Scatter Radiation

By definition, "Scatter radiation occurs when radiation deflects off an object, causing x-rays to be scattered. It is important to keep in mind that scatter radiation has the ability to travel in all different directions," In the case of X-rays, the most common source of scatter radiation for most humans, is the patient, and those scattered rays can continue to scatter around the room based on various design features.

Scatter radiation is probably the biggest single factor contributing to decreased film quality. It is the result of a redirection of the primary x-ray beam and production of new x-rays following the interaction with the patient. Therefore, scatter radiation is present in each radiographic examination. The effect of scatter radiation is to produce a generalized photographic fog on the film, which reduces the contrast between adjacent areas on the radiograph.

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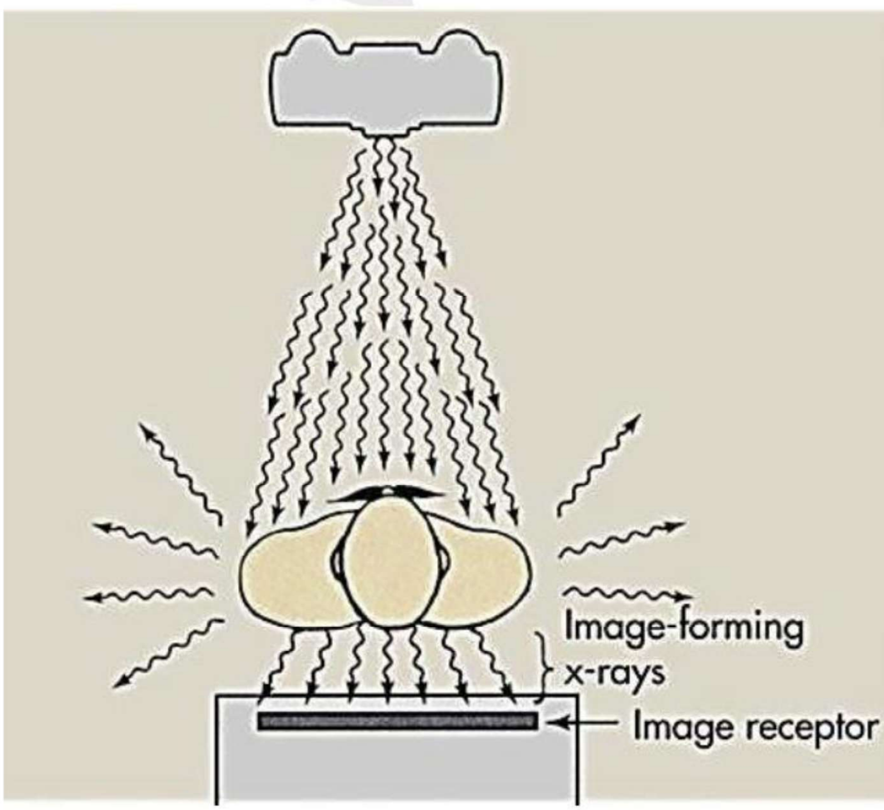

Scatter Radiation Occurs in Three Ways:

⇉ **Bulk Scatter radiation.** This type of radiation derives from the X-rays bouncing off the patient's body.

⇉ **Back scatter.** This type of scatter radiation is created from behind the film and directed back towards the X-ray tube. To prevent backscatter, the industry has adopted the standard procedure of adding a 0.005 lead screen in front and a 0.01 screen behind the film for added protection. Additionally, a letter "B" is placed on the back of the cassette to indicate an abundance of backscatter. If the B is visible in the resulting image, backscatter is occurring, the strength of the "B"'s visibility indicating the level of backscatter taking place.

⇉ **Side scatter.** Side scatter is caused by objects in the immediate areas, such as walls, floors and tables. To mitigate side scatter, the X-ray rooms are typically void of other objects and the table is located in the center of the space. This isolates the X-rays as much as possible so they are less prone to side scatter.

Factors contribute to an increase in scatter are:

➥Increased kVp

As x-ray energy increases, photoelectric decrease and Compton interactions increases. At 50 kVp 79% photoelectric, 21% Compton & less than 1% transmission. At 80 kVp 46% photoelectric, 52% Compton & 2% transmission.

➥Increased x-ray field size

As field size increases, the intensity of scatter radiation also increases rapidly. especially during fluoroscopy.

