PALO VERDE NUCLEAR GENERATING STATION UNIT 1

DOCKET 50-528

CEN-217(V)-NP
REVISION 01

CPC/CEAC SYSTEM
PHASE I SOFTWARE VERIFICATION
TEST REPORT

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ABSTRACT

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

This report presents the Phase I Test results for the Arizona Nuclear Power Project, PVNGS-1 Plant CPC/CEAC System Software, Revision 00. This report supercedes Reference 3.

The Phase I Testing was performed according to previously issued procedures (Reference 2). The test results indicate that the CPC and CEAC 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 changes to the CPC and CEAC software Rev. 00
for PVNGS-1. The programs affected by these changes, which are
described in Reference 1, were required to undergo Phase I Testing in
accordance with Reference 2. The changes reflect the implementation
of Software Change Requests 257, 258, 267, 336, 337, 339-345, 377,
385, 389, 390, 435-437, 458-463, 476, 484-486, 499, 514, 527-531, 539,
549, 550, and 551. These changes were made in accordance with
Reference 2.

The tests reported herein were conducted on the CPC/CEAC Single
Channel Test facility in Windsor. 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
correct implementation of the Core Protection Calculator System (i.e.,
both CPC and CEAC) software.

1.2 RESULTS

Analysis of the Phase I Design Qualification Tests demonstrated that
the software changes had 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 programs 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 and CEAC 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 #S248 as the PVNGS-1 Rev. 00 software Reference Disk.

Disk #S248 and its backup copy, #S249 were created on June 17, 1983 for Phase I testing. On June 20, 1983 a change to the Penalty Factor Constants program (PFCON) was identified (SCR #551) and disk #S248 was regenerated. A byte by byte comparison was made between disk #S248 and #S249 and demonstrated that all sectors other than that containing PFCON were identical and, thus, that the Phase I testing previously performed for all other programs was valid.

2.1   TEST CONFIGURATION

Phase I Testing of the CPC and CEAC application programs was performed on the CEAC Single Channel Unit. For the purpose of this testing, the Single Channel Unit 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 (CPC) and Figure 2-2 (CEAC). Memory was loaded with this configuration by the following procedure:

1.   The integrated CPC or CEAC system was loaded from the PVNGS-1 Rev. 00 Reference Disk #S248.

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

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

The Automated Phase I Testing software was then used, with CLUB, to test the programs listed in 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 and CEAC 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 them 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
operational system software. 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
portion 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
[   ].

Tests of the Penalty Factor program were run on [   ]. No
software errors were found. Tests on the Display program were run on
[   ]. No software errors were found.

