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ON SITE RADIOLOGICAL REPORT FOR THE PHOEBUS IB REACTOR TEST SERIES

MASTER

SPACE NUCLEAR PROPULSION OFFICE NEVADA EXTENSION

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ON SITE
RADIOLOGICAL REPORT
FOR THE
PHOEBUS IB REACTOR TEST SERIES

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PAN AMERICAN WORLD AIRWAYS, INC.
Nuclear Rocket Development Station Project
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A B S T R A C T

Radiological support for the Phoebus IB reactor test series was conducted essentially according to pre-test plans. The radiation levels at the Control Point during powered operations were a factor of 16 less than on previous full powered runs, resulting from the use of the reactor shield.

Although the hot line for EP-IV was along the five degrees azimuth from the Cell, changing wind conditions attendant with pulse cooling produced on-site contamination at all populated facilities except E-MAD and ETS-1. The maximum particle concentration at any facility was 120 particles per 100 square feet at R-MAD.

Five per cent of 4,100 contamination checks indicated contamination on personnel or their clothing up to an uncorrected radiation level of 200 mR/hr beta-gamma. Decontamination to within the guides, which were increased on run night and the next day, was successful for all skin contamination incidents and for most clothing contamination cases.

A discrete particle was detected on each of two individuals. The assigned dose for the one with the particle on his left cheek was 30.4 rads to the volume of tissue having a surface area of one square centimeter surrounding the particle. The dose assignment for the lens of his left eye was calculated to be 415 ± 207 mrad. The localized dose for the second individual was 4.9 rads to the volume of tissue having a surface area of one square centimeter surrounding the particle on his right forearm.

The total radiation exposure received at Test Cell "C" was 112.5 R during the period from EP-I until the end of March. The maximum individual cumulative exposure was 2.02 R. The major Test Cell decontamination efforts accounted for 80 R of exposure, took about one month, and required the expenditure of \$98,100, which included 5,550 manhours.

Positive activities of non-natural-occurring radioisotopes were detected in 19 individuals out of the 61 who were subjected to whole body counting. As many as five isotopes were detected internally in one individual. The maximum body burden fraction in a single organ was 0.123 for the thyroid. However, the residence time appeared to be three days or less for all internal depositions.

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I N T R O D U C T I O N

Pan American World Airways, Inc. provided on-site radiological support to the Los Alamos Scientific Laboratory for the Phoebus IB Reactor Test Series. This Test Series consisted of four Experimental Plans conducted between January 25, 1967, and February 23, 1967.

The pertinent on-site radiological data that were obtained by Pan Am in support of the Test Series and post-test activities are presented herein. More detailed on and off-site radiological measurements of the effluent activity have been reported in, "Summary of Results -- Effluent Monitoring -- Phoebus IB EP-IV."

The submittal of this report completes the reporting requirements of Operations Directive No. 66-2, Phoebus IB.

GENERAL

General information concerning the Experimental Plans (EPs) of the Phoebus IB reactor test series is summarized below.

PHOEBUS IB REACTOR TEST SERIES

<u>EP</u>	<u>Date</u>	<u>Time Shutdown</u>	<u>Max. Power* Megawatts</u>	<u>Integral MW-sec</u>
I Phase I	1/25	1408	.015	10.2
I Phase 2	1/26	1630	.030	21.6
II Phase I	2/2	1815	.015	48
II Phase 2	2/3	1117	2.3	349
III **	2/10	1315	615	1.28×10^5
IV ***	2/17	1305	-----	≈ 22
IV	2/23	1434	1463	2.84×10^6

* Maximum power level is approximate and does not reflect necessarily sustained operation at that level.

** Reflects only the planned operations.

*** Initial full power EP was postponed because of adverse weather conditions.

RADIOLOGICAL SUPPORT

Radiological support for the Phoebus IB reactor test series has been divided for reporting convenience into Area Monitoring Surveillance and Facility Radiological Support.

A. Area Monitoring Surveillance

Area monitoring surveillance was concerned with radiological support conducted outside Test Cell "C" (TCC) during the run and post-run operations.

1. Exclusion Areas

The exclusion area for EPs I and II was as shown in Figure 1 with the nearest populated facility at least 4000 feet away. No additional personnel controls were necessary. For EPs III and IV the exclusion area was as shown in Figure 2.

During the nuclear powered operations of EP-III, occupants of the Reactor Control Point (CP), the Fire Station and the Security Check Point (Main Gate) were directed to seek shelter because they were downwind from the reactor. For EP-IV additional personnel controls outside the exclusion area were unnecessary during the nuclear reactor test.

2. Direct Radiation Measurements During Reactor Operations

The radiation levels at populated facilities during EPs I through III were of little consequence. Even during the full power operation of EP-IV the measurements, as a result of the reactor shield, were considerably lower than during previous full power tests at reduced power levels. The radiation reduction was approximately a factor of 12 without correcting for the difference in power levels. If this correction is applied, the efficacy of the reactor shield appears to be a factor of 16 at a nominal distance of 2 miles. Representative gamma dose rates as measured with portable survey instruments during Phoebus IB, EP-IV, were: 1.5 mR/hr outside the Cafeteria and at the Radiation Services check station; 1.1 mR/hr outside the Technical Operations, Technical Services, and CP Buildings. See Figure 3 for the CP area survey results. The neutron dose rates were insignificant.

In addition to the portable instrument surveys, a 15-station remote area monitoring system (Figure 4) was used outside the Test Cell area to record radiation levels at stationary locations. Table I shows the radiation dose rates at various power levels and the corresponding locations. Figures 5-9 show the radiation decays for the five stations that indicated significant radiation levels following EP-IV. The curves reflect the additive contributions of the reactor decay and Cell activation radiation levels in varying degrees.

3. Air Samples

Air samples, utilizing millipore and charcoal cartridge filters, were taken during each EP. The air sample results until EP-IV were of little significance and did not exceed 0.1 per cent of the guide for fresh fission product activity. After EP-IV the samples were replaced periodically for several days in order to determine the radioactivity associated with cool-down operations and with drainage winds. All sampling locations from 270 degrees counter-clockwise to the R-MAD gave positive indications of airborne radioactivity during some point of the post-test period. Analyses of other samples normalized to "sample off" time indicated activities up to about three times the guide for radiation workers exposed to airborne mixed fission products for 40 hours each week without respiratory protection. Although the maximum activity detected was on the sample collected at the R-MAD Building, extenuating circumstances prevented analysis of the sample. Other samples of significance -- greater than 10 per cent of the guide for the time interval under consideration -- were collected at all the facilities between azimuths of 190 degrees to 116 degrees. Filter samples and charcoal cartridges were not counted immediately after time off and no factors were applied for leaching of the activity from the collection media.

Autoradiography of filter samples was not performed to identify the extent of discrete particle collection on the samples which would distort airborne activity concentration calculations. See Table II for a tabulation of air sample results and locations.

4. Thermoluminescent Dosimeter Measurements

Thermoluminescent dosimeters were employed for EPs I through III at five-degree intervals on the nominal 2.5 mile arc, but no significant doses (greater than 0.4 mR) were measured. For EP-IV, TLDs were utilized on the

2.5 mile arc between 043 and 185 degrees -- to straddle the predicted effluent hot line. However, the effluent hot line shifted to 005 degrees; and the TLDs were unaffected by cloud passage or direct reactor radiations.

5. Particle Deposition

Portable survey instruments and vehicles with bumper-mounted probes were used after each run to ensure that the NRDS roads and access routes were free from particulate activity. Subsequent surveys were performed along accessible downwind arcs to determine deposited particle concentrations and to collect particles for further analyses.

Except for one particle after EP-III, no other particles were found until after EP-IV. The one particle released during EP-III was located along Road "G", 0.75 miles from the CP intersection, about 30 minutes after shutdown. The portable survey instrument readings on the particle in the field were 6 R/hr, beta gamma, and 3 R/hr, gamma, at one inch. Further examination indicated the particle to have a 128 micron diameter; to decay according to a $t^{-1.04}$ equation; and to exhibit a typical fresh fission product spectrum with a beta activity of 3.84×10^8 disintegrations per minute calculated for 30 minutes after shutdown.

