

SAN ONOFRE NUCLEAR GENERATING STATION-UNIT 3
END-OF-CYCLE 1 DIAGNOSTIC FUEL EXAMINATION REPORT

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A REPORT TO
SOUTHERN CALIFORNIA EDISON COMPANY

FROM

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1.0 INTRODUCTION

This report documents the fuel examinations conducted at Southern California Edison's (SCE) San Onofre Nuclear Generating Station - Unit 3 (SONGS-3) during the end-of-cycle 1 (EOC-1) refueling outage. [

]

The fuel examinations performed during the EOC-1 outage concentrated on the identification of fuel assemblies and the individual fuel rods within those assemblies which contain cladding perforations (Zircaloy-4 cladding). Examinations performed on assemblies identified as containing perforated fuel rods were directed toward diagnostic determination of the cause(s) of the perforations. The primary method used to identify assemblies containing perforated fuel rods was wet sipping. The method used to determine the location of leaking rods within an assembly and to resolve ambiguous sipping results was the Failed Fuel Rod Detection System (FFRDS) that utilizes ultrasonic techniques to detect the presence of water within a fuel rod. Diagnostic examinations performed to ascertain the cause(s) of fuel rod failure included assembly and single-rod visual examinations, and fuel rod eddy current testing.

2.0 ASSEMBLY EXAMINATIONS

2.1 FUEL ASSEMBLY LEAK TESTING

A total of [] of the 217 assemblies that comprised the Cycle 1 core loading were leak tested by wet sipping. The assemblies that were leak tested included [

] Table 2.1 lists the assemblies identified as containing perforated fuel rods by wet sipping.

Table 2.1
SONGS-3 Fuel Assemblies Identified As
Containing Perforated Fuel Rods by Wet Sipping

--

[

]

2.2 ULTRASONIC TESTING TO DETECT LEAKING FUEL RODS

The Failed Fuel Rod Detection (FFRD) System, that utilizes ultrasonic techniques to detect water within fuel rods, was used as the method to identify the location of the perforated rods within an assembly previously designated as containing leaking fuel rods by sipping. In addition, the FFRD System was also used to resolve ambiguous assembly leak testing results and to determine the location of leaking rods in discharged Batch A Assemblies that were not sipped. A total of [] assemblies were tested by the FFRD System. The tested assemblies are grouped in the following manner:



A total of [] of the two hundred and seventeen (217) fuel assemblies in the Cycle 1 core loading of SONGS-3 were determined to contain [] leaking fuel rods. These include [] One discharged Batch A Assembly (A043) was not tested either by sipping or the FFRD System. Table 2.2 lists the fuel assemblies with leaking rods and the number of leaking rods in each. Figure 2.1 presents a Cycle 1 core schematic that identifies the location of the assemblies containing perforated fuel rods in the core.

