

## Acoustics laboratory facilities

### 1. Hearing protection test facilities (fixtures and facility compliant with AS/NZS 1270)

The Acoustics Research Group has developed a test facility for the assessment of hearing protection devices (HPDs) in accordance with the method for real-ear attenuation at threshold (REAT) as defined in AS/NZS 1270:2002, to enable research, development and testing of HPDs. The REAT method is a subjective HPD method based on the assessment of a participant's hearing threshold with (occluded) and without HPDs fitted (open-ear). Hearing thresholds are assessed using individual one-third octave bands of pink noise with octave band centre frequencies from 125 to 8000 Hz. The difference in hearing thresholds between the occluded and open-ear conditions represents the attenuation of the HPD at each centre frequency. The individual attenuations can then be used to determine the class of the HPD, which is common to end users of HPDs. The facility and test procedure has been accredited by IANZ.

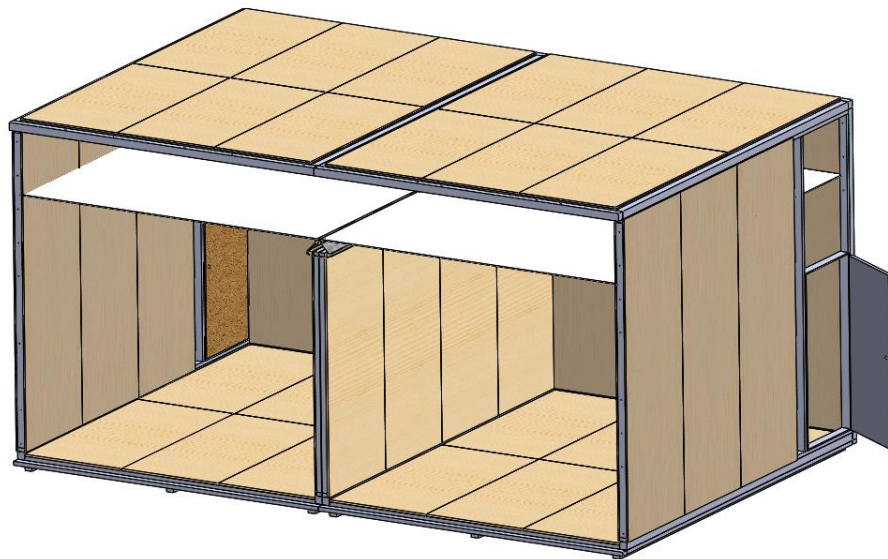


Head and torso simulator in hearing testing facility

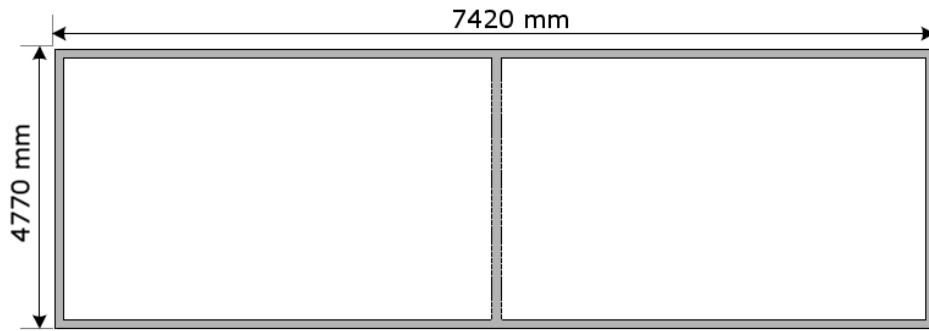
## 2. Ceiling flanking noise facility compliant with ASTM E1414

The Department of Mechanical Engineering has constructed a facility for the study of noise transmission through suspended ceiling systems, as shown below. The test facility is capable of determining the acoustic performance of suspended ceiling systems as well as the effect of in-plenum acoustic treatments. The facility has been designed in accordance with ASTM 1414 and consists of two adjoining rectangular rooms that are structurally isolated from each other. Each room is 3.6 m high, 3.6 m long and 4.8 m wide with a separating wall between the two rooms being 760 mm lower than the roof of the rooms. The suspended ceiling is constructed on the top of the separating wall to create a common plenum between the two rooms. The performance of the suspended ceiling is obtained by placing a continuous noise source (that produces sound between 125 Hz and 4000 Hz) within one of the two rooms and measuring the response in the other room. Microphones are placed in each of the rooms to measure the sound pressure levels.

