



Radiation Safety Program

Gemini Diffractometer

Policy Review:

Policy Review Dates/ Number of Revision December 14, 2011				
01/2012 Revision 2	02/2015 Revision 5			
01/2013- Revision 3				
01/2014 Revision 4				

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Radiation Safety Program - Gemini Diffractometer

EMERGENCY TELEPHONE NUMBERS

	Phone	Hours
Environmental, Health and Safety	336-217-5143	8:00am-5:00pm
Radiation Safety Officer	336-217-5143	8:00am-5:00pm
Afterhours (weekends, holidays)	336-419-9397	
Greensboro Police	911	24 Hours
Fire or Smoke	911	24 Hours
Medical Emergencies	911	24 Hours
North Carolina Poison Control Center	1-800-672-1697	24 Hours

***The Environmental, Health and Safety Manager carries a cell phone and can be reached after hours at the number listed above.**

SPECIAL INCIDENT REPORTING:

	Work Hours	After-Hours
Radiation Safety Incidents or Safety Questions	EHS 217-2143	419-9397
Gas Leaks or Odors	EHS 217-5143	911/ 419-9397
Chemical Spills	EHS 217-5143	419-9397

Revised: February 2015

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PREFACE

Gateway University Research Park strives to provide a safe and healthful environment for all persons associated with the Research Park, including faculty, staff, tenants, students, visitors, and members of the Gateway community. Attainment of this goal requires cooperation and commitment on the part of us all.

Gateway emphasizes safety education and training as the primary means of achieving this goal. While the Environmental, Health and Safety Manager, is the person primarily responsible for health and safety functions at the Research Park, performs various periodic inspections, department heads, faculty members, tenants, and supervisors are considered directly responsible for maintaining full compliance with Gateway's safety policies and procedures.

With regard to radiation safety matters, the respective University's (NC A&T/ UNCG) Radiation Safety Committees, appointed by the Chancellors of both Universities, formulates radiation policies and procedures. Responsibility for carrying out these policies and procedures rests with the Gateway's Radiation Safety Officer, who directs the Radiation Safety Section, of the Environmental, Health and Safety Department.

The elements of Gateway's radiation safety program are presented in this Radiation Safety Manual. The safety program has been carefully developed to assist all radiation users in utilizing the unique advantages of radiation source(s) while meeting their safety responsibilities in as efficient a manner as possible. In addition, radiation safety philosophy includes an objective of maintaining all exposures at levels as far below specified limits as can reasonably be achieved. Gateway's strongly supports this "***As Low As Reasonably Achievable***" safety goal. The policies and procedures found in this manual promote and ensure the routine achievement of this goal.

In this era of increasing concern for occupational safety and for the environment, it is essential that all members of the Gateway community become and remain thoroughly familiar with their responsibilities for compliance with health and safety regulations, including these radiation safety policies and procedures. Study the contents of this manual. Know and practice these, and all other, safety rules. Thank you for your cooperation.

John R. Merrill, Executive Director
Gateway University Research Park

Revised: February 2015

Introduction

Gateway University Research Park has been authorized by the State of North Carolina Department of Health and Human Services, Radiation Protection Section, to use radiation sources in education, research, and development activities. The respective University's Radiation Safety Committee may authorize individual faculty members, as Authorized Users, to use radiation sources after a review of the proposed use, adequacy of facilities, and experience of the applicant. Although this provision allows the Research Park greater flexibility in dealing with the multitude of radiation sources and research uses encountered on campus, it places equally greater responsibility on investigators and the administration to comply with State regulations so that this flexibility may continue.

This manual summarizes the terms of the Research Park's authorization and the regulations most applicable to campus utilization of the Gemini Diffractometer. This document shall be kept on the shelf inside the lab of the Nano-Chem Analytical Instrument Laboratory-BL05, in the school of Nanoscience and Nanoengineering, in a binder clearly titled "Radiation Safety Program – Gemini Diffractometer". A copy will also be in the office of the Radiation Safety Officer (RSO). Special precautions, regulations, and other operating procedures specified by the respective University's Radiation Safety Committee and/or Gateway's Radiation Safety Officer as a condition for approval of radiation source authorization must also be maintained and made available to laboratory personnel and the respective University's EHS safety officers.

Everyone involved with the use of the Diffractometer or with the use of radiation sources in any way is required to be familiar with the provisions of this manual. The manual must be readily available to all interested individuals. All radiation exposure must be maintained to levels that are as low as are reasonably achievable (ALARA).

Principals of ALARA: All forms of radiation is potentially harmful: In accordance with [Rule .1606(b)] Gateway University Research Park endeavors to practice ALARA (As Low As Reasonable Achievable) principle by complying with protection standards described in the below sections.

