Chapter 4
Technical Packages

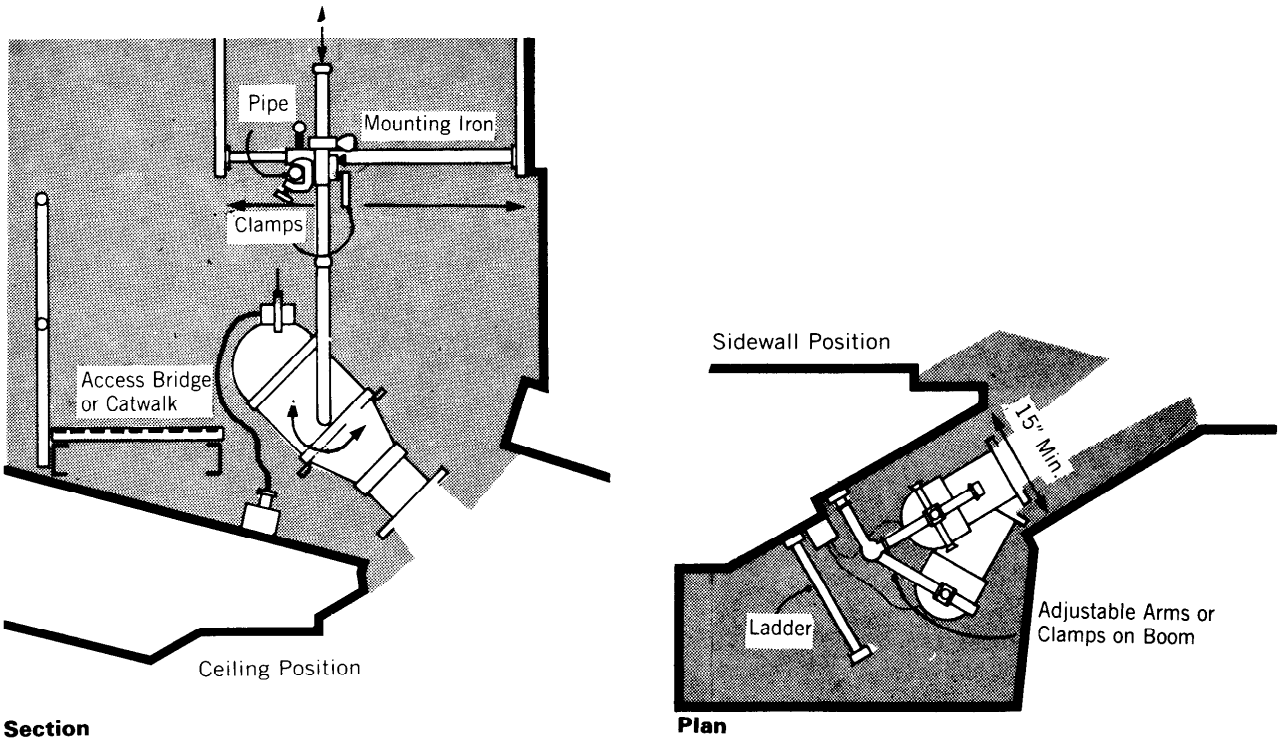


FIGURE 4-1.1 CEILING AND SIDEWALL SLOTS

Chapter 4 contains collected technical information and equipment requirements for the construction and operation of Army Music and Drama Centers. The topics addressed have been treated in less detail in preceding chapters, in order to preserve the pace of conceptual discussion. Chapter 4 is intended to give the design service and reviewing agencies an understanding of the scope of equipment and detailed study needed to produce a fully functional performance facility. It is not to be considered a substitute for technical expertise essential to project development. However, project participants will find it a useful reference in making statements of functional requirements and as a budget preparation checklist.

4-1. THEATER LIGHTING

The function of theater lighting and its relationship to Room design is discussed in Section 3-8C, in terms of its position in space, and in 3-9D regarding access to it. This Section contains a more succinct enumeration of system components.

Overstage positions: Pipes and bridges extend the width of the acting area in pairs 7-10 feet apart up and down-stage for the full depth of the stage, and are adjustable in elevation. Instruments are clamped in place, adjusted in place, and powered through pigtail interlocking plugs to cable carried in raceway or tied to the pipes. The cables run to an interconnect panel or patch-board on stage. Bridges permit maintenance and manual adjustment without lowering the entire line of instruments and without the use of ladders. Bridges are recommended for the most-used first pipe “teaser” position and for the cyclorama backdrop position, where large quantities of several kinds of instruments are common. Bridges extend to the fly gallery for access, and are invaluable where box sets interfere with lowered pipes.

Sidestage positions: Pipe booms are floor supported and ladder frames are hung from the gridiron. The fly gallery and wall-mounted ladders may also be utilized, as well as tormentor

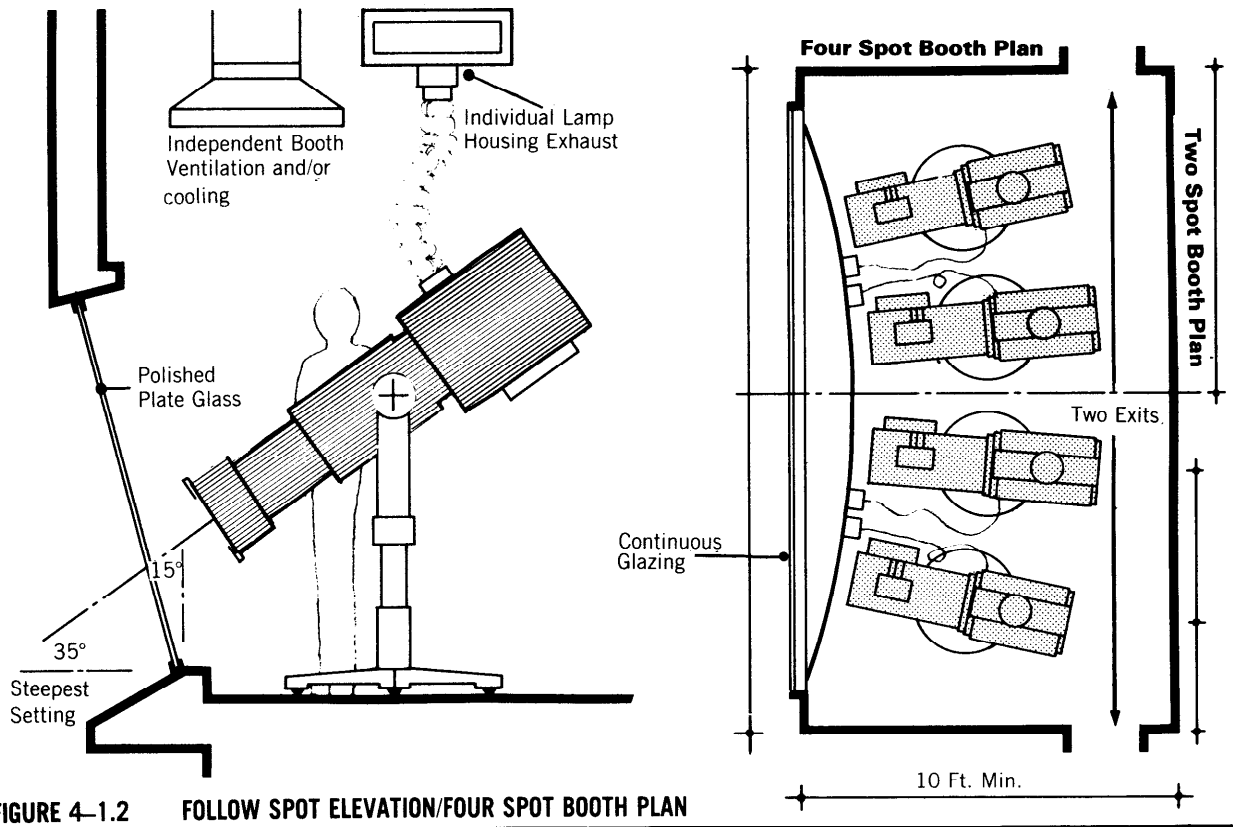


FIGURE 4–1.2 FOLLOW SPOT ELEVATION/FOUR SPOT BOOTH PLAN

locations just behind the proscenium arch. One sidestage position on each side of the stage is generally associated with each overhead pair of pipes.

Stage floor positions: Footlight troughs, cyclorama pit and deck boxes called "floor pockets" accept sub-surface instruments for wash-lighting scenery and drops; footlights are rarely used to light actors but are commonly used to light scenery. There may also be individual instruments on portable stands.

Proscenium positions: Slots alongside and above the proscenium on the house side contain specials, wash, strip and spotlights in proximity to a personnel ladder giving access to the overhead catwalk.

Sidewall positions: Vertical slots in the house walls or surface-mounted arms carry spotlights essential for down-stage and forestage lighting.

Ceiling positions: Catwalks at or above the house ceiling carry the bulk of front lighting. They extend wall to wall. Critical dimensions are incident angle to the actor's face, distance of throw and angle of adjustable aim. Frontlights must be adjustable in place from a technicians' catwalk, and each spotlight must have a clear shot at the whole stage.

Balcony positions: Supplemental spotlighting is sometimes mounted on fascias. The mount must have a pan to catch dropped filters and burst lamps. Electricians also stand in the pan to adjust the spotlights.

Followspots and projectors: At least two instruments per booth or platform is recommended. One center position may be augmented by one at each side. Booths may be shared with film projectors for scenic images. An incident angle of 30-35° to the leading edge of stage may in some cases permit movie projection on an elevated screen. However, a separate film projection booth under the balcony or at the back aisle is preferred.

Lighting control systems: With the possible exception of house and worklight autotransformer dimming from a position on stage, theater lighting makes use of indirect electronic dimming controls operated from a small console in

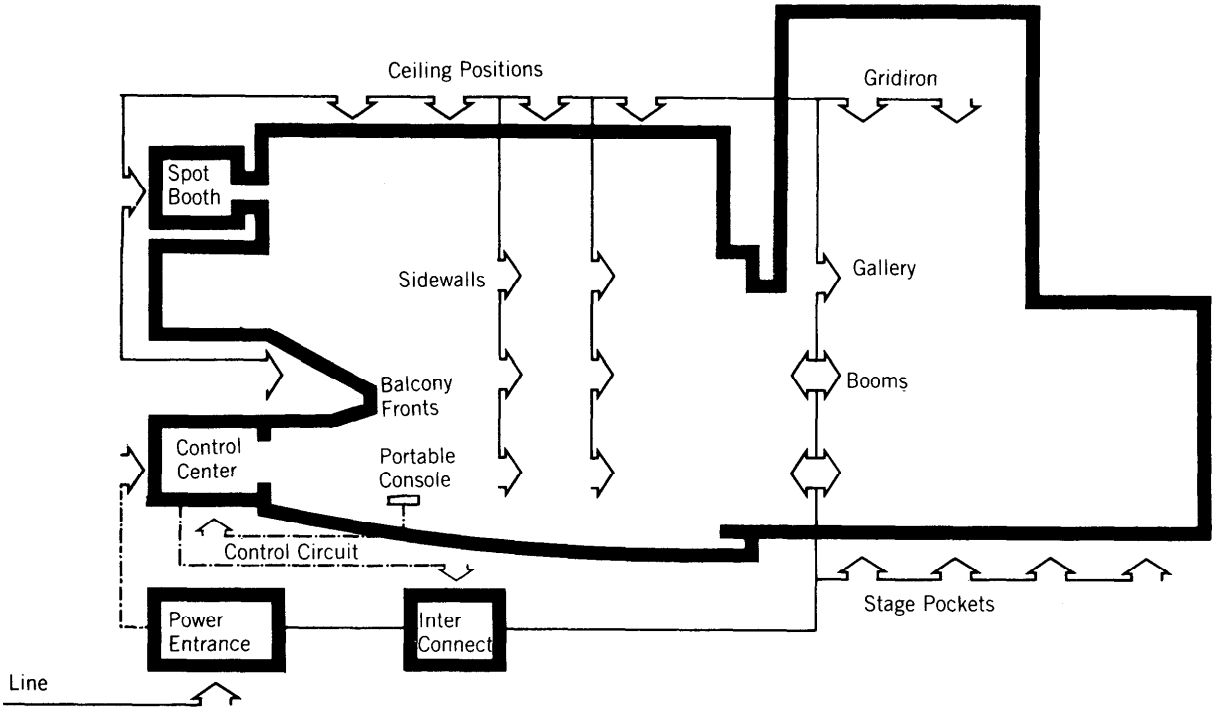


FIGURE 4-1.3 POWER CENTER DISTRIBUTION

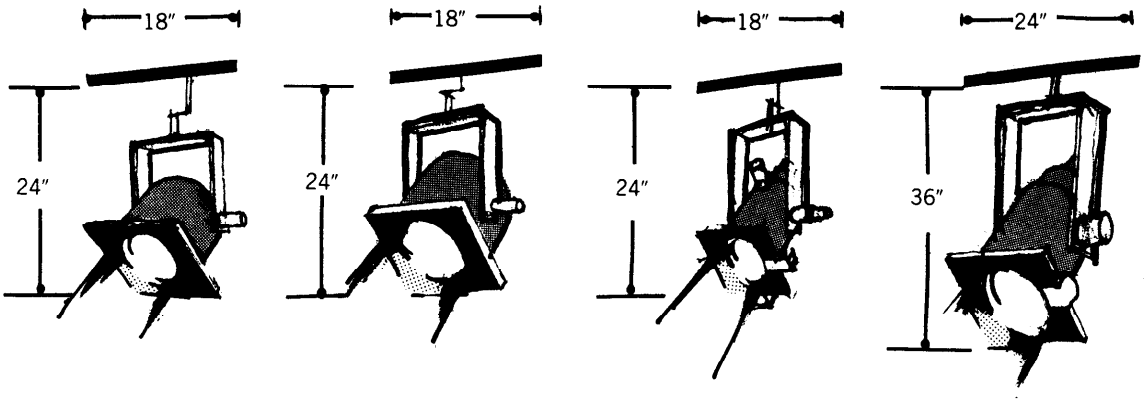
or behind the house. The remotely controlled dimmer bank is normally located in low-value space under or alongside the house and between the control center and patch panel. It is preferably nearer the patch panel to minimize high-load wiring, but the location of power service entry of 300-800 KVA to the dimmers may rule the choice. The bank needs no access during performance, but the patch panel is located on or near stage, again to minimize load-circuit wiring to the lighting positions. The patch panel requires continuous access from the stage. Low-voltage control circuits activate the dimmers which feed load circuits selected at the patch panel and into which circuits the lighting instruments are plugged.

A more recent and economical development is the dimmer-per-circuit system. The interconnect (patch panel) function takes place at the control center in low-voltage circuitry. Dimmers are installed in racks in or adjacent to the stagehouse, one dimmer per loaded circuit into which instruments are selectively plugged. Remember that dimmers make noise and should be isolated.

