

Lecture 4

Lecture 4: Other radiographic equipment

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In this Lecture

- Learn about x-ray beam limiting devices
 - Learn about grids. What they are. Why they are great. The drawbacks of using grids. Finally, understand the appropriate use of a grid.
 - Know what a cassette is
 - Know what intensifying screens are. Why we use them. The drawbacks of using them.
 - Know about film color sensitivity and why it is important.
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O.k. so far we made some x-rays, the x-rays went out of the x-ray tube, hit the patient, interacted with the patient, and we started to talk about a radiographic image. We got stuck for a little while on the subject of scatter and the fact that it causes a crummy image. In this lecture we will continue to look at ways that we can make a better image. In order to do so, we will look at additional equipment necessary to make the image. In later lectures, we will look at things that we can do with this equipment in order to make a pretty picture. We start with that nagging question...what is collimation?

X-ray beam limiting devices

Previously we said that it was important to limit the size of the x ray field. There are two reasons for this:

1. Smaller fields mean less scatter. Less scatter means a better image. If this sounds redundant, it is. It is important.
2. Smaller fields mean less **exposure** for the patient. Remember, we want to reduce the amount of ionizing radiation that our patients receive.

There are many devices used to accomplish this task of decreasing the size of the x-ray field. Cones, cylinders, and aperture diaphragms have been used in the past. Currently, the standard technology is the **collimator**.

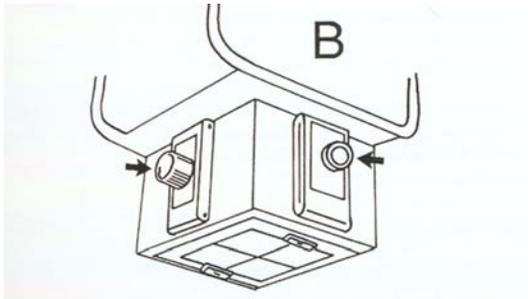


Fig. 5-3

ADJUSTABLE LEAD SHUTTER BEAM LIMITING DEVICE

A photograph of a beam limiting device (arrow) with two pairs of "L" shaped lead shutters that move independently to produce an unlimited number of square or rectangular shaped exposure fields (A). A drawing of a similar type of beam limiting device with individual controls that are available for independent adjustment (arrows) (B).

Collimators allow a variety of x-ray field sizes to be selected by using a series of lead shutters and a light beam that shows the size of the field. Most systems use a mirror to align the light field. Some portable systems use a laser to center the field.

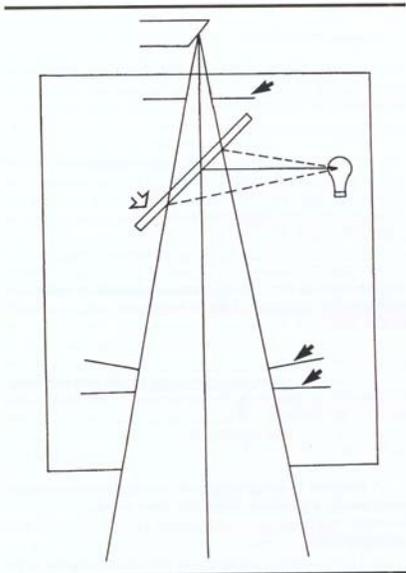


Fig. 5-4

SCHEMATIC DRAWING OF A BEAM RESTRICTOR

The x-ray beam originates at the tube and is limited by a series of shutters (solid arrows). The beam passes through a mirror (hollow arrow) that reflects a light beam in such a way that the area irradiated by the x-ray beam is equal in size and location to the area illuminated by the light.

Collimators do not focus the x-ray beam, they merely shape it by cutting off the edges of the beam. Again, collimators simply exclude the part of the beam we don't want to use. Since x-rays do not have a mass or charge, they cannot be focused.

Collimators are not fool proof. The mirror system can get out of whack. Therefore, a good maintenance schedule will evaluate the accuracy of the collimator light on a routine basis. A good description of how this test is performed can be found on page 28 of Morgans's Techniques of Veterinary Radiography listed in the reference list.

