Charles R. Pierce
Regulatory Affairs Director

Southern Nuclear
Operating Company, Inc.
40 Inverness Center Parkway
Post Office Box 1295
Birmingham, AL 35242

Tel 205.992.7872
Fax 205.992.7601

SOUTHERN COMPANY

June 16, 2014

Docket Nos.: 50-348
50-364

NL-14-0702

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D. C. 20555-0001

Joseph M. Farley Nuclear Plant – Units 1 and 2
Supplement to Response for Additional Information Regarding Condensate
Storage Tank Minimum Level License Amendment Request

Ladies and Gentlemen:

By letter to the U.S. Nuclear Regulatory Commission (NRC) dated August 20, 2012 (Agencywide Documents Access and Management System (ADAMS), Accession No. ML 12234A743), Southern Nuclear Operating Company, Inc., (SNC) submitted a license amendment request (LAR) for TS 3.7.6, "Condensate Storage Tank." The change revises the minimum condensate storage tank level from 150,000 gallons to 164,000 gallons. Subsequently, there have been three letters from the NRC with requests for additional information (RAI) for this LAR; letters dated September 25, 2012 (ADAMS Accession Number ML12257A098), November 26, 2012 (ADAMS Accession Number ML12320A543), and April 18, 2013 (ADAMS Accession Number ML13101A354). Responses to the requests for additional information were submitted by SNC in letters dating October 25, 2012 (ADAMS Accession Number ML12300A279), November 8, 2012 (ADAMS Accession Number ML12319A150), and July 2, 2013 (ADAMS Accession Number ML13198A443).

The SNC responses to the aforementioned RAIs contained references to a study performed by Duke Energy. This study was unable to be referenced by the NRC reviewer; therefore, this letter contains modified responses to the affected RAIs which do not reference the Duke Energy study.

Enclosure 1 of this letter contains modifications to the responses for questions 3 and 4 from the NRC letter dated September 25, 2012. Enclosure 2 contains a revision of an SNC calculation, which includes a revision of a report from Fauske and Associates that is referenced in Enclosure 1. Enclosure 3 contains the same SNC calculation and attachments from Enclosure 2, but with the proprietary information redacted.

Enclosures 4 and 5 contain a modified response to the RAI posed in NRC letter dated April 18, 2013 and a revision of a report from Fauske and Associates used to support Enclosure 4, respectively. Enclosure 6 contains the same report from Enclosure 5, but with proprietary information redacted.

Enclosure 7 of this letter contains the Westinghouse Application for Withholding Proprietary Information from Public Disclosure CAW-14-3974, accompanying Affidavit, Proprietary Information Notice, and Copyright Notice. It is respectfully requested that Enclosures 2 and 5, which contain information which is considered proprietary to Westinghouse Electric Company LLC, be withheld from public disclosure in accordance with Section 2.390 of the Commission's regulations.

This letter contains no NRC commitments. If you have any questions, please contact Ken McElroy at (205) 992-7369.

Mr. C. R. Pierce states he is Regulatory Affairs Director of Southern Nuclear Operating Company, is authorized to execute this oath on behalf of Southern Nuclear Operating Company and, to the best of his knowledge and belief, the facts set forth in this letter are true.

Respectfully submitted,

C. R. Pierce

C. R. Pierce
Regulatory Affairs Director

CRP/JMC/lac

Sworn to and subscribed before me this 16th *day of* June, *2014.*

Notary Public

My commission expires: 1/2/2018

Enclosures:

1. Modified Response to Questions 3 and 4 of Request for Additional Information Dated September 25, 2012
2. SNC Calculation SM-SNC335993-001, "CST AFW Pump Suction – Submergence Analysis," Version 3.0 (Proprietary)
3. SNC Calculation SM-SNC335993-001, "CST AFW Pump Suction – Submergence Analysis," Version 3.0 (Non-Proprietary)

4. Modified Response to Request for Additional Information Dated April 18, 2013

5. Fauske and Associates, LLC Report No. FAI/13-0392-P, "Request for Additional Information by the Office of Nuclear Reactor Regulation, Joseph M. Farley Nuclear Plants, Units 1 and 2, Southern Nuclear Operating Company, Docket Nos. 50-348 and 50-364, Revision 2" (Proprietary)

6. Fauske and Associates, LLC Report No. FAI/13-0392-NP, "Request for Additional Information by the Office of Nuclear Reactor Regulation, Joseph M. Farley Nuclear Plants, Units 1 and 2, Southern Nuclear Operating Company, Docket Nos. 50-348 and 50-364, Revision 2" (Non-Proprietary)

7. Westinghouse Electric Company, LLC CAW-14-3974, "Application for Withholding Proprietary Information from Public Disclosure," June 10, 2014

cc: Southern Nuclear Operating Company
Mr. S. E. Kuczynski, Chairman, President & CEO
Mr. D. G. Bost, Executive Vice President & Chief Nuclear Officer
Ms. C. A. Gayheart, Vice President – Farley
Mr. B. L. Ivey, Vice President – Regulatory Affairs
Mr. D. R. Madison, Vice President – Fleet Operations
Mr. B. J. Adams, Vice President - Engineering
RTYPE: CFA04.054

U. S. Nuclear Regulatory Commission
Mr. V. M. McCree, Regional Administrator
Mr. S. A. Williams, NRR Project Manager - Farley
Mr. P. K. Niebaum, Senior Resident Inspector - Farley
Mr. J. R. Sowa, Resident Inspector - Farley

Joseph M. Farley Nuclear Plant – Units 1 and 2
Supplement to Response for Additional Information Regarding Condensate
Storage Tank Minimum Level License Amendment Request

Enclosure 1

Modified Response to Questions 3 and 4 of Request for Additional
Information Dated September 25, 2012

There were two SNC responses from the Request for Additional Information (RAI) letter dated September 25, 2012 (ADAMS Accession Number ML12257A098) that made reference to a Fauske and Associates document (FAI/09-19, Rev 0) which discussed a Duke Energy study that SNC was unable to provide for the NRC review. Following are the two affected questions and SNC's response to those questions without information pertaining to the Duke Energy study. The other two questions from the RAI response are acceptable, therefore; they are not included below.

Question 3:
The LAR states that additional consideration regarding vortexing was applied during the revised calculation of the CST minimum volume. However, the LAR did not describe specific considerations that factored into changes made to the referenced revised calculations. Provide additional information to describe how the licensee factored in the vortexing effects as part of the revised calculation for the CST volume.

SNC Response:

During a CDBI inspection at Farley Nuclear Plant that was completed on December 8, 2011, the NRC team identified an unresolved item (URI 05000348, 364/2011010-04) regarding the evaluation of the CST minimum required submergence for the AFW pumps, given the potential for vortex formation in the CST. During the inspection, it was observed that the design calculation for the CST sizing did not evaluate the effects of tornado missile damage to the un-protected portion of the CST which could create an air introduction path under the CST bladder which would allow a vortex formation. Subsequently, a Green non-cited violation was issued in the NRC Quarterly Report "Joseph M. Farley Nuclear Plant – NRC Integrated Inspection Report 05000348/2012003, and 05000364/2012033", dated July 20, 2012.

In response to this URI and Green non-cited violation, compensatory measures have been taken to evaluate the minimum required submergence for the AFW pumps assuming the potential for vortex formation in the CST. This evaluation has been performed and issued as a separate and unique design calculation that determines the minimum submergence level required for the specific physical configuration of the AFW pump's suction piping (Enclosure 2). The results of this calculation have been used as design input into determining the minimum required volume of the CST.

The CST has two 8″ AFW suction pipes – one for the TDAFW pump and one for both MDAFW pumps. Both suction pipes open at 4″ from the tank's bottom, facing down at a 45 degree angle with the entry to the piping being parallel to the tank bottom. The suction piping centers are approximately 1′-3″ apart. The CST has an internal bladder that prevents introduction of air under normal operating conditions.
The primary technical reference utilized in determination of the minimum submergence level is Calculation-Note Number FAI/09-19, Rev. 1, titled

"Vortex Evaluation for Vogtle and Farley RWSTs and Hatch CSTs", dated April 2014, by Fauske and Associates, Inc. This calculation-note is Attachment 3 of Calculation SM-SNC335993-001 (See Enclosure 2).

This calculation-note was issued to Southern Nuclear by Westinghouse Nuclear Services as supporting documentation to the GL 2008-01 response. This calculation-note was reviewed and evaluated for applicability to the Farley CST in determining the minimum submergence level required to prevent vortex formation. This document states in the summary that data taken for tank configurations at D.C. Cook and Cooper nuclear plants all relate to the specific configurations used in the Southern Nuclear plants. In addition, it states that specific measurements all provide justification for the manner in which air intrusion should be assessed for the Vogtle, Farley, and Hatch CSTs. The results obtained from data taken produced results that are consistent with radial inflow conditions being the mechanism whereby significant gas intrusion would be drawn into the specific suction configurations. The downward facing suction configuration that is installed in Farley's CSTs acts to considerably suppress the potential for air intrusion. Evaluations of this radial inflow to the downward-facing elbow resulted in a bounding correlation for misbehavior. This correlation can be found in Enclosure 2, page 20 of 24. Since the Farley CST AFW pump's nozzle configuration is a 45 degree downward facing configuration that is similar to the downward facing elbow, the above correlation could be used to determine the submergence required to suppress air intrusion and vortex formation.

However, upon development of the calculation for determining the minimum submergence (Enclosure 2) for the Farley AFW pump's suction nozzles, the equation also presented in the calculation-note FAI/09-19 based on the Harleman correlation was utilized (note: for the Froude numbers of interest, the Harleman correlation bounds the above correlation developed for a downward-facing elbow.) This correlation defines the submergence level required above the horizontal entrance to a vertically downward suction as shown in Figure 5(a) of the calculation-note FAI/09-19. This correlation is given as $S_H/D = 0.75[N_{Fr}]^{0.4}$ on page 17 of 24. Even though the Farley suction nozzle is a 45 degree downward facing nozzle configuration, the Harleman correlation was used to provide a conservative submergence level. Using this vertically downward suction correlation increased the submergence level by a factor of two over the submergence for a 45 degree angle pipe or elbow nozzle facing downward. Thus, this greater submergence level was used in determining the volume component required in the CST sizing calculation for vortex prevention.

Question 4:
The LAR is incomplete and the staff cannot initiate a technical review until, at a minimum, the following is provided:

- Calculation of post-trip water requirements.
- Information that supports an independent evaluation of the level necessary to prevent vortexing.
- Provide the licensee's determination of the level that prevents vortexing.
- Applicable updated Final Safety Analysis Report sections.

SNC Response:

a) Calculation of post-trip water requirement.

Part (a) of the response was not affected by the new revision of FAI/09-19. Please refer to SNC letter dated July 2, 2013 (ADAMS Accession Number ML13198A443.)

b) Information that supports an independent evaluation of the level necessary to prevent vortexing.

The information necessary to support this request can be found in SNC's calculation, SM-SNC335993-001 Version 3.0, titled "CST AFW Pump Suction – Submergence Analysis" (see Enclosure 2). This calculation states "for the withdrawal of water from the CST, determine the minimum submergence water level in the tank to prevent vortexing at the AFW suction inlet when the flow rate is 700 gpm." This level (water volume) has been incorporated as input into the "Verification of CST Sizing Basis" calculation, BM-95-0961-001, which was sent in a previous SNC letter dated October 25, 2012 (ADAMS Accession Number ML12300A279). As stated, this calculation provides the bases for the method used in determination of the submergence level required to prevent vortex formation and air intrusion into the AFW pump's suction piping.

