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October 20, 1998

Re: Indian Point Unit No. 2
Docket No. 50-247

Document Control Desk
US Nuclear Regulatory Commission
Mail Station P1-137
Washington, DC 20555-0001

Subject: Additional Information Regarding Response to Generic Letter 97-04, "Assurance of Sufficient Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal Pumps," for Indian Point Unit No. 2. (TAC No. M99999)

Reference: 1) Con Edison Letter to USNRC dated July 31, 1998.
2) USNRC Letter to Con Edison dated June 2, 1998.

In Reference 1, Consolidated Edison Company of New York, Inc. (Con Edison) provided additional information relative to our response to Generic Letter 97-04, "Assurance of Sufficient Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal Pumps." Subsequent to the submittal of this information, Con Edison committed to provide a revised response addressing flow conditions, other than nominal pump design cases, which also affect net positive suction head available (NPSHA). The attachment to this letter provides our revised response and supersedes Reference 1 in its entirety.

Should you or your staff have any concerns regarding this matter, please contact Mr. Charles W. Jackson, Manager, Nuclear Safety & Licensing.

A076

Very truly yours,

J. S. Baumstark

Attachment

Subscribed and sworn to
before me 20th day
of October 1998.

Karen L. Lancaster
Notary Public

KAREN L. LANCASTER
Notary Public, State of New York
No. 60-4643659
Qualified In Westchester County
Term Expires 9/30/99

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<u>ATTACHMENT</u>

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION REGARDING RESPONSE TO GENERIC LETTER 97-04, "ASSURANCE OF SUFFICIENT NET POSITIVE SUCTION HEAD FOR EMERGENCY CORE COOLING AND CONTAINMENT HEAT REMOVAL PUMPS."

Consolidated Edison Company of New York, Inc.
Indian Point Unit No. 2
Docket No. 50-247
October 1998

Generic Letter Requested Information Item 1

Specify the general methodology used to calculate the head loss associated with the emergency core cooling system (ECCS) suction strainer.

Response

The basic methodology used for determining pump net suction head (NPSH) involves a comparison of the difference between the total available suction head (Absolute head measure at the pump impeller eye) and the vapor head (absolute) of the pumped fluid. This basic methodology is reflected in the following equation:

$NPSH = h_a - h_{vps} + h_{sh} - h_{fs}$

h_a = atmospheric head, absolute pressure (in feet of liquid) on the surface of the liquid being pumped.

h_{vps} = vapor head, the head in feet corresponding to the vapor pressure of liquid at temperature being pumped.

h_{sh} = static head, static height in feet that the liquid supply level is above the pump impeller eye.

h_{fs} = friction head, all suction line losses (in feet) including all sump screen and form losses as well as losses through piping, valves and fitting, and strainers (if present).

In applying the above basic relationship to the ECCS for the sump recirculation mode, the following conservative methodology and assumptions were used to establish each item:

h_a = absolute pressure (in feet of liquid) on the surface of the liquid being pumped.

This term is defined as a product of the containment pressure and the specific volume of the liquid being pumped. The NPSH calculations assume that the sump fluid temperature is at saturation, corresponding to the containment pressure. As such the vapor pressure of the sump fluid equals to the pressure on the surface of the liquid being pumped. This assumption is consistent with NRC Regulatory Guide 1.1 which states that no credit is to be taken for post accident containment pressure.

h_{vps} = vapor pressure of liquid at temperature being pumped.

This term is defined as a product of the saturation pressure at temperature and the specific volume of the pumped fluid at that temperature. The NPSH calculations assume the sump fluid temperature of 212 F. This temperature is the maximum that the sump fluid can reach at atmospheric pressure.

h_{sh} = static height in feet that the liquid supply level is above the pump impeller eye.

