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# Secret Room Acoustics

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## ABSTRACT

Most buildings require a range of acoustic privacy ratings to allow them to function adequately for the proposed uses. Selected government and private buildings have requirements for spaces where Secret and Top Secret discussions can be undertaken. These rooms have not only acoustic requirements but also other design requirements to address potential physical and electronic intrusion into these spaces. The author has worked on a number of projects incorporating Secret and Top Secret rooms with various configurations. This paper discusses acoustic and related security requirements for these rooms, and also examines the practicality of achieving the required performance via various elements of the room including the results of field testing to confirm compliance with the design intent.

## INTRODUCTION

While many government and private buildings contain mainly standard office spaces, selected buildings require rooms or open plan areas with a certified level of acoustic privacy to allow "Secret and Top Secret" discussions to be undertaken. These buildings can include: Police headquaters, Bureau of Statistics, Defence, ASIO, Court Rooms, Legal offices, and Government Chambers. The need for these secure rooms and their location in various buildings is determined by the client as part of their planning process for the new facilities. Clients have their own staff that specialise in the security requirements for these rooms. Consultants are also able to undergo training to become security experts to assist the design team during the building project. These staff become involved during the planning stage, design review, sign-off stage with the consultants, and final building inspections during construction. This work is undertaken to ensure the rooms meet the security requirements specified by the client.

Acoustic privacy is only one of several aspects that have to be addressed in the design of the Secret and Top Secret rooms. Other aspects include:

- Physical intrusion via ducts or walls;
- Visual privacy;
- "Bug-proofing";
- Transmitting device control.

The authors company has undertaken the acoustic design for several building projects which have included Secret and Top Secret rooms. Lessons learnt during work on three sites are discussed in this paper.

## CRITERIA

Typical requirements for the acoustic performance of secure rooms are shown in Table 1.

**Table 1**. Noise Criteria

| | | |
|---|---|---|
| *Secret Rooms – Speech Privacy* | NIC40 | Dw40 |
| *Top Secret Rooms – Audio Secure* | NIC45 | Dw45 |

The Secret rooms are to be used for secret or infrequent top secret discussions, while the Top Secret rooms can be used for top secret discussions regularly. It is usual that some impact isolation be provided for the secret and top secret room walls.

Noise Isolation Class (NIC) and Weighted Level Difference (Dw) are measures of the sound isolation achieved from inside to outside the tested rooms. Hence the amount of acoustic absorption in the receiving space affects the result. The NIC criteria have been replaced by the Dw criteria over recent years.

In addition to the sound attenuation requirements, it is also important to maintain reasonable background noise levels in the spaces surrounding the secret and top secret rooms. This is necessary as speech privacy is a factor of both the sound isolation and the ambient noise level in the listening space. It is recommended that the air conditioning system be designed to provide background levels as noted in AS2107 [1].

## SECURITY DESIGN ITEMS

Clients have a range of requirements that must be considered for each secure room. Several of these can impact on the acoustic design and may include:

- flush plasterboard ceilings, to show any attempts to install bugging devices;
- clear conduits and inspection/ vision panels through secure room acoustic walls;
- metal stickers on clear plastic cable points to show if tampered with;
- bars installed in ducts;
- plywood or steel sheeting in partitions;
- cubicles for leaving transmitting devices (ie. mobile phones) outside of secret room areas;
- separate corridor around ground floor rooms;
- perimeter fence around ground level secure rooms;
- security coded locks to rooms;
- secure passageways and secure plantrooms;
- ideally no external windows;
- guards may be posted outside secure rooms.

## ACOUSTIC DESIGN

### Typical design issues

Typical design issues for secure rooms include:

- wall construction and sealing;
- ductwork – both noise travelling down the duct and noise breakout from the ducts;
- exhaust and fresh air ducts through roof or walls;
- roof construction;
- glazing;
- vision panels around clear cable conduits; and
- doors - typically are the “weakest link”.

### Door design

Doors are typically the lowest performing element in the secure room design. Good quality acoustic rated doors can still achieve an as installed performance 5dB lower than the manufacturer’s laboratory tested performance. Single doors often provide the greatest challenge, and hence soundlocks are used where possible.

