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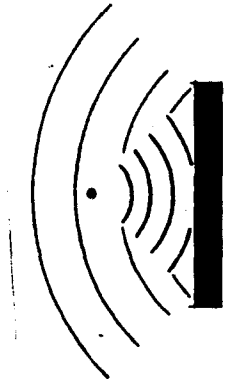
ACOUSTICS

INTRODUCTION



The acoustical environment of a space is a product of the physical geometry of that space, the acoustical properties of the materials of which it is constructed, and of the type and intensity of use.

At any time of day a typical elementary school contains areas which are quiet and areas of intense activity. In any area or room there is the potential to generate more noise than the activity, as well as, adjacent occupancies, can accept. It is important that classrooms and other areas be essentially sound absorptive, rather than sound reflective, so that diverse activities can occur simultaneously witout mutual interference.

An enclosed space has three primary characteristics which determine the quality of the acoustical environment. These are:

- Ambient sound level, which measures the amount of existing background noise;
- Reverberation time, which measures the tendency of sound to 'dwell' in the space (its decay time); and
- Attenuation, which indicates the loss of intensity of sound transmitted over distance or through a wall.

Determining, by direct measurement, the behavior of individual spaces within each of the schools in regard to these three criteria and comparison with accepted standards of acoustical performance results in an indication of the acoustical quality of the school environment.

METHOD OF EXAMINATION

Two methods of acoustical examination were used in this study. Ambient noise and attenuation tests were performed in the classrooms and corridors primarily using a Bruel & Kjaer Type 2203 precision sound level meter equiped with a Type 1613 octave band analyzer. White noise for determining sound transmission was provided on a pre-recorded casette tape. These measurements provided a basis for analytic comparisons of classroom acoustics and the transmission characteristics of the interior walls, both within and between the various schools, to accepted standards.

Bolt, Beranek and Newman, Inc., was retained to measure and analyze reverberation time, particularly of spaces in excess of 2000 square feet.

The results of these testing procedures are presented in graph form in the following section, Detailed Findings. For a more detailed descritpion of the testing procedures used, refer to the Field Tests Manual, 'Buildings In Use' Study. December, 1974.

SUMMARY OF PERFORMANCE

	P	R	S	M
AMBIENT NOISE				
Unoccupied Classroom	O	O	O	O
Unoccupied Large Spaces	O	O	O	⊙
Occupied Classroom	O	O	O	O
Occupied Large Spaces	⊙	⊖	O	O
Lighting and Mechanical Equipment	⊙	O	O	⊙
TRANSMISSION				
Between Classrooms	⊙	O	O	NA
Hallway/Classrooms	⊙	⊙	⊙	NA
Multipurpose Room/ Classroom	NA	⊖	NA	NA
REVERBERATION				
Classroom	O	O	O	O
Large Spaces	●	●	⊙	O

SUMMARY OF FINDINGS

LEARNING AREAS (UNDER 2000 SQ.FT.)

Classroom acoustics in all the schools is almost entirely adequate. Ambient sound levels are loud enough to provide 'masking' of minor noises and low enough to prevent interference with learning activities. Room-to-room sound isolation is satisfactory, although one school does have a somewhat lower level of performance. Sound isolation between the hallway and classrooms was found to be only marginally adequate (75-85%), however.

At Richards school, a centralized multi-purpose room and the high sound levels generated there does interfere with adjacent classrooms which, because of their curricular needs, tend to leave their doors open. In the other schools the multi-purpose/gym is not adjacent to classrooms.

High reverberation times were found in the large, double (30 ft. x 60 ft.) Smith classrooms due to a 'hard' metal pan ceiling, the carpeting on the floor notwithstanding. That ceiling has since been replaced by acoustically-absorbant ceiling tiles which have reduced reverberation to within acceptable limits. Smith's smaller classrooms have the original metal pan ceilings and reverberation times there are somewhat higher than at the other schools, although still within acceptable limits. At the Parkside School the mechnical noise (ballasts) were judged too noisy in classroom areas.

LARGE AREAS (OVER 2000 SQ.FT.)

Room-to-room transmission is the only area of adequate performance for large activity areas.