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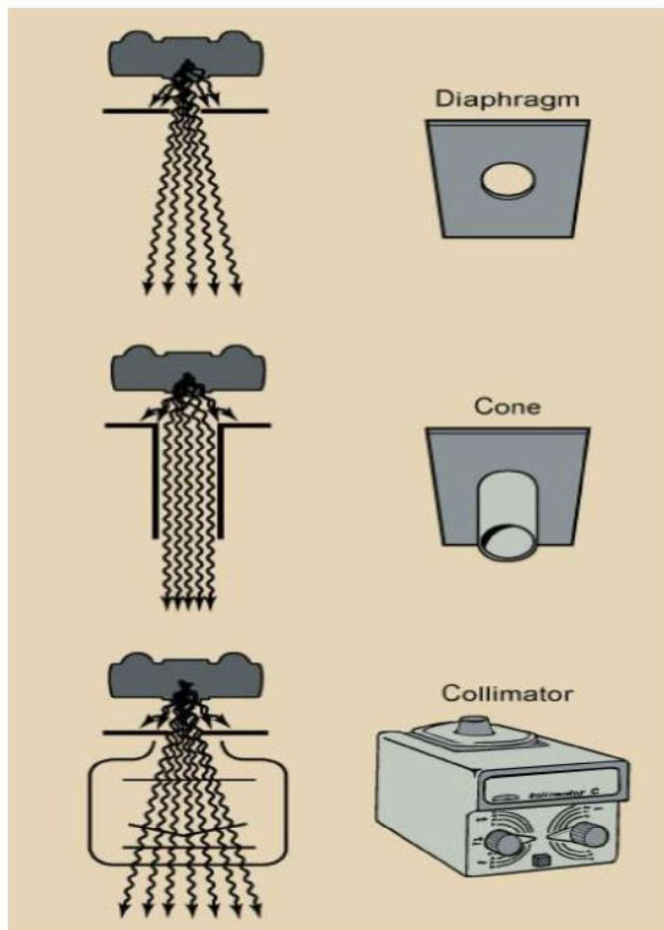
➥Increased patient thickness

Imaging thick parts of the body results in more scatter radiation than thin. The radiographer can control the patient thickness by compression devices, to improve the spatial resolution and bringing the object closer to the IR (image receptor). Compression also reduces patient dose (reducing fog).

Control of Scatter Radiation

The unrestricted primary beam is cone shaped and projects a round field on the patient and IR. If not restricted in some way, the x-ray field extends and goes beyond the boundaries of the anatomic area of interest and IR size, resulting in increasing the amount of scatter radiation reaching the IR and unnecessary patient exposure. So, the x-ray beam field size must be limited to the anatomic area of interest. Technologists routinely use many types of devices such as:

1. beam-restricting devices, which include: Aperture Diaphragm, Cones & Cylinders



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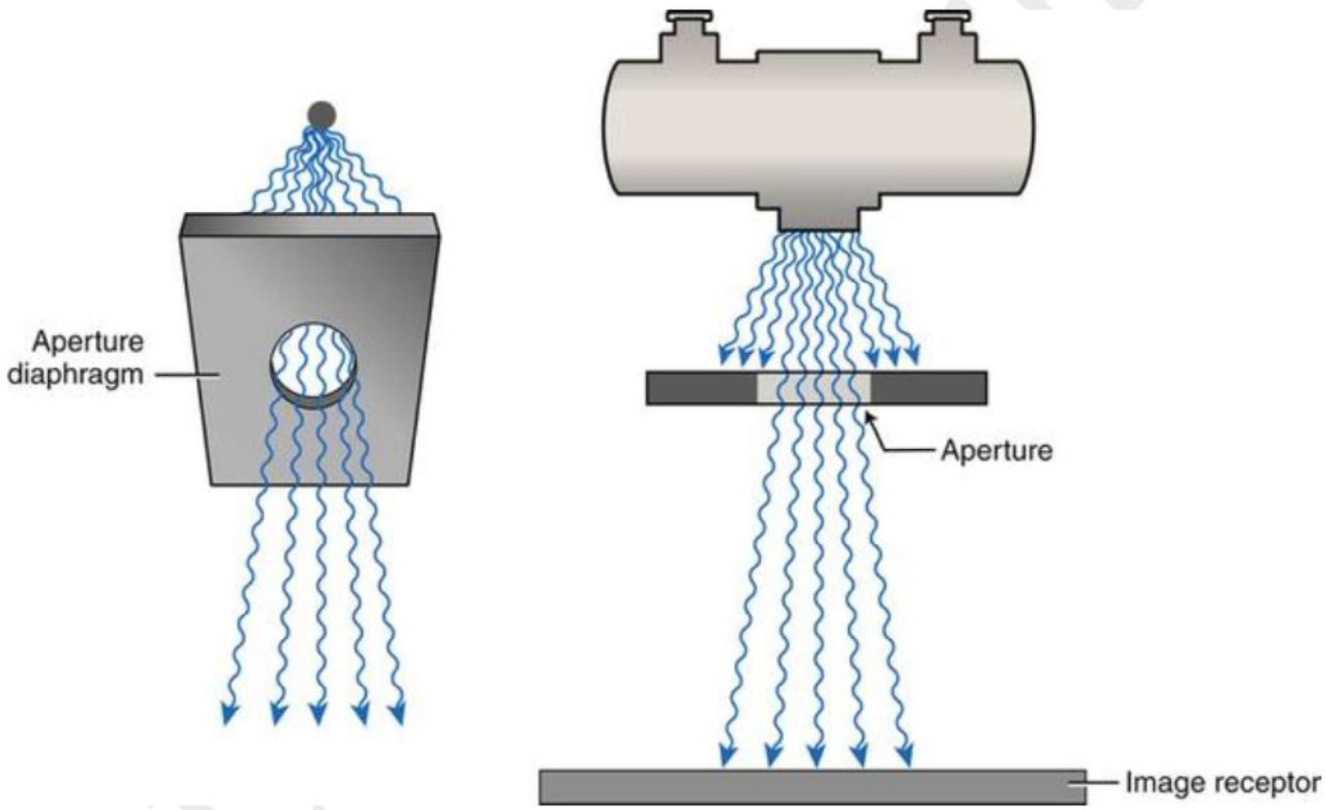
A. Aperture Diaphragm

