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Recd. 7/27/89

UNION CARBIDE CORPORATION
P. O. BOX 8361, SOUTH CHARLESTON, W. VA. 25303

U. S. Nuclear Regulatory Commission, Region II
Nuclear Materials Safety Section
101 Marietta Street, Suite 2900
Atlanta, Ga 30323

July 25,1989

Subject: Renewal of USNRC License 47-00260-02

Attached you will find documents, in duplicate, related to the renewal of our USNRC License 47-00260-02. A check for $700.00 to cover the applicable fee is also enclosed. We have recently committed our radiological control manual to a word processor after making a few minor revisions to it. Two draft copies of this manual are also enclosed.

Revisions include adding some of our Standard Operating Procedures as appendices to the manual, updating the personnel and equipment lists, formalizing changing the name of the company from Union Carbide Corporation to Union Carbide Chemicals and Plastics Company, Inc. and changing the meeting schedule for the Radiation Safety Committee (RSC). We solicit your approval or comments on the last change proposed.

We have found that we seldom have any activities underway which are of concern to the RSC. We are proposing to change our procedures so that if no activities of concern to the RSC are underway or being proposed, the quarterly meeting of the RSC be waived in favor of an annual meeting. If any activities of concern to the RSC are underway, they will meet on a quarterly or more frequent basis as appropriate. This change is incorporated on page 9 of the draft copy of "Technical Center Radiological Control Manual".

If you have any questions or comments on these changes you may call me at 304/747-5314.

Yours truly,

Michael L. Green
Radiation Safety Officer

License Fee Information
on application

Information in this record was deleted
in accordance with the Freedom of Information
Act, exemptions 6
FOIA 2007-0179

D-8

NRC FORM 313
(10-87)
10 CFR 30, 32, 33, 34, 35 and 40

APPLICATION FOR MATERIAL LICENSE

U.S. NUCLEAR REGULATORY COMMISSION
APPROVED BY OMB
3150-0120
Expires: 6-30-90

INSTRUCTIONS: SEE THE APPROPRIATE LICENSE APPLICATION GUIDE FOR DETAILED INSTRUCTIONS FOR COMPLETING APPLICATION. SEND TWO COPIES OF THE ENTIRE COMPLETED APPLICATION TO THE NRC OFFICE SPECIFIED BELOW.

APPLICATIONS FOR DISTRIBUTION OF EXEMPT PRODUCTS FILE APPLICATIONS WITH:

U.S. NUCLEAR REGULATORY COMMISSION
DIVISION OF FUEL CYCLE AND MATERIAL SAFETY, NMSS
WASHINGTON, DC 20555

ALL OTHER PERSONS FILE APPLICATIONS AS FOLLOWS. IF YOU ARE LOCATED IN:

CONNECTICUT, DELAWARE, DISTRICT OF COLUMBIA, MAINE, MARYLAND, MASSACHUSETTS, NEW HAMPSHIRE, NEW JERSEY, NEW YORK, PENNSYLVANIA, RHODE ISLAND, OR VERMONT, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION I
NUCLEAR MATERIALS SAFETY SECTION B
475 ALLENDALE ROAD
KING OF PRUSSIA, PA 19406

ALABAMA, FLORIDA, GEORGIA, KENTUCKY, MISSISSIPPI, NORTH CAROLINA, PUERTO RICO, SOUTH CAROLINA, TENNESSEE, VIRGINIA, VIRGIN ISLANDS, OR WEST VIRGINIA, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION II
NUCEAR MATERIALS SAFETY SECTION
101 MARIETTA STREET, SUITE 2900
ATLANTA, GA 30323

IF YOU ARE LOCATED IN:

ILLINOIS, INDIANA, IOWA, MICHIGAN, MINNESOTA, MISSOURI, OHIO, OR WISCONSIN, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION III
MATERIALS LICENSING SECTION
799 ROOSEVELT ROAD
GLEN ELLYN, IL 60137

ARKANSAS, COLORADO, IDAHO, KANSAS, LOUISIANA, MONTANA, NEBRASKA, NEW MEXICO, NORTH DAKOTA, OKLAHOMA, SOUTH DAKOTA, TEXAS, UTAH, OR WYOMING, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION IV
MATERIAL RADIATION PROTECTION SECTION
611 RYAN PLAZA DRIVE, SUITE 1000
ARLINGTON, TX 76011

ALASKA, ARIZONA, CALIFORNIA, HAWAII, NEVADA, OREGON, WASHINGTON, AND U.S. TERRITORIES AND POSSESSIONS IN THE PACIFIC, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION V
NUCLEAR MATERIALS SAFETY SECTION
1450 MARIA LANE, SUITE 210
WALNUT CREEK, CA 94596

PERSONS LOCATED IN AGREEMENT STATES SEND APPLICATIONS TO THE U.S. NUCLEAR REGULATORY COMMISSION ONLY IF THEY WISH TO POSSESS AND USE LICENSED MATERIAL IN STATES SUBJECT TO U.S. NUCLEAR REGULATORY COMMISSION JURISDICTION.

1. THIS IS AN APPLICATION FOR *(Check appropriate item)*

- [ ] A. NEW LICENSE
- [ ] B. AMENDMENT TO LICENSE NUMBER _____
- [X] C. RENEWAL OF LICENSE NUMBER 47-00260-02

2. NAME AND MAILING ADDRESS OF APPLICANT *(Include Zip Code)*

Union Carbide Chemicals & Plastics Company, Inc.
Technical Center
P. O. Box 8361 (Bldg. 740)
So. Chas. WV 25560

3. ADDRESS(ES) WHERE LICENSED MATERIAL WILL BE USED OR POSSESSED.

Union Carbide Chemicals & Plastics Company, Inc.
Technical Center
P. O. Box 8361
So. Charleston, WV 25560

4. NAME OF PERSON TO BE CONTACTED ABOUT THIS APPLICATION

Michael L. Green

TELEPHONE NUMBER: 304/747-5314

SUBMIT ITEMS 5 THROUGH 11 ON 8½ x 11" PAPER. THE TYPE AND SCOPE OF INFORMATION TO BE PROVIDED IS DESCRIBED IN THE LICENSE APPLICATION GUIDE.

5. RADIOACTIVE MATERIAL
a. Element and mass number, b. chemical and/or physical form, and c. maximum amount which will be possessed at any one time.

6. PURPOSE(S) FOR WHICH LICENSED MATERIAL WILL BE USED.

7. INDIVIDUAL(S) RESPONSIBLE FOR RADIATION SAFETY PROGRAM AND THEIR TRAINING AND EXPERIENCE.

8. TRAINING FOR INDIVIDUALS WORKING IN OR FREQUENTING RESTRICTED AREAS.

9. FACILITIES AND EQUIPMENT.

10. RADIATION SAFETY PROGRAM.

11. WASTE MANAGEMENT.

12. LICENSEE FEES *(See 10 CFR 170 and Section 170.31)*
FEE CATEGORY: 3L
AMOUNT ENCLOSED: $ 700.00

13. CERTIFICATION. *(Must be completed by applicant)* THE APPLICANT UNDERSTANDS THAT ALL STATEMENTS AND REPRESENTATIONS MADE IN THIS APPLICATION ARE BINDING UPON THE APPLICANT.

THE APPLICANT AND ANY OFFICIAL EXECUTING THIS CERTIFICATION ON BEHALF OF THE APPLICANT, NAMED IN ITEM 2, CERTIFY THAT THIS APPLICATION IS PREPARED IN CONFORMITY WITH TITLE 10, CODE OF FEDERAL REGULATIONS, PARTS 30, 32, 33, 34, 35, AND 40 AND THAT ALL INFORMATION CONTAINED HEREIN, IS TRUE AND CORRECT TO THE BEST OF THEIR KNOWLEDGE AND BELIEF.

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.

SIGNATURE–CERTIFYING OFFICER	TYPED/PRINTED NAME	TITLE	DATE
J E Sanders	Joe E. Sanders	Dir. of Engineering	7/21/89

FOR NRC USE ONLY

TYPE OF FEE	FEE LOG	FEE CATEGORY	COMMENTS	APPROVED BY
Ren	Aug-2-II	3L 3N 3P		M. Nunes
AMOUNT RECEIVED	CHECK NUMBER			DATE
$700/1,050	123425/113045		25293Y	8/1/89

ITEM 5.--Radioactive Material

Element and Mass No.	Form	Maximum Quantity
A. Any byproduct material, except alpha emitters, with atomic numbers 1 through 83 inclusive.	Sealed sources	300 curies total
B. Americium 241	Sealed neutron sources	25 curies total
C. Any byproduct material except alpha emitters, with atomic numbers 1-83 inclusive	Any	Not to exceed one curie per radionuclide and 2 curies total except carbon 14 two curies total

ITEM 6--Purpose for which material will be used

A. & B. For possession, storage, and/or use in the following:

(1) Research and development as defined in Section 30.4(q), 10 CFR Part 30.

(2) Maintenance, repair, installation, removal and replacement of sealed sources, operation testing, and servicing of gauging devices including the performance of initial radiation surveys and leak testing of sealed sources.

(3) In gas chromatographs for sample analysis.

(4) Instrument calibration.

(5) Field analysis of level and density.

(6) Testing steel vessels for carbon buildup (Am-241 only).

C. For possession, storage and/or use in research and development as defined in Section 30.4(q), 10CFR30.

ITEM 7--Individuals Responsible For Radiation Safety

See Chapter I in the "Technical Center Radiation Control Manual", "The Radiation Safety Committee" and the attached description of their training and experience

ITEM 8--Training

See chapter XII in the "Technical Center Radiation Control Manual"

ITEM 9--Facilities and Equipment

See Chapter XI and Appendix III in the "Technical Center Radiation Control Manual"

ITEM 10--Radiation Safety Program.

See the "Technical Center Radiation Control Manual"

ITEM 11--Waste Management

See Chapter IV in the "Technical Center Radiation Control Manual"

RADIATION SAFETY COMMITTEE
Training and Experience

The following people are current members of the Radiation Safety Committee.

J. H. Brubaker	Management
W. K. Becher	Nucleonics Applications
M. L. Green (RPO)	Nucleonics Applications/Radiation Safety
C. B. McCorkle	Purchasing
J. A. Boggess (Alt. RPO)	Radiation Safety
M. A. Patel	Industrial Hygiene

Each person's training and experience are on the following pages.

M. L. GREEN

TYPE OF TRAINING	WHERE TRAINED	DURATION OF TRAINING	ON THE JOB	FORMAL COURSE
a. Principles and practices of radiation protection	Univ. of Kentucky	9 months	No	Yes
	Univ. of Kentucky	3 months	Yes	No
	Mound Lab. (AEC)	39 months	Yes	No
	Univ. of Cincinnati	8 months	No	Yes
	Union Carbide Corp.	6 months	Yes	No
b. Radioactivity measurement standardization and monitoring techniques and instruments	Univ. of Kentucky	9 months	No	Yes
	Univ. of Kentucky	3 months	Yes	No
	Mound Lab. (AEC)	39 months	Yes	No
	Univ. of Cincinnati	8 months	Yes	No
	Union Carbide Corp.	6 months	Yes	No
	Harvard School of Public Health (4-84)	1 week	No	Yes
c. Mathematics and calculations basic to the use and measurement of radioactivity	Univ. of Kentucky	9 months	No	Yes
	Univ. of Cincinnati	8 months	No	Yes
	Union Carbide Corp.	3 months	Yes	No
d. Biological effects of radiation	Univ. of Kentucky	5 days	No	Yes.
	Mound Lab. (AEC)			

EXPERIENCE (M. L. GREEN)

ISOTOPE	MAXIMUM AMOUNT	WHERE EXPERIENCED GAINED	DURATION OF EXPERIENCE	TYPE OF USE
U-238	Kilograms	Univ. of Kentucky	3 months	Sub-critical Reactor
Classified	Classified	Monsanto Research Corp.	39 months	Classified
Cs-137	Curies	Union Carbide Corp.	18 years	Gauging
Ra-226	m Curies	Union Carbide Corp.	3 years	Gauging
Xe-133	m Curies	Union Carbide Corp.	6 months	Tracer
Cs-137	m Curies	Union Carbide Corp.	6 months	Tracer
Am-241	Curies	Union Carbide Corp.	15 years	Testing and Gauging
C-14	m Curies	Union Carbide Corp.	5 years	Tracer Studies
H-3	m Curies	Union Carbide Corp.	1 month	Tracer Studies

EDUCATION

B.S [redacted] Physics - University of Kentucky

MLG

(b)(6)

J. A. BOGGESS

ISOTOPE	WHERE EXPERIENCED GAINED	DURATION OF EXPERIENCE	ON THE JOB	FORMAL COURSE
a. Principles and practices of radiation protection	Union Carbide Corp.	8 months	Yes	No
	UCC RPO School	2 weeks	Yes	No
	Army CBR Training	2 weeks	No	Yes
b. Radioactivity measurement standardization and monitoring techniques and instruments	Union Carbide Corp.	8 years	Yes	No
	UCC RPO School	2 weeks	Yes	No
	Army CBR Training	2 weeks	No	Yes
c. Mathematics and calculations basic to the use and measurement of radioactivity	Union Carbide Corp.	8 years	Yes	No
	UCC RPO School	2 weeks	Yes	Yes
	Army CBR Training	2 weeks	No	Yes
d. Biological effects of radiation	Union Carbide Corp.	8 years	Yes	No.
	UCC RPO School	2 weeks	Yes	Yes
	Army CBR Training	2 weeks	No	Yes

EXPERIENCE (J. A. BOGGESS)

ISOTOPE	MAXIMUM AMOUNT	WHERE EXPERIENCED GAINED	DURATION OF EXPERIENCE	TYPE OF USE
CS-137	Curies	Union Carbide Corp.	22 years	Density and Level Gauge, Tracer
Co-60	Curies	Union Carbide Corp.	ll years	Density and Level Gauge
Ra-226 & daughters	Millicuries	Union Carbide Corp.	ll years	Density and Level Gauge, Tracer
C-14	m Curies	Union Carbide Corp.	8 years	R&D Gracer
H-3	m Curies	Union Carbide Corp.	6 years	Tracer
Xe-133	m Curies	Union Carbide Corp.	3 months	Tracer
Kr-79	m Curies	Union Carbide Corp.	3 months	Tracer
Sr-90	m Curies	Union Carbide Corp.	8 years	R&D
Au-198	m Curies	Union Carbide Corp.	1 year	Tracer
I-131	m Curies	Union Carbide Corp.	3 months	Tracer
Cs-131	m Curies	Union Carbide Corp.	3 months	Tracer
Rb-86	m Curies	Union Carbide Corp.	3 months	Tracer
Am-241-Be	m Curies	Union Carbide Corp.	14 years	Carbon Measurement

J. H. BRUBAKER

TYPE OF TRAINING	WHERE TRAINED	DURATION OF TRAINING	ON THE JOB	FORMAL COURSE
a. Principles and practices of radiation protection	Union Carbide Corp. RPO School	2 weeks	Yes	Yes
b. Radioactivity measurement standardization and monitoring techniques and instruments	Union Carbide Corp. RPO School	2 weeks	Yes	Yes
c. Mathematics and calculations basic to the use and measurement of radioactivity	Union Carbide Corp. RPO School	8 years	Yes	No
	Univ. of Florida	9 months	No	Yes
d. Biological effects of radiation	Union Carbide Corp.	2 weeks	Yes	Yes

