Authorization and Inspection of Linear Accelerator (LINACS) Used in Radiotherapy
Instructors Manual, revision 1
May 2020

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1.0 Course Objective

- To educate regulators on the basics of Linear Accelerator use in Radiation Oncology and to share best practices of regulating the safe use of Linear Accelerators to protect: patients, workers, and members of the public.
- To understand the use of regulations and licensing to ensure appropriate facility safety controls as well as the basis of these requirements.
- To develop an understanding of the basis of safety requirements and their function, aiding regulators to determining violation severity levels and evaluation of proposed corrective actions implemented by licensees.
- To help participants prepare for and tour an actual Linear Accelerator facility and perform an inspection of the Linear Accelerator facility in compliance with the best practice suggestions provided during the presentations during the course.

2.0 Instructor Qualifications

Instructor should have a graduate degree in Medical Physics, Health Physics, Physics or other technical field and at least five (5) years of experience as a regulator of radioactive materials and/or radiation producing machines. Experience regulating Radiation Oncology Modalities such as Linear Accelerator, Teletherapy, and High Dose Rate Remote After Loader, preferred. Experience as a Therapeutic Medical Physicist responsible for Linear Accelerator management (QA, QM, etc) may be substituted for up to (2) years of regulatory experience.

3.0 Student Qualifications

Students should have a local baccalaureate equivalent degree in Medical Physics, Health Physics, Physics or other technical field and at least one (1) years of experience as a regulator of radioactive materials and/or radiation producing machines or as a Therapeutic Medical Physicist responsible for Linear Accelerator management (QA, QM, etc).

4.0 Venue Needs

Classroom

The classroom should have air-conditioning or heating as appropriate for the season. There should be restrooms available for males and females, shared facilities are acceptable if cultural norms of the country allow shared facilities. Chairs for all participants are required, as the lecture days will be at least 8 hours in length.

Number of Students

Class size should be limited to less than 10, preferably 5-8 students, to manage onsite tour or inspection with local facility. Sites will usually be providing patient care during the inspection and large groups can pose not only hazardous situations such as blockages in pedestrian walkways but can also negatively affect patient experiences at the hospital.

Technical Requirements

Projector with HDMI or mini-dataport connector and area for screening blank wall/sheet. USB memory sticks, at least 10 GB to transfer references as needed. Black and white printer and 50 pages of 8 x 11 ½

paper for printing of exercise worksheets and other references as needed. Pens and paper for all participants. Conversion adaptors to US or EU power outlets appreciated, not required.

Exercise

Access to Current Linear Accelerator: Regulations, Licensees or Registrations, Inspection Templates, Facility and personnel. Vehicles and drivers to transport all class participants to the Linear Accelerator Facility. Dosimetry and survey meters should be provided if required by the local governing authority. Participants are unlikely to exceed IAEA ICRP 103 public dose limits during this exercise, but employers should perform an evaluation for all functions performed during employment and provide dosimetry accordingly or dosimetry should be provided if required by the local authority.

5.0 Instructor Notes

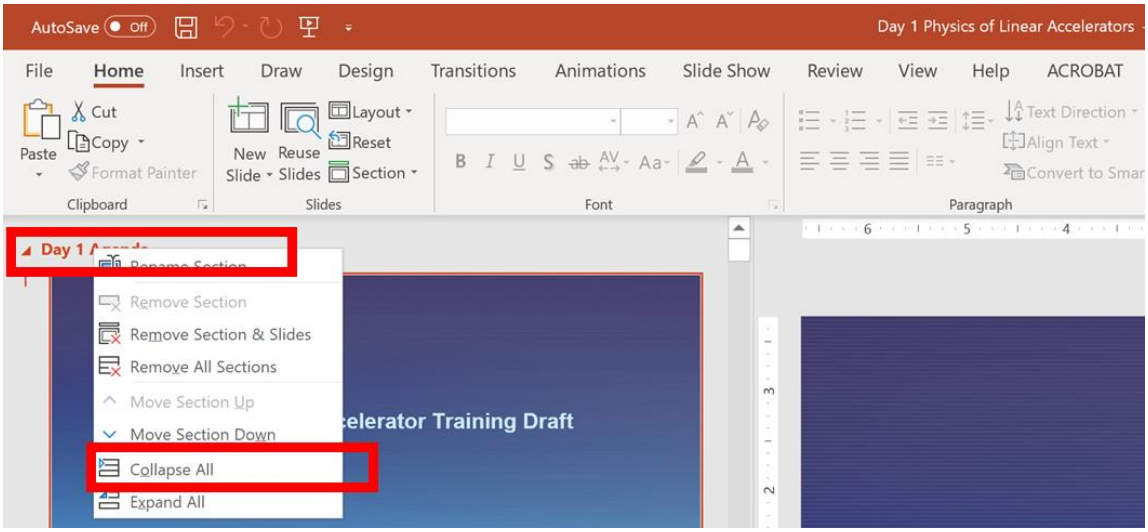
Agenda

The course should begin promptly at 0800 with a debrief of the previous day, highlighting if there were any safety concerns (flooding, weather, electrical) and summary of topics covered previously and to be covered that day. Allow time for questions from participants.

Breaks should be given approximately every hour for 10 minutes as content and interest allow. Lunch should be provided for 1 hour. The course should end at approximately 1600 every evening.

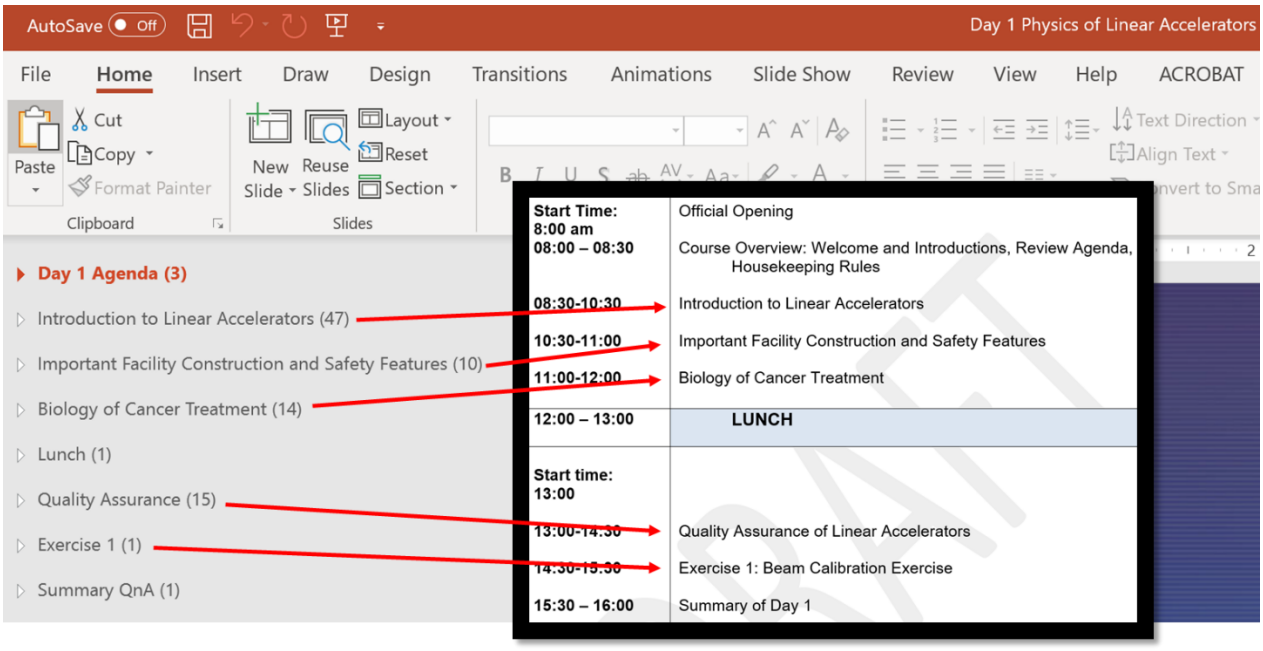
For each selected day, the topics listed in the agenda will have a matching section inside of the power point presentation.

To use the sections inside of a selected day's power point presentation, first, open the power point presentation (i.e. Day 1 Physics of Linear Accelerators) using power point. Then, observe the section heading in the left-hand pane (i.e. Day 1 Agenda, highlighted with a red box below), and right click with your mouse or touchpad. The menu below should include the option to "Collapse All", highlighted with a red box below. Click "Collapse All".

