Building Sealing

Health Technical Advice HTA 2024-001

Purpose

This Health Technical Advice (HTA) provides general guidance on building sealing for health projects. This HTA does not cover specific air permeability and pressure regimes for clinical or laboratory spaces.

This HTA is to be read in conjunction with the Guidelines for sustainability in health care capital works <https://www.vhba.vic.gov.au/sites/default/files/2021-10/Sustainability-guidelines-for-capital-works-VHBA-Revised-October-2021.pdf> ('the Guidelines').

Building sealing

What is building sealing?

Building sealing (sometimes referred to as 'building airtightness') is the practice of designing and constructing buildings to have a continuous air barrier between the indoor and outdoor environment. The level of building sealing is assessed through an air permeability test.

Why is building sealing important?

Building sealing is an important passive design initiative to improve building performance across a range of indicators.

Energy efficiency

If a building is not well-sealed, it can be prone to uncontrolled air exchange (often referred to as 'air infiltration' or 'air leakage') between the indoor and outdoor environment, resulting in higher heating and cooling energy consumption. In Victoria, where heating dominates annual energy consumption, well-sealed buildings have significantly lower annual heating energy consumption and associated utility bills. This benefit is even greater for buildings that operate 24 hours per day, such as hospitals.

Occupant health and wellbeing

A well-sealed building typically has better temperature control and less chance of draughts, improving occupant thermal comfort.

Proper building sealing can also improve indoor air quality by keeping out external pollutants such as traffic fumes, bushfire smoke, and noise.

Building fabric protection

Well-sealed buildings have a lower chance of moisture ingress which protects internal materials, such as wall insulation, from water damage. In some cases, undetected water ingress can lead to mould, which poses a significant health risk to occupants and can incur significant cost and disruption to rectify.

Climate change resilience

Climate change is expected to result in more extreme weather conditions, some of which are already being experienced in Australia. Providing a high-performance, well-sealed building envelope increases resilience of the infrastructure and helps to protect occupants of a building from the effects of events such as heat waves, high winds, and storms.

Infection control

Delivering a well-sealed building is beneficial for accurately controlling pressure regimes that are often required in health care buildings for infection control. With less air leakage, it is easier to pressurise zones and control air movement through the building as per the design intent.

Isolation rooms and associated anterooms are required to undergo separate air permeability testing which is not covered in this HTA. Refer to the VHBA engineering guidelines for healthcare facilities <https://www.vhba.vic.gov.au/engineering-guidelines-healthcare-facilities> for more information on health care pressure regimes.

Air permeability testing

Why are health care buildings required to undertake air permeability testing?

The Guidelines require that health projects undergo air permeability testing to provide assurance that the completed building is well-sealed and delivers on the sustainability and performance benefits outlined above.

The National Construction Code includes prescriptive building sealing requirements in ‘Part J5 Building Sealing’. These prescriptive requirements provide a good starting point for delivering a well-sealed building however, it is possible to meet these provisions and still deliver a ‘leaky’ building. This is because delivering a well-sealed building is not a checkbox exercise, requiring attention to detail during the design phase and additional diligence during construction to ensure a continuous air barrier is achieved.

How is air permeability testing carried out?

For health projects, the Guidelines refer to the NCC J1V4 methodology, which calls up AS/NZS ISO 9972 Method 1 as the testing protocol. This testing protocol (often referred to as a ‘blower door test’) requires pressurisation of the building with large fans so that air leakage can be measured as the pressurised air in the building leaks out – the rate of this air leakage defines the test result. For this test, natural ventilation openings (e.g., windows and doors) are closed, and mechanical ventilation or air conditioning inlets and outlets of systems that operate continuously are sealed, thus isolating the air permeability of the building envelope for the test. It should be noted that intermittently operating mechanical ventilation or air conditioning inlets and outlets cannot be sealed for the test, therefore these systems must be designed with dampers that automatically close when the system is not in use.

It is noted that there is a conflict in the current Guidelines, which states that 10% of the building, by floor area, is to undergo testing. AS/NZS ISO 9972 Method 1 does not permit partial testing of buildings, as the tested envelope area must only include external building envelope surfaces of the conditioned volume (including spill air zones such as ceiling voids).

