ATTACHMENT 3

GPU Nuclear

TECHNICAL DATA REPORT

TDR NO. 529	REVISION NO. 0
BUDGET ACTIVITY NO. 412032	PAGE 1 OF 26
PROJECT:	DEPARTMENT/SECTION Systems Engineering/ Nuclear Analysis & Fuels
	RELEASE DATE _____ REVISION DATE _____

DOCUMENT TITLE:
TMI-1; Post Accident Containment Atmosphere Sampling Radiological Analysis

ORIGINATOR SIGNATURE	DATE	APPROVAL(S) SIGNATURE	DATE
Moussa Mahgerefteh	5/24/84	G. R. Bond	5-29-84
		APPROVAL FOR EXTERNAL DISTRIBUTION	DATE
		T. G. Broughton	6-4-84

Does this TDR include recommendation(s)? ☐ Yes ☒ No If yes, TFWR/TR # _____

•	DISTRIBUTION
	G. R. Bond
	T. G. Broughton
	T. Y. Byoun
*	D. K. Croneberger
	J. P. Donnachie (TMI)
	L. W. Harding
*	J. W. Langenbach
	J. D. Luoma
	M. Mahgerefteh
	R. P. Shaw (TMI)
	J. D. Snell
	J. A. Tangen
*	P. S. Walsh
	J. Wetmore
*	R. F. Wilsom
	R. J. Toole (TMI)
	M.R. Knight (TMI)
	E. C. Fuhrer (TMI)

ABSTRACT:

This report evaluates the radiological condition, and its compliance with NUREG-0737, of the existing TMI-1 nuclear sampling facility for obtaining and analyzing the Post Accident Containment Building atmosphere sample.

Personnel exposure during the post accident containment atmosphere sampling activities is evaluated.

RESULTS AND CONCLUSIONS

The existing sampling system is in compliance with the limits set by NUREG-0737.

The radiation exposure to personnel during the sampling activities are:

	WHOLE BODY DOSE (REM)	EXTREMITY (REM)
With Hydrogen Recombiners Contribution	1.1	1.7
Without Hydrogen Recombiners	0.6	1.7

These results demonstrate that TMI-1 Containment Atmosphere Sampling System is in compliance with NUREG-0737 limits of 5 Rem whole body and 75 Rem extremity.

•COVER PAGE ONLY

99EE WORK PAGE ON HOW TO RUN THIS JOB AND PLEASE KEEP UPDATED

TABLE OF CONTENTS

LIST OF TABLES

List of Figures

1. INTRODUCTION

The purpose of this TDR is to evaluate radiaton exposures during a post accident containment atmosphere sampling utilizing existing TMI-1 facilities. The facilities to be examined are the containment atmosphere sample station (located in the intermediate building) and the counting room. Based on time-and-motion data during the post accident condition, the personnel radiation exposure for compliance with the radiation criteria set by NUREG 0737, II B.3 is evaluated.

NRC requires the licensee to have the capability to promptly obtain (within 3 hours) a containment atmosphere sample under accident conditions without incurring a radiation exposure to any individual in excess of 5 rem whole body and 75 rem extremity.

The radiation source term data used in this report are the same as those stipulated in Regulatory Guides 1.3 and 1.4. Radiation dose rates are analyzed by using the computer code ISOSHLD-II (Ref. 1), which employs a point kernel integration method.

2.0 METHODS AND DATA

2.1 Source Terms

An isotopic core inventory for 310 effective full power days in an equilibrium cycle with a power level of 2552 MWt was utilized for the development of the source terms (Ref. 2). The source terms are presented in Table 1. This inventory is conservative for the use of the present study because the TMI-1 rated core power level is 2535 MWt.

The activity assumed for the containment atmosphere source term calculations is based on 100% of the noble gas core inventory and 25% of the halogen core inventory (in accordance with Regulatory Guide 1.3 or 1.4). The containment source term is shown in Table 1.

Table 1 presents the containment activity concentration for the time period immediately after a postulated accident.

