

WCAP-10989
Addendum 1

COBRA-NC, ANALYSIS FOR A MAIN STEAMLINE BREAK
IN THE CATAWBA UNIT 1 ICE CONDENSER
CONTAINMENT (RESPONSE TO NRC QUESTIONS)

MAY, 1988

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1.0 SUMMARY

This addendum responds to NRC questions regarding the COBRA-NC/Model 3 calculations in the WCAP in order for the NRC to authorize the Argonne National Laboratory (ANL) to review them. The NRC is authorizing ANL to perform an independent confirmatory analysis using the computer code COMMIX to calculate the resulting condition of the main steam line break in ice condenser containments.

2.0 RESPONSE TO NRC QUESTIONS

QUESTION 1

The values of Δr and $\Delta\theta$ in generating the computational cells as shown in Fig. 2.10.

Page 15: "The interior of the lower containment is divided into three radial rings and eight sectors." Provide the specific values of the radial (Δr) and circumferential ($\Delta\theta$) dimensions for each cell.

RESPONSE TO QUESTION 1

The radii of the rings and the dividing angles are shown in Fig. 1 attached. Please see Fig. 1.

QUESTION 2

- (1) Describe how the hydraulic diameters listed in Table 5.2 were calculated.
- (2) Page 75: "Nominal areas and wetted parameters were normally based on the size of the subchannels as shown in the plans views for each section. Area and wetted parameter multipliers were then applied for each axial elevation to account for equipment and structural changes."

Were the actual flow area and the wetted parameter for calculating the hydraulic diameter at each cell obtained from the above statement?

- (3) Are the area and wetted parameter multipliers only applicable in the axial direction for each computational cell? If not, there should be three hydraulic diameters calculated from three sets of flow area and wetted parameter for a particular cell since the flow is three-dimensional. How did COBRA-NC resolve this problem?

RESPONSE TO QUESTION 2

- (1) The hydraulic diameters of Table 2 were calculated by the equation $4.0 \cdot AN / PW$, where AN is the "nominal continuity cell area" and PW is the wetted perimeter. Example: Consider the 1st line of Table 5.2. The volume for the bottom cell of Channel 1 in Section A is 9652.00 ft.³ The height of this cell is 14.04 ft. (SEE INPUT DATA LINE 752). The nominal continuity cell area AN is then $9652.0 / 14.04 \approx 687.5$ ft.² (SEE LINE 19). INPUT DATA LINE 19 also gives $PW = 114.6$ ft. The reference hydraulic diameter is then:

$$4.0 \cdot AN / PW = 4.0 \cdot 687.5 / 114.6 = 24.00 \text{ ft.}$$

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- (2) The statement given in page 75 is true. The hydraulic diameter is based on the actual flow area (at center of the momentum cell) and the wetted parameter.
- (3) The area and wetted parameter multipliers are only applicable in the axial (vertical) direction.

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(See Figure 2 for gap definitions)

QUESTION 3

The actual flow area between cells.

In COMMIX, the volume porosity and surface permeability are introduced in the formulation of governing equations. The volume porosity and surface permeability are defined as

$$\text{Volume porosity} = \frac{\text{Volume occupied by fluid in a control volume}}{\text{Total control surface}}$$

$$\text{Surface permeability} = \frac{\text{Area allowed for fluid flow through a control surface}}{\text{Total control surface}}$$

The volume porosity for each cell in the COBRA-NC model is provided in Table 5.2, while the surface permeability is not available in the report, although the area multipliers and flow restricted area have been mentioned on page 75. Provide the actual flow area between cells for every cell in Section A, Section B, and vessel enclosures of Section C of the COBRA-NC/Model 3.

RESPONSE TO QUESTION 3

The "porosity" shown in Table 5.2 is the ratio of the actual continuity-cell area to the nominal continuity-cell area of the channel. It is NOT the volume porosity defined by the equation shown in the question. The volumes listed in Table 5.2 are those occupied by fluid in each cell, they are not the total control volume for the cell.

If the momentum-cell parameters are entered as 0.0 (or blank), they default to the continuity-cell values. The area multipliers are given in the variation tables listed in the INPUT DATA deck LINES 872-1748. Using this information, all the axial flow areas can be obtained.

For the transverse directions, the flow areas are given by (gap width)*(cell height), as described in Response to Question 2 (2-3).

QUESTION 4

The loss coefficients and other drag coefficients used in computing the pressure drop between cells.

On page 75: "Flow area restrictions were conservatively modeled using sharp edge orifice loss coefficients, which would reduce the flow between cells. Nominal flow areas were used computing velocities."

What is the restricted area between cells? Is it related to the surface permeability as described in Item 3? Which correlation was used in calculating the loss coefficient? If the correlation is based on the area ratio and Reynolds number, what is the other area used besides the orifice area and how was the Reynolds number computed? Provide the loss coefficients and other drag coefficients used in the COBRA-NC/Model 3.

RESPONSE TO QUESTION 4

In the INPUT DATA list, the index for the axial form-loss coefficient table for each channel is given by COLUMNS 46-50, from LINE 19 to LINE 146. The tables are shown in LINES 872-1748

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If the loss coefficients entered in the even-numbered lines are defaulted (0.0), the code will take the table indicated in the next odd lines and use the input values of these tables as the form-loss coefficients. The tables are listed in the INPUT DATA LINES 873-1748.

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QUESTION 5

The location and dimension of the 8 foot high pipe tunnel underneath the spent fuel storage area.

On page 5: "An 8 ft. high pipe tunnel runs underneath the spent fuel storage region so that there is flow communication around the full 360° at this level."

Which cells are connected to the pipe tunnel in the COBRA-NC model?

RESPONSE TO QUESTION 5

QUESTION 6

Material properties of heat conductors.

What values of thermal conductivity, heat capacity, and density of the heat conductors described in Table 5.1 are used in the COBRA-NC calculation?

Is the thermal resistance of paint on concrete and steel surfaces being considered? If yes, what is the thickness of paint used in the calculation and what is the material property?

RESPONSE TO QUESTION 6

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There were 6 geometry types as indicated in Table 5.1. They were also specified in the INPUT DATA LINES 2037-2053. Each of the geometry types may contain several regions of different materials. Four basic materials (concrete, stainless steel, carbon steel and insulation) were used, and were

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The thermal resistance of paint on concrete and steel was not considered.