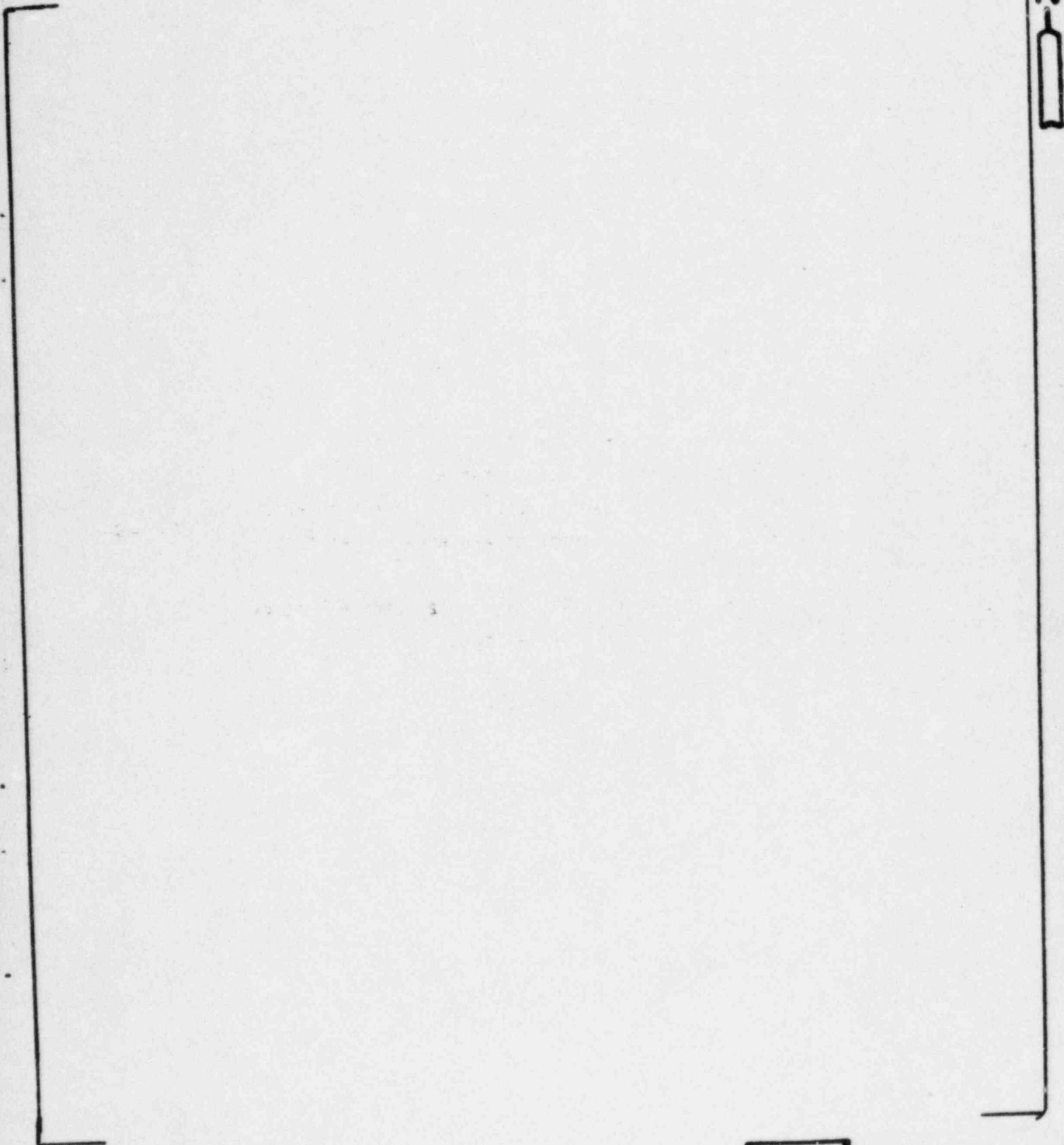
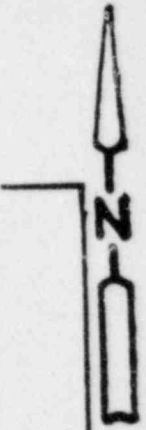
The [] Assemblies, identified to contain perforated rods and designated for insertion in Cycle 2, were reconstituted. Each of these assemblies was disassembled and perforated rods were removed. Replacement rods, consisting of []

TABLE 2.2

SONGS-3 Fuel Assemblies Containing Perforated Fuel Rods

<u>ASSEMBLY</u>	<u>NO. OF FAILED RODS</u>
TOTALS	

Figure 2.1
SONGS-3 CYCLE 1.
LOADING PATTERN



ASSEMBLY
WITH LEAKING
ROD(S)

locations of removed fuel rods.] were inserted to occupy the matrix

2.3 FUEL ASSEMBLY VISUAL EXAMINATIONS

Fuel assembly visual examinations were performed using a curb-mounted, underwater periscope system. The periscope system includes a 35-mm camera that permits high resolution photographic documentation of anomalous or pertinent features observed during examination.

