MARTIN COMPANY

NUCLEAR DIVISION
Baltimore, Maryland
21203

RECEIVED
APR 20 1964
U.S. Atomic Energy Commission
DIVISION OF LICENSING & REGULATION

In reply refer to:
ACC-277

April 15, 1964

Material Licensing Division
U. S. Atomic Energy Commission
Washington, D. C.

Attention: Mr. Lyall E. Johnson, Acting Director
Material Licensing Division

Subject: Renewal of Byproduct Material License 19-1398-29

Enclosure:
(1) Application for Byproduct Material License Form AEC-313 (6 copies)
(2) Radioisotopes Pilot Plant - Facility Design and Safety Evaluation MND-3137 (6 copies)
(3) Cell 4 Process Control Panel N-0009748 (6 copies)
(4) Cell and Isolation Concept for Cells 3 and 4 N-0009744 (6 copies)

Gentlemen:

We request that Byproduct Material License No. 19-1398-29, covering the operation of the Martin Marietta Corporation Pilot Plant at Quehanna, Pennsylvania utilized for the production of isotopic heat sources, be renewed.

We have compiled "Radioisotopes Pilot Plant - Facility Design and Safety Evaluation", MND-3137 in support of our request for license renewal. Chapter 3, Part 3.6 of MND-3137 "Reagents" sets forth classified information in connection with License No. 19-1398-29 and is being forwarded under separate cover.

B-69

A DIVISION OF MARTIN MARIETTA

We intend that "Radioisotopes Pilot Plant - Facility Design and Safety Evaluation", MND-3137, replace all previous submissions in connection with the existing byproduct license 19-1398-29 with the following exceptions:

(1) A Proposed Amendment to License 19-1398-29 submitted to you on April 1, 1964 covering the removal and disposal of the Stationary Overhead Transfer System.

(2) A proposed amendment to be submitted to you in the near future to obtain Commission approval for the rehabilitation of Cells 1 and 2.

Your approval of this submission is required no later than July 1, 1964 in order that we may resume production of heat sources at that time.

We will be happy to participate in any discussions you may desire and will contact your office in approximately two weeks to establish a firm meeting date to discuss any questions you may have concerning this submission. Please contact me on 301-687-3800, Extension 513 at any time if we can be of assistance in this matter.

Thank you for your early consideration of this matter and for the excellant cooperation of your personnel in past licensing actions.

Very truly yours,

C W Keller

C. W. Keller,
Nuclear Accountability &
Licensing Representative

CWK/mc

Encls.

Form AEC-313 (5-58)	ATOMIC ENERGY COMMISSION **APPLICATION FOR BYPRODUCT MATERIAL LICENSE**	Form approved. Budget Bureau No. 38-R027.4.

INSTRUCTIONS.—Complete Items 1 through 16 if this is an initial application. If application is for renewal of a license, complete only Items 1 through 7 and indicate new information or changes in the program as requested in Items 8 through 15. Use supplemental sheets where necessary. Item 16 must be completed on all applications. Mail three copies to: U. S. Atomic Energy Commission, Washington 25, D. C. Attention: Isotopes Branch, Division of Licensing and Regulation. Upon approval of this application, the applicant will receive an AEC Byproduct Material License. An AEC Byproduct Material License is issued in accordance with the general requirements contained in Title 10, Code of Federal Regulations, Part 30 and the Licensee is subject to Title 10, Code of Federal Regulations, Part 20.

1. (a) NAME AND STREET ADDRESS OF APPLICANT. *(Institution, firm, hospital, person, etc.)*

Martin Marietta Corporation
Baltimore, Maryland

(b) STREET ADDRESS(ES) AT WHICH BYPRODUCT MATERIAL WILL BE USED. *(If different from 1 (a).)*

Martin Marietta Pilot Plant
Quehanna, Pennsylvania

2. DEPARTMENT TO USE BYPRODUCT MATERIAL

Martin Marietta Corporation
Nuclear Division

3. PREVIOUS LICENSE NUMBER(S). *(If this is an application for renewal of a license, please indicate and give number.)*

Renewal of Byproduct License
19-1398-29

4. INDIVIDUAL USER(S). *(Name and title of individual(s) who will use or directly supervise use of byproduct material. Give training and experience in Items 8 and 9.)*

Please refer to Chapter 4, Part 4.4 of MND-3137

5. RADIATION PROTECTION OFFICER *(Name of person designated as radiation protection officer if other than individual user. Attach resume of his training and experience as in Items 8 and 9.)*

Richard J. Brisson
(Resume submitted in regards to license #9 dated 3/29/63)

6. (a) BYPRODUCT MATERIAL. *(Elements and mass number of each.)*	(b) CHEMICAL AND/OR PHYSICAL FORM AND MAXIMUM NUMBER OF MILLICURIES OF EACH CHEMICAL AND/OR PHYSICAL FORM THAT YOU WILL POSSESS AT ANY ONE TIME. *(If sealed source(s), also state name of manufacturer, model number, number of sources and maximum activity per source.)*	
Strontium-90	6,000,000 curies	Please refer to Chapter 3 of MND-3137 especially Part 3.6 "Reagents" which is classified.
<u>Associated Contaminants</u>		
Strontium-89	1,800,000 curies	
Cerium-144	30,000 curies	
Other gross fission products	30,000 curies	

7. DESCRIBE PURPOSE FOR WHICH BYPRODUCT MATERIAL WILL BE USED. *(If byproduct material is for "human use," supplement A (Form AEC-313a) must be completed in lieu of this item. If byproduct material is in the form of a sealed source, include the make and model number of the storage container and/or device in which the source will be stored and/or used.)*

For the production of isotopic heat sources.

(Continued on reverse side)

In reply refer to:
ACC-277

April 15, 1964

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U. S. Atomic Energy Commission
Washington, D. C.

Attention: Mr. Lyall E. Johnson, Acting Director
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Thank you for your early consideration of this matter and for the excellent cooperation of your personnel in past licensing actions.

Very truly yours,

C. W. Keller,
Nuclear Accountability &
Licensing Representative

CWK/mc

Encls.

Form AEC-313 (5-58)

ATOMIC ENERGY COMMISSION

APPLICATION FOR BYPRODUCT MATERIAL LICENSE

Form approved. Budget Bureau No. 38-R027.4.

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Baltimore, Maryland

(b) STREET ADDRESS(ES) AT WHICH BYPRODUCT MATERIAL WILL BE USED. (If different from 1 (a).)

Martin Marietta Pilot Plant
Quehanna, Pennsylvania

2. DEPARTMENT TO USE BYPRODUCT MATERIAL

Martin Marietta Corporation
Nuclear Division

3. PREVIOUS LICENSE NUMBER(S). (If this is an application for renewal of a license, please indicate and give number.)

Renewal of Byproduct License
19-1305-28

4. INDIVIDUAL USER(S). (Name and title of individual(s) who will use or directly supervise use of byproduct material. Give training and experience in Items 8 and 9.)

Please refer to Chapter 4,
Part 4.4 of MND-3137

5. RADIATION PROTECTION OFFICER (Name of person designated as radiation protection officer if other than individual user. Attach resume of his training and experience as in Items 8 and 9.)

Richard J. Ericson
(Resume submitted in regards
to license #0 dated 3/28/83)

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(b) CHEMICAL AND/OR PHYSICAL FORM AND MAXIMUM NUMBER OF MILLICURIES OF EACH CHEMICAL AND/OR PHYSICAL FORM THAT YOU WILL POSSESS AT ANY ONE TIME. (If sealed source(s), also state name of manufacturer, model number, number of sources and maximum activity per source.)

(a)	(b)
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Associated Contaminants	
Strontium-89	1,800,000 curies
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Other gross fission products	30,000 curies

Please refer to
Chapter 5 of MND-3137
especially Part 5.6
"Reagents" which is
classified.

7. DESCRIBE PURPOSE FOR WHICH BYPRODUCT MATERIAL WILL BE USED. (If byproduct material is for "human use," supplement A (Form AEC-313a) must be completed in lieu of this item. If byproduct material is in the form of a sealed source, include the make and model number of the storage container and/or device in which the source will be stored and/or used.)

For the production of isotopic heat sources.

(Continued on reverse side)

TRAINING AND EXPERIENCE OF EACH INDIVIDUAL NAMED IN ITEM 4 *(Use supplemental sheets if necessary)*

8. TYPE OF TRAINING	WHERE TRAINED	DURATION OF TRAINING	ON THE JOB (Circle answer)	FORMAL COURSE (Circle answer)
a. Principles and practices of radiation protection	Please refer to Chapter 4 Part 4.4 of MND-3137		Yes No	Yes No
b. Radioactivity measurement standardization and monitoring techniques and instruments			Yes No	Yes No
c. Mathematics and calculations basic to the use and measurement of radioactivity			Yes No	Yes No
d. Biological effects of radiation			Yes No	Yes No

9. EXPERIENCE WITH RADIATION. *(Actual use of radioisotopes or equivalent experience.)*

ISOTOPE	MAXIMUM AMOUNT	WHERE EXPERIENCE WAS GAINED	DURATION OF EXPERIENCE	TYPE OF USE
	Please refer to Chapter 4, Part 4.4 of MND-3137			

10. RADIATION DETECTION INSTRUMENTS. *(Use supplemental sheets if necessary.)*

TYPE OF INSTRUMENTS (Include make and model number of each)	NUMBER AVAILABLE	RADIATION DETECTED	SENSITIVITY RANGE (mr/hr)	WINDOW THICKNESS (mg/cm²)	USE (Monitoring, surveying, measuring)
Please refer to Chapter 10 of MND-3137					

11. METHOD, FREQUENCY, AND STANDARDS USED IN CALIBRATING INSTRUMENTS LISTED ABOVE.

Please refer to Chapter 10 of MND-3137

12. FILM BADGES, DOSIMETERS, AND BIO-ASSAY PROCEDURES USED. *(For film badges, specify method of calibrating and processing, or name of supplier.)*

Please refer to Chapter 10 of MND-3137

INFORMATION TO BE SUBMITTED ON ADDITIONAL SHEETS

13. FACILITIES AND EQUIPMENT. Describe laboratory facilities and remote handling equipment, storage containers, shielding, fume hoods, etc. Explanatory sketch of facility is attached. (Circle answer) Yes No

Please refer to Chapter 8, MND-3137

14. RADIATION PROTECTION PROGRAM. Describe the radiation protection program including control measures. If application covers sealed sources, submit leak testing procedures where applicable, name, training, and experience of person to perform leak tests, and arrangements for performing initial radiation survey, servicing, maintenance and repair of the source.

Please refer to Chapter 10, MND-3137

15. WASTE DISPOSAL. If a commercial waste disposal service is employed, specify name of company. Otherwise, submit detailed description of methods which will be used for disposing of radioactive wastes and estimates of the type and amount of activity involved.

Chapter 7, MND-3137

CERTIFICATE (This item must be completed by applicant)

16. THE APPLICANT AND ANY OFFICIAL EXECUTING THIS CERTIFICATE ON BEHALF OF THE APPLICANT NAMED IN ITEM 1, CERTIFY THAT THIS APPLICATION IS PREPARED IN CONFORMITY WITH TITLE 10, CODE OF FEDERAL REGULATIONS, PART 30, AND THAT ALL INFORMATION CONTAINED HEREIN, INCLUDING ANY SUPPLEMENTS ATTACHED HERETO, IS TRUE AND CORRECT TO THE BEST OF OUR KNOWLEDGE AND BELIEF.

MARTIN MARIETTA CORPORATION

Applicant

April 15, 1964

Date

C. W. Keller

Nuclear Accountability & Licensing Representative

Title of certifying official

WARNING.—18 U. S. C., Section 1001; Act of June 25, 1948; 62 Stat. 749; makes it a criminal offense to make a willfully false statement or representation to any department or agency of the United States as to any matter within its jurisdiction.

U.S. GOVERNMENT PRINTING OFFICE 1961 O—615963

Martin Marietta Corporation

RADIOISOTOPES PILOT PLANT

Quehanna, Pennsylvania

FACILITY DESIGN AND SAFETY EVALUATION

MND-3137

April 1964

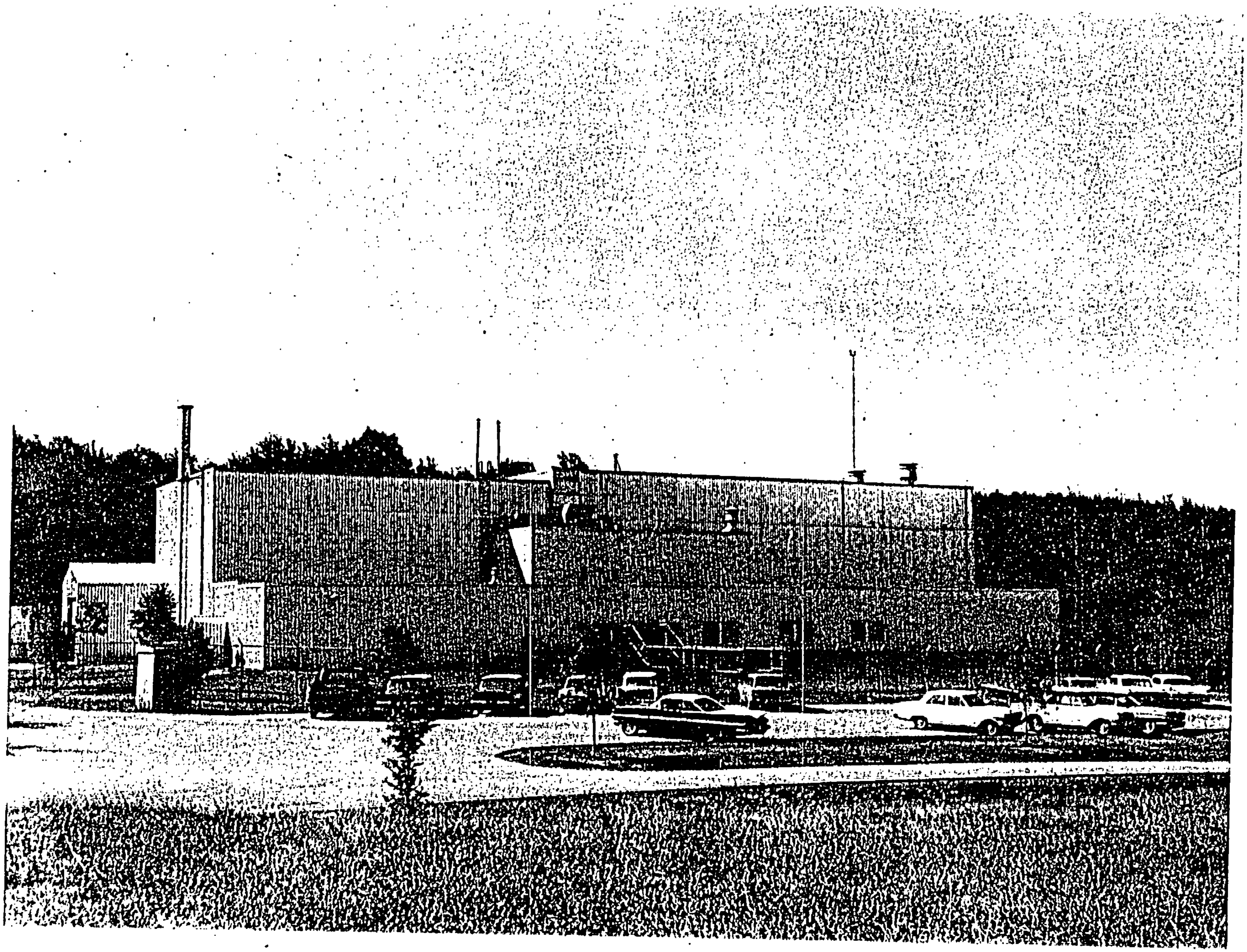
Prepared by: C. O. Riggs

T. W. Conway

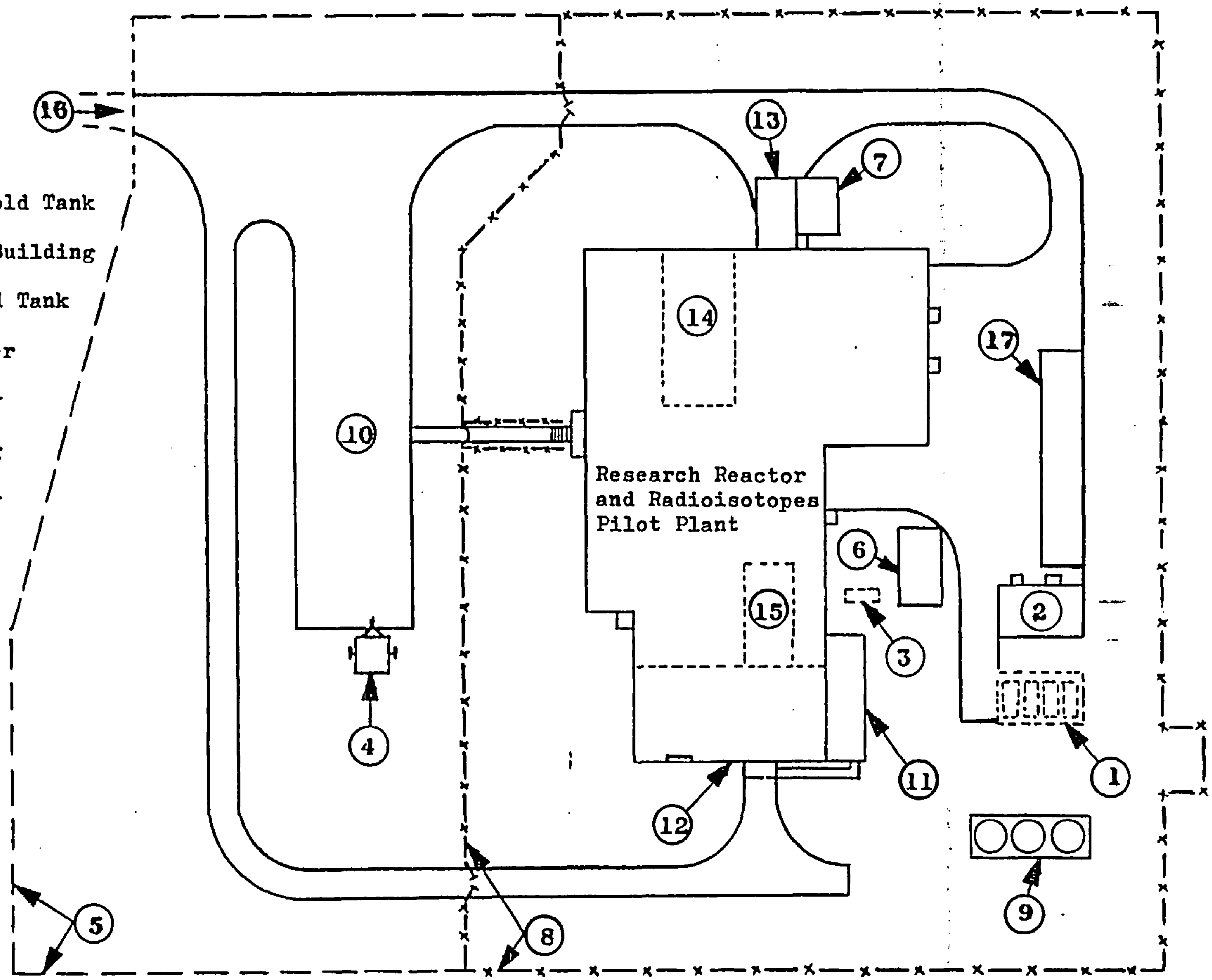
L. K. Clark

Approved by: W. A. Vogele, Suprv.
Nuclear Safety Unit

W. G. Ruehle



1. 4 Underground Hold Tank
2. Waste Disposal Building
3. Underground Hold Tank
4. Emergency Trailer
5. Project Boundary
6. Storage Building
7. Storage Building
8. Security Fence
9. Cooling Tower
10. Parking Area
11. Pump Room
12. Basement
13. Air Lock
14. Fan Room
15. Pool
16. Road
17. **Waste Storage Building**



Layout of the Radioisotopes Pilot Plant Site

ACKNOWLEDGEMENTS

This report has been prepared and edited by members of the Nuclear Safety Unit of the Martin Nuclear Division. In addition to those listed on the title page, R. Huebschman assisted in the early portion of the work. I. Gray also assisted the Unit in the beginning.

The work could not have been brought to a successful completion without the continued cooperation and assistance of the Quehanna Plant staff, including J. Cochran, Plant Manager, and M. Bowles. The latter, designated for liaison, worked closely with the Unit.

The chapter on health physics was prepared by R. Brisson, Supervisor of Health Physics, and J. Toennies. This group gave other valuable criticisms and suggestions.

The sections on shielding were prepared by D. C. Anderson, A. Spamer and K. Davenport of the Shielding Unit and they have reviewed other sections, as appropriate.

Dr. Merrill Eisenbud, Professor of Industrial Medicine has reviewed the report and made highly valued comments.

Figure 2.2 has been reproduced from the official state map of Pennsylvania by the kind permission of that state's Department of Highways. Figure 2.3 was prepared from a map of the United States Geological Survey.

FOREWORD

This report is submitted to the Division of Licensing and Regulation of the United States Atomic Energy Commission by the Nuclear Division of the Martin Company. It presents the plant design, process description and safety evaluation of the Radioisotopes Pilot Plant at Quehanna, Pennsylvania. It is presented in support of the Martin Company application for license to continue the production of radio-strontium fuel forms.

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CHAPTER 1

INTRODUCTION

This summary report has been prepared by Martin Nuclear Division, Baltimore, Maryland, a division of Martin Marietta Corporation. It presents the plant design and production process of the Radioisotopes Pilot Plant at Quehanna, Pennsylvania, and provides a general safety evaluation of the facility and operation. The report is submitted to the United States Atomic Energy Commission in support of an application for license to continue processing multi-curie quantities of radiostrontium.

The Radioisotopes Pilot Plant has been operated by the Martin Company since July, 1962. In this time invaluable experience has been gained and much of this is reflected in the improvements in plant design, process equipment and procedures and safety provisions described in the present report.

The operations of the Radioisotopes Production Pilot Plant are directed to the production of radioisotopic sources of heat. Several generators employing such sources are now in use furnishing power for remotely-located automatically-reporting weather stations, navigation buoys, etc., and are contemplated for use in space vehicles. The requirements in these field are expected to utilize the full capacity of the Pilot Plants in the immediate future and to exceed it in the near future.

The building in which the Radioisotopes Production Pilot Plant is located was constructed by the Curtiss-Wright Corporation in 1957 and presented to the Pennsylvania State University in September 1960. The Martin Company leases from the University which retains control of part of the building and monitors the liquid waste disposal to the streams.

CHAPTER 2

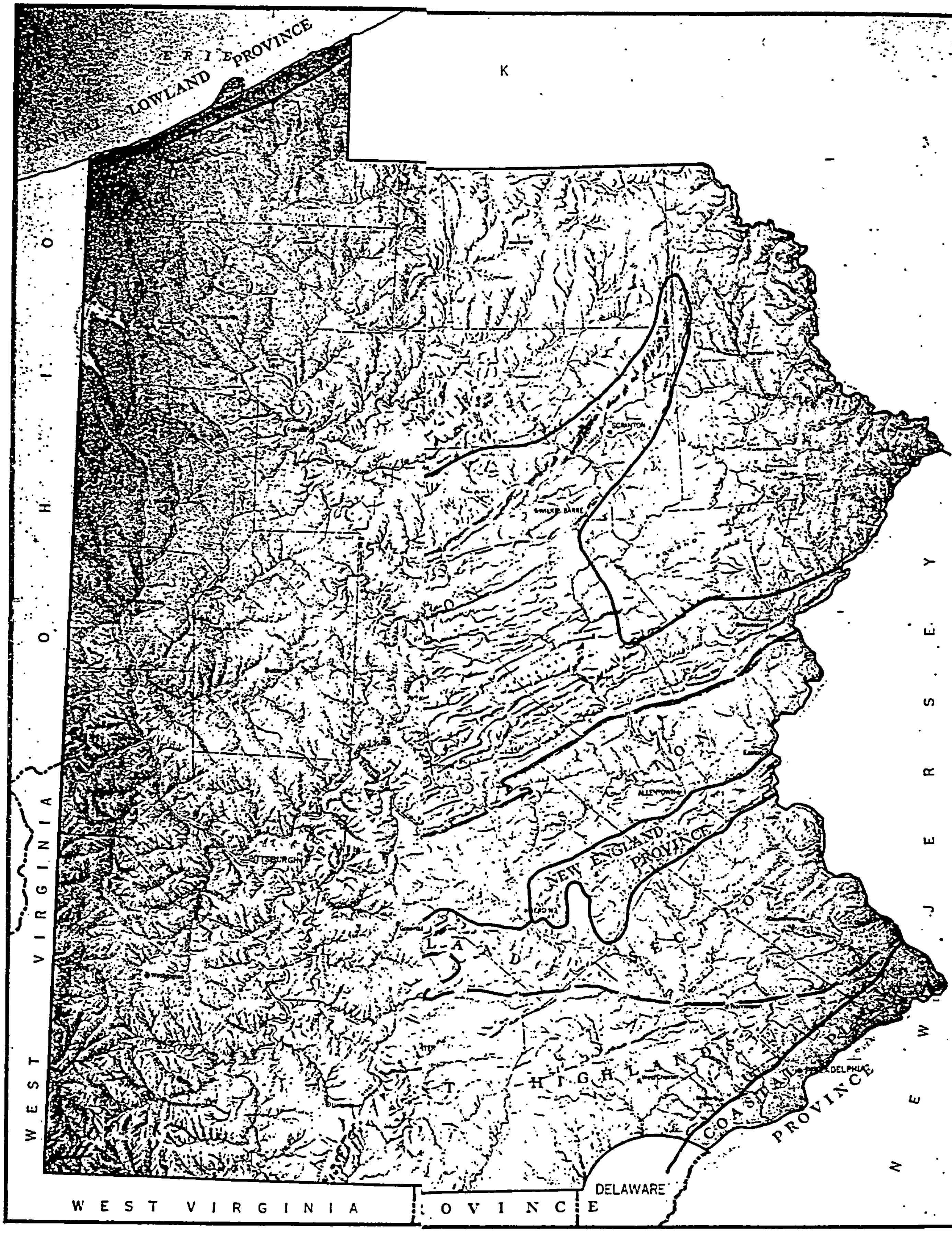
QUEHANNA SITE

The area within which the Martin Radioisotopes Pilot Plant is located is the former Curtiss-Wright Quehanna Research Facility, 45 miles northwest of State College in north-central Pennsylvania. It includes parts of Elk, Cameron, and Clearfield Counties. Figure 2.1 shows the area in relation to the State of Pennsylvania. This location is perhaps the most remote one for a nuclear facility in the eastern United States, since it is in a sparsely populated region and has an area of approximately 80 square miles. The nearest population centers, Sinnemahoning (population 300) and Karthaus (population 400), are nine miles from the site. This site is ideal for the hot cell operations with respect to its population, meteorologic and hydrologic characteristics. Its general features are representative of those of the Appalachian Plateau physiographic province. Radioisotope production has been carried out by the Martin Company on the site under license from the Atomic Energy Commission since 1962; previous to that reactor and nuclear facilities were operated by the Curtiss-Wright Corporation and the Pennsylvania State University. This study extends and brings up-to-date a previous site description (Reference 2.1)

2.1 Site Location

2.1.1 Regional

Figure 2.2 is a political map of the area around the facility showing the highway network and towns and villages.



E R I E
LOWLAND PROVINCE
K
O H I O
WEST VIRGINIA
W E S T V I R G I N I A
O V I N C E
DELAWARE
N E W J E R S E Y
SCRANTON
WILKES BARRE
ALLENTOWN
NEW ENGLAND PROVINCE
PITTSBURGH
PHILADELPHIA
COASTAL PLAIN PROVINCE

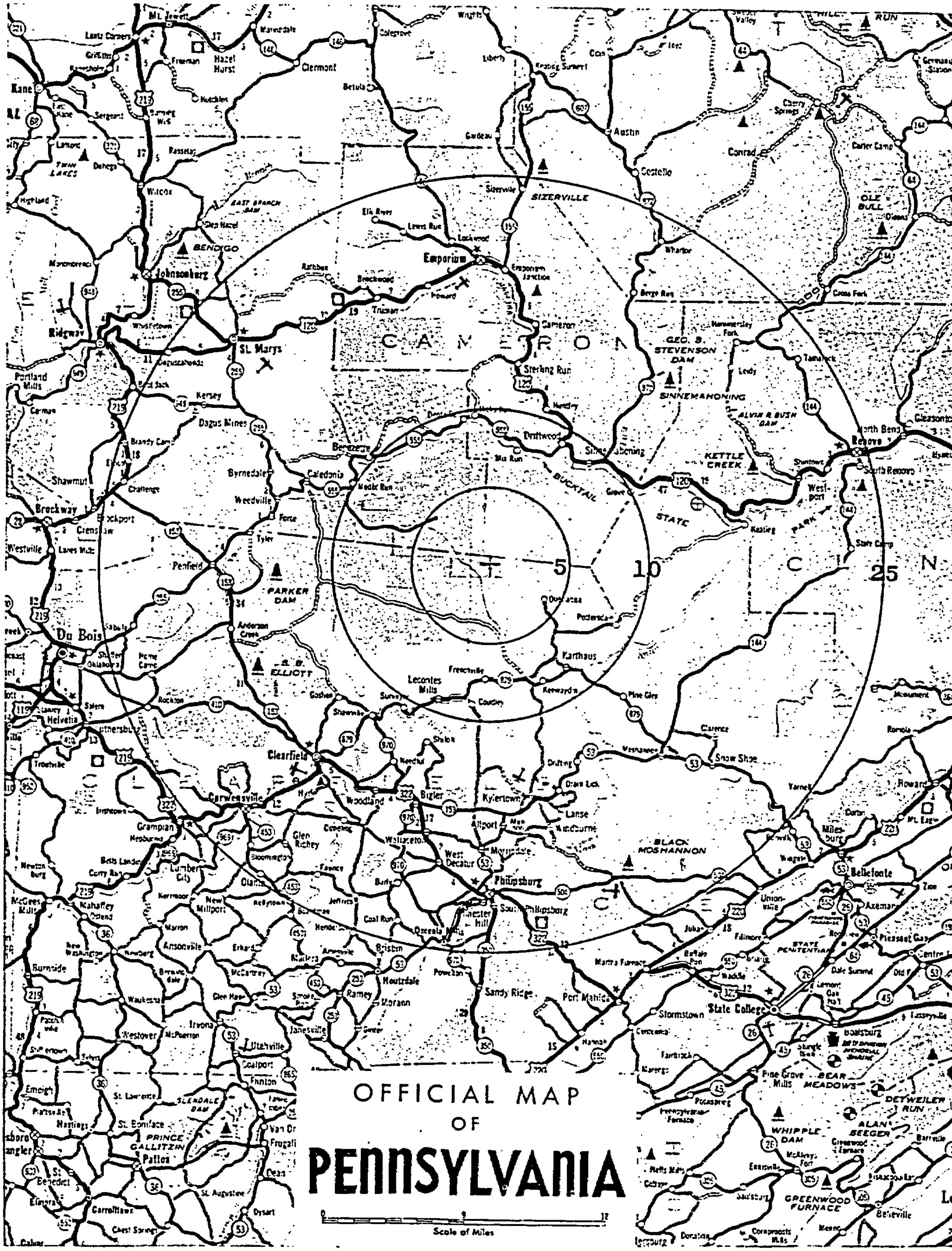


Figure 2.2
Environs of Martin
Radioisotopes Pilot Plant,
Quehanna, Pennsylvania

The land is largely state forest and state gameland. Circles of 5, 10 and 25 mile radius have been superimposed on the map.

2.1.2 Exclusion Area

Figure 2.3 is a reproduction of a topographic map of the site area. The laboratory site is shown near the upper left corner of the map.

The exclusion area is defined as that area around the laboratory which is under control of the Martin Company and the Pennsylvania State University. The terms of the agreement between Martin and the University with respect to this exclusion area are described in Reference 2.2. The reference states that "all necessary steps" are being taken to assure that an exclusion area is maintained which will be satisfactory to Martin and the Atomic Energy Commission. Control is maintained around the facility via Cyclone fence and guard service.

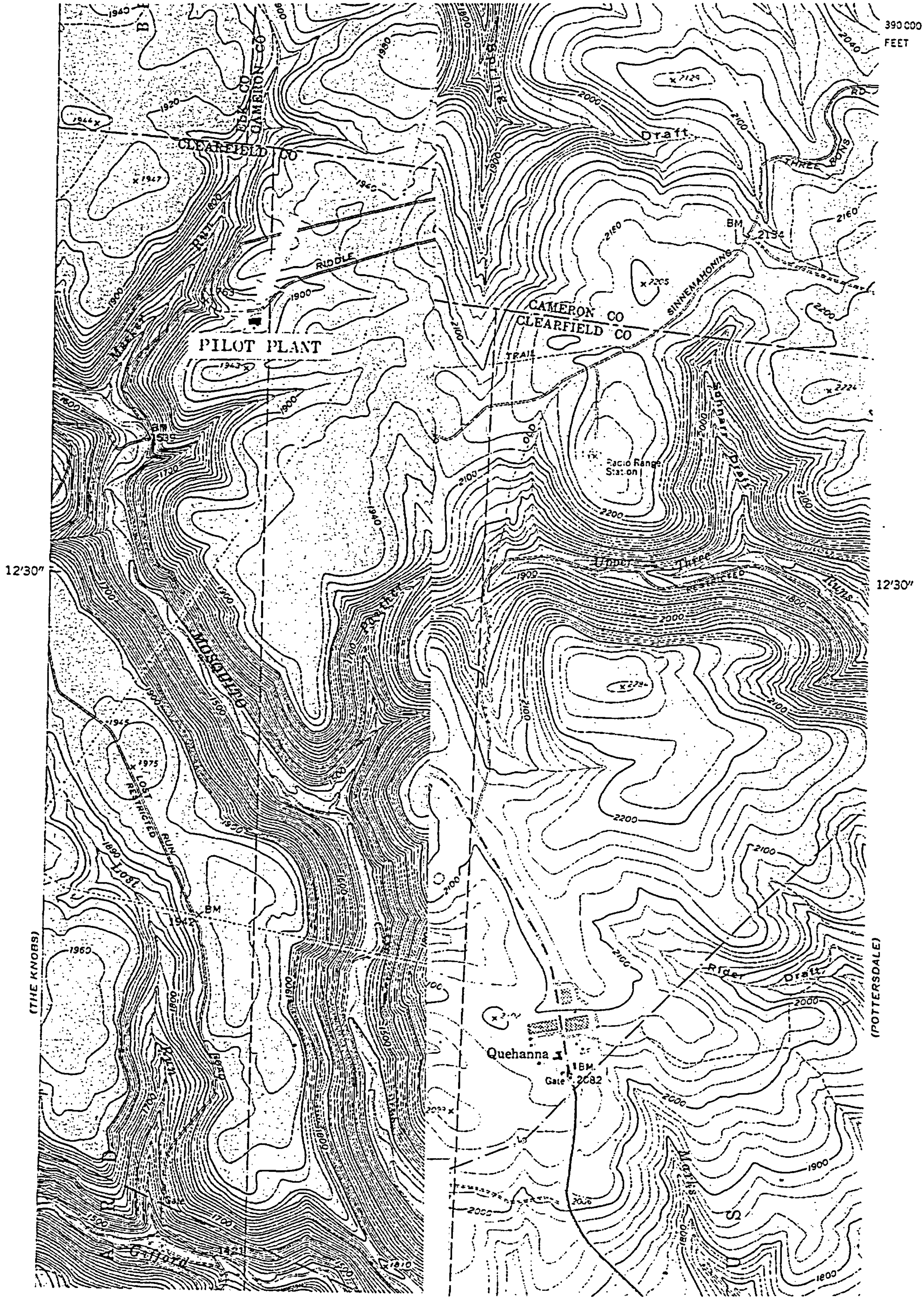
2.2 Geography

2.2.1 Topography

The topography of the region is typical of the Appalachian Plateau; it is a relatively flat area at an average elevation of 2000 feet above mean sea level. The edge of the exclusion perimeter is incised by several gorges up to one-half mile in width and 1000 feet in depth which radiate from their origin near the center of the site.

2.2.2 Land Usage

The area is included in state forest land with a secondary growth of trees. In this area, there is seasonal


390 000
FEET
CLEARFIELD CO
CAMERON CO
ELK CO
RIDDLE
PILOT PLANT
Draft
THREE RUNS
SINNEMAHONING
TRAIL
Radio Range
Station
Upper Three Runs
RESTRICTED
Mosquito
LOST
RESTRICTED
RUN
Lost
Rider Draft
Quehanna
Gate
BM
2082
Gifford
12'30"
12'30"
(THE KNOBS)
(POTTERSDALE)

recreation activity especially hunting. Beyond the state forest land, within outlying townships, there is small-scale agricultural activity. Land usage is therefore quite limited.

2.3 Population Density and Distribution

The sparse population in its environs is perhaps the most favorable feature of the site. The state forest surrounding the facility has a low permanent population density. Within a 25 mile radius of the site, the population density is 27 individuals per square mile, with a total population within this zone of about 53,000.

The population within a 25 mile radius of the site is distributed into about 50 small villages with populations less than 1000 individuals (average 400), six small towns averaging 5000 individuals and a minimal number of outlying individual habitations. The total population of this zone has decreased by about 8000 during the past 8 years due to the closing of nearby mines and stripping operations.

Table 2.1 gives the population distribution within a 25 mile radius of the site. The population within 22.5° sectors of this area is listed in Table 2.2.

The predominant wind directions at the site are from the west-northwest and south-southeast. From a population distribution standpoint these are favorable, since they are not directed at the major population centers of the region nor into areas of above average population density.

2.4 Meteorology (Reference 2.3)

TABLE 2.1

Towns Nearest Reactor Site*

	Population		Population
Allport	300	Kylertown	300
Bald Hill	250	Lanse	300
**Bellefonte	6088	Lecontes Mills	250
Benezette	200	Medix Run	60
Bigler	500	Mineral Springs	500
Bloomington	160	Morrisdale	800
Blue Hill	450	Moshannon	500
Brandy Camp	400	Munson	450
**Brockport	450	Oak Grove	200
**Brockway	2563	Olanta	80
Caledonia	300	Oshanter	150
Cameron	80	**Orviston	275
Challenge	30	Penfield	700
Chester Hill	919	Philipsburg	3872
Clarence	500	Pine Glen	50
Clearfield	9200	Pottersdale	50
**Crenshaw	350	**Renovo	3316
Curwensville	3231	**Ridgway	6387
Dagus Mines	450	Rockton	200
Dents Run	30	Sabula	80
Drifting	50	**State College	22500

TABLE 2.1 (Cont'd)

	Population		Population
Driftwood	203	St. Marys	8065
Drury Run	200	Shawville	25
**Dubois	10,600	Shintown	65
Elbon	150	Sinnemahoning	300
Emporium	3397	Snow Shoe	714
Force	400	**South Renovo	777
Frenchville	50	Sterling Run	150
Glen Rickey	400	Surveyor	100
Grassflat	850	**Sykesville	1479
Hammersley Fork	15	Truman	75
Hawk Run	850	Tyler	250
Hollywood	200	Wallaceton	429
Howard	45	Weedville	500
Hyde	850	West Decatur	750
**Johnsonburg	4966	Westport	135
**Kane	5380	Wharton	25
Karthaus	400	Woodland	900
Keating	35	Windburne	800
Keewaydin	35	Byrnedale	500
Kersey	600		

*From Rand McNally Commercial Atlas and Marketing Guide, 1963 Edition. Includes towns within 25 mile radius of site.

**Towns slightly outside the 25 mile radius.

TABLE 2.2

Population within 25 mile Radius of Site by 22.5° Sectors.

Sector	Population
N-NNE	3627
NNE-NE	228
NE-ENE	415
ENE-E	4328
E-ESE	275
ESE-SE	1264
SE-SSE	1050
SSE-S	8472
S-SSW	3748
SSW-SW	14696
SW-WSW	200
WSW-W	780
W-WNW	3530
WNW-NW	9375
NW-NNW	~ 0
NNW-N	~ 150

2.4.1 Data Available

Meteorological data recorded at the facility site show its weather conditions to be quite similar to those at the Philipsburg airport, 27 miles southeast of the site, for which complete meteorological records have been kept. The information reported here is taken from observations at the airport, although observations are now being recorded at the site.

2.4.2 Wind Flow

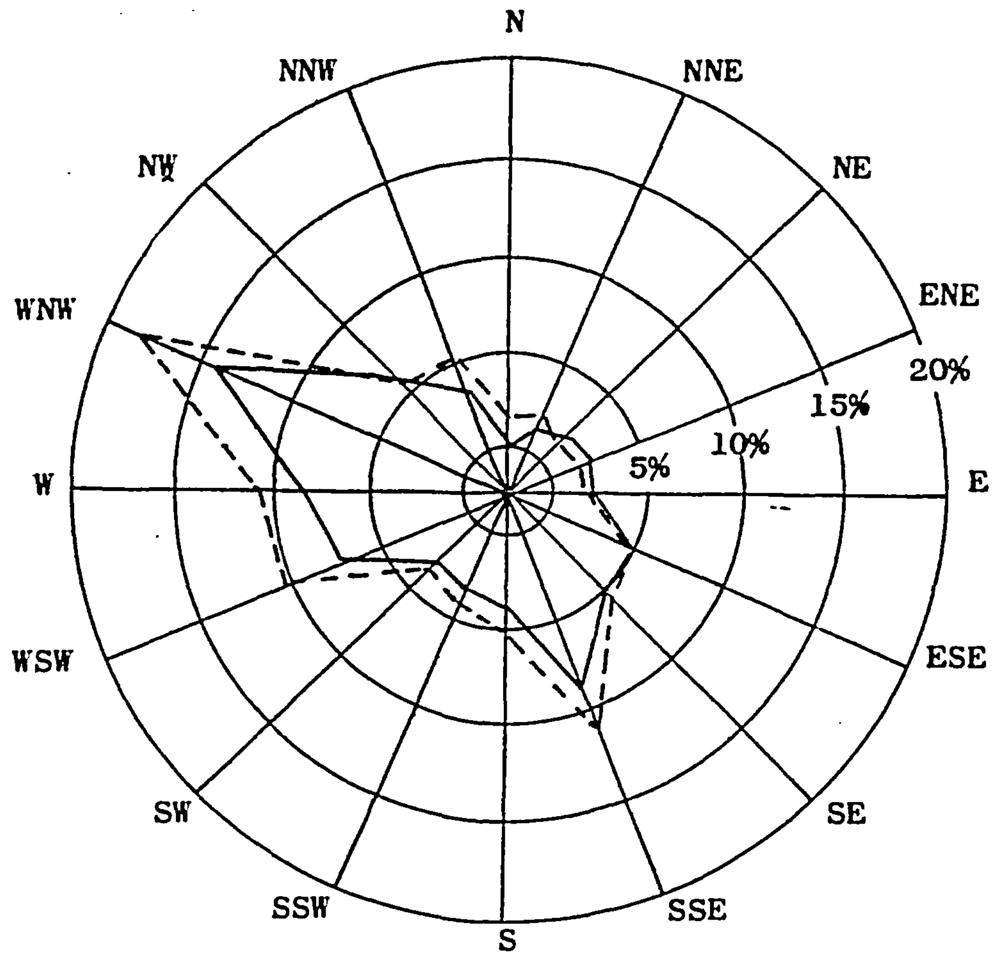
Hourly wind observations for an eight-year period were studied in detail. Table 2.3 presents the annual frequency of wind speeds for various times and weather conditions; Figure 2.4 and Table 2.4 show the annual frequency due to time of day, weather condition and season of the year. The winds are predominantly from north-northwest to west-southwest and occur 30 to 40% of the the time. About 20% of the winds are from the sector from east-southeast to south.

Wind speeds during the daylight hours vary from a maximum average of 12.4 mph (spring) to 8.2 mph (summer). Night time speeds are somewhat lower, with a highest average speed of 10.1 mph (winter) and a lowest speed of 4.2 mph (summer). The maximum number of calms occur during the summer (night) when, 39% of the time, the wind is less than 1 mph. Maximum wind speeds are generally from the west with a maximum speed of 50 mph and a peak instantaneous gust of 60 mph recorded. Unrecorded

TABLE 2.3

Annual Frequency of Wind Speeds (%) at Airport Philipsburg, Pennsylvania

Wind Speed (mph)	Calm	1 to 3	4 to 12	13 to 24	25 to 31	32 to 46	> 47
Daylight	6.8	3.4	59.8	27.3	2.2	0.4	<0.1
Night	23.0	7.9	51.2	16.3	1.3	0.3	<0.1
During Precipitation	5.1	3.4	52.4	34.4	3.8	0.9	<0.1
Visibility ≤ 6 miles	16.9	6.9	55.1	19.1	1.7	0.4	<0.1



Day	3 mph and calm	10.1%
	Average speed	10.4 mph
Night	3 mph and calm	30%
	Average speed	7.3 mph

Fig. 2.4 Annual Wind Direction at Airport, Philipsburg, Pennsylvania

TABLE 2.4

Annual Frequency of Wind Directions at Airport, Philipsburg, Pennsylvania

Direction (Wind Speed > 4 mph)	Daylight (07-1700 EST)	Night (18-0600 EST)	During Precipitation	During Low Visibility
N	1.7	0.9	0.8	0.8
NNE	2.1	1.4	1.4	1.3
NE	1.2	2.1	1.1	1.5
ENE	1.6	2.3	2.0	2.4
E	1.7	2.0	2.3	2.5
ESE	4.9	4.9	7.1	7.1
SE	5.5	5.1	6.8	7.3
SSE	11.1	8.6	11.7	12.2
S	5.1	3.8	4.2	5.0
SSW	4.1	3.1	5.5	4.3
SW	3.5	3.8	2.4	3.2
WSW	10.1	7.0	9.2	8.0
W	10.6	8.3	10.2	8.6
WNW	18.8	14.3	21.9	13.1
NW	5.7	6.1	5.2	3.4
NNW	5.4	3.4	3.2	2.4
3 mph and calm	10.1	30.9	8.5	23.8
Avg. speed (mph)	10.4	7.3	11.8	8.3

gusts may attain 80 to 90 mph. It is noted that the most frequent winds are between 4 and 12 mph (50%) with the second frequency preference in the 13 to 24 mph category. Five tornadoes have been reported in the surrounding five counties in a 35-year period. The winds aloft have the same general pattern as the surface winds, except that they increase in velocity with altitude.

2.4.3 Precipitation

The average annual precipitation at the site is estimated to be between 40 and 50 inches per year. Maximum precipitation occurs in May through July, and the minimum precipitation occurs in November and December. The range of average precipitation is from 2.5 to 4.5 inches per month. Table 2.5 shows the average number of days of precipitation. Because of the frequency of storms, precipitation is quite variable. Storms occur throughout the year, with heavy rainfall from thunderstorms during the spring and summer months. Maximum precipitation varies from 1.38 inches, registered over a one-hour period, to 4.68 inches, recorded in a 48 hour period.

Snowfall is estimated to be an average total of 40 inches per year. Heavy snowfalls are not uncommon (10 inches in a single storm). The maximum snowfall recorded was 20.0 inches over a 24 hour period.

2.4.4 Atmospheric Stability

The vertical temperature distribution at or

TABLE 2.5

Average Number of Days of Precipitation
at Airport
Philipsburg, Pennsylvania

Inches	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Annual
≥0.10	8	10	9	9	10	8	7	6	6	6	8	6	89
≥0.50	1	2	3	3	3	2	2	2	2	3	2	2	27
≥1.00	*	*	1	1	1	1	1	1	1	1	1	1	9

Range of Precipitation Occurrences

≥0.10	From 72/year to 113/year
≥0.50	24/year to 38 year
≥1.00	3/year to 15/year

near the site has not been measured. Extrapolation has been made from other locations having similar weather conditions. Observations indicate that inversion conditions exist about one-third of the time, chiefly at night. Variations are expected in the duration of inversions due to the site topography where inversions in the air drainage of the radial gorges will be more prolonged than those on the plateau above. However, good dispersion is expected during the daylight hours, and inversions would be of short duration.