QUESTION 7

The tabulated mass flowrate through the ice condenser door as a function of time at each sector.

The COBRA-NC/Model 3 results show the ice condenser door vapor velocities in Figures 6.57 through 6.58 for doors 32a, 32b, and 32c. Where are these three doors located? Tabulate the mass flow rate through the doors.

RESPONSE TO QUESTION 7

Doors 32a, 32b and 32c are the interfaces between Channel 32 and Channels 31, 107 and 110, in Section B, respectively (see Figure 5.4). In the COBRA-NC's INPUT DATA, these doors were represented by Gaps 45 (LINE 342), 156 (LINE 562) and 124 (LINE 568). The flow rates through these doors (gaps) are shown in the tables attached.

QUESTION 8

The numerical values of the calculated drain mass flowrate and distribution in COBRA-NC/Model 3.

- (1) The calculated drain mass flowrate as shown in Figures 6.61 and 6.62 on page 171 are difficult to read. Provide values of the drain flowrate as a function of time for Model 3.

- (1) Figure 2.10 and Figure 5.4 are the same. There is no figure that describes the grid layout of Section B for the COBRA-NC/Model 2 in the report, while all data listed in Tables 5.2 and 5.3 is for Model 2.
- (2) On page 162, the physical structure in the middle figure is different from the other two.
- (3) The description of the ice condenser doors in the last paragraph of page 134 is not consistent with Figure 6.22.

Confirm the accuracy of the values in Tables 4.3 through 4.15 and Tables 5.1 through 5.3. The COMMIX code will use the current information as input.

RESPONSE TO QUESTION 9

- (1) The subchannels 105-110 shown in Figure 2.10 should have been deleted, as shown by Figure 1 attached.
- (2) The drawings for the structure in the top and bottom figures on page 162 were in error. They should have been the same as that in the middle figure on page 162.
- (3) The last paragraph on page 134 should have been written as:

On the hotter side of the containment, door 28 closed at 200 seconds, door 32 above the break closed at about 275 seconds, door 24 never completely closed and door 36 received most of the steam flow during the later parts of the transient.

The values shown in Tables 4.3 to 4.15 and Tables 5.1 to 5.3 are correct.

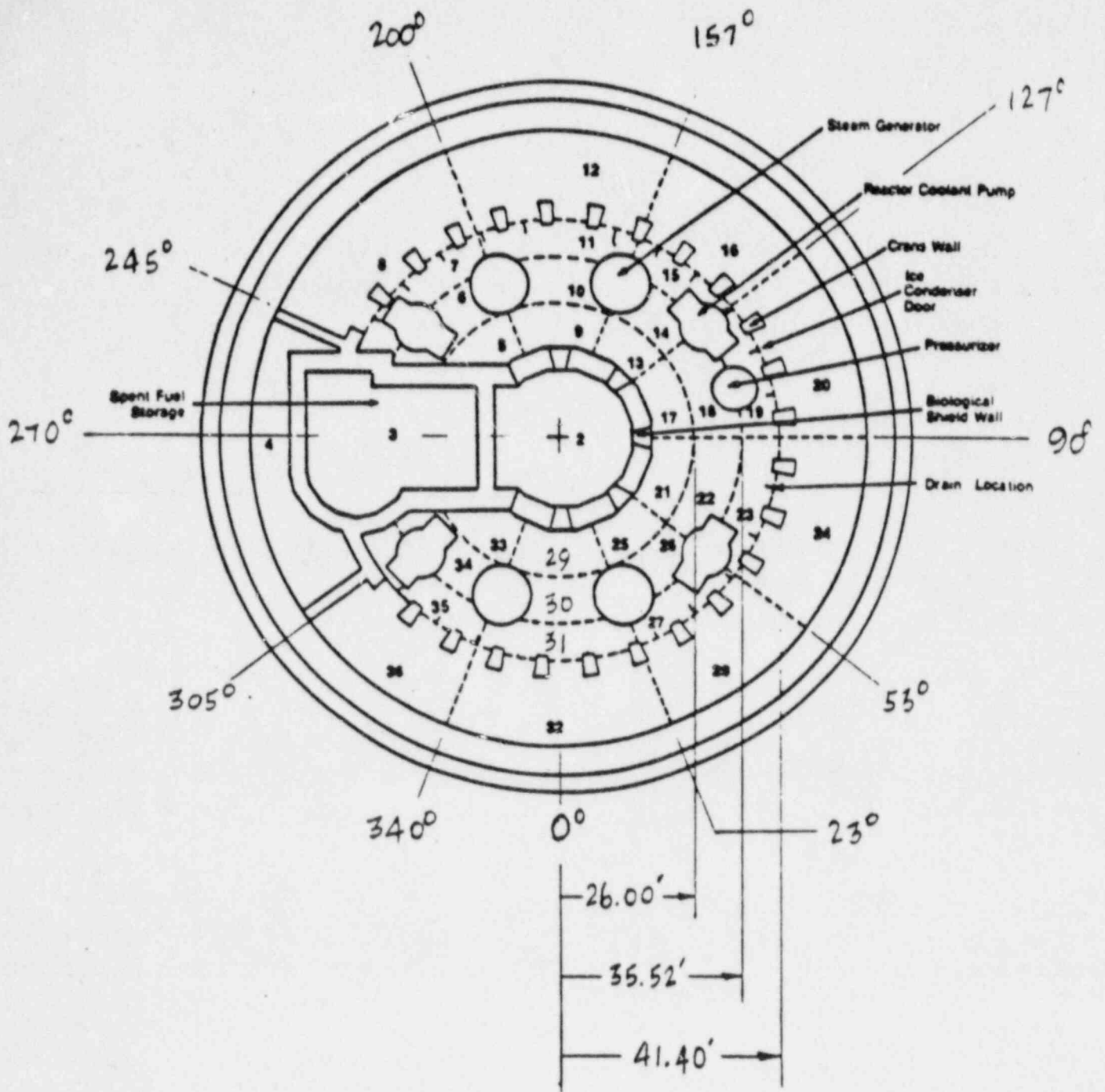
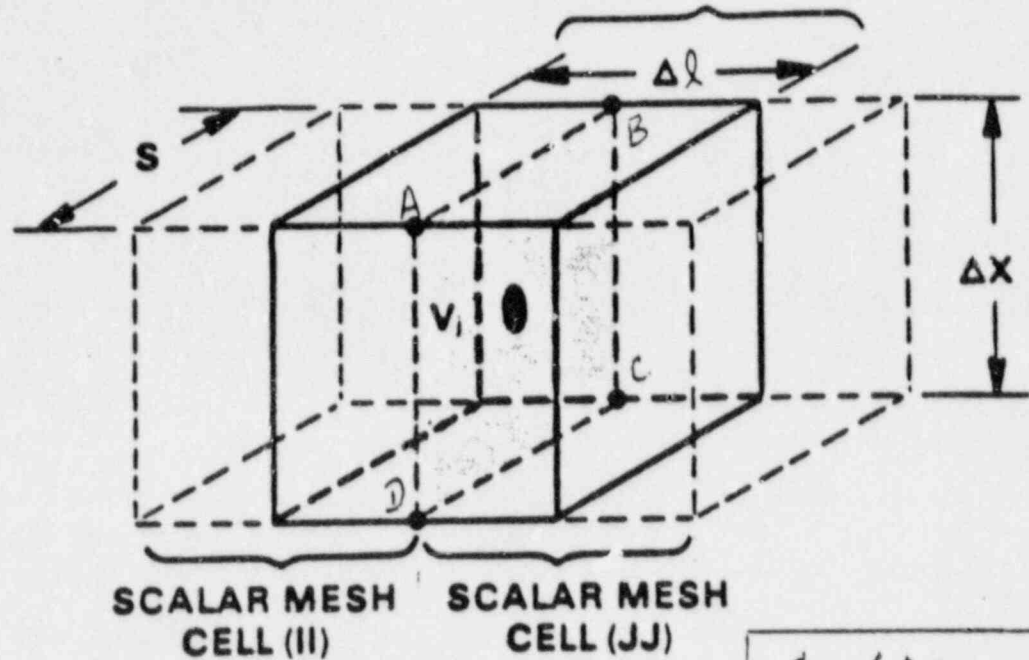


