AREVA

August 10, 2011
NRC:11:088

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

Response to U.S. EPR Design Certification Application RAI No. 437, Supplement 7

In Reference 1, the NRC provided a request for additional information (RAI) regarding the U.S. EPR design certification application. Reference 2 provided a schedule for technically correct and complete responses to the 6 questions in RAI No. 437. Reference 3 provided Supplement 1 response to RAI No. 437 to revise the schedule for responding to Question 06.02.01-98. Reference 4 provided Supplement 2 response to RAI No. 437 to revise the schedule for responding to Questions 06.02.01-96, 06.02.01-97, 06.02.01-98, 06.02.01-99, 06.02.01-100 and 06.02.01-101. Reference 5 provided Supplement 3 response to RAI No. 437 to revise the schedule for responding to Questions 06.02.01-99, 06.02.01-100 and 06.02.01-101. Reference 6 provided Supplement 4 response to RAI No. 437 to revise the schedule for responding to Questions 06.02.01-96, 06.02.01-97 and 06.02.01-98. Reference 7 provided Supplement 5 response to RAI No. 437 to revise the schedule for responding to Questions 06.02.01-99, 06.02.01-100 and 06.02.01-101. Reference 8 provided Supplement 6 response to RAI No. 437 to provide technically correct and complete responses to Questions 06.02.01-96, 06.02.01-97 and 06.02.01-98.

The enclosure to this letter provides a technically correct and complete response to Question 06.02.01-100 and Question 06.02.01-101. AREVA NP considers some of the material contained in the enclosed response to be proprietary. As required by 10 CFR 2.390(b), an affidavit is enclosed to support the withholding of the information from public disclosure. Proprietary and non-proprietary versions of the enclosure to this letter are provided.

The following table indicates the respective pages in the enclosure that contain AREVA NP's final response to the subject questions.

Question #	Start Page	End Page
RAI 437 — 06.02.01-100	2	22
RAI 437 — 06.02.01-101	23	24

The schedule for a technically correct and complete response is provided below for the one remaining question of RAI No. 437.

Question #	Response Date
RAI 437 — 06.02.01-99	October 5, 2011

D077

NRO

AREVA INC.
3315 Old Forest Road, P.O. Box 10935, Lynchburg, VA 24506-0935
Tel.: 434 832 3000 www.areva.com

If you have any questions related to this submittal, please contact me by telephone at 434-832-2369 or by e-mail to sandra.sloan@areva.com.

Sincerely,

Sandra M. Sloan

Sandra M. Sloan, Manager
New Plants Regulatory Affairs
AREVA NP Inc.

Enclosures

cc: G. Tesfaye
Docket No. 52-020

References

Ref. 1: E-mail, Getachew Tesfaye (NRC) to Martin C. Bryan (AREVA NP Inc.), "U.S. EPR Design Certification Application RAI No. 437 (4953), FSAR Ch. 6," October 20, 2010.

Ref. 2: E-mail, Martin C. Bryan (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 437, FSAR Ch. 6," November 19, 2010.

Ref. 3: E-mail, Russell Wells (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 437, FSAR Ch. 6, Supplement 1," February 24, 2011.

Ref. 4: E-mail, Russell Wells (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 437, FSAR Ch. 6, Supplement 2," March 16, 2011.

Ref. 5: E-mail, Russell Wells (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 437, FSAR Ch. 6, Supplement 3," April 14, 2011.

Ref. 6: E-mail, Russell Wells (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 437, FSAR Ch. 6, Supplement 4," April 28, 2011.

Ref. 7: E-mail, Dennis Williford (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 437, FSAR Ch. 6, Supplement 5," May 25, 2011.

Ref. 8: E-mail, Tom Ryan (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 437, FSAR Ch. 6, Supplement 6," June 15, 2011.

bcc: NRC:11:088
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AFFIDAVIT

COMMONWEALTH OF VIRGINIA)
) ss.
COUNTY OF CAMPBELL)

1. My name is Sandra M. Sloan. I am Manager, Regulatory Affairs for New Plants, for AREVA NP Inc. and as such I am authorized to execute this Affidavit.

2. I am familiar with the criteria applied by AREVA NP to determine whether certain AREVA NP information is proprietary. I am familiar with the policies established by AREVA NP to ensure the proper application of these criteria.

3. I am familiar with the AREVA NP information contained in, "Response to U.S. EPR Design Certification Application RAI No. 437, Supplement 7," and referred to herein as "Document." Information contained in this Document has been classified by AREVA NP as proprietary in accordance with the policies established by AREVA NP for the control and protection of proprietary and confidential information.

4. This Document contains information of a proprietary and confidential nature and is of the type customarily held in confidence by AREVA NP and not made available to the public. Based on my experience, I am aware that other companies regard information of the kind contained in this Document as proprietary and confidential.

5. This Document has been made available to the U.S. Nuclear Regulatory Commission in confidence with the request that the information contained in this Document be withheld from public disclosure. The request for withholding of proprietary information is made in accordance with 10 CFR 2.390. The information for which withholding from disclosure is

requested qualifies under 10 CFR 2.390(a)(4) "Trade secrets and commercial or financial information".

6. The following criteria are customarily applied by AREVA NP to determine whether information should be classified as proprietary:

(a) The information reveals details of AREVA NP's research and development plans and programs or their results.

(b) Use of the information by a competitor would permit the competitor to significantly reduce its expenditures, in time or resources, to design, produce, or market a similar product or service.

(c) The information includes test data or analytical techniques concerning a process, methodology, or component, the application of which results in a competitive advantage for AREVA NP.

(d) The information reveals certain distinguishing aspects of a process, methodology, or component, the exclusive use of which provides a competitive advantage for AREVA NP in product optimization or marketability.

(e) The information is vital to a competitive advantage held by AREVA NP, would be helpful to competitors to AREVA NP, and would likely cause substantial harm to the competitive position of AREVA NP.

The information in the Document is considered proprietary for the reasons set forth in paragraphs 6(b) and 6(c) above.

7. In accordance with AREVA NP's policies governing the protection and control of information, proprietary information contained in this Document has been made available, on a limited basis, to others outside AREVA NP only as required and under suitable agreement providing for nondisclosure and limited use of the information.

8. AREVA NP policy requires that proprietary information be kept in a secured file or area and distributed on a need-to-know basis.

9. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

Sandra M. Sloan

SUBSCRIBED before me this 10th
day of August, 2011.

Kathleen A. Bennett

Kathleen A. Bennett
NOTARY PUBLIC, COMMONWEALTH OF VIRGINIA
MY COMMISSION EXPIRES: 8/31/2015
Reg. #110864

KATHLEEN ANN BENNETT
Notary Public
Commonwealth of Virginia
110864
My Commission Expires Aug 31, 2015

Response to

Request for Additional Information No. 437(4953), Supplement 7, Revision 1

10/20/2010

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 06.02.01 - Containment Functional Design
Application Section: 6.02.01, 14.03

QUESTIONS for Containment and Ventilation Branch 1 (AP1000/EPR Projects) (SPCV)

Question 06.02.01-100:

During an NRC's audit review of the GOTHIC EPR model used to perform DBA containment analysis, a number of nodalization issues arose concerning the selection of rooms included in lumped control volumes (CVs) as described in AREVA's response to RAI No. 40. For example, some rooms included in CV21 and CV22 appear, from reviews of the EPR general arrangement drawings and recently obtained tables from AREVA NP document 38-9028970-000, to be isolated from the assessable middle annulus space by doors (Rooms 11-025, 11-026, 11-031, and 11-021). In other cases, for example, in the upper annulus volumes, dead-ended rooms connected via small pathways to an open space are lumped into a single control volume CV24 (Rooms 29-022 and 34-022). Provide the following information to help us with our review of the GOTHIC EPR multi-cell model used to analyze containment DBA events:

a. Provide the nodalization methodology that was used to reduce the approximately 146 containment rooms or regions of the EPR containment into the small number of lumped parameter volumes that define the EPR multi-cell model, as described in the response to RAI No. 40. Include in the discussion a response to issues raised concerning isolated rooms or small connects to dead-ended rooms included in a lumped parameter volume.

b. Referencing the pathway numbers in Table 2 (Listing of Primary EPR Data: Connections) from NP document 38-9028970-000, list the pathway open or closed status that was used in the DBA calculations reported in chapter 6.2 of the EPR FSAR.

c. From Table 2 of NP document 38-9028970-000, the path between compartments UJA11-021 to UJA11-013 is indicated as "free opening", see page 42, item No. 95. Page 4 from the RAI 340 Supplement 1, Question 06.02.01-54 response indicates there is a door between the two compartments. The AREVA RAI response No. 82, Supplement 3 Question 06.02.01-12-3d dated 10/03/2008 also indicates there is a door (see page 7 of 64). Explain this apparent inconsistency.

d. Provide a discussion of the QA requirements that the GOTHIC EPR multi-cell deck was subjected to prior to being used to provide input to chapter 6.2 of the EPR FSAR.