High ambient noise and high reverberation times are present in almost all large spaces, primarily because of inadequate sound absorption. The Richards and Parkside multi-purpose rooms have the greatest problems because:

a) acoustical inadequacies, in terms of ambient noise and reverberation time, are much more pronounced than at the other schools; and

b) both spaces concerned being multi-purpose spaces, a variety of activities with a wide range of acoustical requirements are programmed to occur in them. Alternate spaces do not exist.

The above problem also exists at the Smith and Mount Healthy Schools. However, because the inadequacies of the acoustical environments are less pronounced and because other areas of these schools can be programmed for assemblies, meetings, drama, etc., the effects of these inadequacies are minimized and performance is more acceptable because the criteria are not so strict.

DETAILS OF FINDINGS

AMBIENT NOISE

AMBIENT NOISE/UNOCCUPIED CLASSROOM

Results: Ambient noise within acceptable limits (NC 35+ 5 db for traditional classrooms, NC 45+ 5 db for open classrooms).
Probable cause: Not applicable.
Discussion: Ambient noise levels should neither be too high, causing noise which interferes with clear hearing, not too quiet, an environment in which you can hear 'a pin drop'. Mechanical systems and lighting equipment provide most of this ambient 'background' noise level.

AMBIENT NOISE/UNOCCUPIED LARGE SPACES

Results: On the whole, large spaces fall within acceptable limits with the exception of the gymnasium at the Mount Healthy School where noise levels exceeded 62-63 DBA (75-85% performance).
Probable cause: Very loud ceiling mounted HVAC equipment within the space.
Discussion: Notwithstanding that this area is used only for gym-type activities, the background noise created by the mechanical equipment is above acceptable levels, making communication difficult even for such typically loud activities as gym classes.

AMBIENT NOISE/OCCUPIED CLASSROOM

Results: Within acceptable limits
Probable cause: Not applicable

Discussion: At the Mount Healthy School, the higher ambient noise levels reflect the children's activities added to the background ambient noise levels. An open classroom building, such as Mount Healthy, requires more 'masking' noise than a traditional school. The carpeting and exposed mineral fiber ceiling provides the absorption necessary to prevent unacceptable noise levels.

AMBIENT NOISE/OCCUPIED LARGE SPACES

Results: Satisfactory at Smith and Mount Healthy (85% performance). Occupied ambient noise levels at Parkside and Richards are much too high, especially during lunch-time and physical education activities (below 75% performance level).
Probable cause: Lack of absorptive surface materials.
Discussion: Originally built without absorptive materials, the gymnasium at the Smith School was extensively resurfaced with acoustical tile a year prior to this study, apparently with good results. The ambient noise levels reached at the unimproved older schools (Parkside and Richards) severely affect communication and other activities in the same area. The peak ambient noise levels found in the multi-purpose rooms of these two schools, 90-100+ dbA, are severe enough to cause severe discomfort, and even pain. Other problems also occur because of this lack of absorptive surface.

AMBIENT NOISE/LIGHTING AND MECHANICAL EQUIPMENT

Results: Satisfactory in all schools except Parkside where increases in ambient levels in a few classrooms (3-6 dbA resulting in approximately 40 dbA) do interfere with normal classroom communication (75-85% performance). Frequency of this distinct humming is in the normal speech range.

Probable cause: Loud humming lighting ballasts cause this increase in ambient levels.
Discussion: The flourescent ballasts were either specified incorrectly to begin with or have deteriorated in performance with age. The latter reason is most likely - the ballasts are 13 years old.

While the sound levels produced are not detrimental at these levels (approximately 40 dbA unoccupied) it is necessary to 'talk over' this background noise which is rather distinct. While it is an unconscious and easily made adaptation, is not the preferred condition.

TRANSMISSION

TRANSMISSION/BETWEEN CLASSROOMS

Results: Transmission of sounds between classrooms is within acceptable limits in all schools.
Probable cause: Not applicable.
Discussion: While attenuation between classrooms is lower at Parkside due to acoustical 'leaking' at the laminated beams, this transmission between spaces does not cause any difficulty in classroom situations. The transmitted sound is 'masked' by existing occupied ambient noise. Mount Healthy, with no walls between 'classrooms', was excluded from this test.

Note: The extension of the block partition above the hung ceiling at the Richards School was quite effective in reducing transmission through the ceiling cavity.

