CPC/CEAC SOFTWARE MODIFICATIONS

FOR THE

CPC IMPROVEMENT PROGRAM

CEN-308-NP

Revision 00-NP

AUGUST, 1985

COMBUSTION ENGINEERING, INC.

Nuclear Power Systems
Power Systems Group
Windsor, Connecticut

LEGAL NOTICE

This report was prepared as an account of work sponsored by Combustion Engineering, Inc. Neither Combustion Engineering nor any person acting on its behalf:

a. Makes any warranty or representation, express or implied including the warranties of fitness for a particular purpose or merchantability, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

b. Assumes any liabilities with respect to the use of, or for damages resulting from the use of, any information, apparatus, method or process disclosed in this report.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

1.1 REPORT SCOPE

The Core Protection Calculator System (CPCS) is designed to provide the low DNBR and high Local Power Density (LPD) trips to (1) ensure that the specified acceptable fuel design limits on departure from nucleate boiling and centerline fuel melting are not exceeded during Anticipated Operational Occurrences (AOOs) and (2) assist the Engineered Safety Features System in limiting the consequences of certain postulated accidents.

The COLSS/CPC Oversight Committee, consisting of Arizona Nuclear Power Project, Arkansas Power and Light Company, Louisiana Power and Light Company and Southern California Edison, with Combustion Engineering as its technical consultant, has developed the CPC Improvement Program (CIP), a program of CPC Modifications and Methodology Improvements scheduled to be implemented in 1986 and 1987. An initial presentation of concepts was provided on November 8, 1984, the schedule for implementation of the program was presented to the NRC on March 8, 1985 and a detailed presentation of the portions of the program scheduled for implementation in early 1986 was provided on April 18, 1985. Reference 3 describes the program as presented in April.

The CPC Improvement Program consists of three major areas:

- Part A - Optimization of CPC/CEAC Software for Reloads
- Part B - CEAC Desensitization to Spurious Signals
- Part C - Reload Data Block Constants

This document provides a detailed description of the CPC algorithm changes for Parts A and B.

The modifications described in this document will apply to Arkansas Nuclear One Unit 2 (ANO-2); Palo Verde Nuclear Generating Station (PVNGS) Units 1, 2 and 3; San Onofre Nuclear Generating Station (SONGS) Units 2 and 3; and Waterford Unit 3 and are intended to be implemented at each plant at the next available software change.

1.2 REPORT SUMMARY

Algorithm modifications for the CPC Improvement Program will affect the following programs:

[ ]

Changes are described as revisions relative to the algorithms currently in place at SONGS-2 Cycle 2 and ANO-2 Cycle 5 (References 1 and 2). The general format used in describing each modification contained in this report is a statement of the change, the reason for the change, and a detailed description of the algorithm in symbolic algebra. All equation numbers and figure numbers are consistent with those in References 1 and 2.

2.0 CPC SOFTWARE MODIFICATIONS

2.1 MODIFICATIONS TO FLOW ALGORITHM

Change

[redacted]

Reason

[redacted]

Description:

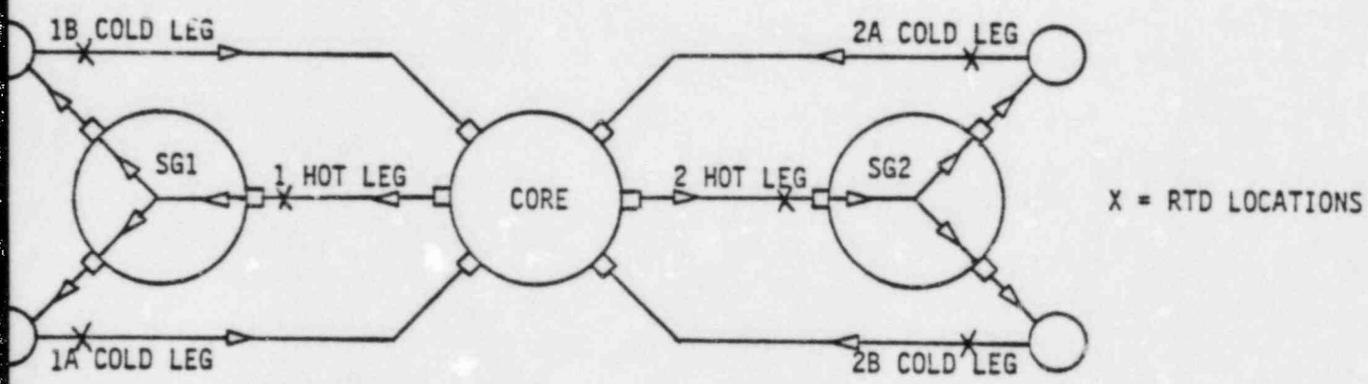
A complete revised FLOW algorithm is as follows:

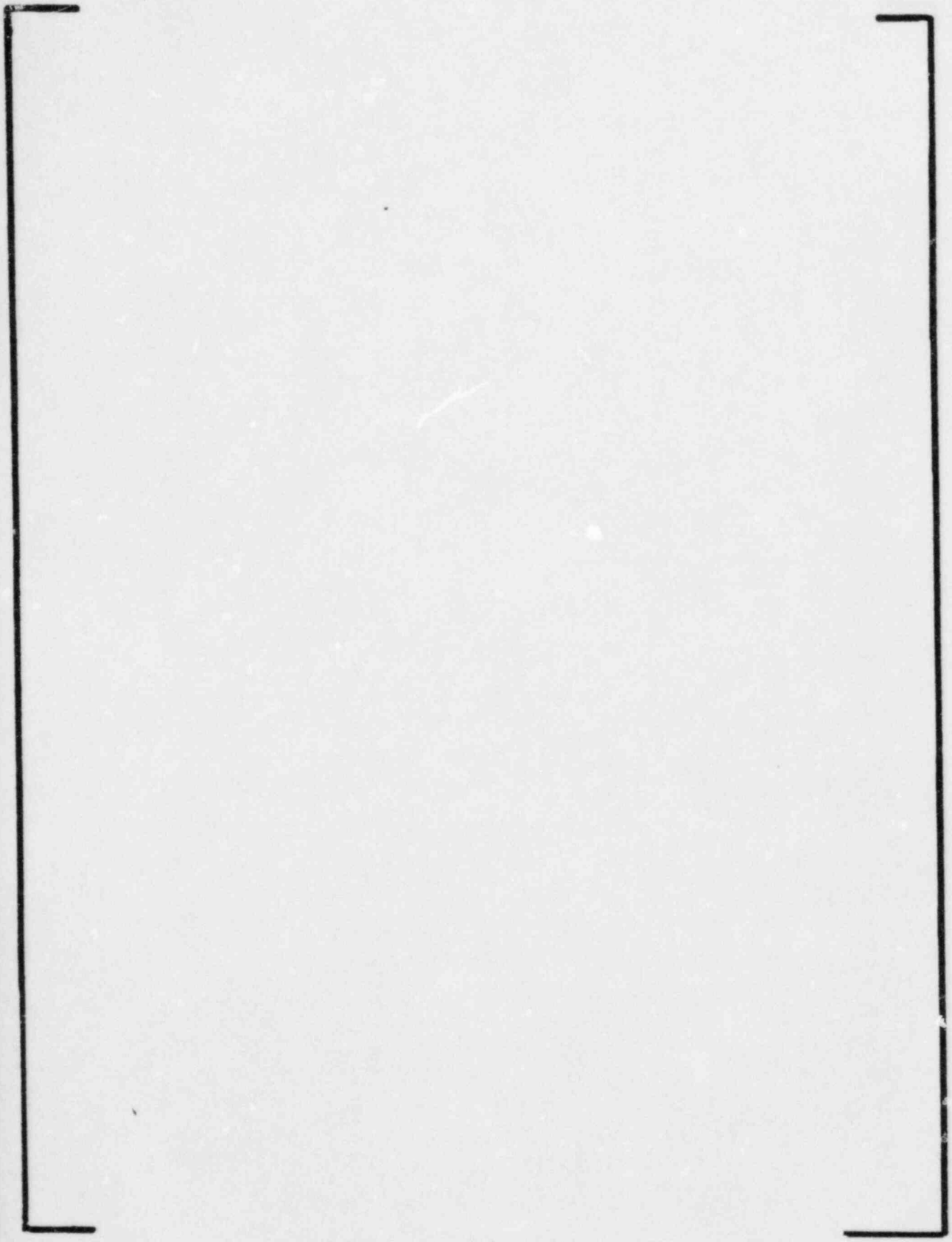
Algorithm Input

The FLOW algorithm requires the following process parameters from other CPC programs:

FIGURE 4-1

Typical Schematic of Primary System Showing
Approximate Location of Temperature Sensors





FLOW Output

Variable Name	Description	Destination

FLOW Constants

2.2 MODIFICATIONS TO UPDATE ALGORITHM

2.2.1 Variable Overpower Trip (VOPT)

Change

[redacted]

Reason

[redacted]

Description:

[

]

2.2.2 Asymmetric Steam Generator Transient (ASGT)

Change

[

]

Reason

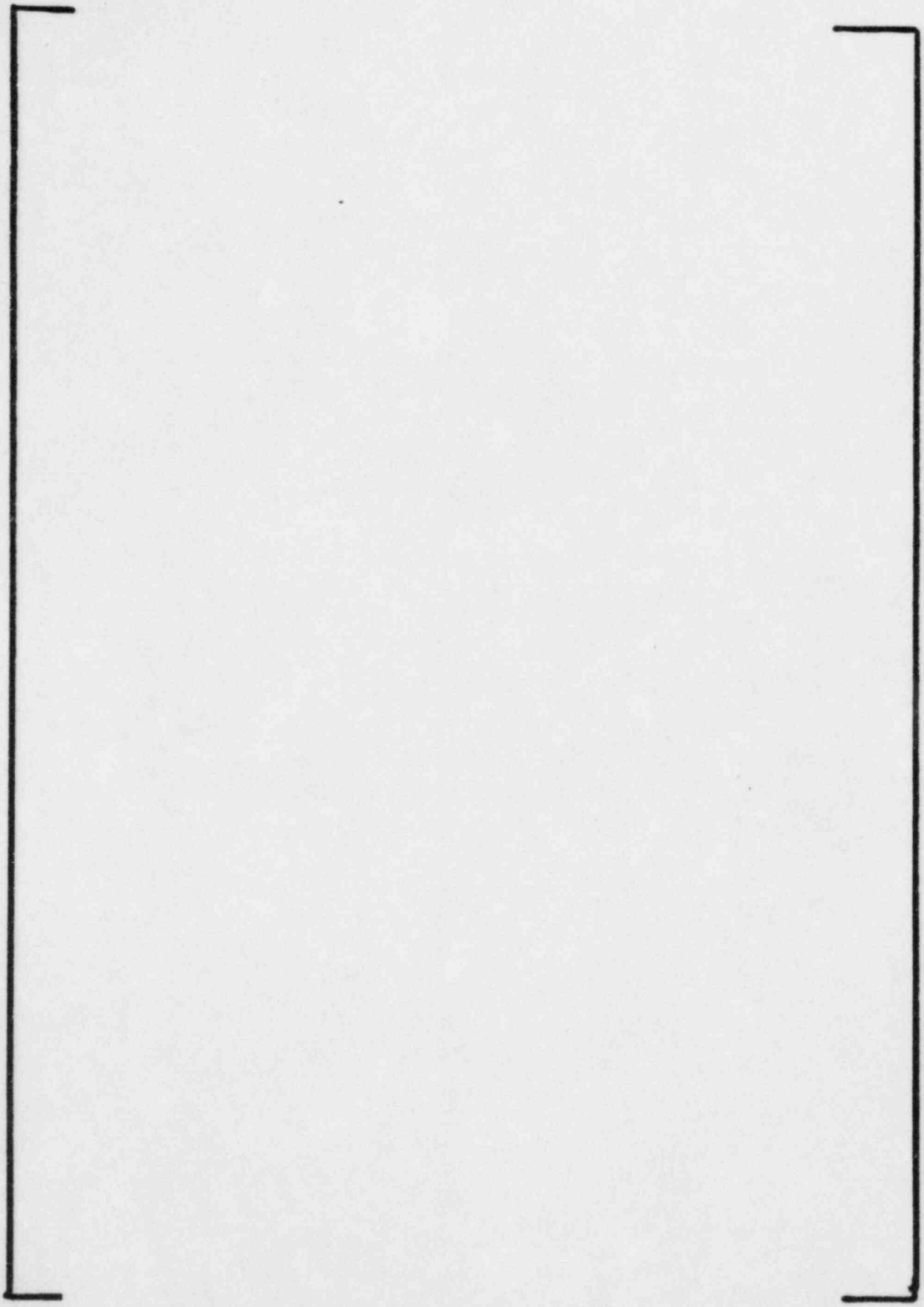
[

]

Description:

[

]



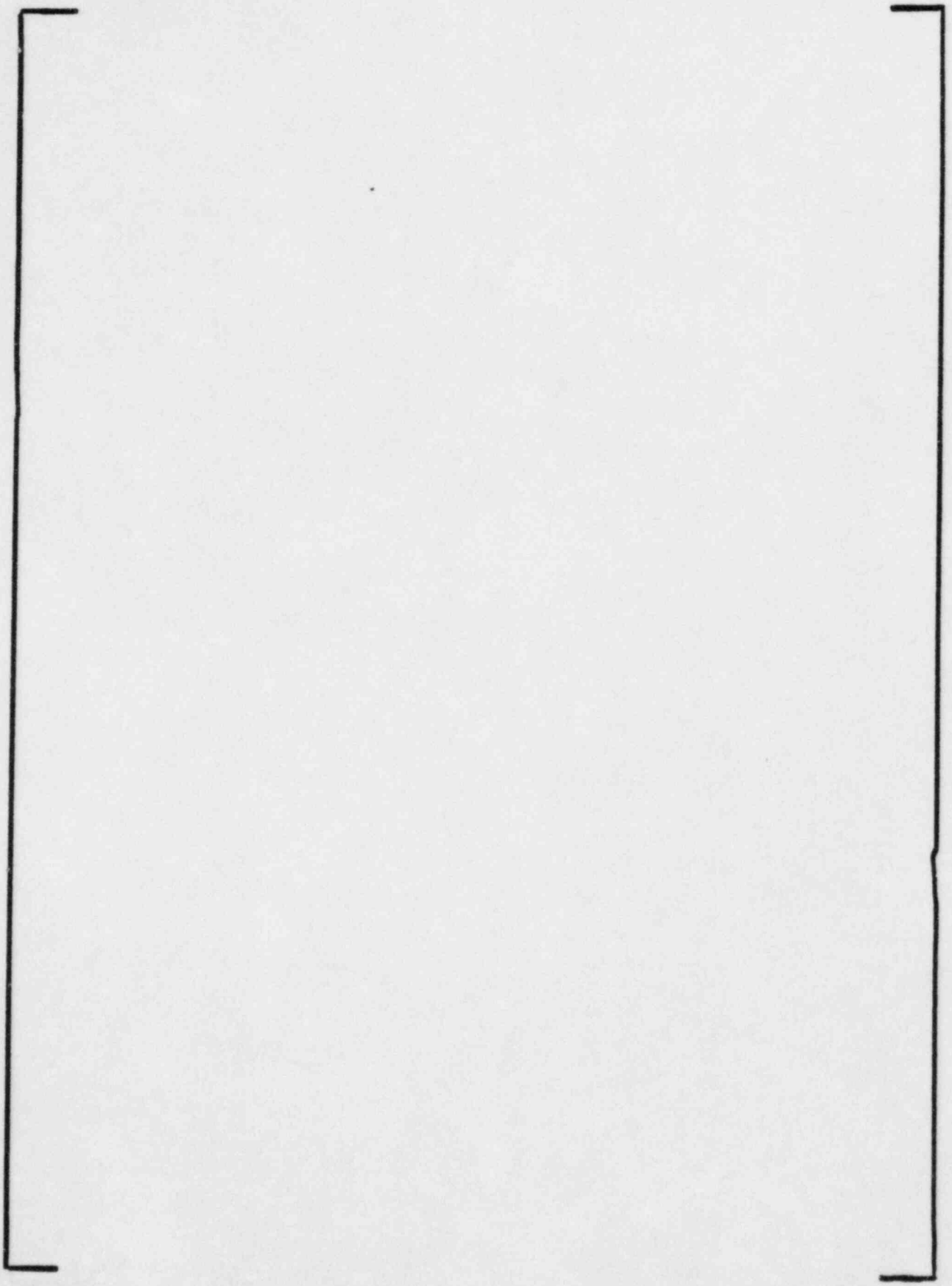
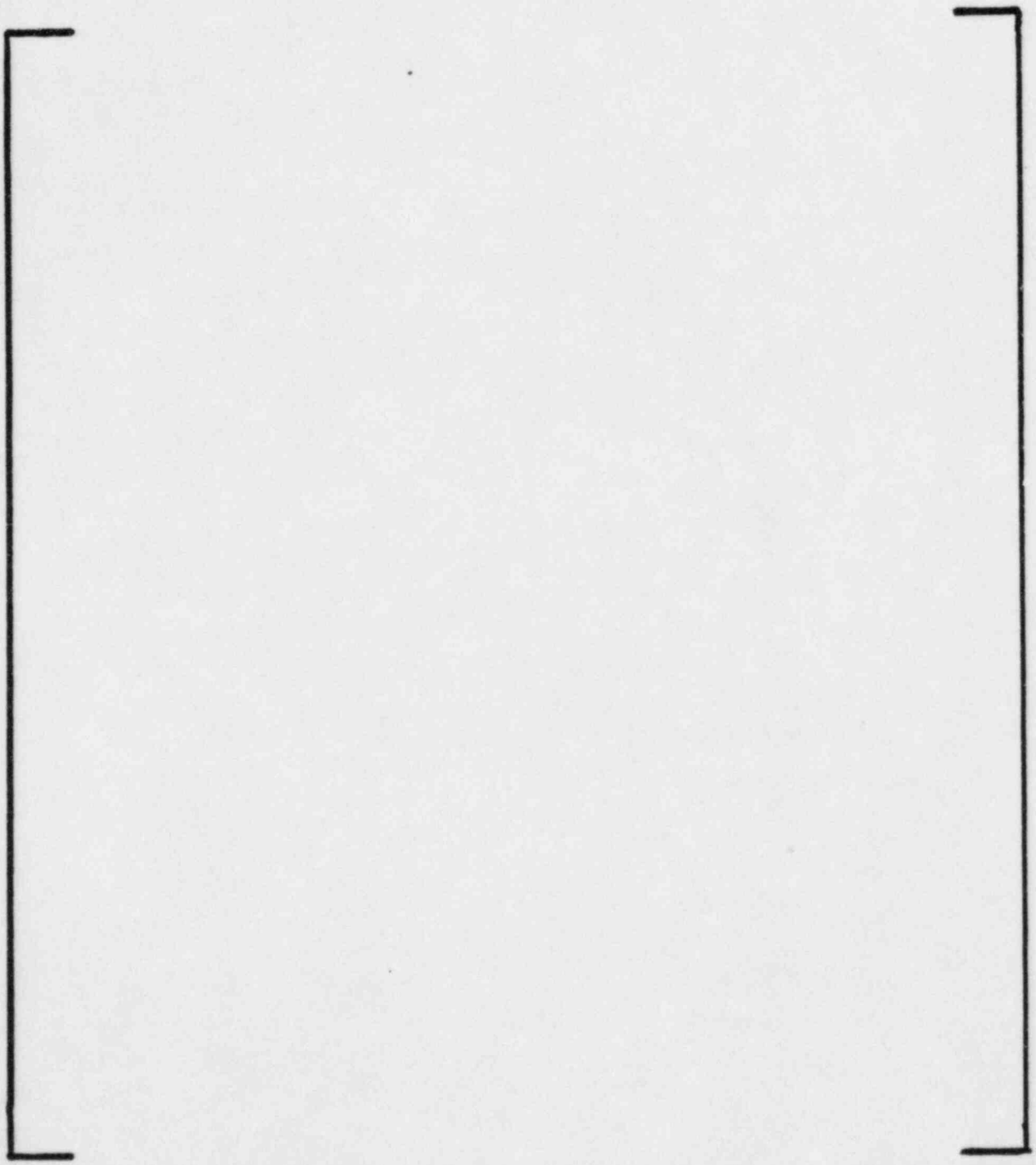