Grids: ummm more on scatter

We said numerous times that good collimation will reduce scatter. However, even though we try to limit the exposed field, tissue is, of course, exposed and scatter is produced. Anytime scatter hits the film, there is image degradation. A grid is used to reduce scatter from hitting the film a grid is used. Keep in mind that grids do not decrease scatter formation, they just stop scatter from hitting the film.

Grids should be used anytime a body part thicker than 10cm is radiographed.
(That statement is in bold and has a funny font. What do you think that means?)

Grid Composition: Grids are composed of hundreds of alternating thin lead strips with aluminum or fiber interspacers. X-rays can pass through the interspacers without interactions. However, the grid absorbs x-rays that hit the lead strips. These strips are encased in a protective cover for protection so the soft, thin lead strips won't bend.

Grid basics: In most grids, the lead strips are angled to be in alignment with the **primary x-ray beam**. this type of grid is a focused grid. Remember the primary beam is the part of the beam that we want to use to expose the radiographic film. **Scatter**, however, will not be aligned with the spaces in the grid and will be absorbed by the lead strips. Thus, scatter photons cannot hit the film because the grid absorbs them.

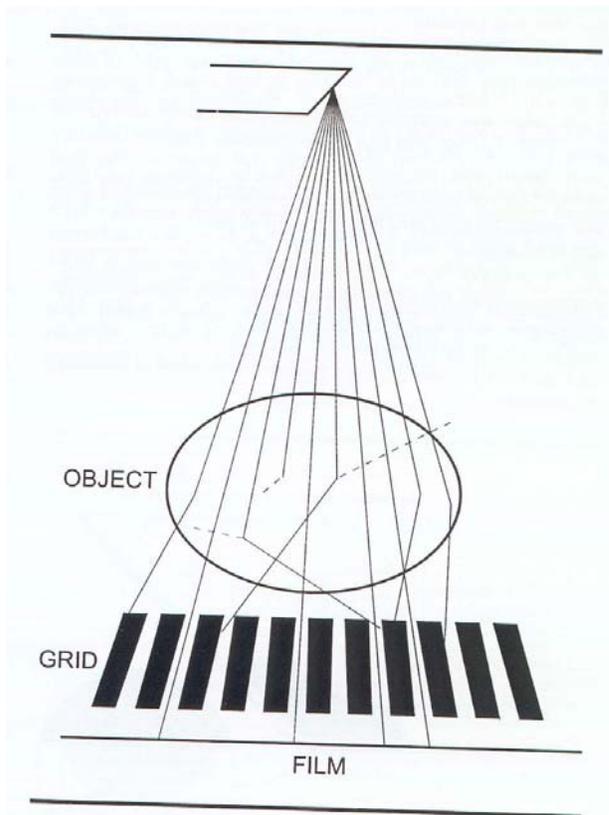


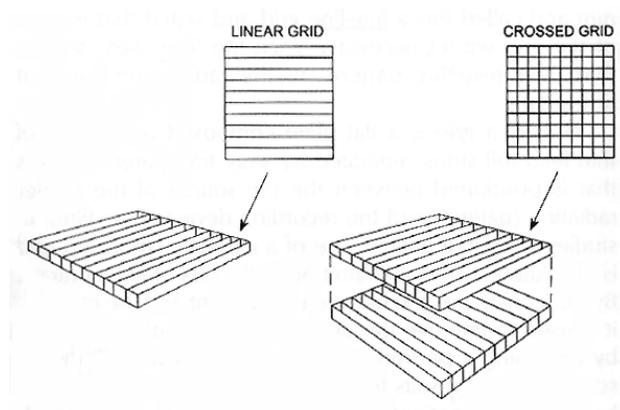
Fig. 5-6
GRID USE

A drawing shows interaction of the x-ray beam with a patient creating scatter radiation that results in generalized fogging of the film unless a device such as a grid is placed between the patient and the film where it absorbs a part of these newly directly photons. A part of the primary beam passes through the patient and radiolucent spaces in the grid and reaches the film. Other photons interact within the patient and alter their direction causing interaction with the lead strips in the grid.

