FOUNDATION
FOR
EFFECTIVE AUDIOVISUAL PROJECTION

MOTION PICTURES • SLIDES • FILMSTRIPS
LARGE TRANSPARENCIES • OPAQUE MATERIALS

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FOUNDATION FOR EFFECTIVE AUDIOVISUAL PROJECTION

Motion Pictures • Slides • Filmstrips • Large Transparencies • Opaque Materials

Successful projection transfers ideas and images from film to people's minds. Good projection clears away physical and mental hurdles along the film-to-mind path.

As good projection makes the communication path easier, it increases the chances of conveying ideas and impressions successfully and of changing attitudes and behavior.

"Check-list" jobs, such as scheduling the material to be shown and notifying people of the meeting, are usually no great problem. But this routine often neglects the matter of selecting appropriate apparatus and arranging it in the room to insure the most effective projection. This must be done well to make sure that the message reaches the audience, without interference by the projection process.

For Good Projection, Follow These Steps

(clarified in the following pages)

1. Choose a room with adequate facilities.
2. Select a seating plan and screen type.
3. Determine the screen size and location.
4. Choose loud-speaker location.
5. Select the projector location and lens focal length.
6. Determine the image brightness required.
7. Select a projector-lens-lamp combination to meet the need.

Although these steps are in logical order, in practice it is often necessary to compensate for available equipment and facilities which may be less than ideal by backtracking and modifying early decisions.

This leaflet takes up these steps in order. The suggestions and data will help you prepare for an effective audiovisual presentation in almost any type of room. The information is not intended for application to commercial theater projection. Nor is it intended to detail the operation of a projector or "showmanship" techniques.

1. ROOM FACILITIES

Where the "ideal" room is not available, modifying existing conditions will improve a "possible" room.

The room should:

a. Be large enough for the greatest number of viewers expected. Large auditoriums or meeting rooms with folding chairs need 5 to 6 square feet of floor space per person within the good viewing area. Conference rooms or classrooms with fixed seating require about twice that area — 10 to 12 square feet per viewer within the good viewing area.

b. Permit suitable light control. For daytime projection in rooms with outside windows, ordinary window shades are usually suitable for Class C materials (page 13) opaque shades, two thicknesses of ordinary shades, ordinary venetian blinds, or drapes, for Class B. Almost complete darkening is usually needed for Class A materials.

Temporary opaque drapes, portable blackboards, or other makeshift devices to shield light from the screen may be used if darkening is inadequate. Light shields may be placed either at the screen or to block general room lighting coming in a window. For some specific purposes, a permanent shadow box around a screen may be desirable.

c. Provide needed illumination. Light sources which provide some illumination during projection, but not directly on the screen, help maintain a social atmosphere and permit note-taking. During projection the screen image highlights should be brighter than any other surface within the viewers' field of view. "Hot spots," caused by the glare from bare bulbs, reflections from shiny surfaces, or gaps in window covering, should be eliminated.

d. Provide adequate electrical control. Preferably, room lights should be controllable from a point near either the projector or the speaker's stand. Or, arrangements may be made for someone to turn lights off as soon as an image appears on the screen. The electrical outlet for the projector must remain "live" when room lights are turned off.

e. Provide good ventilation. The ventilation should be independent of the room-darkening devices. If smoking is permitted, a generous supply of fresh air will be needed.

f. Be acoustically good. Most rooms are satisfactory. Check reverberation by a smart clap of the hands. A sharp, ringing echo indicates too much reverberation for good intelligibility. A "live" room (with objectionable echoes) is improved acoustically when well filled with people. Any high-volume noises or clearly intelligible speech at any level coming from outside the room should be controlled or eliminated. Low-level background noise does little or no harm.

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2. SEATING PLAN AND SCREEN TYPE

All screen and image dimensions in this leaflet apply to picture aspect ratios commonly used in audiovisual materials. These range from squares to rectangles with the longer dimension no more than 1 1/2 times the shorter.

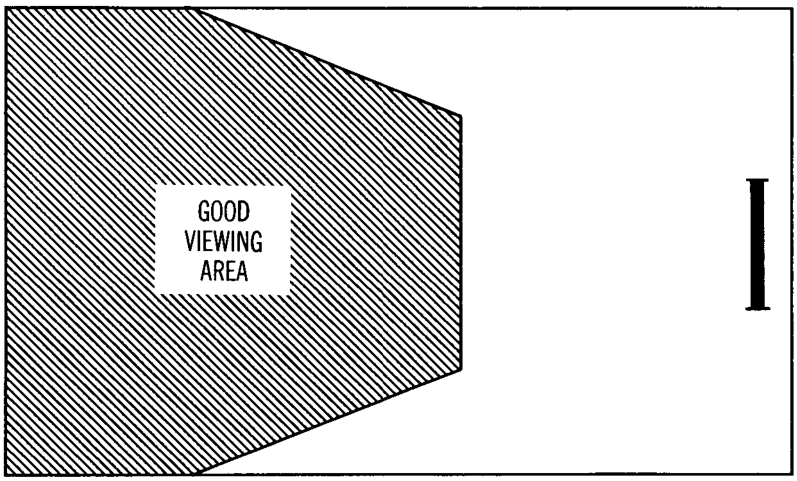


Figure 1 – In a long, narrow room (more than 1½ times as long as wide), the best arrangement is usually that shown. A beaded screen or other narrow-angle screen is suitable.