Figure 1. Definition Sketch for Section B



$S = \text{GAP WIDTH}$
 $\Delta L = \text{GAP LENGTH}$
 $\Delta X = \text{CELL HEIGHT}$

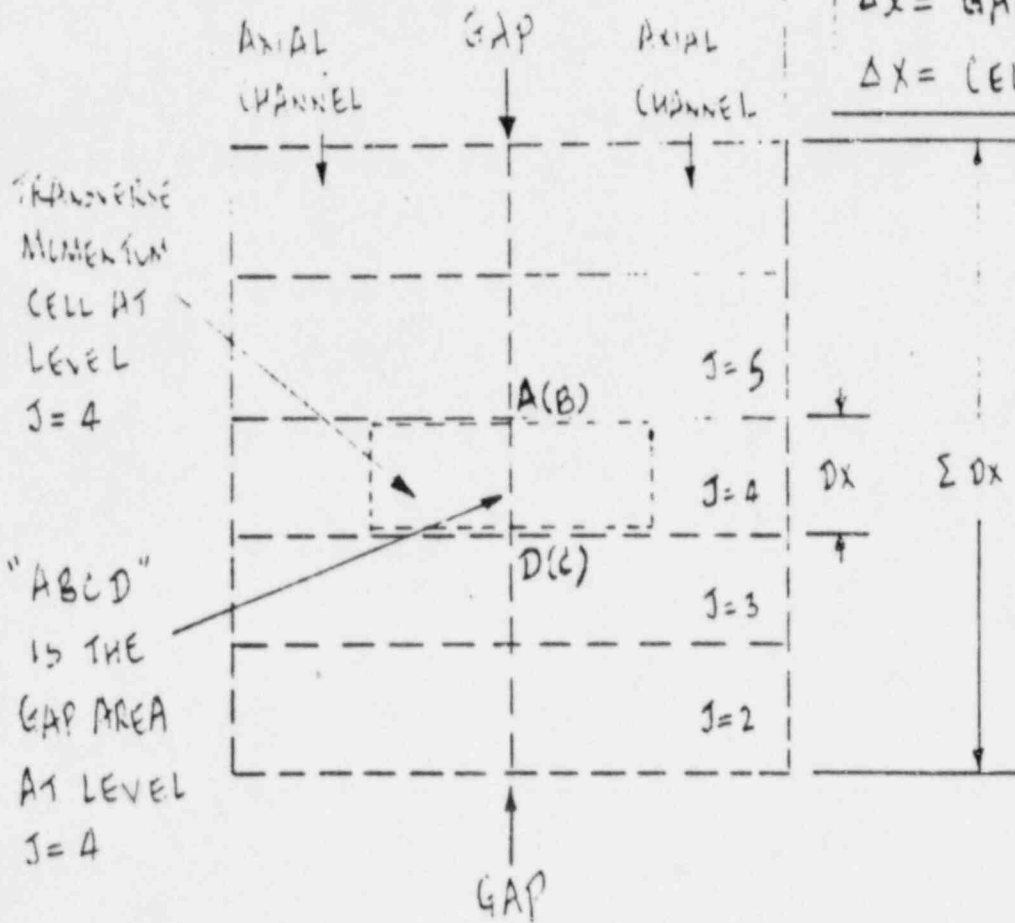