2.4.5 Temperature

The average monthly temperature ranges from 65°F in July to 22°F in January, with an annual average temperature of 44°F. Below-freezing temperatures occur many days per year.

2.4.6 Summary

Qualitative estimates of the meteorological pattern can be made from the Philipsburg Airport data and from regional characteristics which are relatively uniform. Diffusion characteristics can be deduced from the local topography and subsequent air drainage into the surrounding gorges.

2.5 Geology

2.5.1 Stratigraphy

Table 2.6 shows the stratigraphic section in the site area. Outcrops in the area are meager and incomplete logs of drill holes must serve as the basis for evaluation.

TABLE 2.6

Generalized Section of Geology at
Quehanna, Karthaus, Pennsylvania

Age	Formation	Thickness(ft)	Description	Water-Bearing Properties
Pennsylvanian	Pottsville	200 ±	Consists of massive coarse-grained gray-to-white sandstones with pebbles as large as hazelnuts. Caps hilltops. Probably represents the Olean member of formation.	Sandstones productive where found below drainage level, generally yield small to moderate supplies elsewhere.
Mississippian	Mauch Chunk shale	50 ±	Red and green argillaceous shale with some sandstone. Not generally exposed, indicated by terrace developed between Pottsville conglomeratic cliffs above and steep Knapp slopes below.	Not a water-bearing horizon, probably forms impervious strata retarding downward percolation of water.
Mississippian or Devonian	Knapp (Pocono)	600 ±	Succession of alternating olive-gray, gritty, micaceous sandstones gray-green argillaceous shales. Some red beds occur near bottom of formation.	Productive consolidated rock where encountered below drainage level.

However, due to the lack of tectonic disturbances in the area, lateral correlation from existing data is possible. The lower portion of the Pottsville formation caps the area. It consists of sandstones, with the lowest sandstone member as the predominant aquifer. This is underlain by the Mauch Chunk shale which is an impervious layer about 50 feet thick. Beneath it is the Pocono formation of interbedded sandstones and shales which form the steep slopes of the gorges.

2.5.2 Structure

In the site area the beds are generally horizontal and demonstrate the lack of structural disturbance in the area. In the northern portion of the site area, there is field evidence of gentle folding. Faults, joints and fractures are probably not abundant at the site, and the area is considered to be stable.

2.6 Hydrology

2.6.1 Subsurface Hydrology

As stated previously, the predominant aquifer in the area is contained at the base of the Pottsville, though it is not very productive. Since the Pottsville forms the surface exposure, it collects water and transmits it downward to a saturated sandstone member 40 feet thick near the interformational contact with the impervious Mauch Chunk shale. Secondary recharge is provided by streams cutting the Pottsville, and discharge occurs at springs at the interformational contact. The top of Mauch Chunk is less than 1900 feet elevation and is presumed to be less than 100 feet, vertically, from the laboratory.

Water for the facility is obtained from a dam on Meeker Run. The dam is located upstream from the facility approximately 1100 feet down the mountain and is capable of releasing 120 gpm.

Downward transmission of contaminants released to the Pottsville formation is prevented by the underlying impervious Mauch Chunk shale. Lateral transmission within the Pottsville aquifer would be of a somewhat limited nature and would not pose a significant subsurface contamination problem in the light of the large exclusion area surrounding the laboratory. In fact, the movement of soluble contaminants within the Pottsville would be measured in the terms of feet per year. (Reference 2.4).

2.6.2 Surface Hydrology

Surface drainage from the site exclusion area is from four major radial stream systems; Mix Run (north), Wykoff Run (northeast), Upper Three Run (southeast), and Mosquito Creek (south). The former two streams drain into Sinnemahoning Creek, which flows into the west branch of the Susquehanna River; the later two drain directly into the river.

Of prime interest is Mosquito Creek, which drains the laboratory area as shown in Figure 2.5. Surface water in this area flows successively into Reactor Run, Meeker Run, Mosquito Creek and ultimately into the west branch of the Susquehanna. The river has a rather large average flow rate at Karthaus (maximum, 50,900 cfs; average, 2463 cfs; minimum 109 cfs). This branch of the Susquehanna is not used for public water supply because of its acidity (pH=3, Reference 2.4).

There are two reservoirs within the exclusion area, both of which are removed from the laboratory by several miles, and away from the runoff of Meeker Run.

2.7 Seismology

A total of six recorded earthquakes have had their epicenters in Pennsylvania, with some of the anadian and New York state earthquakes being felt there. Of the six epicenters cited, none was in the site region, and all were in Eastern Pennsylvania, involving low-intensity shock (maximum 6 to 7 Rossi-Forel Scale). It is consluded that, due to their low frequency and intensity, the foundation material, of the facility and its massive structure, earthquakes do not present a significant problem (Reference 2.5).

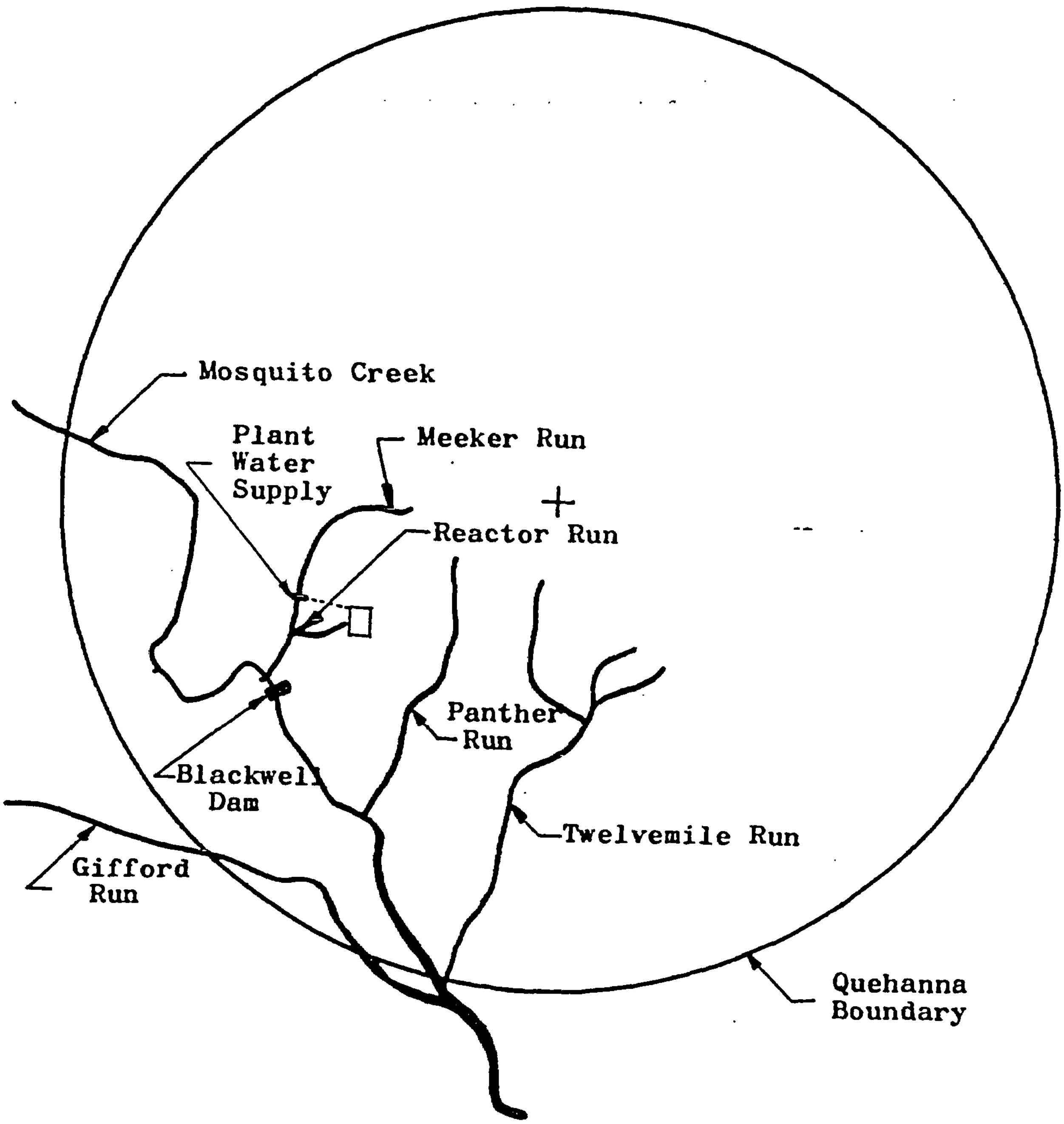


Fig. 2.5 Site Drainage--Radioisotopes Production Facility, Quehanna, Pennsylvania

2.8 <u>References</u>

2.1 "Hazards Evaluation Report, Curtiss-Wright Research Reactor, 4 Megawatt, "CWR-4062, April 1959.

2.2 Donkin, M., Vice President and Treasurer, The Pennsylvania State University, Letter to the Division of Lecensing and Regulation, AEC, October 28, 1960.

2.3 Pack, D. H., "Meteorological Appreisal of the Quehanna, Pennsylvania, Site of Curtiss-Wright," May 1956.

2.4 DeBuchananne, G. D., "Reconnaissance of the Geology and Hydrology of the Quehanna Site," U. S. Geological Survey, April, 1956.

2.5 Heck, H. N., "Earthquake History of the United States, Part I," USCGS 609, 1947.

CHAPTER 3

PROCESS DESCRIPTION FOR STRONTIUM-90

3.1 General Description

3.1.1 Summary

The Quehanna Radioisotopes Pilot Plant processes strontium-90 to encapsulated sources suitable for a variety of uses. In this chapter the Quehanna process and planned variations used in production of strontium-90 fuel forms are described. In all variations of the process, a precipitate is formed from a $Sr(NO_3)_2$ solution by addition of inorganic nonflammable reagents. The precipitate is filtered and dried; the resulting powder is loaded and densified; the fuel container is sealed and decontaminated; measurements are made as desired and the final fuel container is loaded into a generator, cask or storage facility.

3.1.2 Possession and Process Limits

The Quehanna Radioisotope Pilot Plant is authorized to have in its possession a maximum of 6,000,000 curies of strontium-90. Radioactive contaminents in association with the 6,000,000 curies of strontium-90 will not exceed:

Strontium-89	1,800,000 curies
Cerium-144	30,000 curies
Other gross fission products	30,000 curies

The ratio of contaminents to Sr-90 will not be changed by processing.

Further limitations are established for maximum quantities of strontium-90 within the facility. These are:

1. Feed solution in HAPO shipping cask - 500,000 curies
2. Feed material stored in T-31 - 750,000 curies
3. Material in process, i.e., withdrawn from T-31, but not processed to final fuel form. (A final fuel form is a sintered pellet or fully processed fuel, densely packed into a fuel container by pressure or heat. A final fuel form does not consist of loosely packed fuel in a container.) - 50,000 curies
4. Material stored in final fuel form in chamber 4A, but not necessarily with the final seal made on the fuel container. - 150,000 curies
5. Total in chamber 4A - 150,000 curies
6. Sealed in metal containers and stored in chamber 4B - 100,000 curies
7. Total in process box - 250,000 curies
8. Sealed material in Cell 5 storage - 1,000,000 curies
9. Doubly-sealed material in pool storage - 5,000,000 curies

10. Waste; packaged in not more than 500 containers and awaiting removal - 22,000 curies

3.2 Feed Material Handling

3.2.1 Receipt of Shipping Cask

The AEC furnishes radioactive feed material to the Radioisotope Pilot Plant at Quehanna, Pennsylvania. Strontium-90, in the form of $SrCO_3$, is shipped in casks designed and fabricated by Hanford Atomic Products Operation of General Electric Company. This feed material, prepared from gross fission products, may contain, in addition to the strontium-90, activity due to strontium-89, cerium-144, and other fission products. There may also be non-radioactive strontium, barium and calcium compounds.

Each cask, loaded at the Hanford Works, is shipped from Richland, Washington, by rail and by motor truck to Quehanna. Upon arrival at the building containing the hot cells, the cask is removed from the truck by a crane and placed on a pallet truck; it is then moved into an airlock which provides access to the hot cell service area.

The cask and its content are under the continuing surveillance of the Health Physics group from its arrival until it leaves the site after being emptied. This surveillance includes appropriate surveys at each step in the process and any indicated corrective action required for the protection of personnel and the area from radiation and contamination. (See Chapter 10 for details).

3.2.2 Preparation of Cask for Removal of Feed Material

The cask is moved from the airlock, through the service area and into the isolation room of Cell 4. The exterior of the cask is usually covered with heavy-duty aluminum foil at this point, both to guard against possible contamination of the cask during subsequent operations, and to lower the heat transfer rate of the cask cooling fins. The decreased heat loss is desirable for the leak check of the cask cooling coil performed prior to cask unloading. The protective blanks are removed from the cask cooling coil and the heater well and the outer well cover is removed from the depression on top of the cask which contains the triply-sealed process line blanks; the cover of the triply-sealed cask vent valve connection is also removed. The following connections, which may vary with the particular cask as indicated, are made:

(1) A line is connected to the cask cooling coil inlet to permit introduction of either high velocity (up to 60 cfm) air, or water from ambient temperature to 180°F.

(2) A line is connected to the cask cooling coil outlet. This line is provided with valves which permit the air from the coils to be exhausted through the filtered cell

air exhaust system and water from the coils to be returned to the closed cycle water system.

(3) A thermocouple is inserted through a well on the cask to indicate the cask inner temperature.

(4) A special rod-type electric heater is inserted in the heater well on the top of the cask. The heater is connected to an electrical circuit through controlling and monitoring devices such as a variable output transformer or volt-ampere meters.

(5) In cases where the cask is fitted with a gas pressure transmitter over the internal annulus containing the heat transfer medium, air lines are connected to a booster valve and indicator or other appropriate readout instrument. In cases where a direct reading pressure gauge is provided, the gauge is read by the use of a closed circuit television system.

The next step is a leak test of the cask cooling coils. The test is performed in accordance with standard instructions from Hanford and consists of the following steps:

(1) The cask temperature is increased until

the heat transfer medium is molten. The electrical heater is normally used for this step.

(2) High pressure air (about 70 psig) is introduced to the cask cooling coil with the discharge line closed.

(3) The pressure on the cask gauge or transmitter is observed for thirty minutes. Since the gauge lead on the cask penetrates to the argon filled volume in the same cavity with the molten alloy, any increase in pressure on the gauge would indicate a leak in the cooling coil.

(4a) Should no leak in the coil be indicated, the cask is cooled according to a standard procedure to minimize internal stress on the cask and coils as the alloy solidifies and the cask is readied for unloading. The cask may be cooled by simply removing the electrical heater and passing high velocity cool air through the coil or, after partial cooling has been achieved, controlled temperature water may be used to increase the heat loss.

(4b) Should it be determined that a leak exists in the coil, the electrical heater would be turned off and steps would be taken to cool the cask short of introducing water to the coil. The AEC would be notified and no further action would be taken to unload the cask pending instructions from the AEC.

The leak check may be performed either directly or remotely. It is usually performed remotely because complete instrumentation is provided on the cell face for the operation.

Upon completion of the leak test, a ventilated cupola is sealed to the top of the cask. This cupola is similar to a standard glovebox in concept in that it has glove ports, an absolute type filter on both the inlet and exhaust air lines and a transfer port as well as provisions for sealing the process line penetrations. The four process lines are inserted into the cupola and the insertion port is sealed, after which the following operations are performed:

(1) The two secondary covers are removed from the cask vent valve, the vent line is attached, and the vent valve is opened to relieve any pressure in the container.

(2) The second of the three protective covers are removed from each of the three cask process line blanked connections which are located in a well.

(3) Each of the cask process line blank fittings are removed and the connection to its respective line is made in such a manner that only one line is open to the cupola at one time. The connections are not necessarily made in the order given below.

(a) The solvent feed line is attached to the cask connection marked FILTRATE OUT. This method of adding the solvent permits a back-washing action of the filter and a subsequent fast release of the filter cake to the bottom of the cask container.

(b) One branch of the line leading to the feed storage tank is connected to the cask fitting marked SLURRY IN. The SLURRY IN line penetrates only to the top of the product container, so when fitted with a separate valve, this connection permits release of the gas buildup encountered during dissolution of cask content without forcing the dissolving liquid out of the bottom of the cask.

(c) The second branch of the line mentioned in (b) above, is also fitted with individual valving and is connected to the cask fitting marked SOLVENT IN. This line penetrates to the bottom of the cask container and is used to transfer the dissolved product to the feed storage tank.

3.2.3 Removal of Feed Material From Shipping Cask

The feed material is received as a solid strontium carbonate cake loaded on a filter screen in the product container portion of the shipping cask. Nitric acid of various concentrations is used to loosen the cake from the screen and to dissolve it for transfer to the feed storage tank as soluble strontium nitrate.

Each dissolution is calculated from the analysis furnished by HAPO. This analysis gives the curies of strontium-90, the ratio of total strontium to strontium-90, and the amount of inert impurities as a ratio to total strontium as well as the radioactive impurities as a ratio to the curies of strontium-90. The quantity of nitric acid required to completely dissolve the contents of the cask and leave the resulting feed solution from 0.4 to 0.6 molar in free acid is then added. The total liquid volume is calculated to make the radioactive concentration of the feed solution from 2.0 to 3.0 curies per milliliter with respect to strontium-90. The actual dissolution of the cake and transfer of the resulting solution is carried out as follows:

(1) The fittings between the cask and the storage tank are leak checked by pulling a vacuum on the system, closing the vacuum valve, and observing the leak-down rate. No acid is added to the system until a satisfactory vacuum can be maintained.

(2) The valve in the line connected to the cask SLURRY IN fitting is opened to permit release of carbon dioxide, a slight vacuum is placed on both the cask and the feed storage tank through the storage tank (T-31), and a few (5 to 10) liters of dilute (0.5 to 1.0 molar) nitric acid are added through the solvent feed line. This first addition is made at a carefully controlled rate which does not exceed 100 ml per minute in order to prevent an overly vigorous reaction and to permit the vacuum to be maintained in the system. Added precautions, such as a check valve in the solvent feed line to prevent release of carbon dioxide through that system are included. As noted previously the feed storage tank

(T-31) is maintained at a negative pressure during dissolution. The vacuum system has an 8.4-cfm pump and a surge volume in excess of 200 liters. The acid is added at a rate that does not exceed 0.3 moler per minute. If the carbon dioxide is released at the same rate the evolution does not exceed 6.72 liters/minute, STP. The volume produced is negligible in comparison to the capacity of the vacuum system. No difficulty has been encountered in maintaining a negative pressure in the cask.

(3) The material added in step (2) is allowed to digest until no further reaction is apparent, after which small volumes of more concentrated (up to 4 molar) nitric acid are added and allowed to digest. The technique described in steps (2) and (3) prevents an overly vigorous reaction rate with attendant loss of control while permitting one to obtain a relative high nitrate ion concentration in the final solution.

(4) When the cask is filled with liquid and

digestion is complete, the valve on the SLURRY IN line is closed, the valve on the SOLVENT IN line is opened, and the solution is transferred to the feed storage tank by vacuum.

(5) Steps (2), (3) and (4) are repeated with variations in acid concentration until all the acid has been added and a final water wash of the cask has been performed.

(6) The contents of the feed storage tank are air sparged and a sample is taken and radioassayed. This assay is compared to the Hanford analysis to determine the amount of activity remaining in the cask.

The cask is dried by the use of heat and vacuum, the lines disconnected, the seals replaced, the cask decontaminated, placed in its outer shipping container or bumper, and returned to the railhead for shipment to Hanford.

3.3 Processing to Fuel Form

3.3.1 Metering and Precipitation of Feed Solution

The solution in the feed storage tank (T-31) is mixed by air sparging prior to transferring each batch of solution; this is accomplished by opening the air sparge valve connected to the vent header and drawing a slight vacuum on the tank to bubble air through the solution for 15 to 30 minutes. After sparging, a sample is taken to check the free acid content of the solution and to insure that no evaporation with accompanying concentration of the solution has occurred. The remainder of the required analyses, such as total cation concentration and strontium-89/strontium-90 ratio are run at the start of processing each new cask as a check on the Hanford furnished analysis. Experience to date has shown the Hanford analysis to be accurate in every case within the limits of experimental error.

The process feed batch is transferred from the feed storage tank (T-31) to the precipitation tank (T-33) via a fine metering tank (T-32). In addition to the Foxboro liquid level indicator, accurate to plus or minus 0.5 percent, this small tank is equipped with three calibrated stand pipes which deliver 1, 2 or 3 liters. All excess solution is returned to the feed storage tank and, if for any reason it is not desired to dump the batch to the precipitator, all feed may be returned to the storage tank.

The acidic strontium nitrate solution is adjusted to the desired pH with a sodium hydroxide solution.

The temperature of the precipitator may be varied from about 55°F to nearly 180°F by circulating water at a controlled temperature through the external coils of T-33. All liquid reagents are added to the precipitator from a metering tank in the operations area by means of a diaphragm pump through appropriate block valves, check valves and a siphon break. Solid, reagents, such as TiO_2, are weighed in the laboratory into small plastic bottles, passed into the process box and dumped into the top of the precipitator through a funnel which may be sealed when a vacuum on the precipitator vessel is required. See Section 3.6 for reagents and quantities used.

The precipitating reagents are added to the neutralized or slightly basic strontium nitrate solution in amounts stoichiometric to the total cation concentration. The mixture is stirred, either by an air driven mechanical stirrer or by pressure air sparging at approximately three liters per minute and 5 psig pressure. The air supply for sparging is located in the isolation room of Cell 4. It is controlled by check valves and double pressure reducers. The sparging is turned on and off from outside the isolation room. A bleed line is installed adjacent to the bottle; in the event the line becomes clogged the pressure can be released to the cell. The optimum flow rate for sparging varies slightly with batch size.

Upon completion of the digestion period, the precipitator may be brought to ambient temperature and cold water added to speed settling of the precipitate. After allowing time for settling, the precipitate is drawn over to an alundum filter-crucible in filter housing T-34 and the filtrate collected in the filtrate storage tank (T-25) by applying vacuum to T-35 and opening the valve connecting T-33 through T-34 to T-35. T-33 and the precipitate are washed with water, as required, by adding water to T-33 and drawing it by vacuum into T-35.

The filtrate and washings, stored-in T-35, are assayed. Should an activity of more than 3 curies/liter be present as would occur if insufficient sodium hydroxide or precipitating reagent were added to the batch or if the T-34 filter had been defective or the seals had been imperfect, the washed precipitate would be removed from T-34 in its crucible, the crucible would be replaced with an empty one, and the filtrate and wash from T-35 would be recycled through T-33 and T-34 to T-35 after any required reagents had been added. The T-35 solution would be resampled and, if the strontium content were low enough, the solution would be vacuum-transferred to the waste storage tank, T-20. The T-35 solution is normally transferred to T-20 immediately after assay.

3.3.2 **Calcination, Blending and Compaction**

The alundum crucible containing the precipitate is removed from the stainless steel filter holder (T-34) by swinging back the top and lifting out the crucible with manipulators using a special handling tool. The contents of the crucible are examined visually and the crucible and contents are placed in the furnace for the drying and/or calcination step.

3.3.2.1 Process Furnace

The furnace used for the drying step is a versatile unit capable of sustained operation at temperatures as high as 1500°C; it is also used for subsequent sintering steps. The furnace proper is heated by three sets of four "glo-bar" resistance elements, with each set being individually adjustable for output from the control panel in the operations area. The entire furnace is powered and automatically controlled through a saturable reactor which receives its signal from one of six replaceable thermocouples in the furnace; the furnace cycle can be varied within a wide range by use of precision cut cams. The in-cell portion of the assembly is easily removable from its water-cooled well in the process box for replacement of heating elements and thermocouples.

3.3.2.2 Drying and Calcination

The purpose of this operation is to dry the filtrate and remove CO_2 without raising the temperature high enough to sinter the product. The furnace is closed, but not sealed air tight. The temperature is taken to 250 to 300°C and held for sufficient time to insure removal of free water vapor. After this drying is complete, the temperature in the furnace is increased to 600 - 970°C depending on the batch size and the product desired. Maximum temperature is maintained for a predetermined period. In one case, the reaction rate of the strontium carbonate - TiO_2 mixture is temperature dependent above its initiation temperature and since considerable self-heating occurs from the strontium-90 content a relatively low temperature is maintained for several hours to permit conversion to strontium titanate without sintering the central portion of the cake. In the other case the removal of occluded water is a relatively slow process.

3.3.2.3 Blending

It is necessary to break up lumps and reduce the particle size of the dried and calcined cake prior to final fuel forming to obtain consistently high density material. At the present time, a Waring-type blender is used for this operation, but other equipment such as a "y" tube blender and a small, enclosed hammer mill will probably be tested and used.

3.3.2.4 Powder Densifying

Strontium titanate powder has traditionally been pressed into "green" pellets by standard powder metallurgical techniques, using a die of the desired dimensions, loading the die with the desired mass of powder and pressing with a hydraulic press. The pellet is then sintered at high temperature to cause it to shrink with an accompanying increase in density. The Quehanna Pilot Plant has retained this capability, which requires a pressure of only about 5 tons per square inch on the pellet area, and at the same time has built-in versatility to permit more efficient compaction. When sintered pellets are loaded into capsules there are always void spaces which decrease the power density. Work done by Martin Nuclear Division indicates that good density material without voids may be obtained by "step pressing," particularly when strontium compounds other than the titanate are made. In this process, a fuel container is placed in a large die and a small volume of powder is added and pressed at 40 to 50 tsi. The process is repeated until the container is full or until the desired thermal output is obtained. A 250-ton press with a 12-inch ram is employed in the process box. The hydraulic unit is located in the operations area and connected to the ram by high pressure tubing through the cell wall. When step pressing is employed, sintering is omitted.

3.3.2.5 Sintering

Green titanate pellets are transferred onto zirconia covered setter plates, the plates are loaded into the furnace in as many as three trays at different elevations and a programmed sintering cycle is initiated. The maximum sintering temperature is about 1450°C and a complete cycle requires approximately 20 hours. Inert gas services are provided in the furnace. Upon removal from the furnace, the fuel pellet is checked for physical characteristics and thermal output.

3.3.3 Interim Fuel Storage

Shielded storage units are ~~provided in~~ both chambers of the process box to permit storage of either exposed or sealed fuel and containers as desired during processing. If the pellet form of material is required, batches of pellets would be stored in special open liners until the correct number and type of pellets were available to make a final capsule loading. If step-press loading is employed, a container or containers will also be stored temporarily until loading is completed. Open storage will be used only in the shielded storage chamber accessible to the A side of the process box. Shielded storage is also provided on the B side of the process box for temporary storage of sealed containers. The shielded storage chambers are so designed that air will circulate through the interior and the fuel will thus be cooled by convection currents.

3.3.4 Fuel Container Welding

Both final fuel containers and containers to be used for long-term storage are welded shut. The welding is performed by use of an Heliarc power supply placed near the face of the cell and a welded tip and jig within the cell. Materials to be welded will be chosen from among 300 series stainless steel, Hastelloy C, Haynes 25 and tantalum. Techniques and apparatus for each welding requirement are tested and approved by Quality Control prior to utilization. Such materials as Hastelloy C and 300 series of steel have been remotely welded successfully with penetrations from 0.015 inch ~~for light~~ stainless steel liners to 0.090 inch on Hastelloy C with this apparatus.

Prior to removing any welded fuel container from the process box, a mass spectrometer leak check is performed. The existing system can detect leaks as small as 10^{-8} standard cc's of helium/second; the acceptable maximum leak rate for a welded fuel container is 5×10^{-6} standard cc's of helium/second.

3.3.5 Fuel Container Decontamination

Decontamination of each sealed fuel container is performed in several steps. The first step is in the A side of the process box accomplished by the use of an immersion bath.

Each immersion tank is fitted with ultrasonic transducers to assist in the cleaning. After the preliminary decontamination, the container is moved to the B side of the process box and immersed in additional ultrasonic cleaning tanks. The immersion may be interspaced with scrubbing and/or the use of special reagents as required. Swipe samples are taken, removed from the box and counted to determine when the fuel container is sufficiently cleaned for removal from the B section of the process box. The decontaminated container is transferred to Cell 5 for calorimetry and storage in the shielded capsule storage container. From there, if long-term storage will be required, it is sealed in a secondary stainless steel container, welded, leak checked and transferred to the gamma pool after the required waiting period.

3.4 On-Site Storage

3.4.1 Cell 5 Storage

Storage in this cell is described in Paragraph 9.1.3.3.

3.4.2 Transfer from Cell 5 to Pool Storage

The cask (see Paragraph 9.1.2.3) containing the doubly sealed and leak-tested capsules is removed from Cell 5 in either of two ways.

The service area crane is used to lift the cask out the top of Cell 5 through the opening left by removing the concrete roof plugs. The crane then moves on an unobstructed direct path to the pool. The cask is moved over the pool edge above the specified section of pool in which no capsules are stored. This prevents the possibility of the cask being accidently dropped on a capsule. The cask is lowered into the pool. A special tool is used to remove the capsules from the cask. The cask is removed from the pool, drained and decontaminated, if necessary, for further use.

The other method of transfer is performed by using a dolly to remove the cask from Cell 5. The dolly is moved across the smooth, unobstructed floor to the edge of the pool. The service area crane is then used to place the cask in the pool as in the other method.

3.5 Final Loading Operations

Prior to loading into a generator or shipping cask the decontaminated fuel capsules are accumulated in the Cell 5 shielded storage container. Calorimetry is repeated if desired, all capsules returned to the Cell 5 shielded storage container and the generator or cask is moved into Cell 5. The loading operation entails either the placement of one or more fuel capsules in the shielded generator block, addition of shielding to the generator, and a final checkout of the generator internal atmosphere and electrical output prior to shipment to the Baltimore site for further testing, or, loading one or more fuel capsules into a shipping cask, attaching the cover and final checking of the cask before release for shipment to its destination.

3.6 Reagents

This section is classified and will be transmitted as a separate submittal.

CHAPTER 4

ADMINISTRATIVE CONTROL

The function of the administration of the Radioisotopes Production Pilot Plant is the economical processing and encapsulation of radiostrontium for power production. Recognizing that the handling of multicurie quantities of strontium-90 presents safety problems unique in private industrial operations, the Martin Company has set up administrative controls designed to enable the plant operations to be carried on with the least possible hazard. (Refer to Figure 4.1)

4.1 Operations and Responsibilities

In order to achieve the necessary degree of administrative control, reliance is placed not only on defined procedures but also on properly trained and indoctrinated personnel. This concept of administrative control starts with the hot cell operator and his responsibilities, and works up in the line and staff organization through a series of overlapping responsibilities which provide necessary checks on the operations. This system may perhaps be explained most readily by a review of responsibilities.

4.1.1 Hot Cell Operator

The hot cell operator is responsible for carrying out the actual processing operations. The operations to be conducted during each shift are reviewed with the operator by

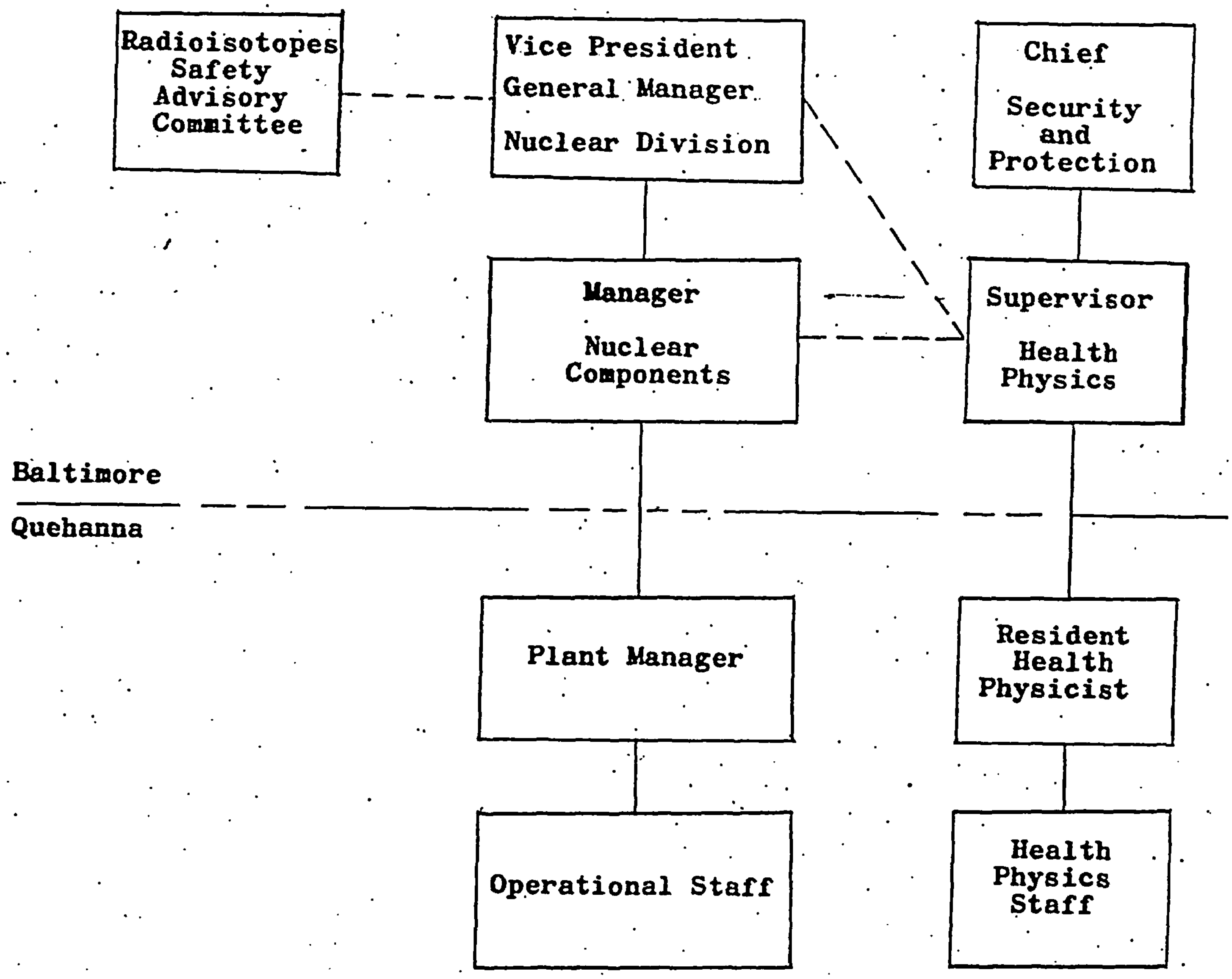


Figure 4.1 Organization Chart

the shift supervisor. Operations are carried out in accordance with previously defined and authorized procedures. The operator will have been trained not only in these specific procedures but also in the basic arts of health physics and radiochemistry with emphasis on proper actions in case of emergency. Apprentice operators will work along with experienced operators.

The operator will keep a running log of the tasks he performs, recording all pertinent data, e.g., volume of solutions transferred, temperatures of solutions, duration of operations, analytical results. Any evidence of unusual behavior in the process, process equipment or facility equipment will be recorded and brought immediately to the attention of the shift supervisor.

No deviations from the defined, normal operating procedures will be made by any operator unless authorized by his shift supervisor. Such deviations must be noted and emphasized in the log. The operations log is the basic record of all operations at the facility.

4.1.2 <u>Shift Supervisor</u>

The shift supervisor is responsible for conducting scheduled operations in accordance with the authorized procedures and instructions, and for directing and assisting his assigned operators in their work. He will receive written and oral instructions from the Supervisor of Process and Quality

Control defining the operations to be performed on his shift. Third shift supervisor will usually receive only written instructions, with oral instructions transmitted to the second shift supervisor. In order to cope with minor deviations in the process, the shift supervisor will be authorized to improvise manipulative changes to correct the aberrations. He is encouraged to delineate facts and make recommendations, but he will not make any changes involving additions of chemicals or alterations in process conditions without review and approval by higher authority.

The activities of the shift will be summarized in the operations log by the shift supervisor. He will note the transfer of radioactive material from one location to another and from one form to another, unusual occurrences in process or facility, and unusual maintenance requirements. He will examine and initial his instruction log book and bring the next shift supervisor up to date on the facility status and production situation.

4.1.3 Process and Quality Control Supervisor

The Supervisor, Process and Quality Control, is responsible for planning production operations, improving operational techniques and maintaining the quality of product. He will make daily assignments of operating orders and check housekeeping through daily personal surveillance and review of the shift operations log.

Through coordination with the Plant Manager, Process Chemist, Licensing Specialist, Process Equipment Engineer and resident Health Physicist, he will insure that all materials are available and requirements met for safe accomplishment of production schedules.

He will review suggestions for process or procedure changes and forward his recommendations to the Plant Manager. He may not authorize any substantive change in established operating procedures without higher approval.

The Supervisor of Process and Quality Control will submit a daily report to the Plant Manager summarizing the information in the operation log and will inlcude his personal observations and comments concerning the achievement of production schedules and the safety of the operations.

4.1.4 Manager, Radioisotope Pilot Plant Section (Plant Manager)

The Plant Manager is responsible for the safe and productive operation of the Quehanna facility. He will direct all operations, approve operating procedures and establish goals consistent with the license for the facility and any further restrictions he deems necessary. He will receive processing requests and funding from other areas of the Nuclear Division. He will coordinate and measure the activities within his section, and will request the support required from other sections through the Manager, Nuclear Components, so that training, preparation and stockpiling will be achieved on time and in proper degree to meet established goals.

He shall stop, or prevent the start-up, of any operation at the Quehanna facility when, in his judgment, such operation would be in violation of the license, or otherwise be in contradiction to safe practice. He shall take similar action, regardless of his personal judgment, if so ordered by the Manager, Nuclear Components, or the Commission.

He will review the daily reports of the Supervisor, Process and Quality Control, the weekly reports of the resident Health Physicist and make frequent personal inspection of the facility and logs. From these and other data, he will submit a written report to the Manager, Nuclear Components, on a weekly basis, summarizing the status of the facility and the week's activities.

He is responsible for anticipating the need for amending or up-dating sections of the license and initiating action. In this regard, he will frequently compare the goals and long range plans for the facility with the license and current practice. From this analysis, he will take action within his section and request support from other sections as required to prepare other reports and data as ordered by the Manager, Nuclear Components.

4.1.5 Manager, Nuclear Components Department (Department Manager)

The Manager, Nuclear Components, is responsible for maintaining a satisfactory Radioisotope Pilot Plant facility, a competent operating staff of adequate size and for assuring safe operation of the facility in accordance with the license. He will review and retain for file in Baltimore the weekly summary reports by the Plant Manager, make personal inspections of the facility and logs at 4 to 6 week intervals, and take whatever other action he deems necessary to assure himself that the facility and operations are maintained in accordance with the license. He has the authority to order the cessation of any operation he deems unsafe. He will advise the General Manager of the Nuclear Division of the status at Quehanna on a weekly basis. He will provide, or take necessary action to provide, the required support activities for Quehanna. He will cooperate with the Radioisotope Safety Advisory Committee, providing reports and data requested and assisting the Committee in its investigations.

4.2 Administrative Checks

In addition to the control provided in the organization and mode of operation of the Nuclear Components Department, two independent parallel administrative checks have been established. These are the Nuclear Division Radioisotope

Safety Advisory Committee and the administrative participation of the Health Physics organization.

4.2.1 Health Physics

The organization and responsibilities of Health Physics are presented in Chapter 10. In addition to its conventional duties the Health Physics organization participates in the administrative control of the Radioisotopes Production Pilot Plant. As an ultimate check, the resident Health Physicist may stop any operation at the facility which he feels is being carried out in a manner contrary to safety regulations and constituting a definite hazard to the facility personnel and to the public.

4.2.2 Radioisotopes Safety Advisory Committee

The Radioisotopes Safety Advisory Committee has been constituted for the purpose of increasing assurance of the safe use and possession of radioisotopes within the Nuclear Division. It reviews the criteria that are generated by line organizations to ensure the safe operation of any activities utilizing radioisotopes. It carries out periodic surveillance of such operations. The chairman of the Committee reports directly to the General Manager and Vice-President of the Nuclear Division.

4.3 Fire Prevention and Control

The unusual nature of the plant operations with the potential hazard of radioisotopic contamination and nuclear radiation, and the isolated location of the Quehanna facility have caused considerations of fire prevention and control to be of particular concern. This leads to the requirement of frequent inspections and special training in fire fighting.

4.3.1 Inspections

Monthly inspections are made by the Quehanna Radioisotope Pilot Plant personnel accompanied by the representative of the Pennsylvania State University. Findings of these inspections are distributed to officials at Pennsylvania State University and the Plant Manager for action.

4.3.2 Training Program

All male personnel at the Quehanna site are trained in fire fighting. The training program is described in Chapter II, Summary of Emergency Control Measures.

4.4 Qualifications of Personnel

4.4.1 Operating Personnel

The following categories of personnel are actively engaged in the handling and/or control of radioactive materials at the pilot plant. The minimum acceptable qualifications for each category are:

4.4.1.1 Hot Cell Operator

4.4.1.1.1 Operator C (trainee)

High school education and at least 4 years experience of a general mechanical nature.

2 years of college--2 years of college may be substituted for the general experience and non-diploma technical courses may be substituted for experience in some cases.

Each employee must be of such character as to permit obtaining an AEC Q clearance.

4.4.1.1.2 Operator B (intermediate)

All qualifications listed above plus (1) successful completion of a radiation protection training course of at least 16 hours duration, (2) demonstrated competence in each mainpulative operation involved in processing, and (3) at least 18 months experience in handling radioactive materials.

4.4.1.1.3 Operator A (journeyman)

All qualifications listed above plus (1) at least 36 months experience in handling radioactive materials, (2) an understanding of each phase of all operations and a demonstrated ability to explain the operation to others, and (3) understanding and awareness of the radiation hazard in any operation with radioactive materials and a demonstrated record of safety.

4.4.1.2 Shift Supervisor

(1) all qualifications of an A operator, (2) demonstrated initiative and organizational ability, (3) at least 5 years experience in the nuclear field, of which at least 2 years must have been spent as an A operator or equivalent.

4.4.1.3 Supervisor, Production and Quality Control

Education--BS, Chemistry or Chemical Engineering. Directly applicable experience in the field may be substituted on the basis of 2 years experience for 1 year of college.

Experience--at least 8 years of high level radioactive chemical experience required, of which at least 3 years must have been in a supervisory capacity.

4.4.1.4 Manager, Quehanna Pilot Plant

Education--BS, Chemistry, Chemical Engineering or Nuclear Engineering.

Experience--8 years experience handling high level high specific activity radioactive materials. Advanced schooling in radiochemistry, nuclear engineering or radiation protection may be substituted on a year-for-year basis for up to 3 years experience. A minimum of 2 years supervisory experience in the nuclear field is required.

4.4.2 <u>Health Physics Personnel</u>

4.4.2.1 Resident Health Physicist

The following minimum requirements are necessary for the position of Resident Health Physicist:

Education: B.S. in Physics, Chemistry or equivalent.

Experience: Two (2) years experience in Health Physics administration and control procedures with particular emphasis being placed on personnel possessing high level hot cell experience.

4.4.2.2 Health Physics Technician

The following minimum requirements are necessary for the position of Health Physics Technician.

Education: High School graduate or equivalent plus specialized training in radiological protection, electronics, or laboratory techniques.

Experience: Six months experience in Health Physics or related work to become familiar with radiological monitoring and laboratory methods and procedures. In addition will require an apprenticeship period at the facility working along with experienced Health Physics Technicians. The length of on-the-job training will be governed by an individual's ability, experience and educational background.

4.5 Summary

In recapitulation, the Martin Company has set up an administrative system that provides safety in the handling of multi-kilocurie amounts of radioisotopes. This system is based upon the following elements:

4.5.1 A physical plant providing for control of radioactive material in normal and conceivable emergency circumstances.

4.5.2 Experienced personnel well-trained and indoctrinated in requirements for safe handling of radioisotopes.

4.5.3 A system of supervisory progression within the line group providing for overlapping responsibilities and checks upon the standard operating procedures.

4.5.4 A system of records and reports which provide complete awareness of the status of the facility and its contained radioactive materials at any time.

4.5.5 An independent staff function through Health Physics which provides a continuous check upon the operations of the line group and the safety of the facility.

4.5.6 A second independent staff function through the Radioisotopes Safety Advisory Committee which advises the General Manager in matters related to safe operation of facilities.

4.5.7 A special concern for indoctrination and good training in fire prevention and control.

CHAPTER 5

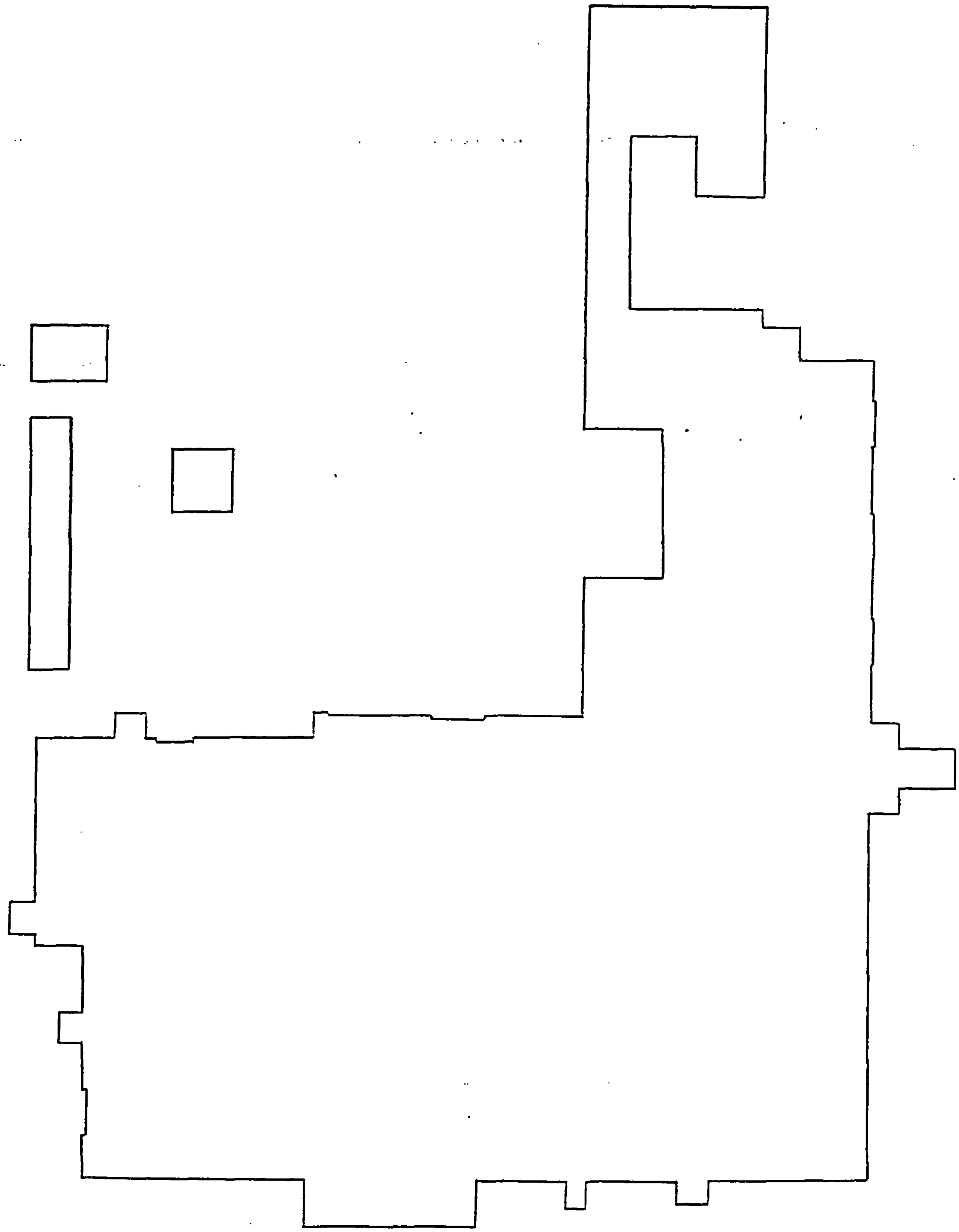
PLANT DESCRIPTION

5.1 Description and Arrangement

5.1.1 General

A view of the exterior of the facility building is shown in the frontispiece. The exterior, of simplified contemporary design, consists largely of insulated aluminum curtain walls applied to the steel frame. The two large bays housing the reactor and the hot cell service area are evident. The reactor area is isolated from the cell service area, except for a large truck door and a pedestrian door, both of which will normally be closed and locked. The general layout of the site (frontispiece) shows the relative position of the main plant, radioactive waste treatment plant, storage buildings, and underground holdup and storage tanks.