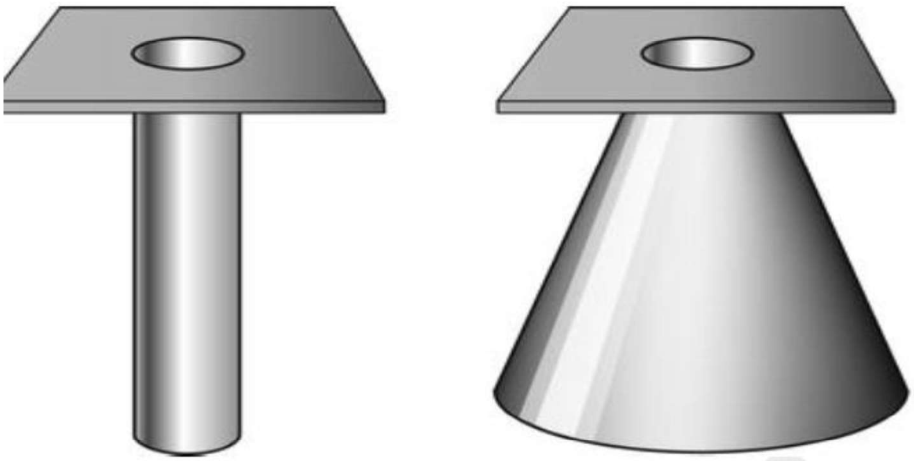
The simplest of all beam-restricting devices. Is a flat piece of lead or lead-lined metal diaphragm attached to the x-ray tube head (diaphragm) that has a hole (aperture) in it. The hole is usually designed to cover just less than the IR used. Aperture diaphragms are easy to use. They are placed directly below the x-ray tube window.



B. Cones & Cylinders

Cones and cylinders are modifications of the aperture diaphragm, and they have many of the same attributes. A **cone** or **cylinder** is essentially an aperture diaphragm that has an extended flange attached to it. The flange can vary in length and can be shaped as either a cone or a cylinder. Like aperture diaphragms, cones and cylinders are easy to use. They slide onto the tube directly below the window.

Cones have a particular disadvantage compared with cylinders. If the angle of the flange of the cone is greater than the angle of divergence of the primary beam, the base plate or aperture diaphragm of the cone is the only metal actually restricting the primary beam. Therefore cylinders generally are more useful than cones.



