# THE USE OF RADIATION PRODUCING MACHINES

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PREFACE

These instructions are provided to staff so that CTRC can comply with the state rules for radiation control. The Texas Department of State Health Services, Bureau of Radiation Control, enforces the radiation rules in Texas. These rules require that radiation producing equipment meet specific requirements. These rules also require that certain procedures be followed and that certain record be kept. A copy of these rules are available for staff to read and review. It is entitled Texas Administrative Code (TAC) and is kept in the Radiation Safety Office.

The intent of this manual is to establish procedures that require operation of radiation producing equipment in such a manner so to minimize the exposure to radiation to all patients, personnel and general public. Staff members who operate radiation-producing equipment shall be familiar with these procedures and with the TAC as it applies to their working situation.

All operators of radiation producing equipment are responsible for radiation safety. The Radiation Safety Officer (RSO) has the responsibility and authority for overseeing matters relating to radiation protection. The RSO has the authority to terminate the operation of the megavoltage linear accelerators. The RSO confirms all training and serves as the liaison with the Texas Department of State Health Service (DSHS). Any questions or concerns about radiation safety procedures should be brought to the attention of the RSO.

Michael A. Charlton, PhD, LMP, CHP
Radiation Safety Officer

Nikos Papanikolaou, PhD, LMP
Therapy Medical Physicist

Revised 02/12/01; 03/11/02; 06/07/07; 03/02/10, 06/15/2010, 8/25/2011, 1/5/2012, 8/27/2012, 4/16/2013
**EMERGENCY TELEPHONE NUMBERS**

DURING ROUTINE OFFICE HOURS CONTACT RADIATION SAFETY AT TELEPHONE # *(210) 567-2955*

AFTER HOURS CONTACT UNIVERSITY OF TEXAS POLICE AT TELEPHONE # *(210) 567-2800*

Radiation Safety Officer
Michael A. Charlton, PhD *(210) 567-2955*

UTHSCSA Police *(210) 567-2800*

In case of incidents involving unusual radiation exposure, all personnel are required to notify the Radiation Safety Office immediately.

After 5:00 pm, University of Texas Health Science Center Police will assist in contacting Radiation Safety Personnel.
REGULATIONS

All radiation producing machines are regulated by state and federal laws (e.g. Texas Regulations for Control of Radiation and the Food and Drug Administration). Cancer Therapy and Research Center will comply with the required regulations.

REGISTRATION

All radiation producing machines must be registered with the Texas Department of State Health services, Bureau of Radiation Control if used or stored at the Cancer Therapy and Research Center. All units are to be registered within thirty days.

Contact the Radiation Safety Office when:
   a) Planning to purchase and install a new unit.
   b) Relocating a unit, major repairs or replacement of tube head.
   c) Disposal of a linear accelerator (at or above 10 MeV) – must notify Radiation Safety prior to the removal of the accelerator as a radiation survey and contamination smear must be performed and documented by Radiation Safety.
   d) Disposal, transfer or sale of an x-ray unit occurs. The name of the individual or company receiving working units that are transferred or sold is required when notifying the Texas Department of State Health services, Bureau of Radiation Control, of the deletion [§289.226(p)].

Copies and/or pink original of assembler's installation reports, FDA Form 2579, must be sent to the Radiation Safety Office following installation.

Registration of the individual x-ray units on our state permit will be performed by the Radiation Safety Office.

For accelerators at or above 1 MeV, a person may energize the unit for purposes of installation and acceptance testing prior to receiving a Certificate or Registration, but it cannot be used on humans or for treatment until the Certificate of Registration is received by the Texas Department of State Health Services.

RADIATION SAFETY OFFICER

A Radiation Safety Officer is required to be designated and to have the responsibility and authority to ensure safe radiation practices and serves as the contact person between the Cancer Therapy and Research Center and the Bureau of Radiation Control. [§289.226(t)(1)]. The individual currently designated is Michael A. Charlton, PhD.

COMPLIANCE FOR TECHNICAL STANDARDS OF RADIATION MACHINES

All radiation producing machines will comply with the technical standards of 25 Texas Administrative Code (TAC) §289.227 unless an exemption has been requested and
received from the Texas Department of State Health Services, Bureau of Radiation Control. Copies of the regulations are located at each site.

RADIATION SAFETY SURVEYS

Radiation safety surveys will be performed annually by the Radiation Safety Office in accordance with 25 TAC §289.227. Surveys are to be performed on diagnostic and fluoroscopic equipment within 30 days of the installation. Access to the equipment must be allowed periodically in order to conduct routine safety surveys. A survey may be required after major repair is performed or a tube head is replaced. Contact the Radiation Safety Office when such is performed upon a unit. The x-ray producing equipment at CTRC was installed following the manufacturer's specifications.

PERSONNEL DOSIMETERS

Any person likely to receive greater than 10% of the annual occupational limit (500 mrem) will be required to wear a personnel dosimeter while utilizing x-ray units. The dosimeter may be a monthly, bimonthly or quarterly. The maximum permissible radiation dose limits are found in 25TAC §289.202(f) and may be summarized:

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<th>Regulatory Dose Limits</th>
<th>Maximum Annual Individual Dose (mrem/year)</th>
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<td>Whole body; head and trunk, active blood forming organs; or gonads</td>
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<tr>
<td>Hands and forearms; feet and ankles; skin of the whole body</td>
<td>50,000</td>
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<tr>
<td>Lens of the eye</td>
<td>15,000</td>
</tr>
<tr>
<td>Minors</td>
<td>500</td>
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<td>Declared Pregnant Worker</td>
<td>500 / 9 months</td>
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<td>General Public</td>
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The dosimeter:

1. is to be worn between the neck and the waist. [§289.202(r)(1)(A)]
2. is to be worn at the neck outside of the apron, if a lead apron is worn. [§289.202(r)(1)(A)]
3. is to be worn only by the individual assigned the dosimeter each time the employee has exposure to ionizing radiation. [§289.202(r)(1)(E)]
4. is to be kept in a safe, low radiation area when not being worn. Dosimeters will not be taken home. [§289.202(r)(3)]
5. is to be exchanged and the old badge returned for readout promptly.  
   [§289.202(r)(2)]

6. is never to be exposed deliberately or willfully damaged.  
   [§289.202(r)(3)]

A fetal/embryo badge will be issued to a woman who has declared her pregnancy in writing to the Radiation Safety Office. This is to be worn at the umbilicus (belly-button) level. A pregnant radiation worker may voluntarily declare her pregnancy, but is not required to do so. The declaration automatically reduces the regulatory limit for the woman to 500 mrem for the entire nine months. Any “declared” pregnant worker likely to receive greater than 50 mrem in the nine months must use a personal dosimeter. However, dose history from conception until declaration date is included in the reduced limit, so actual monthly limits may be less due to exposure prior to declaration. The form “Pregnancy Declaration” may be obtained from the Radiation Safety Office. It is to be completed and returned to the Radiation Safety Officer to initiate the necessary actions. Should a radiation worker choose not to declare her pregnancy, the regulatory limit for an undeclared worker remains at the same level as any radiation worker, 5,000 mrem per year.

