CONTROL AND ACCOUNTABILITY OF RADIATION MACHINES

1.0 PURPOSE

To provide instructions for the registration, use, operation, control, and accountability of radiation machines at the Georgia Institute of Technology (Georgia Tech).

2.0 SCOPE

2.1 This procedure is applicable to Georgia Tech covering all operations involving radiation machines, including work at temporary job sites within the state of Georgia.

2.2 This procedure is applicable to all operations involving radiation machines including equipment with an electron beam above 5 keV.

2.3 Description of each category of radiation machines, as well as any additional requirements, are found in the following appendices:

2.3.1 Analytical units such as an XRD (Appendix A)
2.3.2 Cabinet machines (Appendix B)
2.3.3 Open units (Appendix C)
2.3.4 Non-medical radiography and fluoroscopy units (Appendix D)
2.3.5 Byproduct machines (Appendix E)
2.3.6 Radiation machines used in the healing arts (Appendix F)
2.3.7 Particle accelerators including neutron generators (Appendix G)

3.0 RESPONSIBILITIES

3.1 The Radiation Safety Committee (RSC) is responsible for reviewing and enforcing policies governing the registration, operation, control, and accountability of radiation machines. The RSC is responsible for acting on a Form A submitted by a prospective AU for the use of a radiation machine. Any Form A for the use of a radiation machine must be approved by the RSC before the radiation machine is operated. The RSC can modify, suspend, or revoke any Form A.

3.2 The Radiation Safety Officer (RSO) is responsible for the Georgia Tech Radiation Safety Program including determining compliance with rules and regulations of the State of Georgia, the Georgia Tech Radiation Safety Policy Manual, and the conditions under which the Authorized User (AU) obtained approval from the RSC.

3.3 The Office of Radiological Safety (ORS) is responsible for providing radiation protection services such as personnel monitoring, periodic equipment surveys, maintenance of records required by the State of Georgia, and consultation on the safe use of radiation machines.

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ORS is authorized to enter any room housing a radiation machine at any time for the purpose of determining compliance with the State of Georgia regulations for personnel health and safety.

3.4 The Authorized User (AU) is responsible for using radiation machines in accordance with the requirements of this procedure, the Georgia Tech Radiation Safety Policy Manual, and related procedures, and the conditions of their approved Form A. The AU is also responsible for ensuring that any individual using their radiation machine does the same.

4.0 REFERENCES/REQUIREMENTS

4.1 Requirements and Specifications

4.1.1 Radiation Safety Policy Manual, Georgia Institute of Technology

4.1.2 State of Georgia Rules and Regulations for X-ray, Chapter 290-5-22

4.1.3 ANSI/HPS N43.3-2008, Radiation Safety for Installations Using Non-Medical X-Ray and Sealed Gamma-Ray Sources, Energies up to 10 MeV

4.2 Related Procedures

4.2.1 Procedure 9300, Facilities Requirements and Guidelines for Radioactive Material or Radiation Machine Laboratories

4.2.2 Procedure 9310, Posting and Labeling for Radioactive Materials and Radiation Machines

4.2.3 Procedure 9316, Personnel Dosimetry

4.3 Equipment/Materials Required **(**available at www.ehs.gatech.edu/radiation/xray/forms**)**

4.3.1 Form A (RS-004a) - Application for Authorized User Status for Use of an X-Ray Generating Device

4.3.2 Form B (RS-019b) - Radiation Worker Registration Form

4.3.3 Form C (RS-004c) - Acquisition of Radiation Producing Equipment

4.3.4 RS-136 - Quarterly Tests of X-Ray Generating Devices Form

5.0 DEFINITIONS

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5.1 Authorized User (AU) - Georgia Tech faculty or staff member whose use of radiation machines has been approved by the RSC. The AU is normally in charge of a research project involving radiation or is responsible for a course with laboratory or field exercises in which radiation is involved. An AU is also a Radiation Worker who has completed all requirements of 6.1 and 6.2.

5.2 Byproduct X-Ray Machine – a machine in which electrons are accelerated to an energy in excess of 5 keV potentially resulting in the production of x-rays (e.g., electron microscopes or e-beam evaporators).