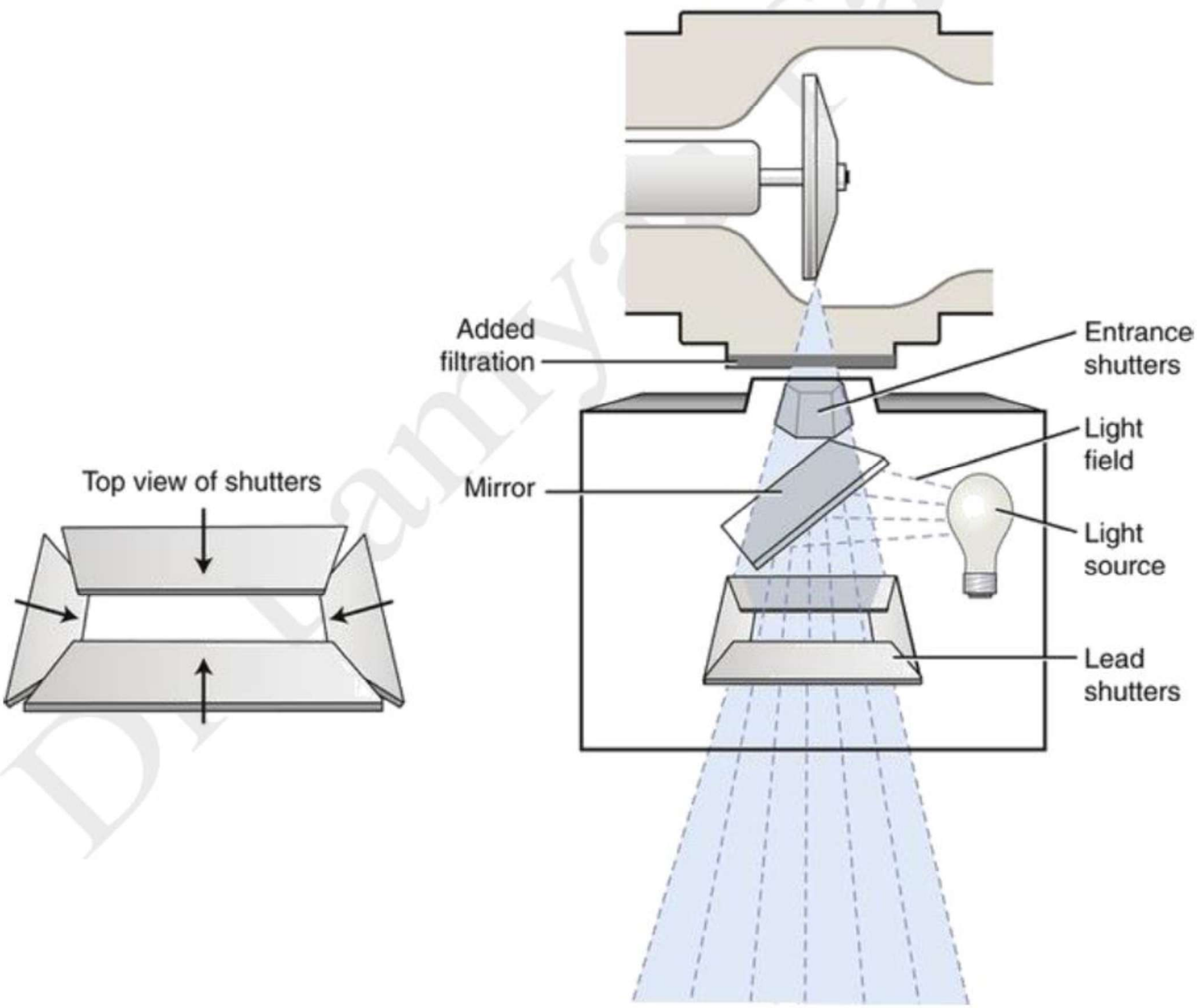
Cyclinder Cone

c. Variable Aperture Collimator

The most sophisticated, useful, and accepted beam-restricting device is the light-localizing variable aperture collimator.

A **collimator** has two or three sets of lead shutters. Located immediately below the tube window, the entrance shutters limit the x-ray beam much as the aperture diaphragm does. These shutters consist of longitudinal and lateral leaves or blades, each with its own control. This makes the collimator adjustable in that it can produce projected fields of varying sizes. Collimators are equipped with a white light source and a mirror to project a light field onto the patient. This light is intended to accurately indicate where the primary x-ray beam will be projected during exposure. The collimator lamp must be adjusted so that the projected light field coincides with the x-ray beam. Misalignment of the light field and beam can result in collimator cutoff of anatomic structures. This helps ensure that the radiographer does not open the collimator to produce a field that is larger than the IR. **Always the collimated area must be smaller than the size of the IR or cassette.**

The Beam-restricting devices are helpful to improve contrast resolution; however the inherent problem is they are placed between the source and the patient. Even under the most favorable conditions, most of the remnant x-rays are scattered.



