J B Philipson

FINAL REPORT

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

(PHASE I)

MASTER

NERVA TEST OPERATIONS

Jackass Flats, Nevada

NTO-R-0038

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Shielding Integrity Check (SIC) Tests
for the
E-MAD Facility
Phase I
Contract SNP-1

Prepared for
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F O R E W O R D

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 Postmortem intercell walls), analyze and evaluate the results relative to program requirements and provide for minor facility modifications to correct deficiencies".

A B S T R A C T

This report contains the data and results obtained from the Phase I portion of the Shielding Integrity Check (SIC) Tests at the E-MAD building. This portion of the SIC tests was performed by NERVA Test Operations (NTO) under Contract SNP-1, Sub-subtask 7.5.1.

The Phase I portion, which included the main Hot Disassembly Bay (Room 122) and the Crane Maintenance Balcony (Room 306), was performed to disclose any defects in shielding which might be present. The violations of the shielding integrity found were reviewed by a Test Evaluations Committee (TEC) to determine whether a construction contractor type fix or the establishment of administrative controls would be required.

There were a total of thirteen (13) violations of shielding integrity found in the Phase I portion of the SIC tests. Five (5) of these violations involved leakage through blocked-up windows. It was determined that three (3) of the violations required a construction contractor type fix and that two (2) violations could be provided for by establishment of appropriate administrative controls. One (1) violation was apparently due to a minor lead brick stacking error which was subsequently corrected. The two (2) remaining violations were the result of an existent condition, constructed as designed, which will be repaired by NTO.

All of the violations, with the exception of the last two (2) violations itemized above and a single area on the West Wall of the Main Hot Disassembly Bay, were repaired, rechecked and found to be satisfactory.

N. E. Erickson, Manager
NERVA Test Operations

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I. INTRODUCTION

The evaluation of the shielding integrity of walls, doors, floors and other radiation barriers at the E-MAD building, referred to as the Shielding Integrity Check (SIC) Tests, was divided into five (5) phases as follows:

Phase I - The Hot Disassembly Area (Hot Bay, Room 122) and the Crane Maintenance Balcony (Room 306)

Phase II - The Postmortem Cell Faces and Ceilings

Phase III - the Hot Hold and Transfer Tunnel (HHTT) and Cell Service Area (CSA); and Phase III addendum, the blocked-up pass-throughs of the Engine and Core Disassembly Cells

Phase IV - Postmortem Intercell Walls

Phase V - The Engine and Core Disassembly Cells

This report describes and details the results of the Phase I Shielding Integrity Check (SIC) Tests.

The procedure for the conduct of the SIC tests for this portion of the E-MAD building was issued previously as a separate report which provided detailed instructions for performing the work, divided as follows:

1. Mapping and indexing of all surface areas to be surveyed.
2. Scanning of areas with a radioactive source monitored by radiographic detectors.
3. Evaluating the results by the Test Evaluations Committee (TEC).

4. Upon recommendation of the TEC, performing the corrective action required and confirming the fixes.

The radioactive source employed in the conduct of the SIC tests was a Picker X-Ray Corporation Cobalt-60 Radiographic source. This particular source was selected, after much negotiation and delay, in preference to the ETR fuel elements originally contemplated for use as the source.

The selection of the ETR fuel elements for use as a radiation source for the SIC test was based on recommendations by Vitro Engineering Company in a letter signed by Vitro's E. W. Copeland, Jr. to the attention of Mr. R. R. Brookshire at SNPO-C, dated 1 November 1963 (Item (2) of the Bibliography). Vitro made three suggestions for radiation sources; (1) A Barium-Lanthanum source, (2) a Cobalt-60 source and (3) an MTR fuel element source. Barium-Lanthanum sources were not readily available. The MTR fuel element source seemed to lend itself to our needs better because for source strengths discussed in the Vitro letter, the fuel elements appeared to give more penetration and thus better test statistics. Later, ETR fuel elements were substituted for MTR fuel elements because of availability. For our purposes, the two were identical. Both types were to be procured from Phillips Petroleum Company, Idaho Falls, Idaho.

