J. D. Phillips

FINAL REPORT

SHIELDING INTEGRITY CHECK (SIC) TESTS FOR THE E-MAD FACILITY

(PHASE III AND PHASE III ADDENDUM)

MASTER

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NERVA TEST OPERATIONS

Jackass Flats, Nevada

NTO-R-0039

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FINAL REPORT

15 OCTOBER 1965

Report NTO-R-0039

Shielding Integrity Check (SIC) Tests
for the

E-MAD Facility

Phase III and Phase III Addendum

Contract SNP-1

MASTER

Prepared for

Space Nuclear Propulsion Office

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FOREWORD

This report is presented in partial fulfillment of Contract SNP-1, Sub-Subtask 7.5.1, for Contract Year 1965, which states in part, "Complete Shielding Integrity (SIC) Tests for shielded walls (except for post-mortem intercell walls), analyze and evaluate the results relative to program requirements and provide for minor facility modification(s) to correct deficiencies".

ABSTRACT

This report contains the data and results obtained from the Phase III and Phase III Addendum portions of the Shielding Integrity Check (SIC) tests at the E-MAD Building. These portions of the SIC Tests were performed by NERVA Test Operations (NTO) under Contract SNP-1, Sub-Subtask 7.5.1.

The Phase III portion, the Hot Hold and Transfer Tunnel (HHTT) and the Cell Service Areas (CSA), and the Phase III Addendum portion, the blocked-up transfer drawer pass-throughs and the Engine and Core Disassembly Cells, were tested to disclose any defects in shielding which might be present. The violations of shielding integrity found were corrected by physical reconstruction and/or repair (construction contractor fixes), or by establishment of administrative controls to be enforced during an operational phase, depending upon the severity of the violation.

There were no violations of shielding integrity found in the Phase III portion of the SIC tests which required a construction contractor type fix, and only the administrative type **operational** controls will be required to assure personnel safety.

There were two (2) violations of shielding integrity found in the Phase III Addendum portion of the SIC tests which were of sufficient magnitude to require a **construction** contractor type fix. These violations were repaired and re-checked. The repaired violations were found to possess adequate shielding integrity.

N. E. Erickson, Manager
NERVA Test Operations

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I. INTRODUCTION

The purpose of performing the Shielding Integrity Check (SIC) Tests is to determine the radiation shielding capabilities existent in a particular shielded area by a technique which will enable the detection, pin-pointing of exact location, and quantitative evaluation of any shielding defect so that corrective action can be taken to insure the safety of personnel working within that area.

The total scope of work required for performance of Shielding Integrity Check (SIC) Tests for all of E-MAD was divided into five (5) distinct phases as follows:

1. Phase I - The Hot Disassembly Area consisting of Hot Bay (Room 122) and the Crane Maintenance Balcony (Room 306).
2. Phase II - The Post Mortem Cells
3. Phase III - The Hot Hold and Transfer Tunnel (HHTT) and Cell Service Area (SCA)
4. Phase IV - The Post Mortem Intercell Walls
5. Phase V - The Engine and Core Disassembly Cells.

After this initial division had been made, it was decided that an addendum to the Phase III portion of the SIC tests be made which would encompass the scanning of the areas around the blocked-up transfer drawer pass-throughs in the Core and Engine Disassembly Cells, since the type of construction in this area had been found deficient in the Hot Disassembly area.

This report describes and details the results of the Phase III portion of the Shielding Integrity (SIC) Tests, namely the Hot Hold and Transfer Tunnel (HHTT) and Cell Service Area (SCA), and the Phase III Addendum portion of the SIC Tests, the Core and Engine Disassembly Cell blocked-up transfer drawer pass-throughs as described in the paragraph above.

The procedure for conduct of SIC Tests, of these areas was issued previously as a separate report which provided detailed instructions for performing that portion of the work concerned with mapping and indexing of all surface areas to be surveyed; the scanning of these areas with a radioactive source monitored by radiation detectors; and for the evaluation of the results followed by a subsequent recommendation for the corrective action to be taken. Similarly, the procedure for conduct of the Phase III Addendum portion, was issued previously as Addendum No. 1. to the Phase III SIC Procedure.

In addition to the above procedures, an E-MAD Standard Operating Procedure (SOP) Safety Standard No. 1 was issued (refer to bibliography #4) to cover the responsibility and safety considerations involved in the use of a high-level source at E-MAD.

II. SUMMARY

The data and results obtained for completion of the Phase III portion of the SIC Tests did not disclose any violations of shielding integrity which were of sufficient magnitude as to require a construction contractor type fix. There were a number of violations disclosed which were cataloged in the following two (2) types:

1. Those where the thickness of the shielding barrier had been reduced by passage of an air duct or by a thinning of the wall at a higher elevation in accord with design requirements.