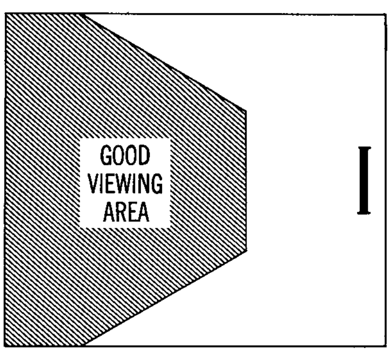


Figure 2 – In "squarish" rooms, more people will be able to see a satisfactory image if a matte or lenticular screen is chosen, because of the wider viewing angle it permits.

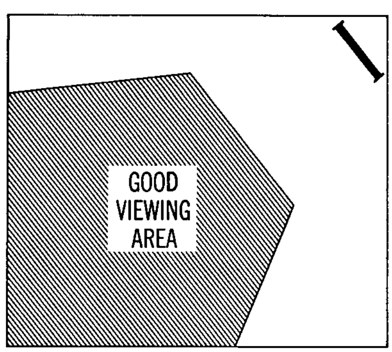


Figure 3 – In "squarish" rooms, more people can often sit in the good viewing area if projection is diagonal. A slightly larger screen may be needed because of the greater maximum viewing distance.

In the use of two or three screen images, the adequacy of each image or image area should be considered individually, whether the images are on the same or different screens. That is, image size, as well as brightness and legibility requirements, is the same for each image as if it were the only image.

The screen is often the weakest link in a projection chain. A projection screen interrupts the light falling on it from the projector (or other sources) and diverts it to the viewers' eyes. The efficiency with which it does this affects image brightness, evenness of image brightness, color saturation, and contrast of the image. Following are brief discussions of some screen types and their qualities.

Matte screens diffuse light evenly in all directions. Images on matte screens appear almost equally bright at any viewing angle. To avoid distortion because of viewing angle, however, viewers should be no more than about 30 degrees to the side of the projection axis, and not closer than two image widths to the screen.

Most matte screens are about 85 percent efficient. That is, an illumination level of 10 foot-candles on the screen provides a screen surface brightness of 8.5 foot-lamberts, regardless of viewing angle or the angle at which light strikes the screen.

Lenticular screens have a regular pattern of stripes, ribs, rectangles or diamond-shaped areas. The pattern is too small to see at viewing distances for which the screen is designed. The screen surface may appear to be enameled, pearlescent, granular metal, or smooth metal; and it may or may not have a coating over the reflective surface.

By control of the shape of the reflecting surfaces, the screen can reflect nearly all the light from the projector evenly over a fan-shaped area 70 degrees wide and 20 degrees deep. People seated farther to the sides of the screen than the 70-degree angle or above or below the 20-degree angle would see no image — no image-forming light would be wasted outside the viewing area. It is also possible to produce a surface which will reject light from outside the viewing area that might otherwise reduce the contrast of the projected image. Many lenticular screens provide an image three or four times as bright as a matte screen would.

Other lenticular screens may provide wider viewing angles with less "gain" or narrower viewing angles with more gain.

Because the characteristics of lenticular screens do vary, it may be difficult to select the best screen for a particular use. But often the improved results make it well worth while.

Beaded screens are useful in long narrow rooms or other locations where most viewers are near the projector beam. They are white surfaces with imbedded or attached small clear glass beads. Most of the light reaching the beads is reflected back toward its source. Thus, a beaded screen provides a very bright image for viewers seated near the projector beam.

As a viewer moves away from the beam, the image brightness decreases. At about 22 degrees from the projector beam, the image brightness on a beaded screen will be about the same as that on a matte screen. Beyond this angle it will be less bright than on the matte screen.

Since non-image or stray light is also reflected back in the general direction from which it comes, stray light falling on a beaded screen from a viewer's position at the side of a room can be a major problem.

Rear-projection images have the same requirements for image brightness, size, and contrast as front-projected images. Rear projection has advantages in some situations, disadvantages in others.

A person or object in front (on the viewer side) of a rear-projected image does not interfere with the projection beam. This makes rear projection useful for situations in which the mechanism of projection must be unobtrusive or hidden as in displays. It permits close examination of the screen image.