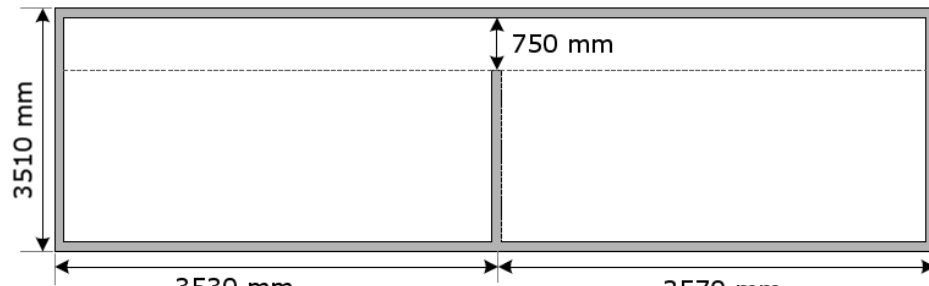
The acoustic performance of suspended ceilings is important for reducing noise transmitted between rooms that share a common plenum and from services that are commonly installed within the ceiling plenum (air conditioning and ventilation ducts, and pipework for example).



The facility: consisting of two rooms each with a single access door



Plan



Front

Dimensions of the test facility

### 3. Tyre-road noise measuring system

The Acoustics Research Group, in collaboration with the New Zealand Transport Agency (NZTA), has constructed and commissioned a close-proximity (CPX) trailer to measure road surface noise generated by vehicle tyre interaction. The trailer meets the requirements of the draft standard ISO/DIS 11819-2. The CPX trailer is towed along a selected section of road at a steady reference speed of 80 km/h. Two microphones continuously measure noise at a position close to where the road is in contact with a reference tyre on the nearside wheel of the trailer. The microphone system is enclosed in an acoustically lined box. An on-board computer calculates the average noise levels over each 20 metre length of the road being tested. The measurement runs are repeated a number of times and the results averaged. The data gives a complete picture of how surface noise varies along the length of road, and how that compares to other roads.



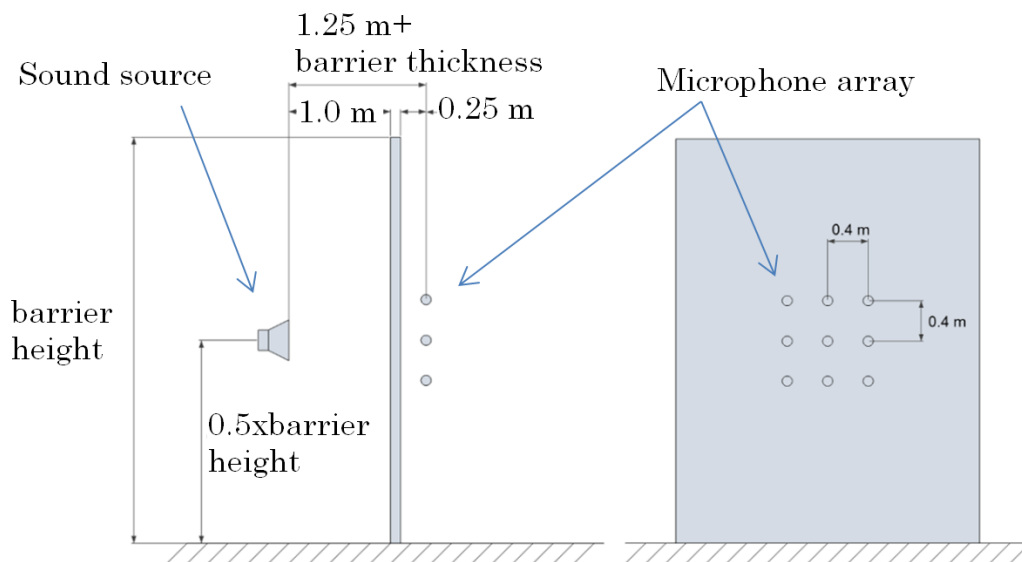
Tyre road noise measurement trailer and towing vehicle

#### 4. Traffic noise barrier measurement system

A measurement system for the in-situ measurement of the airborne sound insulation of traffic noise barrier systems has been developed and validated at the University of Canterbury. The system meets the requirements of EN 1793-6:2012, which describes the methodology and this standard has become a common means of quantifying the performance of road traffic noise reducing devices. Newly installed products can be tested to reveal any construction defects and periodic testing can help to identify long term weaknesses in a design.

