# FAN COIL ACOUSTICS

# BEST PRACTICE

Nov 2009

HEVAC

# CONTENTS

# FAN COIL TESTING

Factory ‘type’ testing is carried out in accordance with :

BS 4856-4:1997 Methods for testing and rating fan coil units, unit heaters and unit coolers. Determination of sound power levels of fan coil units, unit heaters and unit coolers using reverberating rooms.

The FCU is mounted within a reverberant chamber and ducted via spiral ducting in to another chamber.

The room Background and Reverberant time is measured across the octave centre frequencies (usually 63Hz, 125Hz, 250Hz, 500Hz, 1KHz, 2KHz, 4KHz and 8KHz).

The unit is switched on and the voltage to the fan is controlled remotely. The air velocity is measured using a pitot tube traverse in each duct to determine the total air volume.

The external pressure is regulated via dampers on the air inlet or discharge of the reverberant chamber.
The voltage and dampers are varied to achieve the desired air volume against design external pressure.

The sound pressure levels (SPL) are measured at the above frequencies. The Inlet/Casing Radiated Sound Power Level (SWL) in one chamber and Discharge SWL in the other can then be calculated.

# FAN COIL ACOUSTICS - INTRODUCTION

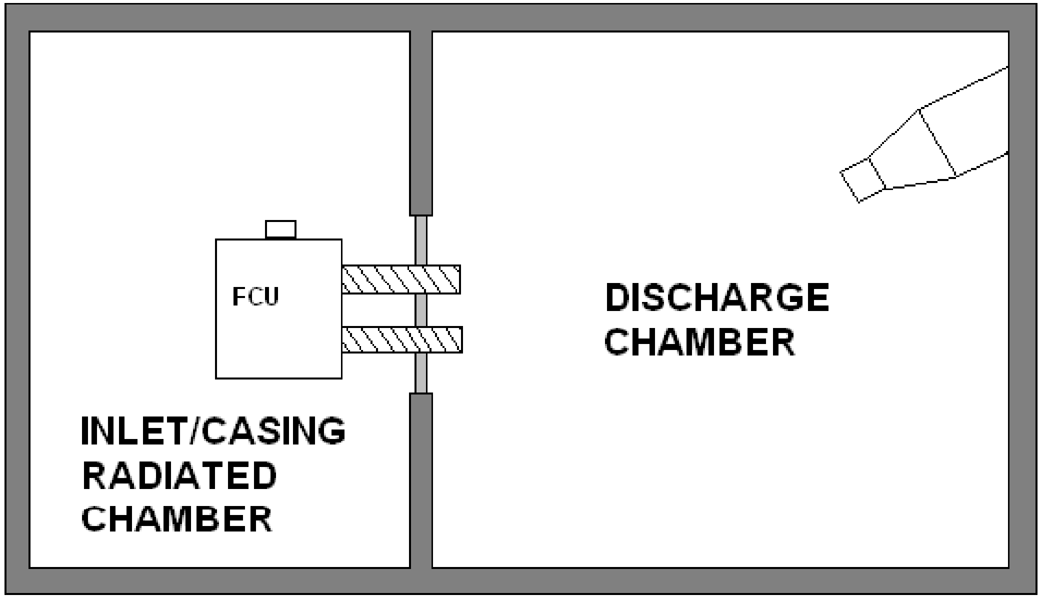
Fan coil manufacturers manufacture fan coils, they do not make or install ductwork, grilles, diffusers or ceilings – the other components that are critical to system noise. However, in selling fan coils, it has become common practice for fan coil manufacturers to specify acoustic installation requirements, and base installation noise predictions on that specification. It is therefore important that the key aspects of a complete system are widely understood and correctly applied on site.

The purpose of this document is to highlight those system components, the effect they can have, and the associated pitfalls that can occur, especially in relation to small scale projects.

Key points to note are:

- THERE IS NO INDUSTRY STANDARD FOR NR PREDICTIONS.
- ACOUSTIC ASSUMPTIONS HAVE TO BE MADE WHICH AFFECT THE SPECIFICATION OF OTHER EQUIPMENT/SUBCONTRACT WORK.
- THE SPACING OF THE UNITS AFFECTS THE RESULTING NOISE LEVEL
- CEILING ATTENUATION IS CRUCIAL
- DISCHARGE DUCT ATTENUATION IS MORE IMPORTANT THAN INLET ATTENUATION
- THE FABRIC OF THE SERVED ENVIRONMENT AFFECTS THE RESULTING NOISE LEVEL