A total of [] fuel assemblies were examined during the EOC-1 outage. The majority of the assemblies examined were those identified as containing perforated fuel rods. Fuel rod perforations that could be seen prior to fuel bundle disassembly had the appearance of through-wall. [] Individual fuel rods were examined later and a discussion of those results are in Section 3.0. Each of the fuel assemblies reconstituted for insertion into Cycle 2 was examined [] The purpose of the examination was to 1) identify any potential anomalies within the assembly that could indicate the cause of failures, 2) determine the overall condition of the assembly relative to its ability to be reconstituted, and 3) confirm the identity and location of peripheral fuel rods designated as perforated by the FFRD System.

The overall condition of the assemblies examined, [] was very good. The crud observed on the clad surface was light and fairly uniform. Although no measurements were made, oxidation of the fuel rods within the assemblies appeared typical of one-cycle, PWR rods.

Examination of the Zircaloy-4 and Inconel grid perimeter strips indicated no anomalous observations. No evidence of grid wear or handling damage was observed on any of the assemblies.

No evidence of fuel rod fretting was observed on any of the assemblies examined or on the individual fuel rods examined and reported in Section 3.0.

One small piece of debris was observed during the examination of Assembly B059. A small metallic object, having the appearance of either a nail or brad, was observed stuck under the perimeter strip wiper tab between Rods 7 and 8⁽¹⁾ of Grid 2⁽²⁾ on the assembly's, 90° face. The size of this object was ~0.75 inches long with a diameter of ~0.03 inches. The debris was dislodged from the assembly in the spent fuel pool but was not retrieved.

Visual examination of Assemblies [

]

- (1) Rods are numbered 1 to 16, left to right across the assembly face.
- (2) Grids are numbered 0 through 10. The Inconel grid is Grid 0 and the Zircaloy grids are numbered 1 to 10, bottom to top.

Based on results obtained from the assembly visual examinations, no mechanism(s) could be identified as being responsible for the observed fuel rod cladding perforations.

2.3.1 []
[]

] The approach taken[

] as shown in Figure 2.2. [

] Figure 2.2 presents a schematic of [

] The [] were eddy current tested and a limited number were visually examined. The results of the eddy current testing and visual exams are discussed in Sections 3.1 and 3.2 of this report.

