Westinghouse Electric Company LLC Report
A-GEN-FE-0118, Revision 0
"Isotopic Number Densities for
Discharged Westinghouse 17x17 Fuel Assemblies"
Westinghouse Proprietary Class 2

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Westinghouse Non-proprietary

WESTINGHOUSE ELECTRIC COMPANY LLC

A-GEN-FE-0118, REV. 00

ISOTOPIC NUMBER DENSITIES FOR DISCHARGED WESTINGHOUSE 17X17 FUEL ASSEMBLIES

JANUARY 2002

Title: **Isotopic Number Densities for Discharged Westinghouse 17X17 Fuel Assemblies**

Document Number: **A-GEN-FE-0118** **Revision Number:** **00**

1. Verification Status:

☒ Complete ☐ Not Required ☐ Complete with Contingencies / Assumptions

2. Approval of Completed Analysis

This Design Analysis is complete and verified. Management authorizes the use of its results and attests to the qualification of the Cognizant Engineer(s), Mentor and Independent Reviewer(s).

	Printed Name	Signature	Date
Cognizant Engineer	Prakash A. Narayanan		
Mentor ☒ **None**			
Independent Reviewer	Paul F. O'Donnell		
Management Approval	Jeffrey A. Brown		

3. Package Contents (this section may be completed after Management approval):

Total page count, including body, appendices, attachments, etc. 77

List associated CD-ROM disk Volume Numbers and path names: ☐ **None**

CD-ROM Volume Numbers	Path Names (to lowest directory which uniquely applies to this document)
	../dms/commit/a_gen_fe/0118r00/out
	../dms/commit/a_gen_fe/0118r00/tar

Other attachments (specify): ☒ **None**

4. Distribution:

QR(2)

Record Of Revisions

Rev. No.	Issue Date	Author	Independent Reviewer	Management Approver	Revised Pages			Net Revised Contents		
					Replaced	Added	Deleted	Body	Appendix & Attachs.	Other
00	11/15/2000	P.A. Narayanan	P.F.O'Donnell	J.A. Brown	n/a	n/a	n/a	61	App. A : 6 App. B : 10	CDROM

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Abstract

OBJECTIVE

- To develop a database of Number densities for the key isotopes used in Criticality Safety Analysis for the Westinghouse Standard 17X17 fuel assembly
- To use a simplified axial burnup model in generating the database

METHODOLOGY

[

]

RESULTS

- The [ ] model is found to adequately represent [ ]
- The isotopic number densities necessary to model the Westinghouse 17X17 standard fuel assembly have been determined for various burnup and initial enrichment combinations

CONCLUSIONS

- This database enables us to represent the Westinghouse 17X17 fuel assembly in [ ]. Therefore, future Criticality Analyses involving these fuel assemblies can be performed with the [ ]

1.0 Introduction

1.1 Objective

This report presents the isotopic number densities for the Westinghouse 17X17 Standard fuel assembly. This model is based on a [ ] representation of the fuel assembly and is compared to a [ ] The isotopic number densities of the Westinghouse 17X17 fuel assembly, based on the [ ], for various initial enrichment and burnup combinations, are also determined. The primary objectives of this analysis are as follows:

1. to establish a [ ]

2. to benchmark the [ ]

3. to determine the isotopic number densities for various combinations of initial enrichment and burnup for the Westinghouse 17X17 Standard fuel assembly. These number densities will be used to model the fuel assembly in [ ] for criticality analyses.

1.2 Methodology

This section describes the analysis methodology employed to determine the isotopic number densities for the Westinghouse 17X17 Standard fuel assembly. The analysis methodology employs:

] The following sections describe the application of these codes in more detail.

1.2.1 [ ]

[

]

1.2.2 Application to Fuel Storage Pool Calculations

As noted above, the [

]

1.2.3 [ ]

[

]

[

]

1.2.4 Representation of the Fuel Assembly in [ ] Results

For the purpose of spent fuel pool criticality analysis calculations, the [

]

1.3 Assumptions

There are no assumptions for this analysis

1.4 Analysis Results

The primary objectives of this analysis were accomplished; a summary of the results is as follows.

1) [

]

2) The [ ] was benchmarked against the [ ] and was found to be adequate.

3) [

]

Section 4 of this report contains the results of the above calculations and also lists the isotopic number densities.

Table 1.2-1
Standard Material Compositions Employed in the Analysis

Material	Element	Weight Fraction
Zircaloy-4	Zr	0.9829
Den.= 6.56 g/cc	Sn	0.0140
	Fe	0.0021
	Cr	0.0010
Water	SCALE Standard Composition Library w/ Den. = 0.9982 @ 293 °K	
Fresh UO_2	Fraction of Theoretical Density = 0.95	

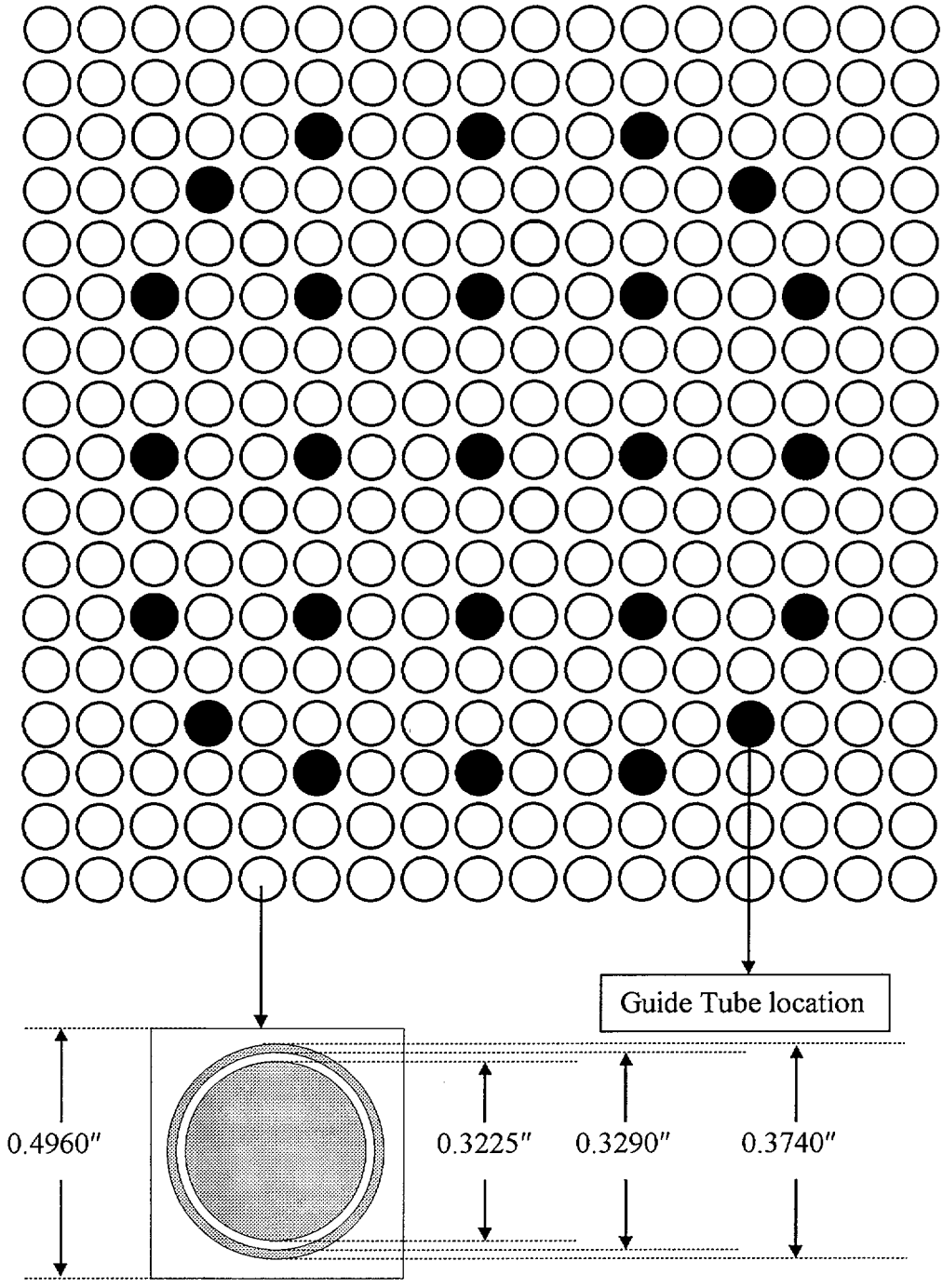
2.0 Design Input

The only design input used in this analysis is the geometric description of the Westinghouse 17X17 Standard Fuel assembly. This input is derived from Table 2 (page 8) of Attachment D of Reference 5. The description of the fuel assembly data is shown in Table 2.0-1 and illustrated in Figure 2.0-1.

Table 2.0-1
Input Parameters for Fuel Assembly Model

Description	W Std.
Rods/Assy.	264
Guide Tubes/ Assy.	25
Instrument Tubes / Assy.	1
Rod Pitch, in.	0.496
Pellet OD, in.	0.3225
Pellet Density, % TD	95
Active Fuel Length, in.	144
Clad OD, in.	0.374
Clad Thickness, in.	0.0225
Clad Material	Zirc.-4
Guide Tube OD, in.	0.482
Guide Tube Thickness, in.	0.016
Guide Tube Mat.	Zirc.-4

Figure 2.0-1
Geometrical View of Westinghouse 17x17 Standard Fuel Assembly



3.0 Analysis

3.1 [ ]

[

]

3.2 Modeling of Axial Burnup Distributions

A key aspect of the [

]

In this analysis, a [

]

[

]

Table 3.2-1
Relative Power, and Fuel and Moderator Temperatures for the [ ]

Zone No.	Height (in.)	Relative Power	Fuel Temperature (°F)	Moderator Temperature (°F)

Table 3.2-2
Relative Power, and Fuel and Moderator Temperatures for the [ ]

Zone No.	Height (in.)	Relative Power	Fuel Temperature (°F)	Moderator Temperature (°F)

Table 3.2-3
Burnup and Initial Enrichments combinations used to determine the Isotopic Number Densities

Figure 3.2-1
[ ] Model Employed in Fuel Assembly

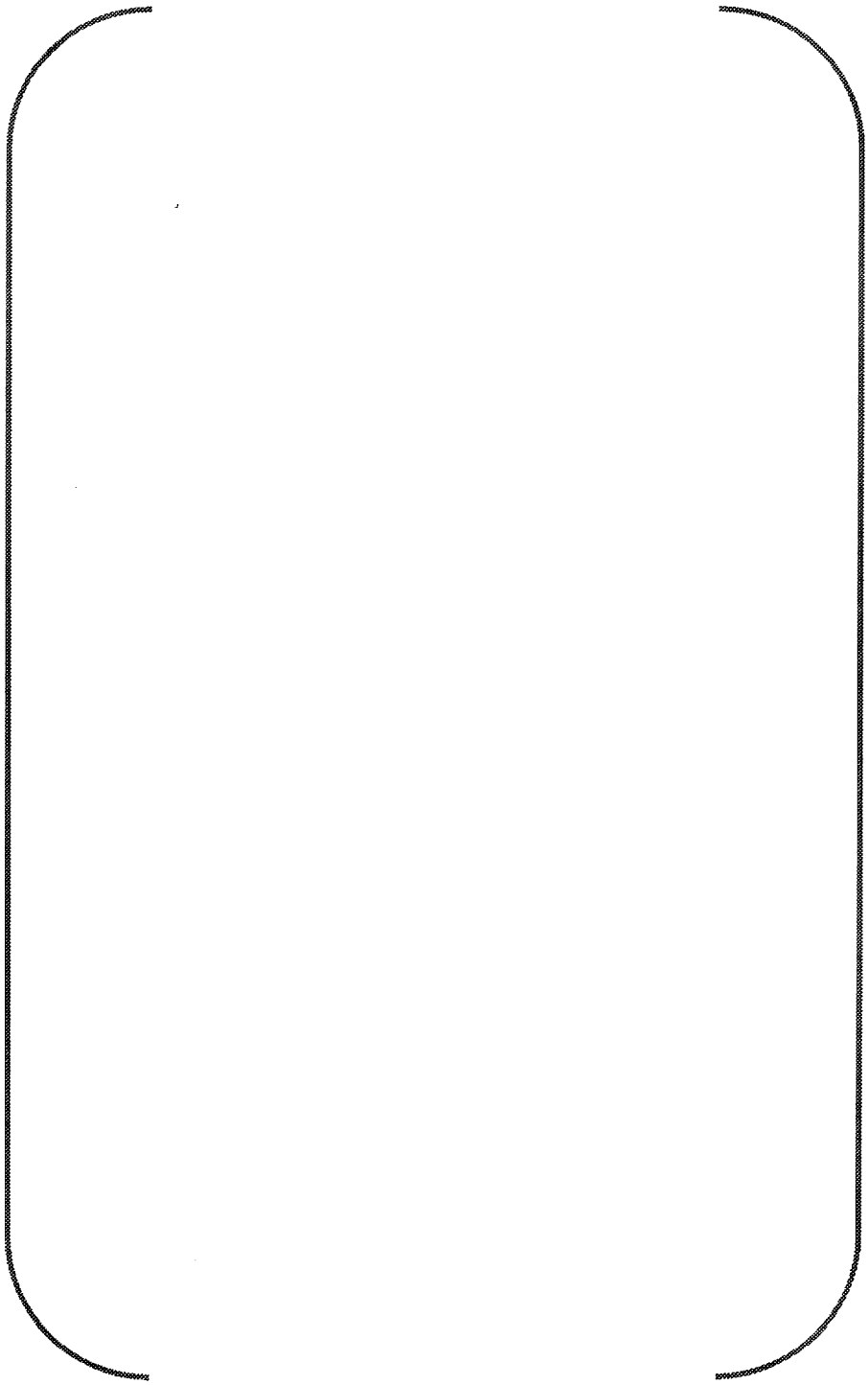


Figure 3.2-2

[ ]

