



**METRO NORTH
ORAL HEARING**

**SD2 5M Acoustic Design Report
(Final)**

Mater Stop
Acoustic Design Report
M000384/243231/SD-2.5M



RPA
PG2 Parkgate Business Centre
Parkgate Street
Dublin 9

Mater Stop
Acoustic Design Report
M000384/243231/SD-2.5M

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Mott MacDonald
St Anne House
20-26 Wellesley Road
Croydon
Surrey
CR9 2UL
UK
Tel : 44 (0)20 8774 2000
Fax : 44 (0)20 8681 5706

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V Koo
K.D. Grabauskas
C. Bennie
M S Akbar

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1 Introduction

The key objective of the architectural acoustics design report is to provide physical and psychological aural comfort for passengers and staff. A further aspect is to ensure safety requirements are achieved by allowing clear messages to be put out over the Public Address system. The intelligibility aspects of the PA system are to be determined by the System Wide Designers (SWD).

This report is broken down into the following sections:

- Section 1: Provides an introduction to the scope of this Acoustic Design Report.
- Section 2: Reviews the criteria for the architectural acoustics design as well as presents the concepts of direct and reverberant sound. The Formula used for calculating the reverberation times in each area of the Stop are also presented.
- Section 3: Discusses the specific acoustic aspects for the public areas for Mater Stop.

1.1 Scope

The acoustic environment is a key aspect in the station design, which can influence passenger satisfaction, health and safety and the effectiveness of the day to day operations which rely on good aural communication.

The aspects of architectural acoustics covered in this report will be described under the following headings:

- Background Noise (Sound Level)
- Room response (Sound Absorption and Reverberation time)

The aim of this report is to review the acoustic design criteria and to make recommendations for acoustic treatment in the public areas of the Stop which will support the future design of the PA system.

The speech intelligibility of the public address system is a function of the design and selection of the PA system components, notably the speakers which are selected and located to achieve satisfactory signal to noise ratios. The design of the PA systems will be completed by the SWD and is outside the scope of this report.

The following sections will present and review the acoustic design criteria to be applied in Mater Stop and describe the methods to be adopted to determine how best to achieve the design criteria for the acoustic environment.

1.2 Architectural Treatment

The acoustic performance of materials within Mater Stop have been designed as part of an overall 'system', acoustic absorbers are not applied to other materials and expressed as such. Indeed, the acoustic attenuation required is placed behind architectural finishes with required open area to allow the passage of sound into the absorber behind.

This strategy allows for maximum flexibility in the number of manufacturers able to be invited to provide materials which are fit for purpose. Where this forms a combined system such as stainless steel perforated ceiling tiles, felt backing and acoustic absorber, the whole system may need to be tested for compliance with all materials used in the construction to be in accordance with the Fire precautions (Sub-surface Railway Stations) Regulations 1989 and amendments thereto or equivalent Irish legislation.

As stated in SD2.8, Architectural Design Report, reverberation times in public areas at 1 kHz should not exceed 1.8 seconds. The following describes the strategy for each public level of accommodation

i) Street Level: Acoustic attenuation is proposed to be integrated with the ceiling design. The design of the entrance structure is lead by the adjacent MCHD entrance structure as shown on reflected ceiling plans (RCP). At the time of publication the Mater hospital entrance RCP's were requested but remain outstanding.

ii) Concourse Level: Space is allocated for acoustic attenuation above the stainless steel rodded ceiling panels which span between structural beams at 6m centres. This allows for flexibility in the amount of attenuation provided which would be visually screened by black felt backing. The rodded panels will be detailed to allow for periodic inspection and/or access. Refer to Architectural drawings and sample panel for details.

iii) Platform Level: Perforated stainless steel panels are mounted horizontally at +3000mm above FFL, forming the platform soffit. Acoustic absorption is included within this ceiling system.

iv) Vertical circulation – Escalator boom (2800 above pitch line), to have acoustic absorber within side panels of system to contractor design.

Non public areas:

Where identified on drawings, acoustic absorber provided to staff areas by perforated, drop in ceiling tiles with acoustic absorber behind to manufacturers' design.

Paint grade blockwork to general circulation in back of house will provide limited attenuation and assist in reduction of reverberation times.