Figure 1. Air permeability testing fans during construction phase of a VHBA project

As such, 100% of the building conditioned volume should be tested when following AS/NZS ISO 9972 Method 1.

What test result is deemed compliant?

For health projects, a maximum air permeability test result of $5m^3/hr.m^2$ at 50Pa is required as per the Guidelines.

The project may have set a lower leakage rate as part of the sustainability strategy, in which case this more stringent target takes precedent.

What happens if the building doesn’t comply?

If the air permeability test result is greater that $5m^3/hr.m^2$ at 50Pa (or a more stringent project specific target), air leakage will need to be remediated and retested until compliance is demonstrated. This can potentially cause delays to project program and is therefore a project delivery risk. Following the process outlined in this HTA may reduce the risk of a non-compliant test result through an enhanced design and construction approach that focusses on building sealing, and the associated project delivery risks.

Managing vapour control and ventilation

Adequate mechanical ventilation is crucial when designing well-sealed buildings. Inadequate ventilation in a well-sealed building may lead high levels airborne pollutants (e.g., carbon dioxide, or dust), condensation, and mould – all of which can have negative health impacts for building occupants.

Appropriate vapour permeability and wall construction details must consider and mitigate interstitial condensation risk and comply with relevant regulations.

Advice on vapour control should be sought from a qualified professional such as a façade consultant. In some cases (such as a bespoke wall construction), this may need to be validated during the design phase using steady state or dynamic hygrothermal analysis to ensure the risk of interstitial moisture occurring in the building envelope is minimised.

Delivering a well-sealed health care building

Delivering a well-sealed building requires consideration throughout the design, construction, and operational phases. The following section provides a resource to assist project teams in delivering well-sealed buildings that deliver on the sustainability and building performance benefits outlined earlier in this HTA.

Projects have a sustainability budget of 2.5% of total construction cost dedicated to delivering sustainability initiatives that exceed the business-as-usual (BAU) requirements nominated in the Guidelines. This budget may be utilised for engaging an air tightness specialist during the design and construction stages and to undertake the final testing.

Additionally, the 2.5% sustainability budget may support any additional construction materials or processes over and above the base cost as required to meet a more stringent air permeability target than the minimum requirement of 5m3/hr.m2@50Pa.

Engaging an airtightness specialist

Depending on project scale, complexity, and targeted air permeability test result, it can be beneficial to engage a qualified airtightness specialist to provide design stage advice and construction quality assurance prior to final testing, reducing the risk of a non-compliant test result. The project team, in collaboration with the VHBA sustainability team, should decide early in the Schematic Design phase what is the most appropriate strategy for the specific project.

Air tightness design consultancy, quality assurance, and testing must be undertaken by a suitably qualified airtightness testing practitioner who is a member of the Air Tightness Testing and Measurement Association (ATTMA) or a testing member of the Air Infiltration and Ventilation Association of Australia (AIVAA). A model scope of works for an airtightness specialist to assist project teams in engaging appropriate services is provided in Appendix 1.

During the design stage, engagement of an airtightness specialist should be to the Principal Consultant. Post-tender, the engagement is directly to the Contractor.

Schematic design

As with most holistic design approaches, when considered early in the design, building sealing can be integrated more easily and with lower capital cost impact.

An air barrier schematic (sometimes called a ‘red line drawing’) should be developed, that shows in plan and section the location of the continuous air barrier enclosing the conditioned areas of the building. This should be coordinated with other requirements such as building services penetrations and smoke / fire compartments. This will identify the specific constructions and junctions in the design that need to be considered from an airtightness perspective in the detailed design phase. Constructability, cost, and program impacts should be reviewed and allowed for.

At this stage the team may wish to investigate the energy benefit of exceeding minimum building sealing requirement through an assessment. This can be done through manual calculations or whole building energy modelling. When using energy modelling, air leakage parameters in the model should be adjusted using the methodology outlined in CIBSE Guide A (2015, UK), which converts the air permeability test target into air leakage at atmospheric pressure. Whole building energy modelling should already be included in the Building Services or ESD consultant scope.