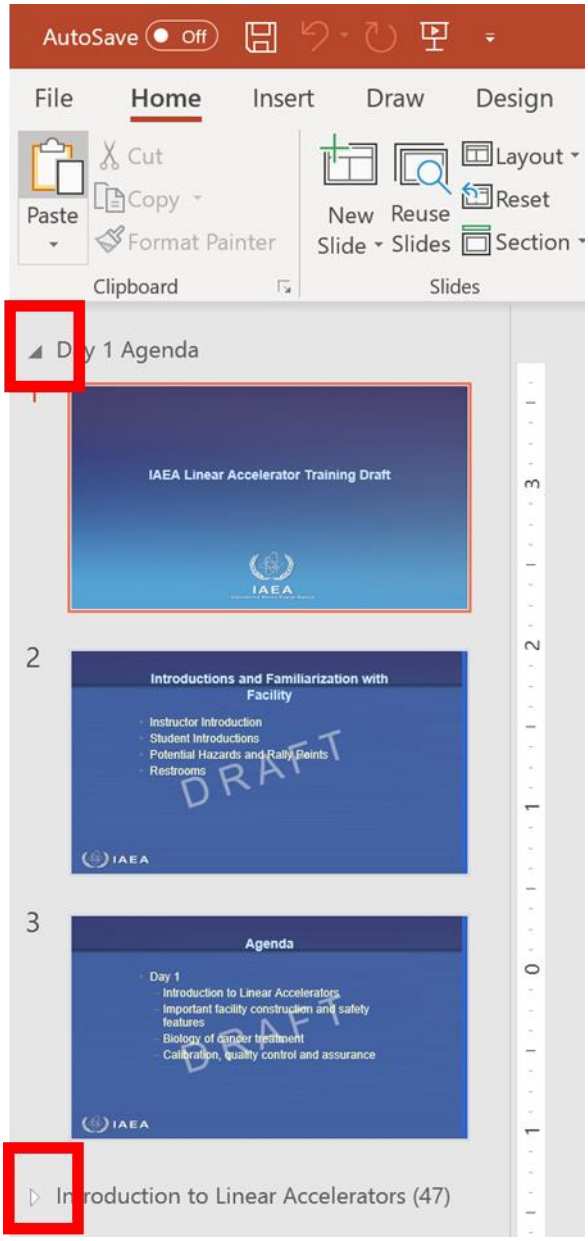


The section headings should now be visible in the left-hand viewing pane, these section headings will match the Agenda topics for that day, in order that they appear in the Agenda. There are placeholder

sections for Lunch and for each exercise should be presented to the class.



Sections can be opened one at a time for ease of viewing. Click on the arrow toggle to the left of the topic and you can view only the slides for that particular section. In the example below, the “Agenda” section for Day 1 is “opened”. The section for Introduction to Linear Accelerators is closed, hiding those slides until the presenter is ready to review or present them.



Quizzes

After each section is a quiz of varying length to reinforce the critical message of each section. The instructor should allow the students about 5-10 minutes to collect their answers before going through the answers one by one and provide a discussion. A break should be provided before going into the next session.

The quizzes for all sessions in the day are then collected into the Questions and Answers session at the end of the day. If students have not prepared their own questions to bring to the group, the instructor may elect to again go through questions from the quizzes to either re-iterate critical messages or go deeper into discussions that were truncated earlier in the day.

References

The instructor should review training slides, references, and worksheets prior to arrival onsite. Slides will have talking points or point to references; additional notes should be added to reflect the personal experience of the selected instructor. Additional sections can be added to cover a host country's specific needs if submitted in a timely fashion prior to arrival. Each exercise will have detailed instructions below in section 6.0.

The instructor should review references for familiarity. Questions from participants may arise that require a more in-depth discussion than that provided in the slides. It is recommended to cater to the participant to ensure proper comprehension of material and applicability of learned material to daily challenges in developing a Linear Accelerator regulatory process.

IAEA References

Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards; General Safety Requirements Part 3 No. GSR Part 3 (version July 2014)

Radiation Protection of the Public and the Environment General Safety Guide No. GSG-8 R (May 2018)

Safety Reports Series No. 47 Radiation Protection in the Design of Radiotherapy Facilities

Governmental, Legal and Regulatory Framework for Safety General Safety Requirements GSR Part 1 (Rev. 1) (February 2016)

IAEA TECDOC – Notification, Authorization, Inspection and Enforcement for the Safety and Security of Radiation Sources (Version Date: November 14, 2019)

IAEA TECDOC-1526 (April 2007)

IAEA TECDOC-1525 (April 2007)

Technical Report Series 398 Absorbed Dose Determination in External Beam Radiotherapy An International Code of Practice for Dosimetry Based on Standards of Absorbed Dose to Water (2006)

AAPM references

Guidance document on delivery, treatment planning, and clinical implementation of IMRT

RPT 46 Comprehensive QA for Radiation Oncology

TG-25 Clinical Electron Beam Dosimetry

TG-35 Medical Accelerator Safety Considerations

TG-45 AAPM Code of Practice for Radiotherapy Accelerators

TG-51 Protocol for clinical Reference Dosimetry of High Energy Photon Beams

TG-53 Quality Assurance for Clinical Radiotherapy Treatment Planning

TG-72 Intraoperative Radiation Therapy Using Mobile Electron Linear Accelerators

TG-100 Application of Risk Analysis Methods to Radiation Therapy Quality Management

TG-106 Accelerator Beam Data Commissioning Equipment and Procedures

TG-119 IMRT Commissioning Multiple Institution Planning and Dosimetry

TG-142 Quality Assurance of Medical Accelerators

TG-147 Quality Assurance for Non-Radiographic Radiotherapy Localization

TG-179 Quality Assurance for image-guided radiation therapy utilizing CT-based

RPT-19 Neutron Measurements around High Energy X-Ray Beams

RPT-24 Radiotherapy Portal Image Quality

RPT-54 Stereotactic Radiosurgery

RPT-55 Treatment Planning Dosimetry Verification

HPS references

An Unrecognized Occupancy Change in the Vicinity of a Medical Linear Accelerator, Robert J. Barish, February 2012

SKYSHINE RADIATION RESULTING FROM 6 MV AND 10 MV PHOTON BEAMS FROM A MEDICAL ACCELERATOR Deirdre H. Elder, Joseph F. Harmon, and Thomas B. Borak, July 2010, Volume 99, Number 1

Neutron Production Associated with Radiotherapy Linear Accelerators using Intensity Modulated Radiation Therapy Mode, Edward J. Waller, Operational Radiation Safety November 2003

Health Physics Aspects of Neutron Activated Components in a Linear Accelerator, Shuntong Guo and Paul L. Ziemer, May 2004

COUNT RATE LIMITATIONS FOR PULSE-COUNTING INSTRUMENTATION IN PULSED ACCELERATOR FIELDS, Alan L. Justus, January 2012, Volume 102, Number 1

Nuclear Regulatory Commission

Title 10 Code of Federal Regulations Parts 19, 20, 30 and 35

NUREG 1556 Volume 9, Revision 3 - Program Specific Guidance About Medical Use Licenses

