



Stage Lighting **A Guide to the Planning of Theatres and Auditoriums**



Stage Lighting—A Guide to the Planning of Theatres and Auditoriums

Publication of this Design Guide
has been approved by the IES.
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be directed to the IES.

Prepared by:
The Theatre, Television and Film Lighting Committee of the
Illuminating Engineering Society of North America

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Prepared by the Theatre, Television, and Film Lighting Committee

Theatre, Television, and Film Lighting Committee

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Stage Lighting – A Guide to the Planning of Theatres and Auditoriums

1.0 FOREWORD

The Theatre, Television and Film Lighting Committee developed this Design Guide to assist design professionals in specifying or understanding the requirements of performance lighting and control systems. This Guide considers the factors involved in achieving a successful, functioning space for live performances. It outlines the unique nature of these facilities and general techniques for creative lighting, but leaves the details to architects and the special consultants involved in the design of these spaces.

As a complete review and revision of prior Committee documents in this area (CP-34 and CP-35), this Design Guide incorporates the latest design and application information associated with contemporary theatrical architecture, lighting positions in both the house and stage, typical luminaires and layouts, the effects of lighting on mechanical and acoustical elements, and the lighting controls used in the lighting of activities and presentations.

2.0 INTRODUCTION

Lighting for any kind of stage involves the use of specialized lighting “instruments,” generally using tungsten-halogen lamps and flexible control equipment. The building must include many mounting positions for the lights, circuiting, and the dimming systems. In this Guide, the term “theatre” means a space to present live performances including all necessary ancillary facilities. Theatres may be found in buildings such as lecture and concert halls, churches, platforms, motion picture houses, portions of restaurants, and sports arenas. Factors for the successful design of theatre-related areas are considered in this Guide.

There are several Society publications that designers should consider. These include the most recent edition of the *IESNA Lighting Handbook*, the most recent revision of ASHRAE/IESNA 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings* (ANSI Approved), and IESNA LM-73, *Testing of Entertainment Luminaires Using Incandescent Filament Lamps or High Density Discharge Lamps*.

Please note that the theatrical lighting community uses a few unique terms that differ from those typically accepted in the general lighting industry. One

of these is (*stage*) *lighting instrument* for a lighting device otherwise known as a *luminaire*. Other unique terms are explained in the glossary. This Guide attempts to explain theatrical lighting and its practice using the terms of the trade as the theatrical lighting community understands them.

3.0 GENERAL OBJECTIVES

The objective of stage lighting is to support the live performance for both the performers and the audience. Lighting is used to help control visibility, contribute to scene composition, enhance movement of the performance action, and set a mood (atmosphere) for the presentation, no matter what the theatre type or production values.

The theatrical lighting designer needs complete flexibility as to choice of lighting instruments, mounting location, wattage, color, intensity, beam shape, beam direction, and light movement. The design team should provide a facility with suitable infrastructure to support the creative process at a level commensurate with the proposed program.

3.1 Considerations for Design Professionals

The architect involved with theatre design should be aware of all participants who will use the facility. The “clients” are not just the owner or producer, but the performers, designers, and technicians. It is to the architect's advantage to seek them out and solicit their design input.

Theatre facility design is a unique form of architecture that frequently requires specialized design assistance. The scope and complexity of each project will determine the need for additional design advice. Specialized consultants are readily available for stage machinery and rigging, lighting, acoustics, and other theatre disciplines. Their participation will help ensure that the building functions properly.

Often, the architect is the project leader. In these cases, the consultants should have direct access to the clients (architect and facility stakeholders) and to each other. All work should be coordinated and communicated through the architect.

On occasion, the owner may engage the theatre consultant directly. In this case, the theatre consultant is expected to interpret and articulate the owner's requirements for the architect and other design team members. No matter who is in charge, the design team must work closely together for the benefit of the project. There are numerous special requirements

and restrictions on theatre facilities, making necessary specific, timely communications to the various engineering practitioners involved.