The summary of conclusions states the minimum submergence level required in the CST based on the operation of two (2) MDAFW pumps or the TDAFW pumps shall be 9.78 inches from the bottom of the tank which includes 4 inches of unusable volume below the suction nozzles. Also, the minimum submergence level required in the CST based on the operation of one (1) MDAFW pumps shall be 8.36 inches from the bottom of the tank.

c) Provide the licensee's determination of the level that prevents vortexing.

The equation based on the Harleman correlation presented on page 17 of 24 of calculation-note FAI/09-19 defines the submergence as the water height above the horizontal entrance to the vertically downward suction location as shown in Figure 5(a) of this calculation-note. This correlation is given as $S_H/D = 0.75[N_{Fr}]^{0.4}$. Even though the Farley suction nozzle is a 45 degree downward facing nozzle configuration that results in a lesser submergence level, as shown in Figure 6, the Harleman correlation was used to provide a conservative submergence level. Using this vertically downward suction correlation increased the submergence level by a factor of two over the submergence for a 45 degree angle pipe or elbow nozzle facing downward. Thus, this greater submergence level was used in determining the volume component required in the CST sizing calculation for vortex prevention. The submergence level, based on the vertically downward suction configuration, the piping size, and the AFW pumps flow rates, was determined to be 5.78 inches. Since the AFW pump's suction pipes open at 4 inches from the tank's bottom, the submergence level used to determine the CST's volume component to prevent air intrusion and vortex formation is 9.78 inches (using the correlation for the downward-facing elbow gives a smaller value of 7.7 inches).

d) Applicable updated Final Safety Analysis report sections.

Part (d) of the response was not affected by the new revision of FAI/09-19. Please refer to SNC letter dated July 2, 2013 (ADAMS Accession Number ML13198A443.)

Joseph M. Farley Nuclear Plant – Units 1 and 2
Supplement to Response for Additional Information Regarding Condensate
Storage Tank Minimum Level License Amendment Request

Enclosure 3

SNC Calculation SM-SNC335993-001,
"CST AFW Pump Suction – Submergence Analysis," Version 3.0
(Non-Proprietary)

SOUTHERN COMPANY
Energy to Serve Your World

Southern Nuclear Design Calculation

Calculation Number: SM-SNC335993-001

Plant: FARLEY	Unit: ☐ 1 ☐ 2 ■ 1 & 2	Discipline: Mechanical
Title: CST AFW Pump Suction – Submergence Analysis		Subject: CST Vortex Analysis
Purpose / Objective: CST AFW Pump Suction Vortex Potential		
System or Equipment Tag Numbers: Q1/2P11T001		

Contents

Nuclear Quality Level

■ Safety-Related ☐ Safety Significant ☐ Non- Safety –Significant

Version Record

Version No.	Description	Originator Printed Name Initial / Date	Reviewer Printed Name Initial / Date	Approval 1 Printed Name Initial / Date	Approval 2 Printed Name Initial / Date
1.0	Issue calc. in response to WO # SNC335993/CR355457	Willie Jennings WJJ/ 10/3/11	Jorge Marcano JM/ 10/3/11	C.M. Sellers CMS/ 10/3/11	C.M. Sellers CMS/ 10/3/11
2.0	Revise Methodology Reference	Willie Jennings WJJ/ 5/25/12	Andy Patko AJP/ 5/25/12	C.M. Sellers CMS/ 5/25/12	C.M. Sellers CMS/ 5/25/12
3.0	Revised to incorporate non-proprietary version of supporting Fauske Report (Att. 3)	Andy Patko Patko 5/28/14	SF Berryhill SFB 5/28/2014	DL Lambert DL 5/28/14	DL Lambert DL 5/28/14

Notes: Fauske Report FAI/09-19 Revision 1 was issued on April 2014. Revision 0 contains some proprietary Duke Energy experimental submergence testing performed at Alden Laboratories.

Plant: Farley Nuclear Plant	Calculation Number: SM- SNC335993-001	Sheet: 1 of 4

Design Inputs / References:

1. U-161703 Rev. ~~B~~ 0.3; U-161694 Rev. ~~C~~ 0.4; U-213481 Version 3.0
2. Fauske and Associates, Inc.; FAI/09-19 Rev. ~~0~~ 1; Vortex Evaluation for Vogtle and Farley RWST and Hatch CSTs.
3. P&IDs: D-175007 Version 31; D-205007 Version 25
4. CST Tank Drawing U 161693, Version 2.0; ~~U-213481 Version 3.0~~

3

Purpose of Calculation:

For the withdrawal of water from the CST, determine the minimum submergence water level in the tank to prevent vortexing at the AFW suction inlet when the flow rate is 700 gpm. This level (water volume) will be input into the "Verification of CST Sizing Basis" calculation, BM-95-0961-001 Version 5.0.

Summary of Conclusions:

The minimum submergence level required in the CST based on the operation of two (2) MDAFW pumps or the TDAFW pumps shall be 9.78 inches from the bottom of the tank.

The minimum submergence level required in the CST based on the operation of one (1) MDAFW pump shall be 8.36 inches from the bottom of the tank.

Methodology:

The methodology used is based on Fauske and Associates, Inc. ; FAI/09-19 Rev. ~~0~~ 1; Vortex Evaluation for Vogtle and Farley RWST and the Hatch CSTs (Ref. 2). 3

Assumptions:

1. It is assumed a failure of the condensate makeup line to the CST has occured due to a tornado or seismic event or a failure of the AFW recirculation piping to the CST has occurred due to a tornado missile, either event allowing air to enter the tank beneath the diaphragm creating the potential for vortex formation.
2. It is assumed the maximum flow is 700 gpm through the pumps' suction piping, since the MDAFW pumps are rated at 350 gpm each and share a common suction piping from the CST and the TDAFW pump is rated at 700 gpm and has it's on individual suction piping.

Body of Calculation:

Determine the minimum submergence per the following equation per Ref. 2

$S_H/D = 0.75 \times N_{Fr}^{0.4}$;

First, determine the Froude Number for the suction piping from $N_{Fr} = V_{pipe} / (g \times d_h)^{0.5}$

Q = 700 gpm = 1.56 ft^3/sec. per assumption 2

(the geometrical cross section of the pipe is shown in Attachment 2)

The hydraulic diameter (d_h) is determined by:

$$d_h = 4 \cdot \frac{A_{pipe}}{p_e}$$

and

$$V_{pipe} = \frac{Q}{A_{pipe}}$$, g, gravitational acceleration – 32.2 ft/s^2

Suction pipe is 8 inch sch 40 with a 7.981" ID and runs on a 45 degree angle. Therefore, the dimensions of this cross section is based on elliptical formulas. See Attachments 1 and 2.

Pipe diameter; d = 7.981" (width of ellipse)

Surface length: $d_A = \frac{d}{\sin(45deg)}$ d_A = 11.29 in.

Area of ellipse......... $A_{pipe} = \pi$ a b , where a = d_A/2; b= d/2

a = 5.64 in; b = 4.0 in.

$A_{pipe} = \pi$ (5.64) x (4.0) = 70.87 in^2 = 0.4921 ft^2

Perimeter (approx.) of ellipse...... $p_{e\_approx} = 2\pi \sqrt{\frac{a^2 + b^2}{2}}$

$$p_{e\_approx} = 2\pi\sqrt{\frac{(5.64)^2+(4)^2}{2}}$$

$p_{e\ approx.} = 30.72$ in $= 2.56$ ft.

Hydraulic diameter........... $$d_h = 4\cdot\frac{A_{pipe}}{p_e}$$

$d_h = 0.77$ ft.

Now, Pipe velocity at inlet is; $$V_{pipe} = \frac{Q}{A_{pipe}}$$

$V_{pipe} = 1.56\ ft^3 / 0.4921\ ft^2 = 3.17$ ft/sec

Now, Froude number; $N_{Fr} = V_{pipe}\ /\ (g \times d_h)^{0.5}$

$N_{Fr} = 3.17 / (32.2 \times 0.77)^{0.5}$

Thus $N_{Fr} = 0.64$

From Reference 2 for centrally located tank outlet, the critical submergence, S_H

$(S_H/D) = 0.75 \times N_{Fr}^{0.4}$;

$S_H = 0.75 \times (0.64)^{0.4} \times 9.22 =$ **5.78 inches**

Based on the inlet of the piping being 4 inches from the bottom of the tank as shown on Attachment 1, the minimum submergence above the tank's bottom shall be 9.78 inches or greater for a flow of 700 gpm.

Plant: Farley Nuclear Plant	Calculation Number: SM- SNC335993-001	Sheet: 4 of 4

Should only one MDAFW pump is in operation:

$Q = 350$ gpm $= 0.78$ ft^3/sec

Pipe Velocity with $A_{pipe} = 0.4921$ ft^2

$V_{pipe} =$ 0.78 ft^3/sec / 0.4921 ft^2 = 1.58 ft/sec

$N_{Fr} = 1.58/ (32.2 \times 0.77)^{0.5} = 0.317$

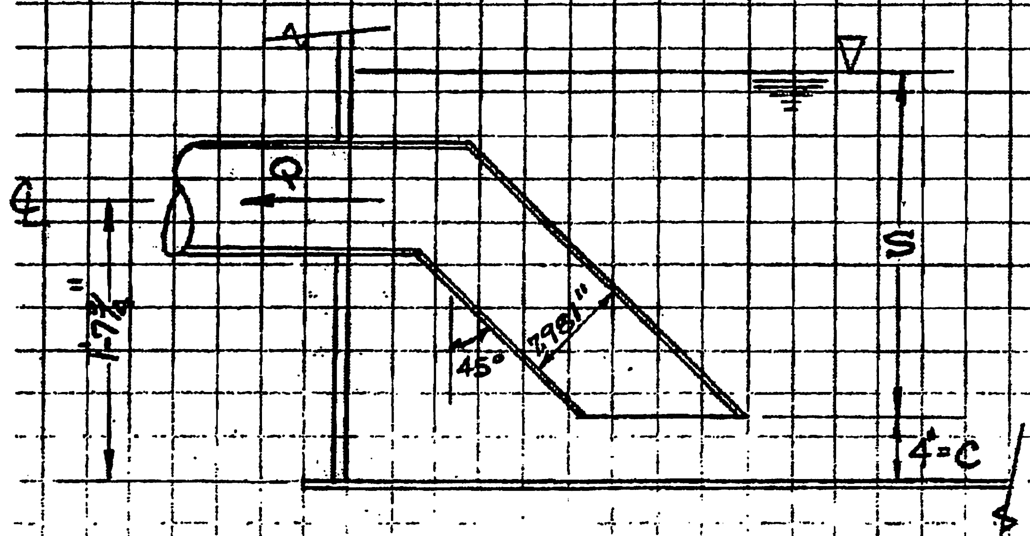
$S_H \geq 0.75 \times (0.317)^{0.4} \times 9.22 \geq$ **4.36 inches**

Based on the inlet of the piping being 4 inches from the bottom of the as shown on sheet, the minimum submergence above the tank's bottom shall be 8.36 inches or greater for a flow of 350 gpm.

