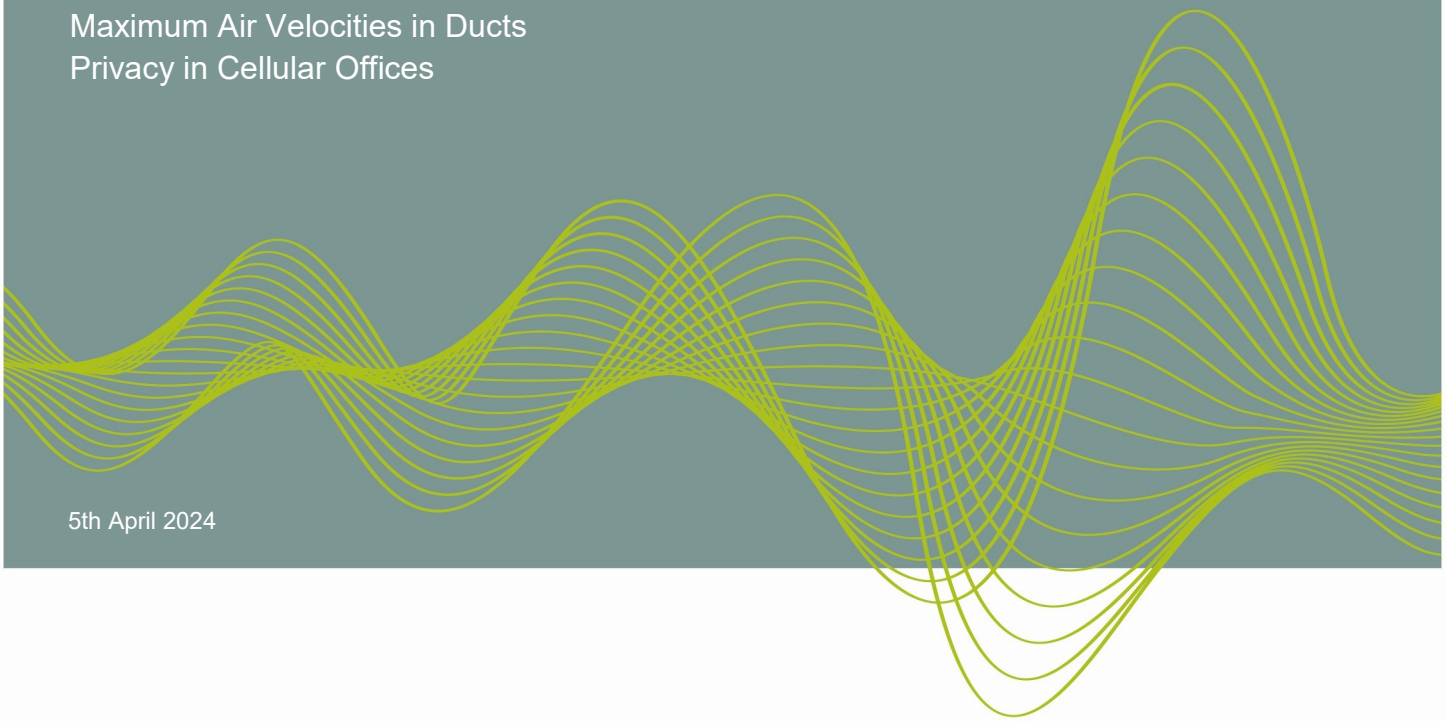
caice
Acoustic Air Movement Ltd

Acoustic Design Guide

NR and NC Curves
CIBSE Noise Ratings
Environmental Noise Control
Maximum Air Velocities in Ducts
Privacy in Cellular Offices