Figure 2. Definition Sketch for Gap

TABLE 1 - SUMMARY FOR GAP 45

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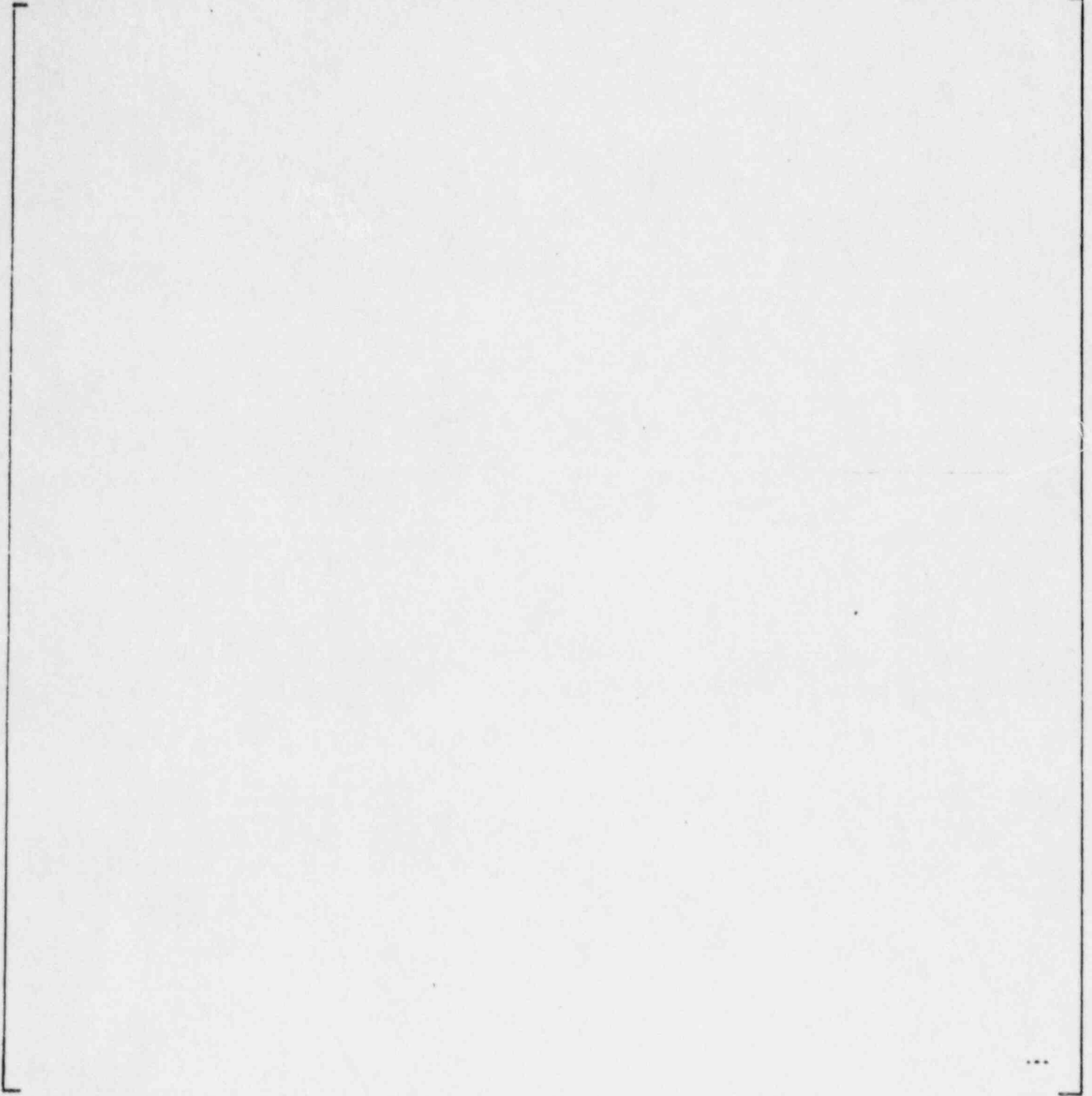
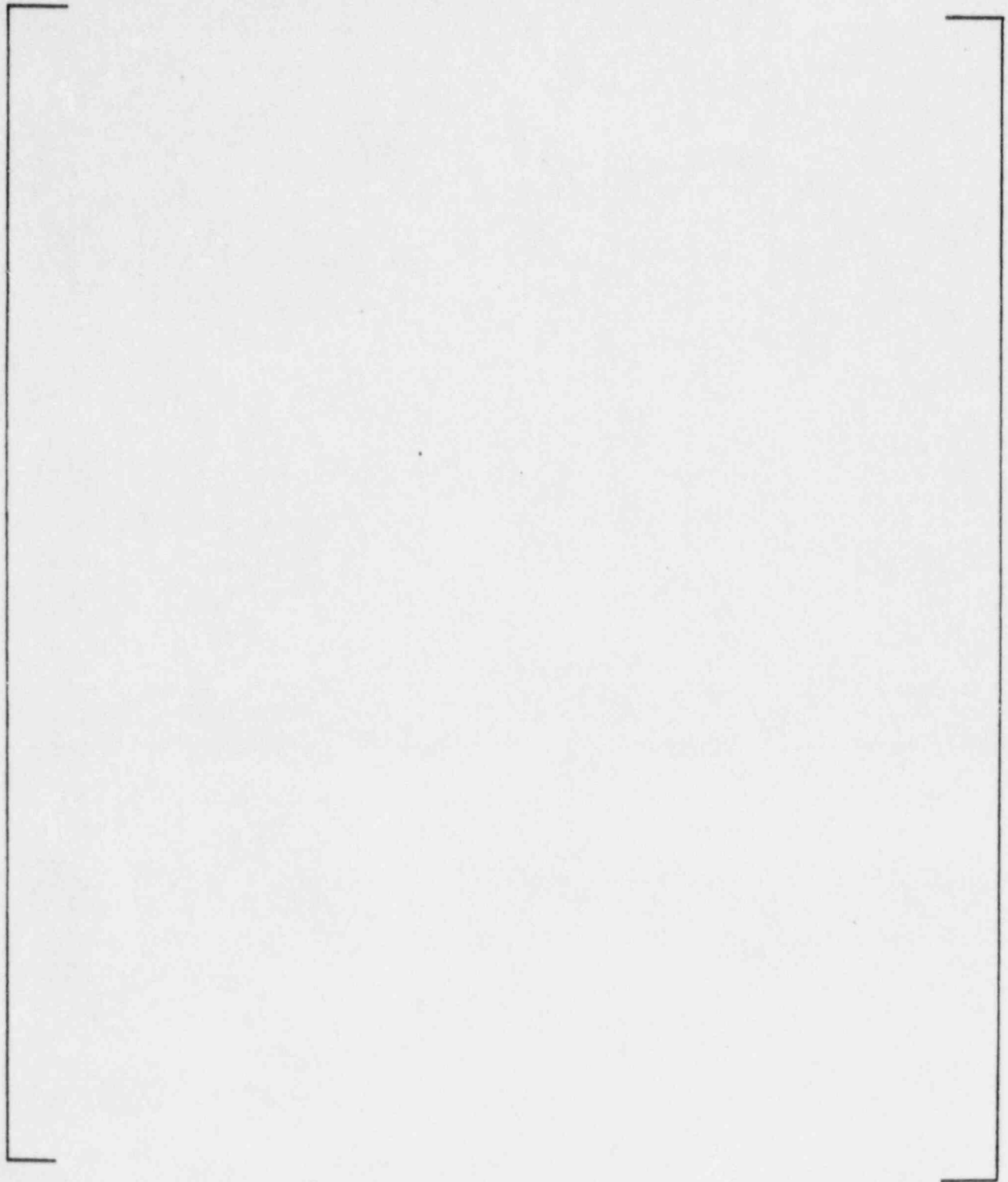