Control center equipment: Controls include manual and automatic preset potentiometers, or memory systems, or both. Power levels are set manually as the lighting plot is developed. These are recorded when satisfactory and a fade-duration established for cross fading from one scene to the next. The operator can manually set the levels and durations during performance, activating the sequence on cue, or the entire plot can be fed into a memory system that operates the cues and displays the status of the plot for on-the-spot adjustments. Except in very small systems the memory controls are less expensive, more capable, and therefore preferred.

In any case, house lights, work lights and lecture lights are separately controlled to avoid disturbing console setups. Touring groups often travel with their own lighting equipment, including controls, and are provided a power takeoff and company switch in the stagehouse. This is another reason for careful consideration of power service entrance location and selection of the most common compatible system interconnections to enable use of the facility's control center.

Power Consumption: By its very nature, stage-lighting power demand tends to be related to the acting area dimensions, as is the number of in-



Instrument	6" Fresnel	8" Fresnel	6" Ellipsoidal	8" Ellipsoidal
Wattage	750W	1,000W	750W	1,000W
Absolute Maximum Distance	25′	40′	40′	60′
Use	Spotlight	Spotlight	Framing Spotlight	Framing Spotlight

FIGURE 4–1.4 LIGHTING INSTRUMENTS

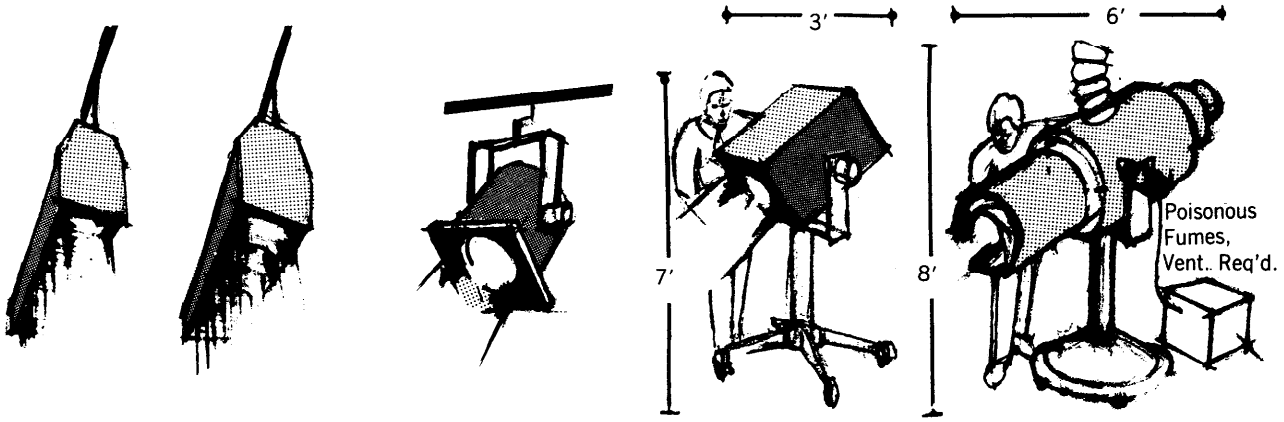
The sizes and quantities of stage lighting equipment are determined primarily by the net stage area and secondarily by the type of use. Refer to Sections 3–6 and 3–7 for typical stage configurations and potential use combinations.

The quantities given in table 4–1.1 are for multi-purpose rooms. Apply the following multipliers for other uses.

Use	**Multiplying Factor**
Broadcast Quality Color Television	1.3
Drama	1.0
Musical Comedy	1.0
Opera	1.0
Closed Circuit Television	.5 to .8
Entertainment (Rock & Roll)	.8
Symphonic Concert Music	.5

NET STAGE AREA IN S.F.[1]	**1000**	**1500**	**2000**	**2500**
Stage lighting electrical feed to dim. rack & co. sw. in KVA[2]	**216**	**288**	**432**	**432**
Total # of stage lighting circuits[3]	**180**	**270**	**360**	**450**
Near auditorium ceiling	12	18	18	18
Mid auditorium ceiling	20	30	30	36
Far auditorium ceiling	12	18	24	36
Auditorium side wall pos.	12	18	30	42
First electric pipe	24	30	36	42
Upstage light pipes	60	112	164	204
Side stage booms and ladders	32	32	40	48
Stage Floor	8	12	18	24
Number of dimmers[4] [5]	**60**	**80**	**100**	**120**
Number of stage lighting fixtures				
40° Ellipsoidal Refl. spotlight	8	12	16	20
30° Ellipsoidal Refl. spotlight	40	60	80	60
20° Ellipsoidal Refl. spotlight	20	30	50	80

TABLE 4–1.1 STAGE LIGHTING REQUIREMENTS



6″ Striplight	8″ striplight	Par 64	Small Followspot for Drama	Large Followspot for Entertainment
150W Lamps Every 6″ on 4 color circuits	300W Lamps Every 8″ on 4 color circuits	100W	1,000W	20 Amparc
30′	40′	VNSP 60′ NSP 50′ MFL 40′ WFL 30′	60′	200′
Wash for Hanging Scenery and Floors Normal Section 6′ long	Wash for Hanging Scenery and Floors Normal Section 8′ long	Work-lights, Special Washes, Accents, Backlight	Notes: Lamps have stagepin connectors on 36″ pigtails, clamps for 1½″ I.D. pipe, and color frames. Followspots have a 6-color color changer. All lighting from the auditorium is done with Ellipsoidals and Followspots.	

12° Ellipsoidal Refl. spotlight	16	30	60	80
10° Ellipsoidal Refl. spotlight	0	0	18	36
6″ Fresnel Lens spotlight	8	12	16	20
8″ Fresnel Lens spotlight	20	30	40	50
Par 64 units	16	24	32	40
6″ striplights	30	30	40	40
8″ striplights	20	20	20	20
Followspots[6,7]	2	2	2	4
Approximate # of pipe battens used as light pipes	6	9	12	15
Accessories[8]				
Pipe booms or ladders	10	10	10	10
Side arms with tees	60	90	120	150
Hi Hats	40	60	80	100
Stage Cables 5′	20	30	40	50
10′	20	30	40	50
25′	20	30	40	50
50′	20	30	40	50
100′	10	15	20	25
"Twofers"	20	30	40	50

Notes

1 Width of proscenium opening and full depth from lip of stage to back wall.

2 Company switch and dimmer rack feeder are each this size, but total instantaneous connected load will not be greater than this.

3 90% of circuits are 20 amp, run with 2 # 10 AWG, no common neutrals.
10% of circuits are 50 amp, run with 2 # 6 AWG, no common neutrals.

4 If dimmer-per-circuit is used, number of dimmers is approximately the same as number of circuits, eliminating the patch panel.

5 40% of dimmers are 3–4 KW, 40% are 6–7.2 KW, and 20% are 10–12 KW. except for dimmer-per-circuit where 90% are 2.4 KW., and 10% are 6 KW.

6 Follow spots for use in drama must be incandescent. White followspots for use in all other situations must be arc lamps, of which there are several types.

7 Adjacent to the followspots actually purchased, allow space and power for temporary addition of two more.

8 These are in addition to accessories which come with each fixture such as color frames, clamps, and connectors.

struments needed. It is unwise to underestimate potential connected load in sizing the service. Common practice is to apply a factor of 80% to the total dimmer capacity, but this should be carefully considered. (N.B., 50% to 80% for dimmer-per-circuit systems). Planners must ask themselves, does installed capacity take into account likely future growth (it always grows) and the arrival of a road show with super power amplifiers and motorized devices as well as lighting equipment?

The sizes and quantities of stage lighting equipment are determined primarily by the net stage area and secondarily by the type of use. Refer to Sections 3-6 and 3-7 for typical stage configurations and potential use combinations.

4-2. SCENERY AND SOFTGOODS

The topic of stage dressing and sets is discussed briefly in Sections 3-6 through 3-8 and elsewhere in terms of its influence on stage shape, vision criteria, movement, sound absorption and production activities—in short, it relates to many functional requirements of theater design primarily because it is an indeterminate element of the artist's stagecraft. This Guide seeks only to ensure free 'reign to his creativity. From this viewpoint, the major concern is to define adequate space, built-in mechanisms, lighting, safety provisions and organization to facilitate set construction. and use. Draperies and softgoods, however, must be either furnished or built custom fit, and merit discussion here.

House Curtains: The major proscenium drape was traditionally an ornate biparting curtain. It is often of heavy opaque material to muffle preparations on stage as the audience is being seated. It signals the beginning and end of major sections, the points at which house lights are lowered or raised and the audience is returned to "the real world". Modern practice installs the house curtain on the first pipe or set of rigging, enabling it to be drawn both vertically aloft and horizontally on a traveller. Before performance, it is usually lighted with "curtain warmers".

Teaser or Header: The second pipe holds the foremost border behind the house curtain. It forms the apparent frame during performance. The proscenium may be higher, and curved or splayed for acoustic purposes, while the teaser sets the initial scale of audience/performer contact. It may be moved up or down, and hides the lighting bridge or pipe immediately behind it.

Tormentors or Legs: The third pipe holds the principal legs or side masks that can be moved on or offstage to set the width of the opening. In fact, both tormentors and teaser can be soft fabric draperies, wood or steel frames covered with fabric or solid panel construction. The stretched fabric may be chosen for its appearance, ability to assume a particular shape, or its ability to screen temporary or permanent loudspeakers. It is usually required for trimming to a shaped music shell; some. shells work better with solid panel masks. Heavy tormentors can be mounted on tracks supported on the stage floor, and may carry lighting towers with them. The fabric is usually black velour.

Performance Curtain: The fourth and sometimes fifth pipes usually hold lighting instruments. However, the fourth pipe may hold a second, lightweight curtain that rises on the scene after lighting levels and audience vision have adjusted, the entr'acte or overture concludes, etc. It provides the intermediate veiling and unveiling of the stage set during performance without grossly interrupting continuity. The fourth pipe may also hold a scenic image for a transformation effect.

Legs and Borders: The remaining pipes are assigned as needed to lighting, scenery or more masking. Legs and borders form a series of parallel frames that screen lighting instruments, flies and wagon sets awaiting use, and actors or cast members offstage. The position of legs can be varied to alter the acting area shape and size, and borders can be raised or lowered to adjust the impression of great height or "interior" scale. With lighting alone, successive frames can create a wide range of depth illusion. Three to five such frames are provided depending on stage size, and are typically black velour fabric. This technique has particular application to Dance, Opera and some Drama where constructed "box sets" are not used.

Other Draperies: Typical accessory draperies include a full size black velour backdrop, a full size mid-stage black velour drop, a black sharks tooth scrim, miscellaneous special purpose black velour pieces, and a projection screen. Sometimes variety acts are performed in front of the Act Curtain, usually the liveliest backdrop visually, which serves to screen scene changes being

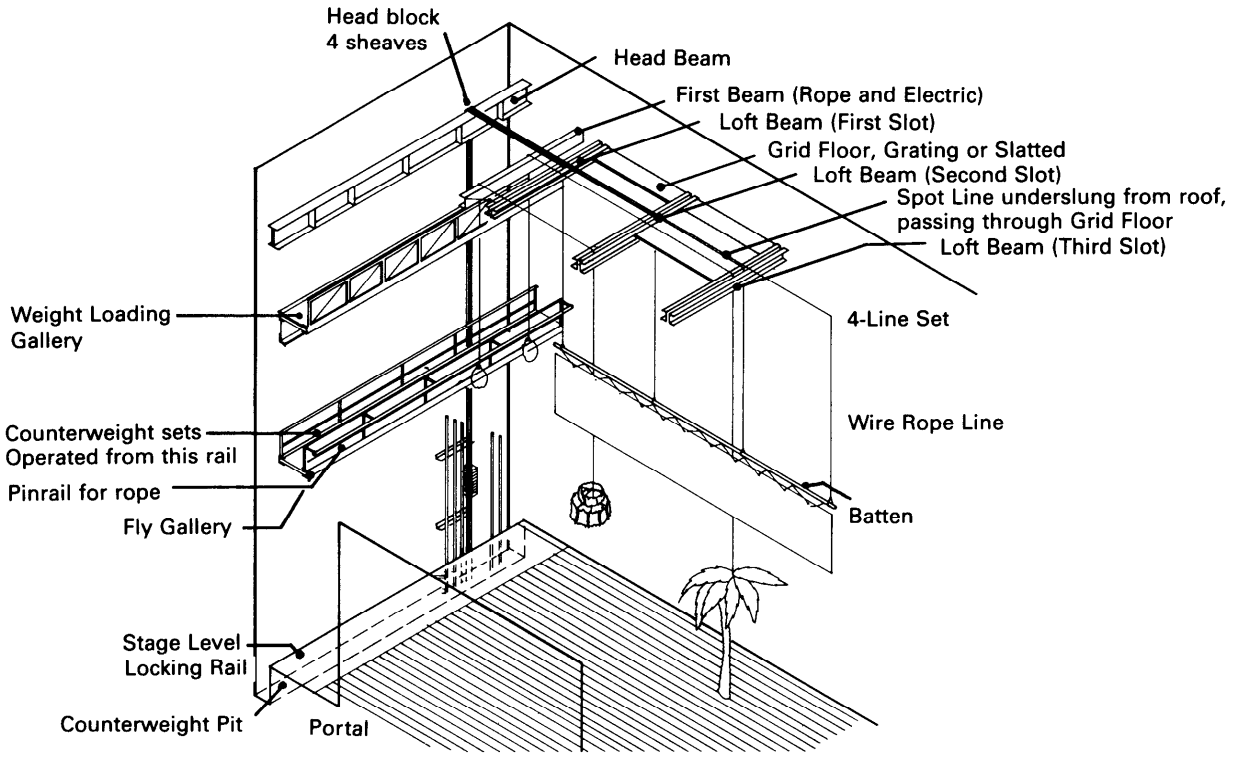


FIGURE 4-3.1 GRIDIRON RIGGING

made behind it while the variety act is in progress. It is functionally much like the optional Performance Curtain, but hangs eight to twelve feet behind the House Curtain. Frequent use of a movie projection screen suggests a position in front of the teaser and Performance Curtain.

Accessories: Typical accessories in the soft goods include storage bags and demountable traveller tracks.

4-3. RIGGING AND STAGE MECHANISMS

A. COMMENTARY

The Room design implications of scene handling devices and their basic purpose is noted in sections 3-6, 3-8 and 3-9. Selection of systems is based on anticipated performance uses.