The effluent cloud at the NRDS Main Gate, about three miles from TCC, produced ground level dose rates up to 0.2 mR/hr. Cloud passage started nine minutes after shutdown and ended six minutes later with the peak measurement occurring at the midtime of passage according to portable survey instrument indications.

For EP-IV the first indication of fallout or cloud passage occurred simultaneously with shutdown, 1434 PST, at 12,300 feet and 015 degrees from the reactor. All during the nuclear power operation the remote area monitoring detector at this location registered background. The almost instantaneous increase in reading -- background at 1433 and 200 mR/hr at 1434 -- decayed to 190 mR/hr, then increased to 220 mR/hr. The subsequent decay (See Figure 10.) was attributable to fallout and not cloud passage per se. The measured values undoubtedly reflect variations of particle proximity to the detector, three feet above grade, induced by wind conditions.

On run night a survey on the 2.5 mile arc using a vehicle with bumper-mounted probes indicated particulate activity between 350 degrees and 17 degrees with the highest activity between 360 and 13 degrees. Particle concentrations were not determined.

On R + 13 a bumper probe survey was conducted on accessible roads north of the Cell. This survey confirmed the lateral azimuths of radioactive particulate deposition as determined on run night. Extensive concentration measurements were not made, but the maximum concentration appeared to be at a distance of 5.5 air miles north of the Cell on the Topopah Springs Road.

Because of the extensive site contamination and the delay in its appearance at occupied facilities; and because of the magnitude of effort involved, a chronological sequence of the contamination developments is presented below. Unless stated otherwise, instrument readings are at one inch and have not been corrected for source size, geometry factors, etc.

<u>Date</u>	<u>Time</u>	
2/23	1430-1800	No contamination detected at occupied NRDS facilities.
	1730	450 feet south of TCC -- no contamination.
	1800	800 feet east of TCC -- survey vehicle contaminated inside and out with particles indicating up to 3.5 R/hr, beta-gamma ($\beta\gamma$)
	1800	R-MAD -- 4-5 particles per 100 ft ² , 260 $\beta\gamma$ /100 γ .
	1815	CP -- fallout first detected.
	1930	CP Cafeteria -- survey indicated 50 mR/hr, $\beta\gamma$, on shoe soles of occupants and 5 mR/hr, $\beta\gamma$, on floor.
	2000-2100	Established monitoring road blocks at Main Gate, ETS-1, and at Lathrop Wells Gate.
	2000-2200	Extent of road contamination: "H" road between 207° and 224°, 3-10 mR/hr $\beta\gamma$; Second Street, 10 mR/hr $\beta\gamma$; Lathrop Wells Road from A&E to two miles west of A&E Building, 1 particle/100 ft ² , 20 mR/hr $\beta\gamma$, 2 mR/hr γ ; access highway one mile south of Main Gate, 1 particle/500 ft ² and none at 1.5 miles.

<u>Date</u>	<u>Time</u>	
2/23	2030	ETS-1 and E-MAD -- no contamination.
	2100	A&E Parking Lot -- 1 particle/150 ft ² , 35 mR/hr βγ, 5 mR/hr γ; 0.7 miles east of A&E Building -- 2 particles/100 ft ² , 12 mR/hr βγ, 0.5 mR/hr γ; 1.4 miles east of A&E Building -- no contamination.
2/24	0030	CP Cafeteria -- Smears on tables and floors, 3 mR/hr βγ, 0.3 mR/hr γ.
	0200	ETS-1 -- Discontinued monitoring station.
	0300	A&E Parking Lot -- 30 particles/100 ft ² , 200 mR/hr βγ, 130 mR/hr γ.
	0325	CP to R-MAD Road -- 30 particles/100 ft ² ; 150 mR/hr βγ; R-MAD Compound -- 120 particles/100 ft ² ; 50 mR/hr βγ and 0.5 mR/hr βγ at 3 feet. Cane Springs Road eastward from the Main Gate -- 60 particles/100 ft ² in first half-mile; 150 mR/hr βγ, 1.5 mR/hr γ; at 1.6 miles -- 20 particles/100 ft ² ; 0.3 particles/100 ft ² from 1.7 miles to 2.3 miles from intersection.
	0330	"H" Road westward to Second Street -- 6 particles/100 ft ² ; 200 mR/hr βγ, 10 mR/hr γ, maximum.
	0330	CP Cafeteria -- Decontaminated. Booties required for entry.
	0430	CP Area -- 6 particles detected on booties; 50 mR/hr βγ, 2 mR/hr γ, maximum.
	0630	Outside Weather Bureau Observation Facility -- 2 particles/100 ft ² ; 5 mR/hr βγ, and bootie smear indicated 4 mR/hr βγ. PAA Carpenter Shop, Inside -- 3 mR/hr βγ on smear.
	0700	A&E South Parking Lot was washed effectively. Brock House in Bus Parking Lot -- 6 particles/100 ft ² on and around house, 150 mR/hr βγ, 1 mR/hr γ. Particles removed from shack surface. No contamination detected inside. ETS-1 -- No contamination in tunnel or inside tunnel entrances.
	0715	Main Gate -- Discontinued surveys of all personnel and vehicles leaving the site.
	0745	Road from CP to Main Gate after flushing -- 2 spots detected with maximum level of 50 mR/hr βγ.

<u>Date</u>	<u>Time</u>	
2/24	0745	Road from Main Gate to A&E -- 3 spots detected with maximum level of 35 mR/hr $\beta\gamma$.
	0800	All areas except R-MAD opened for normal traffic. R-MAD was under control with a contamination release guide of 5 mR/hr γ . Release guide at other facilities was 5 mR/hr $\beta\gamma$.
	0900-1130	Survey of air conditioning filters
		Rad-Safe Supply Trailer -- 30 mR/hr $\beta\gamma$, 3 mR/hr γ .
		CP Buildings, A&E Building, and Cafeteria -- ≤ 3 mR/hr $\beta\gamma$, 0.3 mR/hr γ .
		E-MAD -- 6 mR/hr $\beta\gamma$, 0.5 mR/hr γ -- 3 particles detected.
2/25	1010	Road survey after flushing:
		Test Cell "A" -- R-MAD Road, 2 particles on road; 7 mR/hr $\beta\gamma$. Technical Operations Building, north end of parking lot -- 12-15 particles/100 ft ² ; 35 mR/hr $\beta\gamma$.
		"H" Road -- 6-8 particles/100 ft ² between 185° and 205° and Second Street had same concentration between 193° degrees and 195°. However, considerably more activity was detected alongside the road as a result of flushing and collection thereat.
		CP to R-MAD Road -- 1 particle found.
		Main Gate to A&E and on roads in Support Area -- No contamination detected.
		"H" Road from E-MAD to ETS-1 -- No contamination detected.
		Cafeteria Parking Lot -- No contamination.
		Cafeteria -- Bootie survey indicated 0.4 mR/hr.
2/27	0830	Test Cell "A", ETL, and trailers -- Smearable activity of less than 0.2 mR/hr $\beta\gamma$. CP Building, Technical Services, Technical Operations, Cafeteria, A&E, PAA Warehouse, PAA Shops, and Medical Dispensary -- No contamination detected.
	1400	Road from Burn Pit to A&E -- No discrete particles detected.
	1700	"F" and "J" Road Junction -- 3 particles/100 ft ² ; 30 mR/hr $\beta\gamma$.
2/28	1630	Road from "F" and "J" Junction to Test Cell "C" -- 1.5 particles/100 ft ² in first half-mile using bumper probes.

B. Facility Radiological Support

Facility radiological support was concerned with monitoring activities conducted in Test Cell "C" for the Phoebus IB test series. Radiation monitoring was provided for the re-entries into the Cell following each test. Additionally, surveys were conducted at specific locations at various times to accumulate decay data for application in future tests. Measurement frequency and scope were contingent on radiation levels. Consequently, after the higher powered runs, the decay data are sporadic. However, there is some indication of the affects of the reactor's presence in the Cell, the reactor shield and the shield water. The results of Cell surveys for EPs III and IV appear in Tables III and IV. The results of the Test Cell pad surveys appear in Tables V thru VII. These data do provide a basis for approximating decay rates and radiation intensities at specific locations in the Cell, but only if short-lived activation products are no longer present.