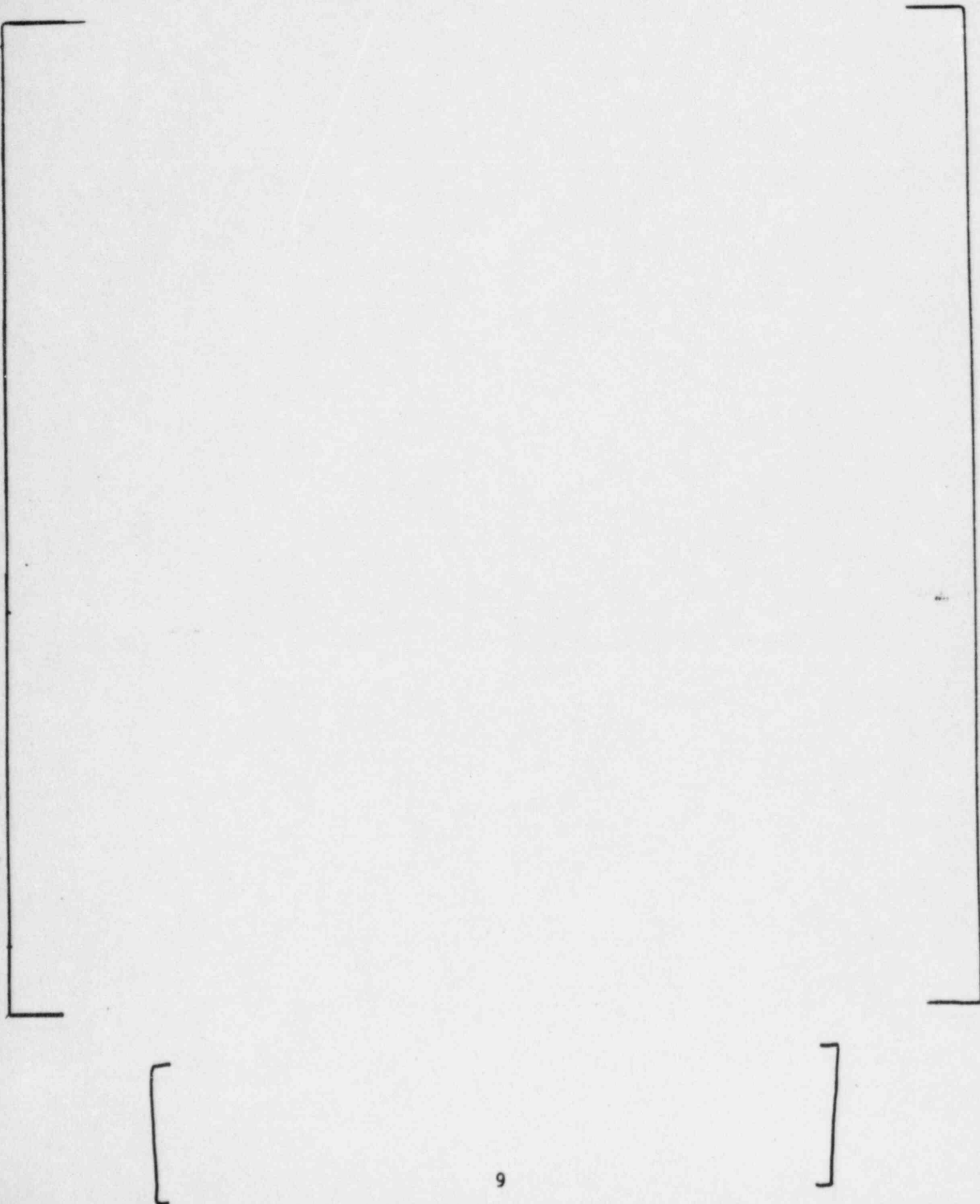
The visual examination of [

]

[

]

Figure 2.2
[] SCHEMATIC



[

]

[

]

Visual examination of the structural components in [] (e.g., spacer grids) indicated the grids were in excellent condition. No observations of grid damage were made. All welds visible during this examination appeared intact and structurally sound. No evidence of debris was found in the [] and no evidence of coolant flow blockage was apparent.

Based on the results of the in-situ examination of [] no apparent cause for the fuel rod perforations could be ascertained. [

]

3.0 SINGLE-ROD EXAMINATION

3.1 EDDY CURRENT TESTING

Single-rod eddy current testing (ECT) was performed on [] from the reconstituted Batch B and C Assemblies. In addition, [] were tested.

A total of [] were eddy current tested from []

The eddy current testing was performed, using an encircling coil, at frequencies of []

The results of the eddy current tests on []

[]

]

] Figure 3.1 presents a histogram of the locations of these perforations []

The eddy current tests performed for diagnostic purposes on []

] []] [] [] [] []

Figure 3.1

LOCATIONS OF PERFORATIONS
ON RODS WITH



All [] The majority of these []

]

The []

]

3.2 PERISCOPE VISUAL EXAMINATION

Visual examinations were performed on individual fuel rods using the underwater periscope system mounted on the Fuel Inspection Stand (FIS).

A total of [] were examined. The rods examined include the following:

[]

Examination of the fuel rods that contained perforations resulted in [

]