1. Fly-Loft Components

Scenery, drapes and lights are moved vertically by a system of lines, pulleys, counterweights and/or winches supporting a pipe, all of which constitute a ***set.*** *Sets are supported on a structural grating, the* ***gridiron,*** *above the stage and fixed in place at a* ***pinrail*** *or* ***locking rail*** *anchored to the stagehouse wall, floor, or fly gallery.* ***Gridiron*** *is positioned to allow man-high working space below the roof structure.* ***Loft beams*** *comprised of 10 inch steel channels extend the full depth of the stagehouse in pairs, providing a cable slot every 10 or 12 feet. The* ***grid floor*** *normally consists of 1½" x 3" channel steel laid web-up 6" on center, or 1½" subway grating. Individual lines can thus be dropped through almost anywhere on stage. At one end of the stagehouse, major* ***head block beams*** *resist the lateral and vertical loads imposed by the sets.*

Line sets *consist of two or more rope or wire cable lines attached to each flown unit as it rests on the stage floor. The lines run up over moveable* ***loft blocks*** *mounted on the loft beams; blocks shift up and downstage for adjustment. Individual (single) rope lines may also pass through the grid floor. The lines of each set are*

	Recommended Minimum Number of Sets	Recommended Maximum Working Load
Elaborate Musical Comedy	**30 or more sets**	**700 lbs./set**
Ordinary Musical and Revue	**10 to 20 sets**	**700 lbs./set**
Opera	**5 to 15 sets**	**1000 lbs./set**
Presentation	**5 to 10 sets**	**1000 lbs./set**
Elaborate Drama	**15 sets**	**700 lbs./set**
Ordinary Drama	**5 to 10 sets**	**700 lbs./set**

TABLE 4-3.1 TYPICAL LINE SETS NEEDED

*collected at a **head block** with multiple sheaves and then pass downward. Each set is trimmed to equalize tension according to the load, and hoisted as a unit. Battens are loaded with a gross weight of 30 pounds per linear foot and usually extend 3 to 5 feet past the proscenium opening. Rope lines are tied off on a **pinrail,** which is the onstage edge of the **fly gallery** from which the flies are operated. Each line may be sandbagged to adjust tension. The fly gallery keeps this activity away from the stage floor, where space is highly-valued. The gallery's elevation is usually set by the tallest piece of standing scenery and the ability to see into the flies-that is, 20 to 30 feet above the floor, and at least as high as the proscenium opening.*

*Wire line sets are **counterweight sets.** After passing over the head block, the lines are fastened by chains and turnbuckles to a counterweight carriage. The turnbuckles enable the set to be trimmed. The carriage runs up and down, usually at the wall, travelling a distance equal to that travelled by the flown pipe. The weights are pig-iron, added incrementally until the set is counterbalanced to a degree that permits manual operation by pulling on a manila **purchase line** attached to the top of the carriage, running over the headblock, down through a rope lock to a tension block at the floor and up again to the carriage. The lines are operated from the fly gallery or from stage floor, but the weights are stored and added at a **loading gallery** at the top of the carriage run, level with the carriage bottom to minimize lifting. Dimensional difficulties in the design of counterweight systems usually require provision of a **counterweight pit** in the stage floor to increase carriage travel. If it is absolutely essential that the floor be kept clear (e.g., for the movement of scene wagons) a combination of pulleys can reduce carriage travel to half the fly, by placing the tension block at fly gallery elevation-a complicated, expensive, and inconvenient arrangement.*

*There are three kinds of carriage guide systems. The least costly is the **wire guide,** two tensioned cables engaged by the carriage. Since there are no wall anchors, the sets can be moved up and downstage. Carriage sway requires they be spaced approximately a foot apart to avoid fouling. The maximum height of wire guide systems is 30 feet.*

***T-Track guides** are steel or aluminum rails standing out from the wall, each engaged by two carriages. The resultant close grouping of sets provides the maximum number of available sets per linear depth of stage, but where only a few sets are installed in a group, their effective gridiron coverage is limited by the divergent angle of lines passing over the head blocks. **Lattice tracks** for single carriages consist of two guide rails separated by ladder-like rungs. They are useful for isolated sets such as house curtains or fire curtains.*

***Winch systems** are based on a somewhat different organizational logic. The gridiron line set concept assumes that most flown material is arranged in parallel planes behind the proscenium. However, there are situations in which randomly located lines are of great value; for instance, for diagonal drops and flown orchestra shells and reflectors. The winch lines can be used in combination with conventional sets by locating the loft blocks above the gridiron, underslung from the roof structure. Each line is taken up on a rotating drum driven by a speed-controlled synchronous motor. Controls can be located anywhere and there are no weight guides, lines, sandbags or pinrails to deal with. However,*

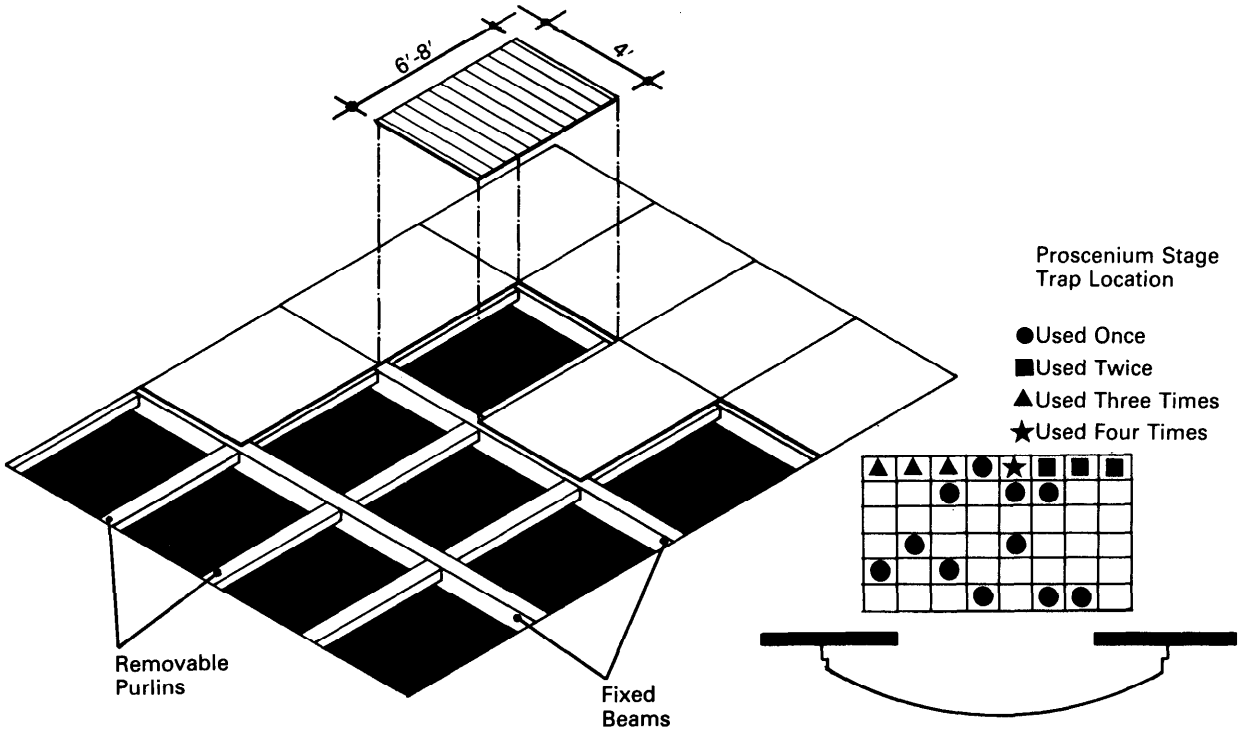


FIGURE 4–3.2 TRAPS

winches are expensive and slow-acting. A similar single-line arrangement with overhead blocks can be used to hang lightweight objects above an open stage, the lines tied back to catwalk rails. Counterweight sets can also be winch driven, which is considered safer because the winch takes up only part of the load.

2. Stage-Level Components

Standing scenery is moved horizontally on casters and dollies, or on tracked chassis called ***wagons,*** *or on* ***turntables.***

The decision to employ roll-on scene pieces must be part of early planning, since it has great impact on the organization of other stagehouse mechanisms. Wagon guide tracks, if used, must be recessed in the floor. This will affect structure, trap locations, details of wingspace layout, and the form of cyclorama and other accessories such as lightbooms that might otherwise be floor-supported. Steel plate tracks are needed to prevent damage to the softwood floor. Rolling sets have beneficial application to the open stage without flyloft, and to musical drama employing elaborate constructed scenery as well as flown pieces. Wagons are also commonly built by the user as part of portable scenery. Wing space is used to hold these wagons when they are not on stage. Each scene change involves clearing the stage floor and moving the next set in. Each wagon must also have a storage area out of the scene space.

Wing storage *can be used in several ways. Wagons slightly wider than the acting area can be moved laterally in one motion from either wing; the total stagehouse dimension will be at least four times the proscenium width. Wagons half as wide can be brought together at center for one scene. A second pair upstage forms the next scene, if the stagehouse depth is sufficient. Wagons can jackknife at a downstage pivot point, reducing the wing dimension required, but sweeping a large area.*

Wing storage takes up a great deal of space, congesting side entries. If more than two scenes are required, free storage must be associated with each wagon, so that one may be changed while the other is in use. In that case, any wing storage scheme involves an exceptionally broad stagehouse.

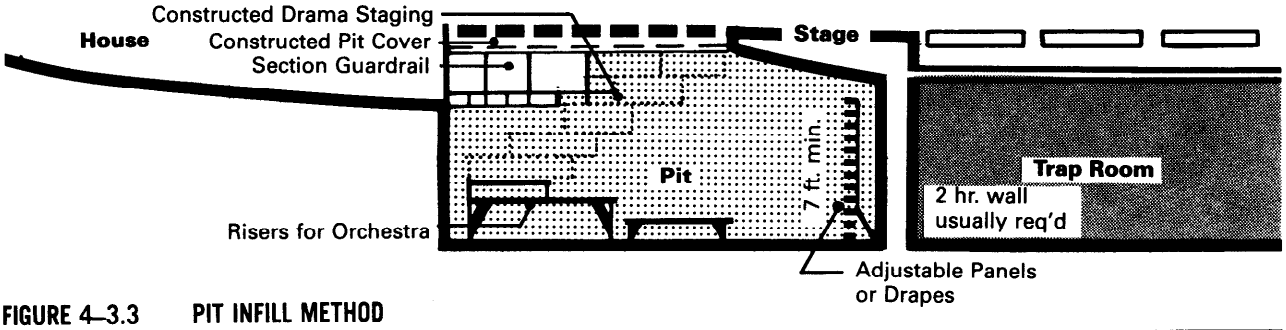


FIGURE 4–3.3 PIT INFILL METHOD

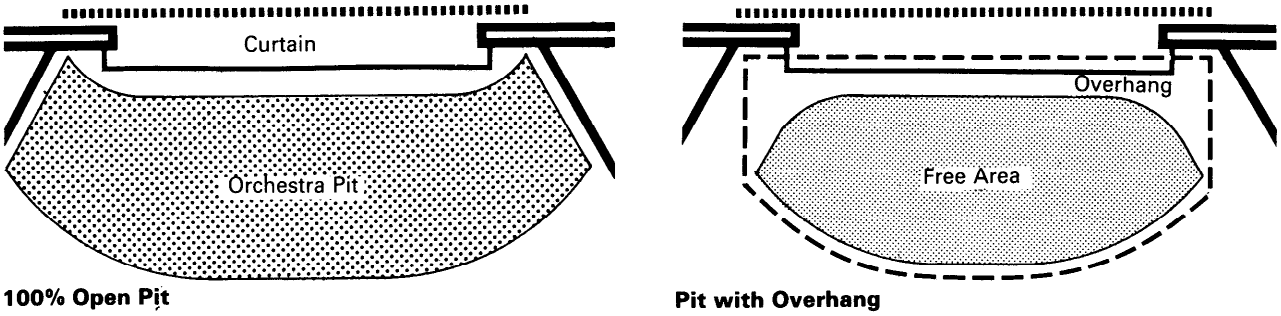


FIGURE 4–3.4 ORCHESTRA PIT PLAN

Upstage storage *can be used to serve additional wagons or to minimize wingspace use. It has the advantage of avoiding pinrail and line sets for the flyloft, and need be only as high as the tallest piece of scenery. A deep stagehouse has other benefits in terms of multi-use and rear projection capability.*

Offstage storage *may be regarded as the logical conclusion. If wagons can be moved out of the stagehouse, scene changes can be effected without noise in the performance Room and under superior conditions of work-lighting and mechanical aids. At other times, the wagon room can be used for set construction and rehearsals.*

Turntables, *while mechanically complex and somewhat more costly, avoid the problem of wingspace interference. Three or four scenes can be constructed on a large revolve and moved into place in no time. Even more scenes can be managed by resetting the segments facing the wingspace. The disadvantages of turntables include the geometric constraints imposed on the scene designer and the restriction of backgrounds to drops that cannot hang to the floor. If the table is demountable, the stage floor must be built up around it, altering sightline conditions. All permanent mechanisms such as wagons and turntables are useful only to the resident user. Touring companies do not expect to find these devices and plan their shows without them.*

3. Understage Components

Scenery and actors are moved vertically from below stage through a system of removable ***traps,*** *on lifts, hoists or stairs and ladders. Included in this concept are* ***orchestra pit elevators*** *and* ***forestage lifts.***

Traps *are removable sections of the stage floor by which actors can enter or descend from the acting area, scenery pushed or hoisted up, or special lighting effects obtained. In comparison to other stage mechanisms, traps are among the best dollar-value assets for the drama stage. Traps are most often used in open stage, projected and surround Rooms as an alternative to the run-on entry from the house, and sometimes are the only way to dispose of scene properties that can't be hoisted into a lot?.*

Stage elevators *used by major opera companies enable whole scene wagons to be brought from below, a luxury too exotic for consideration at the scale of Army MDC's. Large stages for music*

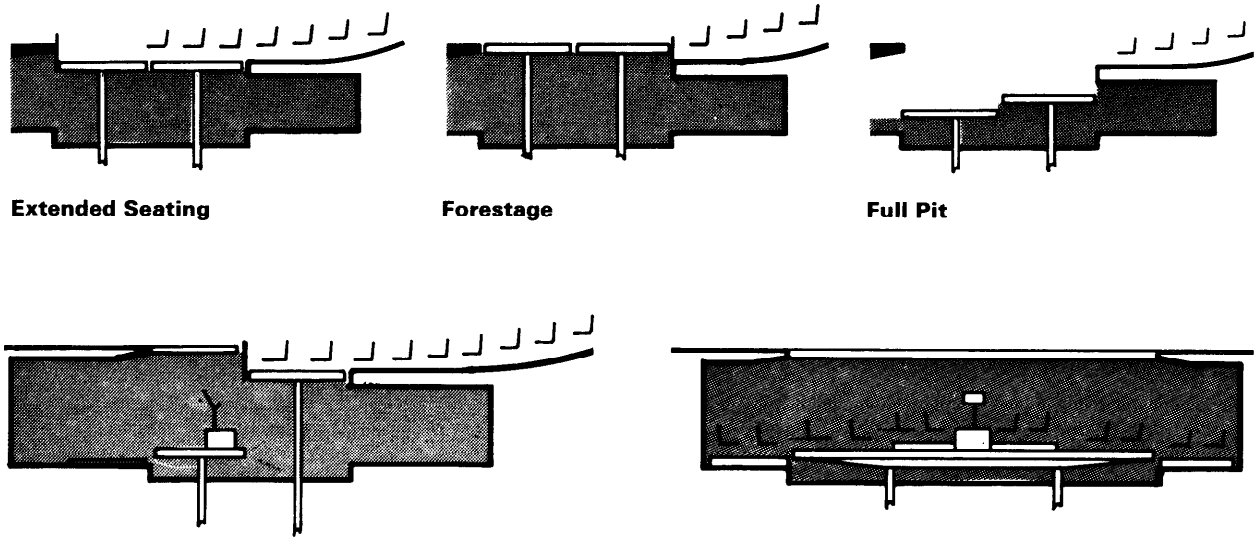


FIGURE 4-3.5 ORCHESTRA PIT SET-UPS

performance in particular may merit installation of low-speed geared or screwjack carriages designed to raise a portion of the stage rather than building up on it. An apron platform and/or hydraulic pit lift is also desirable but of questionable priority in relation to regular use. The pit lift is probably more important than the stage lift. Only exceptional programming and high labor costs can justify the expense. The feasibility of limited travel platform lifts used in combination with a pit cover and infill units should be examined if a mixed program of full orchestra, orchestra and chorus, musical drama and/or dance is contemplated. Unfortunately, there is a tendency to leave things in place if they can't be altered easily. ***Correct sightlines must be planned for the full extension of the stage.*** *The stage apron is in need of the same services as the rear portion of the stage, and should be provided with the same density of rigging, sets, electric pipes, and circuits.*

4. Orchestra Pit

This is indeed a valuable facility where any combination of music and speech is contemplated. In addition to the sightline considerations affecting the conductor's position, the key elements of pit design are adequate floor area, free area, overhang and depth.