TRANSMISSION/HALLWAY/CLASSROOMS

Results: In the three schools studied which have partitions between hallway and classrooms, performance was found to be marginally adequate (75-85%). Sound is definitely transmitted to the classroom from the hallway (6-12 dbA at ambient level).
Probable cause: In each case an open grillwork is provided for return air from classrooms to centralized return grills in the corridors.
Discussion: Not an unexpected result under these design conditions. A direct path exists between source and receiver room. The traditional nature of the schools, where interference from the corridors is not expected adds to this problem. However, since corridors contain few or no 'activities' the situation is ameliorated.

TRANSMISSION/MULTIPURPOSE ROOM/CLASSROOM

Results: Richards School. Excessive transmission between the multi-purpose room and adjacent classrooms, notwithstanding the corridor between them.
Probable cause: Centralized location of the multi-purpose room proximate to the classrooms with intensive use generating high ambient noise levels in the multi-purpose room with little sound absorption. Curricular needs require doors between the multi-purpose room and the classrooms remain open to their mutual corridor.
Discussion: This problem is inherent in the concept of the centralized multi-purpose room used at Parkside. Careful acoustical treatment is necessary to prevent and correct this problem.

REVERBERATION

REVERBERATION/CLASSROOM

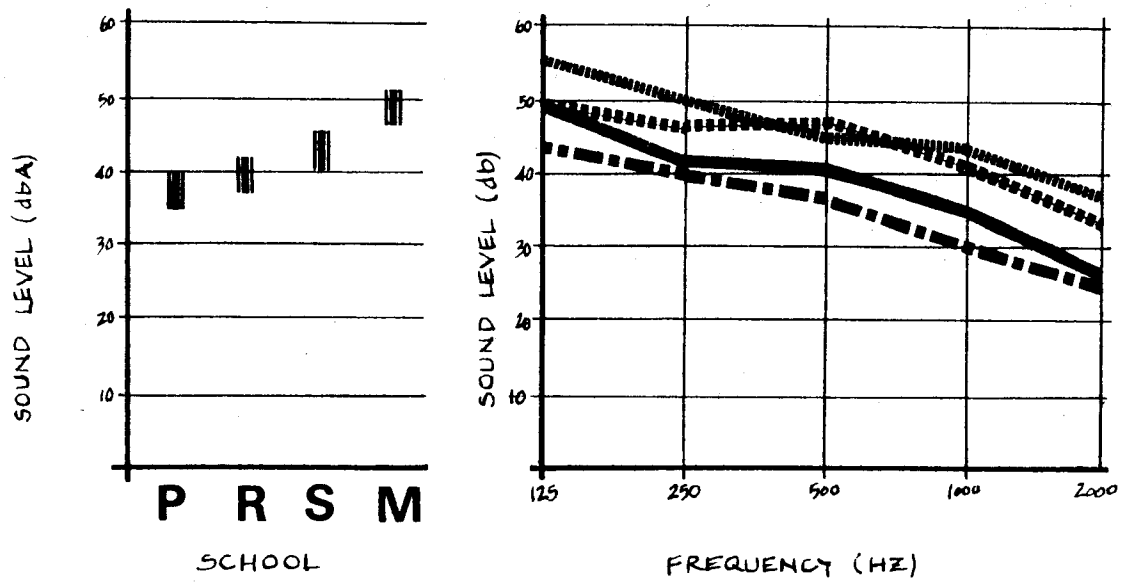
Results: Reverberation is within acceptable limits in all classrooms.
Probable cause: Not applicable.
Discussion: Just prior to the beginning of our study, the six double classrooms at the Smith School had their metal pan ceilings covered with acoustical tile. Based on the existing conditions and considering the previous ceiling finish--exposed metal pans--the original reverberation time would have been in excess of recommended standards. Significantly, in the single classroom at Richards which has not had such tile installed, the reverberation time borders on the limit of acceptability.

