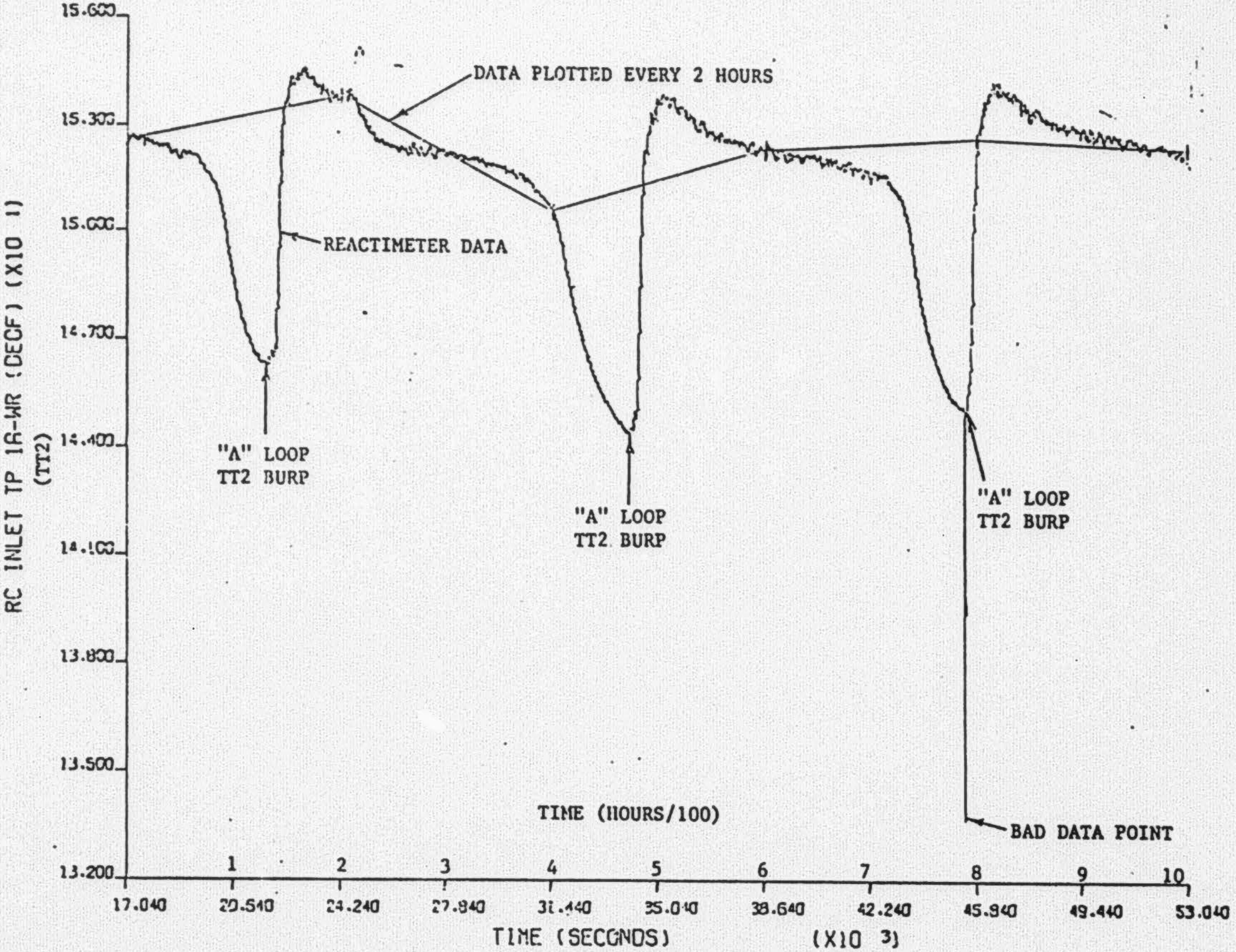
FIGURE 7

"A" LOOP INCORE AND STEAM TEMPERATURE VS TIME

APPENDIX A

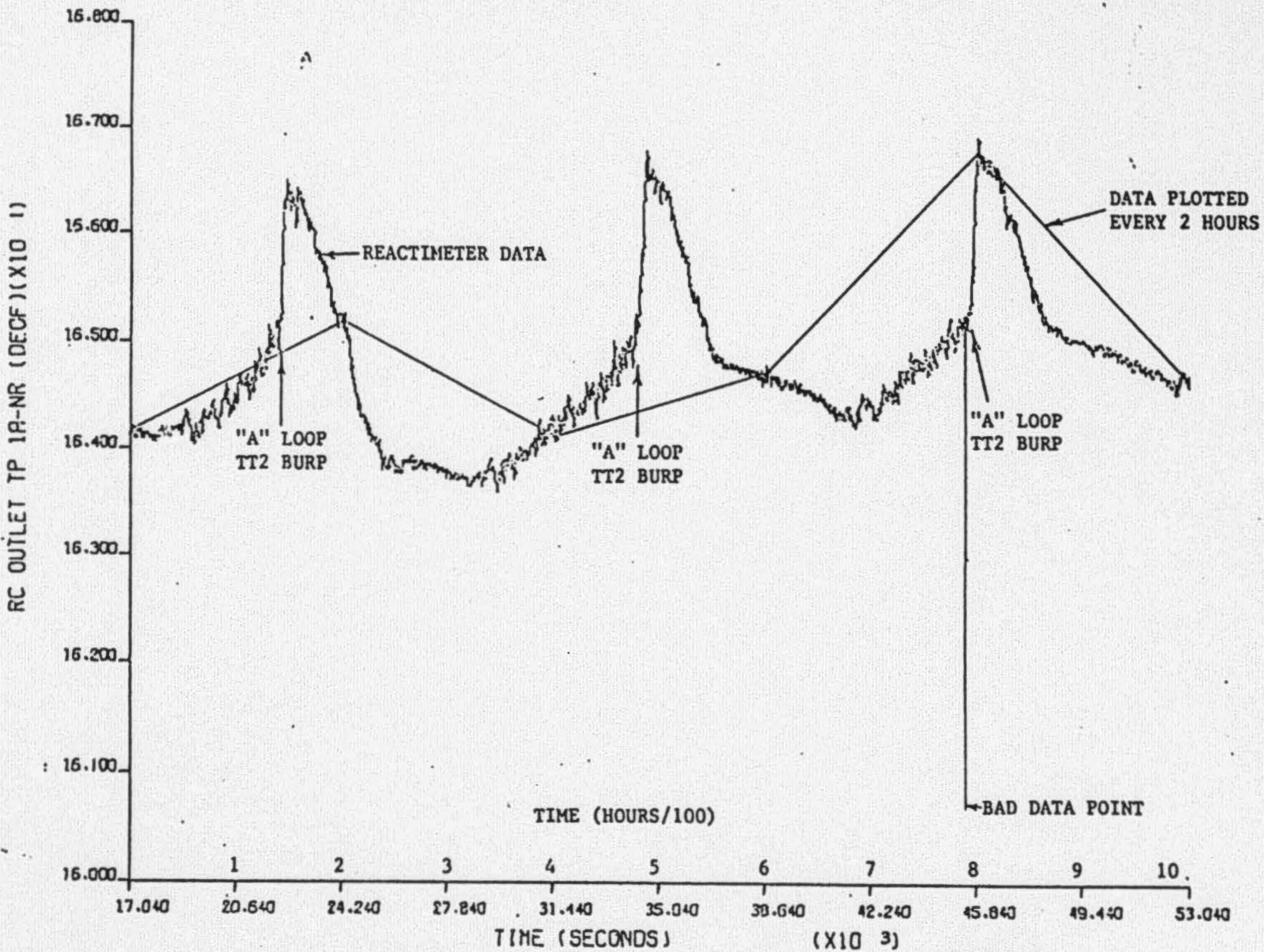