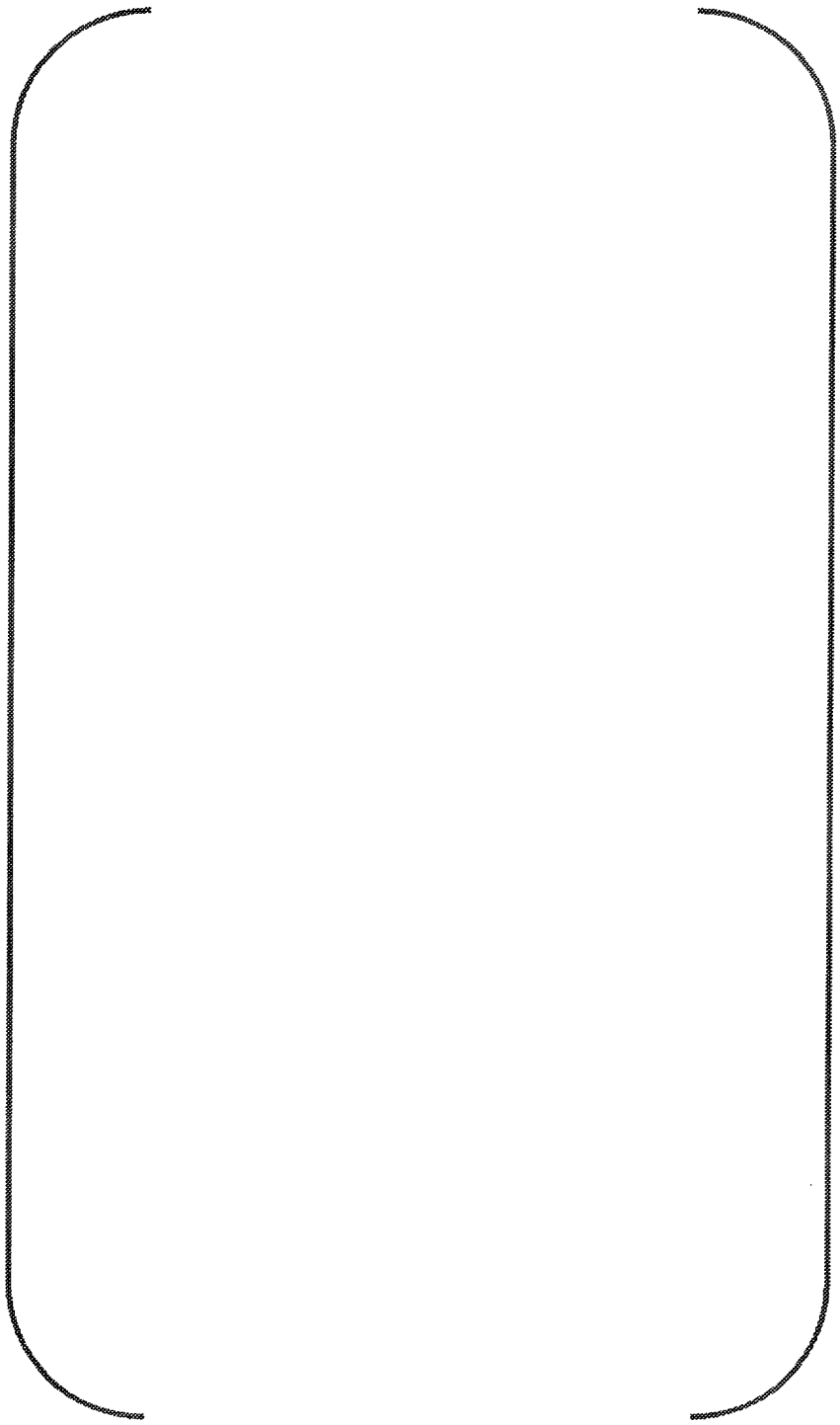
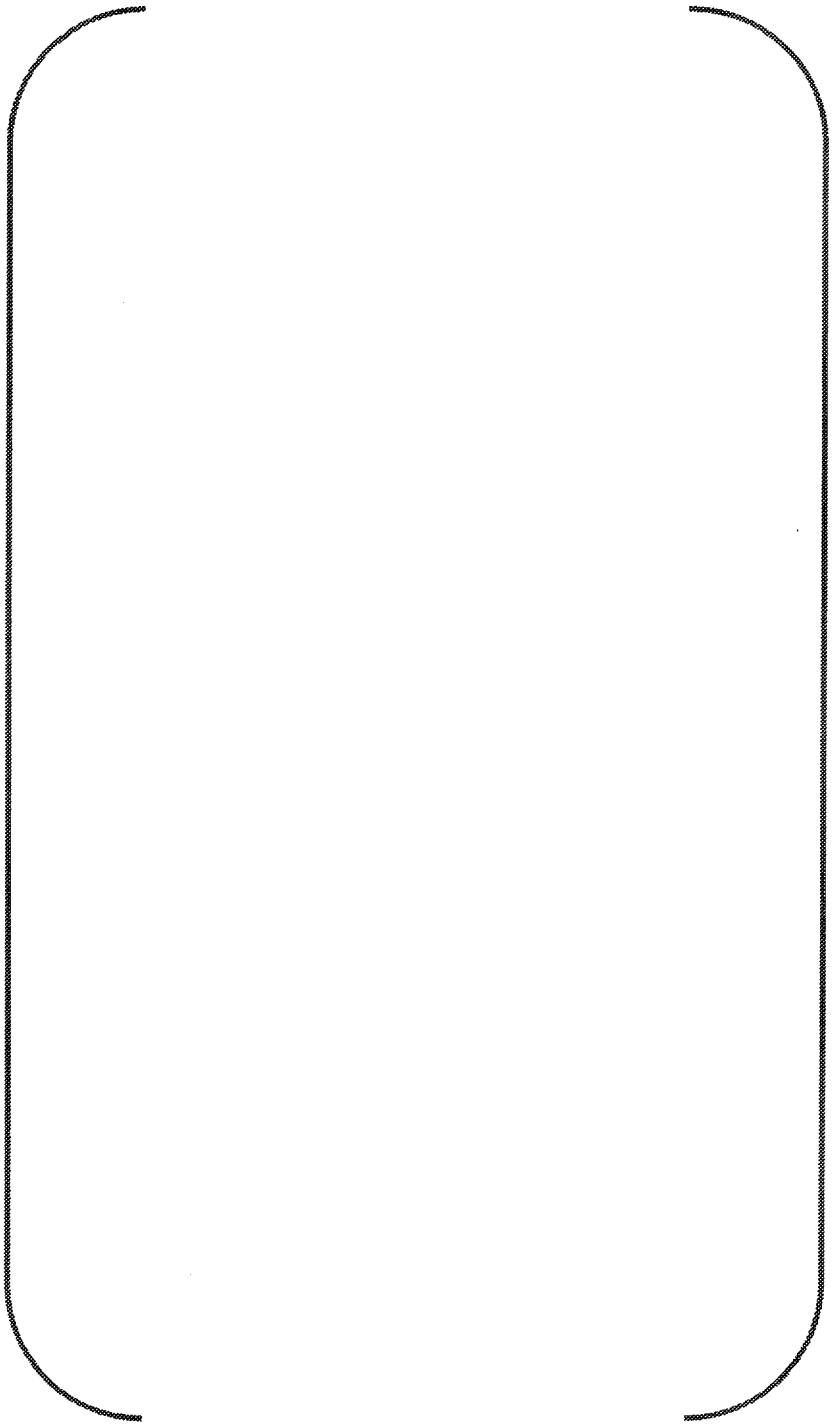


Figure 3.2-3

[ ]



4.0 Results and Conclusions

4.1 Benchmarking Results

The benchmarking calculations are performed to compare the [
]. All of these benchmarking calculations have been performed using a [

] The case details and the results are shown in Table 4.1-1.

Table 4.1-1
Results of the Benchmarking Calculations

These results indicate that the [ ] is comparable in accuracy to the [
]. All the results agree to within "2σ", the basis for the 95/95 value. Further, this also indicates that the [

]. This is also evidenced by the

[

]

The isotopic number densities for the Westinghouse 17X17 fuel assembly are shown in the next several pages. These values are displayed in a format that can be directly used as [

]. The isotopic number densities for the Westinghouse 17X17 Standard fuel assembly have been determined for the various initial enrichment and burnup combinations shown in the following table:

Burnup (MWD/MTU)	**Initial Enrichment (w/o U-235)**		

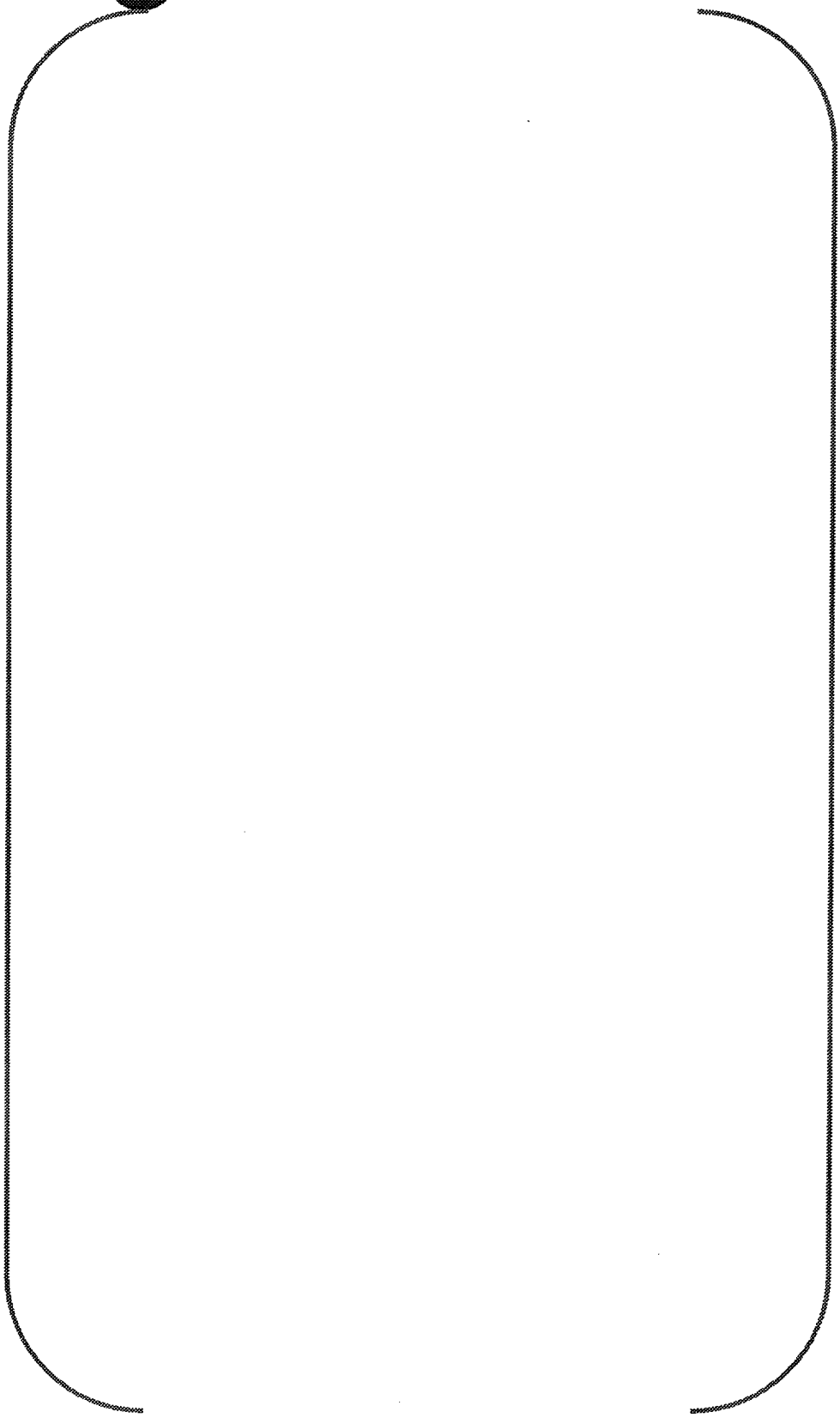
The number densities for these burnup and enrichment combinations are shown in the next several pages. Also, the values for the [ ] are also shown as part of the results. For the [ ] representation, the number densities are shown for [ ]
The Pu-241 decay models are not shown in these results. However, the isotopic number densities in [ ] are listed as part of Computer Input and Output (Section 5) Section of this document.

