Radiation Safety

relating to veterinary medicine and animal health technology in California

2012

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Section 1:

Effects of Radiation to the Body

Radiation injures tissue by ionizing molecules within body cells, that is, depositing energy and causing an electron or electrons to be removed from an atom of the molecule. These ionized molecules may be inactivated and cell death may result. There is a greater variation in the response of different tissues to radiation. The cells most sensitive to radiation are those which divide the most actively-examples include: epithelium, hematopoietic cells, cells lining the small intestine, and reproductive cells. The fetus is particularly sensitive to radiation. Cells more resistant to the effects of radiation include those cells which do not actively divide such as nerve and muscle cells.

Ionizing radiation can cause both somatic and genetic damage. An example of somatic damage is a squamous cell carcinoma developing on the hand of an individual who received a high level of radiation exposure to the hand. Genetic damage produces injury to the reproductive cells of the exposed individual. Such damage may result in birth defects in children born to the exposed person (Birth defects may also appear in children born in later generations).

The effects of radiation may be demonstrated almost immediately, or they may be latent and not observed for a long period of time. Examples of immediate effects of radiation include erythema of the skin following radiation therapy. Latent effects develop slowly and may not become apparent until years after the exposure. Slowly developing cataracts in the eyes of a person with small but chronic exposure to radiation could exemplify the latent effects of radiation exposure.

The radiation risks of most concern to veterinary radiographers are the sensitivity of unprotected areas of the body (i.e. the lens of the eye) and the cumulative effects of radiation. Although the cumulative effects of radiation are less understood than the effects of a single massive dose of radiation to the whole body, the repeated exposure of an individual to small amounts of radiation day after day can add up to potentially harmful levels.

Chronic exposure of individuals to low levels of radiation is believed to produce the following effects:

- Increase in the incidence of neoplasia.
- Specific increase in the incidence of squamous cell carcinoma.
- Increase in the frequency of occurrence of leukemia.
- Premature aging.

Responsibilities of the licensed veterinarian

- Following California Code of Regulations requirements including the federal standards of protection against radiation and applicable dose limits as incorporated by reference in Section 30253 of the California Code of Regulations (CCR), Title 17.
- Providing the employee with reasons for the requirements.

- Veterinarians are not required to provide individual monitoring devices unless employees are likely to receive a radiation dose in excess of 10 percent of the listed limit during one year. Most veterinarians have elected to provide individual monitors, however, other means of monitoring exposure are acceptable.
- Explaining the available options for protecting the embryo/fetus.

Considerations for occupationally exposed women of childbearing age

California Code of Regulations, Title 17, Section 30255 states that each California licensed veterinarian must instruct occupationally exposed individuals (veterinary radiographers) of the health protection problems associated with radiation. A special situation arises with occupationally exposed women of childbearing age. Precaution should be taken by limiting exposure to young women, especially if they are pregnant. X-ray exposure to the abdomen of such workers would involve a radiation dose to the embryo or fetus.

Reasons for these requirements

Some studies have shown that there is an increased risk of leukemia and other cancers in children if the expectant mother was exposed to a significant amount of radiation. Women employees must be aware of possible risks so they can take appropriate steps to protect their offspring.

Considerations for the embryo/fetus

Regulatory provisions (10 CFR 20, Section 20.1208):

- The licensed veterinarian shall ensure that the dose to an embryo/fetus during the entire pregnancy, due to occupational exposure of a declared pregnant woman, does not exceed 0.5 rem (500 millirems or 5 milli Seiverts (mSv)).
- The licensed veterinarian shall make efforts to avoid substantial variation above a uniform monthly exposure rate to a declared pregnant woman so as to satisfy the limit in paragraph (a) of Section 20.1208.
- The dose to an embryo/fetus shall be taken as the deep dose equivalent to the declared pregnant woman.
- If the dose to an embryo/fetus is found to have exceeded 0.5 rem (5 mSv), plus or minus 0.05 rems, by the time the woman declares the pregnancy to the licensed veterinarian, the veterinarian shall be deemed to be in compliance with paragraph (a) of Section 20.1208 if the additional dose to the embryo/fetus does not exceed 0.05 rems (0.5 mSv) during the remainder of the pregnancy.
- Once a woman declares her pregnancy in writing, the radiation dose of the embryo/fetus shall be no greater than 0.05 rems (50 millirems) in any month (excluding medical exposure).

Female employees should be aware of the following facts:

- The first three months of pregnancy are the most important as the embryo/fetus is most sensitive to radiation at this time.

- In most cases of occupational exposure, the actual dose received by the embryo/fetus is less than the dose received by the mother, because some of the dose is absorbed by the mother's body.
- At the present occupational dose equivalent limits, the risk to the unborn baby is considered to be small, but experts disagree on the exact amount of risk.
- There is no need for women to be concerned about sterility or loss of ability to bear children from occupational exposure that is within legal limits.
- Once a woman declares her pregnancy in writing, the radiation dose of the embryo/fetus shall be no greater than 0.05 rems in any month.
- The 0.5 rems dose equivalent limit applies to the full nine months of pregnancy.

It is strongly suggested that the instruction be given both orally and in writing. Also, each woman employee should be given an opportunity to ask questions, and each woman employee should be asked to acknowledge in writing that the instruction has been received. Further, it would be prudent to keep records of such acknowledgment indefinitely.