Detailed design

The design should be further developed to include air barrier continuity on building plans, sections, and details, and coordinated between relevant design disciplines.

A review should be carried out to ensure that the design is on track to achieve the target air permeability test result. This review includes material and product selection, interior separations between conditioned and unconditioned spaces, junctions and details between building elements, and the impact of building services installations on air barrier continuity. Constructability, cost, and program impacts should be reviewed and allowed for.

Include airtightness membrane specification/performance requirements in documentation and detailing in architectural and façade documentation.

Each project has a bespoke design and its own challenges when it comes to detailing and constructing a continuous air barrier. Some commonly identified air leakage paths are listed Appendix 2 to assist project teams.

Tender documentation

The contract preliminaries should clearly outline that the specified air permeability test result is a contractual requirement, with the Contractor having overall responsibility for management of the trades, engagement of the airtightness testing practitioner post tender, coordination of the testing, and (if required) undertaking air leakage identification, remediation works, and retesting should the specified performance target not be achieved.

Achieving the specified air permeability test result should be identified as a contract hold point so that any required rectification works are carried out before further work progresses that may hamper air leakage identification and remedial sealing.

Construction

If not engaged during the design stage, the air tightness practitioner should be engaged post tender to provide an air tightness testing and quality assurance plan which is coordinated with the overall construction program. The air tightness testing plan is to be prepared by the qualified airtightness specialist, and should define the testing methodology, relevant quality control checkpoints during construction (physical inspections, spot tests, etc.), and the program for testing of the building.

Diligence during the construction phase is crucial for delivering a well-sealed building. It is recommended that the Contractor nominates a site ‘Airtightness Champion’ who will undertake regular inspections, engage with trades to ensure the airtightness barrier is maintained throughout construction, and coordinate with the airtightness practitioner for quality control checkpoints during construction.

Where possible, it is recommended that air permeability testing occurs prior to internal linings being applied. In the case of a failing test result, this allows simpler access for air leakage path identification and remedial sealing works.

The use of application-based tools is a current trend in the construction phase, whereby issues identified during quality control can be photographed and then remedial works logged to demonstrate that rectification has taken place without the need for excessive site inspections.

Air permeability testing

The building should be prepared for testing in accordance with the testing plan. This includes closing all ventilation openings, sealing continuously operating ventilation systems, and ensuring motorised dampers for intermittently operating ventilation systems are in the close position. If isolating the test area from an existing conditioned space, ensure any temporary partitions are installed and inspected.

Air permeability testing is to be performed in accordance with Method 1 of AS/NZS ISO 9972:2015 and relevant parts of ATTMA TSL2 and TSL3 (2021).

If the specified air permeability test result is not achieved, the air leakage path must be identified through methods such as ultrasonic scanning or smoke tests, remediated, and retested until compliance with the project target is achieved.

Building handover

Identify air tightness barrier on the IFC / As Built drawings so that any future modifications or maintenance activities can plan to avoid compromising the air barrier.

Building operation

Should any major works to the building envelope occur in the future, retesting to achieve the original air permeability target should be included in the project scope.

Appendix 1

Airtightness specialist model scope of works

This Appendix includes a model scope of works for engaging an airtightness practitioner through the project design and construction phases.

Overview

The [*Principal*] is seeking a qualified airtightness specialist to act on its behalf for the [*project name*]. It is proposed that the airtightness specialist will be engaged early in the [*project phase*] phase.

The [*Principal's*] target for the airtightness of the end facility is [*X*m^3/m^2.h @50pa].

The airtightness specialist's services and fees are to be split between the design and construction phases. It is noted that during construction the airtightness specialist will be engaged by the contractor or novated to the contractor depending on project procurement method.

Qualifications

- Airtightness design consultancy, quality assurance, and testing must be undertaken by a suitably qualified air tightness testing practitioner who is a member of the Air Tightness Testing and Measurement Association (ATTMA) or a testing member of the Air Infiltration and Ventilation Association of Australia (AIVAA).

