What Should a Prison Sound Like?

PRISONS ARE HARD, tough places, and they sound like it. Architects know that enclosing a space with predominately hard, reflective surface finishes will result in reverberant, noisy spaces. Mechanical designers know that equipment selection and duct layouts determine system noise levels. Electrical designers know that light-ballast and engine-generator noise affect indoor and environmental noise levels.

Yet, a visitor to many modern correctional facilities could easily assume that noise was never considered in the design process.

It's easy to understand why: Budgets do not support extravagant design luxuries. Security and maintenance requirements prohibit use of fragile materials. Energy-efficiency requirements for mechanical and electrical systems overshadow operational concerns. Sure, we would like to have good acoustics, but after all, these facilities are for incarceration of criminals.

Design professionals should ask "What are the purposes of these facilities?" Are they purely punitive, or are they correctional facilities for training and rehabilitation? Is it safe to subject staff and inmates alike to intolerable environments known to induce stress and antisocial behavior? As practitioners of a state-licensed design profession, is it ethical to ignore issues that could help create more efficient, secure, and successful correctional environments?

The fact is that good acoustics and noise control can be achieved economically without jeopardizing security. The design process is simply incomplete if acoustical problems are not defined, analyzed, and solved as part of the architectural and engineering design effort. A correctional facility's professional design team should include knowledgeable and experienced acoustical consultants to assist with interpretation of criteria, determination of potential noise or acoustical problems, analyses of architectural and engineering schemes, and development of design solutions.

Source, Path, Receiver

ACOUSTICS and noise control deal with three basic variables: the source, path, and receiver of sound. Of these, the receiver is the most complex and hardest to quantify and deal with; architectural and engineering designers can achieve the greatest effect on source and path variables, although these must go beyond typical "rule-of-thumb" band-aids. Attenuation or modification of noise sources is often feasible for mechanical and electrical equipment, but much less so for (inmate) occupants. Barriers in the path of sound can reduce transmission. Sound that reflects off room walls, floors, and ceilings is affected by the surface characteristics.

Acoustical Criteria

HOW MUCH noise is too much? Architectural designers need to consider the types of spaces that will be created, and the facility's design and operational parameters, to assess the noise impact on the various functional areas. And they should remember that it is neither precise nor efficient to say that rooms should be "quiet."

Some groups have put together acoustical criteria, although these are not always useful. The American Correctional Association (ACA), for example, in its *Standards for Adult Correctional Institutions* (third edition), says "Noise levels in inmate housing units [should] not exceed 70 dBA in daytime and 45 dBA at night." But the ACA standard is believed by many to be inadequate, since it is vague as to whether the controlled variable is continuous background noise level of an unoccupied room (primarily HVAC noise), or occupant-generated noise (including speech, radios, TVs, and PA systems), and because, in either case, the ACA's stated levels may be excessive. The 45-dBA level is associated with known sleep-disturbance levels, and the daytime level is louder than average conversational speech; it would require staff and inmates to speak in raised voices. Finally, the ACA standard disregards fatigue and annoyance due to low-frequency rumble.

In Texas prisons today, designers routinely ignore acoustical issues that can affect stress and antisocial behavior. But these issues can be addressed economically without jeopardizing security.

The Advisory Council on Corrections and Acoustics, a board of corrections officials, architects, and acoustical consultants, has developed better criteria. The following chart, from the group's 1993 publication, "Acoustics Design Guide for Corrections," shows recommended acoustical design goals for correctional facilities

Functional Space	Background Level (dBA)	Reverberation @ 500 Hz (sec.)
Administrative Offices	45	0.90
Conference Rooms	35	0.75
Classrooms	40	0.75
Clinic or Infirmary	45	0.90
Dayrooms	50	1.50
Dining Areas	45	1.50
Exercise Rooms	50	1.50
Housing Units	40	1.00
Shops-Vocational	70	1.50
Shops–Maintenance & Manufacturing	75	1.50

For the purpose of specifying smooth-spectrum ambient-sound levels (avoiding tonality or unbalanced spectrum annoyances), acoustical consultants recommend use of Noise Criteria (NC) of Room Criteria (RC), as characterized by ASHRAE (1991 HVAC Applications, Chapter 42, Sound and Vibration Control), and used for engineering design of most commercial and institutional building projects.