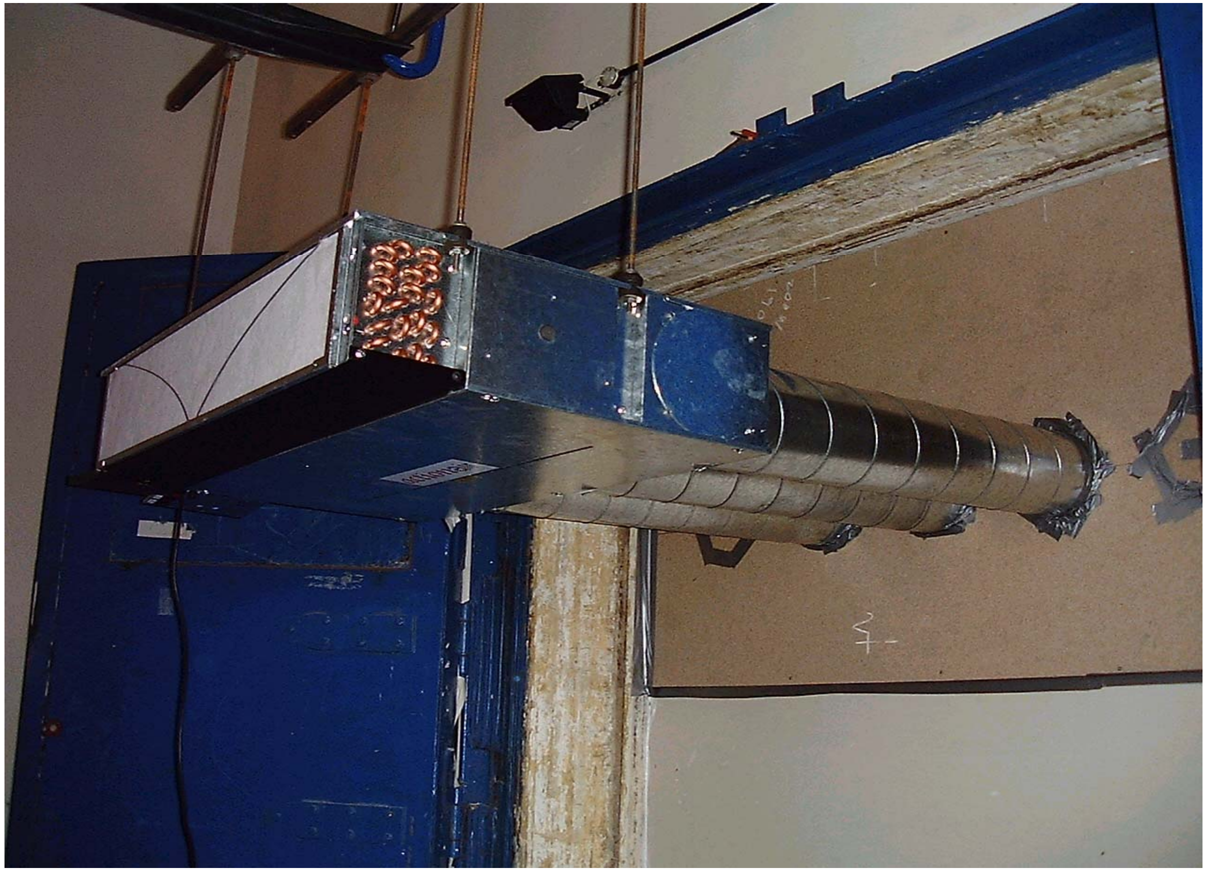
# Layout of Reverberant Chamber




TEST CHAMBER

HEVAC

Fan Coil Noise Test Installation – Inlet and Casing Radiated sound measurement



Fan Coil Noise Test Installation – Discharge sound measurement

HEVAC

# INSTALLATION FEATURES AND THE EFFECT ON RESULTANT NOISE

The installation built up over the next few pages is a horizontal ceiling slab suspended fan coil unit in a cellular office. The unit is installed with circular discharge duct, rectangular plenum and linear slot diffuser. The office walls and floor are initially hard surfaces, and subsequently carpets and other softening items are introduced. The suspended ceiling system is a 600mm square grid with fibre or insulated metal pan tiles. Correct and incorrect return air path design is indicated. Along the way, common pitfalls are identified in the panel on the right of the page.

The stated NR noise levels are for comparison before and after the addition of system components, and actual NR values will vary depending on other variables such as the design and selection of the fan coil and the size/shape of the room.