EXPERIENCE

ISOTOPE	MAXIMUM AMOUNT	WHERE EXPERIENCE GAINED	DURATION OF EXPERIENCE	TYPE OF USE
Cs-137	Curies	Union Carbide Corp.	8 yrs.	Process Gauging
Am-241	m Curies	Union Carbide Corp.	8 yrs.	Carbon Detection

EDUCATION

Degree	College or University	Date Acquired	Major
AA	Hershey Jr. College		Science
BS	Univ. of Florida		Physics
MS	Univ. of Florida		Astronomy-Physics

(b)(6)

W. K. BECHER

TYPE OF TRAINING	WHERE TRAINED	DURATION OF TRAINING	ON THE JOB	FORMAL COURSE
a. Principles and practices of radiation protection	Electric Corp. Westinghouse	4 years	Yes	Yes
	CGR Medical Corp.	5 years	Yes	No
	Union Carbide Corp. Training for RPO	80 hours	Yes	Yes
	USAF Keesler AFB	2 weeks	No	Yes
b. Radioactivity measurement standardization and monitoring techniques and instruments	Electric Corp. Westinghouse	4 years	Yes	Yes
	CGR Medical Corp.	5 years	Yes	No
	Union Carbide Corp. Training for RPO	80 hours	Yes	Yes
	USAF Keesler AFB	2 weeks	No	Yes
c. Mathematics and calculations basic to the use and measurement of radioactivity	Electric Corp. Westinghouse	4 years	Yes	Yes
	CGR Medical Corp.	5 years	Yes	No
	Union Carbide Corp. Training for RPO	80 hours	Yes	Yes
	USAF Keesler AFB	2 weeks	No	Yes
d. Biological effects of radiation	Electric Corp. Westinghouse	4 years	Yes	Yes
	CGR Medical Corp.	5 years	Yes	No
	Union Carbide Corp. Training for RPO	80 hours	Yes	Yes
	USAF Keesler AFB	2 weeks	No	Yes

EXPERIENCE

ISOTOPE	MAXIMUM AMOUNT	WHERE EXPERIENCE GAINED	DURATION OF EXPERIENCE	TYPE OF USE
Co^{60}	Curies	Westinghouse Electric	4 yrs.	Medical
Co^{60}	Curies	CGR Medical Corp.	5 yrs.	Medical
Cs-137	Curies	Union Carbide Corp.	12 yrs.	Density & Level Gauge
Cs-137	m Curies	Union Carbide Corp.	12 yrs.	Density & Level Gauge
Am-241 Be	Neutron	Union Carbide Corp.	12 yrs.	Carbon Measuremt.

C. B. MCCORKLE

Ms. McCorkle has no formal training or experience with radioactive materials. Her sole purpose for sitting on the committee is to provide a direct link between the Committee and the Purchasing Department. She has all responsibility for processing purchase orders for radioactive material controlled by this license.

M. A. PATEL

Mr Patel is a Certified Industrial Hygienist. He earned a B.S. in Biology and Chemistry in [redacted] an M.S. in Biochemistry in [redacted] and a Masters of Science in Public Health in [redacted] from the University of Michigan. He has also successfully completed a Union Carbide class in radiation safety. He is currently the site Industrial Hygienist.

(b)(6)

Withheld Attachment 2 pages 1-81

TECHNICAL CENTER
RADIOLOGICAL CONTROL MANUAL

Draft Copy
M J Green

August 1, 1979
Revised July, 1984
Revised July, 1989

Nuclear Measurements Skill Center
Automated Analytical Systems
Central Research and Engineering Technology
Union Carbide Chemicals & Plastics Co., Inc.
South Charleston, West Virginia

TABLE OF CONTENTS

CHAPTER I

INTRODUCTION AND ORGANIZATION

1. PURPOSE

This Radiological Control Manual (a) outlines and prescribes the Union Carbide Corporation's Technical Center Radiation Control Program and identities responsibilities for its implementation and operation; (b) identifies this manual as the official technical publication for controlling the use of radioactive materials, X-ray equipment, and other harmful electromagnetic and particulate radiation-producing sources; and (c) identifies the functions of the Radiation Safety Committee.

Preparation and maintenance of the Technical Center Radiological Control Manual will be the responsibility of the Technical Center Radiation Protection Officer. The manual will establish detailed policies, procedures, standards, and guidelines to be followed in insuring proper radiological health and safety controls, compliance with NRC Regulations, and the capability of the Technical Center to secure and retain those types of NRC licenses which provide the necessary flexibility for operational requirements. The manual will include, but not be limited to, the following subjects:

A. Special requirements and procedures for the acquisition, accountability, and control of radioactive material and radiation devices.

B. Functions and procedures of the Radiation Safety Committee, and Radiation Protection Officer.

C. Radiological safety procedures and radiation monitoring.

D. Procedures for securing approval of work involving the use of ionizing radiation, including user requests, licenses from NRC, and special work permits.

2. SCOPE

This manual is applicable to all Technical Center operations, including contractor operations that involve the use of radioactive material or radiation-producing devices.

3. OBJECTIVES

The primary objectives and required uses of this manual are to:

A. Ensure against excessive and unnecessary exposure of personnel to harmful radiation.

B. Prevent contamination of equipment, materials, and the environment with radioactive materials.

C. Ensure compliance with requirements of the Nuclear Regulatory Commission (NRC) and all other governmental agencies.

4. ORGANIZATION

The Technical Center holds a Broad Scope NRC Specific Licenses numbered 47-00260-02. This license permits authorized Technical Center personnel to evaluate, develop, install, and test gauging equipment containing encapsulated isotopes, permits use of sealed sources in shielded source holders in the field determination of process levels and densities, permits the use of radioisotopes in any form for research and development as defined in 10 CFR 30 and permits the use of neutron sources in the testing of steel vessels for carbon buildup.

5. SITE REGULATION

It is management's intent to exercise centralized control over the use

of ionizing radiation sources to ensure that exposure will be adequately controlled so as to prevent adverse effects on the health and safety of employees. Persons involved in the use of ionizing radiation are responsible for ensuring compliance with NRC licensing constraints and radiation protection requirements. All proposed uses of ionizing radiation, all procurement actions for sources of such radiation, and all facility and equipment design criteria for use of such radiation shall receive the written approval of the Radioactive Safety Committee with the following exception. Use of conventional commercial level & density gauging devices and chromatograph electron capture detectors require only approval of the RPO.

6. RADIATION PROTECTION OFFICER (RPO)

The RPO will coordinate and supervise the Radiation Safety Program at the Technical Center. The RPO will serve as Chairman of the Radiation Safety Committee. The RPO will be responsible at all times for the status of the Radiation Safety Program. The RPO, or persons designated by him, will perform the following duties:

A. Maintain all records pertaining to the Radiation Safety Program.

B. Make periodic surveys (at least semi-annually) to ensure that the radiation protection required is adequate and that the provisions 10 CFR 20, "Standards for Protection Against Radiation," and the provisions of this Radiological Control Manual are being met.

C. Assist in developing operating and emergency procedures for radiological operations.

D. Review plans of proposed operations involving the use of radiation to ensure that adequate protective measures are being incorporated into the design of the operation, and make recommendations to Committee members.

E. Assist in the performance of leak tests on sealed sources, or see that they are performed by personnel authorized for this task.

F. Supervise and coordinate the Radioactive Waste Disposal Program.

G. Assume responsibility for receiving, delivering, and opening all incoming shipments of radioactive material, and receiving, packaging, and shipping all radioactive material leaving the Technical Center.

H. Distribute and process personnel monitoring equipment, determine the need for and evaluation of bioassays, maintain personnel exposure and bioassay records, and notify individuals and their supervisors of exposures approaching maximum permissible amounts.

I. Conduct training program and instruct personnel in the proper procedures for the use of radioactive material prior to use, and conduct refresher training courses periodically.

J. Maintain an inventory of all radioisotopes at the Technical Center and limit the quantity of radionuclides to the amounts authorized by the license.

K. In addition to the above, the RPO has the authority to:

1) Impound radioactive material;

2) Seal off contaminated areas;

3) Require tests of potentially contaminated personnel in consultation with the Medical Department as required;

4) Approve all procurement and shipment of radioactive material and its documentation; and

5) Approve purchase requests for all radiation-producing devices.

7. USER

When an employee of the Technical Center or a contractor intends to use radioactive material and/or radiation-producing devices, he must prepare a memorandum requesting the approval of the Radiation Safety Committee. This request procedure is outlined in Chapter II.

8. RADIATION SAFETY COMMITTEE

The Radiation Safety Committee shall have ultimate authority in all issues concerning radioactive materials and radiation-producing devices. The Radiation Safety Committee will receive requests for use of radioactive as authorized by the USNRC Broad Scope License. Membership to the Radiation Safety Committee will include but not be limited to:

A. Technical Center RPO (Chairman)

B. Technical Center Radiation Protection Personnel

C. Nucleonics Applications Personnel

D. Management Representative (Group Leader)

E. Purchasing Representative

F. Site Industrial Hygienist

The Committee will be required to meet at least quarterly to review activities, and whenever necessary to evaluate new proposals for use of radioactive material. If there are no activities underway which required review by the committee or are the result of action by the committee, the quarterly meetings may be waived at the RPO's discretion. Meetings will be held annually as a minimum. A quorum, consisting of the management representative and two representatives from Radiation Protection and Nucleonics Applications, must be present at a meeting for it to be considered official. A proposal must receive a unanimous vote of all members present for it to be approved.

Proposed uses of radioactive materials shall be presented to the Radiation Safety Committee as described in Chapter II, "Procurement of Radioactive Material and Radiation-Producing Devices." Safety evaluations will include consideration to the adequacy of facilities and equipment, operating and emergency procedures, procedures for disposal of the material, and training of proposed users. Also to be considered is the total possession limit of the proposed isotope. All evaluations shall be based on total containment and control of the radioactive material or controlled release as authorized in 10 CFR 20 or as

specifically authorized by the USNRC. All exposures of personnel will be kept as low as reasonably possible with zero exposure as a specific goal.

Use of sealed sources as contained in commercial level and density gauging device will not require approval of the Radiation Safety Committee. The RPO will assure the proper installation and utilization of these devices.

The Committee will maintain control of material by the following procedures:

(1) Only one "Purchasing Agent" is authorized to purchase radioactive materials.. This Purchasing Agent is a member of the RSC.

(2) All purchase orders for radioactive materials must be approved by the Technical Center RPO who is Chairman of the RSC.

(3) All radioactive materials received must be checked in at the Receiving Dock by a Radiation Safety Technician who works directly for the Radiation Protection Officer. This individual is responsible for entering the material into the inventory.

(4) All shipments of radioactive materials from the Technical Center must be approved by the RPO or his alternate who must verify that the recipient is authorized to receive the material.

(5) An inventory of all radioactive materials at the Technical Center will be maintained continually and will be checked by actual inspection semi-annually.

(6) Proceedings of the Radiation Safety Committee including all proposals and their evaluations shall be recorded and maintained in the files.

Review of the Radiation Protection Program as it pertains to the Radiation Safety Committee shall be conducted by the Committee annually. This review shall consist of auditing current users, inventories, and other records required to be maintained.
the Technical Center.

CHAPTER II

PROCUREMENT OF RADIOACTIVE MATERIALS AND RADIATION-PRODUCING DEVICES

1. PROCEDURES

Procurement requests for all radioactive materials will be routed through the RPO for review and approval prior to processing. The procedure is as follows:

The first step for a person who wishes to use a radioisotope is to discuss the proposed project with the Radiation Protection Officer. A formal request for the use of the materials can then be initiated if the RPO is satisfied that the Technical Center is authorized by the NRC to possess the isotope and quantity of material requested, and that the persons who will be handling the material have been adequately trained in the use of radioisotopes.

The formal request will specify what steps will be taken to ensure that the radioactive material is contained at all times and specifically what steps will be taken to prevent the spread of material in the event of an accident. Other items that must be in this request are statements of the specific procedures to be used anytime that the material is handled,

procedures used to control the accessibility of this material to untrained personnel, the exact record system to be used in keeping an accounting of the radioactive material at all stages of the experiment, and the ultimate means of disposal of all material.

After the formal request has been approved by the Radiation Safety Committee, the RPO and the user's supervisor may approve the purchase request and submit it to the Purchasing Department. Only requisitions approved in this manner will be accepted by the Purchasing Department for the procurement of radioactive material or radiation-producing devices.

2. RECORDS OF RECEIPT, TRANSFER, AND DISPOSAL OF RADIOACTIVE MATERIAL

The user must maintain permanent records showing materials accountability for each radioisotope. The records must be available at all times and must contain:

A. The amount of radioisotope and the date received. Retain the original shipping receipt with this record.

B. The amount of radioisotope transferred to any other authorized person and the date of transfer. A signed acknowledgement of receipt must be requested when a radioisotope is transferred.

NOTE:
The regulations of the Post Office Department, Department of Transportation, International Air Transport Agency, International Atomic Energy Agency, U. S. Nuclear Regulatory Commission, and the Interstate Commerce Commission must be met when radioisotopes are shipped by U. S. Mail or common carrier.

C. The user must know the location of any radioactive materials in his possession at all times. An inventory should be performed annually or more frequently where necessary, to assure that materials on hand correspond to those thought to be on hand. Procedures for keeping track of radioactive materials in an experiment are to be worked out with the RPO and included in the format request.

D. The amounts of radioisotopes disposed of and a description of the method and date of disposal. Disposal must always be done in compliance with the requirements as set forth by the NRC Regulations and Committee-approved procedures.

CHAPTER III

RECEIVING, SHIPPING, AND STORAGE OF RADIOACTIVE MATERIAL

1. GENERAL

The receiving, packaging, shipping, and storage of radioactive material must be coordinated and controlled to avoid exposing personnel whose duty assignments otherwise require no such exposure to ionizing radiation. All radioactive material transported, stored, or shipped at the Technical Center shall be properly packaged, labeled, and shielded to minimize radiation hazards.

2. APPLICABLE DIRECTIVES

A. The packaging and labeling of both incoming and outgoing shipments of radioactive material must comply with Department of Transportation (DOT) regulations.

B. THE SHIPPING AND RECEIVING OF RADIOACTIVE MATERIAL WILL BE CONTROLLED LOCALLY BY THE RADIATION PROTECTION OFFICER.

3. RESPONSIBILITIES

A. The authorized user must assure proper identification, shielding, and containment of all material to be shipped off the Technical Center or to be transported within the Technical Center. All shipping containers must be labeled in accordance with DOT regulations.

B. The RPO is responsible for inspecting, labeling, and shipping in

accordance with-DOT and NRC regulations.

C. The RPO will supply technical information as required.

4. PROCEDURES

A. In-coming Shipments

1) Receipt of incoming shipments of radioactive materials will be performed by the Receiving and Shipping Departments.