Rear projection may provide advantages in image contrast and color saturation in a lighted room. A dark rear-projection screen will reduce image brightness, but it will reduce the amount of room light reflected back toward viewers by a greater factor. Thus a dark rear-projection screen can provide better contrast and color saturation when used in a lighted area, provided that stray light does not fall on the back of the screen.

Rear projection may also have disadvantages. With conventional projection, the space over the heads of viewers is usually used for the projector beam. With rear projection, the projection beam is wholly or partially on the opposite side of the screen from the viewers. Consequently, space for the beam must be provided outside the normal room space (behind the screen).

To reduce space requirements in rear projection, short-focal-length lenses are sometimes used. More commonly, one or more mirrors are used to fold the projection beam. Either is likely to reduce image brightness and quality.

Makeshift rear-projection screens, such as ground glass, are seldom satisfactory. Just as the satisfactory viewing angle of lenticular screens can be controlled, so the dispersion (viewing) angle of rear-projection screens can be controlled. A narrow-angle screen will give a bright image for viewers almost directly in front of the screen, but a dim image for people at the sides of the viewing area. As the angle is increased, and within limits, the image will become less bright for the viewer squarely in front of the screen, and brighter for viewers toward the sides.

Another important consideration in rear-projection screens is the darkness of the screen as seen by reflected light. A dark screen can improve image contrast and color saturation in a lighted room. But this is an advantage only if the projector-screen combination can provide a bright enough image for good viewing. As with front projection, the highlight brightness of the image should be as bright, or brighter than, other areas within the viewers' peripheral vision.

If the image is to be viewed in a well-darkened room, there is no advantage in a dark screen. If the image is to be large, a light screen is usually preferable since it will absorb less image light than a dark screen.

With most tungsten projectors, images as wide as 42 or 48 inches will be satisfactory on a dark rear-projection screen in moderately lighted rooms. For larger images a light screen in a darkened room is usually needed. In very brightly lighted rooms, images should usually be no more than 24 or 30 inches wide, and the screen material dark.

The commonest form of rear projection involves a rear-projection cabinet or console. Many of these are on the market. You can, however, build your own. For plans, write to Sales Service Division, Eastman Kodak Company for Rear-Projection Cabinets, KODAK Pamphlet No. T-47.

For an authoritative discussion of rear-projection screens, see "Selection and Specification of Rear-Projection Screens," by Petro Vlahos, in the February, 1961, Journal of the Society of Motion Picture and Television Engineers (Volume 70, No. 2).

3. SCREEN SIZE

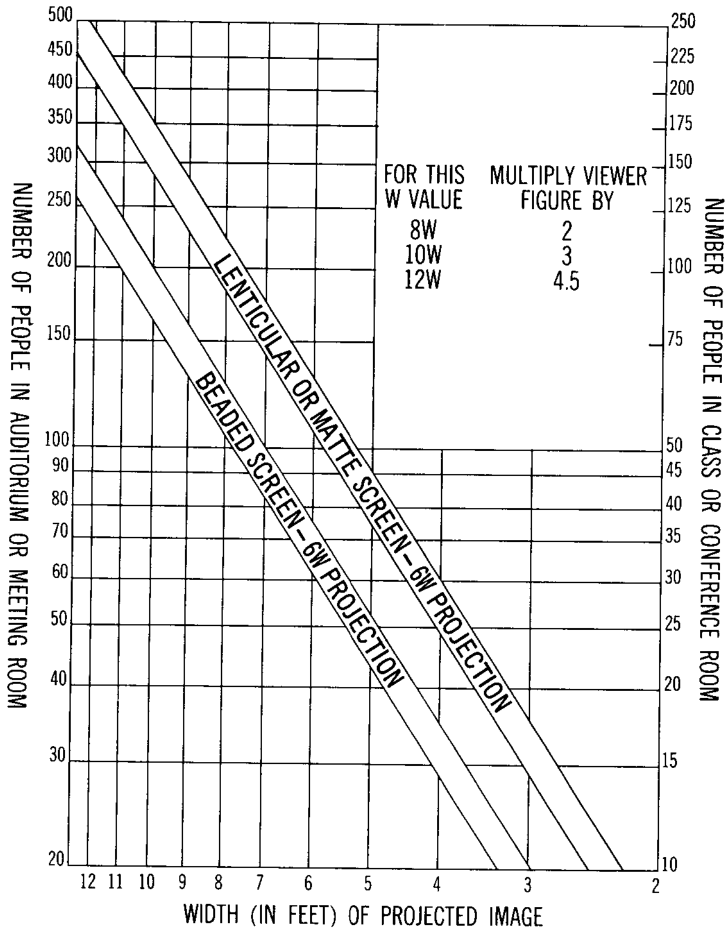
Screen size should be such that the back row of viewers is no more than 6 times the image width (W) from the screen, with the following exceptions:

a. Certain materials, including many teaching films, are designed with titles and important picture elements bold enough to permit satisfactory viewing at distances of 8 to 10 times the image width. If this is true for the materials to be projected, the projector may be moved closer to the screen to give a smaller and brighter image. Moving the projector enough closer to change the back row from 6W to 8W will approximately double the image brightness and allow the front row to be moved a little nearer the screen.