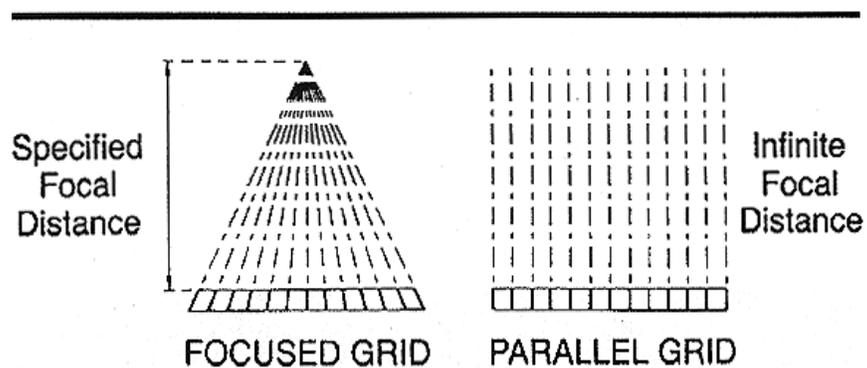
Grids, however, are not perfect. Some of the primary x-ray beam will inevitably hit the lead strips and be absorbed. Therefore, we have to account for this reduction in intensity of the primary x-ray beam when we select an exposure for a radiograph. In general, exposure factors are increased when using a grid vs. not using a grid. It is not uncommon to have to increase the exposure by 10-12 Kvp. Not all grids are created equal. So, the amount you will have to increase the exposure depends on the type of grid you are using. Since grids are expensive (hundreds of dollars) it is important to know what you are buying. When purchasing a grid, grids are described in terms:

1. Lines per inch: the more lead lines per inch, the better the grid is at scatter reduction, however, it absorbs more of the primary x-ray beam which necessitates a larger increase in exposure.

2. Grid Ratio: The grid ratio is the height of the lead strips divides by the distance between the strips. The higher the ratio, the more efficient a grid is.
3. Type of interspace material: Aluminum is better but more expensive. Fiber is cheaper but may result in an inhomogeneous image pattern. Stationary grids should be aluminum while fiber grids are acceptable for a moving grid system. An explanation of moving grids will soon follow. Be patient, grasshopper.
4. Grid type: Most grids are composed of **parallel lines** of lead strips. Some, however, have 2 sets of grid lines running perpendicular to each other and are known as **cross-hatched grids**.

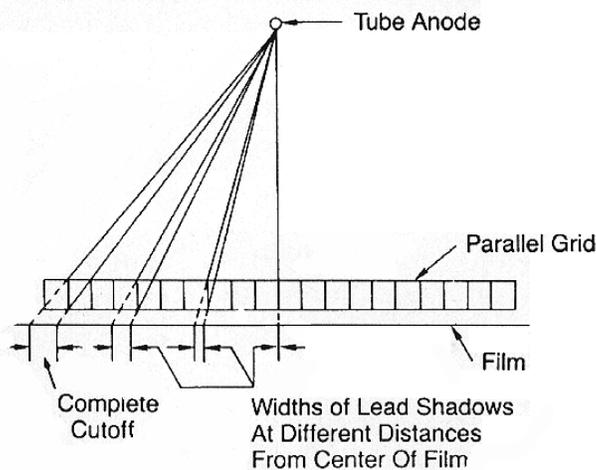


Grids may also have lead strips that are angled toward the x-ray tube. These were described earlier. They are called **focused grids**.

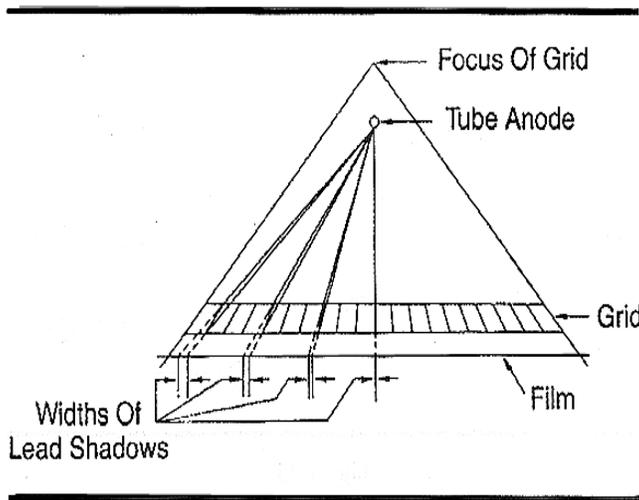


5. Bucky factor: This is the amount of increase in exposure that must be used when using a grid.
6. Focal range: Most grids are **focused**. This means that the lead strips of the grid are angled so that they are in alignment with the fan shape of the x-rays coming from the x-ray tube. Therefore, these grids must be used at a precise distance from the x-ray tube to work properly. If they are used outside (too far away or too close) of the focal distance the dreaded **grid cutoff** occurs.