The Radiation Safety Office maintains personnel dosimetry records. Copies of the current dosimeter readings will be posted on the staff bulletin board. Previous monitoring period readings are available upon request from the Radiation Safety Office.

Applications are available at DTL 1.343T, CTRC Safety Manager (U235) or on the website http://research.uthscsa.edu/safety.

**REQUIREMENTS FOR PERSONNEL**

The Texas Legislature has passed acts that require specific qualifications for x-ray technologists and medical physicists. These requirements are reflected in the Texas Regulations for Control of Radiation and briefly listed below. Do not assist or permit anyone else who does not comply with the above law to operate CTRC equipment.

**OPERATOR REQUIREMENTS**

The operation of radiation producing equipment when exposing humans shall be accomplished by who are in compliance with the credentialing requirements of the Medical Radiologic Technologist Certification Act (MRT Act) Chapter 601. The documentation is kept by the appropriate department.

Individuals who operate radiation machines shall be instructed in and able to demonstrate competence with the facility’s operating and safety procedures. A signed signature form is required of all operators of x-ray producing machines to
signify that they have received a copy and have read the Radiation Producing Machines Handbook.

PHYSICIST QUALIFICATION

The person performing evaluation of diagnostic and mammographic system performance in accordance with these regulations shall hold a current Texas license under the Medical Physics Practice Act, Article 4512n in the appropriate discipline. Physicists performing spot checks or other parameters related to a linear accelerator must be certified as a LMP with therapy credentials.

BIOMEDICAL STAFF REQUIREMENTS

Education and training for persons performing radiation machine assembly, installation or repair must be met according to TAC 289.226 (t) (3). The interval to be followed to calibrate electronic equipment used in radiation machine servicing will be every two years. This includes the kVp meter, voltmeter, oscilloscope.

GUIDELINES FOR PROTECTION

The fundamental objective of the medical use of radiation is to obtain optimum diagnostic information or therapeutic effect with minimum exposure of the patient, the personnel concerned, and the general public.

RESTRICTED AREAS

All medical radiographic rooms and areas containing control consoles are considered to be "restricted" areas. These are areas into which access is controlled by the registrant for purposes of protection of individuals from exposure of radiation. The restriction must be maintained by the operator of the x-ray device within the area. Access to controlled radiation areas is to be maintained by the staff member operation radiation producing equipment.

POSTING NOTICES, INSTRUCTIONS, AND REPORTS TO WORKERS; AND POSTING A RADIATION AREA

1. Read the “Notice to Employees” sign posted in the room and/or in the facility’s break rooms.
2. The general requirement for radiation safety and the staff rights and obligations as a radiation worker are found in the TAC 289.201, 289.202, 289.203, 289.227 and 289.229.
3. The Certificate of Registration for Cancer Therapy and Research Center,
operating and safety procedures, and any notices of violations involving radiological working conditions are located at each individual site.

4. Your rights and obligations as a radiation worker are found in §289.203(c), (d) and (e) of the regulations.

5. The areas are designated by “Caution Radiation Area”, “Caution High Radiation Area”, or “Danger Very High Radiation Area.” No individual other than the patient shall be in the treatment room during irradiation. If a person must be held in position during a treatment, mechanical supporting or restraining devices shall be used. TAC 289.229 (h) (2) (D) (iv) (II).

PROTECTIVE DEVICES

Protective devices such as leaded aprons, vests, skirts, gloves, gonadal shields, thyroid shields, or shin shields are to be visually inspected annually for defects such as holes, tears or cracks. A record of the inspection listing the devices, the results and the identity of the individual conducting the inspection is to be maintained. Any device found defective will be removed from service until repaired or discarded. Labels of inspection should be placed on the lead aprons, vests, skirts and gloves. Do not use a lead apron, vest, etc, if a label is not on the device. Remove from service and call Radiation Safety to inspect and label the device. [§289.227(i)(4)(B)]

The thickness of the protective device is to be as follows:

1. 0.5 millimeter thickness of lead equivalent material is required for protective devices that will be used to shield for direct beam radiation such as fluoroscopy.

2. 0.25 millimeter thickness of lead equivalent material is required for protective devices that will be used to protect for primary (once-scattered) scatter radiation.

Protective devices are provided in all areas with permanent x-ray units in place and in areas of routine C-arm use. Mobile diagnostic units will have at least one protective apron with the unit.

Protective devices are to be used to reduce exposure to radiation and keep radiation exposure as low as reasonably achievable (ALARA). Protective devices must be provided in the following situations:

1. when it is necessary for an individual other than the patient to remain in the room or hold a patient, [§289.227(i)(8)];
2. when it is necessary to protect other patients who cannot be moved out of the room or further than 6 feet [§289.227(i)(12)];
3. when the gonads are in or within 5 cm of the x-ray beam, shields must be
used **UNLESS** the use of the shield interferes with the diagnostic procedure [§289.227(i)(13)];

4. when fluoroscopic procedures are being performed, protective devices such as lead drapes, hinged sliding panels and lead aprons shall be in place.

5. If sterile fields or special procedures prohibit drapes, all persons in the room must wear 0.5mm lead equivalent lead aprons. [§289.227(m)(8)(B)(i)]

**EXPOSURE OF THE INDIVIDUAL (STAFF) AND THE APPLICATION OF ALARA**

It is the responsibility of any person involved in radiation procedures to maintain his or her own exposure below the regulatory limits. The philosophy “As Low As Reasonably Achievable” (ALARA) is to be used as guidance in reducing occupational exposures. Applying ALARA or the reduction of radiation exposure to an individual from external sources of radiation may be achieved by any one or any combination of the following measures:

1. Increasing the distance of the individual from the source.

2. Reducing the duration of exposure.

3. Using protective barriers between the individual and the source.

For medical x-ray equipment, shielding and distance are the factors most readily controlled. Protective shielding includes:

   a) That incorporated into the equipment

   b) Mobile or temporary devices, such as moveable screens

   c) Lead impregnated aprons and gloves

   d) Permanent protective barriers and structural shielding, such as walls containing lead or concrete.