FIGURE 4-2

Cold Leg Temperature

Difference Trip Setpoint Bias vs. Power Level



2.2.3 CEAC Penalty Factor Interpretation

Change

[redacted]

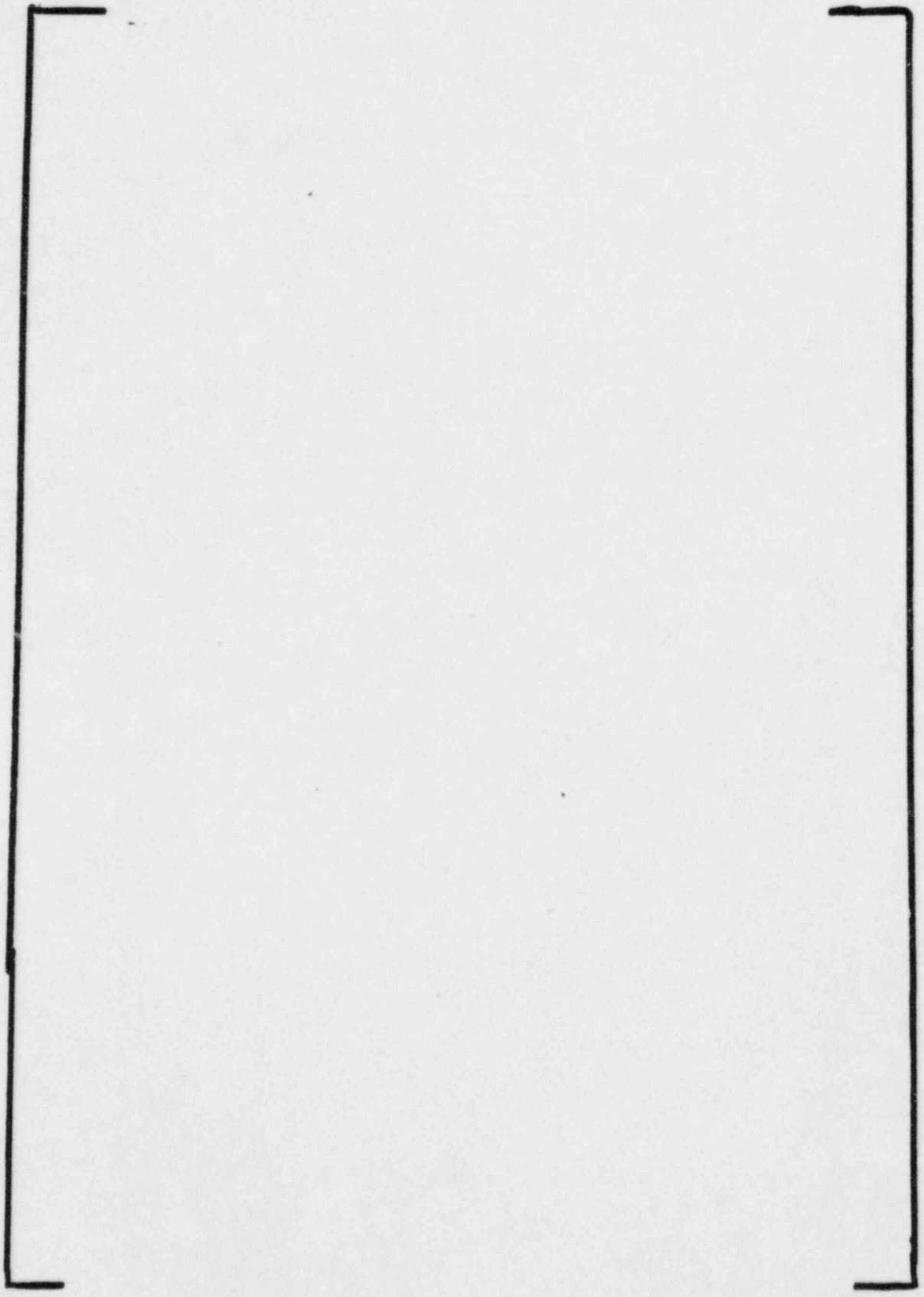
Reasons

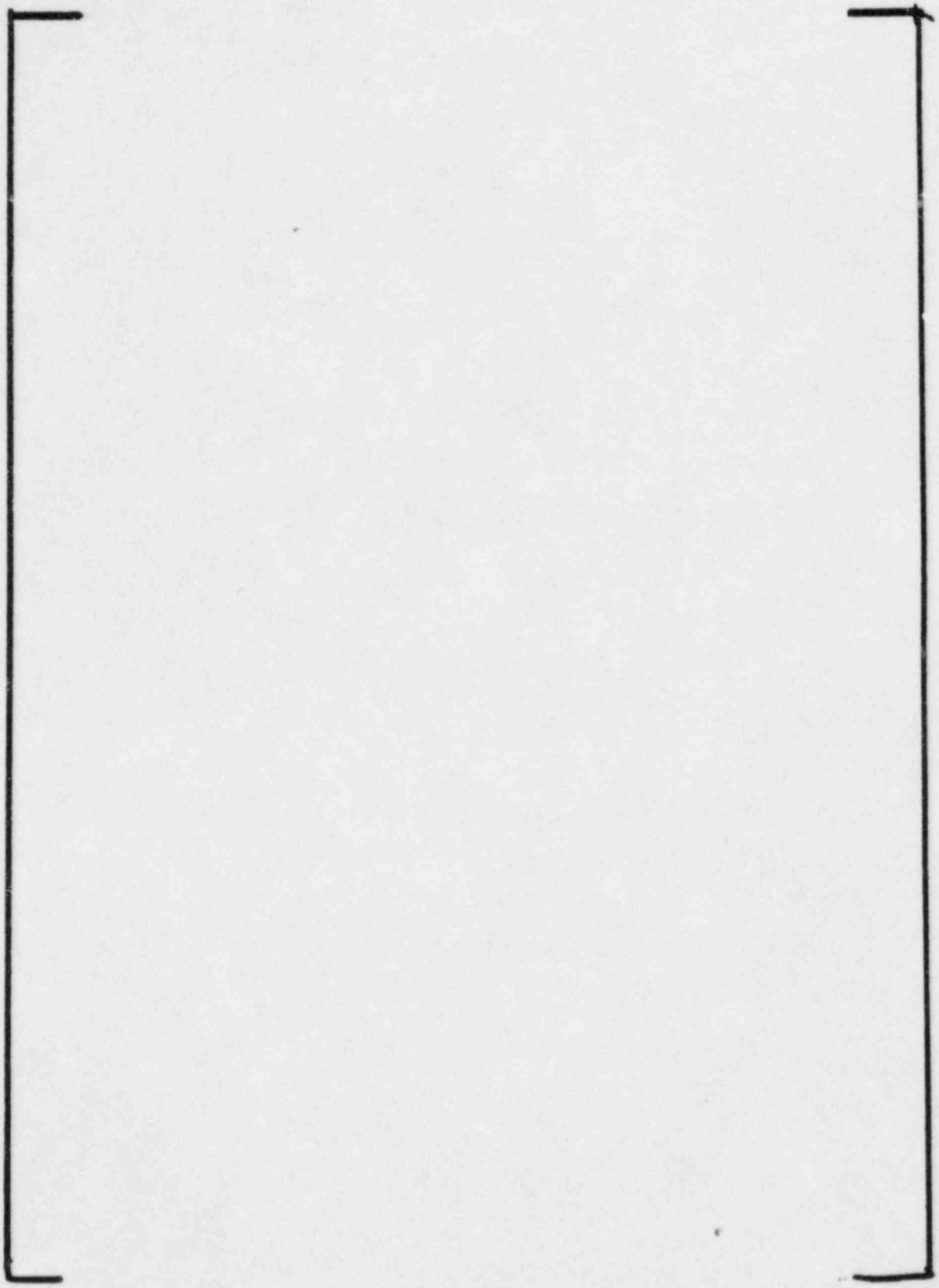
[redacted]

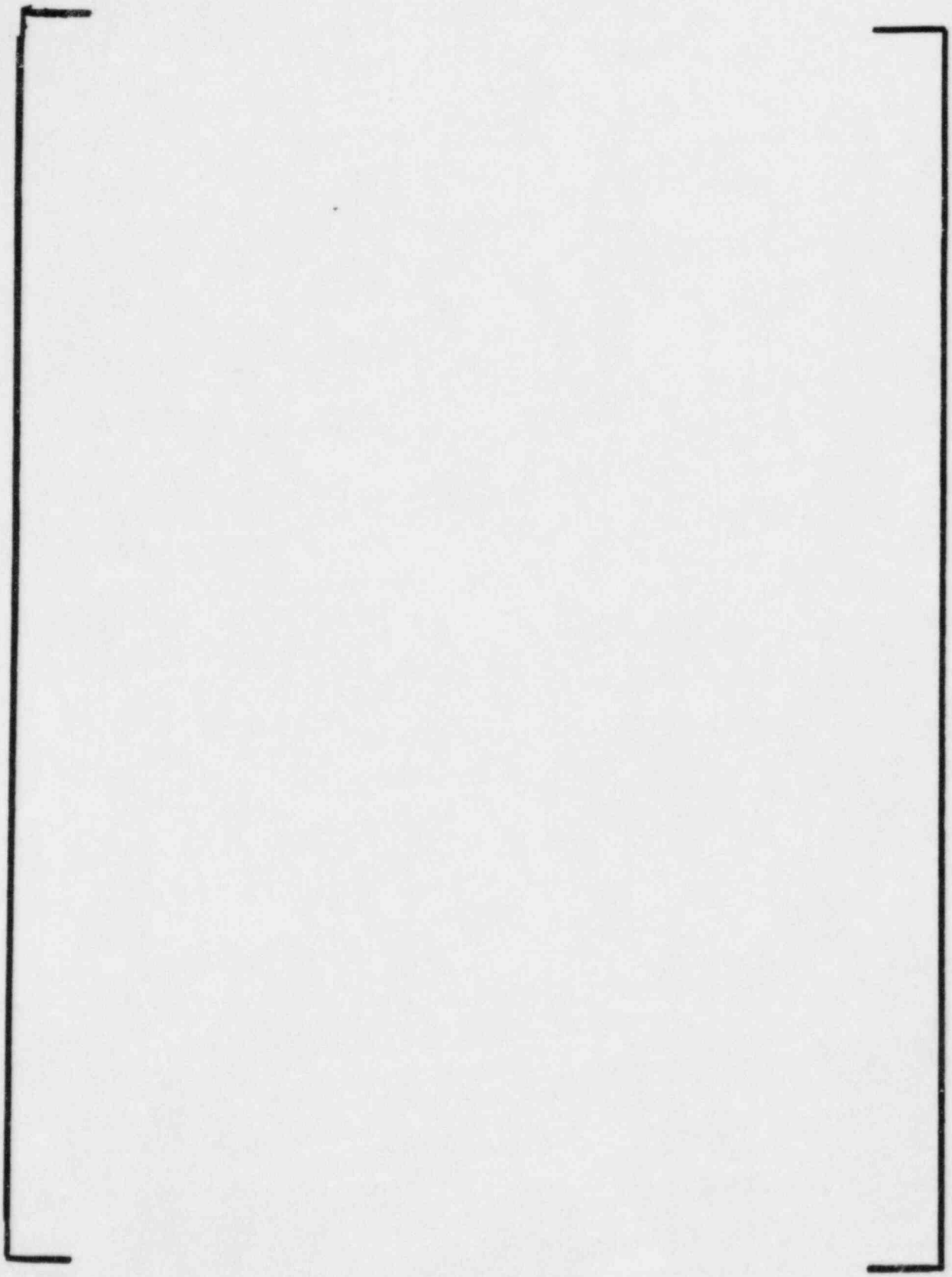
Description:

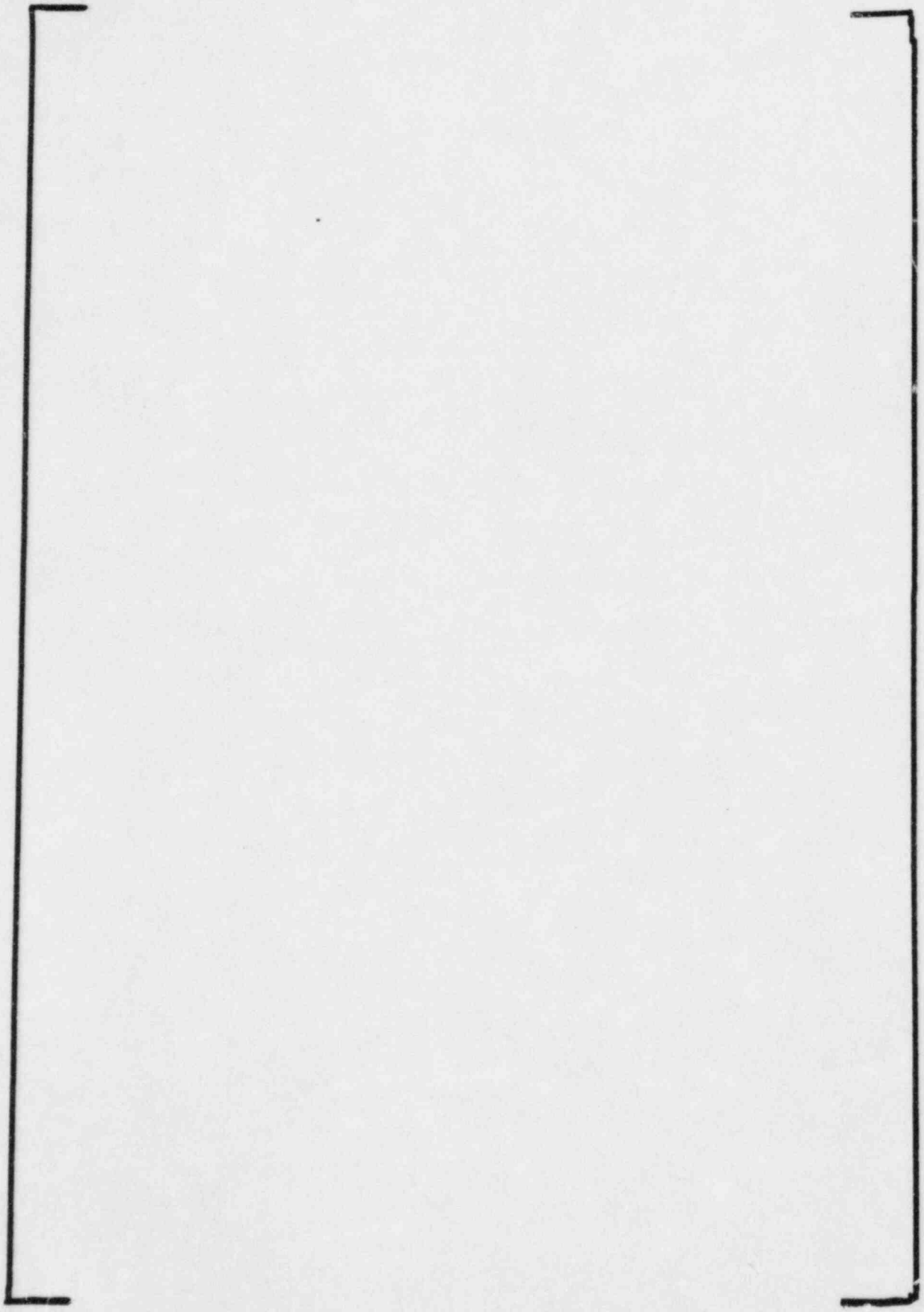
The complete algorithm to determine the DNBR and LPD penalty factors for CEA deviation is described here.

