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1. Introduction

In the province of Alberta, veterinary diagnostic or therapeutic x-ray equipment and facilities as well as lasers are governed by the Radiation Protection Act and Regulation. These documents specify that owners and staff have certain obligations to ensure the health and safety of themselves and the public. The obligations include:

- registering the equipment
- developing a code of practice
- ensuring the installation and operation of equipment and facilities comply with particular standards, and
- implementing quality assurance for x-ray emitting and film processing equipment.

This manual has been developed to assist veterinary facilities with meeting these obligations.

It is the hope of the Alberta Veterinary Medical Association (ABVMA) that this manual will provide you with the documentation necessary to enact a safe workplace in maintaining as low as reasonably achievable (ALARA) radiation dose level for Veterinarians and their employees.

The ABVMA welcomes any feedback regarding this informational material and the administration of the Radiation Protection Program as it will assist in providing competent service to its members. If you have further questions regarding the Radiation Program, please contact the ABVMA Office.

Thank you’s to Ms. Gail Foran, Mr. Bruce Ainslie, Dr. Jocelyn Forseille, Dr. Gellhaus, Dr. Malcom Gray, Richard Back (WCVM), Dr. Doug Lawson, College of Chiropractors, Dr. Herb Strech and the PIPS Committee for their assistance in the production of this manual and the enactment of the program.
2. Standards/Policies

Following is a list of standards which apply to veterinary facilities. This manual consolidates the important information that is required by a veterinary facility on a regular basis. These regulations & bylaws are included behind this section the end if further information is needed please consult the appropriate documents. Please note that it is the owner’s responsibility to ensure the equipment and facility comply with the requirements.

1) Alberta Radiation Protection Act
   This is the provincial legislation which specifies the requirements to be met.

2) Alberta Radiation Protection Regulation
   This is the provincial legislation which specifies the requirements to be met.
   Radiation Protection Regulation, AR 182/2003
   www.qp.gov.ab.ca/catalogue/catalog_results.cfm?frm_isbn=0779731042&search_by=link

3) Health Canada Safety Code 28
   This is federal legislation which specifies the requirements to be met with regards to structural shielding design for medical and veterinary x-ray installations.

Electronic Links

Radiation Protection Act, R-2 RSA 2000 / Radiation Protection Regulation, AR 182/2003

www.qp.gov.ab.ca/catalogue/catalog_results.cfm?frm_isbn=0779741838&search_by=link

www.hc-sc.gc.ca/ewh-semt/pubs/radiation/91ehd-dhm151/index_e.html
3. Registration

3.1 When to Register

The Alberta Veterinary Medical Association (ABVMA) has been delegated the responsibility for registering veterinary x-ray and laser equipment.

Registration is required in the following situations:

1) Change in ownership of the facility or radiation equipment.
2) Installation of equipment in a new or existing veterinary facility regardless of how the equipment was obtained (purchased, leased, gift) or how old the equipment is (new or resale).
3) Relocation within the facility or to another location.
4) Modification of the characteristics of the radiation emitted from the equipment or the protective properties of the facility.

3.2 How to Register

1) Submit a completed Application for Registration of Designated Radiation Equipment to the ABVMA Office.
2) Contact one of the accredited agencies and have them inspect your facility.
3) Following the submission of their report to the ABVMA office, your facility will be certified.

3.3 Owner Update

The owner(s) of the facility is responsible for ensuring that all obligations under the Radiation Protection Act, its regulations and Practice Inspection and Practice Standards Bylaws are met. Please advise the Association if the owner(s) of the facility changes.

3.4 Fees

The annual registration fee for confirmation of existing equipment and the registration of any new equipment will be assessed on a facility rather than on an equipment basis. The fee will be charged on an annual basis to existing clinics and at the time of opening a new facility.

3.5 Compliance Verifications

Compliance verifications of x-ray equipment and facilities must be performed by an Authorized Radiation Protection Agency prior to certification.

Verifications ensure that:

- That the facility is in compliance with current legislation.
- Equipment has been installed correctly and is functioning properly.
- Shielding has been calculated and installed correctly.
• The principle of as low as reasonably achievable (ALARA) has been utilized within the facility design.
• A Quality Control Program is in place.

The Radiation Protection Agencies will complete a Compliance Monitoring Report on your facility and equipment for submission to the ABVMA. This is required to be done every 5 years.

**The owner of the equipment is responsible for:**

• Arranging for the compliance verification by an Authorized Radiation Protection Agency.
• Payment of the Compliance Verification.
• Ensuring that the final report is forwarded to the ABVMA.

To assist the owner with obtaining the services of an Authorized Radiation Protection Agency, a list of these agencies and potential questions to assist in Your selection is provided at the end of this Section.

### 3.6 Maintaining Registration

1) Review and submit an *Annual Confirmation of Registration* form to the ABVMA office, and
2) Submit the *Annual Registration Fee* to the ABVMA office, and
3) Have a full *Compliance Verification* performed by an Authorized Radiation Agency every five (5) years.

Listings for Authorized Radiation Protection Agencies can be found at: [http://employment.alberta.ca/SFW/349.html](http://employment.alberta.ca/SFW/349.html)
Radiation Protection Agency Compliance Verification Checklist for Veterinary X-ray Equipment

In accordance with Safety Code 28, (1991), “Radiation Protection in Veterinary Medicine” Published by Health Canada

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Compliance Item Description</th>
<th>Safety Code Section</th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
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<td>Responsibility User: Veterinarian, Animal Health Technologist or Registered Radiology Technician</td>
<td>3.2</td>
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<tr>
<td></td>
<td>- Ensure that equipment is maintained and functions correctly</td>
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<td></td>
<td>- Ensure that maintenance is performed by competent personnel</td>
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<td></td>
<td>- Ensure that equipment is used correctly and only by competent personnel</td>
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<td></td>
<td>- Establish safe operating procedures</td>
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<td></td>
<td>- Carry out routine checks of equipment and facility safety features</td>
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<td></td>
<td>- Keep records of radiation surveys</td>
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<td>- Maintain personnel monitoring program</td>
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<td></td>
<td>- Investigate overexposures and implement corrective measures</td>
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<td>- Ensure that appropriate warning signs are properly located</td>
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<td>2.</td>
<td>Equipment Operator</td>
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<td></td>
<td>- Adequately trained</td>
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<td></td>
<td>- Aware of radiation hazards</td>
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<td></td>
<td>- Wear personnel monitoring devices</td>
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<td>3.</td>
<td>Students or Operators-in-Training</td>
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<td></td>
<td>- Work only under the direct supervision of a qualified operator</td>
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<td></td>
<td>- Dose limits are not greater than the limits set for members of the public</td>
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<tr>
<td><strong>Equipment Requirements</strong></td>
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<td>4.</td>
<td>An X-ray control panel that is equipped with:</td>
<td>6.1.1</td>
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<td></td>
<td>1. Warning Signs: A permanent and conspicuous sign prohibiting unauthorized use and warning that hazardous X-radiation is emitted when the equipment is in operation</td>
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<td>2. Markings: Controls, meters, lights and other</td>
<td>6.1.2</td>
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indicators relevant to the operation of the equipment that is readily discernible and clearly labelled as to function.
3. Irradiation Light: A readily discernible separate indicator on the control panel that indicates when x-rays are being produced.

5. Mechanical Stability:
   1. The X-ray tube must be securely fixed and correctly aligned within the x-ray tube housing.
   2. The X-ray source assembly must maintain its required position without excessive drift or vibration during operation.

6. Irradiation Control:
   1. There must be an irradiation switch, timer or other device to initiate and terminate X-ray production
   2. This control must automatically terminate the irradiation after a preset time, product of tube current and time, or irradiation value has been reached.
   3. Where an irradiation switch is provided, it must require continuous pressure by the operator to produce X-rays.
   4. A foot switch is to be constructed so that no X-ray can be produced if it is inadvertently overturned.
   5. The irradiation timer must be an electronic type: mechanical timers must not be used.

7. Indication of Loading Factors:
   1. For X-ray equipment having adjustable loading factors, the control panel must incorporate indicators that allow these loading factors to be determined.
   2. For equipment having non-adjustable loading factors, permanent marks or labels may be used to indicate these parameters.

8. Timer Accuracy:
The irradiation timer should be such that at each setting it is accurate to 1/60 second or 7% of that setting, whichever is greater.

9. X-Ray Tube Voltage Accuracy:
The generator should be such that at each setting it is accurate to 5% of that setting.

10. Irradiation Reproducibility:
    For any selected combination of X-ray tube voltage, current and time greater than 1/10 second, the coefficient of variation of any 10 consecutive irradiations taken at the same distance within a period of 1 hour should not exceed 0.1.
11. **X-Ray Tube Shielding:**
   1. The X-ray tube *must* be enclosed in a shielded housing.
   2. The leakage radiation from the X-ray tube housing *must* not exceed 0.873 mGy (100 mR) in 1 hour at 1 metre at the nominal X-ray tube voltage on the equipment.