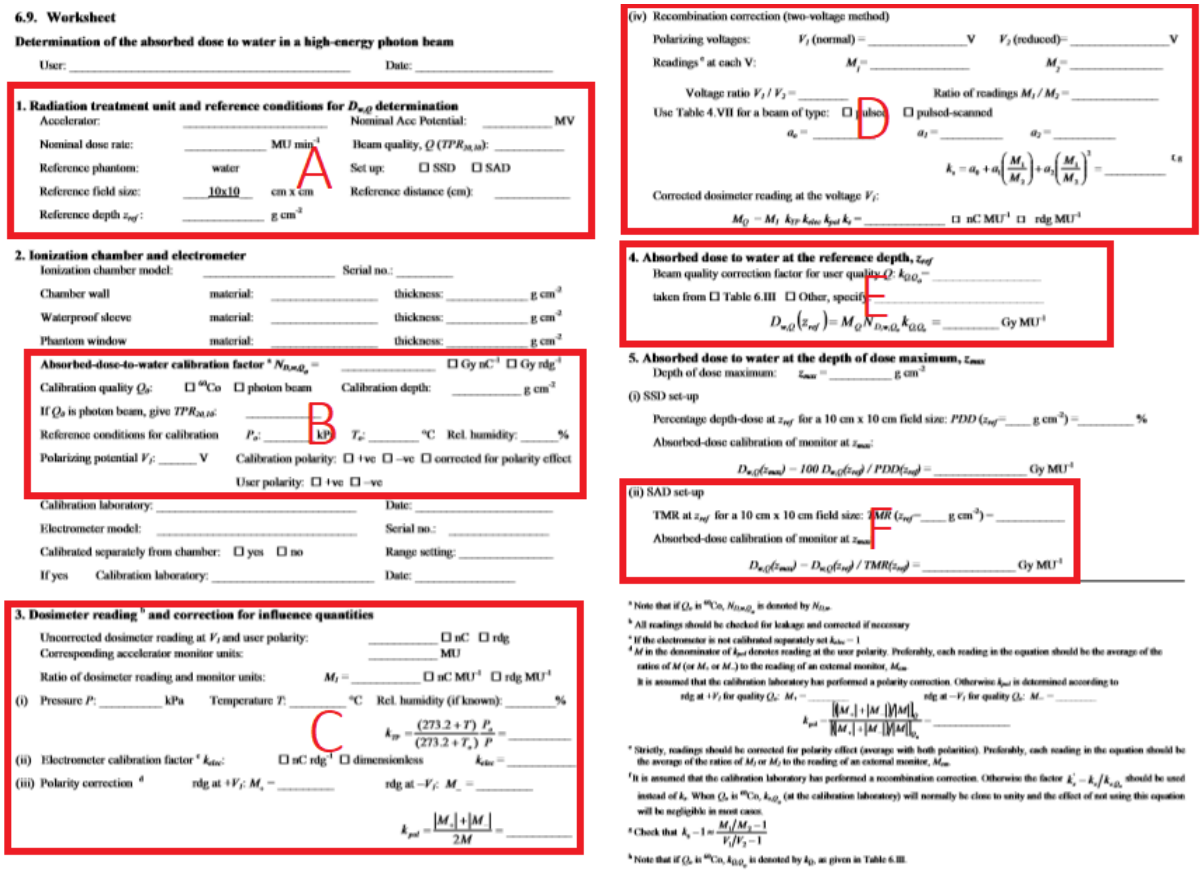
6.0 Exercise Instructions

Exercise 1: Beam Calibration Worksheet

To be completed Day 1: Physics of Linear Accelerators

Worksheet with Quality Assurance prompts to be reviewed by the participants. This worksheet will assist participants in realizing the variables to be tracked during annual QA evaluation of Linear Accelerator Beam Quality, identify the equipment used in obtaining inputs, and practice the math associated.

Form groups of 3-4, and hand each group a copy of the 6.9 Worksheet and the beam calibration exercise and supplement sheets.



6.9. Worksheet

Determination of the absorbed dose to water in a high-energy photon beam

User: _____ Date: _____

1. Radiation treatment unit and reference conditions for $D_{w,Q}$ determination

Accelerator: _____ Nominal Acc Potential: _____ MV

Nominal dose rate: _____ MU min^{-1} Beam quality, Q ($TPR_{20,10}$): _____

Reference phantom: water Set up: ☐ SSD ☐ SAD

Reference field size: 10x10 cm x cm Reference distance (cm): _____

Reference depth z_{ref}: _____ g cm^{-2}

A

2. Ionization chamber and electrometer

Ionization chamber model: _____ Serial no.: _____

Chamber wall material: _____ thickness: _____ g cm^{-2}

Waterproof sleeve material: _____ thickness: _____ g cm^{-2}

Phantom window material: _____ thickness: _____ g cm^{-2}

Absorbed-dose-to-water calibration factor [a] N_{D,w,Q_o} = _____ ☐ Gy nC^{-1} ☐ Gy rdg^{-1}

Calibration quality Q_o: ☐ ^{60}Co ☐ photon beam Calibration depth: _____ g cm^{-2}

If Q_o is photon beam, give $TPR_{20,10}$: _____

Reference conditions for calibration P_o: _____ kPa T_o: _____ °C Rel. humidity: _____ %

Polarizing potential V_1: _____ V Calibration polarity: ☐ +ve ☐ –ve ☐ corrected for polarity effect

User polarity: ☐ +ve ☐ –ve

B

Calibration laboratory: _____ Date: _____

Electrometer model: _____ Serial no.: _____

Calibrated separately from chamber: ☐ yes ☐ no Range setting: _____

If yes Calibration laboratory: _____ Date: _____

3. Dosimeter reading [b] **and correction for influence quantities**

Uncorrected dosimeter reading at V_1 and user polarity: _____ ☐ nC ☐ rdg

Corresponding accelerator monitor units: _____ MU

Ratio of dosimeter reading and monitor units: M_1 = _____ ☐ nC MU^{-1} ☐ rdg MU^{-1}

(i) Pressure P: _____ kPa Temperature T: _____ °C Rel. humidity (if known): _____ %

C

$$k_{TP} = \frac{(273.2+T)}{(273.2+T_o)}\frac{P_o}{P} = _____$$

(ii) Electrometer calibration factor [c] k_{elec}: ☐ nC rdg^{-1} ☐ dimensionless k_{elec} = _____

(iii) Polarity correction [d] rdg at $+V_1$: M_+ = _____ rdg at $-V_1$: M_- = _____

$$k_{pol} = \frac{|M_+| + |M_-|}{2M} = _____$$

(iv) Recombination correction (two-voltage method)

Polarizing voltages: V_1 (normal) = _____ V V_2 (reduced)= _____ V

Readings [e] at each V: M_1 = _____ M_2 = _____

Voltage ratio V_1 / V_2 = _____ Ratio of readings M_1 / M_2 = _____

Use Table 4.VII for a beam of type: ☐ pulsed ☐ pulsed-scanned

D

a_0 = _____ a_1 = _____ a_2 = _____

$$k_s = a_0 + a_1\left(\frac{M_1}{M_2}\right) + a_2\left(\frac{M_1}{M_2}\right)^2 = _____$$ [f,g]

Corrected dosimeter reading at the voltage V_1:

$M_Q = M_1\ k_{TP}\ k_{elec}\ k_{pol}\ k_s$ = _____ ☐ nC MU^{-1} ☐ rdg MU^{-1}

4. Absorbed dose to water at the reference depth, z_{ref}

Beam quality correction factor for user quality Q: k_{Q,Q_o} = _____

taken from ☐ Table 6.III ☐ Other, specify: _____

E

$$D_{w,Q}(z_{ref}) = M_Q N_{D,w,Q_o} k_{Q,Q_o} = _____ \text{ Gy MU}^{-1}$$

5. Absorbed dose to water at the depth of dose maximum, z_{max}

Depth of dose maximum: z_{max} = _____ g cm^{-2}

(i) SSD set-up

Percentage depth-dose at z_{ref} for a 10 cm x 10 cm field size: $PDD(z_{ref}$ = _____ g cm^{-2}) = _____ %

Absorbed-dose calibration of monitor at z_{max}:

$$D_{w,Q}(z_{max}) = 100\ D_{w,Q}(z_{ref}) / PDD(z_{ref}) = _____ \text{ Gy MU}^{-1}$$

(ii) SAD set-up

F

TMR at z_{ref} for a 10 cm x 10 cm field size: $TMR(z_{ref}$ = _____ g cm^{-2}) = _____

Absorbed-dose calibration of monitor at z_{max}:

$$D_{w,Q}(z_{max}) = D_{w,Q}(z_{ref}) / TMR(z_{ref}) = _____ \text{ Gy MU}^{-1}$$

[a] Note that if Q_o is ^{60}Co, N_{D,w,Q_o} is denoted by $N_{D,w}$.

[b] All readings should be checked for leakage and corrected if necessary.

[c] If the electrometer is not calibrated separately set $k_{elec} = 1$.

[d] M in the denominator of k_{pol} denotes reading at the user polarity. Preferably, each reading in the equation should be the average of the ratios of M (M_+ or M_-) to the reading of an external monitor, M_{em}.

It is assumed that the calibration laboratory has performed a polarity correction. Otherwise k_{pol} is determined according to

rdg at $+V_1$ for quality Q_o: M_+ = _____ rdg at $-V_1$ for quality Q_o: M_- = _____

$$k_{pol} = \frac{|M_+| + |M_-|}{|M_+| + |M_-|}_{Q_o} = _____$$

[e] Strictly, readings should be corrected for polarity effect (average with both polarities). Preferably, each reading in the equation should be the average of the ratios of M_1 or M_2 to the reading of an external monitor, M_{em}.

[f] It is assumed that the calibration laboratory has performed a recombination correction. Otherwise the factor $k'_s = k_s / k_{s,Q_o}$ should be used instead of k_s. When Q_o is ^{60}Co, k_{s,Q_o} (at the calibration laboratory) will normally be close to unity and the effect of not using this equation will be negligible in most cases.

[g] Check that $k_s - 1 = \frac{M_1/M_2 - 1}{V_1/V_2 - 1}$

[h] Note that if Q_o is ^{60}Co, k_{Q,Q_o} is denoted by k_Q, as given in Table 6.III.