b. In some situations, materials which limit maximum viewing distance to less than 6W are commonly used. Typewritten material projected with an opaque projector is an example. For showing the full area of an 8 1/2 by 11-inch page, pica type calls for a maximum viewing distance of 3W. A compromise minimum viewing distance of 1 1/2W may be necessary to give adequate audience capacity.

The graph on page 9 is based on floor space within the area of good viewing, not the area of the entire room. For an auditorium or other meeting room, the allowance is 5 to 6 square feet per viewer; it is 10 to 12 square feet for a conference room or classroom with fixed seating. The table includes an allowance for aisles within the seating area and assumes the entire trapezoidal area of good viewing is available for seating. It may be used in determining either the screen size needed for a given number of people or the number of people accommodated by an image of a given size.

For example, a 5-foot image in an auditorium or other meeting room can be expected to provide good viewing for 50 people if a beaded screen is used or for 80 people if a matte or lenticular screen is used. Other factors, of course, must also be satisfactory. Conversely, if 50 people are expected, a 5-foot image will be required if a beaded screen is used; a 4-foot image, if a matte or lenticular screen is used.

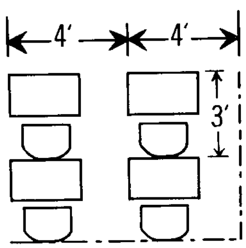


For a conference room or classroom with fixed seating, the number of viewers is shown at the right of the chart. Thus, a 5-foot image will provide good viewing for 25 people if a beaded screen is used, for 40 people if a matte screen is used. Or, if 25 people are expected for a conference or classroom presentation, a 5-foot beaded or 4-foot matte screen will be needed.

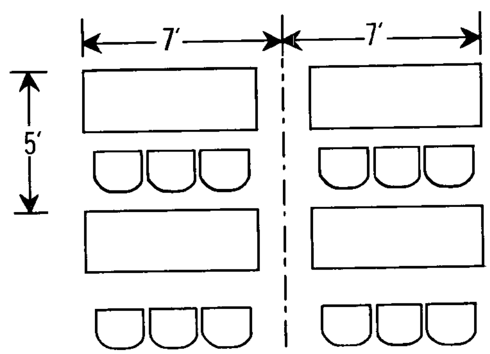
If the character of the projected materials is such that 8W (rather than 6W) viewing is satisfactory, the number of people accommodated may be multiplied by a factor of 2, as shown in the table in the upper-right corner. Thus, a 5-foot image on a beaded screen would provide adequate viewing for 100 people in an auditorium or other meeting room; or a 5-foot image on a matte screen would be adequate for about 170 people. Conversely, if 50 people were expected and 8W projection were satisfactory, either a 3 1/2-foot beaded screen or a matte screen a little less than 3 feet wide would be adequate.

These image-size considerations are based on legibility. For a more complete discussion, see KODAK Pamphlet No. S-4, "Legibility Standards for Projected Materials," available on request from the Sales Service Division, Eastman Kodak Company, Rochester 4, New York. There is often a psychological advantage in having a large image, even though it may not be required for legibility.

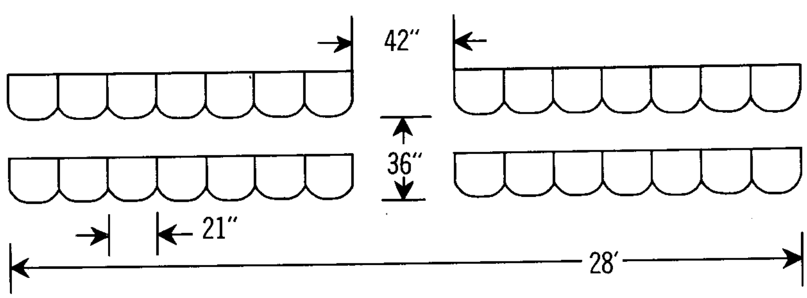
Typical seating measurements are shown in the following diagrams:



CLASSROOM WITH FIXED SEATING



CONFERENCE OR SEMINAR



AUDITORIUM OR OTHER MEETING ROOM

If vertical or square pictures are to be shown, a square screen is preferable. If only horizontal pictures are to be shown, either a horizontal screen with proportions of about 3:4 or a square screen masked or opened part way is usually preferred.

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4. LOUD-SPEAKER LOCATION

Sound quality is usually most satisfactory if the loud-speaker is near the screen and high enough to be seen by everyone. Low placement causes loss of intelligibility for all except those in the front row.

