The Scottish Government

BUILDING STANDARDS DIVISION

SOUND AND AIR-TIGHTNESS TESTING

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CONTENTS

1 INTRODUCTION

1.1 Background

There are aspects of building performance which can only be demonstrated through testing. Following recent improvements to the Technical Handbooks for noise and energy, the need to assess and report on these matters becomes increasingly important in order to demonstrate that the building's intended performance is achieved when constructed.

The building standards system has always been pre-emptive, based on the verification that designs comply with standards before a building warrant is granted and work begins on site. Over the years this has worked well, particularly where standards are primarily concerned with health and safety. However, as standards are improved in the areas of sound and energy, incorrect detailing or poor assembly of components can have a significant impact on the overall performance of building elements and the building as a whole. The need to gain greater certainty during the construction stage that designed performance is being achieved on site has brought about the introduction of performance testing to support the completion certificate process for buildings.

Sound testing has been in the Scottish building regulations for many years. Up until now it has generally been used to check that non-standard constructions, as built, meet the regulations.

Air-tightness testing was first introduced to the Technical Handbooks in 2007 as a means to demonstrate that high levels of air-tightness declared at the design stage, were being met at the construction stage.

In response to the Scottish Government's Compliance Agenda, the 2010 version of the Technical Handbooks that came into force on 1 October 2010 strengthened both sound and air-tightness testing. On 1 May 2011 testing on a representative sample of buildings will be introduced in phases. As a consequence, buildings will need to be designed and constructed to achieve a consistently good level of performance, so that the sound insulation levels are achieved and heat loss from uncontrolled air infiltration meets the declared performance levels.

1.2 Purpose of document

This document supports guidance in the Technical Handbooks on sound and air-tightness testing. It is intended to provide information that will achieve a national consistency in approach and assist all building professionals, who are not familiar with testing, to better understand their roles and responsibilities in respect of testing. It will also give guidance on how to implement practices to support successful testing and achieve the level of performance needed for compliance in a range of building types.

This document includes methods and descriptions on how to plan and carry out sound and air-tightness testing for buildings. It can be used to assist when deciding on matters such as the number of tests required, if the building is ready for testing,

and informing on measures to be considered if a test fails to meet the required performance levels.

Carrying out sound and air-tightness testing will verify that design levels are achieved. In respect of the latter, that the intended ventilation strategy for the building remains appropriate and that the overall level of energy performance is not downgraded by the air permeability aspect.

1.3 Status of document

This document sets out the process involved in achieving compliance using sound and air-tightness testing. It should be read in conjunction with section 5: Noise and section: 6 Energy, of the Technical Handbooks.

Technical Handbooks for Domestic and Non-Domestic buildings are published on the Scottish Government website www.scotland.gov.uk/bsd and any part may be downloaded free of charge. They are also available, to purchase in hard copy from The Stationery Office (TSO).

2 TESTING

2.1 Levels of testing

Guidance on performance levels to be achieved for sound and air-tightness testing and the recommendations on the ratio for representative sampling of testing are given in the Domestic and Non-domestic Technical Handbooks, section 5: Noise and section 6: Energy, www.scotland.gov.uk/bsd

2.2 Dwelling types

The definition of a dwelling for the purpose of this document is given in Appendix A. It can also be found in Annex A (Defined Terms) of the Technical Handbooks.

2.3 Developing processes to support performance testing

The wider application of performance testing in building regulations raises particular implications for the developer. There is now a need to consider testing as an additional stage within a project. However the quality assurance measures used by designers, developers and contractors can support the construction of buildings to achieve the performance standards.

2.4 Design and construction stage

For those involved in the design and construction stage of new buildings consideration should be given to what additional measures and practices may be needed so that new buildings are 'right first time'. This might include clearer specifications, revised site checks, briefing of site operatives and an enhanced regime of self-testing so that measures implemented are being effective.

Equally important is the involvement of specialist advice from testers at an early stage, particularly where this expertise does not already exist within the development team.

Further guidance to assist in the understanding and application of the design and construction principles needed to meet the sound insulation performance levels can be found in the Example Constructions www.scotland.gov.uk/bsd Guidance on limiting uncontrolled air infiltration is given in the Accredited Construction Details (Scotland) document www.scotland.gov.uk/bsd

3 PLANNING FOR A TEST

3.1 Thinking ahead

In most cases, the party responsible for the development will be in contact with the verifier and are likely to employ a third party to carry out testing. The testing company will normally need to be given enough notice to enable them to carry out testing on the day requested. The verifier should be advised of the test dates to enable them to attend should they consider this necessary.

3.2 Pre- Building Warrant application stage

Before a building warrant application is submitted to the verifier, it is worth considering the elements of the building design that will be assessed under the building warrant and completion certificate process. Paying attention to detailing such as separating walls and floors or the external envelope of the building, including the junctions of external walls/floors or window and door openings in the building, will help to achieve the design performance level or building design intent. Involvement of testing organisations at an early stage in a project will also assist in developing proposals.

3.3 Building Warrant application stage – testing regime agreement

Discussion with the verifier should be carried out during the building warrant application stage. This will allow a schedule of testing to be agreed in writing. This should include the number of plots needed to provide a representative sample, including consideration of variation in building types and constructions used.

This will also allow time to be programmed in for any remedial action needed if a test fails to achieve the required levels and for any additional testing.

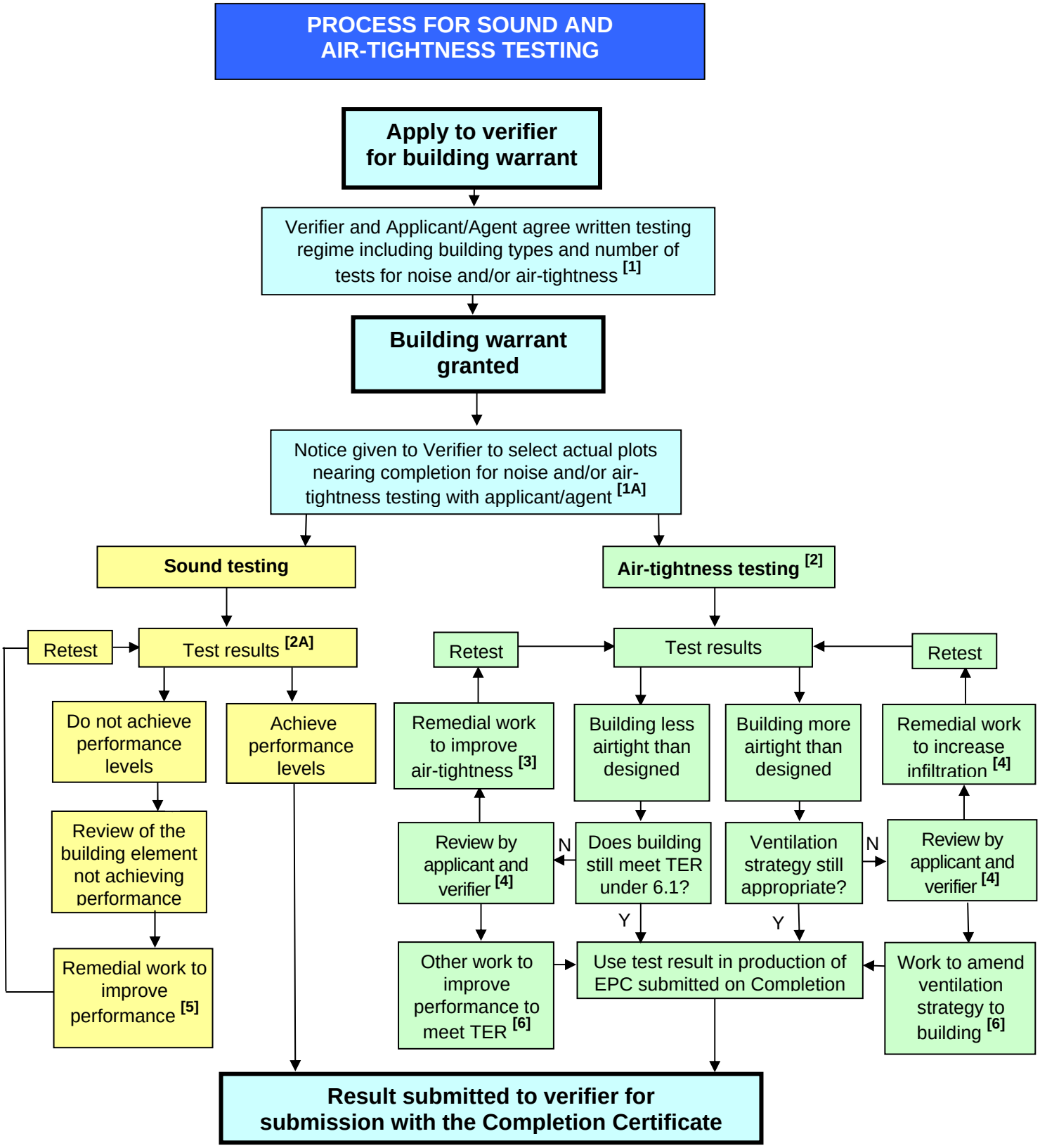
3.4 Who chooses the plots to be tested on site?