**EXPOSURE OF THE PATIENT**

Individuals (patients) shall not be exposed to the useful beam except for healing arts purposes and unless such exposure has been authorized by a licensed practitioner of the healing arts. This provision specifically prohibits deliberate exposure for the following purposes:

1. Exposure of an individual for training, demonstration, or other non-healing arts purposes.

2. Exposure of an individual for the purpose of healing arts screening except as authorized by the Texas Department of State Health services, Bureau of
Radiation Control, to the institution for a specific procedure requested.

3. Exposure of an individual for medical research except research protocols that have been reviewed and approved by the Institutional Review Board and the Radiation Safety Committee. Research protocols involving minors are not allowed unless special state approval is received. Contact the Radiation Safety Office for more information.

**HOLDING OF PATIENT OR FILM/IMAGE RECEPTOR**

When a patient or film must be provided with auxiliary support during a radiation exposure, use mechanical holding devices when the technique permits. Patients should be held only after it is determined that available restraining devices are inadequate. The following situations may require a patient to be held:

1. Trauma Cases
2. Small children and babies
3. Restrained and Combative Patients

The human holder will be protected with appropriate protective lead garments properly positioned. The holder should be positioned so the useful beam does not strike their body. To assist in minimizing exposure, it is important for the radiologic technologist to collimate carefully to the area of clinical interest.

In selecting a holder, no pregnant woman or possibly pregnant woman or individual under 18 years old will be considered. No individual shall be used routinely to hold film or patients. The individual should have seldom held a person during x-ray examinations. [25TAC §289.227(i)(8)] Under no circumstances will anyone physically restrain a patient during a therapy procedure. Mechanical restraints must be used.

When there is a need to immobilize a patient or port film for radiation therapy, mechanical supporting or restraining devices shall be used.

**EXPOSURE OF INDIVIDUALS OTHER THAN THE PATIENT**

For fluoroscopic and diagnostic radiology procedures, only the staff and ancillary personnel required for the medical procedure or training shall be in the room during the radiation exposure.

All individuals, other than the patient being examined, shall be positioned such that no part of the body will be struck by the useful (direct) beam unless protected by an apron, gloves, or other shielding having 0.5 millimeter lead equivalent material.
Staff and ancillary personnel shall be protected from primary scatter by protective aprons or whole body protective barriers or not less than 0.25 millimeters of lead equivalent material (0.5 mm of lead for fluoroscopy).

Other patients who are in line with the primary scatter and who cannot be removed from the room, shall be protected by whole body protective barriers of 0.25 millimeter lead equivalent material or so positioned that the nearest portion of their body is at least 6 feet from both the tube head and the nearest edge of the image receptor.

For therapy procedures, no individual, other than the patient, shall be in the treatment room during exposures from therapeutic radiation machines operating above 150 kV. At energies less than or equal to 150 kV, any individual, other than the patient, in the treatment room shall be protected by a barrier sufficient to meet the requirements of TAC 289.231 (m) and (o).

**OPERATION OF THE X-RAY MACHINE AND FILM PROCESSING**

Techniques employed in radiography should be those which achieve the desired objectives with minimum dose to the patient. Persons performing the x-ray procedures should follow the guides listed below, to reduce the patient exposure:

1. No x-ray exams shall be taken unless ordered by a practitioner. [§289.202(b)and §289.227(b)]

2. Radiation exposure to humans shall be made only at the direction of a physician approved by the CTRC administration or a resident working under the direct supervision of an above approved physician.

3. The operator must be able to continuously view and communicate with the patient. [§289.227(i)(9)]

4. Operator should apply the concept of As Low As Reasonably Achievable during any exposure and utilize protective aprons, gloves, booth, etc.

5. The useful beam should be limited to the smallest area practical (also known as collimated), and consistent with the objectives of the radiological examination or treatment.

6. The voltage and the source-skin distance (SSD) employed in medical radiological examinations should be as great as is practical and consistent with the diagnostic objectives of the study.

7. Protection of the embryo or fetus during radiological examination or treatment of women know to be pregnant should be given special consideration.
Note: Ideally, abdominal radiological examination of a woman of childbearing age should be performed during the first ten (10) days following the onset of a menstrual period to minimize the possibility of irradiation of an embryo. In practice, medical needs should be the primary factors in deciding the timing of the examination.

8. Suitable protective devices to shield the gonads of patients who are potentially procreative should be used when the examination or method of treatment may include the gonads in the useful beam or be within 5 centimeters of the useful beam. This requirement does not apply if the shielding will interfere with the diagnostic procedure. Gonadal shielding shall be of at 0.5 millimeter lead equivalent material.

9. Fluoroscopy should not be used as a substitute of radiography, but should be reserved for the study of dynamics or spatial relationships or for guidance in spot-film recording of critical details.

Begin with the collimators closed, and open collimators so the x-ray beam is restricted to the area of clinical interest [§289.227(m)(8)(B)(ii)]

Reset the 5-minute cumulative timing device before each fluoroscopic procedure [§289.227(m)(7)(A)].

For mobile (C-Arm) units, a 30-centimeter (cm) source-to-skin distance (SSD) is to be used. To achieve the 30 cm, the spacer attached to the x-ray tube must be utilized. [§289.227(m)(3)(A)(iv)(III)]. The spacer is a plastic tube-like device, 10 cm in length that clips or slides onto the x-ray tube head of the C-arm.

A 20cm source-to-skin distance (20cm SSD) may be used for mobile fluoroscopy when the patient is too large to fit between the image intensifier and the tube head with the spacer, the surgeon requires additional room for the procedure or the tube head will not fit under the surgical table due to the structure of the surgical tables.

When the spacer is off (allowing the 20cm SSD), as precautionary measures, use sterile drapes on the image intensifier, minimize the field size to clinical field of interest, position patient as close to the image intensifier as possible, and minimize fluoro time.