Schematic Design Review (optional – delete as required)

- Develop an air barrier schematic for each floor plan and typical building section.
- Undertake a preliminary review of the documentation and provide a schedule of risks and recommendations for further discussion with the project team.
- Facilitate a workshop with the design team to review risks and recommendations.
- Provide input to the schematic design stage report.
- Provide advice on costing for the air barrier system.
- Information required from the design team during this stage includes:

  Architect:

  - Identification of wall, roof, and floor types that form the air barrier including atypical constructions or materials

  Services engineer:

  - Confirmation of conditioned areas
  - Sketch layouts showing services penetrations through the air barrier (internal and façade).

  Building surveyor / Fire engineer:

  - Confirmation of smoke and fire compartments

Detailed Design Review (optional – delete as required)

- Undertake a detailed review of the design and provide advice as follows relating the air barrier:
  - Suitable materials and specifications
  - Wall, roof, and floor types and junction details, including alterative options
  - Construction methods and sequencing
  - Sealing methods

  - Scope of work and necessary coordination between trades and responsibilities

- Facilitate a workshop with the design team to review risks and recommendations.
- Provide a standalone design report.
- Provide advice on costing for the air barrier system.
- Information required from the design team during this stage includes:

  Architect and/or façade engineer:

  - Wall, roof, and floor types and material specifications that form the air barrier
  - Wall sections and details

  Services engineer:

  - Services layout and design drawings
  - Services penetration details

Tender (optional – delete as required)

- Undertake Tender documentation review to ensure recommendations have been fully incorporated in drawings and specifications
- Provide a plan/specification for the commissioning of air tightness for inclusion in the Tender documents

Construction Phase

- Undertake IFC documentation review to ensure recommendations have been fully incorporated (where relevant).
- Prepare an airtightness testing and quality assurance plan:
  - Building air permeability construction activities must be coordinated with the delivery program and other trades
  - Include construction phase inspection and pre-testing checklists
- Conduct trade workshops prior to installation of each element of the air barrier. The purpose of the workshops is:
  - To explain the importance of achieving a well-sealed building
  - Outline the extent of the air barrier
  - Provide guidance on key success factors for installation of a continuous air barrier and maintaining its integrity throughout the construction phase

  The workshop must be attended by all trades installing elements of the air barrier and building services trades.

- Provide ongoing support and advice to the onsite airtightness champion.
- Undertake air barrier inspections throughout the construction phase including inspection of a sample installation of each element of the air barrier to identify any incorrect installation practices early.
- Undertake interim qualitative tests (e.g. ultrasonic scanning or smoke tests) at key air barrier milestones and prior to installation of internal linings.

Whole building permeability test

- Airtightness testing must be carried out in-situ and must include 100% of the conditioned volume.

- All conditioned zone interfaces must be exposed to testing, including leakage to stairwells, risers, lift shafts, plant rooms or other adjacent unconditioned zones. Factory testing or isolated façade system testing will not be accepted.
- Review pre-testing checklist items to ensure building is suitably prepared for permeability testing.
- In scenarios when a new building or extension connects directly to a conditioned zone of an existing building, the new areas must be tested through either permanent or temporary isolation of the existing areas.
- All completion testing, compliant with project targets or otherwise, will be reported to the [*Principal*].
- Testing and reporting are to be performed in accordance with Method 1 of AS/NZS ISO 9972:2015 and relevant parts of ATTMA TSL2 and TSL3 (2021).
- Submit certified test reports to the [*Principal*] and VHBA along with confirmation that air permeability outcomes have been achieved in accordance with the requirements laid out in the contractual documentation and air tightness commissioning plan.

Remediation and retesting

- Should the air permeability result not meet the project target, in collaboration with the Contractor and relevant trades, develop a remediation strategy.

Appendix 2

Common air leakage issues

Each project has a bespoke design and its own challenges when it comes to detailing and constructing a continuous air barrier. Some commonly identified air leakage paths are listed below as a starting point.