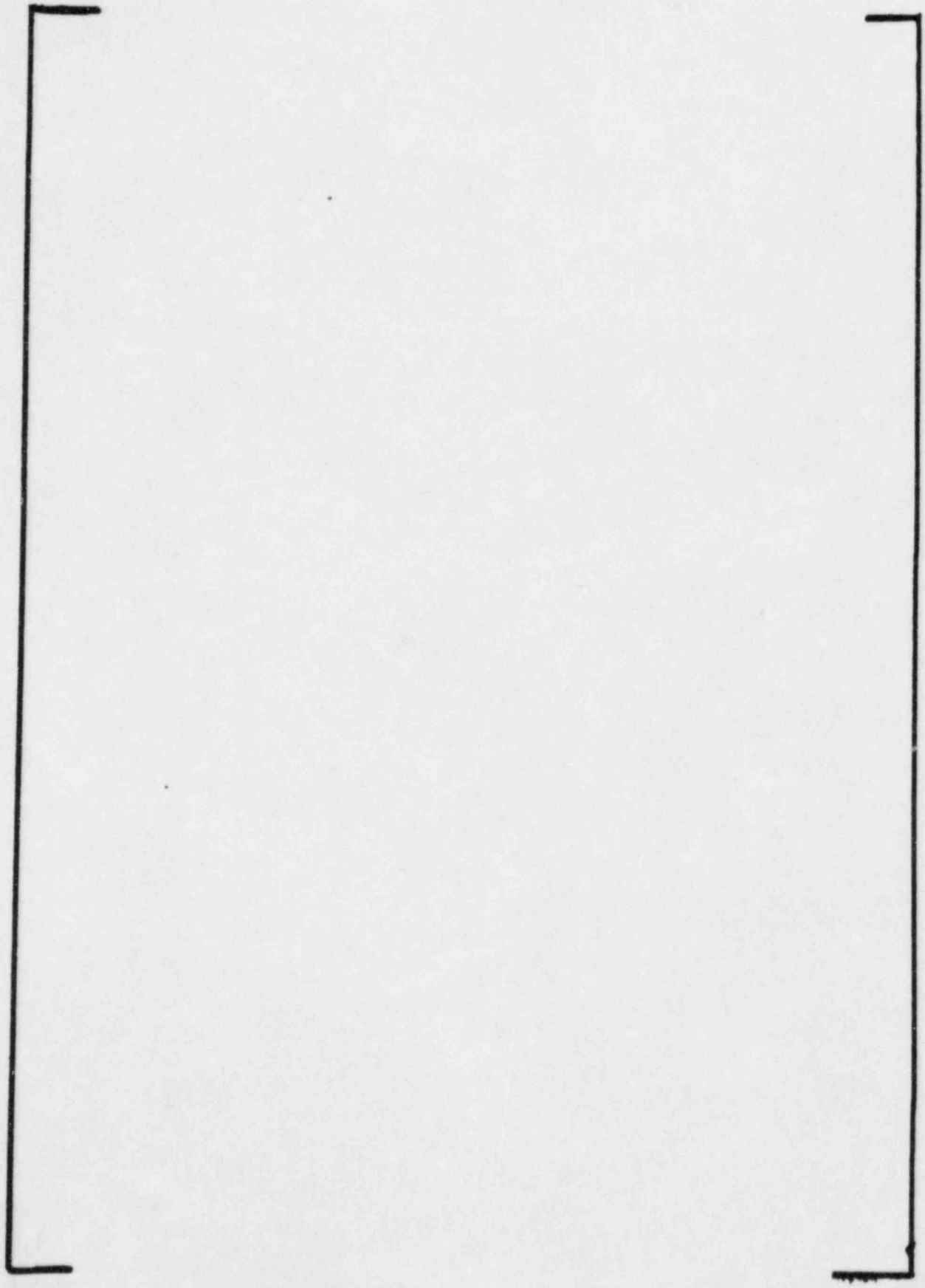
Initialization

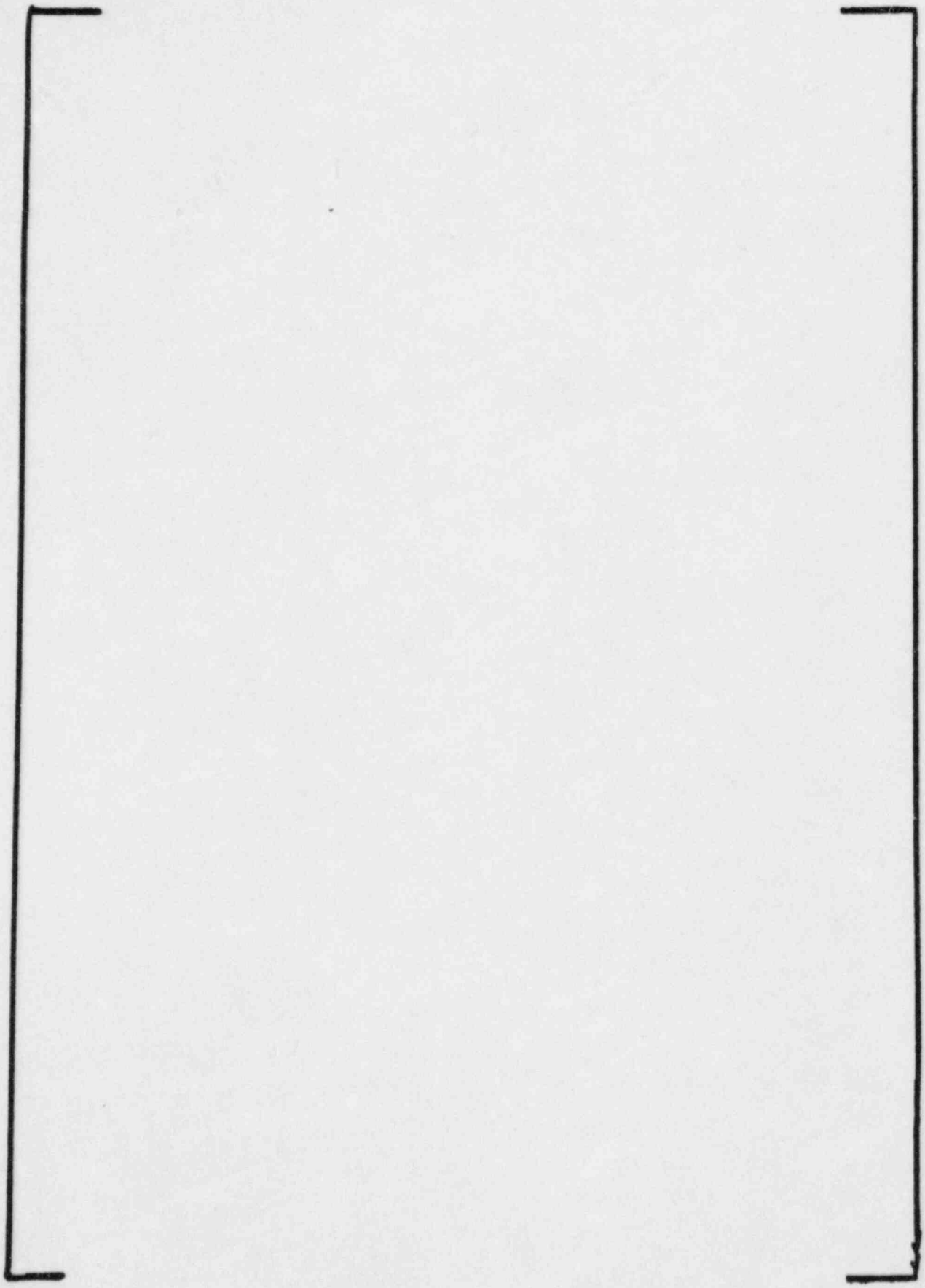


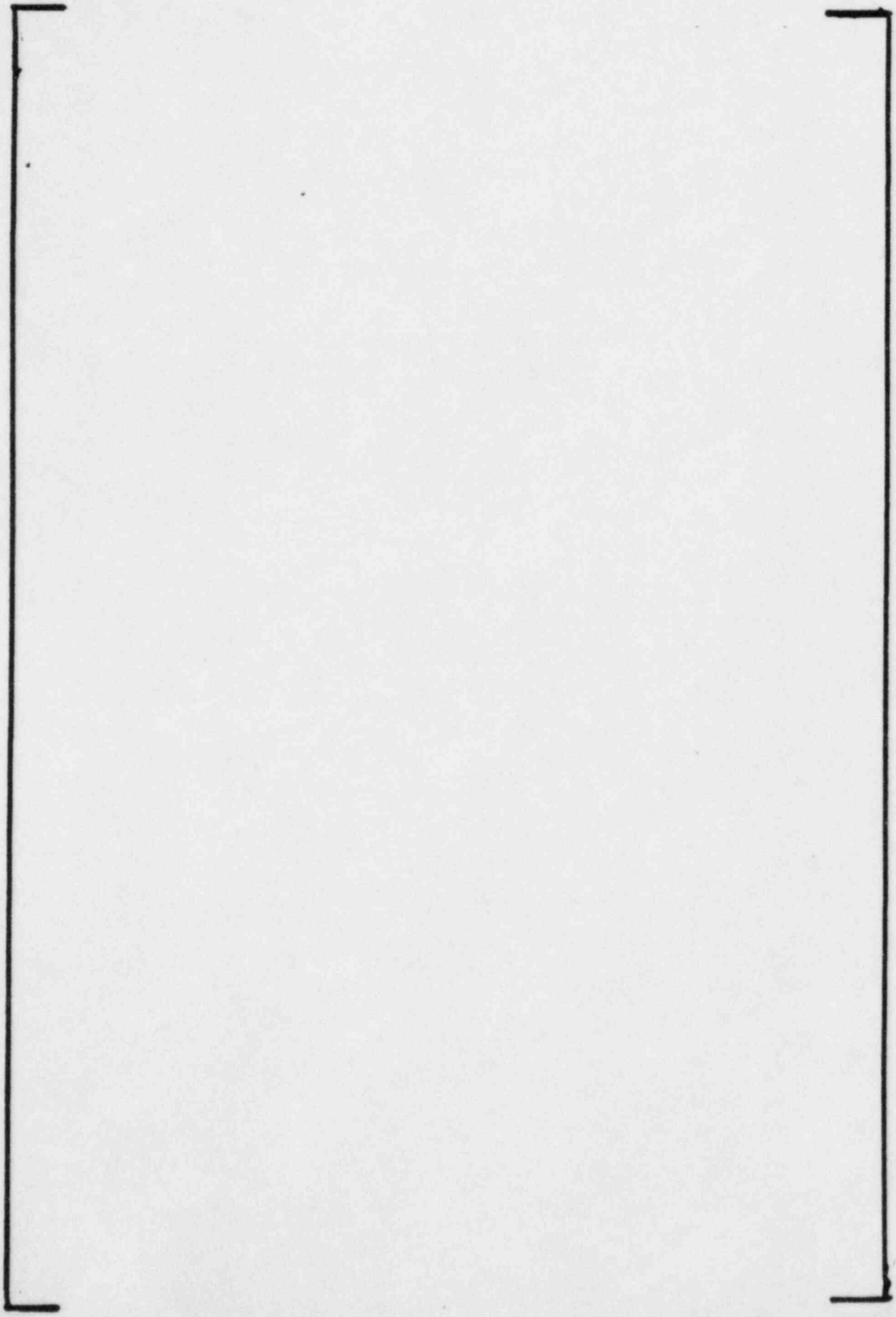


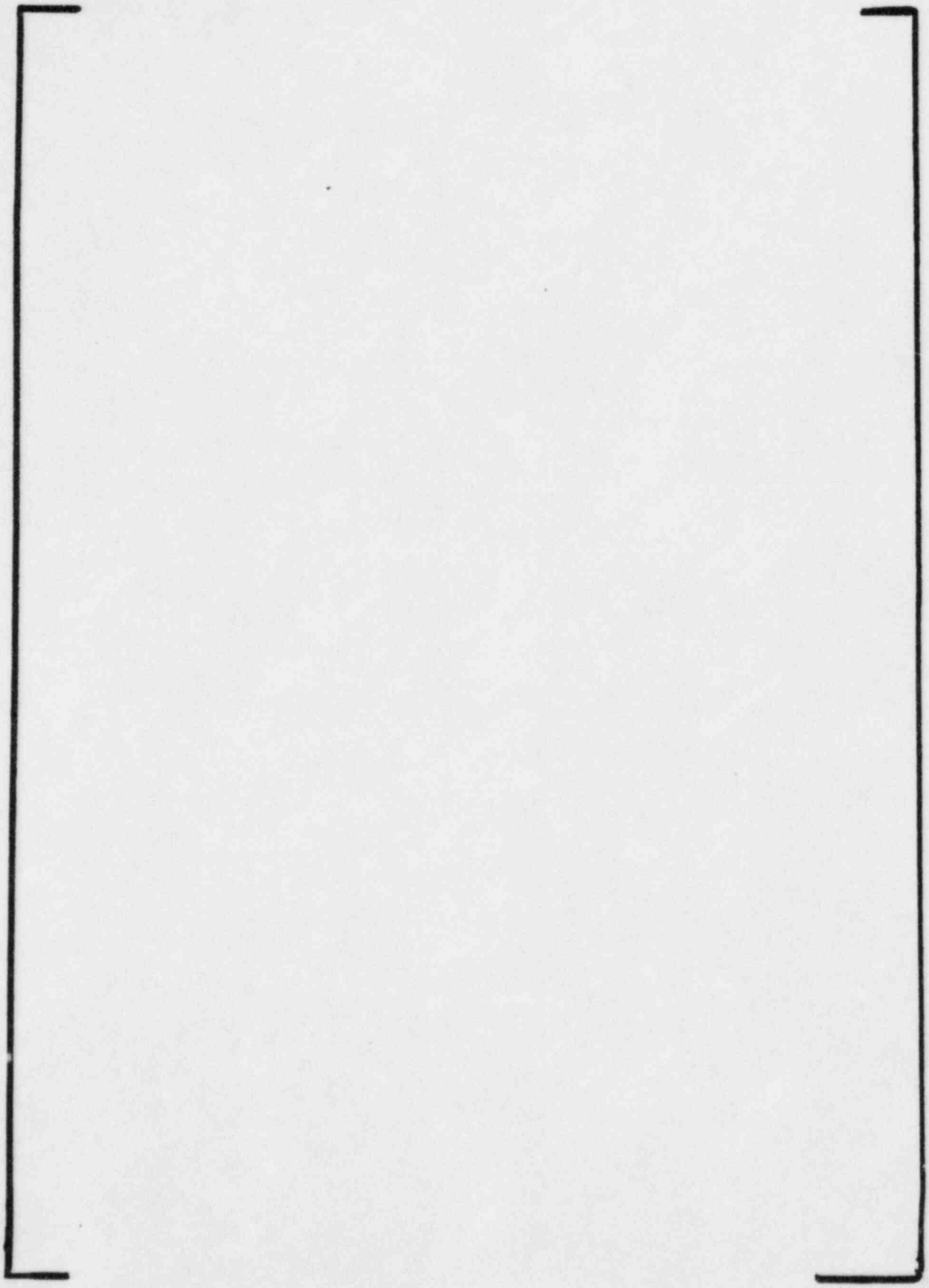


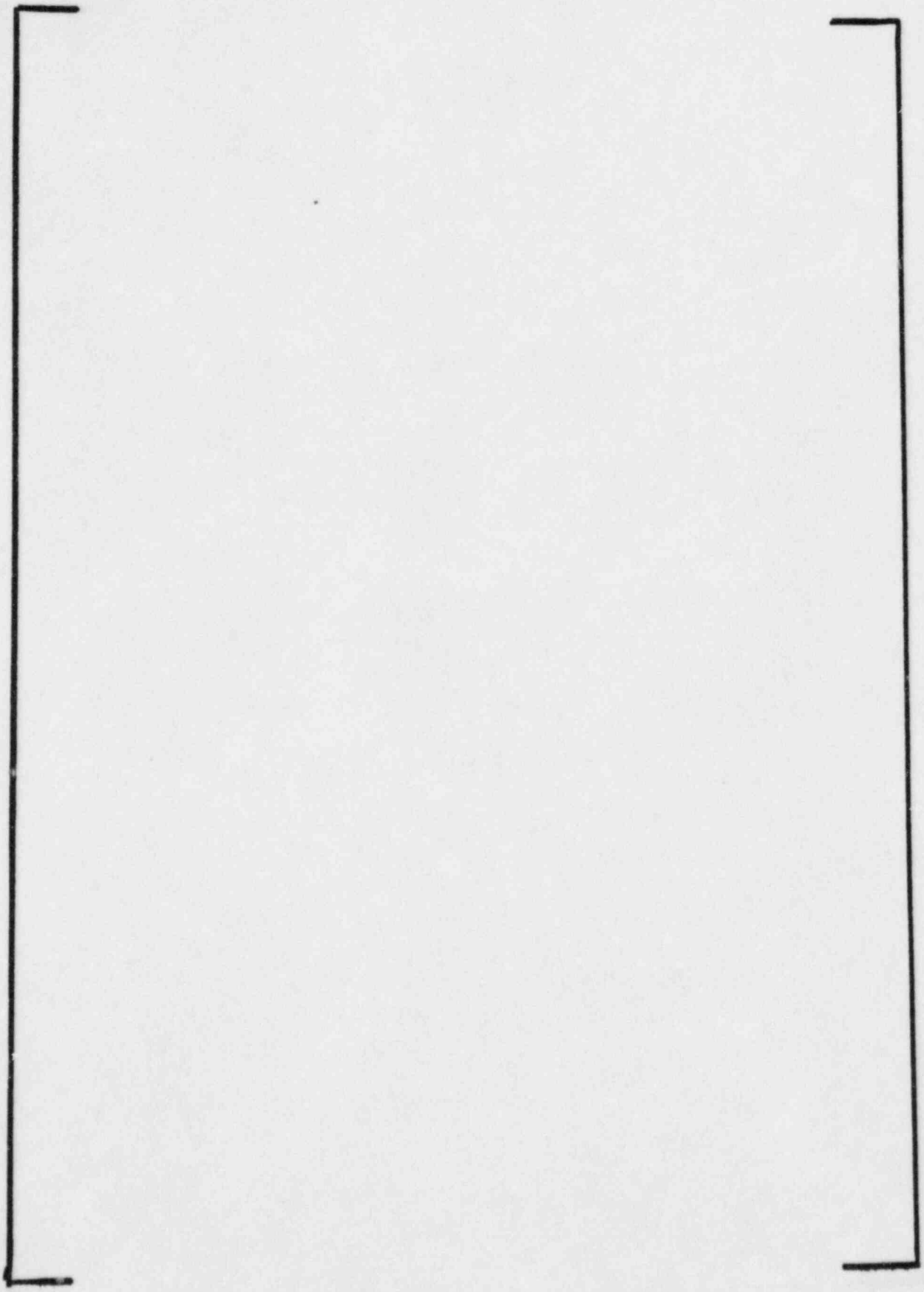


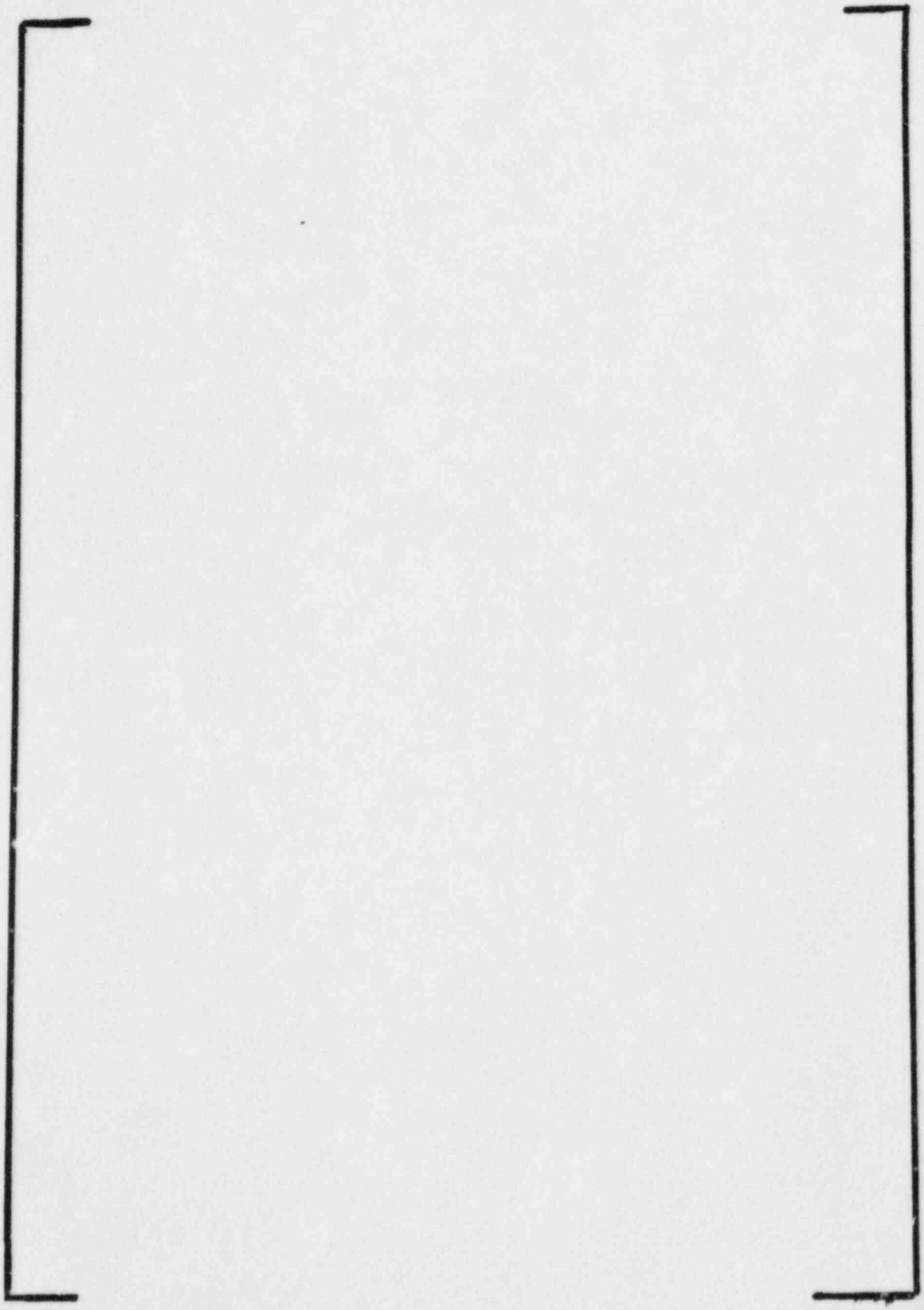


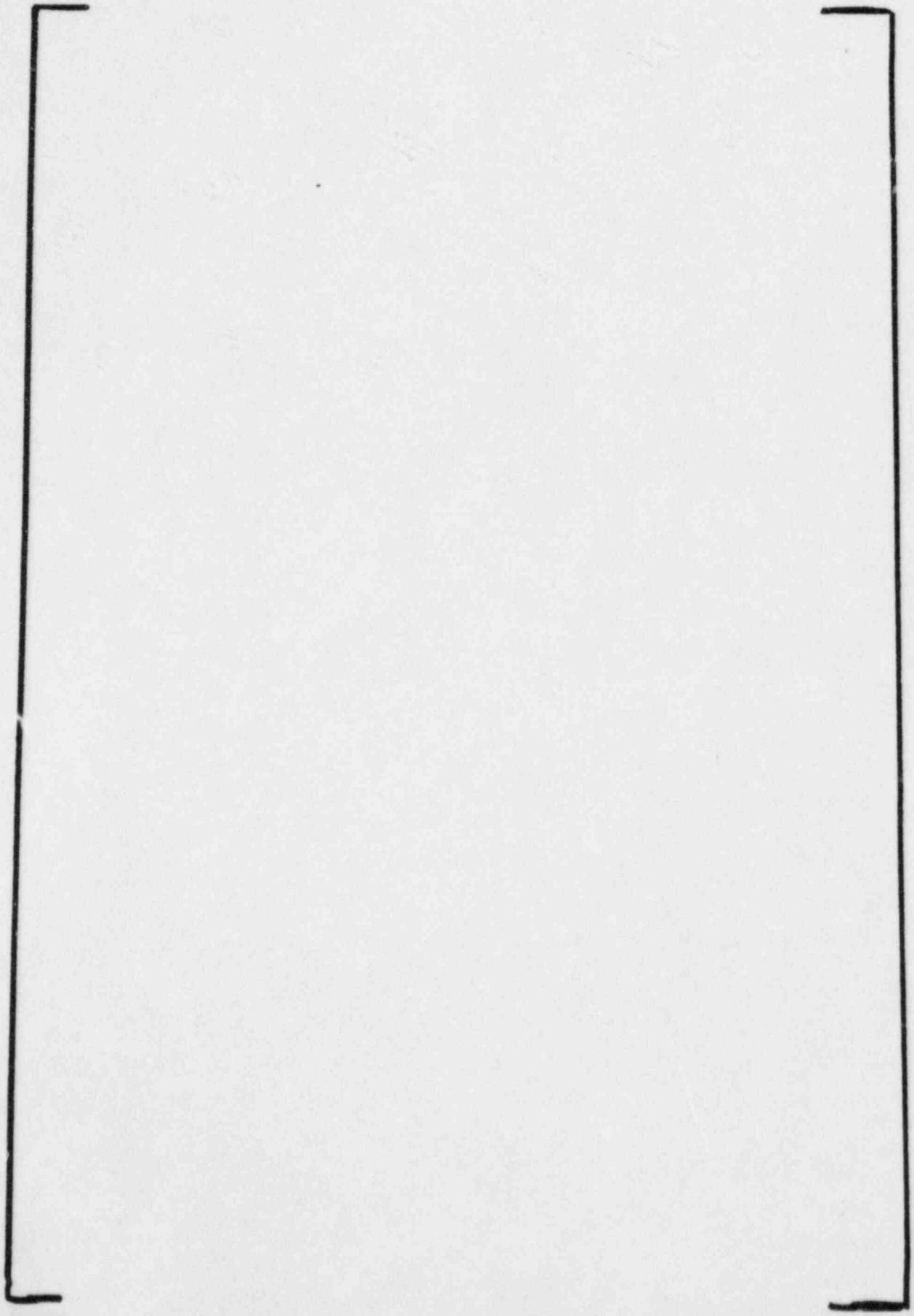