Response to Question 06.02.01-100:

a) The multi-node U.S. EPR containment model, consisting of 30 nodes or control volumes, has been developed for the lumped parameter code GOTHIC. The lumped parameter modeling approach was followed to reduce the approximately 146 containment rooms into the 30 control volumes that define the U.S. EPR multi-node model. The development of the GOTHIC model parallels the modeling approach followed in the EPR COCOSYS report, which developed an equivalent 30-node model for the lumped parameter code COCOSYS. The nodalization methodology associated with this modeling approach is described in the EPR COCOSYS report and is summarized in this section.

The EPR COCOSYS database, also incorporated in the EPR COCOSYS report, compiled detailed data (referred to in the report as Primary Data) of the approximately 146 containment rooms and their associated flow paths and heat sinks. This database enabled the development of the lumped parameter COCOSYS multi-node model and the lumped parameter GOTHIC multi-node model.

The nodalization methodology elements that guided the containment rooms' lumping into control volumes, or "zones," are as follows:

1) Lumped parameter modeling is applicable for slow transients where gravity flows predominate, and momentum in the gas and water phases is not significant.

   The containment pressure and temperature response design basis accident (DBA) calculations in U.S. EPR FSAR Tier 2, Section 6.2, for which this model was used, are slow transients (except the initial blowdown phase). ,

2) The lumped parameter model requirement of homogenously mixed environment in the control volumes is satisfied because the critical fluid velocities resulting from blowdown will forcibly deliver the break flow throughout containment.

3) The subcompartments within a control volume have been lumped together based on flow homogeneity, i.e., based on whether the subcompartments communicate freely so as to be considered well mixed.

4) The nodalization is governed by specific features of the containment design, such as:

   a) Separation of the accessible space from the non-accessible space.
   b) Horizontal divisions of the zones in accordance with the main floors.
   c) Vertical division of the zones in accordance with structures and rooms housing the loops.

5) The nodalization guiding principle is to derive a containment model by lumping containment rooms together to produce a physically adequate representation of the containment without unnecessarily increasing computation time.

   To meet this guiding principle, special treatment is applied for the small containment rooms in the large accessible space that are isolated by doors and/or dead-ended.

   These small auxiliary rooms (such as low head safety injection (LHSI), medium head safety injection (MHSI) valve rooms, and fuel pool purification system (FPPS) valve rooms and containment ventilation equipment) are lumped into the control volumes representing the large accessible middle and upper annulus spaces based on their respective locations. Specific examples have been included in the Response to RAI 437, Question 06.02.01-99.

   Because the free volume of these small rooms constitutes a negligible fraction of the total containment free volume (less than 1 percent), their inclusion in the model has a negligible impact on the containment pressure response calculations in U.S. EPR FSAR Tier 2, Section 6.2.

   The containment free volume input used in the DBA calculations is reduced by a margin of close to 3 percent relative to nominal. Therefore, the free volume of these small rooms is offset by the margin in containment free volume built into the DBA calculations.

6) For the large size containment dome, the local resolution was increased by fine-meshed nodalization to generate 5 x 5 x 19, three-dimensional Cartesian cells for evaluating the potential temperature stratification and monitor steam concentration distributions inside the dome.

b) Table 06.02.01-100-1 identifies the primary vent paths from the EPR COCOSYS database that connect the control volumes used in the multi-node containment model. These primary vent paths in Table 06.02.01-100-1 are linked to the GOTHIC multi-node model with respect to their open or closed status used in the U.S. EPR FSAR Tier 2, Section 6.2 DBA calculations.

Table 06.02.01-100-2 identifies the primary vent paths from the EPR COCOSYS database that are internal flow paths. Because a control volume consists of one or more rooms, the flow paths connecting the constituent rooms are internal to the control volume and are not modeled. These flow paths are labeled in Table 06.02.01-100-2 as internal flow paths and are not included in the multi-node model.

c) The EPR COCOSYS database, primary vent path # 95 was not included in the multi-node containment model because it is an internal flow path, as indicated in Table 06.02.01-100-2. This primary vent path, from room 11-021 to room 11-013, is not explicitly modeled because the connecting rooms are lumped in the same control volume (CV 21).

The current U.S. EPR design information designates this flow path as door # +5 FT Door 12 (see Table 06.02.01-100-2, "Remarks" column). This supersedes the "free opening" designation in the EPR COCOSYS database. Table 06.02.01-100-3 delineates the reconciliation of the EPR COCOSYS primary vent paths to U.S. EPR design.

Table 06.02.01-100-1, Note 1 indicates that the multi-node containment model uses design information for doors, dampers, and foils from the latest U.S. EPR design documents, superseding the information specified for these components in the EPR COCOSYS database.

d) The U.S. EPR containment GOTHIC multi-node model was originally prepared based on volumes, structures, and flow paths geometry data from the COCOSYS database, as described in Part a).

The multi-node model was later revised for the analysis of long term loss of coolant accidents (LOCAs) by adding the following information:

- A vessel control volume representing the reactor coolant system (RCS).
- Pipe break configuration from vessel into containment.
- Flow paths/safety injection (SI) components for recirculating the emergency core cooling system (ECCS) flow from the in-containment refueling water storage tank (IRWST) to the vessel node.

The multi-node model was further revised for improvements to accomplish the following objectives:

1) Using subdivided nodes in the dome region with sufficient meshing to capture potential temperature stratification, as described in the Part a).
2) Updating the door configuration and CONVECT system (i.e., foils and dampers) specification to the latest design information for the U.S. EPR, as explained Part c) and in Table 06.02.01-100-1 through Table 06.02.01-100-3.
3) Modeling of the containment heat sinks to use condensing heat transfer coefficient based on the diffusion layer model (DLM) heat transfer correlation, approved as a heat transfer option for use in the AREVA NP containment GOTHIC methodology. The DLM correlation is used because it allows modeling of heat sink orientation distinguishing between floor/ceiling heat sinks and vertical heat sinks.

   After these modifications, the multi-node model was used to analyze the main steam line breaks (MSLBs) described in U.S. EPR FSAR Tier 2, Section 6.2.