Responsibilities:

The Radiation Safety Committees (NC A&T/UNCG) in liaison with Gateway's EHS Manager- is responsible for establishing policies governing the procurement, use, storage and disposal of radioactive materials and radiation-producing devices. The Committees include individuals experienced in the use or application of radioactive materials and radiation devices and provides a peer review of these uses among researchers at the University. The committee meets, at least quarterly, to review reports on the receipt and disposal of radioactive materials/radiation-producing devices, and to act on applications for authorization to use these sources. The Committee, along with its Chairman, is appointed by the Chancellors of the respective Universities. It makes an annual report of activities to the Executive Director of Gateway University Research Park and the Dean of the Joint School.

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Gateway's EHS Manager in liaison with the departments of EHS (NC A&T/UNCG) - have the administrative responsibility for the Research Park's Radiation Safety program. The EHS staff provides a wide range of radiation protection services such as personnel monitoring, waste disposal, laboratory surveys, instrumentation calibrations, maintenance of records required by the State, and consultation on the safe use of radiation sources.

Gateway's Radiation Safety Officer- is responsible for radiation protection on this campus, including general surveillance of overall activities involving radiation sources and all areas where sources are used; determining compliance with rules and regulations, authorization conditions and the conditions of project approval specified by the respective Radiation Safety Committee; consulting on radiation protection with University EHS staff; determining the need for and evaluation of personnel monitoring; conduction of training programs and otherwise instructing personnel in the proper procedures for the safe use of radiation sources; and immediately terminating any project that is found to be a threat to health or property.

All applications for radiation source use, location, procedures, and possession limit changes are reviewed by the Radiation Safety Officer. The Radiation Safety Officer may grant limited interim approval of those applications to the respective Radiation Safety Committee.

Radiation safety courses are given annually for employees/students who will be working with radiation sources. A schedule may be obtained from the EHS Manager. Other specialized training and consultation can also be arranged by appointment.

Authorized User (AU) - is a faculty member who has been approved to use radiation sources according to the procedures developed by the respective University Radiation Safety Committee and Gateway's EHS Manager. The Authorized User will normally be the principal investigator of a research project involving radiation sources or the faculty member responsible for a course with laboratory or field exercises in which sources are used. Although faculty members may use radiation sources under another faculty member's authorization, each faculty member is encouraged to obtain his/her own authorization. It is the Authorized User's responsibility to ensure that students and staff using radiation sources under his/her authorization are trained in safe laboratory practices, are familiar with the terms of the authorization and do, in fact, comply with Gateway's policies and applicable regulations.

Authorized Operators - are those faculty, students, and tenants who have been authorized by the RSO to use the Diffractometer. To be authorized, the operators shall be trained by the OXFORD DIFFRACTION REPRESENTATIVES or the JSNN lab manager/ supervisor. The instruction will include instruction on:

- Identification of possible radiation hazards and biological effects associated with the use of the equipment
- Additional requirements to monitor radiation exposure for operators who may be pregnant.
- Significance of the various radiation warning and safety devices incorporated into the equipment, or the reasons they have not been installed on certain pieces of equipment and the extra precautions required in these cases
- Proper operating procedures for the equipment

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- Appropriate use and limitation of dosimetric devices
- Proper procedures for reporting an actual or suspected exposure

After the required instruction, each operator must complete the attached form in **Appendix 3 - Review of Radiation Safety Program**, confirming that they have read and understood these instructions.

Duties of an Authorized Operator

- All operators of the Diffractometer are responsible for following the radiation safety procedures outlined in this policy. Employees should submit all radiation questions or concerns about radiation safety to the RSO.
- When required, always wear the personnel monitoring badge (**whole body and ring badges as required**) and make sure it is the badge assigned to you. When not in use, store badges in a low radiation area. The control badge shall be stored in a radiation free area. The RSO is responsible for evaluating the exposure records and exchanging the badges on a quarterly basis.
- During any period of operation of the Diffractometer (generator), the operator is responsible for the safety of themselves and other occupants of the JSNN Analytical Lab as well as occupants of the surrounding labs.
- During any demonstration of the equipment, non-Authorized Operators such as students/tenants who may wish to enter the lab area either to observe or practice any alignment procedure. Before allowing this, the Operator must inquire if the customer has had radiation safety training and show proof to the RSO. If the student/tenant has not had appropriate radiation safety training, then the RSO must provide training prior to allowing them to participate.

