Illinois Power Company
Clinton Power Station
P.O. Box 678
Clinton, IL 61727
Tel 217 935-8881

ILLINOIS POWER

U-602641
L47-96(09 -20)LP
8E.100a

September 20, 1996

Docket No. 50-461

10CFR50.90

Document Control Desk
Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Clinton Power Station Response to Request for Additional Information Related to Proposed Amendment of Facility Operating License No. NPF-62 (PS-95-015)

Dear Madam or Sir:

By letter dated February 22, 1996 (letter number U-602551), Illinois Power (IP) submitted an application for amendment of the Clinton Power Station (CPS) Operating License (License No. NPF-62) to incorporate a proposed change to the CPS Technical Specifications (Appendix A). IP proposed to revise Technical Specification (TS) 3.4.11, "Reactor Coolant System (RCS) Pressure and Temperature (P/T) Limits," to incorporate specific P/T limits for the bottom head region of the reactor vessel, separate and apart from the core beltline region of the reactor vessel.

IP received a Request for Additional Information (RAI) from the NRC (dated June 24, 1996) requesting a formal response to a number of questions that were raised during the review process of the proposed license amendment. IP responded by letter dated July 22, 1996 (U-602612). Teleconferences conducted subsequent to that correspondence resulted in the NRC issuing a second RAI dated August 22, 1996. Attachment 1 to this letter provides IP's response to each of the questions contained in the second RAI.

Sincerely yours,

Michael W. Lyon
Director-Licensing

A001 1/,

JFK/csm

250054

Attachment

cc: NRC Clinton Licensing Project Manager
NRC Resident Office, V-690
Regional Administrator, Region III, USNRC
Illinois Department of Nuclear Safety

By letter dated August 22, 1996, the NRC requested additional information related to Illinois Power's (IP's) February 22, 1996 request to amend the Operating License for Clinton Power Station (CPS). IP's response to each of the NRC's questions is provided below.

Questions and Responses

1. **In your letter of July 22, 1996 (U-602612), you provided General Electric Report SASR 89-59 which states on page 4-1, "Detailed stress analyses, specifically for the purpose of fracture toughness analysis, of non-beltline components were performed for the BWR/6 . . . . Detailed stresses were used according to [8] to develop plots for allowable pressure (P) versus temperature relative to the reference temperature ($T-RT_{NDT}$)."**

 Document the methodology and results of these stress analyses. Also, document the detailed fracture mechanics analyses which made use of the stresses. Finally, provide the fracture toughness data for the materials in the vessel lower head to confirm that the proposed curve for the lower head is applicable to the Clinton Power Station vessel.

Response: **Generic Curve Methodology**

When GE developed non-beltline P-T curves, the approach was to develop curves for a conservatively large BWR/6 (nominal 251-inch inside diameter) and then apply the curves generically to other vessels by using the appropriate RT_{NDT} values for those vessels. The one characteristic of the bottom head which made the analysis different from a shell analysis like that for the beltline was the presence of control rod drive (CRD) penetration holes, with their associated stress concentration.

CBI Nuclear (CBIN) modeled the BWR/6, 251-inch CRD penetration region to compute local stresses for determination of the stress intensity factor, K_I. The results of that computation were $K_I = 154.3$ ksi$\sqrt{in}$ for an applied pressure of 1593 psig (1563 psig preservice hydrotest pressure plus 30 psig hydrostatic pressure at the bottom of the vessel). The computed value of $(T - RT_{NDT})$ was 161°F.

To evaluate the CBIN result, K_I is calculated for the bottom head nominal stress, PR/2t, according to the methods in ASME Code Appendix G (Section III or XI). The result is compared to that determined by CBIN in order to quantify the K magnification associated with the stress concentration created by the multiple bottom head penetrations.