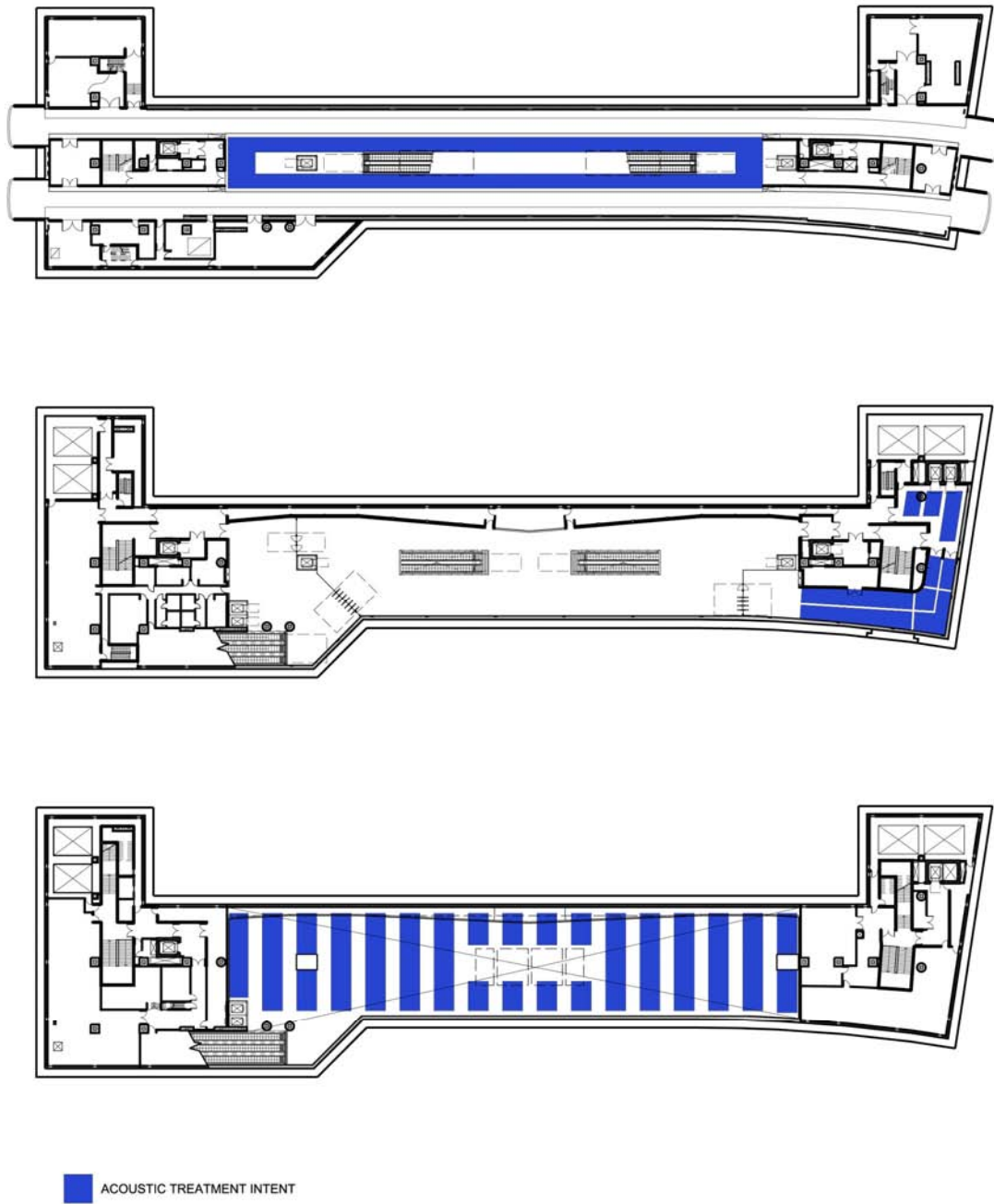


Figure 1-1: Scheme design intended acoustic treatment to reflected ceilings

1.3 Architectural details to be resolved

Detailing is required to ensure that acoustic panels do not form roosting sites for vermin and/or birds.

Detailing is required to ensure that panels cannot fall from mountings or frame but can be easily accessed or are demountable where infrequent inspection and/or access is required.

Where acoustic panelling is within 3000mm of FFL, materials and detailing to be fit for purpose and robust enough to withstand damage through crowd loading and/or malicious intent. System is to be capable of anti graffiti treatment or inherently graffiti resistant.

All components and systems are contractor design including interfacing with other contracts and require approval by Project Manager prior to manufacture.

2 Acoustic Design Criteria

2.1 Background Noise

Background noise level criteria for the different spaces shall be specified for Mater Stop. This criterion gives reference to a particular NR requirement. To meet the NC requirement, the background noise should be at, or below, a specified background noise level. This noise level will be measured and compared with an internationally agreed NR curve at each octave frequency band, with centres at 63Hz to 8000Hz. The target values are listed below in Table 2.1.