The Authorized Operators are:

- Dr. Jianjun Wei- JSNN Assistant Professor- PI of Lab
- Stephen Vance- UNCG Graduate Student
- Dr. Kuila- NC A&T faculty member
- Dr. Zerihun Assefa- NC A&T faculty member
- Mohammad Rafati- NC A&T Graduate student
- Claudia Cardona- Visiting Researcher-PharmaCompany
- Mehendran Samykano- NC A&T Graduate Student
- Jennifer Stanley- NC A&T Graduate Student
- Deomrick Harris-NC A&T Graduate Student
- Jigar Prajapati- NC A&T Graduate Student
- Darkus Jenkins- NC A&T Graduate Student
- Bryce Duncan- UNCG Graduate Student
- Effat Zeidan- UNCG Graduate Student
- Talal Ahmed- NC A&T Graduate Student
- Rui Li- NC A&T Graduate Student
- Henry Ochije-NC A&T Graduate Student

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- Karshak Kosarajo- UNCG Graduate Student
- Dr. Albert Hung- A&T Faculty Member
- Kimberly Riddick-A&T Graduate Student
- Zheng Zeng- UNCG Graduate Student
- Pavan Kasanaboina- NC A&T Graduate Student
- George Agbeworvi- A&T Graduate Student

POSTING REQUIREMENTS:

All rooms authorized for radioactive materials use, storage or disposal must post a copy of the Radiation Safety Rules (attached) to be followed when using radioactive materials and the Radiation Emergency Procedures for responding to incidents (attached).

The NC Radiation Safety “**Standards for Protection Against Radiation, Instruction and Reports to Workers, Notices and Inspections**”: poster shall be posted in areas where the Diffractometer operators and adjacent employees may read it. All areas where radiation may be emitted are to be posted as such, according to **section .1002(c)**.

NOTICE TO EMPLOYEES:

Postings informing employees of their employer’s responsibility and the responsibility of the employee will be available within this manual and posted outside the laboratory door, per .1002(c) of the NC regulations.

The general requirements for radiation safety and your rights and obligations as a radiation worker are found in **section .1600**.

Description

These instructions apply to the operation of the Agilent (formerly Varian/Oxford) ‘Gemini’ X-ray Diffractometer installed at the Gateway University Research Park South Campus, Joint School of Nanoscience and Nanoengineering, in the Nano-Chem Analytical Laboratory- BLO5, 2907 East Lee Street, Greensboro, NC 27401.

Risk Assessment

The Gemini Diffractometer in this facility was installed by the manufacturer, Agilent (formerly Varian/Oxford), following their specifications. **DO NOT** alter, tamper with, or remove any of the shielding, fail-safes, warning systems or in any way cause needless radiation exposure.

The radiological hazard results from the use of an X-ray source while its generator is switched on. The maximum operating parameters of the generator are 60kV and 50mA (3KW) although, normally, the tube is run at no more than 70% of its maximum power. The **target materials** are Molybdenum and Copper. In normal operation, the X-rays are generated and projected in a totally enclosed cabinet constructed of suitable shielding material.

Access to the interior of the cabinet via the front doors is required in order to change the sample, and an interlock is present to close the shutter should the doors be open inadvertently. When the doors are opened during sample change and alignment, the X-ray generator remains on for

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optimum performance and thus radiation leakage might occur between the source and the shutter. This can be expected to be no more than 0.12 $\mu\text{Sv/h}$ from a count rate of 2 c.p.s. It is possible for the shutter to be opened when the collimator is not in place but the shielding of the enclosure is adequate.

It is necessary however, to override the interlock system in order to make initial coarse alignment adjustments of the X-ray tube but this is done at low operating generator powers. There is, therefore, the possibility of exposure to the collimated primary beam particularly of the operator's fingers. If the generator is inadvertently run at higher powers, as well as the increased dose of the primary beam, there is also a risk of the backwards scattered (back towards the X-ray tube) fluorescence radiation. If a shorter collimator is used unnecessarily then there is a greater amount of exposed beam in which to put body parts into.

Machine Operation Procedures:

These instructions are provided to you so that this lab will comply with the state rules for radiation control. The North Carolina Department of Health and Human Services Radiation Protection Section enforces the radiation rules in North Carolina. These rules require that our Diffractometer meets specific requirements. The rules also require that certain procedures be followed and that certain records are kept.

The intent of this document is to establish procedures to minimize radiation exposure of personnel. You, as an operator, are required to know the procedures and requirements in this document and be able to demonstrate that you can use them properly.

No person shall intentionally or recklessly interfere with or misuse the X-ray generator or its safety devices or shall tamper with or override safety interlocks attached to the shielding cabinet in any way other than in accordance with the written system of work detailed below.