12. **Beam Limiting Device:**
   1. The X-ray tube housing *must* be equipped with a beam-limiting device that enables adjustment of the size of the X-ray field.
   2. The beam-limiting device *should* incorporate means to indicate the size of the X-ray field at the image reception area.

13. **Half-Value Layer:**
    For a given Kilovoltage, the measured value of half-value layer of the useful beam *must* follow the limits below:
    1. For equipment designed to operate with X-ray tube potentials below 70 Kilovolts, the half-value layer *must* not be less than 1.5 millimetre of aluminium (mm Al).
    2. For equipment designed to operate with X-ray tube potentials at and above 70 kilovolts peak the half-value layer *must* not be less than:

       - 2.1 mm Al at 70 Kvp
       - 2.3 mm Al at 80 Kvp
       - 2.5 mm Al at 90 Kvp
       - 2.7 mm Al at 100 Kvp
       - 3.0 mm Al at 110 Kvp
       - 3.2 mm Al at 120 Kvp
       - 3.5 mm Al at 130 Kvp
       - 3.8 mm Al at 140 Kvp
       - 4.1 mm Al at 150 Kvp

**Protective Clothing**

14. **Protective Clothing**
    1. Protective aprons, gloves and thyroid shields *must* provide attenuation equivalent to at least 0.5 mm of lead at X-ray tube voltages of up to 150 Kvp.
    2. The lead equivalent thickness of the material used *must* be permanently and legibly marked on the protective device. Protection *must* be provided throughout the glove, including fingers and wrist.
    3. Protective aprons, gloves and thyroid shields *must* be stored and maintained according to manufacturers’ recommendations.
    4. Protective aprons, gloves and thyroid shields should be checked by radiographing them annually or when damage is suspected.
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<td>15. The darkroom <em>must</em> be impervious to light</td>
<td>6.3.1</td>
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<td>16. A warning light or sign <em>should</em> be located outside The darkroom to indicate when the room is in use.</td>
<td>6.3.2</td>
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<td>17. Safelights, fitted with light bulbs of correct intensity and filters appropriate to the specifications of the film used <em>must</em> be provided above the work area within the darkroom.</td>
<td>6.3.3</td>
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<tr>
<td>18. Manufacturers’ recommendations about the strengths and temperatures of the solutions and immersion times <em>must</em> be followed to ensure optimum film processing.</td>
<td>6.3.4</td>
</tr>
<tr>
<td>19. Manufacturers’ recommendations about the operation and servicing of automatic film processors <em>must</em> be followed to ensure optimum film processing.</td>
<td>6.3.5</td>
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<tr>
<td>20. Developing solutions <em>should</em> be replenished and changed according to the manufacturers’ recommendations.</td>
<td>6.3.6</td>
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<td>21. Unexposed radiographic films <em>must</em> be stored in such a manner that they are shielded from stray radiation. Storage <em>should</em> be provided such that no film can be exposed to more than 1.75 uGy (0.2mR) of stray radiation before use.</td>
<td>6.3.7</td>
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<td>22. Films <em>should</em> be stored on end in a cool, dry area.</td>
<td>6.3.8</td>
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<tr>
<th><strong>Radiation Protection</strong></th>
<th><strong>6.3.8</strong></th>
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<tr>
<td>23. Adequate Shielding: 1. 20 mSv for radiation workers 2. 1 mSv for members of the public.</td>
<td>4.1</td>
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<td>24. The radiation beam <em>must</em> always be directed toward adequately shielded or unoccupied areas.</td>
<td>4.2.1</td>
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<td>25. The radiation beam and scattered radiation <em>should</em> be attenuated as closely as possible to the source.</td>
<td>4.2.2</td>
</tr>
<tr>
<td>26. The shielding <em>should</em> be constructed to form an unbroken barrier. Lead must be adequately supported to prevent “creeping”.</td>
<td>4.2.4</td>
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<td>27. A control booth <em>must</em> be provided for the protection of the operator (when necessary). The control booth <em>should</em> be positioned so that during an irradiation no one can enter the radiographic room without the knowledge of the operator.</td>
<td>4.2.5&amp;4.2.6</td>
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<td>28.</td>
<td>Warning signs <strong>must</strong> be posted on all entrance doors of the radiographic room. The warning signs <strong>must</strong> incorporate the X-radiation warning symbol and <strong>should</strong> incorporate the words “Unauthorized Entry Prohibited.”</td>
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<td>29.</td>
<td>Mobile X-ray equipment used routinely in one location is considered to be a fixed installation, and the facility <strong>should</strong> be shielded accordingly.</td>
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<td>30.</td>
<td>Radiation Protection Survey completed.</td>
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<td>31.</td>
<td>All personnel <strong>must</strong> fully use all protective devices available.</td>
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<tr>
<td>32.</td>
<td>The X-ray tube housing <strong>must</strong> never be held by hand or supported by any part of the body during operation.</td>
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<td>33.</td>
<td>If necessary, the animal <strong>should</strong> be sedated or holding devices used during radiography. However, if this is not possible and a person <strong>must</strong> restrain the animal, protective aprons and gloves <strong>must</strong> be worn and irradiation by the X-ray beam <strong>must</strong> be avoided. Individuals <strong>should</strong> avoid performing these duties regularly.</td>
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<tr>
<td>34.</td>
<td>A radiographic cassette holder <strong>must always</strong> be used. The radiographic cassette <strong>must</strong> never be held by hand.</td>
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<tr>
<td>35.</td>
<td>All operations of X-ray equipment, together with personnel who routinely participate in radiological procedures must wear personal dosimeters. When a protective apron is worn the personal dosimeter must be worn underneath. If extremities are likely to be exposed to higher doses; additional monitors <strong>should</strong> be worn on the extremities.</td>
</tr>
<tr>
<td>36.</td>
<td>For tabletop radiography when the sides of the table are not shielded, a sheet of lead at least 1 mm in thickness and slightly larger than the maximum beam size <strong>should</strong> be placed immediately beneath the cassette or film.</td>
</tr>
<tr>
<td>37.</td>
<td>The fastest combination of films and intensifying screens consistent with diagnostically acceptable results and within the capability of the equipment <strong>should</strong> be used.</td>
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4. Code of Practice

"Code of Practice" means a document prepared by an owner or employer to provide information to workers and other persons concerning the safe operation of radiation facilities, radiation equipment or radiation sources, including the following:

(a) practical guidance on the requirements of this Act or the regulations;
(b) safe working and operating procedures;
(c) actions to be taken in emergency situations;
(d) other matters required by the regulations or the Director.

When he is required to do so by the regulations or the Director, an owner or employer shall

(a) establish a code of practice,
(b) ensure that the code of practice is readily available to workers and other persons, and
(c) supply a copy of the code of practice to the Director for review.

4.1 Physical Facility

Design: The radiology section should be designed in a safe yet effective manner. Veterinary facilities must have a room dedicated to radiography to minimize traffic. Design should include consideration of traffic and adjacent room uses. The x-ray machine, control panel and darkroom should be located with safety as well as convenience in mind.

Construction: Safe construction must take into account walls, doors, floors and ceilings; adjacent room use; and workload. Appropriate regulatory authorities should be consulted prior to and during construction of a radiology facility.

A room safely constructed for one x-ray machine may not be adequate for newer equipment of higher capacity. Changes in workload may also necessitate room modifications.

4.2 Staff Exposure

4.2.a. Use of protective clothing and devices:
Apron, gloves and thyroid protectors must be used for workers involved in the holding of patients.

4.2.a.i. Aprons

Proper maintenance is important to preserve the effectiveness of aprons. Aprons should not be folded or crumpled since cracks will develop in the lead lining, leading to decreased protection. Lead
aprons should be hung. The aprons should be periodically evaluated for cracks or tears by making radiographs of the aprons.

4.2.a.ii. Gloves

Labeled gloves should always be worn by any person manually restraining a patient during a radiographic exposure. Gloves with 0.5 mm lead equivalent are preferable.

Gloves only protect the wearer from scatter radiation and do not protect the wearer from the primary beam. Even with leaded gloves, the hands must not be included in the primary beam. Scattered radiation from the patient and table is the hazard to the holder, not the primary beam. Therefore the practice of laying gloves over the top of the bare hands holding the patient is not acceptable. Lead gloves with holes or tears offer less protection of the hand. Gloves should be periodically evaluated for such defects by making radiographs of the gloves.

The service life of gloves can be extended by proper storage (fingers up on specific holder) and by the use of glove liners.

4.2.a.iii. Cassette holders

Cassette holders are devices used to hold and fix the cassette in desired position and thus avoid hand holding a cassette during a radiographic exposure. Since the table supports the cassette with most vertical beam work, their primary application is in horizontal beam work. They should be used whenever possible and hand holding cassettes prohibited.

4.3 Dosimetry

All radiation workers will have dosimetry badges and be monitored as required by the Government of Alberta RPA Regulation, Section 4.