The free volume of the containment is 2×10^6 cubic feet.

In this report the source at T=30 min. was used.

2.2 Dose Acceptance Criteria

1. Criterion of GDC19, Appendix A, 10CFR Part 50 requires that radiation protection be provided such that the dose to personnel should not be in excess of:.

   5 rem Whole Body

   75 rem Extremities

Table 1: Source Terms

Isotope	Decay Constant (1/Sec)	Source Activity[1,2] Ci	Containment Airborne Concentration (μCi/cc) T=o	T=30 min.
Br-84	0.360-3[3]	3.93 + 6	6.94 + 1	3.63 + 1
Kr-83m	0.101-3	9.26 + 6	1.63 + 2	1.36 + 2
-85m	0.437-4	2.19 + 7	3.87 + 2	3.58 + 2
-85	0.438-4	5.30 + 5	9.36 + 0	8.65 + 0
-87	0.152-3	4.00 + 7	7.06 + 2	5.37 + 2
-88	0.686-4	5.60 + 7	9.89 + 2	8.74 + 2
Xe-131m	0.668-6	4.38 + 5	7.73 + 0	7.73 + 0
-133m	0.348-5	3.07 + 6	5.42 + 1	5.39 + 1
-133	0.151-5	1.27 + 8	2.24 + 3	2.23 + 3
-135m	0.743-3	3.26 + 7	5.76 + 2	1.51 + 2
-135	0.209-4	2.09 + 7	3.69 + 2	3.55 + 2
-138	0.296-2	1.17 + 8	2.07 + 3	1.00 + 1
I-131	0.997-6	1.84 + 7	3.25 + 2	3.24 + 2
-132	0.832-4	2.16 + 7	3.81 + 2	3.28 + 2
-133	0.917-5	3.20 + 7	5.65 + 2	5.56 + 2
-134	0.218-3	4.00 + 7	7.06 + 2	4.77 + 2
-135	0.287-4	3.18 + 7	5.62 + 2	5.61 + 2

1) Based on 100% noble gas core inventory and 25% halogen core inventory

2) See Ref. 2

3) Read as 0.36×10^{-3}

2.3 Post Accident Containment Sampling Activity Scenario

The following represents the time and motion scenario for the activities of the personnel performing the containment atmosphere sampling. Figure 1 shows the location of the remote sample panel, air station, sample station and the heat trace switch in the intermediate building.

1. Three min. and thirty sec. from Lab to the sample panel.

2. Forty sec. at the air station (The air station is located in the remote sample panel room).

3. Six min. and fifty sec. at the remote sample panel.

4. Ten sec. total to turn the heat trace switch on and off.

5. Three min. and forty-five sec. from the sample panel to the Lab.*

6. Three min. and thirty sec. from the Lab to the sample panel.*

7. Six min. and forty sec. at the sample station (for 45 sec. of which the sample panel piping is filled with the containment atmosphere and the personnel is standing 3 feet away from the piping).

8. Fifteen sec. holding the sample bomb with one hand (in a kneeling position).

9. Fifteen sec. holding the syringe with both hands (in a kneeling position).

10. Fifteen sec. holding the syringe with one hand to place in shield (in a kneeling position).

11. Five min. stay time in general area for miscellaneous tasks (for example filling out procedure).

* While enroute from Lab to the sample panel or vice versa the personnel pass by the hydrogen recombiner for a period of 30 sec. each way for each trip.

12. Three min. and forty-five sec. from the sample panel to the lab.

2.4 Radioactive Exposure to the Personnel While Sampling

Figure 2 shows the containment atmosphere sample piping . The sample bomb in Figure 2 is a 40 cc container with 9/16 inch and 2-5/8 inch inside diameter and height respectively. During sample removal a 5 cc syringe is used to extract 3 cc of containment sample from the sample bomb.

2.4.1 Dose Rate Due to the Airborne From the Containment.

Technicians are expected to follow plant procedure for protective respirator requirements (RCP-1613) to reduce inhalation doses during the sampling.