In summary, a database of isotopic number densities to represent the Westinghouse 17X17 standard fuel assembly in [ ] has been developed. This database contains the [

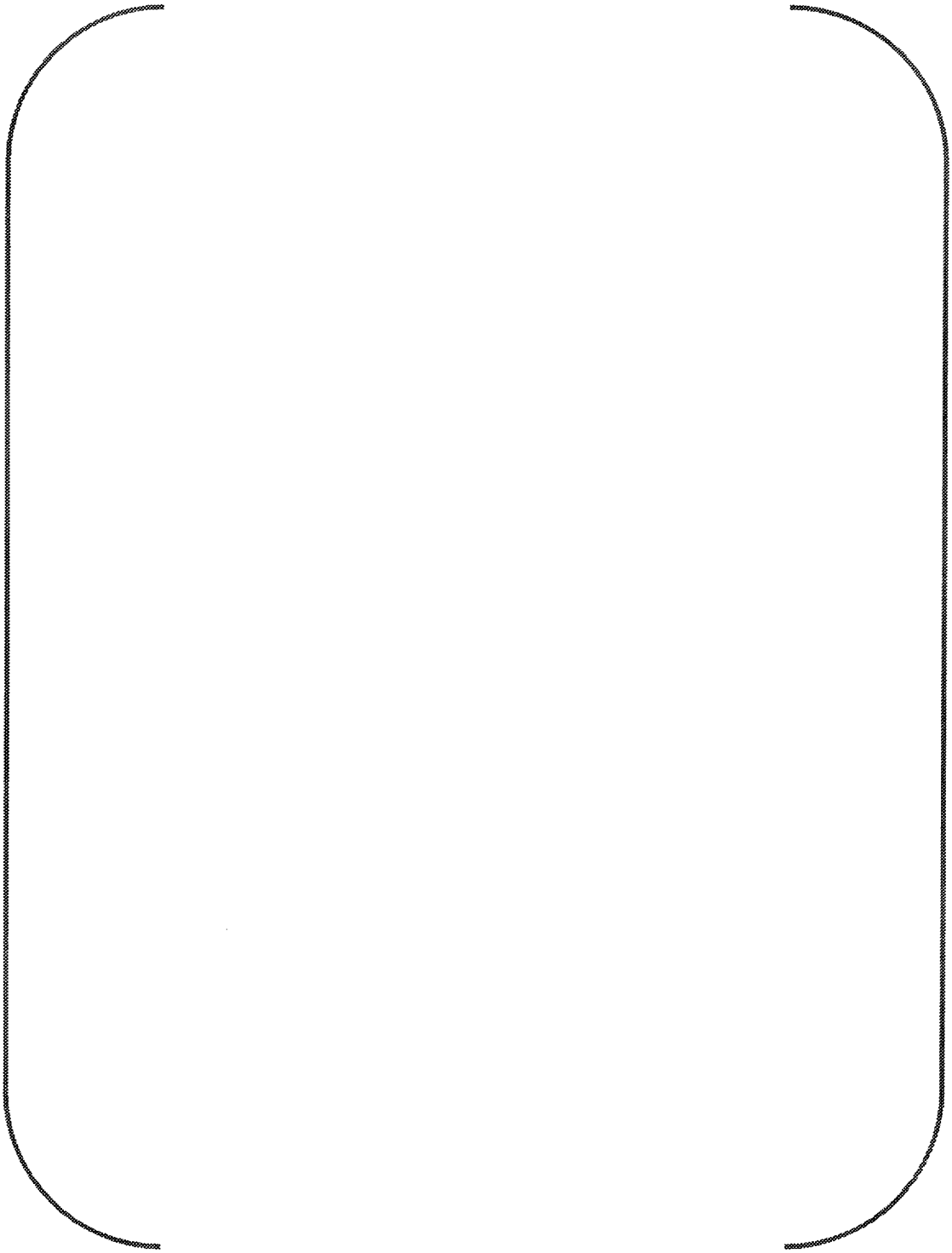
]

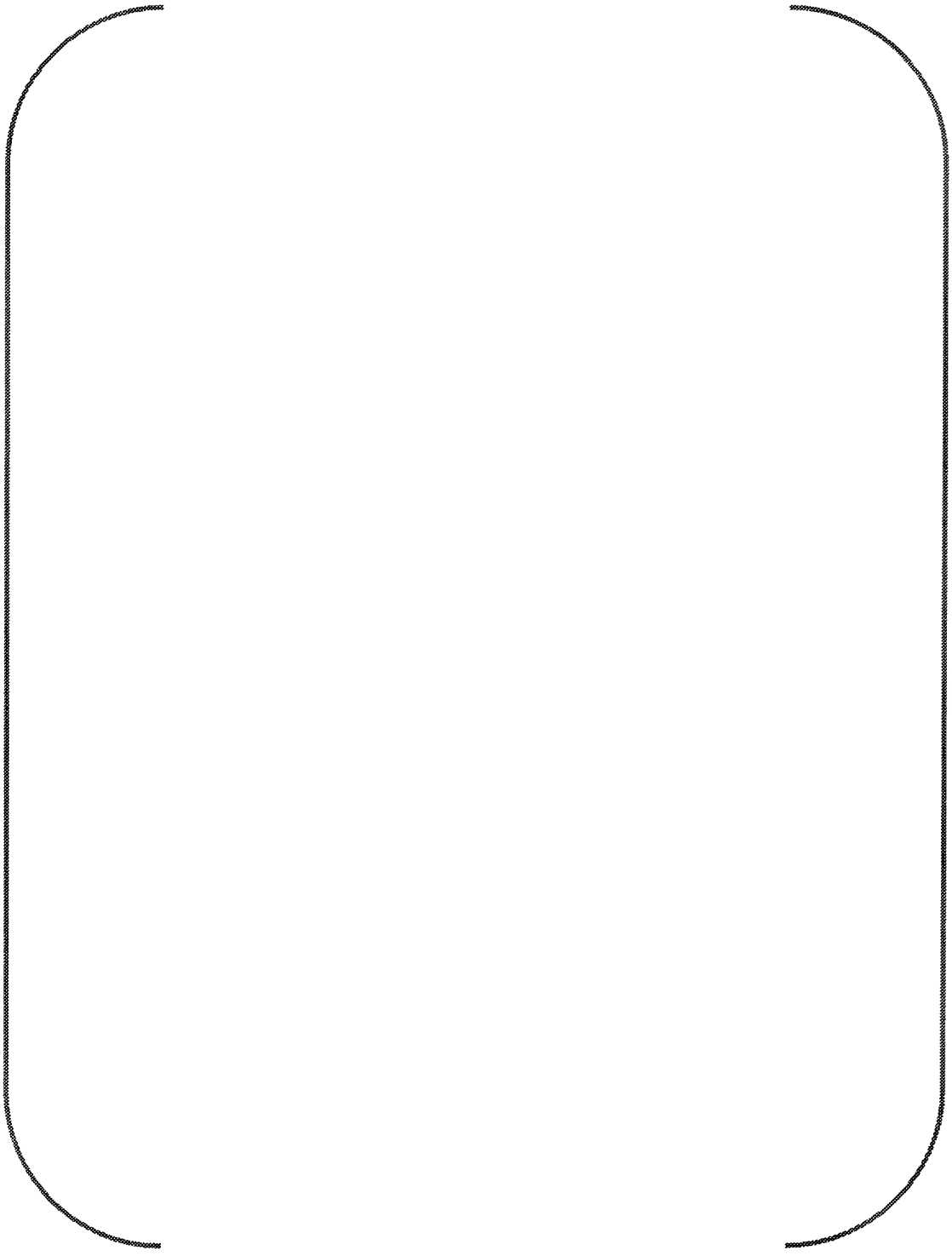
Isotopic Number Densities to be used in [ ]

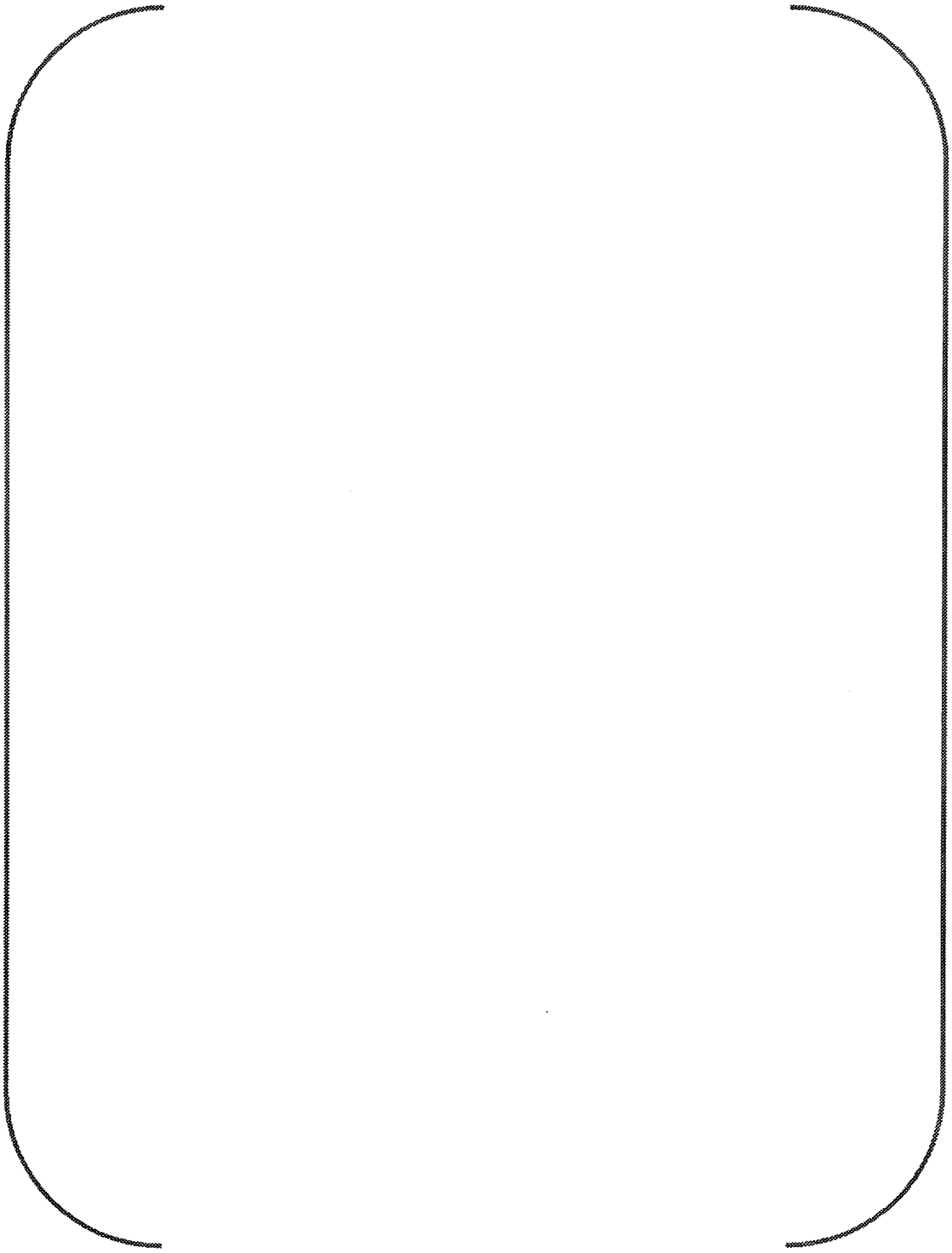
[ ]