All radiation workers employed at multiple locations must be provided a dosimetry badge by their employer for each location that they are working at. Occasional assistants, VMR/VAA students and AHT students shall use a “Guest” dosimeter, which will then be submitted to Health Canada to be read.

Dosimeters must remain in the clinic, and when not being worn, need to be protected from light. They should be stored in the drawer in the treatment area so that the Radiology QA person can access them when needed.

Dosimeters should be worn throughout everyday worked. This will measure any exposure a staff member may have, even if they think they are not being exposed (eg. working at the treatment table outside the x-ray room.) At minimum, the dosimeter needs to be worn when assisting with taking x-rays.
4.3.a. **Authorized Dosimetry Service Providers**

National Dosimetry Services  
Radiation Protection Bureau  
Health Canada  
775 Brookfield Road  
Ottawa, Ontario  
K1A 1C1  
Phone: 1-800-261-6689  
Fax: 1-800-252-6272  
E-mail: NDS-SND@hc-sc.gc.ca  
Website: www.hc-sc.gc.ca/ewh-semt/occup-travail/radiation/dosim/index_e.html

Landauer Inc.  
2 Science Road  
Glenwood, Illinois  
USA 60425-1586  
Phone: 1-800-323-8830  
1-708-755-7000  
Fax: 1-708-755-7016  
Email: custserv@landauerinc.com  
Website: www.landauerinc.com

Mirion Technologies.  
Dosimetry Services Division  
2652 McGaw Avenue  
Irvine, California  
USA 92614  
Phone: 1-800-251-3331  
Fax: (949) 419-1000  
E-mail: info@dosimetry.com  
Website: www.dosimetry.com

4.3.a.i. **Protection of pregnant workers**

Women of childbearing age have an additional risk due to the hazards of radiation for the developing embryo/fetus. These individuals should receive specific information outlining the current regulations and recommendations on women of childbearing age in radiation occupations. It is preferable to reassign this individual and avoid radiology duty for the duration of her pregnancy. In the event that the individual, having been fully appraised of the hazards, elects to continue radiology service, then exposure is kept as low as reasonably achievable (ALARA).

4.4 **Training**

*In accordance with the Radiation Protection Act, Section 6,*

1) Every employer shall ensure that workers employed by them who are
likely to be exposed to radiation are informed of the potential hazards of the radiation and the precautions to be taken to protect the workers and other persons from those hazards.

2) In complying with subsection (1), the employer shall ensure that the following have been brought to the attention of each worker,

(a) the worker’s responsibilities and duties under this Act and the regulations;

(b) the type of radiation source with which the worker will be working;

(c) radiation protection principles and maximum exposure limits of radiation appropriate to the type of radiation with which the worker will be working;

(d) the uses and limitations of the radiation facility, radiation equipment and radiation sources the worker will use;

(e) known or suspected health hazards associated with the form of radiation emitted by the radiation source.

4.5 Records

4.5.a. Logs

Adequate records must be maintained to document important information and maintain consistency.

Exposure Techniques

Exposure techniques utilized in making a radiograph should be logged body part thickness and exposure factors (kVp, mA, time). Utilized should be included if more than one (1) type is available. (See x-ray log sheet).

This information allows for the following:

i. Reproducibility

ii. Accurate corrections of exposure errors

iii. Documentation of workload of the x-ray machine

A radiographic technique chart, however may reduce the need for a detailed x-ray log sheet (x-ray machine settings could be eliminated from the chart) and they generally result in enhanced reproducibility, quality of x-rays, safety and cost effectiveness.

4.6 Dosimetry Records

Records for personnel monitoring document exposure levels. Such records should be permanently maintained for future reference. They are a legal requirement for future reference and offer a means of documenting safety practices. New staff members with previous exposure histories should obtain
copies of their previous reports, so the facility can maintain a file of the individual’s life-time exposure history. The practice must provide such copies for prior staff members who have obtained radiation related employment elsewhere. If you are changing dosimetry service companies, ensure that all previous file information on staff is transferred so that cumulative exposure histories are accurate.

4.7 National Dose Registry
(Repository for personal exposure records)
Radiation Protection Bureau
Health Canada
775 Brookfield Road
A/L 6302C2
Ottawa, Ontario
K1A 1C1
Phone: (613) 954-6664
Fax: (613) 957-0960
E-mail: NDR-FDN@hc-sc.gc.ca
Website: www.hc-sc.gc.ca/ewh-semt/occup-travail/radiation/regist/index_e.html

5. Quality Control

Quality Assurance was defined by Thomas in 1973 as a system of activities whose purpose is to provide assurance that the overall quality control job is in fact being done effectively. The system involves a continuing evaluation of the adequacy and effectiveness of the overall quality control program with a need to having corrective measures initiated where necessary.

Quality Assurance activities include:

(1) Preventative Maintenance
(2) Quality Control
(3) Equipment Calibration
(4) Inservice Education
(5) Evaluation of New Products

5.1 Enacting an x-ray quality control program

Enacting a quality control program consists of implementing quality control procedures and tests resulting in:

➤ Quality diagnostic radiographs providing information for accurate diagnosis.
➤ Lower exposure doses for employees and patients.
- Total better and less costly patient care.
- Less repeats therefore lowering cost to chemistry and film.

The owner of the facility is responsible for insuring the Quality Assurance tests are run and interpreted at the appropriate frequency.

Although frequency of testing may vary depending on the test, the goal of the checks is to isolate and correct potential problems before they become significant enough to affect the quality of radiographs. Tests should be conducted on a set schedule and should be arranged when the least amount of clinic disruption occurs. They should be conducted whenever changes have been made, such as chemical changes in a processor or equipment repairs in an x-ray room or when a problem has been detected. Faults in systems can be isolated thereby saving time and effort in guessing what resources, such as service men, should be called in to correct the problem.

### 6. Equipment Tests & Procedures

#### 6.1 DARKROOM

Those people processing radiographs should understand the basic principles of darkroom technique and should refer to appropriate textbooks/manufacturers instructions for specifics.

**Cleanliness:** The darkroom should be kept clean to avoid radiographic artifacts. This includes both chemistry and care of film and cassettes.

**Darkness:** Proper darkness must be maintained when necessary. This includes elimination of light leaks from doors, safety light filters, etc.

Any noticeable light leaks around doors should be fixed as they develop during the year. Once per year, test the darkroom for leaks. It can be helpful to close yourself into the darkroom with the lights and safelights turned off for about a five minute period. Eyes become accustomed to the dark, and small light leaks that need to be sealed will become apparent.

**Safelights:** Even with proper filtration, safelights can expose radiographic film if the light is too close to the film or the bulb is too strong. A minimum distance of four (4) feet and a maximum of a fifteen (15) watt bulb are recommended. All safelights and filters are not compatible with all brands of films. The film manufacturers recommendations should be followed as to type of filter, wattage of lamp, and distance from the film loading surface.
A GBX filter (red in color) can be used for both blue and green sensitive film. If you have a Wratten 6B filter (orange in color) and have green sensitive film and green emitting intensifying screens, you will have to process your film in complete darkness, until you purchase a GBX filter.
**SAFE LIGHT TEST TOOL**

- Make a safelight test tool by using an 8 ½” x 11” manila envelope.
- Cut one side of the envelope leaving two flaps on either side approximately 5 cm. (2 in.).

<table>
<thead>
<tr>
<th>8 ½”</th>
<th>flap</th>
<th>flap</th>
</tr>
</thead>
<tbody>
<tr>
<td>11”</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

On the other side of the envelope, evenly mark six sections off on flaps. Mark the top part of flap 4 min., next 2 min., 1 min., 30 sec., 15 sec., and 15 sec.

<table>
<thead>
<tr>
<th>8 ½”</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4 min.</td>
<td>2 min.</td>
<td>1 min.</td>
</tr>
<tr>
<td>1 min.</td>
<td>30 sec.</td>
<td>15 sec.</td>
</tr>
<tr>
<td>15 sec.</td>
<td></td>
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<tr>
<td>11”</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>8”</th>
<th>Unexposed</th>
<th>Exposed</th>
</tr>
</thead>
<tbody>
<tr>
<td>10”</td>
<td></td>
<td>Film</td>
</tr>
</tbody>
</table>

Don’t throw your safelight test tool away or you will have to make another one in six (6) months!
SAFELIGHT TEST TOOL PROCEDURE

Darkroom Safelight Test:

1) In total darkness, place a film from the film bin in a 8” x 10” cassette with screens.

2) Cover one half (lengthwise) with a lead mask. Then expose to x-radiation sufficient to produce a low density such that ordinary newsprint can be discerned if the film is placed over it (about 0.6 to 1.0 density). (single phase equipment 100 mA – 1/60 s – 50 KVP).

3) In total darkness, remove exposed film from cassette and place in this test holder. With the sides of the film under the flaps, cover completely with a cardboard.

   CAUTION: Throughout test, be sure numbered flaps are held in close contact with film. It may be necessary to tape the top edges of the flaps to secure contact.