According to GPU calculation (Ref. 5), the maximum exposure due to the airborne activity in the vicinity of the containment is 200 mrem/hr. This was based on Atmospheric Dilution Factor (χ/Q) of 3.44×10^{-3} sec/m^3 with wind speed of 0.782 m/sec and Pasquill Type of "F" condition.

2.4.2 Dose Rate Due to the Containment Direct Shine.

Table 3 presents the dose rate due to the direct shine from the containment at different distances from the surface of containment. These results were based on 100% noble gas and 25% halogen core inventory release and homogenous distribution in the containment free volume. Table 3 shows the dose rate from the containment direct shine with 42 inches of concrete shielding (which is the thickness of the containment wall Ref. 3) and 66 inches of concrete shielding

(for additional wall thickness when there are other walls between the receptor and the containment wall). In this study for the direct shine from the the containment, dose rate of 2.29 rem/hr is used when the technician is in the sample room or heat trace switch room whereas a dose rate of 5 mrem/hr is used for all other locations.

2.4.3 Dose Rate Due to All Piping in the Sample Room.

Figure 2 shows the general arrangement of the containment post accident sample piping in the sample room. The outside diameter of this piping is either 1/2 or 1/4 inch. The analysis conservatively assumed that the entire radius of the piping is filled with containment post accident atmosphere with no credit for piping wall thickness shielding. The dose rates due to this piping at different distances are presented in Table 2.

2.4.4 Dose Rate Due to the Sample Bomb.

The sample bomb is a 40 cc container which contains the containment atmosphere for sample removal. Dose rates due to the sample bomb at different distances from the sample bomb surface are computed and presented in Table 5.

Design modification to remove the sample bomb and installation of small cask at the low point of the piping is recommended by TDR 494 Rev. 2 (Ref. 4). This recommendation is being implemented at the plant. Implementation of this modification in the containment atmosphere sample system will decrease the total radiation exposure by the dose contribution of the sample bomb.

2.4.5 Dose Rate Due to the Sample Syringe.

Sample syringe is a 5 cc container which is used to withdraw 3 cc of the containment atmospnere sample from the sample bomb for

post accident sampling and analysis. The dose rates due to the sample syringe both unshielded and with 1/8 inch lead shielding are computed and are presented in Table 4.

2.4.6 Dose Rate Due to the Hydrogen Recombiner

The hydrogen recombiner is a device which is used to decrease the containment hydrogen concentration during high level hydrogen generation in the containment. This is accomplished by drawing the containment atmosphere and heating it to a high temperature at which free hydrogen is recombined with oxygen to form water vapor. The gas and water vapor are then cooled and returned to the containment (Ref. 6).

In order to compute the dose contribution from the hydrogen recombiners to the personnel while enroute to conduct the containment post accident sampling the recombiner is divided into two parts (see Figure 3), these are:

1) Radiation source contained within the seven inch thick steel well.

2) Radiation source external to the vessel well.

The dose rate due to each part of the hydrogen recombiner at different distance from the vessel surface are computed and presented in Table 6. In this analysis it is conservatively assumed that both recombiners (HRR1A and HRR1B) are operating and the distance of the technician from the HRR1A and HRR1B recombiners, is 10 and 20 feet, respectively, while in transit.

2.4.7 Radiation Exposure During Sample Analyses

The containment atmosphere sample analyses consists of: (1) Gamma scan analyis, and (2) Hydrogen analysis. The total radiation exposure during this time will be approximately .072 rem whole body dose and 0.92 rem extremities. Details of these results are given below.

