Assessing Noise Amenity Within the Context of an Occupational Noise Assessment

Mischa J Mrost

Buildings and Places, AECOM Australia Pty Ltd, Brisbane, Australia

Abstract - With increasing demand for fibre capacity and ongoing technological developments, modern telecommunications (comms) equipment is generally operating with higher capacities in much smaller units. Cooling fan sizes within these units have become smaller and operate at higher speeds. A state-wide roll-out of new comms equipment in comms rooms across Queensland, resulted in numerous and on-going complaints from technicians over the increased noise levels and tonality this equipment produced. While the comms room noise levels complied with workplace health and safety noise exposure limits, a detailed noise investigation was initiated to assess noise amenity. This paper provides an overview of the assessment approach and results, including a broader discussion on improving noise amenity within the context of an occupational noise assessment, which is not currently within the scope of legislative requirements.

1 INTRODUCTION

Comms rooms are buildings which have typically been considered as 'plant rooms' from the perspective of their use and function. They are enclosed spaces housing a variety of equipment, ranging from servers, network switches, cables, connecting hardware and enclosures. Technicians will visit a comms room occasionally for servicing faults and maintenance, but a comms room is generally not accessed daily. Extended work within a comms room will occur during the installation, commissioning or decommissioning of new equipment, commonly referred to as 'project work'. Project work may require on-site attendance by a technician for several continuous days or weeks depending on the size of the project. The occurrence of project work generally depends on the equipment replacement cycle but may be once every 2 to 4 years and up to 15 years.

Due to the nature and typical function of comms rooms, noise amenity within these rooms has not been an area of extensive acoustical research. However, an investigation was conducted to measure the noise levels within comms rooms across Queensland after a recent state-wide roll-out of new comms equipment resulted in numerous and on-going complaints from technicians. Technicians reported significantly increased noise levels and annoying tonality from the new equipment that caused reduced concentration and communication difficulty.

The new equipment replaced 15-year-old technology and improved comms capacity while being housed in smaller units and occupying less comms rack space. However, with the smaller chassis and higher capacity, the new equipment was operating with smaller cooling fans at higher speeds to provide rack cooling. These factors resulted in a higher noise output from the new equipment compared with the old equipment.

The current Australian occupational noise standards and guidelines offer little information regarding noise amenity levels, stating that safe-guard levels have not yet been fully determined. Additionally, the commonly used Australian industry standard for assessing building internal noise levels, AS/NZS 2107:2016 *Acoustics – Recommended design sound levels and reverberation times for building interiors* (AS/NZS 2107:2016) does not provide design internal noise levels for comms rooms.

As such, this paper is presented as a case study for assessing noise levels and noise amenity for comms rooms within the context of an occupational noise assessment. A discussion is provided on the application and limitations of the developed assessment framework, noise amenity within comms rooms based on measured levels, and the potential need for noise mitigation to improve noise amenity within the scope of future occupational workplace noise assessments.

2 ASSESSMENT FRAMEWORK

The amenity sought and addressed in this investigation is primarily concerned with speech intelligibility, as comms technicians require communicating over the phone or with others in a comms room. However, amenity in this assessment also broadly refers to reducing noise nuisance such as tonality.

The assessment referenced the following documents to assess noise amenity within comms rooms:

- *Work Health and Safety Act 2011* (WHS Act, Australian Government, 2024).
- *Work Health and Safety Regulation 2011* (WHS Regulation, Queensland Government, 2024).
- *Managing noise and preventing hearing loss at work* Code of Practice 2021 (WHSQ CoP, Workplace Health and Safety Queensland, 2021). This document is an approved code of practice under section 274 of the WHS Act.
- AS/NZS 2107:2016 *Acoustics – Recommended design sound levels and reverberation times for building interiors* (AS/NZS 2107:2016, Standards Australia, 2016).
- AS 2822-1985 *Acoustics – Methods of assessing and predicting speech privacy and speech intelligibility* (AS 2822-1985, Standards Australia, 1985).

2.1 WHS Act and WHS Regulation

The WHS Act outlines the primary duty of care for eliminating risks arising from hazardous noise. The WHS Regulation stipulates that risks to health and safety relating to noise-induced hearing loss must be managed, and that the noise that a worker is exposed to must not exceed the exposure standard for noise.

The workplace exposure standard for noise as provided in the WHS Regulation is "(a) $L_{Aeq,8h}$ of 85 dB(A), or (b) $L_{C,peak}$ of 140 dB(C)" (WHS Regulation, Queensland Government, 2024).