4) Turn on safelight and slide cardboard down to first line. Expose for 4 minutes. Continue to slide the cardboard down quickly in successive steps for 2 minutes, 1 minute, 30 seconds, 15 seconds and 15 seconds.

5) After the last 15 second exposure, turn off safelight, remove film, and process.

As you are sliding the cardboard down, remember that piece of film will be exposed to safelights twice as long eg. 4 minutes will actually be exposed for 8 minutes, etc., except the last 15 seconds. You may want to write the times on the film, with a pencil.

Faulty safelighting appears in radiographs as a loss of contrast in low and midtone density areas and then as a fog buildup in the unexposed areas of the radiograph. Since it is difficult to see the contrast change in a diagnostic radiograph, the safelight test can be used to determine whether faulty safelighting is affecting contrast. Conducting this test on a 6-month or a yearly basis will indicate whether safelight filters have faded or are cracked.

Safe times for handling film in a radiographic darkroom should be evaluated on the exposed portion of test film because film that has been exposed is much more sensitive to the detrimental effects of excessive safelighting than unexposed film. The actual average time for safe handling of film should, if possible, be about half the time determined by the test in order to provide a margin of safety.

Exposed film is much more sensitive than unexposed film therefore film should be processed as soon as possible after exposure.

SAFELIGHT TEST EVALUATION

Determine the maximum post-exposure safelight handling time using a densitometer or by visual inspection.

Use a densitometer to locate a “step” in the portion of the processed test film that was exposed to both x-radiation and safelighting in which safelighting produced a density about
0.05 greater than the density of the x-ray exposed background (which is the area exposed to x-rays but covered by the flap during the safelight exposures). The time of the cumulative safelight exposure that produced this step is the practical limit for post-exposure safelight handling time.

For visual determination, cover all edges between adjacent density differences on the portion of the test film exposed to both x-radiation and safelight with black opaque tape or strips of black paper. Next, visually examine the same area to locate a step just noticeably darker than the x-ray exposed background. The time of the cumulative safelight exposure that produced this step is the practical limit for post-exposure safelight handling time.

Ideally, in routine use, the actual film-handling time should be less - possibly one-half less – than that determined by the test in order to provide a margin of safety.

The part of the test film that received only safelight exposure can be used to determine the safe handling time for unexposed film to prevent visible fog density. The edges between adjacent density differences on this half of the test film should not be covered for this rigorous inspection because it would be undesirable to use film that already has an observable fog density for exposure of patient. It is likely that the safelight exposure required to produce fog that is just visible on fresh, unexposed film will be 2 to 4 minutes or longer.

Safelight Test Results

If film-handling procedures require more safe time than is permitted by the safelights in use, several factors should be investigated. The safelight filters may be cracked or faded. A bulb of higher wattage than that recommended may have been placed in the safelight holder. If the test shows a need for more safelight time when a bulb with the recommended wattage is used, another test should be made with a bulb of lower wattage. It may be necessary to change a direct safelight over the working area to an indirect one (bounce the light off the ceiling or off a nearby wall) or to turn off the safelight altogether.

Causes of Darkroom Fog:

- White light leak from around a door
- Cracked safelight
- Improper wattage bulb in safelight
- Improper safelight filter
- Safelight too close to the counter
- Improper chemical temperature
- Improper chemical balance

**NOTE:** When doing this test, you can also do the observing of light leakage for your darkroom.
6.2 X-RAY CASSETTES

Clean Intensifying Screens and Cassette:

Each cassette should be identified on both the outside back, and the inside screen (next to the blocker) with a black felt pen (may be washable). If an artifact is visible on the finished film, it will be easy to determine which cassette/screens needs to be cleaned. Beyond this day to day check-up, screens should be cleaned at least once a month. The date should be entered into the log book and put on the back of the cassette with tape.

There are screen cleaners on the market, and they should be only used on the screens if recommended by the manufacturer. A mild liquid detergent and warm water will wash most screen surfaces. Surfaces should not be scrubbed as this will wear off the surface. On many rare earth screen there is not protective surface and scrubbing will wear away the imaging surface. On those screens with protective surfaces, scrubbing will wear away the protective surface and create hot spots (dark spots) on the finished film.

After cleaning, the cassettes should be left propped open slightly overnight to dry. If they are closed when still damp, they will usually bond together and ruin the cassette for further use.

Screen cleaner is recommended, use as per instructions. With a lint-free cloth wipe screens in overlapping strokes up and down then side to side to ensure complete cleaning of the screen.

Use a UV light to inspect your screens for cleanliness or screen faults.

Clean the outside of your cassette with a mild soap and water. Remove all unwanted tape, etc.
WHITE LIGHT LEAKAGE TEST FOR CASSETTES

Reference:
Only when necessary, when edges of film are black.

Objective:
To perform, observe and evaluate the test for cassette white light leakage.

Procedure:
1) With the use of a 100 watt pearl tungsten bulb and a loaded cassette perform a white light leakage test.
2) Inspect cassette for broken hinges, buckled corners and/or loose front.
3) If cassette does not have film, load.
4) Place 100 watt pearl tungsten bulb 1.22 m from cassette.
5) Expose each edge (four in all) and two sides to the bulb for fifteen minute periods. This test will take 1 ½ hours to complete.
6) When test has been completed, identify the top, bottom, right and left before processing.
7) Process film.
8) Observe if there are any patches of fog or leakage present. If the edge darkening is not greater than 1/8” (3.2 mm) the fogging is insignificant.
SCREEN-FILM CONTACT TEST

Test should be conducted if blurriness or fuzziness is apparent.

Objective:

To ensure that the adhesive on the back of the screens within the cassettes is still holding the screen tightly. If the intensifying screen does not make contact with the film there will be decreased and/or “spotty” detail.

Equipment:

Wire mesh test tool or a box of paperclips.

Procedure:

1) Each cassette that is to be tested should be allowed to sit for about 10 minutes before this test is performed. This will allow any trapped air (from loading the film into it) to dissipate. All cassettes in your practice should be tested initially.

2) Place the cassette on the table top.

3) Place the cassette so that the long axis is perpendicular to the anode-cathode axis of the x-ray tube. This is to minimize the heel effect.

4) Place the wire mesh (or paperclips) over the cassette.

5) Use at least a 60 inch SID. You may have to put the cassette on the floor.

6) Cone down to the size of the cassette – use small focal spot.

7) Make an exposure using
   (eg. mA Time KVP)
   100 1/60 70 (single phase equipment)

8) Process the film.

9) View the film on a view box in a dimly lit room.

10) Stand 6 to 8 feet back from viewer. Look for areas of darkness or unsharpness on the film. Areas of poor contact appear as dark areas on the film. If this area is in the middle of the cassette or in an area where you are likely to need a diagnosis, this screen should be replaced.
6.3 FILM PROCESSING

One of the major goals of darkroom technique is to maintain consistency of film processing. The principles of time, temperature and replenishment should be understood and adhered to accurately.

1) **Developer Temperature: (Manual and Automatic)** *(Daily)*

   Developer temperature must be measured daily prior to radiographing patients. The temperature should be taken with a non-mercury type of thermometer. Do not use mercury thermometers because mercury from broken thermometers will react with the developer. If contaminated with mercury, you will have to buy a completed processing unit.

2) **Replenish Processing Solutions: (Manual and Automatic)** *(Daily)*

   Solutions must be brought up to the correct level at the beginning of each day.

3) **Change Processor Solutions: (Manual)** *(As recommended every 4 to 8 weeks)*

   Changing processor solutions **according to manufacturer recommendations** will reduce the amount of retakes due to processor problems. If few films are processed, the solutions will oxidize and lose their stability in a shorter period of time. A tight fitting lid will allow solutions to be kept longer. In offices with low volumes, it is recommended that processors with small tanks be utilized to reduce the expense when the solutions are dumped at a more frequent rate.

**NOTE:** Fixer overflow and fixer dumping must be saved and the silver must be reclaimed prior to dumping the chemistry into the sewer system. In Alberta, the silver recovery system must reduce the amount of silver going down the drain to less than 5 parts per million. Silver – estimating paper is available.

The Processing Record Chart at the end of this section will assist you in recording your processing Quality Control Procedures.
4) **Developing Technique:** *(Manual)*

The biggest problem with manual processing is the tendency to tinker, or to pull the film out of the developer when it looks right. Film should be left in the chemistry for the time recommended by the manufacturer. Ask your supplier or the manufacturer for the appropriate time for your combination of film and chemistry.

The films should be removed from the developer quickly without allowing any solution to drain back into the developer solution. If level of solution is low, then top up with replenisher and stir solution.

5) **Rinsing:** *(Manual)*

After being removed from the developer, the film should be immersed in rinse water composed of clean, fresh, temperature controlled water and agitated vigorously for a minimum of 30 seconds and immediately put into the fixer. If allowed to drip completely, development will continue.