### Room interior treatment

The secure room criteria do not typically include any requirements for acoustics within the space. However it is generally desirable to achieve reverberation times of the order of those recommended in AS/NZS 2107[1] for offices (ie. 0.6 seconds), or longer for larger spaces (eg. briefing rooms). However the matter of interior acoustics is often difficlut to address as clients typically require flush plasterboard for walls and ceilings, as it shows any evidence of tampering (eg. to install bugging devices). Indeed in a typical secure room the only absorption is the carpeted floor, furniture and people. In the future it may be possible to use a membrane type acoustic product for the ceiling or parts of the walls to improve interior acoustics.

The relatively small size of most secure rooms has resulted in satisfactory speech intelligibility within the secure rooms.

### Mechanical Services

In cases where the mechanical plantrooms have been adjacent the secret rooms, one would usually assume that a high level of acoustic privacy would be achieved by default due to the higher ambient noise levels in the plantroom. However discussions with security design staff have indicated that the Secret and Top Secret rooms would have to be tested with the air conditioning off, to ensure the acoustic ratings were achieved.

This required a higher level of attenuation to be designed into the ductwork to control noise escaping to the plantroom via the ducts.

**Figure 1**. These ducts were extended to provide sufficient attenuation between the Top Secret room and plantroom (photo shows ducts prior to extension)

### Communications Cabling

Where communications cabling in conduits for phone, data etc. penetrate a secure room wall, the ends of the conduit are terminated in transparent connection boxes.

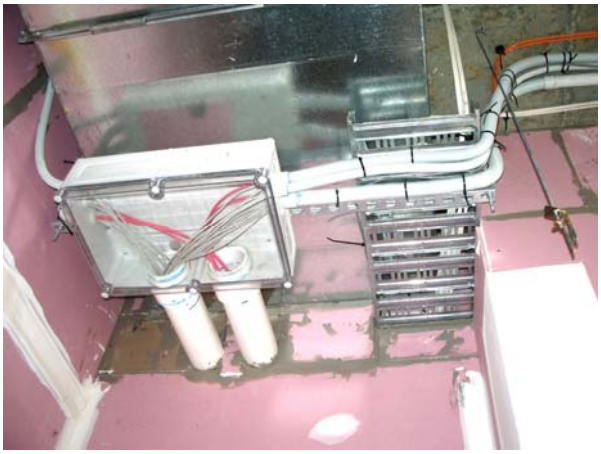

**Figure 2**. Transparent cable connection boxes. Note sealing around penetrations

Communications cables passing thorough acoustic walls (eg. to the computer in a top secret room) were to incorporate clear panels around the clear conduit. A double glazed clear panel was designed to maintain the acoustic performance of the wall.

**Figure 3**. Double glazed vision panel around secret room cables

## CASE STUDIES

### Site 1

This project involved the construction of a new 2 storey training building with three secret rooms located on the ground floor and one added later on the first floor. Secure areas included: briefing room, planning rooms and meeting room.

Key acoustic items- ground floor:

- The ground floor rooms were designed with a secure corridor, accessible via staff with appropriate security clearance. This assisted the acoustic design by physically separating secure and non-secure areas of the building;
- The planning rooms were connected to the secure corridor with 45mm thick solid core timber doors with acoustic seals, and used the secure corridor door to form a sound lock;
- The weakest link was the entry to the briefing room which opened onto a non-secure corridor near the building entry. A sound lock was installed comprising a Sound Transmission Class [2] of 43 (STC43) acoustically rated door (~Rw43 door) to the briefing room and a 45mm thick solid core timber door with acoustic seals (45mm SC+S door) to the corridor;

**Figure 4**. Soundlock entry

- A store room located adjacent the soundlock provided a buffer between the briefing room wall and the adjacent non-secure office area;
- Internal walls comprised plasterboard partitions rated at STC50. These were purposely "up-rated" to allow for loss in performance during construction due to services penetrations and sealing details;
- There were no external windows to these ground floor rooms;
- Being on the ground floor, the ceiling system included an acoustic ceiling and concrete floor slab above;
- External walls were designed to control noise intrusion from aircraft using the nearby runway, and hence would readily meet the Secret room requirement. The construction comprised cavity concrete blockwork with insulation, and internal plasterboard linings;
- The plantroom for the ground floor secure area was located away from the secret rooms which allowed longer duct runs to attenuate noise travelling via the ducts to the plantroom.

