SAP 10 Technical Paper

S10TP-13

Changes to Mechanical Ventilation System assumptions in SAP 10

Issue 1.1

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DOCUMENT REVISION LOG

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TABLE OF CONTENTS

1. Introduction

Dwellings have become more airtight in recent years to meet increasingly demanding regulations requiring reduced energy use. As a result, ventilation provision has tended to change:

- from intermittent extract fans with background ventilation achieved through naturally driven air flows
- to continuously operated mechanical ventilation systems; sometimes these are extract-only and sometimes balanced systems with heat recovery

This paper discusses a number of proposed improvements to the way that SAP evaluates the performance of mechanical ventilation systems and is in three parts.

Part 1 deals with the thermal performance of Mechanical Ventilation and Heat Recovery (MVHR) units, relating to the effects of duct insulation and of being installed inside or outside the building thermal envelope.

Part 2 deals with the test methods and handling of aerodynamic performance data for MVHR units in relation to SAP.

Part 3 deals with the test methods and handling of aerodynamic performance data for decentralised mechanical ventilation (dMEV) in relation to SAP.

Improvements are included relating to each of these areas for SAP 10, together with ways of how the test data and SAP results were made more representative of actual installations.

2. Part 1: MVHR duct insulation and location

2.1 Testing of MVHR products in SAP 2012

For SAP 2012, the SAP test method assesses the thermal performance of an MVHR product based on the test method defined in EN13141-7:2004[1], which in turn is based on the test method defined in EN308:1997[2].

The required ambient laboratory temperature and extract and fresh air temperatures were changed in EN13141-7:2010[3]. Following a review of the impact of this change, it was decided that the older temperature test points should be retained for consistency and to maintain the current level of resolution resulting from the large overall temperature difference.

For entry in the Product Characteristics Database (PCDB), the thermal efficiency of an MVHR unit is tested at each air flow rate used to determine specific fan power, i.e. a flow rate equivalent to a kitchen plus a given number of wet rooms. A good indication of the thermal performance of the product is gained in this way. However, EN308 requires that the temperature of the air in each duct is measured as close as possible to the product spigots to minimise errors. This ensures that the measured efficiency relates to the MVHR only and does not reflect overall system effects.

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[1] EN13141-7:2004. Ventilation for buildings — Performance testing of components/products for residential ventilation. Part 7: Performance testing of a mechanical supply and exhaust ventilation units (including heat recovery) for mechanical ventilation systems intended for single family dwelling

[2] EN308:1997. Heat exchangers - Test procedures for establishing the performance of air to air and flue gases heat recovery devices

[3] EN13141-7:2010. Ventilation for buildings — Performance testing of components/products for residential ventilation. Part 7: Performance testing of a mechanical supply and exhaust ventilation units (including heat recovery) for mechanical ventilation systems intended for single family dwelling

EN308:1997 allowed the laboratory temperature to range from 17 to 27°C. This tolerance was tightened in EN13141-7:2010 to ±1°C of the extract air temperature, i.e. 20±1°C. The SAP test methodology[4] requires the laboratory to be held at these conditions.

2.2 Shortcomings of present assumptions

BRE has undertaken a number of field measurements of MVHR installations and has measured system thermal efficiencies[5] as low as 50% when installed outside the heated envelope[6]. In these cases the laboratory thermal efficiency was typically 90%. This difference results from a combination of the heat lost from the MVHR unit and the lack of effective duct thermal insulation within the cold space. Duct heat losses vary with respect to the length of duct located in the cold space, which in some dwellings is very significant.

The widespread practice of installing MVHRs outside the thermal envelope of a dwelling means that the ambient air temperature around the MVHR during the period of the year when it is actively recovering heat is not the same as that within the test laboratory when the thermal efficiency was measured. When installed in lofts, due to the high levels of insulation in modern houses, the air temperature may be close to outside air temperature. Whether in a well-insulated loft or outside the dwelling, this means that during most of the heating season the ambient temperature of the MVHR and the ductwork is significantly below 20°C.