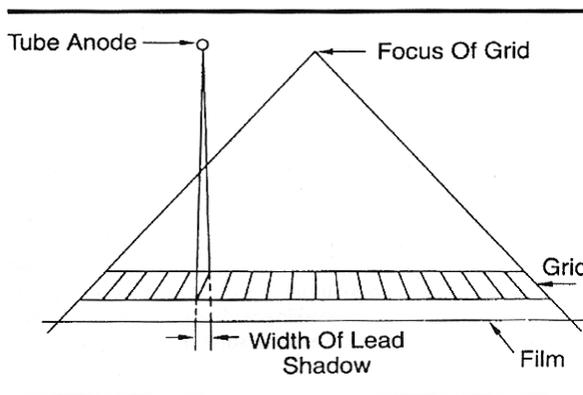
The hassles of using grids....Grid Cutoff: In order to use a grid, the grid must be placed precisely under the center of the central ray on the x-ray beam along the central axis of the grid. That means that it cannot be off to the left, off to the right, too close, or too far away from the x-ray tube and the center of the beam. If any of these things happen, misalignment of the lead strips in the grid to the primary x-ray beam will occur. This results in greater than normal absorption of the primary x-ray beam. The resulting radiograph will be very light or underexposed. The worst possible type of grid cutoff occurs when the grid is placed upside down. The "tube side" is usually labeled on the grid and should be directed toward the x-ray tube.



Grid cutoff with a parallel grid.



A focused grid that is Placed too close to the x-ray tube



A grid that is off center from the anode

Grid Lines and Moving Grids : When grids are used properly, you may see subtle images of the alternating lead strips and spacers in the resulting radiograph. These lines are called **grid lines**. They are an unfortunate consequence of using a grid. With modern grids, these lines are very fine and only slightly distracting. Fortunately, we have a method of making them disappear. In order to do this, the grid is moved back and forth during the radiographic exposure. (Senior year, this is the squeaky noisy you hear in room 1.) By moving the grid back and forth the grid lines are blurred over the

resulting radiograph and cannot be seen. This type of system is called a **moving grid** system or a

Potter-Bucky diaphragm. Most veterinary equipment uses a stationary grid. Most human equipment has a movable grid. This is not all bad as the movement of the grid may startle a patient. If the patient moves during the radiograph motion blurring will occur. In fact, many veterinary hospitals using old human equipment disconnected the moving grid apparatus!

Grid Care: Grids are fragile. Take care of them. If the lead strips become bent or the grid gets warped a number of grid artifacts will be produced that will degrade image quality. Grids should be stored lying flat and handled in a gentle manner. Always instruct your equine patients that they should not kick the grids nor stand on them, as this will undoubtedly ruin the grid.

Quick Review: Grids improve detail and contrast in a radiograph by preventing scatter from hitting the film. However, grids necessitate an increase in technique, which increases patient and personnel exposure. Grid cutoff will cause radiographs to appear streaky and too light or underexposed. Grid lines are the result of proper grid use. They can be eliminated with a moving grid.

Cassettes and Screens

Cassettes and screens are an integral part of modern veterinary practice. Their use and maintenance needs to be fully understood if you want to make in the radiograph.

Cassettes: Radiographic cassettes are rigid, light-tight containers that hold the x-ray film and screens. The screens are permanently mounted in the cassettes. There are many sizes of cassettes available to match the commonly available sizes of radiographic film. A variety of cassette sizes are needed to properly radiograph the variety of animals that veterinarians see each day. Many cassettes have a rectangular lead block, that covers one portion of the screen. This protects an area of the x-ray film from exposure so that can be used later to imprint film identification.