6) **Fixing:** *(Manual)*

Fixing is of course influenced by the temperature of the fixer. Again, follow the manufacturers recommendations, but generally fixing time is two (2) times the clearing time. Clearing time is the time it takes to remove all the unexposed Silver halides. Depending on the freshness of your fixer, after the clearing takes place the film can be quickly viewed and then put back for hardening. Fixing time should be approximately three (3) minutes with fresh solution.

Films must not be taken out of the fixer before fixation is complete. Early removal will result in inadequate hardening of the film and will slow down the drying process, make the film easier to scratch and reduce the permanence of the image. Leaving the film in for more than an hour will **fade** out the image. Fixer should also be replenished to maintain the activity of the solution, and to make sure the film is completely covered with solution. Read manufacturers instructions but remember you are always adding rinse water diluting the concentration.

7) **Washing:** *(Manual)*

Washing requires temperature controlled fresh water. A suitable mixer valve must be in place to insure that temperature of all solutions is stable. The hangers should be placed so that there is adequate flow of water around the film, and the wash time should be at least twenty (20) minutes.
8) **Drying: (Manual)**

Improper drying will result in water marks, scratches, or films sticking together. Over drying (in heated dryers) can result in the films becoming brittle. If using heated dryers, try to vent the air to the outside of the room so that the room does not get over hot or humid. If a heater is used in the room to assist drying, insure that the filaments do not expose the unprocessed film. Film will be very sensitive to infrared heat.

If using manual processing, hangers should be wiped and cleaned on a monthly maintenance.

6.4 **PROCESSOR MAINTENANCE**

**Method:**

*Perform routine checks and processor maintenance.*

1) Maintenance logs must be established. This should include any maintenance performed including preventative and repair and cleaning, dates and who performed the task.

2) Clean cross-over and wipe surfaces of top rollers in racks.

3) Clean racks weekly with fresh water and a non-abrasive cleaning pad.

4) Check roller, springs, gears for wear and/or breakage.

5) Check and tighten screws.

6) LISTEN! Each processor has its own unique sounds. Any changes in sound may affect the quality of the radiograph.
START UP AND SHUT DOWN OF AUTOMATIC FILM PROCESSORS

Start up of Processor:

1) Wipe off all dust and dirt from the film input place.
2) Wash the cross over racks thoroughly.
3) Wash and clean off all dirt and solution splashes from processor body.
4) Check replenisher tanks; and if there is not enough solution, top mix.
5) Replace cross over racks and cover.
6) Open water supply valve.
7) Turn on main switch.
8) Check developer temperature.
9) Put through two (2) or three (3) test cleaning films.
10) Check films for marks, etc.

Shut Down of Processor:

1) Turn main switch off.
2) Close water supply valve.
3) Remove cover and cross overs (dev-fix), (fix-wash) and leave outside processor.
4) Rinse.
5) Leave lid open.
SENSITOMETRY

1) Using a controlled box of film – same lot number, etc. usually 8” x 10”s, exposed one (1) edge with the sensitometer. It is recommended that you flip the film and expose the other side of the film with the sensitometer. This may save you time as if you only do the one edge and it does not turn out, the process will have to be repeated.

2) Process normally.

3) With the densitometer, find a step that has a density of 1.00 or greater. This will be your speed step.

4) Read two steps above and two steps below the established speed step. Subtract these two numbers providing you with a number for contrast. (eg. 1.83 - .53 = 1.30).

You should be able to require the standards of speed, contrast, Base and Fog (B & F) from the manufacturer.

5) Read an area of the film that has received no exposure. (Base and Fog – B & F).

6) On the control or trend charts provided; plot speed, contrast, base and fog, and developer temperature.

7) On each chart, determine the control limits or operating limits.
   a. speed not greater than +/- .15
   b. contrast not greater than +/- .15
   c. base and fog should not increase more than + .05
   d. temperature not greater than +/- 1.1 degrees Celcius or +/- 2 degree Frenheit

8) Analyze control charts carefully.
   • Are we within the limits?
   • Are there any trends?

9) If there are points outside the limits, a second sensitometric film should be processed in one (1) hour.

10) After analyzing the results, corrective action should be taken if necessary.

A control film will have to be established when the processing solutions have been freshly mixed. At least ten (10) film should be processed before producing a control film. This acts as a standard.

The numbers that are established on your control film (eg. speed 1.19, contrast 1.53, base and fog .18) are then written on the middle of each graph. Always do your control film at the temperature set by the manufacturer.
HOW TO MEASURE PROCESSING VARIATIONS

Depending on the sensitometer used, some may have two step wedges and others may only have the 21 step wedge, use the following as a guide.

Using the 7 Step Wedge,

Processor control by visual comparison is practical with the seven step wedge. The test film is placed next to the standard on the viewbox. If the test film exactly matches the standard, the variation is zero. When matching densities requires displacement of the test film standard by one step, the variation from standard is equivalent to 15%. A one step offset from the standard is acceptable. When the test film must be displaced by two steps, the processing variation is equivalent to 30%. A two step variation indicates the need for corrective action. Common Processing Problems are available from the manufacturer.

Using the 21 Step Wedge,

Speed:

- Determine the step number within a density range of 1.00 – 1.30 on the 21-step wedge, that step becomes the Speed Step.
- Enter the step number and density reading on the chart. This step should be used for all future readings.
- Measure and plot the Speed Step daily (or as set up by your Clinic).
- Variations greater than +/- 0.15 indicate the need for corrective action.

Contrast:

- Determine the density of the steps above and below the Speed Step.
- Subtract these densities for a contrast reading. The same two steps should be used for all future contrast readings.
- Calculate and plot this density difference daily (or as set up by your Clinic).
- Variations greater than +/- 0.15 indicate the need for corrective action.

Base & Fog:

- Read an area of the film that has received no exposure.
- Enter reading in the space provided on the chart.
- Measure and plot Base and Fog daily (or as set up by your Clinic).
- Base and Fog should not increase more than + .05 from normal level.

Temperature:

- With a calibrated thermometer, measure developer temperature and enter the reading on the chart. (Always measure at the same location in the tank).
- Measure and plot developer temperature daily.
- Variations greater than +/- 2 degrees Fahrenheit (1.1 degrees Celsius) indicate the need for corrective action.
REPEAT/REJECT FILM ANALYSIS PROCEDURE

All repeat films should be kept and reviewed to determine the cause of rejection. In this way you will be able to determine if most rejections are for positioning, density, or motion problems. This will assist in the correction of these problems. The correction may require a change to the technique charts, the processor maintenance, or to more care in positioning.

This review can be done whenever it is perceived that there is inconsistency of results (remember, a technique chart may help greatly) or every few months (minimum six (6) months). This allows corrections in technique before an inordinate amount of film has been wasted and workers have been unnecessarily exposed to greater radiation dosage. The enclosed Repeat Analysis Form following this section may assist you in documenting your rejects and the following trouble shooting list of Technical Errors may assist in your analysis.
REJECT ANALYSIS

Objective:

Introduce and set up a reject-repeat analysis program.

Reject-Repeat Analysis:

Reduce the number of films that are rejected and repeated.

Rejected films are all scrap film – green, black, clean-up and patient films.

By setting up a Reject Analysis Program (RAP), two things can be accomplished:

1) Reduces film and chemistry used.

2) Reduces exposure to patient and personnel.

The same people should analyze the films each time for consistency.

Reject Analysis Program (RAP) results should never be competitive. Results should be communicated to all the technologists in terms of the overall reject rate.

Strict guidelines must be established concerning the methods of film collection and analysis.

E.g.,

- No copy or subtraction film included
- Positioning – errors made by technologists
- Scout
- Special procedures not included
- Miscellaneous
- Example of “good films”

Look At:

- Total waste films – all films in scrap bin
- Total rejects – all films except clear and Quality Control films
- Total repeats – on patient
  Points that should be noted are type and mixture of patients (large vs. small animals).

Remember that Reject Analysis Program (RAP) data must be collected with extreme care and results must be analyzed with great caution.

Study must be correct and meaningful.
Procedure:

- Determine the actual number of films used.
- Collect all reject films and determine the numbers that were exposed.
- Analyze all reject films.
- Record on a tally sheet.
- Determine the overall reject rate.

_E.g._: 153 rejected films and a total of 1225 films used

\[
\frac{153}{1225} \times 100\% = 12.5\%
\]

Rejects from each category,

_E.g._: 49 films too dark and there are 153 rejects

\[
\frac{49}{153} \times 100\% = 32\%
\]

Acceptance Limits:

Overall reject rate should be less than 10% and ideally down to about 5%.