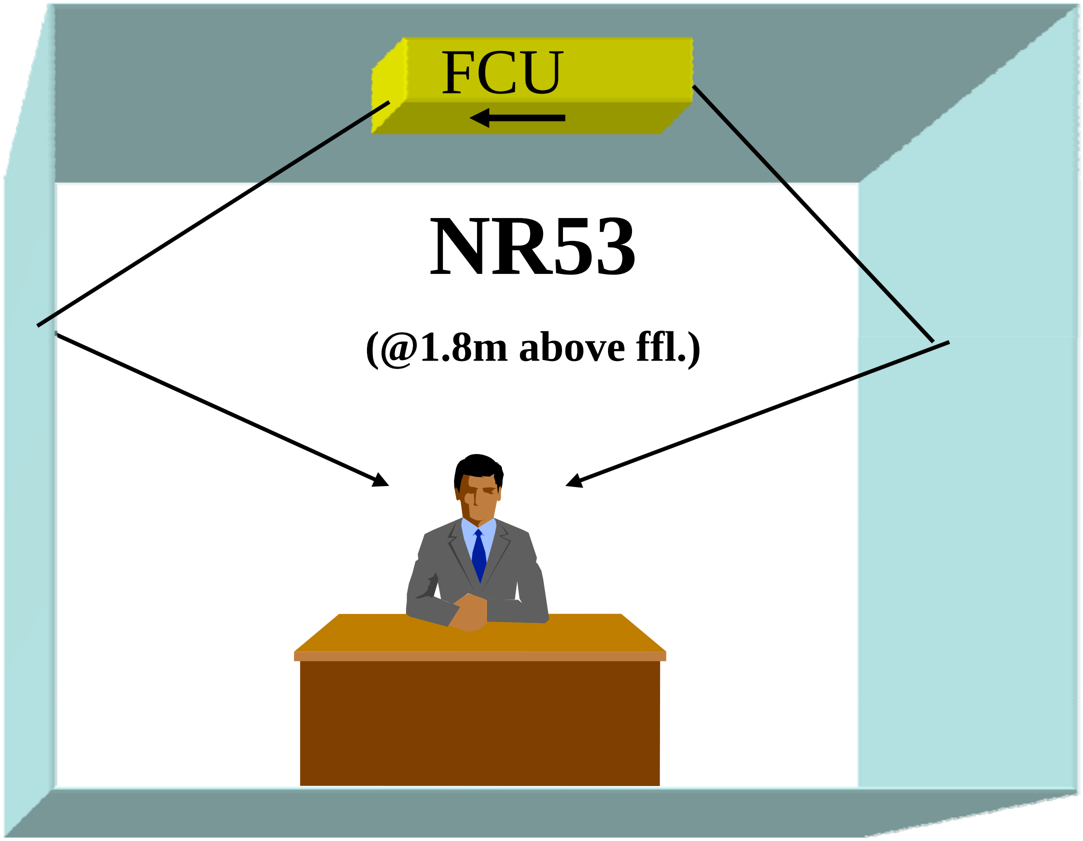
**Multiple Sound Sources**

The more dominant noise sources are indicated in each view. As a rule of thumb, two noise sources of the same magnitude and frequency characteristic, experienced very near to each other, will add together to produce a resultant level 3db higher than the greater of the two noises. This is true for two fan coils very close together, and to a lesser extent for two sources – inlet and outlet - from one fan coil.

For two noises which differ by 5db, the resultant is 1db greater than the loudest original source.

For two noises which differ by 10db, only the greater noise source is experienced.

# NR PREDICTION – 1 CHASSIS UNIT FIXED TO SLAB (HARD ROOM 6m x 6m x 3.2m h)




FCU @ 240 l/s 30 pa
No Room absorption
No Ductwork
No Ceiling

To demonstrate how the different components affect the finished NR level , we have built a room, and then add attenuating items one at a time.When we calculate what the NR level will be without room absorption, ductwork or ceiling, the result is a very high NR53 when measured at head height

## WATCH OUT FOR

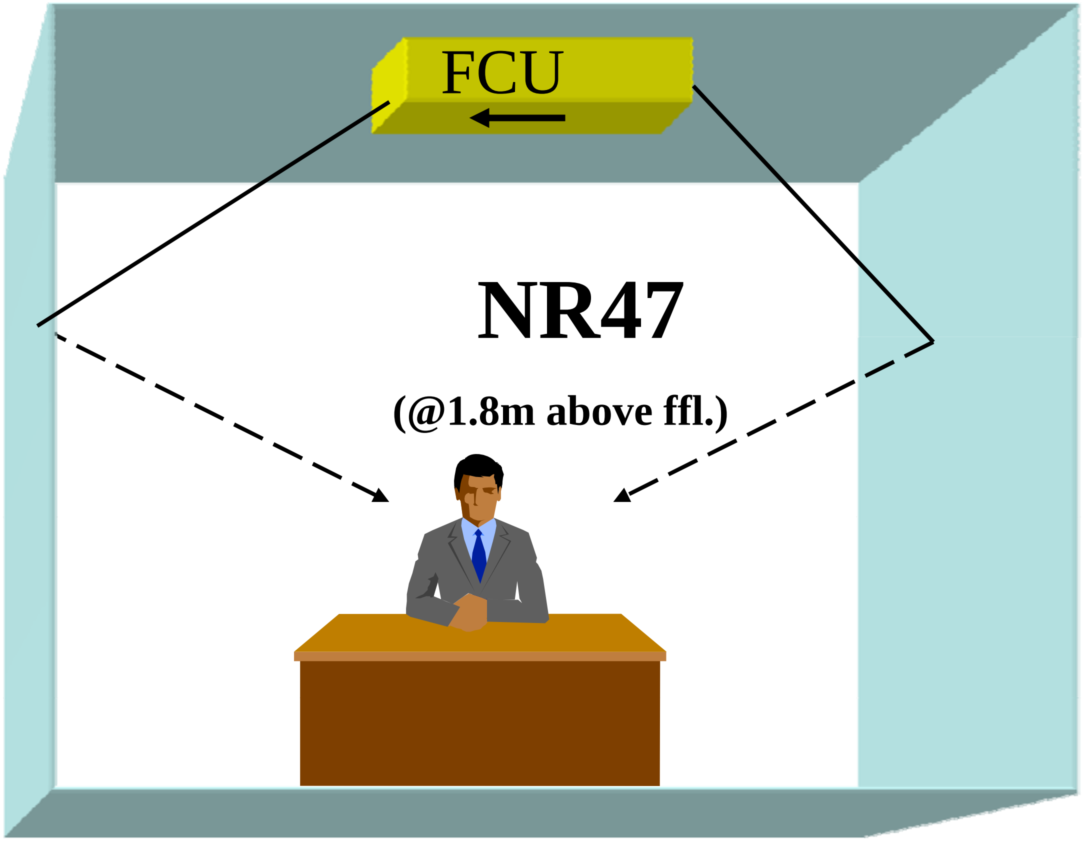
Hard faced walls and floors, large areas of glazing.