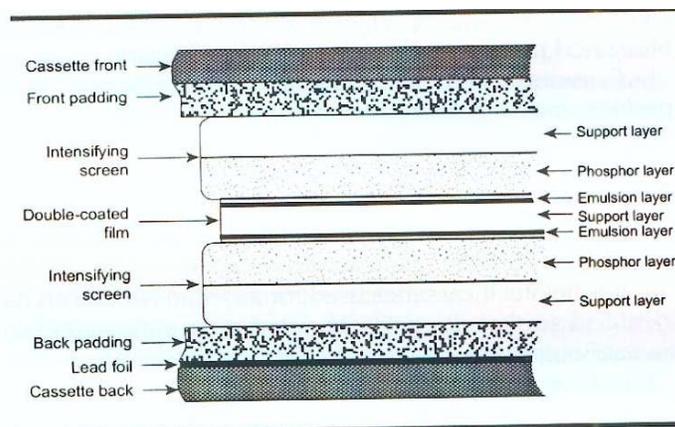


Fig. 6-6

CROSS-SECTION OF A CASSETTE

The parts of the cassette are labeled. Notice the relationship of the cassette, intensifying screens, and the film.

Overall, cassettes serve two main purposes. First, they keep light from hitting the film. Second, they press the intensifying screens tightly against the film (more to come on screens...see below). However, cassettes are expensive and you should take care them. Using a damaged cassette will result in a crummy radiograph. This is due to:

1. Light leakage around the edges
2. They may warp which hampers screen function because the intensifying screen will not be pressed tightly against the film.

Therefore, if you're using older cassettes that are damaged and you're getting crummy radiographs, you may want to replace the cassettes

Intensifying Screens : In general, the sensitivity of x-ray film to x-rays is poor. X-rays can be used to expose film but it would take a lot of radiation and a prohibitively long time for most purposes. In other words, if you tried to make a radiograph using just x-rays it would come out pretty crummy unless the patient was anesthetized and the body part was small like a toe. Intensifying screens are used to increase the efficiency of film exposure. In order to accomplish this, the intensifying screens convert the x-ray radiation into visible light. This increases the efficiency because radiographic film is more sensitive to light than x-rays! They are called intensifying screens because the "intensify" the effect that x-rays have on radiographic film. The color of the light emitted is usually blue but some screens emit green light. It is this visible light that is emitted by the intensifying screens that exposes the x-ray film in addition to the x-rays themselves.

Screen Composition : Screens are composed of phosphor crystals that emit light when they are stimulated by x-rays. Some screens do a better job of converting x-rays into light than others. Thus, they are more efficient. More efficient screens are known as "faster screens" because they need less x-rays to produce a properly exposed radiograph. Slower screens need more x-rays to make a proper radiograph. This is analogous to the ISO number of normal photographic film. A faster photographic film (lets say 800ISO) needs less light to make a proper photograph than let's say 100ISO film. Remember the less radiation we have to expose our patients to, the better. Intensifying screens vastly decrease the amount of radiation our patients and personnel receive. For this reason alone, they should almost always be used in routine practice.

Another benefit of intensifying screens is that they enable us to use faster exposures. Fast exposures are necessary to "stop motion" in a radiograph. Just like when you take a photograph of a person running you need a fast exposure or the person appeared blurred.

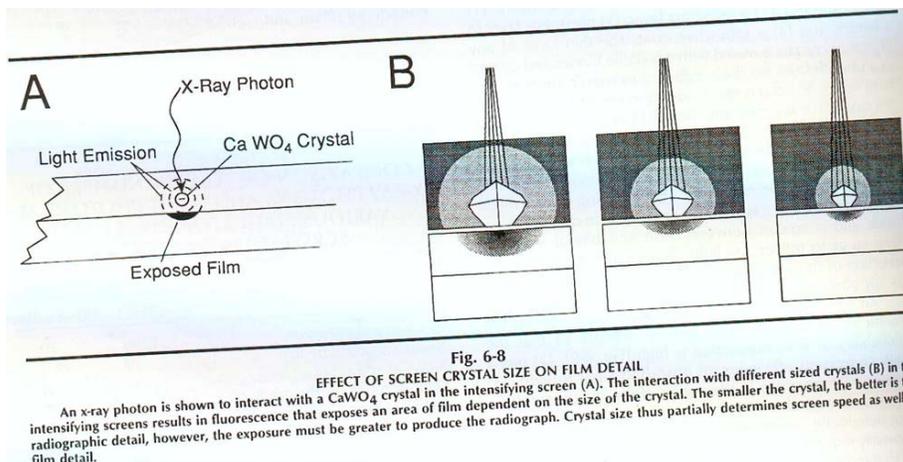
Intensifying screens also increase contrast.