A calculation of K_I is shown below using the BWR/6, 251-inch dimensions:

Bottom Head Radius, R	138.2 inches
Bottom Head Thickness, t	8.0 inches
Bottom Head Material S_y	70 ksi
Bottom Head Pressure	1593 psig

Pressure stress:

$$\sigma = PR/2t = 1593 \text{ psig} * 138.2 \text{ inches} / (2 * 8.0 \text{ inches})$$

$$\sigma = \underline{13800 \text{ psi}}$$

The factor M_m from Figure G-2214-1 depends on (σ/S_y) and $\sqrt{t}$:

$$\sigma/S_y = 13800 / 70000 = 0.\ 2 \text{ (use } \sigma/S_y = 0.5)$$

$$\sqrt{t} = (8.0)^{1/2} = 2.83 \sqrt{in}$$

$$M_m = \underline{2.7}$$

Including the safety factor of 1.5, the stress intensity factor, K_I, is $1.5M_m\sigma$:

$$\text{Nominal } K_I = 1.5 * 2.7 * 13800 = \underline{55.9 \text{ ksi}\sqrt{in}}$$

The CBIN result of 154.3 ksi$\sqrt{in}$ is a factor of 2.76 times the nominal result. This is somewhat conservative compared to the stress computed by CBIN at the penetration, which was 2.6 times the PR/2t stress.

The method to solve for $(T - RT_{NDT})$ for a specific K_I is based on the curve in Figure G-2210-1 in ASME Appendix G:

$$(T - RT_{NDT}) = 1n[(K_I - 26.78)/1.223]/0.0145 - 160$$

$$(T - RT_{NDT}) = 1n[(154.3 - 26.78)/1.223]/0.0145 - 160$$

$$(T - RT_{NDT}) = 161°F:$$

The generic curve was generated by scaling 154.3 ksi$\sqrt{in}$ by the nominal pressures and calculating the associated $(T - RT_{NDT})$:

Nominal Pressure (psig)	K_I (ksi√in)	(T - RT_{NDT})
1563	154.3	161°F
1400	138.2	151°F
1200	118.5	138°F
1000	98.7	121°F
800	79.0	99°F
600	59.2	66°F
400	39.5	1°F

Applicability to CPS

The P-T curve is dependent on the K_I value calculated, which is proportional to the stress and the crack depth according to the relationship:

$$K_I \propto \sigma\sqrt{\pi a}.$$

The stress is proportional to R/t and, for the P-T curves, crack depth, a, is t/4. Thus, K_I is proportional to $R/\sqrt{t}$. The generic curve value of $R/\sqrt{t}$, based on the BWR/6, 251-inch bottom head dimensions, is

$$\text{Generic } R/\sqrt{t} = 138.2/\sqrt{8} = \underline{48.9}.$$

The CPS-specific bottom head dimensions are R = 118.2 inches and t = 7.3 inches. The CPS-specific value of $R/\sqrt{t}$ is

$$\text{CPS-specific } R/\sqrt{t} = 118.2/\sqrt{7.3} = \underline{43.7}.$$

Since the generic value of $R/\sqrt{t}$ is greater than that for CPS, the generic P-T curve is conservative when applied to the CPS bottom head.

As discussed below, the highest RT_{NDT} for the bottom head materials is 10°F. The generic curve is applied to the CPS bottom head by shifting the P vs. (T - RT_{NDT}) values above to reflect the RT_{NDT} value of 10°F. The resulting P-T values are below:

Nominal Pressure (psig)	Bottom Head Temperature
1400	161°F
1200	148°F
1000	131°F
800	109°F
600	76°F
400	11°F

Fracture Toughness (RT_{NDT})

The highest RT_{NDT} for the bottom head plates and welds is 10°F, based on fracture toughness data for the plates, shown in Table 1 (below). The bottom head welds have RT_{NDT} values of -20°F or lower, based on the vessel purchase specification requirements and QA documentation confirming that there were no bottom head plate or weld deviations from those requirements.

Table 1. Fracture Toughness of Bottom Head Plates (Transverse Orientation)

Plate Location	Heat No.	Dropweight NDT	Charpy Test Temp.	Impact Energy, ft-lb	Lateral Expansion, mils	RT_{NDT}
Bottom Center	A2757-1	-10°F	50°F	57,71,74	56,48,58	-10°F
Bottom Sides	C4027-1	-30°F	70°F	66,53,53	46,58,48	10°F
	C4059-2	-20°F	60°F	52,61,55	47,45,45	0°F

2. **Identify the locations during vessel hydrostatic and leak rate testing at which the temperature measurements would be taken to:**

   (a) **verify compliance with the proposed lower vessel head pressure/temperature curve, and**