5.3 Controlled Area - an area to which access is controlled to protect individuals from exposure to radiation, and should be under the supervision of a person who has knowledge of the appropriate radiation protection practices and who has the responsibility for applying them

5.4 Primary X-Ray Machine – A radiation machine designed for the controlled production of x-rays.

5.5 Radiation Machine - any device that is designed for the controlled production of radiation or nuclear particles or which could emit radiation as a byproduct.

5.6 Radiation Worker - individual who has successfully completed all requirements of 6.1.

6.0 **PROCEDURAL STEPS**

6.1 **Obtaining and Maintaining Radiation Worker Status**

6.1.1 Each individual who operates a radiation machine must obtain Radiation Worker status prior to operating the radiation machine. Other individuals working in the proximity of a radiation machine may be required to obtain Radiation Worker status at the discretion of the RSO.

6.1.2 Complete X-Ray Safety Training (or Clinac X-Ray Safety Training, if applicable).

6.1.3 Submit a completed Form B to ORS.

6.1.4 Complete machine specific operational training provided by the manufacturer, AU, or designee.

6.1.5 Complete Refresher X-Ray Safety Training after 2 years and biennially thereafter. If a Radiation Worker does not complete refresher training by the expiration date, the worker may not operate a radiation machine until they have completed the refresher training.

6.2 **Obtaining and Maintaining Authorized User Status**

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6.2.1 A prospective AU must complete the paperwork and training as described in 6.1 of this procedure to become a Radiation Worker before the approval of a Form A.

6.2.2 The prospective AU shall complete and submit a Form C. The RSO shall review the Form C, and if necessary, consult with the prospective AU to evaluate the facilities available (e. g., shielding requirements). Facility requirements and guidelines are found in Procedure 9300.

6.2.3 The prospective AU shall complete and submit a Form A. The RSO shall review the Form A, and if necessary, consult with the prospective AU to discuss the Form A (e.g., training and experience of the applicant, survey equipment available, and the details of the work to be performed).

6.2.4 Upon review and concurrence with the Form A by the RSO, the Form A shall be forwarded to the RSC for review.

6.2.5 Since the RSC may meet only once per quarter, the Chair of the RSC is empowered to signify an interim approval of the Form A. In such instances, the Form A will be presented to the RSC for review at the next meeting.

6.2.6 The RSC may require further data for the Form A, change the conditions of use of the Form A, or return the Form A to the prospective AU without approval.

6.2.7 RSC approval will be signified by the signature of the Chair and the RSO on the Form A.

6.2.8 Upon the approval of a Form A for AU Status, the AU shall also grant ORS access (or provide a key) to the room(s) where the radiation machine will be used and/or stored.

6.2.9 The procedure as described in the approved Form A, along with any modifications incorporated during the review process, shall become the conditions under which the AU and their personnel are authorized to use the radiation machine.

6.2.10 If individuals are observed to be using radiation machine in a manner or under conditions other than that approved by the RSC, the radiation machine may be deemed out of service by the RSO until the RSO states otherwise.

6.3 **Receipt of a Radiation Machine**

6.3.1 When a radiation machine is delivered to Georgia Tech, the AU shall verify that the manufacturer of the radiation machine has provided manuals and instructions which shall include at a minimum the following technical and safety information:

6.3.1.1 Voltage, current, and duty cycle ratings of the x-ray generation equipment,

6.3.1.2 Adequate instructions concerning any radiological safety procedures and precautions which may be necessary because of unique features of the system, and

6.3.1.3 The schedule of maintenance necessary to keep the system in compliance with approved regulations.

6.3.2 The AU shall notify ORS if they are unable to obtain these manuals and instructions.

6.3.3 A key-operated primary control switch, password protected computer interface, BuzzCard control, or other mechanism shall be provided to prevent unauthorized x-ray production shall not be possible.

6.3.4 A radiation survey shall be performed by ORS upon installation of the radiation machine before it is placed into routine use.

6.4 **Registration of a Radiation Machine**

6.4.1 ORS must register any radiation machine within 7 days of acquisition with the Georgia Department of Community Health, Healthcare Facility Regulation Division (DCH).

6.4.2 ORS shall submit to DCH the type of machine, the manufacturer, serial number and location of use.

6.4.3 ORS shall submit shielding plans to DCH if structural shielding is required.

6.5 **Inventory**

6.5.1 ORS shall maintain the master radiation machine inventory for Georgia Tech.

6.5.2 The AU shall maintain accurate records of the receipt, use, maintenance, and disposal of radiation machines under their control. These records are used by ORS to maintain the master inventory.

