APPENDIX 3 Darkroom Design

This appendix has been adapted from material developed by the Ontario Breast Screening Program, Toronto, Canada. The help of that organization is gratefully acknowledged.

A.3.1. General requirements

The darkroom should be designed to provide the following conditions that are required for mammography:

(1) Appropriate lighting conditions for the handling of photosensitive film.
(2) Suitable storage for unexposed film in use with particular regard to radiation levels.
(3) Space for the film processor and accessories.
(4) Space for the storage of chemical solutions.
(5) Adequate facilities for the preparation of chemical solutions and for the cleaning of processor rollers (large sink and hose).
(6) Appropriate ventilation.
(7) Provision of silver recovery system.
(8) Adequate workspace for the loading of films, and a viewing area and workspace for sorting the films.
(9) Fire alarms and other warning signals should be audible inside the darkroom.

Note that these requirements still apply for daylight, or automatic feeding processors, in order to reduce image artefacts. Ventilation of the processor and handling of chemicals remains the same.

A.3.2. Darkroom location and radiation conditions

The darkroom should be located adjacent to the mammography room, and there should be a clear path from the mammography room to the entrance of the darkroom. A pass-box directly from the mammography room to the darkroom will permit increased throughput if there is a darkroom technician, and allows for the storage of loaded cassettes.

Care should be taken that there are no excessive radiation levels in the darkroom and film storage areas. This can be checked using TLD dosimeters. The acceptable level is <20 μGy/week.

A.3.3. Work surface

The dark room area must have a work surface at least 1.3 m long for the loading and unloading of cassettes. This surface should be constructed of a hard, anti-static material that is easily cleaned. A light colour is appropriate for all surfaces in the room, as this reduces the safe-lighting wattage required and allows for the detection of light leaks. Beige or mid-grey is, however a poor choice for darkroom counters or floors since film emulsion is this colour, and a film may not be seen if it is placed on the counter. The film can be stored in film bins under the counter; however there are a number of convenient photographic paper safes available for counter top use, which are easier to use than the standard lead-lined radiographic models. Space should be reserved on the counter for a sensitometer and film identification

camera if required. The film-feed tray of the processor should be oriented to allow for good workflow.

A.3.4. Darkroom door

The entrance door to the darkroom must be light-tight. This involves careful weather-stripping of the door including the installation of a threshold sealer (the automatic style is preferred, as there will be less wear and tear). The seal around the processor is critical and usually requires weather-stripping and perhaps black sealant along the floor. The door should have a lock in the knob that will keep people from unintentionally entering the room while film is being unloaded, however will permit access in case of emergency. A bathroom or entrance lockset is usually used. In order to evaluate light leak levels, one should allow dark adaptation for at least 5 minutes. Darkroom fogging tests should be carried out immediately if any fogging is suspected. A darkroom ventilation louvre installed in the door will serve to allow air flow in and out of the darkroom, and to reduce the turbulence generated when closing the door.

A.3.5. Lighting

Two levels of lighting should be available in the darkroom. A strong white light should be provided by surface-mounted incandescent fixtures. Fluorescent bulbs tend to emit a long afterglow that may fog films if they are switched off just before the films are unloaded or loaded. Recessed lights (pot lights, downlights) are discouraged because they allow light leaks from above the ceiling area into the room. If a pot light or standard recessed fluorescent fixture is used, there must be a fireproof box built above the ceiling to contain the fixture, with all penetrations sealed.

Safe-lighting should be provided, with manufacturer-recommended filters in ceiling mounted fixtures. Fifteen-watt bulbs are the maximum recommended for direct safe-lighting, but 25-watt bulbs may be used if the safe-lighting is indirect. **It is important to check current recommended safelight wattages with the film provider** as some films require much lower power ratings than these levels (e.g. Kodak recommends a 7.5 watt bulb with their Min-R 2000 and EV films). There should be a switched duplex receptacle mounted in the ceiling for the safelight. The switches for the safelight and white light should be located at the door, but at different heights above the floor to avoid errors in the dark.

A.3.6. Safelight filters

Photographic safelight filters are of the absorption gelatin type and are designed so that darkrooms have as high a degree of illumination as is consistent with the safe handling of photosensitive materials. Safelights are designed to transmit in the region of the visible spectrum to which the photographic emulsion is least sensitive. If safelights are chosen carefully, the total safe illumination in the darkroom can often be sufficiently high for very comfortable vision.

Manufacturers recommend replacement of the safelight filters every two years. At the time of replacement, document the date on the filter with a marking pen. The filter should be inserted in such a way that it will be possible to read the writing and easily determine when the next replacement is due. To ensure proper operation, the safelight test (refer to Section. 6.3.3, *White light leakage and safelights*) should be performed once the filters have been replaced.

