SOUTHERN CALIFORNIA EDISON SAN ONOFRE
NUCLEAR GENERATING STATION 2 (SONGS 2)

DOCKET 50-361

CEN-176(S)-NP
REVISION 03-NP

CPC/CEAC SYSTEM
PHASE I SOFTWARE VERIFICATION
TEST REPORT

November, 1984

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ABSTRACT

Phase I Design Qualification Testing is performed on the DNBR/LPD Calculator System to verify that CPC/CEAC system software modifications have been properly implemented.

This report presents the Phase I Test results for the Southern California Edison Company SONGS-2, Cycle 2 CPC/CEAC Revision 03 software.

The Phase I Testing was performed according to previously issued procedures (Reference 2). The test results indicate that the CPC/CEAC system software modifications have been properly implemented.

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1.0 INTRODUCTION AND SUMMARY

This document summarizes the results of the Phase I Design Qualification Testing of the changes to the CPC and CEAC software for SONGS-2 Cycle 2 (Rev. 03). The programs affected by these changes, which are listed in Section 2.3 were required to undergo Phase I Testing in accordance with Reference 2. These changes reflect the implementation of Software Change Requests 257, 258, 267, 622, 624-626 and 629-631. These changes were made in accordance with Reference 2.

The tests reported herein were conducted on the CPC/CEAC design. A discussion of the test configuration, test methodology, and test results are presented in this document.

1.1 OBJECTIVE OF PHASE I TESTING

The objective of Phase I Design Qualification Testing is to verify the implementation of the Core Protection Calculation System (i.e., both CPC and CEAC) software.

1.2 RESULTS

Analysis of the Phase I Design Qualification Tests demonstrated that the software changes have been correctly implemented to meet the system functional requirements.

1.3 CONCLUSIONS

CPC System Phase I Testing was performed in the prescribed manner as described by Phase I Test Procedures. The Phase I Testing was adequate to meet all of the test objectives. The success of the Phase I Testing demonstrates the adequacy of the CPC/CEAC software implementation.

1.4 PREREQUISITES

Before formal Phase I Testing was initiated, the following prerequisites were satisfied:

1. Programmer debug testing was performed on the module changes to remove all obvious errors.

2. The modules and programs that change were integrated into complete software systems and absolute core images were generated on the CPC permanent mass storage medium (floppy disks).

2.0 APPLICATION PROGRAM TESTING

The CPC application programs were tested in accordance with the CPC/CEAC Phase I Test Procedure. This section discusses the actual test configuration, test cases, and test execution and results.

Phase I Test runs used Disk #S358 as the A-B Reference Disk.

2.1 TEST CONFIGURATION

Phase I Testing of the CPC application programs was performed on the CEAC Single Channel Unit. For the purpose of this testing, the single channel was configured with the hardware complement listed in Table 2-1. The software configuration for the application programs Phase I Testing is shown in Figure 2-1 (CEAC). Memory was loaded with this configuration by the following procedure:

1. The integrated CPC system was loaded from the SONGS-2,3 Reference Disk (Disk #S358 for CPCs).

2. The Automated Phase I Testing Software was loaded from magnetic tape, overlaying the CPC/CEAC Executive and an unused portion of memory.

3. The Interdata Hexadecimal Debug Program, CLUB, was loaded from magnetic tape, overlaying an unused portion of memory.

The Automated Phase I Testing software was then used, with CLUB, to test programs 1-4 and 9-11 (CPC) and 1 and 2 (CEAC) of Table 2-2.

2.2 TEST CASES

2.2.1 Inputs

Phase I Test case inputs for the CPC/CEAC application programs were generated in accordance with the CPC/CEAC Phase I Test Procedure. Sufficient test cases were chosen to exercise each functional branch in the application programs. However, several branches were not exercised because assigned constant values made it impossible to branch on certain conditions. All coding that cannot be executed, because of constant assignments, was verified by inspection to assure correct implementation.

2.2.2 Expected Results

Expected results for the CPC application programs Phase I Test cases were generated by two methods. The preferred method for generation of expected results utilized the CPC FORTRAN Simulation Code. Test case inputs were stored on magnetic tape and entered into the Simulation Code. The FORTRAN Code calculated the expected results and stored then on magnetic tape in a format acceptable to the automated Phase I Testing Program. In some instances, such as

input/output handling, the FORTRAN Code does not simulate the CPC code. In these cases, the expected results were hand calculated by the test engineer based on the system functional requirements, the programmer's flowcharts, and the system data base document. The results were then manually entered on magnetic tape in a format acceptable to the Automated Phase I Testing Program.

2.3 TEST EXECUTION AND RESULTS

When test case inputs had been selected and expected results had been generated, the test engineer prepared the test tape to be read by the Automated Phase I Testing Program. The test case inputs overlayed the portions of memory where data is accessed by the software module under test. After each set of inputs overlayed appropriate memory locations, the software module under test was executed and the actual CPC results were compared to the expected results by the Automated Phase I Testing Program. Whenever the actual value differed from the expected value by more than 0.1 percent, an analysis of the error was performed by the test engineer to assure that the deviation was not caused by a coding error.