2) The Receiving Department will immediately notify the RPO of the arrival of a shipment by phone, giving all available information such as type of material, amount, size of package, to whom addressed, etc. The package(s) will be set aside with a minimum of handling until the RPO can inspect it.

3) The RPO or his designated agent will immediately proceed to the receiving area and inspect the shipment. After assurance that the shipment is in proper order and that the addressee is authorized to receive the material, the RPO will authorize the Receiving Department supervisor to take action as appropriate.

4) Under no circumstances may these packages be opened without permission of the RPO or his designated agent whose duty it is to test for dose rates and leakage with the proper equipment.

B. Outgoing Shipments

1) Radiation Protection personnel receive the Radioactive Material Advance Information form from person requesting shipment.

2) Radiation Protection personnel receive authorization from consignee to receive quantity and form of material to be shipped.

3) The shipping container is approved by USNRC and DOT or both, for the quantity and form of material to be shipped.

4) The material is packaged in accordance with the requirements of 49 CFR 173.393.

5) Adequate internal packing material or bracing is used to protect the contents and maintain required spacing under conditions normally incident to transportation.

6) All closures are properly sealed.

7) Packaging is performed in a controlled area, with appropriate surveillance and radiation monitoring.

8) A radiation survey is performed to ensure that limits specified in 49 CFR 173.393 are not exceeded and to determine the appropriate labels to be affixed to the package.

9) A leak wipe survey is performed to assure no leakage above 0.0005 uCi.

10) The following shipping papers are properly prepared and accompany the shipment:

a) Shipper's Certificate.
b) Leak Wipe Results.
c) Guidance for Carriers.
d) Instructions for Consignee.
e) Special Form Certification.

11) The following shipping papers are properly prepared and mailed to the consignee.

a) License Responsibility Transfer.
b) Notification of Radioactive Material Transfer.
c) Radioactive Material Shipment Record Data.

12) The package is labeled with the shipper's address, DOT package designation, and proper shipping name.

13) Transport Index labels are completed and placed on the package (2 labels on opposite sides of package).

14) Lead or tape security seal affixed.

C. Intracenter Transportation

1) The RPO will be notified by phone when it is necessary to move radioactive material to a different location within the Technical Center.

2) Radioactive material to be transported within the Technical Center will be packaged and shielded so that the radiation level does not exceed 5.0 millirems/hr at 1 ft from the source if the shipment is accompanied by a qualified user. If not accompanied by a qualified user, DOT regulations apply.

3) Standard radiation warning stickers required by Code of Federal Regulations, Title 10, Part 20 shall be used.

4) The driver of the vehicle will be apprised of the nature of his cargo. It is highly desirable that the user accompany the driver.

5) If there is a vehicle accident, the driver should notify the security guards and the RPO immediately. The security guards should keep all persons away from the accident area until the RPO has determined that the area is free of radioactivity.

D. Storage

1) All radioactive materials will be stored in designated, properly identified storage areas and will be secured against unauthorized removal.

2) No material will be placed in the Bldg. 747 Radioactive Materials Storage Area without the knowledge and approval of the RPO.

3) Material placed in the storage area will be surveyed and positioned such that the radiation field at the perimeter of the storage area is less than or equal to 2 millirems/hour.

CHAPTER IV

DISPOSAL OF RADIOACTIVE MATERIAL

1. GENERAL

The proper methods to follow for the disposal of any item of radioactive material that becomes unserviceable or unnecessary are included in this chapter.

Some items may be returned to the supplier for repair or disposition. These procedures are applicable regardless of whether the sources require disposal or return to the manufacturer.

2. SCOPE

This chapter includes procedures for all items of radioactive material including waste that requires disposal, regardless of whether the item is controlled by the NRC.

3. PROCEDURES

A. For items requiring disposal, a memorandum requesting the disposal of radioactive material will be forwarded to the RPO. This request will include, as minimum information about the item(s) the following:

1) Isotope(s).

2) Brief description of the chemical and physical form of the items.

3) Millicuries of activity.

4) Description of container(s).

5) Any toxic or chemical hazard involved with this material.

B. In cases not covered by this instruction, or where any uncertainty exists, the RPO should be contacted for specific instructions.

C. The RPO will evaluate the material for potential future use in other UCC applications. If potentially reusable, the material may be stored in the Technical Center Radioactive Materials Storage Area.

D. Upon receipt of the memorandum, the RPO will take the appropriate action to obtain disposition instructions and to dispose of the item(s). The RPO will prepare all shipping documents and make arrangements for transportation of the item(s).

E. No authorization exists for local disposition of any radioactive material, except as authorized in 10 CFR 20. In all cases where radioactive material must be discarded, no matter how small the amount, no material may be disposed of, except as outlined in this chapter.

CHAPTER V

RADIATION PROTECTION GUIDES

1. REFERENCE

Code of Federal Regulations, Title 10, Part 20, "Standards for Protection Against Radiation."

2. GENERAL

A. Unnecessary exposure to radiation should be avoided. In setting standards for Radiation Protection Guides, two types of radiation exposure must be considered:

1) Internal exposure resulting from radioactive material taken into the body by ingestion, inhalation, and absorption through openings in the skin; and

2) External exposure resulting from the body being exposed to radiation from radioactive materials and ionizing radiation produced by machines.

B. The population is divided into two groups for determining Radiation Protection Guides:

1) Occupationally exposed persons, i.e., the small segment of the population whose job requires them to work with radiation. The Radiation Protection Guide is established at a maximum that is not believed to produce detectable damage to an individual over 18 years old, during his lifetime.

2) All other personnel not employed in radiation work. The Radiation Protection Guide for this major portion of the population is established at one-tenth of that established for occupationally exposed persons. (See Item 4E of this chapter.)

C. The area in which radiation fields may exist in excess of those permitted or implied in Paragraph 2.B.2) above must be under the control of the user or the supervisor responsible for the facility, and access to the area must be restricted. No person below the age of 18 can be included in Group 2.B.1).

D. Radiation Protection Guides as outlined in this section do not include doses received from natural background and from medical and dental procedures.

3. DEFINITIONS OF UNITS

Definition of units used in this chapter may be found in Appendix II. (Refer specifically to Radiation Protection Guides, dose, rad, and rem.)

4. BASIC RULES OF RADIATION PROTECTION GUIDELINES

A. Exposure of Individuals to Radiation in Restricted Areas.

1) Except as provided in Paragraph 4.A.2) below, no individual in a restricted area will receive in any calendar quarter from any source a dose in excess of the following:

Rems per Calendar Quarter

a) Whole body; head and trunk; active blood forming organs; lens of eyes; or gonads 1.25

b) Hands and forearms, feet and ankles 18.75

c) Skin of whole body 7.50

2) Individuals in a restricted area may receive a dose to the whole body greater than that permitted under Paragraph 4.A.1) above, provided:

a) During any calendar quarter the dose shall not exceed 3 rems.

b) The dose to the whole body, when added to the accumulated occupational dose to the whole body, shall not exceed 5(N-18) rems, where N equals the individual's age in years at his last birthday; and

c) The individual's accumulated occupational dose to the whole body has been determined and reported on NRC Form 4, "Occupational External Radiation Exposure History," or equivalent.

Determination of accumulated dose will be in accordance with Code of Federal Regulations, Title 10, Part 20, Paragraph 20.102.

The provisions of Code of Federal Regulations, Title 10, Part 20, Paragraph 20.103 shall be strictly adhered to in determining criteria for exposure of individuals to concentrations of radioactive material in restricted area.

The provisions of Code of Federal Regulations, Title 10, Part 20, Paragraph 20.104 shall be strictly followed in determining criteria for exposure to minors.

B. Permissible Levels of Radiation in Unrestricted Areas.

1) Operations will be arranged and performed so that no individual in any unrestricted area is likely to receive a dose in excess of 0.5 rem to the whole body in any period of one calendar year.

2) In no case will any operation be allowed to create in any unrestricted area:

a) Radiation levels which, if an individual were continuously present in the area, could result in his receiving a dose in excess of 2 millirems in any one hour; or

b) Radiation levels which, if an individual were continuously present in the area, could result in his receiving a dose of 100 millirems in any seven consecutive days.

3) Concentrations of effluents in unrestricted areas shall be governed by provisions of Code of Federal Regulations, Title 10, Part 20, Paragraph 20.106.

C. Contamination Guides

Surface contamination guidelines established for restricted and unrestricted areas within the Technical Center are as follows:

Removable Surface Contamination

Type of Surface	dpm/100 cm^2
Lab benches & floors (restricted areas)	500
Hallways and other unrestricted areas	none detectable
Skin & personal clothing	none detectable

Any levels above these recommendations will require decontamination (see Section E).

D. Radiation and Contamination Surveys

In order to assure that radiation and contamination guides are met, surveys will be made at least monthly. Records of these surveys shall remain on file in the radiation protection office at the Technical Center.

In the event that glove boxes, hoods, ductwork, etc., require maintenance, contamination and/or radiation surveys will be made prior to that work.

E. Decontamination Procedures

1) General

Contamination of personnel, plant areas, or equipment areas may present emergency conditions following an accident. Prompt measures must be taken to identify contaminated personnel and to perform required decontamination. As soon after a survey of contamination as possible, preplanned decontamination methods shall be applied to the contaminated plant areas and equipment. Only the RPO or his authorized delegate(s) shall decontaminate personnel or material.

2) Procedure for Decontaminating Personnel

a) All contaminated clothing or clothing suspected to be contaminated shall be removed and placed in suitable waste containers (a plastic bag within a plastic can or equivalent) for later disposal.

b) If the skin is affected, the contaminated area shall be scrubbed thoroughly for two to three minutes, soaping and rinsing repeatedly. Consideration shall be given to the chemistry of the contaminant, and an attempt shall be made to find a suitable agent for dissolving it. Any cleansing agent may be used, but synthetic detergents are preferred to soap. (Note: Prolonged decontamination may result in irritation of the skin and should be avoided.)

c) In serious cases, a physician shall be called immediately, but the decontamination shall proceed until he arrives and gives further instructions. If internal contamination is suspected, the physician must be notified so that he may take appropriate biological samples as needed for examinations.

d) Personnel engaged in contamination surveys and decontamination operations shall wear respirators, coveralls, and shoe covers, as necessary.

3) Decontamination of Tools and Materials

Under the direction of the RPO, vacuum cleaners, mops, detergents, and wetting agents should be employed on the contaminant. Care must be exercised so that these objects themselves do not become contaminated, or, if they do, that they are treated as radioactive waste. Vacuum cleaners must have high efficiency filtered exhausts.

F. Air Sampling

To assure that no workers are exposed to concentrations of radioactive material in air greater than those specified in 10 CFR 20, Appendix B, Table 1, Column 1, activity concentrations will be evaluated on a quarterly basis. Evaluations will be made using a Johnson Laboratories, Inc., TRITON 955B air monitor.

CHAPTER VI

PERSONNEL MONITORING

1. REFERENCE

Code of Federal Regulations, Title 10, Part 20.

2. GENERAL

Paragraph 20.202 of the above referenced Federal regulation requires that appropriate personnel monitoring equipment be applied to:

A. Each individual who enters a restricted area and receives, or is likely to receive, a dose in any calendar year in excess of 25 percent (25%) of the applicable value specified in Paragraph (A) of 20.101 [Paragraph 4.A.1) of Chapter V of this manual

B. Each individual under 18 years of age who enters a restricted area and receives, or is likely to receive, a dose in any calendar quarter in excess of 5 percent (5%) of the applicable value specified in Title 10, CFR 20.101A.

D. Each individual prior to entering a high radiation area.

3. SCOPE

These requirements apply to all employees of the Technical Center, its contractors, its consultants, etc.

4. DEFINITIONS

See Appendix II for definitions of technical terms used in this procedure.

5. RESPONSIBILITIES

The Radiation Protection Officer is responsible for obtaining dosimetry service at the Technical Center. The manager of each activity in which there are projects dealing with radioactive materials or equipment capable of producing or accelerating ionizing particles shall enforce these requirements. The RPO will also provide guidance and establish need for dosimetry services within the Technical Center.

6. TYPES OF DOSIMETERS

A. Film badges
B. Thermoluminescent dosimeters (TLDs)
C. Pocket ion chambers (non-self-reading)
D. Pocket dosimeters (self-reading)

Film badges and TLDs (see Appendix II) are used to obtain a permanent record of the radiation dose to which the individual has been exposed. Pocket ion chambers and pocket dosimeters (see Appendix II) permit the individual to check daily on his accumulated dose. Their use is advisable whenever a person expects to be exposed to radiation fields higher than 5 mr/hr. They are to be used to detect high doses in addition to a film badge or TLD which will be used to obtain a permanent record of the dose.

7. PROCEDURES

The procedures for using each of the above described dosimetry devices are outlined in the following paragraphs:

A. Film Badges and Thermoluminescent Dosimeters
   1) General Precautions
      a) Do not tamper with the film or TLD. When it is delivered at the appointed time, remove the old film or TLD from the holder and insert the new one.

      b) Do not expose the film or TLD to excessive heat or moisture.

      c) Do not leave the film or TLD in a location where it will be exposed to radiation except when worn by the employee.

d) Always wear the film or TLD badge when entering a radiation area (see Appendix II).

e) Wear only your own film or TLD badge.

f) Report any occupational exposure that the badge or TLD may not have recorded.

g) Do not wear film badge or TLD when being exposed to medical X-rays for therapeutic or diagnostic purposes.

2. How to Obtain Badges or TLDs

a) The responsible Technical Center supervisor will, prior to using a radiation source, consult with the RPO to determine dosimetry requirements. If dosimetric service is required. he will request a film badge or TLD for each individual who does not already, have one and who may be exposed. This request will be in the form of a memorandum to the RPO. It will include the name of the individual(s), the type of radioactive material or the radiation-producing device for which dosimetric devices are required, the date they are required, the location where the work is done, and the name of the person who will supervise the work. In addition, the following information for each individual for whom film badges are required is necessary: name, job title, normal work assignment extent of previous radiation exposure, Social Security number, and date of birth.

b) The RPO is responsible for obtaining dosimetry service when it is required. There are several vendors who provide this service for a nominal charge.

B. Pocket Dosimeters and Pocket Chambers

1) Since pocket dosimeters and pocket ion chambers permit daily evaluation of radiation exposure, they should be used to supplement film badges. It is good practice to carry two dosimeters or pocket chambers since they are subject to leakage and accidental discharge. When reading them, the lowest value is recorded. Chambers and dosimeters will be used that measure radiation dose within an accuracy of 10 percent (10%) or better in the average range encountered in the use of sources of ionizing radiation.

2) Dosimeters and pocket chambers will be charged and read by the RPO or a qualified person designated by him. The accumulated dose will be recorded. A record will be maintained for each individual exposed. Since the accumulated dose for the period is maintained, each individual can determine if he has exceeded the maximum permissible exposure. In the event an overexposure is suspected, the individual's film badge will be delivered to the RPO so that it can be evaluated.

8. PERSONNEL MONITORING PERIOD

U. S. Nuclear Regulatory Commission Form 5 "Current Occupational External Radiation Exposure," or its equivalent will be included in the records of applicable individuals who are to be monitored. The RPO will maintain cumulative dose records on each employee exposed to radiation, as required by 10 CFR 20.401.