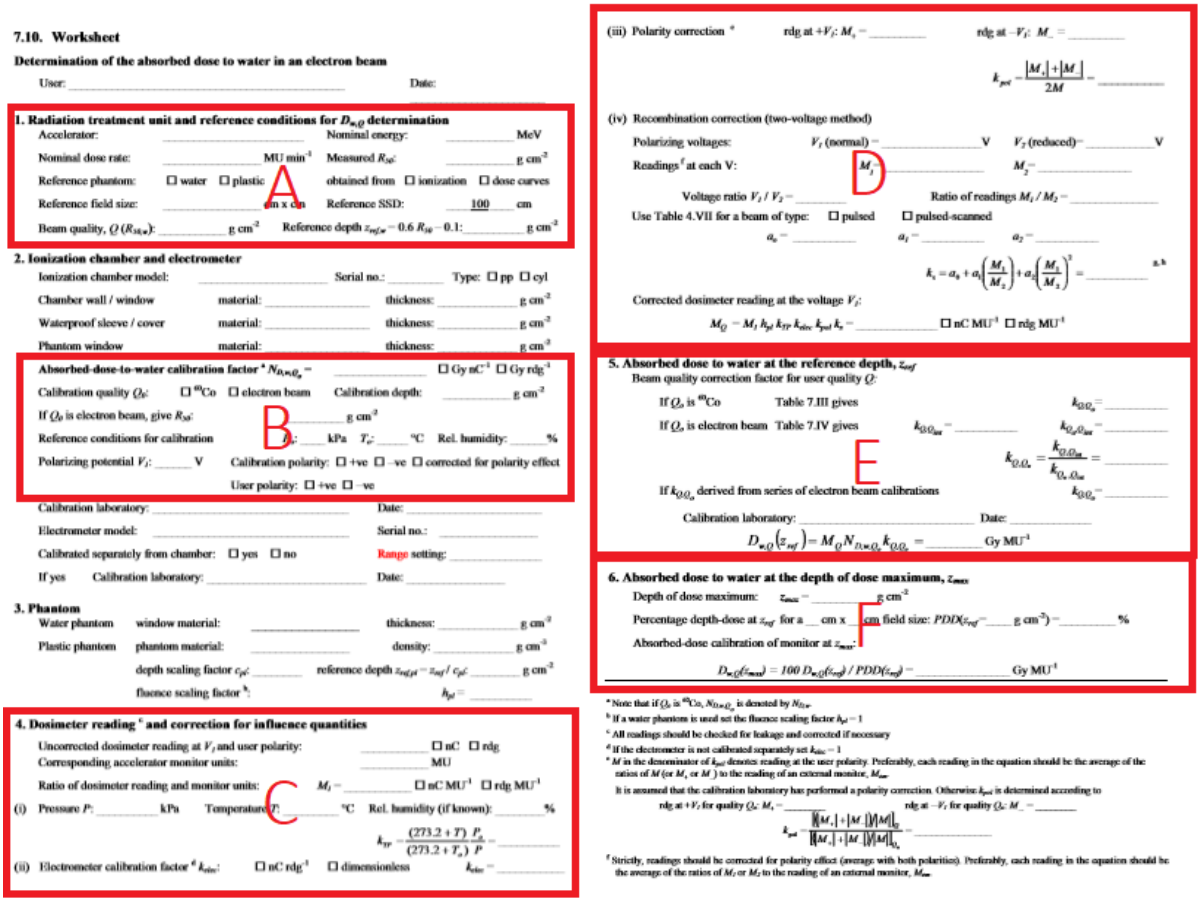
Facilitate them going through the worksheet using the information provided in the exercise while pointing out how the data would be gathered. Allow them to do the work and ask questions, provide help and guidance as needed.

A. This will be a 6MV beam, SAD setup, reference depth zref = 10gcm-2, reference distance = 100cm. TPR20,10 = 0.69. The reference depth is chosen by the facility, the reference depth depends on the beam quality, which if less than 0.7 can be either 5 or 10gcm-2. Using SAD setup

is also the choice of the facility, and must match the setup assumed by the treatment planning system. Mention differences between SSD/SAD.

   a. Section 2 – It could be briefly mentioned that it is expected that a facility provides information on the ion chamber and electrometer, they are the measurement devices that will collect the data we're using to complete this worksheet and must be appropriately calibrated but for learning purposes it's not necessary.

B. Calibration can be done in a cobalt or photon beam, and the calibration depth might differ depending on which one. What's most important for this exercise are ND,w,Q0, the reference conditions for calibration of the ion chamber and the polarizing potential for the electrometer. ND,w,Q0=5.4E7 Gy/C. It may differ depending on the laboratory, so it's important to verify on the calibration document of the chamber, but here reference conditions 20 degrees C and 101.3kPa was used. Here check +ve for both calibration and user polarity.
C. Here is where the actual measurements would be entered.
   a. 100MU and the reading provided in the exercise sheet. Then have the groups calculate the ratio of dosimeter reading and MU.
   b. Have them enter the provided ambient temperature and pressure, then calculate ktp with these, the calibration temperature and pressure, and the provided equation.
   c. They enter the kelec provided, 1.000. This is provided by the calibration laboratory.
   d. Have them calculate the polarity correction using the +300V and –300V readings.
D. Continuation of the last section
   a. For the recombination correction V1 = +300V, V2 = +150V, with the corresponding readings from the information sheet entered below. Then they can calculate the ratios, and using pulsed beam they can look up the three 'a' factors from 4.VII provided in the exercise supplement.
   b. Finally, they will use all the above factors to find MQ.
E. To find kQ they can attempt to read a value off the chart provided in the supplement and TPR20,10, or you can provide a value of 0.989. Then they can calculate Dw,Q.
F. The last step is to find the absorbed dose at zmax = 1.5 cm. Using SAD setup and the TMR (Tissue max ratio, defined as the ratio of the dose at a reference depth to the dose at zmax) at zref which is determined at the time of commissioning . This will give the final Gy/MU calibration
G. Allow reflection on the result. What is the expected result (A: Whatever is input into the TPS, but typically 0.01Gy/MU). What is the tolerance for this result (A: 1%). What might be the proper course of action for the physicist who obtains this result (A: If exceeds tolerance, adjust. If within tolerance adjustment is optional, but acceptable.)



7.10. Worksheet

Determination of the absorbed dose to water in an electron beam

User: _____ Date:

1. Radiation treatment unit and reference conditions for $D_{w,Q}$ determination

Accelerator: _____ Nominal energy: _____ MeV

Nominal dose rate: _____ MU min^{-1} Measured R_{50}: _____ g cm^{-2}

Reference phantom: ☐ water ☐ plastic obtained from ☐ ionization ☐ dose curves

Reference field size: _____ cm x cm Reference SSD: 100 cm

Beam quality, Q ($R_{50,w}$): _____ g cm^{-2} Reference depth $z_{ref,w} = 0.6\,R_{50} - 0.1$: _____ g cm^{-2}

2. Ionization chamber and electrometer

Ionization chamber model: _____ Serial no.: _____ Type: ☐ pp ☐ cyl

Chamber wall / window material: _____ thickness: _____ g cm^{-2}

Waterproof sleeve / cover material: _____ thickness: _____ g cm^{-2}

Phantom window material: _____ thickness: _____ g cm^{-2}

Absorbed-dose-to-water calibration factor [a] N_{D,w,Q_0} = _____ ☐ Gy nC^{-1} ☐ Gy rdg^{-1}

Calibration quality Q_0: ☐ ^{60}Co ☐ electron beam Calibration depth: _____ g cm^{-2}

If Q_0 is electron beam, give R_{50}: _____ g cm^{-2}

Reference conditions for calibration p: ____ kPa T: ____ °C Rel. humidity: ____ %

Polarizing potential V_1: _____ V Calibration polarity: ☐ +ve ☐ –ve ☐ corrected for polarity effect

User polarity: ☐ +ve ☐ –ve

Calibration laboratory: _____ Date: _____

Electrometer model: _____ Serial no.: _____

Calibrated separately from chamber: ☐ yes ☐ no Range setting: _____

If yes Calibration laboratory: _____ Date: _____

3. Phantom

Water phantom window material: _____ thickness: _____ g cm^{-2}

Plastic phantom phantom material: _____ density: _____ g cm^{-3}

depth scaling factor c_{pl}: _____ reference depth $z_{ref,pl} = z_{ref} / c_{pl}$: _____ g cm^{-2}

fluence scaling factor [b]: h_{pl} = _____

4. Dosimeter reading [c] **and correction for influence quantities**

Uncorrected dosimeter reading at V_1 and user polarity: _____ ☐ nC ☐ rdg

Corresponding accelerator monitor units: _____ MU

Ratio of dosimeter reading and monitor units: M_1 = _____ ☐ nC MU^{-1} ☐ rdg MU^{-1}

(i) Pressure P: _____ kPa Temperature T: _____ °C Rel. humidity (if known): _____ %

$$k_{TP} = \frac{(273.2 + T)}{(273.2 + T_o)} \frac{P_o}{P} = ____$$

(ii) Electrometer calibration factor [d] k_{elec}: ☐ nC rdg^{-1} ☐ dimensionless k_{elec} = _____