2. Those where radiation can be made to "shine" between the cracks made by the various shielding doors with the adjacent wall or floor.

The data and results obtained from the conduct of the Phase III Addendum portion of the SIC tests concerned with the blocked-up transfer drawer pass-through of the Engine and Disassembly Cells, disclosed two (2) violations of shielding integrity requiring a construction contractor fix.

These defective areas were fixed by the construction contractor and subsequently rechecked for shielding integrity. The repaired areas were found to be satisfactory.

III. TEST DATA AND RESULTS

The Shielding Integrity Check (SIC) Tests conducted for the Phase III portion of the work disclosed a number of apparent violations, none of which were of sufficient magnitude as to require a construction contractor type fix. These violations are tabulated as follows:

A. Hot Hold and Transfer Tunnel

<u>Violation</u>	<u>Location</u>	<u>Reading</u>	<u>Ref. to Figure</u>
1	Interior East Wall, Row F, Cols. 8-18	1.1 mr/hr (av) 2.3. mr/hr (max.)	1
2	Window E-6	0.13 mr/hr (av.) 0.17 mr/hr (max.)	1
3	Window E-13	0.15 mr/hr (av.)	1
4	Door 130-1	0.07 to 2.0 mr/hr (average)	1
5	Interior South Wall - Door 128-1	25 to 200 mr/hr (through crack between wall and door) 0.7 mr/hr (through crack between two halves of FMHS rails pass)	2
6	Interior West Wall - Row F, Cols. 8-18	0.81 mr/hr (av.)	3
7	Door 127-1	2.2 to 7.0 mr/hr (crack between wall and door) 185 mr/hr (under door through FMHS rails)	3

B. Cell Service Area

<u>Violation</u>	<u>Location</u>	<u>Reading</u>	<u>Ref. to Figure</u>
1	Interior East Wall - Row D, ventilator ducts	155 mr/hr	4
2	Doors 166-171	0.1 - 5.0 mr/hr (through cracks between doors and walls) 0.8 - 18 mr/hr (beneath doors, including those points where FMHS rails pass)	4
3	Interior West Wall - Row D, ventilator ducts	125 mr/hr	5
4	Doors 160-165	0.74 - 5 mr/hr (through cracks between doors and wall)' 0.2 - 190 mr/hr (beneath doors including those points where FMHS rails pass)	5
5	Interior South Wall - Door 173-1	2.5 mr/hr (av) 5.0 mr/hr (max)	6

The Shielding Integrity Check (SIC) Tests conducted for the Phase III Addendum portion disclosed two (2) violations which did require a construction contractor type fix. These violations are tabulated as follows:

<u>Violation</u>	<u>Location</u>	<u>Reading</u>	<u>Ref. to Figure</u>
1	Room 130 - Engine Disassembly Blocked-up transfer drawer pass-through (approx. 1 ft. above the pass-through)	15 mr/hr (max.)	--
2	Room 127 - Core Disassembly Cell Blocked-up transfer drawer pass-through (approx. 1 ft. above and 1 ft. to the west)	100 mr/hr (max.)	

IV. ANALYSIS OF DATA AND CORRECTION OF DEFECTS

In order to evaluate and analyze the data and results obtained from the conduct of the Shielding Integrity Check (SIC) Tests, it was necessary to establish a basis for determining the level of reading which would constitute a violation. This requirement was met by establishment of the following standards and ground rules which were agreed upon by the Test Evaluation Committee (TEC):

1. A maximum reading of five (5) times or less than five (5) times the average level which would be observed through walls known to possess adequate shielding integrity with a source in position will not be considered as significant.

2. A maximum reading greater than five (5) times the average of adjacent or similar construction is considered a violation unless the reading is commensurate with structural design.

3. In those cases where the shielding integrity is in apparent violation, but is commensurate with the design, administrative controls will be employed.

4. If the apparent violation is not commensurate with the design, then a fix by the construction contractor would be required.