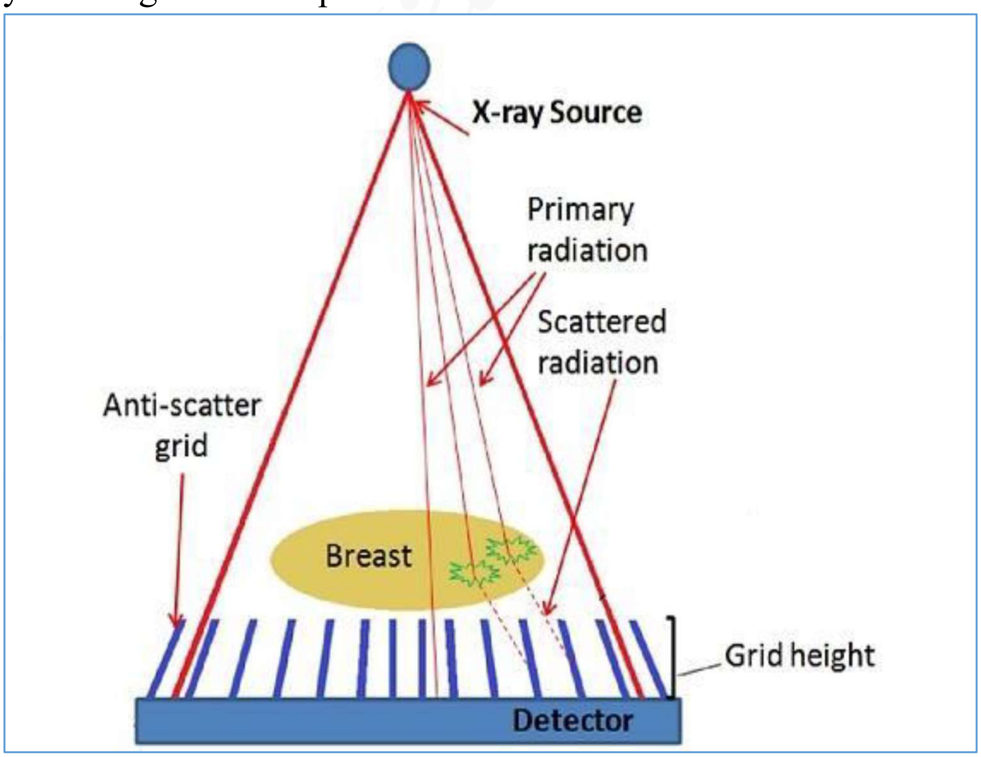
2. Grids

Grid is a device placed between the patient and film to prevent as much scattered radiation as possible from reaching an x-ray film during the exposure of a radiograph. It's used to improve contrast on a radiographic image, by absorption of scatter radiation produced by the patient as the primary beam interacts with the patient's tissues. **Grids are very effective device for reducing and "clean up" scatter radiation.** A high quality grid can attenuate 80 –90 percent of scatter radiation. It is positioned between patient and film.

Grid Construction

It is a flat plate with a series of lead foil strips that is made in various sizes. **Grid strips** should be very thin and have high photon absorption properties. Lead is most common: Tungsten, platinum, gold, and uranium have been tried, but Pb is still most desirable.

Interspace Material (Aluminum or Plastic Fiber) used to maintain precise separation between the delicate lead strips. The grid is encased completely by a thin cover of aluminum , because it provides rigidity for the grid and helps to seal out moisture.



There are some advantages of using aluminum interspaced material than plastic:

1 – Aluminum is no hygroscopic; that is; doesn't absorb moisture as plastic fiber which will result in it to become warped because of its hygroscopicity.

2 – Aluminum – interspace grids are easier to manufacture with high quality because it's easier to form and roll into sheets of precise thickness than fiber.

Grid Ratio

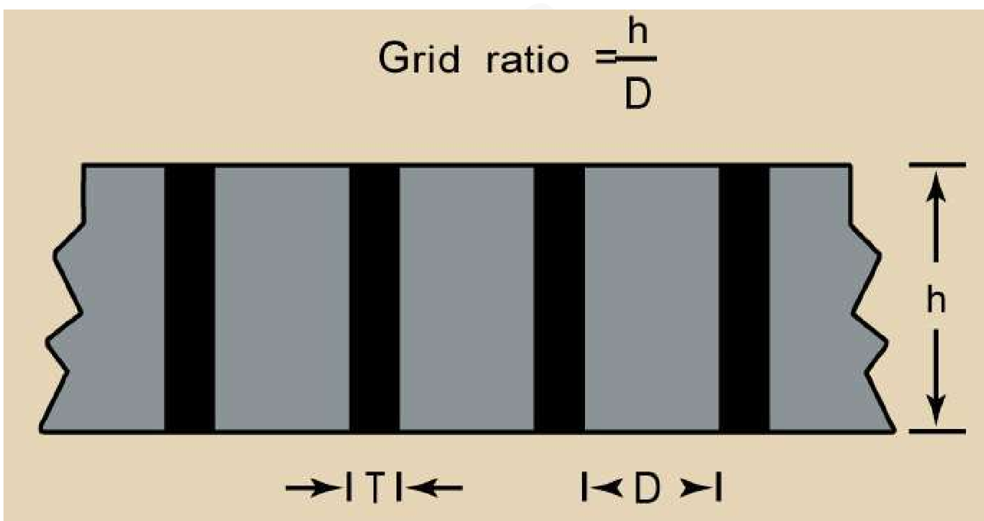
Grid Ratio: Three important dimensions of a grid:

↳ The thickness of the grid strips **(T)**.

↳The width of the interspace material **(D)**.