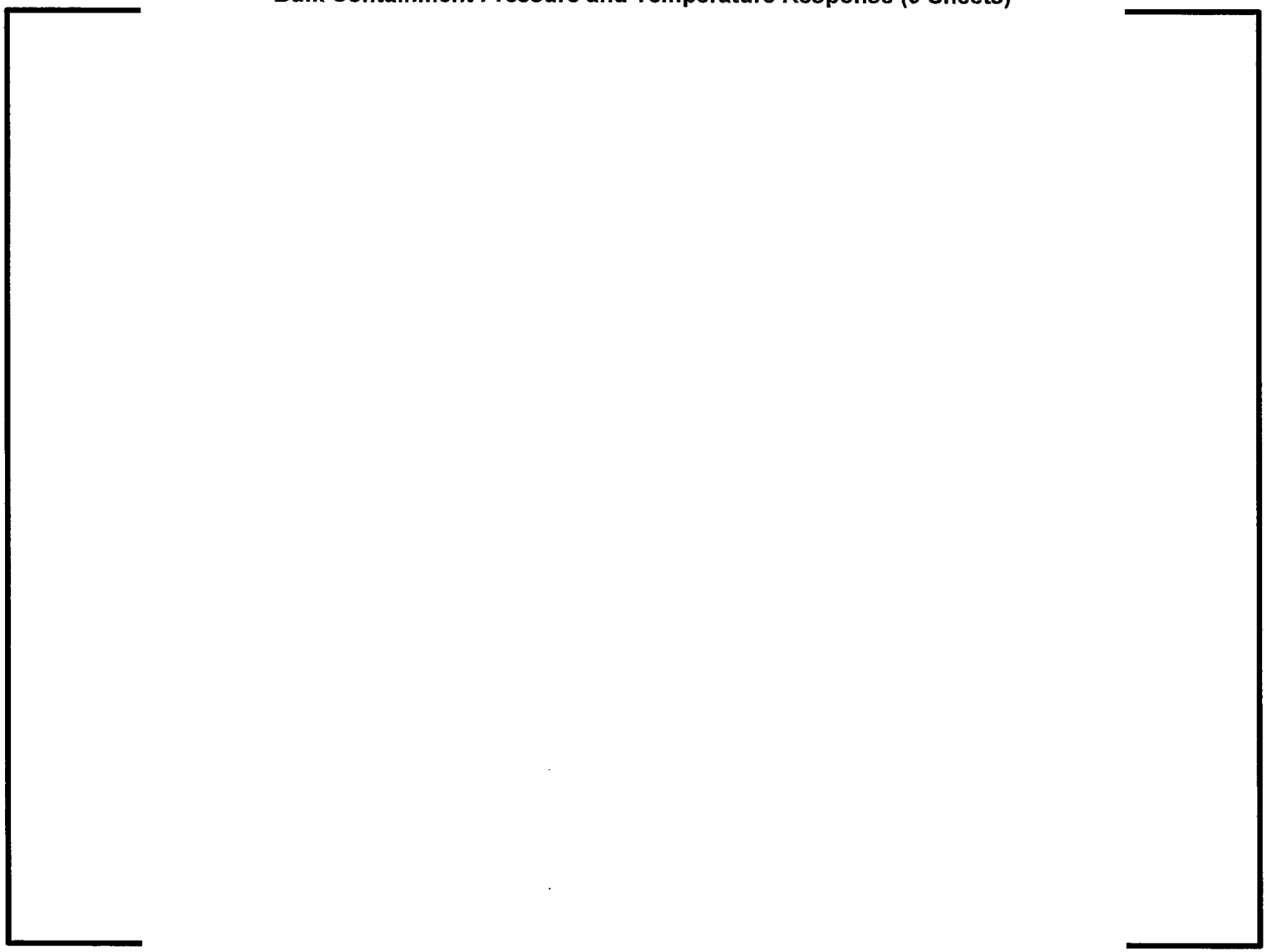
   For the large break loss of coolant accidents (LBLOCAs) described in U.S. EPR FSAR Tier 2, Section 6.2, an updated mass and energy (M&E) prediction methodology was

implemented before using the multi-node model. Technical Report ANP-10299, Revision 2, Chapter 8 describes this methodology, and Chapter 9 illustrates its application in the Sample Problem.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Table 06.02.01-100-1—Primary Vent Paths Included in Multi-Node Containment Model for Bulk Containment Pressure and Temperature Response (9 Sheets)



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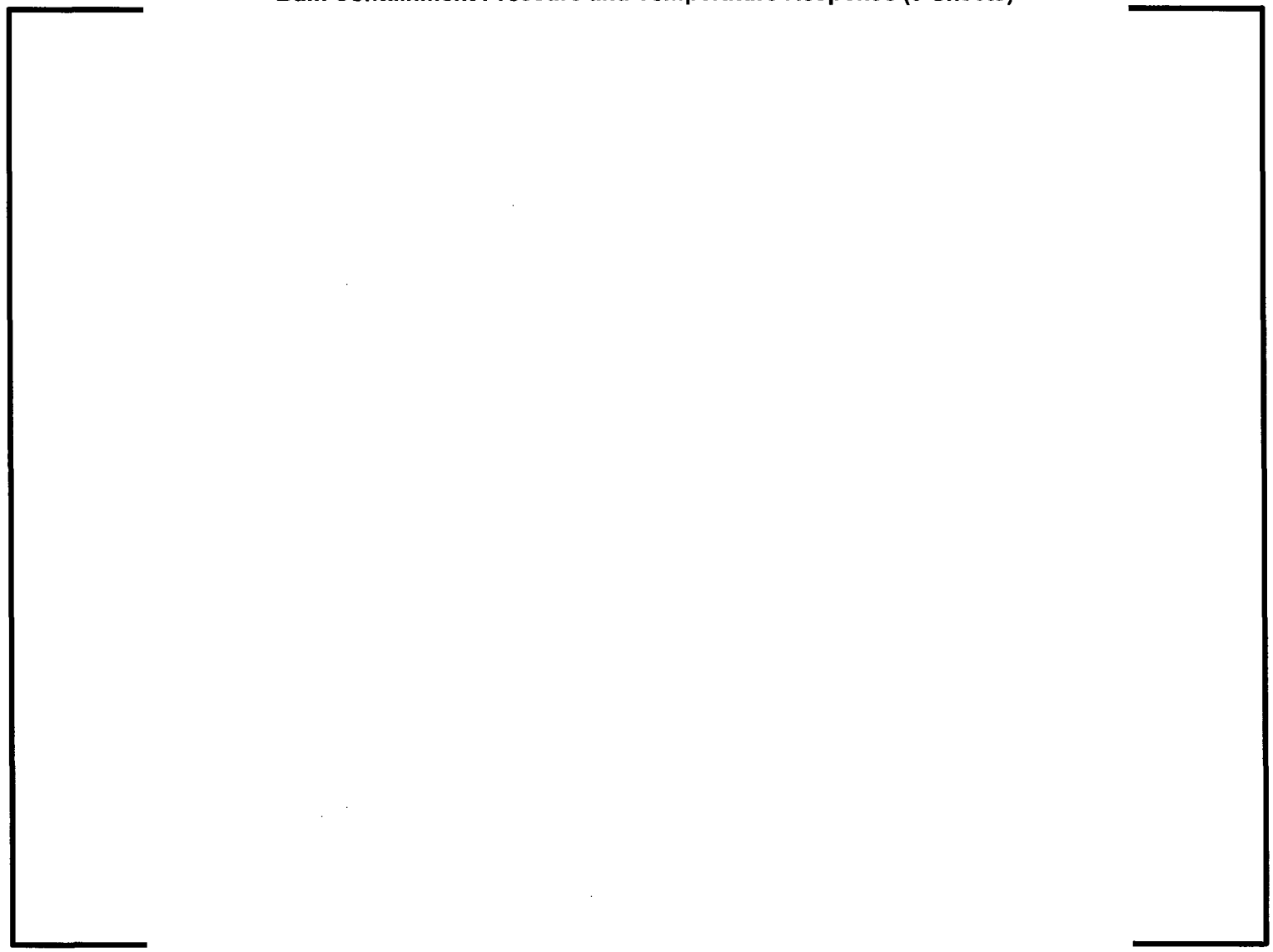