(iii) Polarity correction [e] rdg at $+V_1$: M_+ = _____ rdg at $-V_1$: M_- = _____

$$k_{pol} = \frac{|M_+| + |M_-|}{2M} = ____$$

(iv) Recombination correction (two-voltage method)

Polarizing voltages: V_1 (normal) = _____ V V_2 (reduced) = _____ V

Readings [f] at each V: M_1 = _____ M_2 = _____

Voltage ratio V_1 / V_2 = _____ Ratio of readings M_1 / M_2 = _____

Use Table 4.VII for a beam of type: ☐ pulsed ☐ pulsed-scanned

a_0 = _____ a_1 = _____ a_2 = _____

$$k_s = a_0 + a_1\left(\frac{M_1}{M_2}\right) + a_2\left(\frac{M_1}{M_2}\right)^2 = ____$$ [a, b]

Corrected dosimeter reading at the voltage V_1:

$M_Q = M_1\, k_{pl}\, k_{TP}\, k_{elec}\, k_{pol}\, k_s$ = _____ ☐ nC MU^{-1} ☐ rdg MU^{-1}

5. Absorbed dose to water at the reference depth, z_{ref}

Beam quality correction factor for user quality Q:

If Q_0 is ^{60}Co Table 7.III gives k_{Q,Q_0} = _____

If Q_0 is electron beam Table 7.IV gives $k_{Q,Q_{ion}}$ = _____ $k_{Q_0,Q_{ion}}$ = _____

$$k_{Q,Q_0} = \frac{k_{Q,Q_{ion}}}{k_{Q_0,Q_{ion}}} = ____$$

If k_{Q,Q_0} derived from series of electron beam calibrations k_{Q,Q_0} = _____

Calibration laboratory: _____ Date: _____

$$D_{w,Q}(z_{ref}) = M_Q N_{D,w,Q_0} k_{Q,Q_0} = ____ \text{ Gy MU}^{-1}$$

6. Absorbed dose to water at the depth of dose maximum, z_{max}

Depth of dose maximum: z_{max} = _____ g cm^{-2}

Percentage depth-dose at z_{ref} for a ___ cm x ___ cm field size: $PDD(z_{ref})$ = _____ g cm^{-2}) = _____ %

Absorbed-dose calibration of monitor at z_{max}:

$$D_{w,Q}(z_{max}) = 100\, D_{w,Q}(z_{ref}) / PDD(z_{ref}) = ____ \text{ Gy MU}^{-1}$$

[a] Note that if Q_0 is ^{60}Co, N_{D,w,Q_0} is denoted by $N_{D,w}$.

[b] If a water phantom is used set the fluence scaling factor $h_{pl} = 1$.

[c] All readings should be checked for leakage and corrected if necessary.

[d] If the electrometer is not calibrated separately set $k_{elec} = 1$.

[e] M in the denominator of k_{pol} denotes reading at the user polarity. Preferably, each reading in the equation should be the average of the ratios of M (or M_+ or M_-) to the reading of an external monitor, M_{mu}.

It is assumed that the calibration laboratory has performed a polarity correction. Otherwise k_{pol} is determined according to

rdg at $+V_1$ for quality Q_0: M_+ = _____ rdg at $-V_1$ for quality Q_0: M_- = _____

$$k_{pol} = \frac{\left|\frac{M_+}{M_{mu}}\right| + \left|\frac{M_-}{M_{mu}}\right|}{2\left|\frac{M}{M_{mu}}\right|_{Q_0}} = ____$$

[f] Strictly, readings should be corrected for polarity effect (average with both polarities). Preferably, each reading in the equation should be the average of the ratios of M_1 or M_2 to the reading of an external monitor, M_{mu}.

A. The next portion of the exercise is very similar, for 18MeV electron beams. The measured R50 is provided on the exercise. Reference field size can vary up to 20X20cm2, here use 10x10cm2. The beam quality Q(R50) ~0.9 can be determined from the figure provided in the supplement and the reference depth zref can be calculated based on the provided R50. R50 is determined at the time of commissioning based on depth dose, the depth at which dose reaches 50%. Note this is SSD method.

B. Again it's ND,w,Q and the reference conditions/polarizing potentials that are important. These are all the same values as last time.

C. Skip section 3, we're assuming a water phantom with no window material. Section 4 is the same again as with photons. Assume hpl=1.0.

D. This section is the same as the photon exercise.

E. This can be discussed briefly, but just use kQ,Q0= ~0.9, what was determined in A. Calculate Dw,Q(zref). You can go back to how zref was determined in A, calculated based off of R50.

F. Finally, zmax = 3.0gcm-2. The PDD for the 10x10field at zref is provided. From this information the dose at zmax can be calculated. Reflect on the result as in the photon calculation.

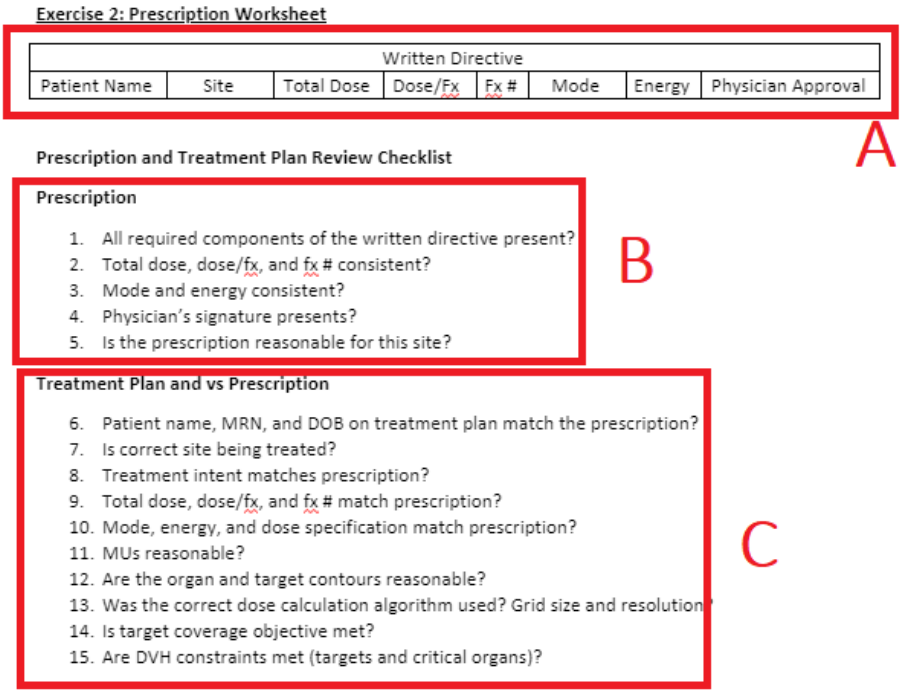
Exercise 2 Prescription Procedures

To be completed Day 2: Regulations and Licensing of Linear Accelerators

Worksheet with Treatment Control Prompts to be filled out by the participants. This worksheet will assist participants in realizing the personnel and checks and balances associated with treatment planning, treatment planning systems, and treatment delivery.

Hand out the checklist, prescriptions, and the two treatment plan reports to each student.

A. First on the checklist review the information included in written directives.
B. Then using the prescription checklist, look at the first prescription on the prescription sheet and have each individual go through and answer the questions, identifying mistakes as they review. Note with item #5 that in the US the practice of medicine is not regulated, and thus this would not be an item for inspectors but is important for clinical plan reviewers.
C. Then have them go through the treatment plan report, comparing it to the prescription with items 6-10 in mind. Again, items 11-15 are given as examples of what a clinical plan review might include, but they are not expected to be able to answer. Item 14 in this case can be checked with the information provided.
D. Finally repeat steps 2 and 3 for the next prescription.



Exercise 2: Prescription Worksheet

Written Directive							
Patient Name	Site	Total Dose	Dose/Fx	Fx #	Mode	Energy	Physician Approval

A

Prescription and Treatment Plan Review Checklist

Prescription

1. All required components of the written directive present?
2. Total dose, dose/fx, and fx # consistent?
3. Mode and energy consistent?
4. Physician's signature presents?
5. Is the prescription reasonable for this site?

B

Treatment Plan and vs Prescription

6. Patient name, MRN, and DOB on treatment plan match the prescription?
7. Is correct site being treated?
8. Treatment intent matches prescription?
9. Total dose, dose/fx, and fx # match prescription?
10. Mode, energy, and dose specification match prescription?
11. MUs reasonable?
12. Are the organ and target contours reasonable?
13. Was the correct dose calculation algorithm used? Grid size and resolution?
14. Is target coverage objective met?
15. Are DVH constraints met (targets and critical organs)?