Screens, however, have a downside. They can decrease image detail. In fact, the faster the screen, the worse the detail. The detail or resolution of the image produced by a given screen is the inverse of it's speed. Once again, this is just like photographic film.

An 800ISO (faster) film will give you an image that is more grainy (not as sharp) than a 100ISO (slower) film. Once again, everything is a tradeoff in radiology. There are two reasons that faster screens give you a crummier image. The first lies in their construction.

Screen Construction: Screens are made of a layer of **phosphor crystals**. The speed of the screen, and conversely the detail it can produce depends on:

1. The type of phosphor: some phosphors are more efficient at converting x-ray energy into visible light. Faster phosphors use less x-rays to make more light than slower ones. Rare earth screens are the most efficient.
2. Phosphor layer thickness, phosphor crystal size and phosphor crystal shape: Basically the more you have of a given phosphor, the faster the system will be. However, (**Big however here folks**) using more phosphor will greatly decrease image detail. The reason for this can be found in the diagram below. As you can see, when a phosphor crystal gives off light the crystal acts like a miniscule flashlight. The beam of light coming from the crystal spreads out in a cone shape. Therefore, if the crystal is farther from the film (due to a thicker phosphor or a thicker phosphor layer) the light has spread out a considerable distance before it hits the film. This “spreading of the light” causes a loss of image detail because a pinpoint area of light has become a big, fat, spread out circle of light.



A crooked image representing Reason #1 that screens degrade image quality

The second reason faster screens give you a crummier image : This factor has to do with probability theory more than anything else. Since probability is boring and I would just confuse you just know reason number 1. If you really want about this mysterious second reason ask me during senior year.

Screens - Putting theory into practice : The bottom line with all of this business is that you need to select a good balance between the speed of the screen and the detail you need for your particular application. Most screen systems used in veterinary practice are **rare earth screens**. These screens are composed of phosphors from the rare-earth elements of the periodic table. These screens offer a good compromise between speed and detail. (FYI: Older screen systems used calcium tungstate as the phosphor. Calcium tungstate crystals are not as efficient as the rare earth crystals at converting x-ray energy to light. Therefore, thick layers of phosphor and large phosphor particles were necessary. You already know this decreases detail. That is why they are used less frequently today.)

In veterinary medicine faster is usually better. The loss of detail incurred by using fast screens is subtle. The loss of detail from patient motion is much greater.

Screen Maintenance: My dad always told me, if something was worth buying it was worth taking care of. Since screens are worth buying, you should take care of them. Screens should be kept clean because as dust and film accumulate on the screen there is a reduction in performance. Screens should be cleaned with a commercially available screen cleaner and lint free cloth. Cassettes should never be left open when not in use because this allows dust and film to accumulate more quickly. Screens also wear out with age. Older screens have a loss in resolution and decreased speed. A high-speed, five-year-old screen has roughly the same efficiency as a new, slower, speed screen.

Some of you may have wondered why I continuously used the phrase "screen system." The reason for this is that screens don't do anything by themselves. They need film. Without film there's nothing to look at. Therefore, when you talk about screens you need to talk about film. Fortunately we have a whole lecture on film. For the time being just keep in mind that one characteristic of x-ray film that must be considered when you purchase film is **colors sensitivity** of the film. X-ray films are only sensitive to one color of visible light. However, different screens give off different colors of visible light. Therefore, you must match the film color sensitivity to the light being emitted from the screen. Older screens emit a "blue violet" light when exposed radiation and appropriate film was "blue light" sensitive. Newer, rare earth screens emit "green" light and require

“green” sensitive film. Some brands of newer rare earth screens are “blue light” emitters and can be used with standard x-ray film.