Systems	MX
Calc. Sub-Type	-
Priority Code	3
Quality Class	Safety-Related

NUCLEAR GENERATION GROUP

ANALYSIS / CALCULATION

S09-0045

(Calculation #)

Integrity Evaluation of Cracked Containment Shell for LODHR

(Title including structures, systems, components)

☐ BNP UNIT _____

☒ CR3 ☐ HNP ☐ RNP ☐ NES ☐ ALL

APPROVAL ☐ Electronically Approved

Rev #	Prepared By	Reviewed By	Supervisor
0	Signature: Nezar Abraham Name: Nezar Abraham Date: 10/6/09	Signature: C.N. Krishnaswamy Name: C.N. Krishnaswamy Date: 10/6/09	Signature: Chris Sward Name: Chris Sward Date: 10/6/09

(For Vendor Calculations)

Vendor Sargent & Lundy LLC Vendor Document No. N/A

Owner's Review By JOHN HOLLIWAY John Holliway Date 10/06/09

MAGDY BISHARA Magdy Bishara 10/06/09

Q-21

List Of Effective Pages

Page	Rev	Page	Rev	Page	Rev	Page	Rev
i-vii	0						
1-7	0						

Attachments

Attach. Number	Rev	Number of Pages
A	0	1
B	0	3

Amendments

Rev & Letter	No of Pages	Rev & Letter	No of Pages	Rev & Letter	No of Pages	Rev & Letter	No of Pages

Table Of Contents

Revision Summary

Revision #	Revision Summary (Include brief description of revision and a list of EC's and other modifications incorporated into revision)
0	Original Issue

Document Indexing Tables

Document Management System Data (For update of PassPort Controlled Document information — Document Service is to delete roll over data only if shown for DELETE in the following tables)

Notes - General

Doc Services Action (Enter ADD, DELETE, or —)	Text of General Notes

Reference Numbers – Reference Systems

Doc Services Action (Enter ADD, DELETE, or —)	System (Two letter code for systems affected by results)
ADD	MX

Reference Numbers – Other References (references to PassPort products)

Doc Services Action (Enter ADD, DELETE, or —)	Type (e.g. AR, EC, WO, etc)	Reference (e.g. AR No, EC No, WO No, etc)	Sub (AR Assign No, WO Task No, etc.)	Title

Input Document References – Controlled Documents with Cross References

Doc Services Action (Enter ADD, REV, DELETE, or —)	**Doc. Type** (e.g. CALC, DWG, NPAS, POM, etc)	Document **Sub-Type**	**Document ID** (e.g., Calc No., Dwg. No., Procedure No)	**Sheet** (Dwg. sheet number if Applicable)	Doc **Rev**	**Minor Rev** (for Calc Amendments)	**Ref Type** (for NPAS Docs)

Description Codes (Key Words)

Doc Services Action (Enter ADD, DELETE, or —)	**Code** (Codes for Key Words) (To be recorded as document description codes in PassPort)
ADD	STMGEN
ADD	STR
ADD	CNT
ADD	TENDON

Output **Document References** (Doc Service is to open listed documents and add or delete this Calc as a reference)

Doc Services Action (Enter ADD, DELETE, or —)	**Document Type** (e.g. CALC, DWG, TAG, PROCEDURE, SOFTWARE)	Document **Sub-Type**	**Document ID** (e.g., Calc No., Dwg. No., Procedure No., Software name and version)	**Revision**	Action Tracking (AR number or EC number that will track revision of affected document for the results of this calculation)
ADD	CALC		S06-0002		1
ADD	CALC		S06-0005		1
ADD	CALC		S06-0007		0

Equipment Database Data (For update of PassPort Equipment Database information)

Equipment Document References

Config Mgt Action (Enter ADD, DELETE, or —)	**Equipment Tag**	**Equipment Type** (includes SFTAPL for analysis software)	Relationship to Calc. (e.g. equipment operation affected by results, equipment design affected by results, analysis software)
ADD	RB;STU;BUILDING	STU	
ADD	5011;TEN	TEN	

Record of Lead Review

Document No. S09-0045 **Revision** 0

The signature below of the Lead Reviewer records that:
- the review indicated below has been performed by the Lead Reviewer;
- appropriate reviews were performed and errors/deficiencies (for all reviews performed) have been resolved and these records are included in the design package;
- the review was performed in accordance with EGR-NGGC-0003.