REVERBERATION/LARGE SPACES

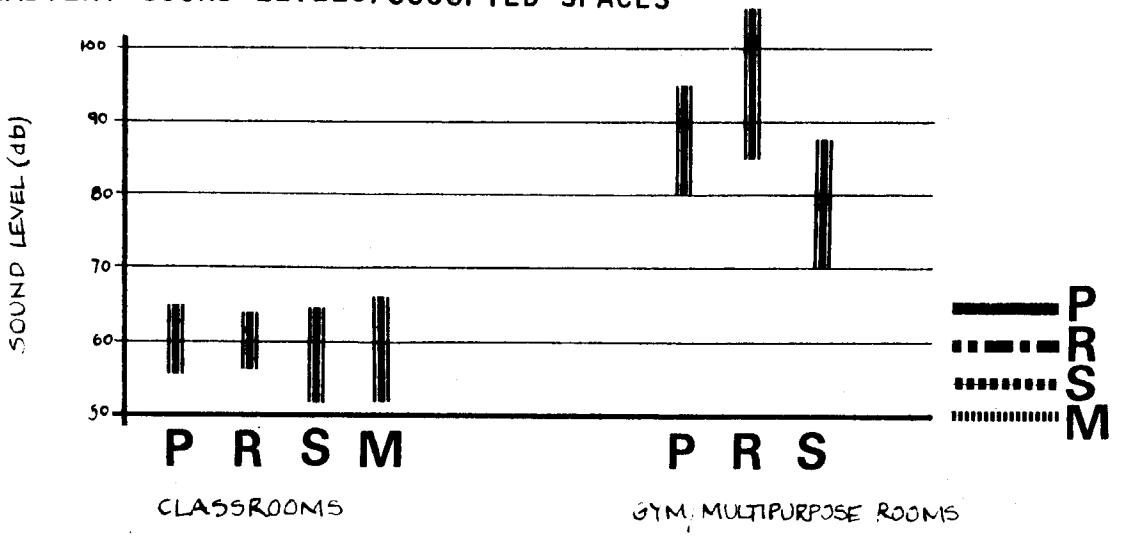
Results: Severe problems in the Parkside and Richards multi-purpose rooms. Previously severe problem at Smith has been corrected. Acceptable conditions at Mount Healthy.
Probable cause: Large volume rooms (80,000 cubic feet) with hard surfaces and a lack of acoustically-absorptive materials.
Discussion: Reverberation time varies directly with the volume and indirectly with the amount of acoustically-absorptive material present. Therefore, large spaces with acoustically 'hard' surfaces have the greatest potential for problems in this area. The Parkside and Richards Schools have virtually no absorption in their large multi-purpose areas and, consequently, very severe reverberation problems. This is affirmed in the responses to a questionnaire given the teachers in both schools. Acoustical problems are so severe as to render these spaces useless for lectures, dramatics and other presentations.

The multi-purpose room at Smith had extensive acoustical treatment prior to the beginning of this study, and present reverberation time is satisfactory although we are most certain this was not the case previously. Mount Healthy's gymnasium, with an exposed mineral tile ceiling, does have enough absorption to provide adequate performance.