CHAPTER VII

LEAK TESTING SEALED SOURCES

1. GENERAL

A. References

National Bureau of Standards Handbook, "Safe Design and Use of Industrial Beta Ray Sources"; Handbook 73, "Protection Against Radiations from Sealed Gamma Sources"; and CFR Title 10.

B. Definition

"Sealed Source" means radioactive material that is encased in, and is to be used in, a container in a manner intended to prevent leakage of the radioactive material.

C. Types of Sealed Sources

1) Gamma ray sources such as 60Co, 137Cs, and 192Ir are used in industrial applications, radiography, and in medical therapy.

2) Beta sources such as 90Sr, 91Y, 99Tc, and 147Pm are used as density gauges, nuclear batteries, static eliminators, etc.

3) Alpha-emitting sources such as 226Ra and 241Am are used in alpha-neutron sources and as sources for ionizing air in devices such as smoke detectors.

D. Deterioration or Rupture of Containers

Any leakage is serious since the escaping material can contaminate surfaces that it contacts and may be inhaled or ingested into the body. Several factors may cause the container or its seal to leak or become

damaged.

1) Radiation from the source itself, either direct or indirect, which accelerates corrosion either directly or by production of corrosive ozone in the air.

2) Attack by chemicals inside the source.

3) Attack by corrosive fumes, solvents, or other chemicals to which the source may be exposed.

4) Buildup of gaseous pressure inside the encapsulating material by the action of radiation or by heating, such as might occur during a fire.

5) Breakdown resulting from discharge of high electrical potentials built up by the transmission of beta particles through insulating material.

6) Vibration, shock, or other mechanical injury.

7) Stresses set up by differences in thermal expansion.

8) Deterioration inherent in the materials used for the container; e.g., loss of solvents or plasticizers from plastics.

9) Damage from high or low temperatures, humidity, low pressure experienced in shipment by air, or any other unfavorable environmental conditions that might occur.

E. Detecting Leaks

For the foregoing reasons, it is mandatory that leak tests be performed on all sealed sources upon receipt, at other specified intervals, and before shipping. The conditions detailed in NRC licenses concerning possession and use of sealed radioactive sources include requirements for performing leak tests and maintaining records of the results

2. EQUIPMENT REQUIRED FOR PERFORMING LEAK TESTS

A. Long-handled forceps or tongs for handling sources.

B. An appropriate survey meter.

C. Filter paper, cotton, or cotton swabs attached to sticks for wiping the container and envelopes.

D. A sensitive counter capable of measuring 0.005 microcuries of the isotope in question.

E. Protective gloves.

F. Film badges.

G. Appropriate shielding.

3. PROCEDURES

A. General

1) Leak wipe test will be made only by the RPO or his authorized representative.

2) Personnel performing the leak tests shall wear film badges.

3) All sources being tested will be handled as though they are leaking until proven not to be leaking.

4) This step should be followed very carefully to insure the proper identification and accuracy of the analysis. Complete the leak test kit labels as to: a) the location of the source; b) the date the leak test was made; c) the identification (a serial number, property number, etc.) and d) type of isotope that is contained within the source holder. After this has been completed, remove the paper backing and attach the label to one of the sample containers.

5) The individual making the test will follow the procedures listed below:

a) Use protective gloves and accessories.

b) Cautiously remove the cover of the storage container so as not to spread contamination in the event the source should be leaking.

c) Do not expose the body to a direct beam from the container.

d) Remove cotton applicator from its container. Saturate the cotton applicator with leak wipe solvent and wipe all external seams, cracks, and openings of the source holder to achieve maximum surface material removal. DO NOT DISASSEMBLE THE SOURCE HOLDER. NOTE: DO NOT PLACE THE COTTON APPLICATOR IN THE SOLVENT DURING OR AFTER IT HAS BEEN USED TO WIPE THE SOURCE.

e) Remove the cotton applicator and survey meter from the radiation field to a location where only background is indicated on the meter. Switch the meter to its lowest range and survey the wipe. Do not touch the survey meter with the cotton applicator. If the wipe reads twice background or greater, shield the wipe as if it is itself a radiation source. Take two more wipes of source.

f) Carefully place the cotton applicator in the labeled container and securely tighten container cap.

After all leak tests have been completed and properly identified, reinsert the containers in the carton and take it to the AAS Nuclear Measurements Skill Center for analysis.

g) Other techniques may be approved by the RPO.

B. Radiographic and Similar Sealed Sources

High intensity gamma ray sources used for radiography or other similar industrial purposes will be leak-tested by wiping the nearest accessible point to the sealed source storage position, and then following the pertinent portions of the procedure outlined in Paragraph 3.A. above.

A. In the event the removable contamination exceeds 0.005 microcuries, the source is considered to be leaking. The source container will be closed and tagged until it can be prepared for shipment, repair, or disposal.

B. Sources that are leaking may be repaired by licensed manufacturers if it is economically feasible; if not economically feasible, they may be disposed of as outlined in Chapter III.

C. Notify the appropriate governmental agency as required in the Technical Center USNRC License and 10 CFR 20 + 10 CFR 21.

CHAPTER VIII

LEAK WIPE COUNTING AND SURVEY METER CALIBRATION

1. GENERAL

The Automated Analytical Systems Group,Nuclear Measurement Skill Center maintain and operate facilities for the counting of leak wipe tests and for the calibration of survey meters and other radiation detection instruments. In addition, a capability is maintained for analysis and repair of damaged or faulty instruments.

2. LEAK WIPE COUNTING CALIBRATION PROCEDURES

The apparatus for counting leak wipes is calibrated at the beginning of each series of leak wipes being counted or more frequently as indicated by the stability of the counting apparatus. The calibration procedure for leak wipe counting is based on the use of calibration sources whose activity is typically known within +5%. A calibration source of the particular isotope which is being analyzed on the leak wipe is used as a calibration source. The system used has the capability of detecting 0.0005 uCi. The step-by-step procedure for calibrating the counting system is as follows:

A. Determine the background count rate by inserting a clean, empty planchet in the counter, and counting it for a statistically significant time period -- usually five to ten minutes.

B. Insert the proper calibration source into a planchet with the active side up and determine the calibration source count rate.

C. Subtract the background count rate from the calibration source

count rate. The calibration factor is obtained by dividing the calibration source size (uCi) by the net count rate (cpm).

3. LEAK WIPE COUNTING PROCEDURES

A. Record all pertinent data on the container holding the leak wipe in the leak wipe log book.

B. Remove the leak wipe from the container. When using the Beckman 7000 to count leak wipes, the entire vial is inserted into the counter.

C. Do not touch the leak wipe with your hands, but use tweezers. At all times consider the leak wipes as being contaminated.

D. Make sure that the leak wipe does not extend over the side of the planchet. It is to be below the edge of the planchet at all times.

E.Insert the planchet into the counter.

F. Obtain the net count rate (activity) of the wipe by measuring its gross count rate and subtracting the background count rate.

G. After counting the leak wipe, if it appears that the leak wipe is contaminated, recount the leak wipe. After all counting of the leak wipe is finished, dispose of it in the radioactive trash, whether it is contaminated or not.

H. Calculate the number of microcuries present on the leak wipes by multiplying the net count rate by the calibration factor if the net count rate is statistically different from zero.

I. Fill out the form to be returned to the person who sent in the leak wipe, keeping one file copy.

J. Record data and calculations in the leak wipe log book.

4. RADIATION SURVEY METER CALIBRATION

The survey meter calibration apparatus consists of a radiation source in

ITEM	AREA	ISOTOPE	SERIAL #	MANUFACTURER	MODEL #	ENCAPSULATION	DATE CALIB.	CALIB. ACTIVITY	UNITS	CURRENT ACTIVITY	AS OF DATE
49	A.1	CS-137	2563	GAMART	GAMA-1	A-5771	Aug-76	500	uCi	566.19	May-90
50	A.1	AM-241	5561	MONSANTO		2722	Jul-84	1000	uCi	991.26	May-90
51	A.1	CS-137	50850	GAMART	LEAD P 5	A-5776	May-84	0.5	uCi	0.47	May-90
52	A.1	CS-137	60234	GAMART	GR-2	A-2102	Jul-74	5000	uCi	2082.24	May-90
53	A.1	CS-137	60695	GAMART	GR-2	A-2102	Jul-74	5000	uCi	2082.24	May-90
54	A.1	CS-137	61065	GAMART	GAMA-1	A-2102	Jul-70	100	uCi	83.28	May-90
55	A.1	CS-137	61064	GAMART	GAMA-1	A-2102	Jul-70	100	uCi	83.28	May-90
56	A.1	CS-137	63141	GAMART	GR-2	A-2102	Jul-74	5000	uCi	2082.24	May-90
57	A.1	CS-137	64126	GAMART	GAMA-1	A-2102	Jun-73	100	uCi	79.90	May-90
58	A.1	CS-137	64127	GAMART	GAMA-1	A-2102	Jun-73	100	uCi	79.90	May-90
59	A.1	CS-137	64128	GAMART	GAMA-1	A-2102	Jun-73	100	uCi	79.90	May-90
60	A.1	CS-137	65402	GAMART	GR-1	A-2102	Nov-74	100	uCi	79.26	May-90
61	A.1	CS-137	66374	GAMART	GALG-1	A-2102	Dec-77	750	uCi	550.14	May-90
62	A.1	CS-137	67026	GAMART	GALG-1	A-2104	Dec-80	5000	uCi	4081.27	May-90
63	A.1	CS-137	71166	GAMART	GA-10	A-2102	May-81	100	uCi	81.29	May-90
64	A.1	CS-137	71167	GAMART	GA-10	A-2102	May-81	100	uCi	81.29	May-90
65	A.1	CS-137	71516	GAMART	GAD	A-2102	Apr-81	150	uCi	174.54	May-90
66	A.1	CS-137	73163	GAMART	GAD	A-2102	Nov-83	150	uCi	129.15	May-90
67	A.1	CS-137	73164	GAMART	GAD	A-2102	Nov-83	150	uCi	129.15	May-90
68	A.1	CS-137	73483	GAMART	GAD	A-2102	Nov-83	150	uCi	129.14	May-90
69	A.1	CS-137	74049	GAMART	GAD	A-2102	Oct-83	50	uCi	42.98	May-90
70	A.1	CS-137	74050	GAMART	GAD	A-2102	Oct-83	50	uCi	42.98	May-90
71	A.1	CS-137	75203	GAMART	GAD	A-2102	Jan-85	100	uCi	88.49	May-90
72	A.1	CS-137	75204	GAMART	GAD	A-2102	Jan-85	100	uCi	88.49	May-90
73	B	NI-63	A-1743	VARIAN	5851		Apr-87	0	mCi	0.00	May-90
74	B	NI-63	C-1048	H-P	5946		Jan-90	15	mCi	13.86	May-90
75	B	NI-63	C-1419	H-P	ECD		Jan-90	15	mCi	13.86	May-90
76	B	NI-63	C-1452	H-P	ECD		Oct-89	15	mCi	13.96	May-90
77	B	NI-63	L-3660	H. P.	ECD		Apr-88	15	mCi	14.98	May-90
78	B	H-3	H-166	CUSTOM MATERIALS			Sep-78	200	uCi	65.34	May-90
79	B	NI-63	9-19026	H-P	19031		Apr-85	15	mCi	14.44	May-90
80	B	NI-63	S-8269	H-P	5884		Jan-90	15	mCi	13.86	May-90
81	B	NI-63	S-8986	H-P	19302		Sep-81	15	mCi	4.26	May-90
82	B	CS-137	299	TEXAS NUC	5191	TN570-571570	Dec-73	20	uCi	16.79	May-90
83	B	CS-137	324	TEXAS NUC	5191	TN570-571570	Oct-74	200	uCi	159.63	May-90
84	B	CS-137	347	TEXAS NUC	5191	TN570-571570	Jan-79	200	uCi	148.44	May-90
85	B	H-3	1662	3M		P01L	Jul-76	300	uCi	91.86	May-90
86	B	NI-63	2823	PERKIN-ELMER	83001		Jun-83	15	mCi	14.29	May-90
87	B	H-3	3274	3M			Dec-82	200	uCi	151.49	May-90
88	B	CS-137	60476	GAMART	GASH-1	A-2102	Dec-68	2000	uCi	1220.18	May-90
89	B	CS-137	64154	GAMART	SHDR-1	A-2102	Feb-75	100	uCi	79.36	May-90
90	C	CS-137	S-1241	TEXAS NUC	5191	TN570-571570	Nov-77	30	uCi	23.49	May-90
91	C	CS-137	S-34	TEXAS NUC	5191	TN570-571570	Dec-79	500	uCi	393.38	May-90
92	C	CS-137	S-35	TEXAS NUC	5191	TN570-571570	Dec-79	1900	uCi	1500.58	May-90
93	C	CS-137	S-36	TEXAS NUC	5191	TN570-571570	Dec-79	2500	uCi	1800.55	May-90
94	C	CS-137	S-74	TEXAS NUC	5191	TN570-571570	Apr-81	500	uCi	439.06	May-90
95	C	CS-137	S-78	TEXAS NUC	5191	TN570-571570	Mar-87	1000	uCi	930.16	May-90
96	C	CS-137	S-79	TEXAS NUC	5191	TN570-571570	Mar-87	1000	uCi	930.16	May-90

a collimated holder with a scale marking the distance from the source. Typically, a 10 to 50 millicurie Cesium-137 source is used with the calibration apparatus.

The radiation field from a Cesium-137 source is measured at several distances from the source using a Victoreen "R" Meter (accuracy +5%). From these readings, a dose-rate-versus-distance-from-the-source curve can be prepared. Different sized sources are used to provide the range of dose rates required to calibrate all instruments.

The detector of the survey meter to be calibrated is placed in the calibrated radiation field from the cesium source. Use care to assure that the entire detector is in the radiation field. Each range is then adjusted at one point in that range to agree with the dose rate measured with the R-meter. The linearity of the meter is verified by checking the detector at several different dose rates in each range. These steps are followed until all ranges have been calibrated and recorded.

Upon completion of calibration, a record is made in a bound notebook. A certification sheet, showing the calibration curve and remarks or recommendations, is forwarded to the owner of the survey meter.

Before the survey meter is returned, a stamp is affixed to show the date and place of calibration.

The basic measurement standard used (the Victoreen R-Meter) is returned to the vendor periodically for a calibration check. Occasional checks of its calibration are made by comparison with the known fields from the Cs-137 sources normally used in the calibration procedure.

Survey meters for use in neutron fields will be returned to the vendor for periodic recalibration.

CHAPTER IX

ANALYTICAL X-RAY DEVICES

1. GENERAL

Although there are published reports dealing with radiation protection and apparatus design, there is a lack of generally accepted standards or recommendations for X-ray diffraction and spectrographic equipment: For these reasons, this chapter was prepared using material developed by the Medical and Occupational Radiation Program of the National Center for Radiological Health. These statements containing the word "shall" are considered necessary to meet minimal standards for protection; those statements using the word "should" are considered advisory and are to be applied when practical.