6.6 **Caution Signs, Labels, and Signals**

6.6.1 Postings of "Radiation Area" or "High Radiation Area", as well as the radiation machine, shall be in accordance with Procedure 9310. These postings and labels are provided by ORS.

6.6.2 For primary x-ray machines, a warning light with the notation **"X-RAY ON"** or equivalent shall be located on the control panel and shall light only when the x-ray tube is activated.

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6.6.3 Audible or visible signals shall be provided in the vicinity of installations to provide warning that the equipment is on and that radiation is being produced and should be activated prior to any exposure.

6.7 **Normal Operation**

6.7.1 Procedures and Logbook

6.7.1.1 Written operating procedures shall be established for each unit and shall be available at the radiation machine including any restrictions or constraints which are imposed to ensure safe operation of the particular device.

6.7.1.2 Emergency shut down procedures shall be established for each unit and shall be posted in a conspicuous location on or near the radiation machine.

6.7.1.3 A logbook shall be kept for each radiation machine, and shall include the following information:

6.7.1.3.1 Name of operator

6.7.1.3.2 Date, time in, time out

6.7.1.3.3 Voltage and current settings (standard settings may be noted at the front of the logbook instead)

6.7.1.3.4 Maintenance performed or problems with the device

6.7.2 Safety Systems (Interlocks) if Applicable

6.7.2.1 Interlocks shall **NOT** be used to de-activate the x-ray tube, except in an emergency or during testing of the interlock system. If the interlock was activated, it shall be possible to restore the machine to full operation only from the control panel.

6.7.2.2 Safety interlocks shall **NOT** be bypassed for operation of the device at any time.

6.7.2.3 Any time a temporary alteration to safety devices such as to interlocks or shielding during maintenance or repair, is planned or anticipated:

6.7.2.3.1 ORS shall be notified prior to initiation of any action.

6.7.2.3.2 Work shall be done by manufacturer certified personnel.

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6.7.2.3.3 A sign shall be posted on the radiation machine that indicates safety systems have been bypassed.

6.7.2.3.4 The date, length of time, operation performed, and signature of person who restored the safety system to normal operation shall be recorded in the logbook.

6.7.3 Maintenance, Service, and Shutter Service Policy

6.7.3.1 Only manufacturer certified personnel shall be permitted to install, repair, or make modifications to the radiation-producing component(s) of the radiation machine (e.g., x-ray tube, ion source, etc.) or to any safety system that prevents personnel exposure (e.g., the shutter, interlocks). As a minimum, the following information shall be recorded in the log book each time maintenance or repair is done: date, person doing maintenance, description of work done.

6.7.3.2 The AU shall have the interlock and shutter systems of all radiation machines in their possession that depend on an interlock and shutter system to prevent personnel x-ray exposure fully inspected by manufacturer certified personnel every five years. The documentation of these inspections shall be a prerequisite for continued operation of the radiation machine at Georgia Tech.

6.7.4 ORS Inspections and Surveys

6.7.4.1 An inspection and radiation survey shall be performed by ORS upon installation of the radiation machine before the radiation machine is placed into routine use.

6.7.4.2 An inspection and radiation survey shall be conducted annually by ORS of each radiation machine. If a radiation machine is not operational or in service at the time of inspection, notification or confirmation of the radiation machine’s inactive status will suffice.

6.7.4.3 The AU shall notify ORS that a radiation survey is needed under any of the following conditions:

6.7.4.3.1 A change in any component or configuration of the system that could result in a change of radiation levels around the machine

6.7.4.3.2 After any maintenance requiring the disassembly or removal of a component in the system,

6.7.4.3.3 During the performance of maintenance and alignment procedures if the procedures require the presence of a primary x-ray beam when any component in the system is disassembled or removed,

6.7.4.3.4 Any time a visual inspection of the radiation machine components reveals an abnormal condition,

6.7.4.3.5 Any change in the shielding integrity of the walls or the radiation machine itself, or

6.7.4.3.6 The radiation machine was inactive at the time of the most recent routine inspection, and it is being put into routine use.