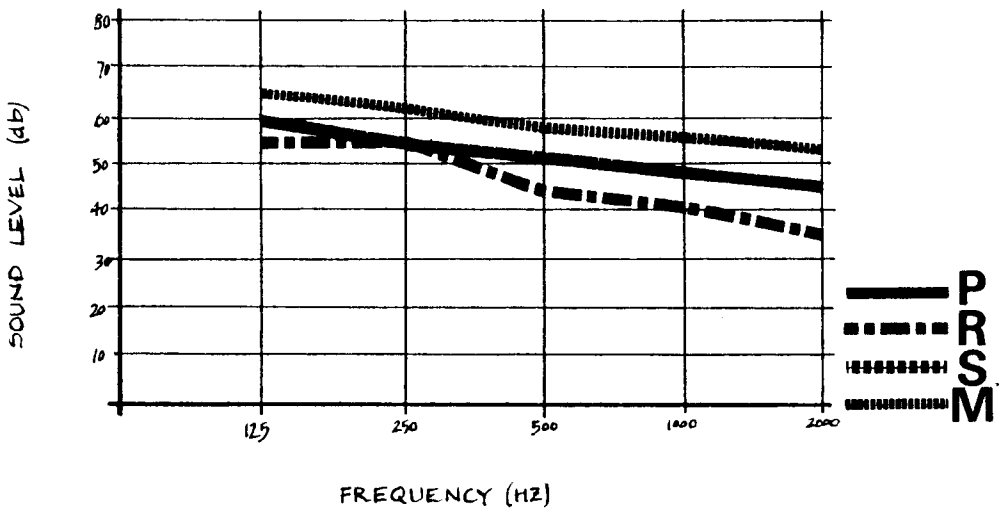
F.1 AMBIENT SOUND LEVELS/UNOCCUPIED CLASSROOMS



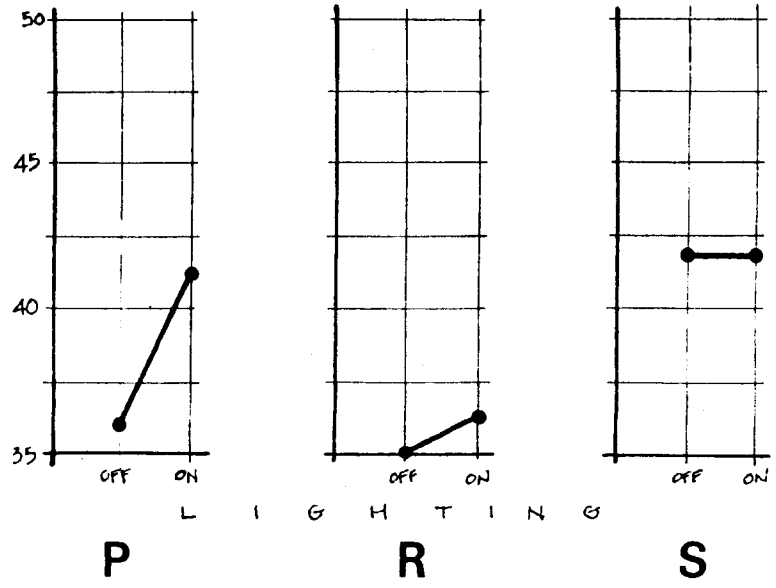
F.2 AMBIENT SOUND LEVELS/OCCUPIED SPACES



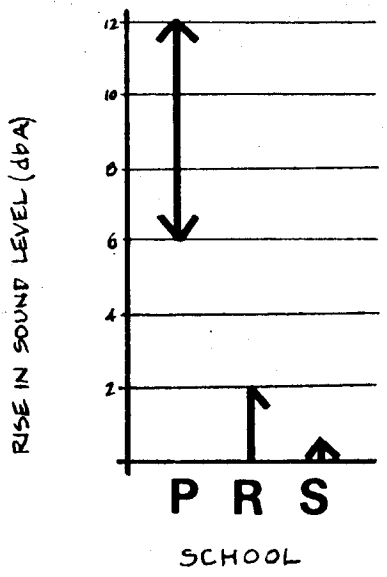
F.3 AMBIENT SOUND LEVELS/GYMS-MULTIPURPOSE ROOMS/UNOCCUPIED

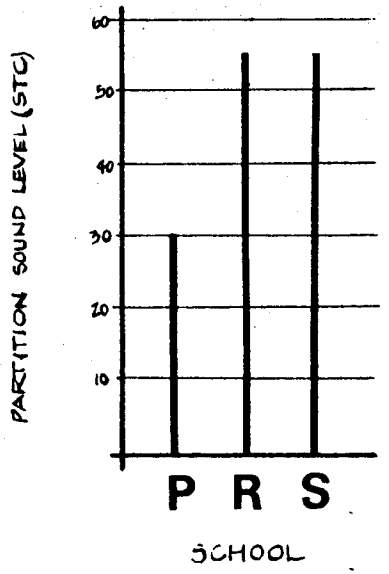


F.4 AMBIENT SOUND LEVELS/LIGHTING BALLAST