Documentation generated by the Automated Phase I Testing Program consisted of listings which contain input and output differences. For several of the modules tested, it was not obvious which branches in the code were taken when observing the outputs. When tracing through a portion of code, the location of each critical instruction was printed when that instruction was executed, which enabled the test engineer to verify that each functional branch was taken. A Phase I Test Log was used to maintain a daily account of testing activities.

Phase I Testing was performed on the CPC application programs on [ ]. Phase I testing of the Executive System was performed on [ ] and [ ]. No software errors were found.

Test on Penalty Factor program were run on [ ]. No software errors were found.

Test on the Display Program were run on [ ]. No software errors were found.

On [ ] the reference disk (#S358) was regenerated due to changes required in the STATIC DNBR program. After updating the reference disk (#S358) a comparison was made to its backup disk (#S359) and indicated differences only in the tracks assigned to the STATIC DNBR program. All other tracks remained unchanged, therefore Phase I testing previously performed on these unchanged programs are valid. Phase I testing of the STATIC DNBR program, on [ ], was successful and its backup (#S359) was regenerated.

On[ ]the reference disk (#S358) was regenerated due to a chnage made in the CEAC Point ID Table. After updating the reference disk (#S358) a comparison was made to its backup disk (#S359) and indicated differences only in the track assigned to the CEAC Point ID table. All other tracks remained unchanged. The CEAC Point ID table is tested only as a part of the Phase II testing procedure. Therefore, all Phase I testing previously performed is valid.

On[ ], during the generation of the Master Test disk, a discrepency was found during comparison of the Channel A,B Reference disk (#S358) and the Channel A, B Master test disk (#S363). It was determined by visual comparison of the listings that a single byte, residing in an unused portion of memory, was the cause of the discrepency. The Reference disk (#S358) was regenerated on[ ]. A comparison was made between the Channel A,B Reference disk (#S358) and its backup (#S359), this in combination with a retest of the comparison between the Channel A,B Reference disk (#S358) and the Master Test disk (#S363), demonstraced a successful compare.

This combination of comparisons verified that only the single byte in question was modified.

It was concluded that Phase I testing revealed no coding errors in the CPC and CEAC application programs.