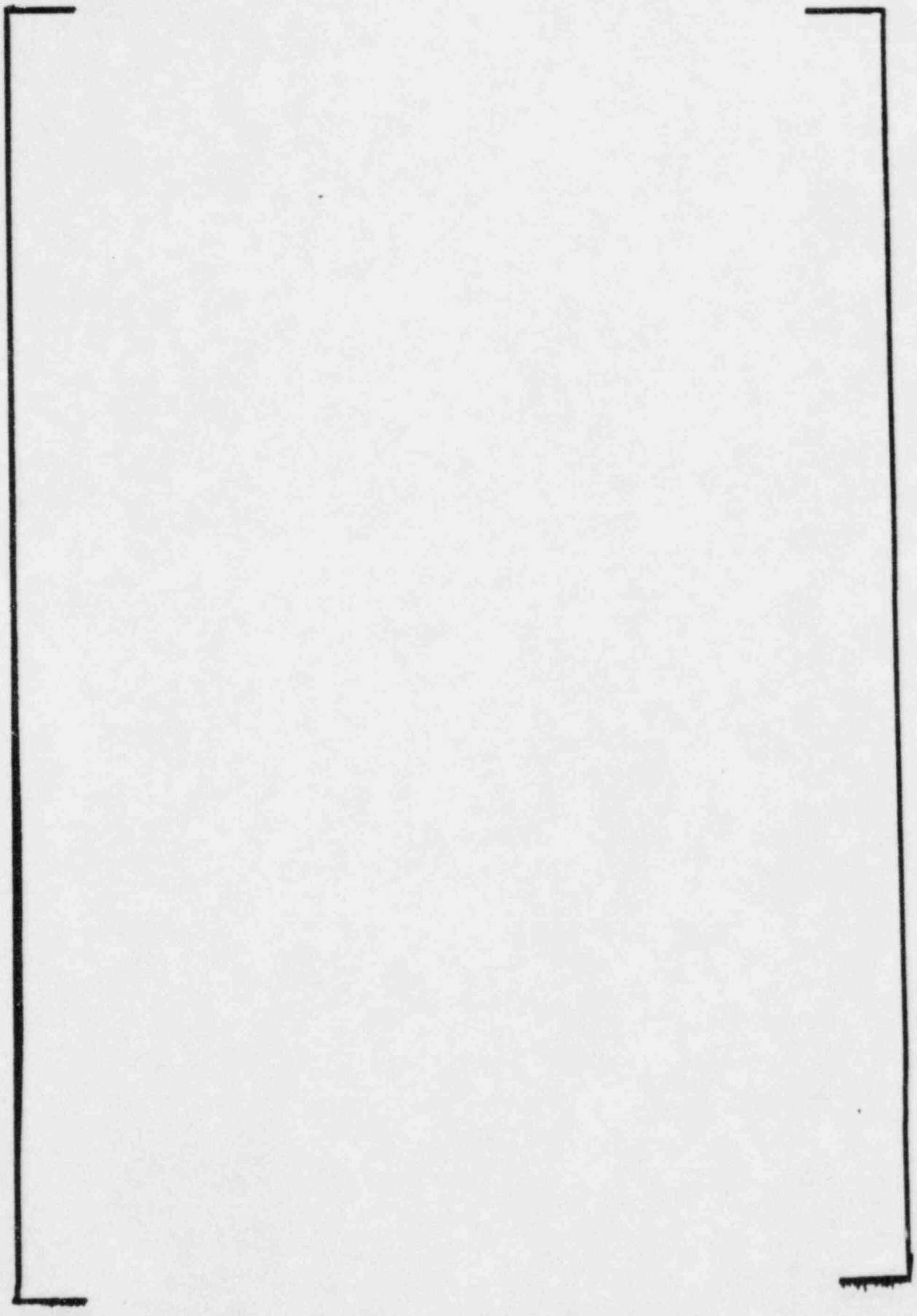












[redacted]

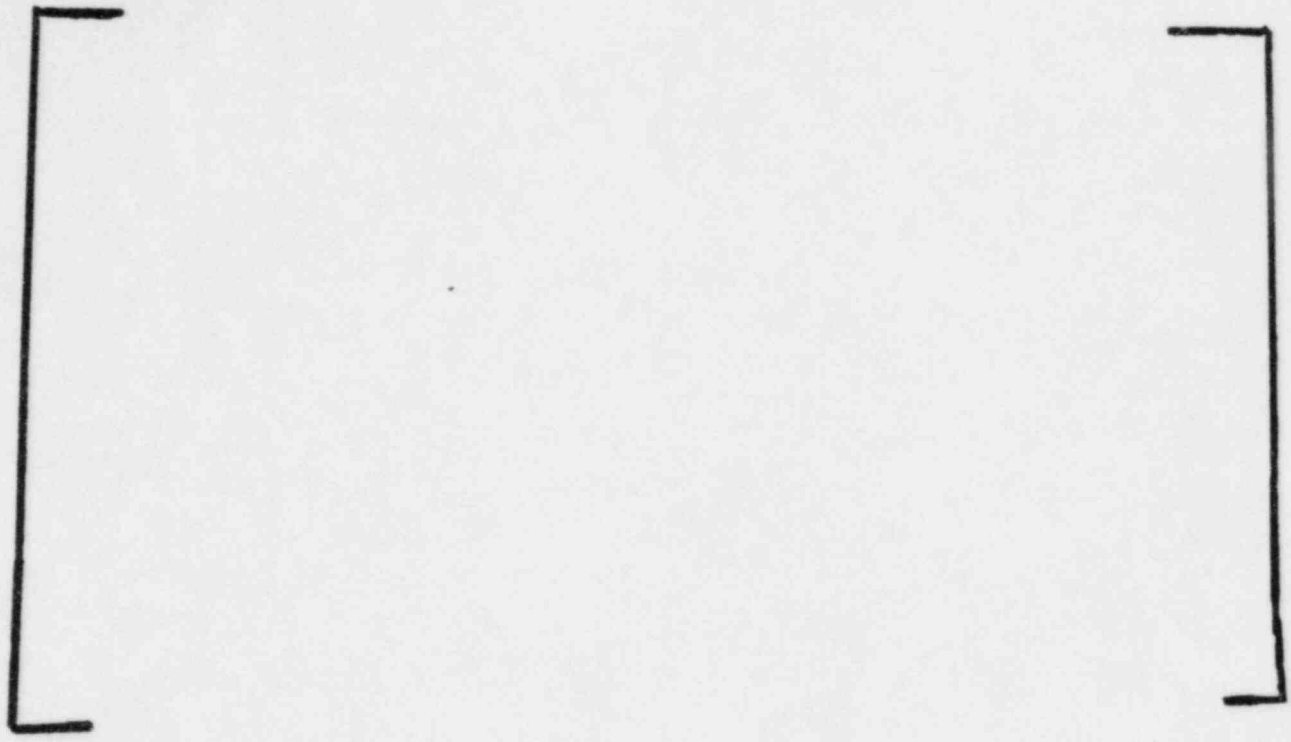
2.2.4 Algorithm Simplification

Changes

[redacted]

Reasons

[redacted]



2.3 MODIFICATIONS TO POWER ALGORITHM

2.3.1 Power Synthesis

Change

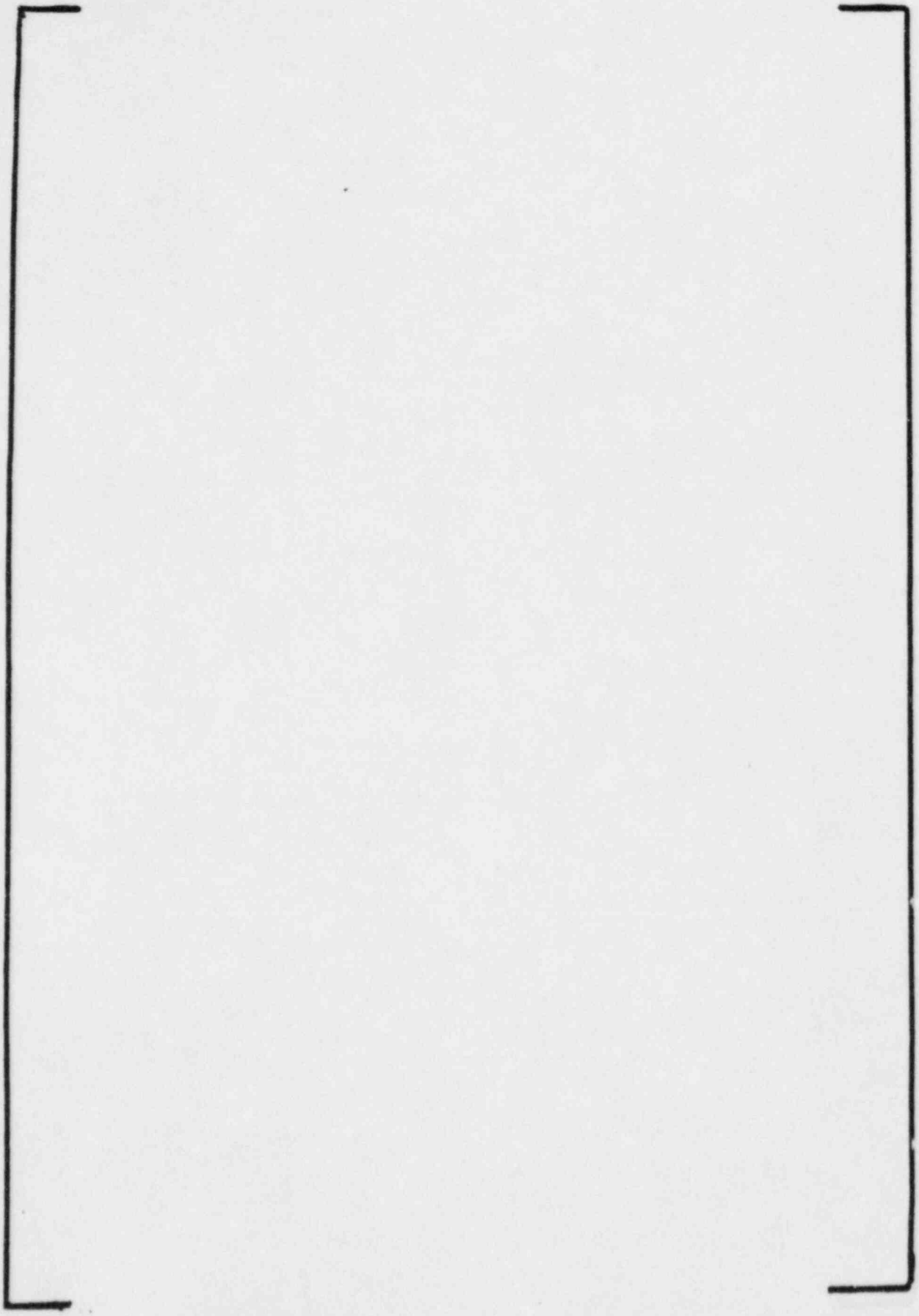
[ ]