1. Test Cell Radiation/Contamination Conditions

Except for one incident following EP-III, radiation monitoring support activities were of a routine nature until EP-IV.

After EP-III a radiation monitor was leaving the Cell, and his attention was drawn to a sudden radiation increase without an obvious cause. Further inspection revealed the presence of a wire on the ground -- 600 feet from the reactor and about 30 feet east of the 200-foot water tower. Without source size correction, the radiation level was about 100 R/hr at six inches from the wire. It was retrieved, emplaced in a storage pig, and taken to the R-MAD Building for identification. The wire was identified as a copper-constantan and tungsten-rhenium thermocouple. Radiation decay data are plotted in Figure 11. Two effective half-lives of about three hours and 20 hours can be determined from the curve. A spectral analysis was not performed to further identify the radio-isotopes present in the wire.

After EP-IV an initial survey team, proceeding from the south, went 200 feet inside the Main Gate of Test Cell "C" for a quick survey three hours after shutdown. Smears taken at distances ranging from 1900 to 450 feet from the reactor indicated contamination levels less than 0.2 mR/hr, open window.

The other initial survey team, approaching the Cell

from the east -- the downwind direction at that time -- detected particulate contamination simultaneously with a cooling pulse about three hours after shutdown. The uncorrected radiation levels were up to 3500 mR/hr, open window, at one inch from the particles, both inside and outside of the vehicle. Subsequent entries were not conducted until the next day, R + 1.

In anticipation of gross contamination in the Cell, all entrants were clothed in double anti-contamination (Anti-Cs) clothing and with respiratory protection. The Rods team entered the Cell about 19 hours after shutdown. Dose rates ranging up to 40 R/hr prohibited extensive Cell surveys. The contamination levels (all measurements at one inch) on the rubber boots of Rods team members upon leaving the Cell were as high as 2000 mR/hr, gamma.

The gross contamination throughout the Cell resulted from pulse cooling, which continued for about two minutes each time at ever increasing intervals. The shed was positioned over the reactor about 26 hours after shutdown to minimize the subsequent particle distribution resulting from pulse cooling. The cooling operation continued for 72 hours after shutdown.

Entries were kept to a minimum for the next few days. Consequently, surveys were not conducted and data are lacking. Four days after the run, radiation measurements at one inch from particles outside the double doors of the Pump Room indicated 20 R/hr, beta-gamma, and 6 R/hr, gamma. Smears from 33 various locations on the fifth day had radiation levels up to 20 R/hr, beta-gamma, and 5 R/hr, gamma, with an average beta-gamma to gamma ratio of 6.5. The contamination levels on booties worn on the reactor pad were as high as 12 R/hr, beta-gamma, and 2 R/hr, gamma. Other representative contamination levels were:

<u>Location</u>	<u>Contamination Levels</u>	
	<u>Beta-gamma</u>	<u>Gamma</u>
Test Cells' Main Gate	360 mR/hr	60 mR/hr
Outside, Air Intake Building	10,000 mR/hr	200 mR/hr
Top of FCR Stairs	1,800 mR/hr	600 mR/hr
Top of Basement Stairs	3,400 mR/hr	740 mR/hr

The radiation levels encountered during re-entries appear in Tables III - VII and in the selected survey results. (See Appendix.) Survey results at specific locations did show some variation because of the accumulation and transportation of particulate activity throughout the Cell. As an example, in Table VII the dose rate of 12 R/hr, three feet above ground, was measured 300 hours after shutdown. This was attributable to an accumulation of radioparticulate activity at the edge of the reactor pad resulting from decontamination efforts.

2. Test Cell Decontamination

Decontamination (decon) efforts in the Cell commenced March 1, the day after the reactor was returned to the R-MAD Building, and consisted of several methods -- none of which was universally superior to any other method.

In general, decon started on the higher structures and surfaces, subsequently working downward to ground level. The methods that were used included: vacuuming; flushing with copious amounts of water; applying foam to suspend particulates, then flushing with water; using neutral detergents, using bases with a pH of 10-11; using acids with a pH of about 3; the use of sweeping compound; swabbing with alcohol; removing and replacing dirt; and painting.

Airborne activities in the Cell fluctuated depending on the wind and type of decon effort in progress. To eliminate the possibility of even one particle being inhaled double Anti-Cs and respiratory protection were required for most of the first month's decon activities.

Many of the decon efforts had to be repeated in the same areas as often as five times because of the cross-contamination created by the wind blowing from contaminated into decontaminated areas.

As might be expected, the decon of all painted surfaces proved to be accomplished more easily than the decon of comparable non-painted surfaces. Based on this decon experience, it was estimated that the plain surfaces took ten times as long as the painted surfaces.

The total decon operation involved large quantities of materials. About 500,000 gallons of water, 130 gallons of foam solution, 50 gallons of base, 110 gallons of acid, 165 gallons of alcohol, and 800 gallons of paint were used;

approximately 500 cubic yards of trash and vacuumed materials were collected and disposed of by burial; and 750 cubic yards of dirt/sand were removed and replaced.

The total cost of the decon operations was \$98,100, which included the cost of materials, heavy equipment operations, 5,050 manhours actually spent on decon and 500 monitoring manhours in support of the decon efforts.

C. Radiation/Contamination Information

1. Personnel Radiation Exposures

Cumulative radiation exposures for all personnel involved with the Phoebus IB reactor test series totaled 112.5 roentgens (R) for the period 1-23-67 through 3-31-67. Of this total, an estimated 80 R were attributable to decontamination efforts at the Cell; and 14 R were assigned to the monitoring force. A weekly breakdown of exposures is shown in Table VIII. The maximum exposure for a monitor was 1.17 R and for non-monitoring personnel, 2.02 R.

2. Personnel Contamination

Personnel contamination incidents prior to EP-IV were of little consequence. For the period of four weeks following EP-IV, activity was detected on 216 personnel out of the 4,100 checks performed. Of these numbers, 176 were clothing contaminations with levels up to 200 mR/hr, beta-gamma, uncorrected. There were 40 skin contamination incidents with activities up to 150 mR/hr, beta-gamma, uncorrected. Incidents involving both clothing and skin contamination have been recorded only as skin contamination cases.

Fifty of the incidents occurred on run night and the next day and involved personnel outside the exclusion area. Of these, 20 involved skin contamination. All skin contamination cases were decontaminated to acceptable levels. In most cases, clothing was decontaminated successfully. However, in several instances, clothing was retained until the activity decayed sufficiently for release.

The extent of the contamination on-site was of sufficient magnitude that the release guides on run night were increased to 25 mR/hr, open window. On the next day the site

release guides were 5 mR/hr, beta-gamma, except at the R-MAD where the level was 5 mR/hr, gamma. Thereafter, the release levels were reduced to the normal release guides.

Even though detectable activities were within the higher release guides, personnel decontamination was attempted to reduce the activity levels when practical.

A discrete particle was detected on each of two skin contamination cases. The particles were retained for analysis and measurement purposes.

One particle, with an approximate diameter of 70 microns had an indicated beta activity of 3.76 microcuries at the earliest estimated time of deposition on the individual. The particle was detected on the left cheek, a radial distance of one, $\pm 1/4$, inch from the eye. Utilizing this information and the residence time, the localized dose was calculated to be 30.4 rads to the volume of tissue having a surface area of one square centimeter surrounding the particle. The assigned dose to the lens of the eye was calculated to be 415 ± 207 mrad, based on the uncertainty of distance from the eye.

The second particle with a diameter of about 120 microns had an indicated activity of 12.3 microcuries at the time of deposition on the individual's right forearm. With this information and the residence time, the localized dose was calculated to be 4.9 rads to the volume of tissue having a surface area of one square centimeter surrounding the particle.

3. Vehicle Contamination

The contamination release guides for vehicles were the same as for personnel release guides.

