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December 23, 1997
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U. S. Nuclear Regulatory Commission
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Subject: Indian Point 3 Nuclear Power Plant
Docket No. 50-286
James A. FitzPatrick Nuclear Power Plant
Docket No. 50-333
90-day Response to NRC Generic Letter 97-04
Assurance of Sufficient Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal Pumps

Reference:
1. NRC Generic Letter 97-04, "Assurance of Sufficient Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal Pumps," dated October 7, 1997
2. NRC letter, K. R. Cotton to W. J. Cahill, Jr. dated December 6, 1996 regarding Amendment 239 to the FitzPatrick Technical Specifications

Dear Sir:

On October 7, 1997, the Nuclear Regulatory Commission issued Generic Letter 97-04 (Reference 1) regarding an issue which may have generic implications for emergency core cooling system pumps. The generic letter asked commercial nuclear power plant licensees to submit within 90 days, information to confirm the adequacy of net positive suction head (NPSH) for emergency core cooling and containment heat removal pumps.

Attachment 1 provides the requested information for the Authority's Indian Point 3 Nuclear Power Plant. Attachment 2 contains the requested information for the James A.

A001

FitzPatrick plant. Based on the information and analyses referred to in these Attachments, the available NPSH at both FitzPatrick and Indian Point 3 is adequate.

At Indian Point 3, no credit is taken for containment overpressure in the calculation of available NPSH. Only minor changes to the structures, systems and components that affect emergency core cooling and containment heat removal pumps NPSH have been made since the plant was completed. Current NPSH analyses are similar to those reviewed and approved by the NRC for the issuance of the Operating License.

At FitzPatrick, torus (suppression pool) overpressure is not credited in HPCI (High Pressure Coolant Injection) pump NPSH calculations. Residual Heat Removal and Core Spray pump NPSH calculations take credit for up to 2 psig of torus overpressure. This is similar to the less than 2 psig of overpressure credited in the NPSH calculations that formed the basis for the issuance of the original FitzPatrick Operating License. Two psig of torus overpressure was also credited in the NPSH analyses performed in support of FitzPatrick's recent power uprate program. Changes to FitzPatrick's Technical Specifications and Operating License, resulting from the power uprate program, were issued by the NRC with Reference 2.

There are no commitments in this letter. If you have any questions, please contact Ms. C. D. Faison.

Very truly yours,

J. Knubel
Chief Nuclear Office and
Senior Vice President

STATE OF NEW YORK
COUNTY OF WESTCHESTER

Subscribed and sworn to before me
this 23rd day of December 1997.

Notary Public

EILEEN E. O'CONNOR
Notary Public, State of New York
No. 4991062
Qualified in Westchester County
Commission Expires January 21, 1998

cc: Next page

Attachments:

1. New York Power Authority – Indian Point 3 Nuclear Power Plant, Response to NRC Generic Letter 97-04

2. New York Power Authority – James A. FitzPatrick Nuclear Power Plant, Response to NRC Generic Letter 97-04

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New York Power Authority – Indian Point 3 Nuclear Power Plant
Response to NRC Generic Letter 97-04

Introduction

The design-basis information requested by Generic Letter 97-04 (Reference 1) is presented below in a question and answer format. Each response to the five questions has three parts; one for the Recirculation Pumps, one for the Residual Heat Removal (RHR) pumps, and one for the Safety Injection (SI) pumps. The analyses referenced in the answers were used to determine the available net positive suction head (NPSH) for the emergency core cooling and containment heat removal pumps.

Design basis secondary line (steam line) breaks are analyzed in UFSAR Section 14.2.5.1. Steam line breaks are relatively short-term events and rely on the volume of water stored in the refueling water storage tank (RWST). As a result, they do not involve use of containment sumps. In addition, containment overpressure is not credited in the calculation of available NPSH.

The paragraphs below provide general background information about Indian Point 3's emergency core cooling and containment heat removal pumps. Refer to UFSAR Chapter 6 for additional information on IP3 engineered safety features.

SI Recirculation (Recirc) Pumps

Two SI recirculation pumps draw water from the recirculation sump located inside the containment building. These pumps are conventional wet pit, vertical condensate type pumps with their suction bells immersed in a shared recirculation sump. These pumps provide flow to both RHR heat exchangers for the post-LOCA (Loss of Coolant Accident) recirculation mode without circulating contaminated sump water outside the containment.

Residual Heat Removal (RHR) Pumps

For purposes of the Generic Letter, the mode of operation of concern is the post-LOCA Recirculation Phase, during which the RHR pumps can be used to draw suction from the Containment. The RHR pumps can provide a backup to the function performed by the two redundant SI recirculation pumps. The RHR pumps would only be used for post-LOCA recirculation in the event neither of the two internal SI recirculation pumps and/or their attendant piping were available. Should the RHR pumps be used for post-LOCA recirculation, their common suction pipe is aligned to the Containment Sump. This sump is a different sump inside the Containment building separate and apart from the recirculation sump which is used only by the SI recirculation pumps.

Safety Injection Pumps

For purposes of the Generic Letter, the mode of operation of concern for the High Head Safety Injection pumps (HHSI) is the post-LOCA recirculation phase. During this mode, the HHSI pumps are normally fed by the recirculation pumps, which are located inside the

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Containment building. The HHSI pumps can be aligned to take suction from the discharge of the recirculation pumps. This will provide the additional head necessary to overcome the RCS pressure for recirculation. In the unlikely event that the two recirculation pumps and/or their attendant piping failed to function, the Residual Heat Removal pumps could similarly be aligned to feed the HHSI pumps. For these modes of operation in this phase of accident event mitigation, the SI pumps would be in what the Generic Letter describes as "piggyback" operation.

Since the HHSI pumps can be fed directly from either the Recirculation or Residual Heat Removal pumps, which can take suction from applicable sumps in the Containment, the Generic Letter questions apply to these pumps. Containment spray may be fed by the Recirculation pumps during the recirculation phase.