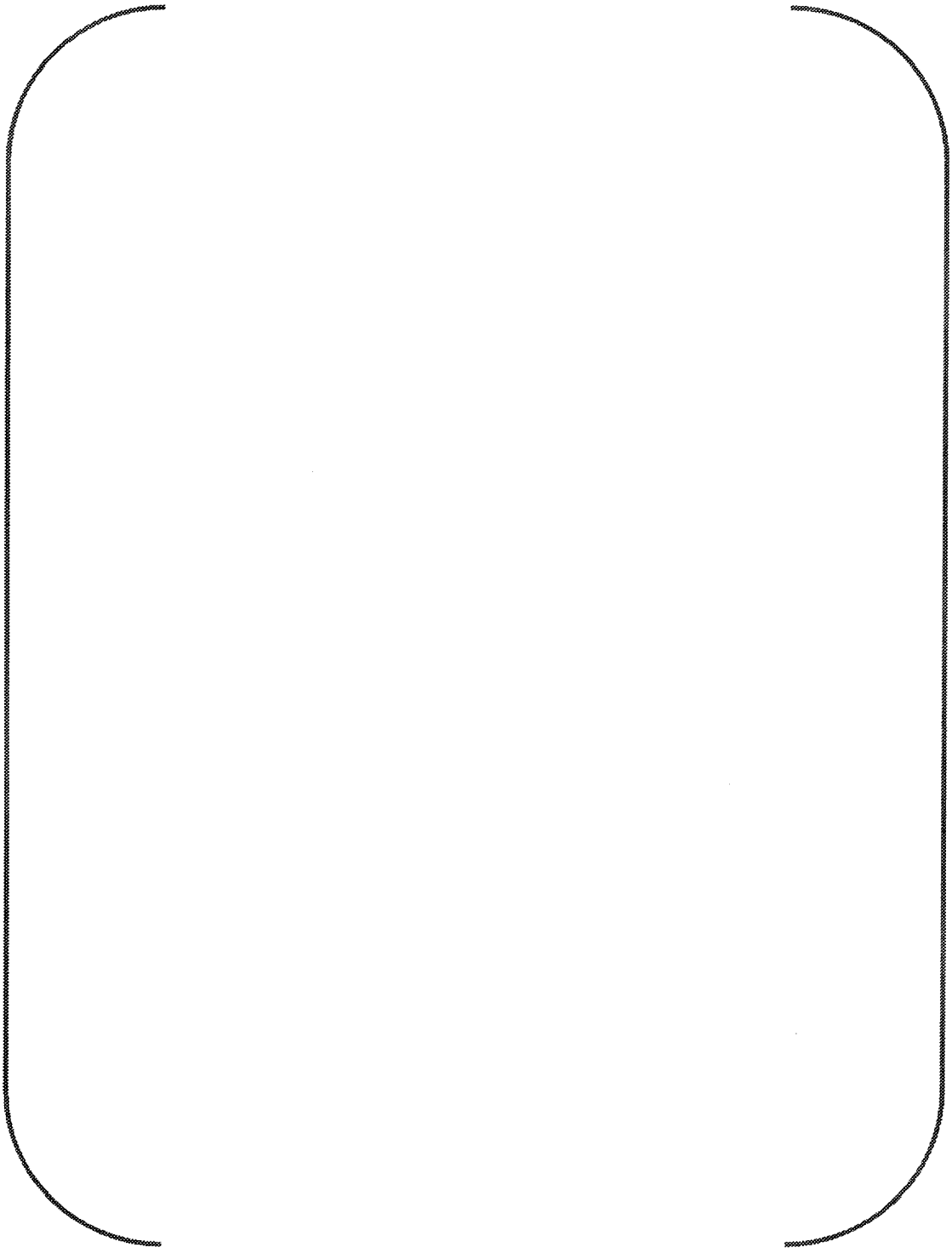


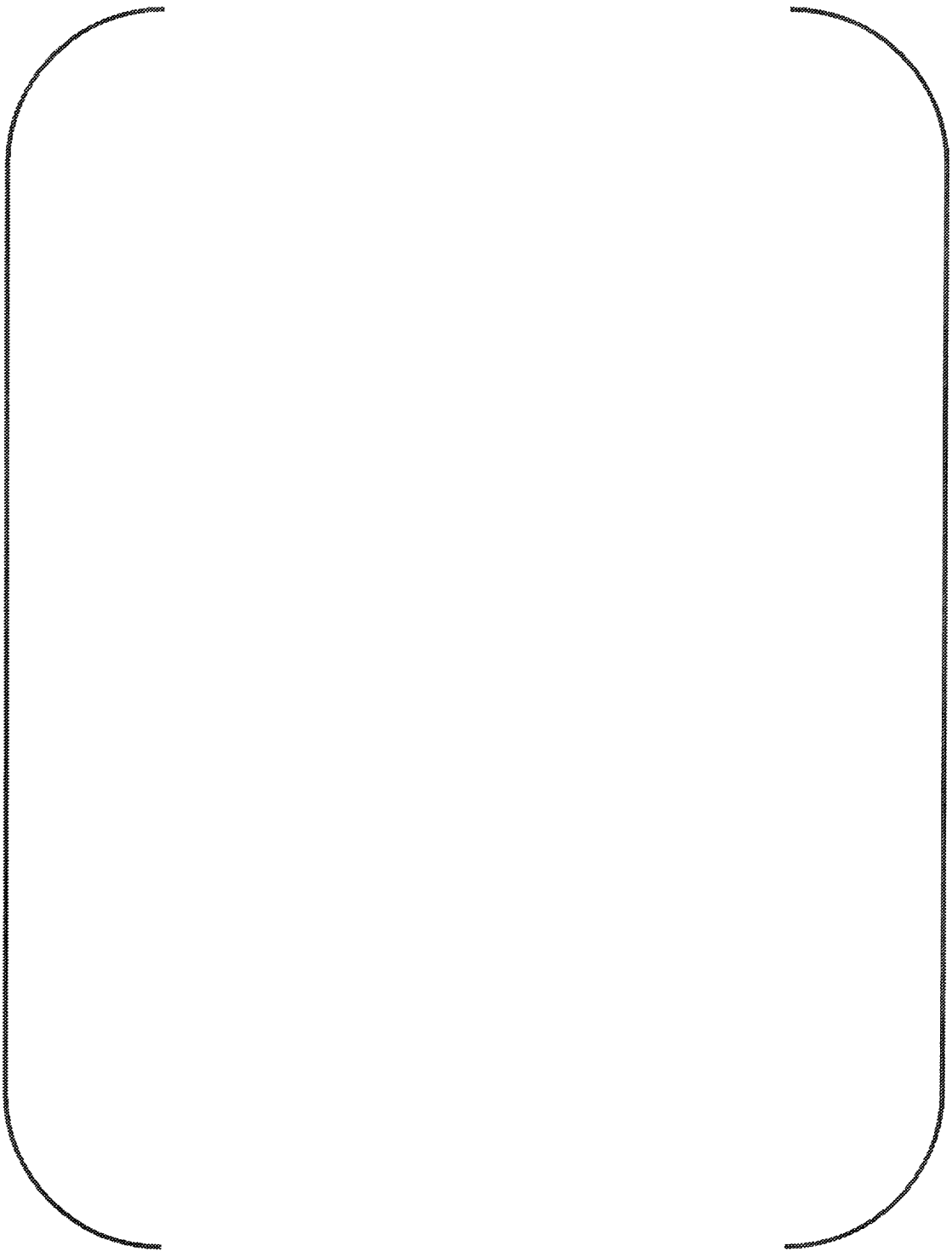
Isotopic Number Densities to be used in [ ]