In cases where the MVHR unit is located within the thermal envelope of the dwelling, the ducts from the outside to the MVHR are inside the building. Both the fresh air duct and exhaust air duct are potentially very cold. If inadequately insulated, the heat transfer from the dwelling to the air in these ducts will be significant. Additionally, the increased air temperature within the fresh air duct will reduce the heat exchanger temperature

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[4] *TESTM-01 - SAP 2012 - Test method for centralised mechanical supply and extract ventilation system packages with heat recovery used in a single dwelling*

[5] This is the heat returned to a dwelling, compared to that removed from a dwelling, both at the thermal envelope boundary.

[6] Refer to NHBC Foundation document: NF52 - *"Assessment of MVHR systems and air quality in zero carbon homes"*

difference and thus the heat recovery potential. For the exhaust air duct, the heat transfer results in a direct heat loss from the dwelling to the outside air. It is vital therefore that both ducts are kept to a minimum length and insulated effectively.

With MVHR thermal efficiencies typically measured at 90% in the laboratory, the need for high levels of thermal insulation to reduce heat losses is critical. The Domestic Ventilation Compliance Guide – 2010 Edition states in Table 7 that ductwork; *should be insulated where it passes through unheated areas and voids with the equivalent of at least 25 mm of a material having a thermal conductivity of ≤0.04W/(m.K) to reduce the possibility of condensation forming.*

BRE staff have frequently observed installations with very limited insulation, in some cases a single wrap of foil backed bubble wrap. Where insulation levels are poor, in cold weather the low efficiency may result in cold air being delivered to rooms (living rooms and bedrooms), causing discomfort.

The current 'in-use' factors were determined in a laboratory, based on a combination of air flow imbalance, resulting in an imbalance in the overall heat recovery, and the heat losses from the MVHR and ducts. The losses from the duct, however, assumed that the duct lengths were minimised and the ducts insulated with appropriate levels of insulation.

The 'in-use' factor applied to the thermal efficiency is set at 0.85 for insulated and 0.70 for uninsulated ducts. These have not been changed in SAP 2009 and 2012, since their introduction in SAP 2005.

2.3 Impact of shortcomings

Where MVHRs are located outside the thermal envelope:

- MVHR system designers are not actively considering the impact on the overall thermal efficiency of the system if the MVHR itself is located outside the thermal envelope. Therefore, where cold lofts are available this space is seen as appropriate for locating the MVHR and a significant amount of the room supply and extract ducts (and all external supply and discharge ducts).

- Where MVHR units are located in cold lofts, system designers are not specifying the correct level of insulation for room supply and extract ducts.

Both of the above shortcomings result in very significant levels of heat loss and thus the thermal efficiency of the system during the heating season is significantly lower than is assumed in SAP. Additionally, where MVHRs are located within the heated envelope:

- The level of insulation applied to the cold (fresh air intake and exhaust) ducts is frequently not of the appropriate level. This leads to increased heat loss and in many cases condensation and mould growth on the ducts.

The use of fixed ‘in-use’ factors means that there is no design incentive to install the MVHR within the heated envelope, or to apply appropriate levels of duct insulation. The current ‘in-use’ factors are therefore failing to discourage poor design practice and this must be rectified.

2.4 Changes for SAP 10

The location of the MVHR is the simplest indication as to whether the heat losses are going to be greater than assumed in the SAP testing. If the MVHR is located outside the thermal envelope, the 'in-use' factor is revised to reflect the likely losses that will occur from the MVHR and ductwork.

<u>For MVHRs located outside the thermal envelope of the dwelling:</u>

This may be in the loft or outside the dwelling.