REACTIMETER DATA PLOTTED





REACTIMETER PLOT TSN=1

PERIOD #1
0000-1000
10/16/79



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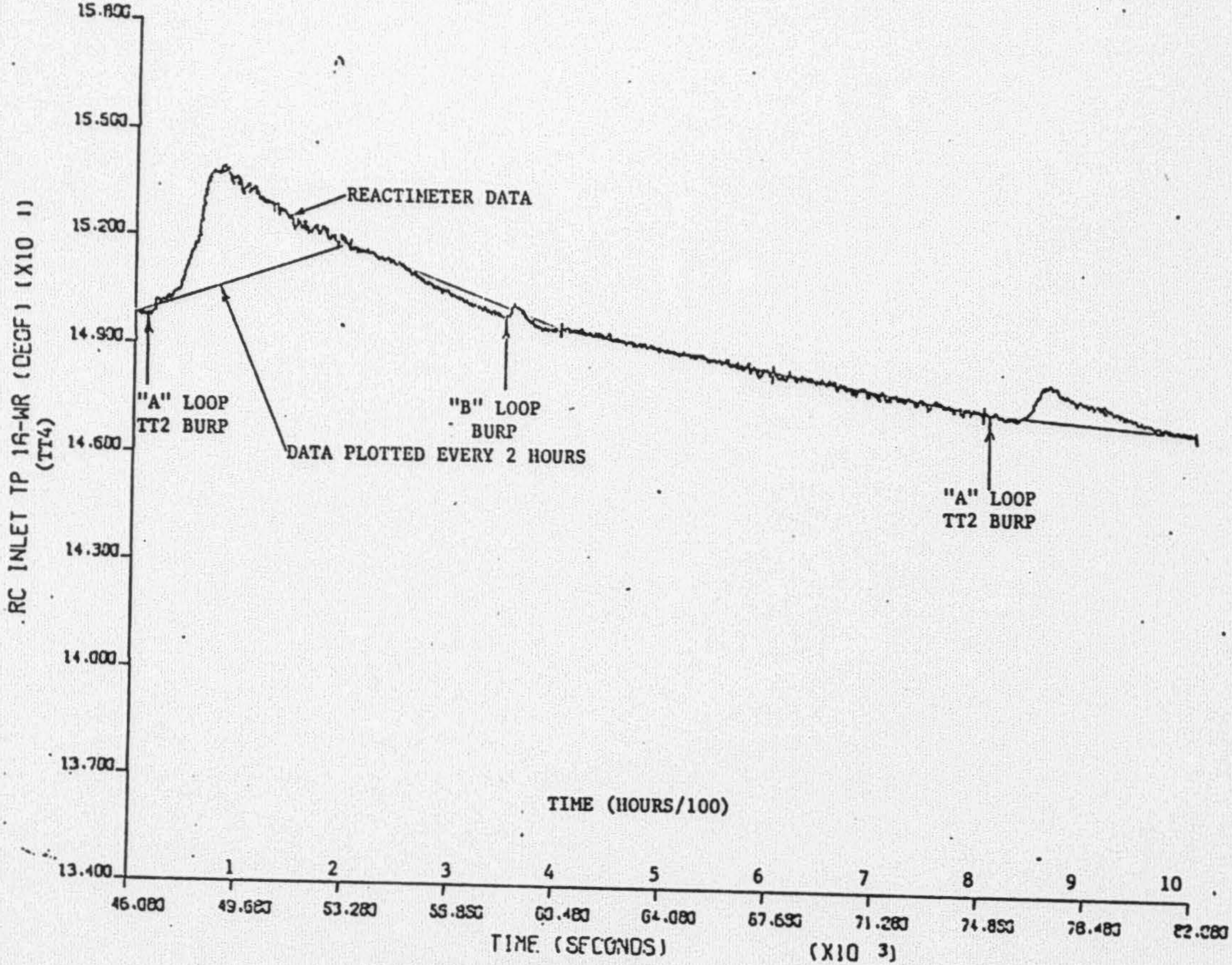
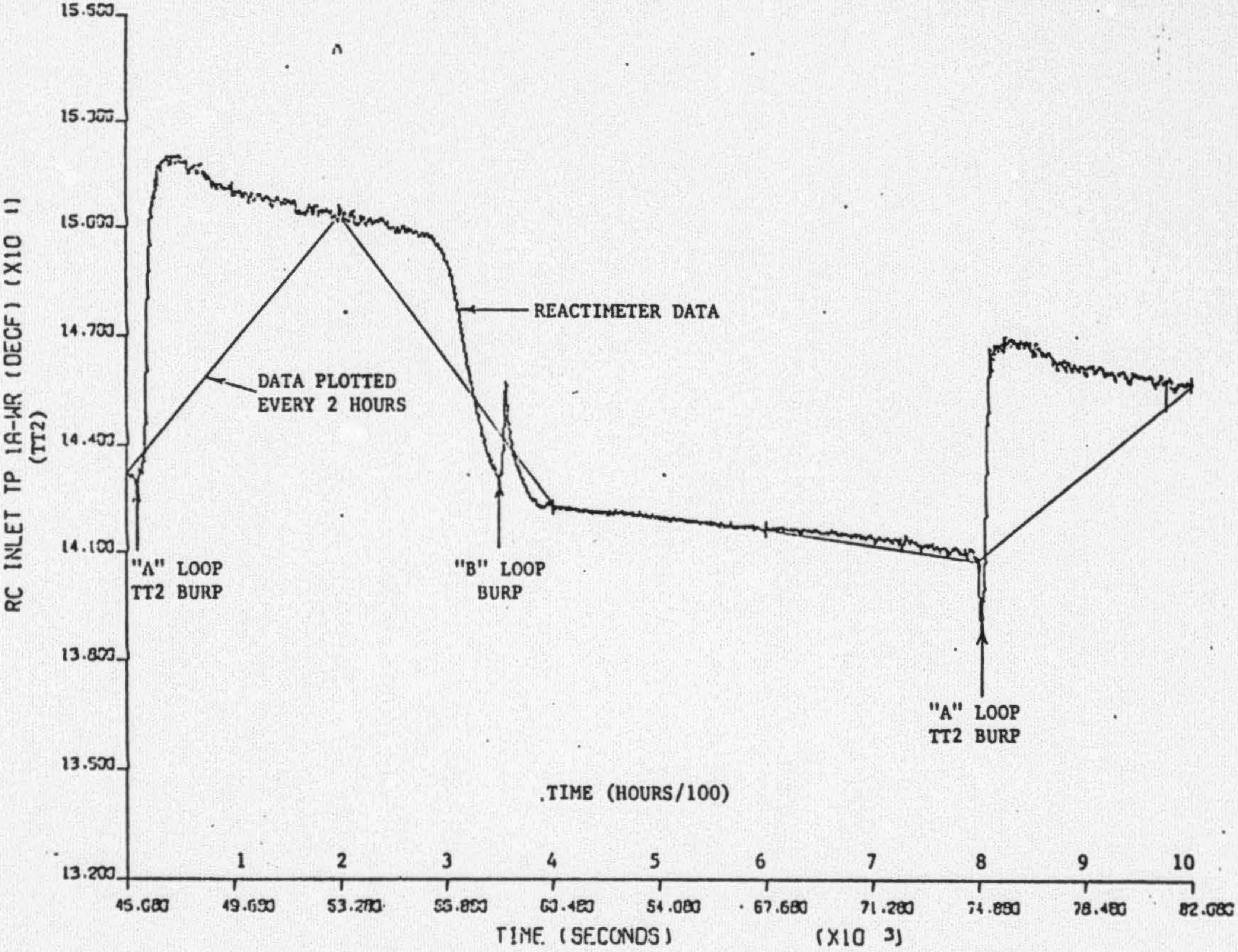
PERIOD #1
000-1000
10/16/79