Should be done on a monthly basis. If left for longer periods of time the longer it will take you to do the task and then it may become a burden!
<table>
<thead>
<tr>
<th>APPEARANCE ON THE RADIOGRAPH</th>
<th>CAUSE</th>
<th>CORRECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Film density increased but Contrast retained</td>
<td>Incorrect machine setting Overmeasurement of body Timer out of Calibration Beam filter not in place Wrong type of screen/film Combination</td>
<td>Lower kVp, mA or time Remeasure Repair timer Replace filter Check screen/film type</td>
</tr>
<tr>
<td>2. Film density decreased</td>
<td>Incorrect machine setting Undermeasurement of body Valve or x-ray tube failure Wrong type of screen/film Combination</td>
<td>Increase kVp, mA or time Remeasure Replace Check screen/film type</td>
</tr>
<tr>
<td>3. Film gray with loss of Contrast (fog)</td>
<td>Film exposed to radiation Film exposed to scatter Film exposed to radiation during storage Film stored where too hot or humid Film old</td>
<td>Remove loaded cassettes from room during exposure Use grid on tissue thickness &gt; 10 or 11 cm. Do not store film near source of radiation Store where dry and cool Discard film</td>
</tr>
<tr>
<td>4. Black marks or areas</td>
<td>Linear scratches on film Crescent marks due to bending roughly after exposure Static electricity</td>
<td>Handle film carefully Handle film carefully Handle film without causing friction; avoid low humidity in darkroom (?) Repair or replace film bin Replace felt strip or replace damaged cassette</td>
</tr>
<tr>
<td>5. White artifacts</td>
<td>Fingerprints or blotches due to fixer on film prior to processing Irregular marks due to dirt, debris or chemical stain on intensifying screen Crescent marks due to bending prior to exposure Irregular white marks due to dirt or iodine-containing medication White streaks near edge of film</td>
<td>Clean bench surface in darkroom and/or clean hands before handling film Clean or replace intensifying screens Handle film more carefully Clean skin/hair prior to radiography Cracks in screens</td>
</tr>
<tr>
<td>APPEARANCE ON THE RADIOGRAPH</td>
<td>CAUSE</td>
<td>CORRECTION</td>
</tr>
<tr>
<td>------------------------------</td>
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</tr>
<tr>
<td>6. Heavy lines across radiograph</td>
<td></td>
<td>Reposition grid</td>
</tr>
<tr>
<td>7. Edge(s) of film white (Underexposed)</td>
<td>Bucky tray not correctly positioned under table Cone cut because of incorrect centering</td>
<td>Reposition bucky tray Reposition so central beam hits center of cassette</td>
</tr>
<tr>
<td>8. Inconstant film density</td>
<td>Target damage</td>
<td>Replace x-ray tube</td>
</tr>
<tr>
<td>9. Double exposure</td>
<td>Cassette exposed twice</td>
<td>Position cassette a certain way to indicate exposure</td>
</tr>
</tbody>
</table>
6.5 X-RAY MACHINE TESTS

Most of these tests will only be performed when a problem is suspected or on an annual basis. The correction of problems may require a visit from an x-ray machine maintenance worker.

**SOURCE-IMAGE DISTANCE (SID) MARKS TEST**

*(once yearly)*

Objective:

Ensure accuracy of the Source-Image Distance (SID)

Equipment:

Steel tape measure

Carpenter’s level

Procedure:

1) Measure from the focal spot mark on the tube housing to the table top. If there is no mark, simply divide the tube housing and cap it into fourths. Using the bottom fourth as the focal spot, make a mark with a permanent marker and measure.

2) Measure from the tabletop to the top of the cassette in the bucky tray. Portable x-ray machines will require a set distance indicator such as a string or tape measure.

3) Add the two numbers together to get the Source-Image Distance (SID).

4) If the collimator has a tape measure on it, check this for accuracy with the external tape measure.
X-RAY FIELD LIGHT TEST

Objective:

To ensure that the field light can be seen properly with the normal room lights on.

Equipment:

Water and cloth

Procedure:

1) Turn off the power to the machine. Wash the plastic covering of the x-ray collimator with warm water and mild soap. Artifacts can show up on the radiograph if the plastic cover over the tube output is dirty or dusty.

(NOTE: On some older equipment, the plastic covering may be part of the filtering system. If that is the case, have a service person check it).

Turn on the power. The collimator light should be bright enough on all edges with the room lights on. If the dimensions of the light field are difficult to see, there is a problem, and a service person will need to be called to increase the light intensity. This should be recorded for future comparison and reference.

The x-ray unit should be wiped and cleaned on a regular basis, just the same as your bathroom!
PERPENDICULARITY TEST

(once yearly)

Objective:

To be sure the x-ray beam is properly centered; we must be sure that the tube stand, collimator and x-ray tube are parallel and aligned. This is important if using a grid.

Equipment:

Carpenter’s level

Procedure:

1) Use the level to confirm that the tube is level and parallel with the table. Stand at the end of the table and look at the tube, collimator and tube stand. Visually verify that they appear perpendicular.

2) Stand alongside the table and verify the same.
Objective:
To check the function of the locks to eliminate any unnecessary motion from the x-ray tube, table or crane.

Equipment:
None

Procedure:
1) Place locks on and off to see whether they lock securely and unlock properly.

2) Check to make sure that the lock switch itself is not broken and functions properly.

If you notice loose screws, etc., tighten them. This may eliminate a service call.
LIGHT FIELD/X-RAY FIELD ALIGNMENT TEST

(every six months)

Objective:
To ensure that the x-ray field is actually going where the light field indicates.

Equipment:
Nine pennies
10” x 12” cassette loaded with film

Procedure:

1) Center the x-ray tube over the table.

2) Set the Source-Image Distance (SID) to 40 inches or your normal SID and verify that the collimator is level.

3) Put a cassette in the bucky tray.

4) Center the tray under the table.

5) Set the collimator field controls at a field that is approximately 6 x 8 inches.

6) Turn the collimator light on, and place one penny in the middle of each edge of the light field inside the light and one penny in the middle of each edge of the light field outside the light. The edges of the pennies should have the light field running between them, but the pennies should be touching.

7) Make and exposure. Use the technique for a carpus or stifle.

8) Develop the film. When developed, the radiograph should show the pennies just as they were placed on the table, on either side of the light field. If they are not, the collimator is in need of adjustment. The width of a penny is 0.75 inches, and 2% of a 40 inch SID is 0.8 inches. So, if the x-ray field is off the width of one penny, it is time to call service personnel.

To ensure that the center of the light and the x-ray field are aligned, draw diagonally from corner to corner of the film itself (all four (4) corners). Make the same drawing from corner to corner on the exposed part. These two pairs of “X’s” also should not be more than 2% of the SID apart. If they are, realignment by service personnel is needed.
MACHINE PARAMETERS FOR CALIBRATION

Objective:

Calibration involves a series of tests that a service person must perform. However, there is one MA check which can be done if you purchase a step wedge and densitometer. As per other more specialized tests described, owners may enhance their knowledge of these procedures by attending an Alberta Veterinary Medical Association Quality Control Workshop. To ensure that kVp, mA and timer settings are accurate. E.g., As an x-ray machine ages, kilovoltage can fluctuate. Also most veterinary clinics have the x-ray machine operating from the same power line as other equipment so that the incoming line voltage will fluctuate. (Don’t make coffee at the same time you expose that film!).

Equipment:

Step Wedge

Densitometer (Visual comparison of film density may be used if a densitometer is not available).

Procedure:

Calibration Of The Step Wedge

1) Raise the x-ray tube to its maximum height.

2) Place a freshly loaded 10 x 12 inch cassette on the tabletop with the long axis of the cassette parallel to the length of the x-ray tube.

3) Block off one-half of the cassette across its length with lead.

4) Place the step wedge on the cassette so it is in the central beam and perpendicular to the anode-cathode axis of the tube.

5) Collimate the beam to the step wedge.

6) Expose the step wedge at 80 kVp using the 100 mA setting and 0.1 seconds.

7) Move the step wedge to the other half of the cassette and block the previously exposed area with the lead sheet.

8) Using the same settings, make two (2) individual exposures of the step wedge. i.e., a double exposure.

9) Develop and check the film. The ideal exposure should exhibit each step of the wedge without the use of a bright light on the single-exposed wedge. If the film is under or overexposed, repeat the exposures and change the exposure factors until an image is produced in which all steps on the wedge are seen on the single-exposed side.
10) Using a densitometer, select a step on the single-exposed wedge that has a density close to or slightly higher than one (1) and mark it with a marking pen. On the double-exposed wedge, read the densities until the step that has the density closest to the one (1) density on the single-exposed wedge is located.

Once the match is found, mark it and count the number of steps between marks on the single and double exposed wedges to determine how many steps represent a 100% change in exposure. For example, if four steps separate the single and double exposure match, then each step will represent a 25% change.

If you do not have a densitometer, cut the film so that the step wedge images can be placed side-by-side on a view box. On the single-exposed wedge select and mark a step that has a medium-gray density equivalent to soft tissue. By sliding the double-exposed strip past the single-exposed, compare the densities until the closest match is found. Then count the number of steps to determine the number to get a 100% change in exposure.
**VIEWBOXES**

Viewboxes should be cleaned weekly. Screen cleaner can be used because it contains an antistatic solution. The plexiglass is like a magnet and attracts dust just like your computer screen. Clean the inside of your viewbox once yearly.