For dwellings and smaller non-domestic buildings, the verifier will select the plots to be tested. These should include the initial building(s) to be completed, thereafter there should be an ‘even spread’ of tests carried out on the remainder of the development.

Testing should be representative of the work being carried out and specific plots should not be selected in advance of the construction work being completed. Instead, test plots should be selected from a range of buildings nearing completion, and be identified at least two days in advance of the test date. Variations can be agreed by mutual consent, to suit changes in programme.

3.5 Flow diagram – Process for Sound and Air-tightness testing

The following flow diagram is provided to aid understanding of the process from building warrant application to completion certificate. Each number in the ‘Notes’ provides additional information or reference to a paragraph within the document that will expand on the relevant stage and provide additional information.



Notes:

1. See clause 3.3
1A. See clause 3.4
2. For dwellings, testing not required where default infiltration rate of 15m³/m².hr @ 50pa is declared
2A See clause 4.4 Noise
3. See clause 5.5 Test results that indicate a need for remedial action may trigger a review of the testing schedule and additional tests
4 See clause 5.5
5 See clause 4.5
6 Work which introduces new elements to design may attract an amendment to the building warrant

4 SOUND TESTING

4.1 What does a sound test involve?

Airborne sound

Separating walls and floors are tested for airborne sound. This should be undertaken by an accredited member of an organisation (see 4.2). When testing airborne sound performance two adjoining rooms are used. A sound source (loudspeaker) see Fig. 3, is set up in one room on one side of the separating wall or floor being tested. The sound levels in each are room are then measured using a sound level meter, see Fig. 2. The difference in sound level is then calculated and compared against the sound performance levels in section 5: Noise of the Technical Handbooks.

Fig. 1 Sound test being carried out

Fig. 2 Typical sound level meter for measuring sound insulation

Fig. 3 Typical loudspeakers used during airborne sound insulation tests

Impact sound

Floors are tested for impact sound. This will also be carried out by an accredited member of an organisation (see 4.2). Impact sound tests involve using a tapping machine, see Fig. 5, on the floor in a room directly above another. The sound level is then measured in the room below. The result is then compared against the sound performance levels in section 5: Noise of the Technical Handbooks.

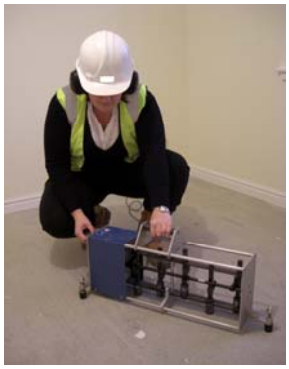


Fig. 4 Impact sound test being carried out

Fig. 5 Typical tapping machines for impact sound insulation tests

The condition the buildings/dwelling is in before and during the test is important, as they can influence the results of the test. The following stages for sound testing will help preparation and also assess the point at which completed buildings can be tested. An example checklist, for use on site, is provided in Appendix B.

Generally before the test the parts of the building/rooms either side of the separating wall or separating floor should be complete. Particular attention should be paid to the following:

- All separating walls and floors and all flanking walls and floors should be complete.
- All wall and floor junctions should be complete.
- All wall finishes should be complete, this should include skirtings being in place. This does not include decorative finishes such as paint.
- Floors must be bare and no carpets should be laid. Except, where a concrete floor with bonded resilient cover is to be fitted with wood based flooring. In this case, the test sample resilient floor cover should be tested with a wood based floor covering laid over the test sample area. See Example Constructions Annex B2.
- All doors should be fully fitted and closed. This includes internal doors and external doors fully fitted with doors seals.
- Windows should be fully fitted with trickle vent covers in place and closed.
- Services should be complete and any voids around ducts finished.
- Electrical sockets should be fitted.
- An electricity supply should be available to the test plots 110v or 240v.

Generally during the test:

- There should be no noise during the test other than from the testing equipment.
- The test plots and adjacent areas within the building should be quiet for the duration of the test.
- No work should be carried out or noise made in the building at the time of the test.
- Site workers should not enter the building or be in the parts of the building undergoing a test.

After the test

A test report or certificate should be provided. This normally provides the following information:

- The company name and/or testers name and address that carried out the test and the accreditation held by the membership organisation.
- The client/applicant name.
- Site address.
- Plots tested – which floors if relevant.
- Wall and floor specification.
- List of equipment used (including details on calibrated equipment) and testing technique.
- Confirmation that the test was in accordance with BS EN ISO 140 Part 4 (airborne) and Part 7 (impact).
- Measurement procedure.
- The results should be calculated in accordance with BS EN ISO 717-1 and 717-2 1997.
- Detailed test results giving a declaration of a pass or fail.
- Date of test.

The test results or certificates will be submitted to the verifier during the completion certificate process.

4.2 Large non-domestic buildings

It is unlikely that there will be many large non-domestic buildings or complex buildings such as nursing homes or student residences, where sound testing will be required. Sound testing is more likely to be required where there is a mixed use building such as a hotel/office complex, where the areas in different occupation have a separating wall or floor.

4.3 Conversions

Conversions and conversion of traditional buildings is common practice, such as changing an office into flats. Where division of the building results in different areas of occupation, such as a flat, there is a need to carry out a sound test.

Pre-conversion sound tests can be carried out prior to the start of any conversion to establish the acoustic performance of the existing construction. This will help to identify any problems that may need the design of a tailored acoustic solution at an early stage.