No modification shall be made to the X-ray generator, ancillary equipment, safety feature or warning device without first notifying the Radiation Safety Officer (RSO). A record must be made of all modifications. Modifications that require disabling of an interlock in any way are strictly forbidden.

System Commissioning (Critical Examination)

Any new installations, modifications, repair, or replacement of existing system or components will be performed by an Agilent representative and will require a Critical Examination to establish the radiation leakage rate before using it for sample measurements. The RSO will ensure that the Critical Examination is performed.

Start-up procedure

Prior to a new period of use, check the interlocks on the doors and the indicator lamps for the shutter and X-ray warning function correctly. **Record the date, time, your initials, and the system parameters** in the Diffractometer Use Log. The X-ray generator needs to be progressively powered up according to the system's Start-up Guide.

Sample change and alignment

The Lab Supervisor/Manager of the Analytical Lab is responsible for providing training on how to properly perform this function.

Unattended operation of system

Unattended operation of the system is forbidden without prior authorization from the Lab Supervisor/Manager which must be recorded in the Diffractometer Use Log.

Shutdown

If the Diffractometer has to be shut down for any reason, the Lab Supervisor/Manager is responsible for: (1.) locking all cabinet door and panels, and the access panel for the X-ray generator. (2.) Switching off all equipment and disconnecting all electricity plugs. (3.) Turning off water supply to the chillers.

Emergency Procedures:

Radiation Emergency Procedures-Analytical Machine

IF YOU ARE EXPOSED TO THE DIRECT X-RAY BEAM, OR SUSPECT AN EXPOSURE, **IMMEDIATELY** FOLLOW THESE STEPS:

1. Shut off the x-ray beam.
2. Remain calm. Call these contacts until: (1) medical advice is obtained and (2) the incident is reported.

Medical Advice/Incident Reporting

911 or Moses Cone Hospital Emergency Room..... 832-8040
EHS Manager..... 217-5143

AFTER HOURS CONTACT:

911..... 911 (Ask for Radiation Safety Assistance)
EHS Manager..... 419-9397

Fire:

In the event of a fire or emergency requiring evacuation from the area, if possible without endangering any persons' safety, the generator should be switched off before evacuation. If this is not possible then the responding Senior Fire Officer or other emergency service personnel must be informed that an X-ray generator is working and that a radiation hazard exists.

Note: If you have visitors they need to be escorted to safety.

Emergency Shut Down of Machine:

In an emergency where evacuation of the lab is necessary, immediately alert other lab occupants as well as occupants in the surrounding labs, and if the operator will not incur undue risk to do so, press the **Red Emergency Stop Button** prior to leaving the lab. Should there be no time or ability to get to the Emergency Stop button, the operator shall immediately exit the lab while ensuring that all other occupants of the lab and surrounding labs are exiting as well. Immediately report to the RSO and any emergency responders that a radiation hazard exists.

If a customer who is a Classified Radiation worker wishes to enter the Controlled Area for the purposes of sample alignment, the RSO must be informed prior to doing so in order that proper precautions may be taken including dosimetry and/or radiation measurement.

Personnel Monitoring – Occupational Dose Limit [1604(a) (1)]

REQUIREMENTS

Radiation protection regulations and Gateway's policy require that appropriate personnel monitoring equipment be provided to individuals who:

- A. Are likely to receive a radiation dose in one year in excess of 10 percent of;
 1. 5 rems (.05 Sv), total effective dose equivalent, to whole body;
 2. 15 rems (0.15 Sv), eye dose equivalent, to the lens of the eyes;
 3. 50 rems(.50 Sv), shallow dose equivalent, to skin or to each of the extremities.

- B. Are **under 18 years of age** and are likely to receive a radiation dose in one year in excess of 10 percent of;
 1. 0.5 rems to the whole body;
 2. 1.5 rems to the lens of the eyes;
 3. 5 rems to the skin or to each of the extremities.

Occupational Exposure:

Annual Limits are as follows:

1. the total effective dose equivalent being equal to five rems (5000 millirems) (0.05 Sv); or
2. the sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 rems (0.5 Sv); and

The annual limits to the lens of the eye, to the skin of the whole body, and to the skin of the extremities which are:

- (A.) an eye dose equivalent of 15 rems (0.15 Sv), and
- (B.) a shallow-dose equivalent of 50 rems (0.50 Sv) to the skin of the whole body or to the skin of any extremity.

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General Public Exposures:

Each licensee or registrant shall conduct operations so that:

1. The total effective dose equivalent to individual members of the public from the licensed or registered operation does not exceed 0.1 rem (1mSv) in a year
2. The dose in any unrestricted area from external sources of radiation, does not exceed 0.002 rem(0.02 mSv) in any one hour.