2. RESPONSIBILITIES

A. For each operation involving radioactivity or radiation-producing devices, a person shall be appointed to be responsible for radiation safety. This person shall be familiar with the basic principles of radiation protection and the particular hazards of the specific device under consideration. This person shall be responsible for the following:

1) Insuring that operational procedures pertaining to radiation safety are established and carried out so that the radiation exposure of each worker is kept at a minimum.

2) Providing instruction in safety practices for all personnel who work with or near the equipment.

3) Arranging for the establishment of radiation control areas, including placement of appropriate radiation warning signs and/or devices.

4) Providing periodic radiation safety inspection of the equipment and operations.

5) Reviewing modifications to X-ray apparatus, including X-ray tube housing, cameras, diffractometers, shielding, and safety interlocks.

6) Investigating any case of abnormal radiation exposure of personnel.

7) Closely coordinating all of the above with the RPO.

B. Operating supervisors will further ensure that:

1) Individuals who act as operators of analytical X-ray devices receive an acceptable amount of training in radiation safety. (Refer to Chapter XII of this manual.)

2) Operators have demonstrated competence in the use of X-ray devices and radiation survey equipment.

C. The operators of analytical X-ray equipment shall be responsible for all operations associated with the equipment, including radiation safety. In particular, he shall:

1) Keep radiation exposure to himself and to others at a minimum.
2) Be familiar with safety procedures as they apply to each machine.
3) Wear personnel-monitoring devices if necessary.
4) Notify his supervisor and the RPO of known or suspected abnormal radiation exposures to himself or others.

3. OPERATING PROCEDURES

For each operation involving analytical X-ray devices, operating procedures reflecting safety practices will be prepared. As a minimum, the following points must be covered. Other points applicable to the specific equipment shall also be included.

A. Personnel shall not expose any part of their body to the primary radiation beam.

B. Only trained personnel shall be permitted to install, repair, or make other than routine modifications to the X-ray generating apparatus and the tube housing apparatus complex.

C. Procedures and apparatus utilized in beam alignment should be designed to minimize radiation exposure to the operator.

D. If, for any reason, it is necessary to alter safety devices temporarily, such as by removing shielding or bypassing interlocks, such action shall be specified in writing, approved by the RPO, and posted near the X-ray tube housing so that other persons will know the existing status of the machine.

E. Radiation exposure to individuals, either within the radiation controlled area or its surroundings, shall be controlled so that dose limits specified in Chapter V of this manual are not exceeded.

4. AREA MONITORING

A. Area radiation protection surveys will be made at frequent intervals to detect stray radiation. Records of these surveys will be maintained by the operator and the RPO.

B. During changes in operations or modification to equipment, surveys will be performed for proper placement of shielding or for the location of barriers that limit the entry of persons into the area.

C. In addition to the above, certain permanent area monitoring locations may be established by the RPO.

CHAPTER X

GAS CHROMATOGRAPHY EQUIPMENT CONTAINING RADIOACTIVE COMPONENTS

All gas chromatography units in which radioactive materials are to be used will be regulated as follows:

1. All radioactive foils to be used in gas chromatograph cells must be shipped to the RPO or the designated responsible individual who will maintain a file describing the type of source and its location.

2. Each cell containing a foil will be registered by the RPO or the designated responsible individual, and assigned a number. A file describing the type of source and its location shall be maintained.

3. Each cell containing a radioactive foil must have a label showing the radiation causing symbol with the words "Caution Radioactive Materials" and the identify and activity of the radioactive material.

4. The radioactive foil shall not be removed from its identifying cell except for cleaning and shall not be transferred to other cells.

5. Gas chromatography units utilizing radioactive sources must be vented through plastic tubing into a chemical hood or room exhaust to avoid contamination of work areas from the release of radioactive tagged samples introduced into the system or from the accidental overheating of radioactive foils in the cell.

6. The RPO shall perform periodic leak tests on all appropriate cells and foils and maintain the necessary records as required by the license on such tests.

7. All work on cells such as cleaning shall be performed in a hood with absorbent material covering the work place. Gloves shall be worn during cleaning operations.

8. Liquids generated during cleaning process may be disposed of into sanitary sewer with large quantities of water.

9. All gas chromatographs shall be operated so as not to exceed the temperature limits specified by the manufacturer.

CHAPTER XI

THE RADIATION PHYSICS LABORATORY

1. GENERAL DESCRIPTION OF THE LABORATORY

The Radiation Physics Laboratory, Building 747, is a 30 x 48 ft one-story masonry building. It consists of an office, a general laboratory, a shielded high radiation area, an instrument storage area, and an unencapsulated radioisotopes laboratory. An area for the storage of radioisotopes are located adjacent to Building 747.

2: DETAILED DESCRIPTION AND SPECIAL FEATURES

A. Building Ventilation Building 747 is maintained at a slightly positive atmosphere pressure. All air entering the building comes through a conventional heating and air conditioning system at an air flow of approximately 1800 cubic feet per minute. The incoming air is distributed throughout the building except for the unencapsulated radioisotopes lab, by a system of conventional metal ducts. All of the air entering the building is exhausted through the radioisotopes lab via two, 16 x 25 inch filtered openings in the wall between the unencapsulated radioisotopes lab and the general lab area. The air is exhausted from this room by means of a blower system at the rate of approximately 1800 cubic feet per minute. By maintaining the above stated air volumes, the air in the main laboratories is changed once about every five minutes, and the air in the unencapsulated radioisotopes laboratory is changed every minute.

B. High Radiation Shielded Area The high radiation area is surrounded by a masonry block wall which is sand filled and is approximately 6 ft in height. A large overhead mirror permits work to be performed over this wall by means of various remote manipulators when necessary. Entry into this area is secured by a locked metal gate and features a high

intensity audible alarm to indicate any openings of the gate or entry into the cell.

C. Unencapsulated Radioisotopes Laboratory This laboratory is constructed of 6-inch thick masonry blocks with two 16 x 25 inch filtered ventilators through which the air from the main lab is admitted. The room is always maintained under slightly negative pressure with respect to the general laboratory by means of a high capacity exhaust fan which operates independently of the main laboratory air handling system. All floor drains in the laboratory are sealed to prevent leakage of any radioactive material into the sewer system. The floors are covered with a vinyl asbestos tile that could be easily removed in case of contamination.

D. General Laboratory Area The general laboratory area contains about 600 sq ft of floor space and is maintained for general laboratory activities, instrument repair, etc. Apparatus for counting leak wipe tests are maintained in this area.

E. Instrument Storage Area This room contains approximately 250 sq ft and is primarily used for storage of instruments.

3. RADIATION STORAGE AREA

The radiation storage area is located approximately 25 ft from the east side of Building 747. The area consists of a 6 x 16 ft masonry building which rests on a concrete pad of approximately 626 sq ft. The area is surrounded by a security type 6 ft high chain link fence, topped by barbed wire. This area is secured by a limited access lock system and is provided with an automatic dusk-to-dawn lighting system.

4. INSTRUMENTATION

The Radiation Physics Laboratory is equipped with the nuclear and electronic instrumentation for radiation monitoring listed in Appendix-IV. The list may be revised without notice.

CHAPTER XII
RADIATION SAFETY TRAINING

Assurance of proper training will be maintained through formalized training requirements for each employee whose regular job assignment involves work with radiation. The Technical Center RPO is responsible for all radiation safety training. Four formal training programs have been developed, as outlined below.

1. RADIATION PROTECTION OFFICERS TRAINING COURSE

The RPO Training Course is a one-week intensive course in radiation safety aimed at preparing Union Carbide personnel to assume the duties of Plant Radiation Protection Officer. This course is also used to train Technical Center personnel as "users" on USNRC License No. 47-260-02. The RPO Training Course is given approximately every eight months. Class size is limited to ten students. A description of the course is listed below:

A. Classroom Lectures:

1) Introduction

2) Health Physics Terminology

Basic terms and definitions necessary to function as a competent RPO - refer to Glossary in the Radiological Health Handbook.

3) Nuclear Physics/Radiation

Classification of matter, model of atom, basic sub-atomic particles atomic structure, periodic table of elements. Define radioactivity, half-life, types of radiation, characteristics and penetration ability of various radiations, shielding and build-up factor. Energy transfer, dose: define Roentgen, rad, rem, discuss natural radioactivity, non-ionizing radiation.

4) Calculation Techniques

Scientific notation, Avagadros #, linear first order equations, inverse square law, dose calculation.

5) Radiation Detection Interaction of radiation and matter with respect to ionization and excitation. Energy deposition. Different detection principles (ionization, scintillation, GM, proportional) specifications and characteristics.

6) Biological Effects of Radiation RBE of various radiations, dose-effect relationship stressing nonthreshold model, acute radiation syndrome, radiation accidents.

7) Personnel Dosimetry Pocket dosimeters, film badges, and thermoluminescent dosimeters, accuracy with respect to different radiations.

8) Survey Meters Theory of gas-filled instruments, operating instructions, calibration procedure.

9) Encapsulated Sources Special Form encapsulation, external radiation exposure hazards, and source holder construction.

10) Leak Wipe Testing Define government limits but stress UCC policy. Show how wipes are analyzed.

11) Transportation Discussion of excellent safety record of transporting radioactive material. Definition of special containers, classifications, labels, placards, transport index, transport group, contamination check, special form.

12) Government Regulations Title 10, Parts 19 (Notice to Workers), 20 (Standards for Protection Against Radiation), 30 (Licensing), 34 (Radiography), and Title 49 (DOT).

13) Record keeping

a) Inventory
b) Personnel Dosimetry
c) R-A Material Data Sheets
d) Survey Meter Calibration
e) Leak Wipe Results
f) Radiation Surveys
g) Transfer Records

h) Shipment Records
i) Disposal Records

14) Emergency Definition of emergencies - explosion resulting in the destruction of containment and shielding, unauthorized servicing of sources, theft of R-A material. Provide emergency phone numbers.

B. Films

1) NEXT Survey Procedures
2) X-Ray Production
3) Biological Effects of Ionizing Radiation - Parts 1 to 4.
4) Double Edge Sword
5) Nuclear Innovation in Process Control
6) Radiation and Man
7) Properties of X-rays
8) Radiation Detection Instruments
9) On the Move
10) Radiation Naturally
11) An Added Sense: Detection of Nuclear Radiation
12) Factor Influencing X-ray Output
13) Principles of Radiation
14) Radiation Protection Guides

and other borrowed or rented films as available and appropriate.

C. Laboratories

1) Half-Life Determination
2) Inverse Square Law
3) Absorption of Gamma Rays
4) Density and Level Gauging
5) Leak Wipes and Survey Techniques.

D. Final Examination The last day of this course includes a one-hour final examination comprised of 40 multiple choice questions. A grade of 70% or better is required to pass the course. A grade between 60% and 69% will enable the student to retake the test. Any grades below 60% require the student to repeat the entire course for a retest. The exam results are kept on file at the Technical center and serve as documentation.

2. RADIATION SAFETY FOR UNENCAPSULATED ISOTOPES

This course is designed for Union Carbide Technical Center personnel who plan on using unencapsulated isotopes in the research laboratory. Each new employee is given a one-day, one-on-one session that provides a short theoretical background and much practical radiation safety information. A description of the course content is listed below.

A. Radioactivity and Radiation Basic definitions of alpha, beta, and gamma radiations, ion production, activity, activity units.

B. Dose and Biological Effect of Radiation Rad, rem, relative biological effectiveness, natural background radiation, short-term and long-term effects, external and internal exposure, biological pathways, critical organs, body burden.

C. Laboratory Control Techniques Contamination hazards, work area housekeeping, isotope inventory, protective clothing, glove boxes, intra-lab transportation, solid and liquid waste disposal, C-14 portable survey meter use.

D. Government Regulations United States Nuclear Regulatory Commission, Code of Federal Regulations Title 10, Parts 19 and 20, West Virginia Department of Health Radiological Health Regulations, United States Department of Transportation Regulation.

E. Examination and Laboratory Training A short written examination is administered at the end of the day, consisting of twenty multiple choice questions. A grade of 70% or better is required before the employee may begin training in the laboratory.

After the formal course, the employee undergoes hands-on training in the laboratory. This training is supplied by the employee's direct supervisor. The training will include all proper laboratory control techniques. The employee will be allowed to work with radioisotopes without supervision only after he/she has demonstrated to their supervisor that they understand the radiological hazards associated with the work and can demonstrate proper experimental techniques.

A shortened, 2-hour version of the formal training course is presented on an annual basis to all employees who use radioisotopes. This assures a continuing awareness of radiation safety.

Researchers using radioisotopes on a one-time, short-term basis, nominally a month or less, are not required to complete this full course. They will receive a shortened version of the training course. These personnel may only use these materials under the direct supervision of a member of the Radiation Protection Staff who is responsible for safe use and control of the material.

3. RADIATION SAFETY FOR RADIOGRAPHERS

Due to the increased usage of radiography by Technical Center personnel, as well as plant personnel, a revised version of the RPO Training Course has been generated for training industrial radiographers and their assistants. This will be a three-day course designed to include most material Outlined in the National Council on Radiation Protection and Measurements (NCRP), Report No. 61, "Radiation Safety Training Criteria for Industrial Radiography." In addition to the RPO Training Manual, handouts for this course include National Bureau of Standards Handbook TT4, "General Safety Standards For Installations Using Non-Medical X-Ray and Sealed Gamma Ray Sources, Energies up to 10 MeV," and NUREG-0495, "Public Meeting on Radiation Safety For Industrial Radiographers." An outline of the course content may be Found in Chapter XIII, Section 10.

A one-hour Final examination will be given at the end of the course. A grade of 70% or higher is required to pass the course, while a grade between 60% and 69% will enable the student to take a retest. Any grades below 60% will require the student to repeat the course.

4. ANALYTICAL X-RAY MACHINE SAFETY

A one-hour short course in radiation safety has beén developed for operating supervisors and operators of all analytical X-ray equipment at the Technical Center. National Bureau of Standards Handbook III, "Radiation Safety for X-Ray Diffraction and Fluorescence Analysis Equipment" is used as a text. To supplement this, a videotape called "The Double-Edged Sword" is shown during the presentation.

New employees proposing to use analytical X-ray equipment must take this course prior to operation. The course is also given on an annual basis as a refresher to operators of these devices.

5. MISCELLANEOUS RADIATION SAFETY TRAINING

Under normal operating circumstances, no unauthorized persons may use radioactive material or radiation-producing devices, or be in a restricted area: All routine housekeeping in unencapsulated laboratories is performed by the technicians assigned to that lab.

Occasionally, however, there are instances where janitors, service personnel, or millwrights need to enter restricted areas to perform nonroutine maintenance or emergency repair. Prior to these instances, radiation safety training will be supplied by the Technical Center RPO. The extent of the training shall be determined by the scope of the job to be accomplished: As a minimum, the following items will be discussed;, radiation, natural background radiation, dose (internal and external), biological effects of radiation, and some government regulations.