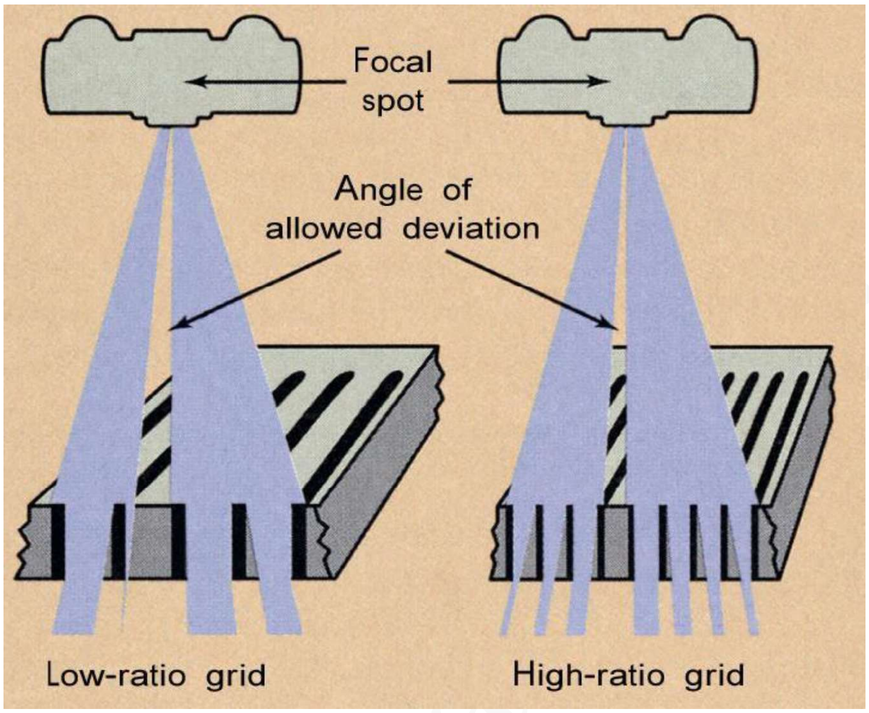
↳The height of the grid **(h)**.

The grid ratio is the **hight** of the grid divided by the **interspace width: Grid ratio = h/D**



High-ratio grids are more effective in cleaning up scatter radiation than low-ratio grids. The angle of deviation is smaller for high-ratio grids and the photon will be traveling in a straighter line to make it through the grid.

High – ratio grids are made by reducing the width of the interspace or increasing the height of the grid material, or as is usual, a combination of both. However, the higher the ratio, the more radiation exposure necessary to get a sufficient number of x-rays through the grid to the IR.



Grid ratios range from **5:1 to 16:1** that will clean up 85% and 97% respectively. Most common **8:1 to 10:1.**

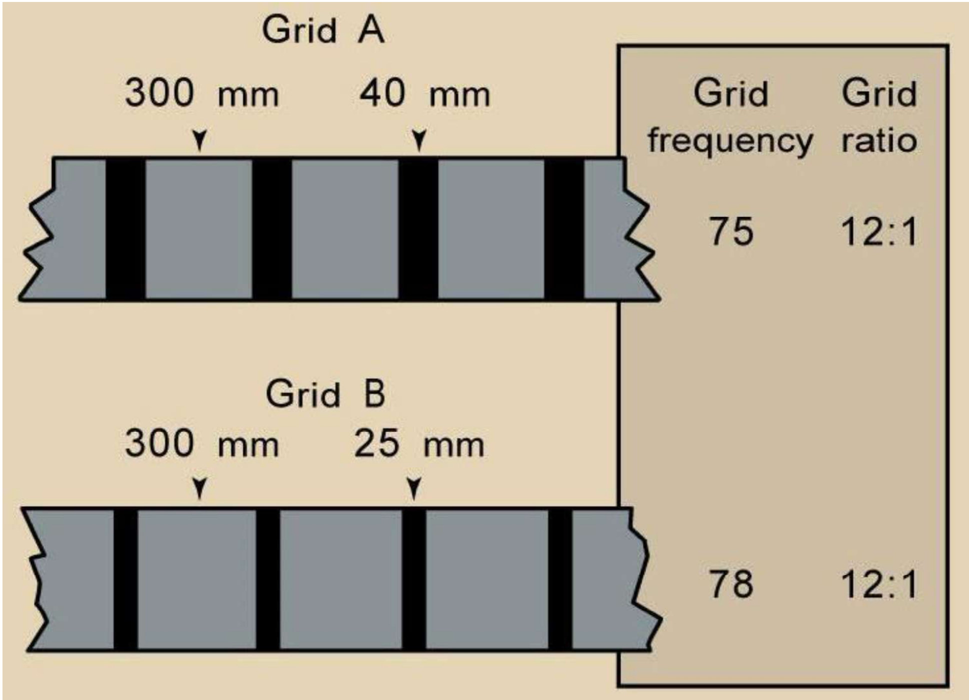
<u>Example:</u>

A certain grid is made of lead 30 μm thick sandwiched between fiber interspace material 300 μm thick. the height of the grid is 2.4 mm. what is the grid ratio?

A/ grid ratio = h/D → 2400/300 = 8:1

<u>Grid Frequency</u>.

The number of grid strips or grid lines per inch or centimeter. The higher the frequency the more strips, and less interspace material and the higher the grid ratio. As grid frequency increases, patient does is increase because more scatter will be absorbed. Some grids reduce the thickness of the strips to reduce the exposure to the patient, this overall reduces the grid clean up. Grids have frequencies in the range of 25 to 45 lines per centimeter (60 to 110 lines per inch).



Grid frequency law:

$$\text{Grid frequency} = \frac{10000\ \mu m / cm}{(T+D)\ \mu m / \text{line pair}}$$

Example:

What is the grid frequency of the previously described grid that had a grid strip thickness of 30 µm and an interspace thickness of 300 µm?