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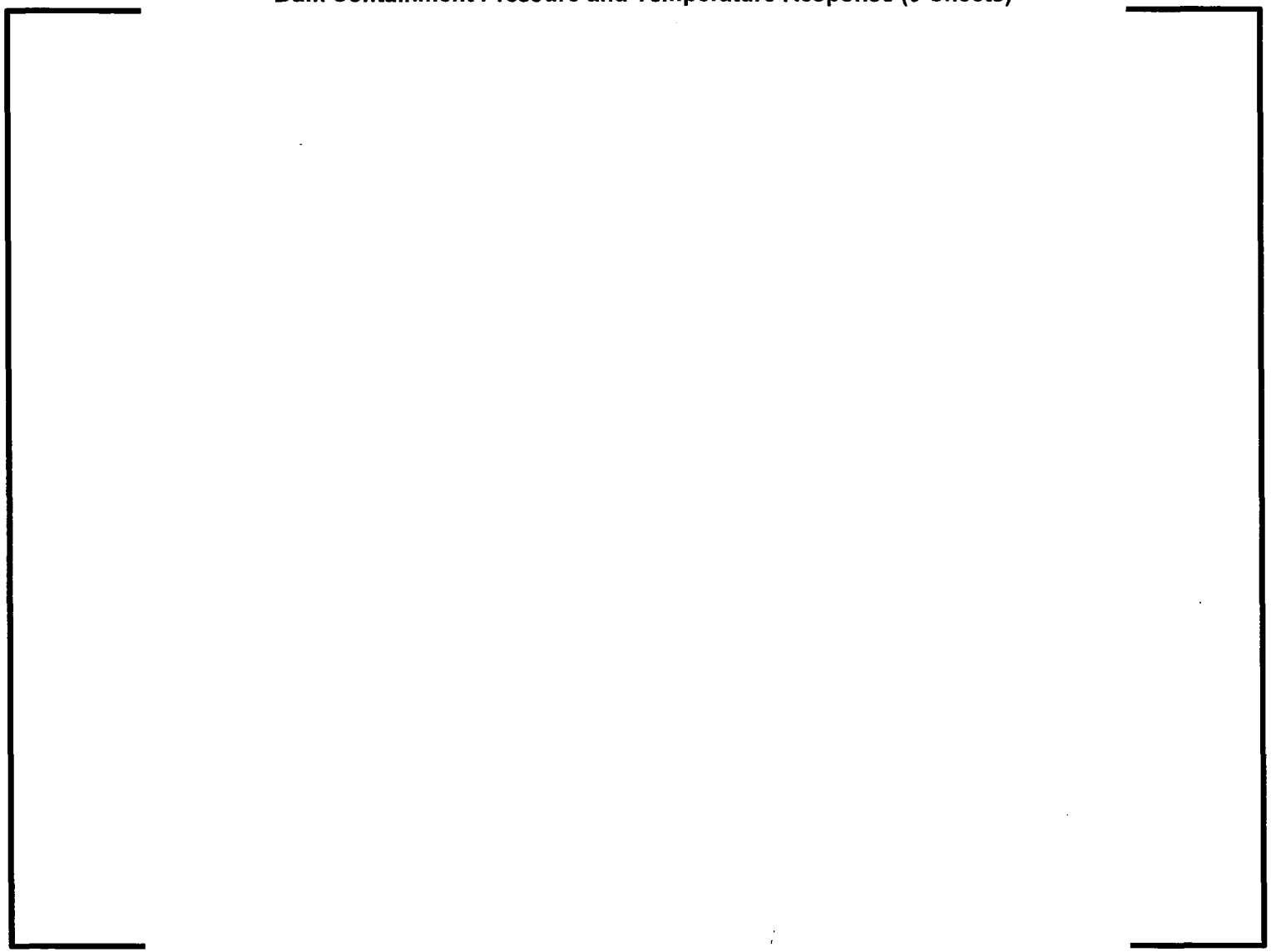

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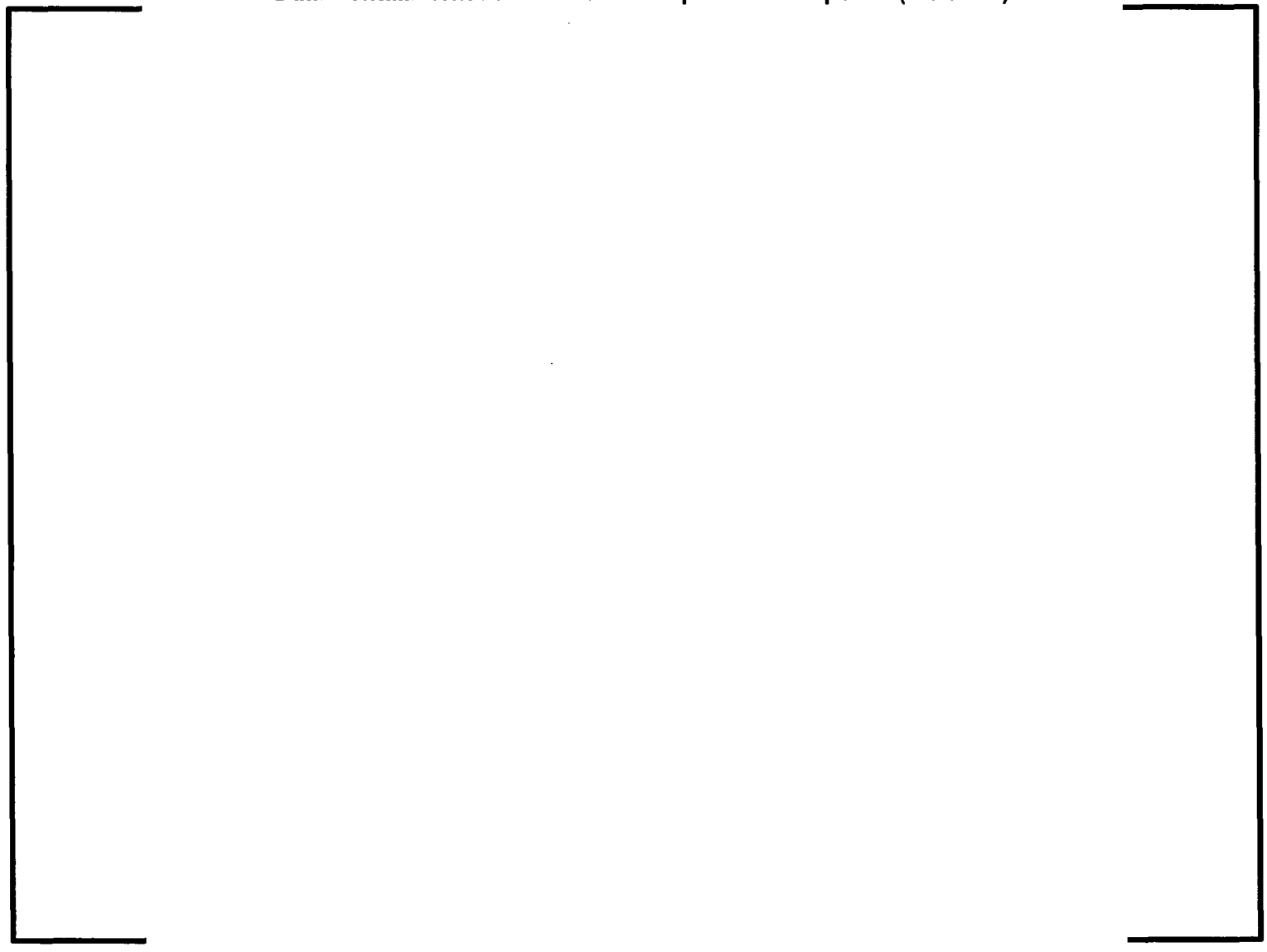