   (b) **verify compliance with the pressure/temperature limits established for the beltline and flange regions.**

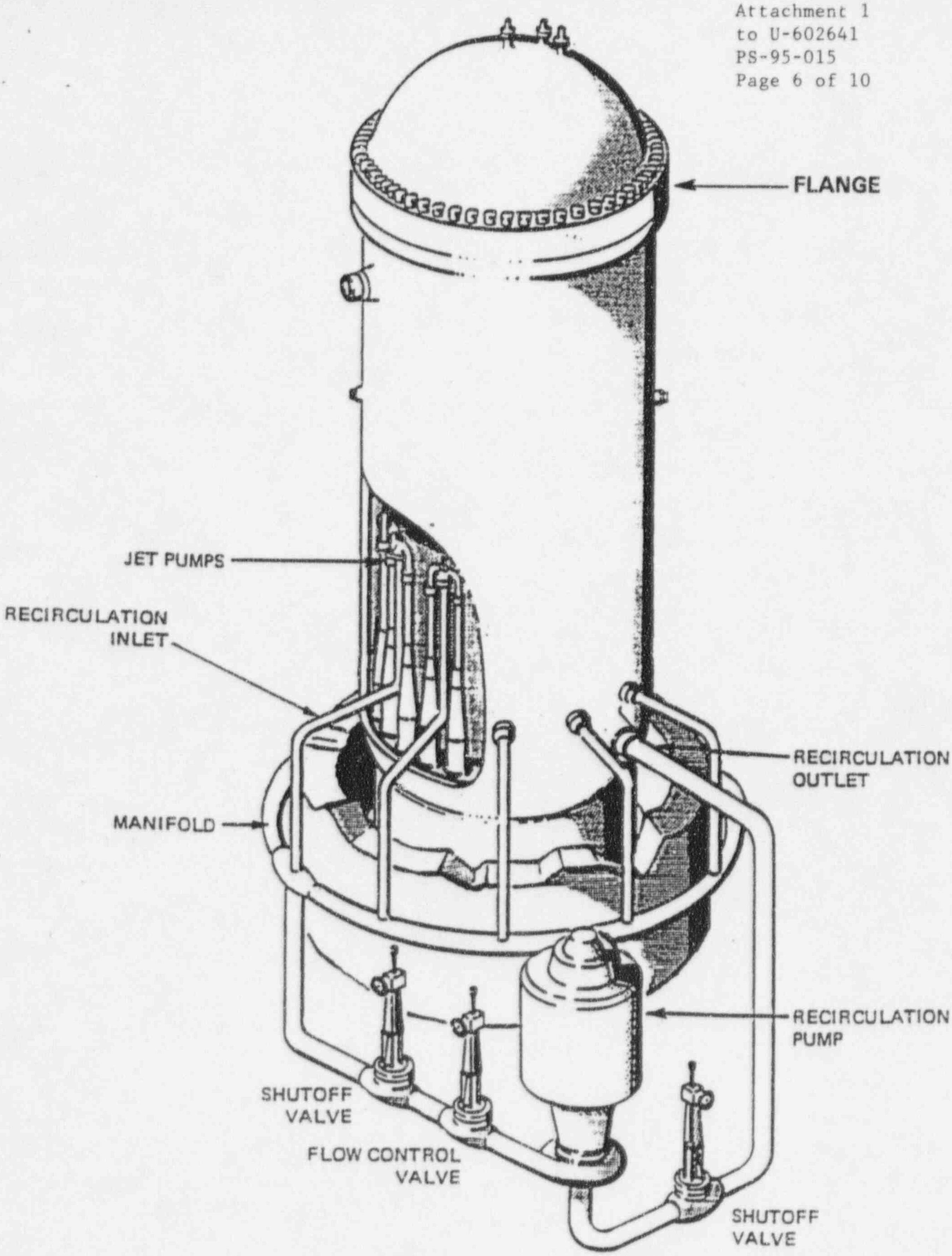
Response: As described in the request dated February 22, 1996, IP is seeking a Technical Specification change such that two different pressure-temperature (P-T) curves (one for the beltline region and one for the bottom head region) may be used to perform low temperature leak tests during each refueling outage. All other temperature limitations shall be maintained. The use of two temperature curves will reduce refueling outage time by several hours and will significantly facilitate the leak testing process. In order to use the two P-T curves, the temperature at the beltline and at the bottom head must be independently determined.