The 24,700 square foot reactor and hot lab building is basically a one-story structure. The main floor plan and the basement floor plan are shown in Figures 5.1 and 5.2. The Martin Radioisotopes Pilot Plant includes all areas encompassed by the heavy line on the vellum overlay. The plant has been designed to provide as positive separation as possible between radioactively contaminated and radioactively clean areas. Those areas which are maintained free of contamination include



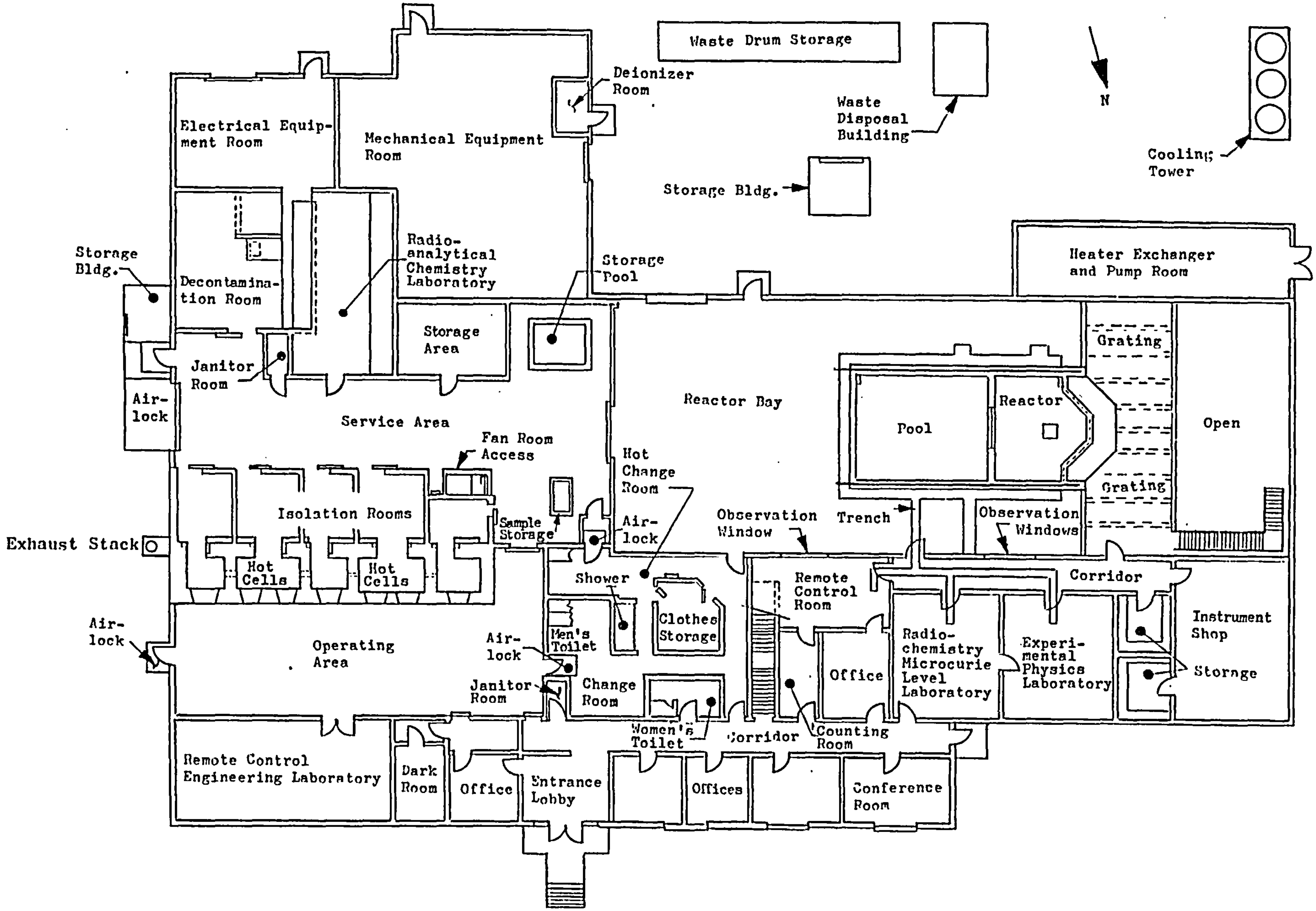


Figure 5.1 Main Floor Plan of Quehanna Nuclear Facility, Showing Radioisotope Pilot Plant in Heavy Outline

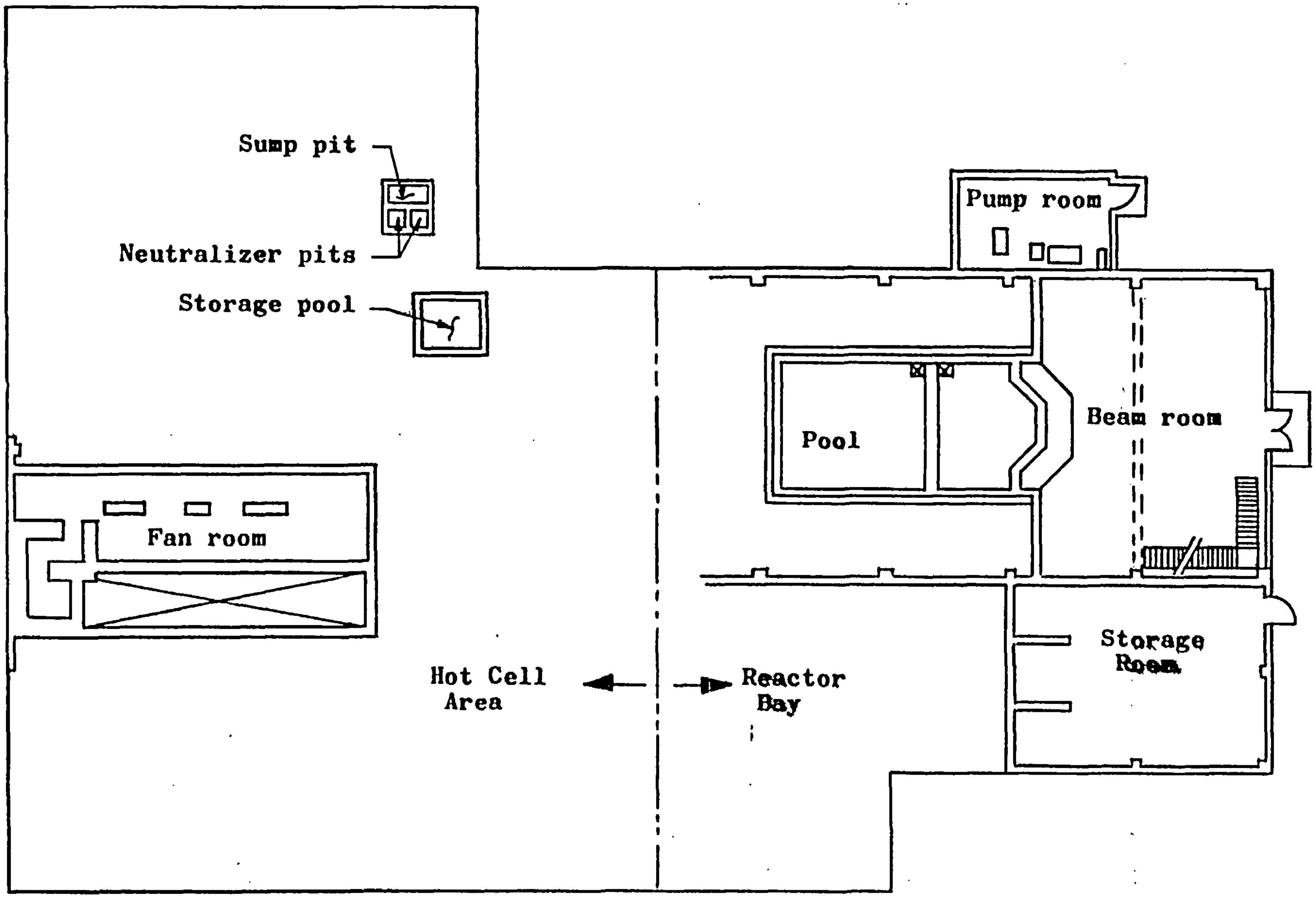


Figure 5.2. Basement Floor Plan of the Quehanna Nuclear Pilot Plant

offices, dark room, staff laboratory, and reactor area. As reference to Figure 5.1 reveals, the only normal access between clean and contaminated areas is via the change room. The large access door between the operating and service areas is normally closed and locked. Because of the relative isolation of the controlled areas, an intercommunication system connecting all parts of the building has been installed.

A more detailed description of that portion of the building with which this report is concerned, the hot cell area, is covered in the following pages. This area, enclosed by the heavy lines in Figure 5.1, includes hot cells, isolation rooms, operating area, service area, radioactive materials storage area, decontamination room, analytical radiochemistry laboratory, and change room and other associated cold areas such as offices and conference rooms. To provide for expansion of the plant in the future, the building was laid out with the entire east wall unobstructed. Additions can be made simply by building additional laboratory space or hot cells in line and extending the operating and service areas.

5.1.2 Philosophy of Multiple Containment

The concept of multiple containment is applied in handling multikilocurie amounts of beta-, and gamma-emitting isotopes of high specific activity. This technique consists of confining the radioisotopes within at least two containment enclosures. This approach has successfully been used at this facility since July 1962, to prevent the release of particulate activity to the external environment.

The Radioisotopes Pilot Plant is divided into two parts: the administrative area and the hot working area. The operating area is usually maintained in an uncontaminated condition. It is normally accessible only through the change room. The flow of air is progressively from uncontaminated areas to those of increasing likelihood of contamination.

The Martin philosophy of multiple containment is evident throughout the process. Four distinct containment barriers exist:

(a) Process equipment
(b) Steel and plastic process box
(c) Hot cell structure and ventilation system
(d) Building

The first containment barrier is the process equipment itself located within the stainless steel process box inside the hot cells. The process equipment, such as tanks, precipitator, etc., is vented directly through the process box exhaust system.

The second, and most positive, containment barrier is the process box. The box is designed to have the lowest air pressure in the system and is protected by both absolute type inlet and outlet air filters. In addition, it is designed to have as small an air flow as possible, consistent with a safe operating pressure drop from the cell environment.

The third containment barrier is the hot cell, which also has absolute type filters on both inlet and outlet air streams. The operating air pressure in the cells is higher than that in the process box but lower than that in the operating area. The transfer of material to or from the process box is accomplished by employing a Stationary Overhead Transfer System (SOTS) which prevents the box atmosphere from direct connection to any regions other than the immediate section of the SOTS.

5.2 Area Descriptions

5.2.1 Hot Cells

This facility is comprised of five cells with physical configurations as indicated in Table 5.1.

Table 5.1

HOT CELL DIMENSIONS

Cell No.	Floor Size (ft)	Ceiling Height (ft)	Wall Thickness (ft)
1	6x7	12	3
2	6x12	15	3
3	6x7	12	3
4	8x12	12	2
5	8x8	12	2

Each of these cells is provided with manipulator ports for the use of Model 8 manipulators. In addition, a Kollmorgen periscope may be used. Cells 2 and 4 have two pairs of manipulator port openings so the entire floor area of the process box may be reached. With slight revisions to the port holes, as many as 23 different manipulator locations are possible throughout the five cells. A side elevation of a typical cell is shown in Figure 5.3. A detailed plan view of the cell block appears in Figure 5.4.

The shielding walls of the cells, which reach to a height of 9½ feet above the floor, are constructed of ferrophosphorous concrete with a minimum density of 280 lb/ft^3. Above 9½ feet, the walls are of ordinary concrete, having a minimum density of approximately 150 lb/ft^3. All dense concrete was poured with 1/4-inch steel plate forms which remained in place to form the inner and outer cell wall surfaces. The steel plates simplify decontamination of the cells, afford a good base for attaching fixtures to the interior or exterior, and prevent chipping of the concrete around plugs, drawers, and access ports.

The radiation shielding windows are oil-filled units of 3.6 gm/cm^3 density glass. Each window is roughly the same thickness as the 4.5 gm/cm^3 density wall in which it is installed so that, in comparison to the wall, it is undershielded. This undershielding can be compensated by using an additional

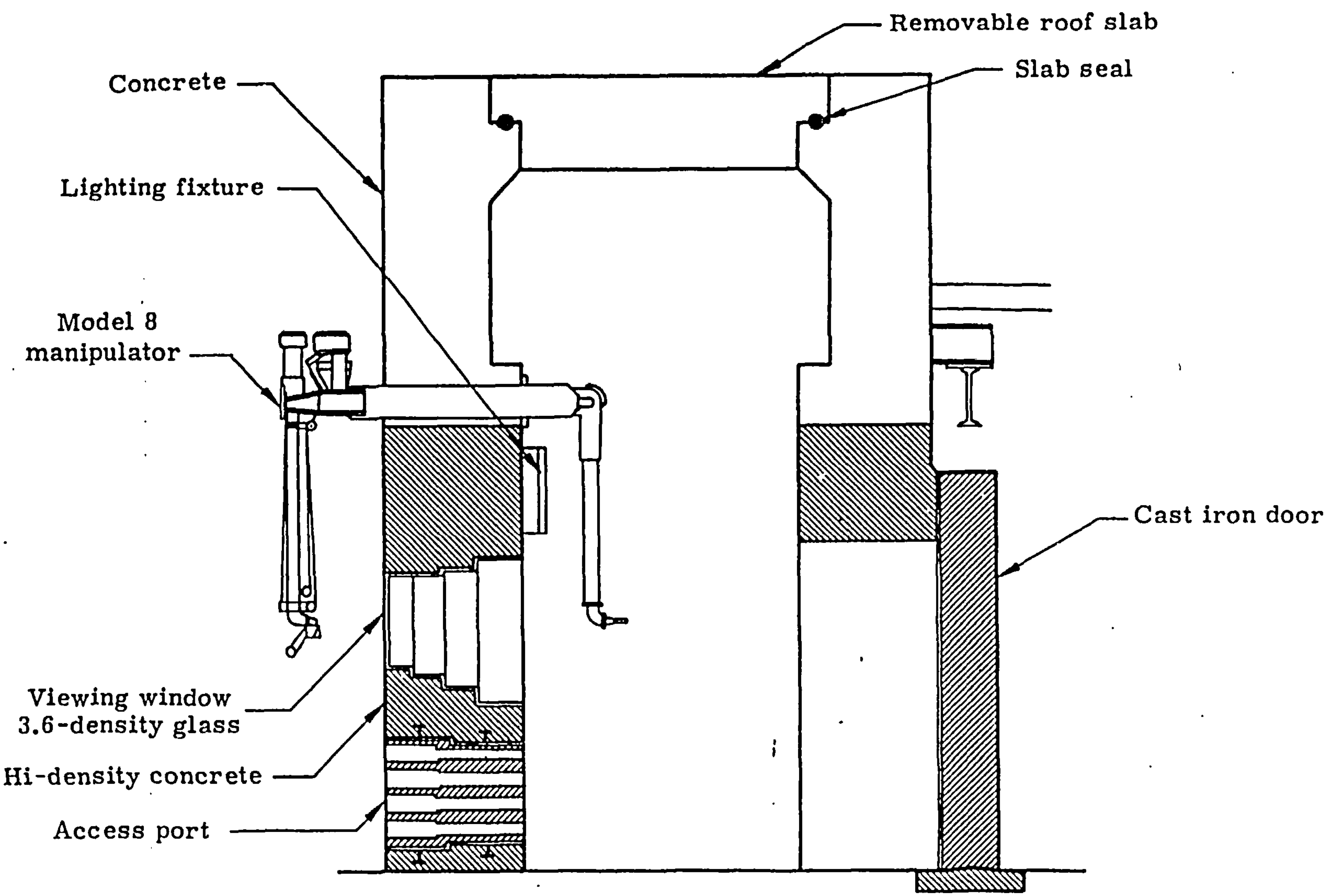


Figure 5.3 Side Elevation--Typical Cell

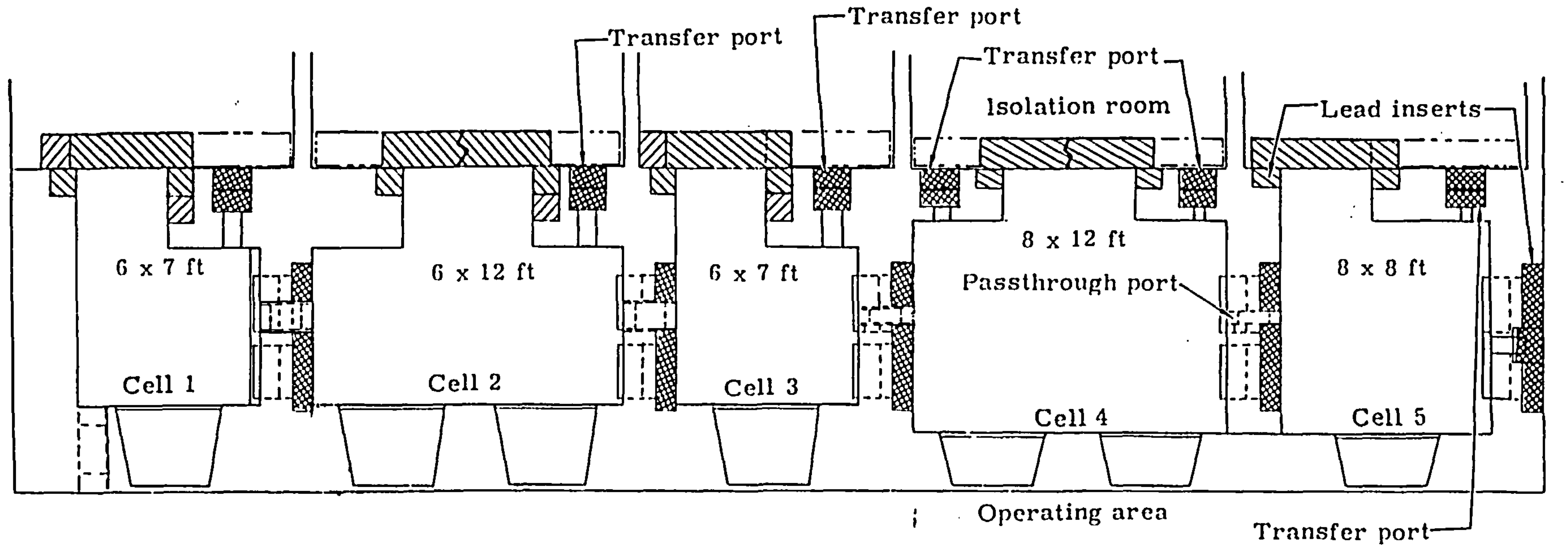
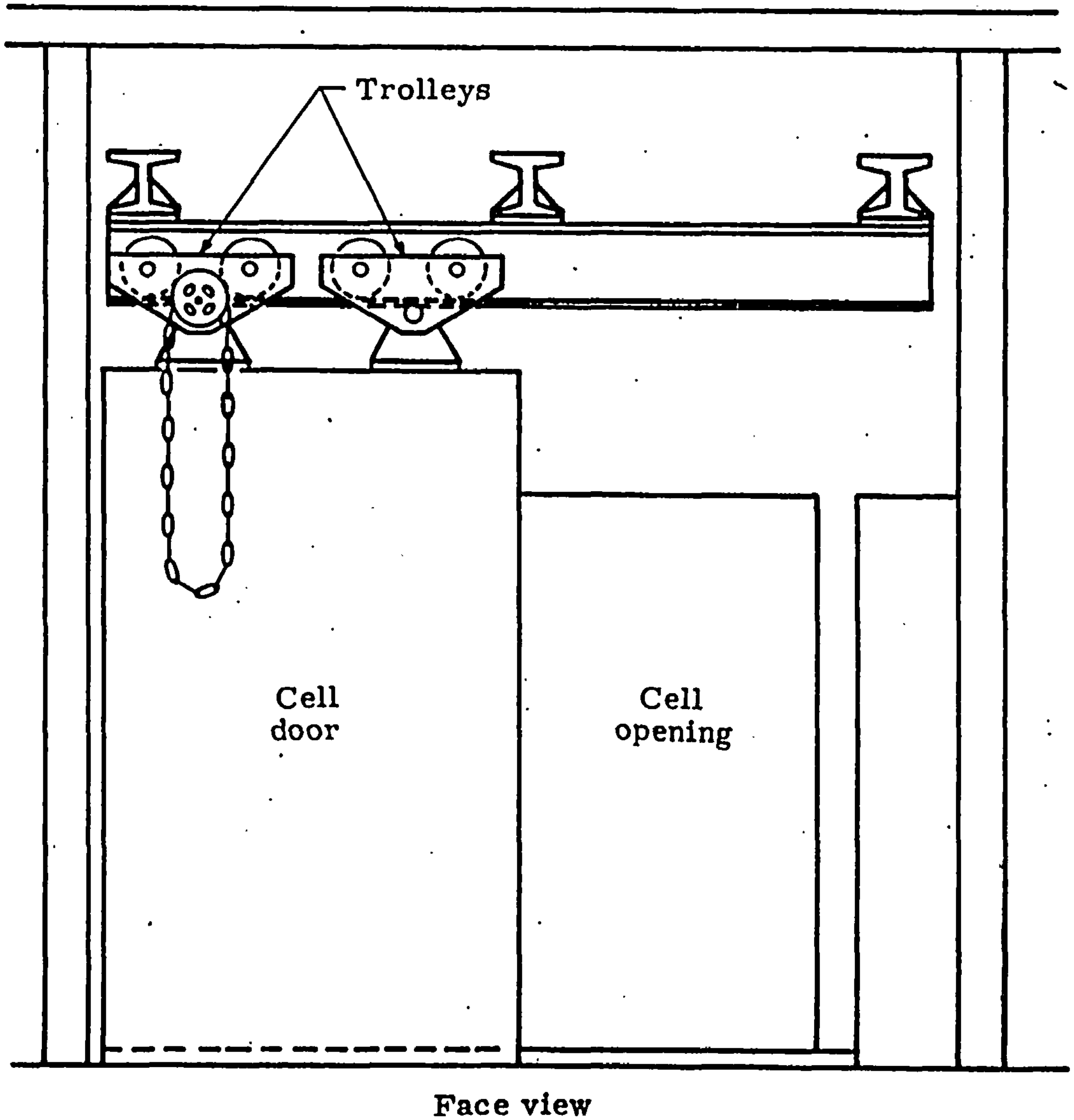


Figure 5.4 Plan View of Hot Cells

slab of 6.2 gm/cm^3 density glass, four inches thick, when additional shielding is required. There are seven windows; two in each of the larger cells and one in each of the remaining three cells. The windows measure 36x48 inches on the hot face, and by virtue of the high refraction index of the glass, permit one to view almost the entire cell area.

The cells may be entered through doors at the rear which open into the isolation room. Details of the door arrangement may be seen in Figure 5.5. As reference to Figure 5.4 reveals, the openings are so placed, and are of such size, that modular equipment tables covering one half (or in the case of the larger cells, one third) of the floor area can easily be removed or rearranged within the cell. This is true of all the cells except Cell 4 where the redesigned isolation room limits access to the cell so that SOTS (see Paragraph 9.2.3) is the only opening for large equipment. Equipment which is too large to pass through the doors (on all cells except 4) may be placed in the cell by removing one or more of the two-foot thick slabs which form the cell roof. By using the 15-ton bridge crane to remove these slabs, the entire cell area may be uncovered if necessary.

Commercial flood lamps supply the cells and process box with the required lighting. Standby or emergency lighting is supplied in all cells so that lamp failures wil not



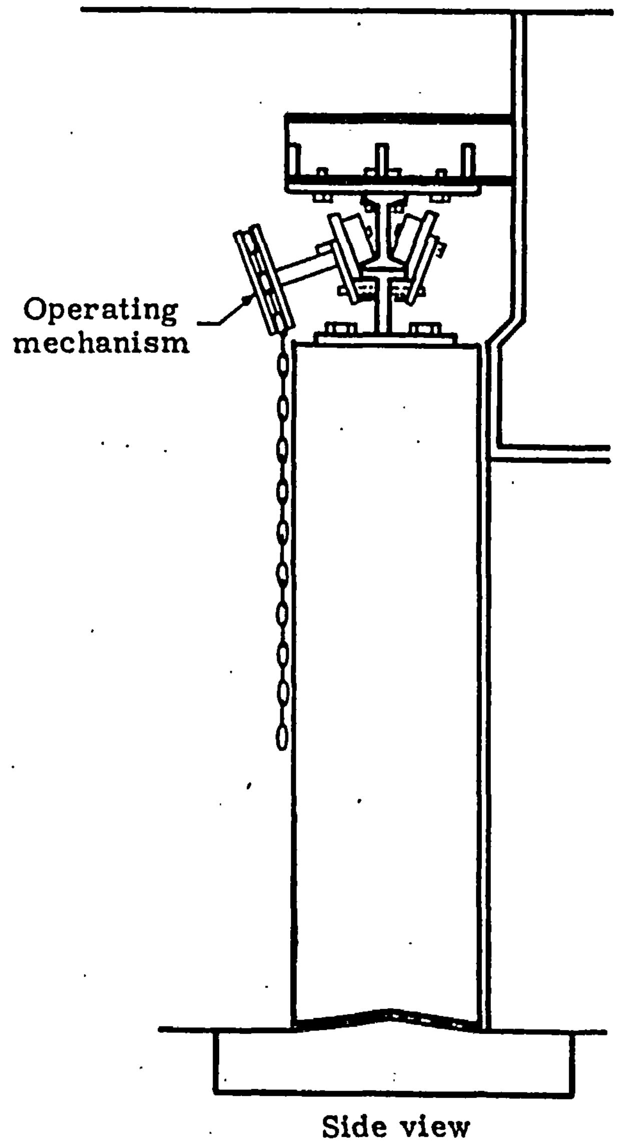


Figure 5.5 Cell Door Detail

cause shutdown. A propane-fueled motor-generator set supplies sufficient power to continue operation of the cell ventilating and lighting systems in case of electrical failure.

The operating faces of the cells are liberally supplied with access ports arranged as shown in Figure 5.6. Many of them have been placed in rectangular drawers or inserts which can be removed and replaced with drawers having plugs designed for specific applications. Individual intercommunication systems connect the operating face and the isolation rooms. There are penetrations from the isolation rooms to the cells and between cells, through which piping and wiring may be passed. All standard services are available in a trench immediately in front of the cell face so that they may be extended through the wall as needed. Channel-through plugs carrying services into the cells are bent so that there is no direct path for radiation from the cell to the operating area. Only a few 110-volt electrical lines are permanently installed within the cells.

5.2.2 <u>Isolation Areas</u>

Figure 5.1 indicates the location of the isolation rooms in reference to the hot cells and the rest of the facility. Table 5.2 indicates the physical configurations.

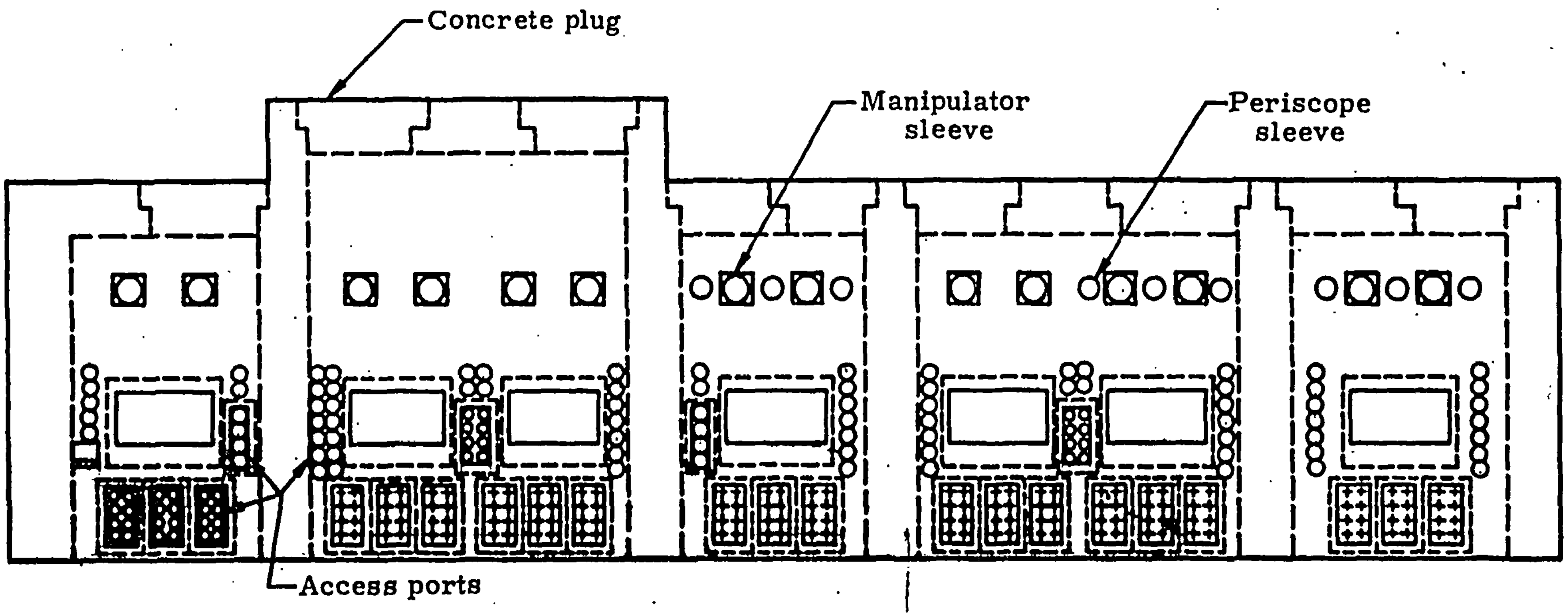


Figure 5.6 Front View of Cells

Table 5.2

ISOLATION ROOM DIMENSIONS

Cell No.	Floor Size (ft)	Wall Thickness (inches)	Ceiling Height (ft)
1	10x14	8	10.67
2	12x14	8	10.67
3	10x14	8	10.67
4	12x14	8	10.67
5	10x10	8	10.67

The walls and ceiling of the isolation rooms are made of precast reinforced concrete. The walls are 8 inches thick and the ceiling 5 inches thick. There are no penetrations in the isolation room surfaces except for the door to the service area and the hot cell door plus sealed conduit pipes for required services.

5.2.3 Operating Area

The operating area is immediately adjacent to the front of the hot cells (Figure 5.1). The walls that form the operating area boundaries are the hot cell walls, the machine shop and metallographic laboratory, the change room, and the exterior wall of the facility. The only normal access to the 20 by 66 foot operating area is through air locks to the change room and to the outside. The door to the outside is part of the integral locking system.

5.2.4 Service Area

The service area is adjacent to the isolation rooms at the back of the cells. The walls that form the service area boundaries (Figure 5.1) are the isolation room, the decontamination room and radiochemistry laboratory and cask storage room, the exterior wall to the facility, and the wall separating the reactor bay from the hot cell area. The only normal personnel access to the service area is again the change room and the outside by way of air locks. The door to the outside is again part of the integral locking system.

5.2.5 Decontamination Room

The decontamination room is adjacent to the service area (see Figure 5.1) and is bounded on the other three walls by the radiochemistry lab, the electrical equipment room, and the outside wall of the facility. The walls to the service area and the electrical equipment room are made of 8-inch concrete blocks and the wall to the radiochemistry lab is a 2-foot thick precast concrete wall. The only access to the 20 by 25 foot room is through the service area.

5.2.6 Radiochemistry Laboratory

The radiochemistry lab is next to the decontamination room and adjacent to the service area (Figure 5.1). Aside from the 2-foot thick precast concrete wall between the radiochemistry lab and the decontamination room, all walls are made of 8-inch concrete blocks. The only access to the 18 by 34 foot room is through the service area.

5.2.7 Storage Area

The storage area (Figure 5.1) is adjacent to the service area and all four walls are of concrete block construction 8 inches thick, approximately 8 feet high, and open at the top. Again the only access to the room is through the service area.

5.2.8 Change Room and Cold Areas

The change room, as mentioned above, is the only way to leave or enter the hot cell area (Figure 5.1). In the change room area are the showers, clothes storage, and the cold area men's toilets. All the walls in this ~~area~~ are 3/4 inch Cemesto board on 2 x 6 inch wood studs. The office area walls are regular construction plaster board on 2 x 4 inch studs. The outside wall of the facility is generally made of insulated aluminum siding applied on a steel frame.

5.2.9 Waste Storage Building

The waste storage building is located about 50 feet south of the plant (Figure 5.1). The prefabricated building, 20 feet by 60 feet, is made of aluminum siding on a steel frame. The building has two roll-up garage type doors which are locked. About one-third of the building has concrete block shielding provided so that the waste drums containing a high level of activity may be stored in this area.

5.2.10 Liquid Waste Treatment Building

The liquid waste treatment building is located about 50 feet south of the plant (Figure 5.1). The 25 x 30 feet building is made of aluminum siding on a steel frame. The building has two doors, which may be locked, one for personnel and one for delivery of supplies and equipment. The building is equipped with a vacuum evaporator system and complete laundry facilities.

5.2.11 Fan Room

The room is located on the lower level, directly under isolation rooms 1-5, (Figure 5.2). The room is 14 ft. wide, 57 feet long and 13 feet high. The only entrance is from the service area. Equipment in this area consists of normal, auxiliary and process box exhaust fans and controls, double filter plenum boxes, vacuum pumps and air samples.

5.2.12 Sub-cell (Cell 6)

This room is located on the lower level adjacent to the fan room, directly under Cell 1. It is a heavily shielded room with 2 to 3 foot concrete walls. It is 6 feet, by 6 feet, by 13 feet high with access corridors 3 feet wide. The entire floor area is covered with stainless steel. The only entrances are from the service area through the fan room and through the Cell 1 floor blocks. The entrance door is normally locked and is part of the integral locking system (Paragraph 10.4.3).

5.3 Area Work Assignments

5.3.1 General

The facility has been designed to provide as positive separation as possible between radioactively contaminated and radioactively clean areas. Those areas which will remain free of contamination include offices, dark room, staff laboratory, and reactor area. Potentially contaminated areas include the change room, hot cells, isolation rooms, cell operating area, service area, radioactive materials storage area, decontamination room and storage area. The only normal access between clean and controlled areas is via the change room.

5.3.2 Specific

	Location	Work Assignment
(1)	Cell 1, 2	Being rehabilitated; to be submitted later.
(2)	Cell 3	Solid waste bag-out station.
(3)	Cell 4	Entire fuel processing from precipitation to encapsulation.
(4)	Cell 5	Generator loading, decontamination, thermal output measurement, and capsule storage.

(5)	Isolation Room	Cell 3 - Waste handling Cell 4 - Dissolution of cask feed material; feed storage; feed sampling; and measurement of process tank levels.
(6)	Operating Area	Remote handling of materials and process computations and controls.
(7)	Service Area	Material storage in pool, cask transfer, and cell service.
(8)	Decontamination Room	Decontamination of portable equipment and materials.
(9)	Radiochemistry Lab	Analysis of curie-level quantities of radioisotopes.
(10)	Storage Area	Temporary storage, process water tanks and Health Physics survey equipment.
(11)	Change Room	Personnel change area.

(12)	Office Area	Administration area.
(13)	Waste Storage Building	Temporary storage of waste drums.
(14)	Liquid Waste Treatment Building	Liquid waste processing.
(15)	Fan Room	Ventilation equipment
(16)	Cell 6 (Sub-cell)	Not used

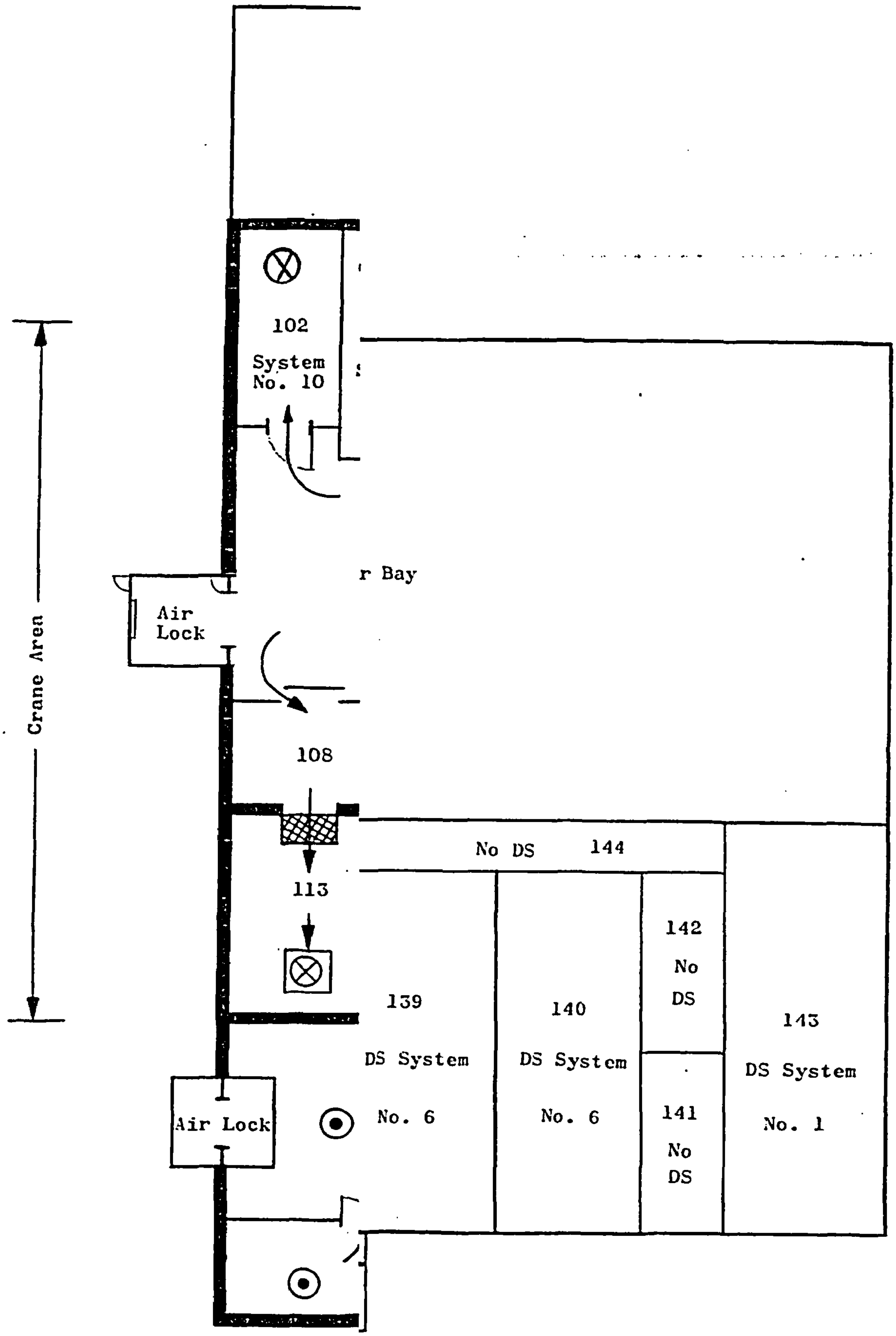
CHAPTER 6

AIR HANDLING SYSTEM

6.1 General Description

Figure 6.1 indicates the areas described in this section and the air flow patterns for these areas. The areas outlined on this drawing include Rooms 102, 103, 105, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118 and 119. All are considered to be in the contained area. All admission to this area is through air locks from outside the building or from adjoining areas.

The contained area is divided into three sub-areas of controlled ventilation served by Supply Air Systems 3, 5 and 7. The areas outside the contained area are served by separate supply and exhaust systems. The airflow pattern within the contained facility is from the machine shop (119) to operation area (118), operation area (118) to service area (107), service area (107) to isolation area (108-112), isolation area (108-112) to cells (113-117), and cells to dry boxes. Most air supplied to the service area is exhausted through the cells, through at least two absolute filters in series, and then to the outside through the main stack. During normal operation, the operation area is at atmospheric pressure or marginally positive, the service area slightly negative, and increasingly more negative pressures in the isolation room, cell and dry



102
System No. 10
r Bay
Air Lock
Crane Area
108
No DS
144
113
142
No DS
139
DS System
No. 6
140
DS System
No. 6
143
DS System
No. 1
141
No DS
Air Lock

box, in that order. The cell in which unsealed fuel is handled has, in addition to the shielding door an absolute type filter to allow airflow into the cell.

The areas outside the contained area are served by separate supply and exhaust systems. For example, system 10, serving the decontamination room, receives its air supply from the service area and discharges to the atmosphere through its own fan and set of high efficiency filters. System 7, which serves the radiochemistry laboratory, has its own outside air supply fan and its own exhaust fan.

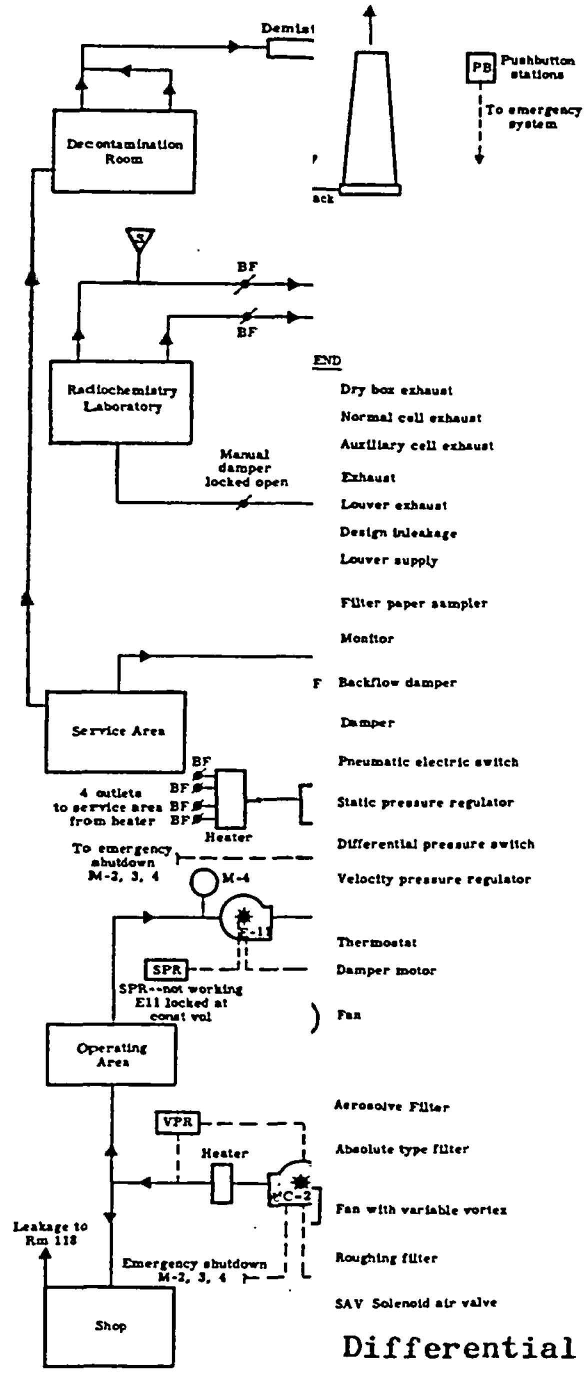
Emergency control systems may-be-actuated manually or automatically. Three emergency buttons will shut off all contained area supply fans. They are located in the service area, operating area and outside the main entrance. Continuous air monitors provide constant monitoring of the air of various areas (see Paragraph 10.5.3.2). Upon alarm of these, control mechanisms are automatically brought into play.

6.2 Ventilation Subsystems Description

Descriptions of the following systems are found on Figure 6.2, Table 6.1 and Table 6.2.

6.2.1 System 3 - Service Area Air Supply

The oil-fired space heater SH-2 located in room 107, the service area, is set to provide a constant supply of outside air. A pneumatic backdraft damper opens and closes



Differential Pressure Gage

nly in Cells Where
nencapsulated Fuel
s Present

·e 6.2 Air Ventilation System

TABLE 6.1

SUMMARY OF VENTILATION SYSTEMS FOR HOT CELL AREA

System No.	Fan No.	Function
3	SH-2	Supplies outside air to the service area.
5	UC-2, E-11	Supplies outside air to the machine shop and exhausts to operations area.
7	UV-2, E-12	Supplies outside air to radio-chemistry laboratory and exhausts to outside.
8	E-4 through E-10	Exhausts air to stack from cells.
9	E-13, E-14	Exhausts air from process box to stack.
10	E-15	Exhausts air from the decon-tamination room.

TABLE 6.2

VENTILATION SYSTEM TYPICAL VOLUME FLOWS

Legend

CL = Controlled Leakage

DS = Direct Supply

EB = Process Box Exhaust

EN = Normal Cell Exhaust

EV = Auxiliary Cell Exhaust

FE = Filtered Exhaust

IL = Design Leakage

LE = Louver Exhaust

LS = Louver Supply

Room	Volume Flow in cfm
2	CL = 440 FE = 440
102	LS = 3080 FE = 3080
103	DS = 2586 FE = 2586
107	DS = 6812
108	CL = 758 FE = 758
109	CL = 1200 FE = 1200
110	CL = 900 FE = 900

111	CL = 1366 FE = 1366
112	CL = 1055 FE = 1055
113	EN = 658 IL = 758 EB = 100 EV = 1285
114	EN = 1100 IL = 1200 EB = 100 EV = 1285
115	EN = 800 IL = 900 EB = 100 EV = 1285
116	EN = 1266 IL = 1366 EB = 100 EV = 1285
117	EN = 955 IL = 1055 EB = 100 EV = 1285
118	DS = 5050 FE = 5987
119	DS = 937 LE = 937

Return air to 118 and 119 = 4755 cfm

as the fan is started and stopped. From the heater, air passes through four outlet ducts, each equipped with a backdraft damper. Under an emergency condition, this fan will shut down, the outside air damper will close (intake side of SH-2) and the four weighted backflow dampers on the positive side of SH-2 will close. As soon as the emergency has cleared, SH-2 will return to normal automatically when the activating monitor is reset. Most of the air exhausted from the service area is eventually exhausted through the cells; the remainder is exhausted through the decontamination room (102).

6.2.2 System 5 - Machine Shop and Operating Area

Supply fan UC-2 supplies a mixture of outside and recirculated air to the operating area and machine shop. Thermostatically controlled dampers located in the intake duct for UC-2 and the return duct from exhaust fan E-11 regulate the air supplied to UC-2. A pneumatically operated damper opens and closes as the fan is started and stopped. A static pressure regulator modulates the inlet damper to fan UC-2 to maintain a constant air supply to the supplied areas.

Air from the operating area is monitored (M-4) as it enters the exhaust duct, serviced by fan E-11. The inlet vanes to this fan are locked wide open to provide maximum air exhaust from the operating area. Air which is not recirculated leaves the building through an exhaust stack provided with a backflow damper.

6.2.3 <u>System 7 - Radio Chemistry Laboratory</u>

Supply fan UV-2 furnishes only outside air to the radio chemistry laboratory. Air from this laboratory is exhausted to roughing and high efficiency filters through fan E-12 to the outside of the facility. Two backflow dampers are provided in the exhaust duct to prevent air from being drawn into the room from the hoods under emergency conditions. On a drop in space temperature, the room thermostat will control the face and by-pass dampers to maintain 70°F. When room temperature rises, the face damper will close. The low limit in the fan discharge may take command away from the ~~room~~ thermostat and open the face damper to prevent the temperature from dropping below 60°F. When the fan is not operating, the face damper will remain closed. A filter paper sampler is located downstream of E-12 and a final backflow damper is located in the exhaust stack.