Key acoustic items- first floor:

- The first floor secret room was converted from a meeting room. It had non-secure office areas surrounding it, and the entry door opened onto a non-secure corridor. This arrangement posed a greater challenge to achieving the acoustic criteria than the ground floor layout;
- Internal walls were rated as per the ground floor, however several 20mm diameter holes (previously installed for data cables) had to be capped and sealed;
- External walls were rated as per the ground floor to exclude aircraft noise and did not pose a problem;
- External windows were located in the meeting room, however these were a double glazed construction (12.76mm laminated glass, 150mm air cavity, 8.38mm laminated glass) to control noise intrusion from aircraft, and met the Secret room requirement;
- The roof/ ceiling construction was a high performance system designed to control the aircraft noise intrusion and met the Secret room requirement;
- The return air transfer duct was lengthened and internally lined to provide sufficient attenuation to the corridor;
- Due to the location of the room it was not possible to install a soundlock and hence a single STC46 acoustic door was installed.

**Figure 5**. Acoustic rated door seals. Note three drop seals to the base of the door (two fully mortised into the door and one surface mounted) to minimise noise leakage via the threshold.

### Site 2

Unlike the other two case studies, this project involved the re-development of a temporary building to enable it to be used for secure purposes. The building would only be required for a short period of time before other more suitable facilities were constructed, and hence the capital cost was to be limited.

The building was a free-standing, lightweight construction with openable windows and standard doors. As such the transmission loss of the facade was around STC25. Rather than extensively upgrading the building construction, it was decided that the best solution was to install a perimeter fence around the building at a distance that would allow the Secret room acoustic requirement to be met. This was a practical and more cost effective solution than acoustically treating the building. The windows to the secure room were sheeted over with plywood to meet visual security requirements, which improved the window acoustic performance.

### Site 3

A new 3 storey headquarters building was to be constructed with secure rooms located on each floor for various functions. A Top Secret room was located on Level 1 and Secret rooms were located on each of the three levels. The initial project scope included: briefing room, three meeting rooms, planning room, top secret server room and adjacent work room. During the construction stage of the project the client required one of the office areas to be upgraded to a Secret rating. This area included private offices and open plan office areas, and was located adjacent the Top Secret room.

Key acoustic items- ground floor:

- The ground floor briefing room was located outside the three story envelope of the building due to architectural requirements, and posed combined issues of persons "listening-in" from the ground outside and also getting access to the single story roof. To address this, the design team proposed a secure corridor around the perimeter of the briefing room to allow it to be swept for bugging devices, and the roof/ ceiling was designed to provide a high acoustic rating;
- External walls were concrete blockwork, and inner walls were Weighted Sound Reduction Index [5] Rw50 rated;
- There were no external windows;
- Entry was via a soundlock which incorporated the kitchenette for the briefing room. The sound lock comprised an Rw40 door to the briefing room wall and a 45mm SC+S door to the kitchenette;
- Doors to the secure corridor had a 45mm SC+S door to the soundlock and an Rw40 door at the other end of the corridor which adjoined the plantroom;
- The plantroom was located adjacent the briefing room and acoustically lined ducts were used to achieve sufficient isolation. Ducts to the roof vents were also acoustically lined to achieve the required Secret room rating to minimise the likelihood of bugging via the roof vents.

Key acoustic items- first floor:

- The first floor included two Secret meeting rooms, planning room, Top Secret room, and additional Secret office area;
- External walls were a lightweight construction as there was no significant external noise at the site. The walls were up-rated using insulation in the wall cavity and two layers of plasterboard on separate steel studs to the interior. These internal layers also attenuated flanking noise travelling via the external wall cavity between the Secret room and the adjacent room;
- It was not practical to use soundlocks for the meeting rooms, and hence minimum Rw45 doors were selected. It was noted that if required, guards could be posted outside the doors to avoid people "listening-in" near these rooms;
- External windows were located in one of the meeting rooms, and the additional Secret office area. Double glazed windows (10.38mm laminated glass, 90mm air cavity, 6.38mm laminated glass) was installed to meet the Secret room requirement;
- Noise to the floor above and below was contained by the concrete floor slabs and ceilings;
- Soundlocks were configured for the additional Secret office area (Rw40 and 45mm SC+S), the planning room (Rw40 and 45mm SC+S) and Top Secret room (Rw45 and 45mm SC+S);
- The mechanical plantroom was located a reasonable distance from the meeting rooms and separate supply air ducts were provided. The return air transfer ducts were shaped and lengthened to meet the Secret room rating. Supply and return air ducts were internally insulated.
- The plantroom for the planning and top secret rooms was located adjacent these spaces which provided relatively short duct runs. The ducts were lengthened and internally lined to achieve the required Secret and Top Secret room performance;
- To further improve the security for this plantroom, the client decided to make the plantroom secure (i.e. keypad access).