Where acoustics are poor, a corner location or extra speakers placed part way back in the room may help. Extra speakers should ordinarily be aimed toward the back of the room to avoid interference between separate units.

Proper tone-control adjustment can help greatly in any room. In an acoustically poor room, best intelligibility is usually achieved with the tone or balance control near maximum treble. These settings do not give the most pleasing reproduction of music, but they do improve crispness of speech and reduce reverberation.

5. PROJECTOR LOCATION

For an undistorted image, the projector lens should be on a line extended at right angles, vertically and horizontally, from the center of the screen surface. For overhead and opaque projectors, this usually requires that the top of the screen be tilted toward the viewers. Projectors should be high enough so that their beams will "clear" obstructions, such as the heads (and hats) of viewers.

Strongly upward or downward projection angles will cause "keystoning" of the image unless the screen is tilted. That is, if the screen is vertical and the projector is tilted upward, an image which should be rectangular will be wider at the top than at the bottom. With beaded screens, such projection angles reduce image brilliance and increase unevenness of image brightness.

The distance from projector to screen is determined by the size of the area being projected, the focal length of the projection lens, and the image size needed.

6. IMAGE BRIGHTNESS REQUIRED

Brightness (the amount of light the viewer sees) depends on viewing angle; screen type; projector design; wattage, life rating, and age of lamp; character of material being projected; image size; line voltage; and design and cleanliness of optics. Lamp wattage alone gives little indication of image brightness; using it as a measure of image brightness is like rating an engine by the fuel consumed rather than the work done.

The work done by a projector, in terms of image brightness, is lumen output. Lumen output divided by image area (in square feet) gives the foot-candles falling on the screen from the projector. Foot-candles of illumination multiplied by the reflectance of the screen (about 0.85 for a good matte screen) give foot-lamberts — the measure of brightness of the image seen by the viewer.

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Projection Distance for Desired Image Width (W)

Type of Material	Lens Focal Length (inches)	Desired Image Width 40"	50"	60"	70"	For other widths, multiply desired width by*
		Projection Distance (Feet – to nearest ½ foot)				
16mm Motion Pictures (0.284" x 0.38" projector mask)	1½	13	16½	20	23	3.9
	1-5/8	14	17½	21	24½	4.2
	2	17½	22	26½	31	5.3
	2½	22	27½	33	38½	6.6
	3	26½	33	40	46½	7.9
	4	35½	44	53	61½	10.5
8mm Motion Pictures (0.129" x 0.172" projector mask)	¾	14½	18	21	26	4.4
	7/8 (22mm)	17	21	25	29	5.0
	zoom (15-25mm)	11½-19	14½-24	17-29	20-33	3.4-5.7
Filmstrip (17.2 x 23.0mm projected area)	3	11	14	17	19½	3.3
	4	15	19	22½	26	4.4
	5	19	23½	28	32½	5.5
	7	26½	33	39	45½	7.7
2 x 2" Slides (23 x 34mm horizontal mask)	3	8	9½	11½	13½	2.3
	4	10½	13	15	18	3.0
	5	13	16	19	22½	3.7
	7	18	22½	26½	31	5.2
	9	23	29	34½	40	6.7
	11	28	35	42	49	8.2
	zoom 3¾-6¼	9½-16	12-20	14½-24	16½-29	2.8-4.7
2 x 2" Slides (38mm square or 26.2 x 38mm horizontal mask)	3	7	8½	10½	12	2.0
	4	9	11½	13½	16	2.7
	5	11½	14½	17	20	3.3
	7	16	20	24	28	4.7
	9	21	26	31	36	6.0
	11	25½	31½	37½	43½	7.4
	zoom 3¾-6¼	8½-14½	10½-18	13-21½	15-25	2.5-4.2
2 x 2" Slides (30mm square mask)	3	9	11	13	15½	2.6
	4	11½	14½	17	20	3.4
	5	14½	18	21½	25	4.2
	7	20½	25	30	35	5.9
	9	26	32½	39	45	7.6
	11	32	39½	47½	55½	9.3
	zoom 3¾-6¼	11-18	13½-22½	16-26½	19-31½	3.2-5.3
Lantern Slides (Mask opening 3" wide)	6½	8	9½	11½	13	2.2
	12	14½	18	21	24½	4.0
	16	19	23½	28	32½	5.3
	26	31	38½	45½	52½	8.7
Overhead and Opaque Material 7" wide	12½	7	8½	10	11½	1.8
Material 10" wide	14 or 14½	6	7	8½	9½	1.4
	18	7½	9	10½	12	1.8
	22	9	11	13	14½	2.2

*After multiplying, add lens focal length for greater accuracy.