TABLE 2-1

CEAC SINGLE CHANNEL
HARDWARE CONFIGURATION FOR PHASE I EXECUTIVE/
APPLICATION PROGRAM TESTING

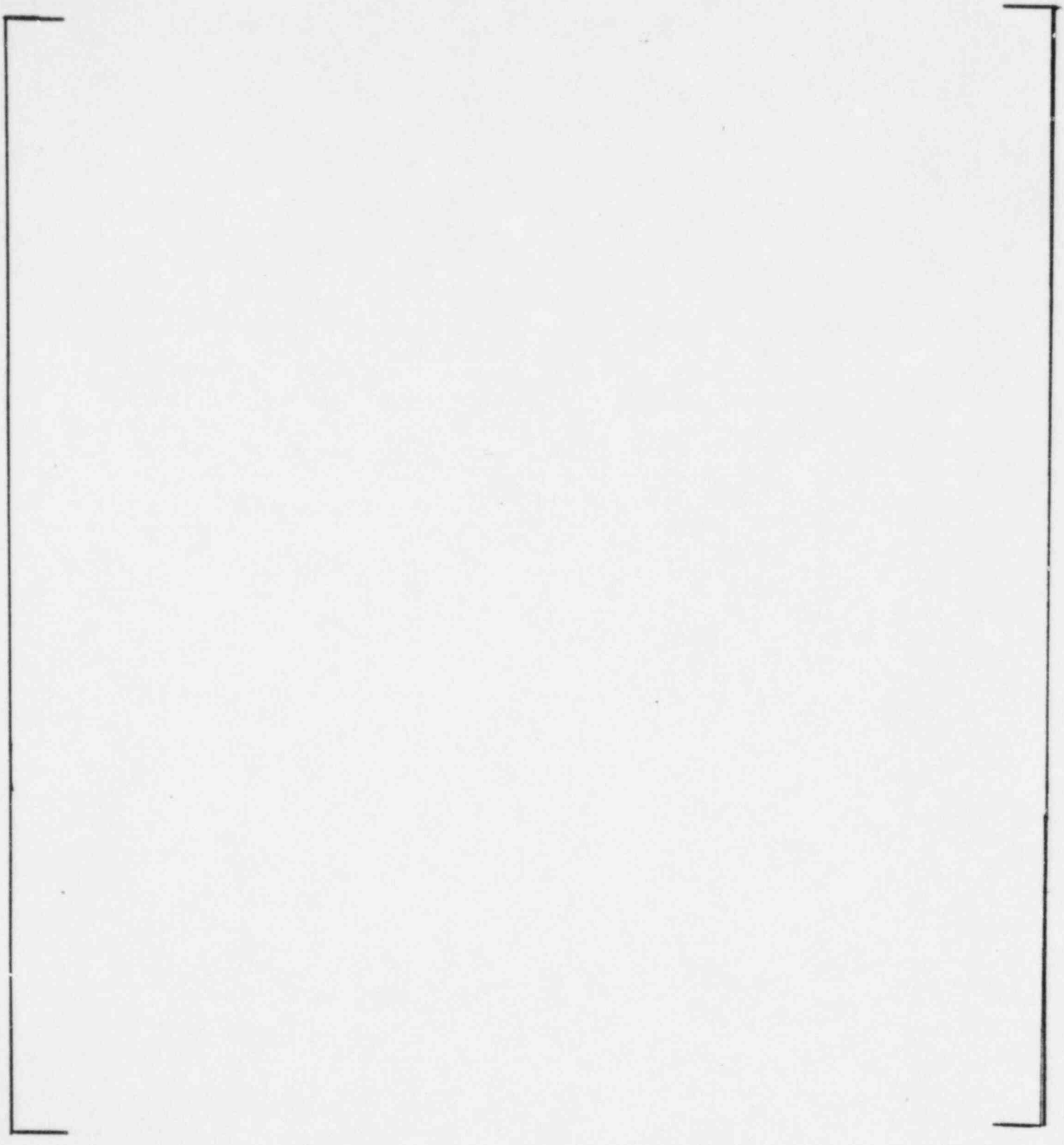

TABLE 2-2

APPLICATION PROGRAMS TESTED WITH THE AUTOMATED PHASE I TESTING PROGRAM

FIGURE 2-1

CEAC SINGLE CHANNEL

MEMORY MAP FOR CPC SYSTEM SOFTWARE PHASE I TESTING

Figure 2-1 (Cont.)

Figure 2.1 (Cont.)

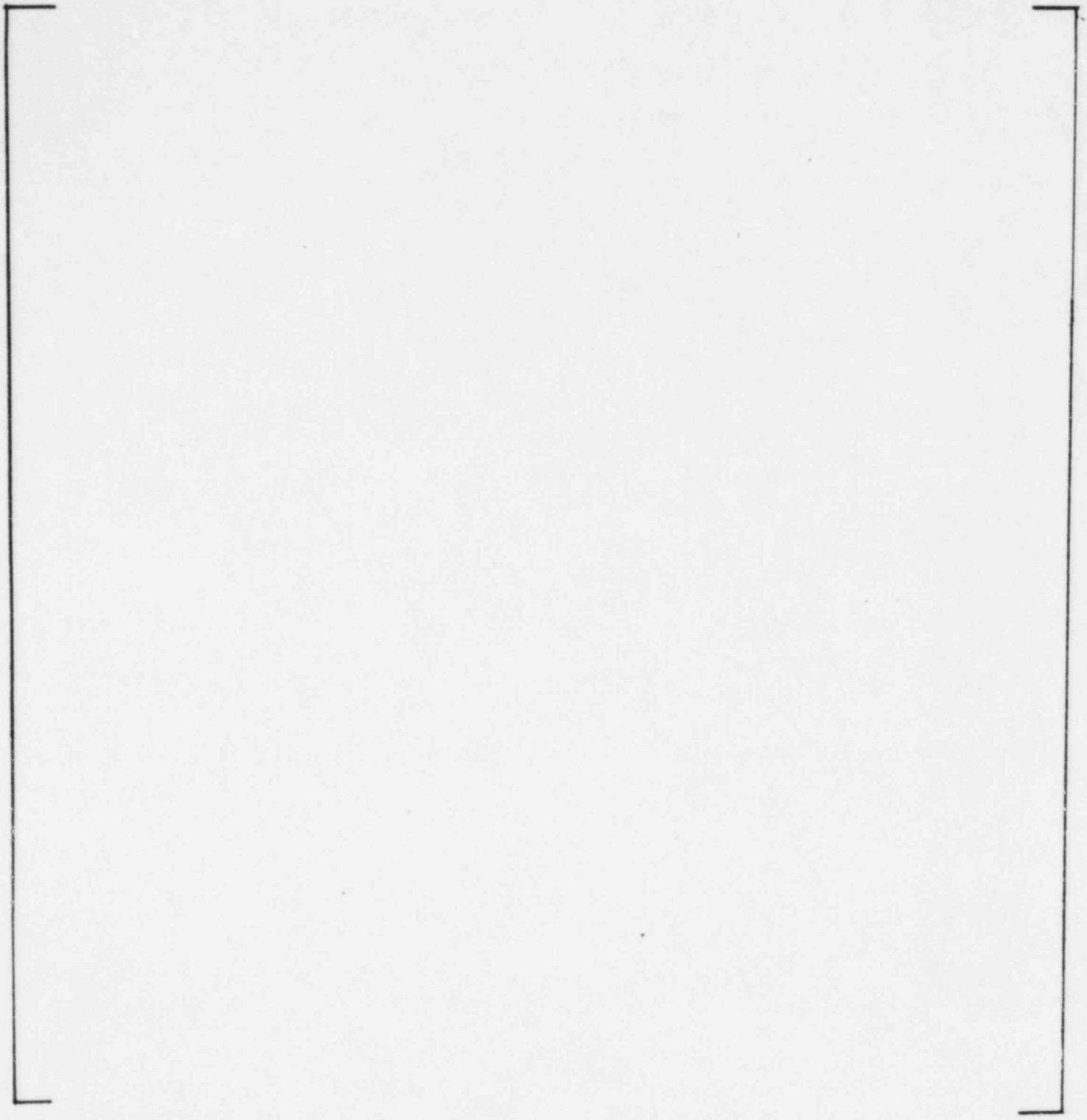

Figure 2-1 (Cont.)