6.2.4 <u>System 8 - Hot Cell Exhaust</u>

6.2.4.1 Main Cell Exhaust

The main exhaust system from each cell takes air from the service area through the isolation rooms into the cells (see Figure 6.3). The air leaving the cell passes through a roughing filter, two high efficiency filters in series through the main cell exhaust fan, to a common header and finally to the stack. The static pressure regulator for each cell will

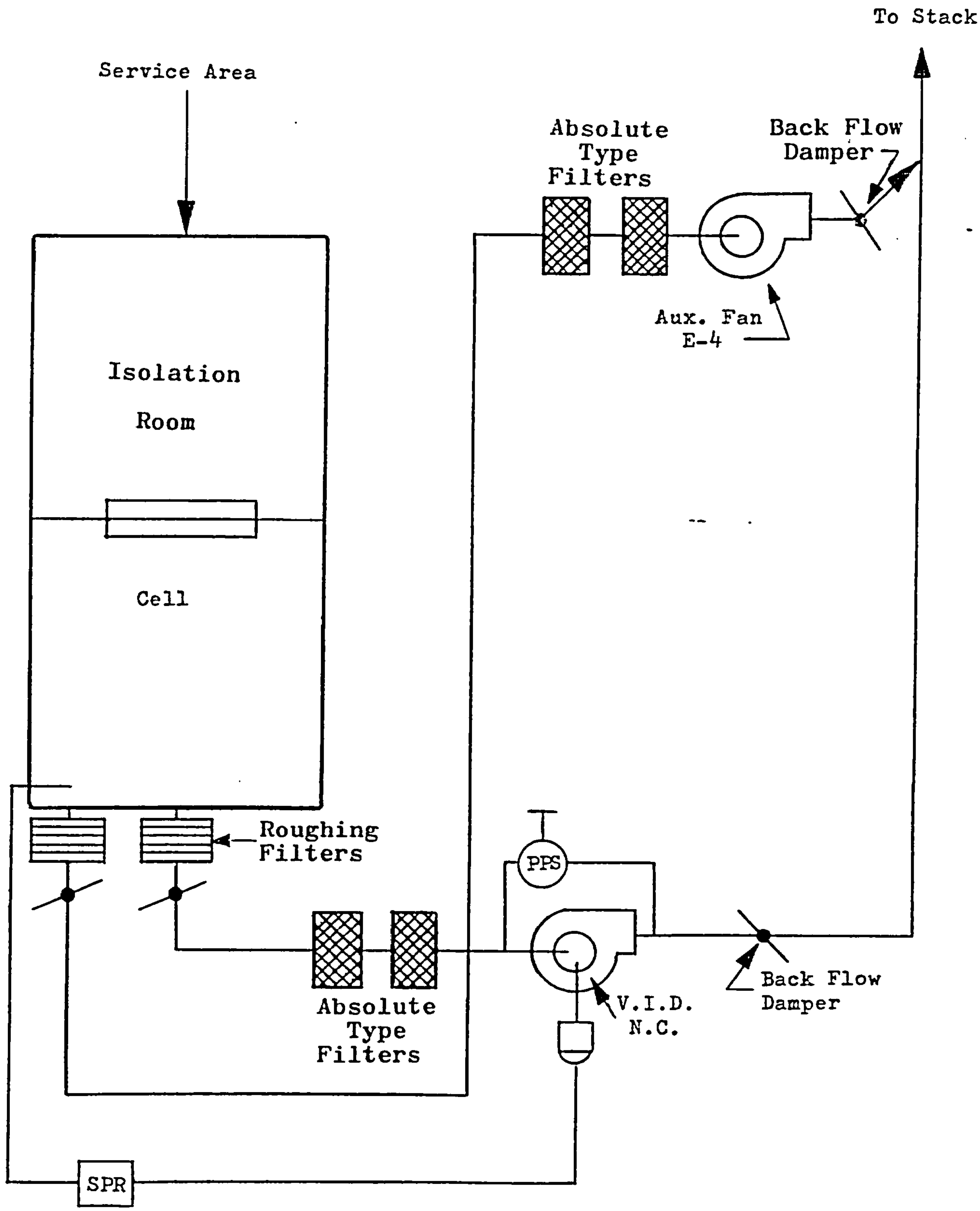


Figure 6.3 Typical Hot Cell Exhaust

modulate the vane inlet damper of the main cell exhaust fan to maintain the required static pressure. If the static pressure rises above the throttling range of the regulator, the auxiliary exhaust fan E-4 will operate and the auxiliary cell intake damper will open. There is about one complete air change per minute in all cells.

6.2.4.2 Auxiliary Cell Exhaust

Usually the normal exhaust fan will be in operation with its intake damper open. However, if the pressure difference across this fan decreases, indicating the possibility of a failure, fan E-4 will start, the auxiliary damper will spring open and the main damper will be motor closed. Air is then exhausted from the cell through a roughing filter and two high efficiency filters in series in the auxiliary exhaust system.

6.2.5 System 9 - Process Box

The air supply to the process box is taken from the cell. (Figures 6.4, 6.5 and 6.6). A differential pressure switch indicates differential pressure across fan E-13. Dampers are adjusted to maintain the box at a negative pressure with respect to the cell. The pressure differentials are given in Table 6.3 and the air velocities associated with the differential pressures are given in Table 6.4. The supply air enters the box through a manifold with two high efficiency filters in parallel. Valves enable use of one filter at a time, the other filter being a spare.

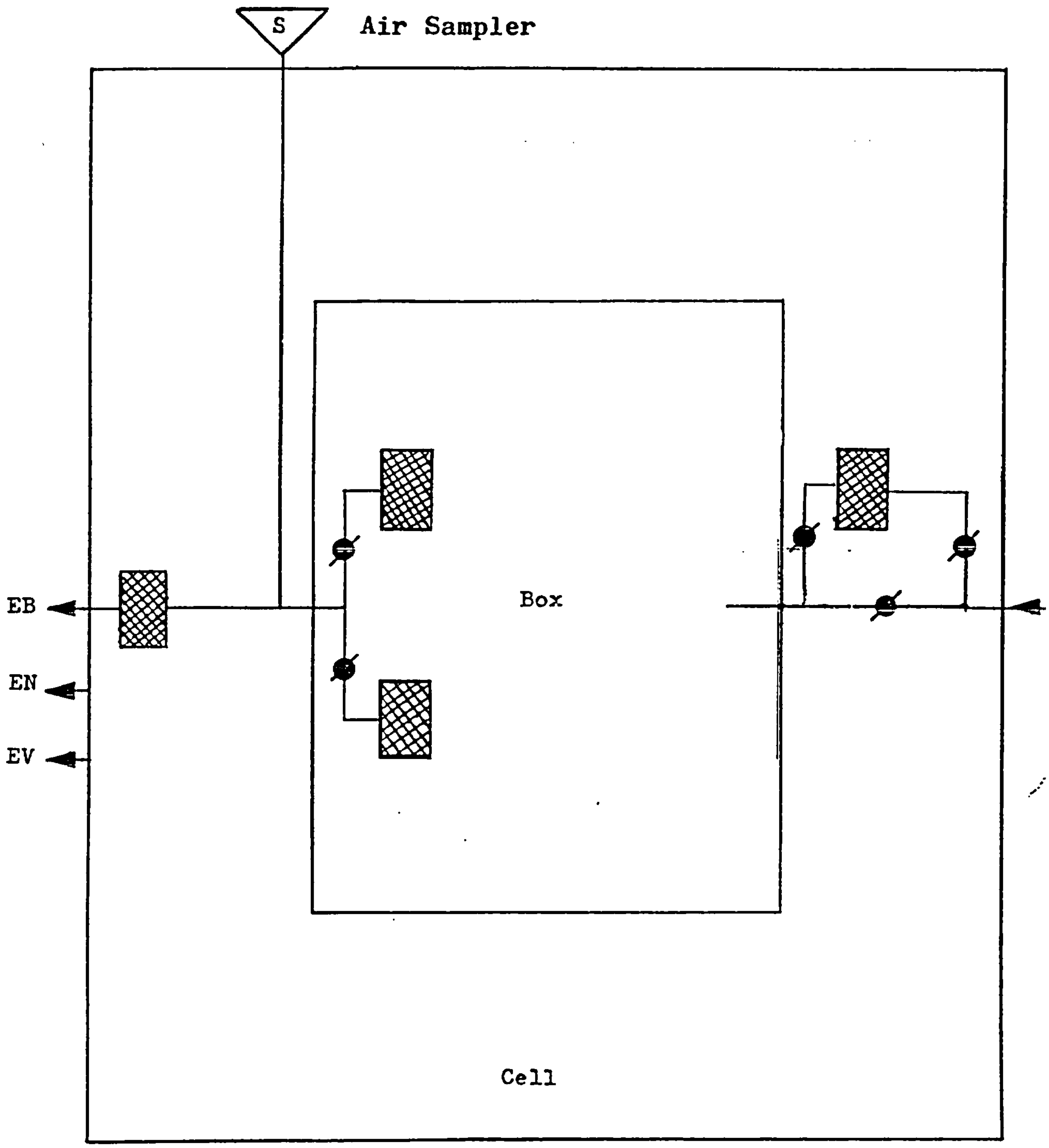


Figure 6.4 Schematic of Ventilation System of Cell Process Box

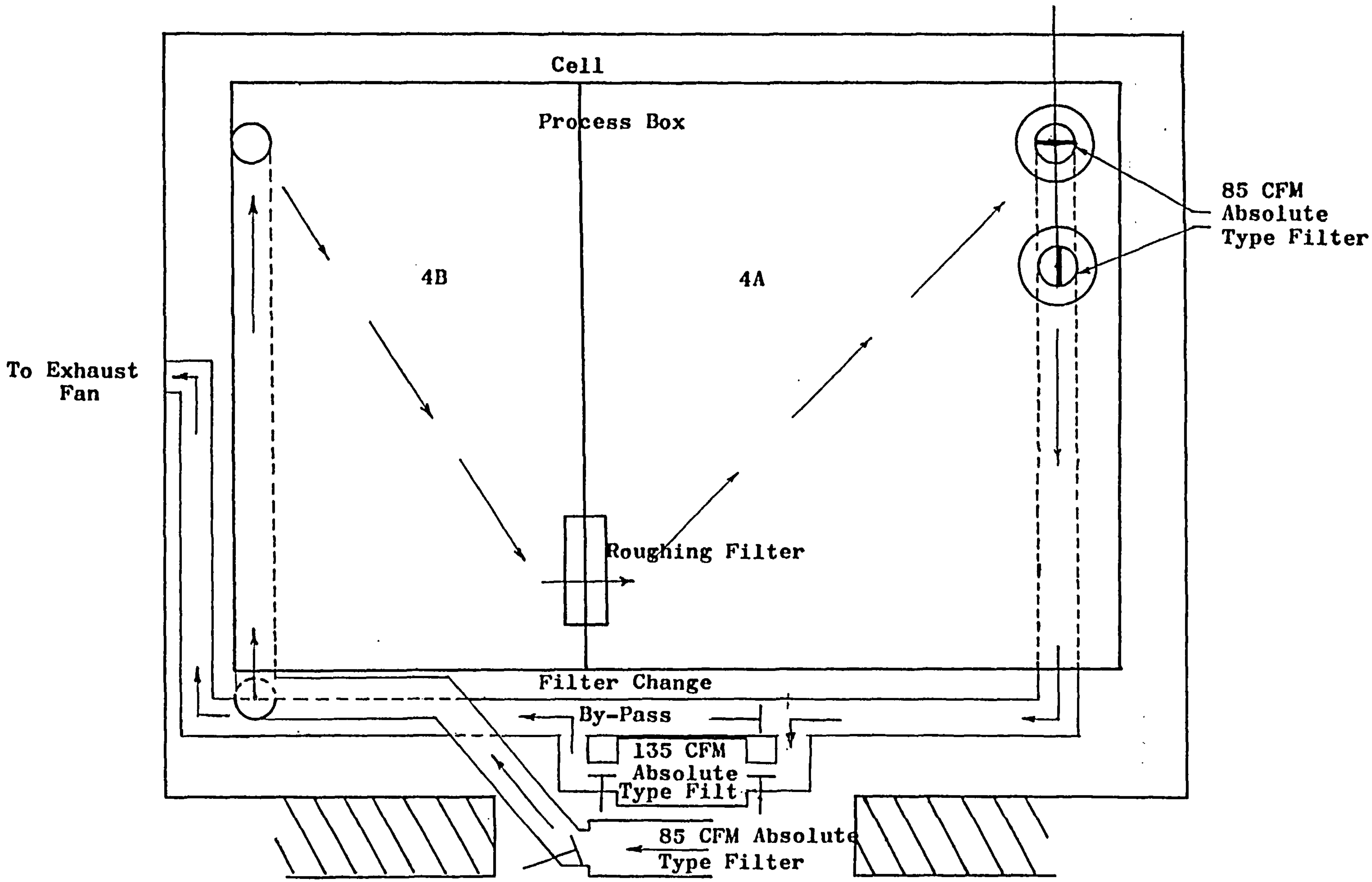


Figure 6.5 Hot Cell and Process Box Ventilation

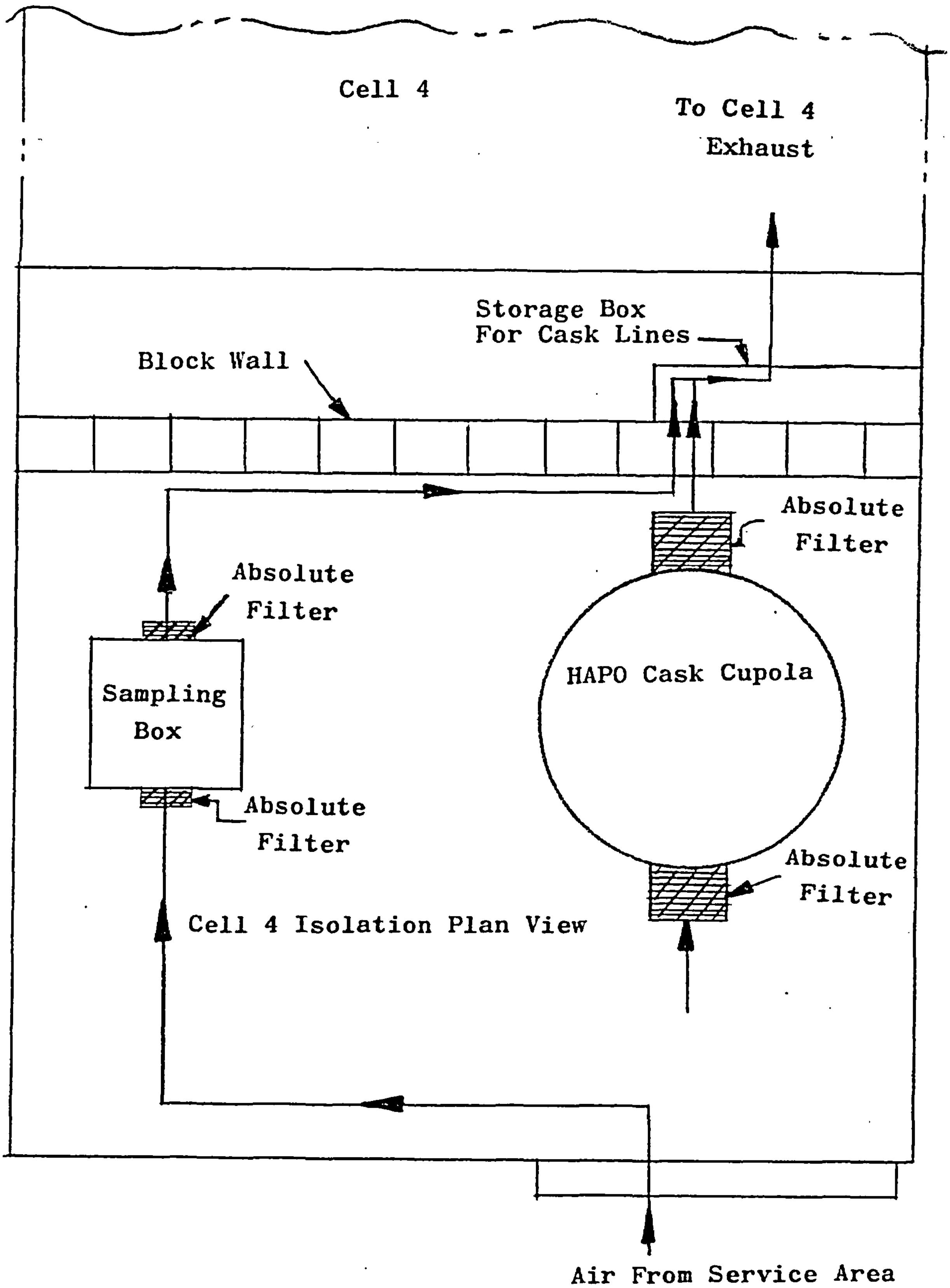


Figure 6.6 Cell 4 Isolation Room Ventilation

TABLE 6.3

PRESSURE DIFFERENTIALS

	READING	GAGE-ACCURACY	MINIMUM
1.	Operations Area to Cell 4	Hays ± .02	0.5
2.	Operations Area to Other Cells	Hays ± .02	0.4
3.	Cell 4 to Process Box	Magnehelic (0-.5) ± .01	0.1
4.	Service Area to Isolation Room 4	Hays ± .02	0.2
5.	Service Area to Other Isolation Rooms	Hays ± .02	0.4
6.	Isolation Room 4 to Cell 4	Hays ± .02	0.2
7.	Isolation Rooms to Other Cells	Hays ± .02	0.0
8.	Operations Area to Outer SOTS	Magnehelic (0-2) ± .04	0.4
9.	Outer to Inner SOTS	Magnehelic (0-.5) ± .01	0.1*
10.	Inner SOTS to 4B (Process Box)		0.05

NOTE: (a) All readings, in inches of water.

(b) Cell 4 always negative with respect to outer SOTS.

(c) Above pressure differentials apply with isolation room door closed.

*Due to structural requirements the maximum is 0.5

TABLE 6.4

MINIMUM AIR VELOCITIES (NORMAL OPERATION)

	VELOCITY (feet/second)
1. Operations Area to Cell 4	47.1
2. Operations Area to Other Cells	42.3
3. Cell 4 to Process Box	21.1
4. Service Area to Isolation Room 4	29.0
5. Service Area to Other Isolation Rooms	42.3
6. Isolation Room 4 to Cell 4	29.0
7. Isolation Rooms to Other Cells	0.0
8. Operations Area to Outer SOTS	42.3*
9. Outer to Inner SOTS	21.1*
10. Inner SOTS to 4B (Process Box)	14.9
11. 4B to 4A (in Process Box)	3.77

*If leakage in the SOTS walls occurs

The box has dual exhaust ducts installed in parallel. Each duct has a high efficiency filter. The exhaust air, after leaving the box, passes through an additional high efficiency filter which is located at the rear of the box inside the cell door. The filter is accessible for changing. The box exhaust then enters the permanent system, passes through two high efficiency filters, through E-13 or E-14 and then to the stack.

Normally the fan E-13 will be in operation with the fan E-14 acting as a standby.

With fan E-13 in operation, ~~the~~ intake damper is open. If the differential pressure switch senses a loss in pressure differential across the exhaust fan E-13, relay R-30 contact will open, causing the control circuit for fan E-13 to be de-energized, making a circuit to exhaust fan E-14 and causing it to start, opening its intake damper, and breaking an interlock so that the exhaust fan E-14 will continue to run and E-13 will not try to restart even through the correct pressure difference has been re-established. An alarm will sound to indicate that all the foregoing has taken place.

6.2.6 <u>System 10 - Decontamination Room</u>

Supply air is drawn into room 102 by fan E-15 from the service area through louvers in the door and exhausted to the outside through roughing filters and high efficiency filters. A backflow damper is provided to prevent leakage back into the hood during emergency conditions.

The velocity pressure regulator VPR-1 will modulate the vane inlet damper motor DM-16 to maintain velocity pressure.

6.3 Normal Operations of Cell Exhaust

The cell exhaust systems are started by one push button located in the motor control center. Fans E-4 through E-10 have individual resets located in the motor control center. This main starter button starts fans E-5 through E-10 with a time delay (15 seconds) before fan SE-2 starts.

A time delay on the differential pressure switch on fans E-5 through E-10 prevents operation of the auxiliary exhaust fan E-4 before the system stabilizes.

There is a differential pressure switch across each cell exhaust fan. On loss of differential pressure due to fan failure, the pressure switch causes the normal damper to close (motorized damper prior to first high efficiency filter) and the weighted back draft damper beyond the fan will close. The auxiliary damper will spring open on that particular cell and auxiliary fan E-4 will start. An alarm sounds, indicating that cell pressure has been lost and the auxiliary fan E-4 has started.

A static pressure regulator connected between each hot cell and the outside atmosphere maintains a negative pressure by modulating the variable inlet vanes at the fan. If the fan is unable to maintain this negative pressure by vane modulation because of an open door or a dirty filter, a pneumatic electric switch will start auxiliary fan E-4 and open the associated auxiliary duct damper on that particular cell. Both the normal cell fans and the auxiliary fan are thus exhausting that cell.

6.4 Method of Operations

With all supply air fans (E-15, SH-2, UC-2, E-11, UV-2, E-12) in operation, and all cell fans (E-5 through E-10 and E-13) operating normally, the auxiliary fan E-4 and E-14 should be stopped.

As previously stated, the main manual push button to control this system is located in the motor control center. Therefore, for any initial start-up this button should be in the OFF position and all switches on the control board shall be turned to AUTOMATIC. The system can now be properly operated by switching the button in the motor control center to ON. All cell fans will start and after a 15 second delay the supply fans will start.

6.4.1 <u>Static Pressure Regulator</u>

The static pressure regulator senses the static pressure differential between the cells and operating area. It provides contacts which begin corrective actions in case the cell static pressure is lost. Gauges associated with the static pressure regulator are normally set at 5 psi or lower operating pressure. Upon loss of cell static pressure, these gauges rise to about 11 psi or a little higher. This pressure actuates the E-4 (auxiliary fan) switch, fan E-4 starts and the associated cell auxiliary duct damper opens.

6.4.2 <u>E-4 Switch</u>

The E-4 switch is connected to the static pressure regulator and, upon activation, causes fan E-4 to start and associated cell auxiliary duct damper to open.

6.4.3 <u>Pneumatic Electrical Switch Reset</u>

When cell static pressure has built up to normal again and can be maintained by the normal cell fan, pushing the pneumatic electrical switch reset turns off fan E-4 and closes the associated cell auxiliary duct damper returning the cell ventilation systems to normal.

6.4.4 <u>Differential Pressure Switch</u>

Any loss of differential pressure across the normal fans is sensed by this differential pressure switch in the basement fan room. In case of fan failure, it closes the associated normal cell duct damper, opens the associated cell auxiliary duct damper and causes fan E-4 to start. Such action is displayed on the annunciator panel.

6.4.5 Differential Pressure Switch Reset

Upon establishment of pressure differential across a fan, pushing the differential pressure switch reset causes fan E-4 to stop, the normal cell damper to open and the associated cell auxiliary duct damper to close, returning the cell ventilation condition to normal.

6.4.6 Hays Gauges

(a) Gauge A displays ~~differential~~ pressure across the first high efficiency filter in the normal cell exhaust duct.

(b) Gauge B displays differential across the cell auxiliary pre-filter.

(c) Gauge C displays differential pressure across the normal cell pre-filter.

(d) Gauge D displays differential pressure across the second high efficiency filter in the normal cell exhaust.

There is no automatic corrective action associated with these differential pressure gauges.

6.4.7 Process Box Control Section

(a) The process box control section of the panel contains the same type of Hays gauges as the rest of the panel to measure the pressure differential across the two final high efficiency filters.

(b) Three magnehelic vacuum gauges are located here to display the operating conditions of three vacuum pumps located in the fan room. These pumps supply vacuum for a filter paper sampling system integrated with the ventilation system.

6.4.8 Auxiliary Fan Control Section

(a) The auxiliary fan control section contains two Hays gauges which display the pressure differential across the two associated high efficiency filters.

(b) It contains one differential pressure switch reset controlling resetting of fan E-13.

(c) It contains one alarm contact, connected to the annunciator panel, which makes contact and sounds an alarm whenever fan E-4 is actuated.

6.5 Emergency System Control

6.5.1 Manual

In the event of any gross contamination within the contained area, all supply air must be shut down insuring that the pressure will remain lower than that of the other areas and the direction of air flow is always toward areas of increasing contamination.

There are three manually operated push button emergency stations; one is located in the service area air exit (east end of building), one is in the operating area at the air lock to the change room and a third button is located on the outside of the main entrance doors.

Activation of any of these manual buttons will stop all fans supplying the contained area. The specific fans involved are:

(1) E-15 - Exhaust air from Decontamination Room 102

(2) SH-2 - Air to Room 107 - Service Area (overhead oil burner)

(3) UC-2 - Air to Machine Shop and Operating Area

(4) E-11 - Air to exhaust from Machine Shop and Operating Areas

(5) UV-2 - Air to Radiochemistry (103)

(6) E-12 - Air exhaust from Radiochemistry (103)

To restart the air supply system the same manual button that was activated will have to be reset. After resetting this manual button, all fans will start automatically except for the following:

(1) UC-2, E-11 - Reset on equipment mezzanine

(2) E-15 - Reset on mezzanine above Decontamination Room 103

(3) Reset on all pneumatic electrical switches and differential pressure switches - Buttons on control panel board

A weighted backflow damper is located in the wall between Rooms 118 - Operating Area and 107 - Service Area. Under normal conditions, this damper will be closed. Under emergency conditions, this damper will be open to purge the operating area.

6.5.2 Monitoring Systems and Controls

Constant air monitors control the air handling systems to assist in the prevention of the spread of contamination. The details of their operation are found in Paragraph 10.5.3.2.

6.6 Stationary Overhead Transfer System Ventilation Plan

6.6.1 Secondary Inlet Air

A 500 cfm absolute type filter will be placed in Cell 3 with a manual 6-inch damper on the inlet which can be operated from the face of the cell. A 6-inch diameter tube will lead from the filter, through the top of Cell 3 into the SOTS secondary containment near Cell 3. That will insure that the secondary containment will be held at a pressure approximately equal to, or less than, the pressure in Cell 3.

6.6.2 Primary Inlet Air

An automatic damper will be installed behind a roughing filter between the primary and secondary SOTS containment near the Cell 3 downcomer door in a manner to make both the filter and damper accessible.

The above damper-filter will be designed to control the pressure drop across the two stages of containment.

6.6.3 Primary Air Exhaust

The inner SOTS containment will be exhausted through filters of at least 100 cfm capacity to the Cell 3 box exhaust system.

The SOTS exhaust duct will originate at a spot high in the inner containment with a 4-inch diameter duct coming down between the two containment barriers and through the Cell 3 roof area. Filters will be set up in parallel with a damper system to permit filter changes while maintaining an uninterrupted air flow.

6.6.4 Pressure Differential - Measurement

Two differential pressure gauges will be installed on the cell face for SOTS. One will indicate the differential between the outer containment and operations and the other will show the differential between the inner containment and operations. A similar system will be provided for the Cell 4 process box.

6.6.5 Ventilation During Transfers

6.6.5.1 Attachment of Drum Liner

The drum and new drum liner will be attached to the SOTS Cell 3 downcomer. A bleed valve ~~will be~~ provided on the downcomer to permit air from the cell to enter the downcomer and a magnehelic gauge will be provided on the downcomer proper to permit visual determination of negative pressure. The internal downcomer pressure will be reduced to permit correct attachment of the drum liner.

6.6.5.2 Pressure Equalization

The Cell 3 SOTS door would be opened and the waste container taken up to SOTS and the Cell 3 door would be closed. At this point, the SOTS inlet damper would be partially closed and the pressure in SOTS would be lowered until the inner pressure reached 0.05 to 0.1 inch water gauge positive with respect to the process box; the box door would then be opened and the transfer made. At no time will SOTS be allowed to become negative with respect to the box, nor will more than one of the SOTS doors be open at one time.

CHAPTER 7

WASTE DISPOSAL SYSTEM

7.1 Description of Facilities

Facilities are available for the control, treatment and disposal of airborne, liquid and solid radioactive wastes.

7.1.1 Solid Wastes

As far as possible, all wastes are converted to solid form and suitably packaged for shipment and ultimate disposal by land burial. Airborne particulates are removed by filtration. When the accumulated solids on the filter begin to impair its flow capacity or reach a radiation level designated as the maximum for operation, the filter is replaced. The old, contaminated filter is removed from the system and packaged in a disposal container for shipment and burial. In similiar fashion, concentrated radioactive liquid process wastes, after neutralization, are absorbed in a suitable medium, such as Flor-co, a commercial product which can absorb about 4 times its own weight of liquid, in the proper proportion to form a monolithic solid. The absorbing mixture is preloaded in the disposal container; after the liquid waste has been added, the container can simply be sealed for shipment.

The disposal containers, which are approved by the Bureau of Explosives, consist of steel drums (see Paragraph 9.1.3.2). For disposal of solids, the inner cavity is filled to capacity (dictated by either mass of material or radiation level), the inner cover put on, the top cavity filled with concrete, and the outer drum cover put on. For disposal of liquids, the inner drum cavity is preloaded with Flor-co and the cover with valved inlet and vacuum line put in place. When the waste liquid has been added, the valves are then closed and the line to the waste storage tank disconnected. Concrete is poured into the top cavity and the top cover put in place. Thus, for liquid process waste disposal, it is necessary only to drain the liquid into the previously prepared drum. The drum for liquid waste is located in the isolation room of Cell 3 and connected to the process lines by appropriate plumbing. For removal of the loaded drum to storage and shipment, the isolation room is entered, the drum removed, and a new drum connected in place.

The solid wastes are removed from the process boxes in specially designed transfer boxes (see Paragraph 9.1.2.4 for specifications) which are transported to Cell 3 by SOTS. The waste is placed in drums using the solid waste bag-out system (see Paragraph 9.1.5.1).

7.1.2 Liquid Wastes

The previous section indicated how high level liquid process wastes are transposed to solids for ultimate disposal. This is practical for the relatively small volume of liquids handled in the process. There are relatively large volumes of low level liquid wastes generated in operations auxiliary to the process, for which the previously described liquid treatment is too costly. A liquid waste treatment plant is available for disposal of this latter category of waste. In this plant, the low level wastes are tested for activity by a Pennsylvania State University Health Physics representative. If a reasonable amount of dilution will lower the activity level to within the specified limits of 10CFR20, the wastes are diluted and discarded to the stream system (see Figure 7.1). If this method is not possible, the liquid is vacuum evaporated to provide a condensate of sufficiently low level contamination for discharge to the streams. The high/level residual liquid remaining in the evaporator is disposed of by the above described method of conversion to a solid.

The plant for treatment of low level liquid wastes is housed in a separate building about 50 feet from the main building. The capacity of this plant is based on an estimated flow of 300 gal/day, of which about 10% might actually require evaporation treatment. In actual experience the plant has safely and efficiently processed 15 gal/hr. by evaporation.

Figure 7.2 shows that wastes flow to the treatment plant by way of two collection systems. The low level waste system originates in areas of potential radioactive liquid wastes and contamination such as the radio-chemistry laboratory drains and the fume hoods in the decontamination room. Drains from areas of unlikely, but possible, radioactive contamination

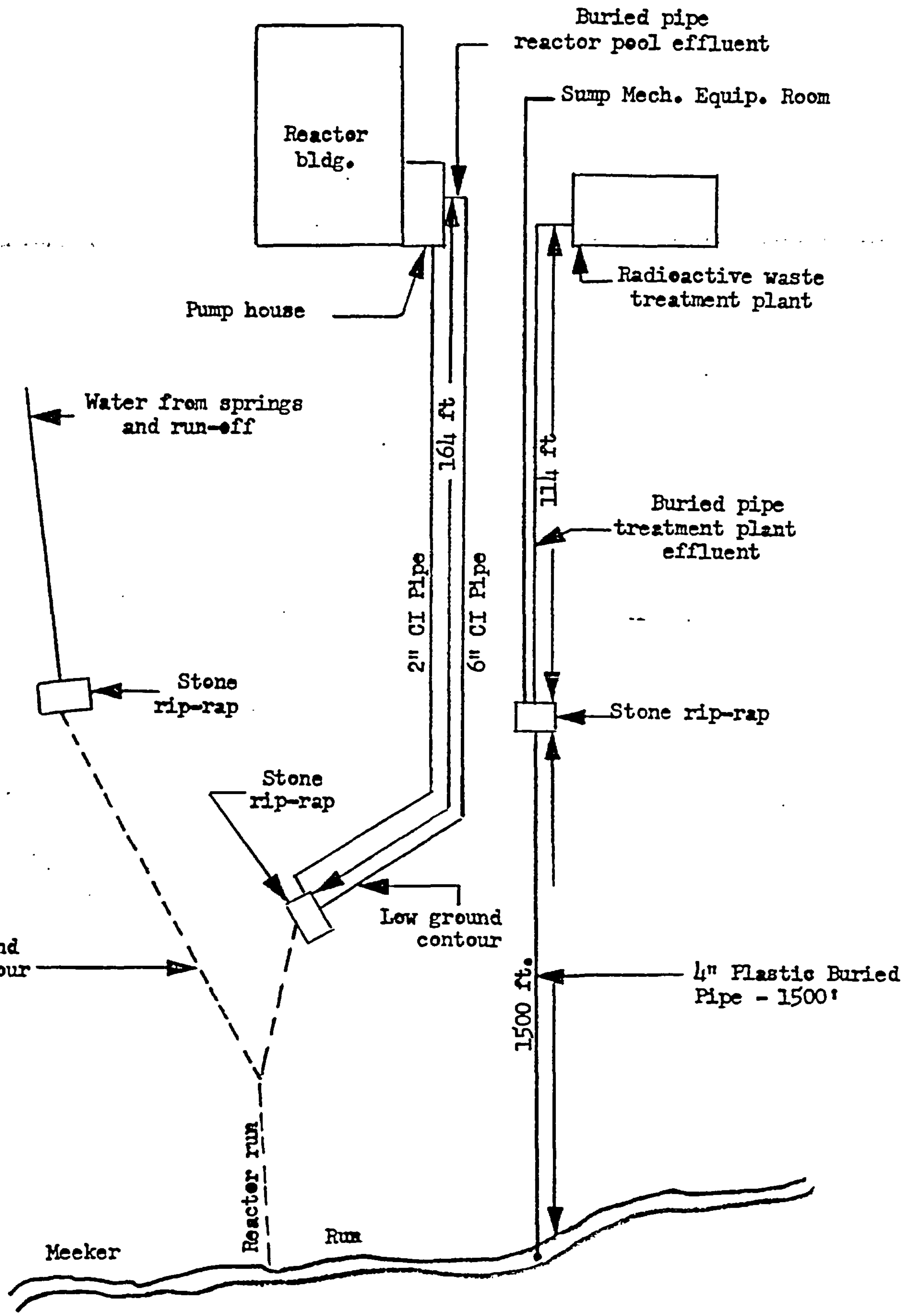


Fig. 7.1 Waste Treatment Runoff

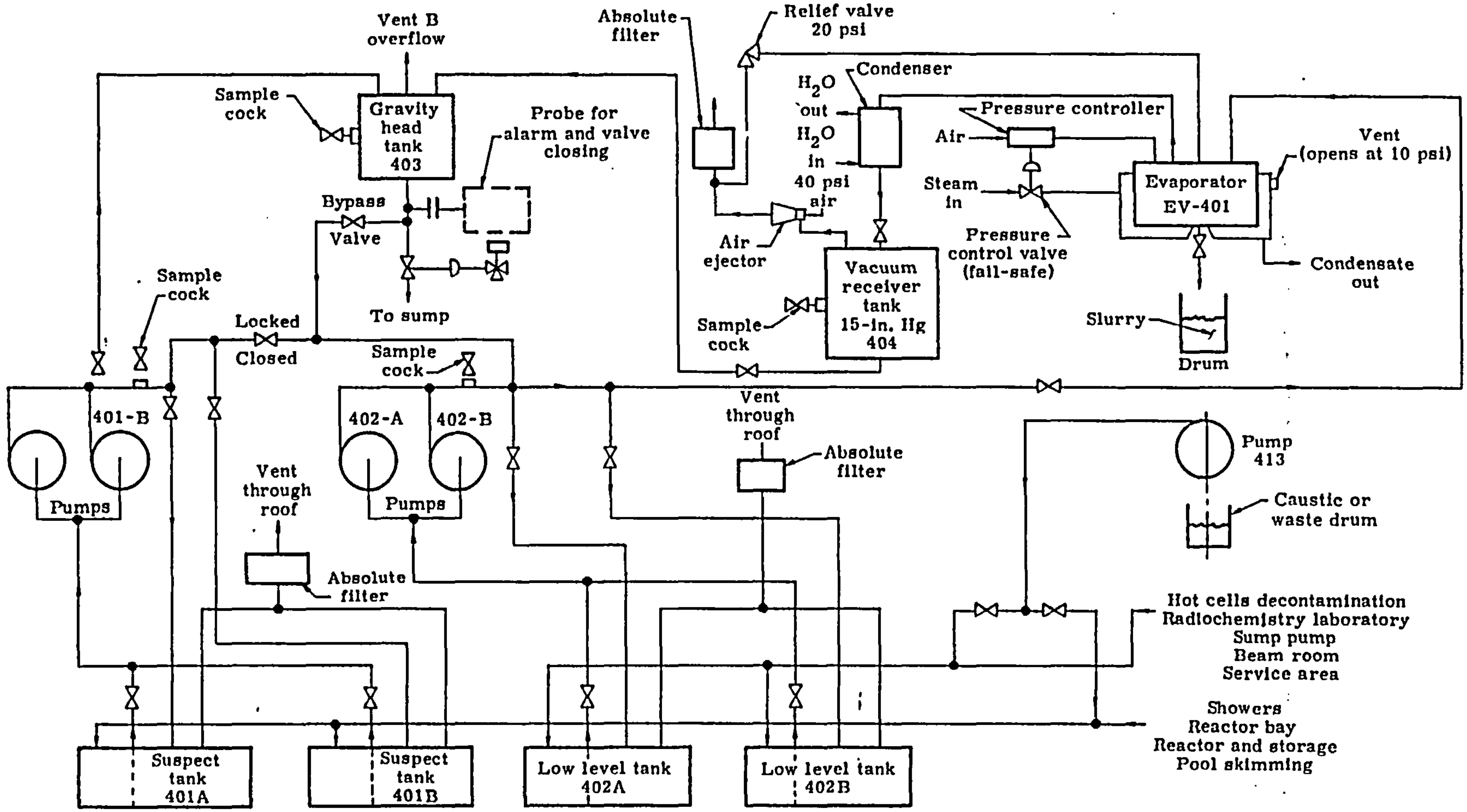


Figure 7.2 Waste Treatment Plant

lead to a "suspect" waste system and originate from such places as the change room showers, reactor area and the personnel decontamination sink in the change room. Each system may be terminated in either of two 3000-gallon underground tanks. When one tank in one system is full, the other tank in the same system may receive drainage.

There are two pumps for each system: one in each system operates when required, with the second used as a standby. When a tank is full, the contents are mixed by circulation through the pump and back to the tank. A sample is then taken from the sampling cock on the pressure side of the pump and an analysis made for radioactivity content. If the activity concentration is below the maximum permissible level for release, the contents of the tank are pumped out for disposal directly to the stream. If the activity concentration is above the permissible level, the contents of the tank are either diluted or pumped to the evaporator.

Following evaporation, the sludge is drained to drums which are shipped offsite for ultimate disposal as mentioned above. The water vapor from the evaporator passes through a heat exchanger-type condenser, and the condensate flows into the 100 gallon vacuum receiver tank and is then transferred to the 1000 gallon gravity head tank where it is analyzed for activity concentration by Pennsylvania State University Health Physics representatives. If the activity is within disposal limits it can be dumped directly into the Meeker Run, 1500 feet from the facility, via 4 inch plastic pipe. If the activity is too high, it can be again put through the evaporator. Active sludge is drained from the evaporator through a 3-inch valve and pipe into a 55-gallon drum which is preloaded with Flor-co. Figure 7.3 is a sketch of the evaporator and preloaded drum system.

A station has been provided for the addition of caustic to any storage tank for acid neutralization. This station may also be used for the transfer of radioactive waste solutions from other laboratories to one of the storage tanks.

Each group of two storage tanks is vented above roof level through absolute type filters.

The system has been designed to be flexible. The following operations are possible:

(1) The contents of any storage tank can be pumped to the evaporator.

(2) The contents of any storage tank can be pumped to the gravity head tank.

(3) The contents of any storage tank can be pumped to any other storage tank.

(4) The contents of the gravity head tank can be routed to any storage tank.

A complete facility for laundering potentially contaminated clothing is also included in the building housing the liquid waste treatment plant. The effluent from the laundry

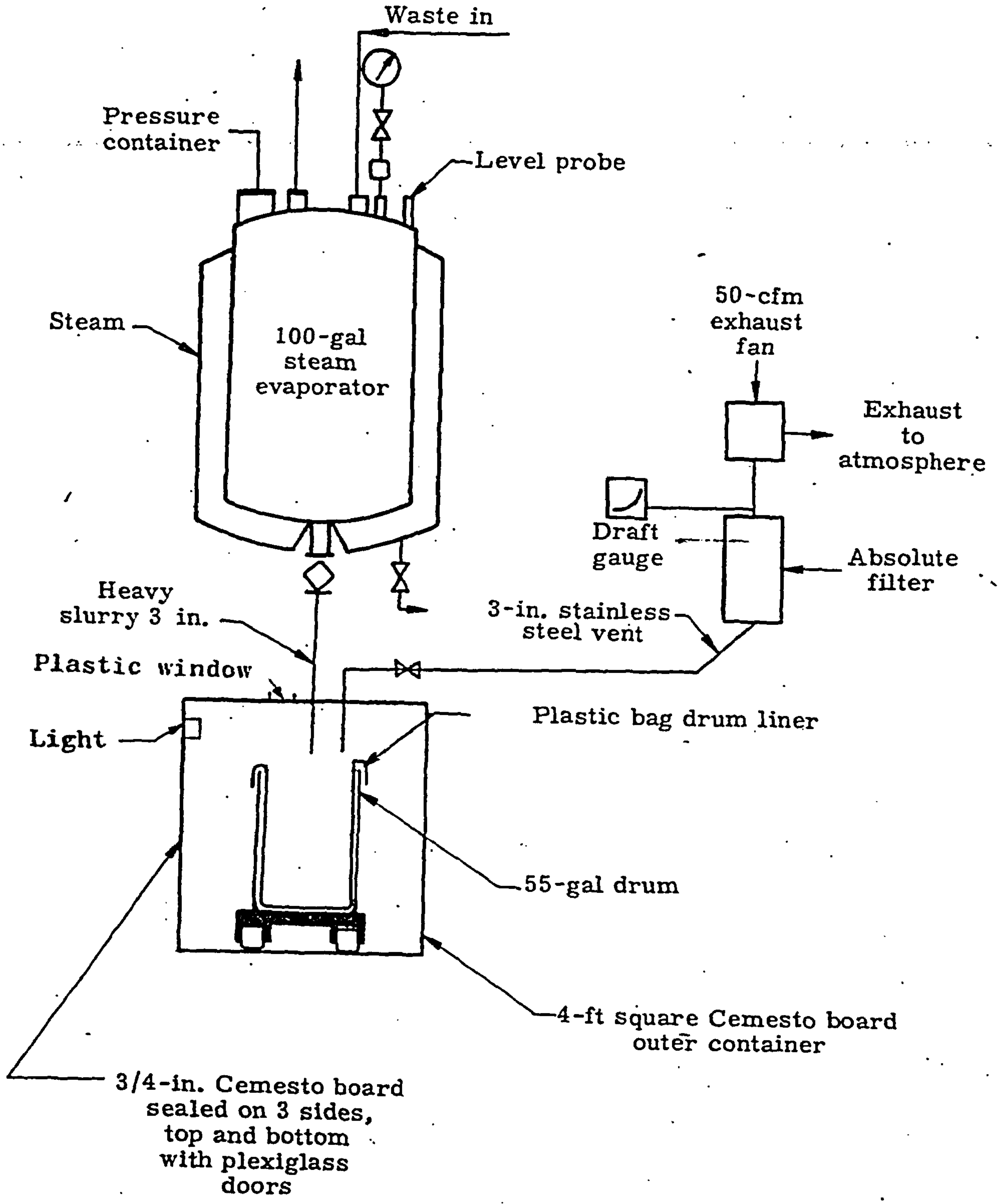


Figure 7.3 Waste Treatment--Sludge Removal

facility drains to the waste storage tank. Under normal operations, this facility is not utilized. The normal procedure is described in Paragraph 10.8.3.

7.1.3 Gaseous System

No radioactive gases or vapors are present in the Strontium-90 process. There is therefore no problem in disposal of gaseous wastes.

Airborne radioactive particulate matter, on the other hand, poses a serious problem. The solution to this problem is achieved through the principle of, and design for, multiple containment. This system includes a barrier of multiple absolute filters in series through which the air must pass before discharge to the stack. The airborne radioactive wastes are collected on filters, and the filter assembly disposed of when the collected particles are sufficient to significantly impair the flow, or the radiation level of the filter is sufficient to dictate replacement.

7.2 Quantities of Wastes

7.2.1 Solids

The principal sources of solid waste are solidified liquids, used filters, contaminated equipment, and the actual solid wastes from the process box. All solid waste is packaged and put in containers for shipment.

Since used filters and contaminated equipment vary in size and shape, it is usually the volume of the drum rather than activity which dictates the amount placed in each drum.

Most of the activity placed in drums comes from the solid waste products of the pellet-making process. Since this waste is of relatively high activity the amount of this waste per drum is dictated by the activity and not the volume. The Bureau of Explosives has approved shipment of drums containing up to 100 curies each. Up to 500 drums can be stored adequately in the waste storage building.

Shipments of waste offsite for burial are at about two-month intervals. Each shipment is 1000-3000 curies, or about 125 drums. These figures are for 10,000 curie batches. The new 25,000 curie batches precipitated will result in more waste but the increase is not anticipated to be large.

7.2.2 Liquids

As mentioned above, the high level liquid wastes from the process are directly converted to solids and shipped as solid waste. Each 10,000 curie batch produces 12 to 20 liters of liquid waste about 40 liters are placed in each drum.

The larger quantity of low level liquid wastes is processed in the waste disposal plant. In the past, the suspect system (very low activity) has collected about 1500 gal/month to be processed. Most of this was diluted with water and discharged to the streams. The low level system has collected about 1000 gal/month. Some of this was run through the vacuum evaporator system and the low level condensate discharged to the streams. The residual liquid was converted to a solid and shipped offsite. The solidified liquid drums are included in the above solid waste quantities.

CHAPTER 8

UTILITIES AND SERVICES

8.1 Introduction

This section covers the normal and emergency utilities and services that are installed at the Quehanna facility. In any radioactive installation it is necessary that provisions be made to supply adequate emergency facilities that will be able to operate critical equipment in the event of a power failure, etc.

8.2 Electricity

8.2.1 Source

Electric power is supplied to ~~the~~ Quehanna Facility by the Pennsylvania Electric Corporation that has a large generating station at Shawville, about 12 miles away. A 13,200-volt power line leads to a substation consisting of two 500-kva, 13,200-volt, 480/277-volt transformers. One of these transformers supplies control and instrument power for the Hot Laboratory and Reactor building sections. The second 500 kva transformer services all heavy electrical motors and equipment in order to control power surges. There are automatic switch-over provisions so that in case either transformer fails the other unit can carry the load. This provision ensures the availability of at least one transformer with power to operate the essential ventilating equipment in the hot cell area. The 440-volt power input is reduced to 208/120-volt service as required for lighting and other services throughout the Radioisotopes Pilot Plant.