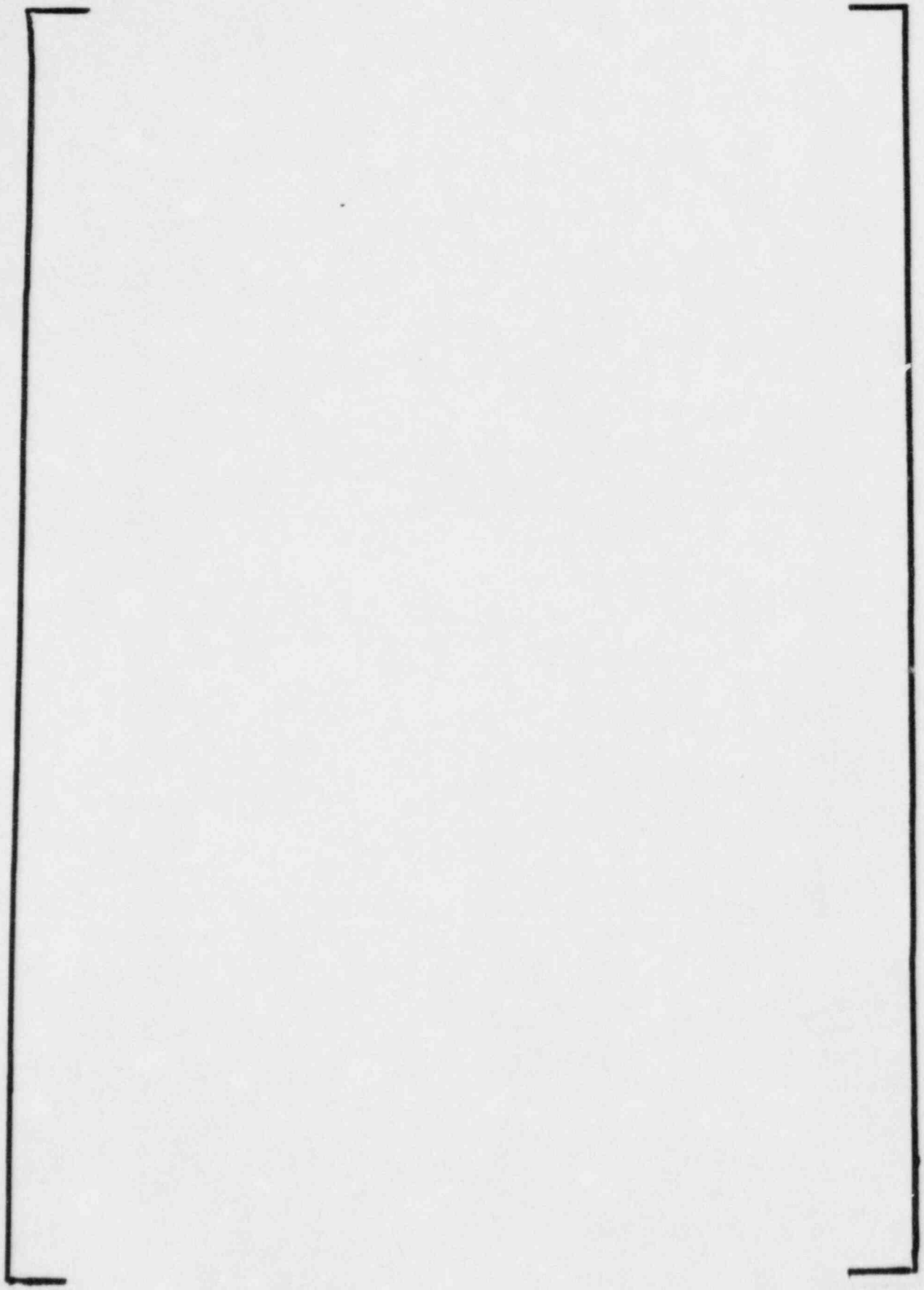
Reason

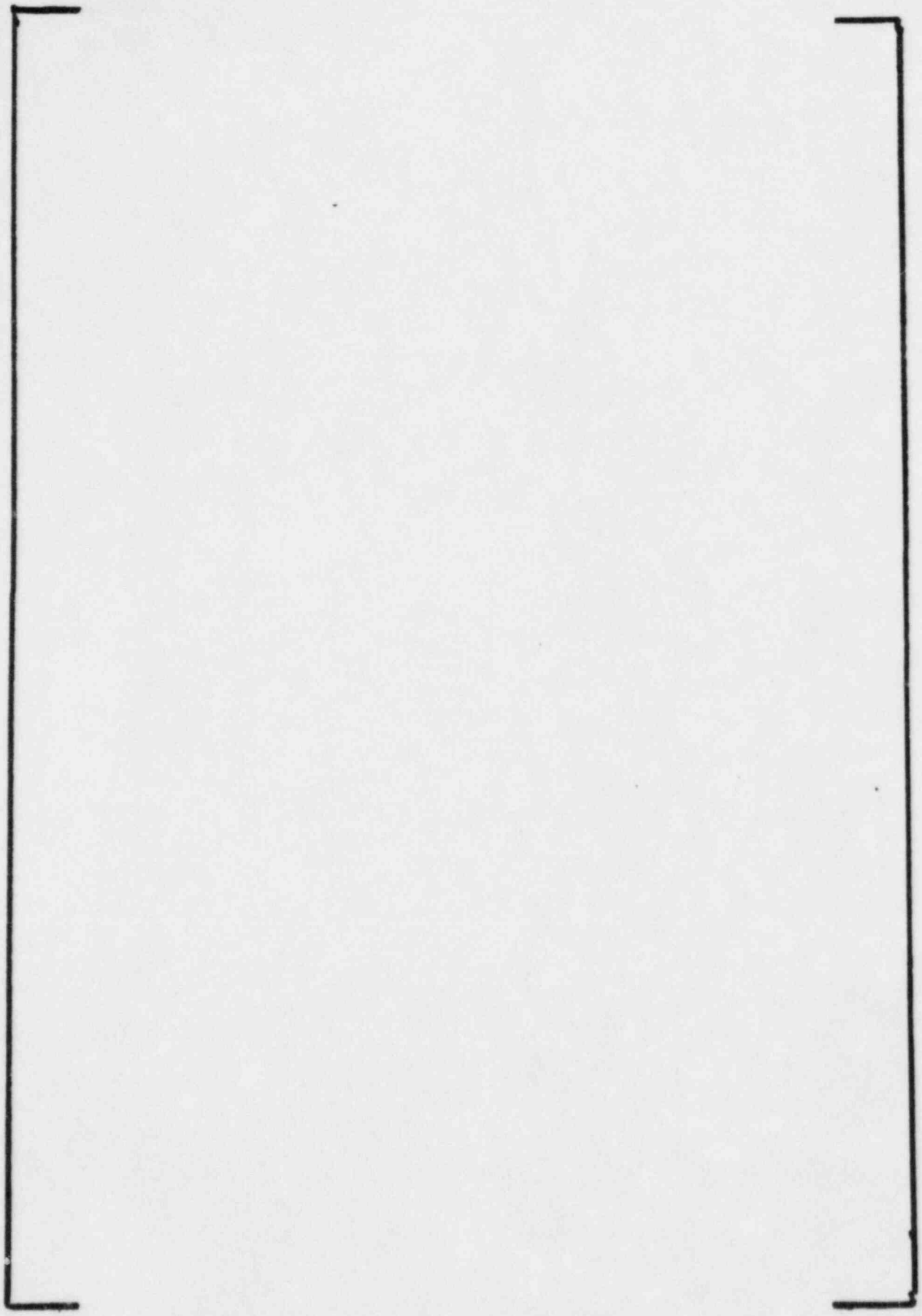
[redacted]

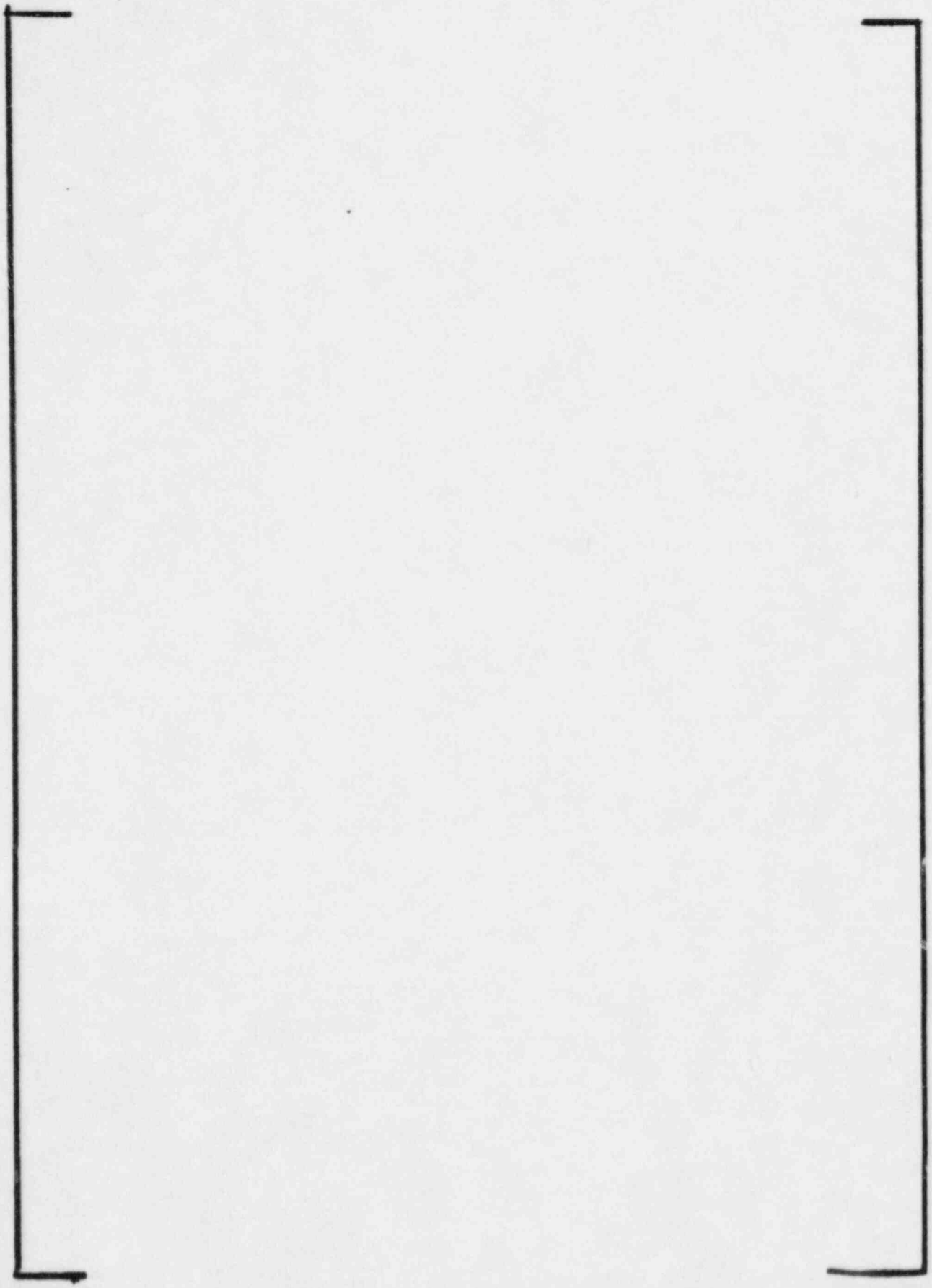
Description

[redacted]









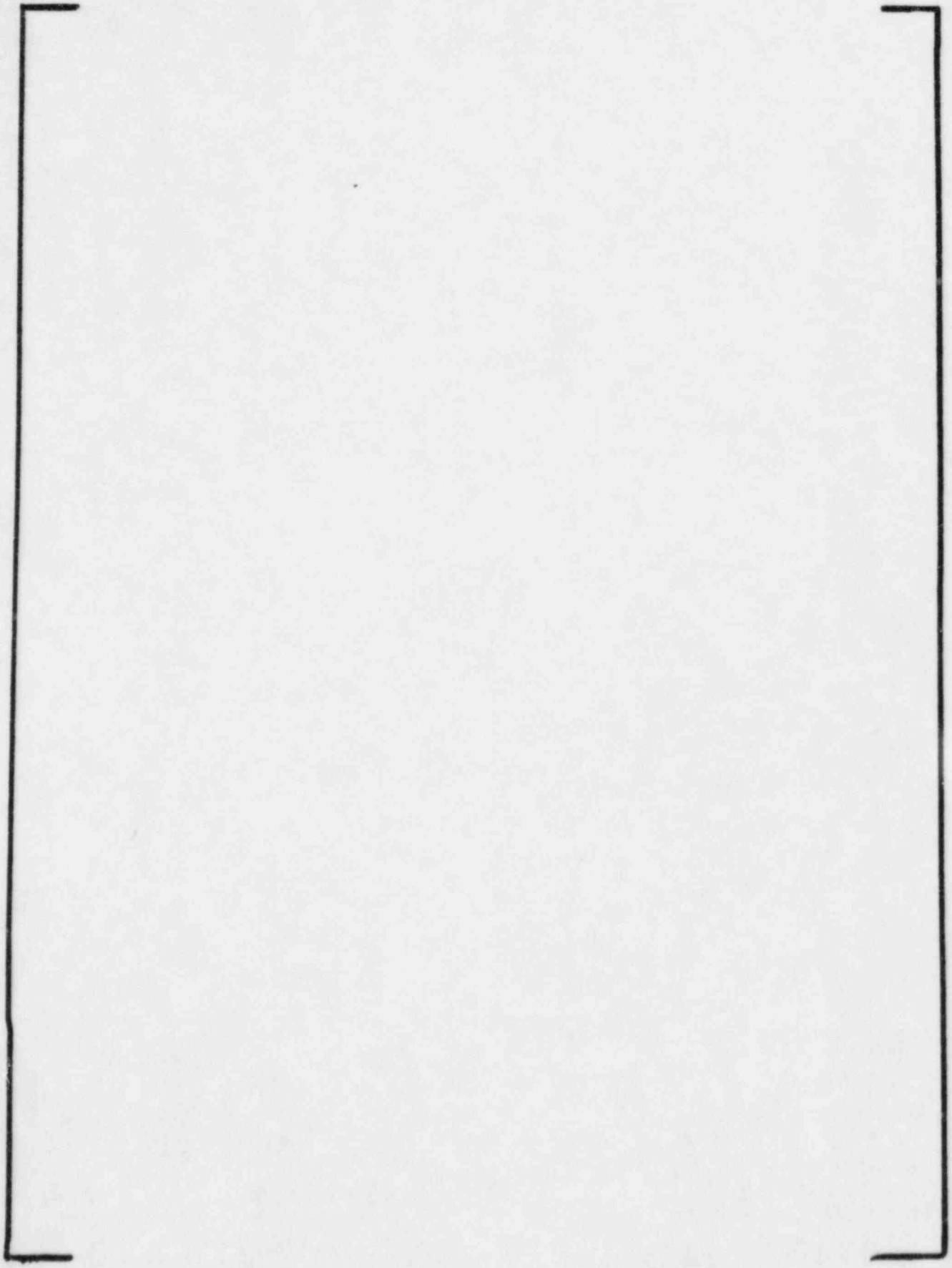


TABLE 1

Core Spline Regions

Region	Non-Zero Spline Function
1	1, 2, 3, 4
2	2, 3, 4, 5
3	3, 4, 5, 6
4	4, 5, 6, 7

[

]

2.3.2 ASI Dependent Parameters

Change

[

]

Reason

[

]

Description

[

]

[ ]