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
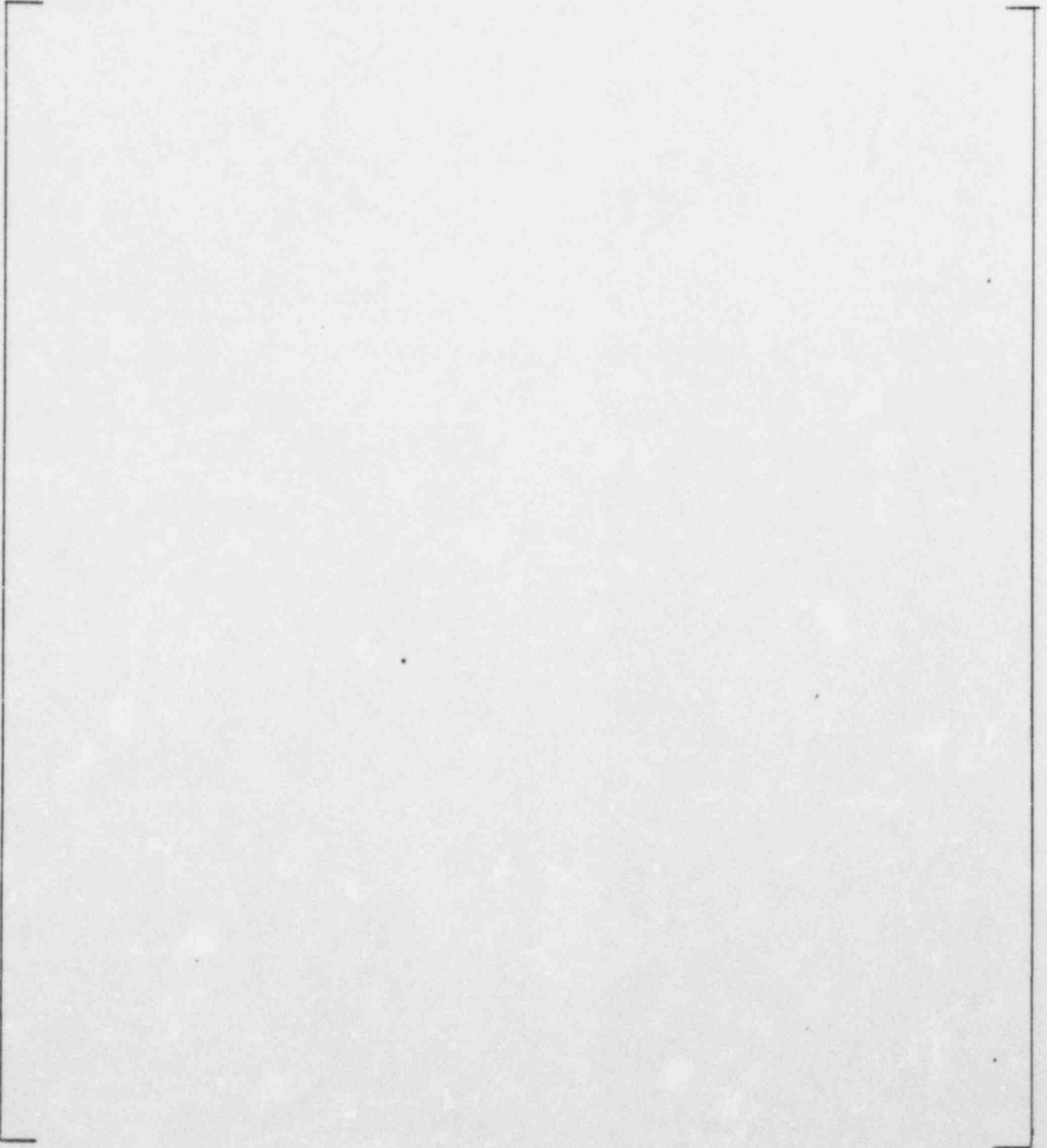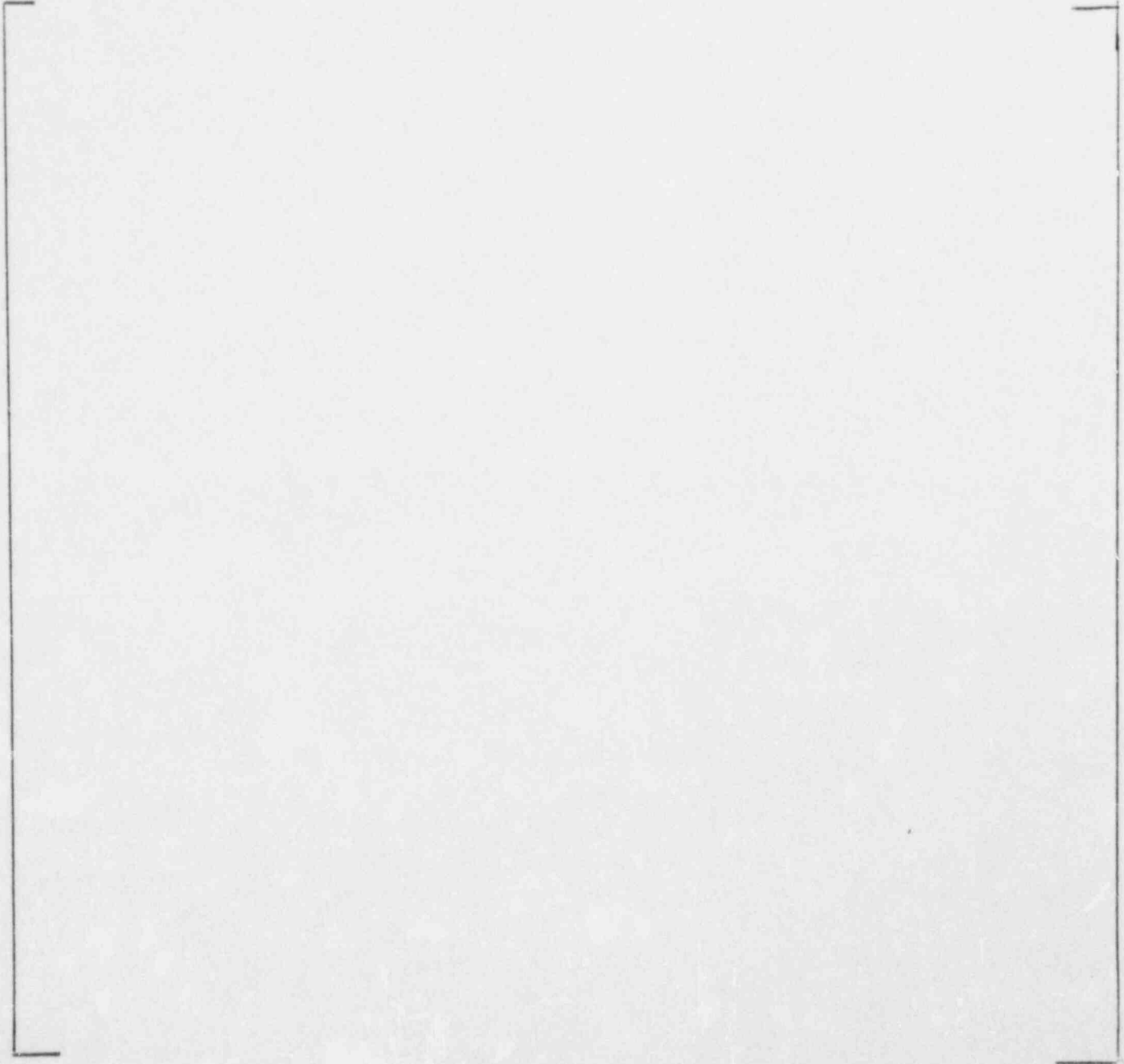CPC SYSTEM SOFTWARE PHASE I TESTING