Phillips agreed to supply the ETR elements. At first, it was decided to "can" the elements to prevent contamination by scaling from the surface of the elements. Calculations showed that heating of the

elements by restriction of convection, if canned, would raise the temperature dangerously close to the melting point of the material of construction, aluminum. This information together with the prediction by Phillips that the ETR fuel elements could be delivered in a clean state and would not scale or in any way present a contamination hazard led to the conclusion that canning was unnecessary. The elements were ordered. They were cleaned by Phillips. Delays of delivery were required on several occasions because certain facility capability necessary for the conduct of the SIC test was not made available to WFO by the construction schedule. When Phillips checked the elements for surface contamination before shipment, the elements were highly contaminated. Re-evaluation of the fuel elements suggested that Phillips had been over-optimistic about their ability to furnish "clean" fuel elements. At this time, the use of ETR fuel elements was abandoned due to concern of potentially contaminating the E-MAD Facility by use of "leakers", and the Picker Cobalt-60 source was selected and used as described in the procedure (Item (1) of the Bibliography).

II. SUMMARY

The Shielding Integrity Check (SIC) Tests of the Phase I portion disclosed a total of thirteen (13) violations. Five (5) of these violations involved leakage through the blocked-up windows in the west wall of the Hot Disassembly Bay (Room 122); windows W-2, W-12, W-13, W-15, W-17 (Figure 5). These violations all seem to be associated with voids in the brick and mortar which was used to fill the windows. These violations were fixed by the construction contractor and a subsequent recheck showed that the repairs were adequate.

When the ceiling was tested, the source was positioned at a distance of 20' below the ceiling. The source was centered on 16' x 16' squares marked off on the roof. Each square was monitored at each setting. Since the roof is 2'9" thick (it tapers to a thickness of 4'6" at the east and west sides beginning 10' from each wall), good statistics were obtained, and no violations were found.

One violation, found in a small area in the Personnel Door 122-3, was apparently due to a minor lead brick stacking error. This door consists essentially of two (2) steel plates with lead brick stacked between the plates. The door was taken apart by the construction contractor and after replacement of the lead bricks, a subsequent recheck showed the violation to have been eliminated.

There were three (3) violations requiring a construction contractor type fix. One of the violations (Figure 1) appeared to be associated

with the failure of concrete packed around the conduit. This particular violation was repaired, rechecked and found to be adequate.

The second of these violations was associated with the pass-through of the southwest corner of the Main Hot Disassembly Bay (Room 122) (Figure 2), resulting from a difficulty experienced in filling a concave key-way above the pass-through with grout, leaving a large irregular cavity. This was repaired by filling with approximately 1600 lbs. of steel shot, followed by capping with concrete. Subsequent tests indicated the repair to be satisfactory.

The third violation was located near the intersection of the west wall of the Hot Disassembly Bay (Room 122) and the north wall door pocket (Room 307)(Figure 4), at about 10' above the third floor level (elevation 146') and appeared to be associated with three (3) pieces of incorrectly installed conduit. This violation has not been repaired to date.

One violation was disclosed which involved the upper portion of the west edge of Door 122-1 (Figure 6), resulting from the low density concrete used in this portion of the door. However, this was an intentional design of the door to reduce its overall weight and bearing load. This violation did not require a repair and the establishment of administrative controls for employment during operation will suffice.

One violation is associated with an incorrectly designed offset in the bottom of Door 306-4 (Figure 7). This violation will be corrected by NTO in the near future by the appropriate addition of steel

plates to the bottom portion of the door.

A violation is associated with the Radioactive Material Storage Vault plugs (Figure 8), which results from the placement of the plugs into the vault. An improper placement of the plugs provides cracks of sufficient width to permit the passage of radiation. This condition does not constitute a violation and the establishment of administrative controls will be employed during the placement of these Radioactive Material Storage Vault plugs.

The final violation is associated with a sleeve that is to house the turntable (NT-1), (Figure 9), power drive shaft when the turntable is installed. This is a temporary violation and administrative controls have been established. A steel plug will be placed into this sleeve prior to any hot operations.