TABLE 1 - SUMMARY FOR GAP 45



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TABLE 1 - SUMMARY FOR GAP 45

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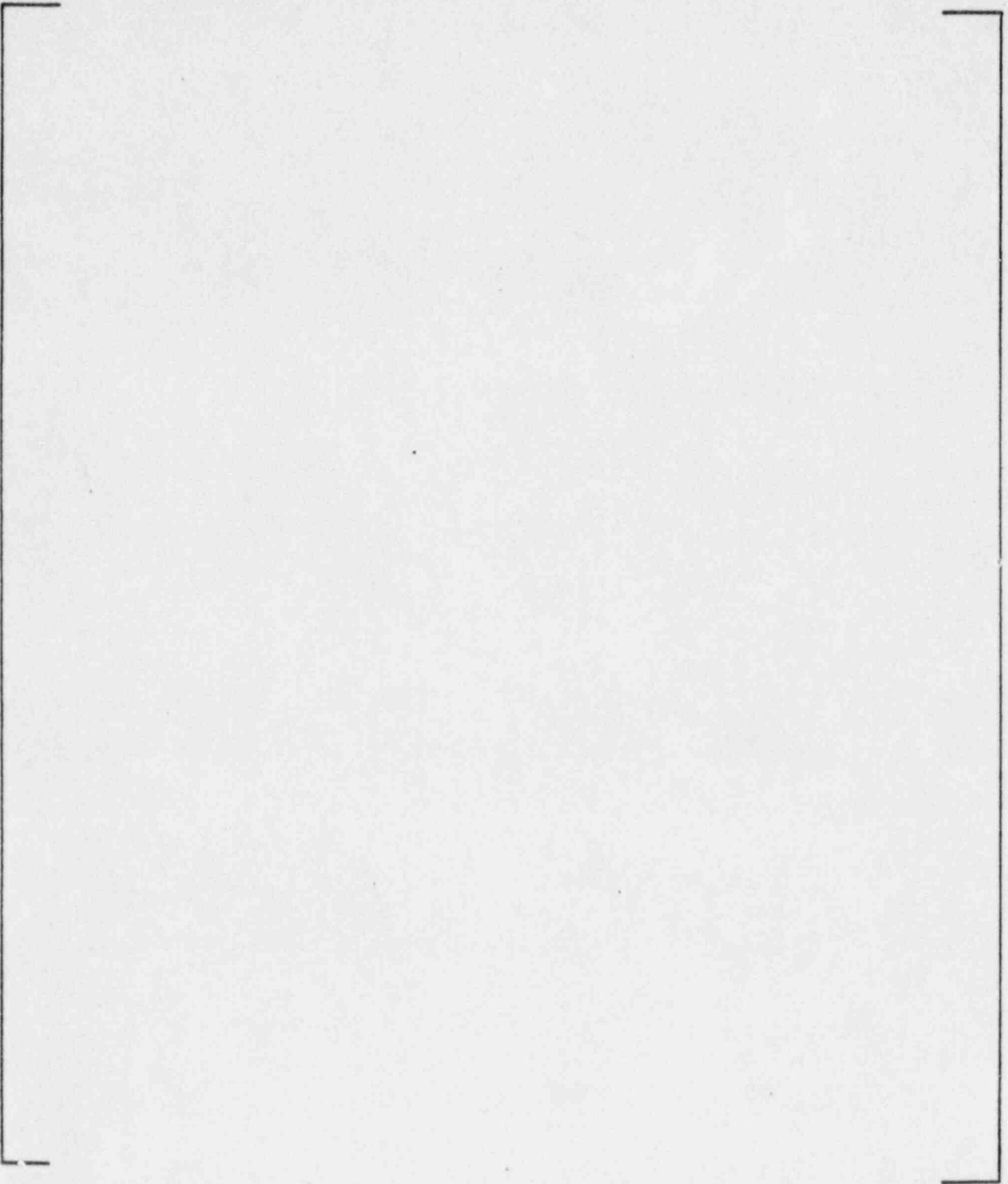
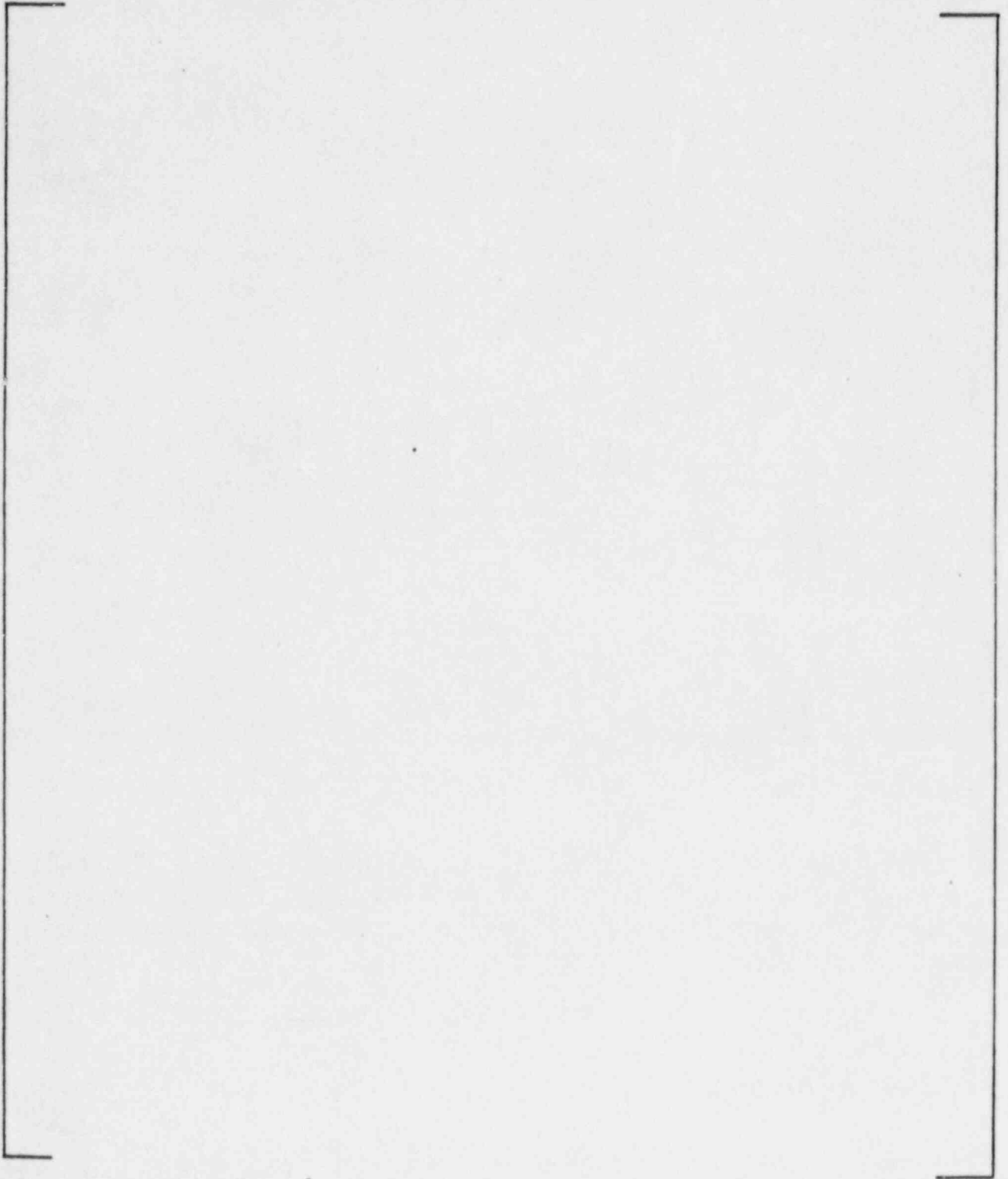