Note: If annual exposure is expected to be above 10% of the dose limit the worker is required to be monitored.

- C. Have declared a pregnancy or planned pregnancy.
The annual limit for a declared pregnant worker is .05 rem (500 millirems/pregnancy)
- D. Enter a High or Very High Radiation Area (exposure to greater than 100 millirems in one hour).
- E. Operate analytical X-ray devices (both ring and whole body dosimeter required as determined by the RSO)
- F. Meet the issuance criteria by the Radiation Safety Officer.

Issuance Criteria:

- **Acquiring Prior Occupational Dose for new employees [.1638(a)(1)&(2)]**
Authorized Users must complete and submit a Lab/ Radiation Worker Registration Form, from their respective University, for each individual who may work with radiation sources. This form provides the basic information regarding training and experience and personnel monitoring needs. Initial personnel monitoring decisions will be based on this information. Further evaluations, and re-evaluations, will be made through radiation employee registration updates, application reviews, personnel monitoring reports, high dose investigations, surveys and individual interviews by the Radiation Safety Officer in conjunction with the Radiation Safety Committees of the user's respective University.

In general, the licensee or registrant (Gateway University Research Park) shall retain each required form or record until the agency (Gateway University Research Park) terminates each pertinent license or registration requiring the record [.1640(g)].

- **Monitoring Protocol:**
 1. Radiation restricted area under such conditions that an occupational radiation dose in excess of 10 percent of the specified calendar year limits may occur. EHS will request prior radiation dose histories form all past employers.
 2. Dosimeters will be exchanged on a quarterly basis.
 3. All personnel occupational radiation dose records shall be maintained by EHS.
 4. It shall be the responsibility of each individual dosimeter recipient to wear and use the dosimeter(s) properly.

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5. Authorized Users are responsible for assuring their radiation workers are wearing badges appropriately and that badges are returned on time for reading.

NOTE: Departments may be charged for late or lost dosimeter.

- **Recording Exposures:**

Measured personnel occupational radiation doses, are to be recorded and maintained on file by EHS.

USE OF PERSONNEL MONITORING DEVICES:

The whole body dosimeter (or other device) is to be worn on the body where it will most likely approximate the radiation exposure to the head and torso of the wearer. A dosimeter assigned for whole body monitoring is not to be used to monitor the extremities (hands, forearms, feet, ankles). Separate badges must be assigned for extremity monitoring.

Generally, whole body badges are to be worn between the waist and neck. When a protective apron is worn, the badge is to be worn at the collar, outside the apron. In some circumstances, where exposure of the neck and lenses of the eyes is negligible, the monitoring badge may appropriately be worn under the apron. The Radiation Safety Officer should be consulted for advice in these circumstances.

Extremity monitoring dosimeters (rings) are available in small medium, or large sizes and for the right or left hand. Ring dosimeters should be worn whenever working with radiation sources. When using radioactive materials, the ring monitoring element (label area) should be turned toward the palm. Gloves should be worn over the ring badge when contamination is possible.

The exposure of a personnel monitoring device to deceptively indicate a dose delivered to an individual is prohibited by North Carolina regulations.

- **Personnel Monitoring Reports [.1640(a)(1) & (g)]:**

Occupational radiation dose reports are sent to Gateway's RSO via the respective university EHS department. The report(s) are posted in the radiation safety manual located in the laboratory so that each authorized operator may learn of his/her own dose record. Routine monitoring periods are currently **quarterly**. Each report will include the name, monitoring period date, dose (millirems) for the immediate past period, current calendar quarter, calendar year and the lifetime dose for each member of the group.

PREGNANT EMPLOYEE – FETAL DOSE POLICY [.1610][.1614(1)(c)] [.16409f] (Refer to Gateway's Fetal Dose Policy attached)

Gateway University Research Park's fetal dose policy incorporates safety information and radiation dose guidelines for ensuring safe radiation limits for the conceptus of occupationally exposed employees. This policy is completely **voluntary** and participation in the program will be left to the operator. A copy of the complete policy, declaration form and information booklet is

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available through the Lab Supervisor. The information must be maintained in the laboratory Radiation Safety records and be readily available to any interested individual. For occupationally exposed employees not working for specific Authorized Users, the policy and supporting information is available upon request from EHS. Any person is welcome to discuss the policy or obtain a copy, by contacting the EHS Manager.