Replace the spacer on the C-arm when finished with the procedure each time it is removed. [§289.227(m)(3)(A)(iv)(III)].

Use protective devices as required in the Protective Devices Section.
10. The use of a technique chart aides in reducing the exposure to the operator and the patient. It must be used for all exposures. The chart is to be posted in the vicinity of the control panel of each x-ray machine or electronically displayed. [§289.227(i)(1)]

11. For Mobile X-ray Machines, during the exposure, the operator must be positioned using the concept of ALARA, such as standing 6 feet away, wear lead apron and never be in the line of the direct beam. [§289.227(i)(10)] The x-ray tube housing shall not be held by an individual during any an x-ray exposure.

12. X-ray film, intensifying screens, and other image recording devices, should be as sensitive as is consistent with the requirements of the examination.

13. Film processing materials and techniques should be those recommended by the x-ray film manufacturer.

14. X-ray films exposed for the purpose of inspection should be retained for two years past the current calendar year.

15. Digital images performed for physics reports should be printed and maintained in the records for at least 3 years.

FILM PROCESSING AND QUALITY ASSURANCE

[TAC 289.229 (h) (4) (A) (viii)], [NCRP 99, Chapter 6]

Conventional film and radiochromic film is used at CTRC for physics QA purposes only. The quarterly QA and PM services performed by the manufacturer are sufficient for such application.

Digital Imaging Acquisition (Electronic Portal Imaging) systems are used for in-vivo imaging and as such must have a QA/QC protocol for image processing that is utilized either following the manufacturer’s protocol or a protocol developed by the registrant. This institution follows the TG142 protocol for all QA guidelines and performs the QC/QA on the digital imaging systems at a monthly frequency.

TECHNICAL STANDARDS FOR RADIATION PRODUCING MACHINES

All radiation producing machines will comply with the technical standards of 25 Texas Administrative Code §289.227 unless an exemption has been requested and received from the Texas Department of State Health Services, Bureau of Radiation Control. All therapy units will comply with technical standards of 25 Texas Administrative Code
QUALITY ASSURANCE PROGRAM

The quality assurance program related to radiation therapy is outlined in the Radiation Oncology Departmental Policies & Procedures to meet the requirements of TAC 289.229 (h)(1)(F).

OPERATION OF LINEAR ACCELERATOR EQUIPMENT

1. Keys which disable the accelerator units will be removed from their key switches at night or when left unattended for an extended period. The key will be stored in a designated area. Therapeutic radiation machines shall not be left unattended unless secured by a locking device which will prevent unauthorized use (A computerized password system constitutes a locking device).

2. At the accelerator units there shall be provided windows, mirrors, or closed-circuit television to permit continuous observation of the patient from the control panel following positioning and during irradiation. [TAC 289.229 (h) (2) (ii)] Since the viewing is by electronic means, an alternate viewing system is available in the event of failure of the primary viewing system. Aural communication will be continuous two-way between the patient and operator who is located at the control panel. Visual and aural communication systems are checked daily before patient treatment.

3. The treatment room entrance shall be provided with a warning light near the outside of all access doors to indicate when the useful beam is on and off.

4. The area leading to the treatment room entrance shall have a sign stating only staff and patients beyond this point.

5. There is a seam connecting the main building to the vault rooms. Staff will ensure that no person is beyond this seam when treatment is taking place.

6. Patients will remain in the waiting area until their treatment time.

7. Entrance interlocks shall be provided. All entrance doors must be closed before treatment can be initiated or continued. If the radiation beam is interrupted by any door opening, it shall not be possible to restore the machine without closing the door and reinitiating irradiation by manual action at the control panel. These interlocks will be checked for proper operation on a daily basis.

8. The therapy system will not be used in the administration of radiation therapy unless these requirements have been met:
   A. The services of a therapeutic radiological physicist are utilized;
   B. Initial surveys have been performed for all new facilities and existing facilities which were not previously surveyed;
   C. Annual calibrations have been performed on all therapy units;
D. Spot checks have been performed during calibration and thereafter at weekly intervals, not exceeding five treatment days;
E. Full calibration measurements and quality assurance checks have been completed; and
F. Spot checks do not indicate a significant change in the operating characteristics of a system as specified in the written procedures.

9. Possible Medical Events 25 TAC 289.229 (h)(i)
   a.) If you believe one of the following has occurred, you are to immediately contact a physicist in the Department of Medical Physics and the Radiation Safety Officer.
      1) The event involves the wrong individual, wrong type of radiation, wrong energy, or wrong treatment site;
      2) The treatment consists of three or fewer fractions and the calculated total administered dose differs from the total prescribed dose by more than 10% of the total prescribed dose, or
      3) The calculated total administered dose differs from the total prescribed dose by more than 20% of the total prescribed dose.
      4) The combination of external beam radiation therapy and radioactive material therapy causes over-radiation of a patient resulting in physical injury or death.

MEGAVOLTAGE LINEAR ACCELERATOR PROCEDURES

a) Calibration of Dosimetry Systems.
   1) Secondary Standard
      A calibrated Farmer 0.6 cc ionization chamber and a calibrated electrometer is dedicated as the secondary standard at CTRC. The secondary standard system is used for comparison with the other dosimetry system only and should not be used for routine calibration and measurements. The $N_D$ value of the standard system shall be calibrated by a national calibration laboratory traceable to the National Bureau Standard. The period of calibration shall be within 2 years, and after any servicing that may have affected its calibration.

   2) Dosimetry Systems Used for Absolute X-Ray and Electron
      Two independent calibration systems are reserved for absolute dose measurements. They are used for annual calibration, monthly output check and any other measurement that requires the absolute dose to be determined. The $N_D$ values of these two systems are determined by comparing with the secondary standard. The AAPM TG51 protocol (Medical Physics 26(9): 1847-1869, Sept 1999) shall be used.

b) Annual Calibration of Megavoltage linear Accelerators
   A full calibration for all linear accelerators shall be performed annually and after any maintenance that would affect the output or energy of the machine.
The calibration shall include (but not limited to the energy of X-rays and electrons), the measurements of the output for different field sizes verification of percent depth dose used, measurements of beam profile, verification of inverse square law and verification of transmission factors of all wedges.