On run night and the next day 37 vehicles -- none of which had been in the exclusion area -- had detectable contamination levels up to 200 mR/hr, beta-gamma, uncorrected. Of these 37 vehicles, 17 were privately owned. Decontamination to within guides was successful in each case.

Contaminated vehicles used in the exclusion area were restricted to that area in order to keep from contaminating additional vehicles. For the 37-day period ending March 31, 1967, a total of 86 vehicles, out of the 2,600 vehicle contami-

nation checks that were performed, were contaminated. All were successfully deconned.

4. Whole Body Counts

Whole body counts were performed on 61 employees in the period following the test series and decontamination efforts in TCC. The employees selected were from five different organizations and were those most likely to have internally deposited radioisotopes arising from airborne radiocontamination.

On run night GM probe surveys of 2 mR/hr, beta-gamma, indicated thyroid radioactivity uptakes on two employees. Whole body counts on each employee confirmed the presence of only one radioisotope, iodine-133. The quantity of iodine-133 was calculated to be 0.036 microcuries in each of the two individuals at the estimated time of uptake. These data have been included in the statistics below.

Positive activities of non-natural occurring radioisotopes were detected in 19 individuals. The radioisotopes detected were iodines-131 and 133; tellurium-iodine-132; ruthenium-103 and -106; zirconium-niobium-95; and barium-lanthanum-140.

Three individuals had uptakes of only one isotope; eight, two isotopes; four, three isotopes; three, four isotopes; and one individual had five isotopes detected internally.

The sum of the fractions of body burdens for the isotopes involved in no case exceeded 0.125 for a critical organ. The use of the critical organ for estimating body burden fractions was conservative based on recount results. Recount data appeared to indicate the activity residence time was three days or less regardless of the isotope(s) or individual involved. The short residence time indicated transient gastrointestinal tract exposures. However, critical organs other than the GI tract were used for calculating body burden fractions.

The maximum body burden fraction calculated for the thyroid was 0.123; for the kidney, 0.049; for bone, 0.01; and for the total body was 0.01.

FIGURES

Figure I
 Test Cell "C" Exclusion Area
 EPs I and II
 Phobus IB Reactor Test Series

Figure II
Test Cell "C" Exclusion Area
EPs III and IV
Phobus IB Reactor Test Series

FULL POWER RUN OF PHOEBUS IB EP-IV

Figure 3

SCHEMATIC LAYOUT OF CP AREA

Figure 5

POST-PHOEBUS 1B, EP-IV

Radiation Measurements

at

Remote Detector #1

---Azimuth 90°, Distance 1000 Feet---

Figure 6

POST-PHOEBUS IB, EP-IV
Radiation Measurements
at
Remote Detector #2

--Azimuth 180°, Distance 1000 Feet--

Figure 7

POST-PHOEBUS IB, EP-IV

Radiation Measurements

at

Remote Detector #3

TC"C" Main Gate

---Azimuth 175°, Distance 643 Feet---

Figure 8
 POST-PHOEBUS IB, EP-IV
 Radiation Measurements
 at
 Remote Detector #4
 West Bunker

---Azimuth 277°, Distance 848 Feet---

Figure 9
 POST-PHOEBUS IB, EP-IV
 Radiation Measurements
 at
 Remote Detector #5
 North Bunker

--Azimuth 80°, Distance 698 Feet

RADIATION LEVEL, mR/hour

10000

9
8
7
6
5
4
3
2

1000

9
8
7
6
5
4
3
2

100

9
8
7
6
5
4
3
2

2

10

HOURS, POST EP III RUN

Figure 11

Radiation Decay Measurements*
of
Thermocouple Found
After
Phoebus IB, EP III

*No Source Size Correction
Factor Applied

T A B L E S

Table I

RAMS STATION RADIATION MEASUREMENTS*
for
PHOEBUS IB REACTOR TEST SERIES

Power Level	Time After Shutdown, Hrs.	Rams Station**							
		1	2	3	4	5	6	7	8
10KW		1.5	0.5	6	4	15	B	B	B
30KW		4	3	70	20	80	B	B	B
2MW		200	300	475	850	5000	6	4	B
500MW		19R	20R	250R	80R	500R	1800	900	60
615MW		20R	25R	500R	100R	500R	2600	1000	46
1463MW		40R	35R	600R	150R	P	4000	2000	150
	0.1	1000	1500	8000	2000	21000	32	5	B
	0.2	700	450	4500	1200	15000	30	1	
	0.3	550	350	3800	1200	12000	30	B	
	0.4	500	310	3400	1100	11000	30		
	0.5	480	310	3200	1000	13000	30		
	0.6	420	280	3100	950	12000	28		
	0.7	400	270	2900	900	12000	28		
	0.8	390	260	2800	850	12000	28		
	0.9	350	250	2800	800	11000			
	1.0	350	240	2700	750	11000			
	1.5	310	210	2200	750	12000			
	2.0	290	180	2000	650	14000			
	2.5	250	160	1800	600	12000			
	3.0	210	140	1600	500	10000			
	3.5	180	130	1400	450	8500			
	4.0	150	100	1500	400	7000			
	4.5	120	120	1500	350	6000			
	5.0	120	120	1400	310	6000			
	6.0	92	83	1000	270	4500			
	7.0	77	73	1000	215	3700			
	8.0	67	73	850	190	3100			
	9.0	52	58	750	160	2800			
	10.0	47	58	700	140	2200			
	11.0	40	48	680	120	2100			
	12.0	37	41	650	110	2000			
	16.4	27	30	500	85	1700			
	19.4	20	24	400	60	1200			
	25.4	14	14	320	45	1000			
	30.4	13	14	250	37	750			
	32.4	12	11	230	33	700			

Power Level	Time After Shutdown, Hrs.	Rams Station**							
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>
	36.4	12	10	220	30	600			
	40.4	7	8	210	25	550			
	43.4	7	7	180	25	480			
	47.4	3	5	160	17	440			
	50.4	5	5	110	15	400			
	54.9	4	4	105	13	350			
	57.9	3	3	110	11	320			
	62.9	3	3	105	10	300			
	66.1	3	3	95	10	270			
	73.4	2	3	85	7	250			
	77.4	2	3	75	7	225			
	81.9	2	2	70	7	200			
	89.4	1.5	1.5	60	7	180			
	92.4	2	1.7	60	5	160			
	93.8	1.5	1.5	55	5	150			
	113.2	1	1	44	2	105			
	115.9	2.5	1	43	5	270			
	116.3	3	1.2	44	5	340			
	117.5	70	2	44	2	110			
	117.55	25	1	40	2	110			
	117.65	6	1	44	2	110			
	118.9	1	1	40	2	105			
	119.1	1	1	40	2	105			
	122.4	1	1	40	2	95			
	142.5	1	1	35	1	90			
	152.4	B	B	25	1	90			

NOTE: B represents background

P represents offscale, greater than 1000 R/hr.

*Results in mR/hr unless followed by R then results are in R/hr.

**No. 1 -- 1,000 feet at 90 degrees.

No. 2 -- 1,000 feet at 180 degrees.

No. 3 -- 643 feet at 175 degrees.

No. 4 -- 848 feet at 277 degrees.

No. 5 -- 698 feet at 8 degrees.

No. 6 -- 3,213 feet at 276 degrees.

No. 7 -- 3,307 feet at 135.5 degrees.

No. 8 -- 5,562 feet at 98 degrees.