5th April 2024

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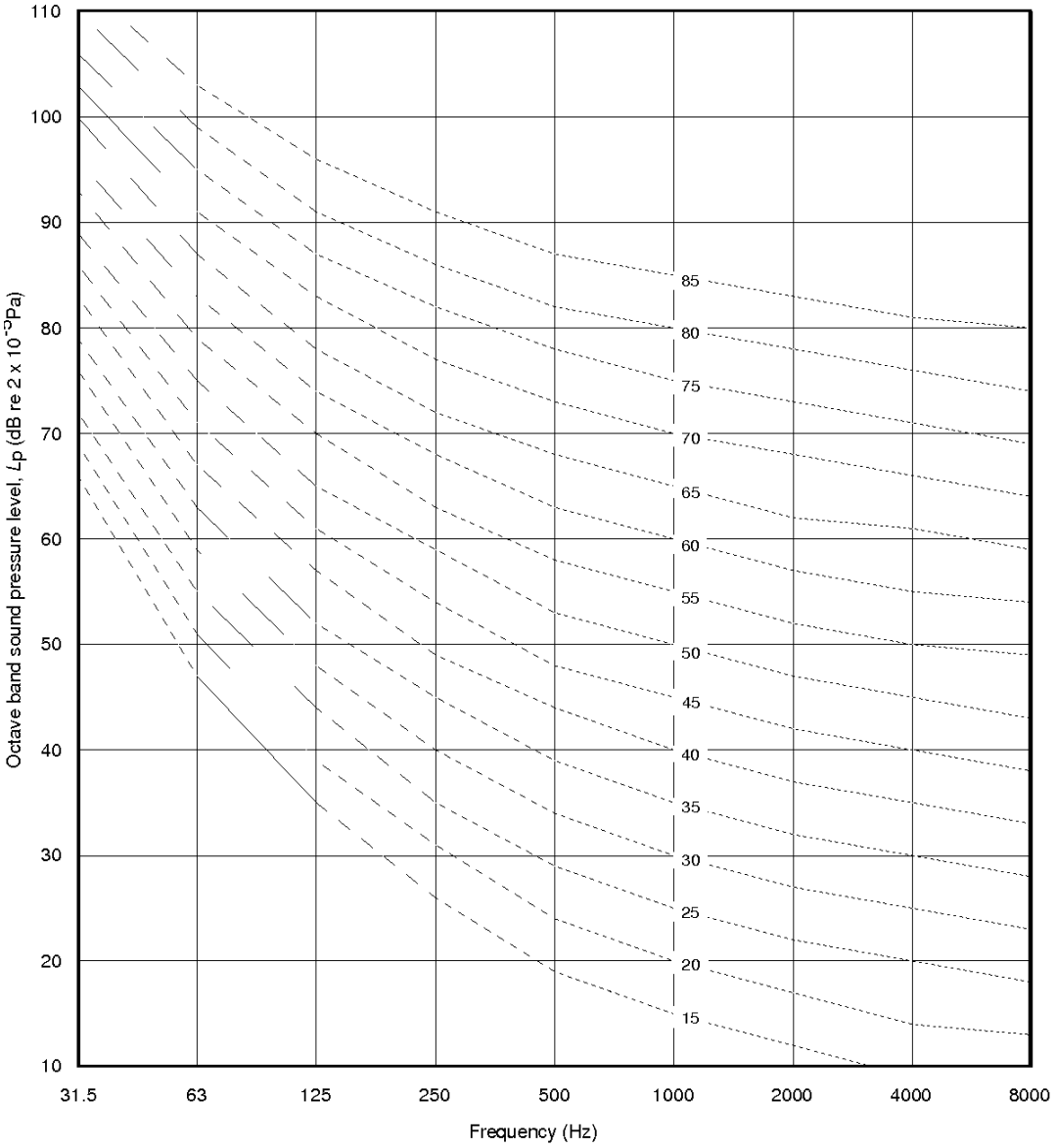
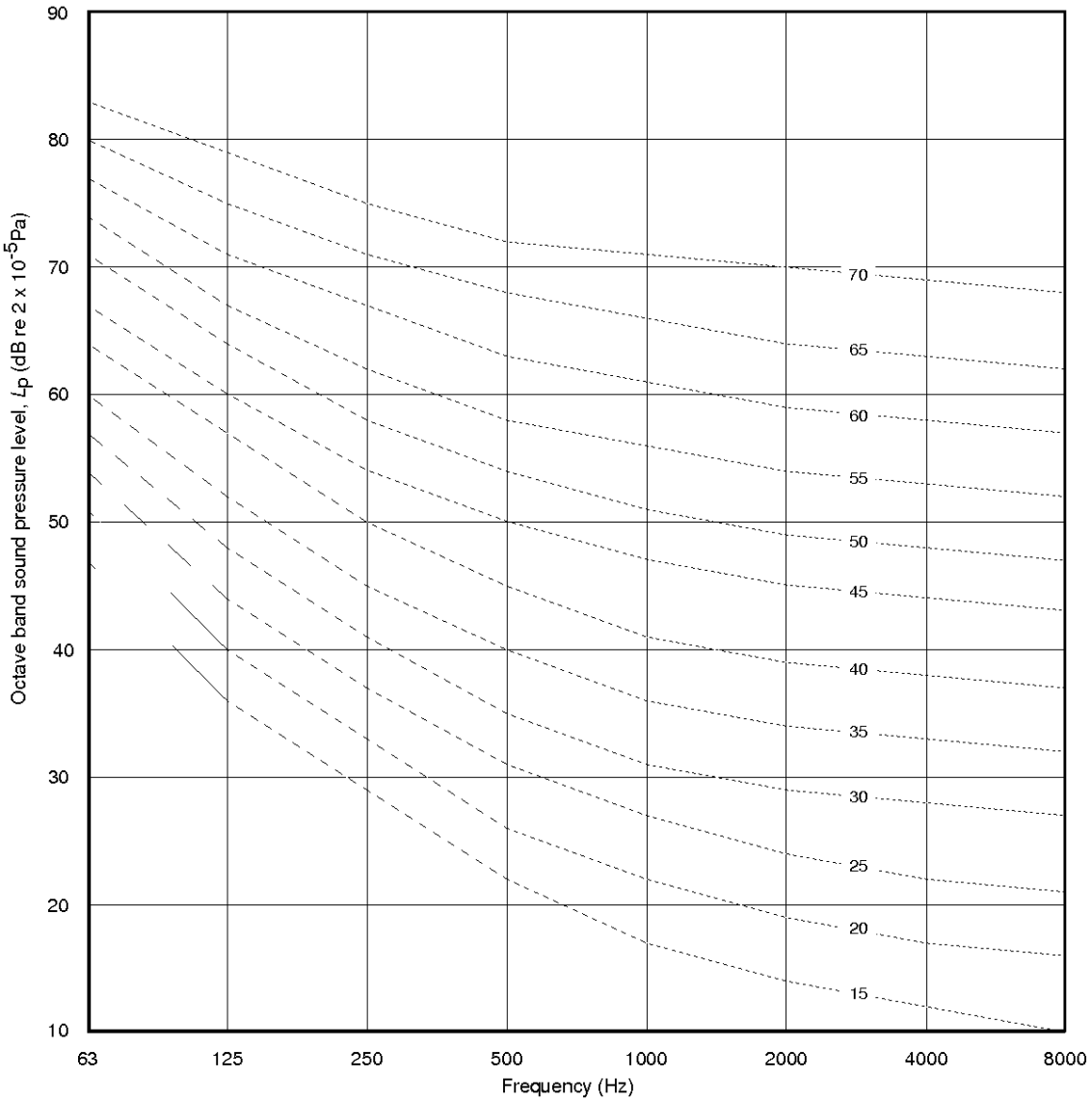
NR Curves and Table