6.8 **Change of Operating Conditions, Location, AU**

6.8.1 To change the approved location of a radiation machine, the AU shall submit a Form C to the RSO. Once the location change has been approved, the radiation machine may be moved. ORS will perform a survey if necessary.

6.8.2 To make any other change to their approved Form A, the AU shall request the change in writing to the RSO and wait for approval of the amendment before instituting any change.

6.8.3 The RSO may require a new Form A if the changes are deemed significant.

6.9 **Out of Service**

6.9.1 The AU shall prevent operation of the machine. For example, remove the keys that operate the radiation machine and store them in a secure place, or change the password to access the software/computer.

6.9.2 The AU shall notify the RSO of the radiation machine's status, who shall tag the radiation machine out of service. The device shall remain tagged out of service until another individual becomes an approved AU for the radiation machine or the AU notifies ORS of a change in status.

6.9.3 A radiation survey shall be conducted by ORS before the radiation machine is put into routine use.

6.10 **Disposal**

6.10.1 Any AU who wishes to dispose of their radiation machine shall notify ORS in writing well ahead of such action.

6.10.2 A radiation machine with an x-ray tube can only be discarded by:

6.10.2.1 Transferring the unit to a DCH approved registrant, or

6.10.2.2 Rendering the unit dysfunctional by removal of the x-ray tube.

6.10.3 Byproduct machines have no ORS restrictions on disposal.

6.10.4 If any radiological, chemical, or biological hazards (e.g., pump oils, refrigerants, target materials, activated components) are present, those shall be handled appropriately.

7.0 RECORDS

7.1 Any ORS records generated as a result of implementation of this procedure shall be maintained as permanent records of Georgia Tech.

7.2 Records of device specific training should be maintained by the AU.

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Appendix A - Analytical X-Ray

1.0 **GENERAL SAFETY PROVISIONS**

1.1 Each analytical system shall be so arranged as to restrict the entry of parts of the body into the primary beam. This may be accomplished by using adequate barriers or interlocks.

1.2 The analytical x-ray device shall be provided with a protective barrier which absorbs the useful beam behind the specimen under examination.

1.3 The coupling between the x-ray tube and the collimator of the diffractometer, camera, or other accessory shall prevent radiation from escaping the coupling.

1.4 All tube head ports which are not in use shall be secured in the closed position in a manner which will prevent casual opening. Port covers shall offer the same degree of protection as is required of the tube housing.

1.5 AU shall not permit the routine operation of any equipment that would require an individual to expose any part of his body to the primary beam.

1.6 Safety glasses shall be provided by the AU and recommended for use by operators, assistants, and maintenance personnel.

2.0 **WARNING LIGHTS, SIGNS, AND LABELS**

2.1 A sign or label shall be placed on or adjacent to each x-ray tube housing and shall be clearly visible to any individual who may be working in close proximity to the primary beam path. The sign or label shall read **"CAUTION - HIGH INTENSITY X-RAY BEAM."** These labels shall be provided by the ORS.

2.2 A warning light with the notation "X-RAY ON," shall be located on the control panel and:

2.2.1 Shall light only when the x-ray tube is activated; and

2.2.2 Shall be wired in series with the primary electrical circuit so that if the warning light is inactivated x-ray generation is not possible.

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3.0 **OPEN BEAM ANALYTICAL**

3.1 Warning lights or signals shall indicate x-ray beam status to alert individuals to the potential radiation hazard.

3.2 Each port shall be equipped with a shutter that cannot be opened unless a collimator or a coupling and recording device with beam absorber has been connected to the port.

3.3 The operator shall be present at all times during operation, unless the area is locked to prevent unauthorized or accidental entry.

4.0 **RADIATION SURVEYS**

4.1 A radiation survey, along with checks of interlocks, shutters, and warning lights, shall be performed quarterly by the AU or by a Radiation Worker on their behalf, and documented using RS-136.

4.2 When the primary x-ray beam is completely enclosed the radiation level shall be less than 2 mrem/hour at 25 centimeters from the apparatus at every specified tube rating.

4.3 The leakage radiation from the tube housing shall not exceed 25 mrem/hour at 5 cm from the surface of the tube housing.

4.4 Radiation originating within the high voltage power supply (i.e., transformers and rectifiers) shall not exceed 0.5 mrem/hour at a distance of 5 centimeters from the power supply at every specified rating.