2.3.3 ASI Calculation

Change

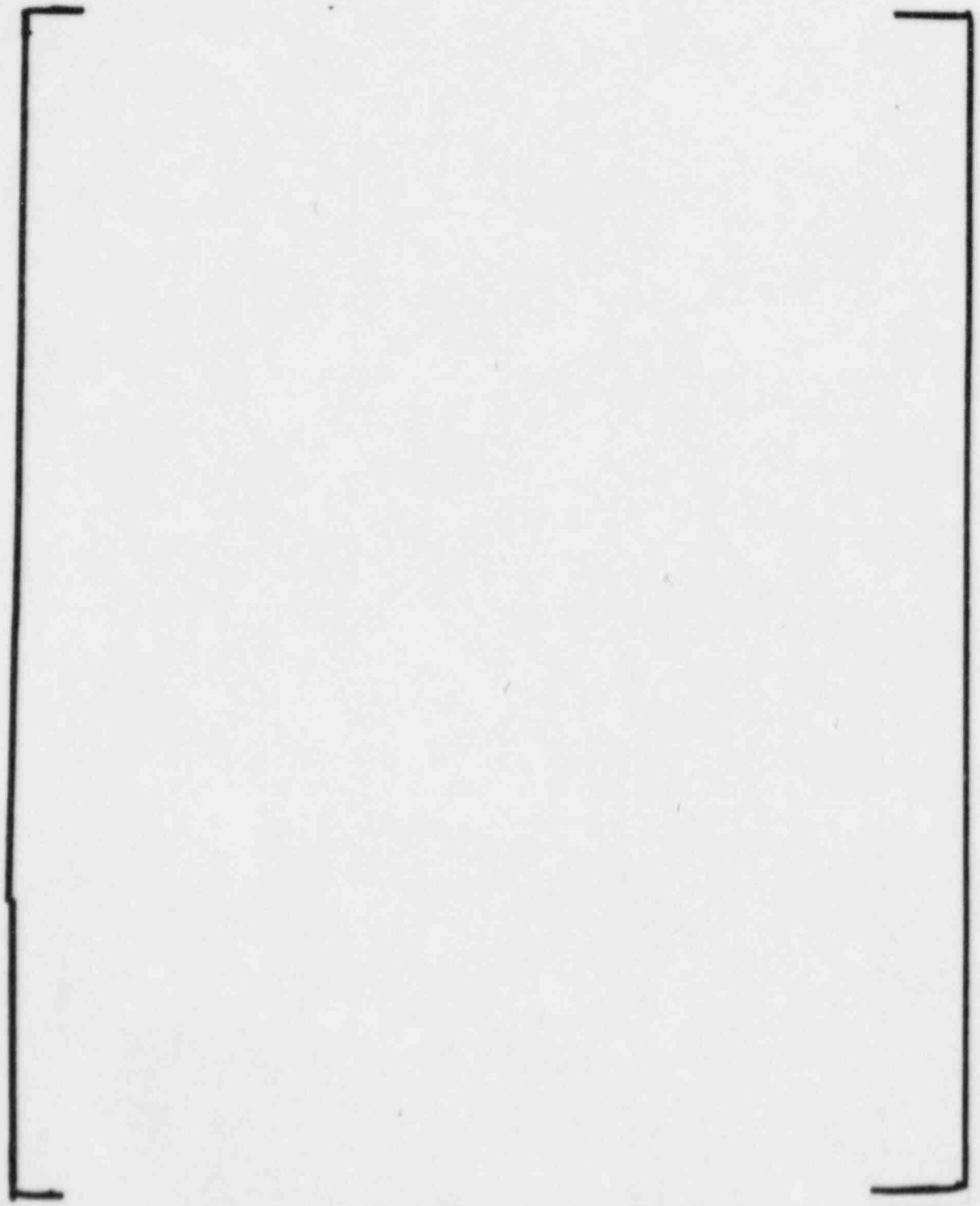
[ ]

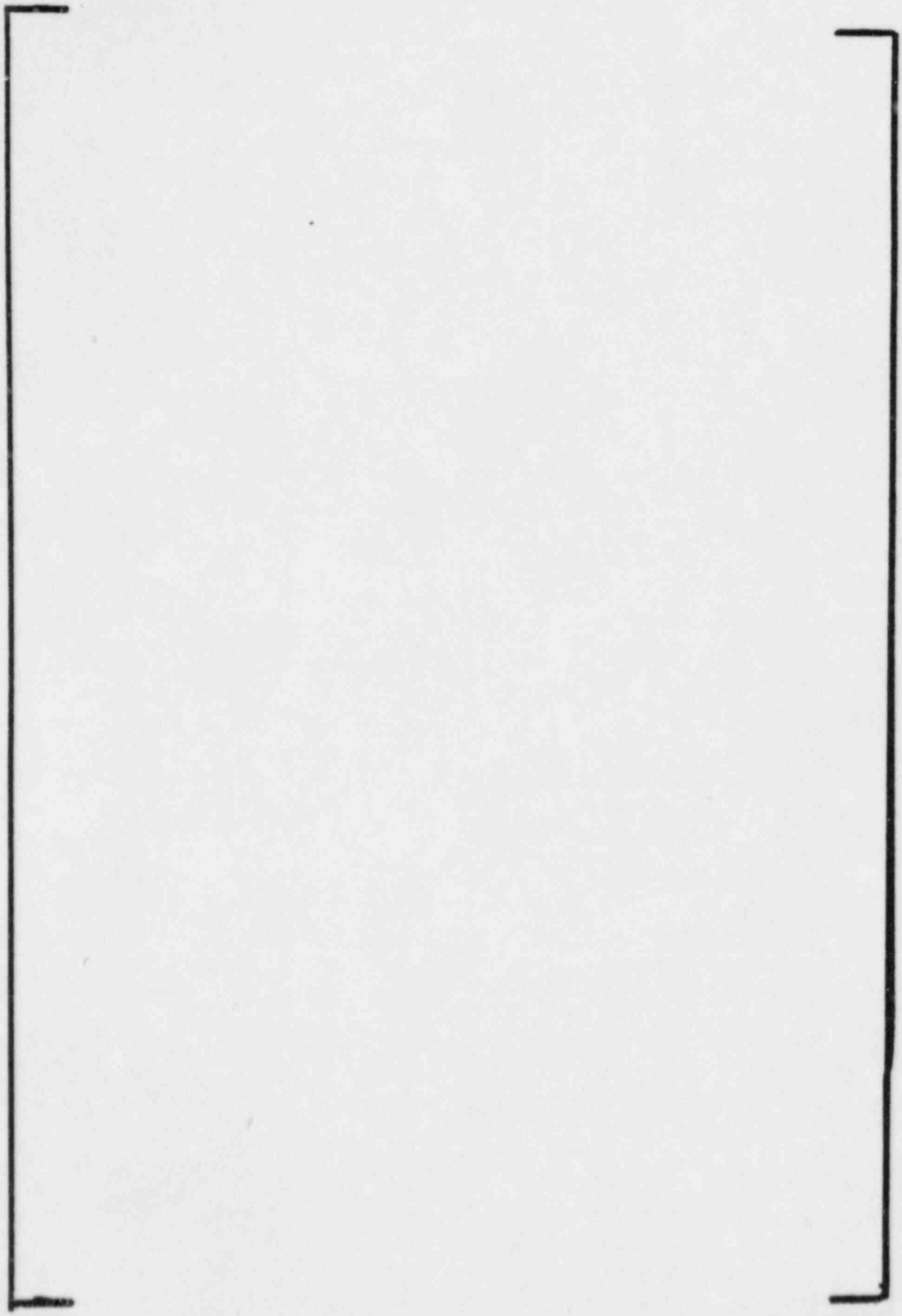
Reason

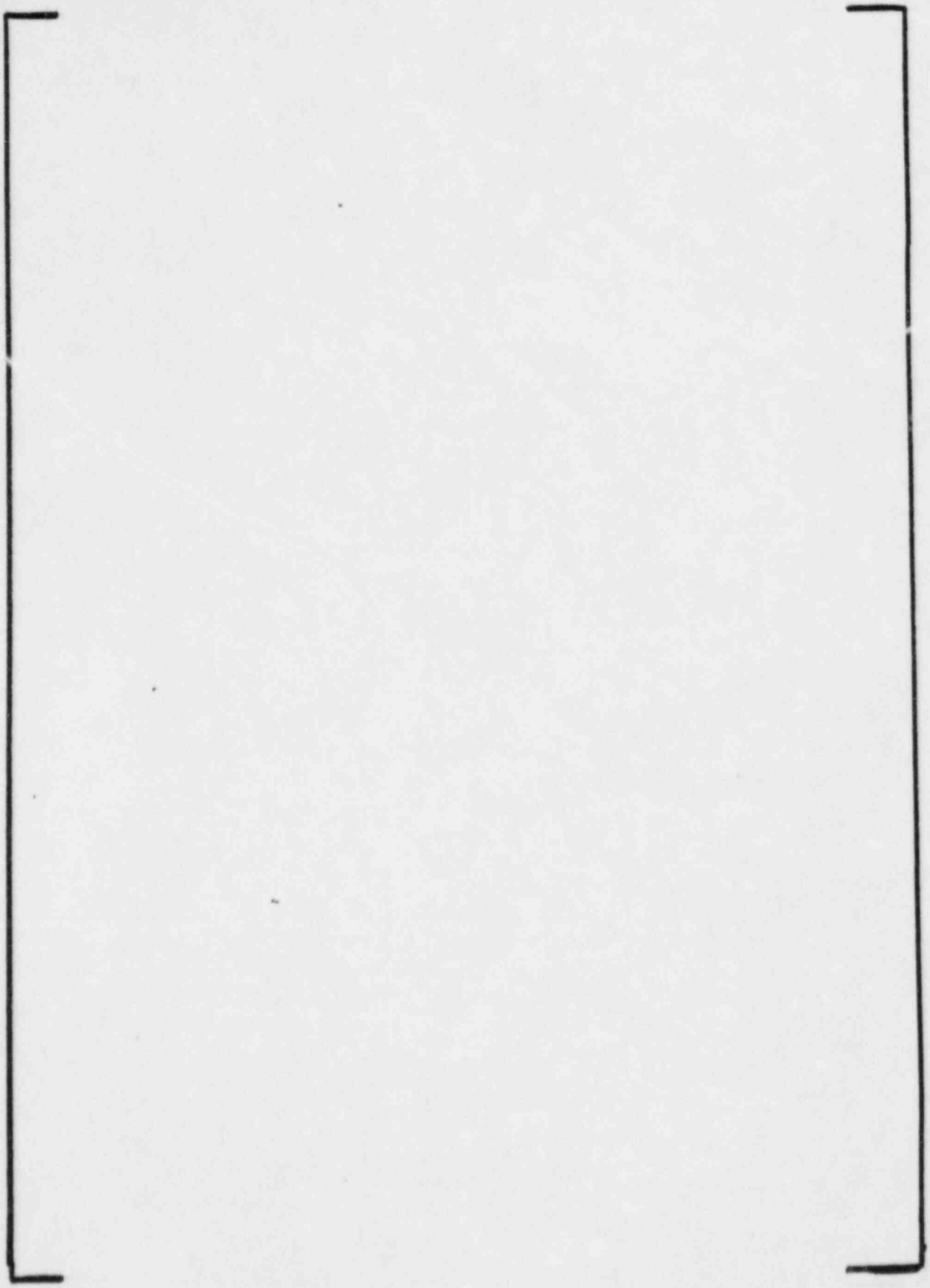
[ ]

modification will permit monitoring of the calculated ASI at power levels below the point where the fixed axial power distribution is used in the calculations.

Description







[redacted]

2.3.4 Elimination of the Augmentation Factor Array

Change

[redacted]

Reason

[redacted]

Description

[redacted]

2.3.5 CEAC Desensitization

Change

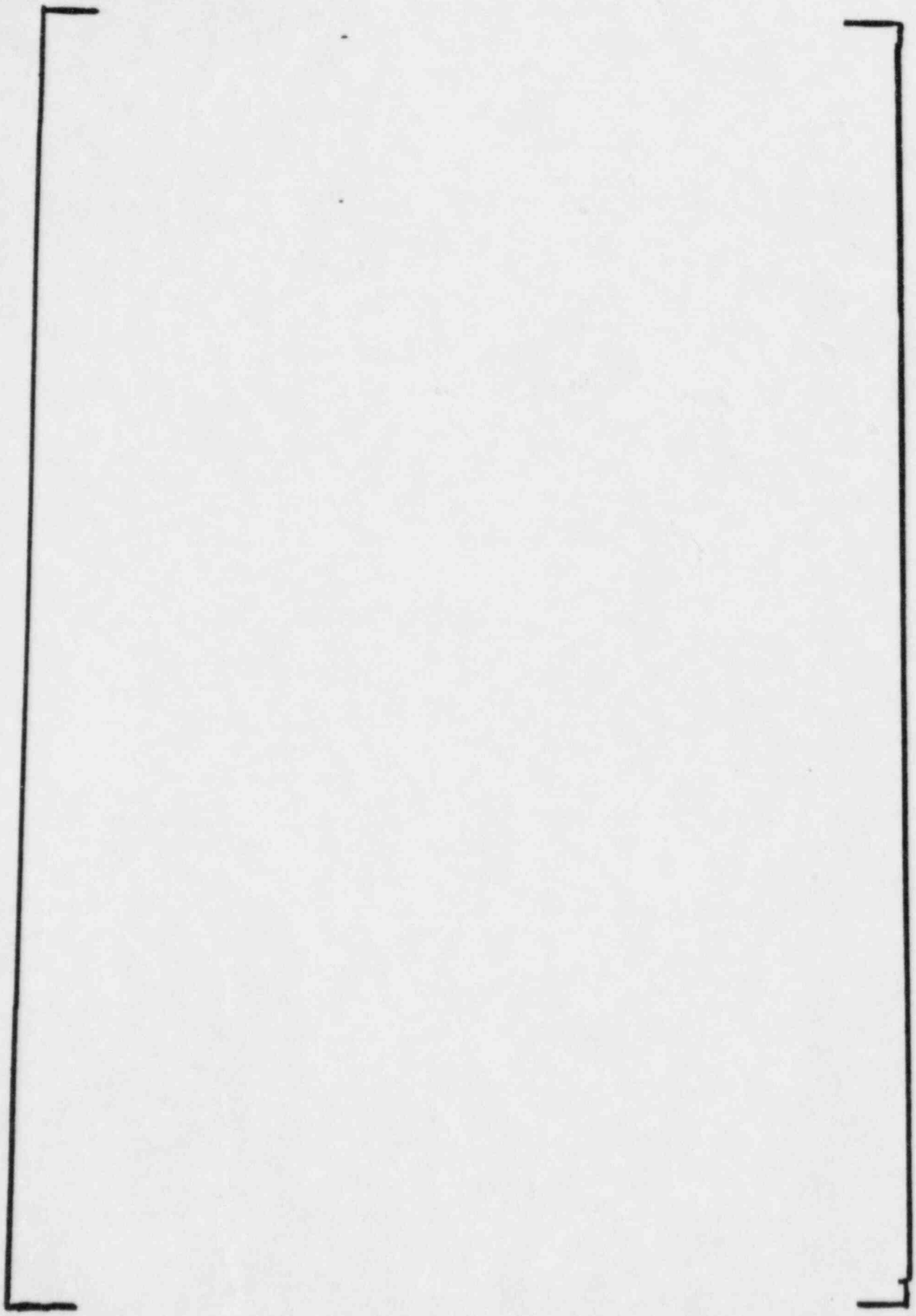
[redacted]