Comment:

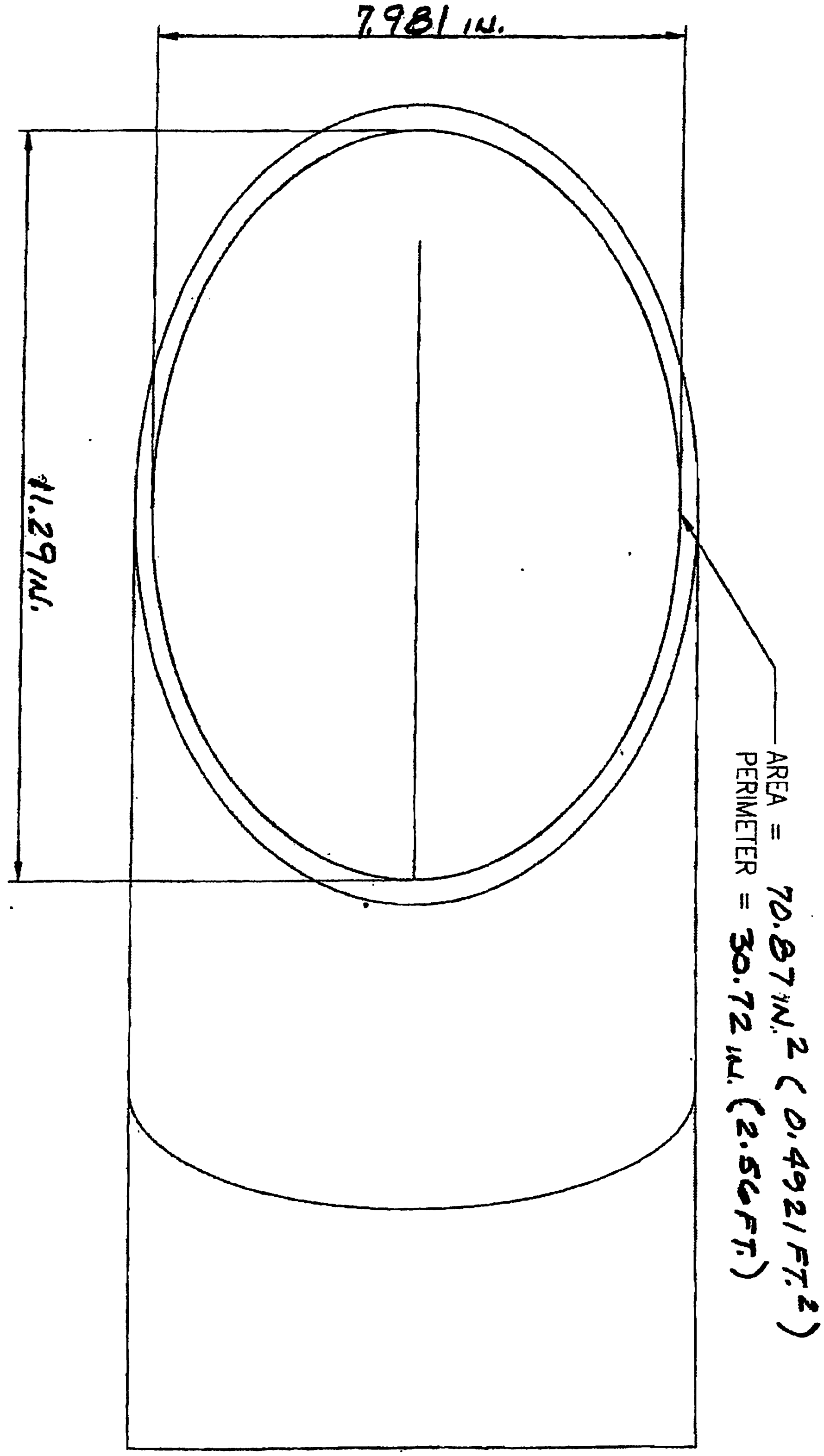
These results are conservative since the minimum submergence height equation used in this methodology represents a vertically downward suction configuration as shown in Figure 5(a) of Attachment 3. However, the AFW pumps suction piping has a configuration of a downward facing inlet as shown in Attachment 1. The minimum submergence scale model test results described in Attachment 3 for the downward facing inlet yield a lower submergence level than the equation used in this calculation. 3

SUCTION PIPE GEOMETRY AND NOTATION



S = SUBMERGENCE ABOVE SUCTION BOTTOM
Q = FLOW IN THE SUCTION PIPE
C = SUCTION PIPE CLEARANCE FROM BOTTOM

Suction Pipe Inlet Dimensions



Westinghouse Non-Proprietary Class 3

Attachment 3 to
Calculation SM-SNC335993-001

FAUSKE & ASSOCIATES, LLC

WORLD LEADER IN NUCLEAR AND CHEMICAL PROCESS SAFETY

Report No.: FAI/09-19-NP

Vortex Evaluation for Vogtle and Farley RWSTs and Hatch CSTs

Revision 1

Project No.: W-SNC-RAI-Vortex

Submitted to:

Southern Nuclear Company

Prepared by:
Robert E. Henry

Reviewed by:
Name
Damian D. Stefanczyk

April 2014

© 2014 Westinghouse Electric Company LLC
All Rights Reserved
16W070 83rd Street • Burr Ridge, Illinois 60527
(877) Fauske1 or (630) 323-8750 • Fax: (630) 986-5481 • E-mail: Info@Fauske.com

CALCULATION NOTE COVER SHEET (Revision 1)

SECTION TO BE COMPLETED BY AUTHOR(S):

Calc-Note Number: FAI/09-19 Revision Number: 1

Title: Vortex Evaluation for Vogtle and Farley RWSTs and Hatch CSTs

Project/Subject: Southern Nuclear Gas Intrusion Evaluations Project Number Or Shop Order: W-SNC-RAI-Vortex

Purpose: The purpose of this report is to document the technical basis for evaluating potential for air intrusion in the Vogtle and Farley RWSTs as well as the Hatch CSTs.

Methods of Analysis*: N/A

Acceptance Criteria*: N/A

Results Summary: Data taken for the tank configuration at D.C. Cook [ ][e] relate to the specific configurations used in the Southern Nuclear plants. These measurements provide justification for the manner in which air intrusion should be assessed for the Vogtle, Farley and Hatch CSTs. [

][b,c]

*Can be N/A and/or a reference to this information in the Design Analysis can be provided.

References of Resulting Reports, Letters, or Memoranda (Optional)

Author(s): Name (Print or Type)	Signature:	Completion Date:
Robert E. Henry	Robert E. Henry	April 25, 2014

SECTION TO BE COMPLETED BY VERIFIER(S):

Verifier(s): Name (Print or Type)	Signature:	Completion Date:
Damian D. Stefanczyk	[signature]	April 25, 2014

Method of Verification:
- Design Review ☐
- Independent Review or Alternate Calculations ☐
- Testing ☐
- 3-Pass Method ☒
- Other (specify): ☐

SECTION TO BE COMPLETED BY MANAGER:

Responsible Manager: Name (Print or Type)	Signature:	Approval Date:
Jens Conzen	[signature]	April 25, 2014

3-PASS VERIFICATION METHODOLOGY CHECKLIST

3-Pass Verification Review Topic	Yes	No	N/A
First Pass			
1. Were the general theme, scope of document and scope of review clear?	☒	☐	
Second Pass			
2. Do the references appear to be documented correctly? Is there enough information present to ensure the referenced document is retrievable?	☒	☐	
3. Do the acceptance criteria seem appropriate?	☒	☐	
4. Does the technical content of the calculation note make sense from a qualitative standpoint and are appropriate methods used?	☒	☐	
Third Pass			
5. Do the results and conclusions meet the acceptance criteria? Do the results and conclusions make sense and support the purpose of the calculation note?	☒	☐	
6. Has the technical content of the document been verified in adequate detail? Examples of technical content include inputs, models, techniques, output, hand calculations, results, tables, plots, units of measure, etc.	☒	☐	
7. Does the calculation note provide sufficient details in a concise manner? Note that sufficient detail is enough information such that a qualified person could understand the analysis and replicate the results without consultation of the author.	☒	☐	
8. Is the calculation note acceptable with respect to spelling, punctuation, and grammar?	☒	☐	
9. Are the references accurate? Do the references to other documents point to the latest revision? If not, are the reasons documented? Are the references retrievable?	☒	☐	☐
10. Are computer code names spelled correctly? If applicable, are numerals included in the official code name as appropriate?	☐	☐	☒
11. Has the calculation note been read word-for-word, cover-to-cover?	☒	☐	

EDITORIAL REVIEW CHECKLIST

Reviewer Name: Damian D. Stefanczyk Date: April, 2014

Document Number: FAI/09-19, Rev. 1

	Yes	No	N/A
General Documents			
1. Proofread the document for general format, readability, punctuation, and grammar. Are these acceptable to you?	☒	☐	☐
2. Is the documentation legible, reproducible and in a form suitable for archiving as a Quality Record?	☒	☐	☐
3. Are all the pages sequentially numbered and are the document number, revision number, and appropriate proprietary classification listed on each page?	☒	☐	☐
4. Is the Record of Revision page filled in correctly including Revision, Date, and Description of Revisions, if applicable?	☒	☐	☐
5. Are the page numbers in the Table of Contents provided and correct?	☒	☐	☐
6. Are Acronyms defined in the document (either individually or on a separate page)?	☒	☐	☐
7. Are Figures labeled consistently and do they include units of measure?	☒	☐	☐
8. Are the units of measure clearly identified and used throughout?	☒	☐	☐
9. Do all cross references to tables, figures, references, and sections point to an object of the given type?	☒	☐	☐
10. Are symbols (e.g., Greek letters) used correctly?	☒	☐	☐
11. Is sufficient information provided for all "References" to facilitate their retrieval including documents not maintained as quality records by Westinghouse, or has a copy been provided in an Appendix to the report?	☒	☐	☐
12. Are all References listed referred to in the text?	☒	☐	☐
13. Is the content of the Appendices consistent with what the document states it is?	☐	☐	☒
Calc Notes			
Body of Calc Notes			
(Note that different Calc Note templates have different Section numbering. See the Section Numbering Key on last page for assistance.)			
14. Is all information in the cover page header block completed appropriately?	☒	☐	☐
15. Are the author and verifier applicable page numbers provided?	☒	☐	☐
16. Is the report revision number on each page?	☒	☐	☐
17. Are Tables labeled consistently and do they include units of measure?	☒	☐	☐

	Yes	No	N/A
18. Is background information and purpose of the calculation clearly stated in the appropriate section?	☒	☐	☐
19. Have the limits of applicability been listed in the appropriate section?	☒	☐	☐
20. Are open items identified in the appropriate section and on the cover page header block?	☐	☐	☒
21. Are the Acceptance Criteria listed in the appropriate section (if applicable)?	☐	☐	☒
22. Does the Calc Note include a discussion on the methodology used?	☒	☐	☐
23. If applicable, are references to the utility, plant, unit, and cycle correct with respect to spelling and consistency of use?	☒	☐	☐
Body of Document			
24. Is the Summary of Results and Conclusions section consistent with the purpose stated and consistent with the results section?	☒	☐	☐
Computer Runs			
25. Are the computer codes used clearly identified in the appropriate section and is all required information included?	☐	☐	☒
26. Are all electronic files listed in the electronically attached file listing?	☐	☐	☒
27. Does the electronically attached file listing appropriately reference the codes used?	☐	☐	☒
Checklists			
28. Has the verifier initiated one or more of the Verification Methods of review in the Verification Method Checklist?	☒	☐	☐
29. Has the verifier provided an explanation of the method of review in the Verification Method Checklist?	☒	☐	☐
30. Is an explanation or justification for any "NO" responses on the 3-Pass Methodology Checklist(s) presented?	☐	☐	☒
31. Are Author's responses provided to Additional Verifier Comments or noted as not required?	☐	☐	☒
Additional Questions for Software Calc Notes			
32. Is the software name, version number, and system state(s) where the software was created or validated provided?	☐	☐	☒
33. Is a source code listing or reference to a controlled location of the source code included?	☐	☐	☒
34. Do the test results include the date of execution and the machine name?	☐	☐	☒
35. Do the test cases include a description of what is being tested?	☐	☐	☒
Editorial Reviewer Comments (if needed):			

RECORD OF REVISIONS

Rev.	Date	Revision Description
0	January, 2009	Original issue.
1	April, 2014	Update to the text based on customer comments.