In addition to the above measurement, for each electron energy, the practical range and energy should also be measured. The full calibration shall be performed by a Texas licensed medical physicist in the specialty area of therapeutic medical physics.

c) Monthly Output Verification of Megavoltage Linear Accelerators

The output of a 10 x 10 field for each energy used for all linear accelerators shall be measured each month by a medical physicist. The absorbed dose rate shall be measured at a user defined depth as established at the time of the annual machine QA. This test is a reproducibility check to verify that the output in the user defined conditions has not changed from the time of the last annual test by more than +2% for photons or +2% for electrons. The medical physicist will tune the machine output if needed based on these measurements. All calibrations and changes in output shall be reviewed by a licensed medical physicist.

d) Spot Checks of Megavoltage Linear Accelerators by the Physics Department

The output spot-check for all linear accelerators shall be performed on each treatment machine after the warm up procedure of the machine has been finished. The output constancy checks are performed weekly (or less) intervals. The period between output constancy checks do not exceed 5 treatment days. If a medical physicist does not perform the spot-check measurement, the results of the spot-check measurement shall be reviewed by the medical physicist within 5 treatment days. If the output varies by more than 3% from the expected value, a licensed medical physicist shall be notified immediately. The licensed medical physicist will make the determination on continuance of patient treatment. The spot check policy for daily and weekly procedures is described in the CTRC P&P manual, Policy Therapy\4.1.18 Daily Machine WarmUp.doc

**STEREOTACTIC RADIOSURGERY WITH CONES**

When delivering a SRS treatment the radiation oncologists, radiation oncology physicists, dosimetrists, and the therapists must follow the SRS Delivery Verification policy outlined in the Appendices. This policy requires the use of the Therapist Checklist, the Cone Interlock Verification Checklist, and the Treatment Planning Checklist. The CT Immobilization and the CT Simulation Checklist need to be followed during the CT imaging. All of these checklists are outlined in the Appendices. For patient treatment, a time-out policy has been
implemented for patient verification purposes as outlined in the Appendices. The SRS procedure, time-out policy, and accompanying checklists are reviewed as needed and annually. The most up-to-date revision of the checklists can be found in the online Departmental Policy and Procedure directory of Radiation Oncology at CTRC.

**RADIATION THERAPY SIMULATION SYSTEMS-TAC 289.229 (H) (4).**

X-ray production in the fluoroscopic mode is controlled by a device, which requires continuous pressure, by the fluoroscopist for the entire time of the exposure (dead-man switch).

During fluoroscopy, the kV and the mA is continuously indicated at the control panel.

The source-to-skin distance (SSD) is not less than 38 centimeters on stationary fluoroscopes installed after March 1, 1989 and 35.5 centimeters if in operation prior to March 1, 1989.

The fluoroscopic timer has a means to preset the cumulative on time of the fluoroscopic x-ray tube. The maximum cumulative time of the timing device shall not exceed five minutes without resetting. A signal audible to the fluoroscopist indicates the completion of any preset cumulative on time. The signal continues to sound while x-rays are produced until the timing device is reset.

**FLUOROSCOPIC AND SPOT-FILM PROCEDURES -TAC 289.229 (H) (4) (C)**

1. Do not perform fluoroscopy, other than localization, without the immediate supervision of a physician properly trained in fluoroscopic procedures. The following personnel are authorized to perform fluoroscopy in compliance with the MRT Act: Radiation Therapist. [MRT Act, NCRP Report No. 33 (1968) and TAC 289.227 (e) (6)]

2. Set the appropriate exposure factors using the technique chart or manual at the control panel of the machine. [TAC 289.227 (e) (1)]

3. Wear full trunk aprons of 0.5 millimeter or more lead equivalent. You must wear your whole body-monitoring badge at the collar, outside the apron.

4. When using the C-Arm or the simulator fluoroscopy unit in catheter placement the following must be observed:
   a) Personnel (except the patient) in the fluoroscopic room wears protective aprons of 0.5 millimeter or more lead equivalent. [TAC 289.227 ( r ) (7) (B) ( i )]
   b) Personnel wear personnel monitoring devices at the neck, outside the apron. [TAC 289.227 ( r ) (7) (B) ( i )]
   c) The fluoroscopist shall reduce the field size to the absolute minimum for the procedure, i.e., to the area of clinical interest, to avoid needless high exposure to the patient and staff. [TAC 289.227 ( r ) (7) (B) (ii)]
d) The fluoroscopy personnel shall exhibit an awareness of indicated safety procedures and conditions.

5. A 20-centimeter spacer may be used for mobile fluoroscopy during surgical procedures, but it must be replaced by the 30-centimeter spacer assembly when the unit is returned for general use. [TAC 289.227 (r) (5) (D)]

6. Reset the 5-minute cumulative timing device before each fluoroscopic procedure. [TAC 289.227 (r) (6)]

CT X-RAY SYSTEMS

1. The CT x-ray system shall be operated by an individual who has been specifically trained in its operation. Requirements for radiation therapy simulators utilizing CT capabilities diagnostically are required to follow 289.229 (h) (4) (D). If the CT is used for simulation purposes only, the following maintenance scheduled does not apply.

The maintenance schedule shall include:
   a) Dose measurements of the radiation output of the CT X-ray system performed by a licensed medical physicist with a specialty in diagnostic radiological physics. The measurements shall be performed as follows:
      1) At intervals not to exceed 12 months.
      2) When major maintenance, except x-ray tube replacement, that could affect radiation output; or
      3) When a major change in equipment operation; such as new software package.
   b) Acquisition of images stored in digital form obtained with phantoms using the same processing mode and CT conditions of operation as are used to perform dose measurements, will done a weekly basis. Refer to TAC 289.229 (h) (4) (D) iii and iv.

OPERATING AND SAFETY INSTRUCTIONS

Operating and safety instructions for the individual type of use are attached at the end the Handbook. The appropriate section is to be used for your x-ray unit. The following radiation safety precautions are the "generic brand".

The following individual pages have the general safety procedures for each specific use of x-ray units.

The uses include:
- General Precautions
- CT Units
- Fluoroscopy
- Therapy Accelerator
GENERAL PRECAUTIONS

1. Wear your dosimeter at all times during working hours.
2. Check to ensure that the correct patient is to be x-rayed.
3. Use the minimum field size necessary for the procedure.
4. Use gonadal shielding when possible for all patients of child bearing age.
5. When it is absolutely necessary to hold the patient, wear a lead apron and glove and avoid having any extremity in the direct x-ray beam.
6. All exams and retakes shall be ordered by the physician / practitioner.