The project design team may provide the following services, which should be clearly defined in a scope statement within the contract:

- Assistance for the architect to determine facility needs — often called programming
- Complete design documents that include specifications and drawings showing:
 - Quantity and locations of lighting positions
 - Fixed lighting mounting details
 - Requirements and details for mounting lighting equipment on theatrical rigging systems
 - Type, quality, quantity, and weights of lighting instruments
 - Budgets
 - One-line wiring diagrams
 - Selection and specification of the lighting control system(s)
 - Coordination of conflicting factors for the electrical distribution, heating ventilating and air-conditioning (HVAC) and fire protection systems in the performance area
 - Code compliance of equipment specified and facility design (a summary of IES recommended illuminances for theatre/auditorium locations and tasks is presented in **Annex A**). Design professionals should refer to all of the appropriate building and safety codes and recommended practices for complete information
 - Work with the Commissioning Agent in the creation of the Owners Project Requirements (OPR) and Basis of Design (BOD) documents

The mechanical and electrical consulting engineers perform all the normal functions of their fields. Architectural lighting of the building and theatre may be designed by the architect, theatre lighting consultant, consulting engineer, or an architectural lighting consultant.

3.2 Budgetary Considerations

Assistance from a design professional is recommended for project budget preparation. In budgeting theatrical projects, consider:

- Theatrical lighting instruments, including control, dimming, related electrical distribution equipment,

and installation are typically part of the base project scope.

- Lighting instrument mounting positions, including the related architectural and electrical infrastructure, can have significant design, cost, and construction impacts. The project should be managed accordingly.
- Procurement of theatrical lighting instruments may be outlined in the base bid, included as an alternate part of the bid, or omitted altogether (if the client intends making a purchase later or through alternate channels).

3.3 Architectural Considerations

Lighting equipment and related hardware may be completely visible to the audience, completely concealed, or in any combination depending upon the architect's or client's wishes. If equipment is mounted in visible locations, consideration should be given to instrument glare/spill light and glare from nearby reflective surfaces.

The architect must pay close attention to support structures, such as catwalks, ladders, and hanging pipes, because they may be visible design elements. If not concealed, instruments and support structures may be incompatible with the architectural appearance of the theatre and the style of some productions. When instruments are concealed, the openings through which they are focused must be designed to minimize any spill light that falls on surfaces visible to the audience.

Performance lighting equipment requires immediate and convenient access. Lamps are serviced during intermissions and lighting instruments are moved, changed, and refocused between shows. Quick access is typically a requirement since difficult access can cost the producers much money.

Architectural finishes within the theatre should minimize distracting reflections. Surfaces subject to spill light from the instruments should have a dark in color and matte finish. The architect must decide how the seated audience will be made aware of the surrounding architectural envelope. In general, the darker the architectural surface, the more it recedes from audience consciousness during performances.

It is important that the design team provide complete specifications/plans so that all the infrastructure and construction equipment can be procured and installed in a timely and cost-effective manner.

3.4 Acoustical Considerations

Stage lighting equipment requirements can conflict with acoustic needs. For example, openings for light

slots sometimes interrupt acoustic reflective surfaces or may destroy the integrity of acoustic isolating envelopes. While it is possible to glaze such openings, this is not desirable because glass reduces the light reaching the stage and can itself become a visible glowing surface. Compromises must be reached that achieve acoustic solutions without infringing on lighting position workability.

Under certain circumstances some lamps may emit a slight audible hum. Suppression and containment of this hum should be considered in the choice of lighting positions and their acoustical treatment. Dimmers operated with forced-air ventilation can also produce distracting fan noise. Such equipment should be acoustically isolated from the performance space.