FREQUENCY	31.5	63	125	250	500	1000	2000	4000	8000	Hz
NR85	113	103	96	91	87	85	83	81	80	dB
NR80	110	99	91	86	82	80	78	76	74	dB
NR75	106	95	87	82	78	75	73	71	69	dB
NR70	103	91	83	77	73	70	68	66	64	dB
NR65	100	87	78	72	68	65	62	61	59	dB
NR60	96	83	74	68	63	60	57	55	54	dB
NR55	93	79	70	63	58	55	52	50	49	dB
NR50	89	75	65	59	53	50	47	45	43	dB
NR45	86	71	61	54	48	45	42	40	38	dB
NR40	83	67	57	49	44	40	37	35	33	dB
NR35	79	63	52	45	39	35	32	30	28	dB
NR30	76	59	48	40	34	30	27	25	23	dB
NR25	72	55	44	35	29	25	22	20	18	dB
NR20	69	51	39	31	24	20	17	14	13	dB
NR15	66	47	35	26	19	15	12	9	7	dB

NC Curves and Table



FREQUENCY	63	125	250	500	1000	2000	4000	8000	Hz
NC70	83	79	75	72	71	70	69	68	dB
NC65	80	75	71	68	66	64	63	62	dB
NC60	77	71	67	63	61	59	58	57	dB
NC55	74	67	62	58	56	54	53	52	dB
NC50	71	64	58	54	51	49	48	47	dB
NC45	67	60	54	49	46	44	43	42	dB
NC40	64	57	50	45	41	39	38	37	dB
NC35	60	52	45	40	36	34	33	32	dB
NC30	57	48	41	35	31	29	28	27	dB
NC25	54	44	37	31	27	24	22	21	dB
NC20	51	40	33	26	22	19	17	16	dB
NC15	47	36	29	22	17	14	12	11	dB

CIBSE Noise Ratings

Situation	NR Value
Concert halls, opera halls, studios for sound reproduction, live theatres (>500 seats).	20
Bedrooms in private homes, live theatres (<500 seats), cathedrals and large churches, television studios, large conference and lecture rooms (>50 people).	25
Living rooms in private homes, board rooms, top management offices, conference and lecture rooms (20-50 people), multi-purpose halls, churches (medium and small), libraries, bedrooms in hotels, etc., banqueting rooms, operating theatres, cinemas, hospital private rooms, large courtrooms.	30
Public rooms in hotels, etc., ballrooms, hospital open wards, middle management and small offices, small conference and lecture rooms (<20 people), school classrooms, small courtrooms, museums, libraries, banking halls, small restaurants, cocktail bars, quality shops.	35
Toilets and washrooms, drawing offices, reception areas (offices), halls, corridors, lobbies in hotels, etc., laboratories, recreation rooms, post offices, large restaurants, bars and night clubs, department stores, shops, gymnasia.	40
Kitchens in hotels, hospitals, etc., laundry rooms, computer rooms, accounting machine rooms, cafeteria, canteens, supermarkets, swimming pools, covered garages in hotels, offices, etc., bowling alleys, landscaped offices.	45

NR50 and above:

NR50 will generally be regarded as very noisy by sedentary workers but most of the classifications listed under NR45 could just accept NR50. Higher noise levels than NR50 will be justified in certain manufacturing areas; such cases must be judged on their own merits.

Notes:

1. The ratings listed above will give general guidance for total services noise but limited adjustment of certain of these criteria may be appropriate in some applications.
2. The intrusion of high external noise levels may, if continuous during occupation, permit relaxation of the standards but services noise should be not less than 5 dB below the minimum intruding noise in any octave band to avoid adding a significant new noise source to the area.
3. Where more than one noise source is present it is the aggregate noise which should meet the criterion.
4. NR is approximately equal to dB(A) value - 6.

The table is reproduced from the CIBSE guide, section A1: Environmental criteria for design (1986) with the permission of the CIBSE, London.

Environmental Noise Control

For the building services designer there is a need to appreciate a method by which environmental noise can be monitored and assessed. With this information, the designer can agree limits with the Local Authority Environmental Health or Planning Officer at the boundary of the development, or at the nearest residential or commercial properties. If required, noise control measures can be implemented such as plant attenuation or the setting of limiting noise levels for specific plant and equipment.