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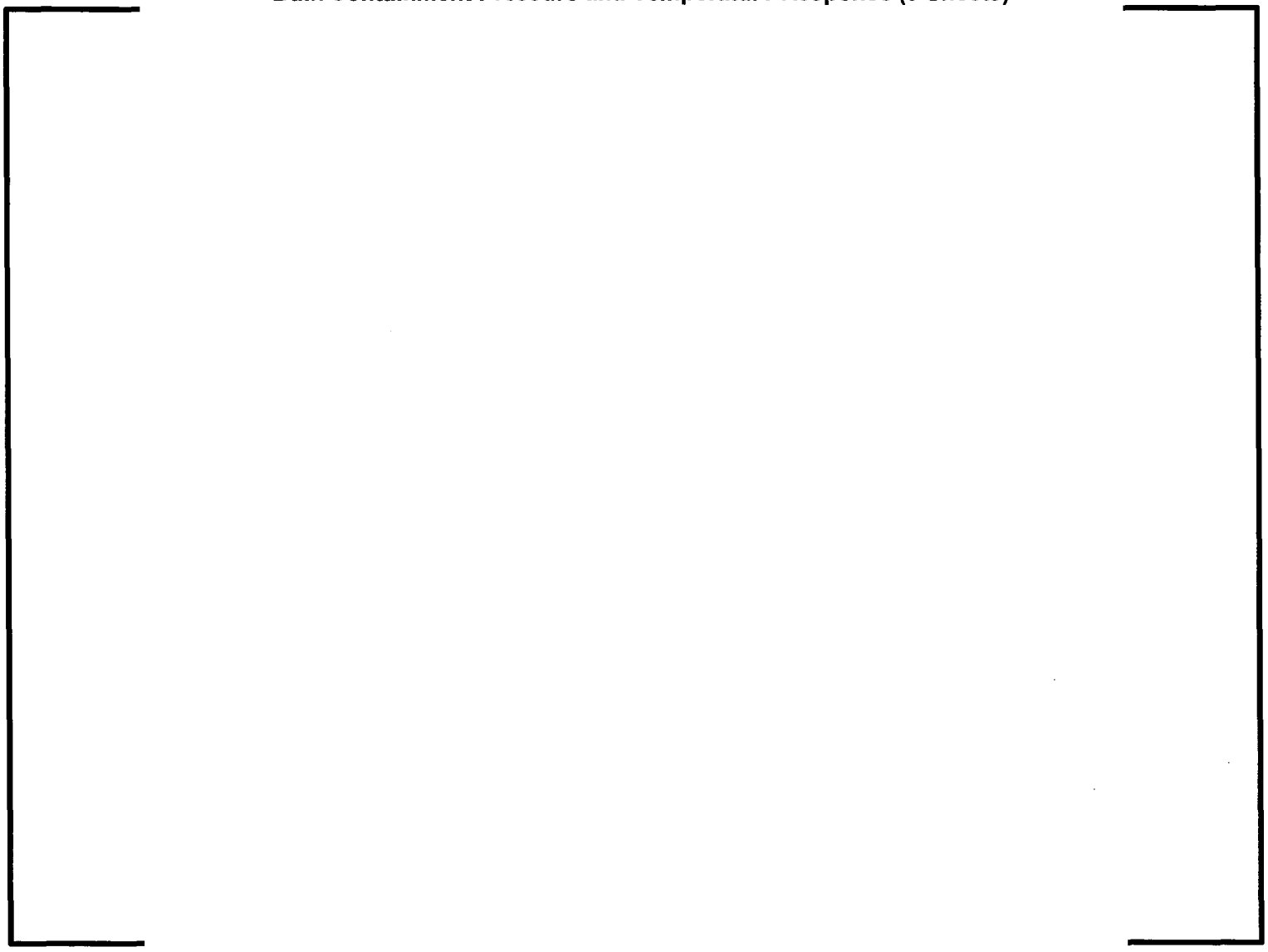

Table 06.02.01-100-1—Primary Vent Paths Included in Multi-Node Containment Model for Bulk Containment Pressure and Temperature Response (9 Sheets)

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Table 06.02.01-100-1—Primary Vent Paths Included in Multi-Node Containment Model for Bulk Containment Pressure and Temperature Response (9 Sheets)

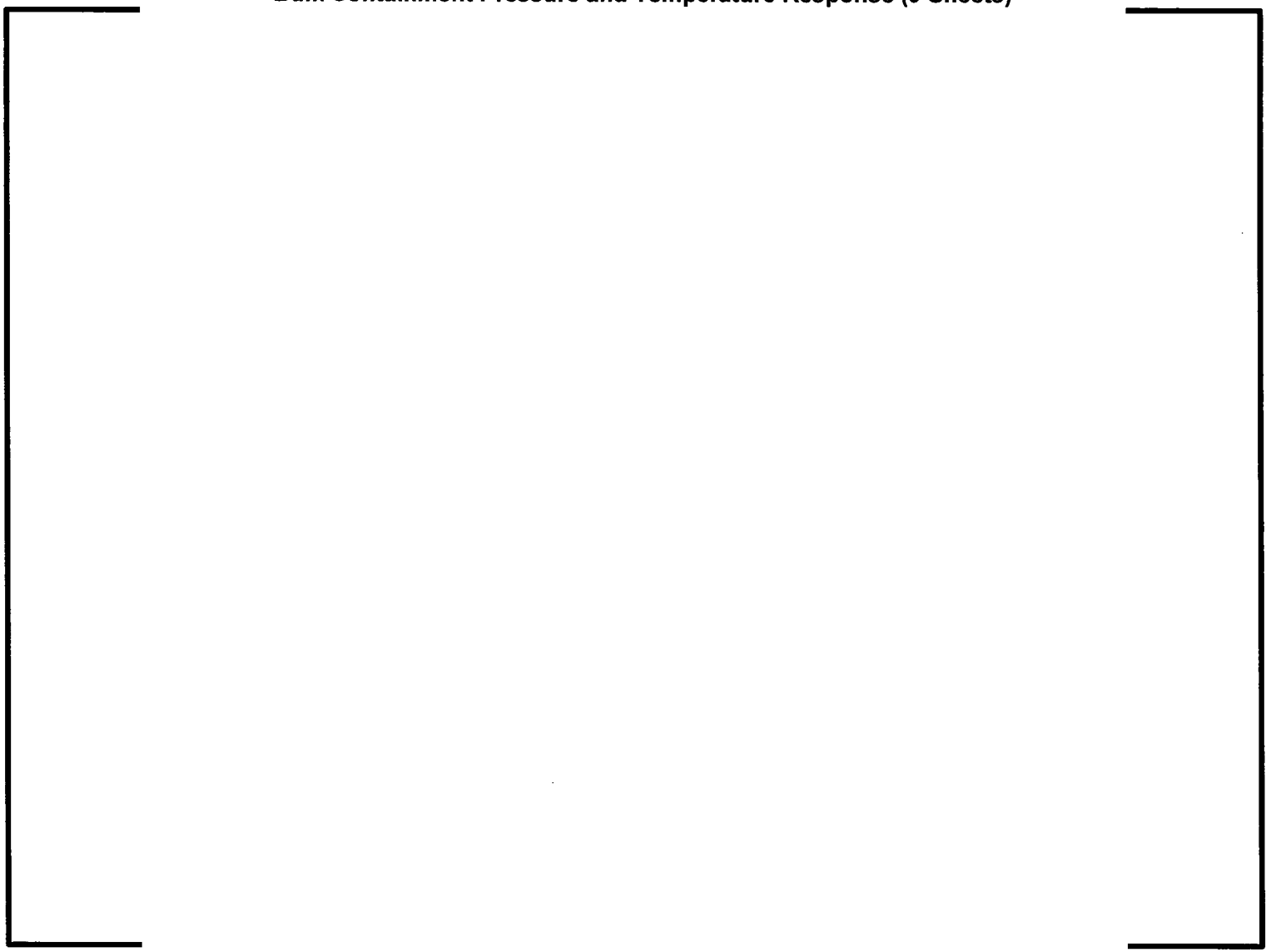


Table 06.02.01-100-1—Primary Vent Paths Included in Multi-Node Containment Model for Bulk Containment Pressure and Temperature Response (9 Sheets)