A/ if 1 line pair = 300 µm + 30 µm = 330 µm , how many line pairs are in 10000 µm (10000 µm = 1 cm)?

$$\frac{10000\ \mu m / cm}{330\ \mu m / \text{line pairs}} = 30.3\ \text{lines /cm}$$

(30.3 line /cm) (2.54 cm/in) = 77 lines / in.

Grid Performance or Efficiency

The ability of a grid to clean up scatter and improve contrast. Classically, the higher the grid ratio, the more efficient.

Criteria for grid efficiency measurement is represented by:

➤ **Selectivity**

Measures a grid's ability to absorb a greater percentage of scatter than primary radiation. Thus, a grid with high lead content would have a greater selectivity. It refers to the amount of maximum absorption of secondary radiation as compared with minimal absorption of primary radiation. When the secondary radiation is materially reduced without any appreciable absorption of primary radiation, the efficiency is high.

➤ **Contrast Improvement Ability**

Is measured by how well a grid function to improve contrast in the clinical setting, and its represented by contrast Improvement Factor (k).

Contrast Improvement Factor (k) = the ratio of the contrast of a radiograph made with a grid to the contrast of the radiograph made without a grid. The higher the grid ratio & frequency the higher the k**.**

It has been shown that as the grid ratio is increased; a greater proportion of the scattered radiation is removed from the beam. It is possible to evaluate the expected contrast for various combinations of grid ratio and ***scatter factors, S***. Some values are shown in the figure below.

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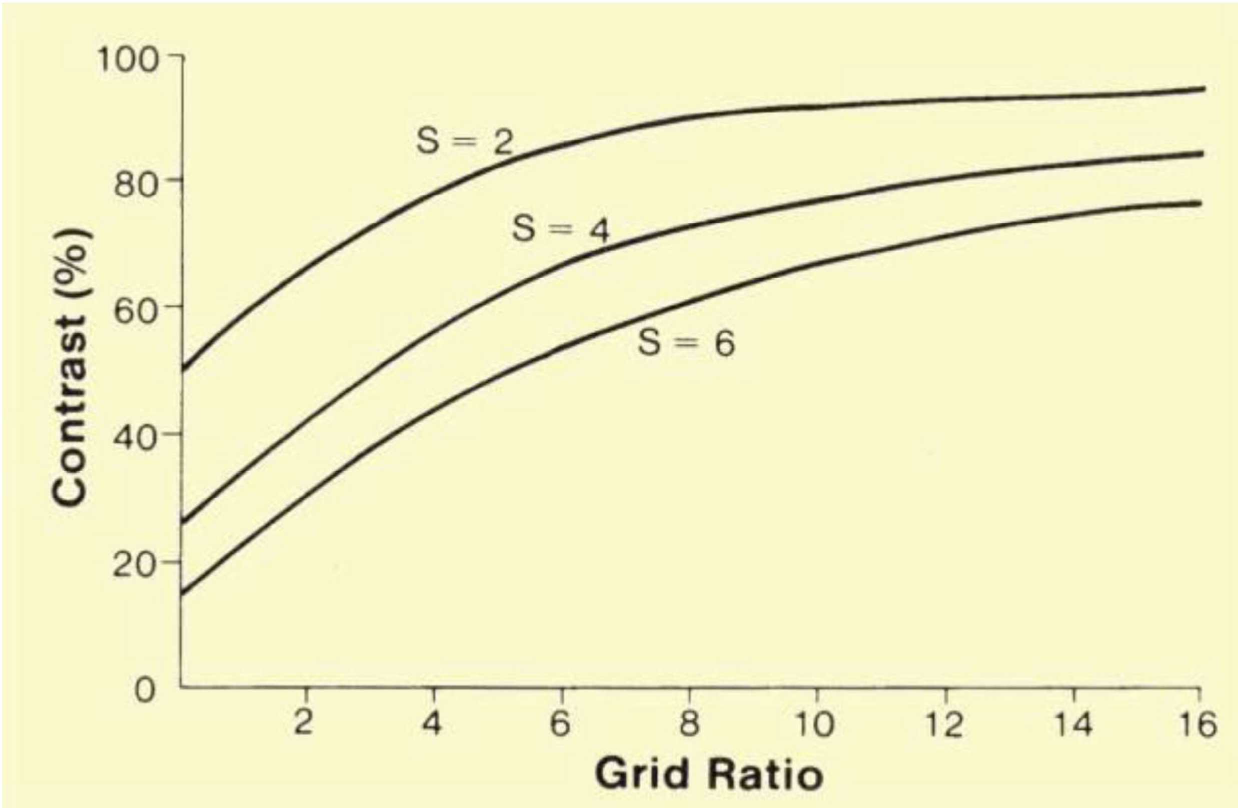
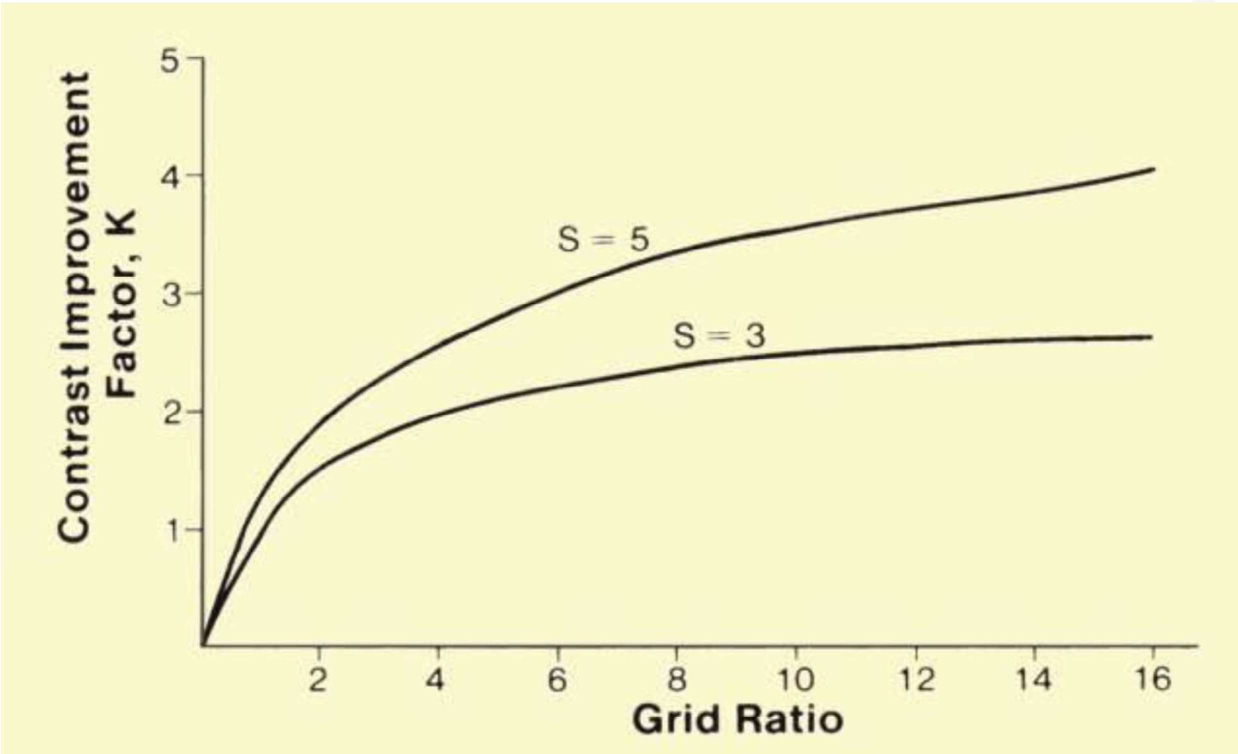