C

Patient Name:	Wilhelm Roentgen		MRN:	000258		DOB:	3/27/1972
Diagnosis:	C01 – Malignant Neoplasm of Base of Tongue					Prior Tx:	None
Chemotherapy:	Concomitant Cisplatin					Intent:	Curative
Written Directive							
Site	Technique	Total Dose	Dose/Fx	Fx #	Mode	Energy	Dose Spec
Base of Tongue	VMAT	70 Gy	2 Gy	35	Photon	6MV	PTV D95%
High Risk Nodal		63 Gy	1.8 Gy				
Low Risk Nodal		56 Gy	1.6 Gy				



B

_____

Marie Curie, M.D.

Approved on 3/29/2020 at 11:11

Patient Name:	Henri Becquerel		MRN:	371010		DOB:	12/15/1971
Diagnosis:	C61 – Malignant Neoplasm of Prostate					Prior Tx:	None
Chemotherapy:	No					Intent:	Curative
Written Directive							
Site	Technique	Total Dose	Dose/Fx (Gy)	Fx #	Mode	Energy	Dose Spec
Prostate	VMAT	81 Gy	2 Gy	45	Electrons	6MV	PTV D95%
		54 Gy	30 Gy	1.8			
Lymph Nodes		45 Gy	1.8 Gy	25			

D

_____

Marie Curie, M.D.

Approved on 2/20/2020 at 20:20

Treatment Plan Report

Patient Name: Wilma Roentgen MRN: 000258 DOB: 3/27/1970 Treatment Intent: Palliative	Total Dose: 70 Gy Dose per Fraction: 35 Gy Number of Fractions: 2 Dose specification: 95% Isodose Line

Treatment Field Information

Field Name: Field 1 Technique: VMAT Gantry Start/Stop: 179/181 degrees Gantry Direction: Clockwise Collimator Rotation: 30 degrees Table Rotation: 0 degrees Energy: 18MV MU: 325 X Field Size: 13 cm X1: 7 cm X2: 6 cm Y Field Size: 18 cm Y1: 9 cm Y2: 9 cm	Field Name: Field 2 Technique: VMAT Gantry Start/Stop: 181/179 degrees Gantry Direction: Counter-Clockwise Collimator Rotation: 330 degrees Table Rotation: 0 degrees Energy: 18MV MU: 336 X Field Size: 14 cm X1: 7 cm X2: 7 cm Y Field Size: 19 cm Y1: 10 cm Y2: 9 cm

Dose Statistics – Summation (Prostate Boost/SemVess Boost/Full PTV)

Organ	Max Dose (Gy)	Min Dose (Gy)	Mean Dose (Gy)	D95% (Gy)
PTV Primary_70	73.2	65.3		68.5
PTV High Risk_63	71.8	63.5		63.3
PTV Low Risk_56	68.9	54.5		58.4
Larynx	56.8	54.5	55.1	
Parotids	64.2	13.4	21.3	
Spinal Cord	44.6	0.6	6.6	
Brainstem	49.8	10.4	23.2	

Exercise 3 Licensing Checklist

To be completed Day 2: Regulation and Licensing of Linear Accelerators

Worksheet with Licensing Requirements to be filled out by the participants. This worksheet will assist participants in realizing the items that should be included in a license application. Splitting into groups of three the participants should pick an accelerator and begin to fill out the application using information from class and the internet. This will assist reviewers with learning to verify submitted information about linear accelerators, and the required information for each phase. If a group cannot propose suggested information, a substitute can be to explain the safety significance of the section and the controls that are attempted to be made. At the end of the hour each group should present their thoughts to the class.

Exercise 3 – Licensing Application

1	**Facility Name:**
2	**Facility Address:** A
3	**Correspondence Address/Phone Number:**
4	**Authorized Personnel that may correspond on behalf of this license (attach management delegation):**
5	**Proposed Radiation Safety Officer and Credentials:**
6	**Proposed Medical Physicist and Credentials:**
7	**Proposed Responsible Physician and Credentials:**

8 Accelerator Description: B

- **Make:**
- **Model:**
- **Serial Number:**
- **Manufacture Year:**
- **Remanufactured Year:**
- **On Board Imaging CT: Yes ☐ No ☐**

9. Maximum Accelerator Energy Data:

- **Electrons** _____ **MeV**
- **Photons** _____ **MV**
- **FFF Photons** _____ **MV**
- **Other Particles** _____
- **Other Particle Energy** _____ **MeV**

10 Describe use of the medical accelerator and applicable radiation safety procedures.

- ☐ **Shielding Evaluation and Acceptance Testing only**
- ☐ **IORT**
- ☐ **IMRT**
- ☐ **Arc Therapy**
- ☐ **Stereotactic (SRS, SRT, SBRT)**
- ☐ **Other (explain)** _____

11 Facility Diagram: Attach a site layout drawing depicting location of each accelerator vault, room number, and operating consoles. At a minimum indicate the following on the diagram: C

- Function and type of occupancy of all areas above, below and adjacent to the accelerator vault.
- Accelerator location and gantry positions
- Location of: Scram buttons, independent radiation monitors, viewing and communication system components

Describe: the independent radiation monitor (make, model and any maintenance testing); beam stop system, identify Recorder/Verifier (Make model and functions involved); any door interlocks (location and if "failsafe"/can be opened from inside), viewing and communication system to the patient

12 Shielding Evaluation: Using IAEA TecDoc 47 Provide shielding evaluation of each bunker demonstrating protection of public and workers. If the accelerator is capable of energies of >10 MeV neutron shielding must be addressed. D

13 Shielding Verification: Submit actual survey result that validate adequacy of the shielding. Include survey meter make model and calibration certificate and name of individual completing the survey. If the accelerator is capable of energies of >10 MeV survey measurements must include neutron fluence. E

14 Quality Assurance Program and Procedures: F

Identify:

- Method for independent biannual check of output
- Equipment available for QA measurements of the Linear Accelerator Beam

Describe:

- Procedure for independent biannual check of output
- Annual calibration procedures
- If a daily warm up is done every morning by the therapists/physicist
- Daily and Monthly checks, including personnel responsibilities for completing the check and review of results
- Include tolerance for each check and corrective actions for failed checks

15 Radiation Safety Program: Describe the following: G

- Disposal of the accelerator
- Prescription Control procedures: what type of patient log book/daily schedule will be kept, how are deviations from the prescription identified, reported and reviewed, How often patient charts are reviewed by a physicist to verify calculations of dose totals, how often the patients are seen by the responsible physician, and annual program review
- Describe occupational monitoring, including any surveys or area monitoring
- Initial and recurrent training for operators, include agenda of topics
- Emergency Procedures and commit to posting a copy of your emergency procedures near the accelerator control panel. Emergency procedures should not be covered or obscured by non-emergency related postings.

A. Responsible personnel credentials are key, this is reviewed on day 3.
B. Selecting the accelerator and realizing how to verify the maximum energy output and capabilities on the internet. If submitted information does not match that possible, the licensee should submit documentation as to why and how they will control the energy usage (i.e. the machine is no long capable of X MeV electrons, provide the manufacturer's report)
C. Draw a facility diagram and discuss occupancies of the areas around. Shielding is discussed at length Day 3. Occupancy is described as number of hours a person may be present throughout the day divided by 24. Certain areas have suggested occupancy values in TecDoc 47 (i.e. door or hallway 1/8, public area 1).
D. Shielding evaluation this is where the shielding calculations from tecdoc 47 should be presented (discussed Day 3). This is theoretical based on the energy of the equipment and the patient load. Discuss expected patient loads. Discuss this at a high level, how many patients do current sites see per day? Per week? Has that ever been evaluated? Do neutrons need to be considered in the evaluation based on the machine capabilities?
E. Shielding verification is the actual survey, students should annotate the facility diagram to document a survey and discuss under what parameters the survey should be done (During acceptance testing when beam is on the highest energies and rotated through all the gantry positions). What kind of meter should be used to do the survey? Where may there be unexpected results? What are potential reasons a survey could fail? When should the survey be submitted for review?
F. Quality assurance plans should be consistent with American Association of Physicist in Medicine standards. Equipment necessary to do calibration and checks should be available and identified as well as calibration frequencies and corrective actions. This was reviewed on Day 1, have students write an outline of a machine quality assurance program and identify corrective actions.
G. Radiation Safety Controls are typically implemented or overseen by the radiation safety officer. Prescription controls were just discussed in the previous section. Outline a quality management program using the prompts and previous discussion. What should be included in annual safety training? Who should receive training? What would an annual audit contain, who should perform and review the annual audit?

Exercise 4 User Qualification Review

To be completed Day 3: User Qualifications and Shielding of Linear Accelerators

Worksheet with Training Prompts to be filled out by the participants. This worksheet will assist participants in realizing what training should be required for responsible physicians, medical physicists and radiation safety officers.