Work Description	Stay Time	Radiation source and Dose Rate (Rem/hr)	Exposure Per Activity (Rem)
Gamma scan Analysis	10 min (1 min contact)	• Airborne from containment = 0.2 • Containment direct shine = 0.005 • Syringe (3 ft) = 9.95-3 • Syringe (contact) = 2.75 + 1	3.6-2 (W.B.) 0.46 (Extremity)
Hydrogen Analysis	10 min. (1 min contact	• Airborne from containment = 0.2 • Containment direct shine = 0.005 • Syringe (3 ft) = 9.95-3 • Syringe (contact) = 2.75 + 1	3.6-2 (W.B.) 0.46 (Extremity)

2.5 Dose Received by Personnel During Post Accident Activities

All the actions and motions of the personnel during the post accident containment building atmosphere sampling have been accounted for. The exposure for both the whole body and extremities due to each source is presented in Table 7. The sample syringe is placed in a syringe carrier which is shielded with 1/8 inch lead lining. The technician keeps the syringe in the syringe carrier one foot away from his body while in transport. The integrated whole body and extremity doses, including dose contribution from the hydrogen recombiners, during sample removal and analyses are 1.1 rem and 1.7 rem respectively. The integrated whole body dose during sample removal and analyses without the contribution from the hydrogen recombiners is 0.6 rem.

3. SUMMARY OF RESULTS

a. Exposures. The radiation exposures to the technician during post accident containment atmosphere sampling activities are:

	Whole Body Dose (Rem)	Extremity (Rem)
With Hydrogen Recombiners Contribution	1.1	1.7
Without Hydrogen Recombiners Contribution	0.6	1.7

These values are in compliance with the limits set by NUREG 0737.

b. Shielding requirement. As shown in Table 4, the dose rate from the syringe is 0.093 Rem/hr, without shielding, at one foot distance. Since it takes 4 min. and 45 sec. to transport the syringe, the whole body dose due to the unshielded syringe is 0.0074 rem. Hence the syringe can be carried unshielded and radiation exposure to the technician will still be within acceptance criteria of 5 rem dose limit.

4. REFERENCES

1. BNWL-236, UC-34 "User's Manual for ISOSHLD Code", June 1966.

2. Midland Final Safety Analysis Report, Table 11.1-2, Total Core Fission Product Activity versus Time in Equilibrium Cycle.

3. TMI-1 FSAR update 7/82.

4. TDR 494 "TMI-1; Post-Accident Sampling Radiological Analysis", 5/10/84, Rev. 2.

5. GPU Calculation No. A120-5412-016. "TMI-1; Post LOCA Airborne and Direct Shine Dose", 2/1/83.

6. "Thermal Hydrogen Recombiner System Operation and Maintenance Manual" Rockwell International, January 30, 1980, Rev. 2.