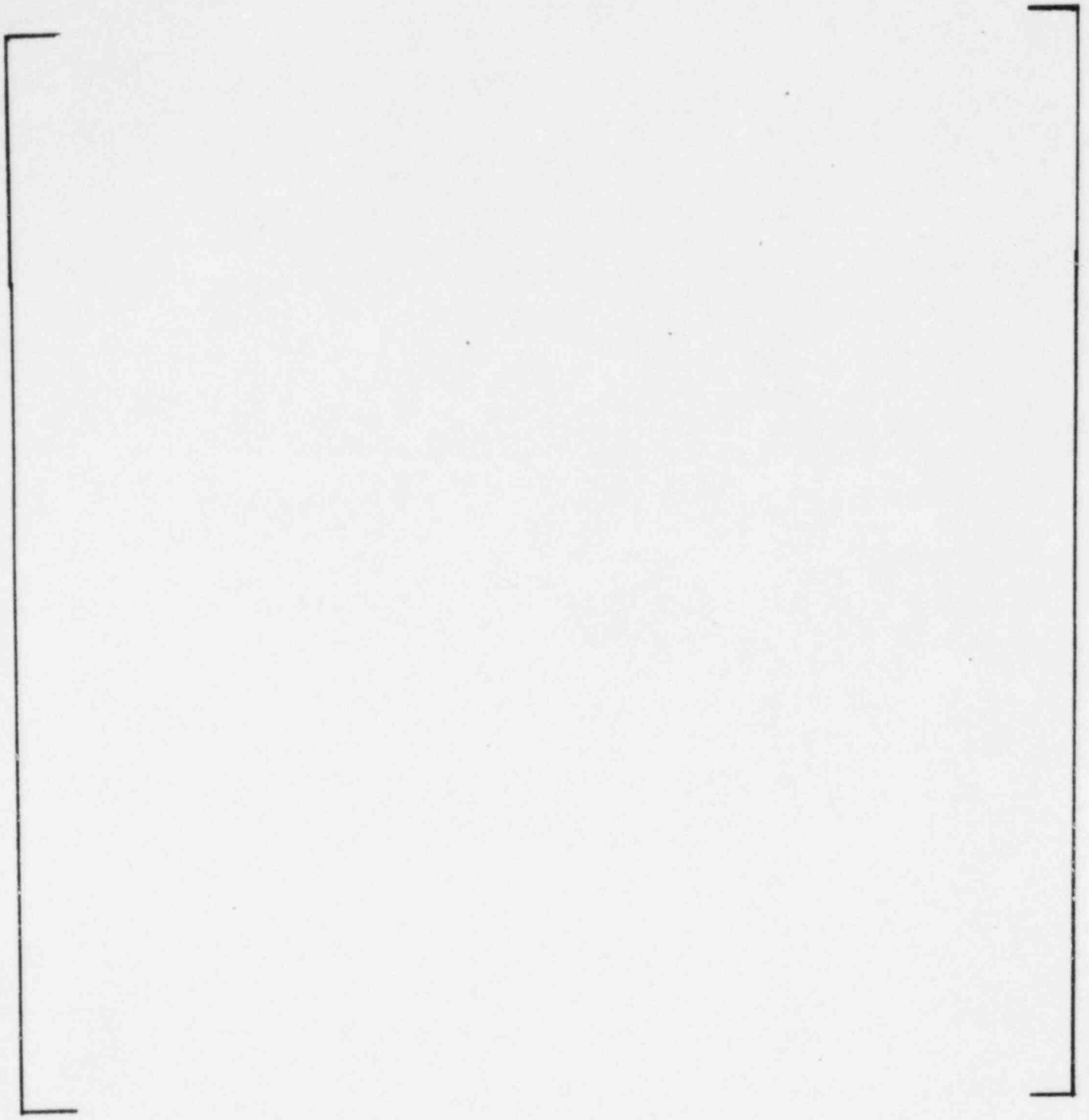

Figure 2-1 (Cont.)