If the ducts are insulated to 25mm minimum depth[7]

- ***the proposed 'in-use' factor is 0.5.***

If the ducts are not insulated to this depth

- ***the proposed 'in-use' factor is 0.25.***

<u>For MVHRs located inside the thermal envelope of the dwelling:</u>

If the duct length from outside to the MVHR is over 2 m then the minimum insulation level needs to be better than 25mm; a minimum of 50 mm insulation depth should be incentivised by the 'in-use factors'.

The minimum insulation depths are therefore:

- ***25mm for ducts less than 2m***
- ***50mm for ducts greater than 2m***

If the insulation depth:

- ***Satisfies this minimum level, the 'in-use' factor is 0.9***
- ***Does not satisfy this minimum or is unknown, the 'in-use' factor is 0.8***

For future revisions to the Domestic Ventilation Compliance Guide, it is suggested that a vapour impermeable insulation layer is required; if cold ducts are installed within the

[7] Continuously insulated and with thermal conductivity 0.04 W/(m.K) or less, as required by the Domestic Ventilation Compliance Guide.

dwelling internal environment, condensation will form on the ducts and the use of mineral fibre insulation without vapour sealing will be less effective.

2.5 Impact of changes

The purpose of the changes is to improve the accuracy and robustness of SAP assessments. It is anticipated that the changes will also encourage improved design practice.

2.6 Summary of changes

MVHRs are tested for entry on the PCDB with a test laboratory temperature of 20±1°C; this does not account for any heat losses from connected ducts. It is common practice to place the MVHR in an unheated space along with a significant amount of distribution ductwork. Reviewing many installations during field inspections[8] has also confirmed that inadequate levels of duct thermal insulation are commonplace.

The 'in-use' factors in SAP 10 are modified to better reflect the impact of locating the MVHR and associated ductwork in an unheated space and the effect of poor insulation of ducts. The overall effects of these changes will be to improve the accuracy of SAP and reflect good design and specification of both the MVHR installation and insulation of ducts.

[8] Anonymous installation sites inspected during BRE site investigations. These include sites inspected as a joint commission by the BRE Trust and Joseph Rowntree Foundation – report not yet published.

3. Part 2: MVHR aerodynamic performance data

3.1 Testing of MVHR products in SAP 2012

Testing mechanical ventilation products to the relevant EN test standards[4] produces a set of fan curves showing fan static pressure against air flow rate. While this data is useful if a full and detailed design of a system is being undertaken, determining the design point based on the fan curve requires a very detailed understanding of the duct distribution system installed. This level of data is not usually available to SAP assessors or Building Control when assessing systems installed in dwellings. A test method was therefore developed for SAP that allowed the determination of performance of mechanical ventilation products against a defined system and at defined air flow rates [4].

The system chosen as being typical in UK dwellings was based on a layout presented in EN13141-6:2004[9], with rectangular 220 x 54 mm plastic duct chosen as typical of the vast majority of MVHR installations. The methodology was agreed with mechanical ventilation trade associations (BEAMA and FETA) before implementation.

The test methodology air flow rates were updated in SAP 2012, increasing from a maximum of 51 l/s to 69 l/s. Total test duct system pressures at the new air flow rates are approximately 200 Pa on the supply side and 270 Pa on the extract side.

Within the SAP calculation, in-use factors are applied to Specific Fan Power (SFP) test measurement values. These are recorded in the PCDB and are:

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[9] EN13141-6:2004. Ventilation for buildings — Performance testing of components/products for residential ventilation. Part 6: Exhaust ventilation system packages used in a single dwelling

	Approved Installer Scheme	In-use factor for Specific Fan Power	
		Flexible duct	Rigid duct
MVHR	No	1.70	1.40
	Yes	1.60	1.25

It is believed that most SAP assessments are undertaken on the basis that rigid duct is installed and such installations are not subject to an "Approved Installer Scheme", that is, a factor of 1.40 is most common.