Exercise 4 – User Qualification Worksheet

Responsible Physician Training and Experience			
1 **Date of Application:**			
2 **Name of Proposed Responsible Physician:**			
Certifications			
3 **Attach copies of Diplomas and/or Certifications held** A			
Training and Experience			
4 **Classroom and Laboratory Training:**			
Description of Training	**Location of Training**	**Clock Hours**	**Dates of Training**
Radiation physics and instrumentation			B
Radiation protection			
Mathematics pertaining to the use and measurement of radiation			
Radiation Biology			
5 **Total hours of classroom and laboratory training:**			
6 **Supervised Work and Clinical Experience:**			
Clinical experience in radiation oncology as part of a formal training program	**Location of Training**	**Clock Hours**	**Dates of Training**
Preparing treatment plans and calculating monitor units			
Using administrative controls to prevent a reportable event			
Emergency procedures			
Selecting the proper dose and how it is administered			
7 **Total hours of training:**			
8 **Supervising Responsible Physician:**			
9 **Device Specific Training :**			
Description of Training	**Location of Training**	**Clock Hours**	**Dates of Training**
Device operation (Identify: Make Machine and Model)			
Safety procedures for the device used			
Clinical use of the device			
10 **Total hours of training:**			

11 **Applicant Attestation:** confirm, I have completed three (3) years of full time training and one (1) year of full time work experience as a responsible physician (signature and date)

I confirm that the information submitted is true and factual (signature and date) C

A. Physician should graduate from medical school and have subsequently completed a residency in radiation oncology. Accredited programs are standardized against international standards to the most practical extent. Accreditation can be verified online, and the accrediting body will provide a syllabus of required training topics and time spent on those topics.
B. These are typical topics trained in. The radiation regulator does not regulate medicine but rather the safe use of the radiation.
C. The attestation includes a time period typical of accredited radiation oncology residency programs. The graduate should have one year of experience under a current responsible physician before application to ensure initial errors and corrective actions are encountered under the supervision and with the available assistance of a more experienced physician.

Exercise 4 – User Qualification Worksheet

Medical Physicist Training and Experience			
1	**Date of Application:**		
2	**Name of Proposed Medical Physicist:**		
Certifications			
3	**Attach copies of Diplomas and/or Certifications held**		
Training and Experience			
4	**Classroom and Laboratory Training**		
Description of Training	**Location of Training**	**Clock Hours**	**Dates of Training**
Medical Physics			
Performing Full Calibration of Linear Accelerators			
Performing Monthly and Daily Sport Checks of Linear Accelerators			
Conducting radiation surveys around Linear Accelerators			
5	**Total hours of classroom and laboratory training:**		
6	**Device Specific Training**		
Description of Training	**Location of Training**	**Clock Hours**	**Dates of Training**
Hands-on device operation			
Safety procedures for device use			
Clinical use of the device			
Treatment Planning system operation			
7	**Total hours of training:**		
8	**Supervising Medical Physicist:**		
9	**Applicant Attestation:** I confirm, I have completed one (1) year of full time training and one (1) year of full time work experience as a medical physicist (signature and date) and I confirm that the information submitted is true and factual (signature and date)		

D. Medical physicists should graduate from medical physics or physics masters or doctorate program and have subsequently completed a residency with linear accelerators. Accredited programs are standardized against international standards to the most practical extent. Accreditation can be verified online, and the accrediting body will provide a syllabus of required training topics and time spent on those topics.

E. The medical physicist is essential in the control of the quality of the beam. Significant classroom and hands on experience is necessary to ensure safety of the patient and users.

F. The attestation includes a time period typical of accredited medical physics residency programs. The graduate should have one year of experience under a current medical physicist before application to ensure initial errors and corrective actions are encountered under the supervision and with the available assistance of a more experienced physician.

Exercise 4 – User Qualification Worksheet

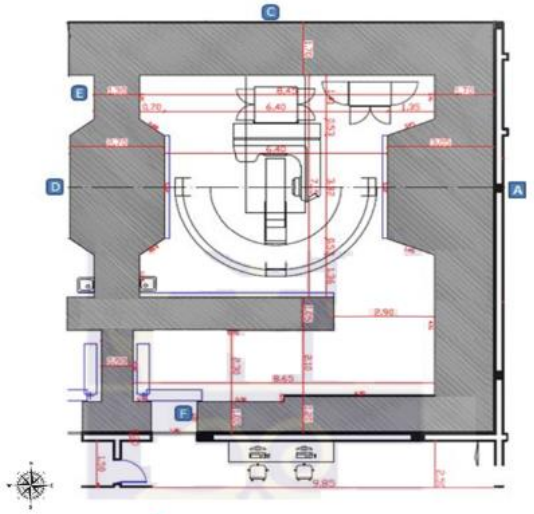
Radiation Safety Officer Training and Experience			
1	**Date of Application:**		
2	**Name of Proposed Radiation Safety Officer:**		
	Certifications		G
3	**Attach copies of Diplomas and/or Certifications held**		
	Training and Experience		
4	**Classroom and Laboratory Training**		
Description of Training	**Location of Training**	**Clock Hours**	**Dates of Training**
Radiation physics and instrumentation			H
Radiation protection			
Mathematics pertaining to the use and measurement of radiation			
Radiation Biology			
Radiation Dosimetry			
Regulations regarding safe use of Linear Accelerators			
5	**Total hours of classroom and laboratory training:**		
6	**Device Specific Training**		
Description of Training	**Location of Training**	**Clock Hours**	**Dates of Training**
Using and performing checks for proper operation of survey meters			
Using administrative controls to avoid mistakes in administration of radiation			
Emergency Procedures			
7	**Total hours of training:**		
8	**Supervising Radiation Safety Officer:**		
9	**Applicant Attestation:** I confirm, I have completed 200 hours of training and one (1) year of full time work experience as a radiation safety officer (signature and date) and I confirm that the information submitted is true and factual (signature and date)		I

G. Radiation Safety Officers typically graduate from physics, biology or other science degrees and rely on on-the-job training. There are limited health physics or radiation safety degrees available internationally.
H. These are typical topics trained in. The radiation safety officer should understand regulation and control of radiation (including measuring radiation to ensure controls are in place and functioning).
I. The attestation includes a time period typical of training and experience. The prospective radiation safety officer should have one year of experience under a current radiation safety officer before application to ensure initial errors and corrective actions are encountered under the supervision and with the available assistance of a more radiation safety officer.

Exercise 5 Shielding Worksheet

To be completed Day 3: User Qualifications and Shielding of Linear Accelerators

Worksheet with Shielding Prompts to be filled out by the participants. This worksheet will assist participants in understanding the variables used in a Shielding Calculation and practice the math associated with the equations in IAEA report 47.



A

For the facility shown in the diagram above, determine if the shielding is sufficient based on weekly dose rates at points C and D considering the following information:

The facility treats an average of 20 patients daily

The average dose per patient is 2Gy at isocenter

The typical QA load is 20Gy per week

Assume just 6MV is used

Assume that all barriers are irradiated equally

Point D is their CT simulator vault

Point C is near a walkway for staff only to enter and exit the building

B

For 18MV

The TVL for concrete is 343mm for the primary beam and 279mm for the secondary beam

The scatter fraction 'a' for patient scatter calculations is 7.27e-4 - assume F = 400cm2 field

The scatter fraction alpha for wall scatter fractions at a 45 degree reflection angle is 4.76e-3

C

PRIMARY BARRIERS

$$B = \frac{P(d+\mathrm{SAD})^2}{WUT}$$

$$\text{No. of TVLs} = \log_{10}\left(\frac{1}{B}\right)$$

Leakage radiation

$$B_L = \frac{1000Pd_L^2}{WT}$$

Scattered radiation

$$B_p = \frac{Pd_{sca}^2 d_{sec}^2}{aWT(F/400)}$$

Break the class into groups of 3-4 and hand each group one of these worksheets. It has all the information needed to complete this exercise.

A. Point out the barriers of interest and discuss if they are primary or secondary barriers (C is secondary, D is both)
B. Read through the provided information to give an overview of what is available. They will refer back to this.
C. The equations needed to perform the exercise are provided here. They should calculate each item step by step, then come to a final answer regarding the required thickness using the two source rule for leakage/scatter, and for the primary barrier to account for primary beam and scatter. Then compare that to the provided thickness and discuss whether the design is sufficient. If it provides vastly more protection than needed, discuss why that might be, what might this vault have been designed for (18MV energies require more shielding, we calculated for 6MV).

Exercise 6 IAEA Inspection Checklist

To be completed Day 4: Inspection of Linear Accelerators

IAEA inspection Checklist to be filled out by the participants. This worksheet will assist participants in understanding the criteria in the checklist and realizing the items to be noted after inspection for documentation.

If there is a local procedure for inspections this should be reviewed instead and/or compared to the suggested items to review from the IAEA.