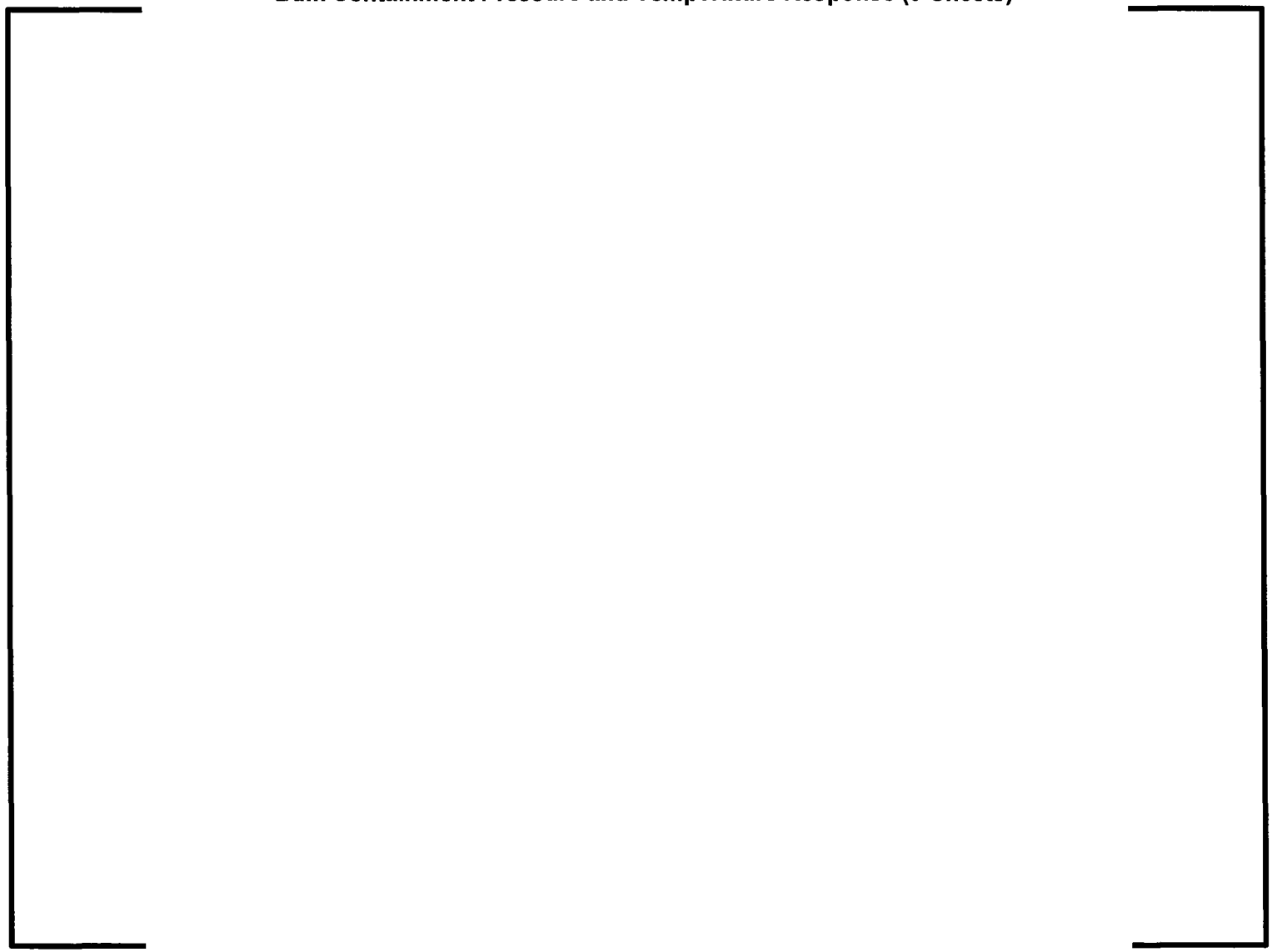
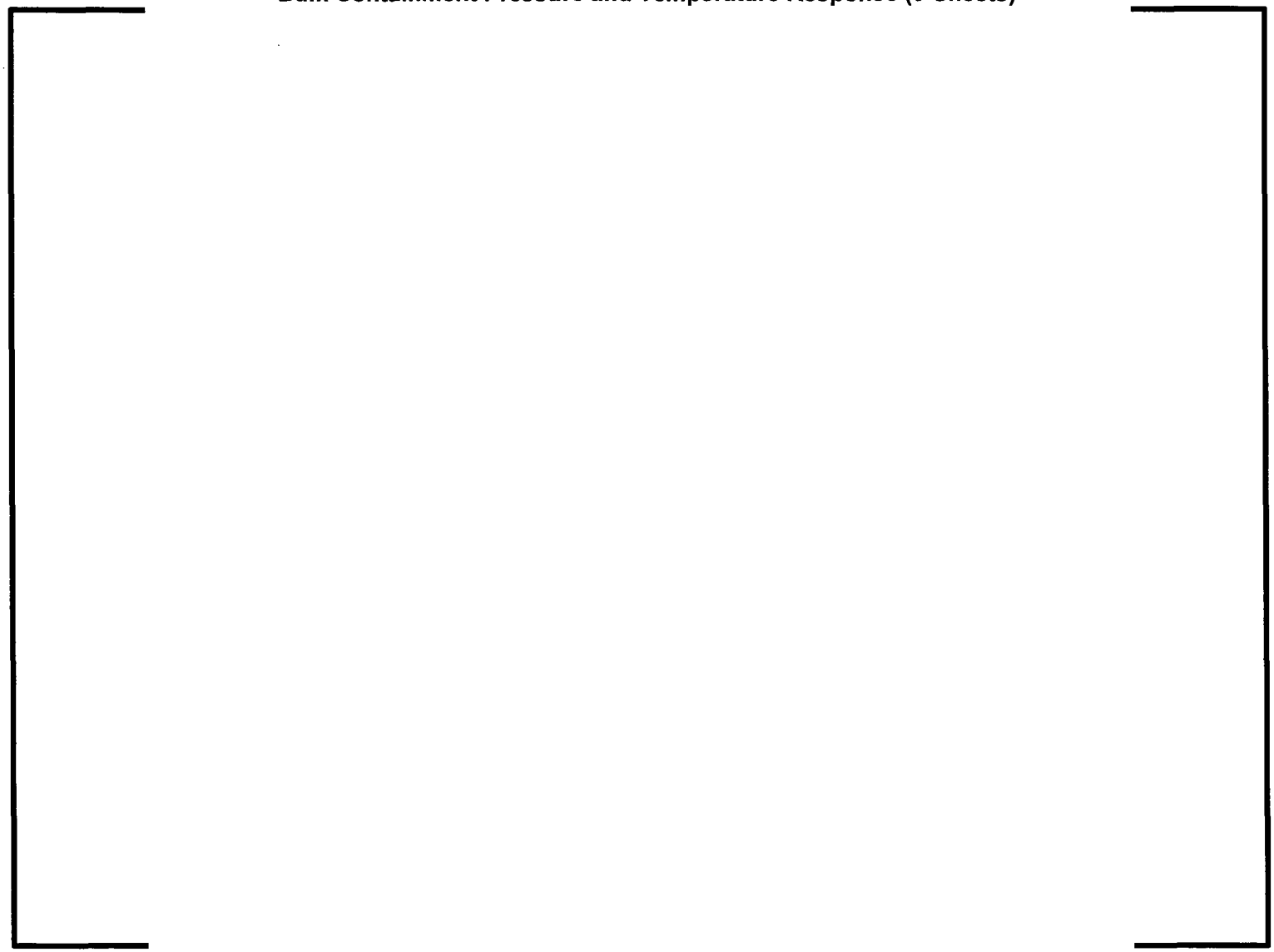


Table 06.02.01-100-1—Primary Vent Paths Included in Multi-Node Containment Model for Bulk Containment Pressure and Temperature Response (9 Sheets)