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Appendix B - Cabinet X-Ray

1.0 **GENERAL SAFETY PROVISIONS**

1.1 All cabinet x-ray machines shall be housed in an interlocked and shielded protective housing, and the protective enclosures and equipment shall be kept in good repair.

1.2 A suitable survey meter shall be available for use at each installation.

1.3 Interlocks shall not be used to deactivate the x-ray tube except in an emergency or during testing of the interlock system; it shall be possible to restore the machine to full operation only from the control panel.

2.0 **SAFETY SYSTEMS AND INTERLOCKS**

2.1 Each door of a cabinet x-ray system shall have a minimum of two operative safety interlocks. One but not both of the required interlocks shall be such that a door opening results in physical disconnection of the energy supply circuit to the high voltage generator, and such disconnection shall not be dependent upon any moving part other than the door. The AU shall:

2.1.1 Maintain records that verify the existence of dual interlocks

2.1.2 Maintain records of any repairs made on the dual interlocks

2.2 For cabinet x-ray systems designed for entry by an individual during the normal course of use of the machine, there shall also be provided:

2.2.1 Audible and visible warning signals (preferably of the rotating or flashing beacon type) within the cabinet which must be activated for at least 10 seconds immediately prior to the first initiation of x-ray production; and

2.2.2 A visible signal within the cabinet which shall remain operative for the entire duration of x-ray production. It shall be automatically initiated prior to x-ray production and terminated with the exposure; and

2.2.3 Suitable means of egress, so that any person may escape the interior of the cabinet without delay, or an effective means within the cabinet for preventing or terminating production of the x-rays, and which cannot be reset from the outside of the cabinet.

2.2.4 An audible signal shall be activated if an interlocked access to the exposure area is opened and the radiation exposure rate exceeds 100 mrem/hour. The signal shall be audible to the operator of the radiation source and to the person entering the exposure area. The audible signal shall be of a frequency or sound pressure level that can be heard over background noise. During normal operations, constant use of audible signals that may be heard outside of the enclosure is discouraged due to the potential desensitization of workers toward responding to alarms.

2.2.5 Installations using cabinet x-ray machines that produce radiation levels in excess of 500 Rad/hour at 1 meter from the radiation source shall employ both audible and visible warning signals. This requirement does not apply to installations in which the very high radiation area is not an accessible area.

3.0 RADIATION SURVEYS

3.1 Radiation exposure shall not exceed 0.5 mrem/hour at a distance of 5 centimeters from the external surface or any component.

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Appendix C - Open X-Ray

1.0 **DEFINITION**

An installation in which the source and all objects exposed to the radiation source are within an area designated as a high radiation area.

2.0 **SETUP**

2.1 A suitable survey meter shall be available for use at each installation.

2.2 Sufficient warning lights or other equally conspicuous signals that operate only when the primary x-ray beam is released from the beam ports shall be provided in such a manner as to alert individuals to the potential radiation hazard. These signals shall be labeled so that their purpose is easily identified.

3.0 **OPERATING PROCEDURE**

3.1 Exposure Rate Barriers

3.1.1 During the initial exposure, radiation levels should be measured around the perimeter of the controlled area and the perimeter adjusted as required. Surveys should be conducted for each new operating condition and the perimeters adjusted accordingly. The area of operation should be monitored periodically.

3.1.2 Measurement of radiation levels for a radiation survey must be performed using a suitable calibrated radiation survey meter. A radiation survey must also be conducted when there is potential for non-uniform exposure to personnel, such as may occur during machine maintenance or work in a radiation machine target area.

3.1.3 Radiation areas shall be identified and suitably posted with caution signs. A fence, rope or other suitable personnel barrier shall be erected along a 5 mrem/hour contour line.

3.1.4 High radiation area shall be identified and suitably posted with “Danger (or Caution): High Radiation Area” warning signs at the distance measured or calculated to produce a radiation level of 100 mrem/hour.

3.1.5 When approaching the radiation source or following the conclusion of an exposure, the operator shall use a suitable survey meter to verify that the x-ray tube has been de-energized.

3.2 Monitoring Devices

3.2.1 One device shall be a personal dosimeter issued by ORS per Procedure 9316.

3.2.2 A supplemental which records total dose, and is calibrated and appropriate for the energy used, shall also be worn.