Relationship of Image Contrast to Scatter and Grid Ratio

As grid ratio is increased and scatter penetration decreases, contrast improves. For relatively small amounts of scattered radiation, that is, S = 2, a grid ratio of 8:1 restores the contrast to 90%. The additional improvement in contrast with higher grid ratios is relatively small. It should be noticed, however, that even with high grid ratios, all contrast is not restored. When the proportion of scattered radiation in the beam is higher, for example, when S has a value of 6, the situation is significantly different. At each grid ratio value, the contrast is much less than for lower scatter factor values. Even with a high-ratio grid, such as 16:1, the contrast is restored to only about 76%. This graph illustrates that contrast is not only a function of grid ratio, but is also determined by the quantity of scattered radiation in the beam, the value of S.
It might appear that the data in the figure above indicate that grids do not remove as much scattered radiation when the amount of scattered radiation in the beam is relatively large, such as for a value of S of 5 or 6.

On the other hand, grids improve contrast ***by larger factors*** when the proportion of scattered radiation in the beam is higher. This can be illustrated by observing values of the contrast improvement factor, K, as shown in the figure below. The contrast improvement factor is the ratio of the contrast when a specific grid is used compared with the contrast without the grid.



Relationship of Contrast Improvement Factor to Scatter Factor and Grid Ratio

The value of the contrast improvement factor, K, generally increases both with grid ratio and with the quantity of scattered radiation in the beam, S. Although it is true that grids improve contrast by larger factors under conditions of high levels of scattered radiation, one significant fact should not be overlooked: the total restoration of contrast for a given grid is always less for the higher values of scattered radiation. For example, in the figure above it is shown that when S is equal to 5 (contrast reduced to one fifth) a 16:1-ratio grid produces a contrast improvement factor of 4. ***The contrast recovery, K/S,*** is four fifths, or 80%. However, at a lower level of scattered radiation, such as S = 3, the same grid produces a contrast improvement factor of 2.7, which represents a contrast recovery of 2.7/3, or 90%.