Figure 1: sample Control Panel and sample Room Location

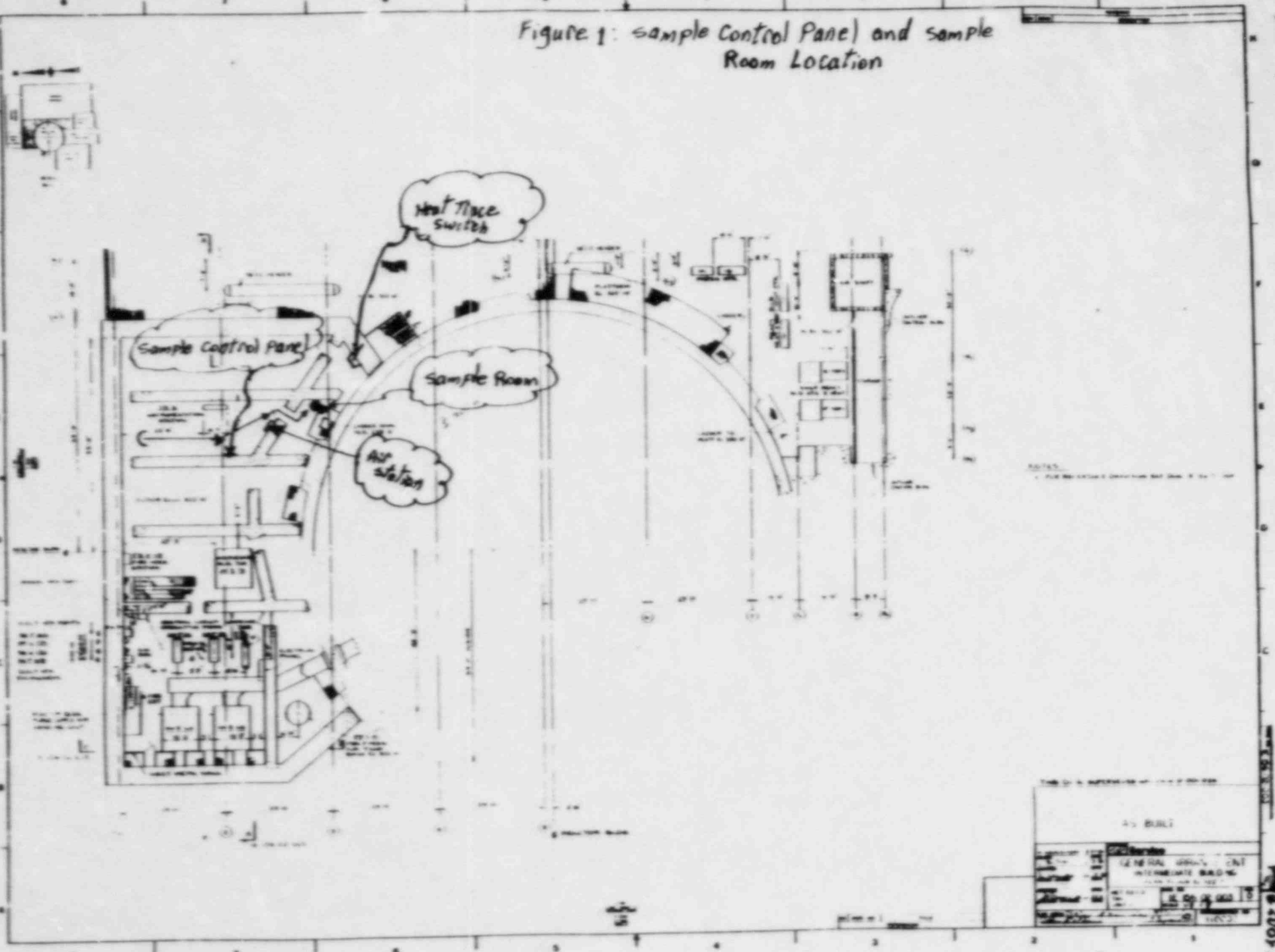
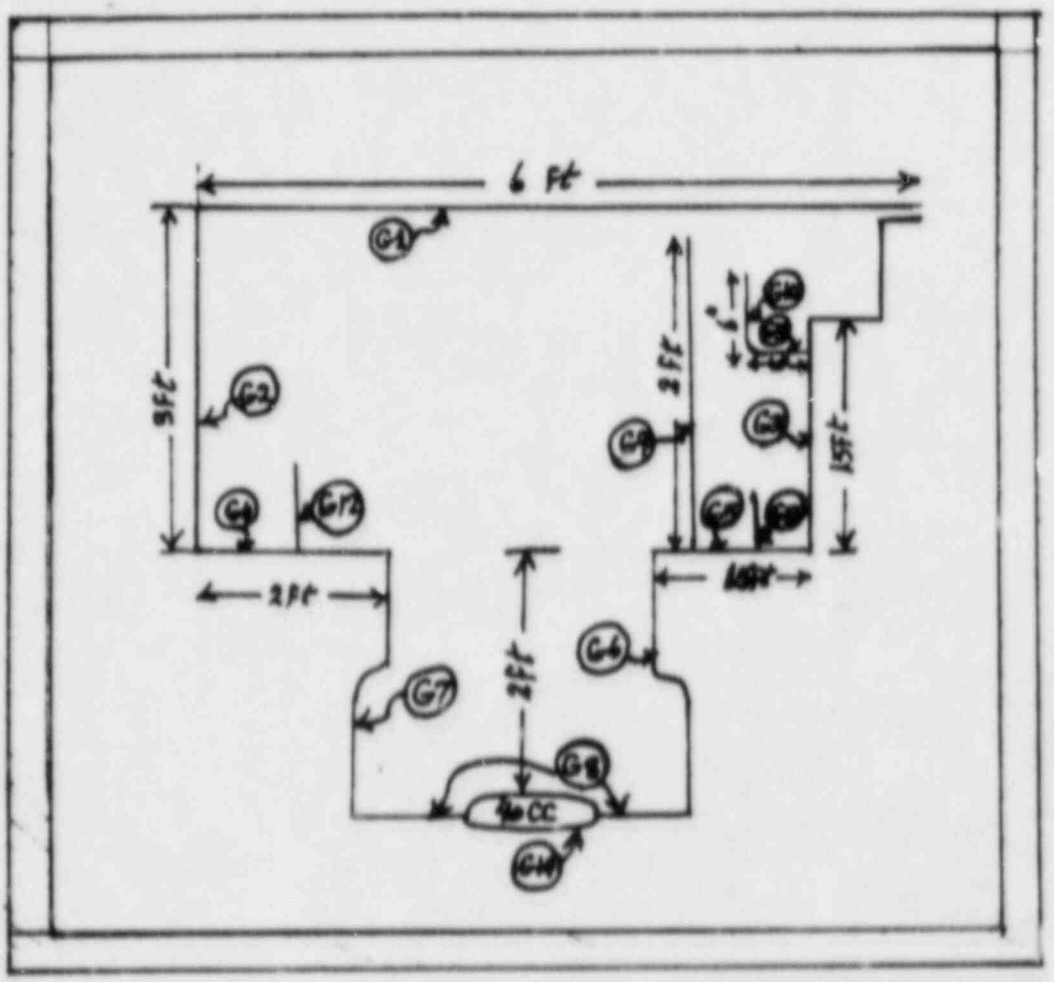