Based on the above standards and ground rules, an evaluation and analysis of the test results obtained for the various areas was made. This analysis and the resolutions agreed upon by the Test Evaluation Committee (TEC) are summarized in the following paragraphs:

A. Hot Hold and Transfer Tunnel

1. Interior East Wall Grid Map - Figure 1

a. Row F, Columns 8-18 permit an average of 1.1 mr/hr to pass (maximum 2.3 mr/hr). This area permits more radiation to pass than five times the average of the adjacent areas below because the wall is reduced in thickness at this level from 6' to 4'. The readings are commensurate with the 4' shielding design. (Ground rule 3)

b. Window E-6 - The average reading of the various portions of Window E-6 is 0.13 mr/hr. The maximum reading is 0.17 mr/hr. Therefore, no violation exists at Window E-6. (Ground rule 3)

c. Window E-13 - The reading of 0.15 mr/hr taken on that portion of Window E-13 which is within the test area is very close to the average reading of other blocked-up windows such as Window E-6 with an average reading of 0.13 mr/hr. Therefore, no violation exists at Window E-13. (Ground rule 3)

d. Door 130-1 - From 0.07 to 2.0 mr/hr can be made to "shine" through the crack between the wall and the door. As much as 140 mr/hr can be made to "shine" through the crack between the wall and the door. As much as 140 mr/hr can be made to "shine" under the door through the FMHS rails. Since the doors, walls and floors appear to be built as designed, no repair of a construction flaw can be made and administrative control of these areas will be employed. (Ground rule 3).

2. Interior South Wall Grid Map - Figure 2

a. Door 128-1 - A shine varying between 25 and 200 mr/hr could be made to pass through various parts of the crack between the wall and Door 128-1. A maximum of 0.7 mr/hr passed in the crack between the two halves of the FMHS rails pass. Administrative control over these areas will be maintained since the construction appears to be consistent with design. (Ground rule 3).

3. Interior West Wall Grid Map - Figure 3

a. Row F, Columns 8-18 permit an average of 0.81 mr/hr to pass (maximum 1.2 mr/hr). This area permits more than five (5) times the average of the adjacent areas below because the wall is reduced in thickness at this level from 6' to 4'. The readings are commensurate with the reduced thickness. (Ground rule 3).

B. Cell Service Area

1. Interior East Wall Grid Map - Figure 4

a. Ten and twelve inch sigmoid ventilation ducts in Row D thin the walls irregularly but markedly, and permit radiation of up to 155 mr/hr to pass while the average reading in the adjacent area below the ducts (Row C) was approximately 0.2 mr/hr. This area is constructed according to design so no repair is required, and administrative controls will be employed. (Ground rule 3).

b. Door 166 through 171 - From 0.1 to 5.0 mr/hr could be made to pass through the cracks between the doors and the walls. From 0.8 to 18 mr/hr could be made to pass beneath Doors 166-171 including those points where the FMHS rails pass. These conditions are built as designed so no violation of shielding integrity is implied. Administrative controls will be employed in these areas.

2. Interior West Wall Grid Map - Figure 5

a. Ten and twelve inch sigmoid ventilation ducts in Row D thin the walls irregularly but markedly, and permit up to 125 mr/hr to pass through the wall. This does not require a repair. Administrative controls will be employed.

b. Doors 160 - 165 - From 0.14 to 5 mr/hr could be made to pass through the cracks between the doors and the walls. From 0.2 to 190 could be made to pass beneath Doors 160-165 including those points where the FMHS rails pass. These conditions exist as designed. Administrative controls will be required for these areas.

3. Interior South Wall Grid Map - Figure 6

a. Door 173-1 permitted an average of 2.5 mr/hr (maximum 5.0 mr/hr) to pass through it under test conditions. Up to 100 mr/hr could be made to pass through the crack between the door and the wall by holding the source at a particular slant angle (found by various trials). Up to 6 mr/hr could be made to pass beneath the door through the FMHS tracks. These conditions are consistent with design and require administrative controls only.

C. Engine and Core Disassembly Cells Transfer Drawer Blocked-up Pass-Throughs

1. Engine Disassembly Bay Blocked-up Pass-Through (Room 130)

A violation of shielding integrity 4' long with a maximum reading of 15 mr/hr (adjacent walls permitted 0.02 mr/hr) was found one foot above the pass-through running horizontally. It was 6" to 7" wide (top to bottom). It constituted a lack of 20" to 25" of concrete. This fault was probably associated with a difficulty in grouting in the pass-through wall liner which was installed after the main concrete pour.

The violation was fixed by the contractor using steel grit. The grit was blown in through a drilled hole slanting in from above the void starting on the gallery side downward into the center of the void. On re-checking the defective area, it was found that the extreme east and west ends of it were still in violation. The construction contractor added more steel grit through holes cut at the points of violation. The areas were checked for the third time, and the second fix proved to be adequate. All drilled holes were concrete capped.

2. Core Disassembly Bay Blocked-Up Pass-Through (Room 127)

A violation in shielding, generally circular in shape with a diameter of approximately 12" was found 12" above and 12" to the west of the Core Disassembly Cell transfer drawer pass-through. The maximum reading of radiation passing through the wall was 100 mr/hr. This violation constitutes a lack of 30" to 35" of concrete. It was probably associated with the installation of the pass-through wall liner after the main pour. The violation was filled in a similar fashion as above with steel grit by the construction contractor. Rechecking of the violation showed the repair to be adequate. All drilled holes were concrete capped.