3.2 Shortcomings of the SAP 2012 test methodology

The use of a fixed test rig distribution system has produced a very detailed and valuable database allowing designers to assess the predicted installed performance for MVHR products in any given dwelling. However, the use of a duct size that was typical of the majority of systems installed in 2006 is, with higher air flow rates now required as part of the test methodology, not reflecting current best practice.

For continuous background ventilation systems, pressures in excess of 200 Pa would be considered too great by most designers. Based on this it could be suggested that a lower pressure drop test rig duct distribution system should be adopted with a larger hydraulic diameter duct or a different distribution system.

However, extensive site investigations[8] over the past few years have highlighted that many new MVHRs are installed with poorly designed or installed duct systems. The aerodynamic performance data below are some of the worst examples from recent field measurements.

MVHR	Air flow rate l/s	System pressure		Specific Fan Power		Approx date of install
		SAP test Pa	Site measured Pa	SAP test W/(l/s)	Site measured W/(l/s)	
Product X[10]	54	150	280	0.80	1.72	2013
Product Y[11]	27	55	85	0.69	1.44	2012
Product Z[12]	27	55	270	0.93	2.70	2013

The reasons for the significant differences between the tested and measured values following re-commissioning of the systems to the design air flow rates were:

- Undersized ducts for air flow rate.
- Excessively long runs and number of bends in primary duct.
- Incorrectly sized roof mounted inlet/exhaust terminal.

In many of the recently investigated cases the design and specification of the duct distribution system has been poor, with installation quality being reasonable and largely in accordance with the design. It is commonly perceived that poor performance has been due to installation quality, but in the observed cases poor system design is more prevalent.

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[10] Measurements commissioned by householder; report unpublished. Measurements undertaken by BRE technician in accordance (as far as practicable) with: *"SAP 2012 - Test method for centralised Mechanical Ventilation and Heat Recovery (MVHR) system packages"*

[11] Measurements commissioned by BRE Trust and Joseph Rowntree Foundation on a range of installation sites; report not yet published. Measurements undertaken by BRE technician in accordance (as far as practicable) with: *"SAP 2012 - Test method for centralised Mechanical Ventilation and Heat Recovery (MVHR) system packages"*

[12] Measurements commissioned by five householders for each of their dwellings, with similar results for dwelling – the quoted value is worst case; report unpublished. Measurements undertaken by BRE technician in accordance (as far as practicable) with: *"SAP 2012 - Test method for centralised Mechanical Ventilation and Heat Recovery (MVHR) system packages"*

3.3 Impact of shortcomings

There are two impacts resulting from the shortcomings identified above:

- MVHR system designers are not taking the aerodynamic performance of the duct distribution system into account sufficiently when designing the system and specifying the components. This is resulting in systems that have significantly higher SFP[13] values than those utilised in SAP calculations.

- Where systems are designed well, and/or use an innovative low pressure drop duct system, such as semi-rigid duct, the SFP values utilised in SAP are excessively high and are not rewarding good design and system specification practice which result in lower energy use.

3.4 Changes for SAP 10

Changing the duct layout to reflect the use of larger ducts for larger systems would allow better design and specification practice to be rewarded, but would result in making comparison of new to existing products difficult. It is therefore proposed that the test duct configuration, which represents a “challenging” configuration, is not changed.

The impact of poor design could be captured through on-site measurement of all systems. It is suggested that this would be difficult to achieve reliably, and the resulting poor on-site measurement may only result in the performance gap increasing.

Current test duct configuration does not significantly differ aerodynamically from many installations and only in some cases is the design of the system such that the overall installed aerodynamic performance is worse than that of the test. The combination of the existing test configuration and current SAP in-use factor of 1.4 is capturing all but the worst installations.