5. RESPONSIBILITIES

Justification [BSS App. II]

	Yes	No
All treatments authorized by appropriately Qualified Practitioners?		
An appropriately Qualified Practitioner is designated as having overall responsibility for patient protection and safety?		
If yes, practitioner's name?		
Does this Qualified Practitioner ensure that procedures are justified?		
If yes, how is this achieved?		
All patient have an individual treatment planning performed by a Medical Physicist?		
If yes, Medical (or hospital) Physicist's name?		
Is always at least one radiotherapist present at the facility while patients are being irradiated?		
Are satisfactory procedures in place to properly identify patients before treatment?		
Does the facility undertake research involving exposure of patients to radiation?		

6. TRAINING AND INSTRUCTION OF WORKERS

Training and retraining requirements and documentation; interviews and observations of routine work; staff knowledge of all routine activities, and emergency response

	Yes	No
All personnel using radiation sources have recognized qualifications?		
All occupationally exposed personnel are provided with initial safety training?		
Refresher radiation safety training is provided periodically?		
Supervision of personnel (e.g. technologists) by specialist Medical Practitioners is satisfactory?		
Training records kept for each worker?		
Interviews with workers demonstrate an appropriate knowledge of safe working rules and emergency procedures (e.g. source recovery?)		

7. INTERNAL AUDITS AND REVIEWS

	Yes	No
Operator reviews the radiation protection programme at appropriate intervals?		
Audits of the facilities, source inventory, working rules and emergency procedures performed at appropriate intervals?		
Audits conducted by		
Frequency		
Records of program reviews and audits maintained?		

8. FACILITIES AND RADIATION SOURCES

Facilities as described; uses; control of access; engineering controls; calibration facilities; shielding [BSS Section 2.34]

	Yes	No
FACILITIES		
Facilities are as described in the authorization application?		
Radiation sources are secured so as to prevent unauthorized use and removal?		
Access to controlled areas by unauthorized persons properly supervised?		
Suitable emergency equipment for radioactive source recovery is available?		
Fire protection satisfactory?		
COMPLIANCE, MAINTENANCE, AND REPAIR (Quality Control)		
The design and performance characteristics of radiation devices, whether using radioactive sources or electrically generated radiation, comply with relevant IEC/ISO standards or other requirements of the Regulatory Body?		
Radiation devices are subject to regular QC tests to ensure continued compliance?		
If so, at what frequency; by whom; date of last test?		
Radiation devices are subject to routine maintenance by authorized service agents?		
If so, at what frequency, by whom; date last maintenance		
Records of compliance tests, maintenance, inspection and service maintained?		

OPERATING CHECKS AND CALIBRATION		
Appropriate checks of the performance and functionality of radiation devices and their associated safety equipment have been prescribed by a medical physicist and are carried out daily and at other suitable periods (where relevant to the device)?		
These checks are performed by the Medical Physicist or the results of these checks are reviewed by him/her within the day?		
Radiation devices are calibrated using acceptable protocols?		
A complete calibration of each device is performed		
- before the device is first used for patient treatment?		
- routinely at prescribed intervals acceptable to the Regulatory Body?		
- if routine operating checks show output variations outside established limits?		
- after major repair or modification?		
- using instruments with calibrations traceable to an approved standard?		
- by a Medical Physicist recognized by the Regulatory Body?		
Records of operating checks and calibrations are maintained?		

10. AREA RADIATION SURVEYS AND CONTAMINATION CONTROL

Radiological surveys; leak tests; inventories; handling of radioactive materials; records; contamination control [BSS - Section I.38]

	Yes	No
Operator possesses appropriate, functioning survey instrument(s)?		
Suitable function checks are performed on instruments prior to use?		
Survey meter calibrations are current?		
Survey meter calibration is performed by an approved facility?		
Name of facility		
Area exposure rate surveys are performed at appropriate intervals?		
Surveys for removable contamination conducted as required?		
Records of calibrations, contamination surveys, etc. maintained?		
Comments:		

11. PERSONNEL RADIATION MONITORING

Radiation protection program with ALARA provisions; dosimetry; exposure evaluations; dose and survey records and reports; notifications to workers] [BSS – Schedule II]

	Yes	No
Operator provides personal dosimeters to all radiation workers?		
Dosimetry supplier is an authorized provider?		
Name of provider		
Dosimeters provided are appropriate for the radiation type and energy?		
Dosimeters are exchanged at the prescribed period?		
Dosimetry reports are promptly reviewed by the RPO?		
Is it evident that personal dosimeters are being worn by workers?		
Individual workers are informed of their monitoring results when each monitoring report is received (regardless of the dose measured)?		
Does the operator apply the optimization principle (ALARA) to occupational exposure?		
Personnel monitoring records are maintained?		
Inspector reviewed personnel monitoring records for the period from/ to		

FACILITIES. Where relevant, are the following operational		
- room entrance barrier/door interlock system?		
- waning signs satisfactory?		
- photon/electron selection and any other beam parameter interlocks?		
- area radiation monitor(s)?		
- beam ON indication?		
- patient viewing and intercom systems?		
OPERATION		
Is the device restricted to particular orientations and/or gantry angles?		
If so, is operation prevented in other orientations?		
OPERATING PROCEDURES		
Operating procedures (in the local language) located at the control console?		
Procedures include response to emergencies or abnormal situations?		
Emergency response telephone numbers clearly displayed?		
Patient is sole occupant in the treatment room during treatment?		
All patients have an individual dosimetric treatment planning performed by the Medical Physicist?		
Qualified staff (Medical Physicist, Radiation Oncologist etc.) physically present throughout all treatments with a gamma stereotactic/radiosurgery devices?		
OPERATIONAL CHECKS AND CALIBRATION		
Were operational checks performed before use today (or when last used)?		
Was any operational fault detected at that check?		
If yes, was appropriate corrective action taken?		
Date last fully calibrated?		
Records confirm checks, calibrations and related actions?		

For each item A-N, assign a student to that section. For each item in their section the student should note whether they might obtain the information through a records review, interview, or observation by marking it with a R, I, or O, respectively.

Then each student should select two items and give a specific example of the record they might request, the question they might ask and of whom, or the job function they might observe to obtain the information in the checklist. Give them 5 minutes to complete this.

Then give each student 1-2 minutes in alphabetical order by section to read their items and how to inspect them, as well as the 2 more detailed responses to the class. After each section give a moment for other students to comment, or make any comments or corrections yourself.

Exercise 7 Medical Event Report

To be completed Day 5: Linear Accelerator Medical Events and Emergencies

Worksheet with Medical Event Prompts to be filled out by the participants. This worksheet will assist participants in realizing the items to be tracked during a Medical Event Investigation and the purpose of each item. The students should “report” an accident discussed during the class and realize the utility of each section of the worksheet.

Exercise 7 – Medical Event Report

1	**Date of Report:**
2	**Name of Person Reporting Event:**
3	**Date of Event:**

A

4	**Facility Name:**
5	**Facility Address:**
6	**Location of Accelerator (room number):**
8	**Correspondence Address/Phone Number:**
9	**Radiation Safety Officer:**
10	**Medical Physicist:**
11	**Responsible Physician:**

B

12	**Accelerator Description:** **Make:** **Model:** **Serial Number:** **Manufacture Year:** **Remanufactured Year:** **On Board Imaging CT: Yes ☐ No ☐**	11	**Maximum Accelerator Energy Data:** **Electrons** ____ **MeV** **Photons** ____ **MV** **FFF Photons** ____ **MV** **Other Particles** ____ **Other Particle Energy** ____ **MeV**

12 **Describe use of the medical accelerator during the incident:**

- ☐ **Quality Assurance Testing**
- ☐ **IORT**
- ☐ **IMRT**
- ☐ **Arc Therapy**
- ☐ **Stereotactic (SRS, SRT, SBRT)**
- ☐ **Other (explain)**

13 **Brief Description of the Event:**

a) When and how did you become aware of the event?
b) What details of the event classified the event as reportable (i.e. what limits were exceeded)?
c) Why did the event occur?
d) The effect, if any, on the individual(s) who received the administration

C

14 **Corrective Actions:** What actions, if any, have been taken or are planned to prevent recurrence?

D

15 **Notifications:**

a) Did you notify the affected individual of the event, if not, why not?
b) Did you notify the referring physician, if not, why not?

E

A. Administrative information; range from date of event and date of report should have a limit of 15-30 days (in regulation)
B. Facility information; tracking trends such as frequent events at a given facility, if unaddressed violations lead to events; verifying inspection completeness; consistent personnel involved in events; determine root causes relating to personnel training and qualification at facility, determine root cases relating to a certain make or model of linear accelerator in a particular mode
C. Details event information; what happened and the results of the facility's root cause analysis
D. Corrective actions should stem from the root cause to follow up on, regulator can determine that the corrective action is not sufficient if proven previously ineffective, must verify on the next inspection, inspection cycle can be shortened.
E. Notification of the patient and referring physician as treatment may not be effective and a change in treatment plan may be necessary.