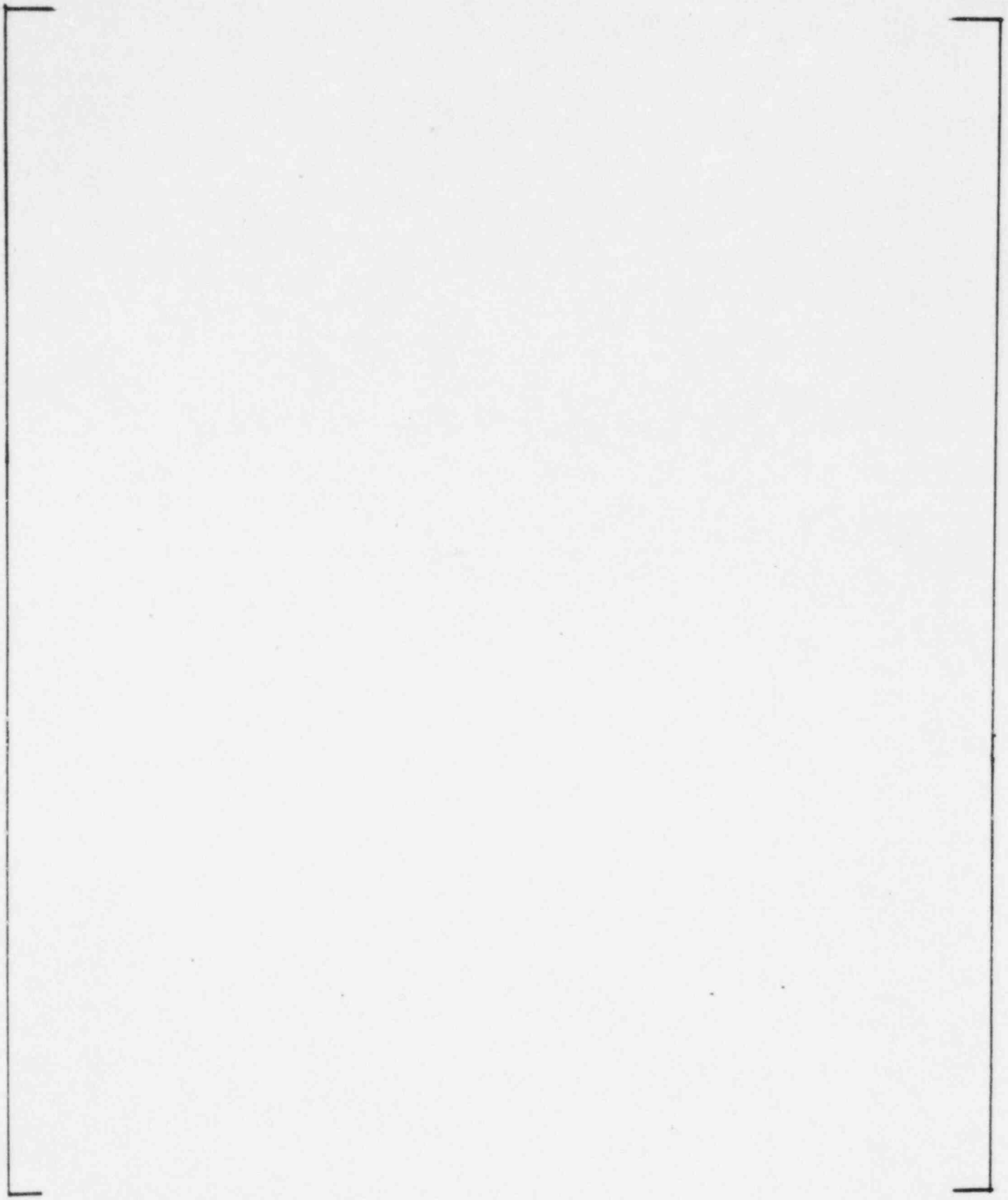

FIGURE 2-2

CEAC SINGLE CHANNEL
MEMORY MAP FOR CEAC SYSTEM SOFTWARE PHASE I TESTING

