PROPOSED STATE-OF-THE-ART CRITERIA FOR OFFICE BUILDING ACOUSTICS

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Background

Public Works Canada (PWC) is the federal Department responsible for the provision, management, and operation of Canadian Government office space. PWC owns around 400 buildings, and manages leases for about 4000 others. In recent years, PWC has established a Productive Work Environment Committee, to oversee research and development projects dedicated to the improvement of interior environmental conditions in PWC buildings. One of the initiatives of the Committee has been the development of performance based standards for building acoustics, complemented by prescriptive guidance where appropriate, for use by the Department and its suppliers. This paper reports on the proposed criteria which have been collated and/or developed, including targets for: background noise (upper *and* lower limits); reverberation times; attenuation with distance; speech transmission coefficients; and office isolation. These criteria are presented for open and closed office space, and meeting rooms. Legal requirements are reviewed, and the unique requirements of hearing impaired occupants are also addressed. It is most important that PWC's criteria are realistic, and can be achieved within our existing budgets, expertise, and equipment resources. The implications of these criteria in way of office fit-up are discussed, and in particular the impact that these criteria can have on other interior environmental performance indicators including indoor air quality (IAQ), thermal comfort, and illumination. Specific recommendations are given for ceiling systems, screens and partitions, and office equipment noise levels.

For further information on PWC's Acoustic Strategy, see reference 1.

Legal Requirements

Mandatory requirements for acoustics (noise levels) in federal buildings are defined by the Canada Labour Code and its associated Canadian Occupational Safety and Health Regulations (see reference 2). These were most recently updated in July 91 and include requirements for: investigation of workplace noise levels of 84 dB(A) or over by a qualified individual; noise exposure levels not to exceed prescribed limits; signage to identify high noise areas; training in the correct use of hearing protection devices; and auditory testing of workers who may be exposed to high noise levels with permanent retention of the results on the employee's medical files. Since the primary focus of this paper is on noise levels far below the limits of relevance to this Regulation, no further discussion of these issues is presented herein.

Performance Criteria

Background noise levels for office accommodation have historically been defined by the building industry in terms of maximums not to be exceeded (see reference 3). These limits are appropriate for HVAC system design, but are not able to fully define the background noise levels and spectrum appropriate for office buildings. With the trend towards more open office workstations (PWC's target for the ratio of open to closed offices is 70/30), there is increased attention being given to the subject of speech privacy. This issue is compounded by the additional tendency to smaller workstations: new fit-up typically provides about ten square metres per occupant. PWC is therefore moving towards a background noise *target* (as opposed to only an upper limit), which is based on the spectrum proposed by Dr. L.L. Baranek in reference 4. This type of spectrum is comparable to that proposed by suppliers of sound masking, which is now being included in many of PWC's projects, at the request of our clients. For further information on sound masking see reference 5. With background noise within the target spectrum discussed above, it becomes easy to set targets for the overall level in dB(A): 45 dB(A) in open offices, 40 dB(A) in closed offices; and 35 dB(A) in meeting rooms, executive offices etc. Tolerances of plus minus one dB(A) are typically achievable in buildings with sound masking.

Persons with **hearing impairments** require lower background noise levels for the correct functioning of hearing aids, and thus are better suited to closed offices, or open office areas with lower background noise levels than those listed above. For more information on building acoustics for the hearing impaired, see reference 6.

Reverberation times are typically not a problem for PWC in way of standard office fit-up, however, there have been instances where higher ceiling heights and reduced amounts of sound absorbing surfaces (such as with concrete coffered ceilings), where sound absorption in the open office has been less than satisfactory. PWC therefore specifies that reverberation times are to be less than 0.6 seconds.

Attenuation with distance is of course directly linked to reverberation times, but may in some circumstances be more easy to measure, depending on the equipment resources available. PWC aims to have at least a 4 dB drop per doubling of distance in open office fit-up.

The determination of **speech transmission coefficients** is yet another way that open office acoustic performance can be quantified. PWC aims to provide speech privacy (RASTI scores below 0.3, see reference 7) at distances beyond one workstation removed.