A.3.7. Darkroom ventilation

It is essential that there be adequate filtered and humidified air introduced into the room, and that sufficient exhaust is provided out of the darkroom in order to remove fumes. There should be a positive pressure in the darkroom, drawing air in through a vent in the door. The return duct should have at least four bends between the grill in the darkroom and a grill in another room in order to prevent light fogging of the film due to reflected light. An in-line dust filter mounted at the supply louvres will reduce dust as well as light transmission. Any dust introduced through a supply duct will seriously degrade the image quality and may cause damage to the screens.

As noted previously, a light-tight vent in the darkroom door will provide constant flow-through and turn over of new air at floor level, and reduce pressure variations as the door is opened and closed. Pressure variations stir up dust particles.

The fumes from processor chemicals are often quite obvious at levels well below the listed harmful levels. While this is true, the chemical smell is sometimes unpleasant, and there are developed "sensitivities" which can result from low level repeated contact to these fumes. This has resulted in increased level of concern by radiographers about exposure to the fumes. From a practical standpoint, with a well functioning darkroom, there should be no odour.

Proper ventilation will also tend to reduce dust artefacts and improve processor operation. Without adequate 24 hour direct processor exhaust, evaporated solutions from the processor will tend to build up on the inside of the processor and on rollers. The deposits may cause dust artefacts on the films, and the vapours will cause corrosion on the other components of the processor. Adequate exhaust is also required to remove the heat and humidity originating from the dryer of the processor.

Darkroom general supply and return air exchange should be enough to remove any residual fumes from the replenisher tanks, which should be well covered to reduce evaporation.

Darkroom ventilation conditions

(1) The processor is to be exhausted to the outside of the building through a special fume exhaust. The outlet separation from the building supply air must meet building code regulations (typically not within 2 metres of a window or air intake). This duct should be capable of removing approximately 2.5 m^3/min) through a 10 cm diameter duct. There should be a 20-50 mm gap in the duct just after it enters the room to ensure that there is less than a 1mm vacuum at the processor outlet. See, for example, Kodak service bulletins #101 and #158 [30].

(2) The exhaust fan for the processor must be left on at all times, and operate throughout the day and night, even when the processor is turned off.

(3) It is recommended that facilities have an "Air Proofing Switch" installed in the processor exhaust vent with an indicator lamp visible in the radiographer work area which will light when the exhaust is working.

(4) There should be at least 10 air changes per hour in the room to ensure removal of chemical fumes from the area. The supply should be located so that it does not "short circuit" and feed directly to the exhaust. A darkroom supply of 50% of the exhaust rate is ideal.

(5) Supply air should be between 15° and 21° C with a humidity level between 30% and 70%.
(6) Supply air should be filtered to remove dust and airborne sources of artefact. This may be done by the use of a local filter. Note that visual inspection of fiberglass filters should be undertaken at least every three months and they should be changed at regular intervals, or as required
(7) After renovations or if ducts are found to be excessively dusty, duct cleaning must be carried out back to the nearest filter.
(8) Evaluation of exhaust fan operation. “Flutter test”: With the processor turned off, a piece of tissue is to be held near the gap in the exhaust duct. The tissue should be seen to be drawn toward the gap. If there is not noticeable movement in the tissue, the flexible duct is to be removed and the negative pressure measured 25 cm into the opening of the duct, using a manometer. If there is inadequate suction, or if the tissue blows away from the gap, the building manager should be requested to obtain the services of a qualified service person.

A.3.8. Air filtration

For local air filtration, HEPA filters can be obtained relatively cheaply combined with an ionizer device. This device charges the air molecules, which henceforth attract dust particles, drawing the dust out of the air. Such filters are often also combined with humidifiers.

A.3.9. Personnel

Contamination from personnel includes hair, dandruff, skin particles, fibres from clothing, cosmetics, medication, and the like. Garments made of monofilament polyester are recommended to avoid the possibility of fibres adding to dust levels. Some garments and footwear also contribute to high static levels. General rules involving cleanliness, such as no eating and smoking in critical areas, must be strictly enforced.

A.3.10. Ceilings

The darkroom ceiling should not be of the suspended tile type. A sealed drywall ceiling is required in order to reduce dust and light leaks to a minimum. Suspended ceilings tend to drop dust from the composition tiles, especially as there tends to be movement in the tiles when the door of the room is opened and closed. Opaque vinyl coated "sanitary grade" ceiling tiles may be used, if they are clipped down using clips designed to meet fire code specifications and the ceiling track is caulked around the perimeter.

A.3.11. Sink

A large sink is required, installed at waist height to accommodate the cleaning of the rollers from the processor. This sink should be at least 60 cm wide by 45 cm deep and be provided with both hot and cold water. There should be a laundry tub hose at least long enough to reach into every part of the processor connected to a mixing faucet through a vacuum breaker as required by most local plumbing codes. A large sink is required even for daylight load processors.