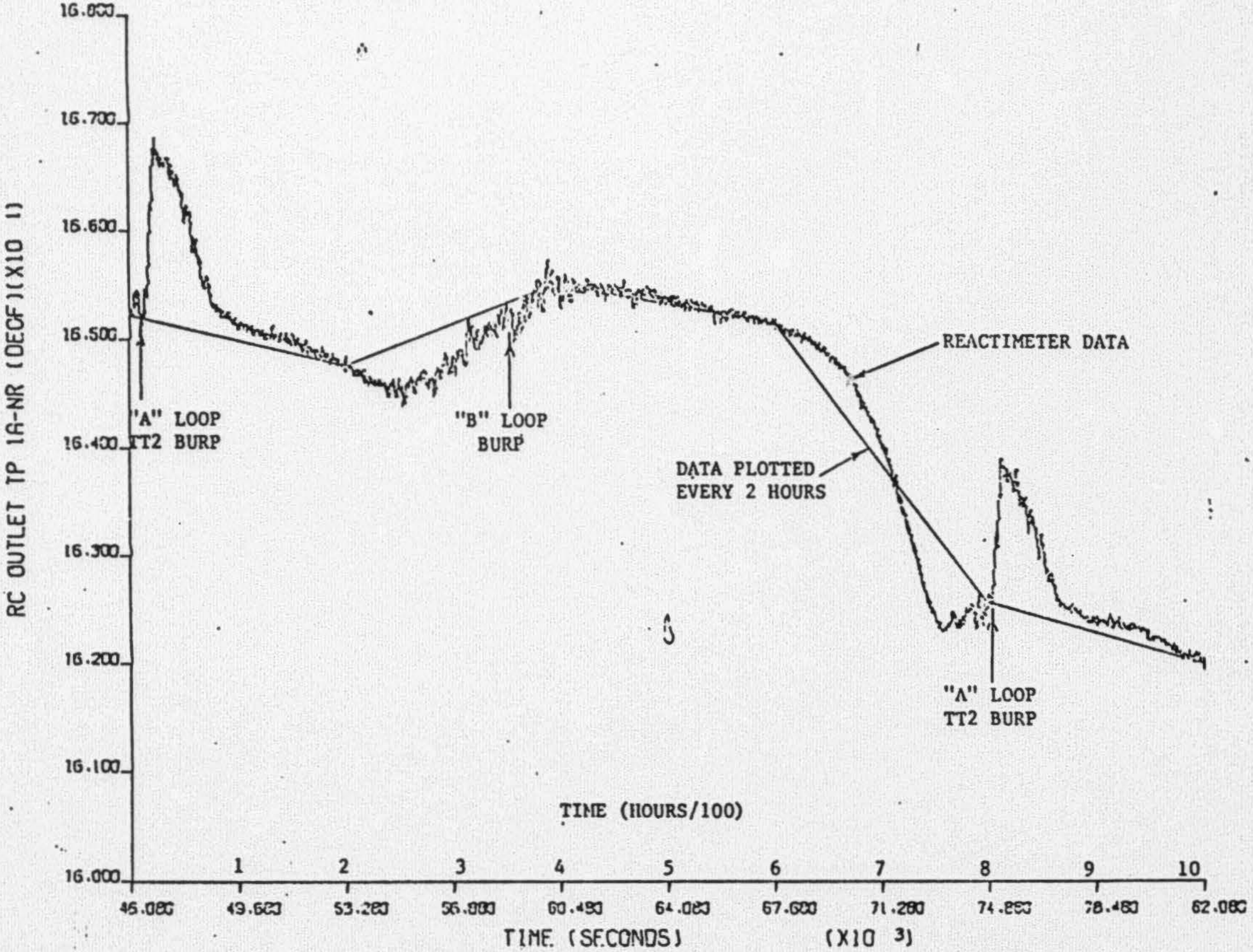
REACTIMETER PLOT . TSN=2

PERIOD #2
0000-1000
10/17/79



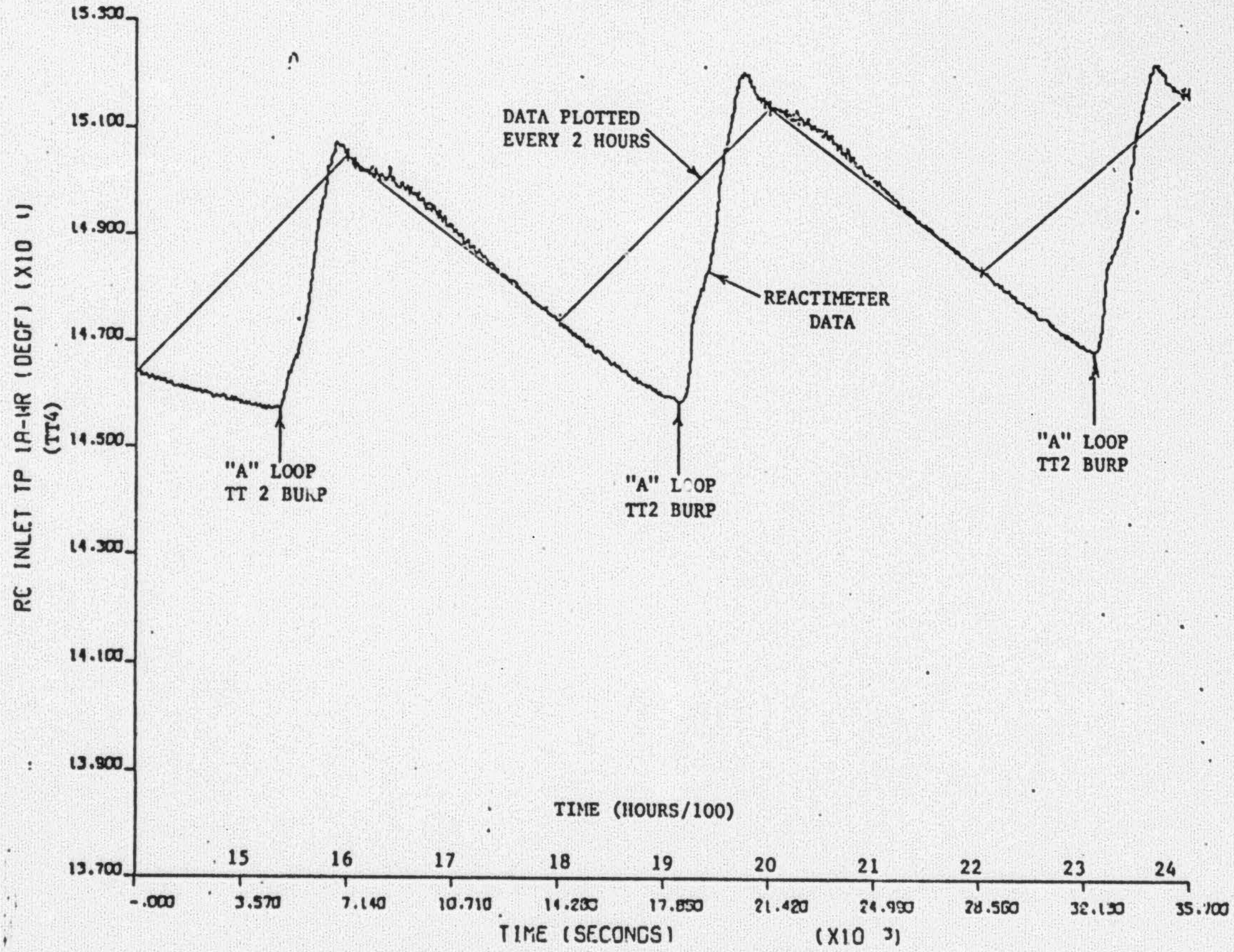
REACTIMETER PLOT · TSN=2