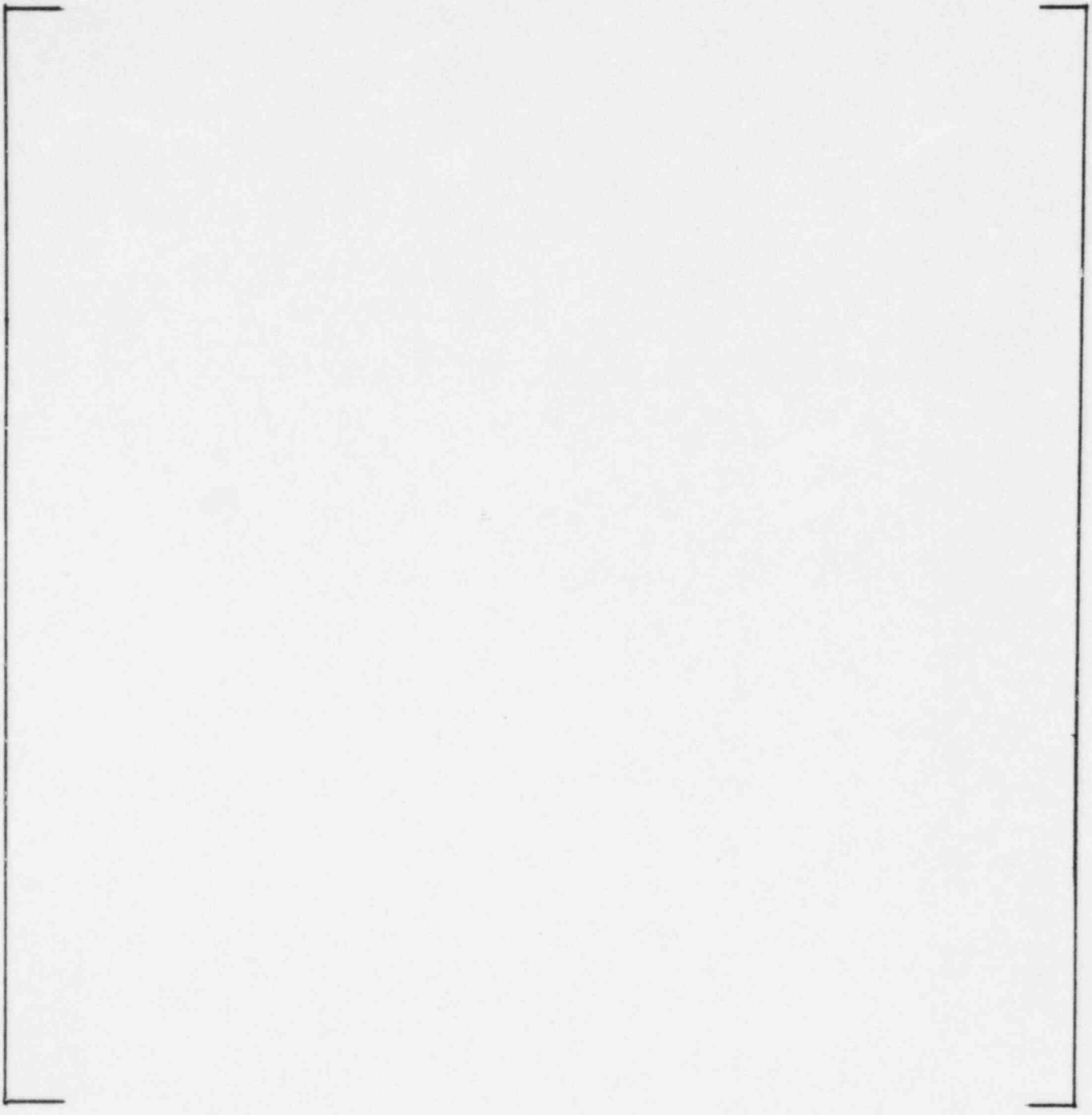

Figure 2-2 (Cont.)

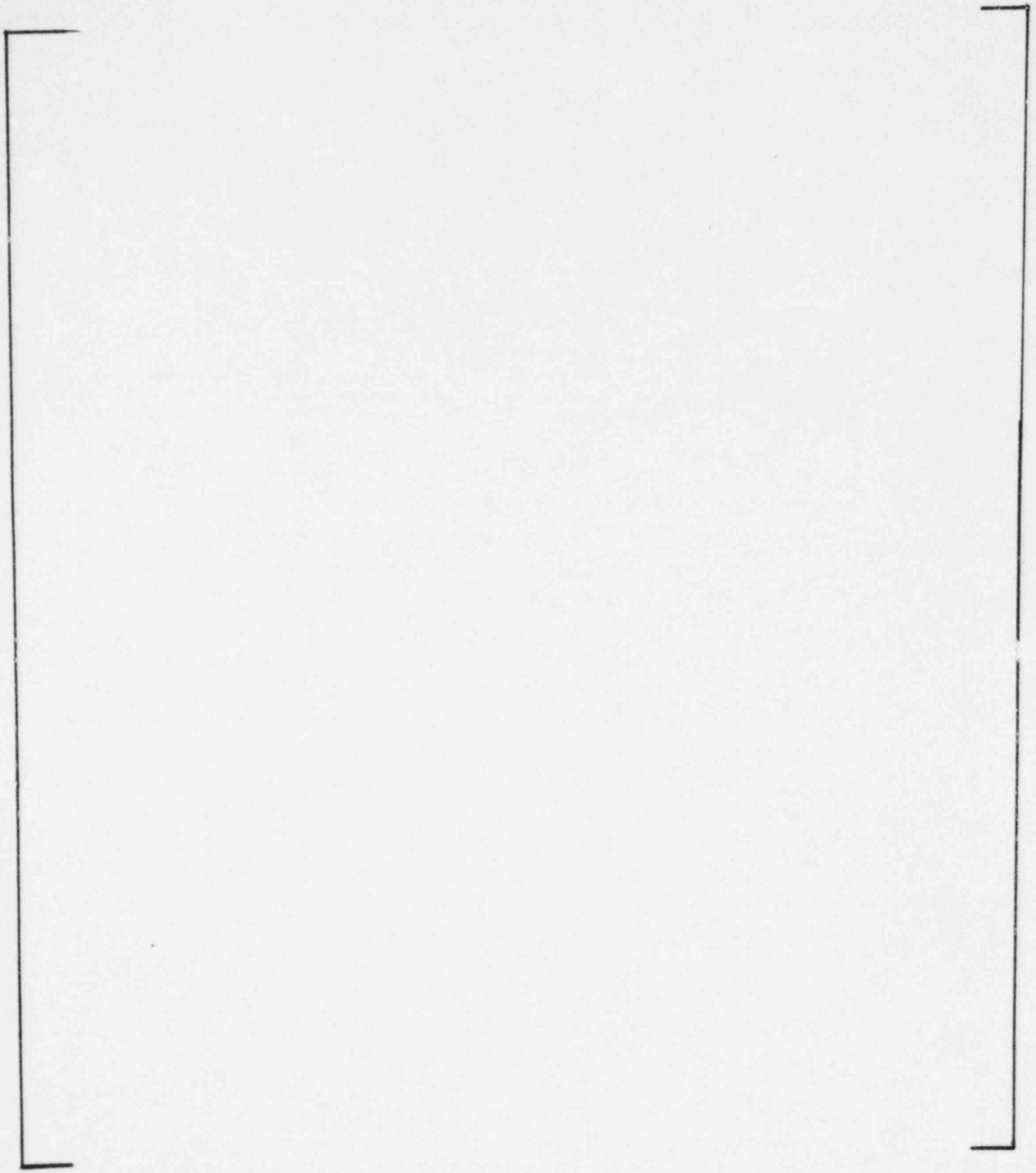

Figure 2-2 (Cont.)