☒ **Design Verification Review** ☐ **Engineering Review** ☐ **Owner's Review**
- ☒ Design Review
- ☐ Alternate Calculation
- ☐ Qualification Testing

☐ **Special Engineering Review**

☐ YES ☒ N/A **Other Records are attached**

C.N. Krishnaswamy	C N Krishna Swamy	NPT/S&CE	10/06/09
Lead Reviewer (print)	**(sign)**	**Discipline**	**Date**

Item No.	Deficiency	Resolution
1	Include to PE e-mail re: excluding seismic loading	Comment incorporated
2	Include photo of vertical concrete cracking at centerline of hoop tendon ducts	Comment incorporated
3	Include note that this is not a design basis evaluation	Comment incorporated
4	Include assumption that the liner is considered as a strength element	Comment incorporated

FORM EGR-NGGC-0003-2-5
This form is a QA Record when completed and included with a completed design package. Owner's Reviews may be processed as stand alone QA records when Owner's Review is completed

Record of Interdisciplinary Reviews

PART I — DESIGN ASSUMPTION / INPUT REVIEW: APPLICABLE ☐ Yes ☒ No

The following organizations have reviewed and concur with the design assumptions and inputs used in this calculation:

	Name	Signature	Date
Systems Engineering			
Operations			
Other			

PART II — RESULTS REVIEW:

The following organizations are aware of the impact of the results of this calculation (on designs, programs and procedures):

Systems Engineering
☐ Yes ☒ NO

Name	Signature	Date

Comments:

Operations
☐ Yes ☒ NO

Name	Signature	Date

Comments:

Other

Name	Signature	Date

Comments:

Other

Name	Signature	Date

Comments:

Other

Name	Signature	Date

Comments:

1.0 Purpose

The structural adequacy of the containment shell with all of the concrete in the Access Opening area in the containment wall removed for the steam generator replacement (SGR) project during the time frame between cold shut down (Mode 5) and defueled mode (Mode 6) was documented previously in Refs. 2.2 and 2.3.

Recently, indications of vertical concrete cracks resembling delamination cracks between the centerline of the hoop tendon ducts in the Access Opening area were observed during concrete removal for the creation of the Access Opening (Attachment A). Until the actual extent of this type of concrete cracking in the remainder of the containment wall is established, it is conservatively assumed that such concrete cracking is present wherever through-thickness reinforcing steel ties are not provided in the containment wall. Furthermore, for this integrity evaluation, consider the steel liner as the only structural strength element in the containment to resist the applicable loads mentioned below.

The purpose of this calculation is to conservatively demonstrate the structural adequacy of the containment shell with the above described cracking for the following loads:

- Dead Load
- Reduced Prestress Load
- Wind Load
- LODHR accident pressure
- LODHR accident temperature

Note: This calculation is not intended to be a design basis calculation.

2.0 References

2.1 Calculation No. S06-0002, Rev. 1, "Containment Shell Analysis for Steam Generator Replacement - Design Criteria".

2.2 Calculation No. S06-0005, Rev. 1, "Containment Shell Analysis for Steam Generator Replacement - Shell Evaluation During Replacement Activities".

2.3 Calculation No. S06-0007, Rev. 1, "Containment Liner Evaluation for SGR".

2.4 October 5, 2009 e-Mail from D. Jopling of Progress Energy to C. A. Sward of S&L (Attachment B).

3.0 Design Inputs

3.1 Access opening in containment shell wall is 26'-6" x 28'-0" (Ref. 2.1).

3.2 Liner plate: ASTM A283 Grade C, Tensile Strength = 55 ksi (Ref. 2.3).

3.3 Liner plate nominal thickness: 3/8" (Ref. 2.1).

3.4 Loss of decay heat removal (LODHR) accident peak pressure = 5.14 psig (Ref. 2.2)

3.5 LODHR peak temperature = 173 deg-F (Ref. 2.2).

3.6 Seismic loading need not be considered for this evaluation (Ref. 2.4).

3.7 The loads to be considered for this evaluation are as follows (Ref. 2.1, Table 6-4):

a. Dead Load
b. Reduced Prestress Load
c. Wind Load
d. LODHR accident pressure
e. LODHR accident temperature

4.0 Assumptions

The only assumption made in this calculation is that the containment steel liner is considered as a structural strength element to resist the above mentioned loads.

5.0 Methodology

1. Conservatively consider that the delamination crack exists in the containment wall wherever through-thickness reinforcing steel ties are not present.

2. Neglect the meridional and hoop reinforcing steel present between the centerline of the hoop tendon ducts and the outer surface of the containment wall without through-thickness reinforcing steel ties.

3. The liner in the Access Opening area in the containment wall with all concrete removed is the most stressed portion of containment wall liner as it is also subjected to significant bending stress in addition to membrane stress.