The system has been used to quantify the airborne sound insulation of eight different types of road traffic noise barriers located along motorways in Auckland, New Zealand. The barriers evaluated include those manufactured in concrete, engineered timber, plywood, slatted timber, and acrylic. Test results agreed with previous studies that have been performed in Europe and confirmed the influenced of air gaps and ageing.

The measurement system has also been used to assist in the development of novel traffic noise barriers.



Noise source (left) and microphone array (right) set up for measurement

## 5. Low noise wind tunnel for aero-acoustic measurements

### Facility

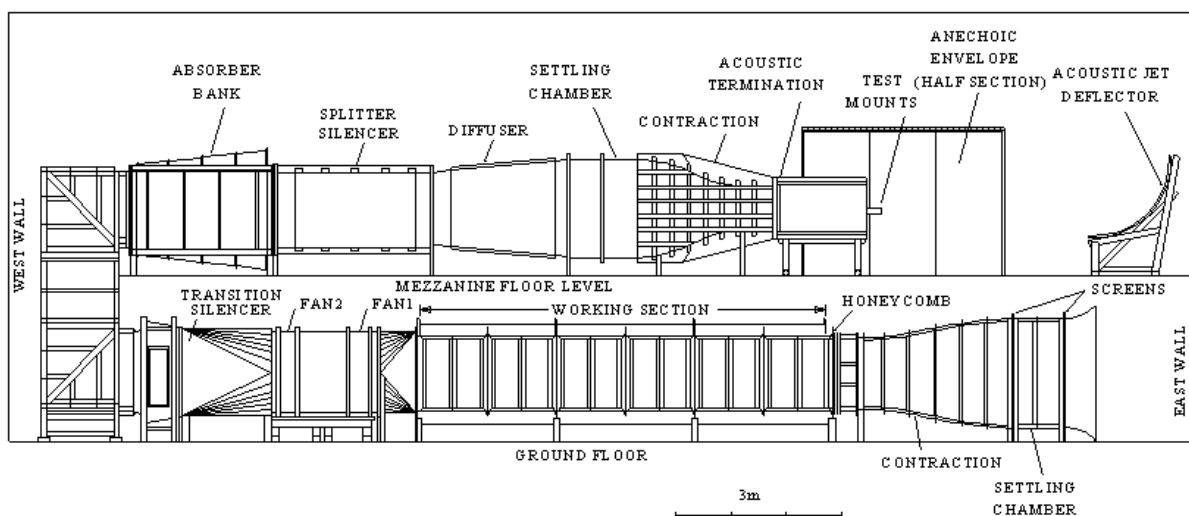
The low noise wind tunnel is of the open circuit type and is located in the laboratories of the Department of Mechanical Engineering. The wind tunnel was refurbished in 2004 to reduce the background noise carried on the air stream. Modifications included shifting the fans downstairs, lining the corner sections and the tunnel sections upstream of the fans with absorbent foam, building a low frequency absorber section to remove fan noise and tunnel resonances and covering the aero-acoustic test position at the outlet jet with a lined anechoic envelope. The arrangement of this facility after the modifications is shown below, along with the acoustic performance. The tunnel is powered by a 1.2m diameter 50kW Woods two-stage contra-rotating fan unit with pneumatic blade pitch control and PDL "Microdrive Elite" variable speed controllers (model ME-46), which can vary fan speed from 0 rpm to a rated value of approximately 1460 rpm. Aero-acoustic tests are undertaken in the outlet jet of the tunnel, which is on a mezzanine level. The outlet jet is 0.76 m square. A maximum flow rate of 27.7 m<sup>3</sup>/s provides a mean speed of 48m/s at the outlet jet. A 1.5m × 0.75 m nozzle can also be fitted at the outlet jet for testing of large objects.