3.2.3 Written records of personnel exposure, safety procedures, and scaled drawings of the 5 mrem/hour contour line shall be at the work site.

3.3 Control of Exposed Areas

3.3.1 The operator of the radiation machine shall coordinate the planned operation with the area supervisor so that personnel are made aware of the potential radiation hazards.

3.3.2 All persons shall be removed from the area to be exposed before irradiation is begun. The operator shall perform a visual check of the controlled area to ensure it is free of all unauthorized personnel immediately prior to activating the radiation machine. The operator shall be the last person to exit the area.

3.3.3 During each operation, either the AU or designee shall maintain direct vigilance of the operation to insure against unauthorized entry into the radiation area. Surveillance of the exposure area shall be maintained during operation, either by visual or by other reliable means, to ensure that no person enters the area.

4.0 UNACCOMPANIED USE OR STORAGE

4.1 The operator shall be in immediate attendance at all times when the equipment is in operation except when the area is locked to protect against unauthorized or accidental entry.

4.2 The radiation machine itself, a critical part (e.g., power cord, key), or the place in which the machine is stored, shall be secured in order to prevent unauthorized use.

4.3 When an x-ray system is left unattended, the control console shall be locked and the key removed to prevent unauthorized use. The radiation machine shall be secured to prevent unauthorized access, removal, or theft of the device.

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Appendix D - Non-Medical Radiography (Shielded Room) and Fluoroscopy

1.0 **SHIELDING AND SETUP**

1.1 The facility shall meet the specifications in Procedure 9300.

1.2 X-ray tubes shall be provided with protective housing(s) appropriate to the nature of the work to afford adequate protection to personnel.

1.3 There shall be suitable means of egress, so that any person may escape the interior of the room or area without delay, or an effective means within the room for preventing or terminating production of the x-rays, and which cannot be reset from the outside of the room.

1.4 It shall not be possible to insert any part of the body into the primary beam.

2.0 **OPERATION**

2.1 A suitable survey meter shall be available for use at each installation.

2.2 Radiation exposure shall not exceed 2 mrem/hour at the boundary of the controlled area.

3.0 **FLUOROSCOPY**

3.1 Hand-held fluoroscopes shall not be used.

3.2 The control panel shall be equipped with a key lock. It shall not be possible to remove the key in the “on” position.

3.3 A positive pressure switch shall be provided to control the exposure and shall be located such that the operator has a clear view of the radiation machine.

3.4 The exposure rate due to transmission through the image receptor shall not exceed 2 mrem/hour at a distance of 10 cm from any point on the receptor.

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Appendix E - Byproduct X-Ray

1.0 SOURCES OF X-RAYS

1.1 Electrons accelerated over 5 keV, as well as the high voltage power supply which accelerates them, cause equipment to be a potential source of ionizing radiation.

1.2 Any apparatus capable of emitting x-rays as an unwanted by-product is regulated by the State of Georgia.

2.0 GENERAL SAFETY PROVISIONS

2.1 All equipment shall be operated in such a manner as to provide adequate protection to meet State of Georgia regulations.

2.2 Equipment shall not have a dose rate at any readily accessible point 5 cm from the surface of the equipment in excess of 0.5 mrem/hour.

2.3 Equipment shall be interlocked or otherwise restrict access to ensure that personnel may not access a controlled area.

2.4 Additional appropriate safety provisions will be determined by the RSO. Shielding may be required to meet Georgia Tech ALARA levels.

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Appendix F - Healing Arts

1.0 **GENERAL SAFETY PROVISIONS**

1.1 Follow all applicable sections of Georgia regulations (OCGA 290-5-22-.04).

1.2 Follow applicable professional standards.

1.3 Additional appropriate safety provisions will be determined by the RSO.

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Appendix G - Particle Accelerators

1.0 GENERAL SAFETY PROVISIONS

1.1.1 All safety and warning devices (including interlocks) shall be checked monthly unless using a portable accelerator for less than 30 consecutive days in one location.

1.1.2 Operating and emergency procedures shall be maintained at the control panel.

1.1.3 Daily source checked survey equipment shall be available.

1.1.4 Smear surveys or special ventilation may be required.