For larger or more complex work, advice on conversions may be sought from an acoustic specialist who should be able to offer design guidance.

4.4 Who can test?

Testing should be carried out by persons who can demonstrate relevant, recognised expertise in acoustics for sound insulation testing. This should include membership of a professional organisation which, by 1 October 2011, accredits its members as competent to both test and confirm the results.

The following organisations are able to accredit members to carry out sound testing:

- UKAS – United Kingdom Accreditation Service;
- IoA – Institute of Acoustics; and
- ANC – Association of Noise Consultants Registration Scheme.

4.5 Remedial action following a test failure

Noise transmission in buildings is a complex subject and it can be difficult to provide definitive guidance on resolving specific problems that have occurred in individual buildings.

Therefore, it may be prudent to seek advice from a specialist who, through experience of building acoustic design and sound testing, may be able to identify and resolve any problems. A specialist is normally a member of the Institute of Acoustics (IoA) or the Association of Noise Consultants (ANC). UKAS accreditation only covers the testing process. However, a UKAS accredited company may have testers with IoA or ANC membership who can give specialist advice.

If the failure is attributed to the construction of the separating and/or associated flanking elements, other rooms that have not been tested may also fail to meet the test performance levels. Additional tests may be needed, over and above the number recommended in clause 5.1.9 of the Technical Handbooks to check that the work achieves the test performance levels.

Where an even spread of tests has been carried out this will assist in identifying, at an early stage, where the failures have been caused by intermittent poor workmanship. Testing may then be required for all plots to identify the ones that require remedial treatment. Where failure is due to a design fault, additional testing may not be required, as all plots with the same design are likely to require remedial treatment.

4.6 Reporting process when a test fails

When a test fails (see 3.3 and 3.4), the report from the tester giving the reasons for failure should be shared with verifier. The developer should send the report together with a proposal on how to resolve the situation.

5 AIR-TIGHTNESS TESTING

5.1 What does an air-tightness test involve?

The test is carried out by an accredited member of an organisation (see 5.3), and involves connecting a fan, or a number of fans, to a suitable aperture/s in the building envelope and pressurising or de-pressurising it over a range of pressure differences. The fan speed is increased incrementally up to a maximum and then gradually decreased. Air volume flow rates through the fan (equal to the air leaking through the building envelope) and the pressure difference across the building envelope are recorded at each fan speed. In calculating air permeability, corrections are made for temperature and barometric pressure.

The condition the building/dwelling is in before and during the test is important, as they can influence the result of the test. The following points for air-tightness testing will help to prepare for a test and also assess the stages at which completed buildings can be offered for testing. An example of a checklist, for use on site, is provided in Appendix C.

Generally before the test the building should be complete and particular attention should be paid to the following:

- Weather forecasts should be checked by the tester prior to the test date. If weather extremes (wind speed or internal/external temperature differential) are forecast, the test may have to be re-scheduled.
- The extent of the building to be tested should be confirmed.
- The type of test (pressurisation/depressurisation of the building envelope) should be confirmed.
- An acceptable route for the air to flow from the fans and pressure to equalise throughout the test enclosure must be agreed.
- The necessary fan flow required to undertake a valid test should be calculated.
- The location for the installation of the fan equipment should be established. If multiple fan systems are to be utilised, these should be located evenly around the building envelope whenever possible.
- There should be adequate space and access for the fan equipment to be delivered and installed.
- An electrical power supply may be necessary.
- Local restrictions, e.g. noise, working hours etc should be checked.
- The external envelope of the building should be complete and test measurements agreed by all parties concerned.
- All incoming service penetrations (e.g. power, telecoms) should be permanently sealed.
- All external doors and windows should be closed, except for the apertures to which test equipment is connected.
- All internal doors should be fully opened and restrained. Lift doors should be closed and any external lift shaft vents should remain open.
- All drainage traps should be filled with water or temporarily sealed.
- Smoke vents should be closed but not artificially sealed.

- Background trickle ventilators should be closed, passive ventilation systems and permanently open uncontrolled natural ventilation openings should be temporarily sealed.
- Mechanical ventilation and air conditioning systems should be turned off and temporarily sealed to prevent air leakage through the systems during the test.
- Any temporary seals must be robust enough to withstand the test pressure.

Generally during the test:

- Adequate fan capacity must be available to undertake the test.
- A record of the barometric pressure, wind speeds and external and internal temperatures should be taken immediately before and after the test.
- The pressure fans should be operated to provide a building pressure differential of approximately 50 Pa.
- Pressure tubes should be kept away from locations where they may get trapped, or may become heated or cooled excessively. The external reference tube should be located away from the building envelope and must terminate out of the air flows induced by the fan pressurisation system. It should be sheltered from any wind.
- Combustion appliances in the building must be switched off.
- Ensure that temporary seals and external doors and windows have remained closed for the duration of the test.

Fig. 6 Dwelling

Fig. 7 Non-domestic building

After the test

The test report should contain the following:

- Contact details and Accreditation number (if applicable) of relevant testing scheme.
- Building identification information e.g. address, plot number, dwelling type etc.
- Detailed description of the building tested or part(s) of the building tested.
- List of equipment used (including details on calibrated equipment) and testing technique.
- Detailed test results giving a declaration of a pass or fail.
- Date of test.
- Confirmation that the test was in accordance with BS EN 13829:2001.

The test results or certificates will be submitted to the verifier during the completion certificate process.

5.2 Large and complex non-domestic buildings

For non-domestic buildings such as large shopping centres or complex buildings such as general hospitals, air-tightness testing should always be undertaken. Testing is achieved in practice by partitioning the building in sections, sealing them from the remainder of the building and testing the performance of individual sections.

The testing regime for the building should be determined early by the applicant, contractor and design team, with the collaboration of the air-tightness testing body. This will allow any circumstances or areas where testing will not be practicable to be identified and recorded, and to propose additional quality assurance procedures which can provide evidence of performance of the envelope in such areas. Any assessment of such practicality should include consideration of amendment to project program or construction sequencing to enable fuller testing.

Air-tightness testing is to be carried out where possible but additional evidence may be provided by the applicant and may include:

- thermal imaging report; and
- additional inspections.

Where additional evidence is considered necessary the verifier should be allowed to comment on the necessary arrangements.

5.3 Conversions

There is no need to carry out an air-tightness test on a converted building.

5.4 Who can test?

Testing should be carried out by persons who can demonstrate relevant, recognised expertise in measuring the air permeability of buildings. This should include membership of a professional organisation which, by 1 October 2011, accredits its members as competent to both test and confirm the results.

The following organisations are able to accredit members to carry out air-tightness testing:

- UKAS – United Kingdom Accreditation Service;
- BINDT - The British Institute of Non-Destructive Testing Air Tightness Testers Registration Scheme; and
- ATTMA – Air-tightness Testing and Measuring Association.

BINDT offers two levels of accreditation for air-tightness testers:

- individual accreditation of testers of dwellings; and
- accreditation of organisations to test dwellings and non-domestic buildings through Air-tightness Testing and Measuring Association (ATTMA).

Other organisations that are UKAS accredited in this field may also offer comparable services.

5.5 Remedial action following a test failure

Even though the air-tightness test helps quantify air leakage, it doesn't identify where the air is leaking from. In some cases when the information provided by the air-tightness test is combined with visualisation methods (such as smoke visualisation or thermography), it can assist in identifying the air leakage paths. However, this can be a complex task. Specialist advice should be sought when the air-tightness test indicates failure to meet the specified air-tightness levels.