Table II
Phoebus IB
On-Site Air Sampling Results
Post EP-IV

ETS-1				E-MAD				Production Control				A & E Outside			
270°				223°				188°				186°			
Off	F*	Isotopes**	C***	Off	F*	Isotopes**	C***	Off	F*	Isotopes**	C***	Off	F*	Isotopes**	C***
1630 2/23	14.8	---	N.S.	1625 2/23	14	¹³² Te-I ¹³³ I	T T	1620 2/23	18	---	N.S.	1615 2/23	27	---	---
2400 2/23	163	¹³² Te-I ¹³³ I	T T	2350 2/23	173	¹³² Te-I ¹³³ I	5.4 11.2	0520 2/24	900	¹³² Te-I ¹³³ I	125 73	2335 2/23	8970	¹³² Te-I ¹³³ I	15 5.8
0520 2/24	250	¹³² Te-I ¹³³ I	T T	0505 2/24	126	¹³² Te-I ¹³³ I	3.2 6.7	1600 2/24	14	---		0405 2/24	1820	¹³² Te-I ¹³³ I	7.3 1.6
0845 2/25	26.4	---	N.S.	1640 2/24	72	¹³² Te-I ¹³³ I	1.2 <1	0830 2/25	16.6	---		1700 2/24	44	FFP	T
1630 2/25	7	---	N.S.	0835 2/25	0.9	¹³² Te-I ¹³³ I	1.1 <1	1645 2/25	20	---		0825 2/25	2.5	FFP	T
0930 2/26	29	¹³¹ I	T	1635 2/25	8.8	¹³² Te-I ¹³³ I	T T	0915 2/26	50	---		1650 2/25	21	---	---
1720 2/26	16	---	N.S.	0920 2/26	41	¹³¹ I	<1	1705 2/26	16.6	---		0845 2/26	82	¹³¹ I ¹³³ I	T T
0845 2/27	30.8	---	N.S.	1710 2/26	17	N.S.	N.S.	0910 2/27	17.2	¹³² Te-I ¹³³ I	T <0.2	1700 2/26	32	¹³¹ I ¹³³ I	T T
				0855 2/27	28.8	¹³² Te-I ¹³³ I	<1 <0.7					0920 2/27	36	---	---

NOTE: N.S. -- Not significant; T -- Trace

* Concentrations are normalized to time off and are in beta disintegrations per minute per cubic meter for the interval since the previous sample.
The first sample calculation was based on time since run.

** Isotopes detected on charcoal cartridges.

*** Concentrations are normalized to time off and are in disintegrations per minute per cubic meter for the interval since the previous sample.
No correction applied for leaching of isotopic activity loss.

Table II (Cont'd.)

A&E Inside				Main Cafeteria				Main Gate				Rad Safe Check Station			
186° 20,000'				171° 9300'				168° 16,800'				167° 9200'			
Off	F*	Isotopes**	C***	Off	F*	Isotopes**	C***	Off	F*	Isotopes**	C***	Off	F*	Isotopes**	C***
1615 2/23	10	---	---	1645 2/23	13.9	---	---	1610 2/23	26.6	---	---	1550 2/23	79	---	---
2340 2/23	311	¹³² Te-I ¹³³ I	12.6 4.6	0030 2/24	6560	¹³² Te-I ¹³³ I	320 1700	2330 2/23	10000	¹³² Te-I ¹³³ I	33 120	1810 2/23	1228	¹³² Te-I ¹³³ I	T T
0400 2/24	800	¹³² Te-I ¹³³ I	3 4.7	0415 2/24	1700	¹³² Te-I ¹³³ I	48 200	0350 2/24	2300	¹³² Te-I ¹³³ I	28 78	1925 2/23	21022	¹³² Te-I ¹³³ I	27 4173
1700 2/24	28	¹³² Te-I ¹³³ I	3.6 1.8	1620 2/24	33	¹³² Te-I ¹³³ I	9 50	1710 2/24	66	---	---	2125 2/23	1628	---	---
0825 2/25	8.8	---	---	0855 2/25	8.5	¹³² Te-I ¹³³ I	6 13	0815 2/25	11	---	---	2325 2/23	3000	¹³² Te-I ¹³³ I	5 T
1650 2/25	8.1	---	---	1625 2/25	7	¹³² Te-I ¹³³ I	20 86	1655 2/25	13	---	---	0230 2/24	350	---	---
0845 2/26	18	---	---	0935 2/26	136	¹³¹ I ¹³² Te-I ¹³³ I	280 94 460	1650 2/26	25.6	---	---	0450 2/24	206	¹³² Te-I ¹³³ I	T 5.7
1700 2/26	10	---	---	1730 2/26	25	¹³² Te-I ¹³³ I	8.6 12	0930 2/27	42.9	---	---	0730 2/24	56	---	---
0920 2/27	12.6	---	---	0835 2/27	23.8	¹³² Te-I ¹³³ I	2.5 4					1600 2/24	11	---	---
												2115 2/24	1.3	---	---

NOTE: T -- Trace

* Concentrations are normalized to time off and are in beta disintegrations per minute per cubic meter for the interval since the previous sample.
The first sample calculation was based on time since run.

** Isotopes detected on charcoal cartridges.

*** Concentrations are normalized to time off and are in disintegrations per minute per cubic meter for the interval since the previous sample.
No correction applied for leaching of isotopic activity loss.

Table II (Cont'd.)

Rad Safe Check Station (Cont'd.)

Rad Safe Lab

R-MAD

167°

9,200'

161°

15,900'

116°

13,000'

Off	F*	Isotopes**	C***	Off	F*	Isotopes **	C***	Off	F*	Isotopes**	C***
0640 2/25	7.2	---	---	1655 2/23	3.2	¹³² Te-I ¹³³ I	6.0 <1	0035 2/24	20,000 *****	****	****
1020 2/25	7.2	---	---	0040 2/24	17,600	¹³² Te-I ¹³³ I	1.4 1.9	0930 2/24	****	****	****
1410 2/25	4.6	---	---	0350 2/24	1,600	¹³² Te-I ¹³³ I	T T	0915 3/2	21.1	⁹⁵ Zr-Nb ¹³¹ I ¹³² Te-I ¹³³ I	0.3 6.63 4.66 10.2
2010 2/25	3.5	---	---	1715 2/24	51	¹³² Te-I ¹³³ I	3.4 15				
0920 2/26	48.6	---	---	0900 2/25	1.6	¹³² Te-I ¹³³ I	<1 2.1				
0820 2/26	16.8	¹³² Te-I ¹³³ I	14 11	1700 2/25	5.9	---	---				
1620 2/26	<1	---	---	0945 2/26	4.9	¹³¹ I	<1				
0420 2/27	3.2	---	---	1735 2/26	15	---	---				
1520 2/27	5	---	---	0935 2/27	23.5	---	---				
0030 2/27	1.3	¹³¹ I	T								
0900 2/28	7.8	---	---								

NOTE: T -- Trace

**** Samples lost.

***** Time off unknown.

* Concentrations are normalized to time off and are in beta disintegrations per minute per cubic meter for the interval since the previous sample. The first sample calculation was based on time since run.

** Isotopes detected on charcoal cartridges.

*** Concentrations are normalized to time off and are in disintegrations per minute per cubic meter for the interval since the previous sample. No correction applied for leaching of isotopic activity loss.

Table III
PHOEBUS IB EP-III
TEST CELL "C" RADIATION SURVEY RESULTS*
SURVEY LOCATION**

DATE	TIME	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
2/10	1400	30																											
2/10	1545	27																			20								
2/10	1723	18	2	130	29	30	40	74	160	200	75	180	115	300	115	620	600	310	340	88	7	86	140	440	41	12	1	260	23
2/10	2110	6	2	56	13	12	15	27	42	40	22	40	30	72	30	180	200	140	120	38	4	36	38	150	14	6	1	80	12
2/10	2254	6	2	48	12	10	9	17	23	34	20	33	21	55	27	170	160	83	70	30	5	24	35	145	13	5	1	52	8
2/11	0100	6	Bkgd.	38	12	8	8	12	18	25	11	20	15	40	20	74	54	57	35	27	8	19	23	68	13	6	2	24	6
2/11	0924	3	Bkgd.	27	6	4	4	5	7	9	4	12	5	16	11	31	38	24	8	10	3	6	7	28	4	2	2	8	5
2/12	0323			12										8		16	18	13					13						
2/12	0909			11										8		12	15	10					10						
2/12	1720			8										5		6	10	8					8						

* RESULTS ARE IN mR/hr.