Figure 3.2 presents histograms of [

] Figure 3.2 (a) presents a

[

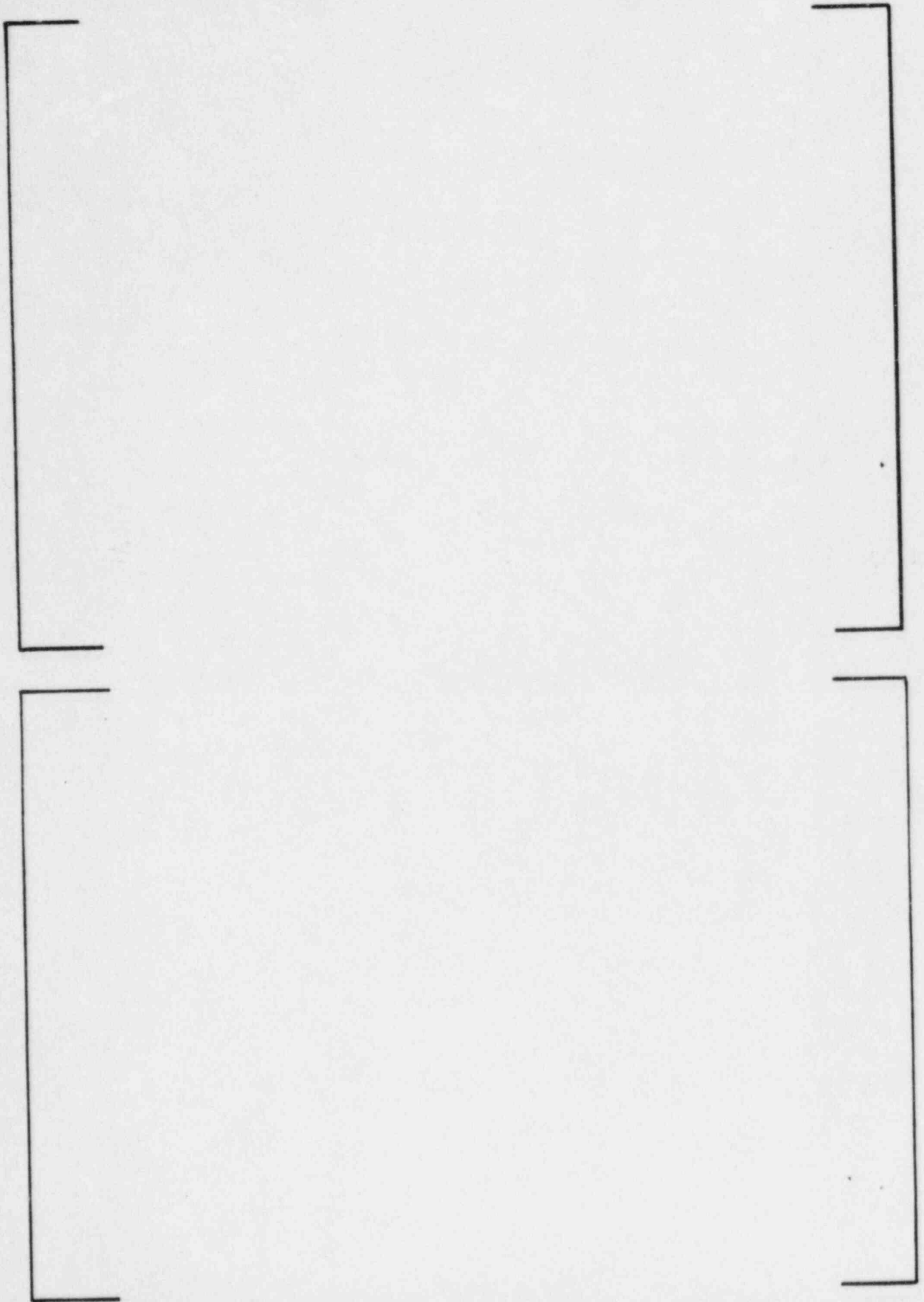
] Figure 3.2 (b) presents the [

]

Several of the [

Figure 3.2

AXIAL ELEVATIONS OF FUEL ROD PERFORATIONS



Visual examination of [

]

Visual examination of [

] As stated in Section 3.1, [

]

4.0 CONCLUSIONS FROM POOLSIDE EXAMINATIONS

The examinations performed on fuel assemblies that contained [

] Several observations and conclusions can be formulated concerning the operable failure mechanism(s) in the SONGS-3, Cycle 1 core.