2.2 WHSQ CoP

The WHSQ CoP presents guidance on managing 'other effects of noise' that do not damage hearing but interfere with concentration and communication. While the WHSQ CoP states that '*safe levels to guard against these effects have not yet been fully determined'* it provides the following guideline levels:

- "50 dB(A) where work is being carried out that requires high concentration or effortless conversation
- 70 dB(A) where more routine work is being carried out that requires speed or attentiveness or where it is important to carry on conversations." (WHSQ CoP, Workplace Health and Safety Queensland, 2021).

2.3 AS/NZS 2107:2016

AS/NZS 2107:2016 is an industry standard for internal acoustic design considerations, however it does not provide recommended sound levels for comms rooms. Additionally, AS/NZS 2107:2016 recommends design criteria for *occupied spaces*. As comms rooms are not regularly occupied, their use is not within the scope of the standard. However, the standard was used for assessing tonality, which can cause additional noise nuisance when considering noise amenity.

Tonality was assessed objectively using the simplified test method described in Appendix D of AS/NZS 2107:2016. The simplified test method determines tonality based on the level difference between the sound level in the one-third octave band under investigation and the arithmetic mean of the sound level in the adjacent one-third octave bands. A tonality adjustment is applied where the level difference exceeds the values in Table 1, reproduced from AS/NZS 2107:2016.

Table 1 – AS/NZS 2107:2016 Table D1 – Level difference between adjacent frequency bands above which the adjustment for tonality is applied

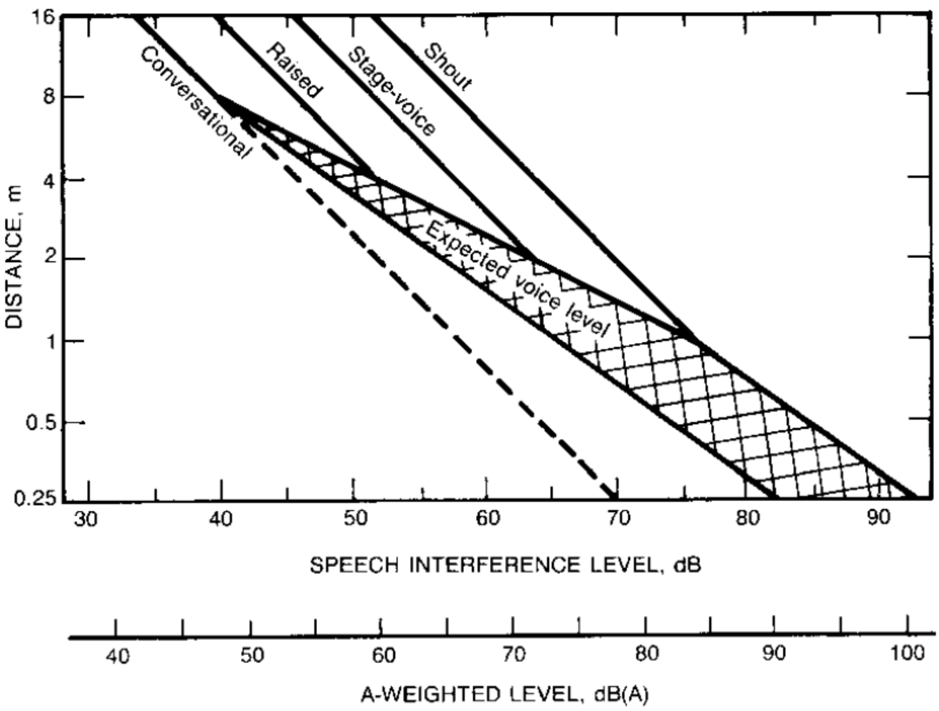
One-third octave band, Hz	Level difference, dB
25 to 125	15
160 to 400	8
500 to 10 000	5

For measured sound levels exhibiting tonality, the standard applies a 5 dB penalty added arithmetically to the overall frequency weighted sound level of the sound under investigation.

2.4 AS 2822-1985

Comms technicians often need to make phone calls or have face-to-face conversation with colleagues, particularly when carrying out fault and maintenance work. Since conversation is a fundamental part of their job, speech amenity was assessed as part of this investigation. AS 2822-1985 provides guidance for reliable communication indoors based on the ambient noise level. This is provided in Figure 1 and Clause 6.3.2 below which have been reproduced from the standard.