INVESTIGATION LEVELS –

External Exposure

Specific procedures for responding to any occupational radiation dose that exceeds Level I or Level II in the following table have been established:

Part of Body	Investigation Levels (millirems per monitoring period)	
	Level I	Level II
1. Whole body: head, trunk, gonads, or lens of the eye	100	400
2. Extremities: elbow, arm, below the elbow, foot, knee, leg below the knee, or skin	1000	3000
3. Conceptus	30	40

Action Procedures [.1004(b)]:

When Level I doses are exceeded, the RSO shall send a written description of the dose report statistics, including the dose history for the previous two monitoring periods, to the person involved with a copy to the Authorized User. The individual will be requested to review his or her radiation safety procedures and work habits in an effort to maintain all the doses as low as reasonably achievable. Radiation Safety reviews and consultations will be offered.

When a Level II dose is exceeded, the RSO shall conduct a direct investigation of the situation, including an interview with the person involved. A written investigational report shall be made, with copies forwarded to the respective Radiation Safety Committee, including dose trends over the past year (as available) for that person. Conclusions drawn from the investigation will provide a basis for confirming or modifying the dose and for establishing any corrective actions taken.

Any radiation worker that receives a total effective dose equivalent (TEDE) greater than 100 mrem will be notified by the RSO (see level II dose exceeded above).

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If a regulatory overexposure occurs as listed **15A NCAC 11 .1647 (a)**, Gateway University Research Park, Radiation Safety Officer, will provide reports as required to the appropriate agencies within 30 days (see section V)

Overexposure Action Procedures

When a dose equivalent exceeds the limits listed in **15A NCAC 11 .1647 (a)**, Gateway University Research Park, Radiation Safety Officer, will provide reports as required to the appropriate agencies within 30 days. In the event a qualified excessive exposure or radiation incident has occurred the following information will be forwarded to NC DHHS Radiation Protection Section.

Who to notify:

NC Department of Health and Human Services
Division of Health Service
Radiation Protection Section
1645 Mail Service Center
Raleigh, NC 27699-1645
Phone: (919) 814-2250

Information to provide:

Name of person(s) involved
Last four digits of Social Security number
Date of Birth
Cause of elevated exposure and estimated dose
Corrective Action

Please also refer to the NC Radiation Protection sections below for detailed information on how and when to notify NC RPS in the event of an overexposure:

Notification of Incidents:

(http://ncradiation.net/all_rules/section1600/1646.html)

Reports of Radiation Exceeding the Limits:

(http://ncradiation.net/all_rules/section1600/1647.htm)

General Radiation Safety Guides for Use of Radiation Producing Machines (refer to Appendix 5):

General Safety Procedures:

X-Ray diffraction and spectrographic devices generate in-beam radiation dose rates of 30 to 7000 rads/sec. Severe tissue damage can be inflicted by very brief exposures to these high dose rates. Surgical treatment or amputation may be required when small body parts, such as fingers, receive greater than 1000 rads.

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It is imperative that stringent safety precautions be applied when using these devices. Safety precautions include mechanical and electrical guards as well as proper training and instruction. The following safety procedures have been established to help prevent accidents. Adherence to these rules is mandatory.

1. **NO PERSON SHALL BE PERMITTED TO OPERATE ANALYTICAL X-RAY MACHINES UNTIL THEY HAVE:**
 - a. Received instructions in relevant radiation hazards and safety.
 - b. Received instructions in the theory and proper use of the machine.
 - c. Demonstrate competence, under supervision, to safely use the machine.
2. **RADIATION EXPOSURE TO THE OPERATOR AND OTHERS SHALL BE KEPT AS LOW AS REASONABLE ACHIEVEABLE. RADIATION SAFETY SURVEYS SHALL BE CONDUCTED PERIODICALLY.**
3. **OPERATORS SHALL WEAR QUARTERLY EXCHANGED FINGER-RING AND WHOLE-BODY RADIATION BADGES, WHILE USING THE EQUIPMENT.**
4. **OPERATORS SHALL REMAIN IN CONSTANT ATTENDANCE WHILE THE X-RAY BEAM IS ON, OR THE DEVICE SHALL BE SECURED AGAINST ACCESS BY UNAUTHORIZED PERSONS.**
5. **ANY CHANGES IN THE STATUS OR LOCATION OF A DEVICE SHALL BE REFERRED TO THE RADIATION SAFETY OFFICER FOR PRIOR APPROVAL.**

Names and Duties of Persons

Radiation Safety Officer (RSO)

The following person has been appointed by Gateway University Research Park, as RSO for this equipment:

Aisha Holloman, MS, MESH, CESCO
Phone: 336-217-5143(office)/ 336-419-9397(afterhours)
aishah@gatewayurp.com

**The RSO has completed a 40-Hr. Radiation Safety and a Radiation Safety Officer course. **

The RSO should be consulted on all matters affecting radiation safety with this equipment.