Computer Software Used in the Calculation:

MathSoft Mathcad Version 11.2a, S&L Computer Program No. 03.7.548-11.2, was used to prepare these calculations. This program, accessed on the S&L LAN, has been validated per S&L Software Verification and Validation procedures for the program functions used in the calculation in accordance with S&L QA program.

This calculation was prepared using S&L PC No. ZL4304.

6.0 CALCULATIONS

6.1 Evaluation of Steel Liner in the Access Opening Area

The steel liner away from the Access Opening will only experience membrane stresses, and thus the critical steel liner section is within the Access Opening as it is subjected to membrance plus bending stresses resulting from a LODHR accident pressure. The critical steel liner section will be evaluated for LODHR pressure and wind loads, which will be conservatively calculated at the base of the containment. The effect due to reduced prestress load, dead load, and accident temperature will be conservatively neglected since they only create compression.

LODHR Loads

The 3/8 " liner was evaluated in Calculated S06-0007, Rev. 1 (Rev. 2.3) and found structurally adequate to withstand the effect of a postulated LODHR of 8 psig with a maximum membrane plus bending stress of 25,667 psi. It is noted that the stresses in the liner from the LODHR load would be less considering a 5.14 psig pressure used and documented in Ref. 2.2. However, conservatively use the maximum stress resulting from 8 psig.

$\sigma_{liner\_LODHR} := 25667 \cdot psi$ — Maximum membrane + bending stress in the liner resulting from 8 psig per Rev. 2.3

Wind Loads

The maximum wind pressure of 0.568 psi corresponding to a basic wind speed of 179 mph was conservatively applied to the entire height of the structure in Calculation S06-0005, Rev. 0 (Rev. 2.2). In the following calculation, the maximum stress on the liner due to wind loading will be calculated and added to the maximum stress on the liner from the accident pressure.

$t_{liner} := 0.375 \cdot in$ — Steel liner thickness per Ref. 2.1

$S_f := 32.7 \cdot ksi$ — Allowable membrane stress calculated in Section 4.1 of Ref. 2.3

$R := 65 \cdot ft$ — Radius of containment per Ref. 2.1

$H_1 := 157 \cdot ft$ — Height of shell above to be considered fof wind load calculation

$H_2 := 17.88 \cdot ft$ — Height of dome

$A_{proj} := H_1 \cdot (2 \cdot R) + \frac{\pi \cdot H_2^{\,2}}{2}$ — Projected area for wind loading

$A_{proj} = 2.091 \times 10^4\ ft^2$

$P_{wind} := 0.568 \cdot psi$ — Wind pressure due to 179 mph (conservative)

$F_{wind} := P_{wind} \cdot A_{proj}$ — Total force due to wind loading

$F_{wind} = 1.71 \times 10^6\ kip$

$$M_{wind\_base} := F_{wind} \cdot \frac{(H_1 + H_2)}{2}$$

Total moment due to wind at the base of the containment (conservative)