III. TEST DATA AND RESULTS

The Shielding Integrity Check (SIC) Tests conducted for Phase I of the work disclosed a total of thirteen (13) violations. Some of these violations required contractor type fixes and others required that administrative controls be established for employment during periods of operation. In addition, there was one violation disclosed which resulted from a condition which existed because of the design, which was correctly followed. These violations are tabulated as follows:

<u>Violation</u>			<u>Refer to Figure</u>
1	West Wall - Square A-9	0.02 mR/hr (background) 50 mR/hr (maximum)	1
2	West Wall - Squares B-33, B-34	3 R/hr	2
3	East Wall - Personnel Door 122-4, Square B-3	120 mR/hr	3
4	West Wall - Squares K-34, L-34	190 mR/hr	4
5	West Wall - Windows W-2, W-12, W-13, W-15, W-17	W- 2 - 0.7 mR/hr W-12 - 3.2 mR/hr W-13 - 0.5 mR/hr W-15 - 0.6 mR/hr W-17 - 1.0 mR/hr	5
6	North Wall - Door 122-1 (Rows H, I, J; Cols. 4-8) (Row 9 - Cols. A-J)	2.0 mR/hr	6
7	Door 306-4	5.0 mR/hr	7
8	Radioactive Material Storage Vault	2.5 mR/hr	8
9	North Turntable Tunnel	160 mR/hr (maximum)	9

A detailed tabulation, shown as Table I, was made to provide additional information on the background count, the average readings and the maximum readings obtained for various areas tested.

T A B L E I

Average and Maximum Readings for Various Areas Tested in mR/hr

LOCATION	BACKGROUND	AVERAGE	MAXIMUM***	COMMENT
<u>Room 122</u>				
East Wall 5'	0.010	0.026	0.036	High Readings (120 mR/hr) were found associated with MSM's at Window E-3.
South Wall	0.020	0.020	0.030	
Bias Wall - MCR Window	0.010	0.012	0.028	
West Wall 6'	0.018	0.024	0.038	
North Wall	0.014	0.014	0.02	Upper Part of Door 122-1 Ave. 1.6 mR/hr.
Ceiling**	0.02	1.4	3.0	
<u>Room 306</u>				
East Wall 6'	0.014	0.014	0.032	Up to 2 mR/hr above OPS haunch.
South Wall 6'	0.016	0.016	0.038	
West Wall 6'	0.018	0.018	0.031	
North Wall*	0.025	0.30	0.7	Excludes Door Cracks.

* The upper part of the south wall of Room 122 and the north wall of Room 306 are the same.

** The ceiling readings for Room 122 and 306 are included here.

*** The maximum reading listed here is the maximum exclusive of violations. The violations are discussed elsewhere.

NOTE: Higher readings are observed above the 48' level due to thinner walls. Higher readings are also observed occasionally near door openings

IV. ANALYSIS OF DATA AND CORRECTION OF DEFECTS

In order to evaluate the 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. Therefore, some initial experimentation was required in using the Cyclops Cobalt-60 Radiographic source to determine the magnitude of reading which would constitute a background count.

In most cases, the source assembly was held normal to the surface being checked so that the closest point of the source head (excluding the lead brick collimator) was 30" from the surface. This meant that the radioactive source within the head was approximately 36" from the surface being checked. In some instances, as during the checking of the North and South Walls of the Hot Disassembly Bay and North Wall of the Crane Maintenance Balcony, it was not possible for the crane to position the source holding fixture closer than 12' from the surface being checked.

This was not true, however, for the lower 8' of these walls, since the source could be used in its own hydalift fixture (rather than removing it and placing it in the special handling fixture). When the source was used in its own fixture, it was possible to bring it within 30" of the surface being checked.

The background readings varied slightly from calibration to calibration and from instrument to instrument. The readings varied between 0.010 and 0.040 mR/hr. In some cases, especially the 6' walls in the Hot Disassembly Bay, the average reading was the same as the back-

ground reading. This was also true when the source could not be made to operate closer than 12' from the shielding surface because of crane travel limitations (such as at Door 122-1).

The use of the source at this distance did not compromise its effectiveness as shown by the ready disclosure of the violations found in the 6' wall. As an additional precaution some of the areas which were checked at this 12' stand-off distance were rechecked at a 30" distance by use of a mobile crane, a Pettibone Mobile Crane (supplied by PAA). The results found after 30" stand-off distance agreed with those found at the greater 12' distance.

The detectors were placed next to the wall on its cold side opposite the source. This meant that the detectors were separated by either 30" or 12' plus the wall thickness from the source.