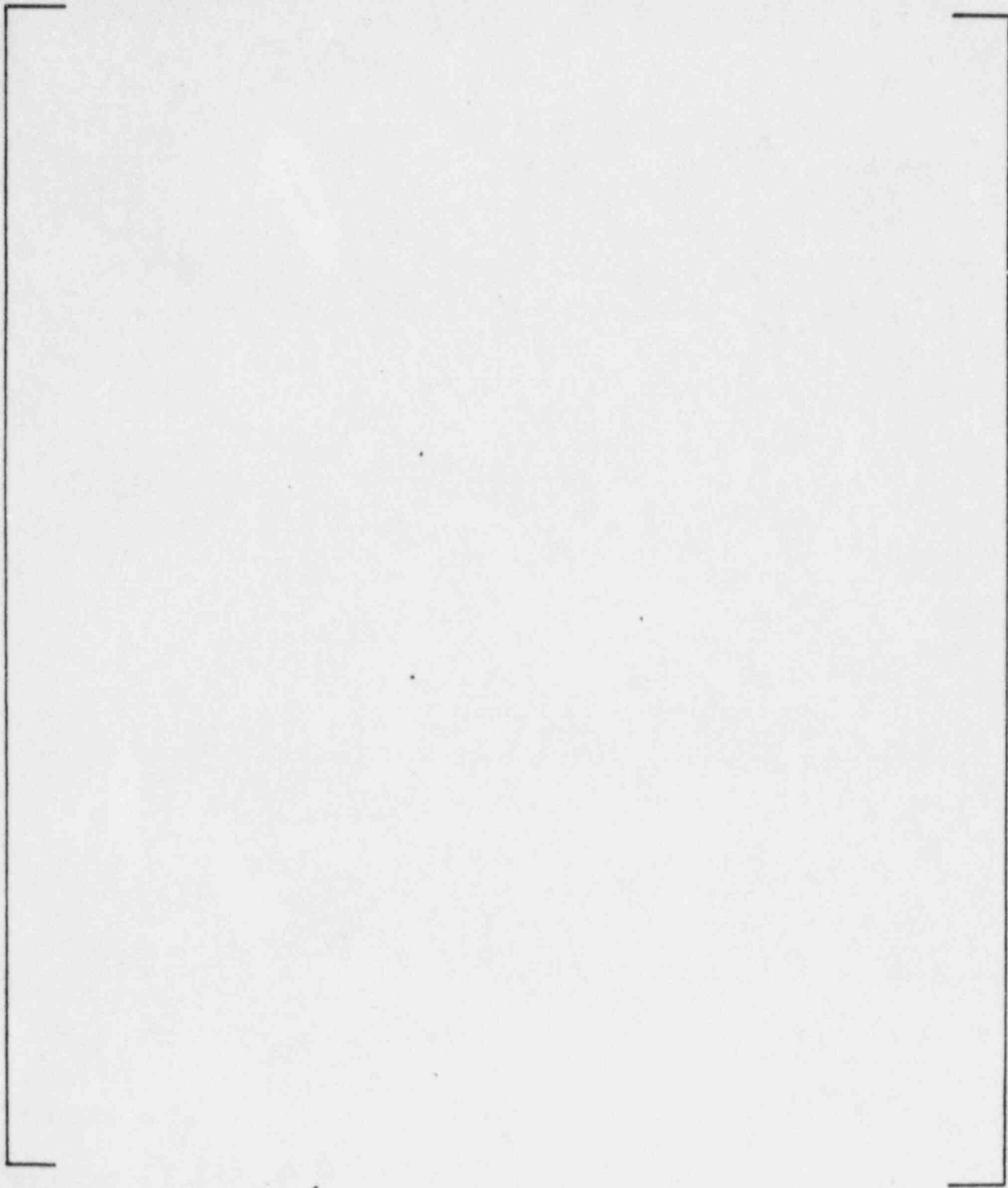
TABLE 1 - SUMMARY FOR G. 45

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TABLE 2 - SUMMARY FOR GAP 156