This term is defined as the elevation difference between the surface level of the fluid being pumped and the center of the pump impeller eye. The calculations use the difference of calculated water level elevation in the containment and the suction elevation of the ECCS suctions. The containment water level is determined conservatively (i.e., minimum water inventory in the RWST including water level instrument uncertainty; where used, minimum RCS inventory by assuming that the Pressurizer and the Safety Injection Accumulator are at low water level), in order to assure that the actual containment water level will be more than that of the calculated level.

h_{fs} = friction losses (in feet) including all sump screen and form losses as well as losses through piping, valves and fittings.

This term is defined as the head loss due to flow resistance encountered by the pumped fluid, up to the pump suction. The NPSH calculations determine the friction loss by the following parameters:

1. Screen and form losses from the sump entrance to the pump suction. These losses were calculated for single pump and two pumps operations. The entrance grates were assumed totally blocked and the flow to the sump is via the trench openings. The fine screen in the sump is assumed 50% blocked.

2. Suction line losses including piping, valves, fittings (i.e., elbows, tees, valves gate, check, and globe where applicable), and reducers, were determined for the given flow conditions. Empirically determined friction factors (i.e., Moody's friction factors), were used, considering pipe wall roughness, pipe diameter and fluid velocity to determine the losses in the pump suction line.

Generic Letter Requested Information Item 2

Identify the required NPSH and the available NPSH.

Response

The NRC Generic Letter 97-04 is applicable to NPSH of the emergency core cooling and containment heat removal pumps. The IP2 emergency core cooling and containment heat removal pumps that draw water from the containment and recirculation sumps following a LOCA are the Safety Injection Pumps, Safety Injection Internal Recirculation Pumps, and the RHR Pumps. The following provides a discussion of the mode of operations that are relevant to the Generic Letter.

Safety Injection Pumps - The Safety Injection Pumps are horizontal centrifugal pumps that provide high head injection flow to the reactor core during the initial phase of a LOCA. They initially take suction from the RWST. When the RWST water inventory is depleted, the Safety Injection pumps can be aligned to take suction from the RHR/Internal Recirculation pump discharge (referred to by the Generic Letter as "piggybacking") for continued core cooling. In this mode, the available NPSH is provided by the RHR/ Internal Recirculation Pumps.

Residual Heat Removal (RHR) Pumps - The RHR System Pumps can be used for post-LOCA recirculation in the event that the Internal Recirculation pumps are not available. Should the RHR System pumps be used for post-LOCA recirculation operation, the RHR Pumps take suction from the Containment Sump (located about 90 degrees counter-clockwise from the Recirculation Sump). The sump fluid is cooled as it passes through the RHR heat exchanger(s), and discharged to the RCS. The available NPSH is determined by the elevation difference between the containment water level and the centerline of the pump, less the friction losses in the pump suction line and the sump. The sump loss was determined assuming that the entrance grates are fully blocked. Flow to the sumps is via the trenches that lead into the sumps. Although, in the determination of the available NPSH, the sump grates are assumed 100% blocked and screens are assumed to be 50% blocked, blockage of the entrance grates and sump screen is highly improbable because of the location of sump and the sump entrance.

The Containment Sump is located inside the crane wall but it is physically separated from the Recirculation Sump, which is located on the south-southeast side of the Containment (see attachment 1). It is a 7'-8" deep labyrinth pit set in the Containment floor. Within this sump is the piping that penetrates the Containment to supply the RHR Pumps. The top of this sump is set flush with the floor at El. 46'-0" and is covered with 1" x 4" floor grating that serves as the grating screen. Water enters the Containment Sump area via several possible flow paths inside the crane wall. There is also a labyrinth passageway into the sump area through the crane wall on its south side.

The Containment Sump is fed by a trench that runs around the eastern exterior of the crane wall for approximately 195°. This trench is covered with 1" x 4" floor grating that serves as the coarse screen. This grating is set flush with the floor in the annular space between the crane wall and the Containment liner

All water that enters the Containment Sump must pass through the grating. The arrangement of the coarse grates and the labyrinth sump enclosure makes the likelihood of debris entering the sump very difficult.