The best way to establish floor area and proportions is to mock up full size the pit layout for the largest anticipated group, and be generous. The free area should be no less than 10 feet in the short dimension, and preferably 12 to 15 feet depending on orchestra size and the depth and proportions required to arrange them around the conductor (not in two sections). The overhang of the stage is very important, one of the means by which the acoustic impact of the orchestra can be adjusted. An ample overhang (5 to 8 feet) will permit flexibility of arrangement, modulation of direct intensity by moving in or out from under, and sufficient space for adjustable reflectors, absorbers, and unused instruments. A minimum depth (height) of 7 feet clear of stage structure is recommended. The user will usually cover the pit floor with portable platforms to tailor the heights of each instrument as needed.

B. SUGGESTED RIGGING SET INVENTORY

The basic needs of the fly loft are listed in Table

4-3.1. The quantities given are for multi-use and drama Rooms. Large theaters follow these same rules. Very small theaters could use 4 borders, 8 legs, and 8 tabs. Where only occasional use will be made of the rigging, the spacing of sets can be increased to 8 inches or 12 inches, which are also standard spacings. In no case should the number of sets in a fly loft drop below 30.

Rooms intended for symphonic concert music alone may not need any soft goods for normal uses if the stage is totally masked with a permanent concert shell. Standard practice is to hang portable lights and masking inside the permanent shell for popular entertainment and amplified music. Winch sets and counterweight sets are frequently provided which drop through the orchestra shell to pick up these portable pieces.

1. Permanent Architecture

1. *Gridiron and access*
2. *Loft block beams*
3. *Head block beams*
4. *Loading gallery under head block beam*
5. *Fly galleries; each side with pin rails*
6. *Counterweight pit with locking rail*

2. Permanent Rigging

1. *Fire curtain or deluge curtain*
2. *T-Track counterweight sets, 6 inches on center for the full depth of the stage*
3. *Hemp lines for spot lines and electric pickups*
4. *Hemp sets for masking and special uses*

3. Soft Goods

1. *House curtain*
2. *Portal header or "teaser"*
3. *Portal legs or "tormentors"*
4. *5 borders, 10 legs, and 10 tabs black velour*
5. *Full stage blackout drop, black velour*
6. *Full stage black scrim, black sharkstooth scrim*
7. *Full stage natural muslin cyclorama*
8. *Full stage black velour cyclorama*

A portable demountable concert shell consists of a ceiling and walls all around the sides and back of the stage. The ceiling is usually hung from standard counterweight sets. The walls are usually supported on rolling castered units and are stored in the wings when not in use. Note that the permanent storage space for a shell could be 500 square feet. The ceiling panels must align with the electric pipes so that the concert can be lighted through the gaps between panels.

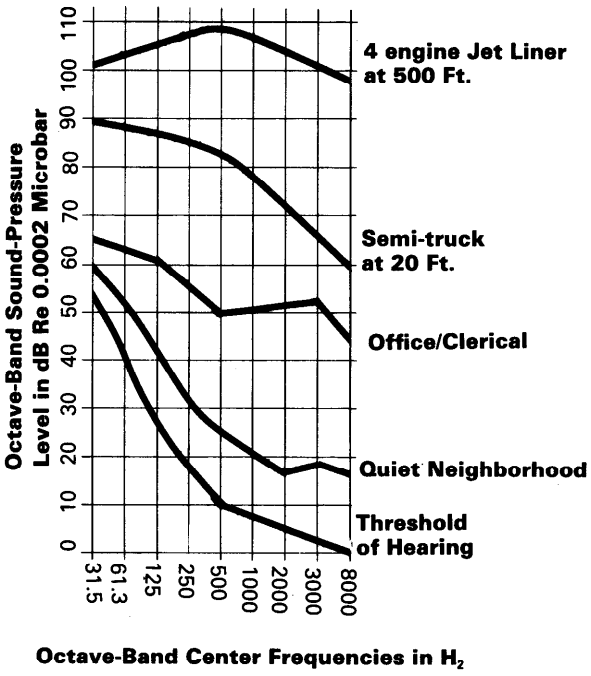


FIGURE 4-4.1 SAMPLE NOISE SOURCE INTENSITY LEVELS

4-4. ACOUSTICAL CONSIDERATIONS

A synopsis of the most important acoustical concepts is presented here. Listening requirements determine acoustic parameters for volume, absorption, background noise, partition isolation, reflection patterns and audience-to-performer relationships. These in turn influence design decisions related to building site, Room scale, materials of construction, Room decor, shapes of surfaces, suspended reflector locations, HVAC air velocities and system treatment, location of ancillary spaces and loudspeaker placement.

Speech intelligibility is essential for a Drama Room. This can be achieved by keeping the volume of the Room low in relation to seating area and placing reflecting surfaces in locations that will direct early high frequency reflections to all listeners.

Background noise must be kept low enough to allow listeners to comfortably perceive average speech sound pressure levels. Continuous background noise from mechanical or electrical

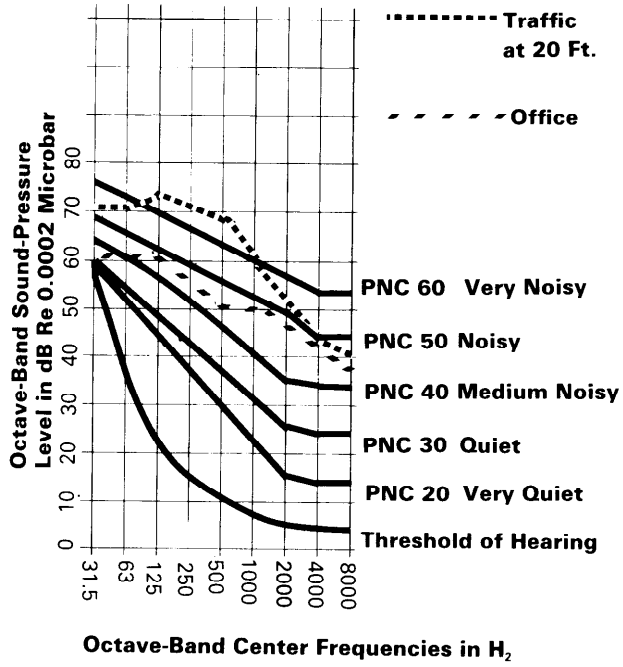


FIGURE 4-4.2 PREFERRED NOISE CRITERIA

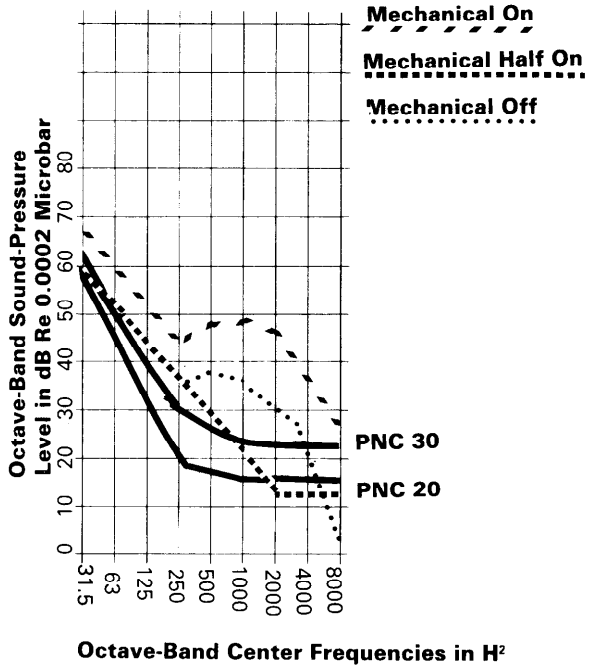


FIGURE 4-4.3 TYPICAL MECHANICAL NOISE CONDITIONS TO BE MITIGATED

equipment can mask speech sounds, making it difficult or impossible to understand performers. Intermittent noise is a distracting element that reduces listening enjoyment.

Acousticians have developed standards for preferred background noise level in relation to activities contemplated in a Room. These standards are referred to as Noise Criteria or NC curves. The NC curve specifies permissible ambient sound pressure levels at each frequency.

Time delays are appreciable. Sound waves moving through air travel much slower (about 1100 fps) than light. This factor must be considered when designing very large Rooms and amphitheaters. Aural and visual perceptions will be non-synchronized when the distance between source and listener is too great. Moreover, live and artificial sound will be non-synchronized and garbled when distributed loudspeakers do not incorporate adjustments for time delay.

Aural feedback is needed by performers to assess their effectiveness. An acoustically "dead" house will cause the actor to force his voice in an unnatural and perhaps harmful manner. Too live a house will produce excessively late reflections which may confuse the actor, causing him to slow his speech in order to gain intelligibility.

Music-theater requires the singing actors to have good aural contact with their accompaniment. This is usually solved by means of good orchestra pit design. When drama or musical-theater is amplified, it is essential that the sound console operator be located somewhere within the audience seating area. Mixing live performance is a delicate and difficult assignment. It cannot be done effectively from a sound booth with or without an operable window.

Music listening enjoyment is largely derived from the relationship between source sound coming from the musicians' instruments and the reflection patterns heard by the listener over a two to three second period. The perception of both the source and reflected sound fields are related to:

1. *Direction from which sound energy reaches listener.*
2. *Amplitude or intensity of sound energy*
3. *Frequency composition of original signal and each reflection.*
4. *Time intervals between arrival of reflected energy signals and direct sound.*

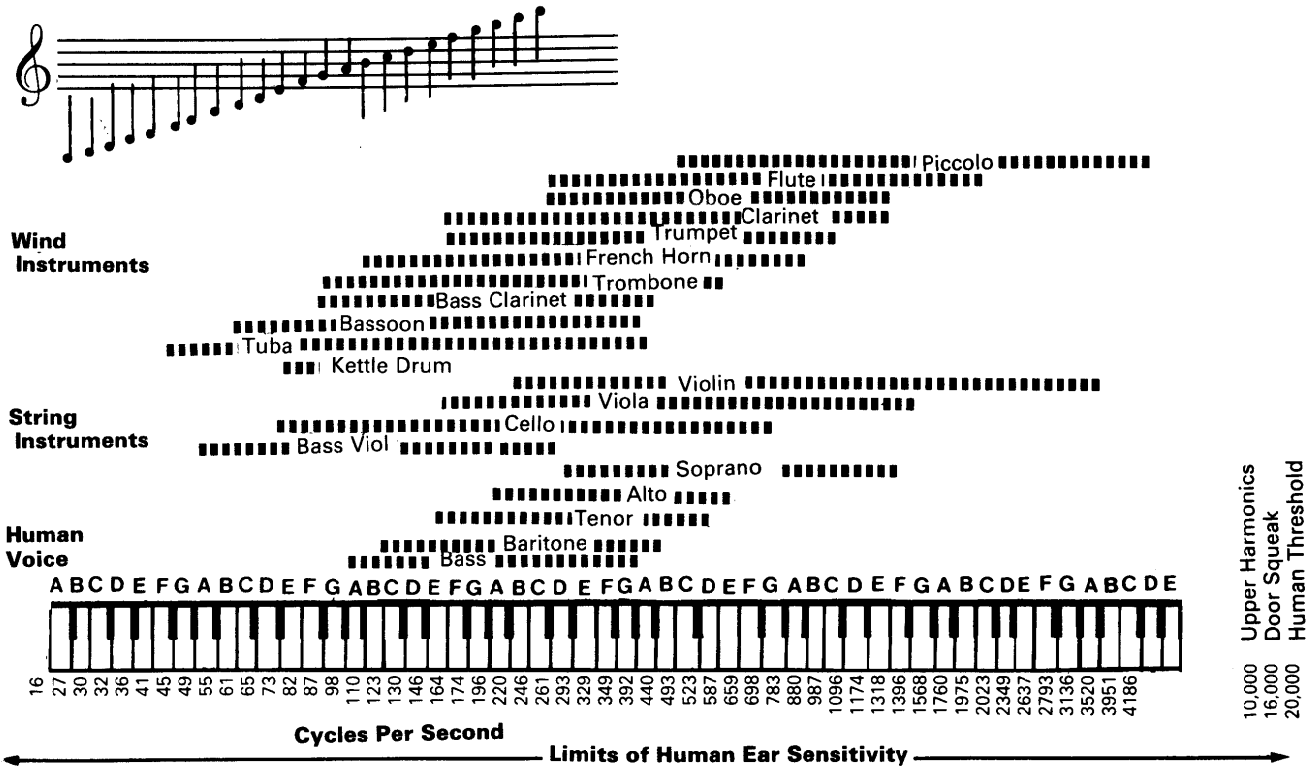


FIGURE 4-4.4 SOUND FREQUENCY CHARACTERISTICS

Reverberation time has been identified as an important general measure of appropriateness for various uses. It is by no means the only measure, nor a simple one. The standard measure is the time required for sound in the Room to decay by 60 decibels after its source is cut off. It differs with frequency and must be evaluated over a range of octaves (frequency bandwidths) discernible by human ears. The typical reference is 500 cycles per second, or C above middle C. However, the center of average hearing range lies between 500 and 1000 cps. A simplified equation for Rt60 is:

$$T = \frac{0.049V}{Sa + 4mV}$$

T = time in seconds; **V** = volume of air in the Room in cubic feet. This includes House and Stage enclosure for Music Rooms. The stagehouse volume behind a Drama curtain is discounted.