Question 1

Specify the general methodology used to calculate the head loss associated with the ECCS suction strainers.

Response 1

SI Recirculation (Recirc) Pumps

The recirculation sump provides two levels of protection from debris for the recirculation sump. A floor grating (with 1" x 4" openings) provides the first barrier and a mesh screen (sized to exclude particles greater than 1/8" in diameter) is the second. The original NPSH calculations performed by Westinghouse (Reference 2) did not identify the head loss through the grating and screens.

NYPA has recently performed a calculation (Reference 3) for the recirculation pumps. This calculation uses information from a previous Bechtel calculation on the recirculation sumps.

These calculations conservatively considered approach velocities at 6000 gpm flows and mesh solidarity ratios. The results determined head loss through the mesh screens assuming 50% blockage to be very minor at 0.023 ft. The grating loss calculation considers the same 6000 gpm flow and the geometry/open areas of the grating. The head loss for the grating at 50% blockage is also minor and is calculated to be 0.05 ft.

These calculations show that losses through the screens and grating, even with 50% blockage, are negligible and validate the assumption in the Westinghouse calculation (Reference 2).. The recently issued NYPA calculation (Reference 3) incorporates these losses.

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Residual Heat Removal (RHR) Pumps

The containment sump provides two levels of protection from debris for the RHR pumps. A floor grating (with 1" x 4" openings) provides the first barrier and a mesh screen (sized to exclude particles greater than 1/8") as the second. The original NPSH calculations performed by Westinghouse (Reference 2) did not identify the head loss through the sump grating and screens.

Bechtel had subsequently been requested to calculate the NPSH required for these pumps (Reference 4). The formulas for screen head loss conservatively considered velocities for two-pump operation at 6000 gpm and mesh solidarity ratios. A head loss coefficient was determined. The results determined head loss through the screens at 0% and 50% blockage to be very minor at 0.01 and 0.06 ft, respectively. The grating loss calculation (Reference 5) considered the same 6000 gpm flow and the geometry/open area of the grating. Again, a head loss coefficient was used. The head loss for the grating at 0% and 50% blockage are also minor and calculated to be 0.06 and 0.7 ft, respectively.

The results from these independent Bechtel calculations demonstrate that the pressure loss through the screens and grating, even with a 50% blockage, is minor. With the relative margins available in the RHR calculations (see Table 1, response to Question 2), these calculations support the acceptability of the Westinghouse calculation (Reference 2), which did not specifically identify these losses.

Note: The Bechtel information is presented in support of the acceptability of the Westinghouse calculation.

Safety Injection Pumps

The SI pumps previously had start-up suction line strainers. These strainers have been removed from the lines. Refer to the information provided on the recirculation and RHR pumps for discussion regarding losses across the grating and strainers.

Question 2

Identify the required NPSH and the available NPSH.

Response 2

Recirculation (Recirc) Pumps

An original Westinghouse calculation (Reference 2) provides NPSH results and refers back to another calculation (Reference 6) for required flow rates. The calculation provides the formula as:

$$NPSHA = (P_{atm} - P_{v.p.}) + H_{elev} - H_{velocity} - H_{friction}$$

Where

P_{atm} = Atmospheric pressure in containment

$P_{v.p.}$ = Vapor pressure of sump water

H_{elev} = Static head of liquid above pump inlet bell

$H_{velocity}$ = Head loss due to fluid velocity

$H_{friction}$ = Head loss due to friction

The (P_{atm} -$P_{v.p.}$) term is set equal to zero assuming saturated liquid conditions. As the pumps are conventional vertical condensate pumps and are immersed in recirculation sump water, the Westinghouse calculations simplified the NPSH equation to NPSHA = H_{elev}. No resistance was factored in for the sump screens or grating. That calculation was recently superseded by a NYPA calculation (Reference 3) to correct the pump inlet datum point - the reference elevation point for NPSH determination, and incorporate new vendor information on NPSH required vs. flow. This NPSH datum reference elevation was raised 10" higher, from the inlet bell up to the eye of the first stage impeller. A new required NPSH curve was provided by the vendor based on a shop test of a first stage impeller of the identical design as used in the IP3 recirculation pumps. The NPSH calculation methodology employed in the NYPA calculation (Reference 3) is the same as the Westinghouse calculation, however; instrument inaccuracies, sump blockage and the affect of pump minimum flow lines were also considered.

From the partially superseded Westinghouse calculation (Reference 2), the results of which are still currently listed in Table 6.2-13 of the IP3 FSAR, the required NPSH at 3000 gpm was approximately equal to 10.5 ft. and available NPSH equal to 10.6 ft. for one pump operation.

From the new NYPA calculation (Reference 3), the results are as follows: NPSHA = 11.03 ft and NPSHR = 10.07 ft at 3262 gpm. Considering the vendor allowance of 90% NSPHR, then NPSHR can be as low as 9.07 ft. The pump vendor provided revised data on NPSHR and cavitation allowance (Reference 20).

Residual Heat Removal (RHR) Pumps

A Westinghouse calculation (Reference 2) provides NPSH results and uses data from two other calculations (References 7 and 8). Reference 8 calculation provides the NPSH formula as follows:

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$$NPSHA = H_{sump\ pres} + H_{elev\ sump\ water} - H_{vapor\ pres} - H_{vel} - H_{losses}$$

Where

$H_{sump\ press}$	= Head corresponding to containment pressure at sump
$H_{elev\ sump\ water}$	= Static head due to sump fluid level above pump
$H_{vapor\ press}$	= Head due to vapor pressure of sump fluid
H_{vel}	= Head loss due to fluid velocity
H_{losses}	= Suction line head loss

Due to saturated conditions, $H_{sump\ pres}$ is said to equal and cancel out $H_{vapor\ pres}$. Credit for overpressurization, or accident pressure is not included in the analysis. Resistance for the sump screens was not specifically accounted for. Calculation References 7 and 8 adjust the losses term due to piping differences between IP2 and IP3 and an additional 10% is added into the overall losses for margin. The result is expressed as a multiplier of the flow rate squared. Two calculations are provided, one for single pump operation and one for dual pump operation, both of which include the 10% margin multiplier. Calculation Reference 2 provides NPSH results with a flow rate of 5200 gpm.