COMPUTED TOMOGRAPHY (CT) PRECAUTIONS

1. Wear your dosimeter at all times during working hours if you have been issued a badge.
2. Check to ensure that the correct patient is to be imaged.
3. Close the door to the room.
4. Necessary personnel only in the room.
5. Position patient correctly.
6. Return to control room and initiate exposure.
7. Maintain visual and auditory contact with the patient at all times.
8. All exams and retakes shall be ordered by the physician/practitioner.
9. Inform the Radiation Safety Officer of any problems requiring maintenance with the unit.
9. Refer to the Radiation Safety Handbook for additional information regarding the use of radiation producing devices.

FLUOROSCOPIC PROCEDURES

1. Make sure that only those persons absolutely necessary for the examination are in the room.
2. Ensure that all personnel in the room are wearing lead aprons, gloves and other appropriate protective devices where necessary.
3. Check to determine that all protective shields and devices such as protective aprons and drapes are in place before the procedure begins.
4. Close all doors leading to the examination room before the procedure begins.
5. Start the examination with the shutters closed.
6. Use pulsed mode fluoro when possible to reduce dose to operator.

1 We no longer have and operate a conventional simulator; it has been replaced with a CT simulator
STERILE FIELD SPECIAL PROCEDURES

Where sterile fields or special procedures prohibits the use of normal protective barriers or drapes, all of the following conditions must be met:

1. All persons, except the patient, in the room where fluoroscopy is performed, shall wear protective aprons which provide a shielding equivalent of 0.5 millimeter of lead.
2. The fluoroscopist and all other personnel in the room, except the patient, shall have appropriate personnel monitoring devices.
3. The fluoroscopic field shall be reduced to the absolute minimum required for the procedure being performed (area of clinical interest).
4. Use pulsed mode fluro when possible to reduce dose to operator.

THERAPY ACCELERATOR GENERAL PRECAUTIONS

1. Wear dosimeter if issued.
2. Follow manufacturer’s operating instructions.
5. Therapy plan in place.
7. Patient only in the room during therapy.
8. Therapist in control room area during therapy.
ADDENDUM - CT QUALITY ASSURANCE SYSTEM PERFORMANCE IN-HOUSE POLICY

SYSTEM PERFORMANCE

- Control & System Requirements For A CT Single Tube Includes The Following:
  - CT conditions of operation (slice thickness, # of slices, gantry angle, etc.) are indicated prior to initiation of the scan [§289.227(p)(1)(B)]
  - CT conditions of operation visible from any position for scan initiation [§289.227(p)(1)(B)]
  - Visible indication of x-ray production [§289.227(p)(1)(C)(i)]
  - Operator required to initiate each scan or series [§289.227(p)(1)(C)(ii)]
  - Termination of x-ray exposure signal visible to the operator [§289.227(p)(1)(D)(i)]
  - Termination of scan greater than 0.5 sec by operator possible at any time [§289.227(p)(1)(D)(iii)]
  - Must reset manually after termination of 0.5 sec or greater [§289.227(p)(1)(D)(iii)]
  - Visual determination (light indicators) of the tomo plane [§289.227(p)(1)(A)(i)]
  - Visual determination of x-ray production at the gantry [§289.227(p)(1)(C)(i)]
  - Emergency buttons and/or switches clearly labeled [§289.227(p)(1)(C)(iii)]
  - Technique chart provided electronically [§289.227(i)(1)]
  - Lead glass permits continuous observation of patient [§289.227(p)(2)(B)]
  - Two way aural communication provided [§289.227(p)(2)(A)]

- Medical Physicist Will Determine The Dose Measurement [§289.227(p)(3)] (Only applies if the system is used diagnostically and not as a therapy simulator)
  - With a properly calibrated dosimetry system [§289.227(p)(3)(B)]
  - Annually [§289.227(p)(3)(A)(i)]
  - After major maintenance affecting radiation output to include kV board change, change in filtration, and at the recommendation of the service engineer, excluding a tube change [§289.227(p)(3)(A)(ii)]
  - Maintain Physics report for three years [§289.227(p)(3)(C)]

- Quality Image Maintenance - Many factors effect Image Quality:
  - Proper alignment of X-ray tube, DAS, detector and table
  - KV and mA adjustments within specifications
  - Current Calibration files
  - Tube Warmup every time the system recommends it
  - Daily Fastcals
  - Appropriate pixel size, slice thickness, reconstruction algorithm, and special processing selections during Scan Rx
- Patient remains motionless during scan acquisition

- **At Least Three people Must Cooperate To Produce Optimum Images:**
  - Service representative aligns the system and adjusts kV and mA
  - Operator follows facility guidelines to maintain daily image quality, prescribe the exams, and update the calibration files
  - Patient follows operator (and autovoice) instructions during exam

- **A QA Program Helps Locate The Source Of Image Quality Problems:**
  - Replaces patient with phantom
  - Provides standard Scan Rx parameters
  - Provides System Performance tests and comparisons

- **QA Program Schedule**
  - The QA will be performed weekly.
  - The CT phantom provided by the vendor will be used to run the QA procedure
  - Manufacturer procedures will be followed to obtain phantom images
  - The phantom images are stored digitally and on film hardcopy  
    [§289.227(p)(4)(B)(ii)]

- **Maintenance**
  - Preventative maintenance by CT unit’s vendor service engineer performed monthly for each CT unit
  - Service agreement with the vendor includes onsite contact.
1. SRS Delivery Verification Policy Number SR.2.1
2. Therapist Checklist
3. Cone Interlock Verification Checklist
4. Treatment Planning Checklist
5. CT Immobilization Checklist
6. CT Simulation Checklist
7. Time-Out Policy
Purpose and scope: This policy describes the process of verifying and delivering a SRS treatment. The policy applies to all radiation oncologists, radiation oncology physicists, dosimetrist, and therapists.

Procedure:

Once the plan and associated e-documents have been approved by the assigned faculty (treating physician and medical physicist), a pre-treatment second check has to be completed by the therapists and a separate medical physicist that was not involved in the planning process. A patient specific QA plan is prepared and executed for all frameless patients treated with IMRT. The QA plan is reviewed by the medical physicist that performs the pre-treatment 2nd check. A faculty physicist will review and sign off on the Winston-Lutz test that was performed and analyzed.