Safety Injection Internal Recirculation Pumps - The two Internal Recirculation pumps are wet pit, vertical, 3-stage impeller pumps, with their suction bells immersed in the sump. These pumps are the preferred pumps for containment recirculation following a LOCA. The available NPSH is determined by the elevation difference between the containment water level and the pump's impeller eye, less losses in the sump. The sump losses were determined assuming that the entrance grates are fully blocked. Flow to the sumps is via the trenches that lead into the sumps. Although, in the determination of the available NPSH, the sump screens are assumed to be 50 % blocked, blockage of the sump screens is highly improbable because of the uniqueness in the sump designs.

The Recirculation Sump is located on the west side of the containment on floor elevation 46'-0" near the inside of the crane wall (see attachment 2). It straddles the Containment Building and the Reactor centerline in the East-West direction. The sump is a labyrinth pit that is divided into three (3) bays. The first bay is 4'-10" x 10'-0" x 12'-0" deep. The sump entrance is covered by a 4'-10" x 10'-0" grating to keep large, bulky debris from entering the sump. The middle bay is also 4'-10" x 10'-0" x 12'-0" deep. A 3'- 0" x 10'-0" opening is provided between the first and the middle bays from elevation 37'-0" to elevation 34'-0". At elevation 41'- 0", #6 stainless steel wire screens are provided to prevent small pieces of debris, that passed through the grating, from entering into the third bay. The third bay is 5'-8" x 10'-0" x 9'-0" deep. The Internal Recirculation Pumps are located in this bay. An opening of 2'-6" x 10'-0", between elevations 42'-0" and 44'-6", is provided between the middle and the third bays.

Water enters the Recirculation Sump enclosure via several pathways. There is a passageway on the north side of the enclosure inside and adjacent to the crane wall and two passageways to the west of the sump through the crane wall. There are also trenches that are fed from curbs located at El. 46'-4'' on the east and south exterior faces of the sump enclosure inside the crane wall.

The Recirculation Sump's fine screens are located inside the sump and are designed to remove particles larger than 1/8". All water entering the Recirculation Sump must pass through the grating, travel downward through an opening near the bottom of the sump and then upward to the fine screens. This arrangement makes blocking the fine screen improbable as the floating debris that made it into the sump must have sufficient downward velocity to get to the bottom opening between the 1st and 2nd bays. Heavy debris is expected to sink to the bottom.

The following tabulation is a summary of the available NPSH and the Required NPSH for the ECCS pumps:

Pump Description	Available NPSH ft.	Required NPSH ft.	Excess NPSH ft.
RHR, (From Containment Sump) one pump at 3000 gpm design flow assumed. (Ref. Calc. # FMX-00045-00)	24.4	10.5	13.9
High Head SI pump recirculation mode	*	17.5	*
Internal Recirculation Pump, one pump at 3000 gpm design flow assumed. (Ref. Calc. # FMX-00036-02)	10.35	9.75	0.60
Internal Recirculation when an additional branch flow path is opened for containment spray (total single pump flow is approx. at 3525 gpm **). (Ref. Calc. # FMX-00036-03)	11.63	**	**

* The high head recirculation is performed by the High Head Safety Injection Pumps. The HHSI pumps take suction from the Internal Recirc/RHR pump discharge (i.e., piggybacking). Therefore, the NPSH available during the High Head recirculation mode is much higher than the NPSH provided by the RWST (i.e., NPSHA from RWST is 37.9 ft. in the injection mode (Ref. Calc. # FMX-00050-00))

** The pump flow is limited to approximately 3525 gpm at 11.63 feet of NPSHA. Per pump manufacturer, Ingersoll-Dresser, when the available NPSH is less than the required NPSH, the pump flow will not be further increased when the system resistance is reduced. The pump's developed head will drop off to match the system resistance. The pump will experience minor cavitation and change in pressure pulsation. The manufacturer indicated that when the submergence requirement is satisfied (i.e., 3.5 feet above the eye of the pump impeller), the pump is acceptable for long term operation with some degradation of the bearing expected. This condition is acceptable for sustained or long term operation.
The manufacturer concludes that pump reliability will not be affected if the pump operates in this deficient NPSH condition for up to 7 days.