NYPA calculation IP3-CALC-RHR-00104 (Reference 9) also employs the resultant formula of the previous Westinghouse calculation (Reference 7) to determine the available NPSH and obtains required NPSH from pump curves at various flow rates for one pump to verify there is at least 15% margin available. This demonstrates an additional 15% above the 10% margin already credited in the Westinghouse formula.

From the Westinghouse calculation (Reference 2), at 5200 gpm the NPSH required is approximately 17.0 ft. and NPSH available is 18.48 ft. for one pump operation. Note: refer to NYPA response to question 3 regarding this Westinghouse calculation and the subsequently performed NYPA calculation and results below.

From the subsequent NYPA calculation (Reference 9), the results of the most restrictive pump are presented in Table 1. (Note that Table 1 does not reflect head losses for suction strainers, i.e. floor grating and mesh screen.)

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Table 1

Required and Available Net Positive Suction Head Following a Design Basis Loss of Coolant Accident – RHR Pumps

Flow (gpm)	NPSHR (feet)	NPSHA (feet)	Margin
4000	15.5	24	55%
4250	17.0	23	35%
4500	18.6	21.9	18%

This calculation demonstrates that with one RHR pump supplying both RHR heat exchangers (with downstream RHR Heat Exchanger outlet valves throttled), there is at least a 15% NPSH margin in addition to the 10% margin applied in the Westinghouse calculation. The 15% margin is reflected in the IP3 FSAR (paragraph 6.2.3).

Safety Injection Pumps

Westinghouse calculation (Reference 2) provides the determination and result of the NPSH for the HHSI pump. The calculation employs the following formula to determine available NPSH:

$$NPSH = H_{Disch\ of\ Recirc\ pump} \pm H_{elev} - H_{vapor\ pres} - H_{Friction} - H_{vel}$$

Where

$H_{Disch\ of\ Recirc\ pump}$ = Discharge head pressure from recirculation pumps

H_{elev} = Static head loss (or gain) due to elevation

$H_{vapor\ press}$ = Head of vapor pressure of sump fluid

$H_{friction}$ = Head loss due to friction

H_{vel} = Head loss due to fluid velocity

The calculations use a low recirculation pump discharge head value of 305 ft. This corresponds to a flow rate of approximately 3400 gpm and is conservative, as lower recirculation pump flow rates will produce more available head. An additional 10% is factored into the overall available NPSH for margin and the result is given for a 650 gpm HHSI flow rate.

From the above referenced calculation, with two SI pumps running at 650 gpm each, the HHSI pump required NPSH is approximately 30 ft. and available NPSH is 79.9 ft. These values currently appear in the IP3 FSAR (Table 6.2-13).

Question 3

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

Response 3

Current NPSH analyses are similar to those reviewed and approved by the NRC for the issuance of the Operating License.

SI Recirculation (Recirc) Pumps

The current design basis analysis differs from the most recent analysis reviewed and approved by the NRC. The recently issued NYPA calculation (Reference 3) was completed in late 1997. This calculation and new vendor curve revises the NPSH data as currently described in FSAR Table 6.2-13 and Figure 6.2-4, respectively.

Nuclear Safety Evaluation NSE 97-3-351 (Reference 10) was issued in support of an EOP review and FSAR change. The recirculation pumps are discussed relative to pump operation with potential flow rates greater that 3000 gpm. The information from the pump manufacturer is cited on the ability of these pumps to operate satisfactorily with a 10% reduction in NPSHR.

In response to AEC (NRC) Question 6.4 (Reference 11), the Authority acknowledged the small margins between NPSHR and NPSHA for the Indian Point 3 recirc pumps. In its response, the Authority stated:

> *"Note that the available NPSH for internal recirculation pumps is just barely greater than the required NPSH. The available NPSH for these pumps is adequate even though almost equal to the required NSPH. These pumps are designed to operate under cavitating conditions and the pump vendor has approved the proposed method of operation. The plant operating instructions will instruct the operator to throttle flow as necessary to avoid long-term operation under cavitating conditions."*

Residual Heat Removal (RHR) Pumps

The current design basis analysis differs from the most recent analysis reviewed and approved by the NRC. NYPA calculation (Reference 9) was performed to support FSAR and operating procedure changes. The FSAR had an erroneously low required NPSH value of 17 ft. for a single RHR pump with a flow rate of 5200 gpm (the correct required

NPSH value @5200 gpm is 24 ft). As a result, operating procedures were changed to prevent pump flows from exceeding 4500 gpm. Reference 12 details the change. Emergency Operating Procedure EOP ES-1.3 (Reference 13) currently allows plant operators to establish up to 4000 gpm with the RHR pumps.

Subsequent to the original IP3 License, additional RHR pump recirculation lines were installed in response to I.E. Bulletin 88-04 (Reference 14) as part of a plant modification (Reference 15). A nuclear safety evaluation (Reference 16) contains the applicable safety evaluation for the changes. These new 3" recirculation lines (Nos. 3042 and 3043) draw off some flow downstream of each RHR pump; however, the original plant pump miniflow line (337) was throttled to compensate for the flow of the new lines. As a result, there is no significant affect on the pumps effective discharge flow or additional NPSH requirements.

Safety Injection Pumps

The current design basis analysis does not differ from the most recent analysis reviewed and approved by the NRC. A NYPA nuclear safety evaluation (NSE 94-3-135 SI, Reference 17) restricts operation to two HHSI pumps during hot leg recirculation. Hot leg recirculation can only be accomplished using the HHSI flow path.