BS 4142:2014 "Methods for rating and assessing industrial and commercial sound"
This standard can be used as a method of determining the level of a noise applicable to a development site, whether new build or the refurbishment of an existing building.

Measuring environmental noise generally in accordance with BS 4142:2014

The specific sound level is the equivalent continuous A-weighted sound pressure level produced by the specific sound source at the assessment location over a given reference time interval, T_r. For existing noise sources, the specific sound level is usually determined by direct measurement. If the specific sound source is not yet in operation, the specific sound level may be determined by calculation or by measurement of an existing "similar" type of source.

The background sound level is defined as the A-weighted sound pressure level that is exceeded by the residual sound at the assessment location for 90% of a given time interval, T. The background sound level is measured in the absence of the specific noise source, over a representative period of the plant's actual/proposed operation. Measurements are normally made at the assessment location, although where this is not possible measurements can be made at another position which is assumed to be equivalent.

Certain acoustic features can increase the significance of impact over that expected from a basic comparison between the specific sound level and the background sound level. The specific sound level should be corrected if tonality, impulsivity, intermittency, or other sound characteristics are present. Different correction values between 2dB and 9dB are added depending on whether the above characteristics are just perceptible or highly perceptible. Typically, the total acoustic feature correction would not be expected to exceed 10dB. The addition of the corrections to the specific sound level gives the rating level, applicable at the assessment location.

Assessing the significance of impact

The Local Authority Planning or Environmental Health department often have standard conditions relating to mechanical plant noise emissions, and these usually form an appropriate basis for design. In the absence of specific Local Authority guidance, BS 4142 gives advice on the significance of impact. Typically, the greater the difference between the rating level of the specific sound source and the background sound level (and the context in which the sound occurs), the greater the magnitude of the impact as follows:

- A difference of around +10 dB or more is likely to be an indication of a significant adverse impact, depending on the context.
- A difference of around +5 dB is likely to be an indication of an adverse impact, depending on the context.
- The lower the rating level is relative to the measured background sound level, the less likely it is that the specific sound source will have an adverse impact or a significant adverse impact. Where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact, depending on the context.

Maximum Air Velocities in Ducts

When considering the acoustic design of a ventilation or air conditioning system, it is important to take into account noise generated by sources other than main air handling plant. This data sheet specifically considers flow generated noise and proposes guidelines for maximum duct velocities relative to noise criteria.

Noise generation elements can be considered under two headings.

Elements producing secondary noise energy into the duct

Duct Runs	Dampers
Bends	Transformations
Tie Rods	Proprietary Fittings
Branches	

Terminal Units

Grilles	Diffusers
VCDs	Proprietary Fittings

To minimise the risk of generated noise, we would suggest that the following maximum duct velocities should be adhered to.

Maximum Duct Velocities (m/s)					
NR Design Levels	Risers	Main Branches	Ductwork To Grilles	Ductwork To Diffusers	Extract Stub Ducts(above ceiling voids)
25	5	3	1.5	1	1.5
30	6	4	2	1.5	2
35	7.5	5	2.5	2	3
38	9	5.5	2.5	2	3.5
40 & above	10	6	3	2.5	4

The above figures are only intended as a guide. The position of the duct relative to the ventilated or air-conditioned space and the geometry of the fittings etc. will determine whether increased or reduced air velocities are acceptable.

Grilles and diffusers should be carefully selected from the manufacturers' catalogue so that they are compatible with the appropriate noise criteria. In addition it should be noted that the choice of individual grilles and diffusers may be affected by their quantity within the room. For example, if there are four diffusers in a room, the NR criterion for each diffuser will need to be 6dB lower than the required NR criterion for the room to allow for the noise generated by each diffuser.

Where ventilation or air-conditioning systems are required to meet noise levels of NR25 or below we would recommend that the services of an Acoustic Consultant be sought.