Considerations for Individuals Under the Age of 18 years

Young individuals are considered to be at a greater risk of radiation injury because of their more rapidly reproducing cells. Thus, all individuals under the age of 18 shall be excluded from performing or assisting in the performance of radiographic examinations.

Section 2:

Competency and Training of Veterinary Radiographers

According to Section 4840.7 of the California Veterinary Medicine Practice Act, a registered veterinary technician (RVT) who has been examined by the Veterinary Medical Board in the area of radiation safety and techniques may operate radiographic equipment under indirect supervision of a licensed veterinarian.

An unregistered assistant may operate radiographic equipment under the direct supervision of an RVT or a licensed veterinarian.

Section 3:

Personnel Monitoring

Personnel monitoring equipment (devices)

Personnel monitoring equipment consists of devices designed to be worn or carried for the purpose of measuring the radiation dose received by an individual in the course of employment, education, or training. Personnel monitoring equipment/devices include: film badges, thermolumnescent dosimeters (TLD), pocket dosimeters, and ring or wrist badges [see CFR Section 20.1003 and CCR Section 30100 (m)]. Film and TLD badges are the most commonly used radiation monitoring devices by the veterinary profession. Personnel monitors may be performed either on a monthly or quarterly basis.

Location of personnel monitoring equipment (devices)

A monitoring device must be worn at the thyroid level on the collar outside the apron. Also if the fluoroscopy is used, an additional ring or wrist band must be worn.

Section 4:

Occupational Dose Equivalent Limits

Compliance with occupational exposure requirements - [Maximum Permissible Dose equivalent (MPD)]

The essential goal of radiation safety is to prevent injury from exposure to ionizing radiation. For this reason, CFR 20, Section 20.1201, establishes the following annual or yearly occupational dose equivalent limits:

- Whole body (total effective dose equivalent): 5 rems.
- Skin and extremities (shallow dose equivalents): 50 rems.
- Lens of the eye (eye dose equivalent): 15 rems.

The regulations distinguish the following:

- Occupational dose equivalent limits for adults (persons over 18 years of age).
- Occupational dose equivalent limits for persons under 18 years of age (may receive 10 percent of the adult occupational dose limits). This is one reason why young people should not be allowed to work in the x-ray room.
- Dose equivalent limits for general population.
- Radiation dose to an embryo/fetus (prenatal radiation exposure).

Section 5:

Veterinary Radiographic Machine Requirements

X-ray Tube Housing

The x-ray tube housing must be of a diagnostic type.

The x-ray beam is generated within a vacuum tube containing a cathode with a tungsten wire filament, and an anode target, usually made of tungsten. The x-ray tube itself is enclosed in a metal housing, with a window through which the useful or primary x-ray beam passes.

Collimating device

A rectangular collimating device, equipped with a light localizer indicating the size and location of the area to be exposed to x-rays, which is capable of restricting the useful beam to the area of clinical interest, shall be provided.

Failure to limit or restrict the x-ray beam only to the area of clinical interest represents one of the most frequent causes of violating the collimation requirement. X-rays that extend beyond the area of clinical interest serve no useful function, increase scatter, and must be eliminated by careful collimation.

There should be an unexposed border on two opposing sides of the film, proving that the x-ray beam did not exceed the size of the film cassette.

By decreasing the amount of tissue exposed, the amount of scatter radiation produced is also reduced, thus reducing the scatter radiation exposure to personnel.

Clinically, reduction of the size of the x-ray beam improves the diagnostic quality of the film by lessening the amount of fog caused by scatter radiation.

X-ray beam filtration

The regulations specify the amount of total filtration required for veterinary x-ray machines to be at least 1.5 millimeters (mm) of aluminum-equivalent for equipment operating up to 70 kilovolt peak (kVp) and at least 2.0 mm of aluminum-equivalent for equipment operating over 70 kVp.

Diagnostic x-rays tubes use aluminum or its equivalent as the filter material.

Except for the window through which the primary useful beam passes, most x-ray tubes are surrounded by oil for electrical insulation and keeping the tube cool. When x-rays leave the tube they must pass through the window's glass covering which adds a small amount of inherent filtration. The amount of inherent filtration produced by most diagnostic x-ray tubes usually ranges from 0.5 to 0.8 mm aluminum-equivalent.

The ability of the x-ray beam to penetrate through the animal patient and to expose the x-ray film is dependent upon its energy measured in kilovolts peak (kVp). The x-ray beam is made up of rays of different energies. Only the x-rays with higher energies (i.e., shorter wavelength) can penetrate the tissue of the animal body and react with the emulsion of the film. The lower

energy (i.e., long wavelength) x-rays do not penetrate the patient, and therefore do not contribute to the diagnostic quality of the radiograph. It is desirable to remove the low energy rays from the x-ray beam. This can be readily accomplished by placing a filter in the path of the useful or primary beam. A filter functions by absorbing preferentially the low energy (long wavelength) x-rays before they reach the patient, while allowing the high energy (short wavelength) x-rays to pass through. [Section 30306(f)].

Exposure cord

The exposure cord on the hand or foot switch cannot be less than six feet in length. [Section 30314(a)(5)].

Exposure timer

The x-ray machine must have a device to terminate the exposure after a preset time or exposure. [Section 202114(a)(4)].