CHAPTER XIII

INDUSTRIAL RADIOGRAPHY

1. GENERAL

A. X-rays are electromagnetic radiations originating in electron clouds surrounding the nuclei of atoms. They are produced when the target material is bombarded by a stream of high energy electrons. They are extremely short wavelength and occupy the portion of the electromagnetic spectrum above the ultraviolet region. Gamma rays have characteristics identical to X-rays, but they originate in the nucleus.

B. X-rays and gamma rays are attenuated or absorbed in matter by three processes that are dependent on their energy and the mass number of the absorber. These processes are:

1) Photoelectric effect
2) Compton effect
3) Pair production.

2. PURPOSE

The regulations in this chapter establish radiation safety requirements for UCC and contractor personnel who utilize any source of radiation for industrial radiography.

3. LICENSING REQUIREMENTS

Industrial radiography is somewhat unique in that the particular governmental agency which regulates its use depends upon the type of source used to produce the radiation. Radiographers in non-Agreement States using radiation sources of byproduct material (see Byproduct Material in the Glossary) such as Cesium-137 or Cobalt-60 are regulated by the U. S. Nuclear Regulatory Commission, whereas radiographers using an X-ray machine or naturally occurring radioactive material such as radium to produce radiation are regulated by the State where they are located. It is important to note that having a license to possess

radiographic material does not permit the use of this material for radiographic purposes. Such permission is granted only by a specific license from the USNRC to perform radiography (see USNRC Rules and Regulations, Title 10, Part 34). In Agreement States, both types of sources may be regulated by one agency.

4. DEFINITIONS (As used in this Chapter)

A. "Radiographer" means any individual who performs or who, in attendance at the site where sources of radiation are being used, personally supervises industrial radiographic operations and who is responsible for assuring compliance with the requirements of these regulations, the regulations of the State where they are located and/or the USNRC Rules and regulations, Title 10, Part 34, and all conditions of the license.

B. "Radiographer's Assistant" means any individual who, under the personal supervision of a radiographer, uses sources of radiation, related handling tools, or survey instruments in industrial radiography.

C. "Industrial Radiography" means the examination of the structure of materials by nondestructive methods utilizing sources of radiation.

D. "Registrant" means any person who is registering or who has registered an industrial radiographic X-ray source with the State where they are located or has obtained a specific license from the USNRC to use byproduct material for radiography. A registrant may or may not be a user.

E. "Person" means any individual who personally utilizes or manipulates a source of radiation.

5. PROTECTION

The principle method of protection from radiation is by shielding the tube and by enclosing the machine or source in a protective housing, or a high density concrete and/or lead-lined room. Other methods used in conjunction with shielding are: restricting the direction of the useful beam, limiting the workload, restricting the occupancy of adjacent

areas, and using interlocks to shut off the beam when the doors or access covers are opened.

6. NEW INSTALLATIONS

A. The design criteria and drawings of each new radiographic installation will be submitted to the RPO for review. Each installation will be designed to limit exposures to those outlined in Chapter V.

B. After the installation is completed, the RPO will be notified so that a survey with radiation detection instruments can be made before operations begin to ensure adequate protection to operators and personnel occupying adjacent areas.

7. STANDARD OPERATING PROCEDURES

A. An adequate operating procedure is required for the operation of all equipment producing ionizing radiation.

B. The operating procedure shall be submitted to the RPO for review and approval prior to commencing operations. It shall include instructions for at least the following:

1) The handling and use of sources of radiation to be employed such that no person is likely to be exposed to radiation doses in excess of the limits established in TO CFR 20, "Standards for Protection Against Radiation" or the applicable State regulations.

2) Methods and occasions for conducting radiation surveys.

3) Methods for controlling access to radiographic areas.

4) Methods and occasions for locking and securing sources of radiation.

5) Personnel monitoring and the use of personnel monitoring equipment.

6) The procedures for notifying proper persons in the event of an

accident.

7) The maintenance of records.

8. GENERAL SAFETY REQUIREMENTS

A. Sources of radiation shall be operated only by trained and qualified personnel.

B. Each registrant or user shall maintain current logs, which shall be kept available for inspection by the RPO, showing for each source of radiation the following information:

1) A description (or make and model number) of each source of radiation.

2) The identity of the radiographer to whom assigned.

3) Methods for controlling access to radiographic areas.

4) This paragraph applies only if the radiation sources are in noninterlocked facilities.

C. No registrant or user shall permit any person to act as a radiographer or a radiographer's assistant unless, at all times during radiographic operations, each person wears a film badge and either a pocket dosimeter or pocket chamber. Pocket dosimeters and pocket chambers shall be capable of measuring doses from 0 to at least 200 milliroentgens. A film badge shall be assigned to and worn by only one person.

D. Pocket dosimeters and pocket chambers shall be read and doses shall be recorded daily. A film badge shall be immediately processed if a pocket chamber or pocket dosimeter is discharged beyond its range. The film badge reports received from the film badge processor and records of pocket dosimeters and pocket chamber readings shall be maintained for inspection by the RPO.

E. Notwithstanding any provisions in 20.204(c) of NRC Regulations, areas in which radiography is being performed shall be conspicuously

posted as required by 10 CFR 20.203 (Note: See Appendix III) or the equivalent State regulations.

F. During each radiographic operation, the radiographer or radiographer's assistant shall maintain a direct surveillance of the operation to protect against unauthorized entry into a high radiation area as defined in Part 20 of the USNRC Regulations, or the equivalent State regulations, except where the high radiation area is equipped with a control device or an alarm system as described in 20.203(C)(2), or where the high radiation area is locked to protect against unauthorized or accidental entry.

G. No radiographic operation shall be conducted unless calibrated and operable radiation survey instrumentation is available and in use at each site where radiographic exposures are made.

Records shall be kept of the surveys required by this chapter and maintained for inspection by the RPO.

H. The registrant or user shall maintain sufficient calibrated and operable radiation survey instruments to make physical radiation surveys. Each radiation survey instrument shall be calibrated at intervals not to exceed three months, and, after each instrument servicing, a record shall be maintained of the latest date of calibration. Instrumentation required by this chapter shall have a range such that 2 milliroentgens/hour through 1 roentgen/hour can be measured for the energy of radiation being measured.

I. Each source of radiation shall be provided with a lock or outer locked container designed to prevent unauthorized or accidental exposure to radiation, and the source shall be kept locked at all times when under direct surveillance.

J. Full use of protective barriers, lead aprons, gloves, etc., will be made.

K. Observe any restrictions on the use of the machines or sources recommended by the RPO.

L. Each sealed source containing byproduct material used for radiographic purposes shall be tested for leakage at intervals not to exceed six months. Sealed sources which are portable will be leak wiped before they are removed from their normal storage or operating locations to a field location. The leak test will be capable of detecting 0.005 microcurie of removable contamination on the sealed source and will be counted as described in Chapter VIII. A record of all leak tests will be kept. Any source found to be leaking will be reported as required in 10 CFR 34.25d, or as required by the State's regulations.

M. All sealed sources of byproduct material used in radiography at the Technical Center will be inventoried quarterly. Records of the inventory will be kept and will include the quantity and kinds of byproduct material, location of sealed sources, and the date of the inventory.

N. A log shall be maintained for each radiographic device which lists its description (or make and model number), the radiographer to whom it is assigned, the site at which it is located or used, and the dates of use.

9. LIMITATIONS

A. The registrant or user shall not permit any person to act as a radiographer until such person has

1) been instructed in the subjects outlined in Paragraph 10 of this chapter and has demonstrated an understanding of them;

2) received a copy of this manual and the User's Operating and Emergency Procedures and has demonstrated an understanding of them; and

3) demonstrated competence in the use of radioactive exposure devices, related handling tools, and survey instruments that will be employed in his assignment.

B. The registrant or user shall not permit any person to act as a radiographer's assistant until such person has:

1) received copies of the instructions in the User's Operating and Emergency Procedures and has demonstrated an understanding of them; and

2) demonstrated competence to use, under the supervision of the radiographer, the radiographic exposure devices, related handling tools, and radiation survey instruments that will be employed in his assignment.

10. RADIATION TRAINING OUTLINE

A. Fundamentals of Radiation Safety

1) Characteristics of Gamma and X-radiation.

2) Units of Radiation Dose (millirem) and Quantity of Radioactivity (curie)

3) Hazards of Excessive Exposure to Radiation

4) Levels of Radiation from Sources or Machines

5) Methods of Controlling Radiation Dose

a) working time

b) working distance

c) shielding.

B. Radiation Detection Instrumentation to be Used

1) Use of Radiation Survey Instruments

a) operation

b) calibration

c) limitations.

2) Survey Techniques

3) Use of Personnel Monitoring Equipment

a) film badges

b) pocket dosimeters

c) pocket chambers.

C. Radiographic Equipment to be Used.

1) Remote Handling Equipment

2) Radiographic Exposure Devices

3) Storage Containers

D. The Requirements of Pertinent Federal and State Regulations

F. The Registrant's or User's Written Operating and Emergency Procedures

CHAPTER XIV
RADIO FREQUENCY RADIATION

1. GENERAL

Radio frequency radiation is being used increasingly within plants for process measurements, telemetry, and heating food in snack bars and cafeteria areas. The biological effects of radio frequency radiation are to a great extent dependent upon the frequency and the average field density or power. When radio frequency radiation is absorbed, it produces localized heating. Frequencies above about 3000 megahertz are reflected or absorbed by the outer layers of the skin where they can be detected by the thermal sensory elements in the skin. At frequencies of less than about 1000 megahertz, the radio frequency radiation can penetrate deeper into the body's tissue where temperature sensors are fewer and hence possible overheating could occur before any sensation of heat or pain is perceived. Frequencies between 1000 and 10,000 megahertz tend to produce eye cataracts.

Radio frequency power densities greater than 1 mW/cm can interfere with the operation of cardiac pacemakers. Areas where this power density may ever potentially exist must be marked with proper warning signs.

2. EXPOSURE LEVELS

The following guidelines for exposures are generally acceptable:

A) Above 10 mW/cm — Potentially hazardous

B) Between 1 and 10 mW/cm — Safe for incidental or occasional exposure

C) Less than 1 mW/cm — Safe for indefinite exposure.

The OSHA radiation protection guide for normal environmental conditions and for incident electromagnetic energy of frequencies from 10 MHz to 100 MHz is 10 mW/cm as averaged over any possible 0.1-hour period.

Power Density: 10 mW/cm for periods of 0.1 hour or more

Energy Density: 1 mWh/cm (milliwatthour per square centimeter during any 0.1-hour period).

3. STANDARD WARNING SYMBOL

The standard warning symbol for radio frequency radiation hazards shall consist of a red isosceles triangle above an inverted black isosceles triangle, separated and outlined by an aluminum colored border. The common side of the two triangles will be about 1.414 times longer than the other sides. The wording "Warning--Radio Frequency Radiation Hazard" shall appear in the upper triangle. The lower triangle may be used for other warnings as necessary.

4. MICROWAVE OVENS

Microwave ovens used in association with food vending services present a particular hazard for several reasons. Since these devices are available to any person in the plant, the potential for a defective machine irradiating a great number of people exists. Most such devices are intended to be tamper proof and failsafe; however, the ingenuity of people in overcoming such safety measures is legendary. Since these machines are usually not used under trained supervision, the potential for misuse or improper use is quite high. Because of their general accessibility, special care should be exercised in posting warning signs near these machines and in checking them for safe operation regularly.

The following list of safe practices should be posted near or on microwave ovens:

a) Stay at least three feet away from the front of an operating oven.
b) Make sure that the oven is off anytime that the door is opened.
c) Do not attempt to watch the food cooking through the viewing port..
d) Never insert objects through the door grill or around the door seal.
e) Never tamper with or inactivate the oven safety interlocks.
f) Do not operate the oven while empty.

Microwave ovens used for heating food in snack areas will be surveyed periodically to check for excess leakage of radiation. Standard

procedures for making this measurement are currently in a state of flux. The most current procedure will be used.

CHAPTER XV
LASERS

1. REFERENCES

A) American National Standard for the Safe Use of Lasers, ANSI.
B) Laser Safety Guide, Laser Institute of America.
C) Radiation Safety Handbook for Ionizing and Nonionizing Radiation, U.S. Department of Health, Education and Welfare.

2. GENERAL

The increasingly widespread use of lasers requires the plant RPO to become familiar with the potential hazards associated with the misuse of lasers. Primary hazards of laser radiation consist of danger to the eyes and skin.

The basic approach of most recent safety standards has been to classify lasers by their potential hazard based upon their optical emission.

3. CONTROL MEASURES

The fundamental objective of the control methods as outlined in this chapter is to limit the possibility of a potentially hazardous exposure, particularly to unaware transient personnel and to provide reasonable and a equate guidance for the safe use of lasers and laser systems.

In establishing laser control measures, the following factors determine the type and amount of control necessary:

a) Power or energy output of laser.
b) Pulse length.
c) Pulse repetition rate.
d) Wavelength.
e) Beam path.
f) Beam shape (divergence, hot spots, atmospheric effects).
g) Number of laser systems at particular location.

h) Position of windows, doors, laboratory layout.
i) Degree of isolation of location.
j) Type of population (informed staff in control, local knowledgeable personnel, uninformed transients).

In addition to the aforementioned factors, control measures also depend on laser classification. In general:

A) A Class I Exempt Laser Device is one that is considered to be incapable of producing damaging radiation levels and is, therefore, exempt from any control measures or other forms or surveillance.

B) A Class II Low Power Laser Device may be viewed directly but must have a caution label warning against continuous intrabeam viewing affixed to the device.

C) A Class III Medium Power Laser Device requires control measures that shall prevent viewing of the direct beam.

D) A Class IV High Power Laser Device requires the use of controls which shall prevent exposure of the eyes and skin to the direct and diffusely reflected beam.

E) Class V lasers are either Class II, Class III, or Class IV lasers contained in a protective housing and operated in such a manner as to be incapable of emitting hazardous radiation from the enclosure; a stringent control system shall be installed and maintained for any laser system to qualify for this classification.

This classification scheme relates specifically to the laser device itself and its potential hazard, based on operating characteristics. The extent to which this section is applicable to FDA facilities utilizing laser or laser systems is dependent on the magnitude of the hazard from these sources within that facility.

For those laboratories using Class II, Class III, and Class IV lasers, a

Laser Safety Officer shall be appointed by the Director. This person shall be properly indoctrinated in laser safety and will have the authority to supervise the control of laser hazards.

If unique problems arise that are beyond the capability of the laser user(s) or Safety Officer, assistance san be obtained from the FDA Radiation Safety Council.

4. SPECIFIC CONTROL MEASURES

To reduce the controls required and the potential hazard from a laser source, a complete enclosure of the laser beam (an enclosed laser) shall be used when feasible. A closed installation (any location where lasers are used which will be closed to transient personnel during laser operation) provides the next most desirable hazard measure. Specific control measures to reduce the possibility of exposure of the eyes and skin to hazardous laser radiation and to other hazards associated with the operation of those devices are outlined in the "American National Standard for the Safe Use of Lasers" (ANSI Z-136.1 - 1973), some of which are excepted below.

A) Class I - Exempt Lasers and Laser-Systems

No control measures or warning labels are required, however, any needless direct exposure of the eyes should be avoided as a matter of good practice.