**1. Main Gate 2. Inside Field Station at Control Console 3. Ground Water Tank Valve 6255 4. Cooling Tower Valve 5. Air Intake Building Door - Outside 6. LN₂ Off-Loading - East 7. Between Dewars 4 & 5 at RAM #31 8. Top of Dewar #5 9. Top of East Walkway over Flare Line 10. Between Tank Farm and High Pressure Room 11. Edge of Test Cell Face - East Wall 12. Outside High Pressure Room Door 13. Top of Flow Control Roof Stairs 14. Outside Neutronics Room Door	15. Bottom of Penthouse - East Stairs 16. Top of South Stairs of Penthouse Roof 17. Center Propellant Room Roof 18. Between Dewars 1 & 2 at L 3 Valve on Catwalk 19. South, Outside Door of FCR Room 20. Hook-up Room 21. Outside Pump Room South Door 22. Between Dewars 1 & 2 at Ground Level 23. Wing Wall, Northwest Corner 24. LH₂ Loading Station - New Dewar Pad 25. Privy Pit Door - Inside 26. Privy Pit Door - Outside 27. Privy Pit - Inside at Center 28. North Edge of Privy - Inside

Table IV
PHOEBUS IB POST EP-IV
TEST CELL "C" RADIATION SURVEY RESULTS *

DATE	TIME	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
2/24	1300																			23000	80	2000							
2/25	1700						200																						
2/26	1430	40	2	80	50	32	75	150		220	540	150	1100	4500		3000				5800	14	200	1000	600	70		1		
2/28	0830	15	2	17	19	13	34	68	160	140	260		780	2000	6000				64	3000		140	470	460					
2/28	1035																						280	445	40				
2/28	1050											750	700							3000		120		680					***
2/28	1145																			3000				680					****
2/28	1310	14	1	14	17	11	30	52	170	140	290	42	640	1800	4600	1000	104	2000	50	400	34	84	380	400	32	4	4	16	6 ****
3/1	1935													1800	1300		500	800											
3/2	1130													1500	650		400	180											
3/2	2245													700	300		400	190											
3/3	1115													1000	560			200											
3/6	0800	6	4																										
3/7	1115	5	1	4	10	20	35	100	30	100	175	45	320	500				40	20	200		50	40	100	14				
3/8	0115	5	1	4	40	58	50	100		240	35	180	40	400	260	120	120	30	20	820		226	26	30	10				
3/10	0130														200														
3/13		2		4	4	8	22	32	14	30	13	13	70	120	150	48	180	16	8	170		18	20	41	7				
3/15	1800	4	<1	6	6			15			20		70	110	130	55	88	27	11	100		10	15		5				
3/20	0730	3	<1	4	4	4	4	6		22	12	20	60	50	70	35	60	18		80	1	34	8		4				
3/27	2130	2		2	4	5	6	16				14	40											16					
4/3	0615	1		<1	<1		2			41	6	5	22	40	60	26	26			32									
4/10	0630	1		3	2	2	6	4		3	3	4	22	32	40	18	30	18	6	32		6	4	14	4				

* RESULTS ARE IN mR/hr.

** SEE TABLE III FOR DESCRIPTION OF SURVEY
LOCATION

*** SHIELD DRAINED AND OPENED 1'

**** SHIELD OPEN WIDE

***** REACTOR TO R-MAD 2/28 AT 1500

Table V

PAD DECAY SURVEY RADIATION MEASUREMENTS *
POST-PHOEBUS IB EP II PHASE II

Time After Shutdown, Hrs	NORTH							EAST					WEST					Remarks
	20'	40'	60'	80'	100'	120'	140'	20'	40'	60'	80'	100'	20'	40'	60'	80'	100'	
0.5													410	350	150	73	47	Shield Closed
0.7	740	320	140	60	40	27	18	380	310	160	72	46						
1.2	340	150	66	32	19	12	9	160	140	56	30	19	190	160	154	31	17	
2.6	140	53	22	12	8	6	4	62	51	22	14	8	64	48	18	12	6	
5.9	2200	415	200	98	58	40	28	330	66	30	16	8	315	86	24	13	9	Shield Open
18.9	200	65	28															
21.2	-	36	18					28	8	3			25	8	2			Shed locked & sealed
25	-	27	13					21	6	3			18	4	1			
32.7	-	20	8					10	4	1			10	6	2			
36.7	-	18	10					14	5	2			12	4	2			Shield Drained & Open
41.7	-	17	9					13	4	1			11	4	1			
45.4	-	14	7					8	4	2			10	4	2			
48.9	-	11	6					7	3	2			8	2	1			
55.2	-	11	6					8	4	1			7	2	1			
59.7	-	11	5					5	2	1			5	3	1			
67.4	-	10	5					7	4	1			9	4	1			
77.4	20	8	3					10	3	-			6	2	-			Shed Removed.

* Measurements are in mR/hr.

NOTE: Distances are from reactor centerline.

Shutdown effected at 1117 on 2/3/67.

Table VI
PAD DECAY SURVEY RADIATION MEASUREMENTS *
POST-PHOEBUS IB EP III

Time After Shutdown, Hrs	NORTH							EAST					WEST					Remarks
	20'	40'	60'	80'	100'	120'	140'	20'	40'	60'	80'	100'	20'	40'	60'	80'	100'	
9.7	6000	2100						6000	2100	1000			6000	2100	1000			
11.2	3300	1300	760					1400	1400	860			1200	1200	710			
20.2	1000	520	260					680	550	260			580	500	260			
44.1	300	150	60	37	29	24	20	160	150	63	40	28	160	160	50	28	20	
52.2	260	94	52	32	22	16	14	200	100	46	30	20	160	96	38	22	14	
90.2	120	58	28	14	8			60	54	23	13	8	58	57	22	10	6	
101.7	-	44	18	10	4	2	1	72	42	17	9	5	74	44	16	8	5	
114.2	130	44	20	10	6			52	39	18	10	7	52	46	18	10	6	
170.7	115	47	21	12	9	6	4	53	37	18	12	7	50	45	19	11	8	
184.7	-	44	20					54	42	18			52	42	18			
200.7	-	50	25					50	35	20			50	40	18			
208.9	88	32	16					36	29	16			37	32	14			
221.7	98	32	13					34	28	14			34	28	10			
232.7	46	28	12					43	26	12			38	26	10			

* Measurements are in mR/hr.
Shutdown effected at 1315 on 2/10/67.

NOTE: Distances are from reactor centerline.

PAD DECAY SURVEY RADIATION MEASUREMENTS *
POST-PHOEBUS IB EP IV

Shutdown effected at 1434 on 2/23/67.

Table VIII

PHOEBUS IB REACTOR TEST SERIES

WEEKLY CUMULATIVE EXPOSURES AT TEST CELL "C"

<u>Week Ending</u>	<u>Cumulative Weekly Dose, mR</u>	
	<u>Monitors</u>	<u>Other *</u>
1/27	65	180
2/3	235	4,470
2/10	810	800
2/17	500	3,525
2/24	695	2,695
3/3	5,180	5,710
3/10	4,095	39,520
3/17	1,585	20,915
3/24	520	12,075
3/31	375	8,590
TOTAL	14,060	98,480

*Other includes all personnel who are not monitors.

A P P E N D I X

SELECTED SURVEY RESULTS

EP-I Phase 1

DATE - JANUARY 25, 1967, Shutdown at 1408

<u>Monitoring Assignment</u>	<u>Time</u>	<u>Survey Location</u>	<u>Dose Rate, mR/hr, OW</u>
Initial Survey	1440 (0.5)	West 2' from Cart	50
		North Edge of Cart	65
		East 2' from Cart	40
		3' above Privy Roof at contact with shield	2200
Drums Lock	1450 (0.7)	Outside Privy Door	20
		Inside Privy	10
Nozzle Survey	1820	Contact at Nozzle Top	1000
(Shield Open & Drained)	(4.2)	1' from Nozzle Top	600
		Contact at Nozzle Throat	1500
		West at 1 meter from Nozzle Throat	700
		West at 18" from Nozzle Bottom	3500
H-8 Dosimetry Recovery from inside Reactor Shield	1840 (4.5)	Average Dose Rate for Removal	3500
		Max. Dose Rate at contact with shield's mid plane	8500
Shutdown Team	1900 (4.9)	North Edge of Car	50

EP-I Phase 2

DATE - JANUARY 26, 1967, Shutdown at 1630

Initial Survey	1650 (0.3)	West Wing Wall	18
		West Privy Door	50
		North End of Reactor Car	80
		East Privy Door	30
		60' North, West and East of Reactor	10

NOTE: Numbers in parentheses represent the approximate time
in hours after nuclear shutdown.