Roof

- Junction between the roof and wall, or roof and box gutter.
- Where profiled steel roof sheets are joined (e.g. at a ridge cap).

Façade

- Junctions between façade modules (e.g. precast panels, speed panel, or curtain wall modules).
- Weep holes (don't rely on an element with weep holds to achieve air tightness).
- Air barrier taped to rough slab edges (use formwork that results in a smooth slab edge).
- External wall and ground slab junction (a plinth may alleviate this issue).
- Discontinued linings in ceiling void (install linings slab to slab where they form the air barrier).
- External canopy ceiling spaces (these voids should be excluded from the air barrier if possible).
- Blockwork (inherently prone to air leakage and requires a sealant coating and specific attention to mortar and expansion joints).
- Missing window and door frame gaskets.
- Damage to installed air barrier by finishing trades (this requires diligence during construction).

Risers

- Risers that are not capped off (if a riser is open to the plant room, this means branches at every floor require careful sealing, and the riser construction itself needs to be well sealed).

Fenestration

- Sliding doors – particularly frameless glass type (difficult to seal due to required clearances for door operation).
- Doors and windows that do not have appropriate air seals (should be "low air infiltration" type as classified by Table 2.3 AS2047:2014 – higher performance may be required if the project to is aiming for high levels of airtightness).
- Interface between window and door frames and walls.
- Window and door frames that do not accommodate effective sealing to air barrier membrane.
- Roller doors are inherently leaky due to the clearances required for the door to operate.

Other

- Lift door seals (where a lift connects to areas outside the conditioned volume such as a car park).
- Dampers on mechanical systems not fully closing (e.g. outdoor air damper).
- Access panels that do not have appropriate air seals.
- Building services penetrations (e.g. ducts or cable trays that penetrate the air barrier).
- Floor penetrations in suspended floors (e.g. plumbing).

- Incorrectly installed building wraps, tapes, or rigid air barrier board (requires a skilled trade to install a continuous barrier that maintains air tightness at slabs and around penetrations).
- Incomplete / compromised caulking of junctions (requires diligence during construction).

Construction air leakage examples

The images below show a selection of air leakage issues identified during the construction phase of a VHBA project. The issues were logged by the air tightness specialist and rectified by the builder prior to air permeability testing. Upon testing, the project complied with the project target air permeability requirement of $5m^3/m^2.h$ @50pa.

Figure 2. Air barrier membrane not taped correctly

Figure 3. Cable penetration not sealed

Figure 4. Smoke wall not continuously sealed

Figure 4. Air leakage path in facade between structure and door module

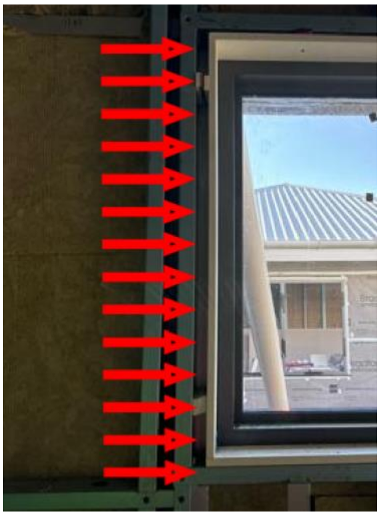

Figure 5. Air leakage path around window module

Figure 6. Seal at roof/wall junction not continuously sealed

Resources

VHBA guidelines

NCC 2022 Volume One <https://ncc.abcb.gov.au/editions/ncc-2022/adopted/volume-one/preface/copyright-and-licence-notice>

Guidelines for Sustainability in Health Care Capital Works <https://www.vhba.vic.gov.au/sites/default/files/2021-10/Sustainability-guidelines-for-capital-works-VHBA-Revised-October-2021.pdf>

VHBA engineering guidelines for healthcare facilities <https://www.vhba.vic.gov.au/engineering-guidelines-healthcare-facilities>

Air tightness testing practitioner registers

Registered air tightness testers - Australia <https://www.bcta.group/attma/members/air-tightness-testers/australia/>

Air Infiltration and Ventilation Association <https://aivaa.asn.au/>

Contacts

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