Exposure switch

The exposure switch must be of the dead-man type. [Section 30314(a)(5)].

Registration requirement

Every person possessing a reportable source of radiation shall register with the California Department of Public Health, Radiologic Health Branch [(RHB) www.cdph.ca.gov/rhb] in accordance with the provisions of Sections 30110 through 30146. [Section 30108].

Initial registration

(a) Every person not already registered who acquires a reportable source of radiation shall register with and pay the fee as specified in Section 30145 to RHB within 30 days of the date of acquisition.

(b) Every person who intends to acquire a radiation machine capable of operating at a potential in excess of 500 kvp shall notify RHB at least 60 days prior to his/her possession of the machine or at least 60 days prior to the commencement of construction or reconstruction of the room which will house the machine, whichever occurs first. This equipment shall not be used to treat patients until written approval of provisions for radiation safety has been obtained by the user from RHB. [Section 30110]

(c) Every person who registers or renews a registration shall complete a separate registration form furnished by RHB for each separate installation.

Renewal of registration

Registration must be renewed with RHB on or before the registration expiration date.

Report of change

The registrant shall report in writing to RHB. Within 30 days of any change in: Registrants name, address, location of the installation, receipt, sale, transfer, disposal, or discontinuance of use of x-ray machine. [Section 30115]

Vendor Obligation

A vendor must inform the receiver of the radiation machine of the registration requirements [Section 30118].

Records to be maintained

Record of individual monitoring results must be maintained until the terminations of their registration [10 CRF 20, section 20.2106].

Payment of Fees

Each registration and registration renewal requires payment of a fee [Section 30146].

Section 6:

Veterinary Radiographer Protective Apparel

The operator shall not stand in the beam but be well away from the tube and animal during X-raying [Section 30314(b), Title 17, CCR].

It is the veterinary radiographers responsibility to require that all individuals unnecessary to the radiographic examination leave the x-ray room prior to making an exposure.

Anyone who is in the x-ray room at the time of exposure must be behind a protective barrier or must wear a protective apron of preferably 0.5 mm lead-equivalent but not less than 0.25 millimeters of lead-equivalent.

Lead impregnated leather or vinyl is used to make aprons and gloves worn by those individuals who must remain in the x-ray room when an exposure is made.

The minimum requirement for both aprons and gloves is 0.25 millimeters of lead equivalent. However, gloves and aprons constructed of 0.5 millimeters of lead-equivalent are available and thus provide greater protection to the radiographer and assistants.

A label stating the lead equivalent thickness can be found on the hem of the apron and in the cuff of the glove.

Aprons and gloves must be evaluated periodically for tears and cracks to avoid radiation penetration. This evaluation can be accomplished by x-raying the gloves or aprons using a cassette and making a routine exposure. Recommended exposure factors are: 85 kVp, 10 milliampere-second (mAs), 40 inch focal-film distance.

Proper storage of aprons and gloves prolongs their life and effectiveness. Aprons should be hung without creases to prevent cracking. Gloves should be stored so that liners can dry.

Gloves and aprons are designed to protect the wearer from scatter radiation only they do not reduce the primary x-ray beam enough to provide sufficient protection.

The reduction in exposure that results from placing 0.25 mm lead-equivalent apron material in a primary x-ray beam of 100 kVp is 60 percent compared to 0.50 mm lead-equivalent apron material that attenuates the beam by 85 percent.

Section 7:

Veterinary Radiographer Responsibilities

Veterinary radiographers are responsible for adhering to all of the following radiation safety procedures:

1. Increase or maximize the distance between the operator and the source of radiation.
   - The intensity of the primary x-ray beam, scatter radiation and leakage from the x-ray tube diminishes rapidly as the distance between the operator and the source of radiation increase (approximately by the square of the relative distances).
   - If an operator can increase his or her distance from radiation sources by a factor of two (2), his or her exposure would be reduced to one-fourth of the original amount (four being the square of two). If the distance factor could be tripled, the exposure would be reduced to one-ninth of the original amount (nine being the square of three).
   - When taking radiographs of large animals, use cassette holders to reduce the assistant's exposure to radiation.

2. Use chemical and mechanical restraints whenever possible to eliminate the need for holding a patient during the radiographic exposure.
   - Mechanical restraining devices and positioning aids available to veterinary radiographers include vinyl or foam covered sandbags, foam wedges, plastic or foam troughs, plastic head braces and mouth specula, rope, gauze, tape, Velcro straps, etc. Their proper utilization not only helps reduce radiation exposure to veterinary radiographers but also helps to improve radiographic quality by preventing patient motion.

3. Use general anesthesia when total immobility and complete relaxation of the animal patient is required for accurate positioning.
   - In all cases, the decision to use anesthetic and tranquilizing agents rests with the attending veterinarian.
   - Tranquilizers may calm the animal patient sufficiently to allow some types of mechanical restraining devices to be used.

4. Use appropriate protective devices, such as gloves, aprons, and protective goggles, as well as fixed or mobile barriers such as walls or movable leaded Plexiglas shields.
   - Mobile lead Plexiglas shield that can be positioned in the examination room between the source of radiation and the assistant can cut radiation exposure significantly.
   - Lead glass goggles offer considerable protection to the lens of the eye.