Sa = total Room absorption in sabines; it is a function of individual absorption coefficients peculiar to materials and furnishings, and their surface areas. Obviously, practical estimates are employed for analysis purposes.

M = air absorption coefficient, which varies according to relative humidity, stated in inverse feet. The difference between 70% and 30% RH is nearly a factor of two (at 2000 cps, M = 0.0006 and 0.0010 respectively).

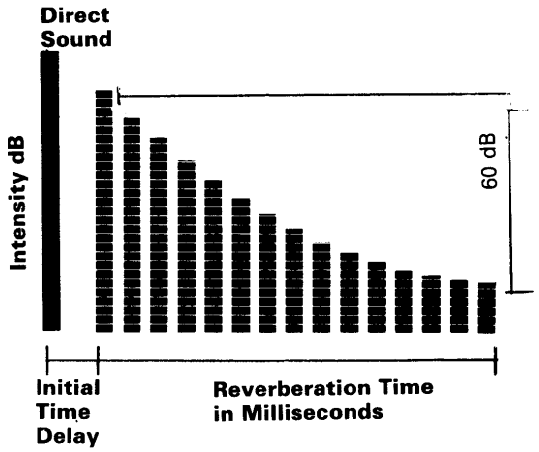


FIGURE 4-4.5 REVERBERATION TIME

Rapid estimates of appropriate Room volume required are made by assuming an "average" Room absorption typical to particular uses, as-

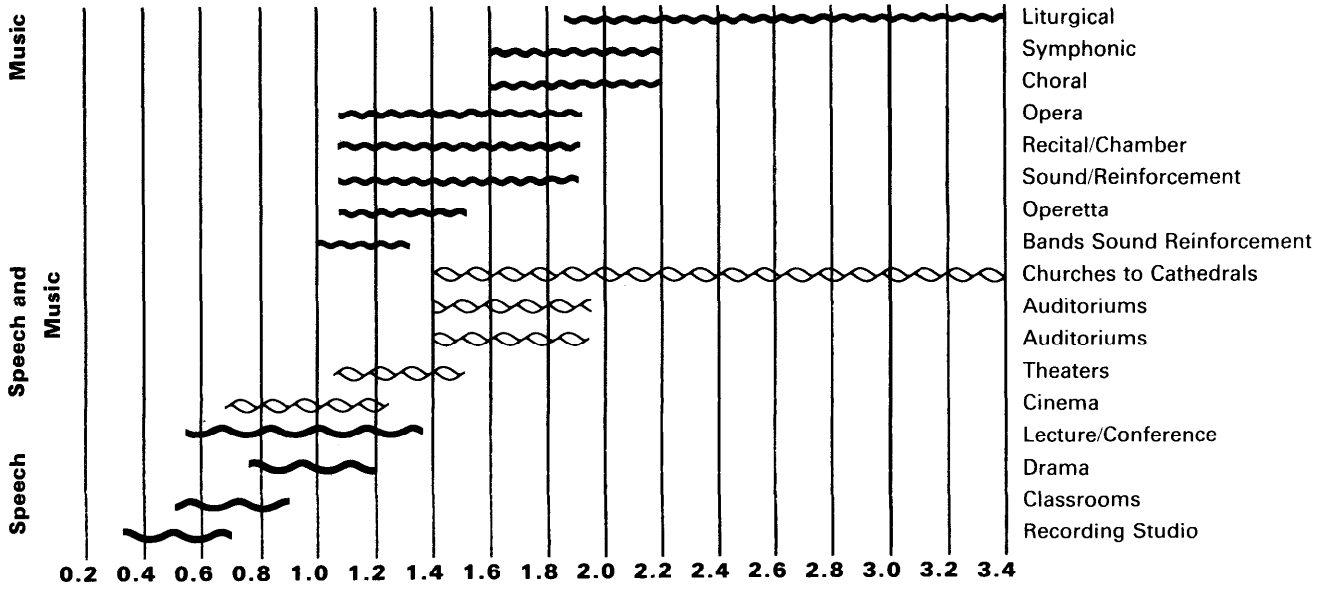


FIGURE 4–4.6 REVERBERATION APPROPRIATE TO PERFORMANCE TYPE

MATERIALS	COEFFICIENTS					
	125H$_z$	250H$_z$	500H$_z$	1000H$_z$	2000H$_z$	4000H$_z$
Brick Unglazed	0.03	0.03	0.03	0.04	0.05	0.07
Carpet Heavy 40 oz. Foam Pad	0.08	0.24	0.57	0.69	0.71	0.73
Concrete Block Coarse	0.36	0.44	0.31	0.29	0.39	0.25
Fabric 10 oz. Velour on Wall	0.03	0.04	0.11	0.17	0.24	0.35
Heavy Velour 18 oz. on Wall	0.14	0.35	0.55	0.72	0.70	0.65
Terrazzo Floor	0.01	0.01	0.015	0.02	0.02	0.02
Wood Floor	0.15	0.11	0.10	0.07	0.06	0.07
Gypsum Brd. ½ in. to 2×4 16 o.c.	0.29	0.10	0.05	0.04	0.07	0.09
Ventilating Grilles				0.15–0.50		
Plaster Smooth on Brick	0.13	0.15	0.02	0.03	0.04	0.05
Air per 1000 cu. ft.	—	—	—	0.9	2.3	7.2
Audience Seated per S.F. flr.	0.60	0.74	0.88	0.96	0.93	0.85
Unoccupied upholstered seats per S.F. flr.	0.49	0.66	0.80	0.88	0.82	0.70
Wooden Pews, occupied S.F. flr.	0.51	0.61	0.75	0.86	0.91	0.86

FIGURE 4–4.7 COEFFICIENTS OF ABSORPTION

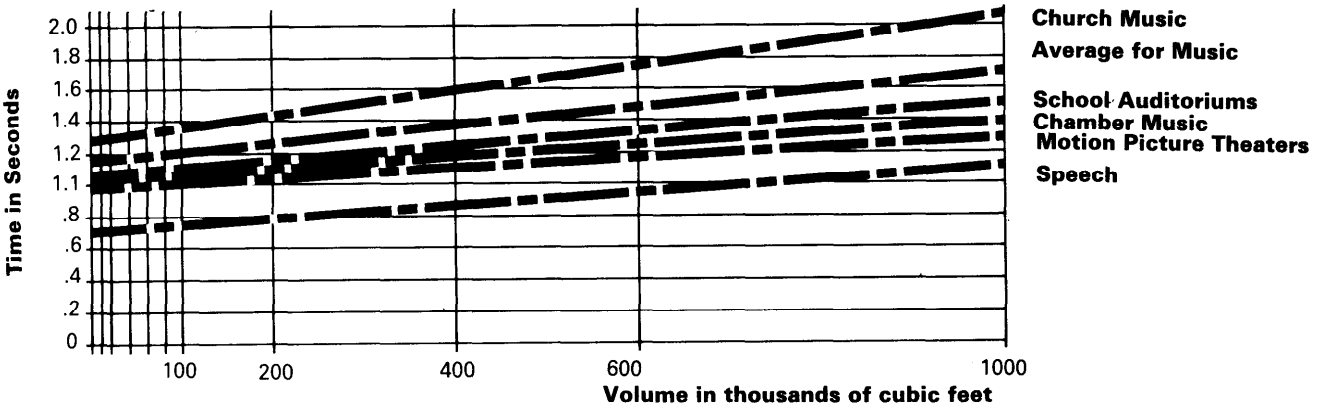


FIGURE 4-4.8 VOLUME ESTIMATE FOR TYPICAL DESIGNS

signing a volume-per-seat factor. This is clearly limited in application to the "typical" Rooms defined. A Surround music hall, for instance, requires a considerably higher volume-per-seat factor.

Decibels are not a direct measure of loudness, but of the difference in the level of two amounts of power-namely, 10 times the logarithm of the ratio. By international agreement, the reference sound intensity of human hearing is 10^{-16} watts per square centimeter. With that as zero decibels, the range extends to 120 decibels, the threshold of discomfort. Decibels measure the energy in a pressure wave. Loudness is a subjective evaluation. A 10db increase doubles apparent loudness, 20db quadruples, etc.

Musicians use their own vocabulary to describe the qualitative aspects of musical sound. It is the role of the acoustician to identify the physical acoustic criteria associated with each subjective parameter and translate these terms into useful architectural concepts.
The accompanying charts and diagrams will help define the empirical basis and physical implications of acoustical properties. Section 4-6 includes sample construction details indicative of requirements for noise control.

4-5. ELECTRONIC SYSTEMS

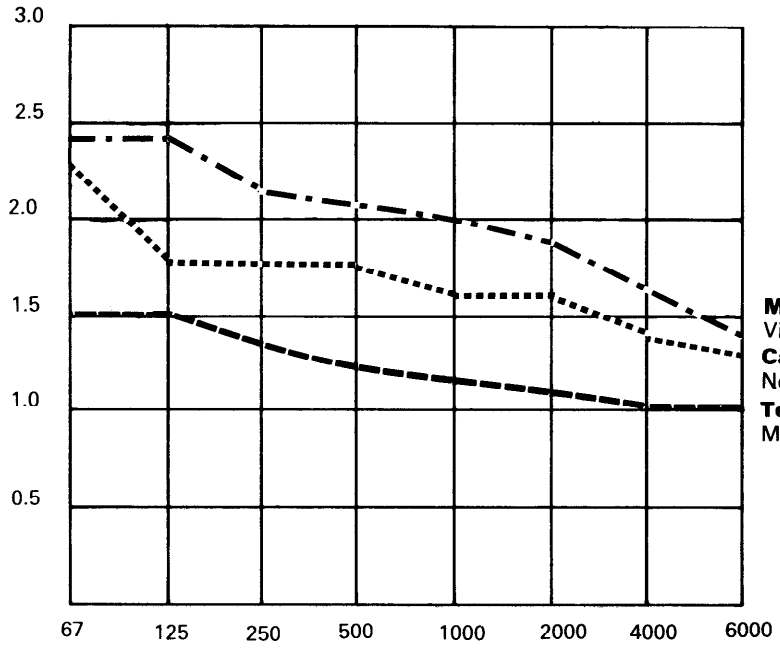
A. COMMENTARY

This Design Guide has tended to emphasize natural acoustics for three reasons. First, it should be remembered that no matter what mechanisms intervene, people hear with their ears, naturally, and impart an innate organization and sensitivity to the process. Second, there may be a tendency for design professionals and non-designers alike to assume the existence of equipment that will "fix" malfunctions brought about by lack of attention to and understanding of acoustic principles; this is usually false, and the misunderstanding can be a costly one. Finally, many of the functional criteria and conditions for good listening apply no matter what means is employed for generating sound to be listened to. Electronic audio systems simply introduce a few more steps in the signal path.

Audio systems have four parts in common: Input transducer (microphone, tape head, phono cartridge), signal processor (tuning, filters, mixing, volume, delay), amplifier, and output transducer (loudspeaker). Signal processing accounts for major differences in application.

Electra-Acoustic Enhancement: This system's purpose is to increase the reverberation time of a Room by introducing very small delays between the input and output by way of a digital processor. It may have one or more predetermined settings appropriate to various Room uses. Ideally, it will not alter the characteristic frequency response spectrum of a well-designed auditorium or provide acoustic gain (increased loudness). But in cases where a portion of the spectrum drops out of reverberant field, the processor can selectively strengthen that part.

This corrective function (called equalization) can be useful when it is desirable to shorten natural reverberation time by adding absorptive material to the volume; the material tends to absorb certain frequencies more than others.

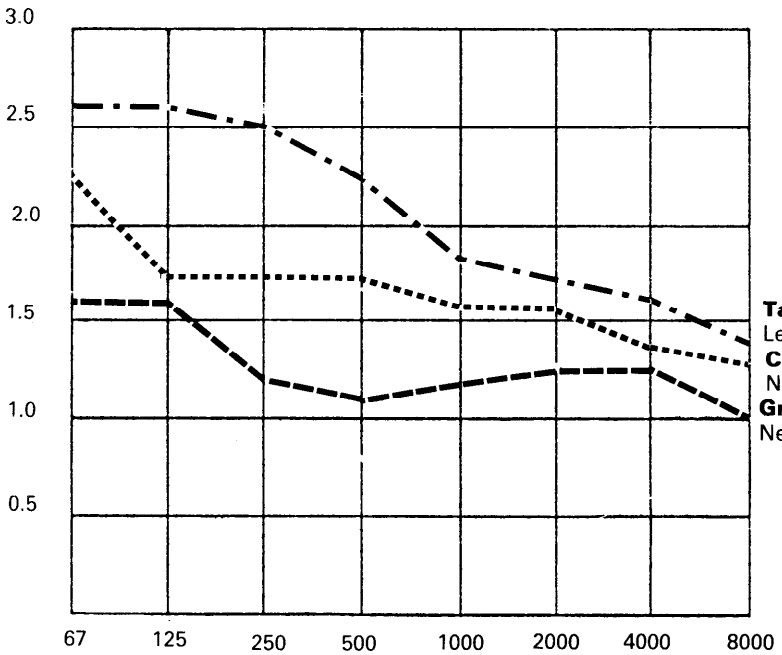


	V	S	V/S	N
A	376,000	15,700	24.0	1658
B	857,000	21,360	40.1	2760
C	397,000	17,600	22.5	2289

	S/N	V/N
Musikvereinssaal—A Vienna, Austria	9.5	227
Carnegie Hall—B New York, New York	7.7	173
Teatro Alla Scala—C Milan, Italy		

FIGURE 4–4.9 REVERBERATION TIME COMPARISON

V = Room Volume
S = Total Absorption
N = Number of Seats



	V	S	V/S	N
A	1,500,000	33,000	45.5	6000
B	857,000	21,360	40.1	2760
C	193,600	6,900	28.1	708

	S/N	V/N
Tanglewood Music Shed—A Lenox, Massachusetts	5.5	250
Carnegie Hall—B New York, New York	7.7	310
Grace Rainey Rogers Auditorium—C New York, New York	9.7	273

FIGURE 4–4.10 REVERBERATION TIME COMPARISON

MUSICIAN TO SCIENTIST TRANSLATION SYSTEM

Symphonic Acoustics	Acoustical	Recital Hall	Music Pavilion	Surround Hall
Warmth-Bass Response	Rich late arriving low frequency reflections	Hard roof cap	Coupled overhead chamber	Coupled moat chamber
Articulation—Definition	Early mid and high reflections (20 ms)	Side walls	Forestage canopy	Forestage canopy
Presence—Intimacy	Early mid and high reflections (20 ms)	Side walls	Forestage canopy	Forestage canopy
Liveness—Reverberation	Proper R/Ts through frequencies	Volume/Absorption Ratio	Volume/Absorption Ratio	Volume/Absorption Ratio
Transparency—Clarity	Smooth R/Ts—Proper stage diffusion	Good diffusion, proper volume, shaping, no echo, no focusing	Good diffusion, proper volume, shaping, no echo, no focusing	Good diffusion, proper volume, shaping, no echo, no focusing
Balance—Sectional Relationships	Stage Design—Orchestral placement	Proper volume, shaping stage, stage risers	Tunable shell and risers	Tunable reflectors and risers
On Stage Hearing—Clarity	Stage Design—Orchestral placement	Proper volume, shaping stage, stage risers	Tunable shell and risers	Tunable reflectors and risers

FIGURE 4-4.11 MUSICIAN TO SCIENTIST TRANSLATION SYSTEM

System design can result in two modes of operation: fixed, unattended, on-off operation; and variable, controlled, programmable operation. For Army facilities, the second system is not recommended, as it requires a fully trained, full-time system operator entirely familiar with its workings and the science of microphone and loudspeaker placement. Although it offers optional control over the widest variety of performance types and conditions of performer and audience arrangement, it will be wiser to build in the quality of selected configurations without reliance on expert operating personnel.