In the case of the ceiling SIC test the source was 20' below the ceiling and centered on 16' x 16' squares marked on the roof. However, each marked-off square of ceiling was monitored at the same distance and comparative data was provided.

An analysis and evaluation of the test conditions employed as described above lead to the establishment of the criteria for determining whether or not a violation existed. This criteria may be summarized as follows:

1. A maximum reading of five times (or less than five times) the average level which would be observed through walls known to possess

adequate shielding integrity with a source in position would not be considered as significant.

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

3. In most cases where the shielding 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 for evaluation and analysis the test results obtained are summarized in the following paragraphs:

Violation 1 is described in Figure 1. It appeared to be associated with failure of concrete to pack around some conduit. An acceptable repair of the area was indicated by confirmation tests. (The confirmation tests were carried out in the same way as described in the SIC Phase I Procedures, (Item (1) of the Bibliography), for the main part of the test).

Violation 2 (Figure 2) was a large violation above the pass-through in the southwest corner of the Main Hot Bay (Room 122). The pass-through was not installed before the concrete was poured. An over-

sized hole was left in the wall so that the pass-through assembly could be installed later. Key-ways were left in the concrete so that when the pass-through assembly was grouted, the key-way would act as an interlock between the old and the new concrete. The key-way above the pass-through was concave, and it was very difficult to fill with grout. A large irregular cavity remained after the installation. This showed up readily during the SIC test. It was subsequently repaired by the contractor by core drilling through the wall into the void and filling with 1600 lbs. of steel shot. Confirmation tests showed that the fix was adequate.

Violation 3 (Figure 3) was a small area in Personnel Door 122-4 (bayside) between the Main Hot Bay (Room 122) and the northeast hot change room (Room 120). The contractor disassembled the door, (it is of lead brick construction stacked between two steel plates), and found no obvious reason for the violation. The violation was apparently due to a minor stacking error because the violation could no longer be observed during the subsequent recheck tests after the door had been reassembled.

Violation 4 (Figure 4) is located near the intersection of the west wall (Room 122) and the north wall of the door pocket (Room 307) at about 10' (elevation 146') above the third floor level. The violation appears to be associated with three pieces of incorrectly installed conduit. (This violation was reported to SNPO-N and CATCO but has not been repaired. For details, see Vitro Drawings 1425-N-20 and 1425-N-38 at Station W-11.)

Violation 5 (Figure 5) is a group of violations, one each, in

five blocked-up windows on the west wall of the Main Hot Bay. The violations all seem to be associated with voids in the brick and mortar used to fill the windows. Confirmation tests showed that adequate repairs of the violations were made by the contractor.

Violation 6 (Figure 6) involves the upper portion and west edge of Door 122-1. The upper portion of the door is constructed with low density concrete. The door was designed using low density concrete to reduce overall weight and bearing loading. The shielding of the door is commensurate with concrete density at the various levels. The apparent violation at the west edge of the door is due to streaming through the crack between the door and the wall. Neither of these violations requires a repair. Administrative control will assure personnel safety. The door will be painted to indicate reduced shielding integrity. Caution areas will be striped on the paved area outside the door where streaming radiation can occur.

Violation 7 (Figure 7) is associated with a design offset in the bottom of Door 306-4. This violation will be repaired by NTO. Funds for the repair of the door have been negotiated and are in the "Program Requirements Document", Report No. 2578.

Violation 8 (Figure 8) concerns the Radioactive Fuel Storage Vault Plugs. The vault plugs can be placed into the vault in such a manner as to result in a crack on one side or other, thereby varying the amount of radiation leakage detected. No repair is anticipated and administrative control in placement of the plugs has been established.

Violation 9 (Figure) was an obvious violation in the NT-1 turntable tunnel . It consists of an intentional open sleeve for the power drive shaft for the NT-1 turntable. Administrative controls were employed during the SIC tests and prior to any hot operations this sleeve will be plugged with a steel shaft.

V. CONCLUSIONS

The conduct of Phase I of the SIC tests were satisfactorily completed. All of the violations with the exception of the one violation (Figure 4) has either been satisfactorily corrected, can be treated by the establishment of appropriate administrative type controls or readily repaired by fairly simple modifications provided by NTO personnel.