Technicians working together on the same equipment where communication is required are typically within 0.5m of each other. The chart in Figure 1 presents that speech can be at a conversational level at 0.5m provided that the ambient A-weighted sound pressure level is below approximately 72 to 73 dB(A), as demonstrated on the auxiliary abscissa scale.



NOTES:
1. The auxiliary abscissa scale, of A-weighted sound pressure level, is for the purpose of Clause 6.3.2.
2. The shaded area shows the range of expected voice levels due to the normal raising of a talker's voice in high ambient sound levels.
3. This figure has been adapted form ANSI S3.14-1977 (Ref. 2).

Figure 1 – AS 2822-1985 Fig. 1 Talker-to-listener distances for just reliable communication

The notes in Figure 1 refer to Clause 6.3.2 of AS 2822-1985 which provides further clarity on the use of the auxiliary abscissa scale. Importantly, for speech communication indoors, the standard notes that the scale is appropriate for cases where the room surfaces are highly sound absorbent (short reverberation times).

3 COMMS ROOM NOISE MEASUREMENTS

Comms room noise measurements were conducted in 14 comms rooms across Queensland. 12 rooms had the new equipment operating. Two rooms allowed for the new equipment to be turned off and two rooms did not have the new equipment operating. All comms equipment was operating with typical load and network traffic and the measurements were not contaminated by extraneous outdoor noise such as rainfall.

3.1 Measured noise levels

Measurements were conducted to determine an overall noise level within each comms room. This involved taking the logarithmic energy average of several short duration (30 to 60 seconds) measurements at locations around the room where the reverberant noise level was expected to be dominant. Measurements were taken at approximately 1.5m above the room's floor, which is the typical height of a technician's ear when standing and working within the rooms.

The measured noise level within each room with the new equipment operating is provided in Table 2.

Table 2 – Rooms with new equipment operating

Room	Measured noise level (dB(A) L_{Aeq})
1	77
2	75
3	75
4	73
5	73
6	73
7	72
8	72
9	71
10	68
11	68
12	66

The measured noise levels varied significantly (66 to 77 dB(A) L_{Aeq}) depending on the room size and the number of units of the new equipment that operated within the room. The measured noise level within each room without the new equipment operating is provided in Table 3.

Table 3 – Rooms without new equipment operating

Room	Measured noise level (dB(A) L_{Aeq})
6	65
14	63
12	60
13	58

The measured noise levels for the rooms without the new equipment operating varied between 58 to 65 dB(A) L_{Aeq}. Room 6 had noticeably louder equipment than the other rooms, comprising several comms multiplexing units with cooling fans. The two rooms where the new equipment could be turned off (Rooms 6 and 12) demonstrated an 8 and 6 dB noise reduction respectively, when the new equipment was turned off. This difference in measured noise level shows that the new equipment was significantly louder than the existing equipment and was the dominant noise source within the comms rooms.

3.2 Reverberation times

Reverberation time measurements were conducted in four comms rooms. Three of the rooms were of a similar size and construction, being typical sandwich panel, raised demountable buildings with no windows and vinyl floors. The fourth comms room comprised brick walls, concrete floors and no windows. All rooms had an approximate volume of 60m^3, with no existing acoustic treatment or soft furnishings. Table 4 presents the measured reverberation times.

Table 4 – Measured reverberation times in comms rooms

Room type	Measured reverberation time ($T_{30,\ 500\ Hz\ to\ 1\ kHz}$, seconds)
Demountable 1	0.7
Demountable 2	0.6
Demountable 3	0.6
Brick	0.7

The reverberation times were close and only varied slightly between 0.6 to 0.7 seconds. This is due to the similar room volumes, finishes and internal furnishings i.e. sheet metal comms racks with no acoustic absorption.

3.3 Tonality

Feedback received from comms technicians was that tonality from the new equipment causes annoyance, particularly when communication is required. All comms rooms were dominated by broadband fan noise, however, tonality was detectable within the reverberant noise field. Tonality became clearly audible when standing closer to certain equipment, including the new equipment.

The measurements within the 14 comms rooms assessed tonality using the method from AS/NZS 2107:2016 (as discussed in Section 2.3). Not all noise level measurements displayed tonality. For the measurements where tonality was identified from the new equipment, this occurred in the 800 Hz one third octave band. An example measurement with tonality is shown in Figure 2.