Once the patient is setup in the treatment room, the treatment team (physician, medical physicist and therapist) verify that the correct patient is being treated, review the treatment setup, denote on patient the correct treatment site (i.e. left or right sided), and verify the correct cone collimator is placed (if applicable). All members of the treatment team have to be physically present at the treatment room/console for the duration of each SRS treatment.

For SRS treatment with the mask system:
1. Physicist will verify that the Therapist Checklist has been completed by the treating therapist.
2. Place the patient on the table and guide them into the mask assembly.
3. Place the cranial array on the patient.
4. Enable the ExacTrac system to position patient to the isocenter.
5. Once in position, remove the cranial array and replace with localizer box.
6. Ensure TWO separate individuals verify in all three planes that the correct isocenter is being treated.
7. Remove the localizer box and replace with cranial array.
8. If cone-based treatment, complete the Cone Interlock Verification Checklist.
9. Acquire initial ExacTrac localization images and proceed with fusion.
10. If initial shifts are <1mm or <1º, continue onto treatment.
11. If not, apply shifts and re-acquire localization images.
12. After image fusion, the shifts must be <1mm or <1º in order to proceed with treatment.
13. If not, remove mask from patient and re setup.
15. Mode up each beam and re-verify the following prior to beam on:
   a. Energy
   b. MU
   c. Time
   d. Field size
   e. Couch, gantry, and collimator angle
   f. Accessory (cone or MLC)
16. Deliver treatment and ensure all MUs are delivered.
17. Repeat steps 15 & 16 for each treatment field.
<table>
<thead>
<tr>
<th>Approved By:</th>
<th>Niko Papanikolaou, Ph.D.</th>
<th>Title: Division Chief</th>
<th>Date:</th>
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<tr>
<th>Approved By:</th>
<th>Tony Eng, M.D.</th>
<th>Title: Clinical Ops Committee</th>
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<th>Approved By:</th>
<th>Chul Ha, M.D.</th>
<th>Title: Department Chair</th>
<th>Date:</th>
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Therapist Checklist: Frameless Radiosurgery

Please complete and initial the following:

- _____ Winston Lutz test completed and passed - Verified by physicist_______
- _____ Printed treatment plan received
- _____ TaPos placed on Localizer Box correctly
  - Verified by physicist _______
- _____ Beams verified for any couch collisions and MLC verified for differences with TaPos patterns
- _____ Completed Therapist column on “RadOnc Chart Check”
- _____ Prescription AND Electronic documents (Plan/2"nd Check) approved by radiation oncologist and physicist
- _____ If applicable, IMRT QA approved by physicist
- _____ Patient data loaded up on Exac Trac system
- _____ Patient ID confirmed as required by Policy RTT 16.0 (Patient Time Out)
- Patient Name: ___________________________________     CTRC#____________________________
- _____ Each coordinate to be double checked by both physicist AND physician/therapist
- If cone-based, fill out Cone Interlock Verification Checklist
- _____ Acquire ExacTrac images, fuse, apply shifts, and acquire verification images
- _____ Physicists AND physician approve fusion
- _____ Disable Varian couch movement motors (Vert, Lat, Long)

Record couch position for each site below

<table>
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<tr>
<th>Coordinates</th>
<th>Iso. #1</th>
<th>Iso. #2</th>
<th>Iso. #3</th>
<th>Iso. #4</th>
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<td>Long.</td>
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<tr>
<td>Lat.</td>
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- _____ Verify beam parameters with physicist prior to delivering radiation
  Responsible Therapist*: _____________________________         Date: __________________
  Responsible Rad Onc Physicist: _____________________________        Date: __________________

By my signature above, I am certifying that the SRS set-up meets the specification in the treatment plan

- _____ Repeat last 5 steps for each isocenter (if applicable)

*Please turn completed form to radiation oncology physicist
Cone Interlock Verification Checklist

Please ensure the following is completed:

☐ Patient Name: ______________________________ Date: _____________________

☐ For Site #1, what is the cone size in the treatment plan: _______mm Initials _________
☐ Are the X- and Y- jaws ≤ 2.0 X 2.0 cm² Initials _________
☐ Is the correct CONE COLLIMATOR placed in the mount and FIELD SIZE mode up:
  ☐ Responsible Therapist: ___________________________
  ☐ Responsible Physicist: ___________________________
  ☐ Responsible Physician: ___________________________

*By my signature above, I am certifying that the SRS set-up meets the specification in the treatment plan

☐ Are multiple cones required for Site #1, Initials _________
  ☐ If so, what is second cone size in the treatment plan: _______mm
  ☐ Are the X- and Y- jaws ≤ 2.0 X 2.0 cm² Initials _________
  ☐ Is the correct CONE COLLIMATOR placed in the mount and FIELD SIZE mode up:
    ☐ Responsible Therapist: ___________________________
    ☐ Responsible Physicist: ___________________________
    ☐ Responsible Physician: ___________________________

*By my signature above, I am certifying that the SRS set-up meets the specification in the treatment plan

☐ For Site #2, what is the cone size in the treatment plan: _______mm Initials _________
☐ Are the X- and Y- jaws ≤ 2.0 X 2.0 cm² Initials _________
☐ Is the correct CONE COLLIMATOR placed in the mount and FIELD SIZE mode up:
  ☐ Responsible Therapist: ___________________________
  ☐ Responsible Physicist: ___________________________
  ☐ Responsible Physician: ___________________________

*By my signature above, I am certifying that the SRS set-up meets the specification in the treatment plan

☐ Are multiple cones required for Site #2, Initials _________
  ☐ If so, what is second cone size in the treatment plan: _______mm
  ☐ Are the X- and Y- jaws ≤ 2.0 X 2.0 cm² Initials _________
  ☐ Is the correct CONE COLLIMATOR placed in the mount and FIELD SIZE mode up:
    ☐ Responsible Therapist: ___________________________
    ☐ Responsible Physicist: ___________________________
    ☐ Responsible Physician: ___________________________

*By my signature above, I am certifying that the SRS set-up meets the specification in the treatment plan

If more than 2 sites, complete a second Cone Interlock Verification Checklist form

P:\Stereotactic Radiotherapy\SRS\Frameless\Therapist Checklist.doc
Treatment Planning Checklist: Frameless Radiosurgery