Adjacent similar noise sources add together.

All FCU in a common space should be a similar noise selection, or the loudest might annoy, even if within specification.

HEVAC

NR PREDICTION 2– CHASSIS UNIT FIXED TO SLAB ( FURNISHED ROOM 6m x 6m x 3.2m h)




WATCH OUT FOR

Dirty filters at time of commissioning.

Higher fan voltage = higher noise.

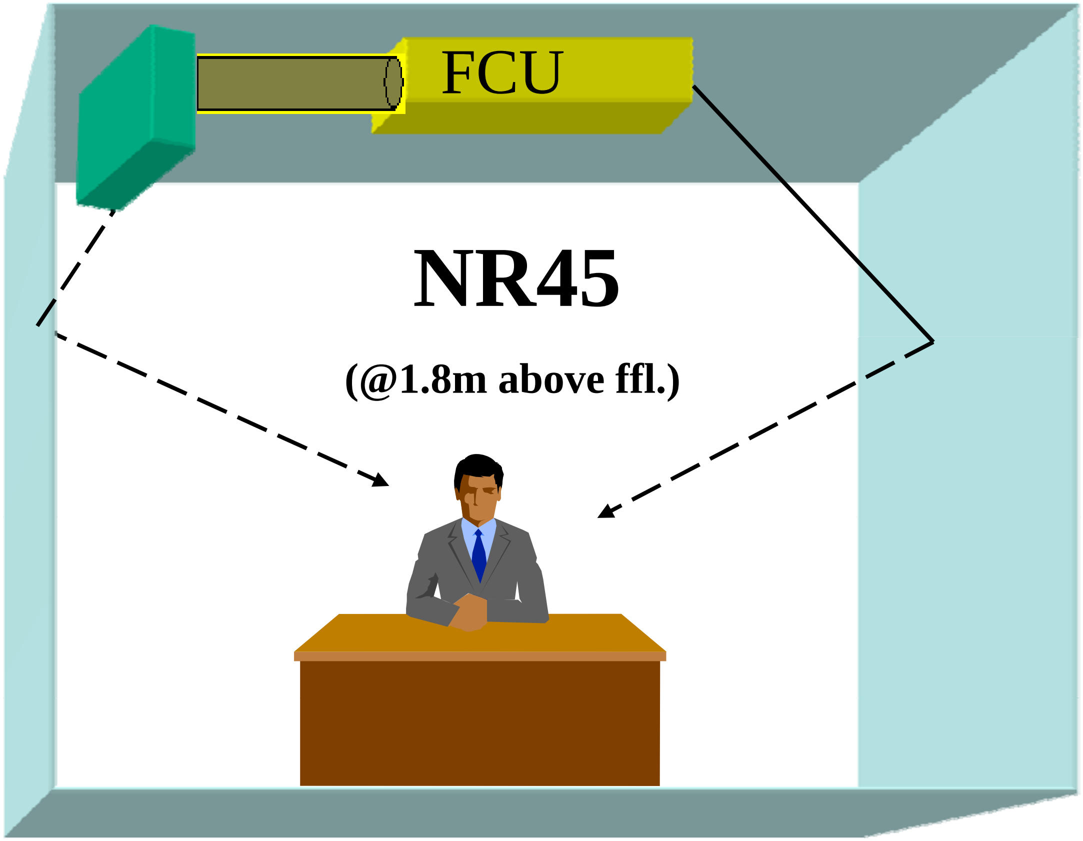
Other sound sources – fresh air duct, external noise and other plant generated noise.