[13] Specific Fan Power – electrical power (W) / air circulated through the fan (l/s)

However, it is believed that SAP's inability to recognise good design and specification of MVHR systems is resulting in poor design becoming commonplace, with the poor performance of systems then being unfairly assigned to the quality of the installation. To act as an incentive to eliminate this,

- ***The actual installed performance of the system can be measured, and directly entered in SAP. This would be an optional input that could be used to recognise good system design or use of a low pressure duct distribution system.***

The parameters that must be measured to enable an audit of the measurements to be made both at a desk top and on-site level are:

- MVHR fan speed settings at continuous background setting.
- Total air flow rate at continuous background setting, supply and extract.
- Electrical power drawn when the system is at continuous background setting.
- Pressure difference across the MVHR on the supply and extract sides of the unit at continuous background setting.

Whilst accurately measuring pressure difference will be more challenging, it is considered practicable to obtain the above measurements given the development in available measurement tools and because this would act as an extension to the existing airflow measurement requirements defined in the Domestic Ventilation Compliance Guide (2010 Edition). Additionally, due to available PCDB data, the risk of measurement result fabrication is considered to be minimised.

- ***The 'in-use' factor for the SFP derived from on-site measured data will be 1.10***

3.5 Impact of changes

The key aim of these revisions is to promote and reward better design practice for MVHR systems. If the electrical power drawn is minimised through good duct distribution system design and component specification, followed by careful installation, then the gap between design and in-use performance will be minimised.

3.6 Summary of changes

MVHRs are currently listed on the PCDB based on test data, with a pre-defined duct configuration for a range of dwelling sizes. The test is now considered pessimistic because the duct sizes and layout do not follow current best practice. However, on-site investigations have revealed many cases where the duct distribution design is resulting in significantly poorer performance.

For SAP 10 it is proposed that this test is not updated to reflect what would be considered as current best practice, since this would tend to reward all systems regardless of design. Instead, for systems designed well or using an innovative low pressure duct distribution system, it is proposed that aerodynamic performance should be determined through measurement and an improved SAP in-use factor applied. This will improve the accuracy of SAP and provide a significant incentive to encourage best practice design and installation quality. The Domestic Ventilation Compliance Guide – 2010 Edition (and 2011 amended version) includes a requirement and format for reporting air flow site measurements; the proposals form an extension of these requirements. A suitable commissioning certificate will be required for handover to the SAP assessor.

4. Part 3: Decentralised MEV performance

4.1 Decentralised mechanical extract ventilation

Continuously operating mechanical extract systems entered in the PCDB were all initially central fans with the extract air being ducted from the various rooms to the fan and then exhausted outside. In 2007, following problems with duct installation quality and a desire to remove the need for ducting within the dwelling as far as possible, decentralised continuous mechanical extract ventilation (dMEV) systems were developed and defined as a category of mechanical ventilation system within SAP. A test method[14] was developed that allowed the performance to be assessed against a range of representative installation configurations.

4.2 SAP test method for dMEV products

In SAP 2012, the test method assesses the aerodynamic performance of a dMEV fan at two fixed air flow rates. These were based on typical air flow rates required in kitchens and other wet rooms. Three installation configurations were used:

1. Through the wall: The fan mounted on a wall and exhausting direct to outside.
2. In room: The fan mounted on a wall or ceiling within a room and exhausting direct to outside via a defined duct.
3. In duct: The fan mounted within the duct and exhausting direct to outside via a defined duct.

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[14] *SAP PCDB: Test method for decentralised exhaust ventilation system packages used in a single dwelling*

The results of the three tests are entered in the PCDB and a SAP assessor uses the specific fan power (SFP) data appropriate to the installation configuration.

4.3 Shortcomings of the SAP 2012 method

Manufacturers of dMEV products have been found to ‘tune’ their products[15] for optimal performance at the two SAP specified test air flow rates, whilst also satisfying the wind backpressure test. Unfortunately, this has led to a range of shortfalls in overall performance:

4.3.1 Performance variations at flow rates below those tested

It has become evident that the aerodynamic performance of many of these products is significantly different when the air flow rate is reduced below that of the SAP test method. For some dMEV products entered in the PCDB, fan curves supplied within marketing literature indicate that the performance drop below the lower air flow rate test point is so significant that the fan could not pass the functional wind backpressure test.