### 6.6 TESTING LEAD APRONS, GLOVES AND THYROID SHIELDS

Use 14 x 17’s, include all of the front parts of the apron, use a high KVP (100) technique. If there are any cracks or faults, these will show up as dark lines. Do the same for gloves and thyroid shields.

Aprons should **NEVER NEVER** be folded. Use a round object to store them on and if this is not available, place flat on the x-ray table. Gloves should be placed on something so air can circulate inside. Juice cans with bottoms cut out are inexpensive – remember, you can drink the juice before removing the ends.
7. Frequency of Testing

**SAFELIGHT TEST** every six (6) months (at least every year, or if changes are incorporated such as bulbs, filters

**INTENSIFY SCREENS** at least once a month

**CASSETTES** wiped once a week

**SCREEN – FILM CONTACT** when image appears blurry or fuzzy

**PROCESSING** three (3) times a week (if equipment is available) pH and specific gravity (s.g.) can be taken if there is a problem. Depending on the type of developer and fixer, pH should be between 4 – 5 for fixer and 9 – 11 for developer. Specific gravity should be 1.084 for developer and 1.110 for fixer +/- .004 (this may vary with different types of solutions).

**REJECT – REPEAT ANALYSIS** once a month. Categorize

**APRONS, GLOVES AND THYROID SHIELDS** once a year or if defect is suspected

**SOURCE-TO-IMAGE DISTANCE (SID)** once yearly

**LIGHT FIELD TEST** once a month

**PERPENDICULARITY TEST** once a year

**LOCKS** once yearly or as required

**COLLIMATOR TEST** every six months

**AUTOMATIC PROCESSOR** clean crossovers daily

**MANUAL PROCESSING** daily maintenance. Check solutions monthly (this depends on usage).

**VIEWBOXES** once a week.
8. Lasers

Lasers = Light Amplification by Stimulated Emission of Radiation

Laser Applications in Veterinary Medicine include declawing, surgery, ophthalmology, upper respiratory tract, urinary and GI tracts and wound management. These applications are used in both small and large animals. Benefits of using lasers in surgery include decreased bleeding, decreased pain during recovery and the destruction of bacteria.

As lasers are becoming more commonly used in Veterinary Medicine there is important information regarding safety that all users should be aware of. Lasers used in Veterinary Medicine are classified as either 3b or 4 lasers. The numerical classification system ranges from 1-4. Lasers used in Veterinary Medicine are designated in the highest hazard classes.

Class 3B and Class 4 – These classifications indicate that the laser radiation emitted from these devices is a hazard to unprotected eyes and/or skin from exposure to the direct beam and that exposure to the reflected or scattered beam may also be hazardous under some conditions. The direct beam may also be a fire hazard if it strikes combustible materials. Even a brief exposure can damage the retina and surrounding tissues, these eye injuries may interfere with vision either temporarily or permanently, in one or both eyes. It is therefore extremely important that all authorized personnel entering the area of the laser be provided with and wear protective eyewear.

** Protective eyewear is the single most important piece of protective equipment needed by persons within the treatment area.

Skin damage can occur if gloves and gowns are not worn. The damage may appear like a severe sunburn. Reflected laser energy can be protected against by using diffuse reflective materials and instruments with low reflectance in or near the beam path.

The primary hazard associated with lasers stems from inadvertent exposure to laser emissions. Exposure to an individual may occur directly from the laser beam, or when the beam is reflected from a shiny surface such as a mirror, ring, glass picture frame etc., or in the case of the CO2 laser from metal instruments and other common operative items. As previously stated the eyes and skin are at greatest risk. Persons at greatest risk are mainly the staff carrying out laser procedures.

Lasers must be treated the same as x-ray equipment in regards to the hazards for veterinarians and staff directly involved with this type of equipment. Proper safety procedures must be in place and strictly followed in order to ensure safe use. The laser treatment area is usually a separate room with a closeable door and covered windows. Appropriate warning signs must be identified at all entrances to the area.

As with all x-ray equipment, lasers must also be registered and certified with the ABVMA. The equipment must also be inspected prior to certification through an Authorized Radiation Protection Agency. The equipment must comply with the following checklist (See Compliance Verification Checklist for Class 3b and 4 Lasers).
Compliance Verification Checklist for Class 3b and 4 Lasers

In accordance with
CAN/CSA-Z386-08 “Safe Use of Lasers in Health Care Facilities”
Published by the Canadian Standards Association

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Compliance Item Description</th>
<th>Standard Section</th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Engineering Controls (Equipment)</strong></td>
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</tr>
<tr>
<td>1.</td>
<td>Guarded activation switch (foot pedal or finger trigger).</td>
<td>4.3.1</td>
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<tr>
<td>2.</td>
<td>Accessory attachments (e.g. handpieces, scopes and filters, fibers, remote controls, scanners, etc.) are compatible and safe.</td>
<td>4.3.2</td>
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<td>3.</td>
<td>Equipment warning labels are visible during normal operation; not covered or removed</td>
<td>4.3.3/4.7.2</td>
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<td></td>
<td><strong>Administrative Controls</strong></td>
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<tr>
<td>4.</td>
<td>Standard Procedures – written &amp; approved</td>
<td>4.2.1</td>
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<td>5.</td>
<td>Manufacturers’ Procedures – approved, available &amp; current</td>
<td>4.2.2</td>
<td></td>
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<tr>
<td>6.</td>
<td>Facility- authorized laser users and assistants</td>
<td>4.2.3</td>
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<td>7.</td>
<td>Assignment of a qualified laser assistant, if applicable</td>
<td>4.2.5</td>
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<tr>
<td>8.</td>
<td>Maintaining a list of authorized laser users and health care professionals</td>
<td>4.2.5</td>
<td></td>
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<tr>
<td>9.</td>
<td>Storage or disabling (removal of key) where unauthorized operation is of concern</td>
<td>4.2.5</td>
<td></td>
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<tr>
<td>10.</td>
<td>Staff is informed of and capable of operating, the emergency stop control.</td>
<td>4.2.5</td>
<td></td>
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<tr>
<td>11.</td>
<td>Ready function is enabled only when the user is ready to treat the target tissue.</td>
<td>4.2.5</td>
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<tr>
<td>12.</td>
<td>Use of diffuse or low reflective instruments &amp; materials in or near the beam path</td>
<td>4.2.5</td>
<td></td>
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<tr>
<td>13.</td>
<td>Where footswitches are used for several instruments, only the footswitch controlling the device in use can be activated.</td>
<td>4.2.5</td>
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<tr>
<td>14.</td>
<td>When the laser is set in the ready mode, the laser assistant shall stay by the laser.</td>
<td>4.2.5</td>
<td></td>
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<tr>
<td>15.</td>
<td>Modifications in laser system design or function require an updated hazard evaluation</td>
<td>4.3.5</td>
<td></td>
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<tr>
<td>16.</td>
<td>Laser safety audit completed (frequency determined by LSO)</td>
<td>4.3.6</td>
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<tr>
<td></td>
<td><strong>Compliance Item Description</strong></td>
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<tr>
<td>17.</td>
<td>A surgical laser shall not be activated if there is a faulty aiming system due to a misaligned device or if the beam appears irregular in its size, shape or intensity. Alignment of the device and beam quality is to be checked by testing the laser beam alignment and quality using an appropriate testing device (such as a wet tongue depressor) prior to surgical use.</td>
<td>9.1</td>
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<tr>
<td></td>
<td><strong>Protective Equipment</strong></td>
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<td>18.</td>
<td>Protective equipment shall be used by all personnel within the NHZ</td>
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<tr>
<td>19.</td>
<td>Protective eyewear shall be specified by the manufacturer or the LSO</td>
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<tr>
<td>20.</td>
<td>Protective eyewear shall be accompanied by the following information: *(1) Optical density and wavelength specified on the eyewear in permanent marking or labelling <em>(2) Manufacturer’s recommendations on shelf life, storage conditions and appropriate cleaning methods</em></td>
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</tbody>
</table>
| 21. | Periodic cleaning and inspection of protective eyewear for: *- pitting, crazing, cracking, discoloration, etc. of attenuation material *
  *- mechanical integrity of the frame *
  *- worn or damaged straps or other retaining devices *
  *- light leaks and coating damage* |
<p>| 22. | Appropriate protective filters shall be used with microscopes and other optical viewing instruments |
| 23. | In the operative field wet towels shall square off regular disposable drapes |
| 24. | Appropriate skin protection- surgical gloves &amp; gown |
| 25. | Patient Eye Protection- Suitable protective eye pads or corneal shields with optical properties to reduce exposure below the applicable MPE. |
| 26. | NHZ shall be provided (for free space) by the laser manufacturer |
| 27. | NHZ determined by the LSO |
| 28. | Extent of the NHZ is indicated if the entire LTCA is not declared as the NHZ |
| 29. | Laser Treatment Controlled Area (LTCA) The room, within which the laser system is used, and the occupancy and activity of those within this area are subject to supervision for the purpose of protection against all hazards associated with the use of the laser system. |
| 30. | Highly reflective specular surfaces, such as mirrors, windows, or other glass objects <em>should</em> be removed or covered if at all possible |
| 31. | Appropriate warning signs(s) posted at all entries to the LTCA (Warning signs <em>should</em> be covered or removed when the laser is not in use). |
| 32. | Warning signs include the following pertinent information: |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>33.</td>
<td>Supervised by Health Care Personnel trained in laser safety</td>
<td>4.4.2.2/4.6.3</td>
</tr>
<tr>
<td>34.</td>
<td>Authorized persons provided with appropriate personal protective equipment for use within the NHZ</td>
<td>4.4.2.3</td>
</tr>
<tr>
<td>35.</td>
<td>All windows, doorways, open portals, etc. within the NHZ either covered or restricted to reduce the laser radiation to levels at or below the appropriate ocular MPE for any laser radiation transmitted from the laser treatment area</td>
<td>4.4.2.4/4.6.3</td>
</tr>
<tr>
<td>36.</td>
<td>Use of door, blocking barrier, screen, or curtains to attenuate laser radiation in the entryway to at or below the appropriate ocular MPE</td>
<td>4.4.2.5</td>
</tr>
<tr>
<td>37.</td>
<td>When the MPE for human skin is exceeded at the facility windows or entryways they <strong>should</strong> be protected with an appropriate fire retardant material</td>
<td>4.6.3</td>
</tr>
<tr>
<td>38.</td>
<td>Area/entry safety controls allow for emergency access/egress</td>
<td>4.4.2.6</td>
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**Non Beam Hazards**