### Air Flow Measurement Equipment

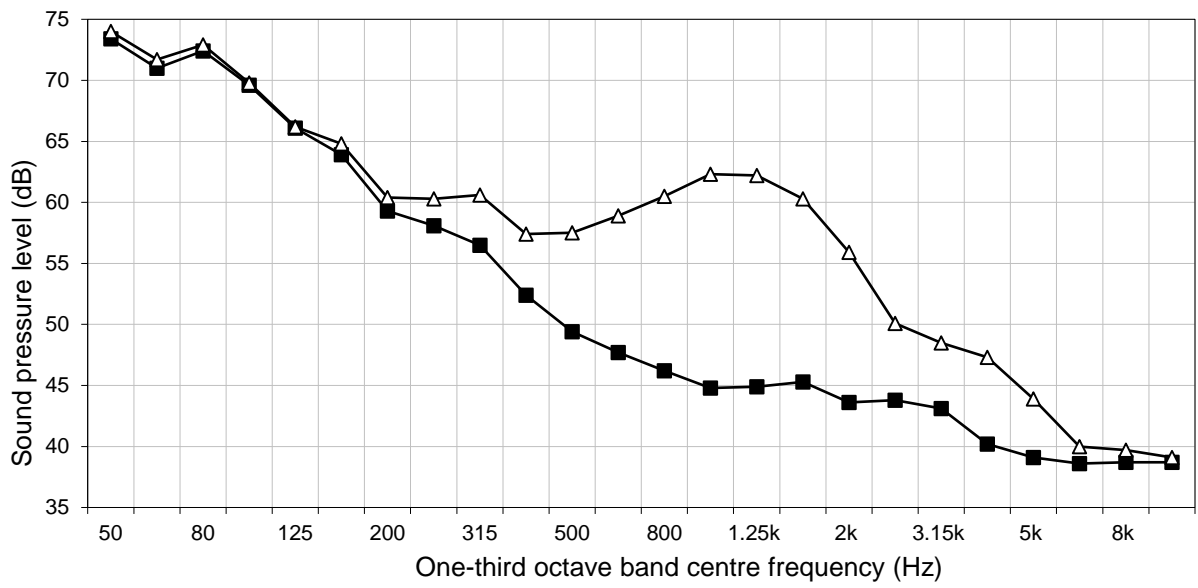
The wind tunnel facilities are equipped with TSI and laboratory developed, miniature hot wire anemometers and associated calibration and repair equipment; computer controlled probe positioning and data handling; smoke generator and helium bubble flow visualization equipment. A Kodak MegaPlus digital video camera system with imaging software (EPIX), together with modulating and non-modulating light sheets, complements the flow visualization facilities. Various airflow anemometers and manometers are also available.

### Noise Measuring Equipment

The very low background noise at the outlet jet of the wind tunnel is utilized for aero-acoustic flow studies that are supported by a well-equipped acoustics laboratory, which includes a Brüel and Kjær 16 channel Pulse system. Microphones, amplifiers, signal generators, narrow band analyzers, cables and calibration equipment are also available together with a range of microphone nose cones to reduce wind noise at high wind speeds.



Schematic of the low noise wind tunnel



Plot of sound pressure level in one-third octave bands:  $\triangle$  Noise produced by a NACA0024 aerofoil submersed in a 28m/s airflow with the microphone positioned 350mm directly below the trailing edge,  $\blacksquare$  wind tunnel background noise with a 28m/s airflow

## **6. Facility for assessing human response to noise**

The Acoustics Research Group has access to test rooms used for presenting a series of sound files with differing sound characteristics, in a controlled laboratory environment, along with a visual stimuli. Subjects are generally instructed on the nature of the tests and the methodology being used, prior to testing. Their responses are collected by way of a questionnaire and form part of population sampling. The responses are statistically analyzed and related to those used in similar studies. The facility is used for example for assessment of predicted tranquility in relation to what can be seen and heard in a selected environment.



## 7. Duct noise test facility

### Measuring Noise in Ducts

The 'Duct Noise Test Facility' in the Department of Mechanical Engineering is used to measure the insertion loss of ducts, duct linings, and other sound attenuating devices that may be placed in a duct.

The facility meets the requirement of ISO 7235: *Measurement procedures for ducted silencers - Insertion loss, flow noise and total pressure loss*. The method of calculating the insertion loss is based on measurements of the sound pressure level before and after the test specimen has been inserted.