Figure 2 : CATPASS Sample Room Piping



lines G1 through G8 are OD of ¼ inch

lines G9 through G13 are OD of ½ inch

The 40 cc sample bomb (G14) is a 2 5/8" by 9/16" cylinder

Figure 3: Hydrogen Recombiner System

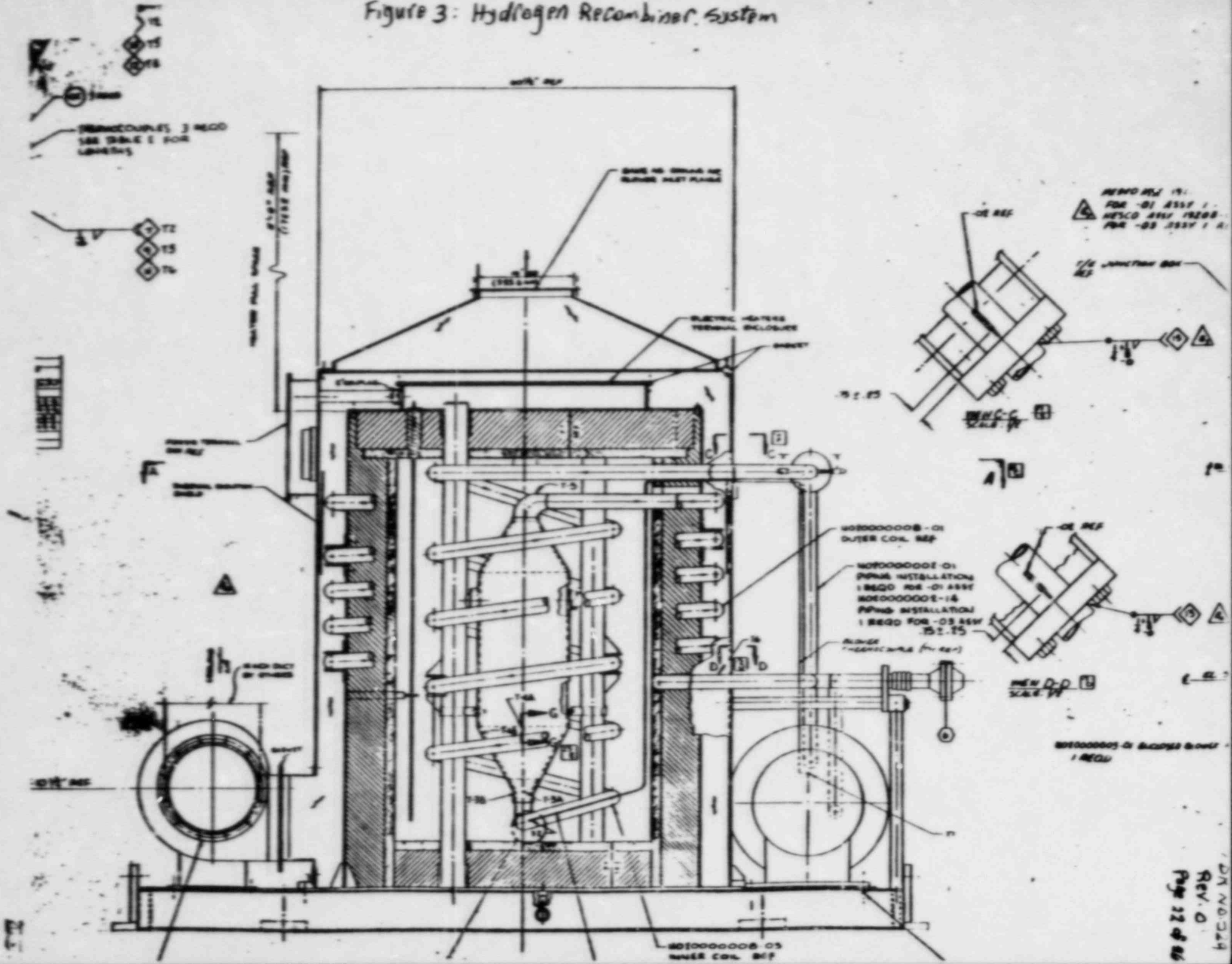


Table 2: Dose Rate Due to the Sample Station Piping (Rem/hr)

Pipe	1 ft.	2 ft.	3 ft.	5 ft.	10 ft.
6 ft. long 1/4" OD	7.15 - 1	2.99 - 1	1.60 - 1	6.63 - 2	1.82 - 2
3 ft. long 1/4" OD	5.57 - 1	1.96 - 1	9.42 - 2	3.58 - 2	2.92 - 3
2 ft. long 1/4" OD	4.42 - 1	1.41 - 1	6.53 - 2	2.42 - 2	6.22 - 3
2 ft. long 1/2" OD	1.78 + 0	5.68 - 1	2.63 - 1	9.74 - 2	2.50 - 2
10" long 1/2" OD	1.01 + 0	2.86 - 1	1.28 - 1	4.66 - 2	1.19 - 2
6" long 1/2" OD	6.25 - 1	1.74 - 1	7.80 - 2	2.83 - 2	7.20 - 3

Table 3: Dose Rate Due to Containment Shine (Rem/hr)

	1 ft*	2 ft	3 ft	5 ft	10 ft	50 ft
Containment with 42" concrete	2.58 + 0	2.52 + 0	2.45 + 0	2.29 + 0	2.02 + 0	9.66 - 1
Containment with 66" concrete	8.54 - 3	8.37 - 3	3.20 - 3	7.73 - 3	7.34 - 3	3.63 - 3

Table 4: Dose Rate Due to Sample Syringe (Rem/hr)
(3 cc Containment Atmosphere Source)

	1 cm*	3 cm	1 ft	1.5 ft	3 ft
Unshielded	2.75 + 1	7.00 + 0	9.27 - 2	3.84 - 2	9.95 - 3
1/8" Pb Shield	1.90 + 1	5.56 + 0	8.72 - 2	3.61 - 2	9.37 - 3