Generic Letter Requested Information Item 3

Specify whether the current design-basis NPSH analysis differs from most recent analysis reviewed and approved by the NRC for which a safety evaluation was issued.

Response

The current design-basis NPSH analysis differs from the analysis originally reviewed and approved by the NRC. The following is the basis for the current calculations: The determination of the available NPSH assumed that the sump liquid is water and is at a saturation temperature corresponding to the containment pressure. As such, no credit is taken for containment overpressure. The containment water level was calculated based on the minimum RWST water inventory. Where used, the RCS spillage during a LOCA is determined by assuming that the Pressurizer and the SI Accumulators are at low water level. The sump and friction losses, up to the suction of the ECCS pumps, were determined conservatively as follows:

a. The screen and form losses from the sump entrance to the pump suction were calculated for single pump and two pump operations. The entrance grates were assumed totally blocked and the flow to the sump via the trench openings. The fine screen in the sump is assumed 50% blocked.

b. Suction line losses including piping, valves, fittings (i.e., elbows, tees, valves gate, check, and globe where applicable), and reducers, were determined for given flow conditions. Empirically determined friction factors (i.e., Moody's friction factors) were used, considering pipe wall roughness, pipe diameter and fluid velocity to determine the losses in the pump suction line.

Our current design-basis NPSH analysis include various hypothetical pump flow rates which exceed the pump nominal design values. The NPSH margins at these hypothetical pump flow rates are provided in Ref. Calcs. #FMX-00036-02 and -03.

Generic Letter Requested Information Item 4

Specify whether containment overpressure (i.e., containment pressure above the vapor pressure of the sump or suppression pool fluid) was credited in the calculation of available NPSH. Specify the amount of overpressure needed and minimum overpressure available.

Response

No credit is taken for containment overpressure in the NPSH calculation. However, in a review of the containment pressures in relation to the containment sump water temperatures following a LOCA, it was determined that there is 10.3 psi to 23.3 psi overpressure.

The maximum containment sump temperature is 260F when the containment pressure is at 42 psig, 1000 seconds (or 16.7 minutes) following the design basis LOCA. At 260F, the saturation pressure of water is 21 psig. The overpressure is 21 psi (42 psig -21 psig). As the containment pressure drops, overpressure will also reduce. At 5040 seconds (or 84 minutes) following a design basis LOCA, the containment pressure is reduced to 24 psig. The corresponding sump water temperature is 225F. The saturation pressure for 225F is 4.3 psig. The overpressure is 19.7 psi (24 psig -4.3 psig). When the sump water temperature is at 212F, the containment pressure is 19.5 psig, an overpressure of 19.5 psi. The sump water reaches a steady state temperature of 190F at about 333 minutes. At this sump temperature, the containment pressure range is from 5 psig to 18 psig. The vapor pressure of water at 190F is 9.4 psia (5.3 psig Vacuum). The overpressure is therefore from 10.3 psi to 23.3 psi for the steady state sump water temperature.