To overcome this lack of aerodynamic performance at low air flow rates, many dMEV products have a constant volume function integrated into the fan speed control. This detects when the air flow rate reduces due to a small increase in back pressure. Some products have this function enabled at all fan speeds, while others have been found to enable it only at the test air flow rates. The effect of this is that at air flow rates below the lower flow rate tested, the fan does not respond to any increase in back pressure and the flow rate, and therefore efficacy, falls very quickly.

4.3.2 Limited flow rate options

A related problem is that dMEV products are being offered to the market with only two defined trickle ventilation air flow rate settings and a boost setting, i.e. the air flow rates required for satisfying the SAP test method[14] plus a boost. This will inevitably mean that

[15] Based on unpublished technical audit testing of a wide selection of product samples that was undertaken in support of maintaining the Product Characteristics Database

the background air flow rate required by the Building Regulations and assumed to be satisfied in SAP may not be achieved.

4.3.3 Duct runs significantly longer than those of the test method

The duct run defined in the test methodology for testing dMEV products assumes a relatively short overall distance between the extract terminal and the exhaust terminal. Assessment of the actual installed configuration has frequently revealed that much greater duct lengths are being installed and a significantly greater number of bends are present.

Reviewing the aerodynamic performance of many of the fans that have come to market in the past few years leads to the conclusion that fan power would have to be significantly increased above that measured during the performance test to achieve the correct air flow rate.

4.3.4 Vents closed

As noted above, the performance of many dMEV products can be significantly influenced by variations in backpressure. There is some evidence that the use of low powered fans and the ability to close trickle vents is resulting in under-ventilation of some rooms.

It is unlikely that this is occurring due to a reduction of overall air flow rate through the fan, unless the levels of air tightness achieved in the construction is very high, but it may mean that the assumed air flow path through a dwelling (e.g. through the trickle vents in the living rooms, through the circulation spaces and into the wet rooms) is not occurring and some living rooms, where vents are closed, are significantly under-ventilated.

4.4 Impact of shortcomings

There are two impacts resulting from the shortcomings identified above:

- The installed power drawn by the fans may be significantly greater than that measured during the test, which implies that the SAP PCDB record will be incorrect.

- The effectiveness of this technology to adequately ventilate dwellings may, in some cases, be significantly below that required, resulting in potential under-ventilation in the whole or areas of a dwelling.

4.5 Changes for SAP 10

Removing this mechanical ventilation category from SAP and returning to a significantly increased default value for all products would address the gap between power actually used and the test assessment. However, this would not increase the effectiveness of this product category, and the removal of any testing may even result in a lowering of the overall performance of products. This option is therefore not considered as appropriate.

4.5.1 Increase the size of the test installation configuration

The current test duct lengths are little over 2 m and include two 90° bends.

- ***The 'in-room' and 'in-duct' test duct lengths have been increased to 5 m and includes four 90° bends.***

This will increase the system pressure drop and be a more realistic representation of many of the installation designs reviewed recently.

4.5.2 Testing a wider range of flow rates and back pressure

To ensure that a dMEV fan will satisfy the functional ventilation of a dwelling, even if the required continuous background ventilation rate is below that of the SAP test,

- ***The system will test the operation of these fans at a wider range of air flow rates, from 5 to 16 l/s.***

At each of these test points it is proposed that the wind back pressure test aligns with that defined in EN13141-6:2014[16], Clause 5.2.4.1.2, Wind conditions, i.e. to test the wind

[16] BS EN 13141-6:2014. Ventilation for buildings — Performance testing of components/products for residential ventilation Part 6: Exhaust ventilation system packages used in a single dwelling

effect, a counter-pressure of + 20 Pa at the exhaust shall be added to the normal conditions for connection to roof/wall outlet.