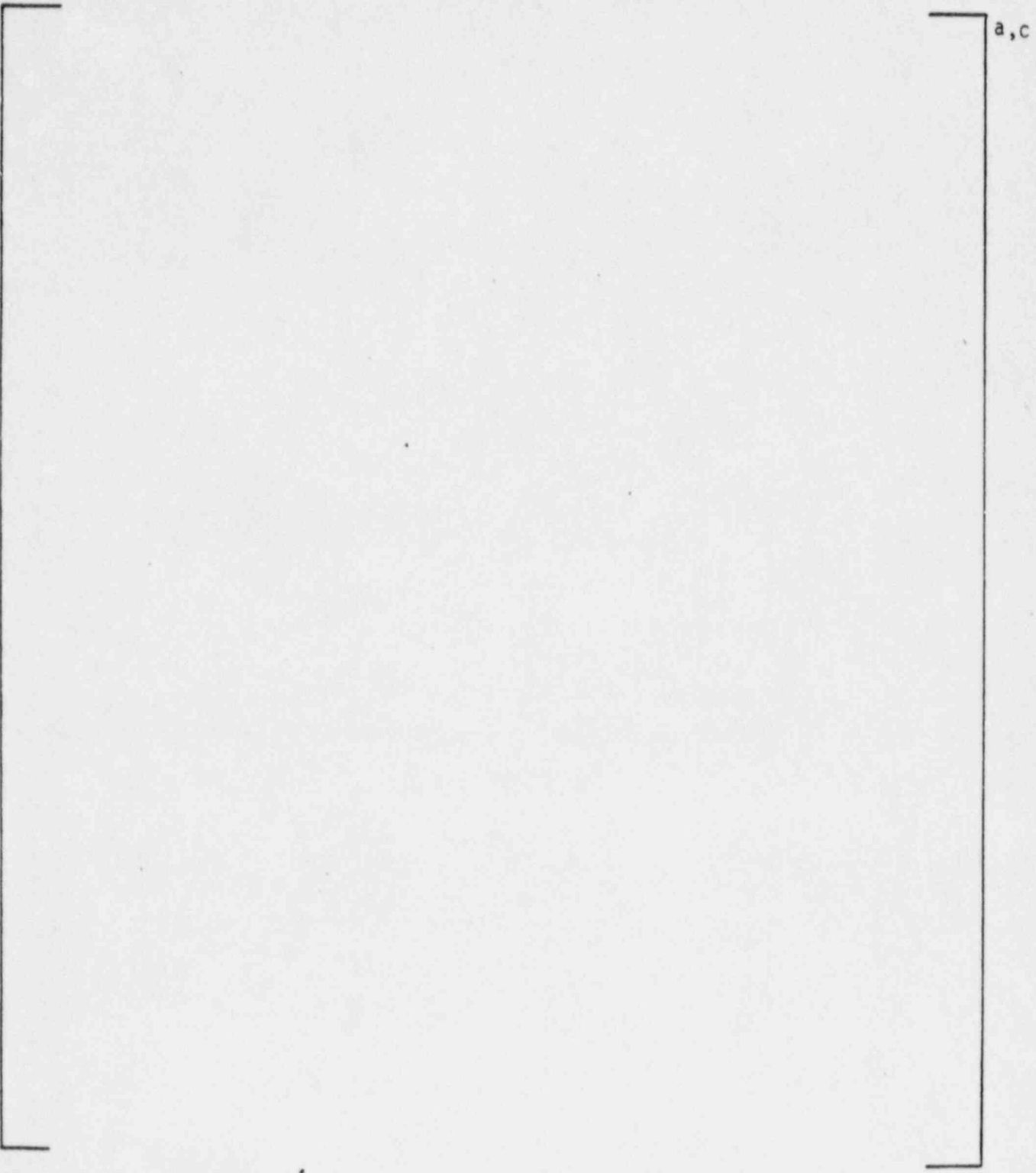
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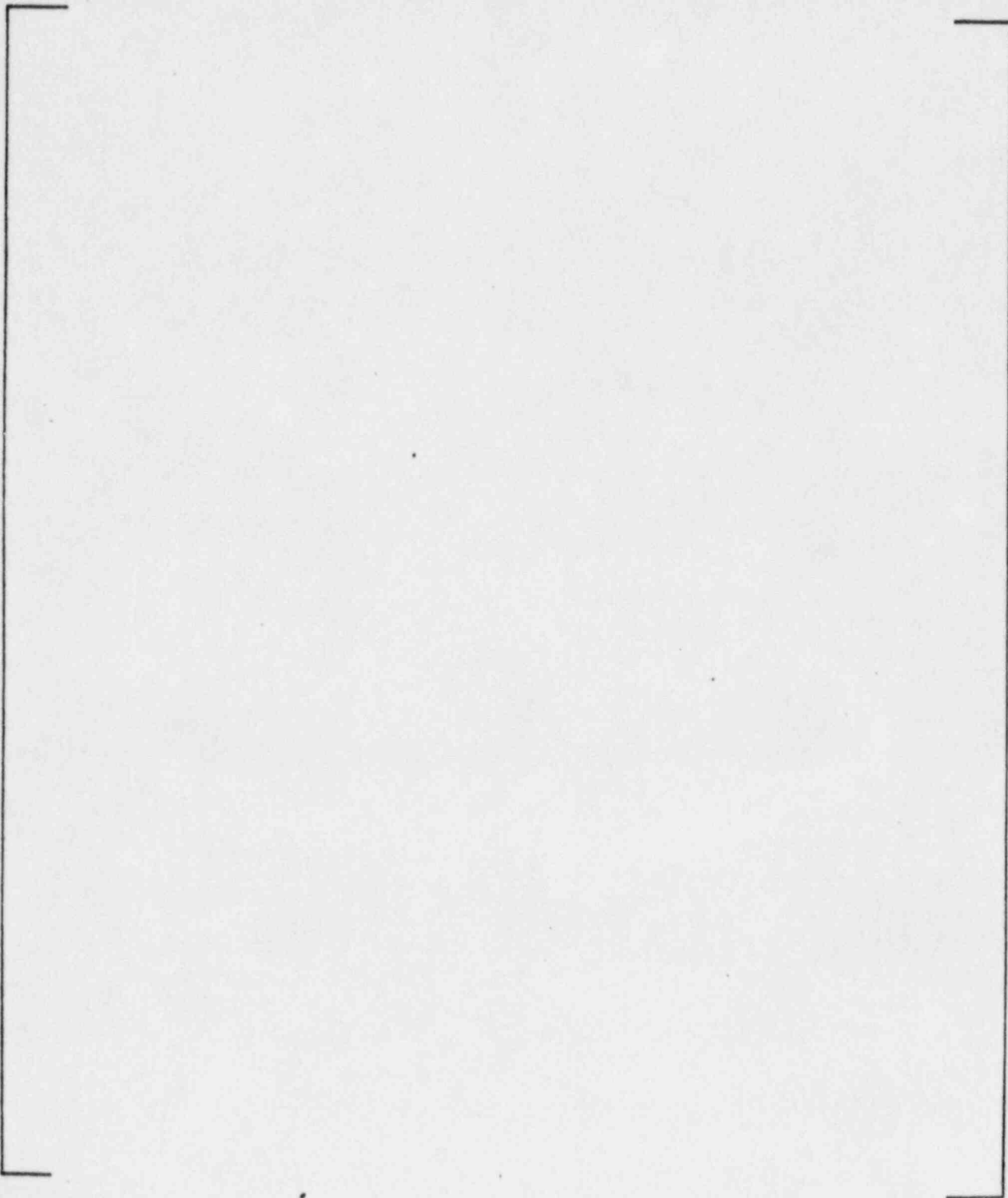
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The image shows a large, empty rectangular frame. The frame is defined by a thin black line. At the top right corner of the frame, there is a small horizontal line segment extending to the right, with the text "a,c" positioned just above it. The rest of the frame is empty.