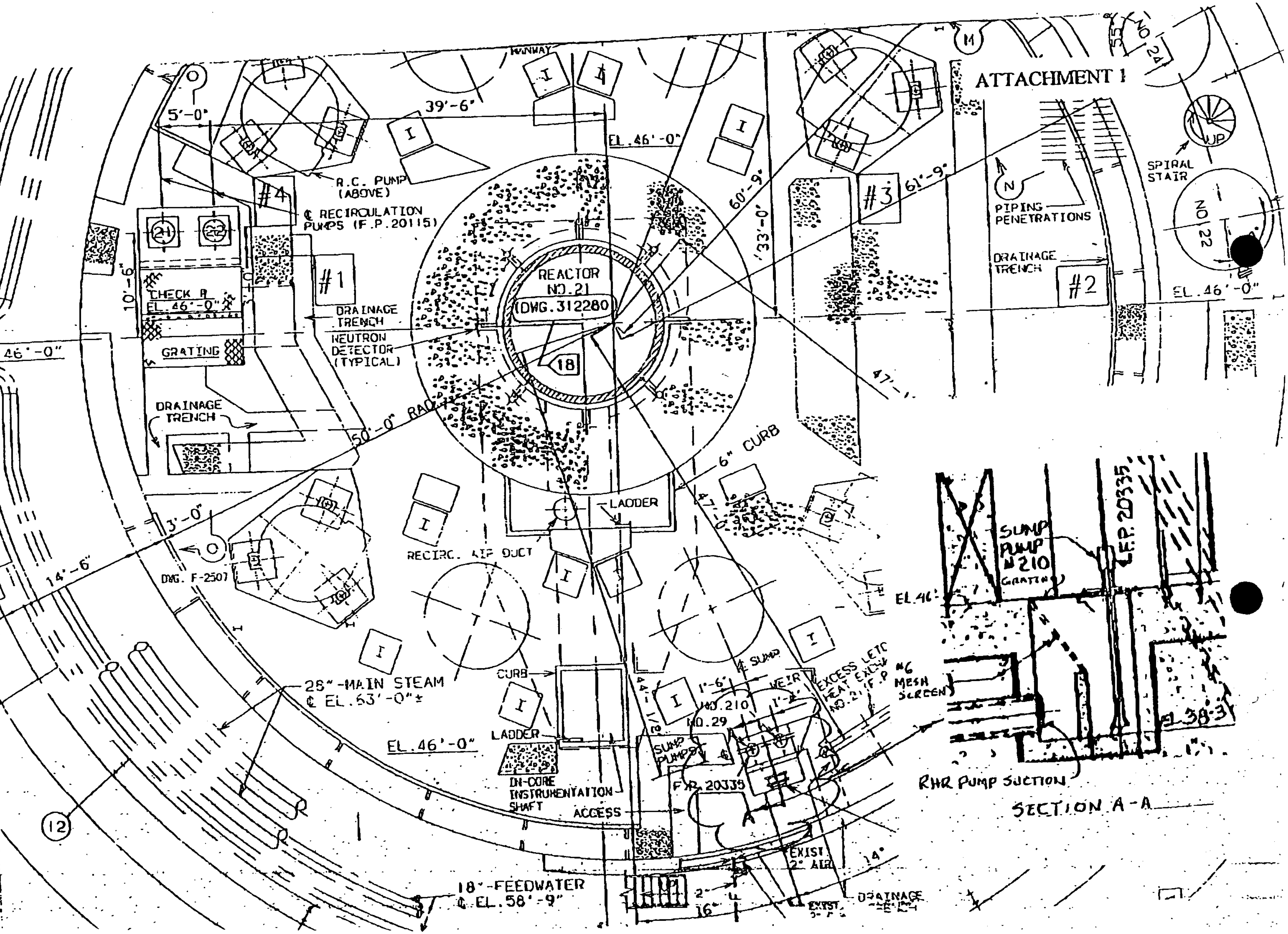
Generic Letter Requested Information Item 5

When containment overpressure is credited in the calculation of the available NPSH, confirm that an appropriate containment pressure analysis was done to establish the minimum containment pressure.