3.0 EXECUTIVE TESTING

The CPC/CEAC Executive software was tested in accordance with the CPC/CEAC Executive Phase I Test Procedure. This section discusses the actual test configuration, test cases, and test execution and results.

3.1 TEST CONFIGURATION

Phase I testing of the CPC/CEAC Executive was performed on the CPC Single Channel System. For the purpose of this testing, the single channel was configured with the hardware complement listed in Table 2-1 (CEAC) and 3-1 (CPC). This hardware configuration is functionally identical to the as-built CPC/CEAC design.

The software configuration for the Executive Phase I Testing is shown in Figure 3-1. Memory was loaded with this configuration by the following procedure:

1. An integrated CPC/CEAC system was loaded from SONGS-2,3 Reference Disk #S358 (the entire image was loaded although only the Executive system is tested).

2. The Interdata Hexadecimal Debug Program, CLUB, was loaded from magnetic tape overlaying an unused area in memory.

The prescribed test cases were then set up and executed using the CLUB program to test the Executive software.

3.2 TEST CASES

The CPC/CEAC Executive Phase I Test Cases are described in the Executive Phase I Test Procedure. Sufficient test cases were chosen to exercise each functional branch in the Executive system.

3.3 TEST EXECUTION AND RESULTS

For testing of the CPC/CEAC Executive, the debug program, CLUB, was used to insert test case inputs into memory; to insert breakpoints to trace and intercept code executions; and to examine results. Documentation produced as a result of Executive Phase I Testing consists of the CLUB teletype printouts, initialed and dated by the test engineer.

The CPC/CEAC Executive was tested on [ ] and [ ]. No software errors were detected.

TABLE 3-1

CPC SINGLE CHANNEL
HARDWARE CONFIGURATION FOR PHASE I
EXECUTIVE PROGRAM TESTING

FIGURE 3-1

MEMORY MAP FOR CPC/CEAC EXECUTIVE PHASE I TESTING

Figure 3-1 (Cont.)

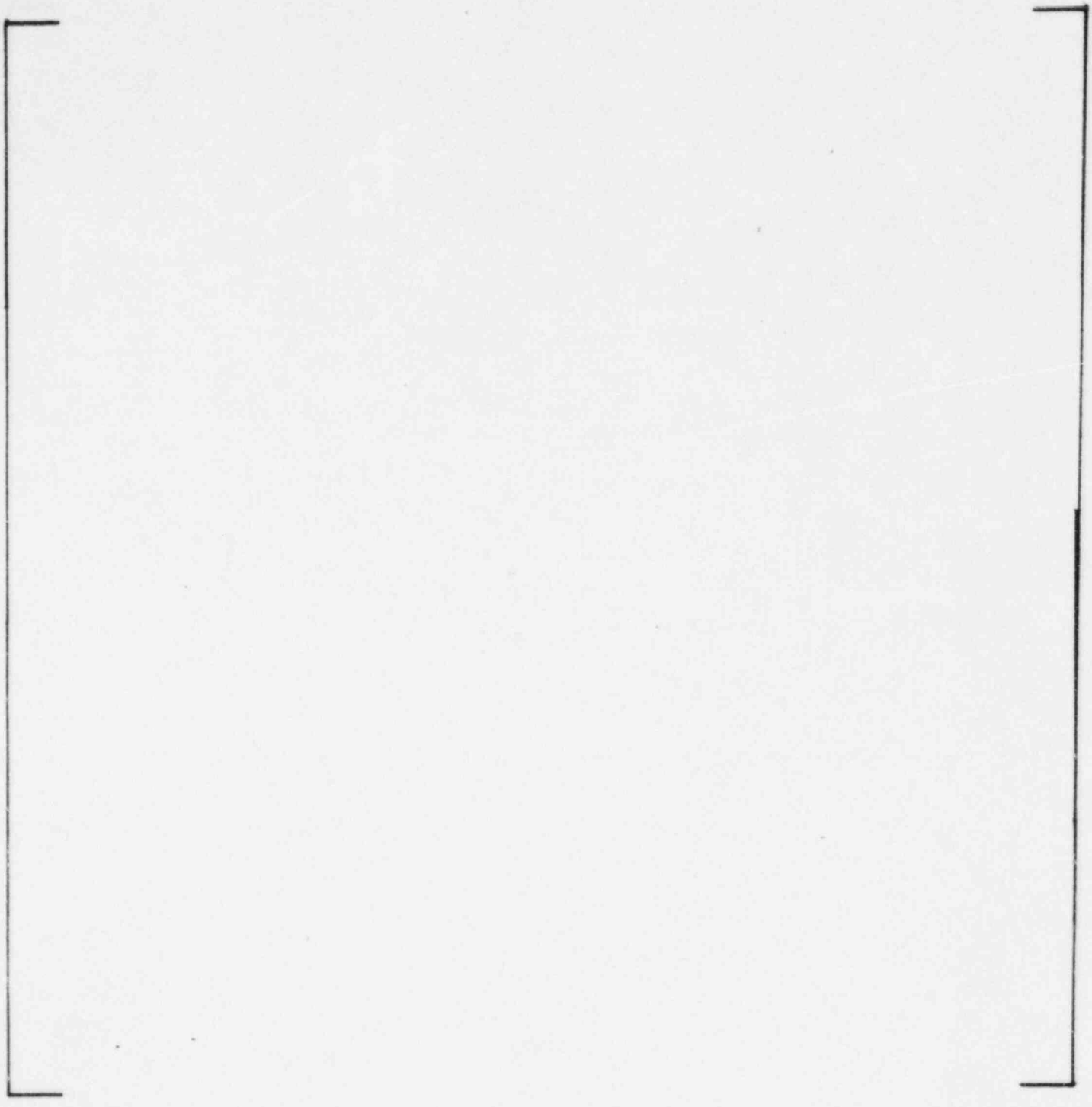

Figure 3-1 (Cont.)