A poor test result will indicate the need for improvement. However, a test result that is more air-tight than the stated design level may also give rise to a need for remedial action where the reported level of infiltration is not compatible with the intended ventilation strategy. This is a particularly important issue for dwellings, where guidance outlines that low infiltration rates would normally result in the need for both input and extract ventilation.

Where an even spread of tests has been carried out, this will assist in identifying, at an early stage, where test failure has been as a result of poor workmanship. Testing may then be required for all plots to identify the buildings that require remedial treatment. Where the test failure is due to the design, additional testing may not be required, as all plots with the same design are likely to require remedial treatment.

5.6 Reporting process when a test fails

When an agreed test fails (see 3.3 and 3.4), the report from the tester giving the reason for the failure should be shared with the verifier. The developer should send the report together with a proposal on how to resolve the situation.

Fig. 8 Smoke testing

6 REMOTE AREAS & SEVERE WEATHER CONDITIONS

6.1 In more remote areas and areas prevalent to severe weather conditions, it may be more difficult and more costly to arrange testing to fit in with a development programme. However, it remains the intention that all domestic and non-domestic buildings are subject to air-tightness testing. Accordingly, where testing services are not locally available advance planning of tests and communicating changes to planned test dates is even more important.

6.2 The intention of the air-tightness testing regime is that all new buildings will be subject to representative sample testing. However, it is recognised that fan pressurisation permeability testing can generally only be carried out if weather conditions are suitable. In particular, wind speed can have an effect on test results to the point where effective testing is either not possible or reliable.

6.3 As many parts of Scotland can regularly be subject to long periods of high wind speeds which affect the practicality of the test, it is important to raise this in discussion with testers and examine available meteorological data when planning a test.

6.4 Thermography may not allow for accurately establishing if buildings have been constructed to their design performance levels. However, the process can establish the extent of localised negative effects from high air infiltration in the building and if carried out internally is not subject to adverse weather conditions. A thermal imaging survey can identify the effect of any air infiltration on the building fabric where there is a temperature difference between the inside and outside of the building. A survey carried out by an accredited thermographer can confirm the construction is not adversely affected by construction defects which result in localised uncontrolled air infiltration. A thermography report giving a qualitative indication of the air permeability of the building should be submitted to the verifier.

6.5 In remote areas, any alternative approach should be agreed in advance of the test with the verifier. This will avoid the situation where completion and occupation of buildings are delayed by prolonged periods of severe weather. The person arranging the test may wish to engage the services of an accredited tester who has the ability to cover both air-tightness testing and thermography, and thereby increase the flexibility of the on-site solution.

6.6 The following organisation is able to accredit members to carry out thermography testing:

- UKTA – United Kingdom Thermography Association

6.7 As sound testing is not weather dependant, there are no alternative arrangements to the process.

APPENDIX A

TESTING - DWELLING TYPES

A.1 Generally

The definition of a dwelling is contained in Appendix A – Defined Terms, of the Technical Handbooks.

"Dwelling" means a unit of residential accommodation occupied (whether or not as a sole or main residence):
a) by an individual or by individuals living together as a family; or
b) by not more than six individuals living together as a single household (including a household where care is provided for residents) and includes any surgeries, consulting rooms, offices or other accommodation, of a floor area not exceeding in the aggregate 50 square metres, forming part of a dwelling and used by an occupant of the dwelling in a professional or business capacity.

A.2 Dwelling types

There are also different dwelling types defined as follows:

"Flat" means a dwelling on one storey, forming part of a building from some other part of which it is divided horizontally, and includes a dwelling of which the main entrance door and associated hall are on a different storey from the remainder of the dwelling.

"High rise domestic buildings" means a domestic building with any storey at a height of more than 18 metres above the ground.

"House" means a dwelling on one or more storeys, either detached or forming part of a building from all other parts of which it is divided only vertically.

"Maisonette" means a dwelling on more than one storey, forming part of a building from some other part of which it is divided horizontally.

A.3 Sound testing

For the purposes of sound testing the above defined terms are used in section 5 in the testing tables. The amount of testing is based on the number of attached dwellings formed and the different types of construction used to form the basis of the number of separating walls and floors to be tested.

A.4 Air-tightness testing

Dwelling types

For dwellings to be considered to be of the same type they must contain the same construction details for each of the main elements, for example, walls, floors, roofs and junctions.

APPENDIX B

EXAMPLE OF A SITE CONDITIONS CHECKLIST – SOUND TESTING

	Description	Complete Yes/No
1	Dwellings to be tested should be complete	
2	Separating walls and floors should be complete as well as flanking walls and floors	
3	Wall and floor junctions should be complete	
4	Wall finishes should be complete including skirting's in place	
5	Floor finishes must be bare. No carpets should be laid	
6	Doors should be in place and fully fitted. External and internal doors fitted with seals	
7	Windows should be fully fitted with vent covers in place	
8	Services should be complete and any voids around ducts made good	
9	Electrical sockets should be fitted	
10	An electricity supply should be available for the test plots 110v or 240v	
11	No noise should be made during the test	
12	No site workers should enter or be in the dwellings during the test	
13	Test plots and adjacent areas within the building should be quiet for the duration of the test	

APPENDIX C

EXAMPLE OF A SITE CONDITIONS CHECKLIST – AIR-TIGHTNESS TESTING

	Description	Complete Yes/No
1	Climatic conditions are within acceptable limits	
2	External envelope of the building is complete	
3	Incoming service penetrations are permanently sealed	
4	External doors and windows are closed	
5	Internal doors are fully opened and restrained	
6	Drainage traps are filled with water or temporarily sealed	
7	Smoke vents and background trickle ventilators are closed but not artificially sealed	
8	Passive ventilation systems and permanently open uncontrolled natural ventilation openings are temporarily sealed	
9	Mechanical ventilation and air conditioning systems are turned off and temporarily sealed	
10	Combustion appliances in the building must be switched off	
11	Pressure tubes are kept away from locations where they may get trapped, or may become heated or cooled excessively and not influenced by air movement	

APPENDIX D

Example Studies

D.1 Examples of selection for testing

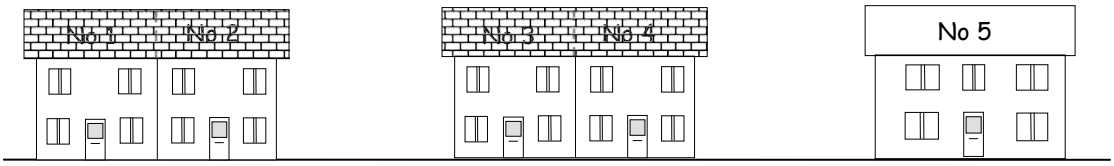
The following examples applies an 'even spread' of testing. If a tester is involved at the design stage there is an opportunity for the owner/developer to agree with them when the tests can be carried out and how much notice will be required. The principles of the process outlined in steps 1 – 4 should be followed for all tests.

D.2 Example 1

Description - 5 plots made up of (3 blocks) all of the same construction:

- 4 dwellings made up of 2 blocks of semi-detached two storey houses; and
- 1 two storey community centre (non-domestic block).