ABSTRACT

Data reported in the open literature for the suction piping configuration of the D.C. Cook Refueling Water Storage Tank (RWST), [ ]e relate to the specific configurations used in the Southern Nuclear plants. These measurements provide justification for the manner in which air intrusion should be assessed for the Vogtle, Farley and Hatch CSTs. [ ]b,c

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

All of the Vogtle and Farley PWR (Pressurized Water Reactor) units have suction pipes that exit the RWSTs through either downward facing elbows or a downward angled pipe. The Vogtle units are also equipped with cage type vortex suppressors at the suction locations as illustrated in Figure 1. The two Hatch BWR (Boiling Water Reactor) units CSTs have a suction pipe exit configuration that is a horizontal pipe in the sidewall of the tank without a vortex suppressor device. Each of these designs needs a technical basis for evaluating the possible onset of air intrusion during drain-down of the tanks under accident conditions. In this regard, each of these can gain substantial technical insights, and therefore an enhanced technical basis from the ¼ scale tests performed for the D. C. Cook RWST performance during drain-down conditions (Sanders, et al, 2001) and [

]b,c

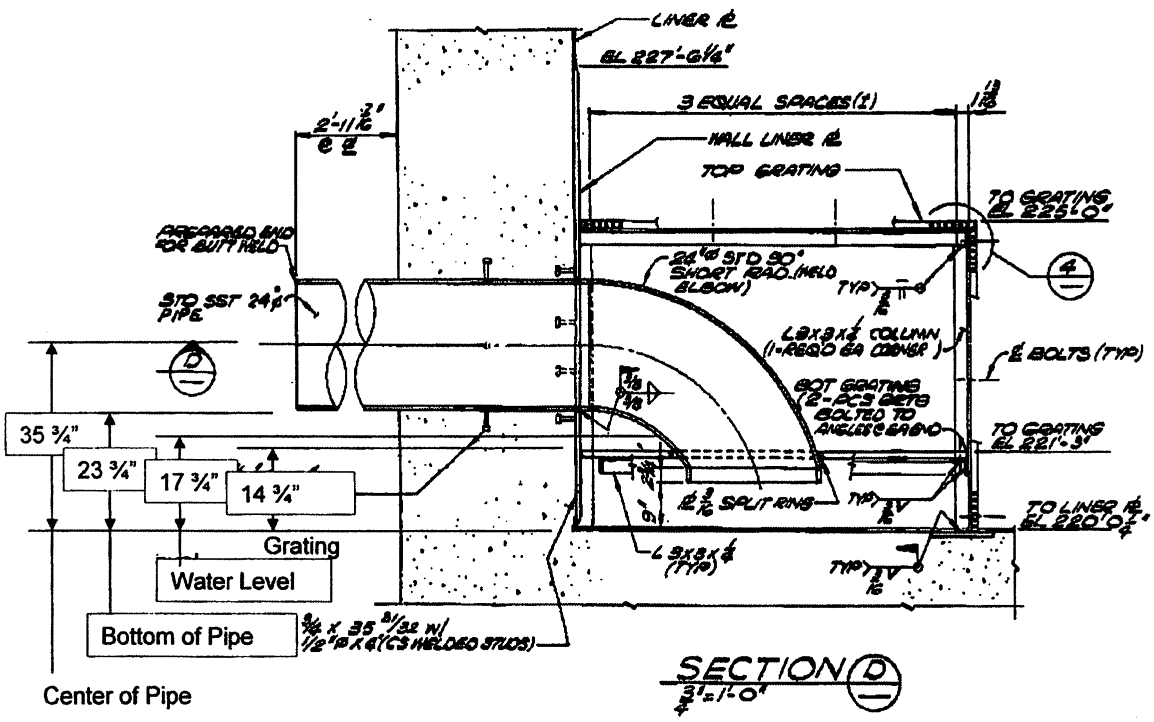


Figure 1 ***Vortex suppression devices used in the Vogtle Units 1 and 2 RWSTs.***

2.0 D.C. COOK TESTS

In the D. C. Cook simulation, the RWST (48 feet in diameter and 32 feet high with a 24 inch diameter suction pipe) was modeled using the 12 foot diameter, 6 foot high tank shown in Figure 2. This tank also included a scaled representation (5.730 inches ID, Inside Diameter) of the horizontal suction pipe as well as the scaled distance of the suction pipe above the tank floor (5-17/32 inches), which is approximately one pipe diameter. The tests were performed in both transient (open loop) and steady-state (closed loop) modes in which the water level, at a given flow rate, was decreased until air intrusion into the horizontal suction pipe was observed. This was documented in terms of: (1) when a steady stream of air bubbles was first detected in the downcomer of the suction piping and (2) when the gas void fraction was estimated to be 2% of the downcomer cross-sectional flow area. As is discussed later, no significant difference was observed between the transient and steady-state test results. Figure 3 shows the reported data for the onset of air intrusion (gray triangular data points) and the conditions that resulted in an estimated void fraction of 2% (red and gray square data points). These data points are represented in terms of the dimensionless water submergence as a function of the Froude number. In the Sanders et al. (2001) reference, the dimensionless submergence is defined as the depth of the water with respect to the bottom inside surface of the suction pipe divided by the pipe internal diameter. The dimensionless Froude number is defined as $U/[g\ D]^{0.5}$ where U is the one-dimensional water superficial velocity, g is the acceleration of gravity and D is the pipe internal diameter. As illustrated, there is little difference between the onset of entrainment and the 2% estimated void fraction. The correlations developed by Sanders et al for this data are shown by the dark blue and red lines in Figure 3.

While based on a somewhat different suction configuration (vertically downward in the center of the tank) it is interesting to compare the results from the D. C. Cook scaled experiments and a representation for radial inflow such as that derived by Harleman et al (1959). A comparison between the experimental data and radial inflow models, such as the Harleman correlation and the Lubin and Springer model (1967), is an important element of the technical basis. These correlations characterize those conditions that would lead to air intrusion from the water surface depression due to the radial inflow to the suction port as illustrated by Ahmed et al. (2003) and included here as Figure 4. Air intrusion resulting from this phenomenon is not due to a vortex, i.e. generated through rotational flow. In fact it has nothing to do with vortex behavior. Since it represents the radial inward flow, it provides the minimum water level before air intrusion would occur. (If the rotational flows in the tank produced a vortex, air intrusion would be initiated at a greater water level than is calculated by the radial inflow models.) Consequently, the Harleman correlation, which has been used in numerous design applications for nuclear power plants, can be viewed as defining the minimum submergence that would prevent air intrusion without induced rotational flows. The scaled tests for D.C. Cook provide insights into whether important rotational flow conditions would be generated as a result of the tank geometry, the drain-down transient, etc.

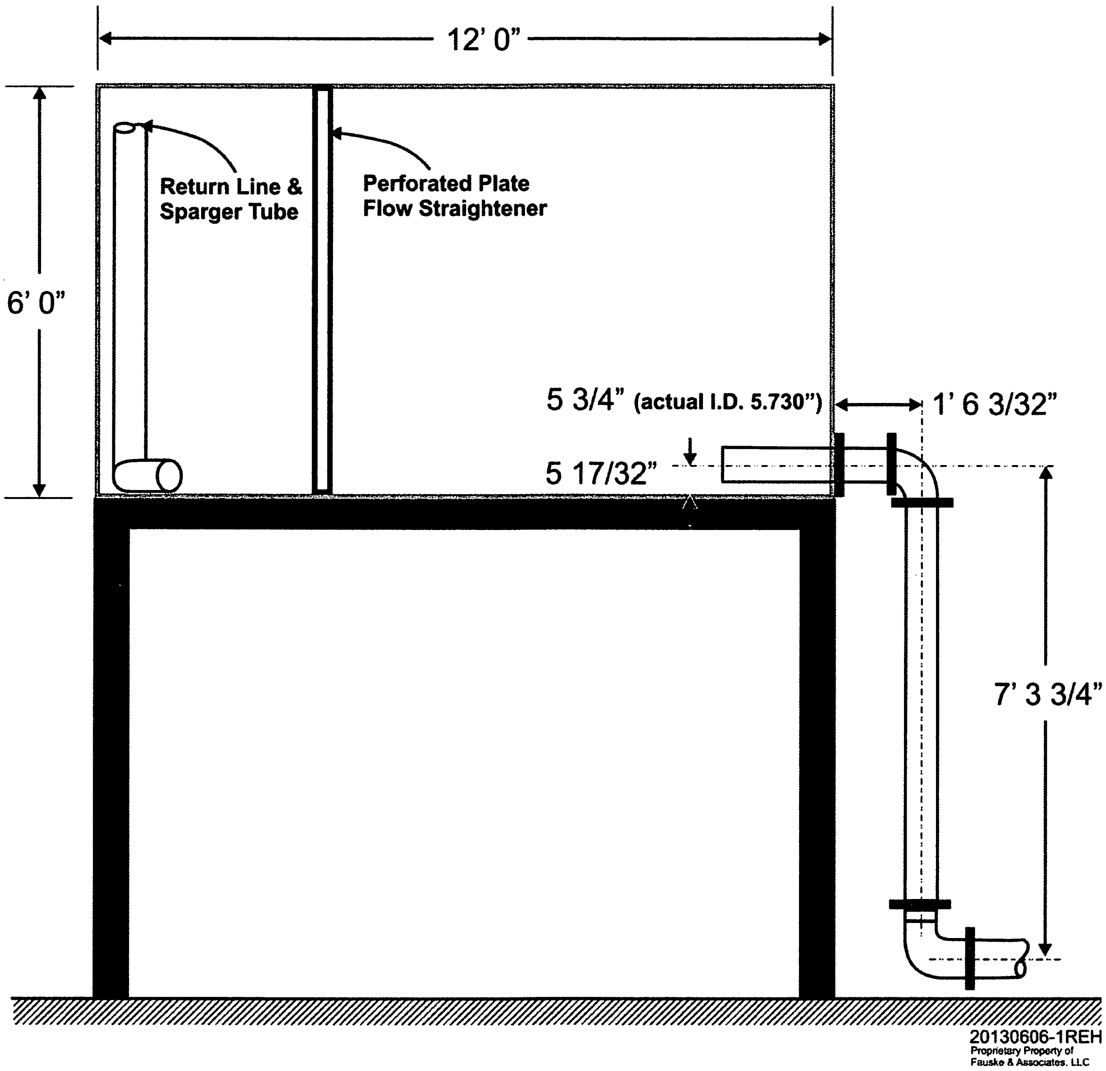


Figure 2 Schematic of 1:4 scale hydraulic model of RWST and suction piping (taken from Sanders et al., 2001).