The [

]

The fuel assembly visual examinations have determined that the [

]

Visual examinations of both assemblies and fuel rods indicated the general appearance of [

]

No [

]

Single-rod examinations performed on [

] In fact, characterization of [

]

Based on the available information obtained by poolside examinations, [

]

5.0 REVIEW OF []

5.1 SUMMARY OF CONCLUSIONS

The early occurrence of the SONGS-3 fuel failures and the results of the poolside examinations (summarized in Section 4.0) are []

[]

] This conclusion is based on reasoning noted below. []

5.2 THE []

[]

[]

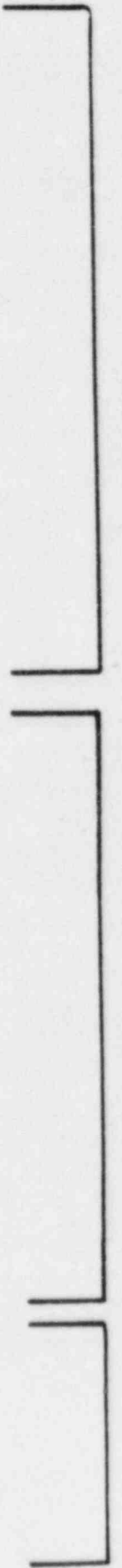
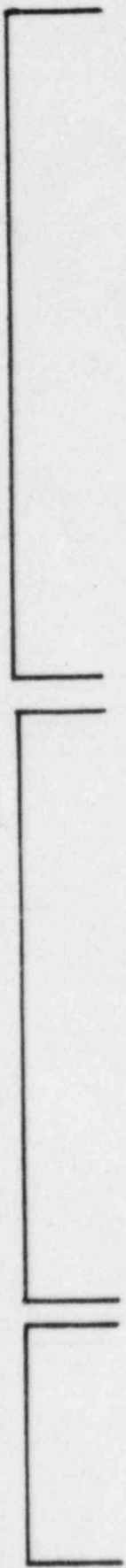
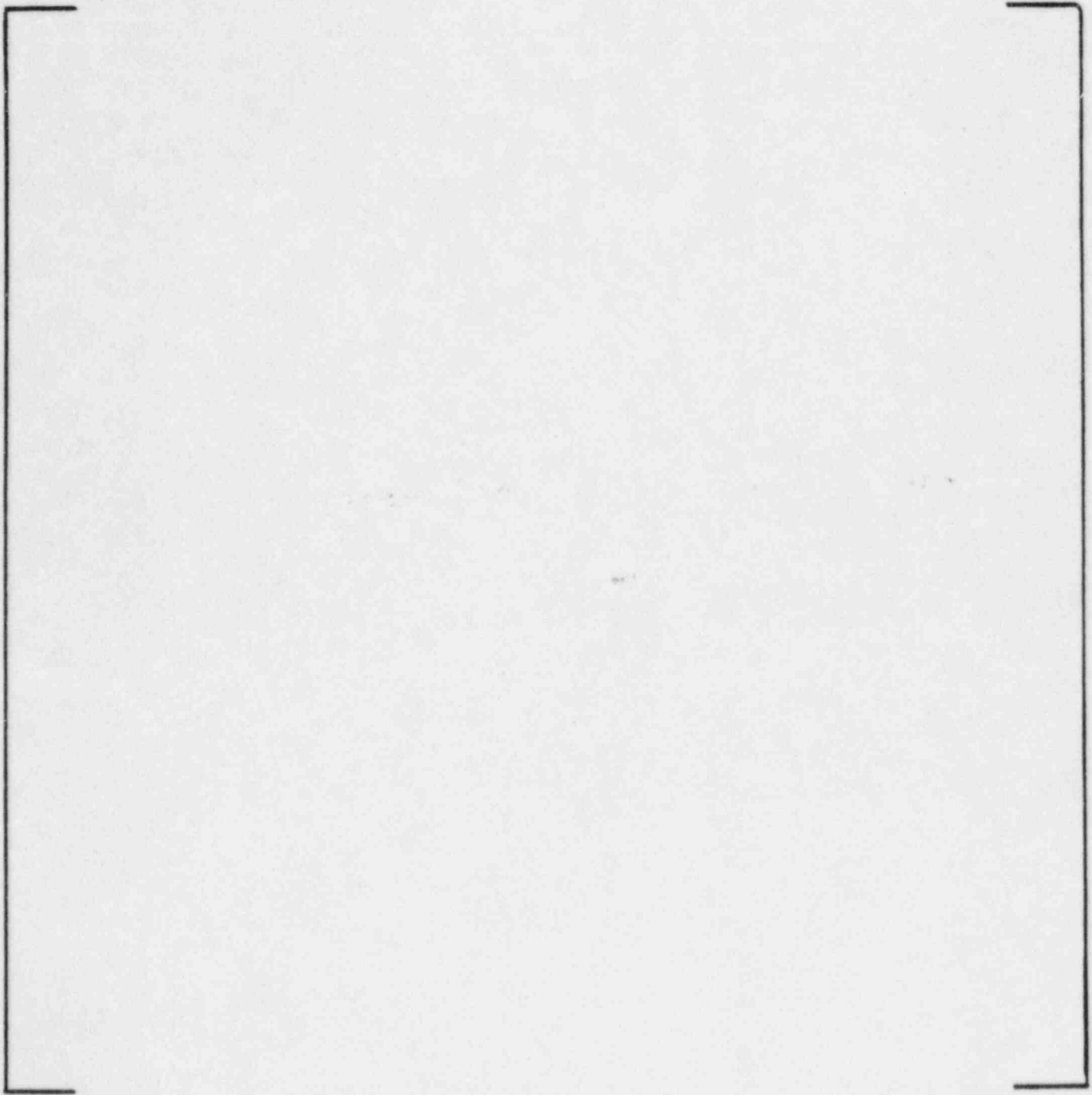