Currently, the vessel head flange, vessel shell flange, the bottom head (metal) and the bottom head drain temperatures are used to ensure that the entire vessel is at the required test temperature. Figures 1 and 2 depict the general arrangement of the reactor vessel, recirculation piping, and internal structures. The region of the vessel that is embrittled by neutron irradiation, i.e., the beltline region, is adjacent to the core and is heated by the water in the annulus (wherein the jet pumps are located). During leak testing, the vessel is water solid and natural circulation provides mixing within the system. The measurement of the temperature at both ends of the vessel adequately ensures that the beltline temperature is known for the purposes of meeting the P-T limits during leak testing.

Regarding verification of compliance with the proposed bottom head P-T curve [Question 2(a)], the bottom head metal temperature and the bottom head drain temperature will be used to verify compliance with the limits imposed by the bottom head curve. These two indications are already used in conjunction with meeting the conditions specified by the existing P-T limits curves. The lowest of the two temperature readings will be used for comparison to the proposed bottom head P-T curve to ensure that the vessel bottom head region is within the required temperature limits during vessel hydrostatic and leak rate testing.

In response to Question 2(b), the vessel head flange, the vessel shell flange, and the reactor recirculation loop suction temperatures will be used to ensure compliance with the P-T curve applicable to the beltline and flange regions.

As described in General Electric Report SASR 89-59 (U-602612, Attachment 2), a BWR/4 has confirmed, by direct measurement of the vessel metal temperature, that there is another method (i.e., reactor