FCU @ 240 l/s 30 pa
With Room absorption
No Ductwork
No Ceiling

Room Absorption (or room effect) resulting from softer surfaces such as carpet, blinds, fixtures and fittings, can reduce the noise level experienced by 6NR

HEVAC

# NR PREDICTION – 3 CHASSIS FIXED TO SLAB WITH ACOUSTIC DISCHARGE DUCTWORK




FCU @ 240 l/s 30 pa
With Room absorption
1 m of Acoustic Ductwork,
Plenum & Grille
No Ceiling

If 1m of acoustic flex and a diffuser is added then a further 2NR comes off the noise level. However all this is doing is attenuating the discharge side of the unit, the dominant noise level is coming from the open casing and inlet of the FCU.

## WATCH OUT FOR

Duct leaks and poor air measurement technique, resulting in fans moving more air than is apparent.

Duct leaks also allow noise to bypass attenuating components, and generate high frequency noise.

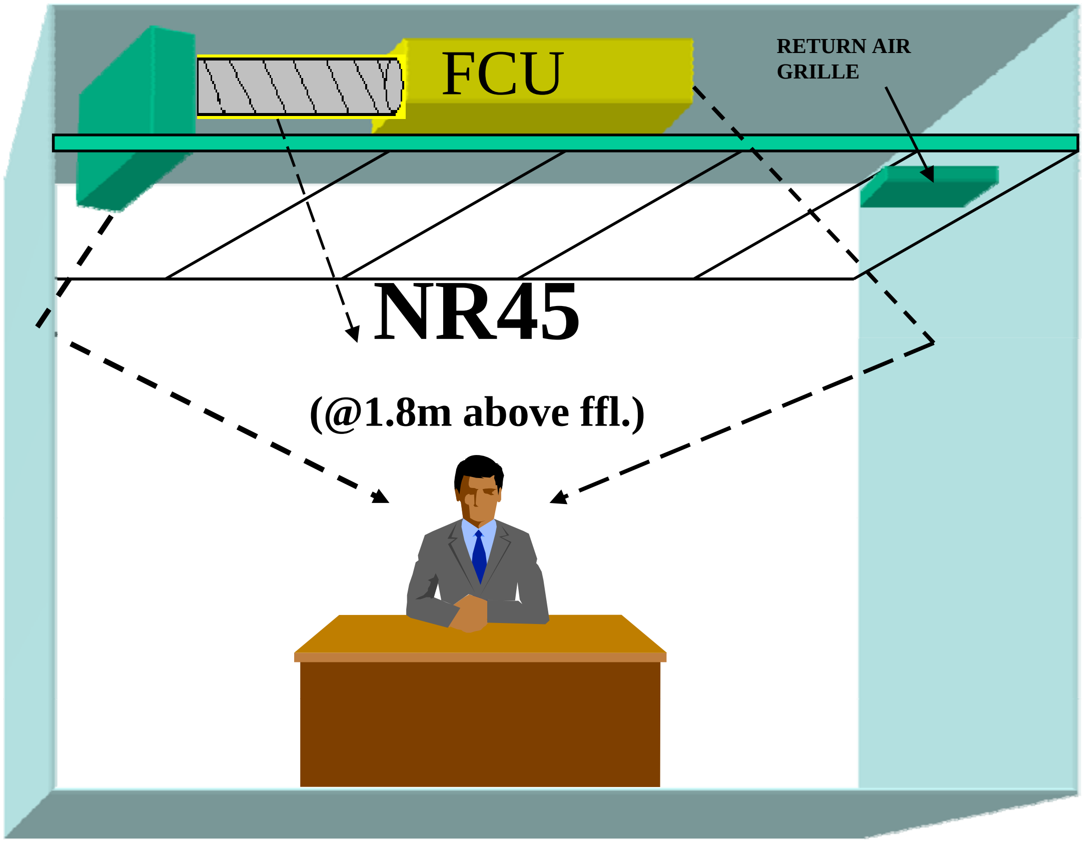
Quantity of duct connections sufficient for total air volume, recommended duct velocity of 3 m/s.

Duct length causing excessive pressure drop.

Volume commissioning should be achieved with fan speed voltage, not with discharge dampers

Higher fan voltage ⇒ higher noise.

NR PREDICTION – 4 CHASSIS UNIT MOUNTED ABOVE A FALSE CEILING WITH SPIRAL DISCHARGE DUCTWORK




FCU @ 240 l/s 30 pa
With room absorption
1 m of spiral ductwork, plenum & grille
With 10mm insulated pan tile ceiling.

To demonstrate that both ends of the fan coil need attenuating, we have now installed a false ceiling with insulated pads above each tile, this provides a good level of attenuation to the Casing/Inlet of the FCU, however we have swapped the acoustic flex for spiral, this has little or no attenuation properties and allows noise transmission through the duct wall.The result is a still unacceptable NR45.