Duties of the RSO:

- To ensure that all staff, tenants, (or outside contractors working on the diffractometer) are provided with safety training on radiation, and an understanding of the hazards of exposure. Training for staff, tenants, and students will be conducted annually. RSO shall keep records detailing the training.
- To ensure that all staff (or outside contractors working on the diffractometer) read, understand and comply with this document, and maintain a signed copy of the page verifying their compliance.

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- To arrange for the immediate repair of any defective interlock, warning light or other safety system.
- In the event of a suspected accidental exposure of any person, to supervise the implementation of the contingency plans.
- To consult the NC Department of Health and Human Services Radiation Protection section, on any other matter of radiation safety about which the RSO is uncertain of the correct action to take.
- To ensure that measurements to determine dose rates around the diffractometer and checks of safety interlock systems, warning lights and emergency stops are carried out monthly or when used, whichever is the longer time period, and that the results are recorded.
- To arrange the regular calibration checks of any monitoring equipment.
- Maintain the following records, located on the shelf inside the NanoChem Analytical Lab, as well as in the office of the RSO:
 - The Notification of Registration
 - Current Operating and Emergency Procedures for Diffractometer
 - Records of calibrations of radiation detection instrumentation
 - Records of utilization logs
 - Records of inspection and maintenance
 - Records of training
 - Records of signature page of operators verifying that they have received training and read this document
 - Records of area surveys
 - Records of personal dosimetry
 - Current copy of NC Regulation for Protection against Radiation

Duties of an Authorized Operator:

- All operators of the Diffractometer are responsible for following the radiation safety procedures. Employees should submit all radiation questions or concerns about radiation safety to the RSO.
- When required, always wear the personnel monitoring badge and make sure it is the badge assigned to you. When not in use, store badges in low radiation area. The control badge shall be stored in a radiation free area. The RSO is responsible for evaluating the exposure records and exchanging the badges on a regular basis.
- During any period of operation of the generator, the operator is responsible for the safety of themselves and other occupants of the JSNN Analytical Lab as well as occupants of the surrounding labs.

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- During any demonstration of the equipment, non Authorized Operators such as customers may wish to enter the lab area either to observe or practice any alignment procedure. Before allowing this, the Operator must inquire if the customer has had radiation safety training and show proof to the RSO. If the customer has not had the appropriate radiation safety training, then the RSO must provide training prior to allowing them to participate.

Designated Areas [.1603 (b)]

During normal operation of the Diffractometer, access to the lab is restricted via card access. When the cabinet interlock is overridden, the entire lab is designated a Controlled Area when the X-ray generator is switched on. Only Authorized Operators or Agilent Technicians and visitors or customers who are individually supervised by the Authorized Operator are permitted access to the Controlled Area. All other people should leave the room. A sign on the door to the lab shall be posted in these circumstances to restrict entry.

Monitoring Routines

Monitoring is to be done with the hand held Ludlum Measurements Inc. Model 3 Survey Meter, serial number 269737 scintillation counter with the cap removed. Details of the X-ray generator voltage and current for the appropriate counter positions are to be recorded in the Diffractometer Use Log in the Diffractometer Lab Book. An example page is given in **Appendix 2**.

The radiation monitor calibration will be checked annually as a courtesy to Gateway by:

Mark Brueckner and Jonathan Moore
Associate Radiation Safety Officers
Department of Environment, Health & Safety
UNC Chapel Hill
1120 Estes Drive Extension, CB#1650 Chapel Hill, NC 27599-1650
(919) 962-5715
(919) 962-0227 (fax)

New or replacement equipment

Any additional or replacement systems should undergo a Critical Examination to establish safe radiation leakage before using it for sample measurements. Use the table and the associated monitoring point diagram in **Appendix 4** to record the results.

Dosimetry

Authorized Operators of the Diffractometer will wear dosimeters, which will be read quarterly. This will ensure that radiation exposure remains below the annual maximum limits. These results will be recorded and kept on file, with copies available on the shelf inside the lab of the NanoChem Analytical Lab for viewing at any time.

Radiation Safety Program - Gemini Diffractometer

Should an Authorized Operator have a suspected or confirmed pregnancy (refer to Policy on Pregnancy), they should contact the RSO immediately. Such information shall remain strictly confidential. The RSO will provide embryo/fetus radiation safety information and provide 2 dosimeters for the operator, one to be worn on the collar, and the other on the abdomen. The RSO will carefully monitor the radiation exposure to ensure safety of the fetus.

Maintenance of Equipment

Only Oxford/Agilent (formerly Varian) authorized technicians will perform yearly maintenance or repair procedures on the Diffractometer.