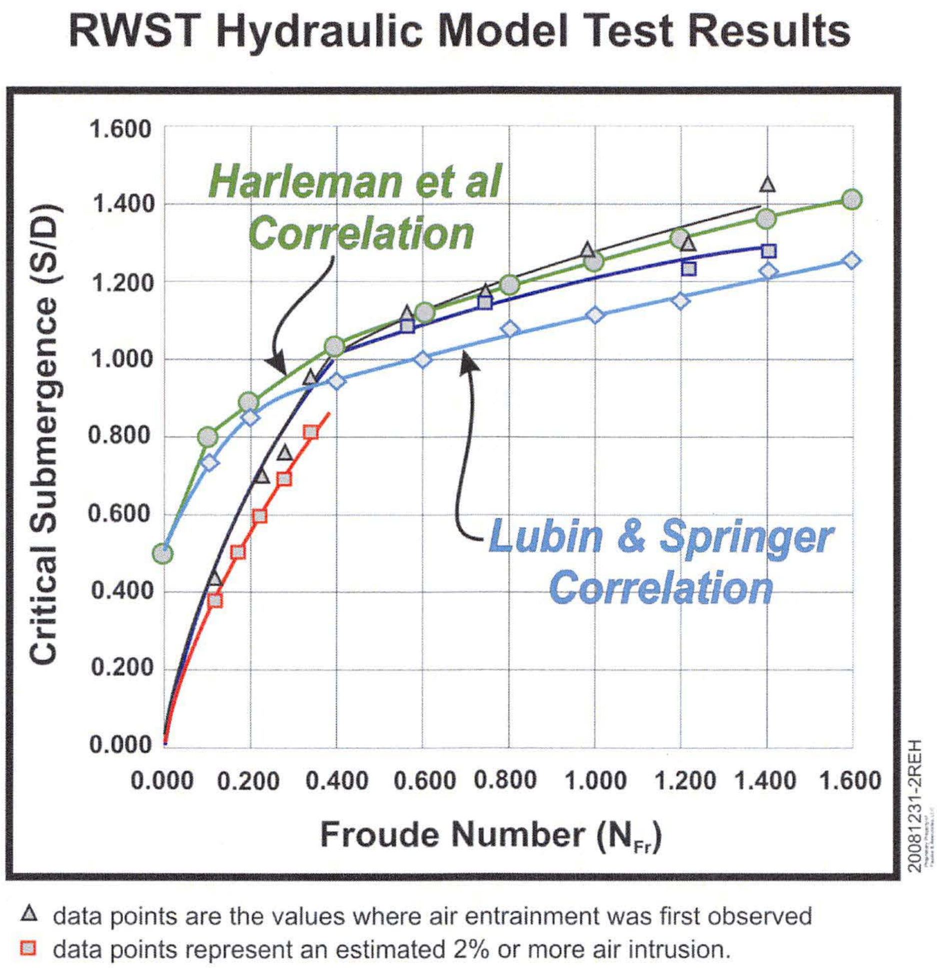


Figure 3 ***Comparison of the Harleman et al. (solid green line) and the Lubin-Springer (light blue line) with the experimental observations for the scaled D.C. Cook RWST.***

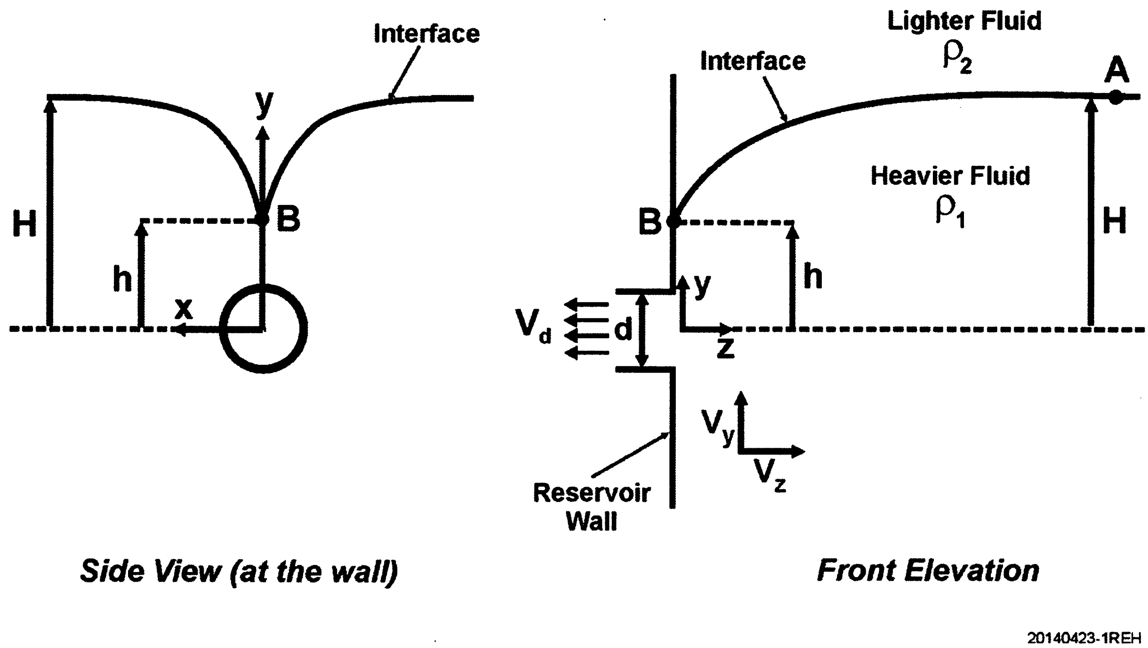


Figure 4 Geometry and coordinate system taken from Ahmed et al. (2003).

The Harleman correlation is given as:

$$S_H/D = 0.75\,[N_{Fr}]^{0.4}$$

where the submergence (S_H) is defined as the water height above the horizontal entrance to the vertically downward suction location as shown in Figure 5(a). For the vertical entrance to a horizontal suction pipe, this location of the "submergence" as represented in this correlation is the centerline of the suction pipe (see Figure 5(b)). To put the submergence described in the Harleman correlation on the same basis as is used for the data characterization in Figure 2 (S), the dimensional submergence needs to be increased by one-half of a diameter. i.e.

$$S/D = 0.75\,[N_{Fr}]^{0.4} + 0.5$$

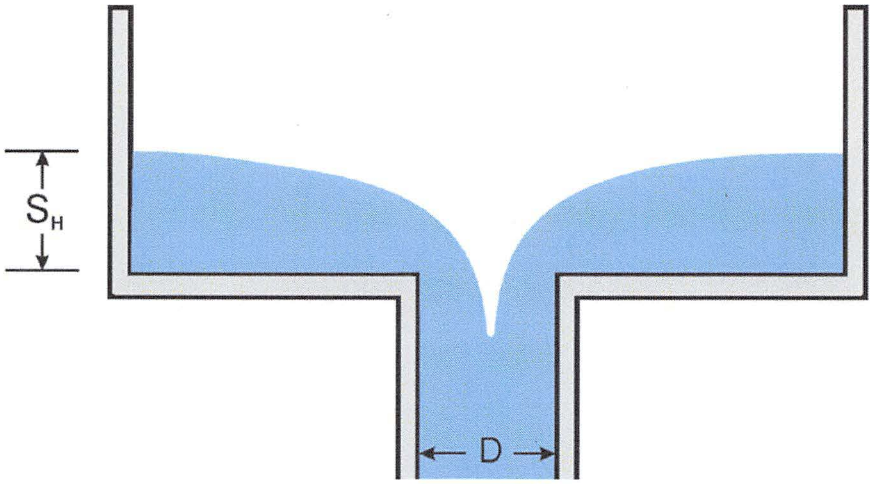
This representation is shown by the solid green curve in Figure 2 and indicates that the observed behavior is dictated by radial inflow and has essentially nothing to do with the formation of vortices.

When examining the comparisons in Figure 2, it must be remembered that a critical submergence (S/D) below a value of unity means that the RWST water level is below the top of the suction pipe. This is not the flow pattern that is illustrated in Figure 5(b) and therefore it is not surprising that the model does not closely represent this segment of the data. However, it does provide a conservative boundary for the experimental observations. More importantly, when the water level is above the top of the pipe, which is the condition of greatest interest, the Harleman et al radial inflow model agrees well with the data. **This close agreement of the radial inflow model with this large scale data when the water level is above the suction location is of fundamental importance to the technical basis for the RWST and CST evaluations for all of the SNC (Southern Nuclear Company) plants.**

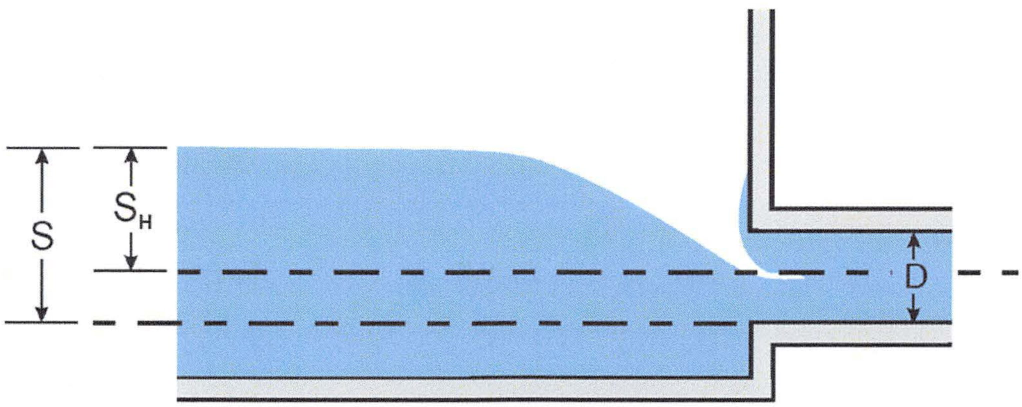
Lubin and Springer (1967) also proposed a model that has the same functional dependency as the correlation proposed by Harleman et al, i.e. only the coefficient is different (0.627 instead of 0.75). This model is shown by the light blue line in Figure 3, and it is seen that this somewhat underestimates the critical submergence observed in the D.C. Cook tests. One of the differences pointed out in the literature between the data taken by Harleman et al and that recorded by Lubin and Springer is that the experimental study that accompanied the latter study waited many hours after filling the tank to let the inherent rotational flows in the water inventory decay. Rotational flows generated by the filling process can have an influence on the flow patterns that are developed during the drain-down transient. While the "waiting time" for the D.C. Cook scaled tests is not given in the reference, both the open loop (Tests 1, 3 and 5 had no recirculation to the RWST tank) and the closed loop experiments (the remaining tests had complete recirculation to the RWST tank) were performed. Table 1 is taken from the reference and shows that the repeat tests (2, 4 and 6) were observed to experience a gas void fraction of 2% or more at the same water level in the simulated RWST. Therefore, while the Harleman et al correlation is in good agreement with the data for the critical submergence characterizing the onset of air entrainment, the two correlations can be viewed as providing bounding values for the radial inflow process. In this context, the Lubin and Springer model can be considered to describe the optimistic boundary where air entrainment of significant magnitude is assured.

Table 1 RWST Hydraulic Model Test Results (from Sanders et al., 2001)

Test Series Number	Flow Rate Through RWST Suction Pipe (gpm)	RWST Water Level (inches)	
		Onset of Air Entrainment	2% or More (by volume) Air Entrainment
1	53.4	3.52	2.83
2	53.4	3.42	2.86
3	175.8	-	6.22
4	177.3	6.32	6.24
5	379.1	-	7.07
6	383.1	7.49	7.10
7	35.5	2.48	2.16
8	70.6	3.98	3.41
9	88.4	4.32	3.94
10	106.3	5.46	4.63
11	235.4	6.68	6.56
12	308.9	7.32	7.01
13	440.8	8.42	7.33



(a)
Basis for the Harleman et al Correlation



(b)
Application of the Harleman et al Correlation to a Horizontal Discharge Pipe

Figure 5 Definition of submergence for vertically downward and horizontal suction configurations

3.0 OTHER EXPERIMENTS

The downward oriented suction configurations in the Vogtle and Farley RWSTs act to considerably suppress the potential for air intrusion as demonstrated in the main body of the report for a downward facing elbow which is part of an FAI investigation [

]^{e} Except for this radial inflow induced gas intrusion at the very low levels, there is no significant gas introduced into the pump suction line even though some very small, tight vortices, as illustrated in the main text, were observed from time to time. [

]^{b,c}

[ ]^{b,c}

[

]^{b,c} (Transient tests involved a scaled drain-down of the experimental water level to match, on a non-dimensional basis, the rate of water level decrease of the larger plant system for the maximum drain-down rate in the plant design. Vortices need to have time to develop because the flow must become organized into a circulatory pattern, which takes time. During the transient tests, whatever circulation exists is continually being eroded by the exiting water flow rate; in contrast to the steady-state tests where the depth and the circulation strength remains constant. [

]^{b,c}

As noted in Figure 1, in addition to the downward facing configuration, the Vogtle suction ports are surrounded by a vortex suppressor fabricated from steel grating. It is noted that the NRC (Nuclear Regulatory Commission) sponsored full scale sump performance experiments (Weigand, et al., 1982) that were conducted with a vortex suppressor fabricated from standard 1 inch floor grating (see Figure 7). As stated in the reference, "A cage type vortex suppressor was found to be very effective in dampening out vortices and reducing air ingestion to 0%." Therefore, Vogtle Units 1 and 2 have both a downward facing elbow suction configuration and a grating cage vortex suppressor. The presence of the cage type vortex suppressor for the RWSTs further buttresses the conclusion that significant air intrusion (sufficient to challenge pump operation) would not occur due to vortex formation.