Privacy in Cellular Offices

A Background to Privacy

What is privacy?

The isolation of normal or raised speech produced in one room from possible listeners in another room.

What main factors determine privacy?

1. The voice level of the person speaking within the source room.

2. The background noise level within the receiving room.

3. The noise reduction of the building structure between the rooms.

Selecting an appropriate privacy criterion or rating

The table below shows privacy criteria in terms of speech intelligibility, with a corresponding privacy rating. The index values shown are calculated by adding the required Noise Rating (NR) level within the receiving room to the average dB noise reduction of the building structure between the two rooms.

Privacy Criteria	Privacy Rating	Index
Intelligible	Low	Below 75dB
Between intelligible and unintelligible	Medium	75 to 80 dB
Unintelligible	High	80 to 90 dB
Inaudible	Very High	Above 90 dB

For example to achieve a high privacy rating when the receiving room background noise level is NR40, the building structure must provide an average noise reduction of between 40 and 50dB.

Speech levels

The index values shown in the table assume normal speech noise levels. Add 6dB if the criteria are to be achieved based on raised speech.

Selecting a suitable building structure

The table below shows a range of average room-to-room noise reductions for different types of building structure.

Building Structure Between Rooms	Average Noise Reduction
Budget demountable partitioning and suspended ceiling	Below 35 dB
Quality demountable partitioning and suspended ceiling	35 to 40 dB
Full height standard studded plasterboard partition-ing	40 to 50 dB
Full height jumbo studded plasterboard partitioning	50 to 55 dB
Full height single leaf dense block wall	50 to 55 dB

Eliminating noise flanking paths

Noise reduction performance of structures will be undermined, unless noise flanking paths, such as those listed below, are eliminated.

- Doors and door seals
- Glazed sections within demountable partitioning
- Demountable partition joint to the suspended ceiling
- Apertures in the suspended ceiling, such as grilles, etc

Privacy in Cellular Offices

Medium privacy in cellular offices

Medium privacy is normally acceptable for cellular offices, and two methods for achieving this are shown, based on the following:

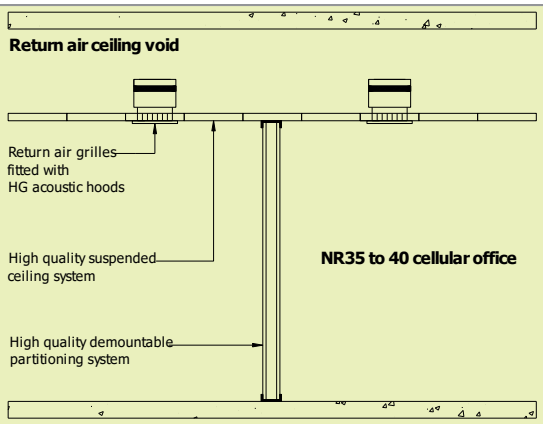
- Demountable partitioning system
- Suspended ceiling system
- Void mounted fan coil units (omitted from drawings for clarity)
- Return air ceiling void
- Background noise level of NR35 to 40

Before selecting one of these methods the following factors should be considered:

- Will the office layout change or is it fixed?
- Is it a new or existing building?
- How many cellular offices are there?
- Which method would be easier to install?
- Which would be most cost effective?

Method 1 - Cellular offices with maximum flexibility and medium privacy

- Ideal for new build if office layouts may change
- Partitions can be moved without affecting privacy
- HG acoustic hoods protect all ceiling apertures
- Return air ceiling void remains clear
- Simple installation makes privacy easy to achieve



This method utilises HG acoustic hoods, which are detailed in the CAICE Acoustic Hood data sheet. In addition high quality demountable partitioning and suspended ceiling systems are incorporated throughout the office.

Hoods should be fitted to the rear of all ceiling penetrations, such as return air grilles, diffusers or luminaires, to ensure that the acoustic integrity of the ceiling system is maintained.