Reactor Vessel

Figure 1

REACTOR VESSEL AND INTERNALS

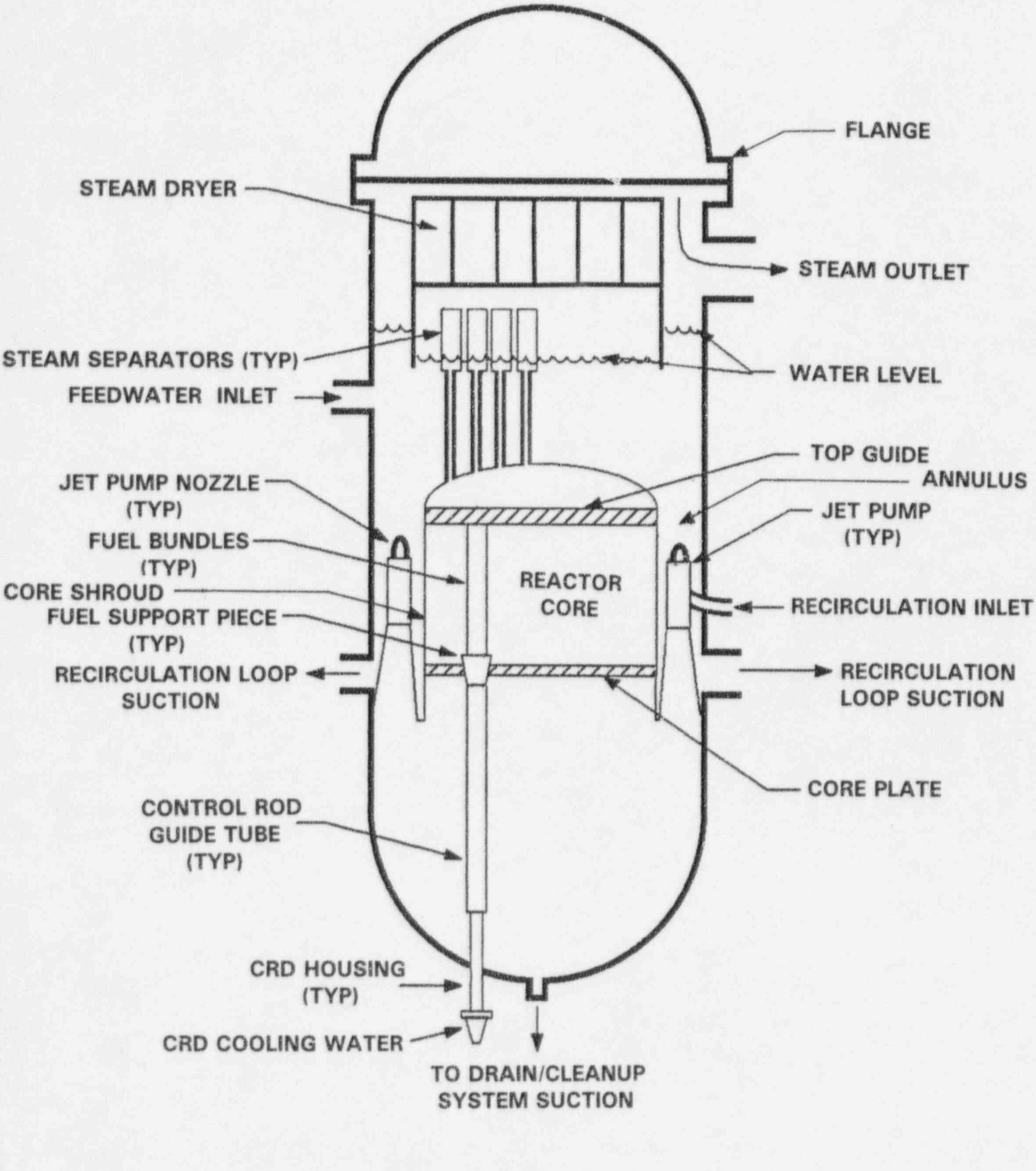


Figure 2

recirculation loop suction temperature) available to determine the vessel metal temperatures in the beltline region. IP proposes that the vessel head flange temperature, the vessel shell flange temperature, and the reactor recirculation loop suction temperature be used to determine whether the P-T limits are being met for the non-bottom head regions of the vessel.

Although IP does not have direct metal temperature measurements of the vessel beltline region from previous leak tests, IP does have reactor coolant temperature data as measured by thermocouples on the suction side of the reactor recirculation pumps.

During the fifth refueling outage, the "A" reactor recirculation loop was isolated to perform a reactor recirculation pump seal replacement. After completing the work, the loop was slowly filled with reactor coolant water and unisolated. Since the reactor heatup for the leak test had already begun, the water in the vessel was at 190°F. Figure 3 is a graphical presentation of the temperature data recorded during this event. The individual data points were taken from test logs, and the data plotted for the curves (Loop A and Loop B) are from strip charts.

Test conditions were such that the reactor recirculation pumps were not running, and the reactor water cleanup system was taking suction from the bottom of the vessel. Cold water was being supplied to the bottom head region of the vessel via the control rod drive system. It should be noted that when the flange temperature measurement was made at 3:00 on April 19th, the vessel was still being filled and level had not reached the flange area. Pressurization of the vessel for the leak test began at approximately 4:00 on 4/20/95.

Inspection of this data shows that when the vessel is filled to the flange, there is good agreement between the flange temperature and the coolant temperature in unisolated loops. It can also be seen that when an isolated loop is refilled, and allowed to communicate with the water from the annulus, it quickly equalizes with the annulus temperature. Given the difference between the bottom head temperatures and the loop temperatures, it is evident that the cooler water in the bottom head region does not readily intermix with the warmer water in the annulus region.

The temperature of the water in the reactor recirculation loop agrees well with the vessel head flange temperatures. This demonstrates a close relationship between water and metal temperatures when free interchange of the water between the vessel head and annulus region is allowed to occur. The vessel metal at the beltline is heated by the water in the annulus