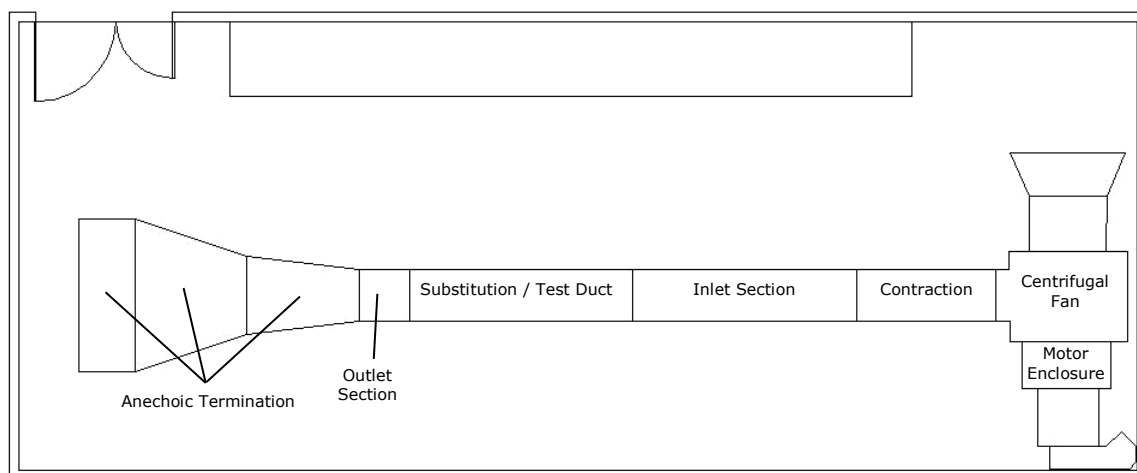
### Measuring Pressure Loss in Ducts

The facility allows the measurement of pressure loss due to a test specimen in the duct. This is measured by taking the difference in pressure loss across a test section, with and without the test specimen.

### Test Facilities

#### *Apparatus*

A schematic of the facility is shown below.



Schematic of Duct Noise Test Facility

A centrifugal fan provides a mean flow for testing. The fan has an impeller diameter of 690 mm consisting of 11 backwards inclined laminar (straight) blades. The volume flow rate is controlled by varying the fan speed via a variable speed AC drive unit connected to the 15 HP three-phase motor. A maximum volume flow rate of  $4 \text{ m}^3\text{s}^{-1}$  can be achieved.

#### *Ducts*

There are two duct sizes available for testing. Each duct size has a number of configurations available for testing.

540 x 300 mm

- 25 mm lined on top and bottom
- 50 mm lined on top and bottom
- 75 mm lined on top and bottom
- 25 mm lined on 4 sides

- substitution duct allowing absorption without an expansion in duct size

270 x 300 mm

- 25 mm lined on top and bottom

- 25 mm lined on 4 sides

- substitution duct allowing absorption without an expansion in duct size

The test facilities is shown below.



Duct Noise Test Rig

## 8. Sound intensity systems

### Introduction

The Acoustics Research Group has two sound intensity measurement systems, one for use with hand-held Bruel & Kjaer dual channel sound level meters (type B&K 2260 or B&K 2270 systems) and one for use with a Bruel & Kjaer Pulse system. These systems find wide application in measuring the sound power in a variety of applications. The relationship of sound power to sound pressure is addressed below and a typical application discussed in terms of locating and quantifying noise sources.

### Sound Power of a Machine and Locating Sources of Noise

*Sound pressure* around a machine or other noise source is often measured in an effort to determine the characteristics of the noise being generated. The measured sound pressure depends on the distance the measurement is made from the source as well as the environment in which the measurements are made. Therefore, by simply measuring sound pressure the noise directly attributable to the source cannot necessarily be determined.

*Sound power* is a more fundamental measure of how much noise a machine makes. A sound source radiates sound power, resulting in a sound pressure. This means that what we hear is sound pressure, but it is caused by the sound power emitted by the source. Sound power describes the rate at which acoustic energy is radiated from a sound source, and is measured in Watts.

It is therefore often preferable to determine the sound power of a source, rather than the sound pressure the source generates at a specific point in any particular environment.

#### *Sound power measurement using sound pressure*

The *sound power* of a source can be determined using *sound pressure* measurements. It is relatively easy to measure sound pressure since the same pressure variations on the eardrum, which we perceive as sound, can be detected by the diaphragm of a microphone. However, sound pressure is only related to sound power under certain controlled conditions. Therefore, to determine the sound power of a machine using sound pressure measurements it must be placed in a special acoustic environment. Such special acoustic environments include anechoic rooms and reverberant rooms.