Question 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 the minimum overpressure available.

Response 4

SI Recirculation (Recirc) Pumps

Containment overpressure is not credited in the calculation of available NPSH. The Westinghouse calculation (Reference 2) assumes that the containment pressure will equal the vapor pressure of the fluid in the containment sump. More recent NYPA calculations (Reference 3), using the Westinghouse methodology, make the same assumption. This is consistent with the guidance in NRC Regulatory Guide 1.1 (Reference 18) and Revision 4 of NUREG-0800 (Reference 19). These guidance documents suggest that containment pressure equal the vapor pressure of the sump water to ensure that credit is not taken for containment overpressure following a design basis LOCA.

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Residual Heat Removal (RHR) Pumps

Containment overpressure is not credited in the calculation of available NPSH. The Westinghouse calculations specify that the containment pressure is equal to the vapor pressure of the fluid in the containment sump. The more recent NYPA calculation, which uses the Westinghouse calculation as its basis, therefore also adheres to this same consideration. This is consistent with Regulatory Guide 1.1, which was further clarified by Revision 4 of NUREG-0800. This guidance states NPSH analysis should be based on the assumption that the containment pressure equals the vapor pressure of the sump water in order to ensure that credit is not taken for containment pressurization following a design basis LOCA.

Safety Injection Pumps

Containment overpressure is not credited in the calculation of available NPSH. In determining the NPSH the Westinghouse calculation (Reference 2) subtracts the vapor pressure for 270 °F sump water, but takes no credit for positive atmospheric pressure. Credit is appropriately taken for the pressure produced by the recirculation pumps feeding the SI pumps. This is consistent with Regulatory Guide 1.1, which was further clarified by Revision 4 of NUREG-0800 that stated that NPSH analyses should be based on the assumption that the containment pressure equals the vapor pressure of the sump water in order to ensure that credit is not taken for containment pressurization following a design basis LOCA. The value for the recirculation pumps discharge head in the calculation corresponds to a minimal value and can be considered a conservative input.

Question 5

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

Response 5

SI Recirculation (Recirc) Pumps

Containment overpressure is not credited in the calculation of available NPSH. Refer to response to question 4 above.

Residual Heat Removal (RHR) Pumps

Containment overpressure is not credited in the calculation of available NPSH. Refer to response to question 4 above.

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Safety Injection Pumps

Containment overpressure is not credited in the calculation of available NPSH. Refer to response to question 4 above.

Conclusion

Based on the information detailed above, the NPSH available for the ECCS pumps, (including recirculation, residual heat removal and safety injection pumps), and containment heat removal pumps following a design basis accident and secondary line break is adequate. The specific situations identified in Generic Letter 97-04 have been reviewed with the following results:

- Containment overpressure is not credited in the calculation of available NPSH.
- Hydraulic losses in suction piping have been considered.
- The methodology used to calculate NPSH is appropriate.
- Current NPSH analyses are similar to those reviewed and approved by the NRC for the issuance of the Operating License.
- A hot fluid correction factor was not used in NPSH calculations.
- NPSH calculations show ECCS pump suction strainers' head losses are negligible.
- Analyses conservatively assume that plant conditions are at the minimum/maximum allowed by Technical Specifications.

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References

1. NRC Generic Letter 97-04, "Assurance of Sufficient Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal Pumps," dated October 7, 1997

2. Westinghouse Calculation RFS-IN-1456, dated April 4, 1972, "Calculation of NPSH Requirements for ECCS Pumps"

3. NYPA Calculation IP3-CALC-SI-02430, Rev. 1, "NPSHA/NPSHR for Internal Recirculation Pumps 31 and 32".

4. Bechtel Calculation 3M90EJ01, Rev. 2, "Net Positive Suction Head-RHR Pumps of Unit 3"

5. Bechtel Calculation IP2-2, Rev. 0, "Flow to Containment Sumps"

6. Westinghouse Calculation RFS-I-892, "SI Low-Head Recirculation," dated February 7, 1972

7. Westinghouse Calculation RFS-IN-963, dated January 31, 1972, " NPSH Available for RHR Pumps During Recirculation and Cool-down"

8. Westinghouse Calculation RFS-I-673, dated February 9, 1972, "Recirculation Operation of RHR Pumps"

9. NYPA Calculation IP3-CALC-RHR-00104, Rev. 0, "RHR Pump NPSH During Recirculation"

10. NYPA Nuclear Safety Evaluation NSE 97-3-351, Rev. 0, "Evaluation of ES-1.3 and FSAR Changes Due to Extent of Condition Review"

11. NYPA response to AEC/NRC Question 6.4, Supplement 4, dated June 1972

12. NYPA Nuclear Safety Evaluation NSE 90-03-280 RHR, Rev. 0, "Evaluation of RHR Pump NPSH Under Long-Term Post-LOCA"

13. NYPA Emergency Operating Procedure, Indian Point 3, EOP ES-1.3, Revision 13, "Transfer to Cold Leg Recirculation"

14. NRC Inspection and Enforcement Bulletin No. 88-04, "Potential Safety-Related Pump Loss," dated May 5, 1988

15. Indian Point 3 modification MOD 89-3-251 RHR, Rev. 0, "RHR Pump Miniflow Modification"

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16. NYPA Nuclear Safety Evaluation NSE 89-03-251 RHR, Rev. 2, "RHR Pump Miniflow Modification"

17. NYPA Nuclear Safety Evaluation NSE 94-3-135 SI, Rev. 0, "Maximum Number of Operating Safety Injection Pumps During Hot Leg Recirculation"

18. NRC Regulatory Guide 1.1, "Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal System Pumps," dated November 2, 1970 (originally Safety Guide 1)

19. NUREG-0800, Revision 4, "Standard Review Plan for the Review of Safety Analysis Reports For Nuclear Power Plants – LWR Edition"

20. IP3-RPT-UNSPEC-02568, Rev. 0, "Engineering Study for NYPA IP3 – IDP Pump Model 24APK-3, Internal Recirculation Pumps S/N A67-019/20"

New York Power Authority – James A. FitzPatrick Nuclear Power Plant
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Introduction

The design-basis information requested by Generic Letter 97-04 (Reference 1) is presented below in a question and answer format. The analyses referenced in the answers were used to determine the available net positive suction head (NPSH) for the emergency core cooling and containment heat removal pumps that take suction from the suppression pool following a design basis LOCA. Specifically, the operation of the Residual Heat Removal (RHR), High Pressure Coolant Injection (HPCI) and Core Spray (CS) pumps were analyzed for short term and long term cooling following a design-basis LOCA. Information included in the responses on HPCI applies only to the HPCI pump (23P-1M/B), the torus suction strainer (23F-9) and the associated torus suction flowpath.