Thus, a projector with a 120-lumen output provides 10 foot-candles of illumination for a 3 by 4-foot (12 square-foot) screen image; that is, 8.5 foot-lamberts of image brightness for the viewer of a good matte screen.

Light output of a projector is measured with no film in the projector but with the standard aperture in place and, for motion-picture projectors, with the shutter running. Image brightness needed is not an absolute value, with one exception, which is discussed later. It depends primarily on the brightness needed to overrride the non-image brightness of the screen in order to give satisfactory image quality.

Non-image brightness of a screen is the result of all the light falling on the screen other than that actually forming the image. High non-image brightness makes it difficult to obtain good blacks or dark areas in the projected image. The principal sources of non-image brightness are ceiling and exit lights in the room or incompletely darkened windows, doors, and skylights.

Light escaping from within the projector itself, as well as from improperly designed or dirty projection optics, also contributes to non-image brightness. These projector sources of non-image light are usually of little consequence in well-designed audiovisual equipment in good condition.

The amount of image brightness needed to override non-image brightness depends on the kind of audiovisual material being projected:

Class of Material	Brightness Ratio		
	Non-Image		Image
CLASS A			
Full-scale continuous-tone black-and-white or color pictures where pictorial values are important and color or tone differences must be discriminated	1	to	100 or more
CLASS B			
Color diagrams and continuous-tone black-and-white pictures in high key.	1	to	25
CLASS C			
Simple line material, such as text, tables, diagrams, and graphs — either positive or negative (reverse).	1	to	5

DETERMINING LUMEN OUTPUT NEEDED

On the next page are three ways of determining lumen output needed. All depend on measuring or estimating non-image brightness of the screen — not on measuring projector output. The first is best, since it depends on actual brightness measurement. The second will serve almost as well if a matte screen is used or if the primary source of stray light on a beaded screen is in the same general direction as the projector. The third, based on estimating non-image brightness, is subject to considerable errors; nevertheless, it is better than trusting to luck.

Method I — For determining the light output required of the projector.

1. With the room lighted as it will be during projection, measure non-image screen brightness with a brightness meter. For greatest accuracy in small rooms, the projector should be operating (with the lens capped). However, the projector usually contributes little stray light in large rooms. Changing the projector lamp to meet brightness requirements usually makes no important difference in stray-light levels. A single measurement taken at 10 to 30 degrees from the projection axis is usually enough for a matte screen. For other screens, the reading should usually be made at the greatest viewing angle (where image brightness will be lowest). Brightness meters give reading in foot-lamberts. They are often available in physics or optics departments of colleges and universities. Commercially available meters include the Spectra Brightness Spot Meter (Photo Research Corp., 127 W. Alameda Avenue, Burbank, California), the Luckiesh-Taylor Brightness Meter (General Electric Co., Instrument Division, 40 Federal Street, West Lynn, Massachusetts), and the Macbeth Illuminometer (Macbeth Instrument Corp., P.O. Box 950, Newburgh, New York).
2. Multiply the non-image brightness reading by 1.2 (to allow for screen-reflectance factor).
3. Multiply by the brightness-ratio factor (5, 25, or 100 — see table, page 13) for the class of material being projected.
4. Multiply by square feet of image area.

Method II — For determining the light output required of the projector.

1. Under the projection conditions listed in Method I (projector capped), measure the non-image light falling on the screen. For use in making measurements of this type, foot-candle meters can be borrowed from most electric power companies: also, some photoelectric exposure meters are suitable.
2. Multiply by the factor for the class of material being projected (5, 25, or 100).
3. To obtain the light output required of the projector, multiply by the square feet of image area. (No allowance is made for screen reflectance. This method assumes similar reflectance for image and non-image light. The error resulting from this assumption may be great with highly directional screens.)

Method III — For making a rough estimate of the lumen output required.
1. Estimate non-image brightness according to these categories:

0.1 foot-lambert:

In a well-darkened room, with exit and aisle lights turned on and the projector running but capped, people at the screen location are visible primarily as silhouettes. At the screen surface, newspaper headlines set in type one inch high are readable with difficulty from a normal reading distance.

5.0 foot-lamberts:

On a sunny day, in a classroom with two layers of tan shades or tightly closed "regular" venetian blinds; the text of a newspaper at the screen surface is readable with some eyestrain.

10 foot-lamberts:

In a classroom with unshaded windows lighted by light from the sky or by direct sun on single-thickness tan shades, reading is fairly easy for newspaper-text type. These estimates assume that there is good screen placement in the room; that, if a beaded screen is used, it does not face a light source; and that, if a matte screen is used, no light from nearby sources is allowed to fall directly on it.

2. Multiply the estimate by the brightness factor for the class of material being projected (5, 25, or 100).
3. Multiply by the image area (in square feet).

(This method is not accurate enough to justify an allowance for screen reflectance.)