If the 3 blocks were of different construction, an air-tightness test would need to be carried out on a dwelling in each of the semi-detached blocks and the non-domestic block, and for both semi-detached blocks for sound testing.



Plots 1 - 5

Step 1 - Building warrant application stage
The overall number of tests was agreed by the verifier and by the agent representing the applicant/developer. The plots to be tested are, one of the semi-detached dwellings for domestic (sound and air-tightness testing) and the non-domestic building (air-tightness testing only). This information was recorded on the building warrant application drawings.

Step 2 - Construction stage – nearing completion of the first set of plots constructed
The specialist/organisation carrying out the testing was able to do both the sound and air-tightness tests on the same day. They were given at least a weeks notice in this case. *However, in some instances 2-3 days for the booking may be sufficient.*

The air-tightness tester requested a copy of the SAP and SBEM calculation sheets, including the air-tightness design level and a set of drawings for each of the plots to be tested once they were selected by the verifier. This allowed the tester to calculate the envelope area for a semi-detached dwelling and the non-domestic building and establish the equipment needed to carry out the air-

tightness test. The testing organisation monitored the weather forecast for the day of the test and the test was carried out as scheduled.

Sound testing ratio

The 'Example Constructions' have been used for the design therefore the testing ratio was 1 in 20. *The ratio would be 1 in 10 if 'other constructions' had been adopted for the design.* However, this particular development has only a few plots and the issue of different ratios has no impact in this case. *Standard 5.1 only applies to attached properties, therefore no sound test was needed on plot 5.*

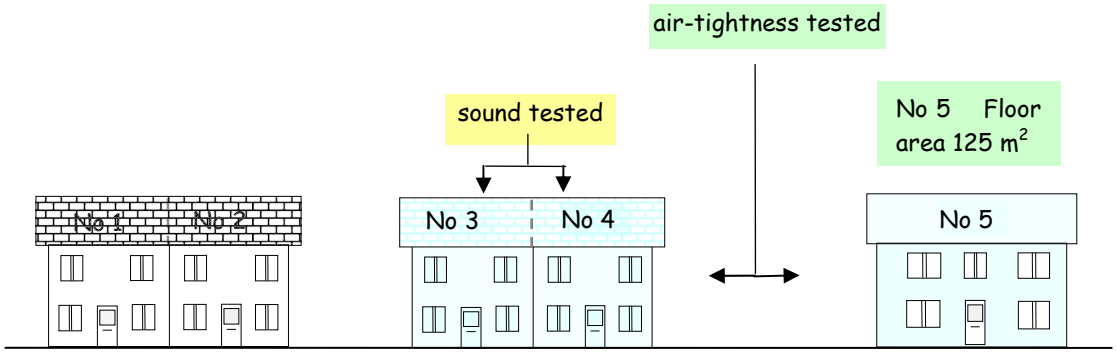
Air- tightness testing ratio

The level of testing is 1 unit in 20 for dwellings and all non-domestic buildings with an area of not more than 150 m². As all buildings are of the same type of construction, a test was needed on a semi-detached dwelling and the non-domestic building.

Testing applied

The verifier was informed the first plots were complete and suitable for testing. The verifier identified the first plots ready for testing as plots 3, 4 and 5.

However, this site with less than 20 dwellings needs 2 sound tests (1 at ground floor and 1 at 1st floor level*).* In terms of domestic testing, the dwellings are all of the same construction and the same type of building, therefore no additional tests were required.



Plots 3, 4 and 5 are selected for testing

Step 3 - Test results

Test reports/certificates outlining the results for both sound and air-tightness were given to the site agent, and copies submitted to the verifier. In this case the sound test failed on the ground floor and passed on the 1st floor. For both the dwelling and community building the air-tightness test reported an air-tightness level of 6 m³/m².h @50 Pa, where the stated design level was 7 m³/m².h @50 Pa.

Sound test – establishing the cause of failure
A small area of gypsum board was removed from the separating wall on the ground floor of plot 3 and it was found that the density of board was inconsistent with the density prescribed in the 'Example Constructions' for timber frame.

After further investigation, it was found that only one side of the separating wall has caused the failure. In this case the defect was identified before the linings on the separating wall in plots 1 and 2 were complete. This allowed corrective action to be taken.

Solution
The board was changed to one giving the correct density, over the full length of separating wall, not only to the room used for the test. A re-test was carried out and a pass achieved.

A specialist can advise where the failure occurs and suggest methods to remedy this, if this service is wanted by the agent. If there are any changes to the specification agreed that deviate from the building warrant plans, this should be discussed with the verifier to decide if an amendment to the building warrant would be required.

Air-tightness testing
The SAP calculation for the dwellings and the SBEM calculation for the community centre were updated to reflect the actual test results. *This means the EPC produced for each building is representative of the built form. This may be requested by the verifier.*

The reported infiltration value of 6 $m^3/m^2.h$ @50 Pa is lower than designed, but no further remedial work was required in respect of the ventilation strategy for the dwelling as this level meets the recommended levels when using a passive ventilation solution.

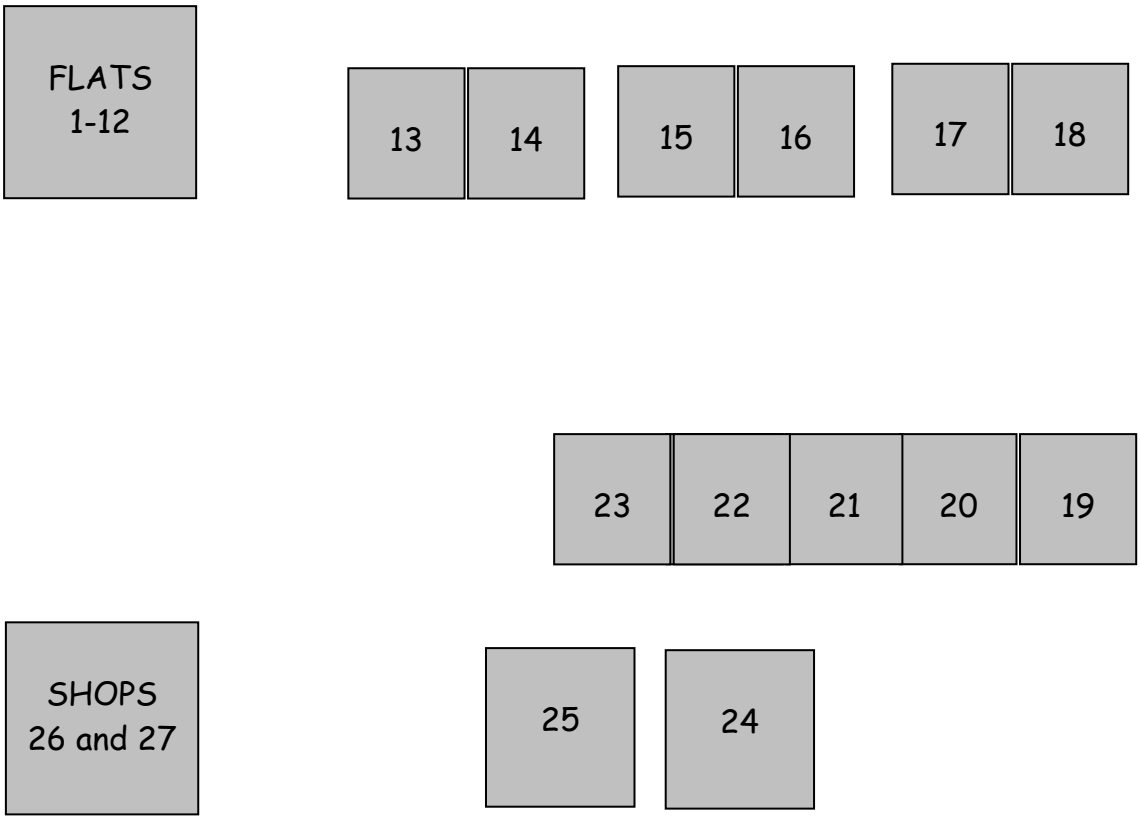
Step 4 – Reporting
The report/certificate was passed to the building standards verifier.