The James A. FitzPatrick Nuclear Power Plant does not use pumps in a "piggyback" operation for recirculation cooling of the reactor core or containment suppression pool.

The HPCI, CS and RHR systems are described in the FitzPatrick UFSAR. See Section 6.4.1 for additional information regarding HPCI, Section 6.4.3 for information regarding CS, and Section 6.4.4 regarding RHR (LPCI mode). UFSAR Section 6.5 outlines the safety basis for ECCS operation.

Question 1

Specify the general methodology used to calculate the head loss associated with the ECCS suction strainers.

Response 1

Residual Heat Removal and Core Spray Pumps

The head losses for each of the suction strainers for the RHR and CS pumps were included in "NPSH-available" calculations of record for each of the systems (References 2 and 3, respectively). These calculations modeled a strainer of equivalent area to that of the remaining open area of the existing strainers after structural blockages were deducted and a 50% strainer blockage criteria was applied. A resistance coefficient (or K-factor) was then selected to conservatively represent the head loss through the equivalent strainer. This K-factor was then added to the total system resistance calculated for the inlet piping to the pumps.

The overall available NPSH was calculated for each pump using the standard formula:

$$NPSH_{AVAILABLE} = H_A + H_{ST} - H_{VP} - H_F$$

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Where;

H_A = Absolute pressure (ft.) on the liquid surface

H_{ST} = Static head (ft.) of liquid level above centerline of pump impeller

H_{VP} = Head (ft.) corresponding to vapor pressure of liquid at pumping temperature

H_F = Head loss due to friction and entrance losses (ft.) in suction to pump

NOTE: A hot-fluid correction factor was not used to reduce the NPSH requirements.

In these calculations, the atmospheric pressure (H_A) on the liquid surface, was fixed and limited to standard atmospheric pressure; no credit was taken for the vapor pressure of the hot liquid. Additionally, the FitzPatrick torus is equipped with vacuum breakers, which prevent the pressure within the drywell from going below atmospheric pressure.

The initial suppression pool temperature at the time of the accident was conservatively assumed to be at the Technical Specification limit of 95°F during normal power operation (Reference 4). The initial torus water level at the time of the accident was conservatively assumed to be at the Technical Specification minimum level of 13.88 ft. above the bottom of the torus (Reference 4).

To meet the NPSH required by the pump at the accident conditions, up to 2 psig of torus pressure must be credited for both the RHR and CS pumps during long-term post-LOCA cooling. See UFSAR Section 6.5.1. The period when torus pressure credit is required is coincident with the period of peak torus temperatures.

High Pressure Coolant Injection (HPCI)

Stone & Webster calculation (Reference 5) determined the pressure drop for the suction lines from the CST (condensate storage tank) and the torus. The calculation used the methods detailed in Crane Technical Paper 410 (Reference 6) with a flow rate of 4250 gpm. A head loss of 1-foot (0.43 psi) was assumed for the torus suction strainer. Torus suction line pressure drop was calculated to be 2.4 psi.

This value (2.4 psi) was used in the power uprate calculation (Reference 7). As part of the power uprate program, available NPSH was re-evaluated and was determined to be adequate with 144°F torus water temperature. (Table 1 is based on conservatively assumed torus water temperature of 150°F at 10 minutes after the start of the event.) A 4°F increase in torus water temperature was a result of the increase in reactor power level.

Question 2

Identify the required NPSH and the available NPSH.

Response 2

Residual Heat Removal and Core Spray Pumps

$NPSH_{REQUIRED}$ and $NPSH_{AVAILABLE}$ for the limiting cases for pumps taking suction from the suppression pool following a design-basis accident LOCA are provided in Table 1.

The NPSH required by each pump was determined from certified, vendor pump test curves. NPSH values were read at flow rates representing maximum system flows during the first ten minutes of the event followed by design basis flow rates for the remainder of the post-LOCA operation. The NPSH analysis case used assumptions and initial conditions that minimize the available suppression chamber pressure (overpressure source) and maximize the suppression pool water temperature.

The available NPSH is dependent on the containment conditions, including overpressure, the number of pumps operating, piping configuration and the suppression pool temperature at the most limiting conditions. The suppression pool temperatures and pressures were based on the most recent accident analysis performed by the General Electric Company (Reference 8) in support of raising the maximum allowable ultimate heat sink (Lake Ontario) temperature for FitzPatrick from 82°F to 85°F at power uprate conditions. Methodologies used to determine the available NPSH for power uprate and current operating conditions were consistent. Current operating conditions is the combination of power uprate and elevated lake water temperature.

The General Electric computer program SHEX was used to analyze containment pressure and temperature response up to one day following an accident. As stated in Reference 8, SHEX has been accepted by the NRC for the calculation of containment response during accidents and transients.