<u>Monitoring Assignment</u>	<u>Time</u>	<u>Survey Location</u>	<u>Dose Rate mR/hr, OW</u>
Drums Lock	1705 (0.6)	West Wing Wall	10
		West Privy Door	20
		Inside Privy	10
Pad Survey	1710 (0.7)	30' North	10
		20' East and West	10

DATE - JANUARY 28, 1967

General Survey	0815 (39.7)	Elephant Gun, Max.	50
		Elephant Gun, Av'g.	20
		Reactor Midplane, contact	630
		Annulus, Av'g.	300
		Inside Privy	5

DATE - JANUARY 29, 1967

General Survey	0630 (62)	Elephant Gun, Max.	40
		Elephant Gun, Av'g.	20
		Reactor Midplane, contact	400
		Reactor Midplane, 2'	180
		Inside Privy	5

DATE - JANUARY 31, 1967

General Survey	0745 (111.2)	Reactor Midplane, contact	260
		Rear Deck of Car	4
		Front Deck of Car	10

DATE - FEBRUARY 1, 1967

	0745 (135.2)	Reactor Midplane, contact	200

EP-II, Phase 1

DATE - FEBRUARY 2, 1967, Shutdown at 1815

100 mR/hr Line	1845 (0.5)	2' West of Privy	100
		2' East of Privy	100
		25' North of Privy	100
10 mR/hr Line	1845 (0.5)	80' West of Privy	10
		80' East of Privy	10
		80' North of Privy	10

<u>Monitoring Assignment</u>	<u>Time</u>	<u>Survey Location</u>	<u>Dose Rate mR/hr. OW</u>
Rods Team	1850 (0.6)	West Wing Wall	14
		Outside Privy Door	20
		West Shed Track	28
		Inside Privy	14
	1907 (0.9)	Pump Room	Bkgd.
		Flow Control Room	Bkgd.
		Hook-up Room	Bkgd.
J-5 Shutdown	1915 (1.0)	Reactor Elect. Pit	2
	1900 (0.8)	Midplane between Dewars 1 & 2	4
		Outside Neutronics Shed Door	4
	1910 (0.9)	Base LN ₂ Dewar	3
	1940	Neutronics Shed Roof- Shielded	6
		Neutronics Shed Roof- Unshielded	14
	1940	20' N., E & W of Reactor	40
	1950	Max. Unshielded on Neutronics Shed Roof	30
		Outside W. Privy Door	20
	1950	Privy Inside	15
	2000 (1.7)	60' W. of Reactor	3

EP-II Phase 2

DATE - FEBRUARY 3, 1967, Shutdown at 1117

Dose Rate Lines	1150 (0.5)	230' W. of Reactor	10
		233' E. of Reactor	10
		250' N. of Reactor	10
		95' W. of Reactor	100
		90' E. & N. of Reactor	100
		30' W. & N. of Reactor	1000
		300' S. of Reactor	1
		200' S. of Reactor	2
		100' S. of Reactor	6
Rods Team	1153 (0.6)	West Wing Wall	280
		Privy Door	200
		W. Shed Track	580
		Inside Privy	220

<u>Monitoring Assignment</u>	<u>Time</u>	<u>Survey Location</u>	<u>Dose Rate m R/hr, OW</u>
Rods Team	1200 (0. 7)	Flow Control Room Pump Room Hook-up Room	Bkgd. Bkgd. Bkgd.
J-5 Team	1200	Between Dewars 1 & 2 Midplane	6
	1212	West Wing Wall	180
	1221	Neutronics Shed Roof, Shielded	26
	1222 (1. 1)	Neutronics Shed Roof, Unshielded	200 avg. 600 max.
	1300 (1. 7)	Neutronics Shed Roof, Shielded	12
	1302	Neutronics Shed Roof, Unshielded	400 max.
Special	1215	Borated Water Tank	2
	1219	LH ₂ Fill Station	1
	1220	TC"C" Main Gate	Bkgd.
	1322	N. Reactor Shield at Crack, Midplane	24, 500
	1323	W. Reactor Shield at Crack, Midplane	16, 000
Dose Rate Lines	1230 (1. 2)	130' W, N & E of Reactor 50' W, N & E of Reactor 20' W of Reactor 20' N of Reactor 20' E of Reactor 100' S of Reactor	10 100 190 340 160 1
Rabbit Recovery	1315 (2)	Reactor Pit Rabbit at Contact Rabbit at 2'	3 140/100* 2
Dose Rate Lines	1400 (2. 7)	20' W & E of Reactor 30' N of Reactor	100 100
N-2 Wire Removal	1420 (3)	Top of Shield, E. Side Middle of Shield, NE Side Middle of Shield, SE Side Contact with Wire	2000 1000 1000 600

DATE: FEBRUARY 6, 1967

General Survey	0750 (68. 5)	N. edge of Reactor Cart	40

*Open Window/Closed Window

<u>Monitoring Assignment</u>	<u>Time</u>	<u>Survey Location</u>	<u>Dose Rate mR/hr, OW</u>
General Survey	0750 (68.5)	N., Top of Privy Roof	380
		N. Center of Cart Deck	150
		S. Center of Cart Deck	200

DATE: FEBRUARY 7, 1967

General	0700 (91.7)	N. Edge of Reactor Cart	28
		N., Top of Privy Roof	300
		N. Center of Cart Deck	87
		S. Center of Cart Deck	200
		Center of Nozzle at 1'	500
		Reactor Midplane at 1'	2500

DATE: FEBRUARY 8, 1967

General Survey	0700 (115.7)	N. Edge of Reactor Cart	25
		N., Top of Privy	210
		N. Center of Cart Deck	86
		S. Center of Cart Deck	98
		Reactor Midplane at 1'	2500
		Center of Nozzle	500

DATE: FEBRUARY 9, 1967

General Survey	0700 (139.7)	N. Edge of Reactor Cart	22
		N. Top of Privy Roof	200
		N., Center of Cart Deck	80
		S., Center of Cart Deck	82
		Center of Nozzle at 1'	500
		Reactor Midplane at 1'	2000

EP-III

DATE: FEBRUARY 10, 1967, Shutdown at 1315

Initial Survey #1	1400	Main Gate	30
		150' W. of Reactor	1000
		250' S. of Reactor	100
	1415	RAM at West Wing Wall	150
	1445	700' W. of Reactor	10
Initial Survey #2	1508	1000' East	10
		480' East	100
		220' East	1000
	1515	1000' North	10
		480' North	100
		220' North	1000

<u>Monitoring Assignment</u>	<u>Time</u>	<u>Survey Location</u>	<u>Dose Rate mR/hr, OW</u>
Rods Team	1509	Steps to Basement	26
	1510	For. Control Room	Bkgd.
	1513	Reactor Pit	1000
	1514	Outside Prop. Pump Room	280
	1515	Inside Prop. Pump (2. 0) Room	80
	1516	Hook-up Room	8
	1528	Local Control Room (LCR)	5
J-5 Shutdown #1	1515	Main Gate	27
	1516	10' from LCR Door	40
	1600	W. Door Flow Control Room (FCR)	280
	1601 (2. 8)	Inside FCR	75
Special Survey	1549	Borated H ₂ O Tank	200
	1610	Under Dewar #2	300
		Under Dewar #1	120
	1650	Wire at 6"	100000
	1700	N. E. Gate	180
	1702	R. R. Gate	140
Car Leak Check	1612 (3)	200' E. of Reactor	1000
N-2 Wire Removal	1615 (3)	LN ₂ Tank Farm, E. 90' E. of Reactor	400 4000
Air Conditioning Check	1635 (3. 2)	FCR Roof 5' from Neut. Door	300
	1637	12" from Elephant Gun	500
	1641	Vent Control Shed	25
J-5 Shutdown	1640 (3. 4)	Stairway to Electrical Room (ELR)	200
	1642	ELR	< 1
	1645	Doorway to Propellant Room	200
	1700	In Propellant Room	12
	1715	Under H ₂ O Storage Tank	400
H-4 Dosimetry Removal	1700 (3. 7)	RAM, 20' South W. Wing Wall, Unshielded Reactor Pit, Top of Ladder	660 10000 800
Rabbit Recovery	1710	Tunnel Entrance	80
	1711	Center of Tunnel	600
	1712	2" from Rabbit Well	25000