Key acoustic items- second floor:

- The second floor included a Secret meeting room, and the construction was as noted for the first floor;
- To address the potential issue of persons "listening in" from the roof (non-secure area, as it had access stairs for maintenance) the roof/ ceiling was designed to provide a high acoustic rating. This was coordinated with the under roof treatment to control rain noise intrusion for the other office areas on the second floor;
- The mechanical plantroom was located a reasonable distance from the meeting room and a separate supply air duct was provided. The return air transfer duct was shaped and lengthened to meet the Secret room rating. Supply and return air ducts were internally insulated.

## CONSTRUCTION

### All sites

In order to maximise the "as-installed" performance of the acoustic treatments, site inspections were undertaken at selected points during the construction of the secure rooms. Key items during the construction included:

- Sealing around all penetrations (cables, conduits, cable trays, ducts) of acoustic and plantroom walls;
- Sealing door and window frames to walls;
- Checking glazing well sealed to frames with neoprene wedges and internal jockey sash seals compressed;
- Door seals installed and adjusted;
- Providing additional details to builder to address acoustic wall connection to window mullions.

### Site 3

The re-design of the office area on the first floor to become an additional Secret office area was proposed when the construction was well advanced. Discussions with the builder indicated that it would be preferable to upgrade the existing partitions (due to time and mechanical services constraints) rather than demolish and replace the partitions that had recently been built. The upgrade was achieved by adding an extra layer of plasterboard on resilient clips to one side of the partition. A soundlock was added to replace the previous single door to the office area.

During construction the builder advised that he would be installing the acoustic rated doors. While this is becoming more common, the preferred approach is for the acoustic rated doors to be supplied and installed by the manufacturer as they have a better understanding of ways to maximise the performance of the door (eg. via more accurate installation and adjustment of door seals). The supplied doors were rated at Rw47 which exceeded the required Rw40 or 45, however the steel doors were only 48mm thick which is considerably thinner than other acoustic doors with similar ratings. This raised some concern regarding their "as-installed" performance. The doors incorporated compression seals and magnetic seals to head and jambs, drop seal to the base of the door and a threshold seal. The threshold seal was reviewed as a potential tripping hazard by the design team, but was considered acceptable.

**Figure 6**. Acoustic rated door showing threshold seal

## CERTIFICATION

As required by the client all of the Secret and Top Secret rooms were tested prior to use. The acoustic tests were one of several requirements to be met before the rooms were deemed suitable for use. Monitoring for the tests was undertaken at several locations surrounding each room at the nearest non-secure areas. For a single Secret room this required measurements on the same floor, the floor above and the floor below. Where the Secret room was on the top floor of a building, measurements were taken on the roof above where the roof was considered to be accessible. For Secret rooms on the external facade of a building, measurements were also taken outside the building. The results of testing for each of the three case studies are discussed below.

### Site 1

Acoustic testing was undertaken in accordance with AS1276 [2] and AS2253 [3].

The ground floor rooms resulted in a minimum field transmission loss performance of NIC49. The lowest result was achieved by the soundlock from the briefing room to the non-secure corridor. This was due to poor fitting of the acoustic seals to the central meeting stile. The door was nominally 100mm thick timber construction with triple seals to the head, jambs and base of the door. Difficulties experienced by the builder during installation of the acoustic seals to the central meeting stile of the door resulted in no seals being present for the central meeting stile during the acoustic testing. Additional measurements on site indicated that the STC43 door was only achieving NIC35 in-situ. Some break-out noise from a duct above the non-secure corridor ceiling was audible but still met the NIC40 requirement.

**Figure 7**. Timber acoustic rated door with seals removed for fitting of door lock

The first floor Secret meeting room achieved a minimum field transmission loss performance of NIC41. The acoustic rated door again provided the lowest result, however the result was reasonable achieving NIC41 from an STC46 door. Prior to testing of the room the door seals were adjusted to achieve suitable levels of compression of the acoustic seals.

The results of this testing highlighted the need for ducts to be acoustically treated and sealed where they penetrate acoustic walls, and the need for acoustic seals to be properly installed with no sections removed for door hardware.

### Site 2

Acoustic testing was undertaken in accordance with AS1276 [2] and AS2253 [3].