D. Ceiling Areas of Hot Hold and Transfer Tunnel and Cell Service Area

1. The shielding integrity check tests of the ceiling of the Hot Hold and Transfer Tunnel (Figure 4) did not disclose any violations and all the readings that were obtained were background.

Similarly the test of the ceiling of the Cell Service Area (Figure 8) did not disclose any violations. The readings obtained for one section of this ceiling were of background level, while another section had readings uniformly at a higher level. However, these higher readings did not constitute any violation and resulted from the fact that the ceiling is of stepped construction and this latter portion of ceiling is approximately a 42-inch thickness of concrete compared to a 62-inch thickness of the section referred to previously, thus establishing a different background.

V. CONCLUSIONS

The conduct of the Phase III portion of the SIC Tests was satisfactorily completed. No serious violations of shielding integrity of the shielding surfaces of the Hot Hold and Transfer Tunnel or Cell Service Area were found. There were a number of suspected areas (apparent violations) found above the doors between the CSA and PM cells, but a subsequent investigation of Vitro drawings indicated the shielding was commensurate with the amount of concrete designed for the area. The presence of the sigmoid ventilation ducts served to reduce the amount of concrete in the area of the particular duct location as compared to adjacent unpenetrated walls.

The "shine" which was experienced in various locations when the source was appropriately positioned implies that there are a number of points for which a particular placement of a source will result in "seeing" an unsafe level of radiation. These points would include such positions where "shine" was observed through door cracks or the FMHS rail grooves.

None of the above enumerated cases are of the types which would require a corrective action involving a construction contractor type fix, since the employment of administrative type controls would present a more practical solution to the problem. These administrative type controls would consist of such things as marking of areas, color coded zoning, a temporary erection of appropriate barricades, and the direct employment of personnel to monitor access to a particular area during the time the operations are in progress. These administrative controls would be maintained "as and when needed" to adequately assure personnel safety.

The conduct of the Phase III Addendum portion of SIC Tests was satisfactorily completed and two (2) major violations were disclosed. These violations were of sufficient magnitude to warrant a construction contractor type fix, which consisted of core drilling the walls and refilling the void and questionable areas with steel grit. These fixes were completed for these two (2) defective areas. These areas were rechecked and refixed as required until both were shown to provide satisfactory shielding integrity.

BIBLIOGRAPHY

1. NTO Final Report for Phase I Shielding Integrity Check (SIC) Test for the E-MAD Facility, NTO Report NTO-R-0038, 15 October 1965.
2. NTO Procedures Report for the Phase III Shielding Integrity Check (SIC) Tests for the E-MAD Facility, NTO Report NTO-I-0026, 12 March 1965.
3. SIC Test of Blocked-Up Pass-Throughs in the Engine and Core Disassembly Cells, Addendum No. 1: to Procedure No. NTO-I-0026, Nto Procedures Report for Phase II of SIC, 1 April 1965.
4. E-MAD Standard Operating Procedure Safety Standard No. 1, issued 10 December 1964, Revision A.
5. TWX: To: N. E. Erickson, L. E. White, C. D. Montgomery, B. P. Helgeson - From: J. B. Philipson; TWX No. 7030/T10323/JH; Subject: Approval of Addendum of SIC Test Phase III.
6. TWX: To: Chandler C. Ross, VP REON - from: R. W. Schroeder, SNPO-C, 19 March 1965; Subject: Approval to Conduct SIC Phase III Tests.

APPENDIX A

I. Chronology:

3/1/65 - 4/2/65	Shielding surfaces were gridded.
3/12/65	Issue of Procedure Phase III
3/19/65	Approval of Procedure by SNPO-C
3/22/65	Equipment checked out
3/23/65 - 4/2/65	Shielding surfaces of Hot Hold and Transfer Tunnel and Cell Service Area were tested for shielding integrity.
4/1/65	Addendum No. 1 to Phase III Procedure issued
4/6/65	Approval of Addendum No. 1 to Phase III Procedure
4/8/65	Blocked-up Pass-throughs in Core and Engine Cell were checked for shielding integrity. Two violations were found, one above each pass-through.
5/17/65	The repaired areas were rechecked. The Core Cell violation was found to be adequately repaired. The Engine Cell repair was inadequate.
6/5/65	A second repair was made for the Engine Cell violation.
7/1/65	The repaired area in the Engine Cell (Room 130) was checked for the third time, and the repair was found to be adequate.