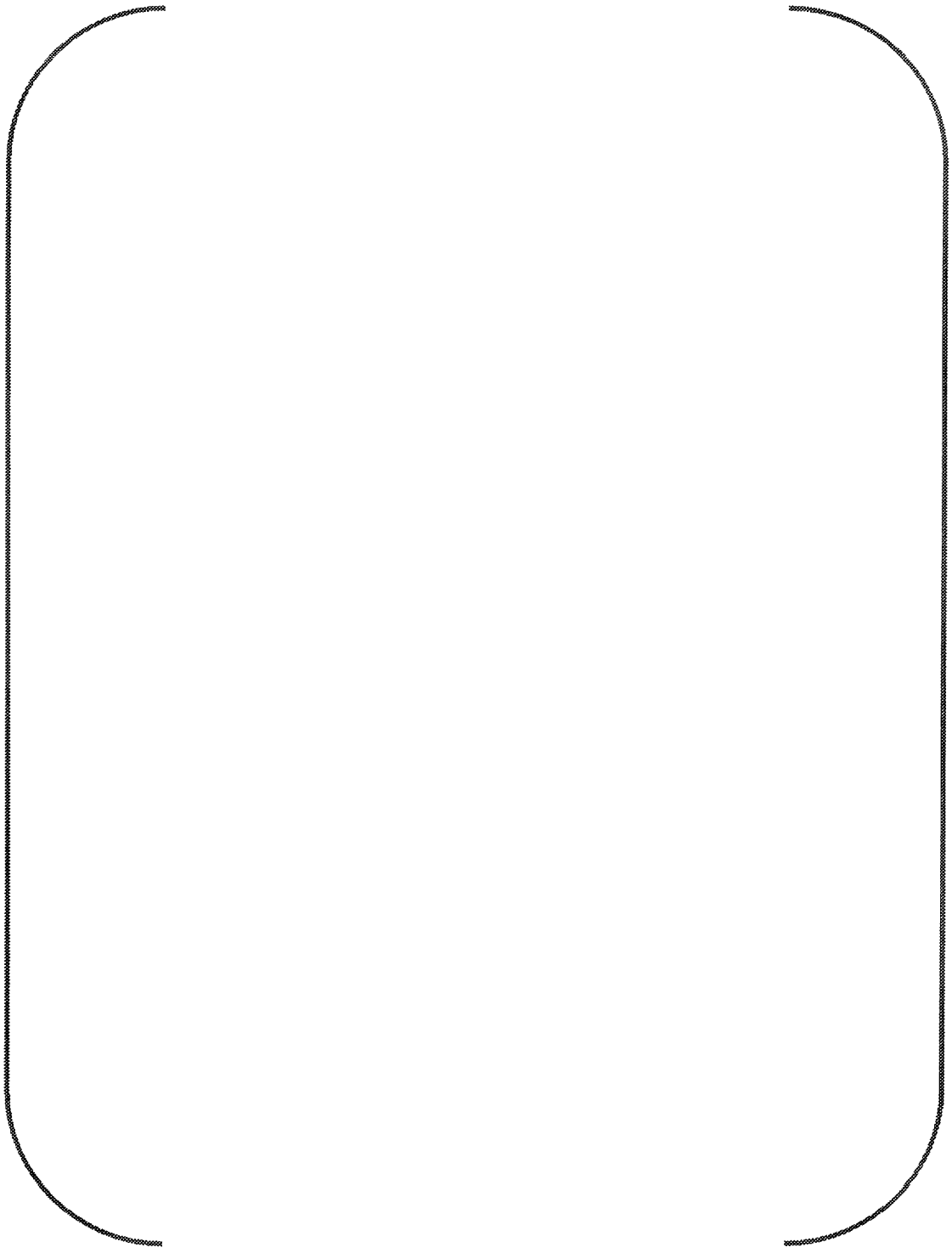


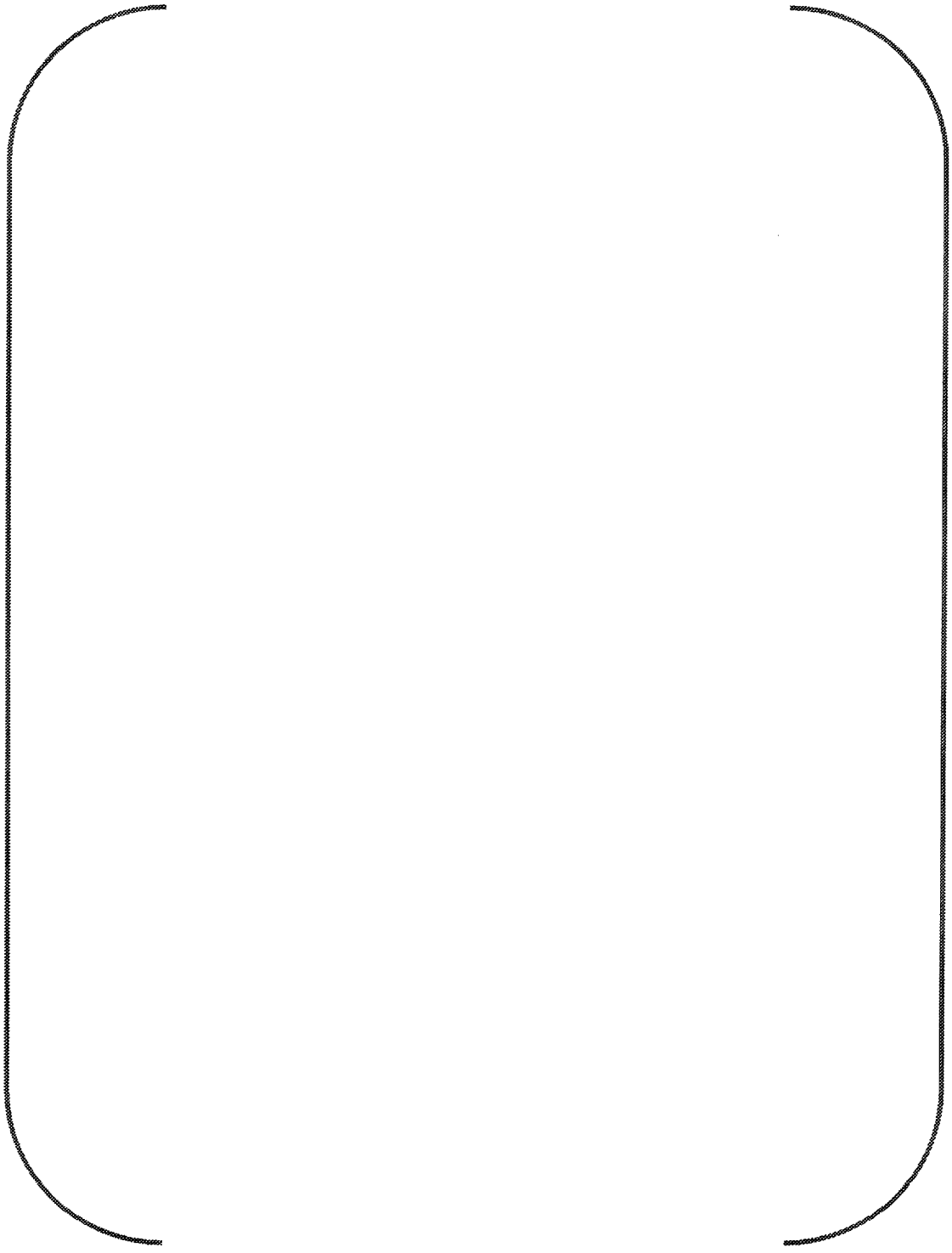


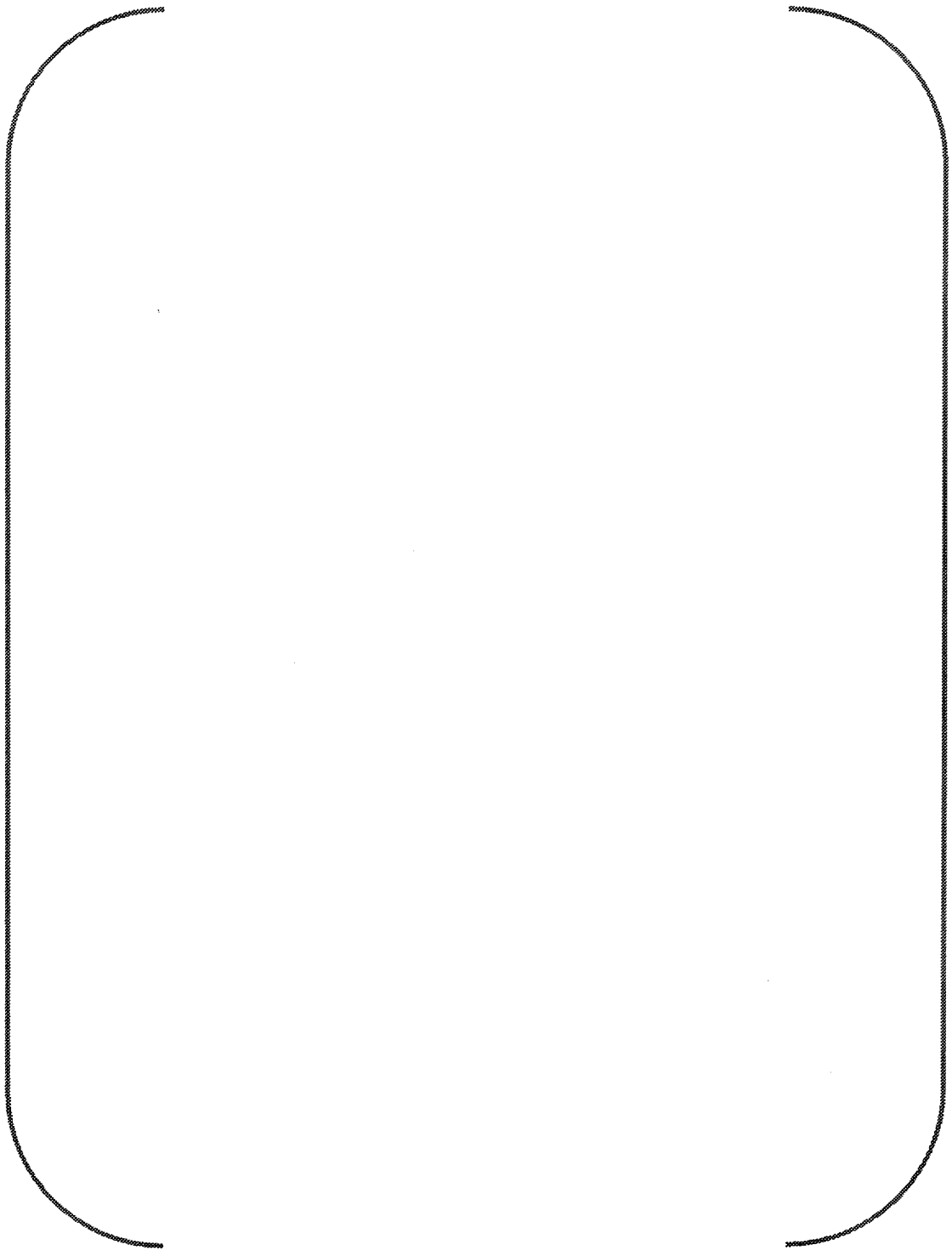


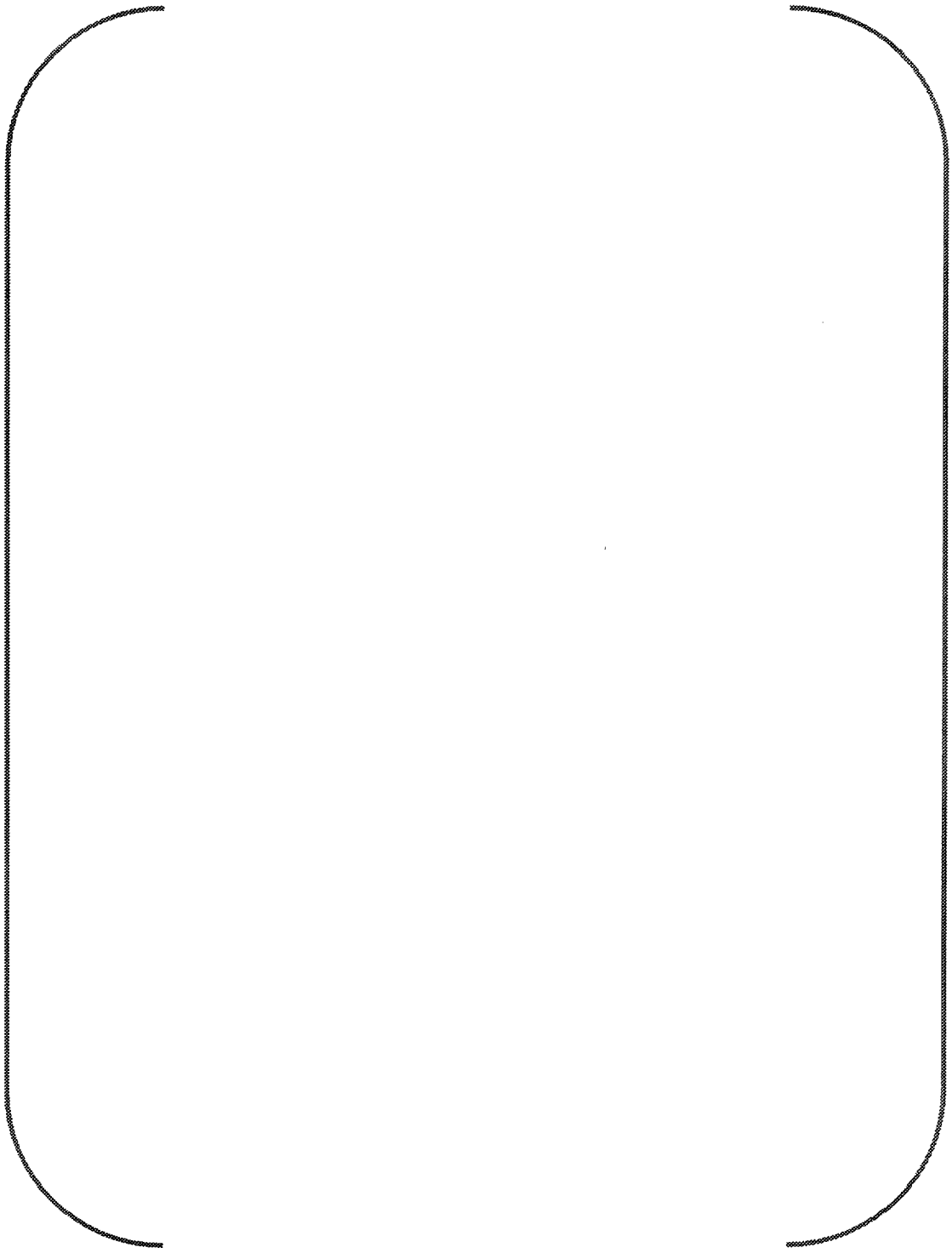


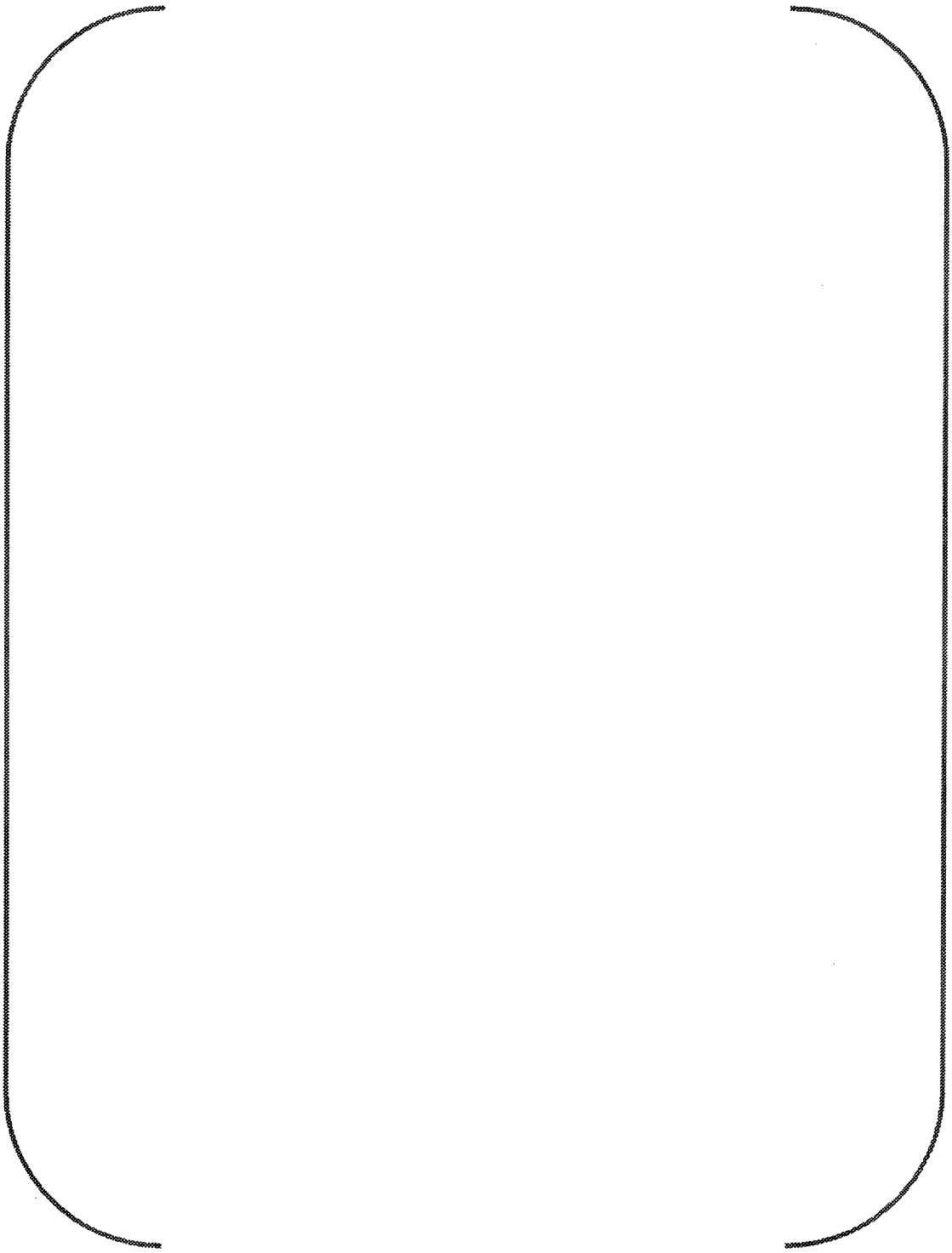


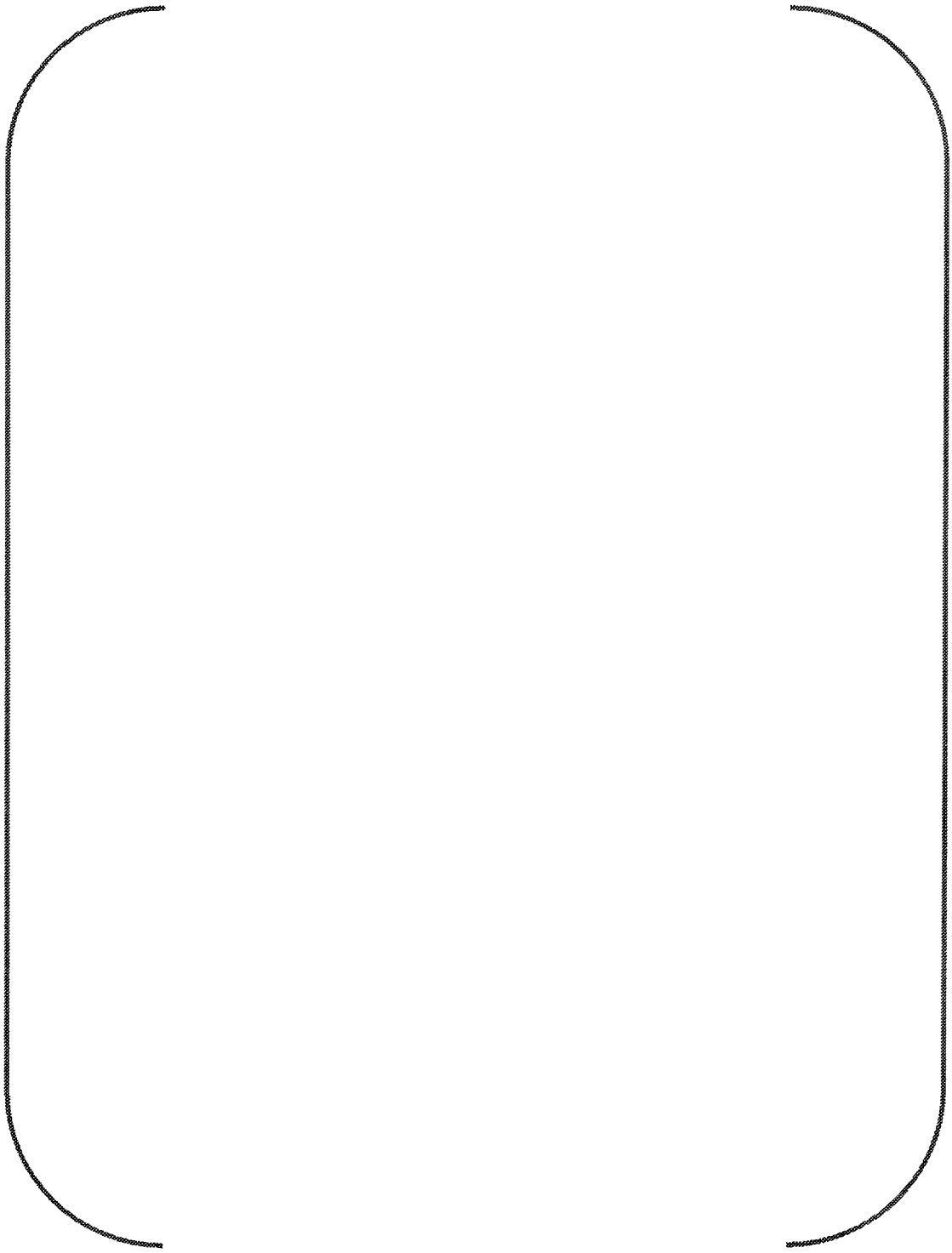


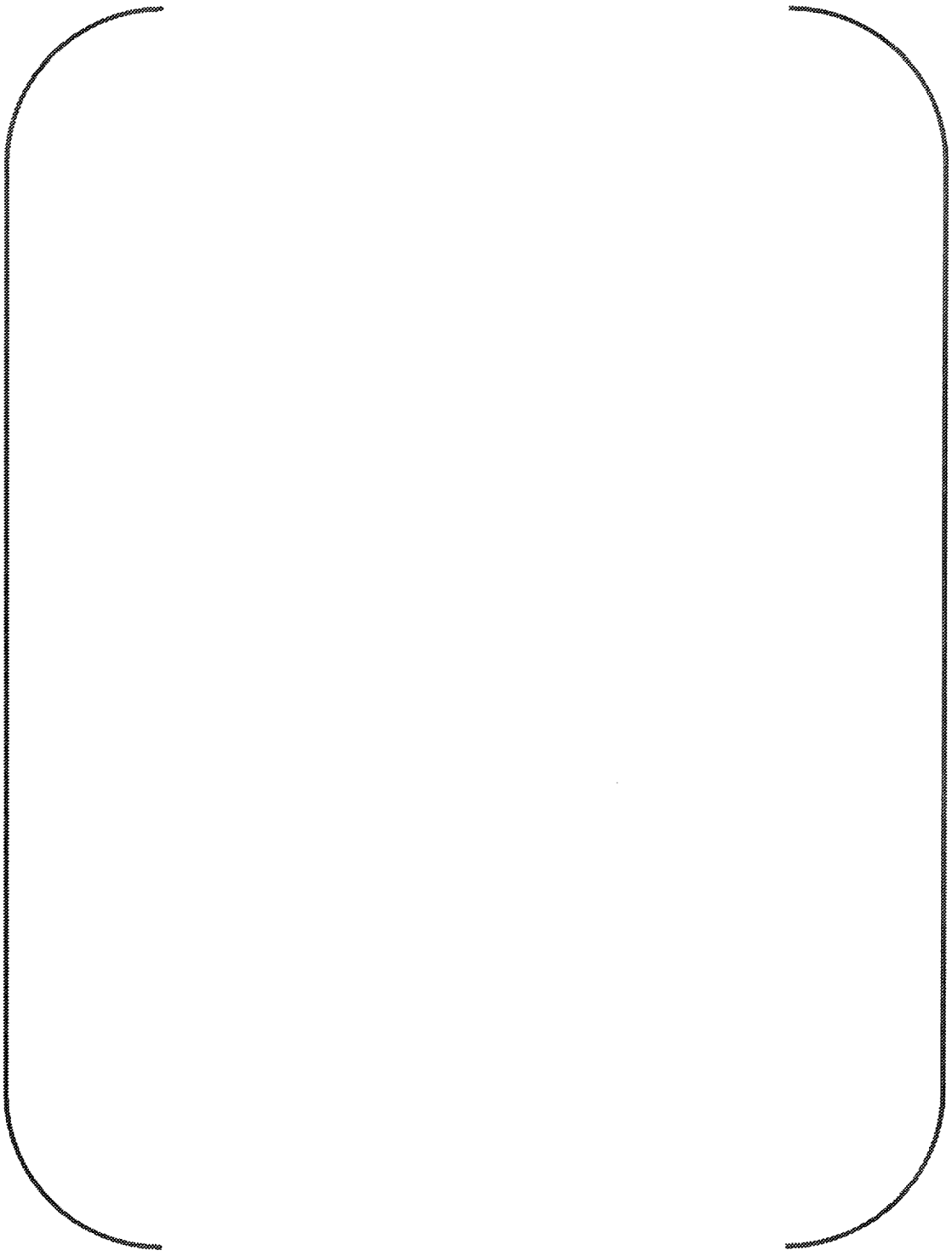


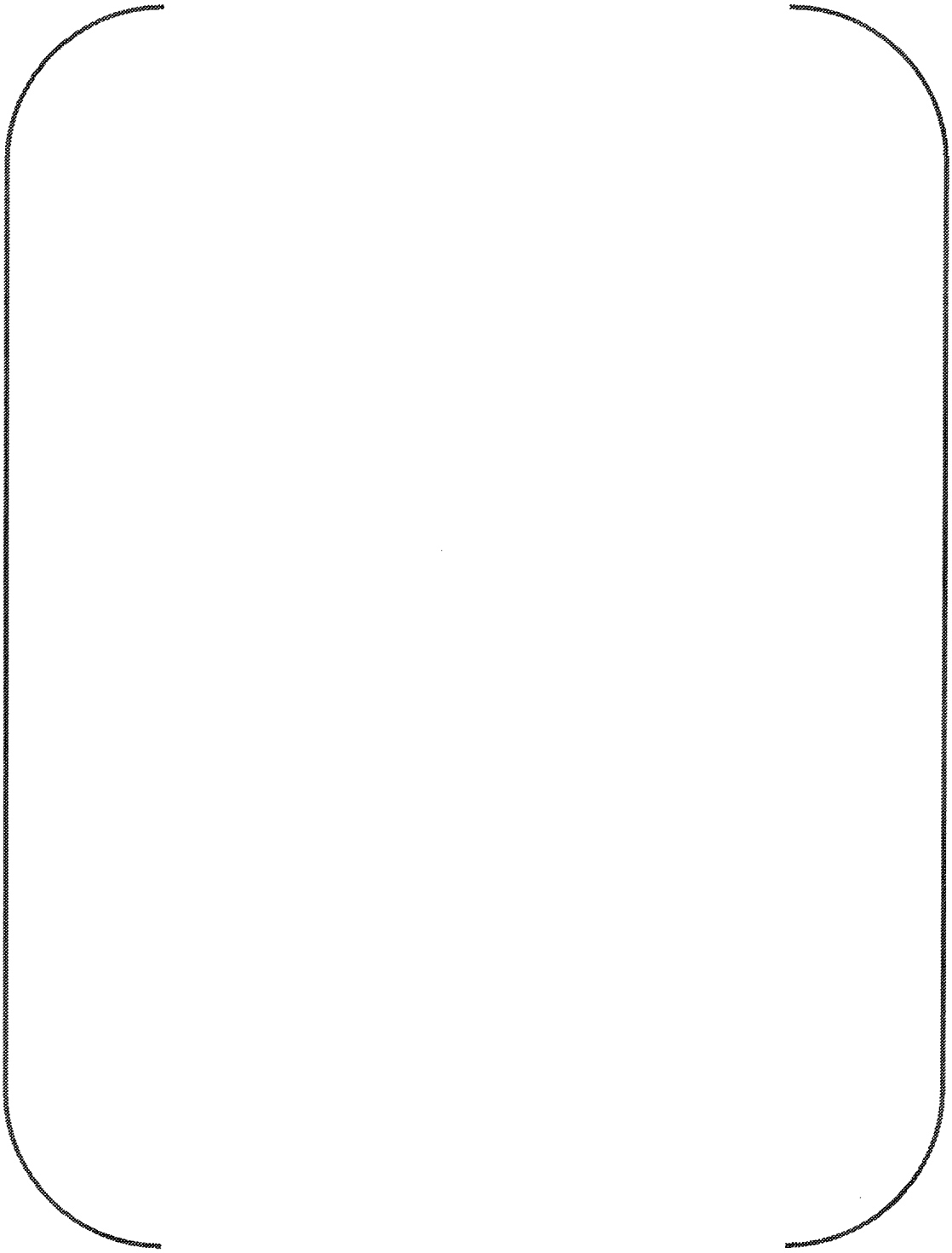


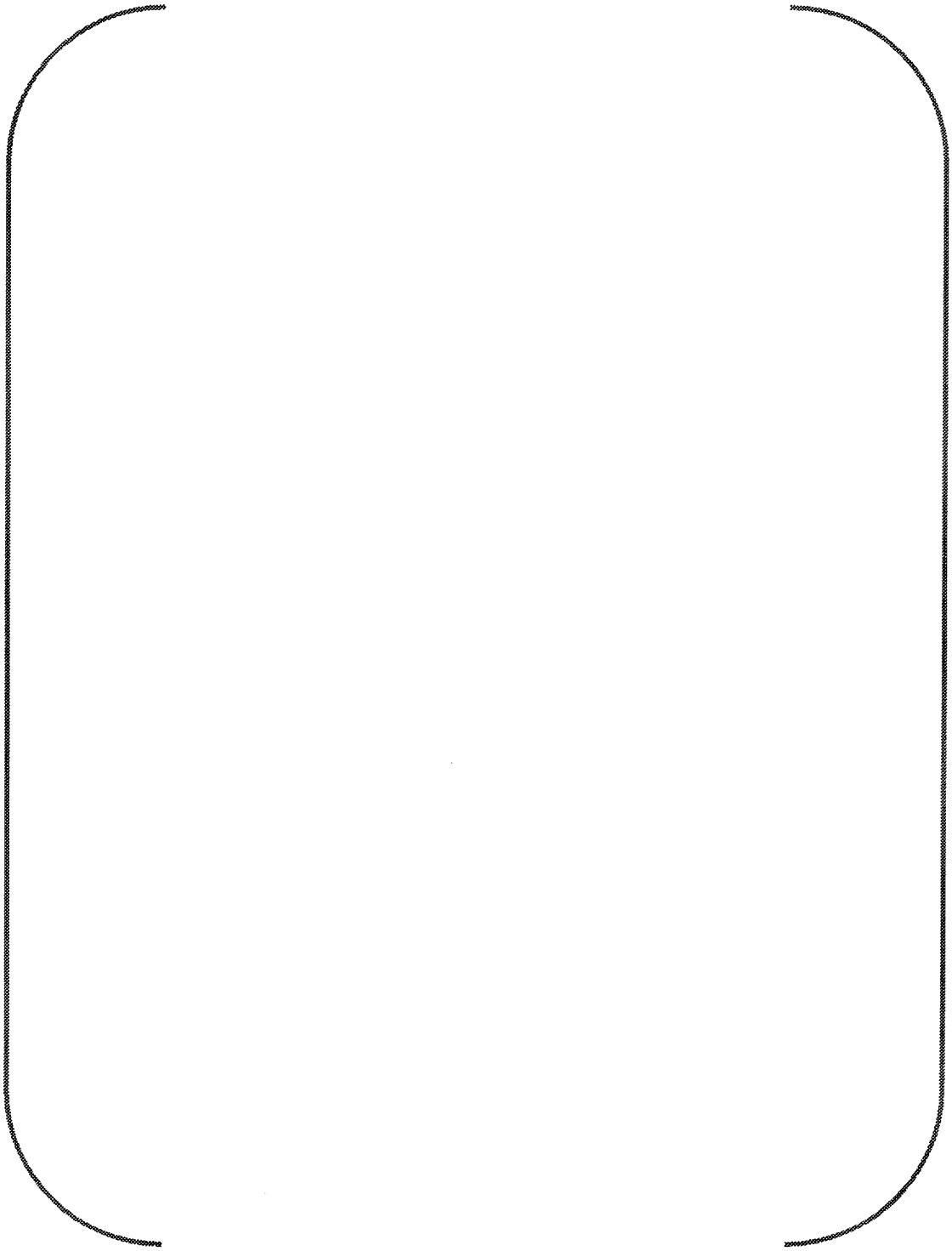


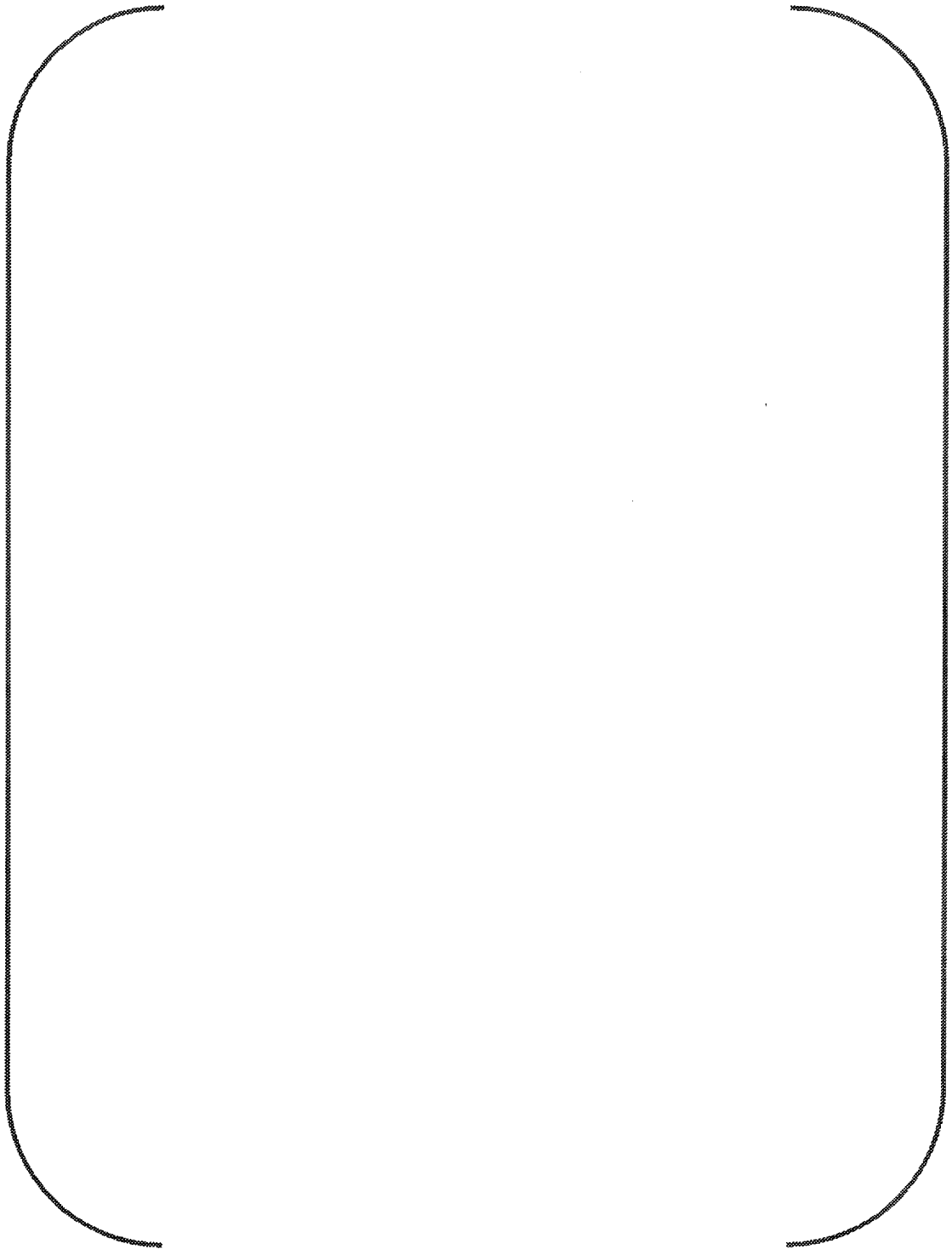












5.0 CDROM and Computer Code Lists

5.1 Computer Codes used in the Design Analyses

Code Name	Computer Type	Revision Identification (i.e. Code Version)

5.2 Computer Jobs on CDROM

[ ]

Job No.	Job ID	Job Date	CDROM File	Remarks

[ ]

Job No.	Job ID	Job Date	CDROM File	Remarks

[ ]

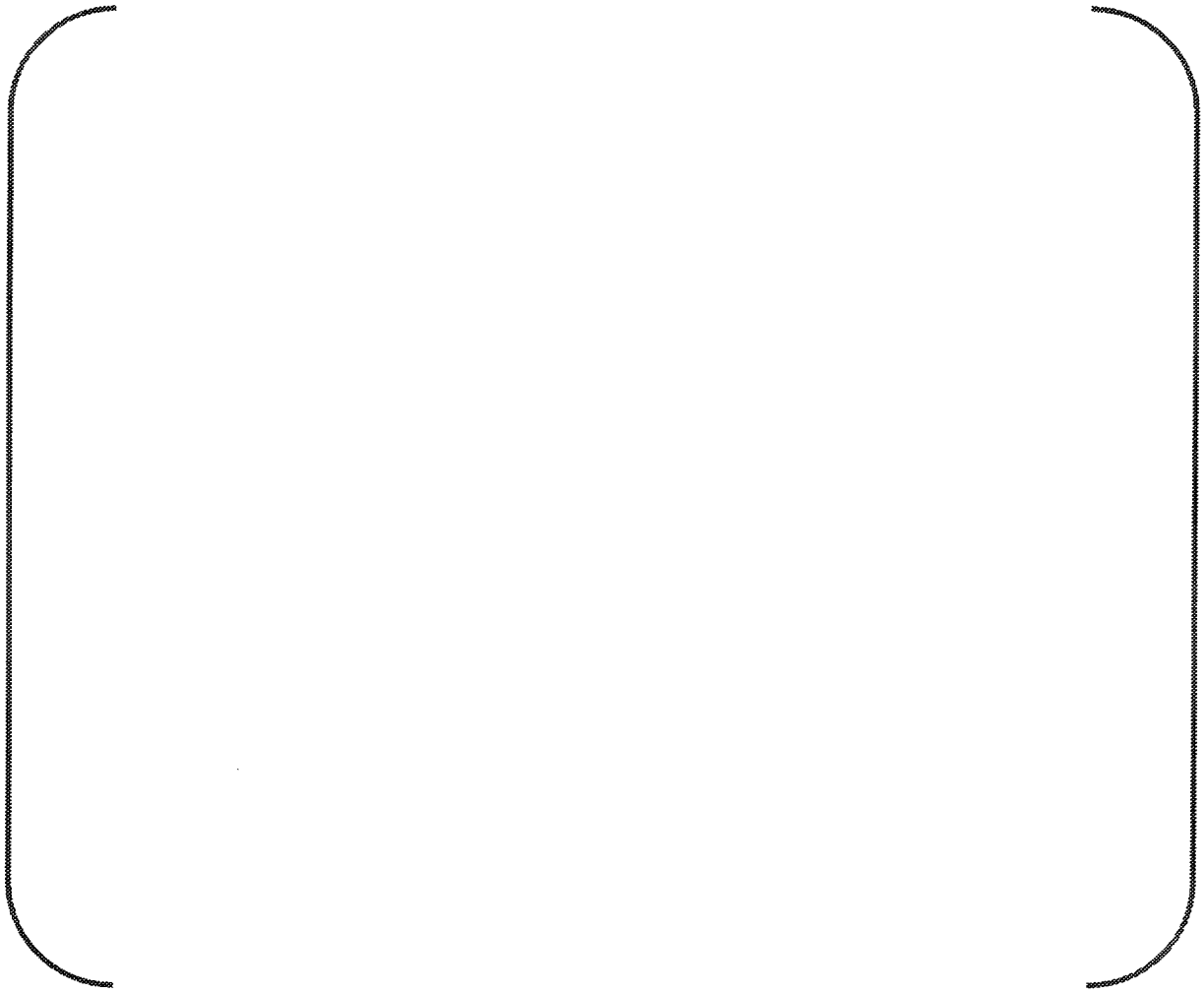
Job No.	Job ID	Job Date	CDROM File	Remarks

[ ]

Job No.	Job ID	Job Date	CDROM File	Remarks

5.3 Contents of the TAR files :

Other Computer jobs and details are provided in three "tar" files. These files are organized as follows:



[ ]

Contents of the subfolder : input3

No.	File Name	Remarks

Contents of the subfolder : input4

No.	File Name	Remarks