The establishment of administrative type controls would consist of such things as marking of areas, color coded zoning, a temporary erection of appropriate barricades and/or 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 and will be covered in appropriate operating procedures.

The modification by NTO personnel would require, in most cases, the employment of some additional shield. For example, in the case of Violation 7, shielding in the form of additional steel plates bolted to a portion of the bottom of the door would be employed to prevent radiation streaming through an oversize crack between the door and wall.

There remains one outstanding violation, namely the violation existing at the 146' level of the west wall of the Main Hot Disassembly Bay just north of the door pocket (Room 307) for which a repair is required. This violation is a result of erroneously putting the conduit in a straight path through the wall rather than bending it as shown on the construction drawings. The responsibility for the adequate repair of this violation remains to be determined.

B I B L I O G R A P H Y

1. NTO Procedures Report for the Phase I Shielding Integrity Check (SIC) Tests for the E-MAD Facility, NTO Report NTO-I-0015 (Revision C), 18 January 1965.
2. Letter: From E. W. Copeland, Jr. to the attention of R. R. Brookshire at SNPO-C, 1 November 1963.
3. TWX: From R. W. Schroeder, SNPO-C, to C. C. Ross/
J. B. Philipson, REON, 18 January 1965; Subject: Tentative Approval of SIC Test Phase I Procedures.
4. TWX: TP & OB/PER; From R. W. Schroeder, SNPO-C, to C. C. Ross/
J. B. Philipson, REON; dated 5 February 1965; Subject: Final Approval of SIC Test Phase I Procedures.
5. Master File: SIC Test Phase I data; Operations Department, E-MAD Building, NRDS.

A P P E N D I X A

I. Chronology:

10/20/64	Began making fiducial marks for wall gridding.
11/2/64 - 11/13/64	Completed 80% of wall gridding. Remainder had to be done after painting and other contractor work was completed. This was done both before and during the "hot" part of the test as various areas became available.
12/28/64 - 12/31/64	SIC Test Phase I - Dry Run.
1/11/65 - 1/22/65	Made changes needed to convert from ETR source orientation to Cobalt-60 source.
1/15/65	Received Cyclops Cobalt-60 source from AGC - Sacramento.
1/18/65	Final Procedures Issued (Item No. 1 of Bibliography).
1/18/65	Approval to do lower 8' of Hot Bay scan (Item No. 3 of Bibliography) and sub-floor areas (NT-1 Turntable and Fuel Storage Vault).
1/25/65 - 2/5/65	Completed 25% of test.
2/5/65	Final approval of SIC test procedures (Item No. 4 of Bibliography).

2/15/65 - 2/26/65	Completed SIC Test Phase I.
3/9/65	Confirmed repair of Violation 2 (Figure 2). Repair adequate.
3/16/65	Confirmed repairs of all violations except Window W-12 and Grid Area L-3 ⁴ west wall which were not repaired. Other repairs adequate.
5/19/65	Confirmed repair of Window W-12. Repair adequate. Repair of L-3 ⁴ violation not yet complete.

A P P E N D I X B

I. Cyclops Cobalt-60 Radiographic Source

A radiographic source was employed for the conduct of the Phase I and Phase I Addendum portions of the SIC tests. This source was the Picker X-Ray Corporation's Cyclops Cobalt-60 radiographic source, an 1850 Curie Cobalt-60 source (Figures 10 and 11). (The source had certified strength of 2105 Curies as of June 1963.) In January 1965, when the SIC tests were started, it's effective source strength was measured as 1700 R/hr at one (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 12). At the opposite end is a counter-balancing basket containing lead bricks.

#1 - VIOLATION - SIC TEST - PHASE I

LOCATION: West Wall - Square A-9

MAXIMUM READING: 50 mr/hr - BACKGROUND: 0.02 mr/hr

SOURCE DISTANCE: 30"

THICKNESS OF CONCRETE (EQUIVALENT) MISSING: 30"

AREA: Approximately 6" Square

SHAPE: Diffuse

FIGURE 1

#2 - VIOLATION - SIC TEST - PHASE I

LOCATION: West Wall - Squares B-33 and B-34

MAXIMUM READING: 3 R/hr

SOURCE DISTANCE: 18"*

THICKNESS (MAXIMUM) OF CONCRETE EQUIVALENT MISSING: 50"

AREA: Approximately 11 Sq. Ft.