[

][b,c]

Figure 6 *[* *][b,c]*

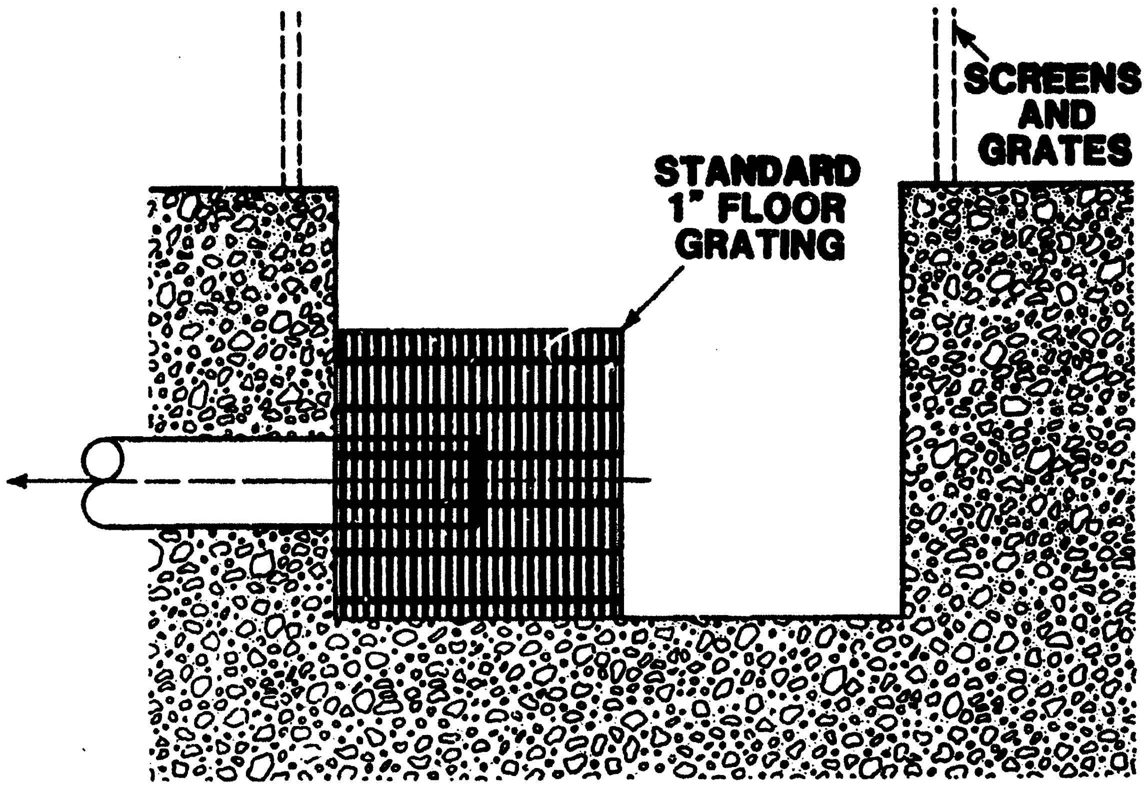


Figure 7 *Cage type vortex suppressor (from Weigand et al, 1982).*

4.0 REFERENCES

Ahmed, M., et al., 2003, "Modeling of the Onset of Gas Entrainment Through a Finite-Side Branch," Transactions of the ASME, Vol. 125, September, pp. 902-909.

[ ]b,c

Harleman, D.R.F., et al, 1959, "Selective Withdrawal from a Vertically Stratified Fluid", International Association for Hydraulic Research, 8th Congress, Montreal, August 24-29, pp 10-C-1 to 10-C-16.

Lubin, B. T. and Springer, G. S., 1967, "The Formation of a Dip on the Surface of a Liquid Draining from a Tank", Journal of Fluid Mechanics, 29, pp. 385-390.

Sanders, R.C., et al, 2001, "Air Entrainment in a Partially Filled Horizontal Pump Suction Line", Proceedings of the JPGC'-01, 2001 International Joint Power Generation Conference, New Orleans, La., Paper JPGC2001/PWR-19010, pp 95-103.

Weigand, G. G., et al., 1982, "A Parametric Study of Containment Emergency Sump Performance," NUREG/CR-2758.

Joseph M. Farley Nuclear Plant – Units 1 and 2
Supplement to Response for Additional Information Regarding Condensate
Storage Tank Minimum Level License Amendment Request

Enclosure 4

Modified Response to Request for Additional Information Dated April 18, 2013

RAI

Farley uses a vortex correlation developed by Harleman (1959) for a vertically downward configuration that differs from the 45 degree upward flow pipe used in the Farley CST. The NRC has requested the following list of additional information regarding the Farley CST installation and the evaluations for the tank response to possible accident conditions.

Provide a complete description of the tests and test results for each test used to substantiate determination of critical submergence that includes the following:

1. Drawing of the plant tank and the plant suction pipe within the tank that provides all relevant dimensions,
2. Drawing of the corresponding test configuration that provides all relevant dimensions,
3. Description of how quantitative air entrainment is determined during testing,
4. Description of conduct of the test that includes any observations, and
5. Summary of the test data such as a plot of critical submergence as a function of Froude number.

SNC Response to Part 1

Part (1) of the response was not affected by the new revision of FAI/13-0392. Please refer to SNC letter dated July 2, 2013 (ADAMS Accession Number ML13198A443.)

SNC Response to Part 2

Refer to pages 11 through 13 of Enclosure 5 of this letter for the response.

SNC Response to Part 3

Refer to pages 13 through 16 of Enclosure 5 of this letter for the response.

SNC Response to Part 4

Refer to page 16 of Enclosure 5 of this letter for the response.

SNC Response to Part 5

Refer to pages 16 through 17 of Enclosure 5 of this letter for the response.

Joseph M. Farley Nuclear Plant – Units 1 and 2
Supplement to Response for Additional Information Regarding Condensate
Storage Tank Minimum Level License Amendment Request

Enclosure 6

Fauske and Associates, LLC Report No. FAI/13-0392-NP, "Request for Additional Information by the Office of Nuclear Reactor Regulation, Joseph M. Farley Nuclear Plants, Units 1 and 2, Southern Nuclear Operating Company, Docket Nos. 50-348 and 50-364, Revision 2" (Non-Proprietary)

Westinghouse Non-Proprietary Class 3

FAUSKE & ASSOCIATES, LLC

WORLD LEADER IN NUCLEAR AND CHEMICAL PROCESS SAFETY

Report No.: FAI/13-0392-NP

Request for Additional Information
by the Office of Nuclear Reactor Regulation
Joseph M. Farley Nuclear Plants, Units 1 and 2
Southern Nuclear Operating Company
Docket Nos. 50-348 and 50-364

Revision 2

Project No.: SNC-WRAI-CST-Vortex

Submitted to:

Southern Nuclear Company
(Farley Nuclear Generating Station)
Dothan, Alabama

Prepared by:
Robert E. Henry

Reviewed by:
Damian D. Stefanczyk

June 2014

© 2014 Westinghouse Electric Company LLC
All Rights Reserved

16W070 83rd Street • Burr Ridge, Illinois 60527
(877) Fauske1 or (630) 323-8750 • Fax: (630) 986-5481 • E-mail: Info@Fauske.com

CALCULATION NOTE COVER SHEET (Revision 1)

SECTION TO BE COMPLETED BY AUTHOR(S):

Calc-Note Number: FAI/13-0392 Revision Number: 2

Title: Request for Additional Information by the Office of Nuclear Reactor Regulation Joseph m. Farley Nuclear Plants, Units 1 and 2 Southern Nuclear Operating Company Docket Nos. 50-348 and 50-364

Project/Subject: RAIs Support for Farley for Vortex Suppression Project Number Or Shop Order: W-SNC-RAI-Vortex

Purpose: The document is issued to provide support to RAIs in regards to vortex suppression work at Farley.

Methods of Analysis*: N/A

Acceptance Criteria*: N/A

Results Summary: The document provides information to address NRC's RAIs.

*Can be N/A and/or a reference to this information in the Design Analysis can be provided.

References of Resulting Reports, Letters, or Memoranda (Optional)

Author(s): Name (Print or Type)	Signature:	Completion Date:
Robert E. Henry	Robert E. Henry	June 4, 2014

SECTION TO BE COMPLETED BY VERIFIER(S):

Verifier(s): Name (Print or Type)	Signature:	Completion Date:
Damian D. Stefanczyk		June 4, 2014

Method of Verification:

- ☐ Design Review
- ☐ Independent Review or Alternate Calculations
- ☐ Testing
- ☒ 3-Pass Method
- ☐ Other (specify):

SECTION TO BE COMPLETED BY MANAGER:

Responsible Manager: Name (Print or Type)	Signature:	Approval Date:
Jens Conzen		June 4, 2014

3-PASS VERIFICATION METHODOLOGY CHECKLIST

3-Pass Verification Review Topic	Yes	No	N/A
First Pass			
1. Were the general theme, scope of document and scope of review clear?	☒	☐	
Second Pass			
2. Do the references appear to be documented correctly? Is there enough information present to ensure the referenced document is retrievable?	☒	☐	
3. Do the acceptance criteria seem appropriate?	☐	☐	☒
4. Does the technical content of the calculation note make sense from a qualitative standpoint and are appropriate methods used?	☒	☐	
Third Pass			
5. Do the results and conclusions meet the acceptance criteria? Do the results and conclusions make sense and support the purpose of the calculation note?	☒	☐	
6. Has the technical content of the document been verified in adequate detail? Examples of technical content include inputs, models, techniques, output, hand calculations, results, tables, plots, units of measure, etc.	☒	☐	
7. Does the calculation note provide sufficient details in a concise manner? Note that sufficient detail is enough information such that a qualified person could understand the analysis and replicate the results without consultation in the author.	☒	☐	
8. Is the calculation note acceptable with respect to spelling, punctuation, and grammar?	☒	☐	
9. Are the references accurate? Do the references to other documents point to the latest revision? If not, are the reasons documented? Are the references retrievable?	☒	☐	☐
10. Are computer code names spelled correctly? If applicable, are numerals included in the official code name as appropriate?	☐	☐	☒
11. Has the calculation note been read word-for-word, cover-to-cover?	☒	☐	

EDITORIAL REVIEW CHECKLIST

Reviewer Name: Damian D. Stefanczyk Date: April, 2014
Document Number: FAI/13-0392, Rev. 2