Alignment of source

This shall only be performed by an Agilent authorized technician, in accordance with the guidelines established by Agilent in the Diffractometer User's Manual.

Exchange of X-ray source

This is a non-adjustable item and should be performed by OXFORD DIFFRACTION (Agilent – formerly Varian) personnel only. X-ray sources are safely and environmentally recycled for us by Agilent. The shipping container should be retained so that the source can be safely returned to Agilent.

System Security

The lab is located in the Joint School of Nanoscience and Nanoengineering BL05 and access to the lab is restricted via card access. The lab manager will ensure that unauthorized persons do not enter the lab unless accompanied by an authorized person. Other access to the laboratory is available from the Lab Supervisor, the Dean of the JSNN, Gateway Project Manager, and the RSO.

Appendix 1- Radiation test sheets

Model:-

Serial Number:-

Location:-

Persons present during examination:-

Examination conducted by:-

Date of examination:-

Instrument used:-

Serial Number:-

Radiation:- Mo α , Cu α

Equipment tested:

Equipment	Model	Serial Number
X-ray generator		
X-ray tube		
X-ray tube		
Optics		

Table of results:

Generator power settings			Shutter	Distance from source	Radiation reading Counts s ⁻¹	Effective Dose (CPS/.68) μ Sv h ⁻¹
0kV	0mA	0kW	Closed	Background		
50kV	40mA	2.0kW	Closed	Outside enclosure		
50kV	40mA	2.0kW	Open	Outside enclosure		
50kV	40mA	2.0kW	Closed	Inside enclosure		
50kV	40mA	2.0kW	Open	At body position		
50kV	40mA	2.0kW	Open	20cm radius from sample		
50kV	40mA	2.0kW	Open	2cm radius from sample		

* Equivalent Dose

System Safety Features

Passed

The shutter closes when the enclosure door is opened.

The shutter closes when each individual enclosure panel is removed.

The shutter remains closed when any indication lamp fails.

*Aisha Holloman
Gateway University Research Park
Radiation Safety Officer*

Appendix 3- Review of Radiation Protection Program

The Radiation Safety procedures have been developed to ensure safe radiological working conditions. Everyone must adhere to these procedures. Prior approval must be obtained for ANY deviation from these procedures.

In accordance with Rule .1603 © the registrant shall annually review the radiation protection program content and implementation. The registrant shall retain the records required by Rule .1636. (E-mail signatures are not acceptable)

Signature of Radiation Safety Officer

Date

OPERATOR STATEMENT:

I have read and understood these instructions and agree to abide by them.

Name (please print)

Signature

Date

Name (please print)

Signature

Date

Name (please print)

Signature

Date

Name (please print)

Signature

Date

Name (please print)

Signature

Date

Name (please print)

Signature

Date

Name (please print)

Signature

Date

Name (please print)

Signature

Date

Name (please print)

Signature

Date

Appendix 4- Critical Examination monitoring point diagram

Appendix 5 - General Radiation Safety Guides for Use of Radiation Producing Machines:

Each individual intending to operate any radiation producing machine must be trained in its use by an individual familiar with the system.

1. Each individual intending to operate any radiation producing machine must be trained in its use by an individual familiar with the system.
2. Each individual working with a radiation machine should know exactly what work is to be done and which safety precautions should be used.
3. Written operating and safety procedures must be available to personnel before operating this type of machine.
4. Visitors and students in the area of work should be supervised by the equipment operator
5. Radiation producing machines must not be left unattended in an operational mode.
6. Structural shielding requirements for any new installation, or any modifications to an existing unit or room, must be approved by the RSO before the machine is used.
7. When the safe use of the equipment depends on the mechanical set up of the unit or on technique factors, these restrictions should be closely followed.
8. Under no circumstances shall shutter mechanisms or interlocks be defeated or in any way modified except in accordance with approved written procedures.
9. All warning lights should be “fail safe” (specific regulations require “fail safe” features).
10. A manually reset cumulative timing device should be used to indicate elapsed time and to turn off the machine when the total exposure reaches the planned amount.
11. Special care is needed when working with x-ray diffraction units. Exposure rates in the primary beam can be in excess of 500,000 rems per minute at the x-ray tube (NIH, 1972). Follow the specific procedures for training, operation and emergency response that have been developed for these devices.
12. Some machines such as analytical x-ray devices, irradiators and accelerators have individual safety programs. These detailed operating and emergency procedures must be posted and followed.
13. Proper maintenance on all radiation producing equipment is essential. Only properly trained technical staff should perform all repairs to these instruments. Service personnel must be licensed or registered by the North Carolina Radiation Protection Section.