D.3 Example 2

Description - 27 plots made up of (8 blocks) different building types and all of the same construction:

- 1 block of flats made up of 12 dwellings (4 flats on each floor);
- 3 blocks of semi-detached two storey houses;
- 1 block of 5 terraced two storey houses;
- 2 blocks of two storey detached houses; and
- 1 block of 2 single storey shops (non-domestic block).

If all 8 blocks were of a different construction an air-tightness test would need to be carried out on a dwelling in each of the building types (i.e. detached, semi-detached). For sound testing all of the blocks with attached dwellings would need to be tested.



The site is built in 3 phases:

1. Phase 1 - Plots 1 – 18;
2. Phase 2 - Plots 19 - 23; and
3. Phase 3 - Plots 24 – 27.

For sound testing:

- 2 separating walls and 2 separating floors of the flats;
- 1 separating wall at ground floor and first floor of the 2 the semi-detached houses; and
- 1 separating wall at ground floor and first floor of the 2 the terraced houses.

For air-tightness testing:

- 1 flat;
- 1 semi-detached house;
- 1 terraced house;
- 1 detached house; and
- 1 non-domestic shop.

Step 1 - Building warrant application stage
The overall number of tests was agreed by the verifier and by the agent representing the applicant/developer. This information was recorded on the building warrant application drawings.

Phase 1 Plots 1 – 18

Step 2 - Construction stage – nearing completion of the first set of plots constructed
The specialist/organisation carrying out the testing was able to do both the sound and air-tightness tests on the same day. They were given at least a weeks notice in this case. *However, in some instances 2-3 days for the booking may be sufficient.*

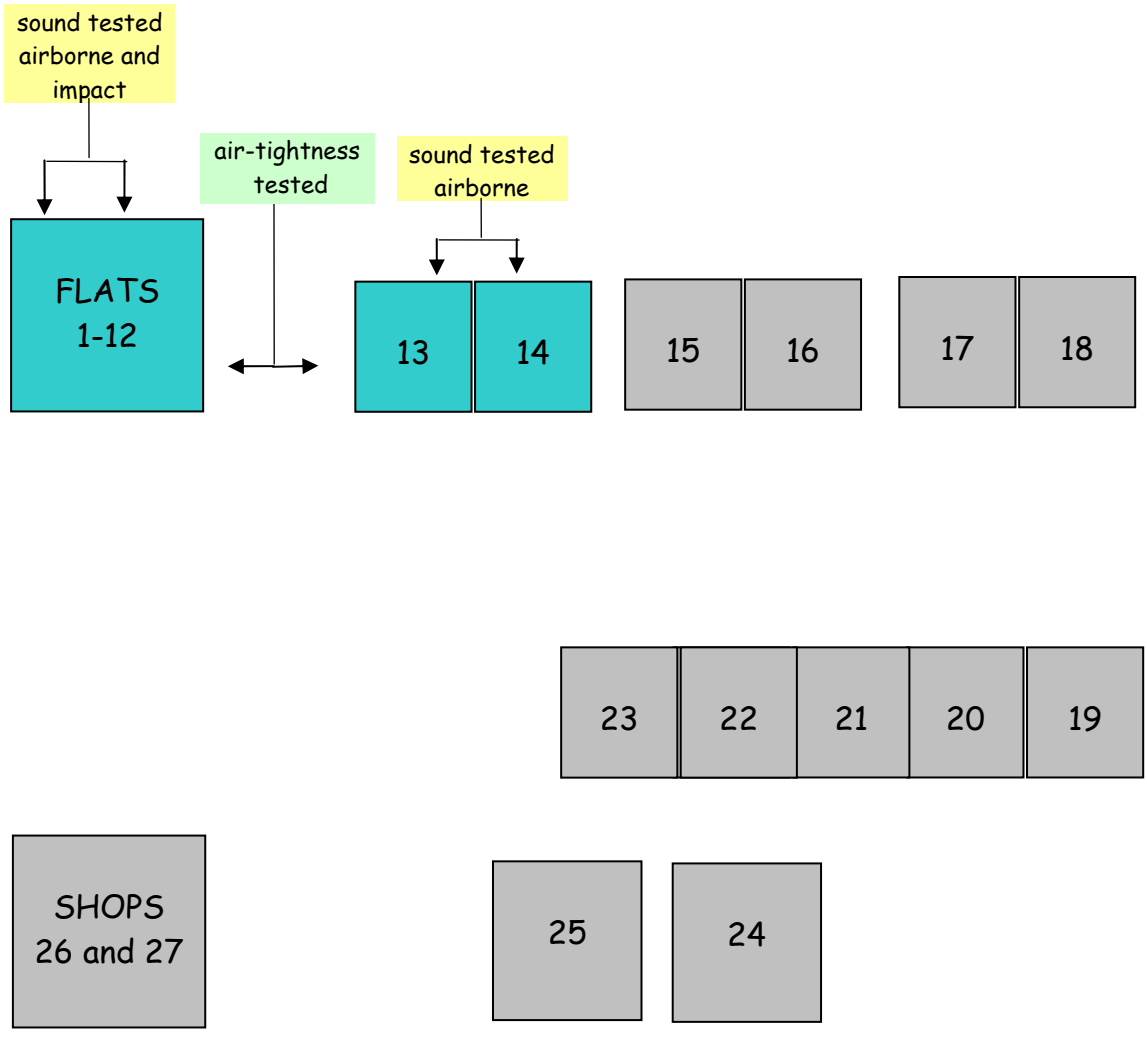
The air-tightness tester requested a copy of the SAP and SBEM calculation sheets, including the air-tightness design level and a set of drawings for each of the plots selected to be tested once they are selected by the verifier. This allowed the tester to calculate the envelope area for the different types of building identified in step 1, and establish the equipment needed for an air-tightness test. The testing organisation monitored the weather forecast for the day of the test and the test was carried out as scheduled.

Sound testing ratio
The 'Example Constructions' have been used for the design therefore the testing ratio was 1 in 20. *The ratio would be 1 in 10 if 'other constructions' had been adopted for the design.* In this particular phase of the development the ratio for testing are 2 separating walls and floors in the block of flats and 1 separating wall in a semi-detached block (one test at ground level and one at first floor level).

Air-tightness testing ratio
The level of testing is 1 unit in 20 for dwellings. All dwellings are of the same construction, but of different types, so a test was carried out on a flatted dwelling and a semi-detached dwelling to provide a testing sample.

Testing applied
The verifier was informed the plots were complete and suitable for testing. The verifier identified the first plots ready for testing as plots 3,4,7 and 8 (flats) and 13 and 14 (semi-detached houses).