Analysis and Design

THE ACOUSTICAL CONSULTANT will analyze large open spaces for reverberation based on room size, shape, volume, and surface finishes, comparing projected reverberation times for various spaces with the criteria to indicate what kind of changes are necessary and how much surface area should be affected. Review of adjacent space functions and ambient sound-level spectra will determine how much sound-transmission loss is necessary in each audible octave. Impact transmission can significantly change barrier-design requirements. The varying needs for low-, mid-, and high-frequency noise reduction prescribe certain wall, floor, and ceiling designs. Analysis of the fan noise generated by air handlers and exhaust fans, and the system attenuation provided by the combination of air distribution system and room losses, will project the room's mechanical sound level. This continuous background sound level may be compared to the noise criteria to determine how much additional attenuation, if any, is needed to achieve permissible levels in each type of space. Other sound sources, such as light-ballast noise radiation, radio, television,

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telephone, and PA-speaker noise, along with impact noises such as exercise-room foot falls and ball bounces, can also be analyzed for effect in the source room or adjacent spaces.

Solution Applications

ARCHITECTURAL ACOUSTICS solutions for most correctional facilities focus on controlling reverberation in dayrooms, dining/assembly halls, and exercise/gym rooms. Smaller spaces, including classrooms, vocational shops, inmate cells or housing units, and administrative offices and conference rooms should also be treated. Security and maintenance require that sturdy, abuse-resistant materials be used wherever inmates have access. Rugged new acoustical products developed specifically for correctional facilities are now available. Several manufacturers produce cost-effective, acoustically absorbent surface finishes, including "Alcan" or "IAC" perforated-metal panels, "Tectum" secure ceiling systems and wall panels, and "Pyrok" cement concrete or gypsum-based acoustic plaster. While most applications are planned for installation out of the reach of inmates, the cement-based plaster can resist abuse at floor levels, particularly in direct-supervision areas.

Sound-isolation and acoustical-privacy separation design in walls, doors, windows, ceilings, and floors may involve use of high-mass materials or unbalanced and decoupled barrier elements, depending on the construction system desired by the architect and building user. Decoupled elements—two or more mass layers separated by resilient layer(s)—are generally a necessity where impacts are common. Sound-isolation design must consider location and detailing of flanking paths or acoustical leaks in the room envelope, resulting from ducts, pipes, conduits, lights, or electrical fixtures, and doors.

HVAC noise has traditionally been controlled in a haphazard manner by assuming that internally lined ducts and elbows would quieten the fan noise. Now, however, most public-sector owner-agencies mandate use of unlined sheet-metal ducts to avoid growth of microbes and airborne transmission of various contaminants, so control of noises from fans, fittings, and velocity in ducts will need to be accomplished with passive duct-attenuator elements. These noise traps should be sized and selected carefully to control pressure drop and additional noise generation. Active-noise-cancellation systems may be employed in specialized cases. In general, fan-noise attenuators should be located as close to the air-handler or mechanical-equipment room as possible. High-frequency attenuators, such as insulated flexible-duct connections to supply diffusers or boots, should be located as near the end of the air-distribution system as possible, to attenuate noise generated in the duct system. Most important, return- and supply-air distribution paths must be considered equally.

Electrical noise sources in occupied spaces, such as ballasts for vapor lamps, should be enclosed or remotely located. Pipes for chilled or hot water or plumbing should not be routed above or through sleeping, classroom, conference, and other quiet spaces, unless enclosed or lagged with decoupled, high-mass noise-containing materials.

Central-plant and emergency-generator equipment should be located remotely from inmate housing and dayrooms. Indoor generator rooms should have noise attenuation for inlet and radiator discharge openings, in addition to mufflers for exhaust pipes. Vibration-isolation systems should be employed for rotating-shaft, reciprocating, and impact sources, as well as attached ducts, pipes, and conduits.

Post-Design Assurance

AFTER PROGRAMMING, planning, and implementing acoustics and noise-control solutions in architectural and engineering contract documents, diligence must be maintained in "value engineering," bidding, and construction phases to assure materials and installations that meet design intent. Post-construction validation measurements of vibration and noise should be conducted by qualified acoustical consultants or according to established standards. Rooms failing to meet criteria should be evaluated for unexpected flanking paths, improper or incomplete installations of acoustical and noise-control elements, on-site modifications of design, or other anomalies. Good planning efforts will create correctional facilities with acceptable acoustics and background noise levels that do not endanger the health of staff and inmates. Integration of acoustical solutions into architectural and engineering designs can provide these benefits with little, if any, additional cost or compromise to security. ***Jack Evans***

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