PERIOD #2
0000/1000
10/17/79



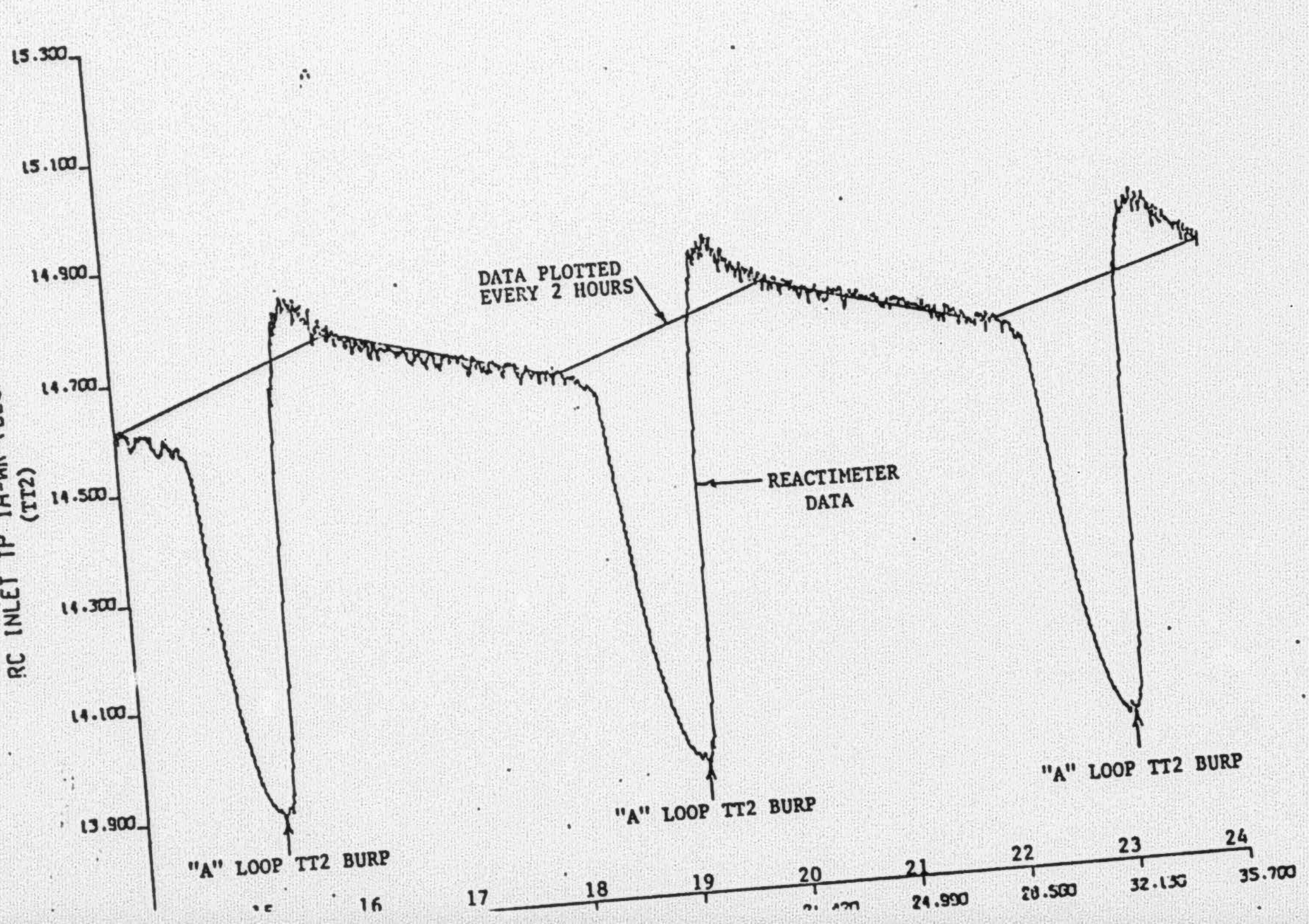
REACTIMETER PLOT TSN=2

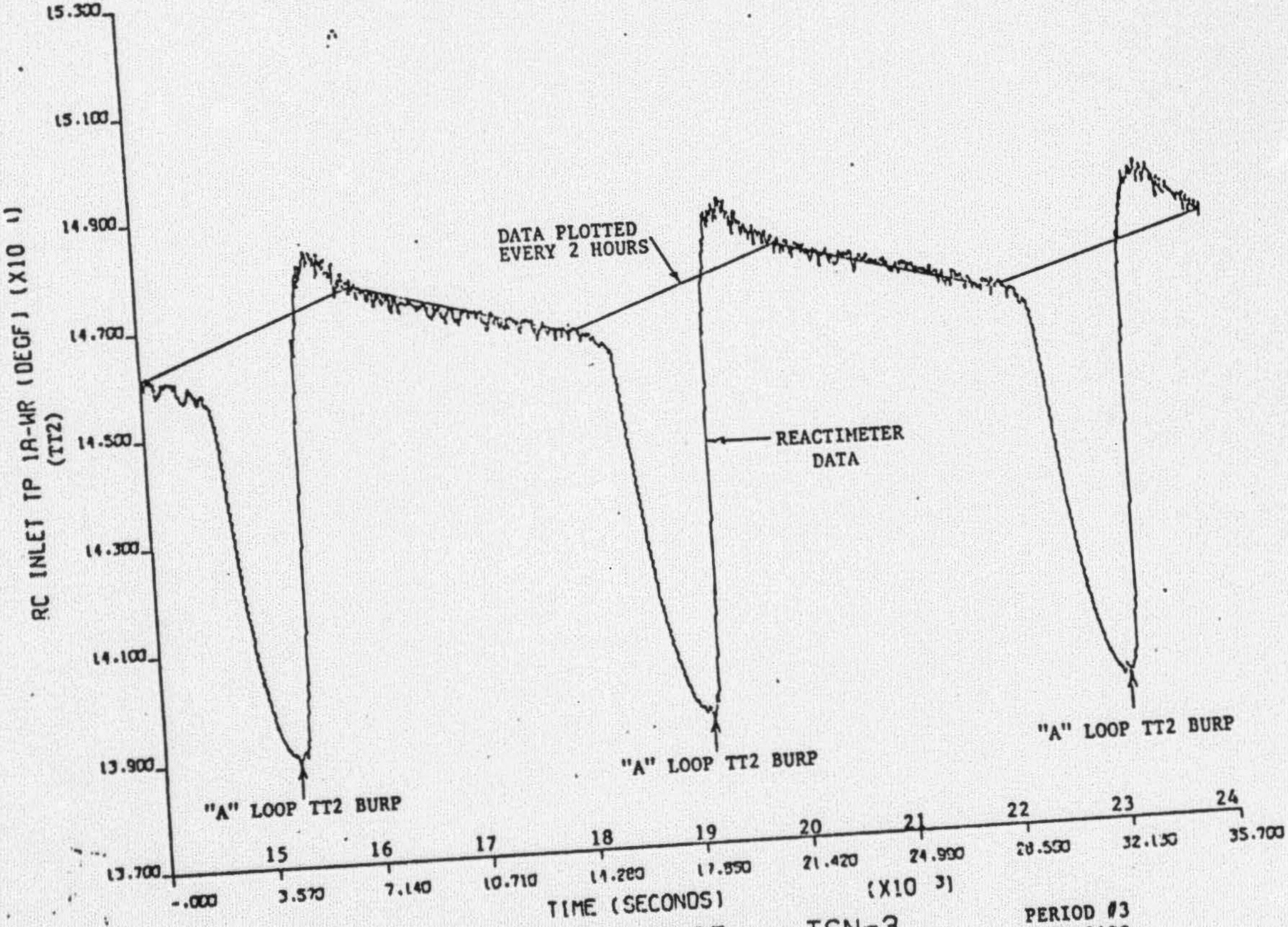
PERIOD #2