3.5 Structural Considerations

Most stage lighting instruments are portable and may be moved between various “fixed” positions as required for each show. Since the number of instruments used and their locations can vary widely from production to production, it is seldom possible to base structural design on the weight and dimensions of specific equipment. Each lighting position must be designed to accommodate the maximum potential load. Fixed items, such as dimmer banks, have significant weight and must not be overlooked in any structural design. Personal protection equipment (e.g., hard hats, gloves, fall protection devices) may be required for personnel accessing the theatre lighting equipment.

3.6 Mechanical and Electrical Supply Considerations

Heat generated by lighting instruments should be taken into account when planning for air conditioning and ventilation. Typically, not all the lights provided for a facility or a production are used at once. Often theatrical lighting instruments are operated through dimmers below the full-rated voltage. The voltage drop in the dimmer equipment can easily be four to eight percent. The resultant energy dissipation generates heat at the dimmer bank. Heat from lighting equipment must be removed from the stage, auditorium, and dimmer locations. The theatrical consultant should determine the heat load for the dimming equipment and coordinate cooling needs with a mechanical engineer.

3.7 Circulation Areas

The theatre lobby appearance and its illumination are significant factors in contributing to the audience's anticipation of what is to come. The lighting design should enhance the architectural design of

the space, support area activities, and provide easy access for maintenance. The lobby may also present an opportunity for limited daylighting if effective light lock “vestibules” are utilized to preserve the auditorium's requirements for dark.

In the foyer, a restful and subdued atmosphere is usually desirable. This often serves as an adaptation area between the darker auditorium and the lobby. Wall and display lighting on statuary, paintings, posters, signs, and plants can create the desired atmosphere. Task light for checking coats and operating concessions should be provided. Conventional or enhanced lighting for restrooms will also be expected.

3.8 House Lighting

The house (or auditorium) lighting deserves special attention because it illuminates the auditorium and prepares the audience for the performance. Frequently, the theatrical lighting designer controls the house lights with the stage lighting control equipment. Therefore, some control and flexibility for the house lighting is desirable. It can be a challenge to provide controllable house lights that comply with the requirements of applicable energy codes. Dimmable fluorescent luminaires are often employed in this instance. Many times decorative luminaries are used to embellish the auditorium's architecture. Such decorative lighting should dim as well.

Where the auditorium also serves as a lecture room, the lighting must provide for critical viewing tasks such as note taking, reading, and writing. Care must be exercised to provide for this multi – function use when the lighting control system is first designed.

Emergency and egress lighting must be designed into the permanent lighting system for the auditorium, lobby, stage, circulation areas, and exterior access ways. Such lighting should be designed by licensed professionals and approved by building officials. Emergency transfer devices and standby electric power sources are often required so that this lighting operates regardless of local utility failures.

4.0 STAGE LIGHTING INSTRUMENTS

In the theater industry, luminaires are known as stage or studio lighting *instruments*. (This industry does not use the terms *luminaire* or *fixture* as the general lighting industry does.) Stage lighting instruments utilize tungsten-halogen lamps almost exclusively for full-range dimming (see **Figure 1**). A wide range of instrument types should be provided because each has unique characteristics and appl