5. Reduce the duration and amount of exposure.
   - Rare-earth screens can reduce patient dose and the exposure to the personnel from between two (2) and five (5) times without any loss of image quality compared to older Acalcium tungstate screens. From the standpoint of radiation safety, intensifying screens of this type are highly advantageous.

- Use a film type proper for screen emittance. For example, blue-light-emitting screens should not be used with greensensitive film and vice versa. Such a film/screen mismatch will result in image degradation and increased radiation exposure.
- Low-absorption cassette fronts (such as Bakelite or carbon fiber reinforced plastic) offer minimum filtration of the x-rays passing through the cassette and can aid in keeping patient dose at a minimum.
- Use high kVp techniques that are appropriate for the body part being x-rayed, permitting the veterinary radiographer to lower the mAs settings and decrease radiation levels. Kilovoltage determines the penetrating ability (quality) of the x-ray beam whereas mAs determines the amount (quantity) of x-radiation.
- The x-ray imaging process starts with the normal x-ray machine, the animal patient and the x-ray cassette arranged in the usual positions. The difference is that the digital cassette contains a reusable phosphor plate, which is sensitive to x-rays but not light. Once the plate has been exposed, it is fed into a laser computer reader, which captures the image in a digital format. The reader then resets the plate ready for reuse. The phosphor plates are expensive but can be reused several thousand times; they are also more x-ray sensitive than film, allowing a slightly lower radiation dose to be used. The advantages of this process over film developing are the elimination of the expensive film, the absence of toxic developing chemicals and the speed. Within 30 seconds, the image is visible, so if the image needs to be repeated for technical reasons this can be done immediately. The radiographer orientates the image on the monitor according to established protocols and can alter the contrast and grey scale (a process known as "windowing").
- The company who supplies the digital equipment should provide information on the recommended receptor exposure factors to ensure diagnostic images with the lowest possible dose for each particular examination.
- It is important for each veterinary practice to set up quality assurance systems to routinely monitor factors including clinical exposure constancy and imaging system sensitivity.
- Digital radiography systems may have different x-ray energy responses to film screen systems. Therefore, the technical exposure factors should be different for that used for film screen systems.
- For existing systems that have been upgraded to use digital radiography or computed radiography, the existing exposure protocols should be adjusted to reflect as 30-50% reduction in mAs and or exposure time. Each image, whether produced on film or soft copy display, should ideally have an associated number to indicate the level of exposure to the detector. Currently all computed radiography systems have a sensitivity index which is related to detector exposure, however, digital radiography systems are generally not supplied with this feature. Once computed radiography and digital radiography are in use, the constancy of applied exposure factors should be monitored on a regular basis.

6. Plan radiographic procedures carefully and avoid unnecessary retakes

- Every examination that must be repeated results in doubling the radiation received by the patient and by personnel. Retakes represent one of the biggest causes of excessive and unnecessary radiation exposure to veterinary radiographers.

- The production of quality radiographs is a complex process demanding careful attention to each detail. Some of the principal factors relating to the production of quality radiographs are:
  - Patient positioning.
  - The body part of clinical interest should be centered on the film.
  - The body part should be perpendicular to the central main x-ray beam and parallel to the film.
  - Align the x-ray tube with the film (cassette).
  - Ensure correct focal-film distance is correct (usually 40 inches).
  - Proper techniques selection.
  - Precisely measure the body part for use with a technique chart.

Section 8:

Darkroom Quality Assurance Requirements (General Provisions)

- A consistent routine should be established in the darkroom.
- Smoking, eating, or drinking should not be permitted in the darkroom.
- The darkroom should be kept free of dust.
- Counter tops and processor feed trays should be cleaned daily.
- Darkroom safe lights should be equipped with an appropriate filter and bulb combination.
- Screens should be cleaned to remove artifacts. Screen cleaner, recommended by the screen manufacturer, should be used on a regular basis--not less than monthly.
- Films should be handled carefully to prevent artifacts due to static electricity or fingerprints.
- The developer and the fixer tanks should be covered to prevent oxidation.
- Boxes of unexposed film should be stored upright and in a protected area away from scatter radiation.
- Expired film stock should be removed from use.
- For digital image processing, strict adherence to the manufacturer's quality assurance and system maintenance manuals is critical in order to take full advantage of any digital radiography system. "Windowing" an image to make it diagnostically acceptable is not an alternative for using the correct technical factors in producing the initial image.

Section 9:

Manual Film Developing

Proper development of film is very important in optimizing diagnostic quality radiographs and reducing the number of retakes. An x-ray film should never be overexposed in order to shorten the developing time. A film that has been overexposed and underdeveloped tends to lose most of its diagnostic quality and results in a significant increase in exposure to the animal patient and veterinary radiographer.

Developing for five (5) minutes at 68-70 degrees Fahrenheit (see Table below) produces optimum diagnostic quality films. Since the correct developing time varies with the temperature of the developing solution, measurements must be made with an accurate thermometer and timer each time a film is developed.

Full Film Development Techniques	
Developer Temperature (Fahrenheit)	Minimum time (minutes)
64-66	7
68-70*	5*
72-76	4
*Optimum temperature and time combination.	

The temperature of developing solutions should not exceed 75 degrees Fahrenheit, or fall below 65 degrees Fahrenheit. Developing solutions function correctly only within the above noted temperature range.