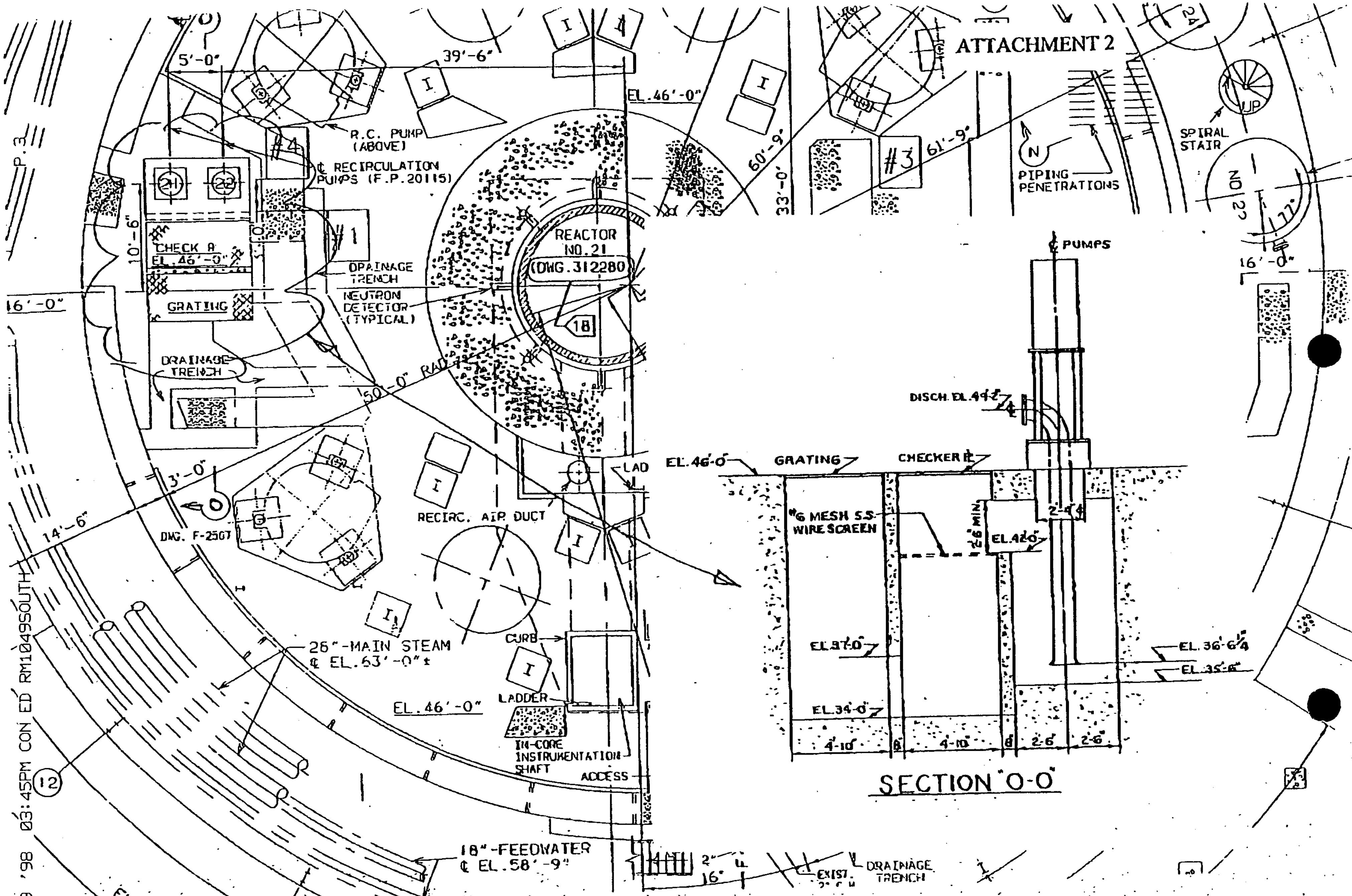
Response

Since containment overpressure was not credited in the calculation of the available NPSH, this question is not applicable to IP2.

ATTACHMENT I



ATTACHMENT 2



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