<u>Monitoring Assignment</u>	<u>Time</u>	<u>Survey Location</u>	<u>Dose Rate mR/hr. CW</u>
Core Photography	2000 (6.7)	FCR Roof-Center	100
		Neut. Rm. Roof, behind Wall	2000
		Neut. Rm. -Periscope	60
		Neut. Rm. -Gen'l Area	15

DATE: FEBRUARY 13, 1967

Reactor Shield	1445 (73.5)	Bottom of Shield at 2' N.	5000
		Bottom of Shield at 2' E.	3500
		Bottom of Shield at 2' W.	7000
		Penthouse Wall, 3' from Igniter	3500

DATE: FEBRUARY 14, 1967

Shield Segment Check	0900 (93.3)	Bottom of Shield at 15'	500
		Top of Shield at 10'	200
		Top Lip of Shield 1' Below Above Nozzle, Level with Shield	440
			50000

DATE: FEBRUARY 17, 1967, Full Power Run Scrubbed

Rods Team	0955	West Wing Wall	26
		W. Shed Tracks	40
		Privy Door	26
		Privy, Inside	20
Dose Rate Lines	1408	90' E., W., & N. of Reactor	10
		15' E. & W. of Reactor	100
		30' N. of Reactor	100

EP-IV

DATE - FEBRUARY 23, 1967, Shutdown at 1434

<u>Monitoring Assignment</u>	<u>Time</u>	<u>Survey Location</u>	<u>Dose Rate mR/hr, OW</u>
Initial Survey #1	1723 (2.8)	1900' South	10
		950' South	100
		450' South	1000
		Main Gate	700
		2300' East	10
		1400' East	100
		800' East	1000

DATE - FEBRUARY 24, 1967

Rods Team	1000 (19.4)	Dewar #1, S. E.	4000
		Forward Control Room	Bkgd.
		Hook up Room, Max.	200
		Hook up Room, Ave.	80
		Top Steps of Basement	2000
		Shoe Covers @ 1", gamma	2000
Photo Teams	1100 (20.4)	W. Camera Bunker, Front	60
		N. Camera Bunker, Front	1400
		N. Camera Bunker, Door	400
		700' North	900
N ₂ Pumping	1145 (21.2)	S. ELR Entrance	40000
		Bottom of Stairs, ELR	600
		N ₂ Fill Sta.	600
		LCR	12
		Main Gate	400
Elephant Gun Canisters	1300 (22.4)	LN ₂ Fill Sta., S. Pad Edge	800
		S. Pump Room Door	2000
		N. Pump Room Door	4000
		Inside Pump Room	2000
		Hook up Room Inside, Ave.	80
		Work Area by E. G.	150
		Inside Neutronics Room Door	350
		#8 Canister, Contact	27000/8000*

* Open Window/Closed Window

<u>Monitoring Assignment</u>	<u>Time</u>	<u>Survey Location</u>	<u>Dose Rate mR/hr, OW</u>
Define Dose Lines	1530 (24.9)	1500' South 600' South 400' South	10 100 1000
DATE - FEBRUARY 25, 1967			
Special Survey	1710 (50.6)	LN ₂ Fill Station Top of Steps to Basement Middle Landing to Basement Bottom Landing to Basement	200 2500 2000 200
DATE - FEBRUARY 27, 1967			
Core Photography	0400 (61.4)	Neutronics Roof Neutronics Room Door Closed Neutronics Room Outer Door Open On Ladder to Neutr. Room	2000/8000 10 1000 400
Rods Team	1025 (67.8)	W. of Motor Drive Bldg. Top of Steps to Basement Mid-Landing to Basement Bottom Landing to Basement Outside W. Door, Propellant Pump Room Inside Propellant Pump Room	9 1800 1000 74 240 16
Flow and Pump Room	1400 (71.4)	Pump Room, Doors Closed S. Pump Room Door, Outside Particles Outside Pump Room Double Doors @ 2"	30/100 200 20000/6000*
DATE - FEBRUARY 28, 1967			
Water Team	0700 (88.4)	Enroute to Neutronics Room Water Storage Tank Area	400 20
Photo Team	0900 (90.4)	N. Bunker, Door N. Bunker, Front	20 25

*Open Window/Closed Window

<u>Monitoring Assignment</u>	<u>Time</u>	<u>Survey Location</u>	<u>Dose Rate mR/hr, OW</u>
N ₂ Pumping	1430 (95.9)	Compressor Room, S.	30
		Motor Drive Bldg, Front	150
		Pump Room Entrance	65
		Pump Room Inside	15
		FCR, S. Entrance	20
		CEL Inside	200
		CEL-FCR Catwalk, Above	800
		CEL-FCR Catwalk, Below	9000
		Bottle Area	250
		N ₂ Dewar Area, Avg.	25
		N ₂ Dewar Area, Max.	60
Reactor Radiation Measurements	1550 (97.2)	Nozzle, 2' Above	2,250,000
		Vessel, Center & Contact	13,500,000
		Nozzle Throat at 2'	3,750,000
General Survey	2030 (101.9)	FCR Center	500
		Smear	5/35
		FCR Roof, N. End	8000
		Smear	5000/20,000
		Prop Pump Roof, Top of Stairs	2500
		Prop Pump Roof, S. End	1000
		Smear	10/20
		Prop Pump Roof, Center	2500
		Smear	5/10
		Neutronics Roof, Center, Near Large Pipe	10,000
		Smear	35/3000

DATE - MARCH 1, 1967

General Survey	1940 (125.1)	FCR Roof, Center	1900
		Penthouse Roof	500

DATE - MARCH 2, 1967

Camera Bunker	1500 (144.4)	N. Camera Bunker, Front	15
General Survey	2245 (152.1)	FCR Roof, Center	650
		Penthouse Roof	400
		S. Dewar, W. Side Pad	36
		Drain and Curb, S. W. Dewar Pad	120

<u>Monitoring Assignment</u>	<u>Time</u>	<u>Survey Location</u>	<u>Dose Rate mR/hr, OW</u>
DATE - MARCH 3, 1967			
Decon	1000 (163.4)	LCR, Outside, Avg. Drain, S. of FCR @ 4" Steps, W. into FCR @ 4" Fill Sta., S. of LCR @ 4"	10 12,000 20,000 80
DATE - MARCH 6, 1967			
General Survey	0830 1030	LCR, Outside FCR Roof Center	6 180
DATE - MARCH 7, 1967			
General Survey	1245 (238.1)	FCR Roof, Center	120
DATE - MARCH 10, 1967			
Reactor Shield (Bottom 1/4)	0100 (346.4)	E. Section: Center Concave Side at Contact Center Concave Side at 1 Meter Center Convex Side at Contact Center Convex Side at 1 Meter Bottom of Shield	4000 3000 800 800 1000
		W. Section: Center Concave Side at Contact with T/C Concave Side at 1 Meter Convex Side at Contact Convex Side at 1 Meter	70,000 13,000 1700 1000
DATE - MARCH 14, 1967			
Shield Removal from Rx Pad	0950 (451.2)	Uncouple and Rig Lift Fixture	4000

<u>Monitoring Assignment</u>	<u>Time</u>	<u>Survey Location</u>	<u>Dose Rate mR/hr, OW</u>
Shield Removal from Rx Pad (cont.)		Guide and Put Water Shields on Car	1000
		Crane Cab	250
		Train Cab	850
Photograph Shield	1315 (456)	10' From Shield In High Ranger	450
		On Ground, 12' From Shield	900