$$M_{wind\_base} = 1.496 \times 10^{8}\ kip \cdot ft$$

$$S_{liner} := \pi \cdot R^{2} \cdot t_{liner}$$

Section modulus of section through the steel liner

$$S_{liner} = 414.788\ ft^{3}$$

$$\sigma_{liner\_wind} := \frac{M_{wind\_base}}{S_{liner}}$$

Maximum stress in the liner due to wind load

$$\sigma_{liner\_wind} = 2.504\ ksi$$

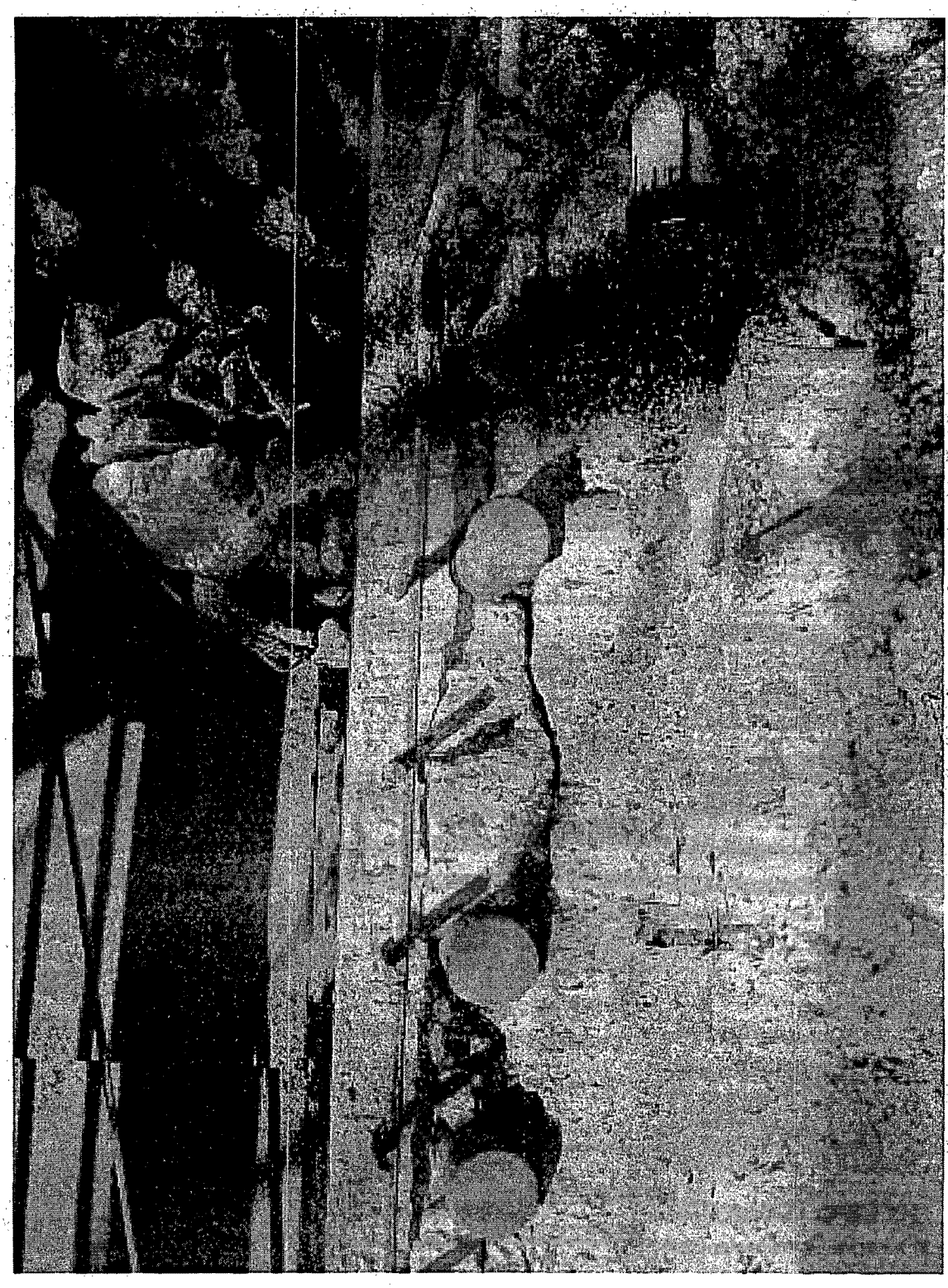
$$\sigma_{liner} := \sigma_{liner\_LODHR} + \sigma_{liner\_wind}$$

Total stress in liner plate due to wind and accident pressure (conservative)

$\sigma_{liner} = 28.171\ ksi$ < $S_f = 32.7\ ksi$ **OK**

7.0 Conclusion

The structural adequacy of the containment shell with the vertical concrete cracks between the centerline of the hoop tendon ducts for the loads described in this calculation was conservatively re-evaluated and found acceptable considering the steel liner plate as the only strength element in the containment



Fw: Containment Integrity for loads associated with Decay Heat

JAVAD MOSLEMIAN to: NEZAR ABRAHAM, CN KRISHNASWAMY 10/06/2009 03:52 PM

Cc: JOHN REGAN, CHRIS A SWARD, JAVAD MOSLEMIAN

----- Forwarded by JAVAD MOSLEMIAN/Sargentlundy on 10/06/2009 03:50 PM -----

From: "Jopling, Daniel L." <DANIEL.JOPLING@pgnmail.com>
To: <JAVAD.MOSLEMIAN@sargentlundy.com>
Date: 10/05/2009 06:18 AM
Subject: RE: FW: Containment Integrity for loads associated with Decay Heat

Yes this is the calc we're looking for. I think it's 5.14 psig. Seismic is not a requirement.