8.2.2 Emergency Power

In the facility, the main emergency power system consists of a generator rated as follows: 43.75-kva, 35-kw, 0.8 pf, 227/480-volt, 3-phase, 4-wire, 60-cycle. The generator is driven by a propane gas-fueled engine delivering a rated output of 81.5 hp at a speed of 1800 rpm. The propane is obtained from the building gas system. An automatic transfer panel transfers the load from the normal source to the emergency source when the normal line voltage fails below 85% and returns the load to normal when all normal line voltages have been restored to 95% or more. Time delay relays are incorporated in the transfer switch to permit the emergency unit to reach rated voltage and speed before the transfer is effected. This takes approximately 10 seconds. When normal power is again available, the system must remain at steady state on the normal bus for 15 minutes before the critical load is automatically transferred from emergency to normal power. The automatic transfer switch is electrically and mechanically interlocked so that there is no feedback from the normal bus to the emergency generator, or vice-versa. Full relay protection guards against phase failure. A built-in test switch to simulate power failure is provided for maintenance checks and testing. A four-position control switch on the control panel permits selection of four operating positions marked STOP, HANDCRANK. TEST and AUTOMATIC.

During a power failure, it is necessary to provide emergency lighting, instrumentation, heating and ventilation for the hot cells. Emergency lighting is supplied in most rooms in the building, and consists mainly of one fluorescent fixture per room. In the hot cells, 50% emergency lighting is provided so that an experiment which is at a critical stage when the normal power fails may continue.

It is necessary to keep the hot cells and process boxes at a negative air pressure with respect to the surrounding areas at all times to prevent leakage of contaminated air into these areas. The following equipment is therefore connected to the emergency power supply:

(1) Exhaust fans E-4 to E-10 and E-13 and E-14
(2) Instrument air compressor (fan controls)
(3) The pneumatic electric switches which cause E-4 to operate in case of an exhaust fan failure
(4) Constant air monitor (CAM)
(5) Remote area radiation monitors (RAM)
(6) Model 8 manipulators
(7) Emergency lighting
(8) Instrumentation power panel

It may be seen that failure of both the normal and emergency power supplies, while most improbable, could cause a potential hazard so emergency exit lights are fed by an independent battery unit. When the normal power is restored, the emergency exit lights are automatically returned to the normal power circuits.

The entire fire alarm system will operate from the normal power bus. In case of a power failure, the system will automatically switch over to a 24-volt d-c supply obtained from storage batteries. Trickle chargers ensure that all batteries are fully charged when not in use.

8.3 Water Supply

8.3.1 General

Water is provided to the facility from a dam on Meeker Run, upstream from the waste disposal discharge point. A float control in the facility reservoir controls the 100-gpm submersible pump located in the Meeker Run Dam. The surface storage reservoir (see Figure 8.1), covered by an aluminum structure, holds not less than 135,000 gallons of usable water when the surface is not frozen. The domestic water suction line removes water from a higher elevation in the reservoir than the fire protection suction line so that, in case of a water drawdown, there will always be 50,000 gallons of water available for fire protection.

These sources provide water for the following general services: hot and cold sanitary water, steam, process cooling water at 50°F, closed loop process water, and hot process water at 180°F. In addition to these standard services, deionized water is available for filling the source storage pool as well as for any other chemical uses that may be required.

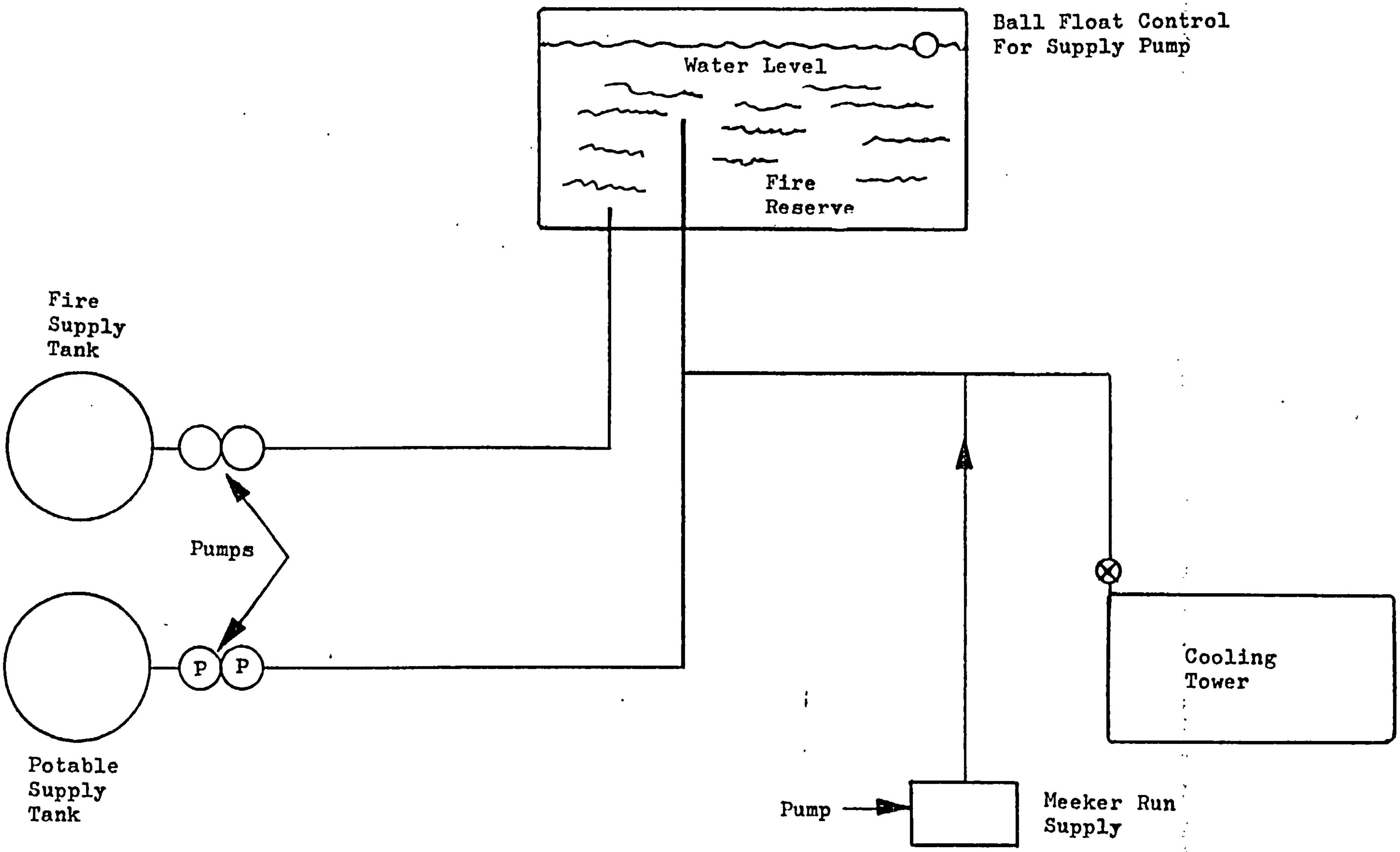


Figure 8.1 Storage Reservoir System

8.3.2 Storage Pool Supply

A deionizing system, installed primarily for the purpose of providing water for the reactor pool, provides deionized water in quite large quantities and ensures a sufficient amount for maintaining the level in the storage pool, even if a leak should develop. The rated capacity of this system is approximately 140,000 gal/day. Figure 8.2 is a block diagram of the system. The storage pool recirculation system is shown in Figure 8.3.

8.3.3 Water for Fire Protection

Three fire hydrants are located outside of the building. The first is approximately 60 feet from the northeast corner of the building, the second about 100 feet from the northwest corner, and the third, a pumper hydrant, on the south side of the building. Each unit is enclosed in a hydrant and hose-reel house which contains 200 feet of 2 1/2 - inch hose and 300 feet of 1 1/2 - inch hose which is sufficiently long to reach any section of the building.

An electrically driven pressure pump on the fire protection pumping system starts at 95 psig and stops at 100 psig and will supply 500 gpm at 100 psig. A booster pump cuts in if the pressure in the fire lines drops to 85 psig and cuts out again when the pressure reaches 110 psig. In case of an electric power failure, a propane-fueled engine-driven pump

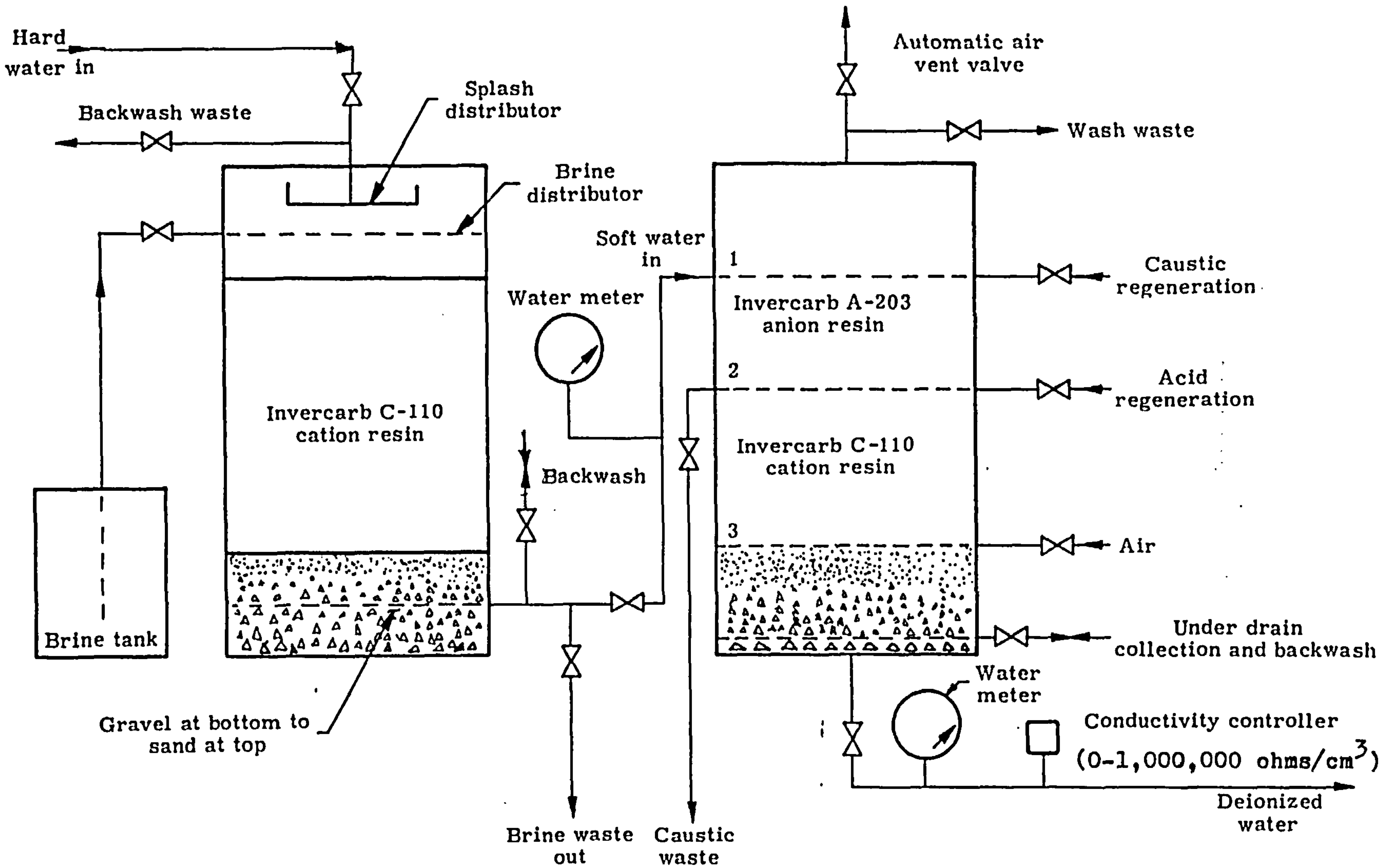
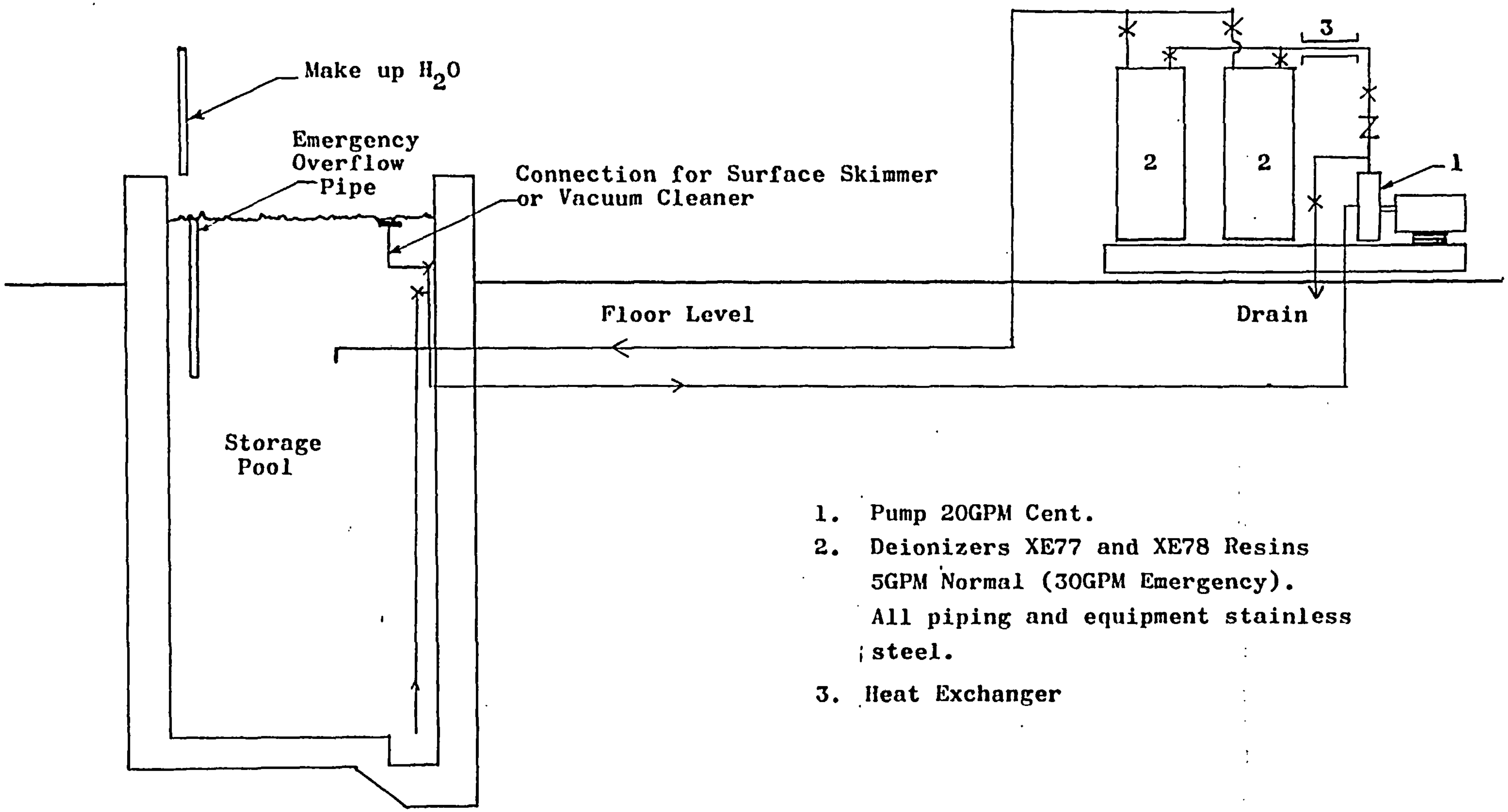


Fig. 8.2 Pool Water Supply System



1. Pump 20GPM Cent.
2. Deionizers XE77 and XE78 Resins 5GPM Normal (30GPM Emergency). All piping and equipment stainless steel.
3. Heat Exchanger

Fig. 8.3 Storage Pool Recirculation System will cut in automatically when the water pressure drops to 75 psig; however, the pump must be stopped manually.

8.4. Services

The Quehanna Facility is equipped to provide the following services:

(1) Compressed air at 125 psig obtained from an air compressor located in the machanical equipment room.

(2) Propane gas for general distribution supplied by a 1600 gallon tank located on the north side of the facility.

(3) Fuel oil for the boiler and other equipment obtained from a 15,000 gallon underground tank near the propane tank.

(4) Steam provided by the boiler in the mechanical equipment room.

(5) Plant sewerage facilities with a 2,500 gallon septic tank located underground outside the north fence.

CHAPTER 9

DESCRIPTION OF EQUIPMENT

The equipment used in a facility which processes radioactive material must be adequate to protect health and to minimize danger to life and property. This chapter of the report describes the equipment used at the Quehanna Facility. There are three main categories to be considered here; containers, devices and instruments.

9.1 Containers

9.1.1 General Description

Anything that functions to retain radioactive material and/or serves as a barrier against the dispersal of contamination may be classified as a container. Included in this category are transport storage containers, work enclosures and product vessels.

9.1.2 Transport Containers

9.1.2.1 HAPO Shipping Casks

Purified strontium-90 feed material is shipped to the Quehanna site from the Hanford Works in special casks (see Figure 9.1) designed and built for this purpose. Upon arrival at Quehanna, the cask is transferred into the isolation room of Cell 4. There are two sizes of casks used, HAPO-I and HAPO-II.

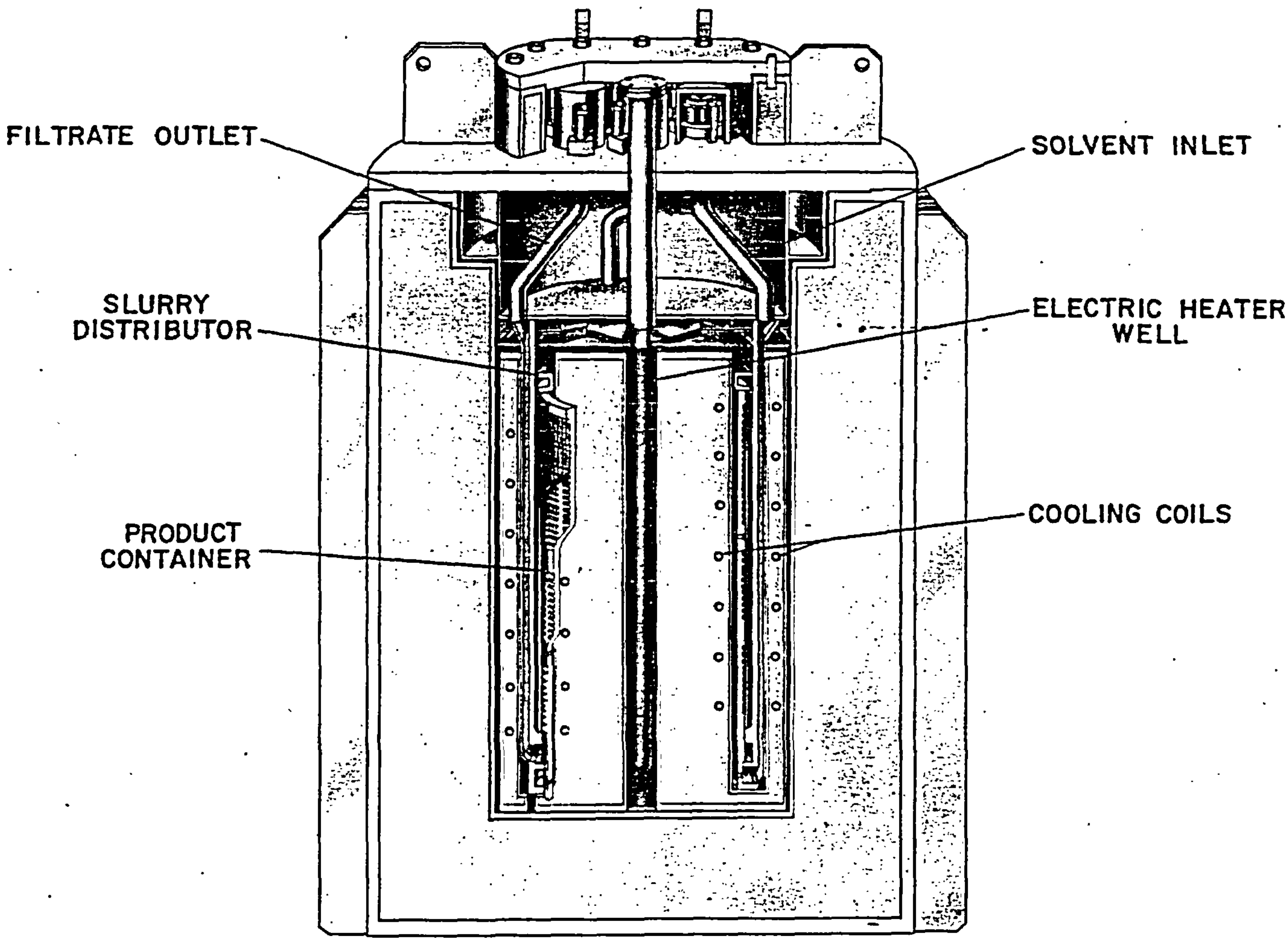


Figure 9.1 HAPO Cask

HAPO-I, the larger of the two sizes of casks, has a capacity of about 500 kilocuries of strontium-90 plus the attendant impurities. Most of the shipments to Quehanna will be made in the HAPO-I casks. The design and accident analysis for both casks are found in reports issued by General Electric Company, Hanford Atomic Products Operation (HW 77963).

HAPO-II, the smaller of the two sizes of casks, has a capacity of about 170 kilocuries of strontium-90 plus the attendant impurities.

9.1.2.2 HAPO Cask Cupola

The cupola (Figure 9.2) is fitted to the top of the HAPO shipping cask before the removal of the strontium fuel is started. Although the cupolas used do not actually hold any strontium fuel, they do serve as protective barriers to dispersal of contaminants during the dissolution procedure. Since it is made of transparent polyvinylchloride, the fittings for the feed solution, etc., may be connected while the cupola is on the cask by using the glove ports and tool port. The procedure for connection of the cupola is described in Paragraph 3.2.2.

After each cask is unloaded, the cupola is bagged and put into a waste drum for disposal. Thus each cask has a clean cupola and no decontamination of the cupola is required.

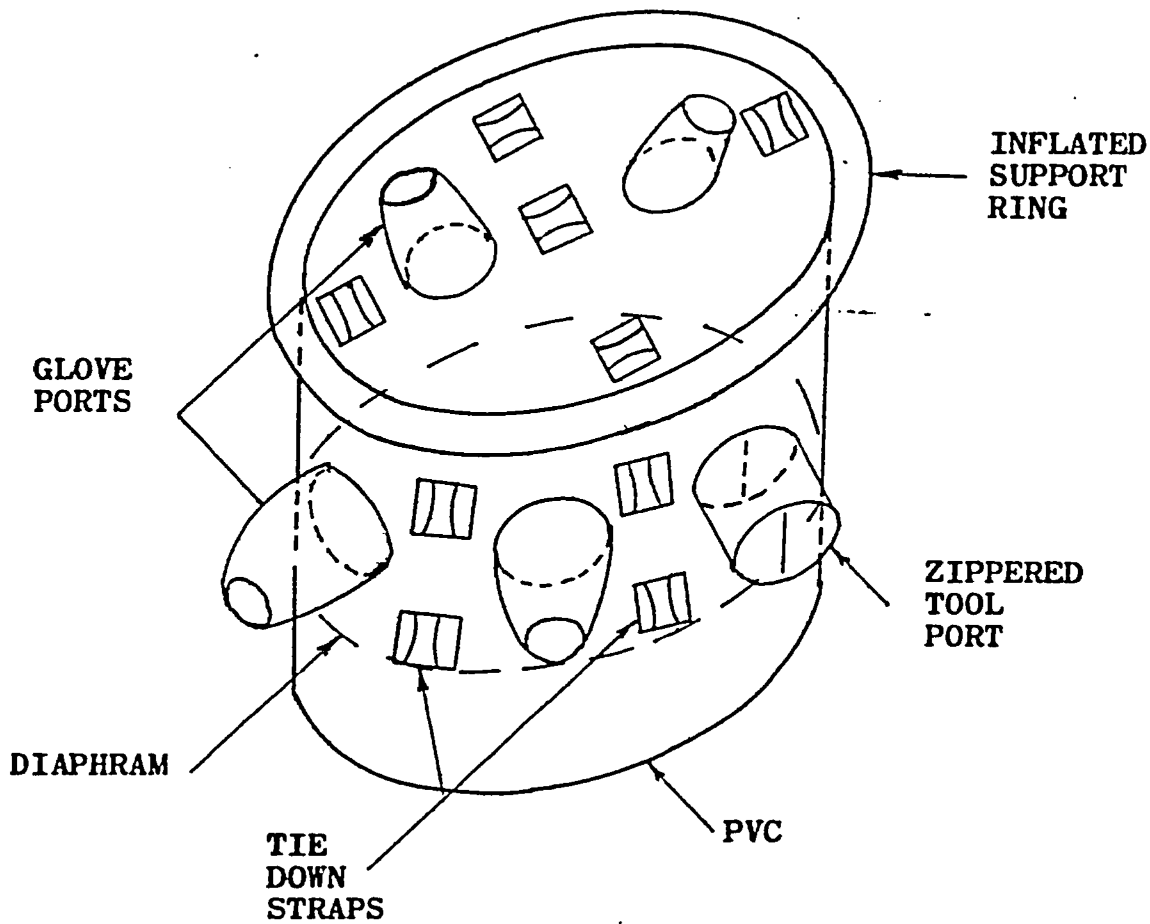


Figure 9.2 Cask Cupola

9.1.2.3 Capsule Transfer Cask

A shielded cask is used to move capsules from the Cell 5 storage to the storage pool. The description of the procedure for transfer is found in Section 3.4.

A typical cask is shown in Figure 9.3. It has 3 inches of lead shielding and is designed for transfer of one capsule at a time. A half-inch steel pin locks the cover in place and serves as a radial support in the event the cask is dropped. Any cask used will be sufficiently shielded for the safe transfer of capsules from Cell 5 to the storage pool.

9.1.2.4 Transfer Box

The transfer box is used to transport small amounts of solid waste and equipment from the process box of Cell 4 to the waste bag-out station in Cell 3. The transfer is made by using the Stationary Overhead Transfer System (SOTS).

Since the box is only used within the confines of the cells and SOTS, no independent shielding is required. The box is made of fire-retardent plywood which is approved by the Underwriters Laboratories, Inc. If equipment larger than this box has to be moved from Cell 4, a new box is made out of fire-retardent plywood or other suitable material.

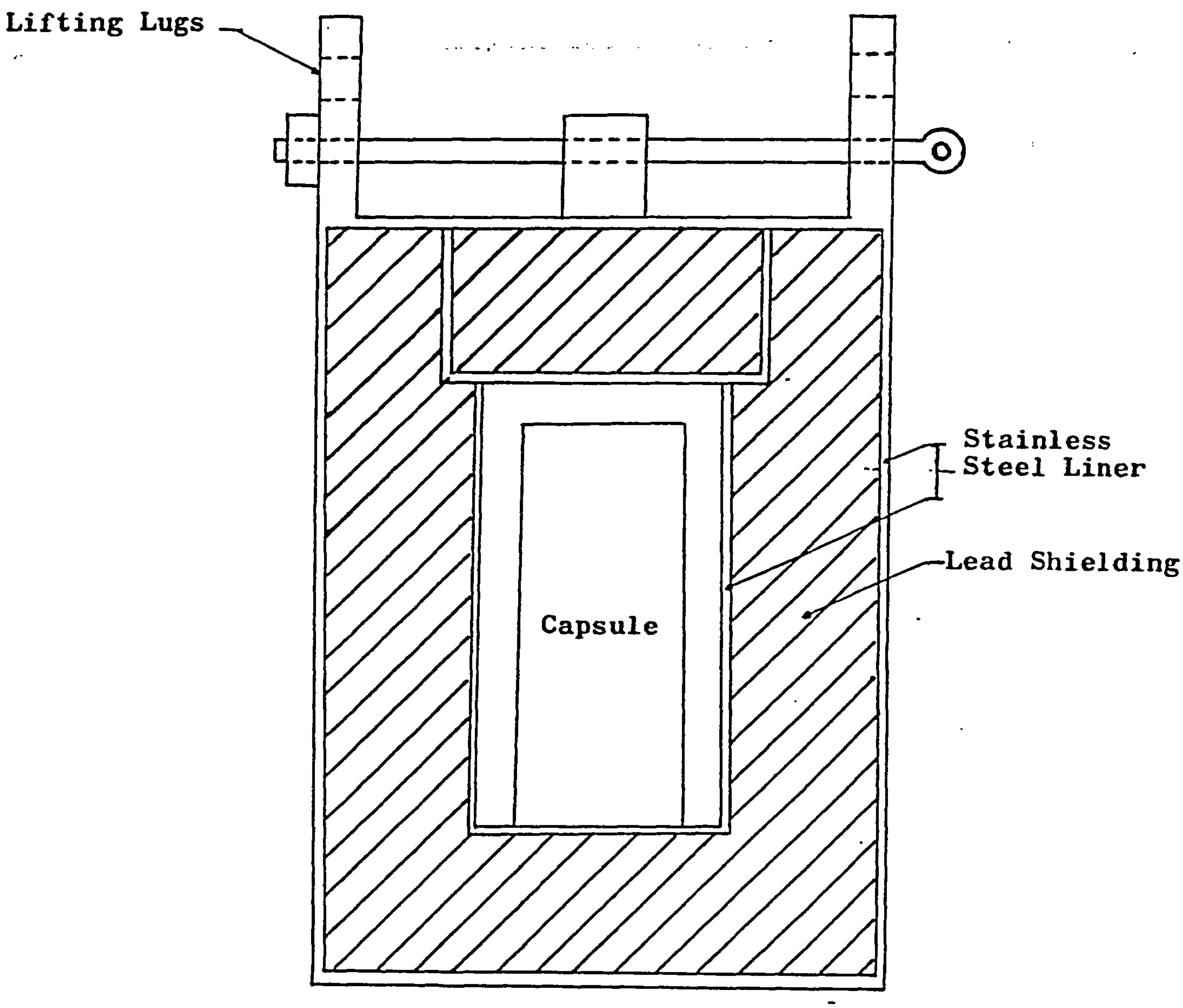


Figure 9.3 Transfer Cask

9.1.3 Storage Containers

9.1.3.1 Storage Pool

Figure 5.1 shows the location of the storage pool in the service area. Capsules are to be stored in the pool, which provides cooling. The pool is 8 feet wide, 10 feet long and 16 feet deep. Its reinforced concrete walls extend 3 feet above the service area floor. The pool is equipped with an expanded metal cover which can be locked in place. The pool is spanned by a bridge which runs on tracks mounted lengthwise atop each 10 foot wall. The bridge is positioned by hand and is used as a platform when samples are moved underwater through the use of long handling tools. The cask used to transfer the capsules (see Paragraph 9.1.2.3) is handled by the service area crane and lowered into the pool, where the capsules are removed for storage. The cask is then lifted above water level, drained, surveyed by Health Physics and removed for further use.

The storage pool is filled from the pool water supply system as described in Section 8.4 of this report. An overflow pipe which terminates one foot below the top of the pool wall leads to the suspect waste system which has a high-level alarm. Paragraph 7.1.2 describes the suspect waste system. The water in the pool passes continuously through a purification system. It is circulated at a nominal flow rate of 20 gpm from a sump sunk below the pool floor level. Then it goes through a single pump and one of a pair of deionizer tanks and then back to the pool where it is released about five feet below the top of the pool wall. A heat exchanger is added to the system when there are more than 1,000,000 curies stored.

Each of the deionizer tanks contains a removable cartridge made up of mixed anion and cation resins. No attempt is made to regenerate the resins; once then become exhausted, the spent cartridge is removed and replaced with a fresh one. The effluent from the deionizer normally contains less than 1.0 ppm total solids. A portable conductivity meter makes it possible to determine when the resins are exhausted. The deionizer units are located in the mechanical equipment room and are surrounded on 3 sides by a concrete block wall. The fourth side of the enclosure is the outside wall of the building. It is not expected that the deionizers will become sufficiently radioactive to require additional shielding; however, under emergency conditions, a shielded drum would be required for disposal of the resin cartridges.

Processed Sr-90 fuel is to be stored in the form of pellets and powder in double encapsulation, each container being separately welded and leak checked.-

9.1.3.2 Waste Containers

All solid wastes, including equipment, solidified liquid, used filters, etc., are placed in containers for shipment for burial offsite . The loading procedure is given in paragraph 7.1.1. The containers normally used are standard 55-gallon steel drums. Nested in them are 30-gallon steel drums with the space filled with concrete for shielding. The resulting concrete shield is normally sufficient to lower the radiation level to the specified maximum of 200 mr/hr at the surface, but occasionally additional shielding is required. The drums are approved by the Bureau of Explosives.

9.1.3.3 Cell 5 Fuel Storage

The encapsulated fuel is stored in a chamber which has 8 inches of lead shielding. The chamber has a remotely operated motorized door. The inner basket, in which the capsules are placed, can hold up to 49 capsules. Cooling air is drawn over the capsules by the normal and auxiliary cell exhaust at least 100 cfm.

9.1.4 Work Enclosures

9.1.4.1 Fume Hoods

There are three standard radioisotope hoods grouped along one wall of the analytical radiochemistry laboratory. There is also a stainless steel laboratory sink and stainless steel-topped work bench. Dimensions of the hoods are: width, 6 feet; depth, 3 feet; height, 4 feet. The hood interiors are fabricated of stainless steel and all working surfaces are ground and polished for easy decontamination. The hood exteriors are of mild steel with a baked enamel finish. Services for air, gas, vacuum and water are provided and are remotely controlled from outside the hoods.

The hoods are of the "airflow" type, containing double-wall end panels to achieve streamlined entrance shapes. A single removable baffle is provided at the rear of the hoods with fixed openings at top and bottom for exhausting air from within the hoods. An automatic air bypass at the top of the sash opening limits the maximum air velocity through the face of the hoods and provides for removing a constant volume of air through the hoods. The exhaust fans for the room draw the exhaust through the hoods and are running at all times. The sash opening is adjusted for safe, efficient operation at a minimum air velocity of 100 linear feet per minute (Lfpm). The maximum velocity attained through the hood opening with the sash lowered is 225 Lfpm. The exhaust system for the fume hoods is described in Paragraph 6.2.3.

9.1.4.2 Analytical Glove Box

The radiochemistry laboratory is also equipped with a glove box of stainless steel with 2 inches of lead shielding. The box sits on a stainless steel-topped bench 25 feet long, 3 feet wide, and 3 feet high, placed along the east concrete wall of the laboratory. An air exhaust hood is suspended from the wall and the ceiling, directly over the bench. After the inlet air is filtered through an absolute-type filter it enters the box and exits through the exhaust hood. The exhaust leads through an absolute-type filter and is rejected to the fume hood exhaust system described above in 9.1.4.1. The analytical glove box is used for millicurie-level analytical work.

9.1.5 **Product Vessels**

9.1.5.1 Solid Waste Bag-out System

The solid wastes are transferred using SOTS to Cell 3 where they are placed in drums for disposal. The solid waste bag-out system consists mainly of a 10 mil polyethelene drum liner, SOTS, and the waste drum. The drum liner is placed in the drum and the open top of the liner is taped to the SOTS downcomer. Then the solid waste, carried to Cell 3 by SOTS, is lowered into the liner and thus into the drum. When the drum is filled, the liner is necked down, closed with tape and sheared off so that the drum and SOTS are sealed and isolated. The drum is then closed and capped with concrete. By this method, wastes are rarely exposed directly to the atmosphere.

9.1.5.2 Process Box

The process box in Cell 4 is divided into two compartments: 4A and 4B. The walls and top of each is 1/8 inch stainless steel and the floors are made of 1/4 inch stainless steel. The greater part of the processing operations are carried out within this box.

9.2 **Devices**

9.2.1 **Manipulators and Periscope**

Standard Model 8 Master-slave manipulators are used in all five cells. The larger cells, Cells 2 and 4, are designed for four manipulators each; the small cells accept two manipulators each. All four manipulators in Cell 4 operate inside the process box, two in each of 4A and 4B.

Special booting is required for the manipulators in Cell 4. The boots consist of a mounting ring that forms an air-tight seal in a special tube on the wall of the process box, a plastic sleeve covering the entire slave arm and full gauntlet over the slave hand (Figure 9.4). The mounting ring is a unique design employing spring steel and flat springs to permit installation through the manipulator port in the cell wall. When installed, the ring occupies a very small annular space and leaves a clear opening for insertion of the manipulator. The boot sleeve is polyvinylchloride reinforced with dacron mesh or equivalent material. The gauntlet is made of heavy polyvinylchloride or similar radiation resistant material.

9.2.2 Service Area Crane

The service area crane is a 15-ton capacity Detroit unit. It is capable of being maneuvered to any location in the service area or above the cells and will clear the SOTS.

9.2.3 Stationary Overhead Transfer System

The Stationary Overhead Transfer System consists of a series of structures which when assembled form doubly-contained airtight compartments connecting the process box 4A and 4B to the bag-out station in Cell 3.

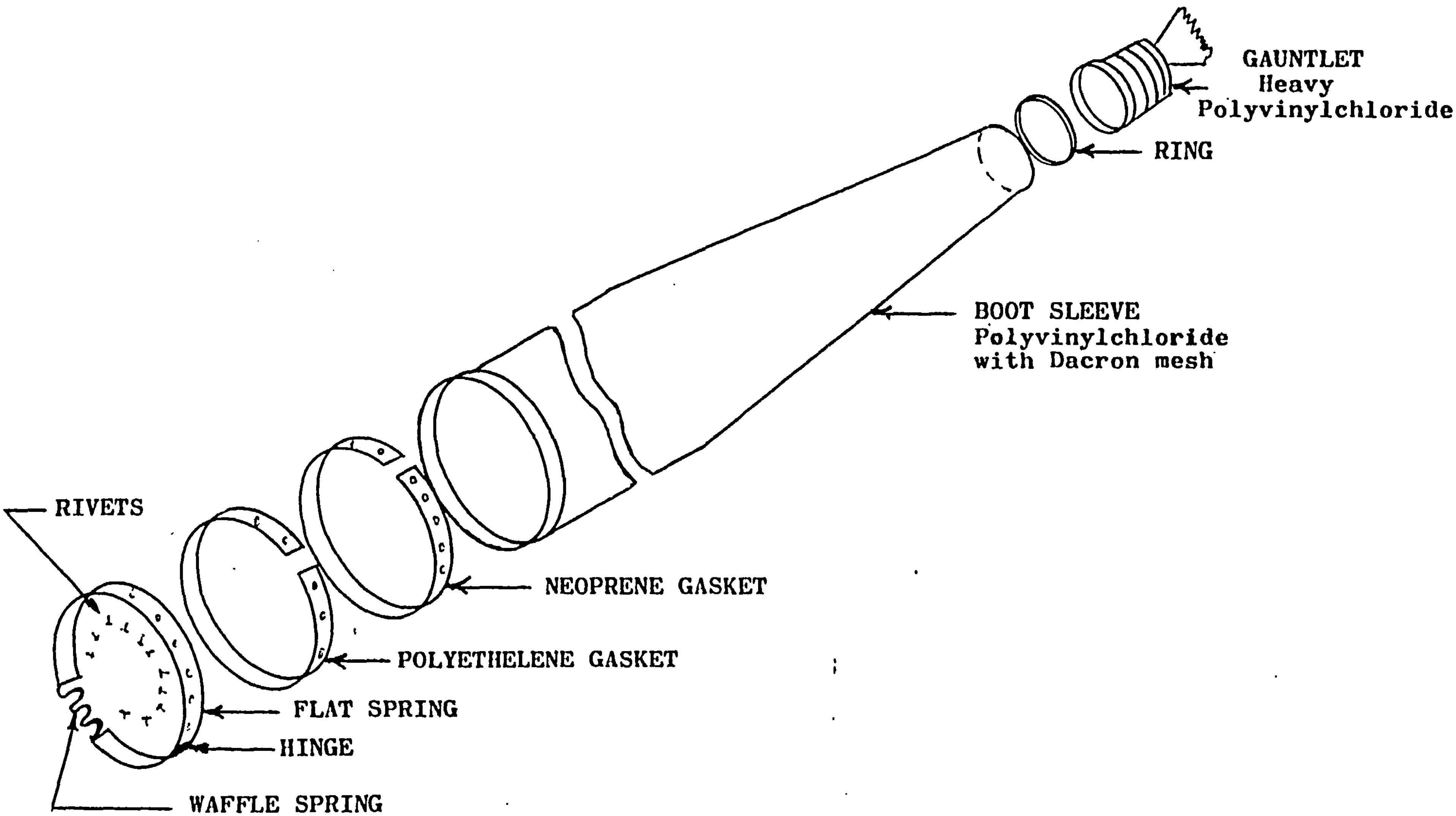


Figure 9.4 Manipulator Boot Assembly

The inner containment unit is approximately 5 ft wide, 7 ft high and 20 ft long and is fabricated of 1/16 inch aluminum. This unit has sealed, bolt-on end plates with windows so that it can be extended in either direction at a later date, and is equipped with a remote operated 2-ton hoist so that material can be moved in or out of Cells 3 and 4. The three doors from process box 4A and 4B and Cell 3 are shielded and motorized (see Figure 9.5).

The secondary containment barrier and main support for the 2-ton hoist is a concrete block wall around the inner barrier approximately 9 ft wide, 7 ft high and 22 ft long. The top has I-beams to support the hoist and is covered with an aluminum leaktight top. Ventilation details are described in Chapter 6. SOTS is equipped with two spray bars which run lengthwise between Cells 3 and 4. These facilitate washdown of the interior. The floor is tilted to provide adequate drainage into a liquid waste disposal container.

9.2.4 Fork Lift Trucks

The fork lift trucks can be used to move the waste drums. One truck is a Clark, propane powered, high-lift model with a capacity of 3,000 pounds. The other is a Raymond Electric with the same capacity.

9.2.5 Pallet Truck

The pallet truck which has been used to transport the HAPO-II casks to and from the isolation room of Cell 4 is an electric powered Automatic Transporter truck with a capacity of 15,000 pounds.

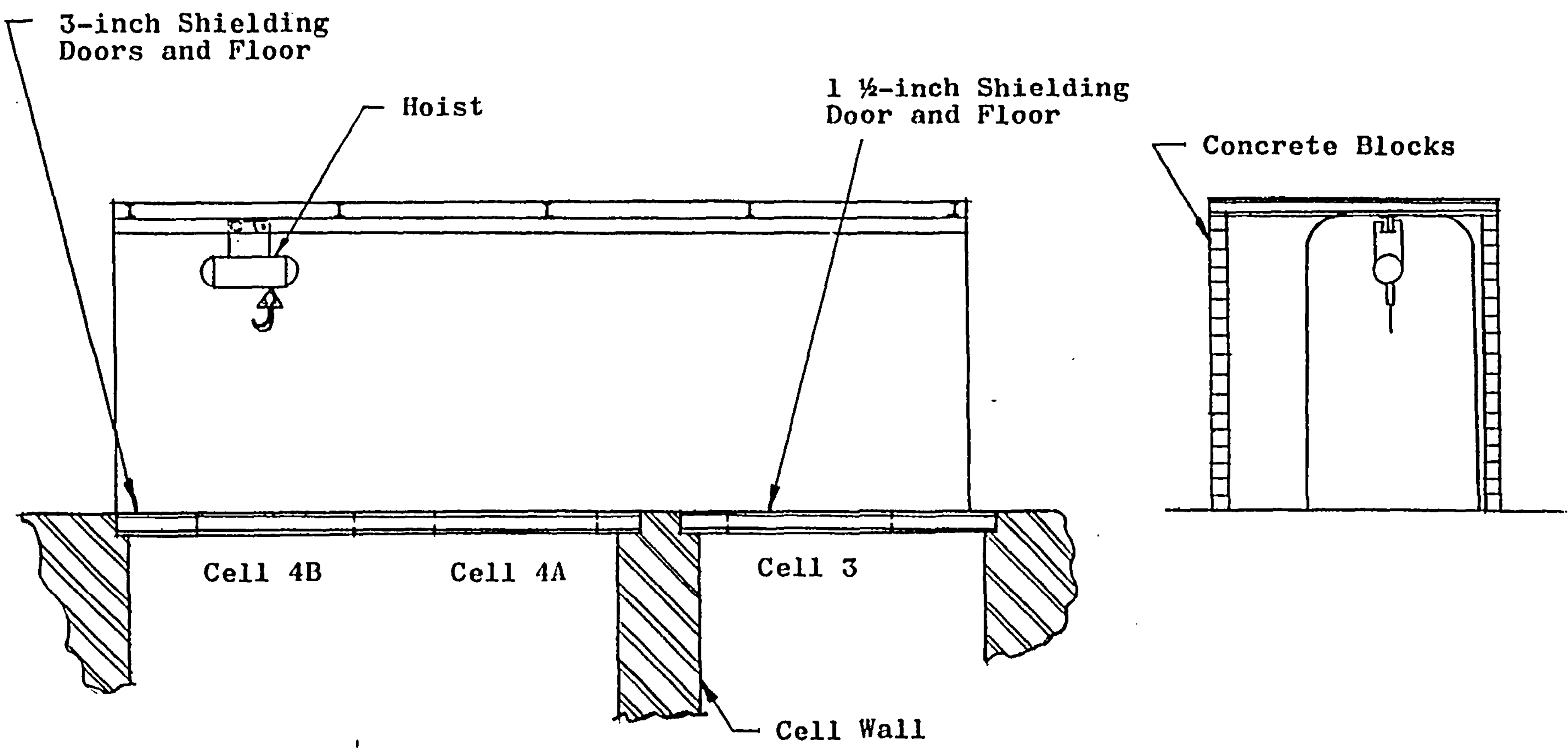


Figure 9.5 Stationary Overhead Transfer System

9.2.6 Flat-bed Truck

The flat-bed truck (see Figure 9.6) is designed to move HAPO-I or HAPO-II casks from outside the building into the isolation room of Cell 4. The four-wheeled, steerable, steel truck is 54 inches wide, 96 inches long and is capable of carrying 40,000 pounds.

9.2.7 Remote Area T.V.

A remote operated television will be installed in isolation room 4. It will be used to monitor the HAPO cask dissolution, read liquid level instruments and observe the sample box and cask cupola. It is a Model ARM 14 R Kin-tel.

9.2.8 Furnace

The Marshall electric furnace used has twelve glo-bars and six thermocouples and is remotely controlled from the operations area. The effective heating volume is 7 inches wide, 13-3/4 inches high and 16 inches long. The upper temperature limit is 1500°C and the furnace is water cooled.

9.2.9 Blender

The blender is used to mix the fuel powder so that an even consistency of powder is available for pellet pressing. The blender may be either a commercial Waring or a Y-type unit.

9.2.10 Pellet Press

The press used is a Modern Hydraulics 250-ton unit with a 12-inch ram and a 6-inch stroke.

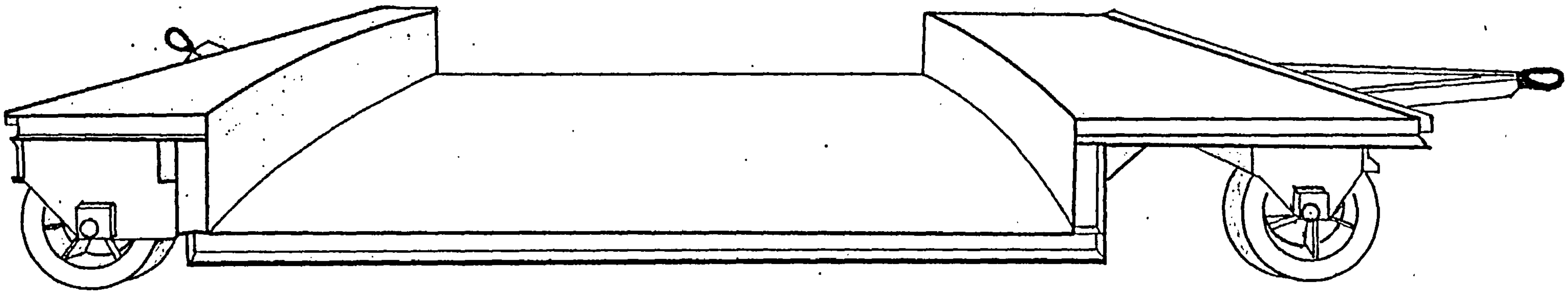


Figure 9.6 Flat-bed Truck for Transporting HAPO Cask

9.2.11 **Capsule Welder**

The capsule welder is a remote controlled, motorized unit using inert gas in a Heliarc process. The unit is Martin fabricated and is powered by a Harnisohfeger P and H power supply.