Contents of the subfolder : input5

No.	File Name	Remarks

Contents of the subfolder : inputz

No.	File Name	Remarks

[ ] Results (w17x17.tar file)

Contents of the subfolder : bench

No.	Job Date	File Name	Remarks

Contents of the subfolder : wt3

No.	Job Date	File Name	Remarks

Contents of the subfolder : wt3

No.	Job Date	File Name	Remarks

Contents of the subfolder : wt4

No.	Job Date	File Name	Remarks

Contents of the subfolder : wt4

No.	Job Date	File Name	Remarks

Contents of the subfolder : wt5

No.	Job Date	File Name	Remarks

Contents of the subfolder : wt5

No.	Job Date	File Name	Remarks

Contents of the subfolder : wt5

No.	Job Date	File Name	Remarks

Contents of the subfolder : wt6

Job No.	Job Date	File Name	Remarks

Contents of the subfolder : wt6

No.	Job Date	File Name	Remarks

Contents of the subfolder : wtz

No.	Job Date	File Name	Remarks

Contents of the subfolder : fuel3

No.	Job Date	File Name	Remarks

Contents of the subfolder : fuel4

No.	Job Date	File Name	Remarks

Contents of the subfolder : fuel5

No.	Job Date	File Name	Remarks

6.0 References

[

2.

]

3. Application for Amendment to Facility Operating License, Revised Spent Fuel Pool Storage Requirements, March 31, 1997; with attachment: Rochester Gas & Electric R.E. Ginna Nuclear Power Plant Spent Fuel Pool Re-racking Licensing Report, February 1997, 51-1258768-01.

4. "Topical Report on Actinide-Only Burnup Credit for PWR Spent Fuel Packages", DOE/RW-0472 Rev. 2, September 1998.

5. License Amendment Request 95-01, PG&E Letter DCL-95-028, dated February 6, 1995, with attachment "Criticality Safety Evaluation of the Diablo Canyon New Fuel Vault with 5% Enrichment, Holtec Report HI-931075", October 1993.

APPENDIX A. Verification

Design Analysis Verification Checklist

Instructions: If a major topic area (generally unnumbered, bold face type such as **Use of Computer Software**) is not applicable, then N/A (not applicable) next to the topic may be checked and the check boxes for all items under it may be left blank. Where there is no check box under N/A for a numbered item, such a response is generally inappropriate. If N/A is checked in such a situation, document the basis at the end of this checklist in the Comments section.