Please ensure the following is completed:

☐ Patient Name: ___________________________     CTRC#________________________

☐ Import & verify images
  ☐ CT
  ☐ MR
    ☐ Hi-resolution (<1.5mm slice thickness)
    ☐ Correct pulse sequence (i.e. T1-weighted, post contrast)

☐ CT Images Localized (Use H&N Localizer for Frameless-based SRS)

☐ Fusion approved by radiation oncologist AND neurosurgeon

☐ Target and normal tissue segmentation approved by radiation oncologist AND neurosurgeon

☐ Apply correct CT Density table

☐ Surface rendering accurate

☐ Treatment prescription verified for ALL lesions

☐ Verify gantry and couch not in collision position

☐ Compute PITV ratio for each lesion—to be included in medical physics consultation

☐ Ensure “Check Mark” is present in top right corner of iPlan software

☐ Plan approved

☐ Complete all steps outlined in SR.1.1 - SRS Planning Documentation Policy

☐ Export treatment plan to ExacTrac and notify therapist

Responsible Physicist: ___________________________     Date: __________________

By my signature above, I am certifying that the SRS set-up meets the specification for SRS treatment plans
CT Immobilization Checklist: Frameless Radiosurgery

Please ensure the following is completed:

☐ Patient ID confirmed as required by Policy RTT 16.0 (Patient Time Out)

☐ Patient Name: ___________________________________     CTRC#____________________________

☐ All jewelry, eye glasses, and hair clips removed from patient

☐ Correct thermoplastic mask selected for procedure
  ☐ Cranial
  ☐ H&N

☐ Patient head position neutral, straight alignment, chin up

☐ Patient head in center of carbon fiber base

☐ Verify no collision between
  ☐ Patient head and localization box
  ☐ Patient head and localization array

☐ Verify posterior portion of mask conforms to TOP of head

☐ Verify 2mm shim is used

☐ Verify mask conforms to patient head, nose bridge, and chin

Responsible CT Tech*: ___________________________                         Date: __________________

*Please turn complete form to radiation oncology physicist

By my signature above, I am certifying that the SRS set-up meets the specification required for treatment plan.
CT Simulation Checklist: Frameless Radiosurgery

Please ensure the following is completed:

☐ Patient ID confirmed as required by Policy RTT 16.0 (Patient Time Out)

☐ Patient Name: _______________________________     CTRC#____________________________

☐ Verify correct patient mask

☐ Use appropriate shims for patient comfort

☐ Verify mask is snug and not poking/pinching patient

☐ Place localization box onto base and align patient to box marks

☐ Contrast consent approved

☐ IV connected to infuser for contrast

☐ **SRT Brain** Protocol selected for CT scan
  ☐ Axial scan
  ☐ Slice thickness: 1.25mm
  ☐ Scan length: Top of head to below jaw

☐ CT localizer rods visible on CT image

☐ Images exported to BrainLAB DICOM dump

Responsible CT Tech*: _______________________________                         Date: ______________

*Please turn complete form to radiation oncology physicist

By my signature above, I am certifying that the SRS set-up meets the specification required for treatment plan
Patient Time out

Scope:
This policy affects all radiation therapists working in the radiation therapy department at the CTRC.

Policy: All Radiation Oncology patients, prior to treatment simulation or treatment delivery are subject to a “time out” whereby the patient’s identification will be verified with a minimum of two independent ways. The site of treatment will also be verbally verified.

Procedure:

1. Prior to initiating simulation, the simulation therapist/technologist will ask the patient to state their full name, date of birth and the site of their disease and will explain the rationale of why they will be required to do this on a daily basis (a minimum of two of the three questions will be asked although it is preferable to ask all three). A patient relative/guardian can be engaged to verify a patient’s identity in the event that a patient is unable consent and identify themselves so of their own volition, so long as that relative/guardian has been identified by the physician/billing group as a valid guardian and/or power of attorney.

2. Prior to each treatment, the therapist will verify the same three elements of name, DOB, and anatomical site to be treated.

3. Prior to the start of each daily treatment, a treating therapist must ask all three elements and compare them to the patient chart currently open in MOSAIQ to include the patient’s ID photo. The therapist will confirm that the corresponding electronic chart is opened prior to any imaging or treatment sessions.

4. All therapists will set individual preferences in MOSAIQ to automatically display the patient ID photo upon opening the electronic chart to aid in patient identification. (To set this preference: Go to the main patient file cabinet, right click the mouse and select the option for enabling photo ID display by moving the cursor over this option and hitting the space bar. ***Upon entering MOSAIQ charts from this point forward will automatically upload that patient’s ID photo.

5. Tomotherapy radiation therapists are responsible for taking and uploading a patient ID photo specific to the tomotherapy machine at the day of validation as currently loaded MOSAIQ ID photos do not interface with the in-room Tomotherapy gantry files for automatic upload and verification.

6. Once the correct patient ID and treatment site have been identified and it is verified that the patient immobilization equipment currently laid out corresponds to the patient in the room, patient setup can commence.

7. If there is any question as to why treatment parameters do not matching, an second therapist must re-verify correct patient with correct chart and treatment site.

8. Therapists should perform a visual check of machine parameters, as they transfer from RV to the treatment console, before turning treatment machine on to include MU, energy, MLC configuration, field size, and that all interlocks have been cleared.

9. Failure to follow this policy will result in disciplinary action up to and including termination.
Conducting a time out:

- **Addressing the patient the therapist says:**
  - Please state your name
  - Please state your birthday
  - Please tell me which anatomical site we are treating

- **(Spanish version) Addressing the patient:**
  - Por favor diga su nombre.
  - Por favor diga su fecha de nacimiento.
  - Por favor digame que parte del cuerpo le daremos tratamiento.

Related Forms:

References:

Approved Date: 5/21/2010    Last revised: 1/28/11

Approvals obtained from:

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<tr>
<td>Kasey Sparks, MS, RTT</td>
<td>Radiation Therapists Manager</td>
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<tr>
<td>Nikos Papanikolaou, PhD</td>
<td>Chief, Division of Medical Physics</td>
</tr>
<tr>
<td>David Raney, MBA</td>
<td>Administrator</td>
</tr>
<tr>
<td>Tony Eng, MD</td>
<td>Clinical Ops Committee chair</td>
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<tr>
<td>Chul Ha, MD</td>
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