The recommended approach to "assisted resonance" requires a carefully worked out pattern of installation designed for a given Room. Since it is the non-directional reverberant field that is energized, a large number of individual input-output channels may be employed, each covering a limited frequency bandwidth, the total of which cover the low- and mid-range spectrum. One microphone mounted in a selective resonant chamber (usually in the reverberant reaches of the Room near the ceiling) feeds one processor-amplifier that drives one carefully located speaker. In some instances, individual signals originating at the stage or orchestra pit may be mixed and fed to a number of full-range speakers in the house ceiling and balcony soffits.

An enhancement system will probably not be required for new Army facilities; good natural acoustic design is preferable at the scale of Rooms and production types anticipated. It will more likely be applicable to found space conversions where acoustical limitations are inherent in the existing construction.

Sound Reinforcement: Amplification raises the level of direct sound sent into the Room, which can have several purposes. It can ensure sufficient loudness (or balance of loudness between stage and pit sources), intelligibility, naturalness, and directional realism if properly designed. It will be an important requirement of multi-use programs especially when absorptive material is used to reduce reverberation time and where (perhaps in conjunction with enhancement) a stagehouse shell has not been provided for music uses.

System design will depend on conditions of use and Room configuration. There are four basic

approaches related to loudspeaker locations. The most common arrangement employed by touring companies using a Room without adequate installed reinforcement is the temporary placement of speakers on each side of the proscenium. Apart from. ease of set-up, there is sometimes the advantage of reaching into underbalcony recesses. However, for the majority of the audience, unnatural amplification will be evident and in many instances distracting, due to directional conflicts between eyes and ears. In extreme cases, sound from the more distant speaker will be heard as echo.

The most common installed system utilizes a central loudspeaker cluster directly over the proscenium. This very simply eliminates split system problems by positioning the speakers in a complementary spatial and temporal relationship to the onstage source; the sound arrives from the same direction and at the same time. The only exceptional circumstances would be dialogue across a very wide proscenium, down a very deep stage, or in a Thrust or Surround arrangement. In other words, it assumes a dominant central focus. Its only physical disadvantage may be the difficulty of reaching under deep balconies from an especially high proscenium position.

A variation of the central cluster scheme responds to the first exception by locating three to five clusters across the width of the proscenium, with corresponding microphone inputs so that apparent sound direction moves with its source. Either the microphones or the wireless receivers (if used) must have directional qualities while the speakers do not, to avoid differential delays caused by source distance across the stage. Alternatively, fixed omnidirectional microphones may incorporate preset time-delay feeds to each speaker, the longest to the most distant speaker, along with a scaled level adjustment. Often only the central cluster is used for speech presentation, and the others turned on for large choral or orchestral groups, stereophonic effects, or high level amplification (rock or popular music) that would overpower and distort the normal central cluster elements.

Finally, carefully designed directional side clusters or a distributed loudspeaker system may be installed supplemental to the central system, for deep under-balcony spaces or for unusually “dead” or uneven Rooms encountered in found space conversions. The distributed system always incorporates time-delay processing, not to provide reverberation but to ensure that live sound arrives, establishing directional realism, closely followed by reinforcement sound. Criteria include low gain relative to stage and central sources, and required proximity to the affected audience to avoid echo perception at the front of the house. A slightly greater (+2 db) gain can be obtained if under-balcony sound arrives about 15 milliseconds after the cluster sound.

The central cluster arrangement is the most likely choice for Army facilities described in this Guide. In fact, it is probable only the large (1400 seat) House will require a reinforcement system for multi-use programming, to increase speech intelligibility for drama presentation and enable popular entertainers, using electronics as part of their art form, to effectively function in the space.

The main components would be a central cluster three-way loudspeaker system with separate low, mid, and high end speaker components. Each of these components should be amplified separately and balanced with electronic crossover networks. The design of such a system requires an experienced professional.

While this preferred system utilizes a limited number of loudspeaker outputs, it requires a multitude of input microphone receptacles in the stage area and current practice is to provide a 40-pair shielded cable from the stage to the control location in the house and the main control booth.

It is essential that the sound reinforcement console be operated from a position in the house. It is impossible for an operator to achieve good balance of either speech or music programs when operating the system in a closed booth, or in a booth having an operable window. For this reason, the tie lines are split at the stage with one set going to an in-house console location, and another set going back to the control room. Since it is necessary to move the console from the control room to the house position frequently, it might very well be advisable to purchase standard commercial reinforcement consoles in modular sections of 8 to 12 input channels each. Three 8-input channel boards can be plugged together to form a 24-input channel mixer, a reasonably sophisticated device for a 1400-seat house.

Please bear in mind that if the 1400-seat house has high drama use, additional output channels and speaker delegation switches will be re-

quired. The normal sound reinforcement system console does not include these components as a standard part of its design.

Theatrical Sound Effects: An effects system is conceptually the opposite of a reinforcement system. It would usually have a limited number of inputs, 4 to 12, with a large number of outputs. Output delegation switches allow the operator to feed the signal to the loudspeaker of his choice in a wide variety of locations both on stage and in the house. Obviously, in such a situation each speaker must be fed by its own individually controlled amplifier.

This system should be independent of the reinforcement system because directional realism may demand that sound effects such as doorbells, thunder, sirens, shots, etc., appear to originate off stage or even in the house. Therefore, it is advisable to keep the design flexible and just provide receptacles for loudspeaker leads in a variety of locations. One left and right on the proscenium and three or four on the backstage wall would be sufficient. Sometimes a receptacle on the loading gallery and pinrail is advisable.

In terms of the House we may find that the director would like to provide a sound effect that is directionally oriented in relation to the seating area. In other words, sound coming from the left to the rear or from the right of the audience, or perhaps a sound that would be panned across the audience in either direction or panned around the audience from one direction to another. In this instance it is good to put a series of small speakers of bookshelf or studio monitor type around the auditorium in certain locations. A minimum arrangement would be one on both the left and right, which would be located about one third of the way from the proscenium to the rear, and one in the rear.

The inputs of effects systems are usually tape recorders, turntables, cassettes and/or voice announcements over a microphone. The intervening electronics are fairly straight forward in terms of a simple mixing console with the required number of output channels to feed the various loudspeaker locations. This console is often remote from reinforcement controls, with a separate operating technician receiving cues from the stage manager.

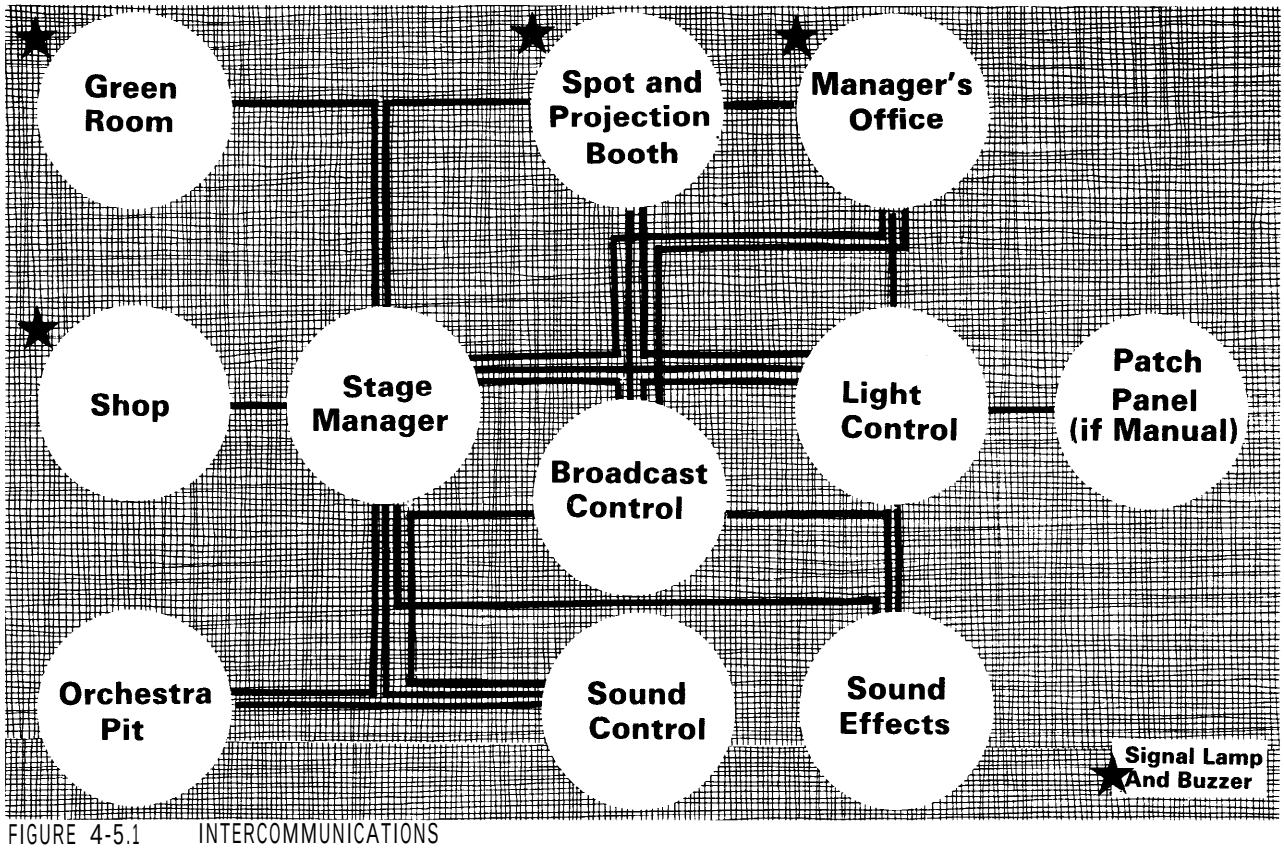


FIGURE 4-5.1 INTERCOMMUNICATIONS

Music reproduction for plays and dance is usually handled through an adaptation of the effects system using all of the same equipment heretofore discussed. Stereo and quadraphonic material can be reproduced as long as four input channels and four output channels are available. In some circumstances the reinforcement speaker clusters may be brought into play. (The reinforcement system has been carefully adjusted to the Room acoustics.) However, when sound does not originate on stage, dancers and other performers may have difficulty hearing it in the stagehouse. In this situation, the music should also be played on stage.

When live music from the pit is miked through the reinforcement system to balance a weak pit orchestra, the above method may need to be modified so that music played on the stage does not arrive in the house too long after the direct and cluster sound. The onstage speakers should be located just behind the proscenium, directed to the actors. Directional pit mikes will minimize feedback. If actors on stage are miked (musical drama) voice/music channel separation becomes very important. A facility with minimal reinforcement capabilities may find it necessary to place a small orchestra itself on stage behind the action, where music and speech sound is picked up by reinforcement microphones.

Microphones: The selection and placement of microphones for various activities is an art in itself and too difficult to describe in this Guide. We would recommend that the using service retain an experienced professional who can assist them in this matter. Most touring drama and professional music groups are familiar with microphone setups and can usually instruct the house crew as to their preference. It is good to have a variety of microphones on hand for various purposes and a good mix is suggested in Table 4-5.1.

Production Communications: These are also discussed under Section 3-8d. A production communication system is one which allows the individual in charge of the production to communicate with members of the technical staff. A minimal system would be a single channel system with the main control position at the stage manager's desk in the stage wing areas. The lighting control operator, the sound effects console operator, the spotlight operators and the crew chief at the stage, pinrail and loading catwalk would all be in communication on this single channel.

Several commercial systems are available. The most popular for theater is a lightweight headset with single earpiece and boom mounted microphone, connected to a separate belt pack that will jack into a wall receptacle. On-stage crewmen sometimes do not like the constriction of this arrangement and prefer their communication in an integral wall mounted unit so they're not trailing any wires. A more sophisticated version of this same system would be a two channel system in which the technical lighting people would be on their own separate cue channel. This is recommended for Drama with more than minimal scenic support.

The actor cue call and program monitor system is usually combined as a single cable loop system starting from the stage manager's desk and going to all the dressing room areas, manager's office, cast bathrooms, assembly areas, technical crew chief's office and general crew offices and staging areas. All of the rooms which are wired to the system will have a single speaker and a wall mounted volume control. A microphone hung just behind the main act curtain on stage will continually feed program and rehearsal material to all of the stations. Concurrently, whenever there is a specific cue call for an actor, orchestra, chorus members, corps de ballet, etc., the announcement emanating from the stage manager's console and activated by a push button will override the program material and announce the cue to all concerned. Should the program material be bothersome at any given time, the control knob on the wall will allow those in the room to reduce the volume to an inaudible level. However, under no circumstances will this deactivate the override actor cue capability. Therefore, even when the control knob is at its lowest position cue calls will always be audible in the various rooms.

In certain rooms it might be desirable to eliminate cue calls; rooms such as the manager's office, the stage manager's office, etc. In these cases the cue call override wire can be snipped and only program material will be fed into these designated spaces.

Table 4-5.1 lists equipment recommended for Army MDC's. Refer to Sections 3-12, 14 and 15. Quantities depend on specific circumstances. Add to these as required (the equipment can be rented) and have on hand at least half as many portable "bookshelf" speakers as there are effects output channels if not permanently mounted.

300 Seat Drama

- Actors call—main plus — 12 stations basic minimum, 20 stations recommended
- Program monitor— 16–24 stations
- Intercom—main plus 10–15 stations
- Effects/reproduction system— 4 input/16 output minimum
- Articulation/ reinforcement— not likely needed

650 Seat Drama

Same systems as 300 seat, more stations likely.

- Actors call — 24 stations extended/touring
- Monitor — 35 stations
- Intercom — 20 stations
- Effects — 8 input/20 output

650 Seat Music

Very little sound equipment is required for a small Music Room.

- Actors call—main plus — 8 stations basic, 12 stations recommended
- Monitor — 15–20 stations
- Intercom—main plus 7–10 stations
- Announce system—portable or built-in, 4 mike locations

1400 Seat Music

Same systems as 650 seat, more stations likely.