Table 2.1: Background Noise Criteria for Key Rooms

Area	Noise Criterion ¹
Public Area – Concourse	NR-37
Office and Staff Accommodation	NR-40
Service Corridors	NR-40
Locker Rooms, Changing Rooms and Toilets	NR-40
Plant Rooms	NR-65
Comms Equipment Room	NR-40

The background noise is an important characteristic. If the background noise level is too high it can become difficult to interpret audible information.

The background noise is made up of a direct sound component and the reverberant sound component. Specific noise sources, for example from ventilation systems, will be acoustically treated to mitigate contribution to the background noise. This aspect is covered in the Design Statement for the Building Services (Report No. SD-2.8).

2.2 Room Response

This is an important characteristic in the design of the PA systems and can be controlled by the careful selection of architectural finishes. The room response is related to the volume of the space and the acoustic characteristics of the room surfaces. This is clarified below.

¹ Reference was made to documents - RPA's Construction and Maintenance Requirements Part 2 Section 3 and Crossrail MDC 2 M&E Services TODFA Subsurface Stations

For a given noise source, sound waves will be generated. These sound waves are radiated away from the source in all directions. As the distance from the source increases, the intensity of the sound decreases. This is due to hemispherical dispersion. The direct sound is not influenced by the room's surfaces. This is known as the direct source.

When these direct sound waves strike a solid surface they will reflect back into the space. The concept of direct and reflected sound is illustrated in Figure 2-1. However, a proportion of the incident energy in the wave will be absorbed by the surface and so the energy in the reflected part can be significantly reduced. The amount of sound energy absorbed by a particular surface is defined by its absorption coefficient.

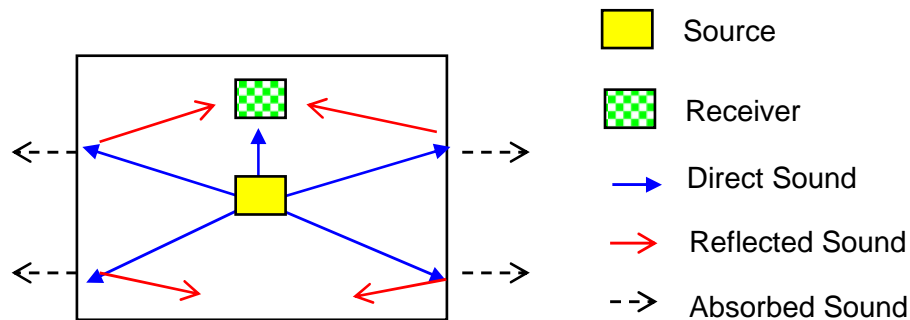


Figure 2-1: Behaviour of Sound Waves in a room

The absorption coefficient is simply the ratio of the absorbed sound (or energy) to the incident sound (or energy). In numerical terms, an absorption coefficient of 0 indicates zero absorption (total reflection), whereas an absorption coefficient of 1 indicates total absorption (no reflection).

Once reflected each new sound wave is treated as a separate sound source, radiating its own energy into the space. These reflected waves build up their own sound field in the room known as the “Reverberant Field”. In rooms with little absorption the reverberant field can become stronger than that of the original sound source. As we hear all sound around us, the original direct sound source can become distorted by the reverberant sound source to such a degree that it becomes unintelligible. The term “Signal to Noise” (S/N) ratio derives from the concept of the ratio between direct and background sound. For good aural intelligibility the signal (direct sound from the source) should be sufficiently amplified over the noise (the local background noise).

2.3 Reverberation Time

The criterion which best serves to quantify the room response is “Reverberation Time” (RT).

This can be simply defined as the time required for the background sound level in a room to decay by 60dB after the source of the sound is removed. From this definition it is easy to see that with little surface absorption, the reverberant sound field will take longer to decay. This is due to the fact that little sound energy is lost at each reflection with the surfaces and so the sound energy is retained in the space longer.

Conversely, in a highly absorbent room (anechoic chamber) a significant proportion of the incident sound energy will be absorbed at the first reflection and so the decrease in the reverberant sound level can be considered to be almost instantaneous.

In practice, most rooms have different surfaces, each with varying sound absorption characteristics. It follows that the reverberation time (room response) can be controlled by the addition or removal of specific surfaces and finishes which can control the reverberation times over a range of particular frequencies, i.e. hard board panels over a significant air space can be used to control low frequency reflections.