	Yes	No	N/A
General Documents			
1. Proofread the document for general format, readability, punctuation, and grammar. Are these acceptable to you?	☒	☐	☐
2. Is the documentation legible, reproducible and in a form suitable for archiving as a Quality Record?	☒	☐	☐
3. Are all the pages sequentially numbered and are the document number, revision number, and appropriate proprietary classification listed on each page?	☒	☐	☐
4. Is the Record of Revision page filled in correctly including Revision, Date, and Description of Revisions, if applicable?	☒	☐	☐
5. Are the page numbers in the Table of Contents provided and correct?	☒	☐	☐
6. Are Acronyms defined in the document (either individually or on a separate page)?	☒	☐	☐
7. Are Figures labeled consistently and do they include units of measure?	☒	☐	☐
8. Are the units of measure clearly identified and used throughout?	☒	☐	☐
9. Do all cross references to tables, figures, references, and sections point to an object of the given type?	☒	☐	☐
10. Are symbols (e.g., Greek letters) used correctly?	☒	☐	☐
11. Is sufficient information provided for all "References" to facilitate their retrieval including documents not maintained as quality records by Westinghouse, or has a copy been provided in an Appendix to the report?	☒	☐	☐
12. Are all References listed referred to in the text?	☒	☐	☐
13. Is the content of the Appendices consistent with what the document states it is?	☐	☐	☒
Calc Notes			
Body of Calc Notes			
(Note that different Calc Note templates have different Section numbering. See the Section Numbering Key on last page for assistance.)			
14. Is all information in the cover page header block completed appropriately?	☒	☐	☐
15. Are the author and verifier applicable page numbers provided?	☒	☐	☐
16. Is the report revision number on each page?	☒	☐	☐
17. Are Tables labeled consistently and do they include units of measure?	☐	☐	☒
18. Is background information and purpose of the calculation clearly stated in the appropriate section?	☒	☐	☐

	Yes	No	N/A
19. Have the limits of applicability been listed in the appropriate section?	☐	☐	☒
20. Are open items identified in the appropriate section and on the cover page header block?	☐	☐	☒
21. Are the Acceptance Criteria listed in the appropriate section (if applicable)?	☐	☐	☒
22. Does the Calc Note include a discussion on the methodology used?	☒	☐	☐
23. If applicable, are references to the utility, plant, unit, and cycle correct with respect to spelling and consistency of use?	☒	☐	☐
Body of Document			
24. Is the Summary of Results and Conclusions section consistent with the purpose stated and consistent with the results section?	☐	☐	☒
Computer Runs			
25. Are the computer codes used clearly identified in the appropriate section and is all required information included?	☐	☐	☒
26. Are all electronic files listed in the electronically attached file listing?	☐	☐	☒
27. Does the electronically attached file listing appropriately reference the codes used?	☐	☐	☒
Checklists			
28. Has the verifier initiated one or more of the Verification Methods of review in the Verification Method Checklist?	☒	☐	☐
29. Has the verifier provided an explanation of the method of review in the Verification Method Checklist?	☒	☐	☐
30. Is an explanation or justification for any "NO" responses on the 3-Pass Methodology Checklist(s) presented?	☐	☐	☒
31. Are Author's responses provided to Additional Verifier Comments or noted as not required?	☐	☐	☒
Additional Questions for Software Calc Notes			
32. Is the software name, version number, and system state(s) where the software was created or validated provided?	☐	☐	☒
33. Is a source code listing or reference to a controlled location of the source code included?	☐	☐	☒
34. Do the test results include the date of execution and the machine name?	☐	☐	☒
35. Do the test cases include a description of what is being tested?	☐	☐	☒
Editorial Reviewer Comments (if needed):			

RECORD OF REVISIONS

Rev.	Date	Revision Description
0	June, 2013	Original issue. This document is being issued as non-proprietary and is available for public release through the NRC.
1	April, 2014	The text to the report was updated based on feedback from the customer. This document is being issued as non-proprietary and is available for public release through the NRC.
2	June, 2014	Changes were made that caused this to become proprietary.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ACRONYMS

CST	Condensate Storage Tank
FAI	Fauske & Associates, LLC
LAR	License Amendment Request
NRC	Nuclear Regulatory Commission
RAI	Request for Additional Information
RWST	Refueling Water Storage Tank

1.0 BACKGROUND/PURPOSE

Farley uses a vortex correlation developed by Harleman (1959) for a vertically downward configuration that differs from the 45 degree upward flow pipe used in the Farley CST. The NRC has requested the following list of additional information regarding the Farley CST installation and the evaluations for the tank response to possible accident conditions.

Provide a complete description of the tests and test results for each test used to substantiate determination of critical submergence that includes the following:

1. Drawing of the plant tank and the plant suction pipe within the tank that provides all relevant dimensions,

2. Drawing of the corresponding test configuration that provides all relevant dimensions,

3. Description of how quantitative air entrainment is determined during testing,

4. Description of conduct of the test that includes any observations, and

5. Summary of the test data such as a plot of critical submergence as a function of Froude number.

2.0 RESPONSES TO RAIs FOR FARLEY CST TS VOLUME LAR

1. Drawings of the plant tank and the plant suction pipe within the tank that provide all relevant dimensions are the following applicable Farley CST drawings:

   U-161693 Version 2.0; Unit 1 CST General Plan,

   U-213481 Version 3.0; Unit 2 CST General Plan,

   U-161703 Version B; Unit 1 CST 8 inch Auxiliary Feed Pump Suction Nozzle, and

   U-213493 Version A; Unit 2 CST 8 inch Auxiliary Feed Pump Suction Nozzle.

2. Drawings of the corresponding test configuration that provide all relevant dimensions are as follows:

   D.C. Cook simulation, RWST dimensions:

   48 feet diameter,

   32 feet high with a 24 inch diameter suction pipe.

The experimental model for D.C. Cook was a 12 foot diameter and 6 feet high tank with a 5.73 inch horizontal suction pipe that was approximately 5.5 inches above the tank floor and approximately 1.75 feet of suction piping inside the tank (Sanders, et al, 2011). See Figure 2-1 that is re-drawn from the figure in the referenced paper which is difficult to read in the original reference.

The scaled tests for D.C. Cook provide insights into whether important rotational flow conditions are generated as a result of the tank geometry, the drain down transient, etc. These results are compared to the Harleman correlation, on page 15 of report (FAI, 2009), where the submergence is increased by one-half of the suction pipe diameter. (The submergence in the D.C. Cook experiments was defined with respect to the inside bottom surface of the suction pipe, as noted in Figure 5b of (FAI, 2009).) The graph in Figure 3 of (FAI, 2009) shows that the Harleman correlation agrees well with the results of the D.C. Cook tests or conservatively bounds the experimental data. Based on the D.C. Cook tests, the FAI report states that the Harleman correlation provides good agreement with the D.C. Cook data for critical submergence characterizing the onset of significant air entrainment.

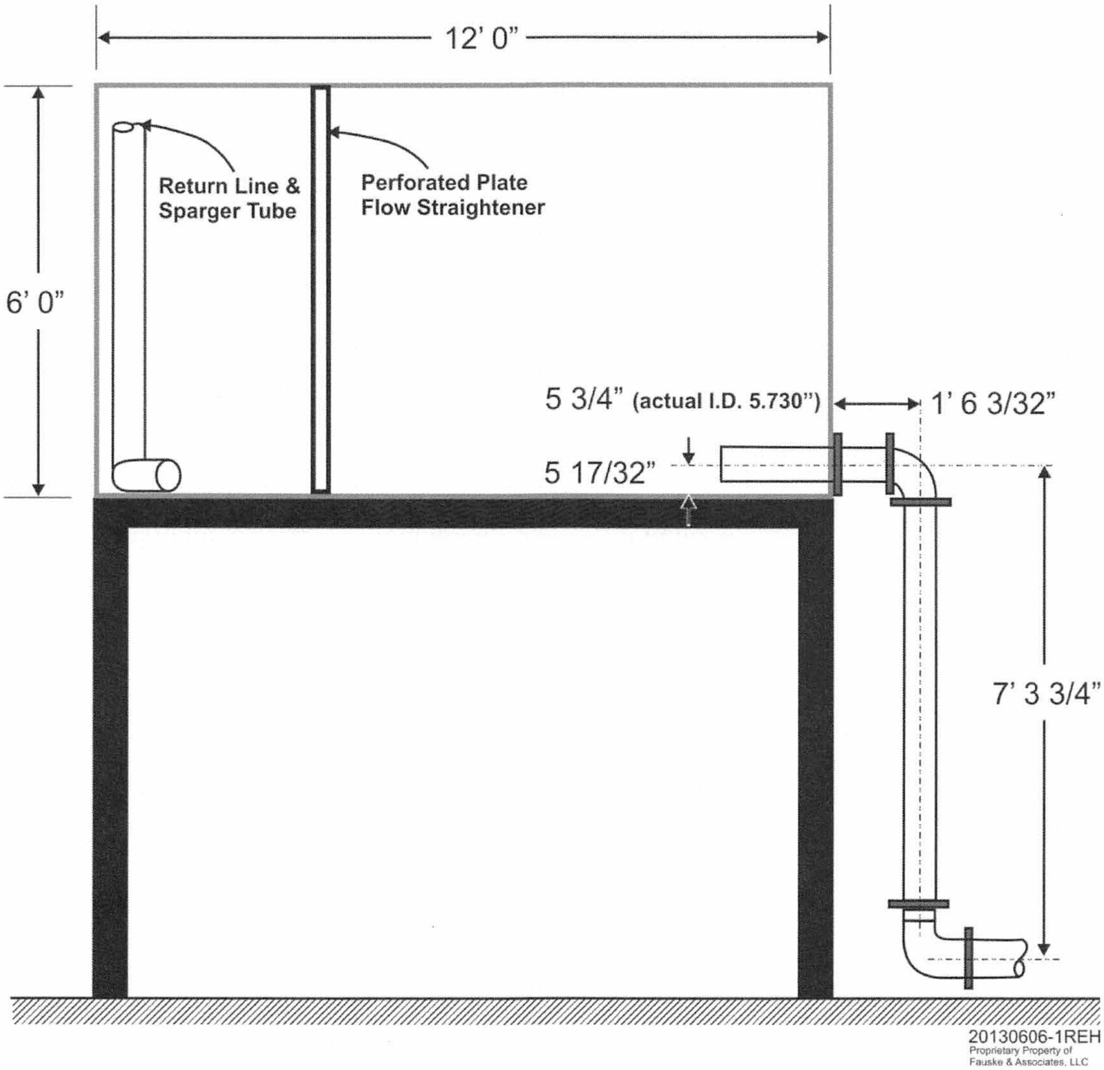


Figure 2-1 Re-drawn figure showing the dimensions of the scaled test for D.C. Cook (based on the illustration in (Sanders et al., 2001)).

[

]b,c

3. Description of how quantitative air entrainment is determined during testing is described as follows:

The FAI report (FAI, 2009) describes the method used for estimating the quantity of air entrainment for the D.C. Cook experiments as identified in the quoted reference. [

]b,c

The referenced paper documenting the D.C. Cook experiments (Sanders et al., 2001), describes a rectangular Plexiglas box that was built around the transparent downcomer piping. This box was filled with water to compensate for the curvature of the pipe. The flow through this region was video recorded to capture when a continuous stream of air bubbles was detected in each test. In addition, the point at which the gas flow was estimated to occupy 2% of the downcomer volume was also noted.

Figure 3 of the FAI report (FAI, 2009) shows the results of air intrusion as Critical Submergence versus Froude number. Results show that there is little difference between the two methods: visual detection of a continuous stream of bubbles and visual estimate that the gas volume fraction in the downcomer pipe is equal to 2%.