9.2.12 **Capsule Leak Detector**

The capsule leak detector is a Vacuum Electronics Corporation (Veeco) mass spectrometer unit.

9.3 **Instrumentation**

The following is a typical list of instruments used to control the process:

Use	Qty.	Make & Model No.	Type
Connects tanks and recorder for liquid level measurements	5	Foxboro Model 13A	Differential pressure cell transmitter w/316 S.S. bodies and diaphrems
Records liquid levels of tanks	5	Foxboro Model 5410-S	Liquid level recorder pneumatic single pen
Supplies air to pneumatic system	5	Foxboro IAS-FE	Indicating air set w/fixed pressure reducer and filter
Charts for various ranges on recorder	3	Foxboro Special Scales	Scale variation by separate charts

Use	Qty.	Make & Model No.	Type
Measure air flow	10	Foxboro Standard Model	Rotometer for air flow
Regulates pressure for air ventilation system	2	Foxboro Standard Model	Pressure regulator
Controls Indicating Receiver	1	Foxboro Model 41E	Indicating receiver controller w/high level contacts
Furnace Control	1	Brown	Controller recorder
Hydraulic Press Control	1	Modern Hydraulics	Electric motor, pump and pressure indicator
Welder Control	2	Harnischfeger, P & H	Heliarc, inert atmosphere
Leak Testing	2	Veeco	Mass spectrometer

CHAPTER 10

HEALTH PHYSICS PROGRAM

10.1 Introduction

The radiological safety program for the Martin Radioisotope Pilot Plant has been developed to assure maximum safety. The overall objectives of the program are to protect facility personnel and the general public.

The definition of responsibilities relative to radiological safety is essential to the safe conduct of all operations involving potential radiological hazards. All parties concerned with any activity which may involve a radiological hazard must be cognizant of their obligations. Overall responsibility for radiological safety, as for any other health or safety matter, rests with management and is discharged through management's representatives.

10.2 Health Physics Organization

The Health Physics Group at Quehanna consists of a resident Health Physicist and Health Physics technicians staffed on a level-of-effort-basis. This group is supervised by the Supervisor, Health Physics Section, Baltimore, who reports to the Director of Support Services for the Baltimore complex of the Martin Marietta Corporation.

10.3 **Overall Health Physics Responsibility**

It is the responsibility of the Health Physics Group to provide the radiological protection program required to support operational activities conducted at the Martin Radioisotope Pilot Plant.

10.3.1 **Supervisor, Health Physics Section - Baltimore**

The Supervisor, Health Physics Section is responsible for continuous surveillance of the performance of the Health Physics Group at the Quehanna Pilot Plant. He routinely visits the site to personally evaluate conditions. In addition, he investigates any anomalies in the weekly summaries or any unresolved condition mentioned in any special incident report provided by the resident Health Physicist. He discusses these special situations by phone with persons at the site who can effect correction. If deemed necessary, he makes an immediate trip to the site to attempt to resolve the problem. Furthermore, it is his duty to inform management regarding abnormal situations. He has complete freedom to cross organizational lines and discuss matters pertaining to radiation safety with any person.

10.3.2 **Resident Health Physicist**

Technical direction of the radiological protection program is the responsibility of the resident Health Physicist. This responsibility includes items such as: development of safe practice rules; review of daily Health Physics and operations log books; facilities, operations and environmental monitoring; surveillance and documentation of personnel exposures; instrument calibration and calibration source control; decontamination and waste disposal consulation and supervision, radiological safety indoctrination; emergency radiological capability; review of facility and equipment design or modification, furthermore, he submits a weekly written summary of Health Physics activities to the Supervisor, Health Physics Section - Baltimore. This summary contains a detailed resume of radiation and contamination conditions resulting from operations, and is supplemented by special reports made via telephone.

10.3.3 Health Physics Technician

Currently a Health Physics Technician is assigned to support each operating shift. His responsibility includes: conducting and documenting radiation-- contamination surveys; notifying supervision of survey results and personnel exposures; inspecting to see that operations are conducted in accordance with approved practices; recommending protective equipment requirements; notifying and consulting with the resident Health Physicist regarding non-routine operations or conditions; calibrating Health Physics instrumentation.

10.4 Control of Access to Radiation Areas

10.4.1 **Radiation Area**

The sections of the facility which are included in the radiation area are: Operations Area, Service Area, Hot Cells, Cell Isolation Rooms, Radiochemical Laboratory, Decontamination Room, Storage Area, Fan Room, and the Machine Shop. Normal access to the areas listed above is through the change room complex. All entrances to this area other than through the change room are kept locked at all times, using the lock system described in Paragraph 10.4.3.

10.4.2 **High Radiation Areas**

Certain hot cells, and isolation rooms are normally high radiation areas. Whenever radiation reaches a level such that a major portion of the body could receive more than 100 mrem/hr, the area is marked as a high radiation area and is suitably restricted. High radiation areas are controlled with a special absolute integrity locking system in lieu of the control device specified in 10CFR20.

10.4.3 **Lock System**

The lock system used is manufactured by Best Universal Lock Company, Indianapolis, Indiana. This system is utilized at several AEC installations and is designed for maximum security. Significant features which make it suitable for controlling "high radiation" and/or "radiation" areas are:

10.4.3.1 Key blanks are of a special design and are not obtainable by unauthorized personnel, therefore, it is not possible to have a key duplicated without proper authorization.

10.4.3.2 The manufacturer will supply locks, keys, and combinations for keys only upon the written authorization of the person who has been designated to control the system.

10.4.3.3 The hardware is very sturdily constructed.

10.4.3.4 The combinated core of any lock in the system can be changed immediately by the person controlling the system. This makes it possible to restrict access to those persons holding a particular key or to prevent access completely. It also allows immediate renewal of the locking system integrity should any key be last.

10.4.4 Administration of the Locking System

The integrity of the locking system is maintained by the following administrative steps:

10.4.4.1 The authority to procure locks, cores, keys, or combinations is restricted absolutely to the Supervisor, Health Physics Section.

10.4.4.2 Alteration of the system installation or removal of locks, or issuance of keys is done by the resident Health Physicist only under a written order from the Plant Manager. A complete record of key receipts and issuances is kept by the resident Health Physicist. All keys and cores are accounted for and an audit of keys including a check of the keys in the possession of the users is conducted quarterly by the resident Health Physicist. The results of the inventory are reported to the Plant Manager and the Supervisor, Health Physics Section - Baltimore.

10.4.4.3 Radiation areas are divided into four categories for controlling access:

10.4.4.3.1 Areas where radiation levels are less than 100 mr/hr - access by facility operation and support personnel.

10.4.4.3.2 Areas where radiation levels are greater than 100 mr/hr but less than 25 r/hr - access by shift supervisor.

10.4.4.3.3 Areas where radiation levels are greater than 25 r/hr - these areas are locked with two separate locks, one of which is controlled by the shift supervisor and one by the Health Physics representative on duty. Both locks must be unlocked in order to gain access.

10.4.4.3.4 Areas requiring special control - access to these areas requires the concurrence of the Plant Manager or the resident Health Physicist with their physical presence.

10.4.5 <u>Radiation Work permit</u>

All activities in "Radiation or High Radiation Areas" are performed in accordance with standard operating procedures. Work performed in these areas requires special authorization in the form of a Radiation Work Permit (RWP).

The RWP is a written instruction sheet that is issued prior to the start of an operation in radiation areas and includes items such as: description of the job, results of the most recent surveys, maximum work time for locations within the area, required protective equipment and personnel monitoring devices, special instructions, approval to start work, signatures of the shift supervisor and the Health Physics representative. The operations supervisor is responsible for initiating the RWP. Health Physics is then notified for pertinent instructions,/preoperational surveys and approval. Once the RWP is in effect, the Health Physics representative ~~provides~~ on-the-job monitoring, as required, depending upon the type of operation and sees that no one enters the work area other than authorized personnel. The RWP becomes void at the conclusion of each job and is returned to the operation Supervisor for filing and retention.

10.4.6 Summary of Operations Requiring Health Physics Monitoring

Survey and control procedures are utilized to effectively limit personnel exposures. Surveys are made to determine external dose rates, the presence or absence of surface contamination and airborne concentrations in work or occupancy areas. Typical operations that require monitoring include: receipt of HAPO cask, HAPO cask installation for dissolution, removal of HAPO cask and preparation of empty cask for return to Hanford, process Sr-90 feed materials, feed sample analysis, radioactive waste handling and shipment, intercell transfer, storage of encapsulated fuel, generator loading operations, and shipment of fueled generators.

10.5 Description of Survey Techniques

Health Physics conducts daily radiation - contamination surveys in the facility. A variety of instruments are available capable of monitoring all ranges of contamination and/or radiation encountered. Any unusual levels are reported to supervision and proper precautions are taken to reduce personnel exposures. The shift supervisor initiates decontamination procedures, and a resurvey of the area is conducted when decontamination is completed. Additional radiation surveys are performed as required to support operational activities.

The individual conducting the survey wears the required protective clothing and equipment as described in 10.7.4 and personnel monitoring equipment described in 10.6.2 and proceeds to make measurements of external radiation and airborne, loose or fixed contamination. The Health Physics representative provides continuous evaluation of the radiological conditions while the job is in progress.

10.5.1 External Radiation Measurements

The measurement of external radiation levels is performed with portable monitoring instruments. A list of the instruments available is contained in Table 10.1 including their detection range and specific uses. Portable instruments are frequently checked in the field utilizing a reference source. Malfunctions are reported to the instrument repair technician.

10.5.1.1 Minimum Routine Survey Schedule

Location	Radiation	Contamination
Operating - Shop Area	Weekly	Daily
Service Area	Weekly	Twice Weekly
Cell Faces	Weekly	Weekly
Iso Rooms	Upon Entry	End-of-Operation
Radio Chem. Lab	Weekly	Twice Weekly
Decon Room	Weekly	Weekly
Change Room	-	Daily
Liquid Waste Bldg.	Weekly	Weekly
Waste Storage Bldg.	Weekly	Weekly
Office Areas	-	Weekly
Lunch Room	Twice Weekly	Twice Weekly

10.5.1.2 Posting Areas

All radiation and high radiation areas are posted with the appropriate warning signs. These areas are surveyed periodically in order to update or change the signs depending on conditions.

TABLE 10.1

Type of Instrument	No. Avail.	Radiation Detected	Window Material and Thickness	Sensitivity Range	Use
NMC AM22R Particulate Monitor	4	Alpha, Beta-Gamma	Gas flow proportional 1/4 mil mylar less than 2 mg/cm^2	10^{-12} $\mu c/ml$ alpha or beta-gamma	Monitoring and Measuring
NMC AM2A Air Particulate Monitor	1	Beta-gamma	Gas flow proportional 1/4 mil mylar less than 2 mg/cm^2	10^{-12} $\mu c/ml$ beta-gamma	Monitoring and Measuring
Area Radiation Monitoring System-Jordan Rams II Ion Chambers Md. 50 LS and 1 LS	1	Gamma	Metal wall ionization chamber	3 stations 1-1000 mr/hr 2 stations 10 - 10,000 mr/hr	Monitoring
Gas flow proportional detectors: NMC Md PCC10 Eberline MD RC4-4	 2 1	Alpha, Beta-Gamma	Gas flow proportional 1/4 mil mylar less than 2 mg/cm^2	1 to 10^6 dpm	With scaling assembly for measuring
Geiger Tube Detectors: End window tubes mounted in lead shields	3	Beta-Gamma	Mica end window 1.4 mg/cm^2	10 to 10^6 dpm	With scaling assembly for measuring
Scaling Assemblies: Baird Atomic Md 1050 Tracerlab Md SC 73 Eberline MD PC-6	6			10^6 cpm	With detectors for measuring

TABLE 10.1 (Cont.)

Type of Instrument	No. Avail.	Radiation Detected	Window Material and Thickness	Sensitivity Range	Use
Count rate meters G.M. Tracerlab SU-3D	2	Beta-gamma	Mica End Window 1.4 mg/cm^2	0-20,000 cpm	Monitoring and Measuring
Count Rate Meters, G.M. Eberline RM-3	3	Beta-gamma	30 mg/cm^2 Metal Wall	0-50,000 cpm	Monitoring and Measuring
Victoreen Thyac G.M. Md. 489	2	Beta-gamma	30 mg/cm^2 Metal Wall	0-20 mr/hr (0-80,000 cpm)	Monitoring and Surveying
Victoreen Md 740 Cutie Pie Ion Chamber	1	Beta-gamma	1/4 mil mylar less than 2 mg/	0-10,000 mr/hr	Monitoring and Surveying
Eberline E-500 B G.M Meter	4	Beta-gamma	30 mg/cm^2 Metal Wall	0-2000 mr/hr	Monitoring and Surveying
NuCor CS-40 ionization Chamber Meter	1	Beta-gamma	75 mg/cm^2 plastic wall	0-20,000 mrad/hr	Monitoring and Surveying
NuCor CS-40A ioniztion chamber meter	4	Beta-gamma	75 mg/cm^2 plastic wall	0-50,000 mrad/hr	Monitoring and Surveying
Technical Associates CP-TP-1A ionization Chamber Meter (extended prove)	1	Beta-gamma	6 mg/cm^2 window 432 mg/cm^2 wall bakelite	0-500 rad/hr	Surveying

TABLE 10.1 (Cont.)

Type of Instrument	No. Avail.	Radiation Detected	Window Material and Thickness	Sensitivity Range	Use
NuCor DA-3 (R) ionization chamber meter (extended probe)	1	Gamma Beta-gamma	Aluminum Chamber Paper chamber, less than 10 mg/cm^2 Savannah River Modification	0-5000 r/hr 0-5000 rad/hr	Surveying Surveying
Technical Associated Model ALM-2 Hand-Foot Counter Geiger Tubes	1	Beta-gamma	30 mg/cm^2 Metal Wall	0-2,000 cpm	Monitoring
Victoreen Model 570 Condenser R-Meter Chambers #651, 228, 552, 576 Calibrated at NBS	1	Beta-gamma	7 to 450 mg/cm^2 Kodapak, Bakelite, Nylon	250 mr to 250 r	Measurement (Secondary Calibration Standard)
EMERGENCY EQUIPMENT LOCATED OUTSIDE THE FACILITY					
G-M Detector Scaler Assembly B.A. 1050 Scaler	1	Beta-gamma	MICA End Window 14 mg/cm^2	$10-10^6$ dpm	Measuring - Emergency
Count-ratemeter GM Tube NCA Model DMID	1	Beta-gamma	30 mg/cm^2 Metal Wall	$0-10^5$ cpm	Monitoring and Surveying-Emergency

EMERGENCY EQUIPMENT LOCATED OUTSIDE THE FACILITY (Cont.)

Type of Instrument	No. Avail.	Radiation Detected	Window Material and Thickness	Sensitivity Range	Use
Victoreen C-D Model 720C Ionization Chamber	3	Beta-gamma	Aluminum, 30 mg/cm^2	0-500 r/hr	Monitoring and Surveying
Victoreen Thyac G.M. Tube	1	Beta-gamma	30 mg/cm^2 Metal Wall	0-20 mr/hr 0-80,000 cpm	Monitoring and Surveying - Emergency
Bendix Dosimeters Models 862 and 611 + Charger	12	Gamma		0-200 mr 0-5 r	Monitoring - Emergency
Film Packets	15	Beta-gamma		5 mr - 600 r	Monitoring - Emergency

10.5.2 <u>Fixed Area Radiation Monitoring System</u>

Overlapping high and low level area radiation monitoring systems are installed. The low level system consists of three detector units with ranges from 1 mr/hr to 1 r/hr located in the operating area, service area, and the radiochemistry laboratory. These units are set to alarm above 10 mr/hr and are connected into a central annunciator panel which activates both a horn and light. The two high level units, with ranges from 10 mr/hr to 10 r/hr, are located in the operating and service areas. These units are connected into the building evacuation alarm siren and ~~are set~~ to alarm above 1 r/hr.

10.5.3 <u>Facility Contamination Measurements</u>

Contamination of areas falls into two broad categories; namely, surface and airborne contamination. Surface contamination in turn is classified as fixed and loose. Separate measurements are necessary to fully evaluate the degree of hazard.

10.5.3.1 Monitoring for Surface Contamination

Smears are used for monitoring loose surface contamination. Geiger-Mueller survey meters, are generally used for detecting and measuring fixed contamination.

10.5.3.1.1 Procedure for Monitoring Loose Surface Contamination

A dry porous paper (smear) is wiped over a standard area (approximately 100 cm^2) of surface being monitored. Precautionary measures are employed when smearing areas where a high degree of contamination is suspected. Used smears are placed in paper smear holders to prevent cross contamination. The smears are monitored for gross contamination with a G. M. count ratemeter unit before they are taken to the counting room for a more refined analysis. Care is exercised in order to avoid contaminating counting equipment.

10.5.3.1.1.1 Counting Smears

Smears are counted for beta-gamma activity utilizing a Geiger tube detector/scaler assembly. The length of count depends upon the activity present on the smear and the counting accuracy required. Most smears are counted for one minute. A diagram indicating location of the smear, instrument reading and contamination level is given to the shift supervisor who initiates decontamination as required. Areas that cannot be immediately decontaminated are marked accordingly and entrance is restricted to authorized personnel wearing the specified protective equipment.

10.5.3.1.2 Procedure for Monitoring Fixed and Loose Surface Contamination. Monitoring for fixed beta-gamma contamination is performed using a G. M. survey meter. The activity indicated is a measure of both fixed and loose surface contamination unless the loose contamination has already been removed. Measurements are made holding the G. M. probe approximately one-half inch above the surface being assayed. The fixed beta-gamma contamination levels are generally expressed in terms of mrad per hour.

10.5.3.2 Monitoring for Particulate Contamination in Air

Continuous air monitors and fixed filter air samplers are used to determine the concentration of airborne radioactivity. Sampling for airborne radioactivity is accomplished by drawing a known volume of air through a filter paper capable of entrapping extremely small particles. The paper used is greater than 99% efficient for particulates greater than 0.3 microns in diameter. The filter paper is then removed from the air sampler or continuous air monitor, scanned for approximate degree of activity, then placed in a gas proportional detector/scaler assembly to precisely measure the degree ~~of~~ radioactivity collected. A calculation is then performed to determine the airborne concentration. This method is capable of detecting less than 1×10^{-11} uc/ml.

10.5.3.2.1 Continuously Monitored Filter Paper Samplers

Filter paper samplers with gas flow proportional detectors and count rate displays are used to continously monitor air exhausted from the processing areas, work areas and the facility exhaust system. Four of these units monitor both alpha and beta-gamma activity in the air and alarm upon a change in ratio between the alpha and the alpha-plus-beta-gamma count rate.

10.5.3.2.1.1 Continuous Air Monitor Sample Locations, Controls and Interlocks

Four continuous air monitors sample and control the air handling systems to minimize dispersal of radioactive contamination from the cell areas to other parts of the facility. Reference Figure 6.2 Air Handling System.

10.5.3.2.1.1.1 Monitor No. 1. (M-1)

This unit monitors the air in the combined discharge duct from the process box exhaust fan and on indication starts Fan E-14 and stops the normal Fan E-13, at the same time the individual dampers are activated and an alarm is sounded on the alarm panelboard in the operating area.

10.5.3.2.1.1.2 Monitor No. 2 (M-2)

This unit monitors the air in the combined cell exhaust duct and on indication starts auxiliary Fan E-4, opens auxiliary motorized exhaust dampers, stops all normal cell exhaust Fans E-5 through E-10 and closes all normal exhaust dampers. At the same time, air supply Fans SH-2, UC-2 and exhaust Fan E-11 are shut down.

10.5.3.2.1.1.3 Monitor No. 3 (M-3)

This unit monitors the air in the service area and on indication stops air supply Fans SH-2, UC-2 and exhaust Fan E-11.

10.5.3.2.1.1.4 Monitor No. 4 (M-4)

This unit monitors the air entering the recirculating duct in the operating area, and on indication stops air supply Fans SH-2, UC-2 and exhaust Fan E-11.

10.5.3.2.1.1.5 Monitor No. 5 (M-5)

This unit is used to monitor for sudden changes in airborne contamination during various operations in the service area, isolation rooms, radiochemical laboratory or decontamination area. Since the unit is transportable, it is not interlocked to any particular system and is moved to the best sampling locations to monitor individual operations in progress.

10.5.3.2.2 Fixed Filter Paper Samplers

A central vacuum system adjusted to sample at a rate of 1 cfm per sampling point, is used to collect samples from various locations in the air handling system to evaluate the performance of the ventilation system filters. (Reference Figure 6.2 Air Handling System). These filter paper air samples are normally changed and radioassayed daily from approximately thirty different locations making it possible to detect ventilation system filter deterioration so that corrective action can be taken before a serious problem develops. Small low volume air pumps are used to collect fixed filter paper air samples from each stack discharging to atmosphere. In addition, another unit is used to sample outside air.

10.5.3.2.2.1 High Volume Air Samples

Grab samples of air are collected prior to, during, and after various operations which may produce airborne contamination. A small high rpm motor is used to draw a high volume (up to 20 cfm) of air through a four inch diameter filter paper. These samples are evaluated in order to determine the airborne contamination levels. Sample times for the collection of high volume air samples vary from 5 to 20 minutes.

10.5.3.2.3 Counting Air Samples

Filter papers used to collect samples of particulate airborne radioactivity are counted utilizing gas flow proportional detector/scaler assemblies. High volume air samples are counted in a large area gas flow proportional detector which is capable of accepting the entire filter paper.

10.5.3.3 Monitoring for Liquid Contamination

Water samples are collected and analyzed for gross beta-gamma activity from the potable water supply, the source storage pool, nearby streams and liquid waste holdup tanks.

10.5.3.3.1 Description of Water Sample Preparation and Counting

A 500 to 1,000 ml water sample is evaporated to approximately 10 ml; transferred to a planchet and evaporated to dryness. The planchet is counted for gross beta-gamma activity in a gas flow proportional detector/scaler assembly. Results of sample analysis are recorded in μc/ml. The procedures utilized allow detection of less than 1×10^{-8} μc/ml.

10.5.4 Records

Radiation and contamination survey results are recorded on sketches of the areas where the survey was performed and are filed in the Health Physics Office.

Air samples results are recorded on air sampling record forms and also filed in the Health Physics Office.

Liquid sample results are also maintained in the Health Physics Office with the exception that Pennsylvania State University maintains the original copy of the results of liquid radioactive waste discharged to the environs.

10.6 Personnel Monitoring

Individuals entering the facility are provided with a personnel monitoring device(s) for determinating radiation exposure. Knowledge of general dose rate and exposure time gives an estimate of personnel exposure, but a more accurate determination is made utilizing personnel monitoring equipment.

10.6.1 Analysis of Exposures

Correlation of job assignments with doses received by individuals sometimes indicates a need for revision of certain job procedures or further training of personnel in the interest of minimizing radiation exposures.

10.6.2 Types of Personnel Monitoring Devices

Two types of personnel monitoring devices, namely film badges and pocket dosimeters, are currently used to provide information regarding personnel exposure.

10.6.3 Description of Film Badge and Film

The film badge currently used at the facility can accommodate two film packets, but is used to hold one Dupont Type 558 film packet for X, beta and gamma radiation detection. The front portion of the badge contains a metallic filter and clear plastic windows used for photon energy determination and distinguishing between beta and gamma radiation. The film is dated adjacent to the clear plastic window to indicate the wearing period. The wearer's name, and identification number are conspicuously displayed on the front of the badge.

10.6.3.1 X, Beta and Gamma Film

Dupont Type 558, or equivalent personnel monitoring film, is used to measure exposures at this facility. This packet contains the sensitive type 508 and the insensitive type 1290 giving a useful dose range up to 600 rem.

10.6.4 Wearing Film Badges

All personnel requiring access to or working in posted radiation areas, or handling radioactive or contaminated materials in or adjacent to the facility are required to wear film badges. These badges are normally worn clipped to outer clothing. During operations where contamination is likely to be present, film badges are worn on innermost clothing to avoid contamination of the badge.

10.6.5 Loss of Film Badge

Any person who loses his badge has been instructed to immediately notify Health Physics to obtain a replacement. Any lost or damaged film badges would be investigated by Health Physics to determine the exposure for the unmonitored period and a report would be written for the personnel monitoring records.

10.6.6 Issuance and Frequency of Film Badge Exchange

The loaded film badges, along with control badges, are placed on racks at a convenient point for their distribution. Operating personnel have been cautioned to occasionally check to see that they are wearing their assigned badge.

At the termination of the work period, all personnel are responsible for returning their badges to the distribution rack. Personnel have been instructed not to take their badge with them when leaving the site.

The frequency of film badge exchange is established by Health Physics and is based upon type of the work being done and anticipated exposures. The normal exchange period is one week, however it is not anticipated to extend it beyond two weeks. At the end of the prescribed wearing period, the used badges are replaced and are submitted for evaluation.

10.6.7 Film Processing

All film badges are checked for contamination prior to submitting the film for processing. Any evidence of contamination is noted and an attempt is made to decontaminate the badge and determine the true exposure. Film badges may be submitted at any time for evaluation. The film processor currently retained under contract is Health Physics Services, Baltimore, Md.

10.6.8 Reports and Records

When film has been processed and the exposure evaluated, the completed radiation report form is sent to the resident Health Physicist; a duplicate copy is sent to the Baltimore Health Physics Office. The current exposure information is transposed to the individual's own exposure report form where a cumulative exposure record is brought up to date. A record of all personnel exposures is kept on file for a period in accordance with 10CFR20.

A comprehensive report of all statutory overexposure incidents will be submitted to management by Health Physics. This report will include an analysis of the cause, and when possible recommendations to prevent recurrence of the incident. Copies of this report will be submitted to the Commission in accordance with the requirements as set forth in 10CRF20.

10.6.9 Other Uses for Film Badges

Film badges are used for area monitoring, monitoring of personnel extremities, and checking film badge service evaluation.

10.6.10 Use of Pocket Dosimeters

Pocket dosimeters are available in the ranges of 0-200 mr, 0-1r and 0-5r, and are worn in accordance with instructions from the Health Physics representative on duty. Usually one low range and one high range dosimeter are worn when conducting work in radiation areas.

10.6.10.1 Issuance and Handling of Pocket Dosimeters

Pocket dosimeters are charged and issued by Health Physics personnel. Each person receiving a dosimeter is instructed to read it periodically and to report the reading to his supervisor or the Health Physics representative on duty. At the end of the work period, the dosimeters are returned to Health Physics and the readings are recorded in the Health Physics log book.

10.6.11 Medical Examination

All employees are required to submit to a medical examination prior to work in areas where ionizing radiation exposure may be involved and routine examinations are conducted periodically thereafter. Special medical examinations are required in the event of unusual or suspect exposures. Arrangements have been made for a nuclear medical consultant to perform these special examinations. Copies of records of all medical exams are retained by the medical department in Baltimore.

10.6.12 <u>Bioassays</u>

Bioassay samples are submitted for analysis by all personnel working with radioactivity. During the early months of hot operations bioassay samples were collected and analyzed on a frequent schedule, and the results were used to establish the present sampling schedule. The exact sampling schedule is governed by the type of work performed and the potential for internal contamination based upon ~~surveys~~. In any event, all persons working with or exposed to radioactive material are sampled at least quarterly. If an individual is known or suspected to have been exposed to radioactive contamination in such a manner that internal deposition is likely, an estimate is made of the internal dose for inclusion in the individual's radiation exposure record. If in a more accurate determination of the body burden is required, arrangements shall be made to utilize a total body counter.

10.6.13 <u>Records</u>

Records of all bioassay results are maintained at Quehanna and Baltimore and are posted in each individual's file.

10.7 Personnel Protective Clothing and Equipment

Any equipment which aids in preventing the deposition of radioactive contaminants onto or within the body may be considered anti-contamination protection. Protective clothing provided by the company is worn when access to a contaminated area is required, or there is a possibility of the release of contamination as the result of some operation. The Health Physics representative on duty shall specify the minimum type and items of protective clothing to be worn and shall inspect their use. This equipment is stored in the change room and is donned prior to entry into contaminated areas.

10.7.1 Protective Clothing

10.7.1.1 Plastic and/or rubber shoe coverings are worn whenever contamination is expected. Coveralls are tucked into the shoe covers and taped prior to entering highly contaminated areas.

10.7.1.2 Gloves are normally worn in areas where contamination may be present. The gloves are taped to the sleeves prior to entering highly contaminated areas. Rubber gloves are always worn when dealing with contaminated liquid.

10.7.1.3 Hoods or caps are used to prevent contamination of the head. Plastic hoods are used in cases where liquid contaminants may be present.

10.7.1.4 Cotton coveralls are issued for protection of the whole body against dry contamination. Coveralls are rarely worn over personal clothing except undergarments.

10.7.1.5 Plastic suits are worn over the coveralls whenever liquid contamination is anticipated or suspected and also worn as outer garments over coveralls when entering highly contaminated areas.

10.7.2 Breathing Equipment

The following types of respiratory protective equipment are available:

(a) Full Face Respirator - Mechanical Filter Type

(b) Scott Pressure Damand Hose Line Equipment

(c) Supplied Air Plastic Hood - Continuous Flow Type

(d) Scott Air Paks - Positive Pressure Facepiece

(e) MSA - Chemox

} (d) and (e): Maintained as part of the emergency equipment.

All personnel receive instructions on the proper use of respiratory protective equipment. Such aspects as the proper fitting of filter elements, damage to filter elements, proper fit of the mask to the face, etc. are emphasized. Personnel are instructed to wear mechanical filter type full face respiratory equipment whenever a potential exists for airborne contamination. The efficiency of the respirator filter units are checked by the manufacturer before shipment. All respiratory equipment is inspected by Health Physics before use for mechanical integrity. It is felt that careful inspection and use is adequate to guarantee the effectiveness of the mechanical filter type respirators since they are not used where air concentrations could result in serious overexposure to the wearer.

Scott pressure demand hose line equipment or supplied air-plastic hoods are used when the preoperational survey indicates air contamination in excess of MPC or the concentration is expected to be highly variable. Scott pressure demand hose line equipment consists of a full facepiece, short length of flexible tubing, an air flow control device designed to maintain a slight positive pressure in the facepiece, an air supply hose equipped with quick disconnect fittings, pressure reducing regulator and compressed air supply.

Supplied air plastic hoods consist of either a plastic hood fastened at the chest and back and worn beneath the upper portion of a two piece plastic suit with the hood taped at the collar of the plastic jacket, or a hooded plastic blouse. The hood being an integral part of the upper portion of the plastic suit. The plastic air supply hose is introduced through the back at the waist and extends upwards through the hose retaining channel in the hood and terminates above the forehead.

The hose is fastened at the top of the hood and at the waist to prevent accidental removal. The plastic air supply hose used is a continuous piece equipped with a quick disconnect fitting connected to an air flow regulator and subsequent air supply. During use, the air supply is adjusted to maintain a minimum flow rate of 6 cfm through the hood. Currently the compressed air supply, used exclusively for breathing air, consists of a bank of cylinders interconnected to allow exchange of cylinders during use without interuption of air supply. This air supply is located outside the work area and is continuously attended when in use.

10.7.3 Classification of Protective Clothing and Equipment

Table 10.2 presents the protective equipment classifications currently utilized at the facility. The Health Physics representative on duty specifies the class of protective clothing to be worn by individuals entering contaminated areas. The protective equipment prescribed is determined on the basis of the preoperational survey or prior operational experience.

10.7.4 Description of Entry Into Radiation - Contamination Areas

10.7.4.1 The protective equipment specified by the RWP is obtained in the change room area. Certain items of equipment are donned in the change room.

TABLE 10.2

CLASSES OF PROTECTIVE CLOTHING

Class	Cover-Alls	Head Cover	Shoe Cover	Gloves	Plastic Jacket and Trousers	Full-Face Respir-ator	Plastic Hood Supplied Air or Airline Respirator	Surface Contami-nation Level	Potential for Airborne Contamination Due to Nature of Work
1	Cover-alls or Lab Coats		X	Depends upon work				< 500 dpm	None
2	X	Cap	2 pr	X				> 500 dpm < 5000 dpm	Measured <MPC not expected to exceed MPC
3	X	Plas-tic Hood	2 pr	2 pr	X	X		> 5000 dpm	Measured <MPC may exceed MPC but <50X
4	2 pr	Plas-tic Hood	2 pr	2 pr	X		X	> 5000 dpm	Measured >MPC variable and could be >50X

10.7.4.2 Personnel monitoring equipment, including any supplementary film badges, wrist badges and dosimeters as specified, is attached in the change room.

10.7.4.3 Personnel proceed to the general work area and assemble all necessary equipment such as tools, meters, decontamination supplies, etc. required to perform the job.

10.7.4.4 Additional protective equipment is donned prior to entering the specific work area.

10.7.4.5 Personnel proceed to the job site and perform the task in accordance with specific operating procedures.

10.7.4.6 When applicable, the Health Physics representative notifies the personnel when their time limit has expired and the personnel leave the job site.

10.7.5 Description of Egress from Radiation - Contaminated Areas

10.7.5.1 Upon completion of the work task or expiration of time limit, personnel leave the specific job site.

10.7.5.2 Monitor and remove outer protective equipment as required to minimize the spread of contamination. Place contaminated equipment in containers provided near the job site.

10.7.5.3 At the completion of the job, all tools and equipment are placed in clean plastic bags at the job site and stored or placed in the decontamination room for survey and/or decontamination.

10.7.5.4 Personnel proceed to the change room to remove their remaining protective equipment, place it in designed containers, and perform personal monitoring utilizing the G.M. count ratemeter.

10.8 Decontamination

Decontamination is the process of removing contaminants by physical or chemical means. Survey techniques for contamination measurements were previously described in 10.5.3.

10.8.1 Decontamination of Areas

Decontamination of areas is carried out as soon as possible after detection. This not only reduces the possibility of airborne contamination hazards, but the contamination is more easily removed before it has a chance to become fixed. The protective clothing requirements for personnel performing decontamination are established by Health Physics based upon the results of surveys. Many areas where contamination is expected to result from a job are covered prior to performing any work. Coverings include paper, polyethylene, metal foil, and strippable paints.

10.8.1.1 Removal of Contaminated Coverings

Contaminated coverings are normally taken up by rolling the contaminated side in on itself. Care is exercised when handling contaminated materials to prevent the contamination from becoming airborne. Strippable painted coverings are recovred with additional paint prior to removal. This step tends to fix the contamination and reduces the airborne hazard.

10.8.1.2 Wiping Contaminated Surfaces with Dust Absorbing Cloths

"Masslin" or other treated dust-retaining cloths may be used to wipe smooth surface areas which require decontamination. For large areas, such as floors, the cloths are mounted on long handled fixtures and gently pushed across the floor. For smaller areas and equipment, the cloths are held in the gloved hand. The cloth is frequently turned to present a clean surface to the area being decontaminated. The cloth is also frequently surveyed to detect the degree of contamination being removed. Contaminated cloths are discarded in the radioactive waste containers.

10.8.2 <u>Decontamination of Equipment</u>

Decontamination of equipment is accomplished in the decontamination room, isolation rooms, or other areas suitably prepared to handle potential contamination arising from decontamination operations.

10.8.2.1 Washing and Scrubbing

Washing and scrubbing with detergents and other chemical agents such as acids, alkalis, and chelating agents are generally effective for removing dirt and grease along with contamination from surfaces. This method is employed where small pieces of equipment are to be decontaminated. Manipulator wrists and similar equipment are immersed in buckets of detergent solution and scrubbed under water to loosen small particles of contamination. They are withdrawn from the detergent solution, dried with rags and reoiled immediately to prevent corrosive galling. Waste rags and liquid are discarded as radioactive waste.

10.8.2.2 Steam Cleaning

Where possible, large pieces of contaminated equipment are steam cleaned. Precautions are taken to avoid plugging and subsequent damage of the ventilation system filters and to collect the steam condensate in containers for treatment as liquid radioactive waste. This method of decontamination is quite effective, especially when detergents are mixed with the steam, however, since facilities for handling large quantities of liquid waste are limited, it is rarely used.

10.8.2.3 Ultrasonic Decontamination

This specialized method of decontamination is normally used to decontaminate small parts. Ultrasonic decontamination tanks are installed in the process box for decontaminating fuel capsules.

10.8.3 <u>Decontamination of Protective Clothing</u>

All protective clothing is monitored and segregated into two groups according to the quantity of contamination present. Group A consists of items indicating less than 6 mrad/hr and Group B more than 6 mrad/hr, but less than 12 mrad/hr average contamination over the entire garment when read at one inch from the surface of the item with a G.M. survey meter. These items are placed in plastic bags, tagged according to radiation level, placed in a shipping container and shipped in compliance with I.C.C. regulations to an approved off site laundry decontamination service. This service is currently being provided by Nuclear Laundry Service, Jeannette, Pa. Items of protective clothing, contaminated above 50 mrad/hr are discarded as radioactive waste.

10.8.4 Decontamination of Breathing Equipment

Breathing equipment is surveyed by Health Physics after completion of jobs where this equipment was used. Noncontaminated equipment is either returned to individuals to which it was assigned, or is stored in the equipment issue area after cleaning. Contaminated equipment is handled as follows:

10.8.4.1 Contaminated face pieces are washed with a detergent in warm water, thoroughly rinsed in warm water, dried surveyed and packaged in a plastic bag.

10.8.4.2 Used respirator filters are discarded.

10.8.4.3 Metal parts of supplied air breathing equipment are washed with warm soapy water and/or wiped with "Masslin" or other suitable contamination removing cloths. Persistent contamination is removed by scrubbing in mild chemical solutions. The items are dried and surveyed prior to storage.

10.8.4.4 Strap webbing is washed in warm soapy water, dried and surveyed.

10.8.4.5 Airlines are discarded after use.

10.8.4.6 Plastic hoods worn in conjunction with supplied air are discarded after use.

10.8.5 <u>Decontamination of Personnel</u>

10.8.5.1 General Washing Procedure

Thorough washing with mild soap and tepid water is the best general method for removing contaminants from the hands or body. If the contamination is localized, it is often more practical to mask off the affected area and cleanse with swabs, before risking the danger of spreading the contaminants. Repeated washings and rinsings may be necessary, however, care should be exercised not to abrade the skin. Applications of lanolin or hand cream may be desirable to prevent chapping after repeating washings. If contamination persists, the following method may be used under Health Physics supervision: Apply a 10% solution of potassium permanganate, rinse in warm water and apply a freshly prepared solution of sodium bisulfite. Rinse thoroughly and wash with a mild soap.

CAUTION: These solutions should not be allowed to remain in contact with the skin for more than 2 minutes per washing.

In the event that contamination cannot be removed by employing these methods, additional decontamination shall be attempted under the direction of the resident Health Physicist with the advice of a consulting physician.

10.8.5.2 Decontamination of Injured Personnel

Decontamination of superficial wounds shall be performed under the supervision of the resident Health Physicist. Services of a consulting physician will be utilized based upon the degree of injury. Arrangements have been made with local physicians and the Clearfield Hospital to provide any necessary medical assistance. In addition, a Nuclear Medical Consultant from the University of Pittsburgh Graduate School of Public Health has been contacted to provide professional services when required.

10.8.6 Decontamination of Liquids

Information regarding liquid waste handling methods is described in Chapter 7.

10.8.7 Decontamination of Air (Air Handling System)

Filters are installed in the air handling system to remove particulate radioactivity resulting from process operations prior to discharge to the environs. A description of the air handling system is presented in Chapter 6.

10.8.8 Storage and Control of Contaminated Material and Equipment

Equipment that cannot be decontaminated immediately is sealed in plastic and stored in the decontamination room. Items of equipment which are used only in contaminated areas on a periodic basis are also sealed in plastic and stored in the decontamination room when not in use.

Pieces of equipment presenting a serious radiation hazard due to the amount of contamination present are decontaminated or discarded as radioactive waste.

10.9 Waste Disposal Monitoring

A description of the methods employed for the disposal of radioactive wastes is presented in Chapter 7.

10.9.1 Monitoring Solid Waste Disposal Containers during Filling and Removal from the Facility

During the removal of solid radioactive waste from the cells and process box, a Health Physics representative monitors for external radiation, surface and airborne contamination. The waste containers are surveyed for surface contamination prior to removal from the cell isolation room after sealing the disposal container. Contaminated containers are decontaminated prior to removal to the waste storage area. All containers of radioactive waste are labeled and tagged in accordance with the applicable regulations.

10.9.2 Monitoring the Solid Waste Disposal Container Storage Area

Sealed radioactive waste disposal containers are moved from the facility to the waste storage building where they are stored until shipped to an approved disposal site. The radioactive waste storage area is monitored at least weekly for external radiation. The general radiation level is posted at a location where it can be observed by personnel entering the area. The storage area is posted with radiation signs in accordance with applicable regulations.

10.9.3 Monitoring Shipping Vehicles

Vehicles used to ship radioactive waste containers to the disposal site are monitored during loading operations. Containers are arranged so that those emitting the maximum radiation levels are shielded by those of lower radiation levels. The exterior of the shipping vehicle is monitored and posted to assure compliance with shipping regulations prior to leaving the site.

10.9.4 Records

Any entry is made in a Solid Radioactive Waste Disposal Log Book after waste containers have been transferred to the waste storage area. This entry includes the radiation level at the surface of the container, the level at one meter from the container surface, an indication of the curie content of the container, results of surface contamination surveys and container weight. These records are maintained by both Health Physics and the administration and are used when loading trucks for waste shipments.

10.9.5 Monitoring Liquid Radioactive Waste

Process liquids are absorbed and treated as solid radioactive waste as described in Chapter 7. Low level liquid waste is monitored by Pennsylvania State University personnel who are responsible for the discharge of liquid waste to the facility environs. Liquid waste samples are collected and analyzed by Penn State personnel under the supervision of the University Health Physics officer. Dilution factors, as required, are supplied by Pennsylvania State University to facility operations personnel, who adjust the flow of dilution liquid so the waste discharge is conducted in compliance with applicable regulations.

10.9.6 Monitoring Liquid Waste Treatment Facilities

Health Physics conducts periodic radiation and contamination surveys in the liquid waste treatment facility. The frequency of surveys is governed by facility utilization. Results of these surveys are recorded and reported to the Plant Manager.

10.9.7 **Liquid Waste Discharge Records**

Records of the activity of liquid waste discharged to the environs are maintained by the Pennsylvania State University Health Physics Office. Duplicates of these records are also retained in the Health Physics files at the facility.

10.10 **Health Physics Instrumentation**

An adequate supply of instruments, capable of detecting and measuring ionizing radiation throughout the facility, are maintained as Health Physics equipment. Table 10.1 presents a list of the typical instruments.

10.10.1 **Description of Instrumentation Check and/or Calibration Method and Frequency**

10.10.1.1 Air Particulate Monitors

The continuous air monitors are functionally checked at least once every 3 months or after each servicing. This check includes utilization of a calibrated strontium-90 reference source placed in view of the detector. If the instrument reading varies beyond ± 20% from the known value of the source, the instrument is adjusted and/or repaired. In addition, the air flow is measured using a calibrated rotameter and adjusted to 4 cfm.

10.10.1.2 Area Radiation Monitoring System

The area radiation monitoring detectors are functionally checked at least once every 3 months or after each servicing. This check includes utilization of a 25 mg radium source placed at varying distances from the detector in order to check the reponse of the detector. If the meter reading varies beyond 20% from the true reading, the equipment is adjusted and/or repaired.

10.10.1.3 Detector/Scaler Counting Assemblies

All counting room instrumentation is checked daily for background and statistical accuracy. A calibrated strontium-90 source is placed in each detector and counted for a preset time. The background and total count is recorded in a log. If the instrument readings vary greater than the calculated statical error, it is recalibrated and/or repaired.

10.10.1.4 Count ratemeters - Hand and Foot Counter

The count ratemeters are functionally checked at least once every three months or after each servicing. This check includes utilization of a calibrated strontium-90 source placed in view of the detector. If the instrument readings vary beyond ± 20% from the known value of the source, the instrument is adjusted and/or repaired.

10.10.1.5 Portable Radiation Detection Instruments

The portable survey meters are calibrated at least once every three months or after each servicing. This calibration includes utilization of a 25 mg radium source and a Martin custom encapsulated 7-curie strontium-90 titanate pellet.

If the instrument readings vary beyond ± 20 from the known dose rate established with a R-meter, the instrument is adjusted and/or repaired.

10.10.2 Instrument Maintenance and Records

Minor instrument repairs and calibrations are performed by Health Physics personnel. Major repairs are performed by the facility instrument technician.

Health Physics maintains permanent records of all instrument calibrations and repair records are maintained by the instrument technician. Each instrument is tagged indicating the calibration date.

10.11 Environmental Monitoring Program

Effluent monitoring data collected since plant startup indicates that during normal operation, no radioactivity in excess of the limits set forth in 10CFR20 is released to the environs.

A practical environmental monitoring program has been developed for the Quehanna site. Consideration has been given to the geographic, geological, hydrological and meterological aspects of the site, as well as to the influence of low population density and the operational activities conducted at the Martin Radioisotope Pilot Plant. The purpose of this program is to obtain data on the normal variations in background radiation which can be used to assess the effect of an accidental release of radioactive material to the environs.

This program includes collection and analysis of: stream water, silt, soil and vegetation, and environmental air.

10.11.1 Samples Location and Frequency

Samples of the environs (refer to Figure 10.1) are collected as accessibility to the sample locations permit on the following schedule:

LOCATION	SAMPLE	FREQUENCY
#1	Water Soil and Vegetation	Monthly Twice per Year
#2	Water Silt	Monthly Twice per Year
#3	Water	Monthly
#4 & 5	Water Silt	Monthly Twice per Year
#6 & 7	Soil and Vegetation	Twice per Year
#8	Environmental Air	Daily
#9	Water (Facility Potable Water)	Daily
#10, 11, 12	Soil and Vegetation	Twice per Year
#13, 14	Water Silt	Monthly Twice per Year

10.11.2 Sample Size and Analysis

One liter of water, approximately 10 gms of vegetation and one pound of soil are collected and analyzed for gross beta-gamma activity. Selected proportions of the samples collected are analyzed for strontium. Records of analysis are maintained by Health Physics.