A special case of this brightness-ratio concept is encountered in rooms where the non-image brightness of the screen falls below 0.1 foot-lambert and the brightness of other surfaces within the field of view is appreciably lower. The minimum acceptable image brightness then depends on the amount of light needed for good seeing rather than on the ratio of image to non-image brightness. Its minimum value is about 5 foot-lamberts, although, in some instances, such as outdoor projection on large screens, levels of 2 or 3 foot-lamberts are tolerated. In general, it is better to show a slightly smaller image and bring the level up to 8 or 10 foot-lamberts.

It must be clearly understood that levels below 5 foot-lamberts are marginal and are not to be recommended where a screen image is being viewed for informative purposes. At low stray-light levels, it is usually possible to avoid excessive contrast for Class B and C materials by increasing the light in the room. If this is done in such a way that little extra light falls on the screen surface, but instead illuminates the wall against which the screen image is viewed, eye comfort is generally improved. The position and intensity of the supplementary light should be such that none of the surfaces it illuminates approaches the brightness of image highlights.

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Supplementary light is especially important with Class C materials. A bright screen image of Class C material in a completely darkened room results in a dazzle which reduces legibility.

7. THE PROJECTOR-LENS-LAMP COMBINATION

When the required lumen output of the projector and focal length of the lens are determined, the equipment most nearly meeting those requirements should be selected.

The table on page 19 gives average lumen output for various KODAK projectors.

Adapting to Requirements

Obviously, the projection equipment available for a given situation will not always meet the exact lumen-output requirements for good projection.

In order to have adequate image brightness, lumen output should be at least as great as specified.

A reasonable excess in lumen output is permissible. Because of the variable image brightness (depending on the viewing angle) of beaded screens, a greater excess can be tolerated when a matte or lenticular screen is used than when a beaded screen is used.

An "overage" of 50 percent in lumen output should be the maximum for a beaded screen. This will give an image approximately 4 1/2 times as bright, near the projection axis, as the desired brightness 20 degrees from the projection axis.

For a matte or lenticular screen, the light output may be 4 times that desirable, giving an image brightness from all viewing angles about 4 times as bright as specified.

Image Not Bright Enough

The difficulty most often recognized is insufficient light output. As suggested on page 8, one possibility for producing brighter and smaller images is to move the projector closer to the screen. Halving the distance will increase image brightness 4 times. However, this solution is satisfactory only when the material being projected is so designed that the information it contains can be discriminated satisfactorily in the smaller size (see page 8).

If the lamp in the projector has a life rating of more than 10 hours or is smaller than the maximum wattage recommended for the projector, light output can be increased by using a 10-hour lamp of maximum permissible wattage. Often 10-hour lamps smaller than 1000 watts are not regularly stocked by dealers. A lamp which is either larger than recommended or rated at substantially lower voltage than the existing line voltage will increase the light output, but it is also very likely to damage film and may cause the condenser lenses or heat-absorbing glass to crack. Heat-absorbing glass should not be removed to increase illumination, because its removal will cause film and equipment damage.

Screen characteristics can be utilized to obtain a brighter image. If it is possible to confine all viewers to an area no more than 10 degrees off the projection axis, the least bright image seen on a beaded screen will be approximately twice as bright as that seen either on a beaded screen from 20 degrees off the projection axis or on a matte screen from any angle.

When stray-light levels are high, locating the screen in the room so that it is seen against the darkest part of the room will help. If a beaded screen is used, stray light from the audience direction may be an especially serious problem.

It may also be possible to increase image brightness and obtain better rejection of stray light by using a metallic screen — either a flat one or one with ribs or lenticules. Most portable metallic screens are highly directional. The projector and screen must be placed and aimed very carefully to take advantage of their special characteristics and to obtain good images with even brightness.

If a visual test of the equipment specified does not demonstrate satisfactory brightness, check these common causes for reduced brightness:

1. When the equipment is operating, the line voltage at the projector plug should be within 5 volts of the rated lamp voltage. A lamp rated at 115 volts produces 15 percent less light when the voltage drops from 115 to 110. At 104 volts, the loss is 30 percent. A light-weight extension cord can easily cause such a voltage drop.

2. All equipment and materials in the optical system should be clean. The optical system includes reflectors or mirrors, lamp envelope, condensing lenses, heat-absorbing glass, cover glasses or glass pressure plates, the material being projected, the projection lens (all surfaces), and the screen itself.

3. Old and darkened projection lamps produce less light. A lamp improperly centered or not locked in position may reduce brightness and cause uneven illumination.

4. Unusually dense (dark) transparencies, of course, give less bright images. Some photographers consistently and intentionally produce dense transparencies, often because they project them regularly on a small screen with a powerful projector. In such a situation, properly exposed transparencies may look "washed out." Thus, the photographer may underexpose reversal film to obtain denser-than-normal transparencies which look well with his own equipment, but are too dense for standard projection.