B) Class II - Low Power Visible Lasers and Laser Systems

These lasers shall have an appropriate warning label (see page Warning Signs and Labels) affixed to a conspicuous place on the laser housing or control panel, or on both the laser housing and control panel.

C) Class III - Medium Power Lasers and Laser Systems

Class III systems shall have engineering controls and appropriate safety mechanisms as an integral part of the system. Examples include beam stops, beam enlarging systems, enclosures, shutters, interlocks, etc.

D) Classes III, IV, and V Lasers and Laser Systems

These shall be operated only in a controlled area (an area where occupancy can be controlled).

1) Special emphasis shall be placed on controlling the beam path of these type lasers by the use of beam enclosures.

2) When a beam enclosure cannot be used, the laser beam shall be terminated by a beam stop at the end of the useful path.

E. Laser Operations

Only authorized personnel shall operate laser systems.

F. All Operators & Other Personnel in the Vicinity of Laser Operations

These personnel shall be duly informed concerning the potential hazards from these devices.

G. Spectators

Spectators shall not be permitted into the laser controlled areas unless appropriate supervisory approval has been obtained and protective measures taken.

H. Responsibility of Laser Safety Officer

The Laser Safety Officer shall have the responsibility and authority to:.

1) Provide consultation services on laser hazard evaluation and control.

2) Suspend, restrict, or terminate the operation of a laser system if he deems that laser hazard control is inadequate.

3) Use this section and applicable sections of ANSI Z-136.1 - 1973

as official guidelines in providing safe practices for laser operations.

4) Maintain the necessary records required by applicable governmental regulations.

5) Provide approved protective equipment to control laser hazards when necessary.

6) Submit the names of those employees to the FDA Radiation Safety Council who are scheduled to work with any laser except Class I. These employees will then be scheduled for medical surveillance.

7) Maintain appropriate records on medical examinations of employees and schedule periodic medical examinations.

8) Survey all areas using laser equipment as frequently as necessary.

9) Review plans for installation and/or modification of laser equipment relative to laser hazards and their control.

10) Investigate upon notification of a real or suspected accident resulting from laser operation and initiate corrective action.

11) Post warning signs in appropriate locations and ascertain that warning systems are functional.

I. Responsibility of Employees Working With or Near Lasers

A. An employee will not work with or near a laser until authorized by the supervisor of the laser.

B. Employees must comply with the safety procedures of this section and with any regulations prescribed by the laser supervisor or safety officer.

C. When an employee knows or suspects that an accident has occurred involving a laser, he will immediately notify the laser supervisor and laser safety officer.

D. All employees shall wear prescribed safety equipment and

observe all safety procedures at all times.

5. WARNING SIGNS AND LABELS

The laser hazard symbol shall be represented by a sunburst pattern consisting of two sets of radial spokes of different lengths and one longer spoke radiating from a common center. The color, dimension, and location of the symbol within the sign shall be as specified in ANSI Z-25.1 - 1972, "Specifications for Accident Prevention Signs."

A. The signal word "Caution" shall be used with all signs and labels associated with Classes II and III lasers having an output power between 1 and 5 mW and a maximum emergent beam irradiance of 2.5 mW per cm as measured over a 7 mm aperture.

B. The signal word "Danger" shall be used on all signs and labels associated with Class III lasers other than those defined above, and Class IV high-powered lasers.

C. In addition to the appropriate signal word, all signs and labels will have sufficient space to allow inclusion of pertinent information. Such information may be included during the printing of the sign or label or may be handwritten in a legible manner to include the following information:

1) Above the tail of the sunburst: Type of laser (Pulsed, Ruby, C. W. Helium - Neon, etc.).

2) Below the tail of the sunburst: Special precautionary instructions or protective actions required by the reader.

APPENDIX I
REFERENCES

1. U. S. DEPARTMENT OF COMMERCE, NATIONAL BUREAU OF STANDARDS

A. Handbook 50, X-Ray Protection Design.

B. Handbook 55, Protection Against Betatron-Synchrotron Radiations up to 100 Million Electron Volts.

C. Handbook 60, X-Ray Protection.

D. Handbook 69, Maximum Permissible Body Burdens and MPS's.

E. Handbook 73, Protection Against Radiation from Sealed Gamma Sources.

F. Handbook 92, Safe Handling of Radioactive Materials.

2. NATIONAL ACADEMY OF SCIENCES - NATIONAL RESEARCH COUNCIL

A. The Biological Effects of Atomic Radiation, Summary Reports.

B. The Biological Effects of Atomic Radiation, A Report to the Public.

3. U. S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE - PUBLIC HEALTH SERVICE

A. Concepts of Radiological Health.

B. Radiological Health Handbook.

4. U. S. NUCLEAR REGULATORY COMMISSION

A. NRCU-2226, Design of Laboratories for Safe Use of Radioisotopes.

B. Rules and Regulations, Title 10, Atomic Energy

1) Part 20, Standards for Protection Against Radiation.

2) Part 30, Rules of General Applicability to Licensing of Byproduct Material.

3) Part 31, General Licenses for Certain quantities of Byproduct Material and Byproduct Material Contained in Certain Items.

4) Part 32, Specific Licenses to Manufacture, Distribute, or Import Exempted and Generally Licensed Items Containing Byproduct Material.

5) Part 33, Specific Licenses of Broad Scope for Byproduct Material.

6) Part 34, Licenses for Radiography and Radiation Safety Requirements for Radiographic Operations.

7) Part 35, Human Uses of Byproduct Material.

8) Part 36, Export and Import of Byproduct Material.

C. Handbook of Federal Regulations Applying to Transportation of Radioactive Materials.

D. Technical Bulletin No. 4, Radiation Hazards of Fire Fighting.

E. Isotope Division Circular B-4, Some Practical Consideration in Radiation Shielding.

5. INTERNAL ASSOCIATION OF FIRE CHIEFS

A. Radiation Hazards of Radioactive Isotopes in Fire Emergencies.

B. Radiation and Monitoring Fundamentals for the Fire Service.

6. AMERICAN STANDARDS ASSOCIATION

A. Z54.1 - 1946, Safety Code for the Industrial Use of X-Rays.

7. SOURCE BOOK OF ATOMIC ENERGY - Glasstone

8. INTERSTATE COMMERCE COMMISSION

Agent T. C. George's Tariff No. 19, Interstate Commerce Commission Regulations for Transportation of Explosives and Other Dangerous Articles by Land and Water in Rail Freight Service and by Motor Vehicle (highway) and Water Including Specifications for Shipping Containers.

9. RADIATION PROTECTION - BRAESTRUP AND WYCKOFF

10. RADIATION HYGIENE HANDBOOK - HANSON BLATZ, MCGRAW HILL, 1959

11. NUCLEAR RADIATION PHYSICS - LAPP & ANDREWS, PRENTICE-HALL, INC. 1963

12. NUCLEAR RADIATION DETECTION - W. J. PRICE, MCGRAW-HILL, 1964

13. RADIOLOGICAL CONTROL MANUAL, J. W. NOBLIN, NASA MARSHALL SPACE FLIGHT CENTER, MARCH 1972.

APPENDIX II

GLOSSARY

1. AGREEMENT STATE: Any State with which the U. S. Nuclear Regulatory Commission has entered into an effective agreement under subsection 274b of the Atomic Energy Act of 1954. Such states effectively assume the regulatory control of byproduct material held by the USNRC in nonagreement states.

2. AIRBORNE RADIOACTIVE MATERIAL: Airborne radioactive material in any form such as dust, mist, or gas.

3. ALPHA PARTICLE: The nucleus of the helium atom, 4He, a particle with a mass of four consisting of two protons and two neutrons and having two units of positive charge; commonly ejected during decay of some naturally occurring heavy isotopes.

4. BEAM: An approximately unidirectional flow of electromagnetic or particulate radiation.

USEFUL BEAM: That part of the primary radiation which passes through the cone, aperture, or other collimating device.

5. BETA PARTICLE: A particle, having the mass and charge of an electron, emitted from the nucleus of an atom; most commonly in artificially produced low atomic mass isotopes.

6. BREMSSTRAHLUNG: Electromagnetic radiation (X-rays) emitted as a result of the interaction of an electron with the nuclear coulomb field of an atom in the target material.

7. BYPRODUCT MATERIAL: Any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure to the radiation incident to the process of producing or utilizing special nuclear material.

8. COLLIMATOR: A device for confining a beam of particles or rays within a defined area and/or direction.

9. COLLISION: An encounter between two subatomic particles (including

photons) that changes the existing momentum and energy conditions; the products of the collision need not be the same as the initial systems.

ELASTIC COLLISION: A collision in which there is no change in the internal energy of each participating system or in the sum of their kinetic energies of translation.

INELASTIC COLLISION: A collision in which there are changes in both the internal energy of one or more of the colliding systems and in the sums of the kinetic energies of translation before and after the collision.

10. COMPTON EFFECT: An attenuation process observed for X- or gamma radiation in which an incident photon interacts with an orbital electron of an atom to produce a recoil election and a scattered photon of energy less than the incident photon.

11. CONTAMINATION, RADIOACTIVE: Radioactive material deposited in any place where it is not desired, and particularly in any place where its presence may be harmful.

12. CONTROL FILM: Film packets used to compute correlation factors for incidental exposure or emulsion deterioration that may occur in transit or storage.

13. CONTROLLED AREA: Any area whose access is restricted by the user for the purpose of limiting radiation exposure.

14. COUNT (MEASURE OF RADIATION): The external indication of a device designed to enumerate ionizing events; it may refer to a single detected event or to the total registered in a given period of time, the term is loosely used to designate a disintegration, an ionizing event, or a voltage pulse.

15. COUNTING RATE METER: A device that gives a continuous indication of the average rate of ionizing events.

16. CURIE: The unit of activity equal to 3.7 x 10 disintegrations/ second.

17. DECAY, RADIOACTIVE: Disintegration of the nucleus of an unstable

nuclide by the spontaneous emission of charged particles and/or photons.

18. DENSITOMETER: An instrument utilizing a photocell to determine the degree of darkening of developed photographic film.

19. DISINTEGRATION, NUCLEAR: The spontaneous breakdown process of a nucleus of an atom characterized by the emission of energy and/or mass from the nucleus.

20. DOSE: According to current usage, the radiation delivered to a specified area or volume or to the whole body. Units for dose specification are rads or rems. In radiology, the dose may be specified in air, on the skin, or at some depth between the surface; no statement of dose is complete without specification of location. In recent years, there has been an increasing tendency to regard a dose of radiation in units of rads. (tissue), the amount of energy absorbed by tissue at the site of interest per unit mass.

ABSORBED DOSE: The energy imparted to matter by ionizing radiation per unit of irradiated material at the place of interest, the special unit of absorbed dose is the rad; one rad equals 100 ergs/gram.

21. DOSE RATE: Radiation dose delivered per unit time.

22. DOSE RATE METER: Any instrument that measures radiation dose rate.

23. DOSIMETER: A device used to detect and measure an accumulated dose of radiation; dosimeters include film badges, pocket chambers, pocket dosimeters, and film rings.

24. DOSIMETRY: Determination of the cumulative dosage of radiation by use of a dosimeter.

25. EXTERNAL RADIATION: Exposure to ionizing radiation when the source is located outside the body.

26. FILM BADGE: A pack of photographic film used for approximate measurement of radiation exposure.

27. FILM EVALUATION: Interpretation of images on developed film into dosage readings.

28. FILM PACKET: One or more pieces of calibrated radiation detection film in a light-proof envelope; fits into film folder.

29. FILM RINGS: A film badge in the form of a finger ring.

30. FLUOROSCOPE: A fluorescent screen suitably mounted with respect to an X-ray tube for ease in observation and protection; used for indirect visualization, by means of X-rays, of internal organs in the body or internal structures in apparatus or in masses of metal.

31. GAMMA RAYS: High energy electromagnetic radiation emitted from the nucleus; usually monoenergetic for a particular radionuclide.

32. HALF-LIFE, RADIOACTIVE: Time required for a radioactive substance to lose 50 percent of its activity by decay; each radioactive isotope has a unique half-life.

33. HIGH RADIATION AREA: A radiation area in which there exists a radiation level in excess of 100 millirem in any 1 hour.

34. HUMAN USE: The internal or external administration of radioactive. material (byproduct material or otherwise) or the radiation therefrom, to human beings.

35. INTERLOCK: A device, usually electrical and/or mechanical in nature, that prevents activation of a control until a preliminary condition has been met or prevents hazardous operations; its purpose usually is safety of personnel or equipment; for example, an interlock may be provided to prevent withdrawing control rods to start reaction in a pile until the flow of coolant has been established.

36. IONIZING RADIATION: Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, in its passage through matter.

37. LICENSED MATERIAL: Source material, special nuclear material, or byproduct material that is authorized for use by the AEC.

38. MILLICURIE: The amount of radioactive material that disintegrates at the rate of 37 million atoms/second; a submultiple of the curie, 0.001 curie.

39. MILLIREM: A submultiple of the rem, 0.001 rem.

40. MONITORING: Periodic or continuous determination of the amount of ionizing radiation or radioactive contamination present in an occupied region as a safety measure for purposes of health protection.

41. NEUTRON: An electrically neutral elementary nuclear particle with a mass approximately the same as that of a hydrogen atom. Neutrons are commonly divided into subclassifications according to their energies as follows: thermal, approximately 0.025 electron-volt; epithermal, 0.1 to 100 electron-volts; slow, less than 100 electron-volts; intermediate, 10' to 10 electron-volts; and fast, greater than 0.1 to 10 electron-volts.

42. PAIR PRODUCTION: An absorption process of X- and gamma radiation in which the incident photon is annihilated in the vicinity of the nucleus of the absorbing atom with subsequent production of an electron-positron pair,; this reaction only occurs for incident photon energies exceeding 1.02 x 10 electron-volts.

43. PHOTO DOSIMETRY: Measurement, by means of exposure, on the photographic film of radiation dosage received from beta, gamma, and X-ray emitting sources including radioactive materials, X-ray machines, nuclear reaction equipment and nuclear bombardment devices.

44. PHOTOELECTRIC EFFECT: A process by which a photon ejects an electron from an atom; all the energy of the photon is absorbed in ejecting the electron and in imparting kinetic energy to it.

45. PHOTON: A quantity of electromagnetic energy whose value in ergs is the product of its frequency in cycles per second and Planck's constant; the equation is $E = hv$.

46. POCKET CHAMBER: A non-self-reading, pencil size, ionization

chamber that requires accessory equipment to charge and to obtain a reading; usually the charging device is used also for reading.

47. POCKET DOSIMETER: A self-reading, pencil size, ionization chamber with a built-in electrometer, but usually requiring an accessory device for "zeroing" or charging.

48. POSITRON: A particle having the mass of an electron and unit positive charge.

49. PROTON: A particle having one mass unit and unit positive charge. A singly ionized hydrogen atom.

50. QUALIFIED EXPERT: A person having the knowledge and training needed to measure radiation and to advise regarding radiation hazards.

51. RAD: The unit of absorbed dose (100 ergs/gram); measure of energy imparted to matter by ionizing particles per unit of mass of irradiated material at the point of interest. The material must be specified; e.g., rads (tissue).