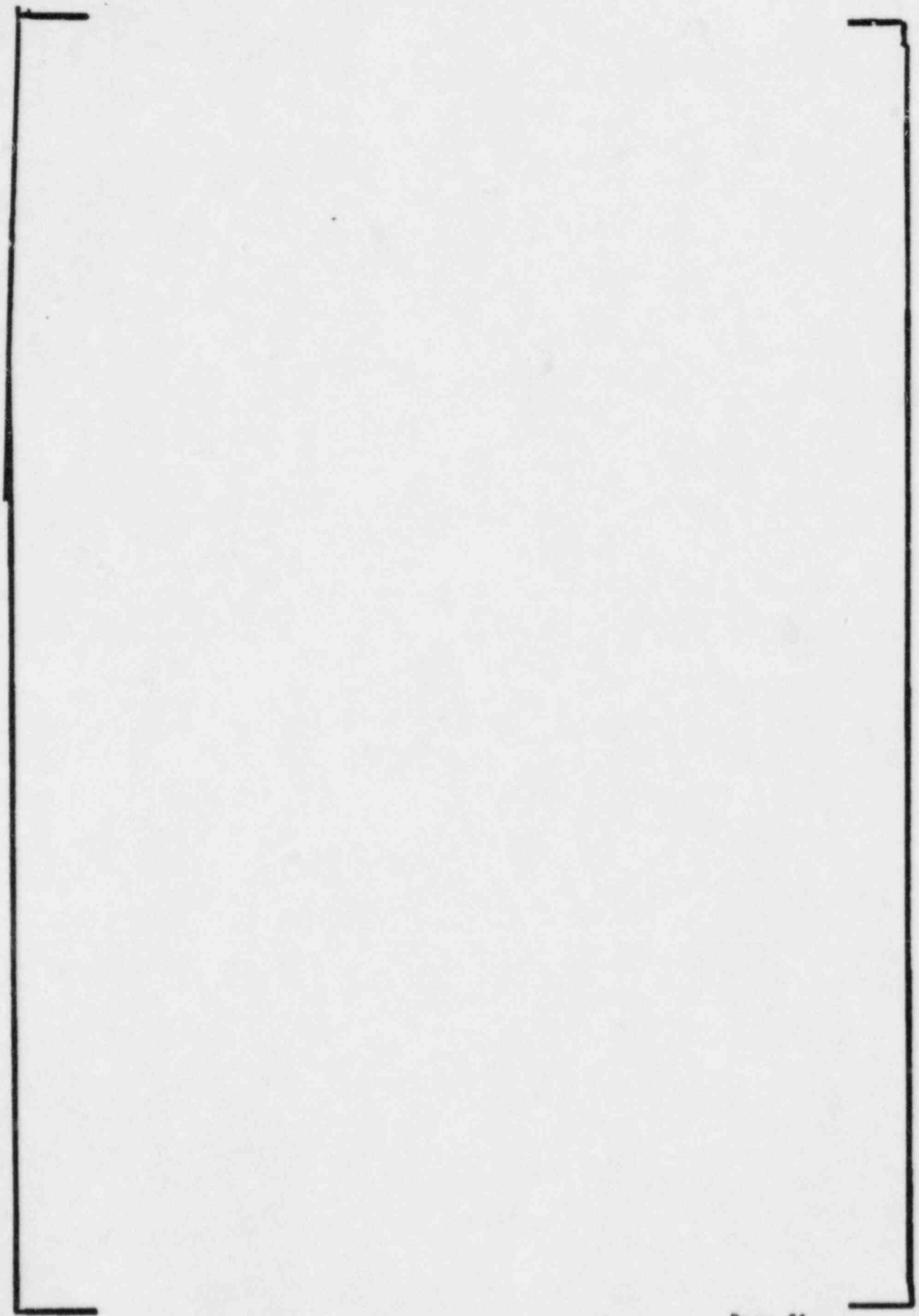
Reason

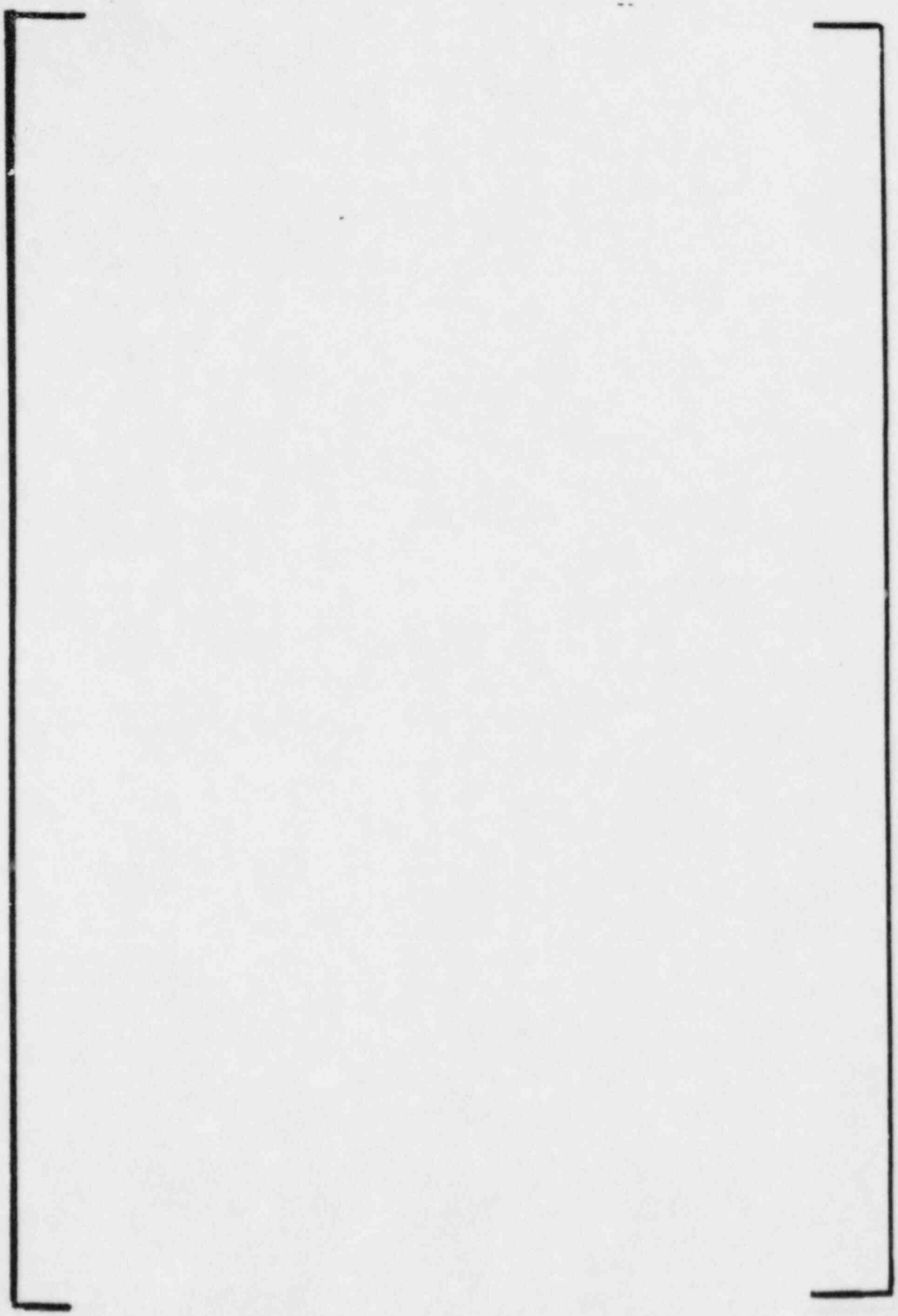
[redacted]

Description

[redacted]







2.4 MODIFICATIONS TO TRIP SEQUENCE ALGORITHM

Changes

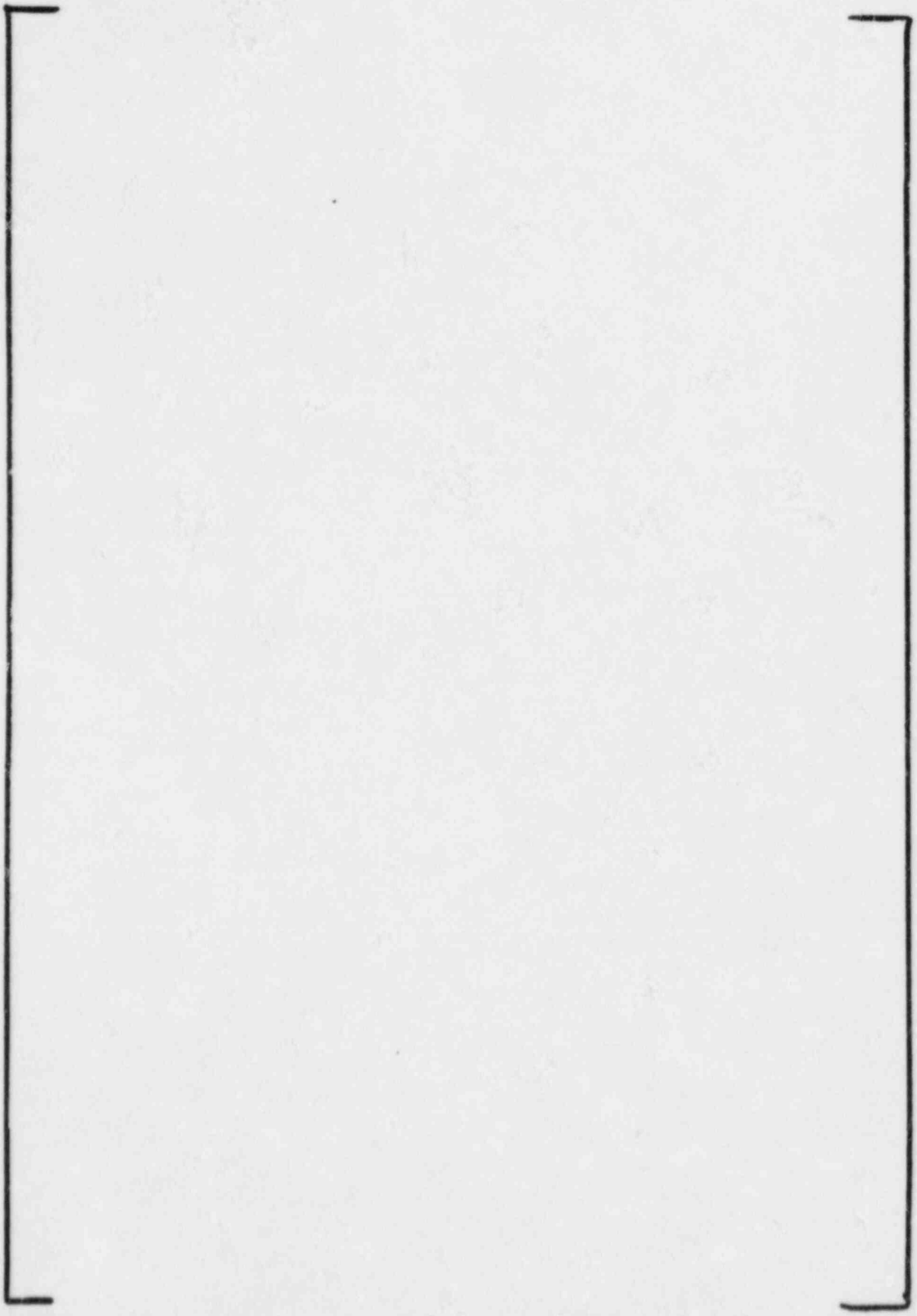
[redacted]

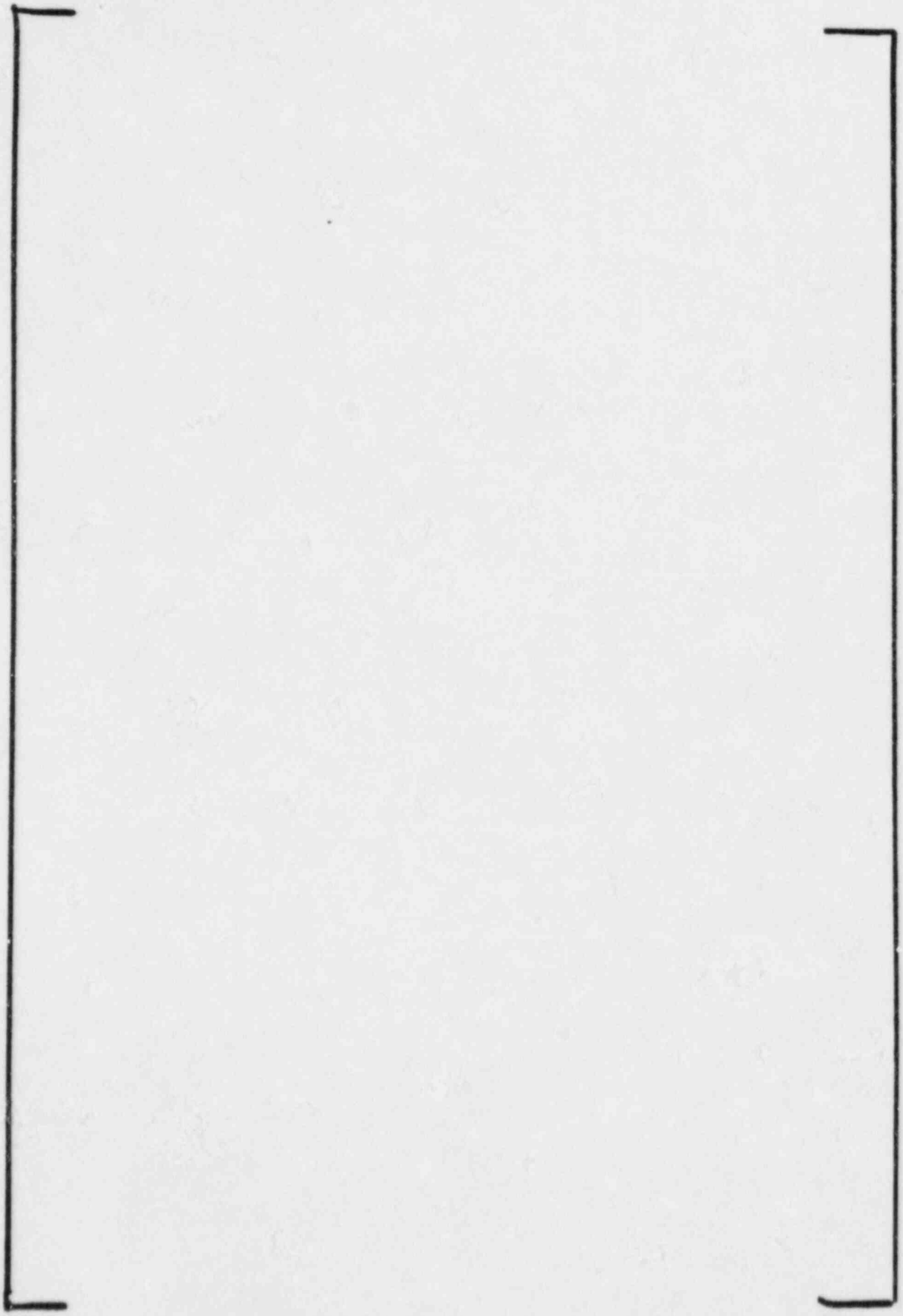
Reasons

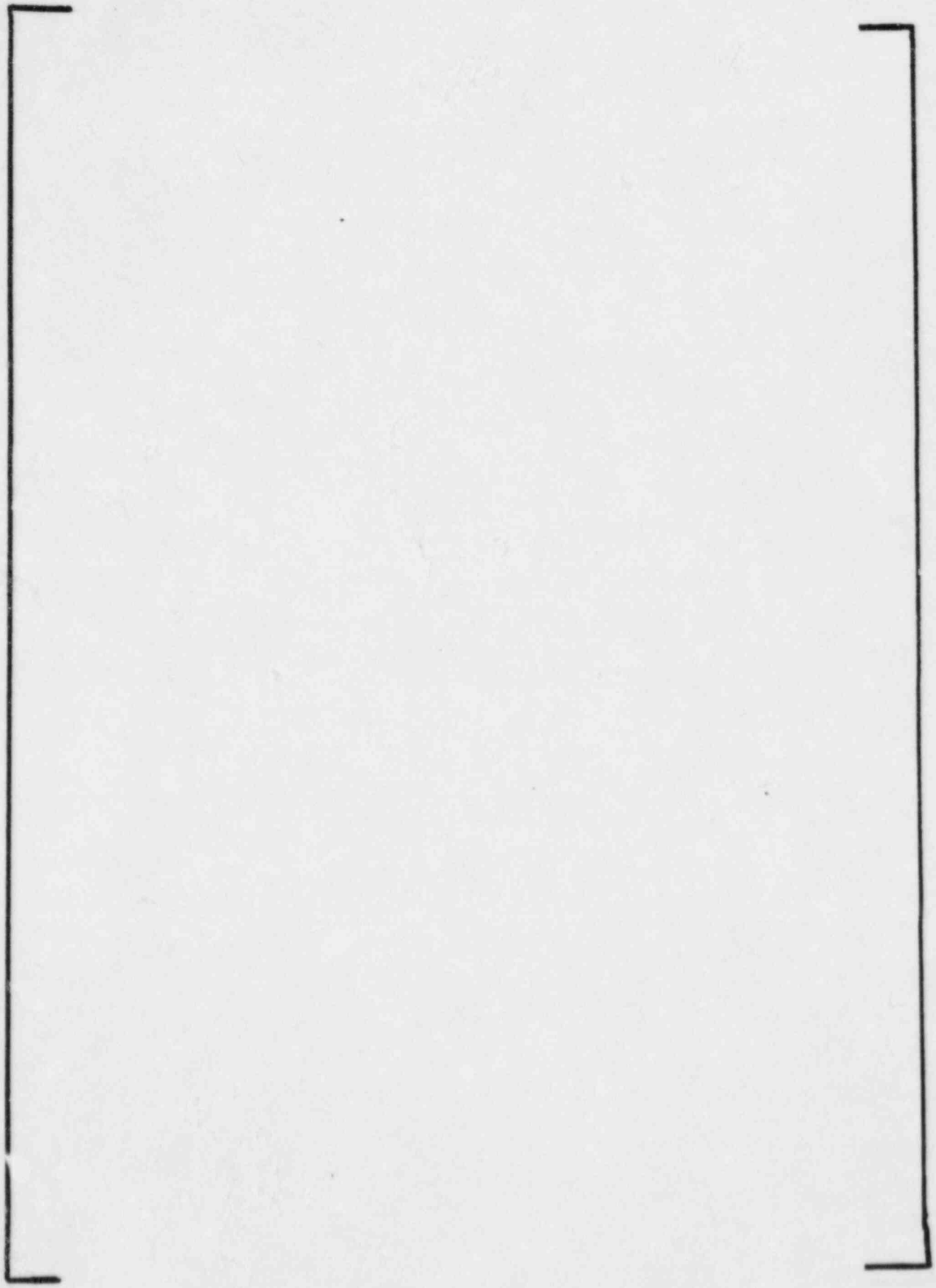
[redacted]