Figure 5.1

FUEL ROD POSITION []



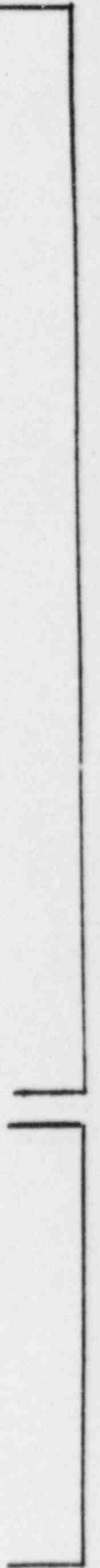
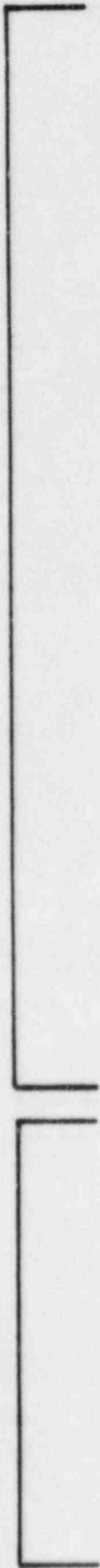
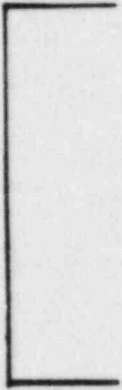
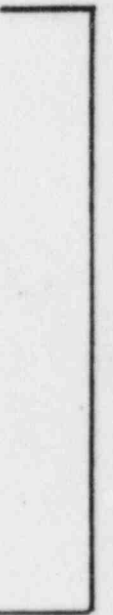
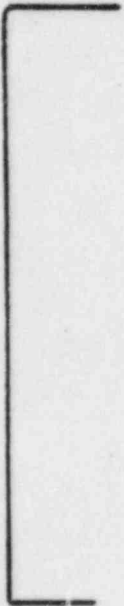


Figure 5.2

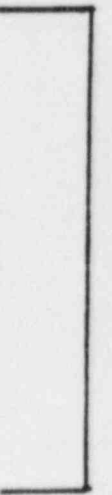
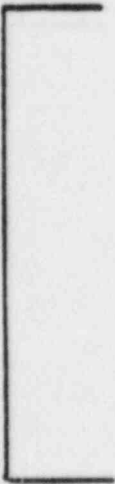
SUMMARY OF PERFORATED ROD DISTRIBUTION

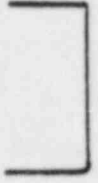
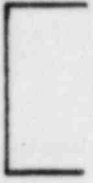


5.3 CONCLUSION



5.4 []





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