The following equations demonstrate an example of the tonality calculation in accordance with AS/NZS 2107:2016.

$$Measured\ noise\ level\ at\ 800\ Hz\ =\ 61\ dB \tag{1}$$

$$Arithmetic\ mean\ of\ noise\ levels\ at\ 630\ Hz\ and\ 1\ kHz\ =\ \frac{53+58}{2} = 56\ dB \tag{2}$$

$$Level\ difference\ =\ 5\ dB\ \therefore\ tonality\ applies \tag{3}$$

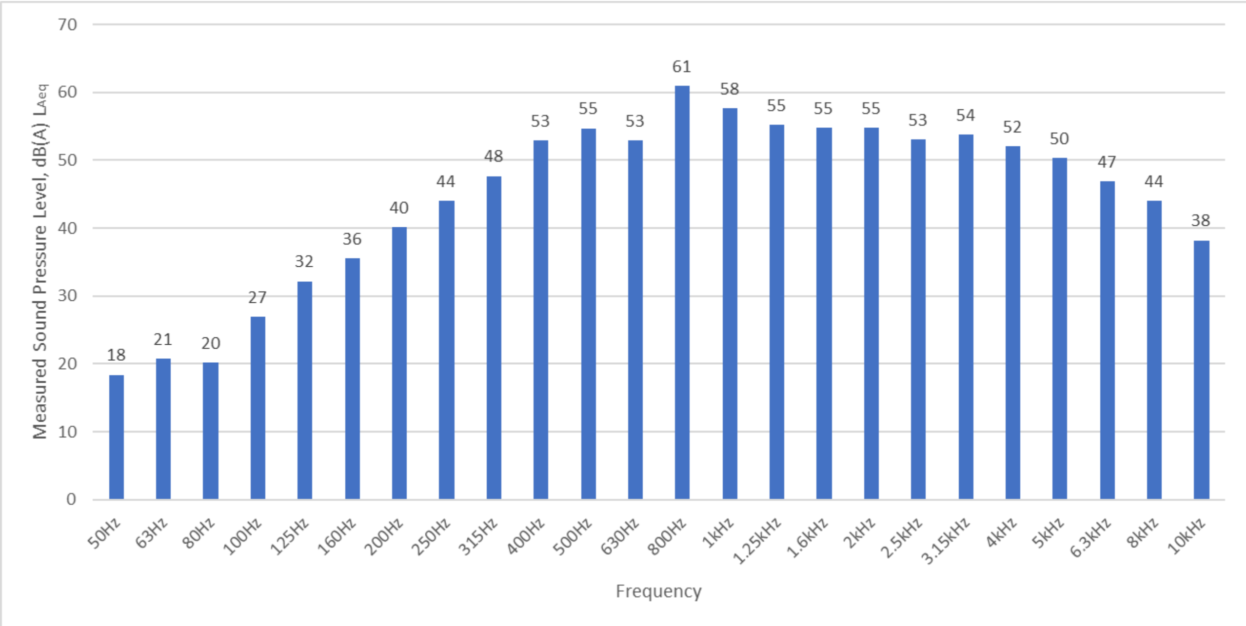


Figure 2 – Tonality exhibited in the measured noise level at 800 Hz with the new equipment

In rooms without the new equipment, not all noise level measurements displayed tonality. For the measurements where tonality was identified from other equipment, this occurred in the 500 Hz and 2 kHz one third octave band. An example measurement from other equipment with tonality is shown in Figure 3.