Solutions should be stirred well before use. Separate stirring paddles must be used for the developer and fixer.

In addition, veterinary radiographers must follow the following rules:

- Use solutions designed for medical x-ray purposes.
- Change solutions regularly and replenish solutions per manufacturer's recommendations.*
- Avoid contaminating solutions.
- Keep films in the fixer solution for at least 10 minutes.
- Wash films in a running water bath for at least 30 minutes.
- Dry films thoroughly.

**NOTE: Silver recovery systems must meet environmental protection laws and regulations.*

Specifically, processing less than 500 gallons per month of silver-containing photographic solutions qualifies a generator to be conditionally exempt if the waste is:

- Hazardous only for silver.
- Treated on-site within 90 days.

- The silver concentration is reduced to a level less than five (5) milligrams per liter (mg/l).

Section 10:

Employing/Supervising Veterinarian Responsibilities

Employing/supervising veterinarian is responsible for all of the following:

Radiation protection - general requirements.

1. Pursuant to Section 30253 take all precautions necessary to provide reasonably adequate protection to the health and safety of all individuals who are subject to exposure to radiation. The main purpose in the control of radiation exposures is to ensure that no exposure is unjustified in relation to its benefits; that any necessary exposures are kept as low as is reasonably achievable (ALARA); and that the doses received to personnel are kept well below the allowable limits.

2. Provide radiation safety rules to each veterinary radiographer including any restrictions of the operating technique required for the safe operation of the particular x-ray equipment.

3. Ascertain that each veterinary radiographer demonstrates familiarity with the radiation safety rules.

4. All individuals whose job requires radiation exposure are monitored (provided personnel monitoring devices).

5. Occupational exposure is recorded regularly at least quarterly and preferably monthly.

6. The operator or any other individual does not stand in the path of the useful beam and remains behind a protective shield or at least six feet away from the animal patient during the exposure.

7. Make or cause to be made such reasonable and necessary surveys and/or tests, including quality assurance (QA) tests necessary for the protection of life, health or property [Section 30275].

8. Report to the RHB any overexposure of x-ray personnel [Sections 30295 and 10 CFR 20.2202/2203].

Animal patient holding

1. No individual is employed or regularly used to hold animal patients during radiation exposures.

2. Veterinary radiographers do not hold animal patients except very infrequently and then only in cases in which no other method of restraint is available.

3. Provide devices to assist in positioning and restraining the anesthetized or sedated patient (such as cassette holders, sandbags).

4. If manual restraint must be used, require the individual to hold the animal patient at arm's length with the body positioned as far away from the animal patient as possible. (The head and body may not be bent over the animal patient.)

Pregnant or potentially pregnant employees

1. According to 10 CFR 20, the employing veterinarian must instruct occupationally exposed individuals in health protection problems associated with exposure to radiation, in precautions or

procedures to minimize exposure, and in the purpose and function of protective devices employed. These instructions shall be given both verbally and in writing.

Posting and record keeping requirements

1. A current copy of Department of Health Services Form RH-2364 (Notice to Employees) must be posted in a sufficient number of places to permit individuals working in the x-ray room to observe a copy on the way to or from the room [10 CFR 20].

2. A current copy of California Control Regulations, Title 17.

3. An annual report of occupational exposure must be provided to all individuals who are being monitored [10 CFR 20].

4. "Caution X-ray" is required signage to be posted [section 30305(c), title 17, CCR].

Section 11:

Review Questions

1. The biological effect of radiation is measured in what units?
   A. Roentgen
   B. Rad
   C. Rem
   D. Curies

2. The amount of x-rays received in the course of employment by an individual since 18 years of age is called what?
   A. Acquired dose
   B. Total dose
   C. Occupational dose
   D. Allowable dose

3. The length of cord on the hand or foot switch cannot be less than how long?
   A. 4 feet
   B. 6 feet
   C. 8 feet
   D. 10 feet

4. How many millirems are there in 7.5 rems of radiation exposure?
   A. 75
   B. 750
   C. 7500
   D. 75,000

5. To evaluate the integrity of gloves, they are best radiographed using the following exposure factors:
   A. 80 kVp, 10 mAs, 40@ffd
   B. 85 kVp, 10 mAs, 40@ffd
   C. 85 kVp, 15 mAs, 40@ffd
   D. 80 kVp, 10 mAs, 36@ffd

6. Which adjustment of the x-ray machine will give variety to the penetrating ability of the x-ray beam?
   A. mA
   B. kVp
   C. Exposure time
   D. Collimation

7. Chronic exposure to x-radiation will most likely cause which of the following?
   A. Increase in rates of leukemia
   B. Increase in rates of neoplasia
   C. Increase incidence of cataracts
   D. All of the above

8. What is the optimum time of development of an x-ray at 68 degrees Fahrenheit?
   A. 3 minutes
   B. 5 minutes
   C. 6 minutes
   D. 7 minutes

9. The minimum standard of lead equivalent for aprons is 0.25 mm and for gloves is what?
   A. The same
   B. 0.30 mm
   C. 0.40 mm
   D. 0.50 mm

10. What causes a clear border around developed x-ray film?
   A. Collimation
   B. Insufficient time in the developer
   C. Using too big of a film for the study
   D. Over exposure of the film

ANSWERS:
1-C; 2-C; 3-B; 4-C; 5-B; 6-B; 7-D; 8-B; 9-A; 10-A

Section 12:

Resources and Regulations

The Radiation Control Regulations are contained in the California Code of Regulations (CCR), Title 17, Division 1, Chapter 5, Subchapter 4, and they are generally referred to as laws or statutes. These regulations are not recommendations but provisions that must be complied with. Health and Safety Code, Section 25866 specifically states that any person who violates any part of the provisions of these regulations is guilty of a misdemeanor.