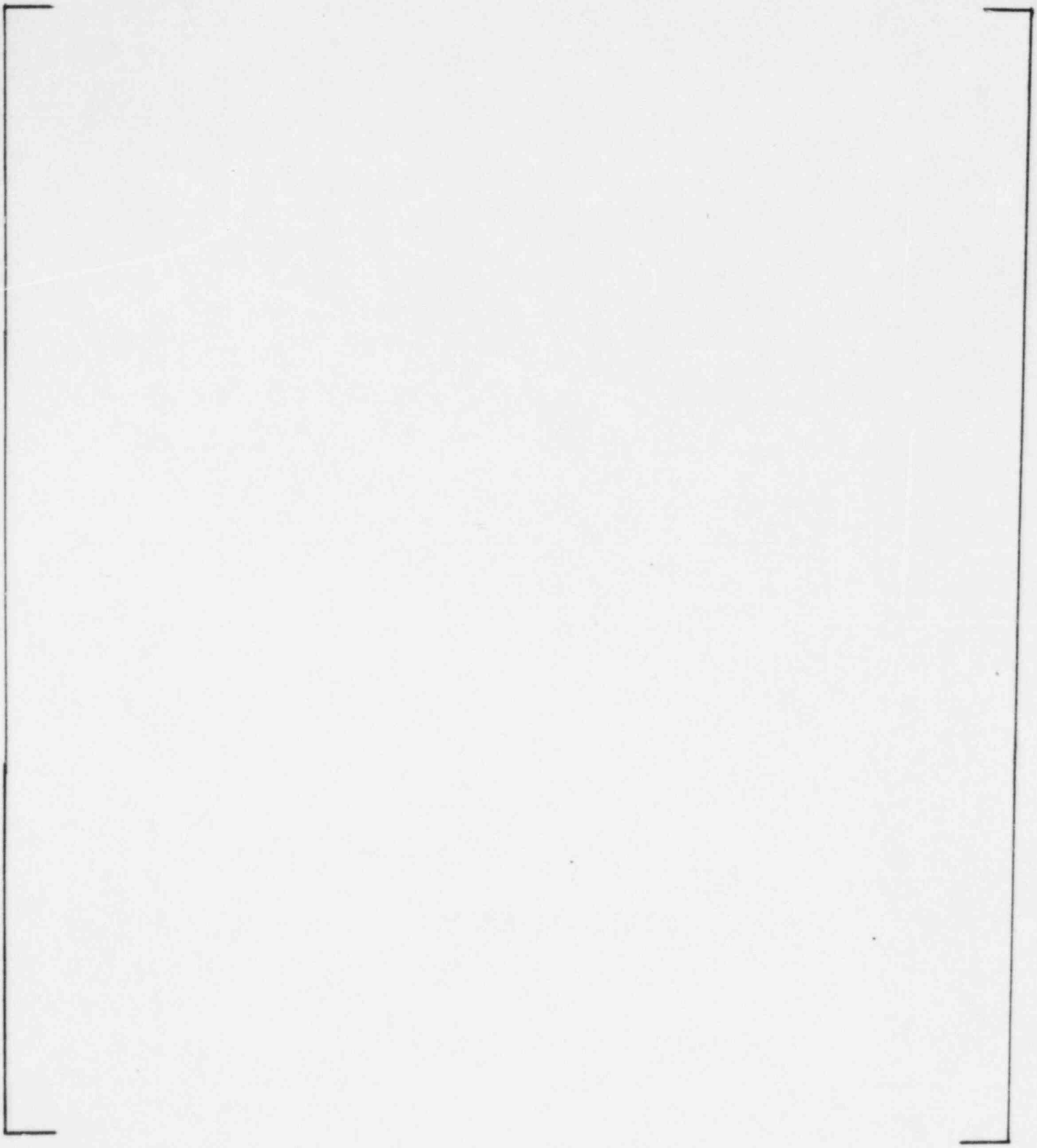

Figure 3-1 (Cont.)

4.0 PHASE I TEST RESULTS SUMMARY

Phase I testing of the CPC and CEAC software for SONGS-2 Cycle 2 (Rev. 03) was performed in accordance with Reference 2. Test results detected no errors in the implementation of the software modifications outlined in Reference 1.

5.0 REFERENCES

1. CPC/CEAC Software Modifications for San Onofre Nuclear Generating Station Units No. 2 and 3, November 1984, CEN-281(S)-P, Rev. 01.

2. CPC Protection Algorithm Software Change Procedure CEN-39(A)-P, Rev. 02, December 21, 1978.

COMBUSTION ENGINEERING, INC.