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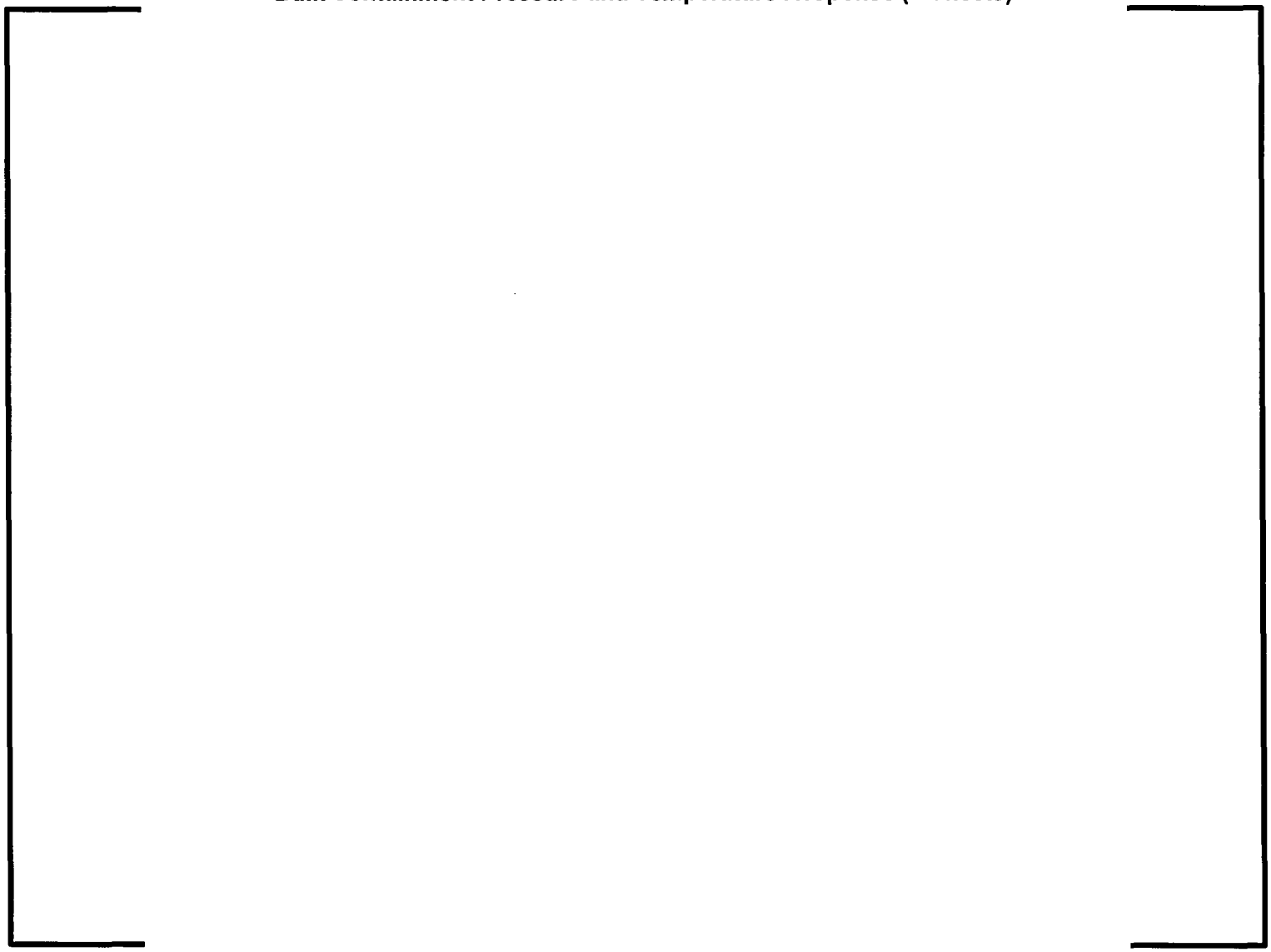

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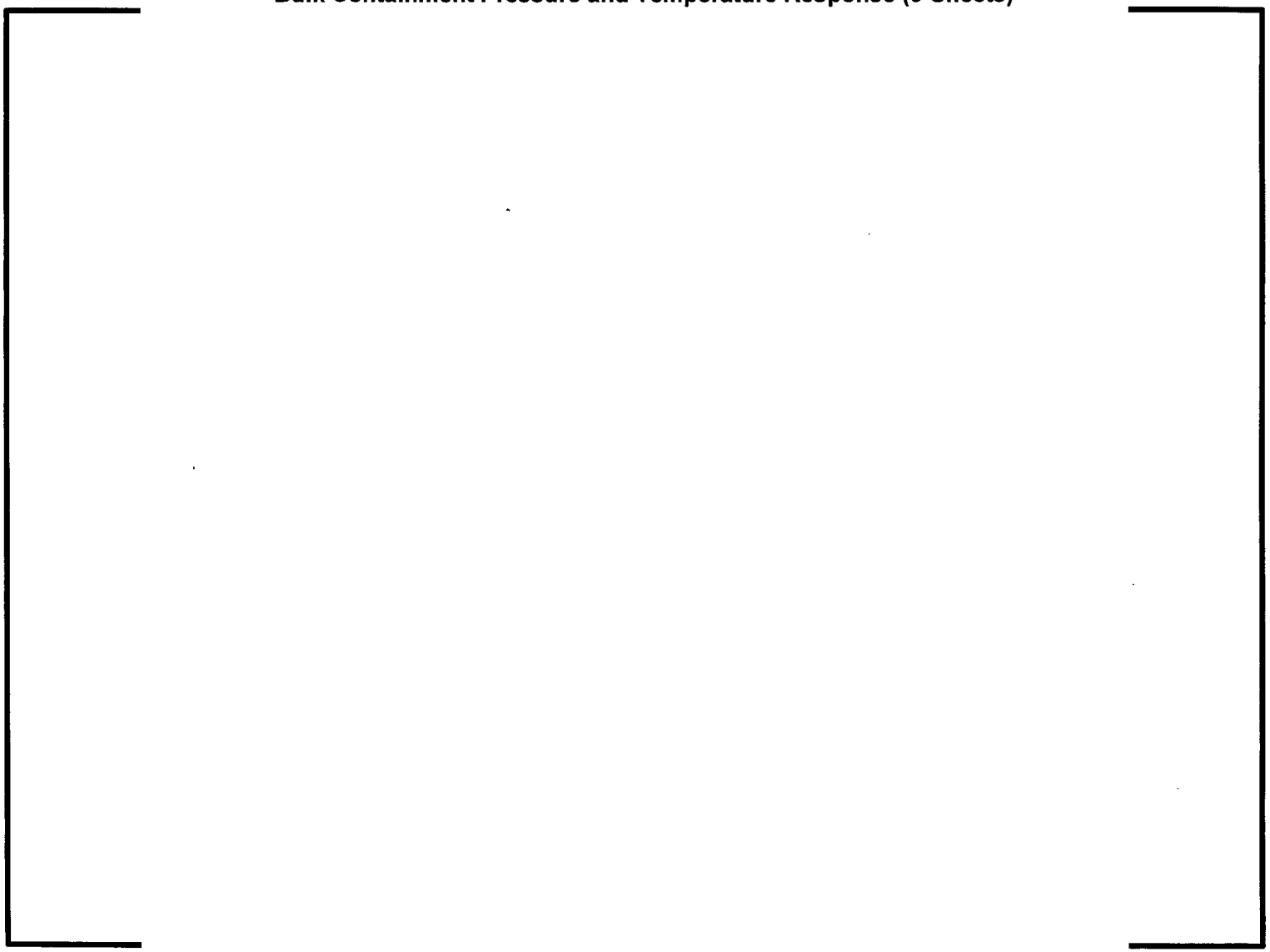