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Table 1
Required and Available Net Positive Suction Head Following a Design Basis Loss of Coolant Accident – Taking Suction from the Suppression Pool

PUMP	Pump Flowrate/ Water Temp (gpm/°F)	Required NPSH(ft)	Available NPSH(ft)	Torus Overpressure Credited	Calculation Reference No.
Residual Heat Removal	10,500 gpm 150°F*	18.0	32.5	None Credited	Ref. 2
	7,700 gpm 213°F**	13.0	8.4	2.0 psi (4.6 ft.)	Ref. 14
Core Spray	6,000 gpm 150°F*	12.0	32.9	None Credited	Ref. 3
	4,725 gpm 213°F**	12.0	8.0	1.7 psi (4.0 ft.)	Ref. 14

Notes for Table 1:

* The limiting short-term case assumes the RHR and CS pumps are at maximum flow conditions. Reference 8 calculated the maximum suppression pool temperature during this phase of the event to be approximately 150 degrees F. No credit is taken for operator action until 10 minutes into the event.

** As outlined in FSAR Section 6.5.1, the limiting long-term case for NPSH available assumes a single failure of a diesel generator and loss of offsite power. (See Ref. 8) In this case, one RHR and one CS pump with flow throttled to design-basis values are assumed. RHR pump B was selected as being representative of the RHR pump piping arrangements. Other pumps are less limiting due to their piping configurations.

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High Pressure Coolant Injection (HPCI)

A calculation completed (Reference 7) as part of the power uprate project concluded that the available NPSH is 30.72 ft. HPCI pump vendor drawing 2.13-6 (Reference 9) shows a required NPSH of 16 ft. at the design flow rate of 4250 gpm.

A recent plant modification (Reference 10) changed the HPCI booster pump (23P-1B) impeller from a 4-vane to a 5-vane design. Discussions (Reference 11) with the HPCI pump vendor (BW/IP Byron-Jackson) confirmed that the 5-vane impeller has the same NPSH requirement characteristics as the 4-vane impeller.

Question 3

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

Response 3

Residual Heat Removal and Core Spray Pumps

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

The current NPSH analysis is based on plant operation at a reactor power level of 2536 MWt and a lake temperature of 85°F. The NRC issued a safety evaluation for Amendment 239 to the FitzPatrick Operating License (Reference 12) which approved an increase in thermal reactor power from 2436 MWt to 2536 MWt (Power Uprate). The increase in power level was approved at a lake temperature of 82°F and took credit for up to 2 psig torus overpressurization for both the CS and LPCI (RHR) pumps.

Subsequent to the issuance of Amendment 239, a change to the plant design-basis was made to allow plant operation with an 85°F lake water (Reference 13). An analysis for a design-basis accident at these conditions included a revised torus response (Reference 8). The result of the three-degree increase in the design-basis lake temperature was a decrease in available NPSH. However, the torus pressure required to meet pump NPSH requirements was still less than the 2 psig credited in the power uprate evaluation and in the original plant licensing basis.

High Pressure Coolant Injection (HPCI)

The current HPCI NPSH analysis (Reference 7) is part of the power uprate supporting documentation. The power uprate project was reviewed and approved by the NRC in the

Safety Evaluation Report associated with Technical Specification Amendment 239 (Reference 12). Therefore, the current design-basis NPSH analysis for the HPCI system does not differ from the most recent analysis reviewed and approved by the NRC for which a safety evaluation was issued.

Question 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 the minimum overpressure available.

Response 4

Residual Heat Removal and Core Spray Pumps

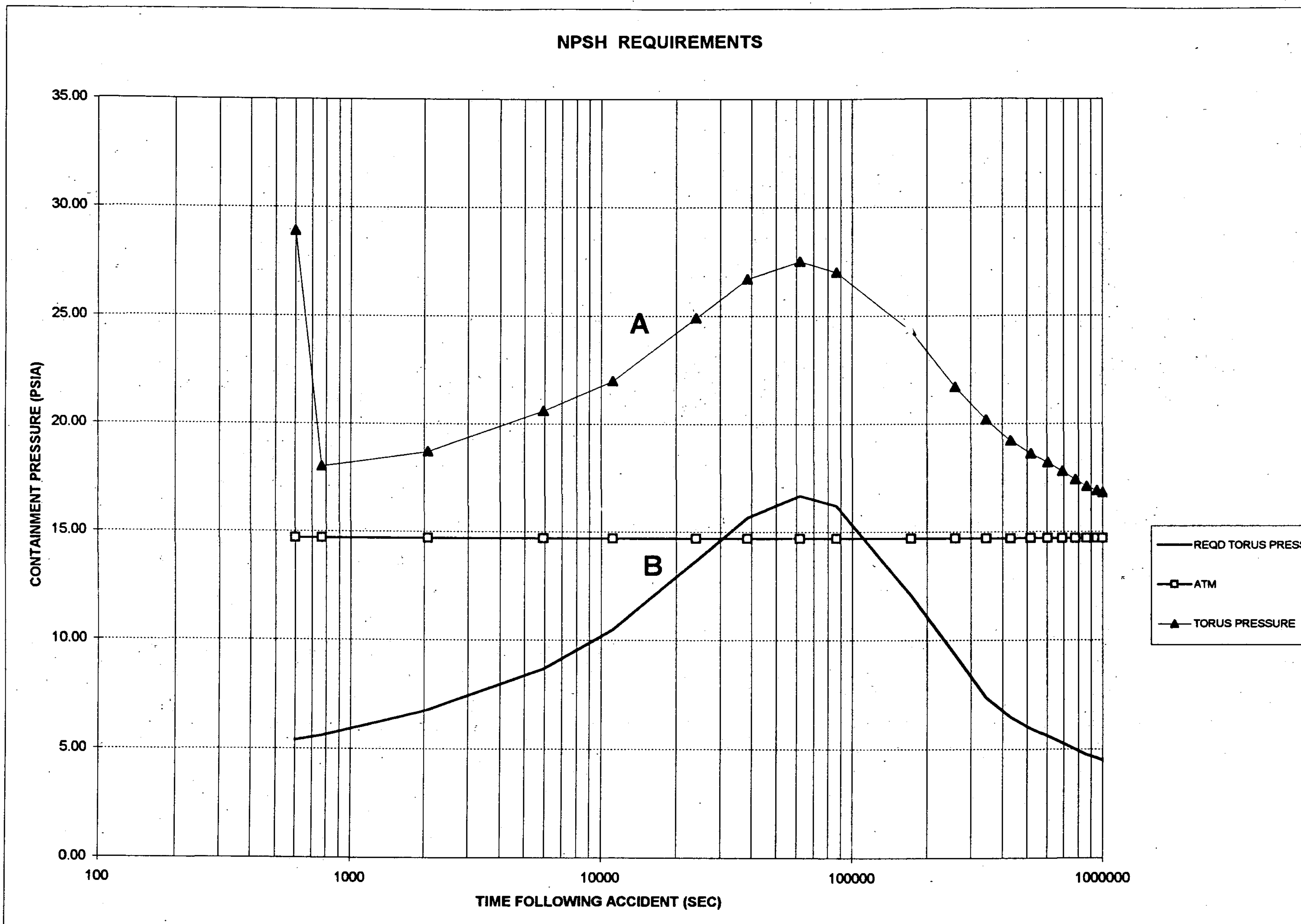
Up to two psig of torus overpressure is required for a period of time during long-term cooling for both the RHR and CS pumps to meet NPSH requirements. Torus overpressure is initially required at approximately the eighteenth hour after the initiation of the event. Reference 14 developed a time response curve for the required torus pressures and compares them to the torus pressure available during that same period. The maximum torus overpressure required to meet the pump NPSH requirements is 1.97 psig (4.6 ft.) for the RHR pumps and 1.75 psig (4.0 ft.) for the CS pumps. See Table 1. Required torus pressure varies with torus accident temperature.