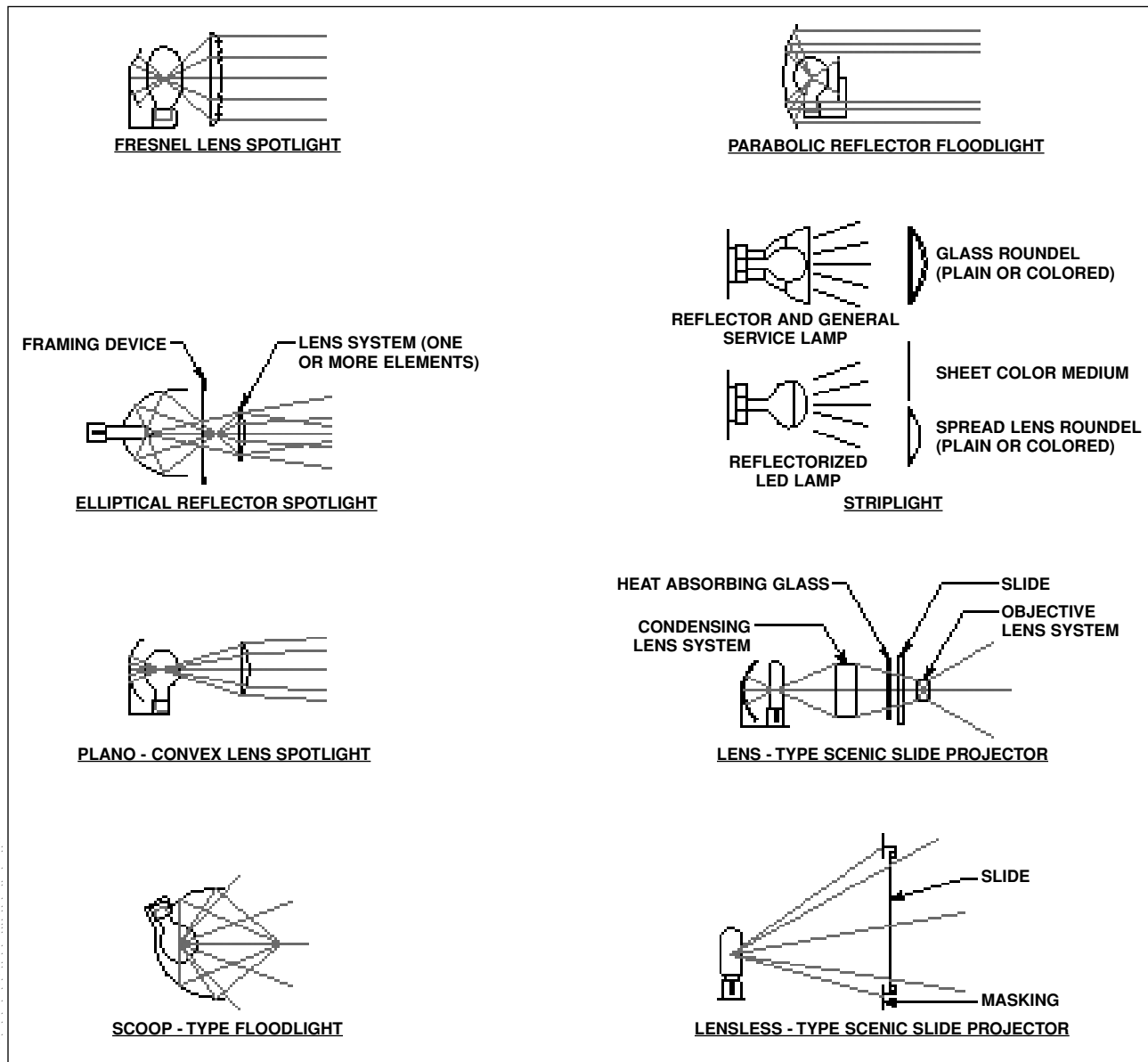


Figure 1. Stage lighting equipment optics. *Note:* These lighting instruments use tungsten-halogen lamps. Modern lamps are usually axially mounted. The more commonly used projectors are video projectors (not shown).

cations. Each type is described in some detail in the following sections.

The selection, location, and focus of the stage lighting instruments will be determined by the production lighting designer. These decisions are based on the desired effect that each instrument can bring to an individual show. The building project design team should assure that a basic inventory of stage lighting instruments is made available.

Most stage lighting instruments have controls for manipulating beam “sharpness.” The process is often referred to as adjusting the “hardness” or “softness” of the beam. Thus theatrical lighting designers are able to deliver and shape the light as individual situations require. Further information on this topic and

the standardizing method used for testing and reporting purposes is found in IESNA LM-73-04, *Testing of Entertainment Luminaires Using Incandescent Filament Lamps or High Intensity Discharge Lamps*.