This phase needs 2 sound tests on the separating walls and 2 on the separating floors, and a separating wall of the semi-detached houses (1 at ground floor and 1 at 1st floor level), and 1 air-tightness test on plot 1 of the flats and also plot 13, the semi-detached house. *As the dwellings are all of the same construction no additional tests are required.*



Step 3 - Test results
Test reports/certificates outlining the results for both sound and air-tightness were given to the site agent, and copies submitted to the verifier. *In this case all of the sound tests passed.* The air-tightness test reported an air-tightness level of 4.8 m³/m².h @ 50 Pa for plot 1, where the stated design level was 7 m³/m².h @ 50 Pa and an air-tightness level of 7 m³/m².h @ 50 Pa for plot 13. No further action was required in respect of plot 13, as the stated design level was 7 m³/m².h @ 50 Pa.

Solution – air-tightness
The test result for plot 1 is below both the stated design level and the minimum recommended design infiltration rate of 5 m^3/m^2.h @ 50 Pa for dwellings using trickle ventilation. As the ventilation strategy for plot 1 is based on natural ventilation, then it must be re-examined by a specialist to assess whether it remains appropriate or whether an alternative ventilation solution or other remedial action is necessary.

A further assessment of the dwelling ventilation was carried out to establish that the dwelling, in use, would still achieve adequate air quality for occupants, through the combination of infiltration and intended ventilation. *This may involve further specialist advice, for example, airflow modelling or onsite testing to establish ventilation rates.*

In this instance, the assessment of air movement confirmed that adequate and consistent ventilation rates were achieved throughout the habitable rooms.

The following documents give further guidance on alternative ventilation and infiltration rates. These are available on the BSD website:

- *Domestic Ventilation Guide – gives examples of alternative ventilation solutions; and*
- *Research published by the Scottish Government - indicates that infiltration rates lower than 3 m³/m².hr @ 50 Pa are likely to result in air quality and condensation problems unless a designed whole house ventilation system (input and extract) is present.*

A specialist can advise when the failure occurs and suggest a method/s to remedy this, if this service is wanted by the agent. If there are any changes to the specification agreed that deviate from the building warrant plans, this should be discussed with the verifier to decide if an amendment to the building warrant would be required.

Step 4 – Reporting
The report/certificate and ventilation assessment was passed to the building standards verifier.

Phase 2 Plots 19 – 23

Step 5 - Construction stage – nearing completion of the next phase/set of plots constructed

The specialist/organisation carrying out the testing was able to do both the sound and air-tightness tests on the same day. They were given at least a weeks notice in this case. *However, in some instances 2-3 days for the booking may be sufficient.*

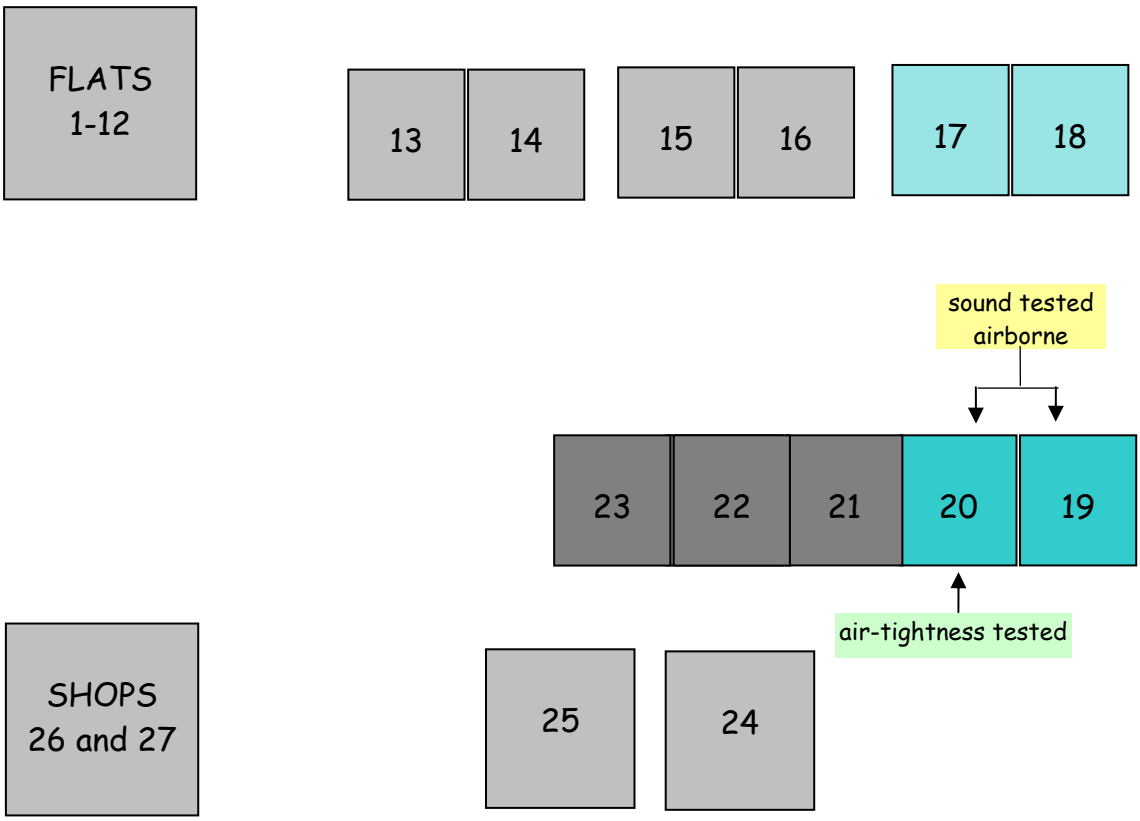
The air-tightness tester requested a copy of the SAP and SBEM calculation sheets, including the air-tightness design level and a set of drawings for each of the plots selected to be tested once they are selected by the verifier. This allowed the tester to calculate the envelope area for the different types of building identified in step 1, and establish the equipment needed for an air-tightness test. The testing organisation monitored the weather forecast for the day of the test and the test was carried out as scheduled.

Sound testing ratio
The ratio for testing in this phase is 1 separating wall in the terraced block (one test at ground level and one at first floor level).

Air-tightness testing ratio
The ratio for testing where all buildings are of the same construction is 1 unit in 20. However, this is a different building type from phase 1 so a test was carried out on a mid terrace house.

Testing applied
The verifier was informed the plots in this phase were complete and suitable for testing. The verifier identified the plots ready for testing as plots 19 and 20.

This phase needs 2 sound tests (1 at ground floor and 1 at 1st floor level) for house plots 19 and 20, and 1 air-tightness test on plot 20. *As the dwellings are all of the same construction, and all of the same type of building (taking account of phase 1) no additional tests are required.*



Stage 6 - Test results

Test reports/certificates outlining the results for both sound and air-tightness were given to the site agent, and copies submitted to the verifier. In this case the sound test failed on the ground floor. The air-tightness test reported an air-tightness level of 5.9 $m^3/m^2.h$ @ 50 Pa, where the stated design level was 6 $m^3/m^2.h$ @ 50 Pa.