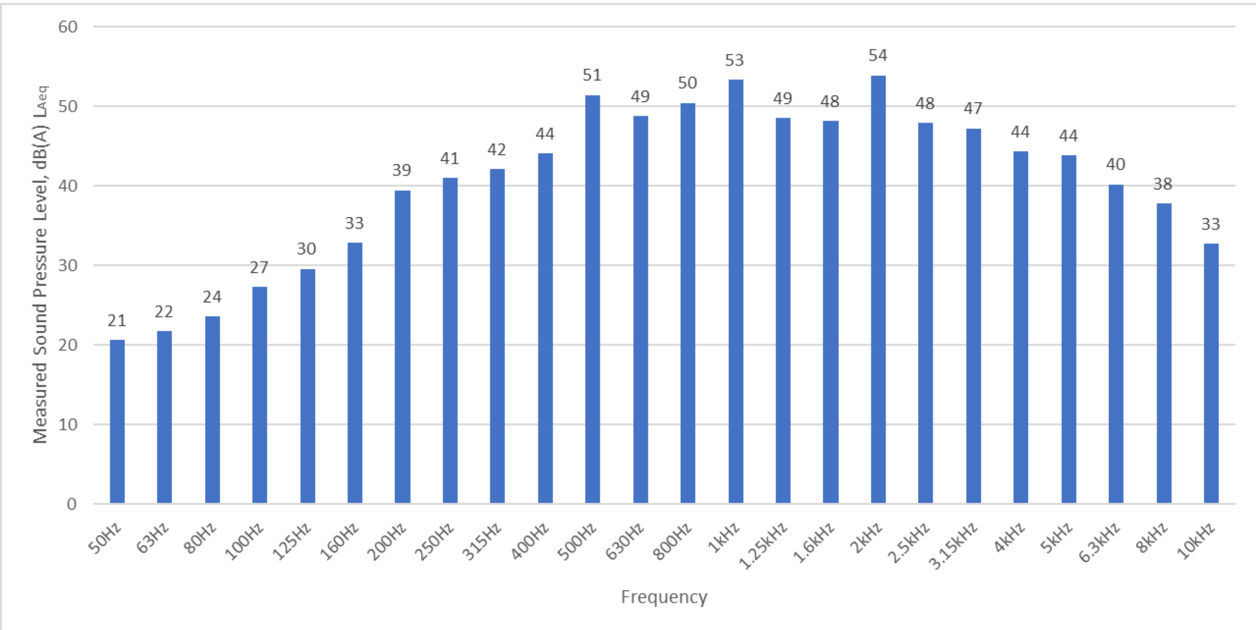


Figure 3 – Tonality exhibited in the measured noise level at 500 Hz and 2 kHz without the new equipment

The presence of discreet tones, when assessing noise levels for tonality in accordance with AS/NZS 2107:2016, results in a 5 dB penalty being added to the measured noise levels (as discussed in Section 2.3). Section 4.2 discusses the applicability of this penalty within the context of comms rooms.

4 DISCUSSION

4.1 Application and limitations of assessment framework

Current occupational noise assessments are based on managing *'hazardous noise'* causing a '*risk of hearing loss'*. Mitigating this risk, according to current WHS legislation, is done by ensuring workers are not exposed to noise levels above 85 dB(A) $L_{Aeq,8h}$. However, noise levels below 85 dB(A) $L_{Aeq,8h}$ can still give rise to noise amenity concerns. In the context of comms rooms, reduced noise amenity can be characterised as difficulty communicating, reduced concentration levels and annoyance.

Noise amenity is not regulated and would be difficult to do so considering the highly subjective nature of noise i.e. the same noise may be acceptable for one person and annoying to another. Noise amenity is also affected by the context of the work and the expectations technicians have for the work environment. For example, technicians reported tolerating higher noise levels in data centres than comms rooms because that is what they were used to.

The WHSQ CoP offers guideline noise levels to minimise the '*risk of adverse health effects'*, however, also states that '*safe levels to guard against these effects have not yet been fully determined'*. The WHSQ CoP presents a level of 70 dB(A) to minimise the risk of adverse health effects for routine work being carried out that requires *'speed or attentiveness or where it is important to carry on conversations*.' In the context of a comms room and the activities performed by comms technicians this may be generally appropriate. It is considered impractical for comms rooms to achieve the WHSQ CoP guideline noise level of 50 dB(A) for '*high concentration or effortless conversation'*. Furthermore, comms technicians are unlikely to expect to work somewhere this quiet. However, if these conditions are required, work should be conducted outside the comms rooms.

While comms rooms are not considered 'occupied spaces', comms technicians can visit multiple comms rooms over consecutive days for maintenance and fault repairs. This continually exposes them to comms rooms noise levels, making them more sensitive to a comms rooms noise environment.

AS 2822-1985 was used to assess the comms room noise environment on the basis that face-to-face communication is required within comms rooms. The standard presents that speech can be at a conversational level at 0.5m provided that the ambient sound pressure level is below approximately 72 to 73 dB(A). The standard qualifies this for rooms with surfaces and fittings that are '*highly sound absorbent (short reverberation times)*' but does not specify target reverberation times to meet this requirement. The measured reverberation times (refer to Section 3.2) within a selection of comms rooms were relatively short, between 0.6 to 0.7 seconds. However, this is location-specific and rooms with longer reverberation times may have degraded speech communication or require lower ambient sound pressure levels.

The guidance levels in the WHSQ CoP and AS 2822-1985 provided a framework within which to assess noise amenity within comms rooms. A target noise level of 68 dB(A) L_{Aeq} was used to determine where noise amenity may begin to be compromised. This level is based on an ambient noise level of 73 dB(A) for conversational speech at 0.5m (adopted from AS 2822-1995) and allowing for a 5 dB tonality correction (adopted from AS/NZS 2107:2016). Considering not all noise level measurements displayed tonality, a target of 68 dB(A) L_{Aeq} is also within the WHSQ CoP guideline level of 70 dB(A).