WATCH OUT FOR

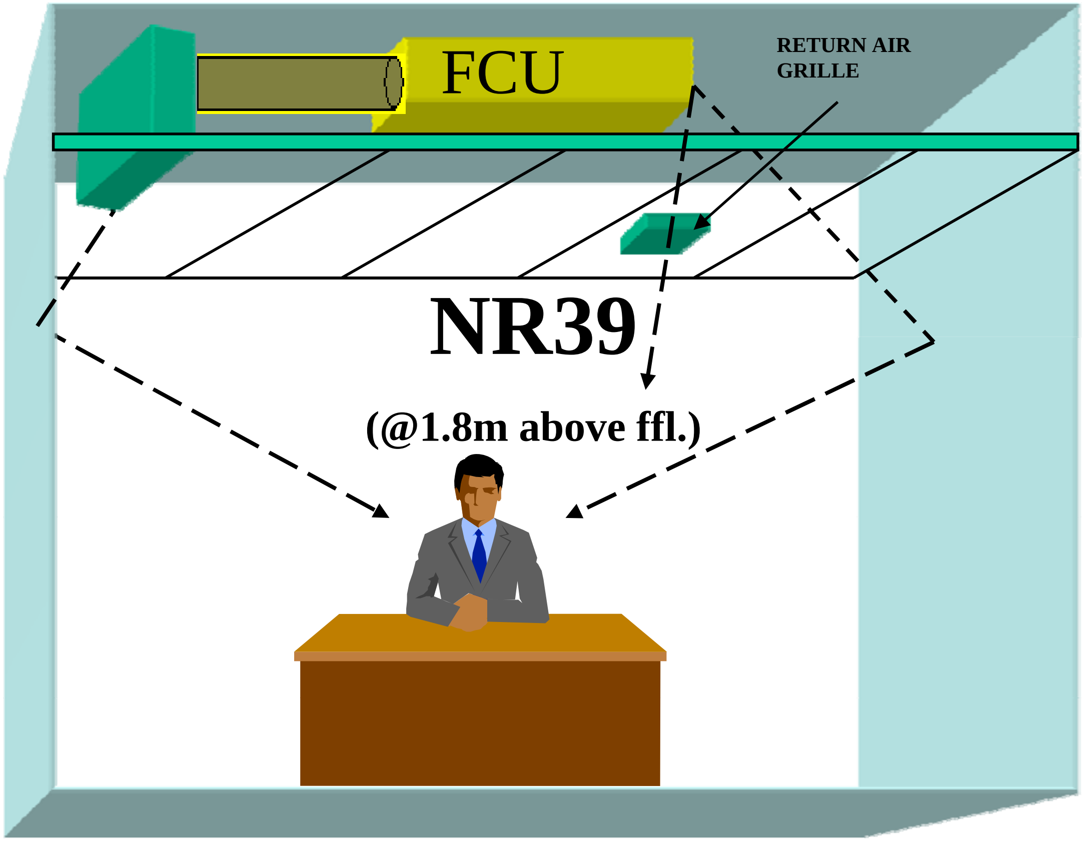
Noise breakout through duct wall.

Poor plenum air entry design generating noise.

Un-insulated plenums installed, where design is based on insulated ones.

HEVAC

NR PREDICTION - 5 CHASSIS UNIT MOUNTED ABOVE A FALSE CEILING WITH ACOUSTIC FLEX DISCHARGE DUCTWORK (POOR RETURN AIR POSITION)




WATCH OUT FOR

Return air grille too close to fan coil inlet, allowing direct transmission of casing/inlet noise.

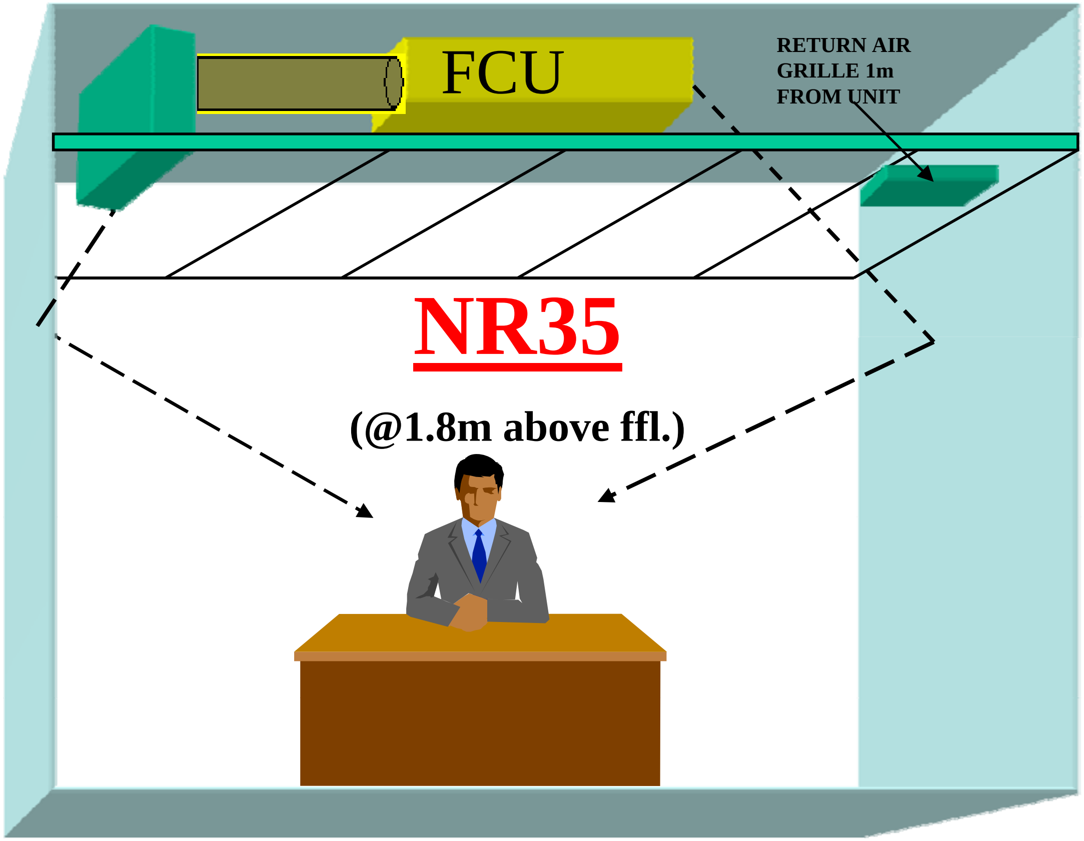
Inadequate return air path area causing extra fan effort.