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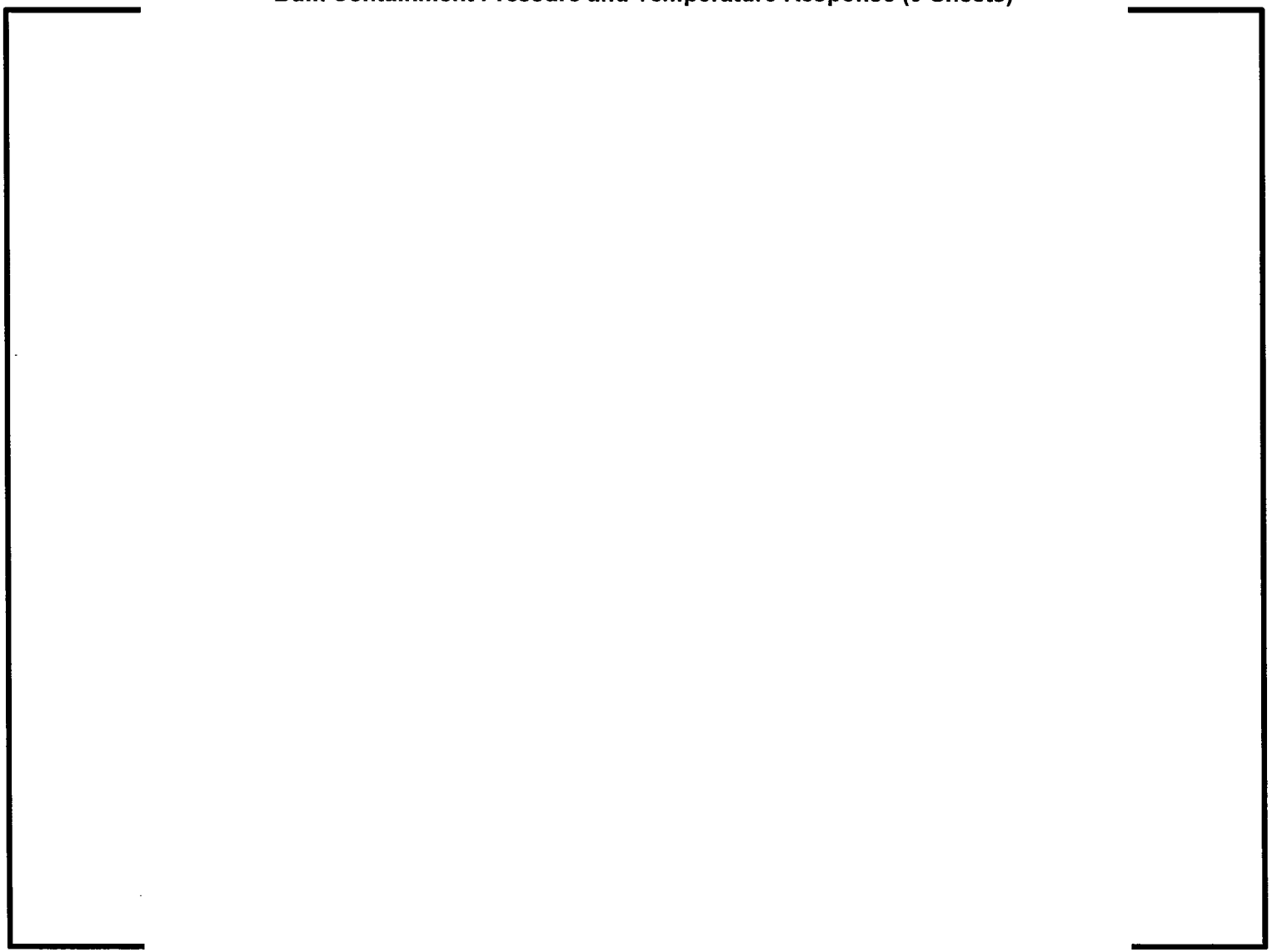


Table 06.02.01-100-2—Primary Vent Paths Omitted from Multi-Node Containment Model for Bulk Containment Pressure Temperature Response (4 Sheets)

Table 06.02.01-100-2—Primary Vent Paths Omitted from Multi-Node Containment Model for Bulk Containment Pressure Temperature Response (4 Sheets)

Table 06.02.01-100-2—Primary Vent Paths Omitted from Multi-Node Containment Model for Bulk Containment Pressure Temperature Response (4 Sheets)

Table 06.02.01-100-2—Primary Vent Paths Omitted from Multi-Node Containment Model for Bulk Containment Pressure Temperature Response (4 Sheets)

Table 06.02.01-100-3—COCOSYS Primary Vent Paths Reconciled to U.S. EPR Design

Primary Vent Path #	From COCOSYS	To U.S. EPR Design
28	free opening	door # -8 FT Door 9
35	free opening	door # -8 FT Door 12
40	door	non-existent flow path
51	door	replaced with wall
55	door	replaced with wall
59	door	non-existent flow path
63	door	non-existent flow path
70	door	non-existent flow path
73	door	non-existent flow path
91	free opening	door # +5 FT Door 5
95	free opening	door # +5 FT Door 12
98	door	free opening
100	free opening	door # +5 FT Door 21
101	free opening	door # +5 FT Door 20
103	free opening	door # +5 FT Door 22
104	free opening	door # +5 FT Door 23
140	door (specified as second door between rooms 15-014 and 15-011)	replaced with wall (only one door exists between rooms 15-014 and 15-011)
158	door	replaced with wall
195	free opening	door # +29 FT Door 13
234	door	non-existent flow path
235	door	non-existent flow path
243	free opening	door # +45 FT Door 15
278	free opening	door # +64 FT Door 5
299	free opening	door # +79 FT Door 3
307	door	replaced with wall
308	door	replaced with wall
309	free opening	door # +94 FT Door 11
310	free opening	door # +94 FT Door 12

Question 06.02.01-101:

Follow-up to RAI 266, Question 06.02.01-11

Supplement 1 response indicated that the rupture foils would not open for a MSLB in the accessible space. The temperature and pressure in the equipment room was calculated to remain at the initial value until 18 seconds into the event when the mixing dampers were assumed to open. With the equipment space isolated from the rest of the containment for the first 18 seconds, the pressure in the accessible space spiked upward rapidly. The staff's understanding is that the foils are designed to rupture on a differential pressure in either direction. At 18 seconds into the event the differential pressure is approximately 50 psid.

a. Provide the reverse differential pressure for which the foils are expected to open.

b. Provide the test results demonstrating the foil's opening capability. When will this test data be available to the NRC staff?

c. If the foils do not open, by 18 seconds when the dampers are assumed to open there will be a very large differential pressure for them to open against. Provide justification that the dampers can open against this differential pressure.

d. If the damper opening time is increased slightly and the foils are not open, the containment design pressure will be exceeded. Discuss the uncertainty in damper opening time and justify that the containment design pressure will not be exceeded.

Response to Question 06.02.01-101:

a) The foils are expected to open at the same differential pressure in either direction. The opening differential pressure is 0.7 psi with a +/- 30 percent tolerance.

b) The July 14, 2011, response to RAI 468, Supplement 1, Question 06.02.02-83 addresses this question.

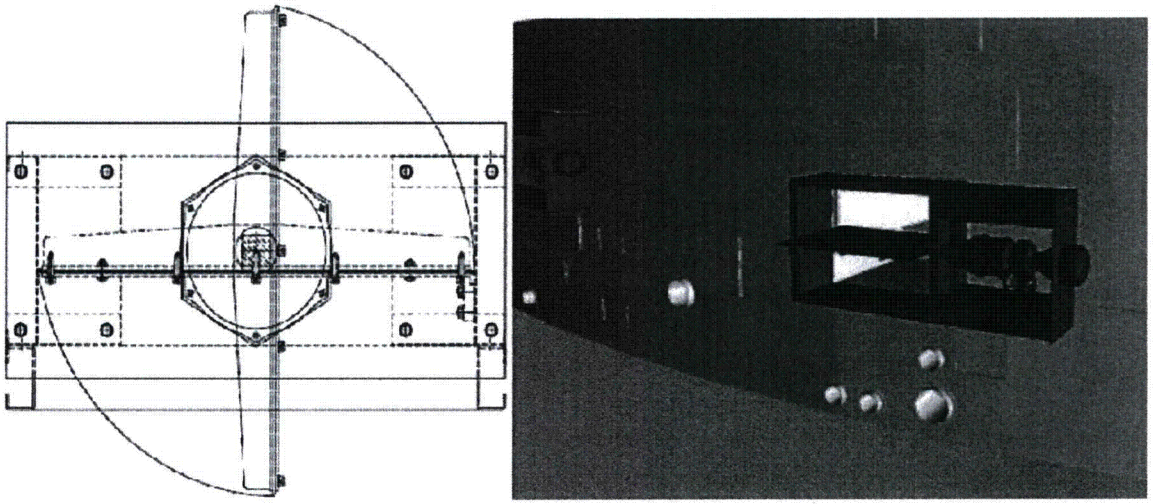
c) In the main steam line break (MSLB) analysis with breaks outside of the steam generator (SG) compartment, the foils were not allowed to rupture on a differential pressure. This is an added conservatism in the model and does not reflect the expected behavior of the foils. Because of the design of the dampers, they will still open against a high differential pressure. The rotation axis for the dampers is in the middle of the opening, so any resistive rotational force from a high differential pressure is negated by an equal and opposite opening rotational force. Figure 06.02.01-101-1 shows how the dampers will open.

d) The dampers are designed with a minimum opening delay time of seven seconds and a maximum delay opening time of 18 seconds. The GOTHIC containment model uses the most conservative value of 18 seconds as the delay opening time.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Figure 06.02.01-101-1—Hydrogen Mixing Damper



Note:

1. This figure shows the damper in an open position. The normal operating position is closed.