5. Even though they are clean, old projection screens may have become yellowed or darkened so that they do not perform well.

Image too Bright

While the need for greater light output is usually recognized, the need for reducing light output can be as great and may be neglected. Over-bright images may cause a dazzling effect and make flicker more apparent in motion pictures. The problem of too much brightness is encountered most often with Class C materials.

A good means of reducing light output is the substitution of lower-wattage lamps. It is usually possible to use a 300- or 500-watt lamp in a projector designed for a 750- or 1000-watt lamp.

Reducing lamp voltage or using a lamp intended for a higher line voltage is a satisfactory way of reducing light output, up to a point. Reducing the lamp voltage 10 or 15 percent will reduce light output 30 or 40 percent, and prolong lamp life 4 or 5 times. Reducing the lamp voltage more than about 15 percent may cause an objectionable shift in color quality toward yellow and red. Only the voltage on the lamp should be reduced; reducing the voltage to a projector motor or amplifier below its minimum design voltage may cause overheating, unsatisfactory operation, and consequent damage.

Raising the general room illumination will often serve the same purpose as reducing image brightness, since it is the brightness ratio, rather than absolute image brightness, which is pertinent. This is especially useful in reducing the dazzle effect of excess brightness in showing negative, or "reverse"-text, slides.

The light output of a KODAK PAGEANT Sound Projector with a KODAK SUPER-40 Shutter can be reduced about 30 percent at sound speed by locking the shutter in the 3-blade position.

Lumen Output of Projectors Manufactured by the Eastman Kodak Co.

(See table on facing page.)

These figures are averages for projectors and lamps randomly selected. Measurements were based on recommendations of the American Standards Association, Inc., for determining projector light output. Each figure represents a number of projector-lens-lamp combinations and measurements for each combination measured. Any individual measurement, of course, may be expected to vary from the average. All figures are for lamps operated at their rated voltages. All are for lamps with a 25-hour life rating, except that 1000 and 1200-watt lamps have a 10-hour rating. The lenses are all KODAK projection lenses. Some projectors no longer manufactured are included because many are still in use.

2 x 2 Slide Projectors

Projector	Mask Size (in mm)	Lens 3" f/3.5	4" f/3.5	5" f/3.5	5" f/2.8	7" f/3.5
CAROUSEL with DFW lamp*	23 x 34 38 x 38	465 –	610 1100	640 1200	750 1390	710 1280
KODAK 500, READY-MATIC or SUPER-MATIC, with CZA or DBJ lamps	23 x 34 38 x 38	440 –	575 950	550 900	750 1390	500 825
CAVALCADE with DFR lamps* Universal condenser	23 x 34 38 x 38	325 –	425 –	415 705	525 750	500 840
135 condenser	23 x 34	465	605	590	750	710
SIGNET 500 with CZX lamp*	23 x 34 38 x 38 17.5 x 23	– – –	– – –	585 1030 270	650 1145 300	600 1040 275

*Use 60% of figures given for "Lo" switch position on CAROUSEL and CAVALCADE projectors; 55% of figures given for SIGNET projectors with 300-watt lamps.

16mm Motion-Picture Projectors

KODAK Pageant*	1½" f/2.0	2" f/1.6	3" f/2.0	4" f/2.5	2" f/1.6 with KODAK Bifocal Converter 1-5/8	2½
750-w lamps	115-165	220-310	180-255	120-170	195-275	135-190
1000-w lamps	150-215	290-410	230-320	150-210	260-365	180-250
1200-w lamps	170-240	350-490	250-350	165-230	290-405	195-275

* Larger figure in each pair is for projector at sound speed with SUPER-40 Shutter in 2-blade position. Use 1200-w lamps only in models designed for them.

EASTMAN 16mm, 2", 2¼", 2-5/8", 3", or 4" f/1.5 lens (With matching condensers, lumen output is approximately the same for all lenses.)

	Model 25	Model 25B
1000-w tungsten lamp	450	595
1200-w tungsten lamp	515	680
Strong arc, 46 amperes		
with filter (for B&W films)	2000	2400
without filter (for color films)	2500	3000

ANALYST II Projector, 2" f/1.6 lens – 750-w lamp, 130 lumens; 100-w lamp, 190 lumens

8mm Motion-Picture Projectors

Current and recent KODAK 8mm Movie Projectors have light outputs ranging from about 80 to 160 lumens, depending on the projector, lamp, lens, and the switch settings on some models. With a projector light-output of 80 to 100 lumens and a matte screen in a well-darkened room, a satisfactory image can be 3 or 4 feet wide; with 130 to 160 lumens and a lenticular screen, 6 to 9 feet wide. For further considerations, see KODAK Pamphlet S-14, What Can You Do with 100 Lumens?

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