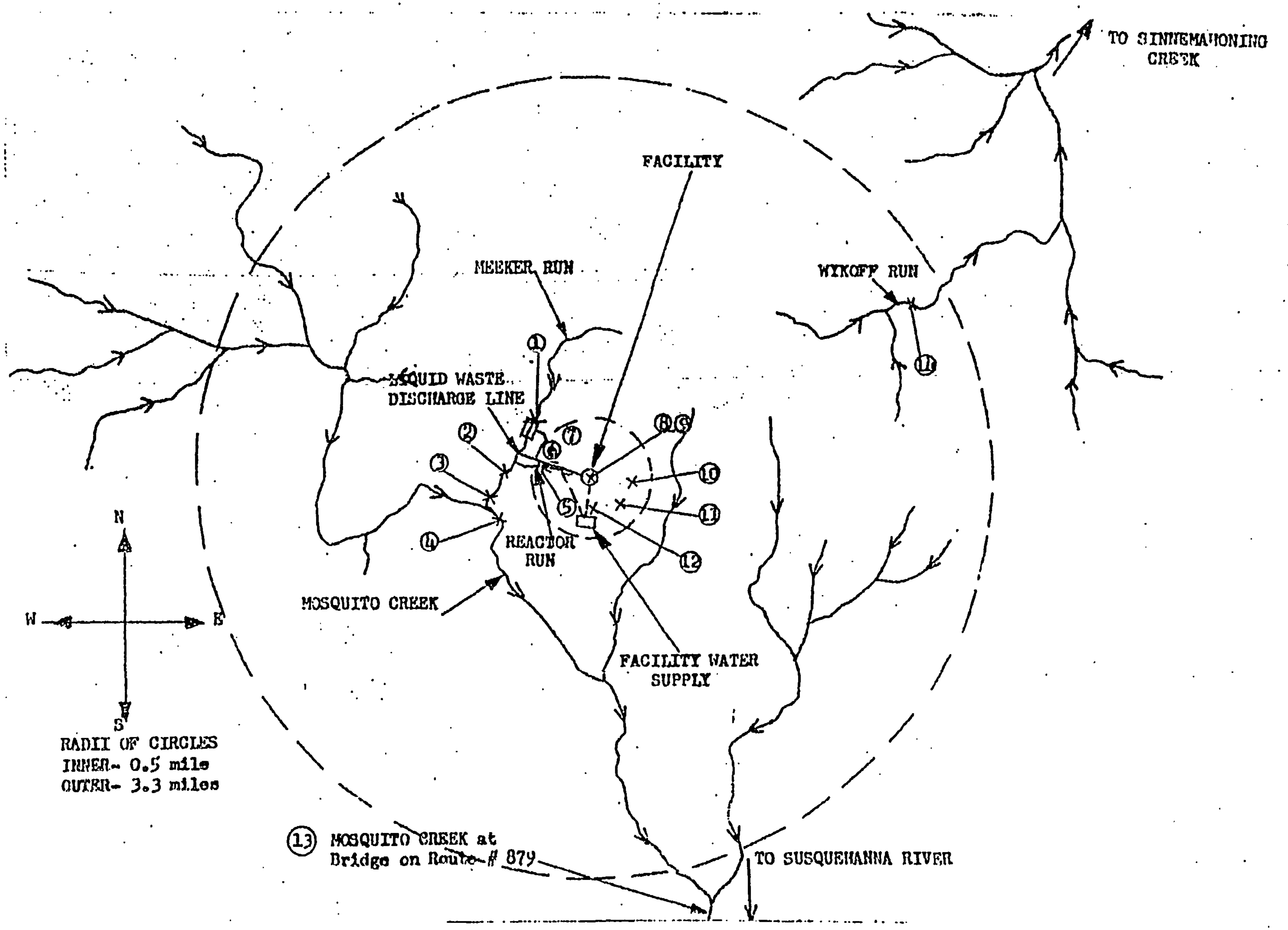


FIGURE 10.3 ENVIRONMENTAL SAMPLING POINTS

CHAPTER 11

SUMMARY OF EMERGENCY CONTROL MEASURES

11.1 Introduction

The Quehanna Radioisotope Production Facility has processed kilocurie quantities of $SrTiO_2$ since July 1962 and much valuable operating experience has been gained. This valuable information has influenced the design of new equipment and the planning of a safe operation. This section presents a summary of the available means for dealing with emergencies. While it is not possible to predict all the accidents that may occur, it is felt that the equipment provided, combined with intelligent understanding of the facility and careful preplanning, make it possible to deal with any emergency that may arise. Detailed emergency that may arise. Detailed emergency procedures are outlined in the Standard Operating Procedures.

11.2 Local Assistance

Pennsylvania state and local police, Pennsylvania State Health Department, hospital and civil defense authorities have been contacted and arrangements completed for mutual assistance in the event of an emergency. These officials are aware of the facility operations and an efficient system for emergency assistance has been agreed upon. Local volunteer fire departments have visited the facility and are familiar with the plant fire fighting equipment.

11.3 Organization

The Plant Manager supervises the emergency control procedures. He issues any alternative procedures which he may feel necessary to cope with a particular situation. It is also his responsibility to report an emergency incident to responsible authorities of Martin, the facility owner (Pennsylvania State University), and the AEC in accordance with the requirements as set forth in 10CFR20. In the absence of the Plant Manager, the shift foreman will assume the responsibility of evacuation coordinator until the Plant Manager arrives on the site.

11.4 Health Physics

The resident Health Physicist acts as consultant on radiation and contamination problems and reports the hazards to the evacuation coordinator. Detailed duties are covered in the Standard Operating Procedures.

11.5 Off-Hour Coverage

During processing of radioactive material, at least two persons will be in attendance at all times. In case of any emergency, the Plant Manager and the resident Health Physicist will be notified.

11.6 Equipment

In addition to the support equipment, ventilation air monitoring systems and controls, the facility maintains and operates an emergency vehicle and trailer outfitted with equipment for detecting and measuring air contamination and radiation levels in the site environs. The unit also contains protective clothing and equipment, decontamination supplies, an emergency generator and other items necessary for handling emergency situations.

11.7 Emergency Drills

Drills are held periodically in order to train the personnel in the proper procedures to follow in case of a radiation or particulate release alarm. All personnel evacuate the facility at the sound of the alarm and congregate in the parking lot. In the event of a real alarm, they will remain in the lot until the Plant Manager and the Health Physicist can determine the cause of the alarm and plan immediate action.

Dosimetry and follow-up procedures are conducted on all personnel who may have become contaminated or exposed. (Reference Chapter 10 - Health Physics).

11.8 Internal Emergencies

11.8.1 Liquid and Dry Spills

In case of major contamination due to a spill or other accident within the building, the contaminated area is marked by Health Physics and decontamination procedures are initiated. Appropriate protective clothing is worn during this time (see Paragraph 10.7.3).

11.8.2 High Air Contamination

The room constant air monitors have a set and an alarm point. In case of an air monitor alarm, all personnel immediately don protective respiratory gear and Health Physics evaluates conditions and advises regarding the course of action. In the event of an evacuation the emergency coordinator and the senior health physicist don respiratory protective and evaluate building conditions. Ventilation is adjusted to minimize the spread of contamination and decontamination procedures are initiated utilizing appropriate protective equipment.

11.8.3 High Radiation Levels

The ventilation system sample filters are changed daily and in case a filter becomes unduly contaminated. While the contaminated filter is being changed, an emergency fan is started and the flow by-passes the contaminated filter.

11.8.4 Leaking Capsule in Pool

If a leak should occur in one of the fuel capsules in the storage pool, it will be detected by either Health Physics analyses of the water or the continuous water monitor. The process by which the leaking capsule is isolated entails the use of a hollow, siphon-fitted can which, when placed around the suspect capsule, draws water to be sampled for excess activity. In addition to water samples, the deionizers which service the storage pool through a continuous recirculating system are monitored on a regular basis. When a capsule is removed from the pool, smears are taken at the earliest convenient time.

11.8.5 Pool Leakage

The following action is taken if the storage pool should leak: the pool water supply is increased to maintain shielding over the fuel capsules; environmental monitoring is initiated to measure the radiation in the area. The cause of the leak is determined by the Plant Manager and Health Physics, and repairs and preventive remedies are initiated.

11.9 External Release

11.9.1 Airborne

If contaminated air should be released to the environment, a survey will be conducted to determine the extent. A high volume air sample mounted on the facility emergency trailer will be used for sample collection and radiation levels will be recorded.

11.9.2 Water Contamination

Contamination of the environmental water system could result from accidental release of high level liquid waste from the waste treatment plant. In this event Health Physics is made aware of the situation via the alarm systems. Water samples of local streams will be collected. After a period of time following an incident, silt samples from the streams will be collected. The proper agencies throughout the area will be notified.

11.10 **Fire Fighting**

11.10.1 **Fire Fighting Plan**

In addition to the general problems involved in in fighting fires, the Quehanna Pilot Plant is faced with two special problem areas. These problems are:

(1) Fighting laboratory fires involving acids, gases, chemical processing apparatus, electrical equipment and other hazardous materials normally found in a laboratory.

(2) All of the above, plus the added hazard that radioactive materials may be present in the area or disseminated in the atmosphere.

A training program is designed to provide a general background and experience (through field demonstrations) in fighting fires, with emphasis on the special precautions required by virtue of the special conditions.

The design of the facility lends itself readily to the establishment of a three-area control system. The areas in which a fire would produce the most serious consequences are the hot cells. In the event of such a fire all efforts will be made to confine the radioactivity to the area while putting out the fire. The second area is the isolation room. If necessary to put out the fire, and if it cannot be confined to the hot cell, radioactivity may be allowed to spread, under control, to the isolation room. The service area provides a third region, the cold area, from which the fire may be approached. If at all possible, radioactive contamination will be kept from this area.

The facility has highly trained personnel, competent in matters pertaining to radiation and radioactive materials control. Most of the training is therefore directed to those problems associated with the proper use of equipment, techniques, philosophy of the three area control and location of emergency supplies. The Pennsylvania State University Fire Marshal and a representative of the NEPIA Agency are available as consultants. Both individuals make periodic inspections and inform the Plant Manager of any deficiencies in the equipment, or new techniques that may be incorporated in the protection plan.

11.10.2 Fire Alarms and Equipment

Fire fighting equipment is installed in and about the building in accordance with the requirements of the National Board of Fire Underwriters. Most sections of the building in which radioactive work is not carried on are protected by an automatic sprinkler system. When any part of this sprinkler system is actuated, an alarm will sound throughout the building. It is also arranged that an alarm will sound if the water pressure in the sprinkler system drops below a preset level.

It is not practical to use sprinkler systems in most areas where chemical and radioactive work take place because the reagent which should be used to put out the fire depends largely on the burning material and other materials in the laboratory. Sprinkler systems also tend to spread radioactive contamination. In such areas, therefore, automatic fire detectors have been installed. If the temperature in one of these areas rises above a preset limit, it will result in the continuous ringing of all fire alarm bells throughout the building. Automatic detectors are located in the reactor bay, remote control room, reactor pump room, mezzanine fan rooms, operating area, above the isolation rooms, the service area, decontamination room, and the analytical radiochemistry lavoratory.

The entire fire alarm system will operate from the normal power bus. In case of power failure, the system will automatically switch over to storage batteries. Provisions are made for the system to be connected to a future central fire station.

In the areas in which only fire detectors are installed, it will be necessary to combat fires with locally available fire extinguishing apparatus. The extinguishing reagents include water, foam, carbon dioxide, and powdered sodium carbonate. The reagent to be used depends upon the type of fire.

There is no provision for fixed sprinkler or automatic fire detector equipment in the hot cells. Each experimental installation is evaluated individually for an associated fire hazard, and appropriate alarm and/or fire extinguishing apparatus is installed with the experimental equipment as required.

11.10.3 The Training Program

Because of the relatively small staff at the Quehanna Radioisotope Pilot Plant, all men are members of the Fire Brigade and will receive fire fighting training. Three hours of preliminary training will be provided in the course of training programs related to Health Physics and the strontium-90 titanate process. The special hazards caused by the particular systems at the facility and the chemical systems to be operated will be reviewed, and techniques for emergency action presented and practiced. Additional classroom training of one hour per quarter will cover such items as alarm code instruction, evacuation procedures, emergency treatment, familiarization with equipment and other related topics. During favorable weather, the fire fighting equipment will be tested in these classes. Field exercises will include techniques of handling high pressure hose and various types of extinguishers. Proper maintenance of hose and equipment after use will be learned. Classes will be conducted by the plant Fire Marshal although any member of the staff or the aforementioned consultants may provide the actual instruction. The following reports will be required reading and will serve as texts for the instruction:

1. Living with Radiation - Volume II
   Fire Service Problems
   U. S. Atomic Energy Commission

2. <u>The Hazard of Radioisotopes under Fire Conditions</u>

Factory Insurance Association

3. <u>Recommended Fire Protection Practices for Nuclear Reactors</u>,

NFPA 802

As part of the training already given, fire hoses are checked periodically.

11.10.4 <u>Specific Emergency Procedures</u>

11.10.4.1 Fires or Explosions in Process ~~Box~~

11.10.4.1.1 Detection

Flammable materials are rarely used in the processing box and the only other possibility is an electric motor becoming overheated. Since the facility is never left unattended visual detection of fires and subsequent remedial action is possible.

11.10.4.1.2 Standard Procedure

The cell operator must do the following things in the event of a fire or explosions:

a. Sound fire alarm if not already done.

b. Don respiratory protection device.

c. Use extinguishing chemicals and reduce air flow via manual damper control.

d. Leave the area if radiation or evacuation alarm sounds.

The emergency coordinator is required to:

a. Check performance of cell operator and assist if necessary.

b. Assure safety of all personnal.

c. Coordinate and direct all emergency measures

d. Inform his superiors.

The Health Physicist in case of fire or explosion is responsible for:

a. Detecting spread of contamination, if any. Initiating radiation-contamination surveys if necessary.

b. Advising emergency coordinator as required.

c. Insuring the wearing of necessary protective equipment.

d. Checking personnel for possible contamination and information regarding radiation exposure.

e. Assisting coordinator as required in making a thorough post-emergency evaluation.

f. Initiating personnel decontamination and administering first aid if necessary.

All the other personnel in the area will report to the parking lot area and await instructions.

11.10.4.2 Fires in Low Hazard Area

11.10.4.2.1 Detection

Non-radiation areas are protected by sprinklers. Radiation areas, with the exception of the cells, are protected by heat detector alarms. Manual fire alarm stations are provided in each area.

11.10.4.2.2 Standard Procedure

A cell operator is required to do the following:

a. Sound the alarm, if not already done.
b. Bring the work in the process cell to a point where it is safe to leave if necessary.
c. After putting on respiratory equipment, assist to extinguish fire if nearby.
d. Check operation of ventilation system.
e. Remain in operation area, alert for problems until instructed otherwise.

The emergency coordinator is required to:

a. Determine location of alarm.
b. Don respiratory protective device.
c. Instruct others to extinguish fire or assist as required.
d. Check with Health Physics.

The Health Physics representative must:

a. Don respiratory equipment.
b. Proceed to fire location.
c. Evaluate hazard.
d. Assist as required

Others persons, if in the vicinity of the fire, must sound the alarm, don respiratory equipment and extinguish the fire. If in another location, they should report to the assembly area to be available to assist.

11.11 Storms

11.11.1 Wind Damage

Under normal conditions, the average wind speed in the area does not affect the building ventilation system. However, if wind speeds should increase to such a degree that they cause a perturbation of the system by varying the static pressure of the building, corrective action will be taken when necessary; i.e., supply air will be reduced to increase negative pressure in the cells and dry boxes, open or close doors and/or dampers to rebalance air system in the operating and service areas. Questionable air flow and pressures will be measured with hot wire anemometer, velometer or smoke tubes.

11.11.2 Flooding

The facility is located on a plateau approximately 1900 feet above sea level. As drainage flows away from the site to lower altitudes, the possibility of flood damage within the facility is quite remote.

11.12 Power Failures

Power failures in the past occasionally have occured. When the power fails, an emergency power system is automatically operated. Transfer from the main source of power to the emergency power system takes place through time delay relays which permit the emergency unit to reach rated speed and voltage in approximately 10 seconds.

CHAPTER 12

SAFETY EVALUATION

12.1 Introduction

The design and operating philosophy of this facility is based on the principle of multiple containment barriers of radioactive materials at all times. In essence, this means that a minimum of two containment structures must fail in order to allow the release of radioactive material to the atmosphere. The criterion of safety emphasized throughout the analysis is reasonable assurance that the general population in areas surrounding the facility and operating personnel will not receive overdoses of radiation as defined by 10CFR20 and the recommendations of the ICRP.

A shielding analysis has been carried out to assure that direct radiation doses to operating personnel do not exceed acceptable limits.

A complete safety evaluation has been performed to determine the radiobiological consequences of accidental activity releases. All cases in which the possibility of primary containment failure exists were analyzed. The results indicate that activity releases due to containment failure are highly improbable. A very conservative approach was assumed in the postulation of a series of failures that might cause the release of activity from the secondary containment to the surrounding environment or to operating areas of the facility. This approach is emphasized particularly in the examination of the maximum credible accident.

In addition to accidental activity releases, all of the chemical processing steps and other operational procedures have been studied to ensure their safety with respect to operating personnel and the general public.

12.2 Shielding Analysis

An analysis has been made of the shielding requirements for the strontium-90 production process. The effectiveness of the cells and auxiliary process equipment shields for shielding against the maximum calculated radiation intensity has been established.

12.2.1 Cell Walls

12.2.1.1 Dose Rate from Strontium-90

An analysis of the shielding value of the hot cell walls and windows has shown that dose rates are extremely low for the anticipated amounts of strontium-90 to be processed and handled in the cells. Dose rate calculations were for a curie strength of 250,000 curies and two forms (solution and solid titanate). The dose rate varies practically linearly with the activity.

Dose rates were calculated at points located in the front of the cell outside the walls and windows, at a point on top of the cells, at a point in back of the cells outside the cast iron door but inside the isolation room, and at a point in back of the cell outside the isolation room but shielded by the cast iron door only. These points are shown in Figures 12.1 and 12.2 and the dose rates are given in Table 12.1. The results are conservative since they neglect self-absorption, the shielding effect of structural materials, and the effect of any localized shielding which may be used for personnel entry into the cell.

12.2.1.2 Effect of Cerium-144 on Cell Wall Analysis

It is estimated that the Cerium-144 content may be as high as 2 to 3 millicuries **per curie of strontium-90.** Table 12.2 shows the increase in dose rates for selected situations around the hot cells. It should be noted that the shielding of the cells is still adequate with this amount of cerium.

The significant bremsstrahlung associated with the decay of Cerium-Praseodymium-144 arise from the approximately 3-mev beta particle of Praseodymium-144. In addition, there are high energy decay gammas associated with Praseodymium-144. As a result, the average energy of the gammas for Cerium-Praseodymium-144 is higher than those from Strontium-Yttrium-90. In terms of shielding, this means that the Cerium-Praseodymium-144 gamma rays become relatively more important and contribute an increasing fraction to the total dose rate as shielding thickness is increased.

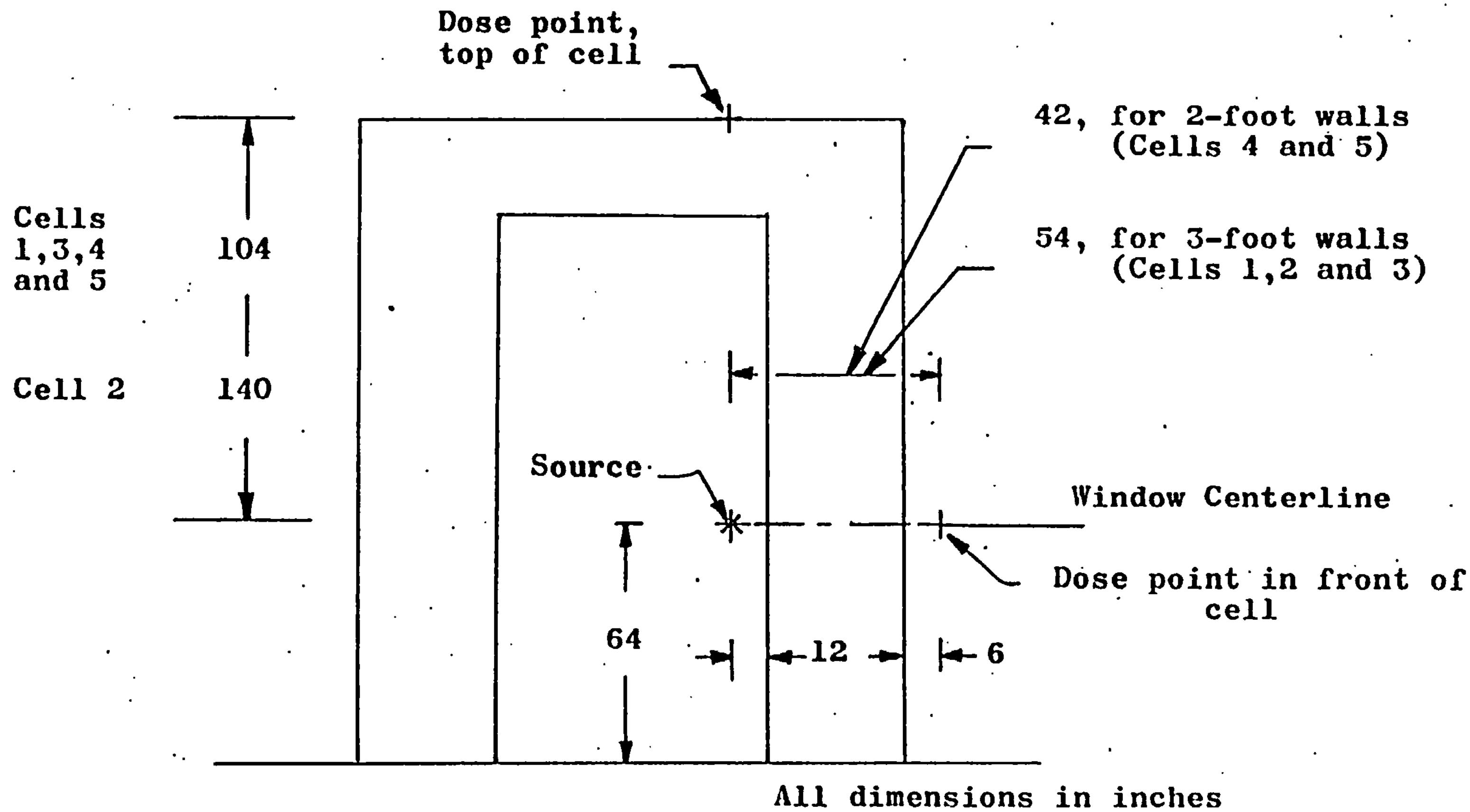


Figure 12.1 Configuration Used for Shielding Analysis of Strontium-90 Processing Cell

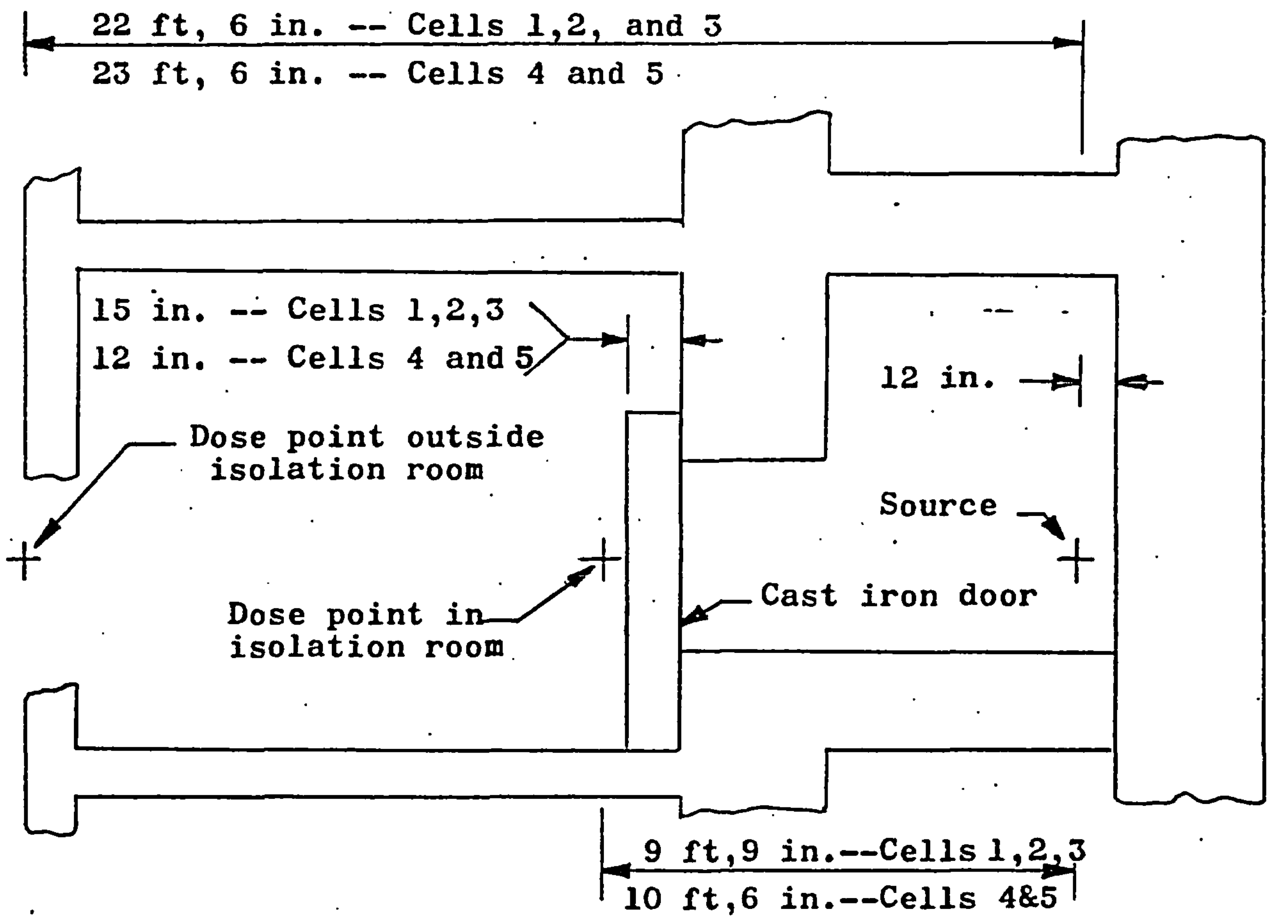


Figure 12.2 Configuration for Shielding Analysis of Rear of Cell

TABLE 12.1

STRONTIUM-90 PROCESSING; DOSE RATES (mr/hr)

For 250,000 curies in hot cell

Form of Strontium	Front of Cell: Cells 1,2,3 3-foot wall	Front of Cell: Cells 4,5 2-foot wall
Solution	2.75×10^{-5}	0.12
Titanate	7.5×10^{-5}	0.15
	3-foot window	2-foot window
Solution	0.04	8.5
Titanate	0.11	22.5

	Rear of Cell In Isolation Room: Cells 1,2,3 15-inch door	Cell 4	Cell 5 12-inch door
Solution	0.073	------	0.80
Titanate	0.19	1.66	2.10
	Outside Isolation Room		
Solution	0.014	------	.1625
Titanate	0.35	.03	.425

	Top of Cell: Cells 1,2 2 ft concrete	Cell 3 1.5 in. steel	Cell 4 2 in. steel 1 in. Al	Cell 5 2 ft concrete
Solution	17.0	------	----------	31.25
Titanate	45.0	5800	5000	80.0

TABLE 12.2

Efect of 2.5 Millicuries of Cerium-144 per Curie of Strontium-90 on Dose Rate (mr/hr)

Isotope	Activity curies	Walls 2-ft	Windows 2-ft	Roof	Isolation Room 12-in. door
Sr-90	250,000	0.148	22.25	80.0	2.08
Ce-144	625	0.200	9.00	14.0	0.45
Total		0.348	31.25	94.0	2.53

12.2.2 **Feed Storage Tank**

The feed storage tank, T-31 and it's shielding, are located in the cell annex of Cell 4. In the determination of the effectiveness of the shielding it was assumed that 750,000 curies, the maximum activity, was distributed uniformly throughout the tank. The points at which the dose rates were determined and the dose rates are shown in Figures 12.3, 12.4 and 12.5. Figure 12.3 is a plan view with the dose rates given for an horizontal plane taken through the middle of the tank. Figure 12.4 and 12.5 are for orthogonal vertical planes.

These tank T-31 dose rate calculations were performed by integrating the Green's function for the dose weighted by the homogeneous source throughout the tank. To accomplish these calculations IBM 7094 Program SPEND was used. Due to the assumptions made and the method of calculation, the calculated dose rates could be high by as much as a factor of two.

Using the maximum possible activity of 750,000 curies, the dose rates are low enough to allow for short periods of work in the vicinity of the tank.

12.2.3 **Dose Rates Through the Shine Shield from the Process Box**

To determine the amount of radiation from the process box, a point source of 100,000 curies was used. The

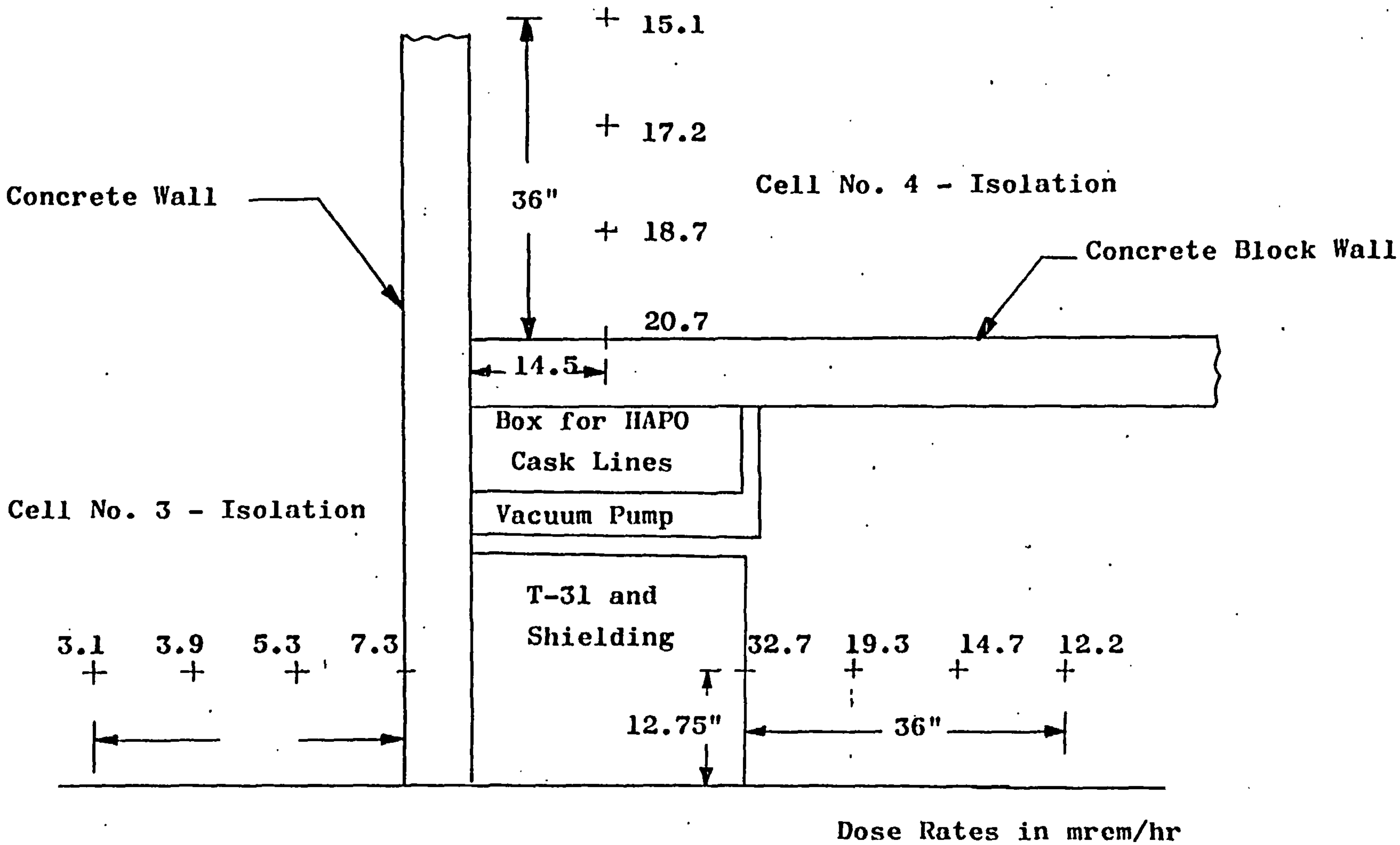


Figure 12.3 Dose Rates from Strontium-90 Storage Tank T-31
Horizontal Plane through Middle of Tank

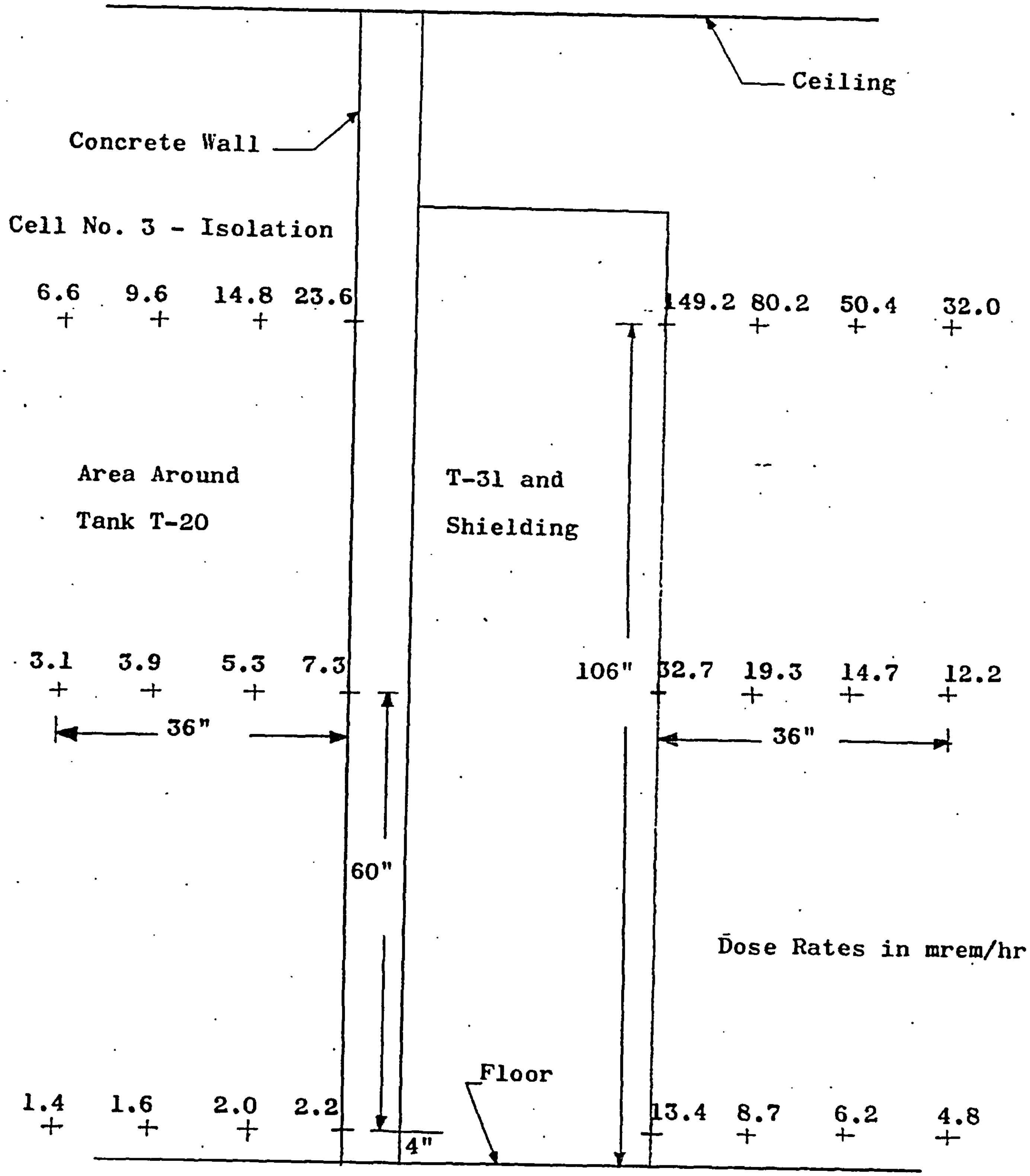


Figure 12.4 Dose Rates from Strontium-90 Storage Tank T-31 Vertical Section Perpendicular to Cell 3 Isolation Room Wall

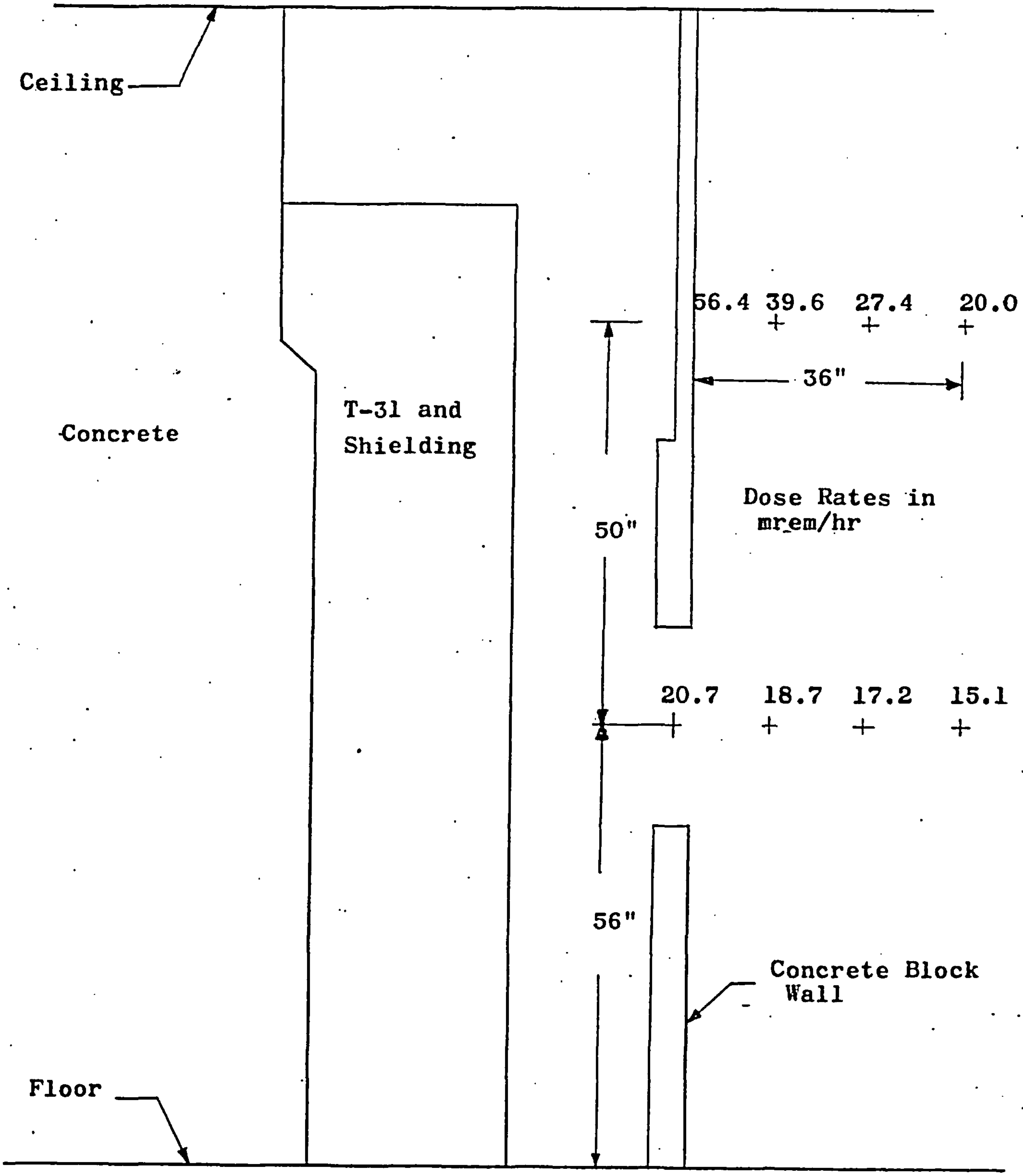


Figure 12.5 Dose Rates from Strontium-90 Storage Tank T-31
Vertical Section Perpendicular to Cell 4 Wall

source was located at a point in the process box closest to the shine shield. Thus the values obtained are conservative.

The calculations were carried out with the 12-inch iron cell door open so that the physical attenuation was due entirely to the shine shield. At a distance of 51 inches from the source the dose rate is 1.66 millrem per hour. Figures 12.6 and 12.7 locate the source and dose points.

It is clear that the shine shield is adequate shielding for the process box. The dose rates are low enough to permit personnel to do necessary maintenance at the closest possible position to the shine shield.

An area which may cause concern is that of the filter plenum. At times when strontium is in the furnace, which is situated in the process box of Cell 4, the dose rate from this source combined with that from tank T-31 and the activity retained by the filter may be high enough to warrant special procedures for changing the filter. Considering only the storage tank T-31 and 25,000 curies in the furnace, dose rates of approximately 25 to 30 millirem per hour are possible.

12.2.4 Temporary Shielding

A curve was prepared for use in estimating temporary shielding for various amounts of strontium-90. Figure 12.8 is a curve of activity versus thickness of lead shielding required to reduce the dose rate to 10 mr/hr at one meter

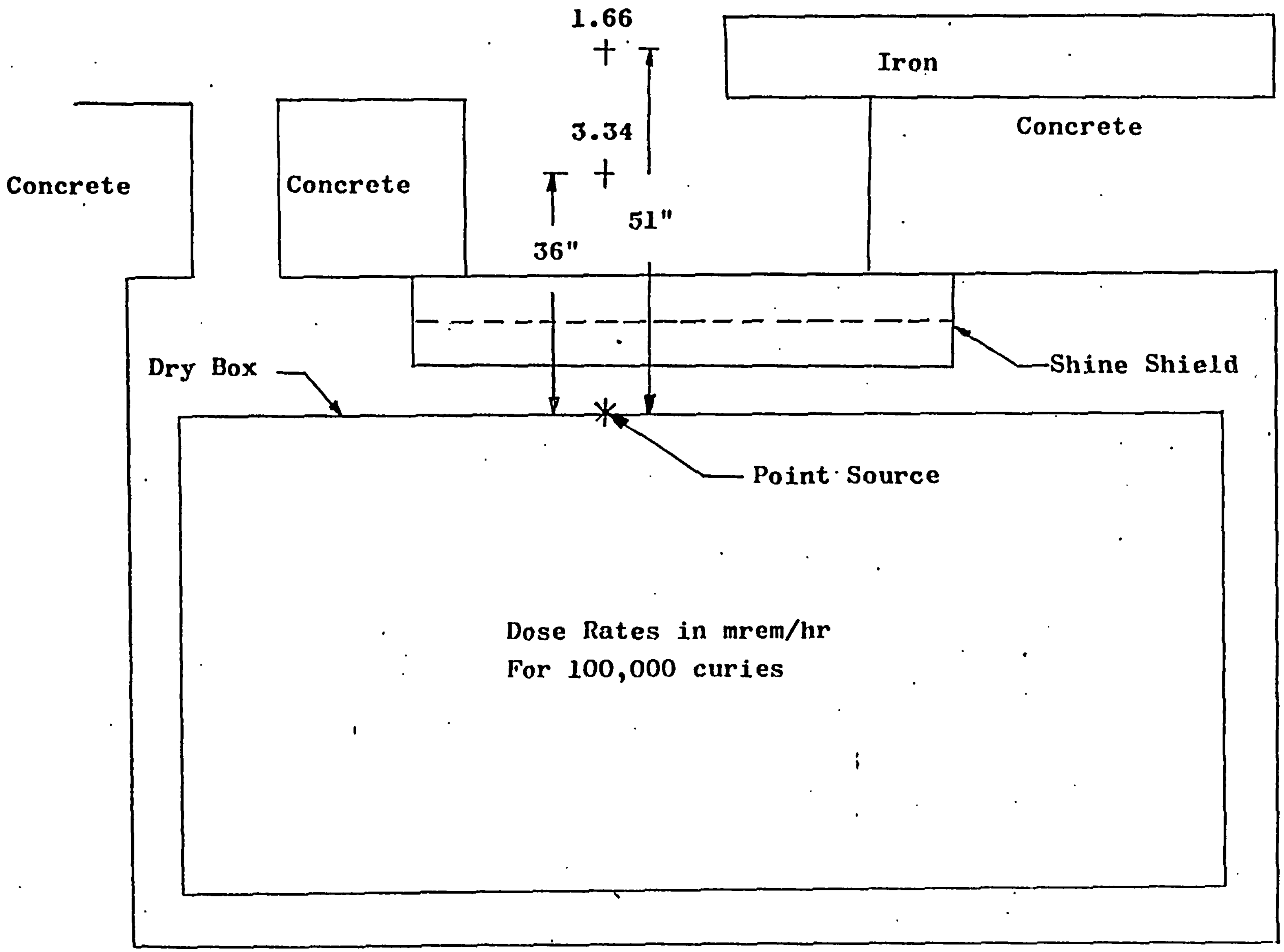


Figure 12.6 Dose Rates from Cell Four Dry Box
Horizontal Section

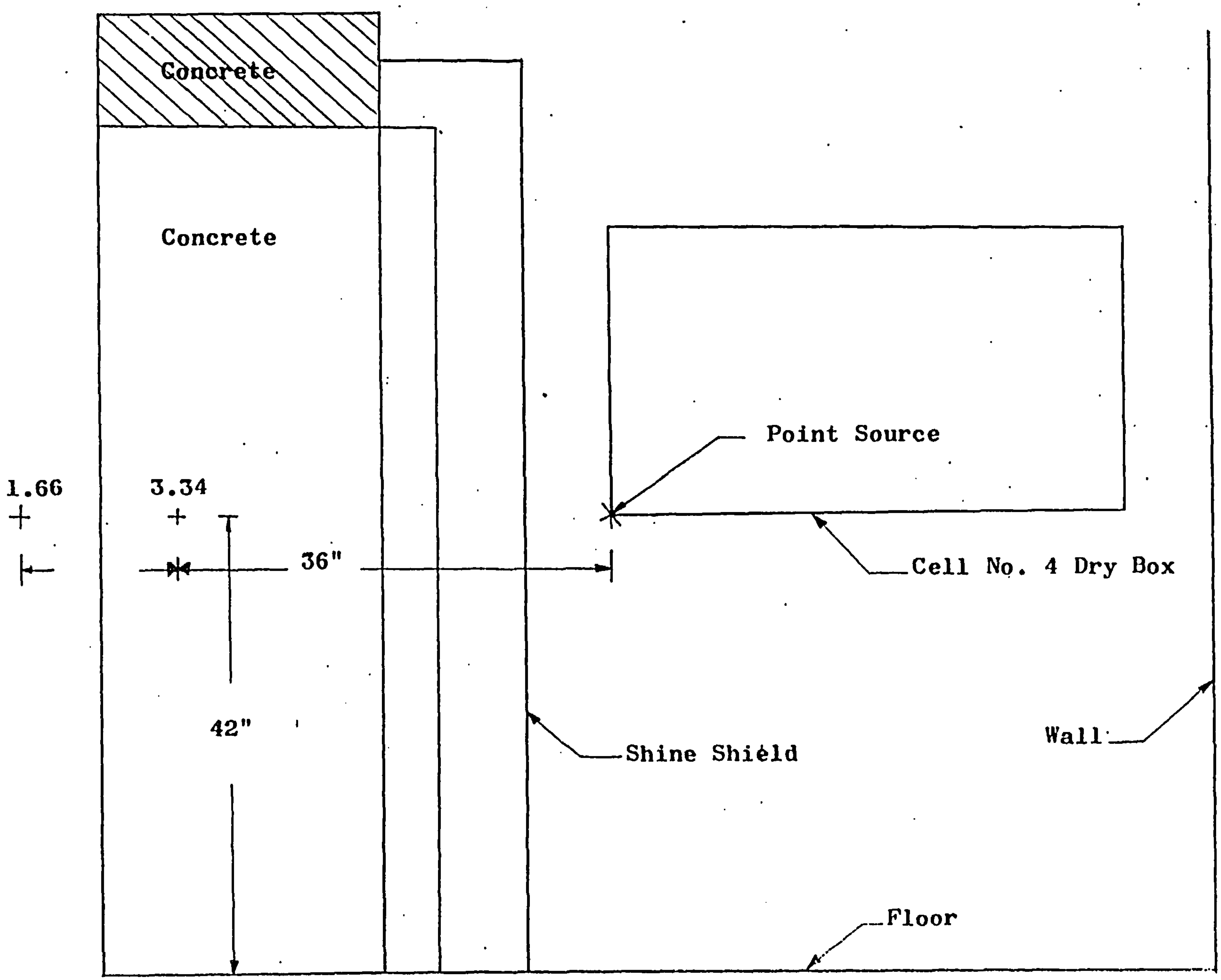


Figure 12.7 Dose Rates from Cell Four Dry Box

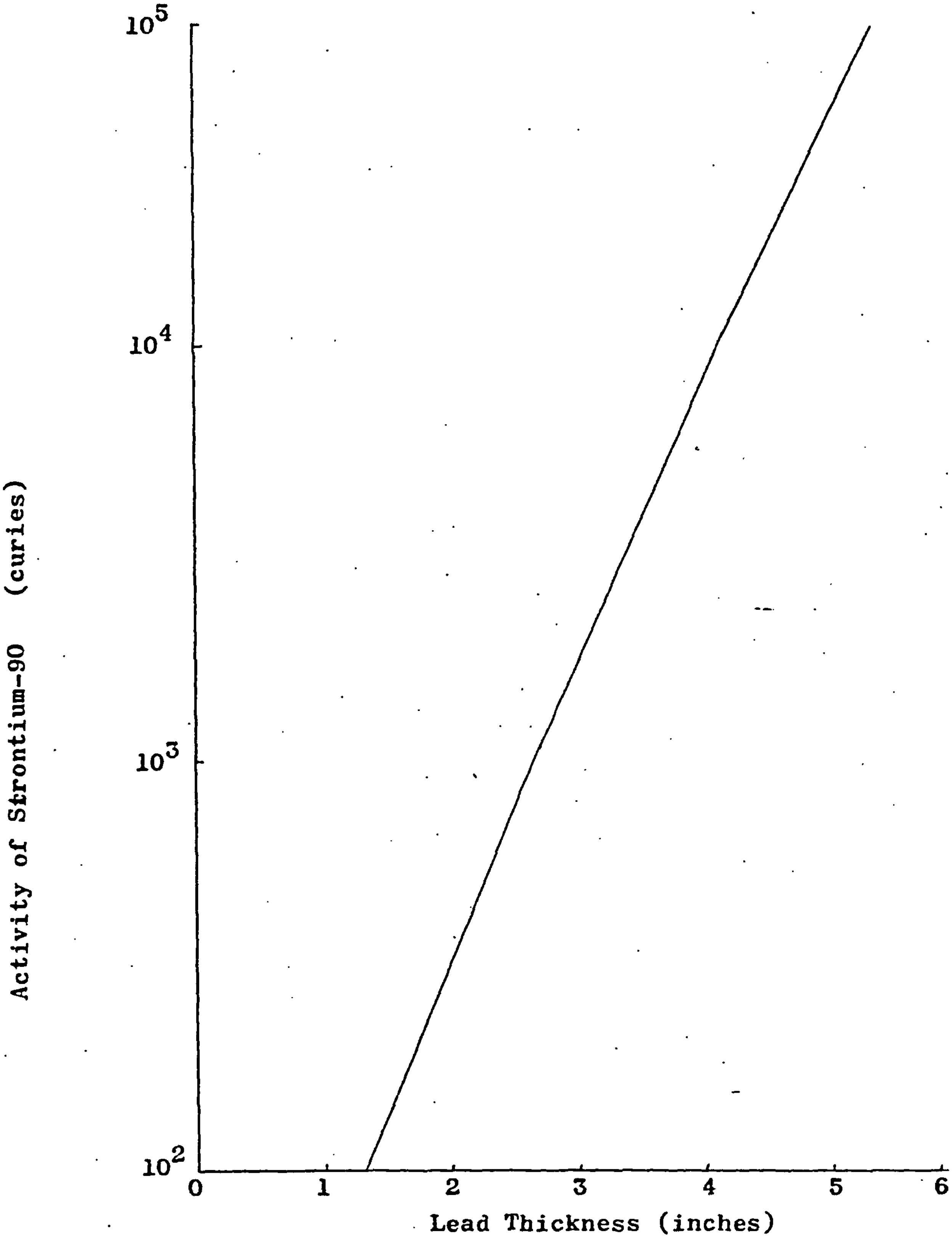


Figure 12.8 Shielding Required to Limit Dose Rate to 10 mr/hr at One Meter from Center of Source

12.3 <u>Chemical Hazards</u>

12.3.1 <u>Radiolysis of $Sr(NO_3)_2$ Solution</u>

12.3.1.1 Hydrogen Formation

The feed storage tank may contain up to 750 kilocuries of strontium-90 in 250 liters. Assuming conservatively that 100% of the radiation energy emitted is involved in decomposition of the solution, the rate of hydrogen evolution from the solution is calculated to be 78.0 cc/min. (STP). The G value of 0.028 (molecules per 100 electron volts) was calculated from an expression given by Sowden (Reference 12.7) for the effect of high nitrate ion concentrations on the radiolytic formation of hydrogen, assuming a nitrate concentration of 1.27M (0.075M excess HNO_3). The rate of hydrogen evolution varies in inverse fashion with increasing nitrate concentration. For example, increasing nitrate ion molarity of 1.95 (0.77M excess HNO_3) suppresses hydrogen evolution to 16.1 cc/min. (STP). The excess of HNO_3 maintained in the feed tank is normally 0.4 to 0.6M.