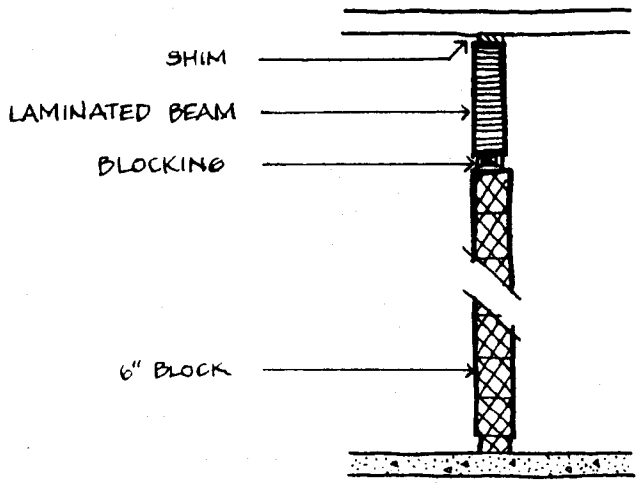


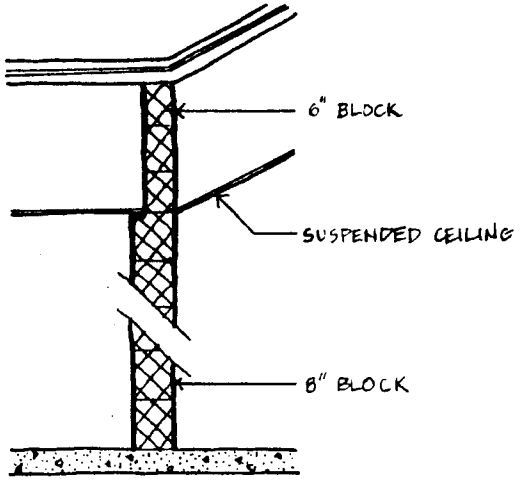
F.5 TRANSMISSION BETWEEN CLASSROOMS



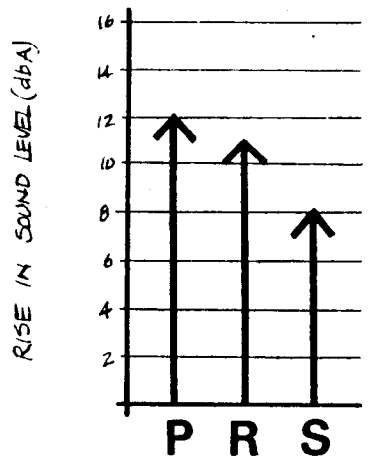


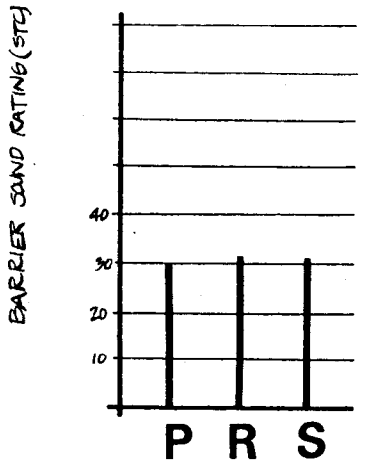
F.6 WALLS BETWEEN CLASSROOMS/SECTION



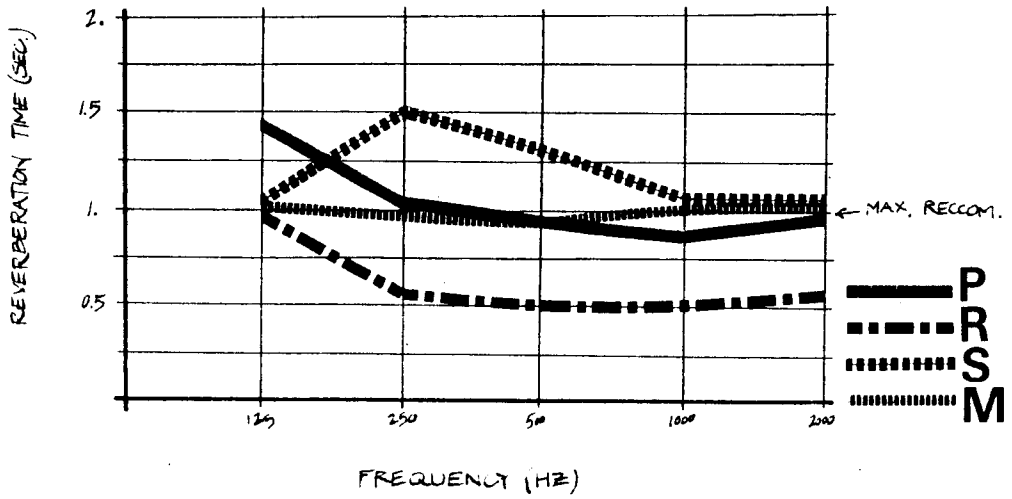


F.7 TRANSMISSION: HALLWAY/ CLASSROOM





F.8 REVERBERATION/CLASSROOMS



F.9 REVERBERATION : GYMS/MULTIPURPOSE ROOMS