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<tr>
<td>39.</td>
<td>Electrical Controls and Power Supplies: All lasers shall be installed and operated in conformance with the Canadian Electrical Code, Part I, the applicable Standards of the Canadian Electrical Code, Part II, provincial occupational health and safety regulations, the Canadian Council on Health Services Accreditation, and related provincial and local laws and regulations.</td>
<td>7.2</td>
</tr>
<tr>
<td>40.</td>
<td>Infection Control: Adequate and effective means to prevent the spread of infection</td>
<td>7.3</td>
</tr>
<tr>
<td>41.</td>
<td>Laser Generated Airborne Contaminants (LGAC): - Local exhaust ventilation is used to capture airborne contaminants as near as practical to the point of production - LGAC is completely trapped within the system or vented out of the area after being rendered harmless - LGAC is not recirculated, but rather exhausted in an environmentally sound manner</td>
<td>7.4</td>
</tr>
<tr>
<td>42.</td>
<td>Collateral and Plasma Radiation: Ultraviolet radiation shall be suitably shielded</td>
<td>7.5</td>
</tr>
<tr>
<td>43.</td>
<td>Fire &amp; Explosion  - Fire retardant or wet drapes, sponges, swabs, etc. used in operative field  - Fire extinguisher and water available</td>
<td>7.6</td>
</tr>
<tr>
<td>Laser- resistant endotracheal tubes used</td>
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<td>----------------------------------------</td>
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<tr>
<th>Inhalation Gas Hazards: Proper evacuation of nitrous oxide, oxygen and anaesthetic gases to minimize the chance of combustion</th>
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</table>

**Responsibility and Personnel**

<table>
<thead>
<tr>
<th>Laser Safety Officer (LSO)</th>
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<tbody>
<tr>
<td>- Ensure that all lasers and laser systems have been labelled by the manufacturer to indicate the appropriate hazard classification</td>
</tr>
<tr>
<td>- Ensure that the product is properly classified and that the correct classification label is affixed (if this classification or label is not available or the system has been modified)</td>
</tr>
<tr>
<td>- Ensure that a hazard evaluation of the laser treatment controlled area has been performed prior to laser operation</td>
</tr>
<tr>
<td>- Immediately inform the user of imminent danger from a laser hazard</td>
</tr>
<tr>
<td>- Ensure that control measures are in effect; and periodically evaluate the effectiveness of the selected controls</td>
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<tr>
<td>- Establish and enforce standard operating procedures (SOP’s)</td>
</tr>
<tr>
<td>- Ensure that protective equipment is available, in good working order and is used correctly</td>
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<tr>
<td>- Ensure that the wording on area signs and equipment labels are accurate &amp; appropriate</td>
</tr>
<tr>
<td>- Conduct hazard evaluations of modifications to existing facilities or laser equipment</td>
</tr>
<tr>
<td>- Ensure that maintenance and service is carried out by qualified personnel</td>
</tr>
<tr>
<td>- Ensure that appropriate safety education and training is provided to all personnel associated with lasers</td>
</tr>
<tr>
<td>- Provide safety instructions, which shall be incorporated into the standard operating procedure (SOP) for the laser (if manufacturer’s labelling safety information does not exist and cannot be obtained from the manufacturer of the distributor of the laser system)</td>
</tr>
<tr>
<td>- Maintain necessary records</td>
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<thead>
<tr>
<th>In a non-hospital environment, the individual user shall:</th>
</tr>
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<tbody>
<tr>
<td>- Assume the administrative responsibilities of the LSO</td>
</tr>
<tr>
<td>- Ensure that all regulations are followed, and nongovernmental controls are in place</td>
</tr>
<tr>
<td>- Be trained in laser safety</td>
</tr>
<tr>
<td>- Have plainly written procedures for safe use</td>
</tr>
<tr>
<td>- Be responsible for:</td>
</tr>
<tr>
<td>- The physical facility and its signs</td>
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<tr>
<td>- Proper use of protective eyewear and other safety measures</td>
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<tr>
<td>- Overseeing maintenance</td>
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</table>

**Laser Safety Programs**

<table>
<thead>
<tr>
<th>Laser Safety Program should contain:</th>
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<tbody>
<tr>
<td>- Delegation of authority and responsibility for the supervision of evaluation and control of laser hazards to an LSO</td>
</tr>
<tr>
<td>- Where diversity of laser usage warrants, a multidisciplinary approach</td>
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<table>
<thead>
<tr>
<th>7.6.3</th>
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<table>
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<tr>
<th>1.3.2</th>
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<tr>
<th>1.4 &amp; 4.3.7</th>
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laser safety committee to advise on laser activity and enforcement of operational policies and procedures
- Criteria and authorization procedures for all Health Care Professionals entering and/or working within the NHZ
- Application of protective measures for the control of laser hazards
- Management and reporting of accidents or occurrences and preparation of action plans to prevent recurrence of an accident or incident
- Education and training of authorized personnel in the assessment and control of laser hazards

48. Safety training documented and provided to
   - LSOs
   - Users
   - Laser technical support staff
   - Nurses and allied health personnel

49. Credentialing process shall require training in the safe clinical use of the laser

Service & Maintenance

50. Facility- authorized maintenance and service technicians, appropriately trained in laser safety

51. Written standard operating procedures detailing alignment methods provided by the manufacturer and approved by the LSO

52. Temporary laser control area established with appropriate Notice Sign

Medical Surveillance of Health Care Personnel

53. Recommended but not required:
   - Pre-placement & post placement baseline eye examinations, including ocular history and examinations specific to laser (wavelength) & procedure

54. All laser incidents (accidents or adverse events) shall require an incident report and an ocular evaluation shall be carried out immediately after a suspected abnormal exposure of the eye

Laser Safety Information Websites

- BC Center for Disease Control – Lasers in Veterinary Practice: Safe Use Guidelines
  www.bccdc.ca/healthenv/Radiation/Lasers/LaserVetPrac.htm

- Canadian Centre for Occupational Health and Safety – Lasers – Health Care Facilities
  www.ccohs.ca/oshanswers/phys_agents/lasers.html

- CSA Z-386-08 “Safe Use of Lasers in Health Care Facilities” is available from: Canadian Standards Association
  5060 Spectrum Way
  Suite 100
  Mississauga, ON
  L4W 5N6
9. Disposal of X-Ray Equipment

Information directly obtained from Section 4.8 of Safety Code 34 “Radiation Protection and Safety for Industrial X-Ray Equipment:”

The owner should follow instructions provided by the manufacturer of the equipment. This information should be found in the product manual, or by contacting the manufacturer. If the manufacturer is no longer in the business of manufacturing, selling or servicing x-ray equipment, the following procedures should be followed:

◊ The vacuum in the x-ray tube must be breached
◊ The x-ray tube window should be inspected to determine whether or not it contains beryllium, if it does, special disposal procedures must apply since beryllium presents a toxic ingestion or inhalation hazard
◊ The transformer oil, if it exists, must be disposed of in accordance with pertinent environmental legislation
◊ The lead must be recycled accordingly
10. References

1) Quality Control in Radiography – Jocelyn Forseille, N.A.I.T., A.H.T. Program

2) AAHA Proceedings – Northwest Region Meeting, October 1995