FCU @ 240 l/s 30 pa
With room absorption
1 m of acoustic ductwork, plenum & grille.
With insulated metal pan ceiling.

An inadequate return air grille (causing increased fan effort) placed immediately under the unit inlet allowing direct transmission of noise also returns the room to unacceptable NR levels.

HEVAC

## NR PREDICTION – 6 CHASSIS UNIT MOUNTED ABOVE A FALSE CEILING WITH ACOUSTIC DISCHARGE DUCTWORK – RECOMMENDED INSTALLATION




FCU @ 240 l/s 30 pa
With room absorption
1 m of acoustic ductwork, plenum & grille.
With 10mm insulated pan tile ceiling.

Once the inlet and casing of the unit is attenuated by the ceiling, the measured NR comes down to an acceptable level. This is because both sides of the unit are now acoustically treated.

The example ceiling has an insulated metal pan tile ceiling, but the same figures can be used for fibre board tiles

### WATCH OUT FOR

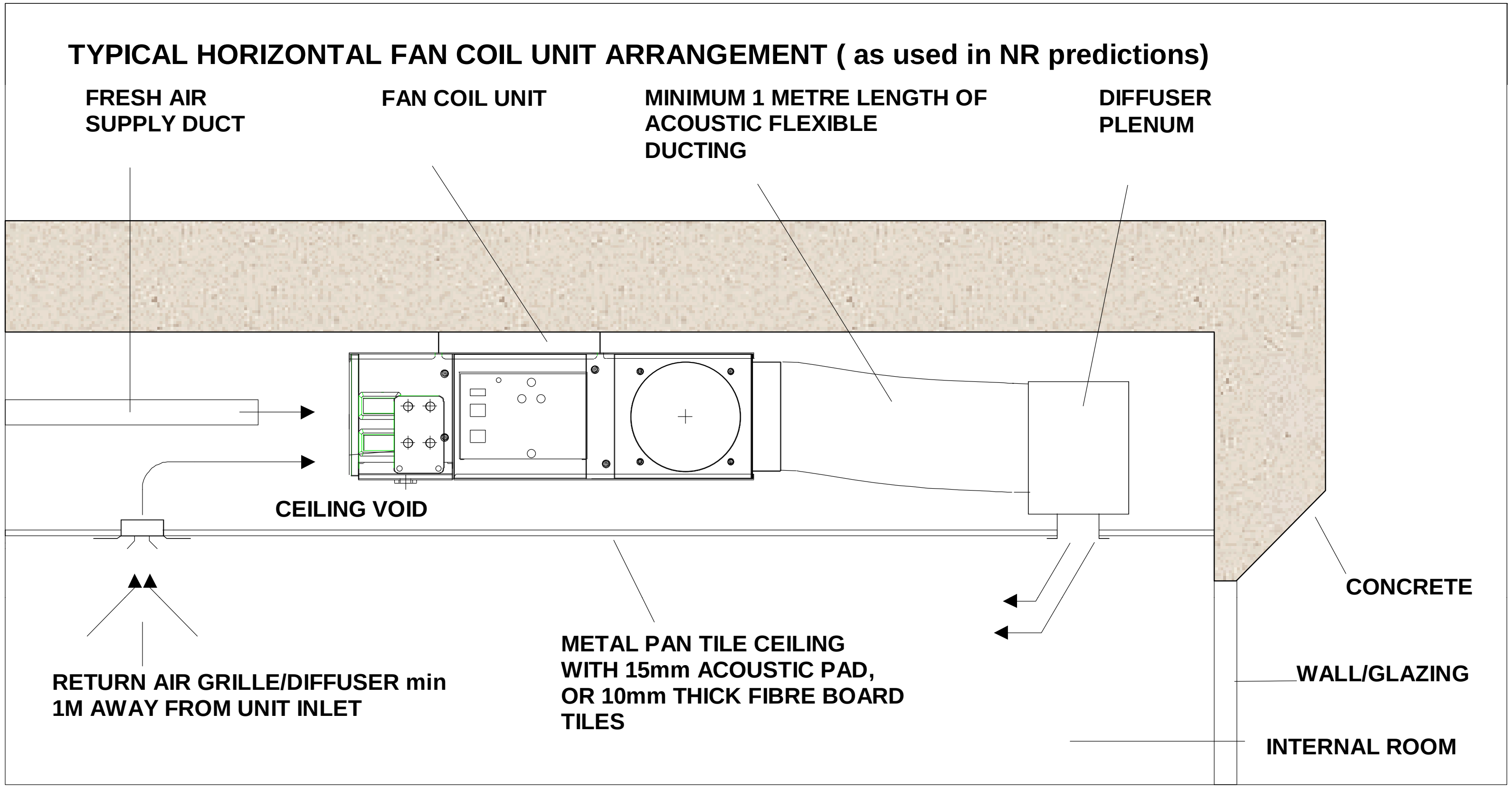
Poor ceiling fit and finish, missing tiles, poor ceiling tile specification.