4.1 Ellipsoidal Reflector Spotlights

The ellipsoidal reflector lighting instrument, or pattern instrument, consists of a lamp and ellipsoidal reflector mounted in a fixed relationship (see **Figure 2**). The light is focused through the optical gate of the instrument where the beam can be shaped with shutters, a gobo (a pattern template), and/or an iris. The shaped beam is then focused by a lens system.

The output of the ellipsoidal stage lighting instrument is light with a very hard edge having precise beam



Figure 2. A typical ellipsoidal instrument using a tungsten-halogen lamp. (Courtesy of Electronic Theatre Controls, Inc., Middleton, WI.)

control. The hard edge can be somewhat softened with the lens system. This instrument should be utilized in front-of-house positions (on the auditorium side of the proscenium) to provide the required light beam control and throw. If used this way, distracting light spills on the proscenium arch or auditorium surfaces are avoided.

The lens diameter and focal length determine throw and coverage of an ellipsoidal instrument. Instruments are available from 10.6-cm (3.5-in.), 250-watts to 30.5-cm (12-in.), 2000-watts, with a large majority of them being either 575 watts or 750 watts. Beam angles are available from 5 degrees (for very long throws) to 90 degrees (for very short throws). While fixed focal length versions are common, “zoom” instruments having a variable focal length are also available.

4.2 Fresnel Lensed Spotlights

The Fresnel spotlight is a lighting instrument that embodies a lamp, a Fresnel lens, and (generally) a spherical reflector behind the lamp. The field and beam angles can be varied by adjusting the distance between the lamp and the lens (this action is called *focusing*). The distance between the lamp and reflector is determined by the instrument designer and does not change during focusing.

The illumination produced by the Fresnel instrument tends to be intermediate or hard, while the beam is soft-edged. The illumination can vary considerably, depending on the instrument’s optics. Typical Fresnels have a beam angle of 10 degrees (in the

spot position) to 60 degrees (in the flood position). Wattages range from 500 watts to 1000 watts for popular 15.25-cm (6-in.) lensed instruments and to 2000 watts for some larger instruments.

Occasionally, spotlights with the optical and application properties of Fresnels are provided that use the root optical system of Fresnels. They are called *plano convex*, or PC spotlights.

4.3 Scoop Floodlights

The scoop floodlight consists of a lamp holder, lamp, and a reflector with a matte or brushed finish. The lamp and reflector may have a fixed or variable relationship. Scoops are equipped with front clips to hold a color frame containing either color media or diffusion material.

The scoop produces illumination having field angles from 90 degrees to less than 180 degrees. The illumination quality is considered soft, with shadow sharpness depending primarily on the texture and size of the reflector. Scoops are available with 30 to 45 cm (12 to 18 in.) diameters and are typically equipped with 500-watt to 2000-watt tungsten-halogen lamps. These lamps are usually frosted. In general, the larger the scoop diameter, the softer the light output.

4.4 PAR Heads

A PAR head instrument comprises a parabolic aluminized reflector (PAR) lamp, lamp holder, socket, cord, and housing. Instrument performance depends upon the type of PAR lamp selected. PAR lamps are available from 300 watts to 1000 watts, and with various beam spreads.

As the beam pattern of most PAR lamps tends to be oval, the instrument is designed so that the lamp may be rotated to cover the desired area. The PAR lamp beam can be shaped and glare-controlled with *barn doors* and the intensity increased by an *intensifier skirt* — an exterior reflector that continues the parabolic contour of the internal lamp reflector.

Certain more-modern spotlights emulate the performance of a PAR instrument, but use a conventional T4-T6 tungsten-halogen lamp. With these instruments a selection of fixed-spread lenses can be changed to vary the output beam spread. Compared with the typical PAR head, the output of these newer instruments is less oval shaped.

4.5 Striplights

A striplight is a compartmentalized multi-lamp stage lighting instrument. Each compartment contains