Figures 1 and 2 provide the time response of the torus pressure and the torus overpressure assist required to meet the pump requirements for the RHR and CS pumps, respectively. As can be seen from the curves, during the period that overpressure is required, there is approximately 12 to 13 psig available torus overpressure. Design-basis LOCA analyses, based on plant operation at original licensing basis conditions, result in approximately 7 psig of torus overpressure. The increase of approximately 5 psig in predicted torus pressure was a result of the increase in reactor power from 2436 MWt to 2536 MWt (power uprate) and the increase in maximum analyzed ultimate heat sink temperature from 77°F to 87°F.

The point at which the maximum torus pressure assist is required is coincident with the maximum available NPSH on the minimum available NPSH curve. See Figures 1 and 2.

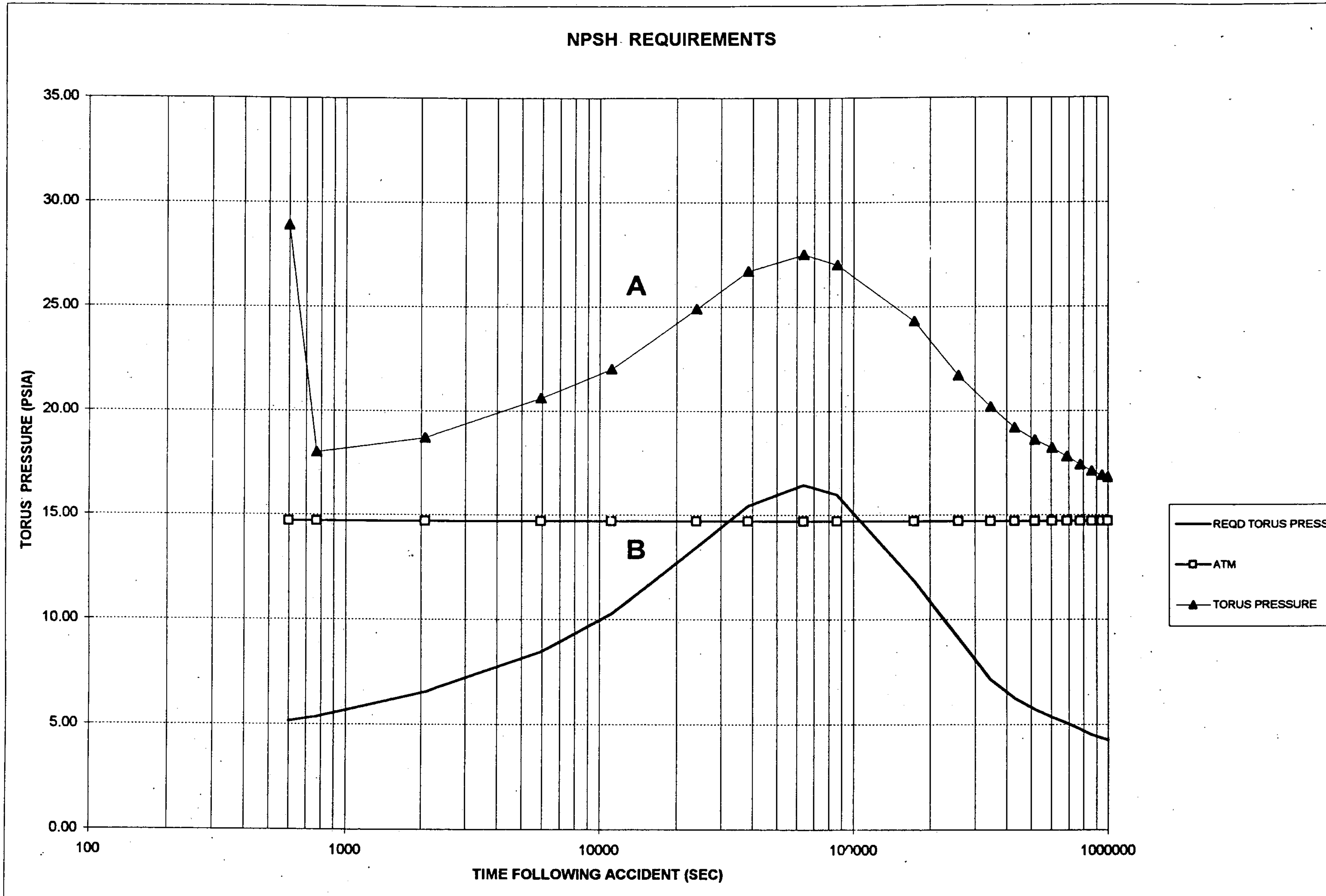
High Pressure Coolant Injection (HPCI)

Calculation (Reference 7) assumes a wetwell (torus airspace) pressure of 14.7 psia. Therefore, no credit is taken for containment overpressure in the calculation of available NPSH for the HPCI pumps.