APPENDIX B

I. Cyclops Cobalt-60 Radiographic Source

A radiographic source was employed for the conduct of the Phase III and Phase III Addendum portions of the SIC Tests. This source was the Picker X-Ray Corporation's Cyclops Cobalt-60 radiographic source, (Figures 7 and 8). The source had a certified strength of 2105 Curies as of June, 1963. In January 1965 when the SIC Tests were started its effective source strength was measured as 1700 R/hr at 1 meter. The Cobalt-60 is contained in an 11" thick lead container. It has a fail-safe remotely operated shutter which opens a window to an 80° solid angle (the 80° solid angle was calculated as the angle of collimation with the jury-rigged lead brick collimator attached). The source is fitted with a hydro-lift type stand on rollers.

The source handling fixture is a counter-balanced horizontal beam, attached to the crane hook adapter near its center and supporting the source head and upper arm at one end. (Figure 9). At the opposite end is a counter-balancing basket containing lead bricks.

INTERIOR EAST WALL GRID MAP-
HOT HOLD AND TRANSFER TUNNEL

FIGURE 1

NOTE: ALL READINGS ARE BACKGROUND UNLESS INDICATED BY READINGS AS SHOWN. BACKGROUND ≈ 0.016 mr/hr⁻¹

NERVA TEST OPERATIONS
NUCLEAR ROCKET DEVELOPMENT STATION

INTERIOR SOUTH WALL GRID MAP
HOT HOLD AND TRANSFER TUNNEL

FIGURE 2

NERVA TEST OPERATIONS
NUCLEAR ROCKET DEVELOPMENT STATION
Jackass Flats, Nevada

INTERIOR WEST WALL GRID MAP-
HOT HOLD AND TRANSFER TUNNEL

FIGURE 3

NOTE: ALL READINGS ARE BACKGROUND UNLESS INDICATED
BY READINGS AS SHOWN. BACKGROUND ≈ 0.016 mr/hr⁻¹

NERVA TEST OPERATIONS
NUCLEAR ROCKET DEVELOPMENT STATION
Jackass Flats, Nevada

INTERIOR CEILING GRID MAP-
HOT HOLD AND TRANSFER TUNNEL

BACKGROUND RADIATION $\approx 0.012 \text{ mr/hr}^{-1}$

FIGURE 4

NERVA TEST OPERATIONS
NUCLEAR ROCKET DEVELOPMENT STATION
Jackass Flats Nevada

INTERIOR EAST WALL GRID MAP-
CELL SERVICE AREA

NOTE: OTHER HIGH READINGS INDICATES IN DOOR AREAS
ARE RESULT OF AVERAGING READINGS WITH
THOSE THROUGH DOOR CRACKS

FIGURE 5

NERVA TEST OPERATIONS
NUCLEAR ROCKET DEVELOPMENT STATION
Jackass Flats, Nevada

FROM 0.2 mr/hr to 190 mr/hr COULD BE MADE TO PASS UNDER THE DOORS INCLUDING THOSE PLACES WHERE THE BLOCKS EXIST

INTERIOR WEST WALL GRID MAP- CELL SERVICE AREA

READINGS SOMEWHAT HIGHER IN THESE AREAS DUE TO PRESENCE OF AIR FILTER DUCTS

NOTE: OTHER HIGH READINGS INDICATED IN DOOR AREAS ARE RESULT OF AVERAGING READINGS WITH THOSE THROUGH DOOR CRACKS

FIGURE 6

INTERIOR SOUTH WALL GRID MAP
CELL SERVICE AREA

NOTE: HIGH READINGS INDICATED IN DOOR AREAS
ARE RESULT OF AVERAGING READINGS WITH
THOSE THROUGH DOOR CRACKS

FIGURE 7

NERVA TEST OPERATIONS
NUCLEAR ROCKET DEVELOPMENT STATION
Jackass Flats, Nevada

INTERIOR CEILING GRID MAP-
CELL SERVICE AREA

ALL READINGS OF THIS PORTION OF
THE CELL SERVICE AREA CEILING WERE
BACKGROUND EXCEPT AS INDICATED

BACKGROUND RADIATION ≈ 0.02 mr/hr

FIGURE 8

NERVA TEST OPERATIONS
NUCLEAR ROCKET DEVELOPMENT STATION
Jackass Flats, Nevada

CYCLOPS COBALT-60 RADIOGRAPHIC
SOURCE

1X-5022

T55-223

CYCLOPS COBALT-60 SOURCE CONTROL

FIG. 10

COBALT SOURCE HANDLING FIXTURE

FIG. II