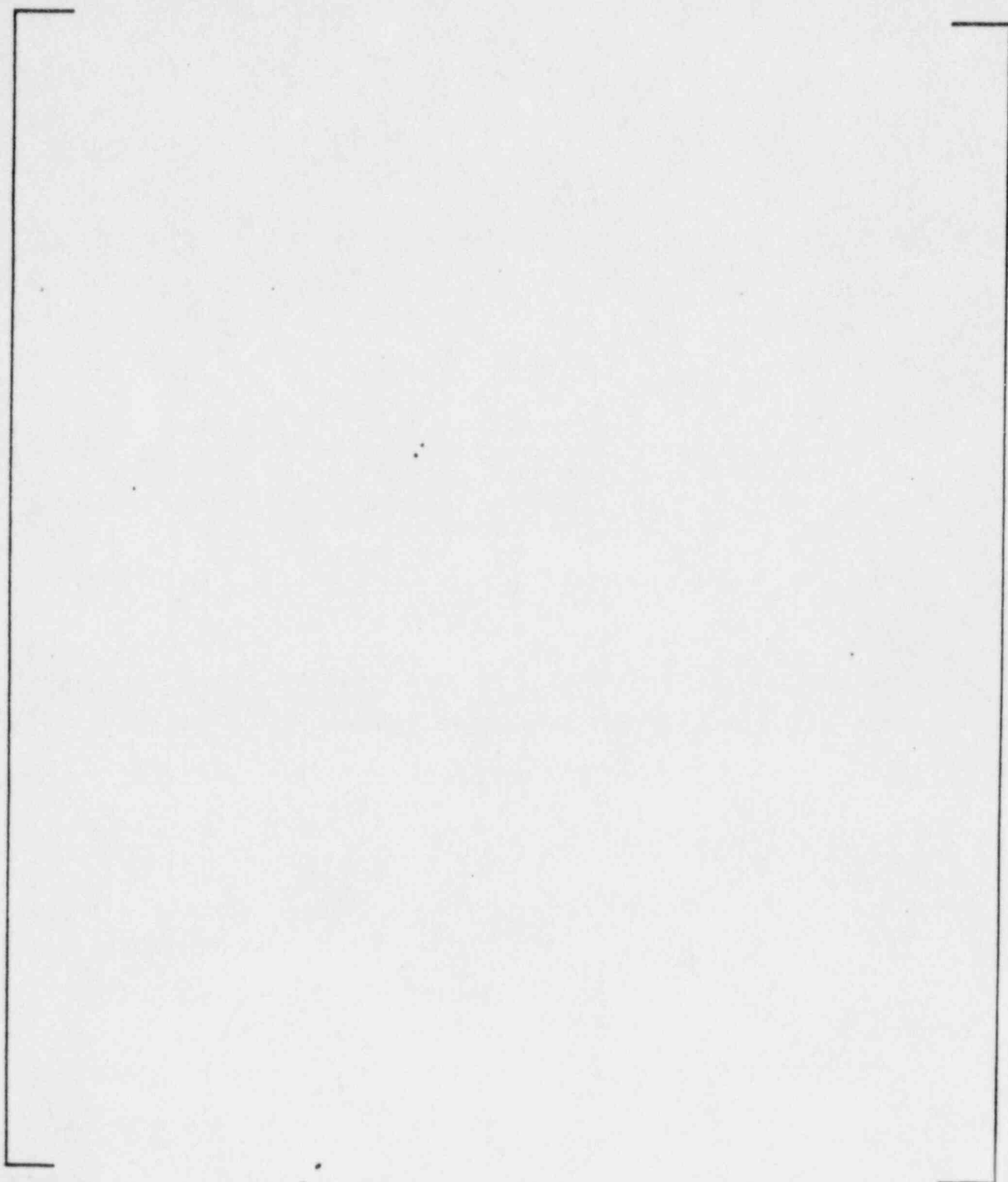


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TABLE 3 - SUMMARY FOR GAP 124



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a,c

TABLE 3 - SUMMARY FOR GAP 124

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3.0 REFERENCES

- 3.1 Letter from NRC, Mr. G. G. Zech, to TVA, Mr. S. A. White, entitled, Request for Additional Information Regarding Main Steam Line Breaks In Ice Condenser Plants, dated April 8, 1988, with attachment entitled Request for Additional Information for the Review of Topical Report WCAP-10988, Main Steam Line Break In Ice Condenser Containments.