The design value of the RT is important where speech recognition is a key parameter in the design. A long RT can undermine speech clarity, since late reflections can distort speech recognition.

Reverberation times in public areas at 1 kHz should not exceed 1.8 seconds as stated in Report SD2.8 - Architectural Design Statement.

2.4 Reverberation Time Calculations

To estimate the reverberation time in each area, calculations will need to be carried out. These calculations have been used to assist the architect in making selections of finishes.

The classic calculation formula for reverberation time is the Sabine formula. This formula is simply written as:

$$RT = 0.161 V / S\alpha$$

Where RT = reverberation time at a particular frequency of interest, seconds

V = volume of the space, m³

S= Total boundary surface area

α = average absorption coefficient for area.

The Sabine formula is widely accepted as an accurate method of assessing reverberation time. However, its accuracy is dependant on the distance, between opposing surfaces of the rooms, being in equal proportion. This formula would be valid for calculation of the more regularly shaped rooms such as plant rooms and back of house areas in the Stop.

However, the accuracy of the Sabine formula is reduced in irregular rectangular shaped rooms such as the concourse and platforms in railway stations. To address this, the Fitzroy Equation has been employed. The Fitzroy Equation was first put forward, in the Journal of the Acoustical Society of America 1959. The formula, based on Sabine's formula, calculates the RT time between opposing faces and as such can take into account the differences of irregular shaped rooms. The Fitzroy Equation is written as:

$$RT_{60} = S_x/S (0.161V/S.\alpha_x) + S_y/S (0.161V/S.\alpha_y) + S_z/S (0.161V/S.\alpha_z)$$

Where RT = reverberation time at a particular frequency of interest, seconds

V = volume of the space, m³

S= Total boundary surface area, and the subscript of X,Y and Z represent

X = side walls, Y = end walls and Z = floor and ceilings

In large spaces the sound absorption characteristics of air can be important above 1000Hz and so the Fitzroy Equation can be rewritten as

$$RT60 = S_x/S (0.161V/(S.\alpha_x+4mV)) + S_y/S (0.161V/(S.\alpha_Y+4mV)) + S_z/S (0.161V/(S.\alpha_z+4mV))$$

Where m = air absorption coefficient.

Calculations to be carried out during detail design, by PPPCo.

2.5 Speech Intelligibility

The Rapid Assessment of Speech Transmission Index (RASTI) value represents a convenient way of specifying the intelligibility of PA systems. A RASTI value of 0 is poor and a RASTI value of 1 is excellent. The value derives for the concepts of Speech Transmission Index (STI) or Articulation Index (AI). The value is measured by special equipment rather than being calculated. Targeted RASTI value is to be confirmed with Dublin Fire Brigade.

Causes of reduced intelligibility include:

- Poor Signal to Noise (S/N) ratio
- Excessive reverberation and focusing of reflected sound waves.
- Specific long, delayed, high level reflections
- Loudspeaker misalignment between alike devices
- Miss-equalization
- Poor quality PA system or incorrect selection of speakers
- The distance of the speakers from the receiver

Excessive reverberation time is only one aspect that can have an impact on the RASTI values achieved. However, the PA specification and layout of the PA speakers, which are designed by the SWD, can ultimately determine whether or not the required speech intelligibility will be achieved.

3 Assessment of Acoustic Designs for Mater Stop

3.1 Public Area

The public areas for Mater Stop are regular in shape and are not expected to require any special acoustic treatment other than providing sufficient mid to high frequency absorption at the ceiling, in the form of ceiling tiles with acoustic backing, to bring down the reverberation times to acceptable levels. Refer to Section 1.2 for details.

The RT calculations are to be carried out during detail design, by PPPCo.

The estimated reverberations times for Mater Stop are detailed in Table 3.1 below:

Table 3.1 - Target Reverberation Time Criteria *(to be completed in Stage 3)*

Height of Space (m)	Octave Band Centre Frequency					
	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
4m to 8m						
Concourse						
Platform						

3.2 Plant Rooms

All plant rooms have hard surfaces and will have higher reverberation times than the design criteria if no acoustic treatment is provided.

Calculations to be completed for a typical fan room and the results of the calculations are to be shown in Table 3.2 below.

Table 3.2 - Plant room Reverberation Time Criteria *(to be completed in Stage 3)*

	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
Plant room						
Design						

Railway Procurement Agency
Ghníomhaireacht um Fháil Iamróid
Parkgate Business Centre,
Parkgate Street, Dublin 8, Ireland
Phone +353 1 646 3400
Fax +353 1 646 3401
www.rpa.ie

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