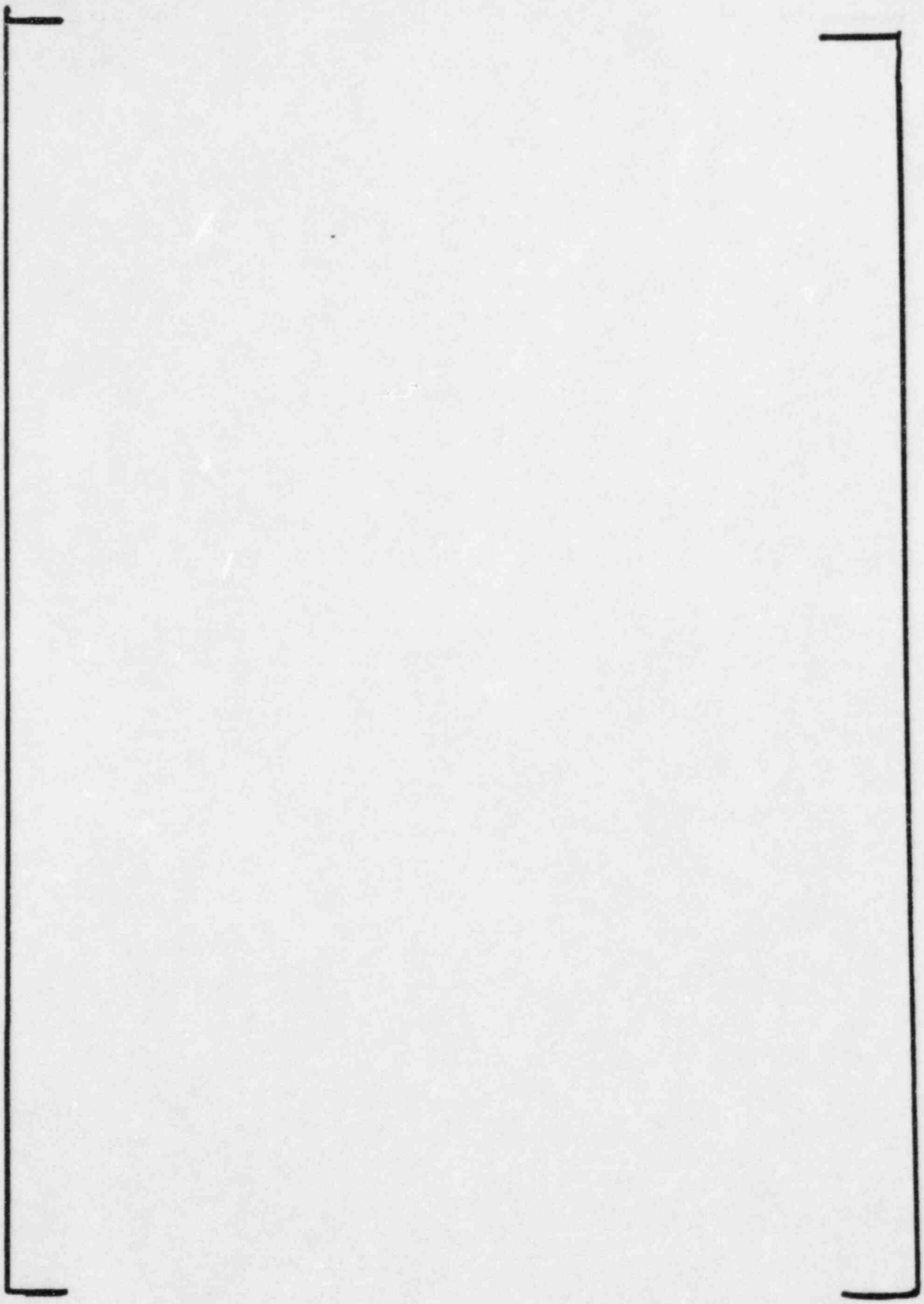
Description

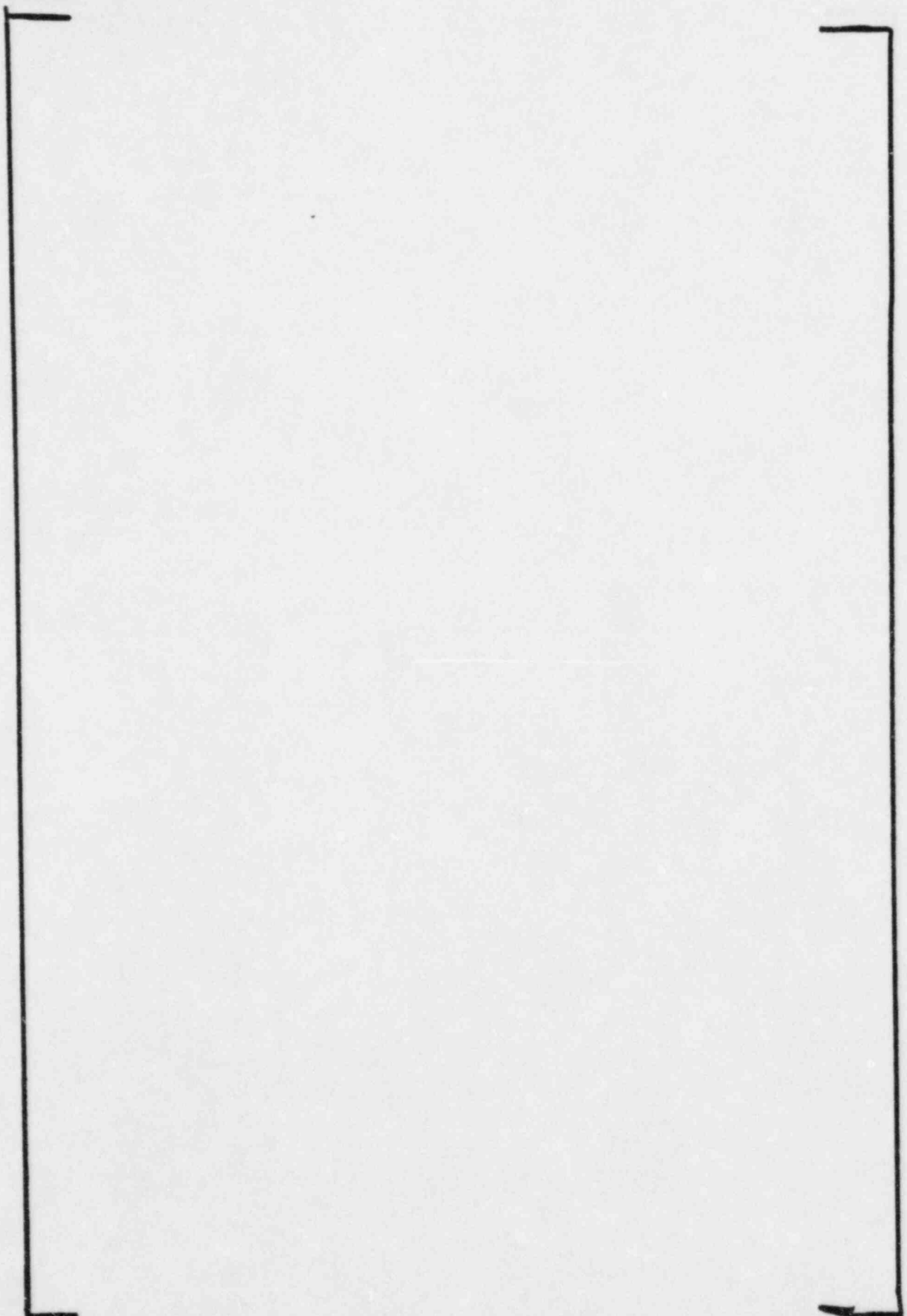
[redacted]











3.0 CEAC SOFTWARE MODIFICATION

Change

[redacted]

Reason

[redacted]

Description

[redacted]

4.0 ADDRESSABLE CONSTANTS

Certain CPC constants are addressable so that they can be changed as required during operation. Addressable constants include (1) constants that are measured during startup [redacted]

Changes to Addressable Constants

As a result of the CPCS software modifications described in Sections 2.0 and 3.0, changes have been made to the list of addressable constants. These changes are listed in Table 2 and summarized below.

a. As a result of the VOPT modification addressable constants [redacted]

b. As a result of the simplification of the flow calculations, addressable constant [redacted]

c. As a result of changes to the [redacted]

d. As a result of the [redacted]

e. Combination of the penalty factor multipliers for DNBR and LPD into a [ ]

f. As a result of power synthesis algorithm changes in [ ]

g. As a result of TRIPSEQ program modifications, the [ ] setpoint will be made an addressable constant.

TABLE 2

ADDRESSABLE CONSTANTS

Present A/C	Delete	Add
060		
061	X	[ ], Pump speed setpoint
062		
063		
064		
065		
066		
067		
068		
069		
070		
071		
072		
073	X	[ ], DNBR Trip setpoint
074		
075		
076		
077		
078		
079	X	[ ] (max value of VOPT setpoint)
080	X	[ ] (amt. of offset between VOPT setpoint & FOLLOW)
081		
082		
083		
084		
085		

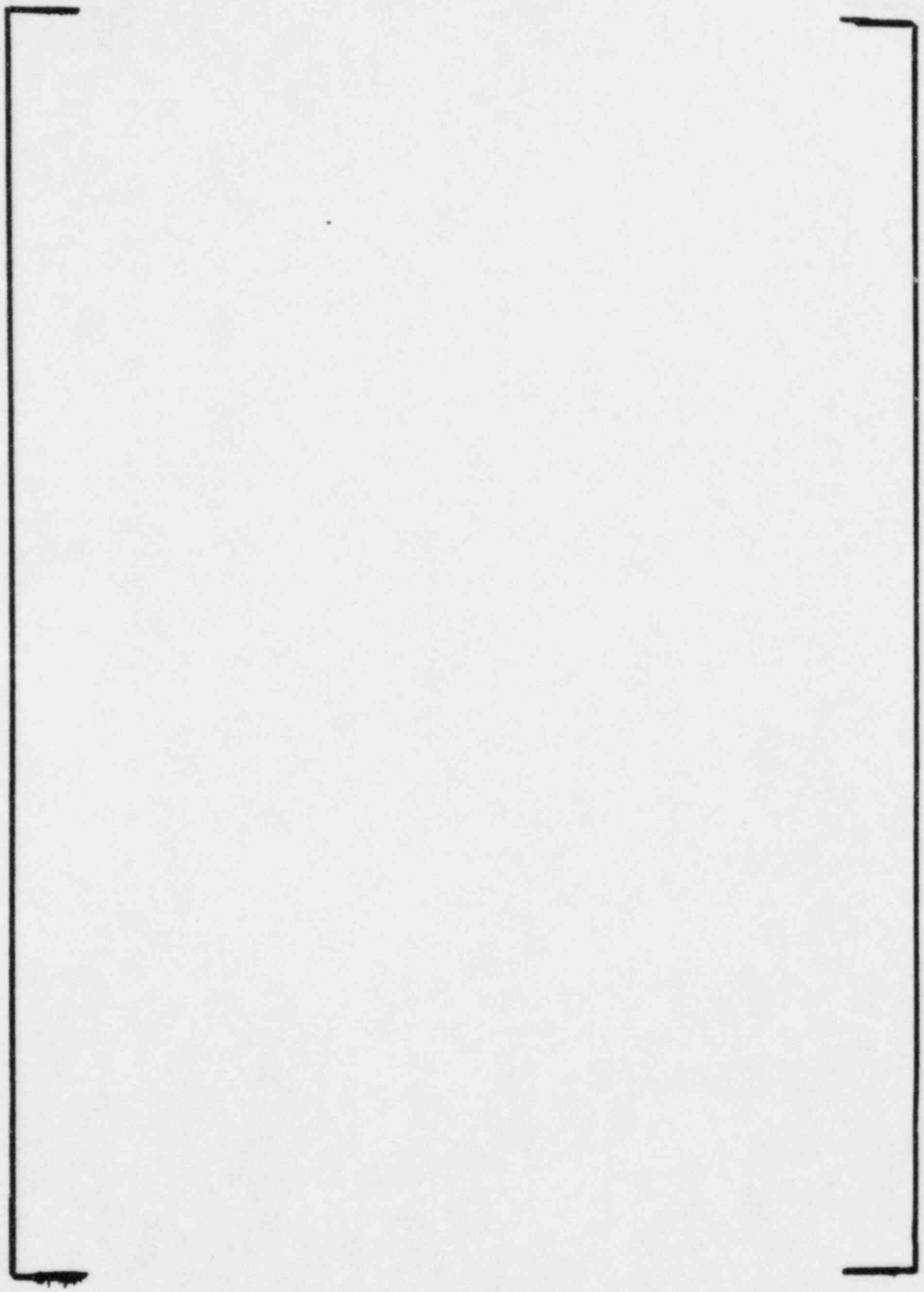
TABLE 2 (con't)

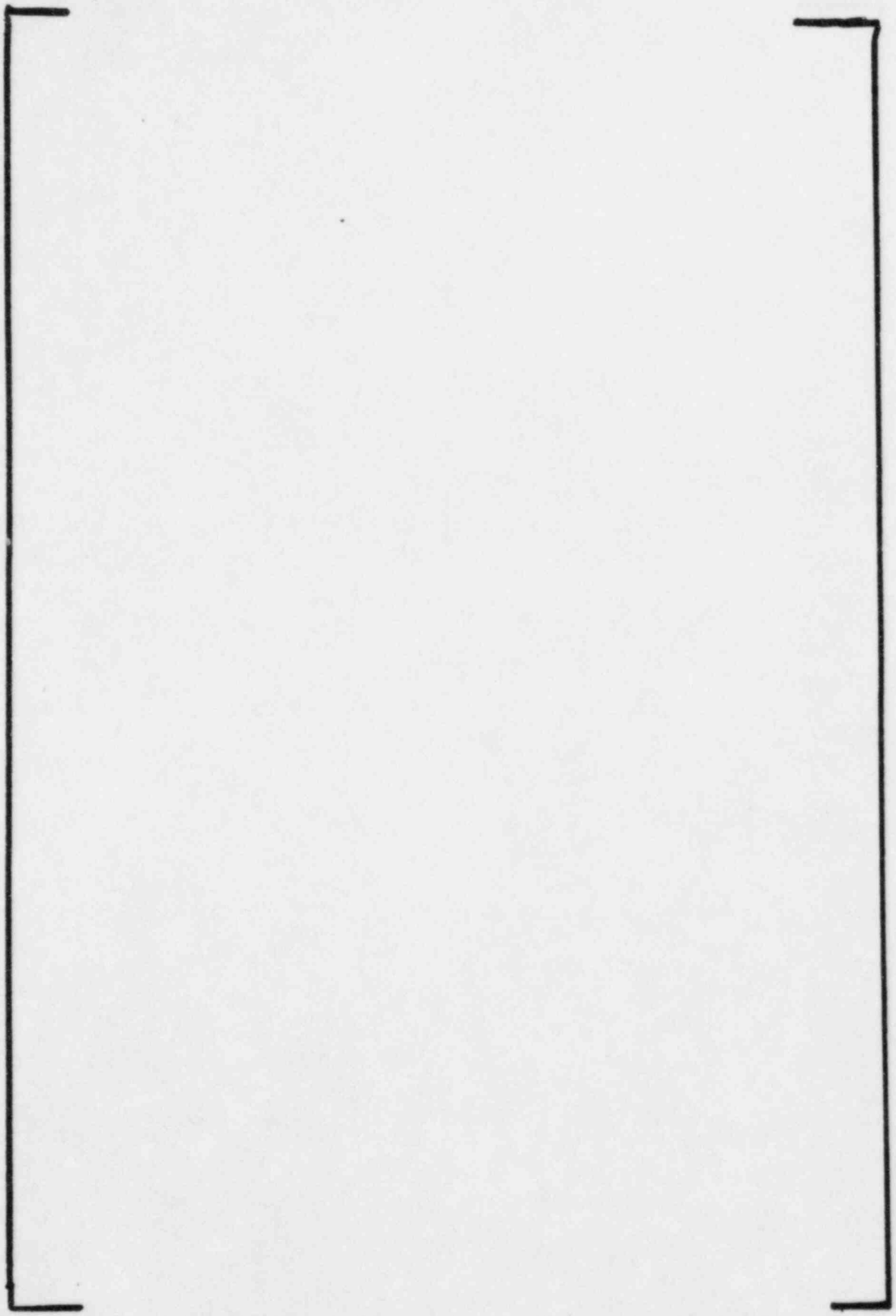
ADDRESSABLE CONSTANTS

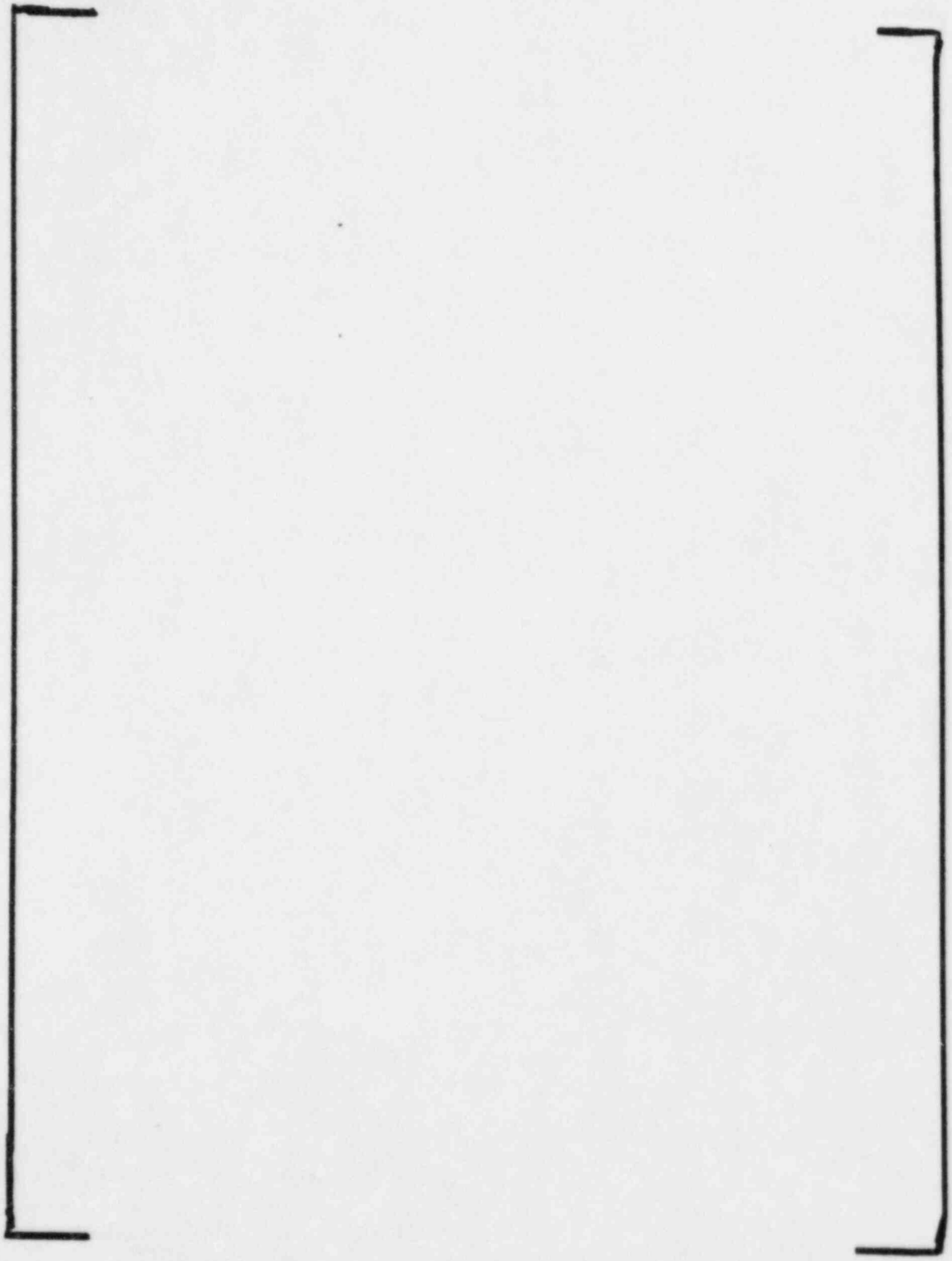
Present A/C	Delete	Add
086		
087		
088		
089		
090	X	[ ] (common multiplier for DNBR and LPD)
091	X	[ ], PF time delay
092		
093		
094		
095		
096	X	[ ], ASGT ΔT Trip setpoint
097	X	
098		
099		
100		
101		
102		
103		
104		

* Type 1 addressable constants

5.0 TYPICAL VALUES OF DATA BASE CONSTANTS FOR MODIFIED ALGORITHMS







6.0 REFERENCES

1. Functional Design Requirement for a Core Protection Calculator, CEN-305-NP, July, 1985.

2. Functional Design Requirement for a Control Element Assembly Calculator, CEN-304-NP, July 1985.

3. CPC Improvements Program, Detailed Presentation to the NRC, CEN-302 (S)-NP, April, 1985.

4. "CEPAN Method of Analyzing Creep Collapse of Oval Cladding, Volume 5: Evaluation of Interpellet Gap Formation and Clad Collapse in Modern PWR Fuel Rods," EPRI NP-3966-CCM, Volume 5, Project 2061-6, Computer Code Manual, April 1985.

COMBUSTION ENGINEERING, INC.