Dan Jopling
Supervisor
Steam Generator Replacement Project
352 563 2943 X 1759
v net 240 1759
Cell (b)(6)

From: JAVAD.MOSLEMIAN@sargentlundy.com [mailto:JAVAD.MOSLEMIAN@sargentlundy.com]
Sent: Monday, October 05, 2009 6:28 AM
To: Jopling, Daniel L.
Cc: Holliday, John; Bishara, Magdy M.; JOHN.REGAN@sargentlundy.com; CHRIS.A.SWARD@sargentlundy.com; CN.KRISHNASWAMY@sargentlundy.com
Subject: Re: FW: Containment Integrity for loads associated with Decay Heat
Importance: High

Dan / John,

I believe what you are asking for is integrity evaluation of the containment to withstand normal loads plus a pressure of 5.24 psi due to Loss of Decay Heat Removal without considering any seismic loads.

Please confirm this is what you are asking for as soon as possible.

Regards
Javad

From: "Jopling, Daniel L." <DANIEL.JOPLING@pgnmail.com>
To: <JAVAD.MOSLEMIAN@sargentlundy.com>
Cc: "Bishara, Magdy M." <Magdy.Bishara@pgnmail.com>, "Holliday, John" <John.Holliday@pgnmail.com>
Date: 10/03/2009 08:02 AM
Subject: FW: Containment Integrity for loads associated with Decay Heat

One other pointer. We're really not looking for operability. All we're looking to establish is pressure retaining for Loss of Decay Heat Removal (5.24 psi) which is not an operability issue.

Dan Jopling
Supervisor
Steam Generator Replacement Project
352 563 2943 X 1759
v net 240 1759
Cell (b)(6)

From: Jopling, Daniel L.
Sent: Saturday, October 03, 2009 8:43 AM
To: 'JAVAD.MOSLEMIAN@sargentlundy.com'
Cc: 'JOHN.REGAN@sargentlundy.com'; 'CHRIS.A.SWARD@sargentlundy.com'; Bishara, Magdy M.
Subject: RE: Containment Integrity for loads associated with Decay Heat

Thank you for this support. I have an action to finalize the pressure retaining issue Monday late afternoon. As a result I would appreciate your final documentation by 3:00 pm Monday.

Dan Jopling
Supervisor
Steam Generator Replacement Project
352 563 2943 X 1759
v net 240 1759
Cell (b)(6)

From: JAVAD.MOSLEMIAN@sargentlundy.com [mailto:JAVAD.MOSLEMIAN@sargentlundy.com]
Sent: Friday, October 02, 2009 5:16 PM
To: Holliday, John
Cc: Jopling, Daniel L.; Jones, David (CR3); Terry Jr, James H.; Bishara, Magdy M.; Powell, Sid; JOHN.REGAN@sargentlundy.com; CONSTANTINE.N.PETROPOULOS@sargentlundy.com;; CN.KRISHNASWAMY@sargentlundy.com; AMIR.M.MOID@Sargentlundy.com; NEZAR.ABRAHAM@Sargentlundy.com; CHI-HOLT.KO@sargentlundy.com; Javad Moslemian
Subject: Containment Integrity for loads associated with Decay Heat
Importance: High

John,

Note; In general, we do not determine "Operability". Normally operability determination and declaration is by the appropriate individuals from the utility. What is stated below is our collective engineering judgment that may be used by qualified Progress Energy's staff in their determination and declaration of station operability.

As you know, we have evaluated the containment for the loading associated with decay heat when the liner is in-place, concrete within the opening is fully removed and the containment prestress is reduced due to removal and/or detensioning of the tendons within the opening.

Under the existing conditions that we have been informed of, the concrete within the opening is partially

removed, the liner is in place, the tendons within the opening are detensioned, and significant concrete cracks are observed possibly indicating delamination of concrete due to through thickness tensile stress from hoop tendons. It is our collective judgment that even when considering the concrete outside the cylinder formed by the hoop tendons is ineffective, the containment shall will be capable of withstanding the loads associated with decay heat accident.

As agreed upon, evaluations will be performed to verify the above noted engineering judgment.

Regards
Javad

Fro m: "Holliday, John" <John.Holliday@pgnmail.com>
To: <javad.moslemian@sargentlundy.com>
Cc: "Jopling, Daniel L." <DANIEL.JOPLING@pgnmail.com>, "Bishara, Magdy M." <Magdy.Bishara@pgnmail.com>, "Terry Jr, James H." <James.TerryJr@pgnmail.com>, "Jones, David (CR3)" <David.Jones@pgnmail.com>, "Powell, Sid" <Sid.Powell@pgnmail.com>
Dat e: 10/02/2009 03:32 PM
Subj ect: Contact number

Javad,
The individuals I've "cc" in this message need to be included in any future correspondence concerning the cracked RB concrete. My new number here at CR3 is 352-563-2943 x 1753