In the usual course of operations the 250-liter feed storage tank will have a maximum filling of two-thirds, by transfer from a HAPO-I cask, and will consequently have 500 kilocuries and a void space of about 83 liters. Hydrogen evolution at a proportional rate could theoretically bring the composition of the gas in the void space to the lower flammability limit of

4.1 volume percent in about an hour and to the lower detonation limit of 19% in about five hours. (References 12.8 and 12.9). The opportunity for igniting the gas within the tank is negligible since no access to the tank interior is possible, no electrical connections are made to it and it is not exposed to any flame. In addition, the tank is vented to the process box where dilution occurs before the air is exhausted through the air handling system.

The feed storage tank is air sparged at a rate of about 3 liters/minute when it is first filled, and before any subsequent withdrawals. At this time the hydrogen is diluted and carried away through the air handling system.

If, for some inadvertent or unknown reason, the vent and vacuum connections to the tank should be closed for a substantial period of time, it might first be assumed that the hydrogen evolution would cause pressure build-up in the free volume. Theoretically, it would require about 18 hours to raise the pressure to 15 psig. However, it is more logical to assume that in a sealed vessel, hydrogen produced by radiolysis recombines with the other radiolysis products so that no net hydrogen is produced. Allen (Reference 12.11) has commented on this phenomenon at length. In any event, the tank is capable of withstanding internal pressures of at least 100 psig and has been tested to that figure in conformance with the Uniform Unfired Pressure Vessel Code.

12.3.1.2 Nitrite Formation

Another radiolytic reaction is expected to occur in the storage tank, namely the reduction of nitrate ion to nitrite ion, with attendent consumption of hydrogen ion. The G value depends on the nitrate ion concentration and is computed to be 1.95 for the case at hand (Reference 12.12), giving a maximum nitrite ion formation rate of 3.03 gram-mole/hr. No safety considerations are apparent, in the formation of nitrite ion, since strontium nitrite is reported to exhibit essentially the same solubility as the nitrate and has no unusual chemical properties.

12.3.1.3 Oxygen and Peroxide Formation

As far as can be determined by an examination of the literature the formation of oxygen gas or of hydrogen peroxide should not occur to any significant extent in the feed solution.

12.3.2 <u>Chemical Energy Production</u>

12.3.2.1 Heat of Neutralization of Excess Acid

Excess HNO_3 added during the dissolution step is neutralized during the course of carbonate precipitation in Cell 4. The concentration of the excess acid is measured and will not exceed 1M and is usually held to about 0.5M. If the volume of solution aliquoted for precipitation is 9 liters it may contain 9 moles of excess HNO_3. Based on a heat of neutralization of 13.1 kcal/mol, 118 kcal may be liberated during the neutralization step. This can produce a temperature rise of about 10°F but cannot result in any excessive release of energy.

12.3.2.2 Heat of Reaction of Carbonate Precipitation

From data readily available on the heats of formation of the various chemical species involved in the reaction by which strontium carbonate is precipitated, it is found that the reaction is slightly endothermic (Reference 12.13):

$$Sr(NO_3)_2(aq) + Na_2CO_3(aq) \rightarrow SrCO_3(s) + 2\ NaNO_3(aq)$$

Heat of formation:	229.82	276.18	291.28	214.66

$$H = +.06 \text{ kcal/mole}$$

Since a batch size of 25,000 curies of Sr-90 precipitated at a time amounts to about 40 mol of reactive cations, this reaction is of no great concern from an energy release or absorption point of view. The reaction of the calcium present is ignored for purposes of this study since the amount is small and this reaction also involves only a small quantity of heat. The TiO_2 present at the time of carbonate precipitation does not react chemically with the other reagents present.

12.3.2.3 Stability of $SrCO_3$ - TiO_2 Mixture

The mixture of $SrCO_3$ and TiO_2 which is separated by filtration from its supernatant liquid is permitted to dry partially by self-heating before it is processed further. The batch generates heat at the rate of 160 watts. This heat is expanded principally in evaporating the water held in the precipitated mixture.

Following evaporation of the water, the temperature of the cake will rise to an equilibrium figure whose value is determined by various factors unless it is placed within a water-cooled receptacle available for that purpose. In no event can the self-heating of the cake cause a temperature rise sufficient to cause reaction between the $SrCO_3$ and TiO_2, since the reaction rate has been conclusively demonstrated to become significant only above 925°C. It is thought that the reaction between $SrCO_3$ and TiO_2 is perhaps endothermic, but the heat of formation of $SrTiO_3$ has not been determined. The experimental evidence shows that the evolution of heat is, at most, quite small. The reaction is consequently not contributory to any significant energy release during the process.

12.3.2.4 Fires

Neither the material being processed nor any of the reagents used are flammable and it has been shown above that energy releases in the process reactions are quite moderate. No open flames are used. The only combustible materials to be found in the process box at any time are the required electric insulation, manipulator boots, polyethylene reagent bottles and cloth swabs used for minor decontamination. These are present in very small quantities, generally have high ignition temperatures, are non-explosive and even if any of them could become ignited the total energy production is not great.

12.3.3 Radiolysis of Pool Water

The storage of the encapsulated sources in the pool will result in some radiolysis of the pool water. The beta energy of the strontium-90-yttrium-90 chain is entirely dissipated within the capsules, but gamma energy produced as bremsstralung enters the water. In the following calculation, correction has been made for self-absorption within the capsule. A G factor of 0.25 molecules per electron volt has been used.

The total bremsstrahlung energy generated per curie per hour is obtained by integrating the energy yield spectrum:

E	Yield Photons/dis	E	Mev/dis
2.2-1.98	7.42×10^{-7}	2.1	1.56×10^{-6}
1.98-1.76	6.75×10^{-6}	1.87	1.26×10^{-5}
1.76-1.54	2.89×10^{-5}	1.65	4.76×10^{-5}
1.54-1.32	8.51×10^{-5}	1.43	1.22×10^{-4}
1.32-1.10	2.09×10^{-4}	1.21	2.53×10^{-4}
1.10-.88	4.37×10^{-4}	.99	4.32×10^{-4}
.88-.66	8.87×10^{-4}	.77	6.84×10^{-4}
.66-.44	1.82×10^{-3}	.55	1.0×10^{-3}
.44-.22	4.12×10^{-3}	.33	1.36×10^{-3}
.22-0	1.65×10^{-2}	.11	1.81×10^{-3}

$$\int E\phi(E)dE = 5.7 \times 10^{-3} \text{ Mev/dis}$$

For one curie: 2.1×10^{8} Mev/curie sec, or 2.1×10^{14} ev/curie sec

For one megacurie: 2.1×10^{20} ev/curie sec

$$\text{gm moles/sec} = \frac{2.1 \times 10^{20} \text{ ev/sec} \times 0.25 \text{ molecules/ev}}{6.02 \text{ gm moles/molecule}}$$

$= 8.7 \times 10^{-5}$ gm moles/sec or $e.14 \times 10^{-1}$ gm moles/hr

or, 7 liters/hr

This rate of hydrogen generation is not high enough to present a hazard. The pool is covered by an expanded metal cover, and also by a sheet of transparent plastic. The latter is elevated so that air can circulate under it. The air circulation in this area of the facility is good so that there can be no accumulation of hydrogen.

12.4 Transfer Accidents

12.4.1 Cupola Rupture

The purpose of the cupola is to provide secondary containment of the HAPO cask connections during and subsequent to the transferal of the feed solution from the cask to the feed storage tank. The operator, wearing full protective clothing (Section 10.7) and an independent air supply, removes all lines and the thermocouple by working through the glove ports. If the cupola should be torn away during this process, any spilled or otherwise deposited feed solution would remain in the well of the cask. Even though the operator is safe in the absense of the cupola, its presence is justified by the fact that it does, if intact, prevent any release to the surrounding area, that would require cleaning up.

12.4.2 Feedline Breakage

As stated in the process description, subsequent to the connection of all lines and the thermocouple to the HAPO cask, no personnel are in the isolation room. The process from dissolution on is carried out remotely. The strontium solution is vacuum drawn to the feed storage tank through the feed line. Unless the supports fail and the line breaks simultaneously, only a minor spill can occur, the major portion of the solution running back into the cask or being drawn to the feed storage tank. If the feedline should break at the point where it goes into the isolation room wall and if, in addition, the line supports should fail, allowing the line to fall to the floor, then worst-case conditions would be realized. The greatest length that could extend from the HAPO cask to the floor is 8 feet. The inside diameter of the line is 0.275 inch and the solution concentration is a maximum of about 3 curies/cm^3. Thus a maximum of

$$(\pi r^2 h\ \text{cm}^3)(3\ \text{curies/cm}^3) = \pi(0.1375)^2(8 \times 12)\text{in}^3 \times 16.39\ \frac{\text{cm}^3}{\text{in}^3}$$

$$\times\ 3\ \text{curies/cm}^3 = 280\ \text{curies}$$

is released to the floor of the isolation room. As the process is TV monitored, any such release and its extent could be immediately determined. If the maximum release occurs, water dilution will be necessary before manual clean-up (as described in waste hold tank leak section) is initiated.

12.4.3 <u>Capsule Transfer from Cell 5 Storage to Storage Pool</u>

12.4.3.1 Cask or Capsule Rupture During Transfer from Cell to Pool

During transfer of the cask, on a dolly, the dolly will be pushed and guided by trained operators over a smooth, uninterupted, concrete floor from Cell 5 to the service area.

During transfer of the cask by the 15 ton capacity service area crane, the cask will be suspended not more than 15 feet or less above the service room floor as it moves across the service area to the pool. While all handling and movement will be performed by skilled operators, a human error or mechanical failure could result in the dropping of the cask in the area between Cell 5 and the pool.

This cask will be constructed with a steel inner and outer jacket. The inner jacket will be at least 1/4 inch thick and be bonded to the lead so that significant deformation cannot occur if the cask is dropped. The cask cover will be secured to the cask body by a steel pin of at least 1/2 inch diameter to prevent disassembly in case of impact. Thus it is considered incredible for a capsule to become dislodged and crushed or significantly deformed by the cask.

Having established the above criteria for the transfer cask, it is apparent that the maximum load on a capsule will be its own impact force. While the cask will be fastened in a manner to preclude disassembly, the components of the cask will probably not be rigidly connected. Each component will react essentially, as an independently impacting body. So, similarly, will the capsules react. This means that except for the differences in material characteristics between the cask and the floor the impact loads on a capsule impacted within the cask would be the same as the impact loads on a capsule dropped independently. In practice, the bottom of the cask will probably be a better energy absorbing medium than the floor, so that a capsule contained in the cask will be subjected to less stress than one dropped separately.

Using $v = \sqrt{2as}$ it is calculated that a capsule dropped from 15 feet will impact with a velocity of 31 ft/sec. The average weight of a powder capsule is about 5.21 pounds so that its kinetic energy at impact is very nearly 80 ft-lb. The lack of engineering data and correlations for the analysis of containers under impulsive loads precludes a detailed analysis of the stress imposed on the capsule for all attitudes of impact. That the capsule will not rupture under 80 ft-lb impact can be inferred, however, from a calculation of the total energy which the outer container can absorb without rupture. This is simply the area under a standard tensile stress-strain diagram for the container material multiplied by the container volume. The area under the stress-strain curve for A1S1-316 steel is 47,000 in. lbs/in^3 and the outer container volume is 6.095 in^3. The container should be capable of absorbing up to approximately 20,000 ft-lbs without rupturing. Since the impact energy under question is only 80 ft-lbs it is clear that the capsule would not be ruptured by a 15 foot drop onto a concrete floor.

12.4.3.2 Capsule or Pool Damage by the Cask

Dropping the cask into the pool would impose approximately the same load on the capsules in the cask as dropping on the service room floor and is, therefore, no more hazardous. Dropping of the cask upon capsules already in the pool is not credible since the capsules will be stored around the periphery on three sides of the pool with the fourth side being kept free of capsules. The cask will always be transferred across this side of the pool.

It has not been possible to determine if a dropped cask would crack the pool floor. Consensus of opinion, based on the pool design, is that it would not. If the floor were to crack, however, it is believed that the resultant leakage rate would be small and, therefore, not represent a hazardous condition.

12.4.3.3 Capsule Melting

The total weight of strontium fuel and steel in each capsule is less than 6 lb. The specific heat of fuel and capsule is approximately 0.12 BTU/lb.°F. The temperature rise, assuming adiabatic conditions would be:

$$t = \frac{7.4 \text{ BTU/min}}{6 \text{ lb} \times 0.12 \text{ BTU/lb}^\circ\text{F}} = 10^\circ\text{F/min.}$$

This is well below a rate of rise that could cause thermal shock.

An alternate cask is available in which six capsules may be transferred. The most severe heating will occur with six capsules contained in the cask. The maximum heat output per capsule is 130 watts and the cask will be approximately 10 inches ID by 30 inches OD. If the cask is taken as lead only, the inner surface will be raised only a few degrees Fahrenheit above ambient. Assume only radiation loss of heat by the capsules (conservative, since convection will also remove heat). If one-half the lateral surface of the six capsules is taken as the radiative surface and an emissivity of 0.3 is assumed for capsule and inner cask surface, the maximum surface temperature achieved on the capsule is less than 100°F. Since this is well below the melting point of stainless steel (2550°F), there is no danger of capsule melting.

12.5 Storage Accidents

12.5.1 Cell 5 Storage

The capsules that are stored in Cell 5 are cooled by the cell air flow. Since there is an auxiliary cell exhaust system, it is not considered credible that the capsules would be without cooling. If the normal exhaust system should fail, it could be repaired while the auxiliary system maintained the air flow.

The analysis of the accidental dropping of a capsule (Paragraph 12.4.3.1) showed that a capsule could not be damaged by a fall from 15 feet so, since the cell has a 12 foot ceiling, a drop in the cell could not damage a capsule.

12.5.2 Pool Storage

12.5.2.1 Capsule Leakage During Storage in the Pool

Every capsule is doubly contained and leak-checked before removal from Cell 5. However, if both the inner liner and outer container of a capsule are damaged during transfer or installation in the pool, a leak could develop. Such a situation is extremely improbable but is remotely credible.

The presence of a breached capsule would be promptly detected during one of the frequent gross beta count analyses of the pool water and/or as a result of detection by the continuous liquid flow type monitor probe. Furthermore, a device which is capable of locating the leaking capsule is a permanent part of the storage facility. This device consists of a can, open at one end, which fits over the fuel capsule. Flexible tubing, attached to the other end, is connected to a pump which draws water from immediately around the capsule through a liquid flow counter. Available liquid flow counters of the continuously monitoring type are capable of detecting concentrations as low as 10^{-7} μc/cc.

The pool is filled from the 2-inch main pool water supply system. A 2-inch overflow pipe terminates one foot below the top of the pool and connects with the suspect drain-system. Thus, it is not possible for any water from the pool to enter uncontrolled drainage or sewage systems.

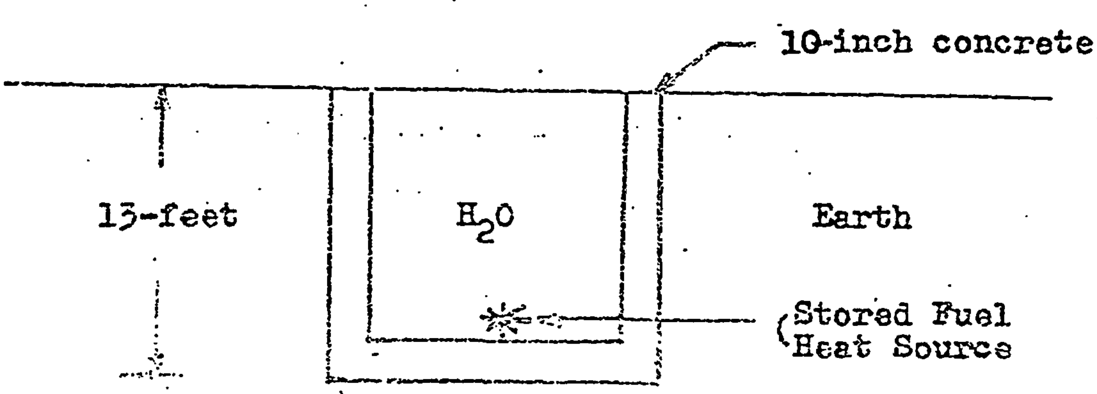
12.5.2.2 Failure of the Pool Water Circulation System

The clean up system for the gamma pool consists of a stainless steel closed circuit system which runs from the gamma pool four and one-half feet underground to a shielded room in the mechanical equipment room. Access to this room is through a separate locked door. The pool water recirculating system is enclosed by three walls of concrete blocks, the building outside wall making up the enclosure. The 3/4-inch plywood top and concrete block walls have a smooth nonporous finish painted with Phenoline 300 or its equivalent. Equipment in the cleanup room consists of two circulating pumps rated at 5 and 20 gpm and two resin beds and two 10-micron filters in parallel. Each of these resin beds is so designed that the valves may be closed to one bed and the complete filter unit, if necessary, can be removed and replaced. Only the resin may be replaced if desired.

If the water circulation system for the storage pool fails, the temperature of the water will increase, since there will be heat transferred out of the pool through the walls and to the air above the pool, an equilibrium temperature will be reached that depends on the activity stored in it.

The storage pool at Quehanna is 13 feet deep with surface dimensions of 8 x 10 feet. The walls are made of 10 inches of concrete. The stored material acts as a constant heat source to the water. Heat is lost from the water in two ways.

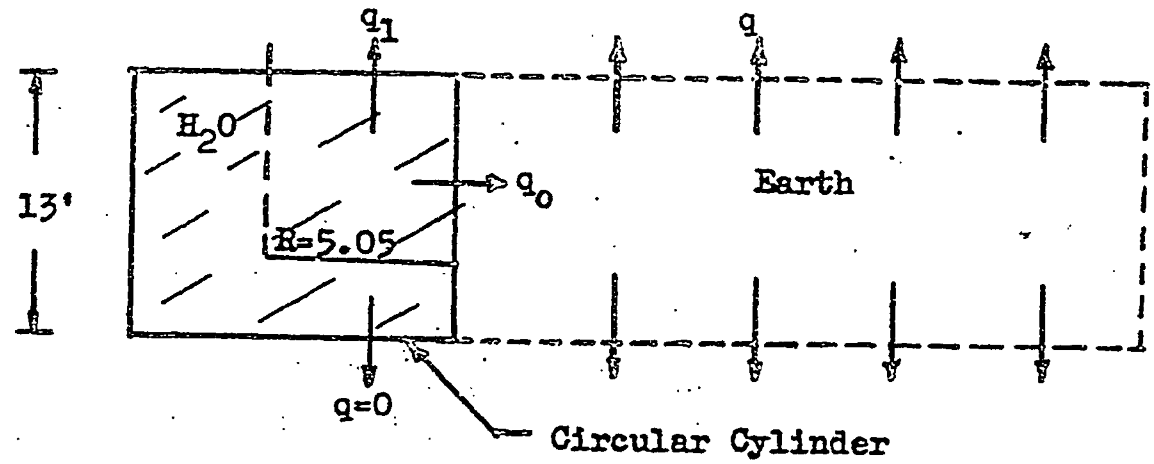
1. Heat is conducted through the concrete walls and into the surrounding earth.
2. Heat is transferred by convection from the upper surface of the water to the air above the pool.



The analytical model chosen to solve the heat transfer problem is that of a circular cylinder. The dimensions of the cylinder are chosen so the surface area of the cylinder is the same as that of the actual pool and the depth is the same.

The assumptions used to simplify the problem are:

1. The air above the pool is still. It is at atmospheric pressure with a temperature of 70°F.
2. Since there will be natural mixing of the heated water, the water is assumed to be the same temperature throughout.
3. No heat is lost through the bottom of the pool.
4. The thermal conductivity of the earth is K = 1.1 BTU/hr ft°F (Reference 12.10). This is the conductivity of the sandstone which is found in the Quehanna area.
5. The cooling affect of the evaporation of water from the surface is neglected.
6. The heat loss through the walls is approximated by calculating the heat loss from an infinitely long fin of earth extending radially from the pool. The fin shape is that of an annular disk.



The results of this calculation are shown in Figure 12.9. It is found that for about 800000 curies stored in the pool the equilibrium temperature reached is 150°F. At this temperature the maximum evaporation rate is about 10 gal/hr. A heat exchanger will prevent the temperature from exceeding 150°F even with 5 megacuries stored in the pool.

A second calculation was made for the rate of evaporation with air circulation over the pool.

The results of the calculations are:

Velocity of Air (ft/min.)	Water Loss (gal/hr.)
0	6.62
10	6.88
60	8.35
120	10.00 = maximum

12.5.2.3 Total Loss of Pool Water

A total loss of pool water, resulting from any sequence of events, is not considered to be credible. The entire water purification and circulation system is in a closed cycle, physically located above the normal water level of the pool. The slow loss of water through a crack in the concrete is

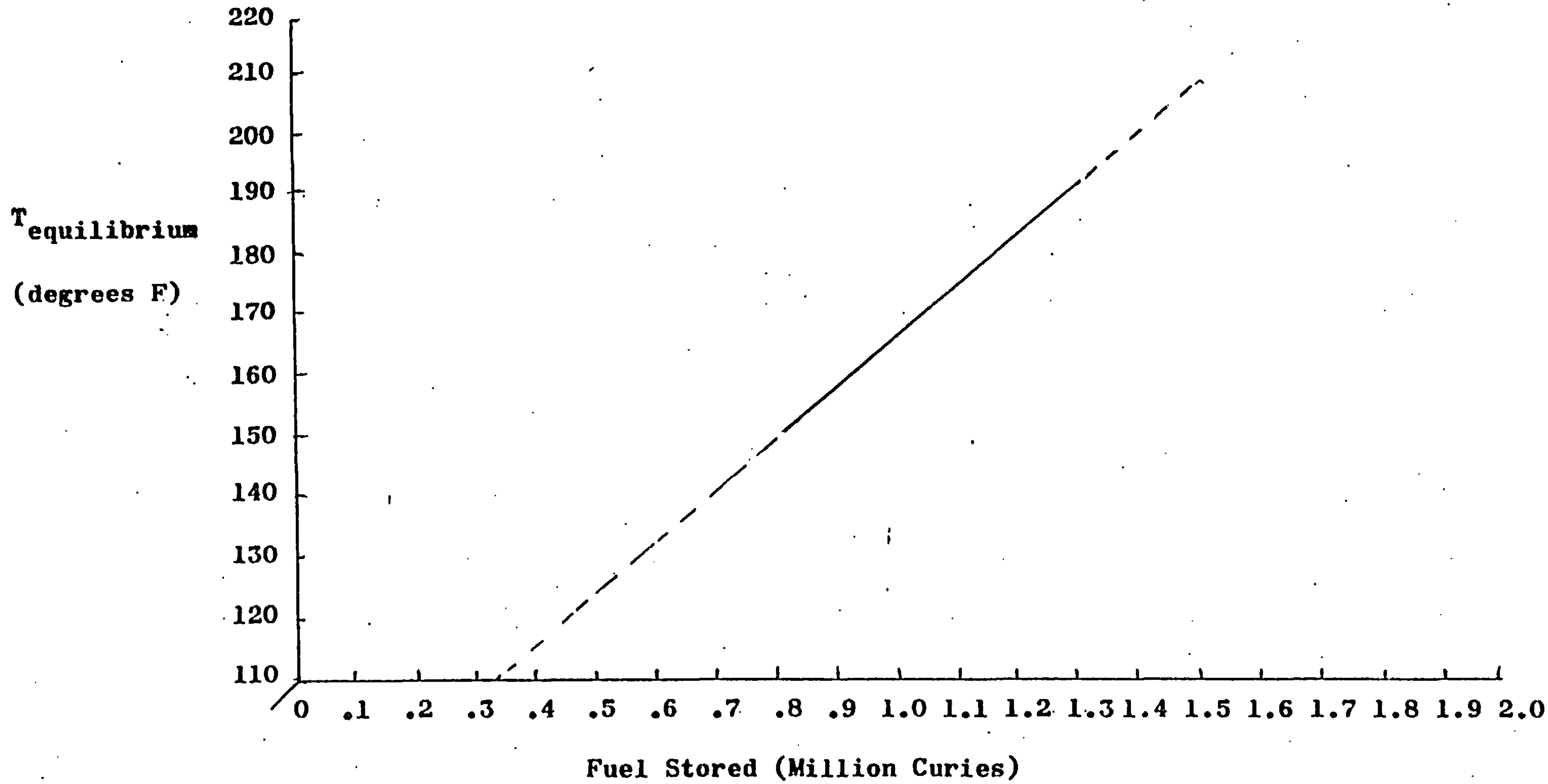


Figure 12.9 Equilibrium Temperature vs. Fuel Stored

possible. The area and the pool are under 24-hour surveillance by facility personnel. In addition, demineralized water is made and is available adjacent to the pool. Thus, the pool water level will be maintained at proper level and immediate response would be given to correction of the source of leak.

12.5.2.4 Accidental Falls into the Pool

The probability of such an accident is extremely remote. A three-foot high concrete rail surrounds the pool and it is covered except during actual transfer and leak testing operations.

12.6 Air Handling Analysis

After considering the possible malfunctions of the ventilation system which might occur during the operation of the plant, the following two cases were taken as representative. They include situations which arise from a malfunction of instruments and the operating error of the personnel.

12.6.1 Instrument Malfunction

In examining the possible ways for a pressure reversal to occur due to instrument malfunction, the following case was considered.

— The normal exhaust fan for Cell 4-(E-6) was considered to have failed. This would only present a problem if the differential pressure switch across this fan would malfunction. Normally, the loss of pressure change across the fan would automatically close the damper in the normal cell exhaust duct, open the damper in the auxiliary cell exhaust duct, start the auxiliary cell exhaust fan and an alarm would signify the stopping of the normal exhaust fan (see Figure 6.2). Also, the loss of air flow in the normal exhaust duct would cause the gravity backflow damper to close in that duct. It was considered that the differential pressure switch failed to acknowlege the loss of pressure change across the normal exhaust fan E-6. The auxiliary cell exhaust system would not come on, nor would the motorized damper in the normal cell exhaust duct close. Also consider that the gravity backflow damper had stuck in the open position. The result of this series of highly unlikely failures of equipment would be that the cell exhaust duct from Cell 4 would be open and no fan would be operating in that duct.

The back pressure from the friction and inertia losses in the stack was calculated to be 0.151 inches of water. This back pressure plus the higher pressure in the exhaust duct on the way to the stack from the other cells would cause a nominal backflow toward Cell 4 along the normal cell exhaust duct. The pressure drops across the two absolute type filters and one roughing filter in series in this duct would reduce the back pressure seen by the cell. The backflow would cause the pressure in Cell 4 to slowly start to rise. The gauges measuring the pressure difference between the cell and the operations area would show the pressure differential reduction and the auxiliary cell exhaust system would be started.

The result would be, even after the highly unlikely series of instrument failures, that the auxiliary cell exhaust system would return the pressure differential to normal with no resulting pressure reversal. The operating personnel would immediately check the normal cell exhaust fan and damper system since, even though the instruments did not show the reduction in pressure differential across the fan, the starting auxiliary exhaust system would indicate that the normal exhaust fan was not in operation.

12.6.2 Operating Personnel Error

In examining the possible hazards created by operator errors, the following case was considered.

To change a manipulator boot the manipulator must be removed from the cell wall. While the manipulator is out of the cell wall there is an 8-inch opening which leads from the operations area into the cell. During a normal boot change, the old boot is left in place while the new boot is pushed through the opening. Therefore the 8-inch opening is covered at the process box end by the old boot. A special tool is used to hold the flat spring (see Figure 9.4) compressed while the new boot is moved through the cell opening. When the new boot is lined up, the old boot is pushed off and the flat spring is released so that the new boot is in place. If the operator should accidently misjudge the alignment or somehow drop the new boot as well as the old boot into the process box, there would be an open path leading directly into the process box.

The resulting air velocity through this opening was calculated to be over 3800 feet per minute when the cell and process box exhaust systems are in operation. If, for some unlikely reason, both the normal and auxiliary cell exhaust systems should fail leaving only the process box exhaust in operation, the velocity is over 280 feet per minute. These velocities are high enough to insure that no upstream diffusion of contamination could occur.

12.7 Process Vessel Leaks

12.7.1 Feed Storage Tank Leak

The feed storage is located in the cell annex of Cell 4 flush against Cell 3 isolation room wall and Cell 4 wall. The tank is designed with a safety factor of five or more. It is leak tested at a pressure of 100 psi for 4 hours. All seams are Heliarc welded and the chance for a leak is indeed remote. If, however, a leak should occur, in keeping with the practice of double containment, a watertight chamber which is constructed of 1/4-inch stainless steel surrounds the feed storage tank. The stainless steel chamber will have a capacity greater than the feed storage tank. A stainless steel line (normally capped at termination) runs from the bottom of this chamber into the cell. It would be used to carry the spilled feed solution into the cell in the event of a leak. Another line is provided to make possible the washing of the feed storage tank exterior.

Cooling the liquid presents no problem as the stainless steel cooling coils spiral about the exterior of the tank and are in direct contact with the liquid. If the cooling from one set of coils is insufficient, a second set parallel to the first can be operated in addition. The release of activity-bearing vapor resulting from such an occurrence is the maximum credible accident and is considered later.

12.7.2 Waste Hold Tank

The waste hold tank is located in the isolation room of Cell 3. Before any solution is transferred to the waste hold tank it is sampled and tested to be sure the activity is low (see paragraph 3.1.4). This assures that a minimum of fuel material is lost to waste, and that the activity level of the waste hold tank is low.

The waste hold tank is made of 1/4 inch stainless steel and all seams are Heliarc welded. The tank has been pressure tested to 100 psi for 4 hours.

The waste contained in the tank is of low enough activity to allow manual clean-up in case of a release. The operator would don full protective clothing as described in Section 10.7 and mop up the spill using long-handled tongs and an absorbent material. The contaminated absorber is deposited in a shielded container and the container is stored in the waste storage building. As in the case in any type of accident, the area is sealed off and the Health Physicist conducts a survey to determine the extent of the contamination.

12.7.3 In Cell Tank Leaks

Cell 4 contains the filtrate tank, capacity 75 liters; the vacuum surge tank, 50 liters; the metering tank, 5 liters; and the precipitation vessel, 50 liters. The latter two are in the process box. All of these tanks are constructed of stainless steel, are Heliarc welded and have been tested to 100 psi for four hours. Leakage of any of these is improbable but in case it should take place the shielding due to the cell wall prevents any direct radiation hazard. Clean-up, decontamination and repair within the process box would be carried out by use of the manipulators. The tanks that are not in the process box cannot be reached by the manipulators so repair would be carried out by other remote means.

12.7.4 Hydraulic Oil Leakage

The hydraulic fluid used in the press is Monsanto Pydraul which is composed of phosphate esters and chlorinated hydrocarbons. These liquids have open cup flash point temperatures of approximately 470°C and fire point temperatures of 675 - 725°C. Therefore, in order for the fluid to flash, it must be completely vaporized and must be subjected to a temperature of at least 700°C.

If a minute hole should form in the hydraulic pressure line during the power stroke of the press, it is conceivable that a portion of the hydraulic fluid could be sprayed out in a vaporized mist. The furnace is the only object in the process box which will even approach the required temperature for flashing the oil. The furnace is surrounded on five sides with panel coil coolers so that the only point of access for oil spray would be the 13-inch high cut out on one panel which is used for the electrical connections for the furnace. However, this area is protected since the hydraulic lines, which are designed with a high margin of safety, enter the 4A section of the process box on the side away from the furnace. The placement of these lines is such that should the line break or spring a small high velocity leak at the weakest point, the connector, the precipitation tank (T-33) would be between the break and the exposed portion of the furnace. For the above reasons the burning of the hydraulic fluid in the process box is not considered to be credible.

12.8 Activity Releases

12.8.1 General

12.8.1.1 Meteorological Models

Sutton's diffusion equations (Reference 12.1) have been used in previous analyses of potential release hazards for the Quehanna site (References 12.2, 12.3) and their use is continued in this study.

The equation for the concentration of a radioactive plume for a continuous point source release is

$$X = \frac{2Q}{\pi u \, C_y \cdot C_z d^{2-n}} \exp\left[- \frac{1}{d^{2-n}} \left(\frac{y^2}{C_y^{\,2}} + \frac{z^2}{C_z^{\,2}} \right) \right]$$

where

X = cloud concentration at ground level curie/meter^3, equivalent to $\mu c/cc$)

Q = activity release (curie/sec)

C_y = cross-wind diffusion coefficient (meters$^{n/2}$)

C_z = vertical diffusion coefficient (meters$^{n/2}$)

u = wind velocity (meters/sec)

d = distance from release point (meters)

n = atmospheric stability parameter

y = crosswind distance from centerline of cloud (meters)

z = vertical distance from ground to centerline of cloud (meters)

Calculations are usually made for ground level under the centerline of the cloud in which case the y^2/C_y^2 term in the exponential drops out.

Two meteorological situations shown in Chapter 2 to be appropriate to the site have been examined. The first of these which tends to prevail during the day is a neutral condition with approximately adiabatic lapse rate. The second which occurs frequently at night, and in the early morning, is a stable inversion condition. The values of the parameters as used for the two models are:

Parameter	Model	
	Neutral	Inversion
C_y	0.40	0.40
C_z	0.40	0.05
n	0.25	0.55
u	5	3

It has been assumed that any discharge to the environment takes place from the stack which has a height of 15.25 meters (50 ft); consequently this value has been used for z.

12.8.1.2 Inhalation Doses

In an airborne release of radiostrontium the principal dose to a receptor in the cloud path is incurred by inhalation. The activity inhaled is calculated directly.

$$I = XBt$$

where

I = activity inhaled (microcuries)

B = breathing rate (cc/second)

t = exposure time (seconds)

It is assumed that the "standard man" inhales 20,000 liters (2.0×10^7 cc) of air in 24 hours. The average breathing rate is consequently 232 cc/sec. However, it is usually assumed that half of the 20,000 liters is inhaled during the more active 8 hours of the day. The breathing rate during this period is consequently 347 cc/sec (Reference 12.4).

The most significant assessment of the potential radiation hazard from inhalation is obtained by a calculation of the integrated lifetime dose to the critical organ accruing from the activity inhaled. This may be calculated by the method proposed by Burnett (Reference 12.5). The applicable equation is: $D' = \frac{73.8\, f_a \Sigma E(RBE)n\, T_E}{m}$

D' = lifetime dose for activity inhaled, (rem/μc)

f_a = fraction of activity inhaled that remains in the critical organ

Σ FE(RBE)n = energy per disintegration delivered to the critical organ, considering the relative biological effectiveness (RBE) of the radiation, and n the relative damage factor for nuclides deposited in the bone (Mev).

T_E = effective half life of the activity in the critical organ (days)

m = mass of the critical organ (grams)

For the inhalation of strontium-90 a distinction should be made between soluble and insoluble forms. The bone is the critical organ for the soluble form and the effective halflife is long. For the insoluble form the lung is the critical organ and the residence time of the activity is relatively short. In the subsequent calculations the values used for the parameters for strontium-90 with its daughter product, yttrium-90, are given below (from Reference 12.4).

Parameter	Insoluble	Soluble
f_a	0.12	0.12
Σ FE(RBE)n	1.1	
T_E	120	6.4×10^3
Critical organ	Lung	Bone (including marrow)
Mass	1000	10000
D' rem/μc	1.18	31.1

12.8.1.3 Areas of Potential Exposures

Calculations have been made for the two selected meteorological models of the plume concentration, activity inhaled and integrated lifetime dose for three distances from the Radioisotope Pilot Plant. The first of these, 4800 meters, is the approximate distance to the nearest point on the perimeter of the exclusion area. This is a point not easily accessible and is not normally occupied; it may be visited occasionally by hunters in season. The nearest approach of unrestricted roads is about 8000 meters. The nearest occupied village or town, Sinnemahoning, is distant about 16,000 meters.

12.8.2 Releases to the Environment

12.8.2.1 Maximum Credible Accident

It is assumed that in the future the Radioisotopes Pilot Plant will receive shipments in the HAPO I cask of 500 kilocuries of Strontium-90 and that up to 750 kilocuries may be held in the feed storage tank. This tank is located in a stainless steel chamber in the cell annex of Cell 4. Refer to Chapter 3 and the detached drawings. This tank is made of stainless steel and has fittings and connecting plumbing for connection to the HAPO Cask and to the metering vessel. A rupture of the feed storage tank permitting a large quantity of the strontium nitrate solution to leak into the stainless steel changer is highly improbable but will be considered to be credible. The strontium nitrate in solution is not volatile. It is thought that the dual set of cooling coils is sufficient to maintain the feed solution temperature below boiling. But it is assumed that with boiling due to self-heating a fraction of the activity becomes airborne in aerosol form. This fraction is pessimistically assumed to be 0.1%; thus it is postulated that 750 curies can be released. If there should be a failure of one roughing filter and three absolute type filters this activity could be released into the ventilation system and discharged through the stack. It is estimated that there is essentially a complete change of air in the building in about 13 minutes. The rate of release of activity to the environment is assumed to be a continuous uniform release of the 750 curies in 780 seconds, or Q = 0.962 curie/sec.

Thus the maximum credible accident is postulated to be the result of six sequential or simultaneous and scarcely related accidents of varying credibility.

The plume concentrations, activity inhaled and lifetime dose for various distances and the two selected meteorological models are presented in the following table. The greatest dose received, that at 4800 meters under inversion conditions, is 187 rems. This is, of course, a significant radiation dose, but it should be emphasized that this is the total integrated dose received over many years. The

	NEUTRAL CONDITIONS			INVERSION CONDITIONS		
Distance	Plume Conc.	Activity Inhaled	Lifetime Dose	Plume Conc.	Activity Inhaled	Lifetime Dose
d	X	I		X	I	
meters	μc/cc	μc	rem	μc/cc	μc	rem
4800	2.76×10^{-7}	5.05×10^{-2}	1.57	3.29×10^{-5}	6.01	187
8000	1.130×10^{-7}	2.04×10^{-2}	0.635	1.960×10^{-5}	3.54	110
16000	3.37×10^{-8}	6.09×10^{-3}	0.19	8.18×10^{-6}	1.48	46

dose received during the first year is 3.95% of the total, or 7.4 rem, and this quantity decreases progressively each year. It is not expected that clinical symptons would ever be observed in an individual with this exposure.

It should be emphasized that if even one absolute-type filter in the system remained inviolate the plume concentrations at all points would be decreased by a factor of at least 100.

12.8.2.2 Other Accidents

It is assumed that the largest quantity of the strontium nitrate that will be withdrawn from the feed storage tank for batch processing is 25,000 curies. This quantity will be measured in the metering tank and transferred to the process vessels. These transfers are by suction so that any failures due to line leakage or rupture would release only minimal quantities of liquid. After transfer to the process cess vessel there is multiple containment, i.e. the process vessel, process box and cell. It is difficult to conceive of any accident in the processing of the material whereby any large fraction of the activity in the solution could become airborne. For release to the environment there would have to be simultaneous or sequential failure of four absolute type filters. Even if there could be release of as much as 1% of the material, the activity released would be 250 curies and the consequences would be less severe than for the maximum credible accident examined above.

12.8.3 Releases Within the Building

12.8.3.1 General Consideration

The greatest potential hazard to the operating personnel of the Pilot Plant arises from accidents that might release airborne particulate material into the operations area. The situation that appears to be credible is the rupture of a manipulator boot. This hypothetical accident will be discussed in the following analysis.

It is assumed that the largest quantity of strontium titanate powder (or other fuel form) that may be in process in the process box 4A at one time is 150,000 curies. Of this quantity not more than 50,000 curies will be in a loose form subject to becoming airborne. The remainder will have been pelletized, or at least compressed in the way of producing a pellet.

The alundum filter crucible serves as the container in the furnace so that the only pouring of dry powder is into the pellet press.

It is extremely difficult to make a estimate of the quantity of dry powder that could become airborne in the worst circumstances. Various approaches consider the mass concentration of known aerosols and the ratio of exposed surface to the mass of the powder. Postulation of 0.1% as the maximum quantity to become airborne appears to be highly pessimistic. Thus if 50 curies become airborne in process box 4A that has a volume of $9.15 m^3$ ($323 ft^3$) the concentration is 5.46 uc/cc.

12.8.3.2 Rupture of Manipulator Boot

A 1/2 inch annular gap exists between the manipulator support tube and the device which clamps the manipulator boot to the wall of the process box. This gap permits the boot to breathe cell air internally as the manipulator is moved in and out. If the pressure in the boot, or in the process box if the boot is ruptured, is considered as rising above the cell pressure, than air is expelled through the gap into the cell.

If a manipulator boot is torn, it is conceivable that, if the manipulator is pushed rapidly into the box, the boot will be filled to some extent with contaminated air from the box, although in practice most of this air will come from the air at higher pressure in the cell. If the manipulator is now withdrawn rapidly, portions of the contaminated air will be expelled into the cell and into the operating area, and a portion will be returned to the box. For the purposes of this analysis, the worst possible case is assumed: the boot is filled only with contaminated air and, once filled, the boot expels the contaminated air only to the cell and operating area. The largest boot employed varies uniformly in average diameter from 10 inches to 4 inches and has a maximum working stroke of 45 inches. It encloses a manipulator arm 4 inches in diameter. Thus, the maximum volume of air pumped is 0.74 $ft.^3$ Based on the steady state flow rate figures computed on the basis of relative opening areas, about 90% of this will flow into the cell and 10% into the operating area if the manipulator can be moved quickly enough to raise the pressure in the boot to greater than the operating area pressure. This would be almost impossible to achieve in practice, but again for the purposes of the analysis it is assumed to occur. Therefore, 0.074 ft^3 of air would be expelled into the operating area. This 0.074 ft^3, or 2100 cc would contain 1.15×10^4 microcuries. If it is assumed that this activity becomes uniformly dispersed through the volume of the operating area, 18,930 ft^3 or 536 m^3, the concentration becomes 2.24×10^{-5} μc/cc. This is a factor of 4500 times the occupational MPC for insoluble strontium-90. The area monitoring system is capable of detecting levels of the order of the MPC in about one or two minutes, and thus the release of the stated amount of activity would be detected almost immediately, the alarm would be sounded and face masks would be donned. If it is further assumed that the cell operators would breathe the contaminated air for 20 seconds at the 347 cc/sec rate, before the alarm is sounded, the activity inhaled is 0.155 microcuries. The corresponding lifetime dose due to strontium-90 in the insoluble form is 0.185 rem. In contrast to the inhalation of the soluble form, as previously discussed, this dose would be received substantially in the first year. Even if the dispersion of the activity is only into one-tenth of the volume of the operating room, the situation is still tolerable. If this postulated dry release were of a soluble form, the corresponding lifetime dose would be about 4.8 rem.

12.9 References

12.1 Meteorology and Atomic Energy. Prepared by the U.S. Weather Bureau for the U.S. Atomic Energy Commission. July 1955

12.2 Hazards Evaluation Report- Curtiss-Wright Research Reactor. Curtiss-Wright Corporation. April 1959

12.3 Radioisotopes Production Facility at Quehanna. MND-2410 Revision A. Martin Marietta Corporation. November 1961.

12.4 International Commission on Radiological Protection, Report of Committee II. 1959

12.5 Burnett, T.J., Reactors, Hazard vs Power ~~Level~~, Nuclear Science and Engineering, 2,382-393. 1957.

12.6 Materials in Design Engineering, 52(6), 55.

12.7 Sowden, R.Y., J.A.C.S. 79, 1263(1957).

12.8 Zabetakis, M.Y., Research on the Combustion and Explosion Hazards of Hydrogen- Water Vapor- Air Mixtures. AECU-3327, 1956

12.9 Kuhn, D.W., et al., Explosion Limits in Mixtures of Hydrogen, Oxygen, Steam and Helium. Y-731, 1951.

12.10 Marks, Lionel S., Mechanical Engineers Handbook, McGraw-Hill Book Company, Inc., 368, 1951.

12.11 Allen, A.O., The Radiation Chemistry of Water and Aqueous Solutions, D. Van Nostrand Co., Inc., 1961

12.12 Mahlman, H.A., and Schweitzer, Y.K. J. Inorg. Nuclear Chem., 5,213-218 (1958).

12.13 Handbook of Chemistry and Physics, Chemical Rubber Publishing Company.