Table 5: Dose Rate Due to the Sample Bomb (Rem/hr)
(.2 cm Wall Thickness)

1 cm*	3 cm	6 inch	1 ft	1.5 ft	3 ft
9.83 + 1	4.36 + 1	4.36 + 0	1.21 + 0	5.65 - 1	1.46 - 1

Table 6: Dose Rate Due to the Hydrogen Recombiner (Rem/hr)

	Contact	1 ft	2 ft	3 ft	5 ft	10 ft	20 ft
Reaction Chamber and Heating Coil	6.10 + 0	3.60 + 0	2.33 + 0	1.60 + 0	8.08 + 0	2.66 - 1	7.51 - 2
Cooling Coil and Piping	4.54 + 3	3.80 + 2	1.66 + 2	9.36 + 1	4.14 + 1	1.19 + 1	3.18 + 0
Total	4.55 + 3	3.84 + 2	1.68 + 2	9.52 + 1	4.22 + 1	1.22 + 1	3.20 + 0

Note:

* Distance from the outside surface

Table 7: Radioactive Exposure During Post-Accident Activities

Description	Stay Time	Radiation Sources	Radiation level (Rem/hr)	Rad. Exposure During the Work (Rem)
Travel from Lab to the remote sample panel (Two trips)	7 min	. Airborne from containment . Containment direct shine	0.2 0.005	0.024 (W.B.)
Travel time in the vicinity of the hydrogen recombiner (Two trips)	1 min	. Hydrogen recombiner	15.5	0.258 (W.B.)
Time spent at air station	40 sec	. Airborne from containment . Containment direct shine	0.2 0.005	0.0023 (W.B.)
Time spent at the remote sample panel	6 min & 50 sec	. Airborne from containment . Containment direct shine	0.2 0.005	0.023 (W.B.)
Time to switch heat trace (on and off)	10 sec	. Airborne from containment . Containment direct shine . Airborne from containment	0.2 2.29 0.16	0.0069 (W.B.)
Time spent at the sample station	6 min & 40 sec	. Airborne from containment . Containment direct shine . All piping (assume the sample piping is full with containment atmosphere for 45 sec and personnel is standing 3 ft away from the piping)	0.2 2.29 1.31	0.293 (W.B.)
Time to draw sample from sample station (draw 3 cc sample from 40 cc sample bomb)	45 sec	. Airborne from containment . Containment direct shine . All pipings . Sample bomb . Sample syringe	0.2 2.29 3.35 1.21 .0927	0.09 (W.B.)
		. Sample bomb (hold sample bomb with one hand for 15 sec)	98.3 (contact)	0.75 (extremity)
		. Sample syringe (hold sample syringe with both hand for 15 sec)	27.5 (contact)	
		. Sample syringe (hold sample syringe with one hand to place in shield for 15 sec)	27.5 (contact)	

Table 7: Radioactive Exposure During Post-Accident Activities
(continued)

Description	Stay Time	Radiation Sources	Radiatian level (Rem/hr)	Rad. Exposure During the Work (Rem)
Additional time spent in general area (e.g. reading procedure filling out forms)	5 min	. Airborne from containment . Containment direct shine	0.2 0.005	0.017 (W.B.)
Travel from sample station to Lab (Two trips)	7 min & 30 sec	. Airborne from containment . Containment direct shine . Syringe with 1/8 in. lead shield (transport time for the syringe is 3 min. 45 sec.)	0.2 0.005 0.087	0.0311 (W.B.)
Travel time in the vicinity of the hydrogen recombiner (Two trips)	1 min	. Hydrogen recombiner	15.5	0.258 (W.B.)
	20 min	. See section 2.4.7		0.072 (W.B.) 0.92 (Extremity)
		Total dose including contribution from Hydrogen recombiners		1.1 Rem (W.B) 1.7 Rem (extremity)
		Total dose excluding contribution from Hydrogen recombiners		0.6 Rem (W.B.) 1.7 Rem (extremity)