Copies of the California Code of Regulations (CCR), Title 17 can be obtained by contacting:

Barclays Law Publishers
PO Box 3066
South San Francisco, CA 94083-3066
(415) 589-8200

To obtain a copy of Department of Health Services Form RH-2364, The Notice to Employees, contact:

California Department of Public Health
Radiologic Health Branch
PO Box 997414, MS-7610
Sacramento, CA 9589-7414
(916) 327-5106

The Notice to Employees, regulation information and X-Ray Machine Registration forms can be found on the CDPH website:

www.cdph.ca.gov/rhb

Additional Resources

National Council on Radiation Protection and Measurements
Radiation Protection in Veterinary Medicine
Report No. 148, December, 2004.

Department of Toxic Substances Control
PO Box 806
Sacramento, CA 95812-0806

Department of Toxics website:

http://www.dtsc.ca.gov/

For information regarding processing solutions and their disposal, contact:

Department of Toxic Substances Control
Onsite Hazardous Waste Treatment Unit
400 P Street, 4th Floor, PO Box 806

Sacramento, CA 95812-0806
(916) 323-5871

Regulations that are of particular interest to the RVT are summarized below. For the complete listing of regulations, consult the California Code of Regulations (CCR), Title 17, Sections 30100-30314 and Sections 20.1003-20.2202.

General Definitions

Absorbed dose

The energy imparted by ionizing radiation per unit of irradiated material. The units of absorbed does are the rad and the Gray (Gy).

Adult

An individual 18 or more years of age.

ALARA (As Low As is Reasonably Achievable)

Making every reasonable effort to maintain exposures to radiation as far below the dose limits in this part as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest.

Automatic exposure control

A device which automatically controls one or more technique factors in order to obtain at a preselected location(s) a required quantity of radiation.

Collective dose

The sum of the individual doses received in a given period of time by a specified population from exposure to a specified source of radiation.

Controlled area

An area, outside of a restricted area but inside the site boundary, access to which can be limited by the licensee for any reason.

Declared pregnant woman

A woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception.

Dead-man switch

A switch so constructed that a circuit-closing contact can only be maintained by continuous pressure by the operator.

Diagnostic-type tube housing

An x-ray tube housing so constructed that the leakage radiation measured at a distance of one meter from the source cannot exceed 100 milliroentgens in one hour when the tube is operated at its maximum continuous rate of current for the maximum rated tube potential.

Dose equivalent (HT)

The product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the rem and the seivert (Sv).

Effective dose (HE)

The sum of the products of the dose equivalent to the organ or tissue (HT) and the weighting factors (wT) applicable to each of the body organs or tissues that are irradiated (HE=3wTHT).

Embryo/fetus
The developing human organism from conception until the time of birth.

Exposure
Being exposed to ionizing radiation or to radioactive material.

Eye dose equivalent
Applies to the external exposure of the lens of the eye and is taken as the dose equivalent at a tissue depth of 0.3 centimeters (300 mg/cm2).

Filter
Material placed in the useful beam to absorb preferentially the less penetrating radiations.

Gray (Gy)
The SI unit of absorbed dose. One Gray is equal to an absorbed dose of one joule/kilogram (100 rads).

Individual
Any human being.

Installation
The location where one or more reportable sources of radiation are possessed.

Interlock
A device for precluding access to an area of radiation hazard either by preventing entry or by automatically removing the hazard.

Leakage radiation
All radiation coming from within the x-ray tube housing except the useful beam.

Licensee
The holder of a license [Note: the licensee is usually the veterinarian].

Member of the Public
An individual in a controlled or unrestricted area. However, an individual is not a member of the public during any period in which the individual receives an occupational dose.

Minor
Any individual less than 18 years of age.

Nonstochastic effect or deterministic effect
Health effects, the severity of which varies with the dose and for which a threshold is believed to exist. Radiation-induced cataract formation is an example of a nonstochastic effect (also called a deterministic effect).

Occupational dose
The dose received by an individual in a restricted area or in the course of employment in which the individuals assigned duties involve exposure to radiation and to radioactive material from licensed and unlicensed sources of radiation, whether in the possession of the licensee or other persons. Occupational dose does not include dose received from

background radiation, as a patient from medical practices, from voluntary participation in medical research programs, or as a member of the general public.

Other official agency specifically designated by the Dept.

An agency with which the Department has entered into agreement pursuant to Section 114990 of the Health and Safety Code.

Person

Any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, agency, political subdivision of this State, any other state or political subdivision or agency thereof, and any legal successor or representative, agent, or agency of the foregoing, other than the United States Nuclear Regulatory Commission, the United States Department of Energy, or any successor thereto, and other than Federal Government agencies licensed by the United States Nuclear Regulatory Commission, under prime contract to the United States Department of Energy, or any successor thereto.