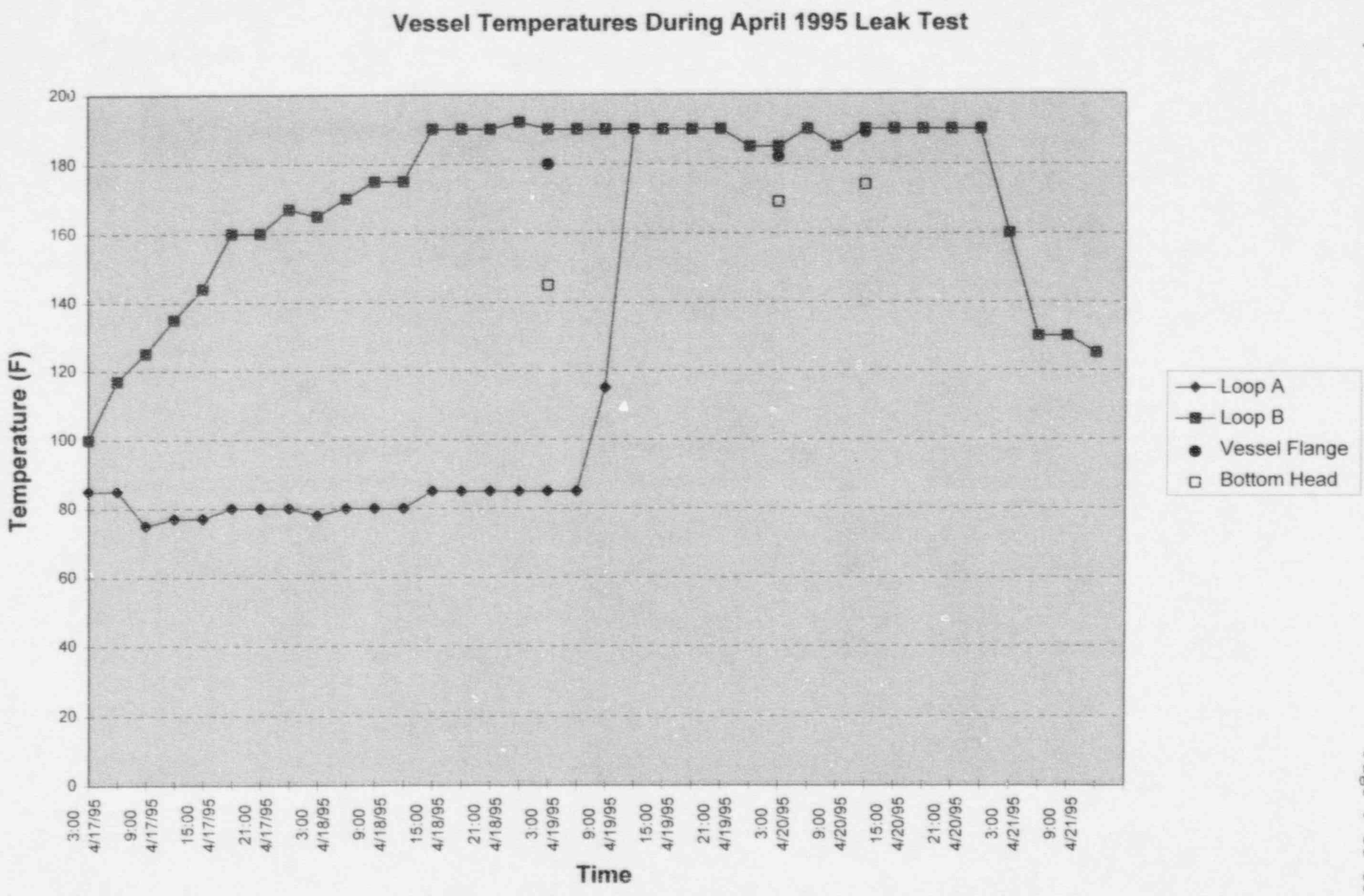

Vessel Temperatures During April 1995 Leak Test
Temperature (F)
200
180
160
140
120
100
80
60
40
20
0
3:00 4/17/95
9:00 4/17/95
15:00 4/17/95
21:00 4/17/95
3:00 4/18/95
9:00 4/18/95
15:00 4/18/95
21:00 4/18/95
3:00 4/19/95
9:00 4/19/95
15:00 4/19/95
21:00 4/19/95
3:00 4/20/95
9:00 4/20/95
15:00 4/20/95
21:00 4/20/95
3:00 4/21/95
9:00 4/21/95
Time
Loop A
Loop B
Vessel Flange
Bottom Head

Figure 3

region. Since the annulus is adequately isolated from the cooler water in the bottom head region, the water temperature in the annulus will be representative of the beltline metal temperature. Thus, measuring recirculation loop water temperature (that is at equilibrium with the annulus water) will provide adequate indication of the vessel beltline metal temperature.