[

]b,c

[ ][b,c]

[ ][b,c]

[ ][b,c]

[ ][b,c]

[ ][b,c]

[ ][b,c]

[ ][b,c]

[

][b,c]

[

][b,c]

[

][b,c]

[

]b,c

Figure 2-2 [

]b,c

[

]b,c

Figure 2-3 [ ]b,c

This is important for the assessment of vortex formation in the transient, because the outflow consumes much of the turbulence/swirl that is trying to organize into a vortex. As noted in Section 2 of (Knauss, 1987): "Once a vortex is reduced in strength or dissipated, such as by wall friction, it takes some time for the flow to 'reorganize' and produce enough circulation for the vortex to reform." [

]^{b,c}

4. Description of conduct of the test that includes any observations, and

   See the expanded discussion given above in point 3.

5. Summary of the test data such as a plot of critical submergence as a function of Froude number:

   Figure 3 of (FAI, 2009) is a plot of the reported test data for the onset of air intrusion and the conditions that resulted in an estimated void fraction of 2%. These data points are represented in terms of dimensionless water submergence as a function of the Froude Number. As discussed in point 1, the D.C. Cook tests are a representation of air intrusion (open loop) and steady state (closed loop) modes in which the water level, at a given flow rate, was decreased until air intrusion into the horizontal pipe was observed.

   Furthermore, Figure 3 of (FAI, 2009) also plots the Harleman et al. and Lubin-Springer correlations to compare to the experimental data from the D.C. Cook tests. The Lubin-Springer correlation somewhat underestimates the critical submergence observed in the D.C. Cook tests. However, the Harleman et al. correlation is in good agreement with the data for the critical submergence characterizing the onset of air entrainment. The Harleman et al. correlation for horizontal suction pipe is described in the second equation on Page 17 of 24 of (FAI, 2009). As noted earlier, the 0.5 is added because the submergences reported for the scaled D.C. Cook RWST experiments are with respect to the inner bottom surface of the discharge pipe instead of the pipe centerline as is the basis for the Harleman correlation. Also, when the measured critical submergence was less than 1.0 in Figure 3, the water level was below the top of the suction pipe and gas could begin to accumulate in the discharge piping as was observed for the D.C. Cook tests.

[

]b,c

3.0 REFERENCES

[

]e

FAI. (2009). *"Vortex Evaluation for Vogtle and Farley RWSTs and Hatch CSTs".* FAI/09-19: Fauske & Associates, LLC.

Harleman et al. (1959). *"Selective Withdrawal from a Vertically Stratified Fluid".* 8th Congress, Montreal, August 24-29: International Association for Hydraulic Research.

Knauss, J. (1987). *"Swirling Flow Problems at Intakes".* Roterdam: Hydraulic Structures Design Manual, A. A. Balkema.

Lubin/Springer. (1967). *"The Formation of a Dip on the Surface of a Liquid Draining from a Tank".* Journal of Fluid Mechanics, 29, pp. 385-390.

Sanders et al. (2001). *"Air Entrainment in a Partially Filled Horizontal Pump Suction Line".* New Orleans, La., Paper JPGC2001/PWR-19010, pp 95-103: Proceedings of the JPGC'-01, 2001 International Joint Power Generation Conference.

Joseph M. Farley Nuclear Plant – Units 1 and 2
Supplement to Response for Additional Information Regarding Condensate
Storage Tank Minimum Level License Amendment Request

Enclosure 7

Westinghouse Electric Company, LLC CAW-14-3974, "Application for Withholding Proprietary Information from Public Disclosure," June 10, 2014

Westinghouse

Westinghouse Electric Company
Engineering, Equipment and Major Projects
1000 Westinghouse Drive, Building 3
Cranberry Township, Pennsylvania 16066
USA

U.S. Nuclear Regulatory Commission
Document Control Desk
11555 Rockville Pike
Rockville, MD 20852

Direct tel: (412) 374-4643
Direct fax: (724) 940-8560
e-mail: greshaja@westinghouse.com
Proj letter: NL-14-0702

CAW-14-3974

June 10, 2014

APPLICATION FOR WITHHOLDING PROPRIETARY
INFORMATION FROM PUBLIC DISCLOSURE

Subject: FAI/09-19-P, Rev. 1, "Vortex Evaluation for Vogtle and Farley RWSTs and Hatch CSTs" (Proprietary) and
FAI/13-0392-P, Rev. 2, "Request for Additional Information by the Office of Nuclear Regulation Joseph M. Farley Nuclear Plants, Units 1 and 2 Southern Nuclear Operating Company Docket Nos. 50-348 and 50-364" (Proprietary)

The proprietary information for which withholding is being requested in the above-referenced report is further identified in Affidavit CAW-14-3974 signed by the owner of the proprietary information, Westinghouse Electric Company LLC. The Affidavit, which accompanies this letter, sets forth the basis on which the information may be withheld from public disclosure by the Commission and addresses with specificity the considerations listed in paragraph (b)(4) of 10 CFR Section 2.390 of the Commission's regulations.

Accordingly, this letter authorizes the utilization of the accompanying Affidavit by Southern Nuclear Operating Company.

Correspondence with respect to the proprietary aspects of the application for withholding or the Westinghouse Affidavit should reference CAW-14-3974 and should be addressed to James A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company, 1000 Westinghouse Drive, Building 3 Suite 310, Cranberry Township, Pennsylvania 16066.

Very truly yours,

FOR

James A. Gresham, Manager

Regulatory Compliance

Enclosures

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF BUTLER:

Before me, the undersigned authority, personally appeared James A. Gresham, who, being by me duly sworn according to law, deposes and says that he is authorized to execute this Affidavit on behalf of Westinghouse Electric Company LLC (Westinghouse), and that the averments of fact set forth in this Affidavit are true and correct to the best of his knowledge, information, and belief:

J.A. Gresham

James A. Gresham, Manager
Regulatory Compliance

Sworn to and subscribed before me
this 6th day of June 2014

Anne M. Stegman
Notary Public

COMMONWEALTH OF PENNSYLVANIA
Notarial Seal
Anne M. Stegman, Notary Public
Unity Twp., Westmoreland County
My Commission Expires Aug. 7, 2016
MEMBER, PENNSYLVANIA ASSOCIATION OF NOTARIES

(1) I am Manager, Regulatory Compliance, Westinghouse Electric Company LLC (Westinghouse), and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing and rule making proceedings, and am authorized to apply for its withholding on behalf of Westinghouse.

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.390 of the Commission's regulations and in conjunction with the Westinghouse Application for Withholding Proprietary Information from Public Disclosure accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by Westinghouse in designating information as a trade secret, privileged or as confidential commercial or financial information.

(4) Pursuant to the provisions of paragraph (b)(4) of Section 2.390 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.

(i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Westinghouse.

(ii) The information is of a type customarily held in confidence by Westinghouse and not customarily disclosed to the public. Westinghouse has a rational basis for determining the types of information customarily held in confidence by it and, in that connection, utilizes a system to determine when and whether to hold certain types of information in confidence. The application of that system and the substance of that system constitute Westinghouse policy and provide the rational basis required.

Under that system, information is held in confidence if it falls in one or more of several types, the release of which might result in the loss of an existing or potential competitive advantage, as follows:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of

Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage, e.g., by optimization or improved marketability.

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

(e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.

(f) It contains patentable ideas, for which patent protection may be desirable.

(iii) There are sound policy reasons behind the Westinghouse system which include the following:

(a) The use of such information by Westinghouse gives Westinghouse a competitive advantage over its competitors. It is, therefore, withheld from disclosure to protect the Westinghouse competitive position.

(b) It is information that is marketable in many ways. The extent to which such information is available to competitors diminishes the Westinghouse ability to sell products and services involving the use of the information.

(c) Use by our competitor would put Westinghouse at a competitive disadvantage by reducing his expenditure of resources at our expense.

(d) Each component of proprietary information pertinent to a particular competitive advantage is potentially as valuable as the total competitive advantage. If competitors acquire components of proprietary information, any one component may be the key to the entire puzzle, thereby depriving Westinghouse of a competitive advantage.

(e) Unrestricted disclosure would jeopardize the position of prominence of Westinghouse in the world market, and thereby give a market advantage to the competition of those countries.

(f) The Westinghouse capacity to invest corporate assets in research and development depends upon the success in obtaining and maintaining a competitive advantage.

(iv) The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR Section 2.390, it is to be received in confidence by the Commission.

(v) The information sought to be protected is not available in public sources or available information has not been previously employed in the same original manner or method to the best of our knowledge and belief.

(vi) The proprietary information sought to be withheld in this submittal is that which is appropriately marked in 1) FAI/09-19-P, Rev. 1, "Vortex Evaluation for Vogtle and Farley RWSTs and Hatch CSTs" (Proprietary) and 2) FAI/13-0392-P, Rev.2, "Request for Additional Information by the Office of Nuclear Regulation Joseph M. Farley Nuclear Plants, Units 1 and 2 Southern Nuclear Operating Company Docket Nos. 50-348 and 50-364" (Proprietary), for submittal to the Commission, being transmitted by Southern Nuclear Operating Company letter and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk. The proprietary information as submitted by Westinghouse is that associated with: 1) the experimental data for downward facing suction piping, as well as the interpretation of that data and 2) a request for additional information (respectively), and may be used only for that purpose.

(a) This information is part of that which will enable Westinghouse to:

(i) Provide relevant experimental data to support plant specific analysis for prevention of significant gas intrusion to the system pumps.

(ii) Provide analysis support for the spectrum of suction piping types used for various water storage tanks throughout the commercial nuclear industry.

(b) Further this information has substantial commercial value as follows:

(i) Westinghouse plans to sell the use of the information to its customers for the purpose of evaluating the influence of downward facing suction piping regarding the prevention of significant gas intrusion to the pumps. In addition, the manner in which suction conditions can be addressed for different suction piping is also considered to be of commercial value.

(ii) Westinghouse can sell support and defense of the plant specific protection against significant gas intrusion through the suction piping.

(iii) The information requested to be withheld reveals the distinguishing aspects of a methodology which was developed by Westinghouse.

Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar technical evaluations, using FAI/Westinghouse data, and licensing defense services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

The development of the technology described in part by the information is the result of applying the results of many years of experience in an intensive Westinghouse effort and the expenditure of a considerable sum of money.

In order for competitors of Westinghouse to duplicate this information, similar technical programs would have to be performed and a significant manpower effort, having the requisite talent and experience, would have to be expended.

Further the deponent sayeth not.

PROPRIETARY INFORMATION NOTICE

Transmitted herewith are proprietary and/or non-proprietary versions of documents furnished to the NRC associated with the experimental data for downward facing suction piping, as well as the interpretation of that data; and also a request for additional information, and may be used only for that purpose.

In order to conform to the requirements of 10 CFR 2.390 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the Affidavit accompanying this transmittal pursuant to 10 CFR 2.390(b)(1).

COPYRIGHT NOTICE

The reports transmitted herewith each bear a Westinghouse copyright notice. The NRC is permitted to make the number of copies of the information contained in these reports which are necessary for its internal use in connection with generic and plant-specific reviews and approvals as well as the issuance, denial, amendment, transfer, renewal, modification, suspension, revocation, or violation of a license, permit, order, or regulation subject to the requirements of 10 CFR 2.390 regarding restrictions on public disclosure to the extent such information has been identified as proprietary by Westinghouse, copyright protection notwithstanding. With respect to the non-proprietary versions of these reports, the NRC is permitted to make the number of copies beyond those necessary for its internal use which are necessary in order to have one copy available for public viewing in the appropriate docket files in the public document room in Washington, DC and in local public document rooms as may be required by NRC regulations if the number of copies submitted is insufficient for this purpose. Copies made by the NRC must include the copyright notice in all instances and the proprietary notice if the original was identified as proprietary.