Personnel monitoring equipment

Devices designed to be worn or carried by an individual for the purpose of measuring the dose received by that individual (e.g., film badges, pocket chambers, pocket dosimeters, film rings, etc.).

Possessing a reportable source of radiation

Having physical possession of, or having control of, x-ray equipment.

Primary protective barrier

A barrier sufficient to attenuate the useful beam to the required degree.

Protective barrier

A barrier of attenuating material used to reduce radiation exposure.

Rad

The special unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs/gram or 0.01 joule/kilogram (0.01 Gray).

Radiation (ionizing radiation)

Gamma rays and x-rays; alpha and beta particles, high-speed electrons, neutrons, protons, and other nuclear particles; but not sound or radio waves, or visible, infrared, or ultraviolet light.

Radiation machine

Any device capable of producing radiation when the associated control devices are operated, but excluding devices which produce radiation only by the use of radioactive material. For fee purposes, when a radiation machine is equipped with two or more tubes that can be used separately, each tube shall be considered as a single machine, except for machines used solely for research and teaching.

Registrant

Any person who is registering or who has registered with the Department pursuant to group 1.5 Registration of Sources of Radiation.

Rem

The special unit of any of the quantities expressed as dose equivalent. The dose equivalent in rems is equal to the absorbed dose in rads multiplied by the quality factor (1 rem = 0.01 sievert).

Reportable source of radiation

Either of the following:

(1) Radiation machines, when installed in such a manner as to be capable of producing radiation.

(2) Radioactive material contained in devices designed and manufactured for the purpose of detecting, measuring, gauging, controlling thickness, density, level interface location, radiation, leakage, or qualitative or quantitative chemical composition, for producing light or an ionized atmosphere, possessed pursuant to a general license under provisions of Section 30192.1 of group 2 this Subchapter (Licensing of Radioactive Materials).

Scattered radiation

Radiation that, during passage through matter, has been deviated in direction.

Secondary protective barrier

A barrier sufficient to attenuate stray radiation to the required degree.

Shutter

A device, generally of lead, fixed to an x-ray tube housing to intercept the useful beam.

Sievert

The SI unit of any of the quantities expressed as dose equivalent. The dose equivalent is sieverts is equal to the absorbed dose in Grays multiplied by the quality factor (1 Sv = 100 rems).

Source of radiation

A discrete or separate quantity of radioactive material or a single radiation machine.

Stochastic effects

Health effects that occur randomly and for which the probability of the effect occurring, rather than its severity, is assumed to be a linear function of dose without threshold. Heredity effects and cancer incidence are examples of stochastic effects.

Stray radiation

Radiation not serving any useful purpose. It includes leakage and scatter radiation.

Therapeutic-type tube housing

(1) For x-ray therapy equipment not capable of operating at 500 kVp or above, an x-ray tube housing so constructed that the leakage radiation at a distance of one meter from the source does not exceed one roentgen in an hour when the tube is operated at its maximum rated continuous current for the maximum rated tube potential.

(2) For x-ray therapy equipment capable of operating at 500 kVp or above, an x-ray tube housing so constructed that the leakage radiation at a distance of one meter from the source does not exceed either one roentgen in an hour or 0.1 percent of the useful beam dose rate at one meter from the source, whichever is greater, when the machine is operated at its maximum rated continuous current for the maximum rated accelerating potential.

(3) In either case, small areas of reduced protection are acceptable provided the average reading over any 100 square centimeters area at one meters distance from the source does not exceed the values given above.

This regulation
California Code of Regulations (CCR), Title 17, Chapter 5, Subchapter 4.

Unrestricted area
An area, access to which is neither limited nor controlled by the licensee.

Useful beam
That part of the radiation which passes through the window, aperture, cone, or other collimating device of the tube housing.

User
Any person who is licensed to possess radioactive material or who has registered as possessing a reportable source of radiation pursuant to groups 1.5 and 2 of this subchapter, or who otherwise possesses a source of radiation which is subject to licensure or registration.

Whole body
For the purposes of external exposure, head, trunk (including male gonads), arms above the elbow, or legs above the knee.

Worker
Any individual engaged in activities subject to Title 17, California Code of Regulations, Chapter 5, Subchapter 4, and controlled by a user but does not include the user.

STATE OF CALIFORNIA
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DEPARTMENT OF CONSUMER AFFAIRS

STATE AND CONSUMER SERVICES AGENCY • GOVERNOR EDMUND G. BROWN JR.

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RADIATION SAFETY EXAMINATION FOR UNREGISTERED ASSISTANTS

California law requires the employing/supervising veterinarian to provide radiation safety rules to each veterinary radiographer including any restrictions of the operating technique required for the safe operation of the particular x-ray equipment. The purpose of this examination is to ascertain that every unregistered assistant (any individual who is not a board certified Registered Veterinary Technician or a licensed veterinarian) has familiarity with the radiation safety rules.

Please read the Radiation Safety Booklet provided by your employer/supervisor and then answer the questions below. You may refer to the booklet while taking the examination. You are required to achieve a passing score of 80% in order to operate radiographic equipment.

You may not operate radiographic equipment until you have successfully passed this examination or can provide other proof of Radiation Safety Training.

Name: _____

Employer/Supervisor: _____

Circle only one answer.