Bends or collapse in flexible connections restrict air flow causing unnecessary fan effort and noise.

If ductwork has to route through or under beams, ensure sufficient duct area is used to reduce duct velocity to below 3m/s.

HEVAC

# ACOUSTIC INSTALLATION SUMMARY




To ensure that the installed noise levels achieve the suppliers quotations, many manufacturers include an installation specification like this, to ensure that the units are not installed into non-standard applications. Follow best practice and the final system will achieve the specified noise performance.

HEVAC

# CONCLUSION

FOR ECONOMIC FAN COIL SELECTION

- USE ACOUSTIC FLEX ON THE DISCHARGE OF UNIT
- AN INSULATED CEILING IS PART OF THE SYSTEM
- FAN SPEED = FAN VOLTAGE = UNIT NOISE, SO MINIMISE DUCT RESISTANCE AND USE SPEED CONTROL TO MATCH PERFORMANCE TO VARYING DEMAND
- REDUCE OVERSIZING BY USING BEST ACOUSTIC PRACTICE

# GLOSSARY

- **FCU** - Fan Coil Unit – A packaged air conditioning unit consisting of an inlet filter, chilled water and hot water heat exchange coil, fan and discharge plenum
- **SWL**- Sound Power Level –Expressed a relation to the threshold of hearing –$10^{-12}$*Watts or 0.000000000001Watts* in a logarithmic scale named sound power level

  $L_{w,} = 10 \log (N/N_0)$expressed as

  $L_w$ = *Sound Power Level in Decibels (dB)*

  *N = sound power (W)*

  $N_0 = 10^{-12}$ - *reference sound power (W).*

  *i.e A quiet office has a SWL of* $= 10\log (10^{-7}/10^{-12}) = 50 L_w$
- **SPL** – Sound Pressure Level is the force (*N*) of sound on a surface area ($m^2$) perpendicular to the direction of the sound. The SI-unit for the Sound Pressure is $N/m^2$ or *Pa*.

  Sound is usually measured with microphones responding proportionally to the sound pressure - *p*. The power in a sound wave goes as the square of the pressure.

  The log of the square of x is just 2 log x, so this introduces a factor of 2 when we convert to decibels for pressures.

  The lowest sound pressure possible to hear is approximately $2\ 10^{-5}$ *Pa (20 micro Pascal, 0.02 mPa)*, 2 ten billionths of a an atmosphere.

  It therefore convenient to express the sound pressure as a logarithmic decibel scale related to this lowest human hearable sound - $2\ 10^{-5}$ *Pa, 0 dB.*

  The Sound Pressure Level:

  $L_p = 10 \log( p^2 / p_{ref}^2 ) = 10 \log( p / p_{ref} )^2 = 20 \log ( p / p_{ref} )$ (1)

  *where*

  $L_p$ = *sound pressure level (dB)*

  *p = sound pressure (Pa)*

  $p_{ref} = 2\ 10^{-5}$ - *reference sound pressure (Pa)*

- **dB** – Decibel is a logarithmic unit used to describe the ratio of the signal level - power, sound pressure, voltage or intensity or several other things.

  The decibel can be expressed as:

  $decibel = 10 \log(P / P_{ref})$

  *where*

  *P = signal power (W)*

  $P_{ref}$ = *reference power (W*

- **Hz** – The **hertz** (symbol: **Hz**) is the (SI) unit of frequency. It is defined as the number of complete cycles per second.

# Optional Reading

- Noise Control in Building Services – Sound Research Laboratories Ltd
- CIBSE Guide TM43 - Fan Coil Units
- British Council of Offices (BCO) guide
- CIBSE Guide F