4.2 Validity of noise amenity complaints within assessment framework

The measured noise levels within the comms rooms (presented in Section 3.1) were 66 to 77 dB(A) L_{Aeq} with the new equipment, and 58 to 65 dB(A) L_{Aeq} without the new equipment. Comms rooms also exhibited tonality in some measurements (discussed in Section 3.3), where a tonality penalty of 5 dB should be considered. Applying a tonality penalty to the measured noise levels would indicate that the measured noise level with the new equipment ranged between 71 to 82 dB(A) L_{Aeq}, and 63 to 72 dB(A) L_{Aeq} without the new equipment.

With respect to the assessment framework target noise level of 68 dB(A) L_{Aeq} and the requirement for conversational speech within comms rooms, the measured noise levels would suggest that in all comms rooms with the new equipment, and in some instances without the new equipment, noise amenity may be compromised. Improving noise amenity, while not within the scope of current legislative requirements, is discussed further in the following section.

4.3 Improving noise amenity

Noise cancelling hearing protection with telephone connectivity was provided to technicians as an optional mitigation measure to improve noise amenity. However, this incentive was largely unsuccessful in eliminating noise amenity concerns and feedback from the comms technicians was that more substantial noise treatment ought to be implemented. Indeed, personal protective equipment (PPE) is the last measure in the hierarchy of controls from the WHSQ CoP.

Subsequently, this investigation followed through with implementing physical noise mitigation controls to improve the noise amenity within comms rooms with the new equipment. Mitigation was designed to achieve the target noise level of 68 dB(A) L_{Aeq}. This involved a series of acoustic treatments, including absorptive room surface treatment to lower the room reverberation time, solid comms rack doors, and internal comms rack treatment to the new equipment cabinets. The treatment was trialled at one pilot site and resulted in an 8 – 10 dB reduction in noise level. This performance is with the comms cabinet doors closed, however when opening the door, the noise levels would be higher again. With the noise treatment, the noise levels within the comms room were measured to be 60 to 62 dB(A) L_{Aeq}. Tonality from the new equipment was eliminated with the treatment, however tonality was detectable from other equipment once the noise levels from the new equipment reduced.

The post-mitigation noise levels, even with a tonality correction of +5 dB, were below the assessment framework target noise level of 68 dB(A) L_{Aeq}. The noise reduction achieved at the pilot site resulted in greatly improved noise amenity and positive feedback from comms technicians.

5 CONCLUSIONS

This investigation is a case study of noise amenity requiring further consideration in a workplace that is not considered typically occupied. In these cases, complying with occupational noise limits may not be sufficient to address noise complaints in certain industrial settings. For comms technicians working in comms rooms, this investigation found that technicians, while not working continuously in any one comms room, may visit multiple comms rooms regularly. This continually exposes them to comms rooms noise levels, making them more sensitive to a comms rooms noise environment. A change in noise level or noise character within this environment can then lead to noise complaints and amenity concerns.

Furthermore, as technology advances, replacing old equipment with new equipment may not always result in improved noise emissions. In the case of the comms equipment assessed in this investigation, it was observed that the older equipment was quieter than the newer equipment. While the new equipment noise levels did not qualify as ‘hazardous’ in an occupational health setting, complaints were raised over the increased noise levels and tonality causing discomfort and communication difficulty. This required noise reduction measures to improve the comms room noise environment.

Workplaces should consider, when installing new equipment within facilities, the potential for noise amenity concerns and account for these before noise complaints arise.

ACKNOWLEDGEMENTS

I would like to thank Tim Osborne and Aloysius Chang for their continued support and guidance during the lifecycle of this investigation.

REFERENCES

Australian Government. (2024). *Work Health and Safety Act 2011*. Department of Employment and Workplace Relations.

Queensland Government. (2024). *Work Health and Safety Regulation 2011*. Office of the Queensland Parliamentary Counsel.

Standands Australia. (1985). *Acoustics – Methods of assessing and predicting speech privacy and speech intelligibility*. AS 2822-1985.

Standands Australia. (2016). *Acoustics – Recommended design sound levels and reverberation times for building interiors*. AS/NZS 2107:2016.

Workplace Health and Safety Queensland. (2021). *Managing noise and preventing hearing loss at work Code of Practice*. Safe Work Australia.