1. Chronic exposure of individuals to low levels of radiation can have which of the following health effects?
   A. Premature aging
   B. Higher incidence of cancer
   C. Damage to the lens of the eye
   D. All of the above

2. Pregnant women should avoid exposure to radiation because of which of the following increased risks to their fetus?
   A. Childhood leukemia and other cancers
   B. Low birth weight
   C. Premature birth
   D. Glaucoma

3. Why are individuals under the age of 18 excluded from performing or assisting in radiography?
A. They cannot be held legally liable for their actions
B. They are at greater risk of injury because of their inexperience
C. They cannot be exposed to radiation without their parent's permission
D. They are at greater risk of radiation injury because their cells are reproducing more rapidly

4. An unregistered assistant may operate radiographic equipment under which of the following circumstances?
   A. Under the direct supervision of an RVT or a licensed veterinarian
   B. Under the direct supervision of a trained unregistered assistant
   C. Under the indirect supervision of a licensed veterinarian
   D. Under the indirect supervision of an RVT

5. Where should a radiation monitoring device be worn for routine radiography?
   A. Under the apron at waist level
   B. Under the apron at collar level
   C. Outside the apron at waist level
   D. Outside the apron at thyroid level

6. Which of the following statements describes the purpose of collimation?
   A. It reduces the amount of scatter
   B. It increases the amount of scatter
   C. It increases the size of the primary beam.
   D. It reduces the amount of kVp needed for exposure

7. Which of the following actions must a person who is in the x-ray room take at the time of exposure?
   A. Stand in front of a protective barrier
   B Place their hands directly in the primary beam
   C. Hold their breath while the exposure in being made.
   D. Wear a protective apron of preferably 0.5mm lead-equivalent

8. Leaded gloves are required to be worn to protect the operator from which of the following dangers when performing veterinary radiography?
   A. Being bitten by the animal patient
   B. Exposure to the primary beam
   C. Contact with radiographic contrast media
   D. Exposure to scatter radiation

9. Which of the following techniques should a veterinary radiographer use to increase radiation safety?
   A General anesthesia when total mobility and complete relaxation is required for accurate positioning
   B. Chemical and mechanical restraints whenever possible to eliminate need for holding patient
   C. Intensifying screens and/or fast film to reduce exposure time
   D. All of the above

10. Why should leaded goggles be worn when restraining an animal patient for radiography?
   A. To prevent contrast media from getting into the eyes
   B. To protect the lens from exposure to x-rays
   C. To protect the cornea from scratches
   D. To improve the operator's vision

11. What is the effect on the operator's exposure to radiation by increasing the distance between the operator and the source of radiation?
A. Reduces the exposure to radiation
B. Increases the exposure to radiation
C. Exposure to radiation stays the same
D. Cannot be determined

12. What is the purpose of cassette holders in large animal radiography?
A. To keep the cassette from moving during exposure.
B. To prevent the patient from soiling the cassette
C. To reduce the assistant's exposure to radiation
D. To allow rapid change of film in the field.

13. Which of the following statements accurately describes appropriate radiation safety protocol?
A. Anesthesia and restraint devices such as sandbags should be used only if manual restraint won't work
B. No individual should be employed or regularly used to hold animal patients during radiation exposures
C. During manual restraint, assistants should position themselves as close to the animal patient as possible.
D. Veterinary radiographers should restrain patients manually even if other restraint methods are available

14. Which of the following duties is a responsibility of the employing/supervising veterinarian?
A. Ascertain that each veterinary radiographer demonstrates familiarity with radiation safety rules.
B. Assure that no individual stands in the path of the primary beam
C. Provide radiographers with personnel monitoring devices
D. All of the above

15. Which of the following statements describes a female radiographer's special risks?
A. Female assistants should not inform their supervisors if they are pregnant to avoid being relieved of duty
B. The actual dose of radiation exposure to an embryo/fetus is greater than that received by the mother.
C. Her ability to bear children is very likely to be effected by occupational exposure within legal limits.
D. The embryo/fetus is most sensitive to radiation during the first three (3) months of pregnancy.

16. Which of the following statements is true regarding digital radiography?
A. Digital radiography is no safer for the patient and the operator than conventional radiography
B. Digital radiographs take longer to develop than standard radiographs
C. Repeated exposure to digital radiography does not increase radiation dosage
D. The information required to be imprinted on standard, radiographs cannot be imprinted on digital, radiographs

17. Which of the following techniques is recommended when using digital radiography?
    A. Stand as close to the patient as possible when positioning them for a radiograph
    B. Use adjustments in the software to enhance the image
    C. Leave the film in the developer longer if the temperature is colder than normal
    D. Open the collimator as wide as possible to get the largest view of the patient

ANSWERS:
1-D; 2-A; 3-D; 4-A; 5-D; 6-A; 7-D; 8-D; 9-D; 10-B; 11-A; 12-C; 13-B; 14-D; 15-D; 16-A; 17-B

I attest that I have read the Radiation Safety Booklet provided to me by my employer/supervisor and that I have completed this examination by myself after reading the booklet.

Signature: _____

Date: _____

---------- To be completed by employer/supervisor ----------

Examination Score (passing is 80% or 14 out of 17 questions correct): _____

Employer/supervisor's signature: _____

Date: _____