52. RADIATION:

a) The emission and propagation of energy through space or through a material medium in the form of waves; for instance, the emission and propagation of electromagnetic waves or of sound and elastic waves.

b) The energy propagated through space or through a material medium as waves; for example, energy in the form of electromagnetic waves or of elastic waves. The term radiation or radiant energy, when unqualified, usually refers to electromagnetic radiation; such radiation commonly is classified, according to frequency, as Hertzian, Infrared, visible (light) ultraviolet, X-ray, and gamma ray. (See Photon)

c) By extension, particulate emission, such as alpha and beta radiation, or rays of mixed or unknown type, such as cosmic radiation.

53. RADIATION AREA: An area accessible to personnel in which there exists radiation at such levels that a major portion of the body could receive in any 1 hour in excess of 5 millirem or in any 5 consecutive

days a dose of 100 millirem.

54. RADIATION PROTECTION GUIDES (RPG): That radiation dose above which a person should not be exposed in a specified interval of time without a careful consideration of the reasons for doing so.

55. RADIOACTIVE MATERIAL: Any material, whether or not under licensing control of the AEC, that emanates electromagnetic and/or particulate radiations capable of producing ion pairs in the absorbing medium; includes both naturally occurring radioactive elements as well as byproduct, source, and special nuclear material.

56. RADIOACTIVE: Process whereby certain nuclides undergo spontaneous disintegration in which energy is liberated, generally resulting in the formation of new nuclides; the process is accompanied by the emission of one or more types of radiation, such as alpha or beta particles or gamma photons.

57. REM (ROENTGEN EQUIVALENT MAN): A unit of measure of ionizing radiation dose to body tissue in terms of its estimated biological effect related to a dose of 1 roentgen of X-rays (1 millirem (mrem) = 0.001 rem. The relation of the rem to the other dose units depends upon the biological effect under consideration and upon the conditions of irradiation. For the purpose of this regulation, any of the following is considered to be equivalent to a dose of 1 rem.

a. An exposure of 1 roentgen due to X- or gamma radiation.

b. A dose of 1 rad due to X-, gamma, or beta radiation.

c. A dose of 0.1 rad due to neutrons or high energy protons.

d. A dose of 0.05 rad due to particles heavier than protons and with sufficient energy to reach the lens of the eye.

It is more convenient to measure the neutron flux, or equivalent, than to determine the neutron dose in rads; as provided in c. (above), 1 rem of neutron radiation may, for the purposes of this regulation, be

assumed to be equivalent to 14 million neutrons/square centimeter incident upon the body; or if there exists sufficient information to estimate with reasonable accuracy the approximate distribution in energy of the neutrons, the incident number of neutrons per square centimeter equivalent to 1 rem may be estimated from the following table:

Neutron Energy (MeV)	No. of Neutrons/cm^2 Equivalent to a Dose of 1 rem	Average flux to Deliver 100 millirem in 40 hr (neutrons/cm^2/sec)
Thermal	970×10^6	670
0.0001	720×10^6	500
0.005	820×10^6	570
0.02	400×10^6	280
0.1	120×10^6	80
0.5	43×10^6	30
1.0	26×10^6	18
2.5	29×10^6	20
5.0	26×10^6	18
7.5	24×10^6	17
10.0	24×10^6	17
10.0 to 30.0	14×10^6	10

58 RESTRICTED AREA: See Controlled Area.

59. ROENTGEN (R): That quantity of X- or gamma irradiation that will produce 1 statcoulomb of negative ions and 1 statcoulomb of positive ions at 0 degree C and 760 millimeters of mercury pressure in 1 cubic centimeter of air

(STP) = 1.61×10^{12} ion pairs/gram-mass air = 6.8×10^4 megaelectronvolts/cubic centimeter of air (STP). (STP is standard temperature and pressure.)

60. SEALED SOURCE: Any radioactive material that is encased in, and is to be used in, a container in a manner intended to prevent leakage of the radioactive material or any of its daughter products.

61. SOURCE MATERIAL: Any material, except fissionable material, which contains by weight one-twentieth of 1 percent (0.05 percent) or more of (a) uranium, (b) thorium, or (c) any combination thereof.

62. SPECIAL FORM RADIOACTIVE MATERIALS: Radioactive materials in which the radioactive material is in massive solid form or encapsulated and which if released from a package might present direct radiation hazard but would present little radiotoxicity hazard as a result of the inherent properties of the material (such as metals or alloys) or characteristics acquired through encapsulation.

63. SPECIAL NUCLEAR MATERIAL: (a) Plutonium, 233U, uranium enriched in the isotope 233 or in the isotope 235, and by any other material that the NRC determines to be special nuclear material, not including source material; or (b) any material artificially enriched by any of the foregoing not including source material.

64. SURVEY, RADIOLOGICAL: Evaluation of the radiation hazards incident to the production, use, or existence of radioactive materials or other sources of radiation under a specific set of conditions; such evaluation customarily includes a physical survey of the disposition of materials and equipment, measurements of estimates of the levels of radiation that may be involved, and a sufficient knowledge of processes using or affecting these materials to predict hazards resulting from expected or possible changes in materials or equipment.

65. THERMOLUMINESCENT DOSIMETER (TLD): A lithium fluoride chip used for measurement of radiation exposure.

66. TRANSPORT INDEX: A number to be placed on a package label to designate the degree of control to be exercised by the carrier during transportation of radioactive materials. (49 CFR 173.389(i) Typically, this is the highest radiation dose rate in millirem per hour at three feet from any accessible external surface of the package.

67. WEARING PERIOD: The length of time during which a film pocket or TLD is worn by the individual being monitored; usually, service is

furnished for a 1-month period.

68. X-RAY: Penetrating electromagnetic radiations having wavelengths shorter than those of visible light; they are usually produced by bombarding a metallic target with fast electrons in a high vacuum; in nuclear reactions, it is customary to refer to photons originating in the nucleus as gamma rays and to those originating in the extra nuclear part as X-rays.

69: X-RAY AREA: Any area where an X-radiation hazard exists.

APPENDIX III
RADIATION DETECTION INSTRUMENTS

Type of Number	Number Available	Radiations Detected	Sensitivity Range	Window Thickness (mg/cm^2)	Use
Eberline E-520 (Geiger Counter)	5	β,γ	0-0.2, 2.0, 20, 200, 2,000 mr/hr.	30.0	Surveying
Eberline RO-3 (Cutie Pie)	1	α,β,γ	0-5, 5000 5,000, 10,000	3.5	Surveying
Eberline 6112 (Teletector)	2	β,γ	0-2, 50, 2000, 5,000, 10,000 mr/hr. (hi range not cal.)	30.0	Surveying
Eberline PS-1	2	α,β,γ	7500 cpm = 1 mr/hr.	(Scintillation Type)	Fld. Measurg.
Eberline PRM-5 (Portable Rate Meter)	1	α,β,γ	Dependent on Probe		Fld. Measurg.
Eberline PAC-4G (Low Energy Beta)	1	α,β,γ	500, 5K, 50K, & 500K counts/min.	0.85	Surveying
Eberline PNC-4	1	n	0-500,000 counts/min.	(BF_3 tube)	Surveying
Eberline PNR-4	1	n	0-5, 50,000 & 5K millirem/hr.	(BF_3 tube)	Surveying
Dosimeter Corp.	6	γ, fast n	0-200 mrads	--	Personnel Monitoring
Victororeen 570 (Condenser R-Meter)	2	γ	0-1, 2.5, 5, & 25 rems	212, 569 583	Measure field strength for instrument calibration
Single Channel Anal (Tennelec, Ortec components)	1	β,γ	Bkgd-100,000 counts/min.	1.5	Measuring
Beckman Gas Flow Proportional Counter (Low Beta II)	1	α,β	$0.5\text{-}5 \times 10^4$ counts/min.	0.5	Measuring
Beckman Gamma 7000	1	γ	<0.0005 µCi Cs-137 per swab	--	Leak Wipe
Dosimeter Corp. (Digital Survey Meter) FH-40F	1	γ	0-300 µR/hr. to 100 R/hr.	--	Surveying

APPENDIX IV

PROCEDURES FOR FIELD ANALYSIS OF LEVEL AND DENSITY

"Field Analysis" means the use of process nuclear gauge hardware and/or sensitive laboratory electronic devices to make level and density measurements of a non-permanent or investigative nature. The source holder and detector are not permanently mounted to the structure, but are hand-held or controlled by nuclear application technicians. The radiation sources used are source-source holder combinations such as those supplied by Ohmart Corp. or Texas Nuclear Corp. for process level and density gauges. Typical source holders used are Texas Nuclear 5192 or 5176, and Ohmart SR-1 or SHLG-1. Characteristically, these all are lead filled steel vessels with a lockable on/off shutter and tightly collimated beam ports (5° to 10°). An exception to this general rule are a couple of small (1 mCi) special form encapsulated sources which have been placed in fabricated lead pigs. All source holders have less than 5 mr/hr. fields at 12" from their surface except for the directed radiation beam. Sources are normally selected to produce radiation fields of 1 to 10 mr/hr. at the detector.

This work will be performed or supervised by senior nuclear applications personnel, normally the RPO or his alternate. All participating personnel will wear film badges. Auxilliary personnel occasionally required by work site conditions such as hoist operators or chemical safety monitors will be briefly instructed as to the nature and hazards of the activity, issued pocket dosimeters and kept out of any radiation fields. All other personnel will be cleared from the area. Operations will be conducted in a manner consistent with all requirements of 10 CFR Part 20.

The radiation source will be kept under the supervision of UCC nuclear applications personnel at all times during use. During short work breaks, it will be locked in the OFF position and secured to the structure. When not in use, the source will be stored in the facility's radioactive materials storage area. If the facility does not have a storage area, a temporary storage area will be created and posted with signs such that the material is inaccessible to unauthorized personnel. After the source is placed in the storage area, the area perimeter will be surveyed to assure that the area is in compliance with 10 CFR Part 20.

APPENDIX V

OPERATING AND EMERGENCY PROCEDURES

FOR CARBON BUILDUP TESTS USING Am241-Be

OPERATING PROCEDURES

1. Areas at least 20 foot square at both the top and bottom of the reactor will be roped off and posted with "Caution - Radioactive Materials" signs. No one will be allowed inside this area unless equipped with proper dosimetry equipment (film badges or pocket dosimeters).

2 The neutron source will be kept in its shielded container until all personnel are prepared for testing.

3. Personnel will have an operable and calibrated portable neutron survey meter available.

4. The source will be transferred to the detector probe over a flat surface using channel lock pliers. One person will perform the transfer and one person will observe the transfer. The observer should remain close enough to the transferer to locate the source if it is accidentally dropped.

5. The observer will then proceed to place the source in predetermined locations within the vessel while his partner observes the readout device.

6. Upon completion of the test, personnel will remove the source from the detector probe and place it in its shielded container.

EMERGENCY PROCEDURES

While transferring the source, it may accidentally be dropped. The source is an encapsulated sealed source and the spread of contamination is highly improbable; however, it will present a radiation hazard. If the source is dropped:

1. Locate the source. If the transfer was attempted over a flat surface and the source is readily available, pick up the source with the pliers and attached it to the detector probe.

2. If the source is out of sight, attempt to locate it with your survey meter. If you find it, transfer the source to the detector probe.

3. If you cannot locate the source with your survey meter, rope off an area at least 100 foot square and do not let anyone inside. Contact the Plant Rádiation Protection Officer.

Remember, in any radiation hazard, use these simple concepts to minimize your dose:

TIME:	Minimize your time near the source.
DISTANCE:	Maximize your distance from the source.

APPENDIX VI
RADIATION EXPOSURE REQUIREMENTS
"SAFETY CHECKS", FOR LOCKED DOOR PROCEDURE[1]
"X-RAY", BUILDING 713[2]

1.___ Clip on and wear assigned film badge and dosimeter.

2.___ Zero dosimeter and record reading, check dosimeter frequently during radiation exposures.

3.___ Check radiation survey meter-Battery check for operational service. (Survey meter shall be calibrated every three months).

4.__ Review reference code(s), UCC specification(s), drawings for x-ray requirements and acceptance standard regarding the item being examined

5.__ Set up outside safety chain with the radiation caution signs attached.

6.__ Review drawing(s) and identify item for film exposure with lead numbers, letters, penetrameter(s), date. Identify weld joint(s) examined on drawing(s).

7.__ Set up item for x-ray exposure. Direct the x-ray beam towards lead wall; place portable lead shield panels into position.

8.__ Turn on outside warning light and the darkroom lights. Lock all outside doors to darkroom and work shop. Select and load film(s) for area of interest to be exposed.

9.__ Stir film developer, short stop bath, and fix tank solutions. Maintain water temperature in tank reservoir 65°F through 85°F. Temperature of water is not to exceed 90°F.

10.__ Warm up radiation (x-ray) equipment per manufacturer's instruction. Check radiation emission in work shop (through partial door opening) using radiation survey instrument. (Log results).

NOTE: During exposure(s) - radiation intensity level in the darkroom with the door closed, the radiation intensity level shall be such that dose received will be less than 2.0 mr in any one hour. Should the intensity be greater, shut down the x-ray equipment.

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[1]The procedures of the Technical Center Radiation Protection Manual and the regulations of the State of West Virginia shall be followed at all times. Copies of these documents are available from the Radiation Protection Officer.

[2]This record shall be maintained in a permanent file.

Check the portable lead shield panel(s) for improper positioning and/or lower the KV-voltage value for the exposure and compensate for the new exposure time rate. (Enter radiation levels in log).

11.__ After warm up, place film with identification on the area of interest. Establish the source to film distance (SFD) normally 27 inches (may be less or greater) and calculate exposure time rate KV and MA from graphs.

12.__ Upon completion of the radiation exposure, re-check the work shop through the darkroom door with the radiation survey meter before entering. A RADIATION CHECK IS TO BE COMPLETED UPON COMPLETION OF EACH EXPOSURE.

13.__ Remove and develop exposed film. Write "exposed" on film cassette or ready pack holder. To develop film:

Developer	-	5 minutes
Short Stop	-	5 seconds
Fix	-	5 minutes
Water Wash	-	15-30 minutes
Dry	-	In air heater dryer.

Read all exposure (interpretation per required code(s), etc.) and log film exposure finding (acceptance/rejection) on record sheets.

14.__ Upon completion of the job, replace all lead letters and numbers including penetrameters to their respective storage boxes. Disconnect and store x-ray (head) equipment in darkroom, clean up work area. Shut off water to reservoir tank. Replace film badge(s) and dosimeter(s) to storage drawers. Log dosimeter reading change. Remove safety chain and signs; turn off outside warning and darkroom light(s). Lock up.

Date_____ Signature_____

Radiographer Level 1___, 11___, 111___

APPENDIX VII

STANDARDS FOR PROTECTION AGAINST RADIATION

UNITED STATES NUCLEAR REGULATORY COMMISSION

RULES AND REGULATIONS

PARTS 19, 20, 30, AND 34

AND

OSHA RULES AND REGULATIONS FOR

IONIZING AND NONIONIZING RADIATIONS