FIGURE 2-1 (Cont'd.)

FIGURE 2-2

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

FIGURE 2-2 (Cont'd.)

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. Prior to formal Phase I testing of the Executive system software, a change was identified and made to both the CPC and CEAC Executive systems and disk #S248 was regenerated. A byte by byte comparison was made between disk #S248 and #S249 and demonstrated that all sectors other than those containing these programs were identical and, thus, that all previous Phase I testing was valid.

3.1   TEST CONFIGURATION

Phase I testing of the CPC/CEAC Executive was performed on the CPC and CEAC Single Channel Units. For the purpose of this testing, the Single Channel Facility was configured with the hardware complement listed in Table 2-1 (CEAC) and Table 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 PVNGS-1 Rev. 00 Reference Disk #S248 (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 of 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 [   ]. No software errors were detected.
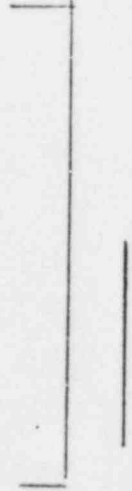
TABLE 3-1

CPC SINGLE CHANNEL HARDWARE CONFIGURATION FOR PHASE I
EXECUTIVE PROGRAM TESTING

FIGURE 3-1

CPC AND CEAC SINGLE CHANNEL
MEMORY MAP FOR CPC/CEAC EXECUTIVE PHASE I TESTING

FIGURE 3-1 (Continued)

4.0 PHASE I TEST RESULTS SUMMARY

Phase I testing of the CPC and CEAC software for PVNGS-1 Cycle 1
(Rev. 00) was performed in accordance with Reference 2. Test results
detected no errors in the implementation of the software modifications
described in Reference 1.

5.0   <u>REFERENCES</u>

1. CPC/CEAC Software Modifications for System 80, Enclosure 1-NP of LD-82-039, March, 1982.

2. CPC Protection Algorithm Software Change Procedure CEN39(A)-P, Revision 02, December 21, 1978.

3. PVNGS-1 CPC/CEAC System Phase I Software Verification Test Report, CEN-217(V)-NP,Revision 00, January 1983.