As the sound test failed, the separating wall of plots 22 and 23 was tested. This also failed. Plots 17 and 18 have been completed and a completion certificate accepted by the verifier. These plots have been sold but are unoccupied. *If these plots had been occupied, negotiations would need to be carried out between the owner/occupier for access to their houses to allow a test to be carried out.* A sound test was then carried out on the separating wall of plots 17 and 18 of the semi-detached houses, of the previous phase, that passed the test. This established the failure was limited to the terraced block of houses.

Sound test – establishing the cause of failure

The skirting board was removed from the ground floor of the separating wall (blockwork construction) and a section of render coat exposed. The render coat was not thick enough and found to be the cause of failure.

Solution
The solution was to apply another coat of render to the full length of the separating wall. *However, an alternative solution could be discussed with the specialist carrying out the sound test.*

A specialist can advise when the failure occurs and suggest methods to remedy this, if this service is wanted by the agent. If there are any changes to the specification agreed that deviate from the building warrant plans, this should be discussed with the verifier to decide if an amendment to the building warrant would be required.

Air-tightness testing
The reported infiltration value of 5.9 $m^3/m^2.h$ @ 50 Pa is lower than designed, but no further remedial work was required in respect of the ventilation strategy for the dwelling as this level meets the recommended levels when using a passive ventilation solution.

The SAP calculation for the dwelling was updated to reflect the actual test results. *This means the EPC produced for the building is representative of the built form. This will be requested by the verifier.*

Step 7 – Reporting
The report/certificate was passed to the building standards verifier.

Phase 3 Plots 24 – 27

Step 8 - Construction stage – nearing completion of the next phase/last set of plots constructed

The specialist/organisation carrying out the testing was able to do both the sound and air-tightness tests on the same day. They were given at least a weeks notice in this case. *However, in some instances 2-3 days for the booking may be sufficient.*

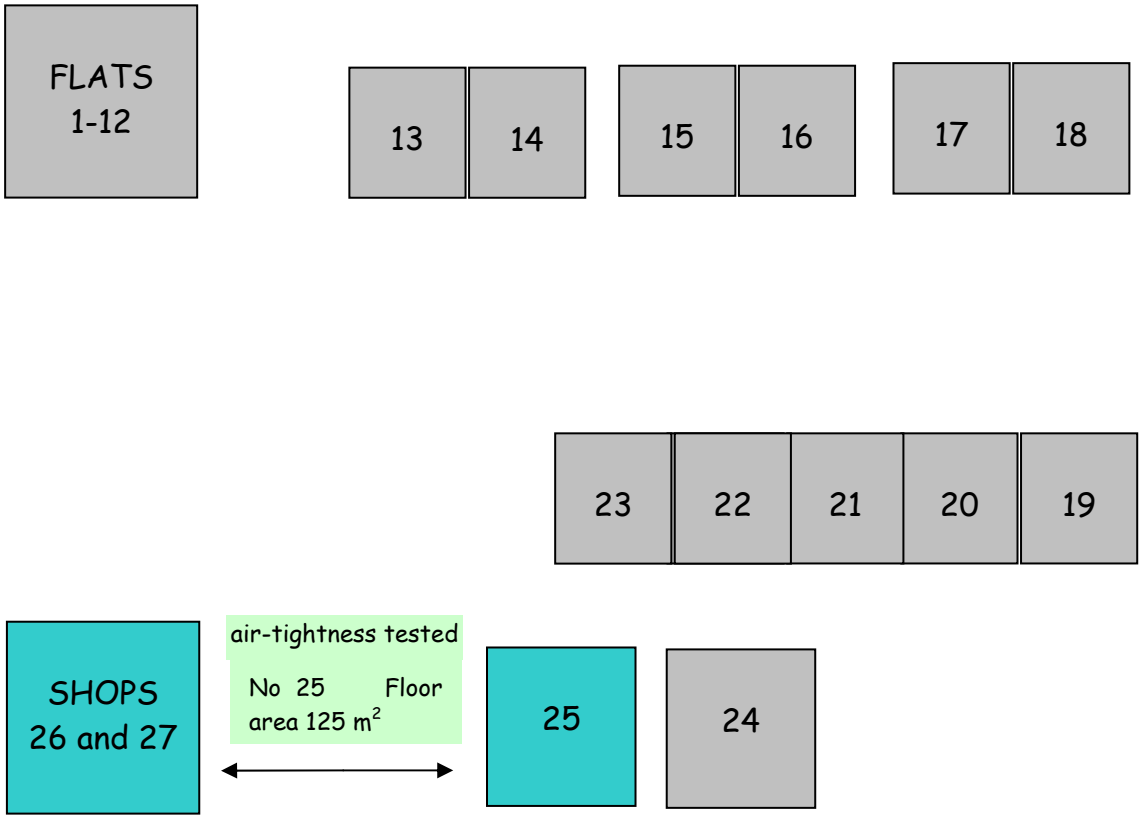
The air-tightness tester requested a copy of the SAP and SBEM calculation sheets, including the air-tightness design level and a set of drawings for each of the plots selected to be tested once they are selected by the verifier. This allowed the tester to calculate the envelope area for the different types of building identified in step 1, and establish the equipment needed for air-tightness test. The testing organisation monitored the weather forecast for the day of the test and the test was carried out as scheduled.

Sound testing ratio
There was no sound testing in this phase as Standard 5.1 does not apply to detached buildings.

Air- tightness testing ratio
The ratio for testing is 1 unit in 20, or part thereof, where all buildings are of the same construction. As there are two building types a detached house and shop, a test was carried out on each one.

Testing applied
The verifier was informed when all of the plots in this phase were complete and suitable for testing. The verifier identified the last plots ready for testing as plots 25 and 26.

This phase needs 1 air-tightness test on plot 25 and 1 on plot 26, as this is one of the 2 non-domestic buildings. *As the dwellings and non-domestic buildings are all of the same construction and the same type of building no additional tests are required.*



Step 9 - Test results
Test reports/certificates outlining the results for air-tightness were given to the site agent, and copies submitted to the verifier. The air-tightness test reported an air-tightness level of:

- 7 m³/m².h @ 50 Pa, where the stated design level was 6 m³/m².h @ 50 Pa for the plot 26 (shop); and
- 7.2 m³/m².h @ 50 Pa, where the stated design level was 6 m³/m².h @ 50 Pa for plot 25 (house).

Air-tightness testing – establishing the cause of failure of design level
The reported infiltration rate of 7 m³/m².h @ 50 Pa for the shop was less air-tight than designed. The SBEM calculation for the shop was updated with the actual test result and the Target Emission Rate was still achieved. No further remedial work was required in respect of the ventilation strategy for the shop.

For the dwelling, the reported infiltration rate of 7.2 $m^3/m^2.h$ @ 50 Pa is less air-tight than designed. The SAP calculation was updated with the actual test result and failed to achieve the Target Emission Rate. Following further investigation by the tester, it was established that the sealing around service penetrations was inadequate. The sealing was improved and the test carried out again where the air infiltration rate had improved to 5.8 $m^3/m^2.h$ @ 50 Pa.

No further remedial work was required in respect of the ventilation strategy for the dwelling, as this level meets the recommended levels when using a passive ventilation solution.

The SAP calculation for the dwelling and the SBEM calculation for the shop were updated to reflect the final test results. *This means the EPC produced for each building is representative of the built form. This will be requested by the verifier.*

Step 10 – Reporting
The report/certificate was passed to the building standards verifier.