- Actors call — 24–30 stations
- Monitor — 36–40 stations
- Intercom — 12–15 stations
- Announce booth plus— 6–8 plug—in receptacles

Multi-Use/Musical Drama

- Actors call — 24–30 stations
- Monitor — 36–40 stations
- Intercom — 24–30 stations
- Effects — 12 input/20–30 output
- Articulation/ Reinforcement — 24–40 input channels

Microphone Assortment, Modest Inventory

- 16 High quality cardioid microphones, either dynamic or condenser type (used for general purpose pickup.)
- 3 Super cardioid microphones (used for difficult situations and for stage floor pickup).
- 3 Omni-directional microphones (especially designed for close-up vocal work).
- 1 Medium quality cardioid microphone with built-in switch (used for off-stage announcements).

2 Lavalier microphones (used for lectures, etc.).

TABLE 4-5.1 SUGGESTED AUDIO/COMMUNICATIONS EQUIPMENT

Qty.	Description	Manufacturer	Type
	1. Articulation System		
2	Loudspeakers	Custom	
3	Microphones	Special	
6	Pre/Summing Amplifiers	Spectra Sonics	110
3	Transformers	" "	T67
3	Power Amplifiers	" "	701
1	Card Holder	" "	202fc
1	Card Holder	" "	201C
1	Regulator	" "	411
1	Power Supply	" "	404RS
1	Rack	Soundolier	300–42
1	Control Panel	Custom	T07
	2. High Level System		
2	Loudspeakers	Spectra Sonics	3000
12	Power Amplifiers	" "	701
2	Electronic Filters	" "	505
2	Transformers	" "	T66
2	Card Holders	" "	202PC
1	Power Supply	" "	404RSD
1	Limiter		610
1	Processor	UREI	567
2	Microphone Plugging Box	Custom	
1	Rack	Emcor	

	3. Effects System		
6	Loudspeaker	JBL	4350
12	Power Amplifier	Spectra Sonics	701
2	Card Holder	" "	202PC
1	Power Supply	" "	404RSD
6	Transformer	" "	T66
2	Patch Panel	ADC	PJ–738
24	Patch Cord	ADC	PJ–712
			TL
	4. Stage Monitor System		
2	Loudspeaker	Bozak	CM–209–11CH
4	Power Amplifier	Spectra Sonics	701
1	Card Holder	" "	202 PC
1	Power Supply	" "	404RS
2	Stage Speaker Plug Box	Custom	
	5. Backstage System		
20	Loudspeaker	Soundolier	C10T70
20	Enclosure	"	95–8
20	Baffle	"	51–8
10	Priority Volume Control	"	AT10PA
2	Power Amplifier	Spectra Sonics	701
1	Line Transformer	" "	T70
1	Power Supply	" "	404RS
1	Card Holder	" "	203 PC
2	Microphone	Electro-Voice	621
1	Fly Microphone	" "	RE–10
2	Mixer/Preamplifier	ALTEC	1589B
1	Stage Manager Control Panel	Custom	
	6. Lobby System		
30	Loudspeaker	Soundolier	C10T70
30	Enclosure	"	95–8
30	Baffle	"	51–8
2	Power Amplifier	Spectra-Sonics	701
	7. Production Intercom		
1	Main Station	Clear-Com	ES–200K
12	Remote Station	" "	RS–100A
12	Headset	" "	CC–240
12	Extension Cable	" "	IC–25
2	King Biscuit	" "	KB–111
	8. Miscellaneous Equipment		
1	Control Console	Tangent	1602a
16	Microphones with Accessories		
1	Tape Recorder	Ampex	AG–440
1	Phono Reproducer		
2	Monitor Speaker	Bozak	CM–200–2
2	Rack	Emcor	

FIGURE 4–5.2 SOUND SYSTEM EQUIPMENT SPECIFIED FOR A 1200 SEAT MUSICAL DRAMA OPEN STAGE

Since the basic house central cluster reinforcement system is of minimal scope for the Army program, it is further suggested the designer furnish sufficient on-stage A.C. power so that touring groups utilizing their own portable sound systems can set them up rapidly, allowing sufficient time for their technical personnel to conduct pre-performance sound checks. This provision is mandatory for the 650 Seat Drama Room and 1400 Seat Music Room having no reinforcement systems.

4-6. CONSTRUCTION DETAILS

These sample details are furnished to illustrate the unusual aspects of performance facility construction. They are by no means exhaustive or prescriptive in definition, but the criteria exemplified will most often be mandatory.

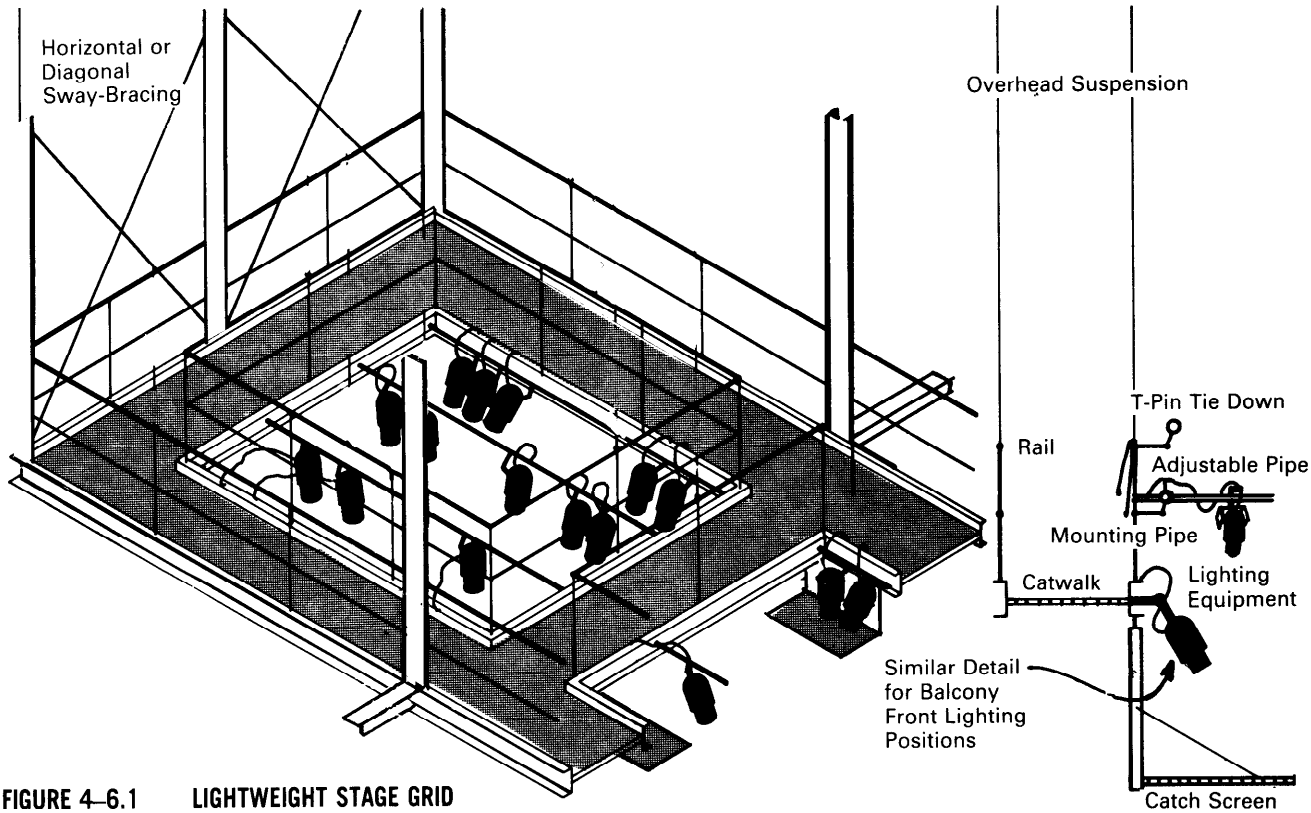
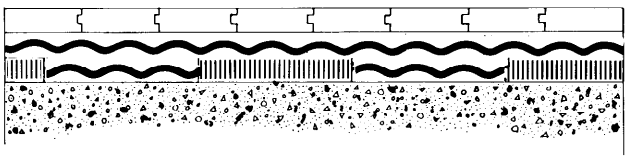
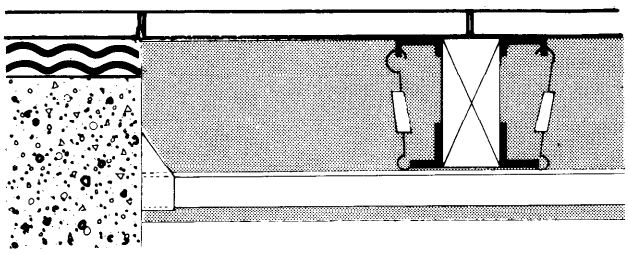


FIGURE 4–6.1 LIGHTWEIGHT STAGE GRID



2″ Tongue and Grove softwood floor on 2″ × 4″ sleepers 16″ on center on 2″ Neoprene Pads 16″ o.c. with fiberglass fill on concrete.

Surface Finish: Sand, Stain, Penetrating Sealant. No varnish or wax.
Music Stages May Require Random Spacing of Sleepers and/or pads.



2″ Tongue and Groove Flooring
4″ × 10″ Wood Purlin
3½″ × 3½″ × ½″ Steel Angles
⅜″ Turnbuckles
6″ × 14″ Wood Joist

FIGURE 4–6.2 STAGE AND REHEARSAL FLOOR CONSTRUCTION TRAP CONSTRUCTION

AIR-BORNE NOISE ORIGINATING IN THE THEATER	
Source	**Method of Prevention**
Radiators	Heat the house entirely by circulated air, or wall or floor radiation. On stage 1. Radiator Return line graded to avoid condensate and resultant banging. No valves to hiss. 2. Circulate hot water rather than steam. 3. Use radiators for rehearsals and pre-performance only.
Stage Wagons, Turntables (Noise magnified because of reverberant stage floor)	1. Well-made ball or roller bearing casters running on level tracks installed over stage floor. 2. Revolving stage on its own support structure. 3. Slow hydraulic elevators are quiet; the screw-jack type are noisy 4. Remote isolated elevator machine room.
Audience (Talk, shuffling)	1. Make crossover sound absorbent. 2. Lobby doors opposite aisles used for exit, not during show. 3. Divide rear crossover from house. 4. Carpets. 5. Silent seats.
Orchestra Pit	1. Rubber feet on chair legs and stands. 2. Prearrange and rehearse placement.
Telephones	Locate only where one open door will not permit sound to reach house or stage. Light instead of bell on stage.
Backstage Noise	Minimize personnel on stage, rehearse cues thoroughly. Minimize loose tools, properties.
SOLID-BORNE NOISES	
Source	**Method of Prevention**
Train or Street Rumble	Vibrant-isolating mounts under columns, vibration-isolating joints in walls. Compliant substance between grade walls and back fill. In case of excessive vibration, float interior walls and floors.
Air-Handling Units	Locate remote. Isolation mounting and soundproof room, regular maintenance.
Vibration from non-theater functions of building	1. Locate in remote building with independent structure. 2. Float the floor of the facility at which the vibration originates. 3. Structurally discontinuous sound-lock connecting passages only.
Motors, Machinery	Vibration-isolating mounts, gearless transmission.
Plumbing	More than one wall between house and facility. Isolate from structural members. Silenced flush valves, vestibule doors.
AIR-BORNE NOISES ORIGINATING OUTSIDE THE HOUSE	
Ingress	**Method of Exclusion**
Doors	Airtight fit (A hairline crack will raise the transmitted sound level 6 db.) Double-door systems are necessary to isolate the scene shop, lobby, street, etc. from the stage. (Doors opening on alleys or halls may be less of a problem than if they open on the street. Open only into spaces which can be kept reasonably quiet.)
Windows	1. Prefer none. 2. Double where used and not capable of being opened.
Ceiling Slots	Exclude sound from loft by roof insulation, solid catwalks, tight doors.
Projection Booth	Quiet machines. Sound absorbent walls and ceiling in booth. Glass in viewing ports.
Ventilation Ducts	1. No metal connection between blower and steel structural members, or blower and duct. 2. Ducts and diffusers sized for PNC when blower operates at full speed (above normal operating speed). 3. Sound-insulated ducts. 4. Long run-out to first diffuser.
Roof	A massive slab with a tight ceiling below it, if necessary. Hang ceiling on resilient mounts.
Alternator, for Motorized Rigging	Locate in soundproof vault outside the theater.

FIGURE 4–6.3 TYPICAL CORRECTIVE MEASURES FOR NOISE CONTROL

	Slot Speed at Terminal	10′ of Duct Before Opening	Next 20 Ft.	Next 20 Ft.
NC–15 Supply	250 Ft/Min.	300	350	400
NC–15 Return	300	350	400	450
NC–20 Supply	300	350	425	500
NC–20 Return	350	400	500	650
NC–25 Supply	350	425	550	700
NC–25 Return	425	500	650	800

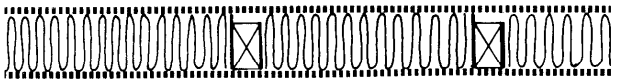
Maximum Duct Velocities (feet/minute)

FIGURE 4–6.4 SUGGESTED HVAC CRITERIA, NOISE CONTROL

CONSTRUCTION	TRANSMISSION LOSS AT LISTEN FREQ. H_z						
Walls	**125**	**250**	**500**	**1000**	**1000**	**4000**	**STC**
2″ Solid gypsum. Sand aggregate plaster 18 PSF	31	32	33	38	45	53	38
4 in. Pumice block, unpainted 16 PSF	18	19	26	32	35	40	38
4½ in. solid brick plastered both sides 45 PSF.	24	35	40	51	57	60	46
2×4 wood studs, ½ in. sand aggregate plaster on ⅜″ gypsum lath both sides 16 PSF	27	25	31	44	34	50	34
3⅝ in. sheetmetal stud ½ in. gypsum board both sides 2½ insulation in airspace 16 PSF	27	36	48	56	50	46	46
2½ in. wire studes ½ in. sand aggregate plaster on ⅜ in. gypsum lath on ½″ resilient metal clips 12 PSF	30	57	43	48	43	60	45
4 in. hollow concrete block 24 PSF painted ½″ gypsum board on resilient furring channels 1″ insulation	27	44	57	64	61	55	51
Two wythes of plastered 4½ solid brick 2″ air space sound absorbing mtl. air space 90 PSF.	43	50	52	61	73	78	59
Floor Ceiling							
Finish & subfloor on wood joists gypsum lath and plaster below 15 PSF	74	32	40	48	51	54	43
Oak flooring on ½″ plywood sub 2×10 joists 6″ o.c., ⅝″ gypsum board on resilient mtl. furring channel.	35	39	45	52	58	63	50
Doors							
1¾″ hollow door hung, ½″ undercut	7	9	13	14	13	12	13
1¾″ special double panel sound absor. flu	31	33	37	40	44	44	40

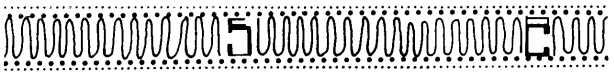
FIGURE 4–6.5 TYPICAL SOUND TRANSMISSION LOSSES

STC

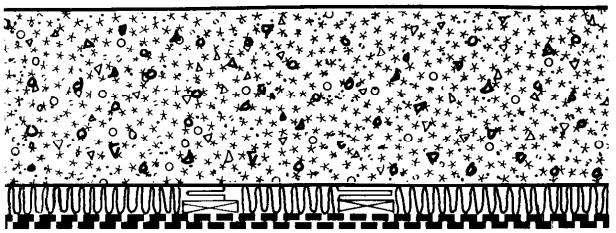


40 ½" wood fiberboard nailed to 2 × 4 stud 16" on center, one side resiliently attached Fiberglass fill.