A.3.12. Physical arrangement of processor and chemicals

There should be an easily accessible area in which to store the replenishment chemistry (normally two tanks 45 cm diameter) and a provision for the hoses that must reach from the replenisher tanks to the processor. These hoses should be allowed to lie flat on the floor, and not be subject to extreme bending or kinking. A silver recovery unit should be located in this area, and connected to the drain. At least 0.5 m clearance is required on the sides of the processor and 1m in front and above for service.

A.3.13. Floating lids

The use of floating lids on solution storage tanks will extend the storage life of the solution by reducing evaporation and chemical oxidation. Lids are also effective for keeping dirt and dust out of processing solutions. In this way, floating lids reduce the need to discard processing solutions.

A.3.14. Silver recovery

The discharge fluid from the processor if allowed to flow directly down the drain will have silver levels which exceed environmental standard limits. Having the fixer enter an electrolytic silver recovery unit, and then the overflow of that unit allowed to pass into a metallic replacement cartridge unit, will ensure that the silver levels are below legal requirements. It is important to regularly (quarterly) replace the units (and harvest the metallic silver).

A.3.15. Electrical services required

In the darkroom there must be an unlighted switch for the white light (1.6 m off floor) and another unlighted switch for the safelight (1.4 m off floor). The counter top must have at least four outlets, although they can be on the same circuit. Generally, an electrical circuit breaker and switch (isolator or disconnect) is required for the processor. The isolator must be located within two metres of the processor and can be either inside or outside the darkroom. Connections to the processor should be made through a flexible, liquid-proof cable or conduit.

A.3.16. Plumbing services required

Most processors require only a cold water supply, but this should be verified. The temperature and pressure of this supply should be relatively stable, and for some locations, a mixing or tempering valve may be required. If water that is too cold is used in a processor or in an automixer, the film response may be degraded. A **50 micron in-line water filter**[1] is recommended. This filter should be **changed annually**, or more often as required. A drain connection is required for the processor to accommodate chemical and water drainage of about 15 L/min. An oversized drain may prevent overflow due to chemical precipitation and

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[1] This filter is not to be confused with the *developer filter* located inside the processor, which should be *replaced monthly*.

deposits reducing the size of the pipe. Glass, stoneware or chemically inert plastics (PVC) are appropriate materials to use, in order to prevent corrosion from the chemicals. There should also be a floor drain in the area with the processor and silver recovery unit.

A.3.17. Floors

The floors of the darkroom and adjacent area must be non-porous, not slippery when wet and stain and water-resistant. They must be suitable for frequent cleaning and not collect dust. The adhesive used to secure the flooring must also be waterproof. A static-free mat may be found useful in the area for the loading and unloading of films.

A.3.18. Humidifiers: relative humidity and static electricity

Static electricity can be the cause of defects in photo-sensitized materials in two different ways. First, the light produced in the discharge of static electricity can fog the sensitized materials, and second, an electrostatic charge on the sensitized materials increases the attraction of dust particles to them. There are several methods for controlling static on film.

Anti-static screen cleaners reduce the amount of charge built up on the screen, cassette and film, but the most effective method for controlling static is to maintain a high relative humidity in the dark room. A high relative humidity does not affect the conductivity of the air but it does increase the electrical conductivity of nearly all surfaces in any area, for example, the walls, floor, and equipment. The higher electrical conductivity helps to drain off static charges as they form.

Corrosion of equipment and tackiness of photographic film generally set an upper limit on the relative humidity that can be used. A relative humidity that is below 30% may cause static attraction of dust to the screens and/or countertops while a relative humidity above 70% may cause the sticking of films.

Steam humidifiers are preferred in a central heating, ventilation and air conditioning (HVAC) system, but evaporative humidifiers work well, if they are regularly maintained, and have an over-flow design. Ultrasonic humidifiers are not recommended for inside or outside darkrooms, as they require constant refilling with distilled water. If tap water is used, fine powder is deposited throughout the facility, as a result of the minerals in the water.

Another method for static reduction is to ionize the air so that static charges can be bled off to the walls, floor, and equipment through the air. Air ionizers produce air flow over the needles of a high-voltage static bar, thus charging the air molecules. The static bar can be hidden so that the film is not exposed by the associated corona discharge.

A.3.19. Storage of film processing chemicals

Chemicals may be obtained in either pre-mixed or "user-to-mix" format. In order to minimize chemical deterioration associated with aging and oxidation, especially in the case of pre-mixed chemicals, it is important that large reserve stocks are not kept on hand but rather supplies are obtained on a frequent and regular basis. The mixed solutions should be stored at room temperature in containers with solid covers to prevent air circulation over the solution.