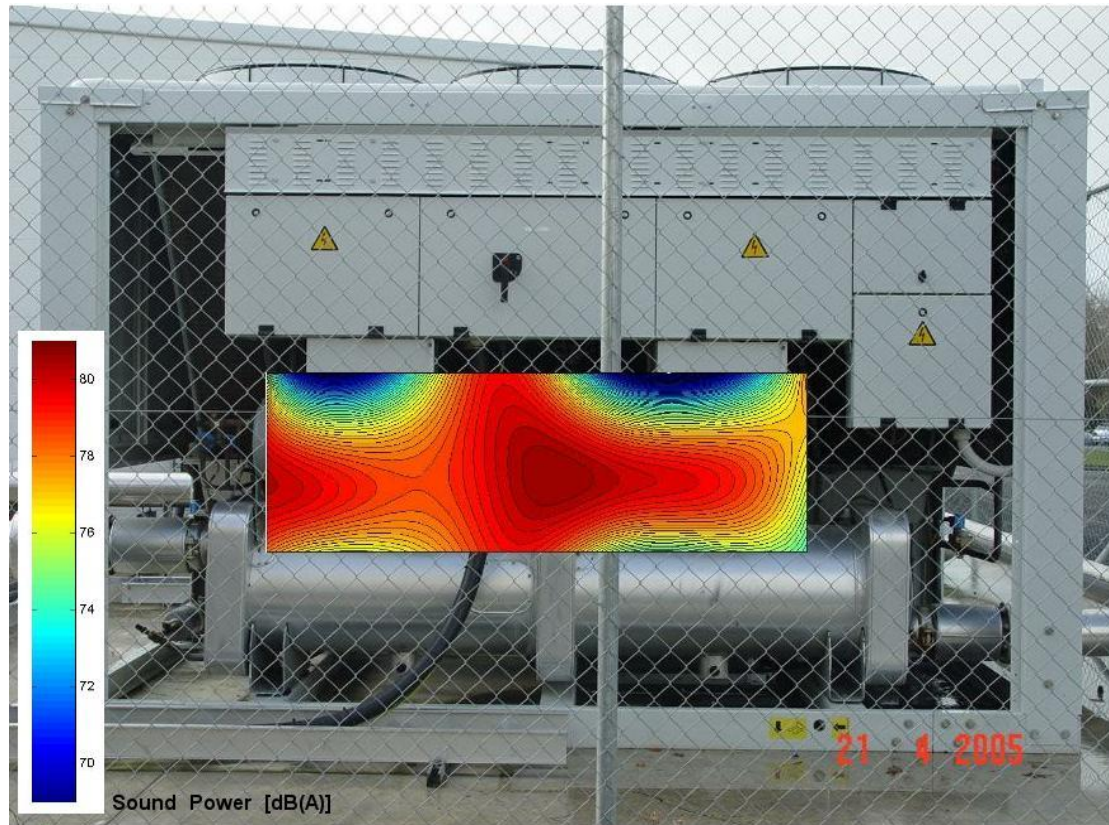
#### *Sound power measurement using sound intensity*

The *sound power* of a source can also be determined using *sound intensity* measurements. Sound intensity describes the rate of energy flow through a known area. Therefore, once the sound intensity of a source has been established, the sound power can be calculated by multiplying the sound intensity by the area over which it was measured. It is more difficult to measure sound intensity (compared to sound pressure) so although the concept of sound intensity has been fundamental to the formulation of acoustic theory for over a hundred years, the commercial era of sound intensity measurement did not begin until 1977, when digital signal processing techniques were applied to the existing theory.

The major benefit of using sound intensity is that it can be measured in any sound field. This means that the sound power of machines, noise sources and installations can be measured in-situ. Furthermore, measurements of individual machines can even be made when other nearby machines are radiating noise, since steady background noise makes no difference to the sound power determined when measuring sound intensity.

*Source location and radiation patterns using sound intensity*

Sound intensity is a *vector quantity*, since it is concerned with the energy flowing through an area. This means there is a direction associated with a sound intensity measurement. Because measured sound intensity gives a measure of direction as well as magnitude it can be used to locate sources of sound. This applies to locating the machines emitting the most noise, and also locating the components of a machine that are the noisiest.



Sound intensity used to study the radiation of sound from a machine

By taking measurements at various points around a machine, the radiation patterns emitted by the machine can be established and visualized by contour plots, such as for an electrical transformer installation shown above.

## **9. Environmental noise measurement and analysis facilities**

The Acoustics Research Group has a Bruel &Kjaer outdoor sound measurement kit including Bruel and Kjaer sound level meters equipped with logging software for the measurements of environmental noise.

The Group also has environmental noise modelling software for predicting noise levels in the environment due to variety of sources.

## 10. Fan noise test facility

The Acoustics Research Group has constructed a plenum chamber test facility following ISO 10302-1. Sound power level measurements are carried out using a ten microphone hemispherical array as described in ISO3744. The rig is typically used to investigate the performance of small axial flow fans and contains means to measure flowrate, fan speed, pressure, electrical power, and sound pressure.



Plenum test chamber