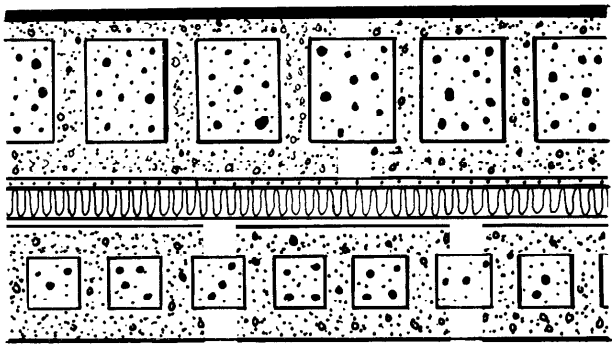
45 ⅝" gypsum board on 3⅝" metal studs 24" on center w/fiberglass fill



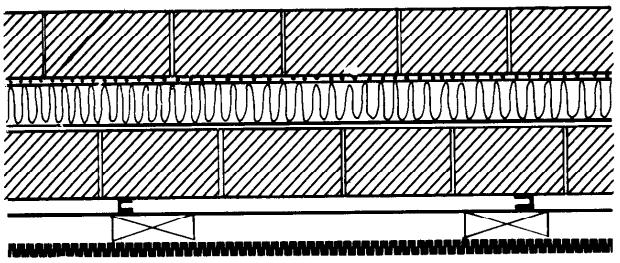
55 ½" sanded gypsum plaster (2 coats) on metal lath resiliently clipped to 3¼" metal studs 16" on center w/fiberglass fill.



65 12" reinforced dense concrete 2 layers ⅝" plywood on furring strips w/1¼" cavity w/fiberglass fill.

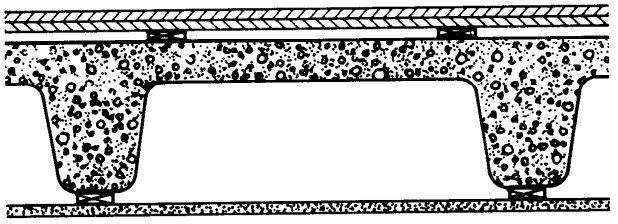


75 12" concrete block w/grout fill 80 Lb/SF 8" concrete block w/grout fill 30 lb/SF plastered cavity w/fiberglass fill

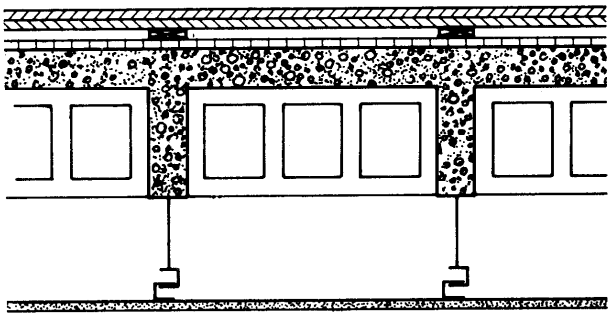


STC	
70	2 wythes brick w/4" air space plastered cavity w/ fiberglass fill 2 layers 5/8" gypsum board on metal furring strips resiliently attached.

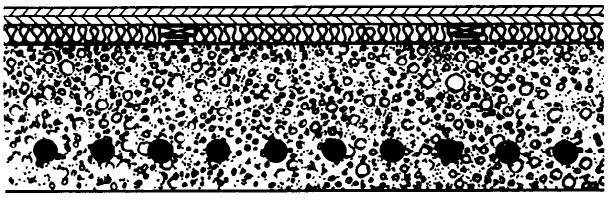
FIGURE 4–6.6 WALL AND PARTITION CONSTRUCTION, NOISE CONTROL



STC	
55	Finished & subfloor on wood sleepers on 2½" concrete slab w/6" ribs 2'0" o.c. 55 Lb/SF w/Ridgidly furred ceiling skin



STC	
75	Finished & subfloor on wood sleepers on resilient fiber board (or eqv.) on 2" slab on 6" hollow filler block 80 lb/SF w/suspended ceiling on resilient runners.

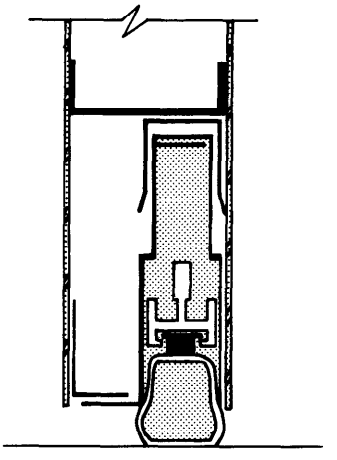


STC	
65	Finish & subfloor on wood sleepers resiliently attached to 8" reinforced concrete 95 lb/SF w/fiberglass fill.

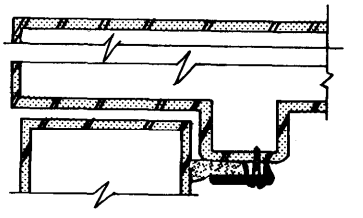
FIGURE 4–6.7 CEILING AND FLOOR CONSTRUCTION, NOISE CONTROL

DOORS

Construction	Thickness	Weight Lb/SF	STC Rating
Hollow core wood	1–3/4″	3.5	19
Solid core wood	1–3/4″	5	29
Hollow metal	1–3/4″	5	30
Packed metal	1–3/4″	7	32
Special Acoustical	1–3/4″	6	35
Sound core wood	2–1/4″	7	32
Special Acoustical	2–1/2″	8	38

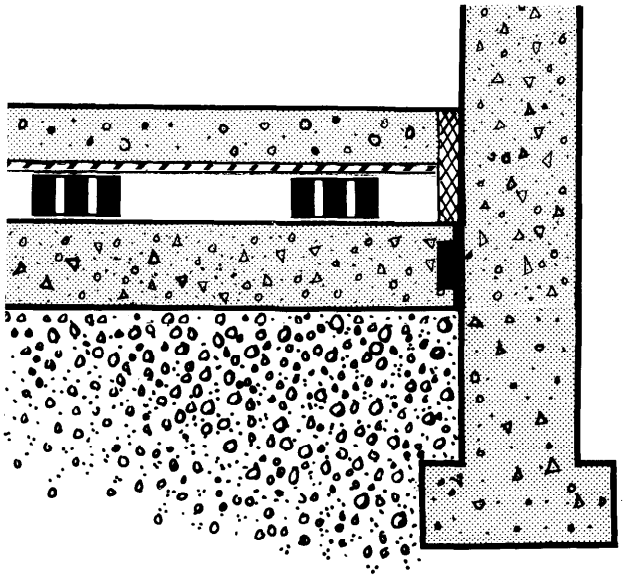


Threshold



Head/Jamb

FIGURE 4–6.8 DOOR CONSTRUCTION, NOISE CONTROL



4″ Reinforced Concrete slab on plastic sheet over ½″ plywood 2″ neoprene pads ≤ 24″ on center on structural slab.

Floating slab and equipment pedestals edged with isolation board.

FIGURE 4–6.9 MECHANICAL ROOM AND EQUIPMENT MOUNTS, NOISE CONTROL

4-7. PRODUCTION SUPPORT

This section is devoted to backstage fittings and essential production equipment required for an operational facility. Basic criteria for support activities are set forth in Sections 3-9 and 3-11.

Costume Workshops require good ventilation and uniform, glare-free illumination. Restful exterior views help combat eyestrain. Deep shelving for bulk material storage is needed, with several mothproof lockers. The design area should have a pattern drafting table 3 x 6 or larger, with overhead diffuse lighting. The construction area requires two or more 3 x 6 cutting tables, a workbench and hand tools, sewing machines and ironing board. If fitting takes place in the shop, it requires full-length dressing mirrors, podium, and ample space to move about (10 x 15) while checking the fit. A separate laundry is recommended, and possibly a dye shop.

Scene Shops will be as elaborate as the scenery is complex. A good scene shop will be two or three times the size of the acting area in order to layout, cut and assemble flats and frames, shift them about and set them up for inspection. Woodworking and welding equipment need a clear-area on all sides to work frames flat, up to 20 feet long and 6 or 8 feet wide. Both linear bulk storage for lumber, plywood, pipe, etc., and vertical storage of flats must be immediately accessible. Overhead rigging is required.

A separate paint shop in which an entire drop can be set up and worked on, should be well ventilated and heated, equipped with a utility sink, paint lockers and storage bins. Drops are as wide as 1½ times the acting area width, 16 to 20 feet high. A winched painter's scaffold is a necessity. Adequate lighting of two kinds is required-daylight fluorescent and stage flood incandescent. Flats should be moved into and out of the paint shop in a straight line, either to shop storage or to the stage.

An electricians shop should be located just offstage with ready access to stagehouse lighting galleries, gridiron and the loft space over the house. The shop is used primarily for repair and maintenance of lighting instruments and stage cables, but it may also serve the sound system and other electronic equipment. Therefore, a separate repair bench area is recommended, one that can be kept dust free and locked to prevent damage to delicate equipment. A combination of fluorescent and incandescent, non-specular lighting will help reduce eyestrain. The bench will have racks for test equipment, drawers for parts and small tools and controlled three-phase AC power supply. The remainder of the shop will have storage for instruments and some of the heavier equipment, cable reels, clamps, pipes and booms, lamp and filter storage and hand tools. Some pre-assembly work will take place here.

Musical instrument repair cannot be done in a scene or general maintenance shop. The work area must be clear of dirt and undue noise. Ideally, it will have a stable temperature and humidity. Repair work may involve carving, shaping, gluing, brazing and metalwork on a small scale as well as electronics. Some repairs will take a considerable time during which the workpiece should remain undisturbed. Therefore, two or more small workbenches are recommended, arranged for non-interference. Lockers or a locked closet should be provided for instruments awaiting attention.

The selection of shop tools and equipment is best done by the skilled personnel or crew chiefs who will use them. Since this may not be practicable, an initial inventory might be guided by the ideal that every piece of equipment should pay for itself through long service, versatility and frequent use. The MDC staff should carefully evaluate the kinds of on-going activity it can reasonably expect to sustain and choose a basic complement before purchasing specialized or sophisticated machinery. After working with it for a few productions, special needs will become apparent.

In hand tools, we suggest good quality for hard use but not the very best cabinetmaker equipment. A high level of volunteer participation will require multiples of basic items, many of which will be inadvertently lost, thrown away or destroyed.

Practicality in selecting power tools depends on several factors besides budget and intended use. When outfitting a shop away from large cities and the maintenance services available there, it may be wisest to purchase all power tools through a reputable supply house that will guarantee repairs and spare parts, or from a nationwide distributor of a good quality line for which parts and servicing are available at local sales

centers or by mail. While it may be possible to reduce the need for parts and service by purchasing only the best quality equipment, there is no perfect power tool. The choice of a personal auto or a kitchenful of appliances is similar.

Figure 4-7.1 is a list of basic tools and equipment compiled for a small country college just initiating its theater program without benefit of permanent staff. It should be regarded as the absolute minimum for a functioning stagecraft support facility.

(Assume a quantity of one unless a greater number follows in parentheses)

1. Power Tools and Accessories

- 10" radial arm saw
- 10" table saw
- 14" band saw
- assorted blades including crosscut, rip, combination, and dado
- router (one H.P. minimum)
- router bit assortment
- 1/4" electric drill (2)
- 1/2" electric drill
- high speed drill bit assortment including countersink and extra length bits
- saber saw (2)
- blade assortment
- orbital sander

2. Hand Tools

- 16 ounce straight claw hammer (8)
- 20 ounce straight claw hammer
- tack hammer (2)
- carpenter's mallet
- nail set assortment
- crow bar
- cross cut saw (2), Diston recommended
- rip saw, Diston recommended
- hack saw
- coping saw
- back saw, Diston recommended
- miter box
- chisel set with ¼, ½, ¾, and 1" blades
- draw knife
- spoke shave
- mat knife (6)
- linoleum knife
- block plane
- jack plane
- oil stone set
- wood rasp assortment
- surform
- brace
- wood bits in assorted sizes including an expansion bit
- framing square (2)
- try square (4)
- combination square (2)
- bevel square
- metal straight edge, 2' long (2)
- metal straight edge, 4' long
- folding rules, 6' (2)
- tape, 8' (6)
- tape, 50'

*snap line

- compass, 8"
- trammel point set
- spirit level
- awl
- C-clamp (12, assorted sizes)
- furniture clamp (4)
- screwdriver, slotted head (12, assorted sizes)
- screwdriver, phillips head (3, assorted sizes)
- screwdriver, ratchet (2), Yankee recommended
- adjustable wrench (4, assorted sizes)
- pipe wrench (2)
- socket wrench set
- hex key wrench set
- slip joint pliers (4)
- long nose pliers (2)
- diagonal cutting pliers (2)
- vise grip pliers
- tin shears
- cold chisel
- metal file assortment
- center punch
- staple gun (2), Arrow T-32 recommended
- staple gun, Arrow T-50 recommended
- staples
- soldering iron
- combination wire stripper and crimper (2)
- volt-ohm meter, Simpson 260 recommended
- continuity tester
- paper cutter with 24" blade
- utility brush, 2" (3)
- utility brush, 3" (3)
- laying-in brush, 4" (6)
- laying-in brush, 6" (4)
- lining brush (6, assorted sizes)
- paint roller, medium size (12)
- roller handle with extension (6)
- compression sprayer (2), Hudson #6335 recommended
- lining stick, 3' (2)
- lining stick, 6'
- pounce wheel
- stencil paper
- bucket, 3 gallon size (4)
- bucket, 1.5 gallon size (6)

3. Miscellaneous

- bench with wood-working vise
- bench with metal-working vise
- extension cords, heavy duty (6, assorted lengths)
- step ladder, 8' (2), recommend wood rather than metal
- step ladder, 14', recommend wood rather than metal
- straight ladder to reach box boom lighting instruments
- vacuum cleaner, wet-dry shop machine recommended
- broom assortment including push brooms and corn brooms
- dust brush (2)
- dust pan (2)
- trash barrels
- general hardware including nails, screws, bolts, washers, etc.
- electrical hardware including solder, electricians tape, etc.
- theatrical hardware including hinges, lash cleats, foot irons, stage screws, etc.
- paint supplies including pigment, canvas, glue, etc.

FIGURE 4-7.1 LIST OF TOOLS AND SHOP EQUIPMENT