Closed office noise isolation is also becoming an increasingly important issue for our clients, with the trend to smaller offices and lighter weight construction techniques. The basic drywall partition is rated with a Sound Transmission Class (STC) of 35, and thus a Noise Isolation Class (NIC) of at least 25 should be achievable with due care and attention to design and construction details. PWC is moving towards specifying closed office isolation in terms of NIC levels to be achieved: NIC 25 for basic office construction; NIC 35 for enhanced; and NIC 45 for executive offices and other sensitive areas. When levels higher than this are required these are typically dealt with on a case by case basis. For more information on the provision of closed office noise isolation, see reference 8. More detailed definitions of acoustical terms, including STC and NIC, can be found in reference 9.

Good acoustics for **meeting rooms** are particularly important to PWC, in that there is not only the requirement for enhanced acoustic security, but also for the interior finishes to be appropriately selected to provide the acoustics necessary for good

speech communication. PWC currently has a field trial underway to develop a concise guideline on how to evaluate existing meeting rooms and determine what improvements can be economically made to improve upon their acoustical performance.

The National Building Code of Canada requires that "in buildings of assembly occupancy, all classrooms, auditoria, meeting rooms and theatres with an area of more than 100 m^2 shall be equipped with an assistive listening system encompassing the entire seating area" (see reference 10).

Prescriptive Criteria

There is always a danger in specifying prescriptive criteria that a supplier will follow them and fail to meet the required performance criteria. Perhaps the best example of this pitfall is the specification of room isolation in terms of STC instead of NIC. However, it has been found that the provision to suppliers of some indications of fit-up component acoustical performance can be beneficial to guide them in their activities.

PWC uses **carpet** in all office space to dampen footfall and other floor related noises.

Acoustic screens typically provide high levels of noise attenuation: PWC uses a minimum of STC 25 and a Noise Reduction (NR) coefficient of 0.6, as rules of thumb. Most screen suppliers provide products well in excess of these figures. Screens should not be higher than 1.6 metres, because of aesthetic issues to do with lines-of-sight in the workplace. Additionally, field measurements made by PWC have shown that when air velocities in the workplace are at the lower limits of ASHRAE recommended values (see reference 11) that there is benefit to air movement, and thus Indoor Air Quality (IAQ) and thermal comfort in the workplace, if the screens have an air gap beneath them, as opposed to resting fully on the carpet.

Acoustical ceiling tiles are an important component of office fit-up, in that in combination with the screens they are the major absorbers of noise. For closed offices in particular, if the partition only extends to the false ceiling, the ceiling is invariably the weak acoustic link. Higher STC tiles (over STC 35) are therefore required for closed offices to support the NIC targets given above, although for closed offices the tile NR coefficient is of lesser importance. For open offices the reverse is the case: very low STC tiles can be used with little penalty, although a higher NR coefficient, say 0.8, is most beneficial in terms of the provision of the desired speech privacy between workstations.

The light reflectance characteristics of carpeting, screens and the ceiling system should be carefully considered for their contribution to good illumination in the workplace.

Noisy office equipment is perhaps one of the biggest offenders of a good acoustical environment in the open office. Fortunately, with the trend towards laser printers, this problem is becoming less of an issue as time progresses and individual impact type printers are replaced by laser printers shared by a group. Nonetheless, it is important to identify any noisy machines which are required in the open office and group them together in less noise sensitive areas, surrounded by ample screens to absorb their noise as close to the source as possible.

References

1) "Acoustic Strategy: Public Works Canada", Canadian Acoustics, Volume 19, Number 4, Sept 91, pp 27.

2) "Levels of Sound", COSHReg Part VII, July 91.

3) "Sound and Vibration Control", 1991 ASHRAE Handbook HVAC Applications, Chapter 42.

4) "Noise and Vibration Control", edited by L.L. Baranek, published by the Institute of Noise Control Engineering in 1989, pp 594, figure 18.16.

5) "Sound Masking Systems: A Guideline", Canadian Acoustics, Volume 20, Number 4, Dec 1992, pp 17.

6) "Acoustical Guidelines for the Hearing Impaired", Public Works Canada, 1992.

7) Bruel and Kjær Type 3361 Speech Transmission Meter equipment manual (RASTI system).

8) "Acoustical Guidelines for High Security Spaces", Public Works Canada, 1992.

9) "Standard Terminology Relating to Environmental Acoustics", ASTM C 634 - 89.

10) National Building Code of Canada, 1990, with revisions and errata to Jan 93, section 3.7.3.7 "Assistive Listening Devices".

11) "Thermal Environmental Conditions for Human Occupancy", ASHRAE Standard 55-1992.