	Author		IR
Overall Assessment	Yes	N/A	Concur.
1. Are the results/conclusions correct and appropriate for their intended use?	☒		☒
2. Are all limitations and contingencies on the results/conclusions documented?	☒		☒
Assignment of Cognizant Engineers, Independent Reviewers and Mentors			
1. If there are multiple Cognizant Engineers, has their scope been documented?	☐	☒	☒
2. If there are multiple Independent Reviewers, has their scope been documented?	☐	☒	☒
3. If there will be multiple Management Approvers, has their scope been documented?	☐	☒	☒
4. If an Independent Reviewer is the supervisor or Project Manager, has authorization as an IR been documented?	☐	☒	☒
5. If there is a Mentor, has their scope and responsibilities been adequately documented?	☐	☒	☒
Use of Computer Software			
For software which has been validated under QP 3.13:		☐	☐
1. Is the software listed on an Approved QC-1 Software List?	☒		☒
2. Is the software applicable for this analysis?	☒		☒
For Code-Like Constructs validated under QP 3.14:		☒	☒
1. Is the Code-Like Construct listed on an Approved QC-1 Software List?	☐		☐
2. Is the Code-Like Construct applicable for this analysis?	☐	No	☐
3. Was the Code-Like Construct used directly in the controlled location?	☐	☐	☐
- If No above, is the copy identical to the version in the controlled location? (Leave blank if not applicable.)	☐		☐
4. If changes were made to a Code-Like Construct to meet specific analysis needs, were such changes documented as non-validated software following para. 3.3.3? (Leave blank if not applicable. Complete the next section if "Yes".)	☐		☐
For software excluding spreadsheets which has not been validated under QP 3.13 or QP 3.14:		☒	☒
1. Is the software identification documented?	☐		☐
2. Is a copy of the software included in the Design Analysis?	☐		☐
3. Have tests been documented which are adequate to demonstrate correct operation for the software's intended use?	☐		☐
4. Is the output from the tests included in the Design Analysis?	☐		☐
5. Has the Cognizant Engineer documented the results of the tests and the basis for concluding the software is operating correctly for its intended use?	☐		☐
6. Did the software, as used in this analysis, give correct results?	☐		☐
For spreadsheets which have not been validated under QP 3.13 or QP 3.14:		☒	☒
1. Were spreadsheets used in this Design Analysis in any way - data display, plotting, computations, etc.?	☐	No ☐	☐
- If data display only (no computations or plotting), check "Yes" and skip remaining sub-questions.	☐	☐	☐

Design Analysis Verification Checklist

Use of Computer Software (continued)	Author Yes	Author N/A	IR Concur.
- If used for computations:	☐	☐	☐
• Are the computations adequately documented and are the results correct?	☐		☐
- If used for plotting:	☐	☐	☐
• Is the data to be plotted correct?	☐		☐
• Are the plots correct in other respects? (titles, scales, labels, etc.)	☐		☐
2. Have tests been documented which are adequate to demonstrate correct operation for the spreadsheet's intended use?	☐		☐
3. Is the output from the tests included in the Design Analysis?	☐		☐
4. Has the Cognizant Engineer documented the results of the tests and the basis for concluding the spreadsheet is operating correctly for its intended use?	☐		☐
5. Has a copy of the spreadsheet file been included in the Design Analysis or has sufficient detail been included in the analysis documentation to permit recreating the spreasdsheet?	☐		☐
Use of software with uncorrected errors:		☒	☒
1. Does any of the software used have uncorrected errors?	☐	☐	☐
2. If yes, is the software identified and documented and has the impact of use been evaluated and documented?	☐	☐	☐
Objective of the Design Analysis			
1. Has information necessary to define the task been included or referenced?	☒		☒
2. Have the objectives been enumerated?	☒		☒
3. Has the applicability and intended use of the results been documented?	☒		☒
Assessment of Significant Design Changes			
1. Have significant design-related changes that might impact this analysis been considered?	☒		☒
2. If any such changes have been identified, have they been adequately addressed?	☐	☒	☒
Analytical Techniques (Methods)			
1. Are the analytical techniques (methods) described in sufficient detail to judge their appropriateness?	☒	No	☒
2. Are the analytical techniques used or their application governed by an NRC issued SER?	☐	☒	☒
If yes, have the applicable SERs been documented?	☐		☐
If yes, has the basis for concluding the analysis is in conformance been documented?	☐		☐
3. Have analytical techniques incorporated by reference to generic, lead plant or previous cycle analyses been previously verified?	☒	☐	☒
4. Are any modifications or departures from previously approved analytical techniques or Conventional or Automated Procedures documented and justified?	☐	☒	☒
5. If superseded approved analytical techniques or engineering procedures are used, is their use justified and approved?	☐	☒	☒
6. Does the issue date of referenced approved Conventional or Automated Procedures predate their use in this analysis?	☐	☒	☒
Selection of Design Inputs			
1. Are the design inputs documented?	☒		☒
2. Are the design inputs correctly selected and traceable to their source?	☒		☒
3. Are the bases for selection of all design inputs documented?	☒	No	☒
4. Is previously unverified design input used in this analysis?	☐	☒	☒
If Yes, is it treated in accordance with QP 3.2, paragraph 3.4 for use of unverified design information?	☐		☐

Design Analysis Verification Checklist

Selection of Design Inputs (continued)	Author Yes	Author N/A	IR Concur.
5. Is the verification status of design inputs transmitted from customers or Nuclear Systems appropriate and documented?	☒	☐	☒
6. Is the use of customer-controlled sources such as Tech Specs, UFSARs, etc. authorized, and does the authorization specify amendment level, revision number, etc.?	☐	☒	☒
Assumptions			
1. If there are no assumptions, is this documented?	☒	☐	☒
2. Are local assumptions documented, fully justified and verified?	☐	☒	☒
3. Are Internal and External Assumptions which must be cleared by CENP or the customer listed on a Contingencies and Assumptions form?	☐	☒	☒
4. Is the Project Manager responsible for clearing the Assumptions identified on the form?	☐	☒	☒
Results/Conclusions			
1. Are all results contained in or referenced in the Results/Conclusion section? (Where feasible, in the enumerated order of the objectives.)	☒		☒
2. Are all limitations on the results/conclusions and their applicability documented in this section?	☒		☒
3. Are all contingencies on the results that must be cleared listed in the Results/Conclusion section or the Contingencies and Assumptions form referenced?	☐	☒	☒
4. Is the Project Manager responsible for clearing the Assumptions or Contingencies identified on the form?	☐	☒	☒
Other Elements			
1. Has a comparison of the results with those of a previous cycle or similar analysis been documented and significant differences explained?	☒	☐	☒
2. Have applicable Codes (e.g., ASME Code) and standards been appropriately referenced and applied?	☐	☒	☒
3. Is the information from relevant literature searches/background data adequately documented and referenced?	☒	☐	☒
4. Are hand calculations correct and appropriately documented?	☒	☐	☒
5. Is all applicable computer output and input included?	☒	☐	☒
6. Is all computer software used identified by name and revision identification?	☒	☐	☒
References			
1. Are all references used to perform the analysis listed?	☒	☐	☒
2. Are the references as direct as possible and appropriate to the source?	☒		☒
3. Is the reference notation specific to the information utilized, including revision level or date of issue, and where appropriate, identification of the location of the information in the reference, such as page, table or paragraph number?	☒		☒

Independent Reviewer's Statement of Verification Activities:

The IR should describe details of verification activities beyond the obvious on this checklist including, but not limited to the review of new methods, use of software under para. 3.3.3, spreadsheet use, assessment of design and methodology changes, engineering judgments, and use of previously unverified inputs.

Check all DIT and KENO input and output. Check 4 vs. 7 zone results. Verify all B-10 number densities. Verify overall methodology.

Checklist Completed by
Independent Reviewer: _____

Printed Name Signature Date

Design Analysis Verification Checklist

The Form and Format section of the Checklist below may be completed by a Checker under the direction of the Independent Reviewer.

Form/Format	Author Yes	Author N/A	IR Concur
1. Is the document legible, reproducible and in a form suitable for filing and retrieving as a Quality Record?	☒		☒
2. Except as permitted by 3.1.3.a, are all pages identified with the document number, including revision number?	☒		☒
3. Except as permitted by 3.1.3.a, do all pages have a unique page number?	☒		☒
4. Are all computer disks identified with the analysis number?	☐	☒	☒
5. Are any unverified sections of an otherwise verified analysis clearly indicated?	☐	☒	☒
For a revision to a completed analysis in the "Complete Revision" and "Page Change Package" formats:		☒	☒
1. Where practical, have changes and additions been identified by mechanisms such as vertical lines, etc.?	☐		☐
2. Where practical, have deletions been identified by mechanisms such as strike outs, etc.?	☐		☐
3. Have indications of change in previous revisions been removed?	☐		☐
4. Does the distribution of the revision include those on the distribution of the previous revision?	☐		☐
For a "Complete Revision":		☒	☒
1. Have the title and document number been preserved without change?	☐		☐
2. Has the revision number been incremented by one?	☐		☐
For a "Page Change Package":		☒	☒
1. Are pages numbered in accordance with the original analysis?	☐		☐
2. Are instructions provided for the insertion and deletion of revised pages?	☐		☐
3. Has a new Title Page been prepared?	☐		☐
4. Does the Package Contents Page reflect the composite document?	☐		☐

☒ Form/Format section completed by the Independent Reviewer.

☐ Form/Format section completed by the Checker identified below:

Checker Name: _____ Signature: _____

Reviewer's Comment Form

Title: Isotopic Number Densities for Discharged Westinghouse 17X17 Fuel Assemblies

Document Number: A-GEN-FE-0118 Revision Number: 00

Comment Number	Reviewer's Comment	Response Required?	Author's Response	Response Accepted?
1	Minor editorial comments	Yes	Incorporated	Yes

APPENDIX B. [ ]

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Westinghouse Electric Company LLC Proprietary Affidavit and Copyright Notice for Westinghouse Electric Company LLC Report A-GEN-FE-0118, Revision 0 "Isotopic Number Densities for Discharged Westinghouse 17x17 Fuel Assemblies" Westinghouse Proprietary Class 2

I, Norton L. Shapiro, depose and say that I am the Advisory Engineer, CE Engineering Technology, of Westinghouse Electric Company LLC (WEC), duly authorized to make this affidavit, and have reviewed or caused to have reviewed the information which is identified as proprietary and described below. I am submitting this affidavit in conformance with the provisions of 10 CFR 2.790 of the Commission's regulations and in conjunction with the application of Pacific Gas & Electric Company for withholding this information. I have personal knowledge of the criteria and procedures utilized by WEC in designating information as a trade secret, privileged, or as confidential commercial or financial information.

The information for which proprietary treatment is sought, and which documents have been appropriately designated as proprietary, is contained in the following:

A-GEN-FE-0118, Rev. 00, "Isotopic Number Densities for Discharged Westinghouse 17x17 Fuel Assemblies", November 15, 2000

Pursuant to the provisions of Section 2.790(b)(4) of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information included in the documents listed above should be withheld from public disclosure.

i. The information sought to be withheld from public disclosure is owned and has been held in confidence by WEC. It consists of details of the methodology for determining isotopic number densities for discharged fuel assemblies.

ii. The information consists of analyses or other similar data concerning a process, method or component, the application of which results in substantial competitive advantage to WEC.

iii. The information is of a type customarily held in confidence by WEC and not customarily disclosed to the public.

iv. The information is being transmitted to the Commission in confidence under the provisions of 10 CFR 2.790 with the understanding that it is to be received in confidence by the Commission.

v. The information, to the best of my knowledge and belief, is not available in public sources, and any disclosure to third parties has been made pursuant to regulatory provisions or proprietary agreements that provide for maintenance of the information in confidence.

vi. Public disclosure of the information is likely to cause substantial harm to the competitive position of WEC because:

   a. A similar product or service is provided by major competitors of Westinghouse.

   b. WEC has invested substantial funds and engineering resources in the development of this information. A competitor would have to undergo similar expense in generating equivalent information.

   c. The information consists of the methodology for determining isotopic number densities for discharged fuel assemblies, the application of which provides a competitive economic advantage. The availability of such information to competitors would enable them to design their product or service to better compete with WEC, take marketing or other actions to improve their product's position or impair the position of WEC's product, and avoid developing similar technical analysis in support of their processes, methods or apparatus.

   d. Significant research, development, engineering, analytical, manufacturing, licensing, quality assurance and other costs and expenses must be included in pricing WEC's products and services. The ability of WEC's competitors to utilize such information without similar expenditure of resources may enable them to sell at prices reflecting significantly lower costs.

   e. Use of the information by competitors in the international marketplace would increase their ability to market comparable products or services by reducing the costs associated with their technology development. In addition, disclosure would have an adverse economic impact on WEC's potential for obtaining or maintaining foreign licenses.

Norton L. Shapiro
Advisory Engineer, CE Engineering Technology
Westinghouse Electric Company LLC

Sworn to before me this
29th day of January 2002

Notary Public
My commission expires: 8/31/04

Westinghouse Electric Company LLC

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