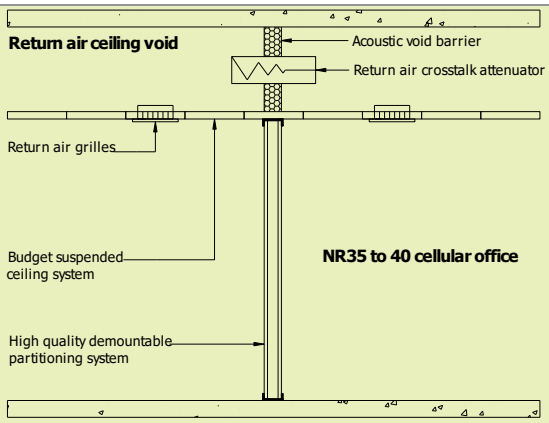
The major benefit of this method is that the demountable partitions can be moved to modify the size and position of the cellular offices, without affecting privacy.

To achieve medium privacy a 40dB (R'w) partition system and a 40dB (Dncw) ceiling system should be used as a minimum.

Privacy in Cellular Offices

Method 2 - Cellular offices with medium privacy and limited flexibility

- Ideal for existing offices where layout is fixed
- Acoustic void barriers required above partitions
- Existing partitions and ceiling may be retained
- Crosstalk attenuators protect return air path
- Void barrier enables budget ceiling to be used



This method utilises acoustic void barriers, penetrated by return air crosstalk attenuators. Although high quality partitioning is still required, a budget ceiling system can be used, as noise between adjacent rooms has to pass through the ceiling and the void barrier.

This method is ideal where the office layout is fixed, or where only a few cellular offices are located within a large office area. However it may not be suitable for new buildings with many cellular offices, where the layouts are subject to change.

This is because the void barriers must be moved in conjunction with the partitions.

To achieve medium privacy a 40dB (R'w) partition system, a 32dB (Dncw) ceiling system, and a 35dB (R'w) void barrier shoud be used.

Typically the return air crosstalk attenuator should be 900mm long, with an average insertion loss of 30dB between 500 and 4000Hz.

Privacy in Cellular Offices

High Privacy in Cellular Offices

High privacy would only normally be required for cellular offices if they were being used for sensitive or confidential discussions.

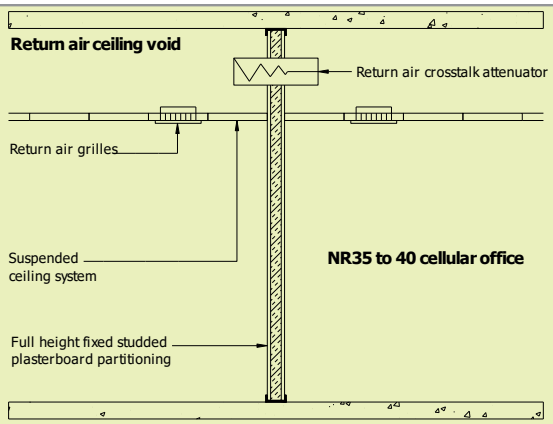
For example a conference room, a board room, an interview room, etc, may all need a higher degree of privacy, but it is difficult to achieve this with demountable partitioning systems.

This method is therefore based on cellular offices with full height studded plasterboard partitioning, which should achieve 50dB (R'w).

However because the partitioning is fixed, there is limited flexibility to subsequently change the office layouts.

Cellular Offices with high privacy but limited flexibility

- Layout of cellular offices is fixed
- Plasterboard partition must be full height
- Crosstalk attenuators protect return air path
- Partition enables budget ceiling to be used



Ceiling acoustic performance is not critical, as the noise reduction between rooms is provided by the full height partition. Typically the return air crosstalk attenuator should be 1200mm long, with an average insertion loss of 40dB between 500 and 4000Hz..

Details on rectangular and circular attenuators suitable for crosstalk applications can be found in the CAICE Attenuator Brochure.

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