The sound source was setup within the temporary building with doors and windows closed and noise levels were measured at several distances outside the building. Post analysis of the noise levels was undertaken to determine the distance (6m from the building facade) the security fence should be located to achieve the NIC40 Secret room performance.

### Site 3

Acoustic testing was undertaken in accordance with ISO140-4 [4] and AS/NZS ISO717.1 [5].

During the first round of testing, it was apparent that the acoustic doors to three of the secret rooms would not meet the acoustic requirements, returning results of Dw 25 - 35. The main leakage point was at the threshold as the drop seals did not align well with the threshold plate. The threshold

plates were replaced with a threshold plate incorporating a compression seal, and the doors were re-tested.

The second round of testing revealed that two doors still required further adjustment, returning results of Dw 37 and 39. Diagnostic tests during this round showed that the drop seals on these doors were not sealing as well as an alternative drop seal used on other doors, particularly at the door hinge end, and these were replaced. It was also observed that the threshold seals should be raised to provide a more positive contact with the door. The head and jamb seals were sealed with flexible mastic sealant to the door frame, to minimise sound leakage. Additional "batwing type" seals were added to the head and jambs, and a sweep seal was added to the base of the doors.

**Figure 8**. Acoustic rated door showing "batwing", magnetic and compression seals to head and jamb

**Figure 9**. Acoustic rated door showing surface mounted drop seal and sweep seal to base of the door

The third test showed that all doors met the acoustic criteria, returning results of Dw41 and 42. During testing it was noted that flexing one of the steel doors increased the Dw by 2dB, as it improved the compression of the seals. However this raised the question of the ability of the doors to achieve the tested ratings in the future if the doors were subjected to similar forces from being wedged open or occasional knocks or kicks during normal use. The supplied doors were a steel construction and were relatively thin 48mm thick compared to other acoustic rated doors (often around 100mm thick). The combination of steel construction and "thin" door allowed the door to flex which reduced the compression of the door seals and hence reduced the door performance.

The final Secret room test results ranged from Dw41 to Dw50. The Top Secret room sound lock achieved Dw49.

The improvement in Dw performance of the lowest performance door is summarised in Table 2.

**Table 2**. Door Test Results

| Test | Dw | Comment |
|---|---|---|
| #1 | 25 | Magnetic and compression seals to head and jamb, and drop seal to base of door |
| #2 | 37 | Threshold seal fitted to the floor |
| #3 | 41 | Installed better drop seal and sweep seal to base of door, installed extra seal to head and jambs, sealed acoustic seals to door frame. |

The acoustic door to one of the Secret rooms faced into an alcove, and it was found that this enhanced the sound pressure level outside the room – effectively reducing the Dw rating. As an alternative to fitting the extra seals, acoustic treatment to the walls of the alcove was considered as another method of increasing the Dw for sound radiating from the room.

## CONCLUSIONS

Based on the design and testing undertaken on the Secret and Top Secret rooms, the following conclusions can be drawn:

- In order to achieve the Secret and Top Secret room acoustic requirements – walls, foor, ceiling, roof, ducting and doors must be acoustically treated;
- Secure corridors should be used where practical to physically separate secure and non-secure areas;
- Doors typically provide the lowest sound isolation;
- Soundlocks should be considered where possible to achieve the required performance through the doors;
- Doors should ideally be installed by the supplier (or by a competent installer) complete with all seals and door hardware as per the laboratory test (to avoid sections of door seals having to be removed for the hardware);
- Doors should be of sufficient thickness and of a rigid construction to ensure door seals are well compressed by the door. "Thin" steel doors may be too flexible to achieve adequate compression of door seals in practice;
- Junctions between walls and window mullions must be designed to avoid leakage;
- Membrane type ceiling and wall acoustic treatments could be investigated for use in secure rooms to achieve suitable reverberation times.

## REFERENCES

1 Australian/ New Zealand Standard AS/NZS 2107 *Acoustics – Recommended design sound levels and reverberation times for building interiors*

2 Australian Standard AS1276 *Methods for determination of sound transmission class and noise isolation class of building partitions*

3 Australian Standard AS2253 *Methods for field measurement of the reduction of airborne sound transmission in buildings*

4 International Standard ISO140-4 *Acoustics - Measurement of sound insulation in buildings and of building elements, Part 4: Field measurements of airborne sound insulation between rooms*

5 Australian/ New Zealand Standard AS/NZS ISO717.1 *Acoustics – Rating of sound insulation in buildings and of building elements, Part 1: Airborne sound insulation*