SHAPE: Ellipse - Semi-major axis (horizontal) 3.5 Ft
Semi-minor axis (vertical) 1.5 Ft

* The source was held at 30" during the routine scan at which time the violation was discovered. It was held at 18" as noted during the detailing of the void.

FIGURE 2

NOTE: The detail of the repair of the violation including the type of materials used will be included in the "as-built" drawings and specifications.

#3 - VIOLATION - SIC TEST - PHASE I

LOCATION: East Wall - Square B-3
Personnel Door 122-4
18" South of North Edge of the Door
28" Below Top of Door

MAXIMUM READING: 120 mr/hr

SOURCE DISTANCE: 30"

THICKNESS (MAXIMUM) OF LEAD MISSING: 5"

AREA: 10 Sq. Inches

SHAPE: Circle

FIGURE 3

#4 - VIOLATION - SIC TEST - PHASE I

LOCATION: West Wall - K-34 and L-34

MAXIMUM READING: 190 mr/hr

SOURCE DISTANCE: 30"

THICKNESS (MAXIMUM) OF CONCRETE EQUIVALENT MISSING: 40"

AREA: 40 Sq. Inches

SHAPE: Rectangular

FIGURE 4

	W-2	W-12	W-13	W-15	W-17
LOCATION	B-9 & B-10	G-17 & H-17	G-23 & 24 H-23 & 24	H-32 & H-33	J-5, K-5 & 6
MAXIMUM READING	0.7 mr/hr	3.2 mr/hr	0.5 mr/hr	0.6 mr/hr	1.0 mr/hr
SOURCE DISTANCE	30"	30"	30"	30"	30"
APPROXIMATE THICKNESS OF CONCRETE EQUIVALENT MISSING	15	30	10	13	20
AREA - SQ. FT.	15	1	2	6	7
SHAPE	3' x 5' RECTANGLE	DIFFUSE	DIFFUSE	2' x 3' RECTANGLE	L-SHAPED

FIGURE 5

#6 - VIOLATION - SIC TEST - PHASE I

LOCATION: North wall - Squares - Included in Rows H, I, J and Columns 4 through 8 and Row 9, Columns A through J

MAXIMUM READING: 2.0 mr/hr

SOURCE DISTANCE: 12 Feet

THICKNESS (MAXIMUM) OF CONCRETE EQUIVALENT MISSING: 30" - 40"

AREA: 400 Sq. Ft.

SHAPE: L-Shaped - (See Diagram)

FIGURE 6

#7 - VIOLATION - SIC TEST - PHASE I

This violation is due to a design deficiency in Door 306-4. When the door is open, the lower 18 inches on the north and south edges is recessed 1-3/4 inches as shown below.

FIGURE 7

Areas of Violation

Door in Door Pocket (Room 307)

NORTH			CENTER			SOUTH		
.12		.2	.06		.1	.08	.08	.08
.08		.16	.08		.24	.22	.08	2.5
.12	.10	.14	.14	.1	.1	.08	.08	.1

MAXIMUM CRACK - 1 1/4"
ALL READINGS IN mR/hr

RADIOACTIVE MATERIAL STORAGE VAULT

FIGURE 8

SOURCE POSITION

- ① $\frac{1}{2}$ OF TUNNEL 2'-0" FROM EAST WALL POINTING STRAIGHT DOWN.
- ② $\frac{1}{2}$ OF TUNNEL 4'-0" FROM EAST WALL POINTING STRAIGHT DOWN
- ③ 7'-0" EAST OF EAST WALL ON BISECTOR OF ARC OF TURN TABLE DEFINED BY NORTH & SOUTH WALLS OF TUNNEL. SOURCE POINTING 30° NORTH OF WEST 45° OFF VERTICAL DOWNWARD

NORTH TURN TABLE TUNNEL

FIGURE 9

CYCLOPS COBALT-60 RADIOGRAPHIC SOURCE

FIG. 10

T55-223

CYCLOPS COBALT-60 SOURCE CONTROL

PX-5022

FIG. II

COBALT SOURCE HANDLING FIXTURE

FIG. 12