A - TRANSIENT RESULTS FROM LOCA (MINIMUM TORUS PRESSURE)
B - TORUS PRESSURE REQUIRED FOR ADEQUATE NPSH AT RHR PUMP

James A. FitzPatrick Nuclear Power Plant
Response to NRC Generic Letter 97-04
Figure 1 - RHR PUMP NPSH REQUIREMENTS



A - TRANSIENT RESULTS FROM LOCA (MINIMUM TORUS PRESSURE)
B - TORUS PRESSURE REQUIRED FOR ADEQUATE NPSH AT CORE SPRAY PUMP

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Figure 2 - CORE SPRAY PUMP NPSH REQUIREMENTS

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Question 5

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

Response 5

Residual Heat Removal and Core Spray Pumps

A containment pressure analysis was done to establish the minimum containment pressure when containment overpressure is credited in the calculation of available NPSH. The accident analysis (Reference 8) performed by General Electric Nuclear Company for operation at power uprate and elevated lake water temperature conditions included a time-dependent response. This analysis included temperatures and pressures in the torus and drywell following the design-basis accident.

In performing the accident analysis for the NPSH evaluation, it was assumed that the drywell and wetwell sprays, along with the RHR heat exchanger are not activated until ten minutes in the event to suppress the wetwell pressure and reduce available NPSH. Also, the initial conditions of drywell pressure and temperature, drywell relative humidity and wetwell pressure were conservatively selected to minimize the initial mass of noncondensibles in the containment. Therefore, the minimum requirements for NPSH for RHR and CS pumps are met at all times following a design-basis accident.

High Pressure Coolant Injection (HPCI)

No containment overpressure was credited in the analysis of required NPSH for the FitzPatrick HPCI pump.

Conclusion

Based on the information detailed above, the NPSH available for the ECCS pumps, including core spray and decay heat removal, and containment heat removal pumps that take suction from the suppression pool following a design basis accident is adequate. The specific situations identified in Generic Letter 97-04 have been reviewed with the following results:

- Hydraulic losses in suction piping have been adequately accounted for.
- The increase in ultimate heat sink temperature to 85°F along with power uprate has been analyzed. The results of these analyses show that there is no need to credit more overpressurization than the original and current licensing basis permits (up to 2 psig).

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- Consistent with the original licensing basis, FitzPatrick need only credit containment pressurization for long-term LOCA events. There is no need to credit overpressure in the short-term.
- The methodology used in the suppression pool temperature analysis is the same as that used for the power uprate program.
- A hot fluid correction factor was not used in any NPSH calculation.
- NPSH calculations use ECCS pump suction head losses consistent with the current licensing basis.
- Analyses conservatively assume that suppression pool pressure and water level is at the minimum levels allowed by Technical Specifications, and that suppression pool water temperature was at the maximum allowable by Technical Specifications.

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References

1. NRC Generic Letter 97-04, "Assurance of Sufficient Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal Pumps," dated October 7, 1997

2. NYPA calculation JAF-CALC-RHR-02578, Rev. 1, "NPSH Calculation for LOCA Event for RHR System at Power Uprate conditions with 85 degree F and 87 degree F lake temperatures," dated April 23, 1997

3. NYPA calculation JAF-CALC-CSP-02581, Rev. 1, "NPSH Calculation for DBA-LOCA event for Core Spray System at Power Uprate with 85 degree F and 87 degree F Lake Temperature," dated May 12, 1997

4. James A. FitzPatrick Nuclear Power Plant Technical Specifications, Section 3.7.A.1, page 165

5. Stone and Webster Calculation 23-5, "HPCI Suction Piping Delta P," dated July 24, 1970.

6. Crane Technical Paper No. 410 "Flow of Fluids Through Valves, Fittings and Pipe"

7. Stone and Webster Power Uprate Calculation 01891-M-011, Revision 0, "High Pressure Injection Pump Available NPSH (Backup to Section 3.9.2.3,)" dated September 18, 1991. Accepted by NYPA July 31, 1995

8. General Electric Report GE-NE-T23-00737-01, "JAFNPP Higher RHR Service Water Temperature Analysis", dated August 1996

9. Byron Jackson test curve T-30036, "HPCI Pump Curve and Test Data – Head vs. GPM at 2000 RPM," Sheet 1 of 2, dated October 3, 1968. Vendor drawing 2.13-6, Rev. B.

10. NYPA modification D1-94-112, Rev. 2, "HPCI Pump Impeller Substitution." Approved December 2, 1994.

11. Record of telephone conversation, "NPSH Required for 5-vane HPCI Booster Pump Impeller (D1-94-112)," dated November 19, 1997

12. NRC letter, Karen R. Cotton to W. J. Cahill, Jr. dated December 6, 1996 regarding "Issuance of Amendment for James A. FitzPatrick Nuclear Power Plant (TAC No. M92781)."

13. NYPA nuclear safety evaluation, JAF-SE-96-048, Rev.1, "Revision to FSAR to Raise Allowable Lake Temperature from 82 degrees F to 85 degrees F," dated May 27, 1997

14. NYPA Calculation JAF-CALC-MULTI-02831, Rev. 0, "Torus Pressure Required to Meet ECCS Pump NPSH Requirements," dated October 23, 1997