0000-1000
10/17/79



REACTIMETER PLOT TSN=3

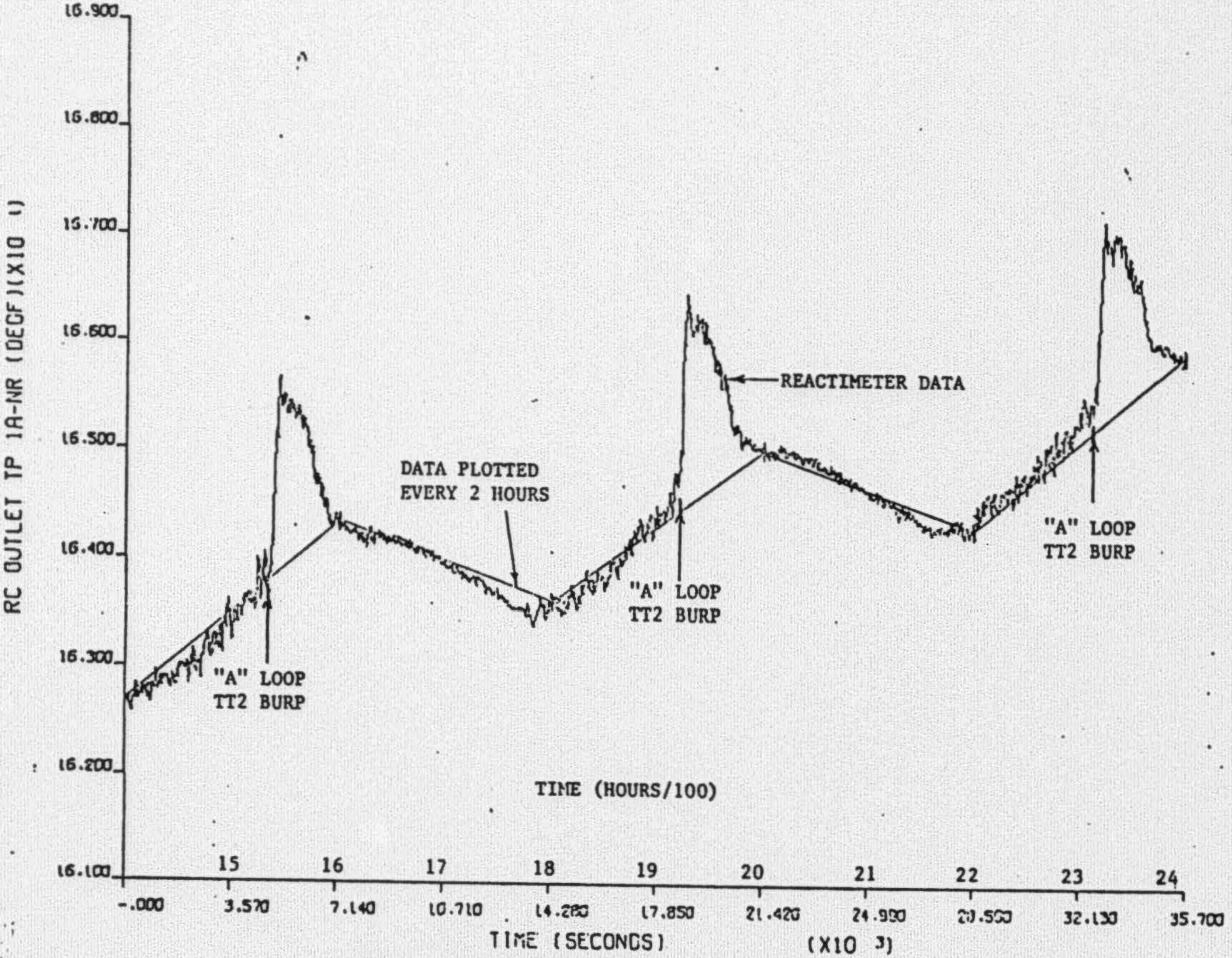
PERIOD 03
1400-2400
10/17/79


RC INLET TP 1A-WR (DEGF) (X10 1)
(TT2)
15.300
15.100
14.900
14.700
14.500
14.300
14.100
13.900
DATA PLOTTED
EVERY 2 HOURS
REACTIMETER
DATA
"A" LOOP TT2 BURP
"A" LOOP TT2 BURP
"A" LOOP TT2 BURP
16
17
18
19
20
21
22
23
24
24.990
28.500
32.150
35.700



REACTIMETER PLOT TSN=3

PERIOD #3
1400-2400
10/17/79



REACTIMETER PLOT TSN=3

PERIOD #3
1400-2400