EN13141-6:2014 does not provide any guidance on the impact of flow short-falls, and to follow the guidance set out in EN13141-8:2014[17], Clause 6.2, Airflow sensitivity classification, and apply it to each air flow rate test. The performance requirement as set out in Clause 6.2 would be that at no test air flow rate would the air flow rate fall by more than 30% at a positive back pressure of 20 Pa.

4.5.3 Pressure controlled trickle-vents

Occupants of a dwelling may close trickle-vents in windy locations in winter to reduce cold draughts. This will tend to result in under-ventilation of some living rooms, and may, in very airtight dwellings, reduce the overall ventilation rate.

For future revisions of the Building Regulations (Approved Document Part F) it is suggested that installing dMEVs with trickle-vents that cannot be shut by occupants be considered, since this may have a significant impact on indoor air quality. Pressure controlled vents would provide one possible solution to this risk, whilst better controlling the dwelling ventilation rate and limiting the maximum airflow caused by wind effects.

4.6 Impact of proposed changes

The following summarises the revisions that have been made:

- Increase the size of the ducted test configuration
- Test a wider range of air flow rates and increased wind back pressure
- **For next revision of Approved Document – Part F:** Require that trickle-vents are of a type that cannot be shut, but include a level of pressure differential control to minimise the risk of cold draughts

[17] BS EN 13141-8:2014. Ventilation for buildings — Performance testing of components/products for residential ventilation Part 8: Performance testing of unducted mechanical supply and exhaust ventilation units (including heat recovery) for mechanical ventilation systems intended for a single room

These revisions will ensure that the performance of this technology category meets the level of aerodynamic performance required to ventilate a dwelling effectively and improve the accuracy of SAP 10.

Note: These changes will mean that a dMEV product tested to the previous test method and entered in the PCDB for use with SAP 2009 and SAP 2012 will require retesting to the revised test method and a new application to the SAP 10 PCDB.

4.7 Summary of changes

Decentralised mechanical extract ventilation fans are widely used in new dwellings, but it has been found that the test methodology may be being used to tune products, which when installed skews their performance, both aerodynamically and in terms of electrical power. In addition, duct lengths and the number of bends have been found to be greater in actual installations than specified in the test methodology.

The SAP 10 test methodology has been updated to include a much wider assessment of performance, both in terms of aerodynamic and electrical power usage when installed. In addition, the duct lengths and number of bends in the test configuration has been increased.

Appendix A: Summary of In-use factors

<table>
<tr><th rowspan="2">Type of mechanical ventilation</th><th rowspan="2">Approved installation scheme or measured SFP</th><th colspan="3">In-use factor for Specific fan power</th><th colspan="4">In-use factor for Efficiency</th></tr>
<tr><th>Flexible duct</th><th>Rigid duct</th><th>No duct</th><th>Level 1 - Insulated ducts [c)]</th><th>Level 2 - insulated ducts [d)]</th><th>Insulated ducts [e)]</th><th>Uninsulated ducts [f)]</th></tr>
<tr><td rowspan="2">Mechanical extract ventilation, centralised [a)]</td><td>No</td><td>1.70</td><td>1.40</td><td>-</td><td colspan="2" rowspan="7">System installed exclusively within dwelling heated envelope</td><td colspan="2" rowspan="7">System <u>not</u> installed exclusively within dwelling heated envelope</td></tr>
<tr><td>Yes</td><td>1.60</td><td>1.30</td><td>-</td></tr>
<tr><td rowspan="2">Mechanical extract ventilation or positive input ventilation from outside, decentralised [a)]</td><td>No</td><td>1.45</td><td>1.30</td><td>1.15</td></tr>
<tr><td>Yes</td><td>1.45</td><td>1.30</td><td>1.15</td></tr>
<tr><td rowspan="3">Balanced whole house mechanical ventilation, without heat recovery [a)]</td><td>No</td><td>1.70</td><td>1.40[b)]</td><td>-</td></tr>
<tr><td>Yes</td><td>1.60</td><td>1.25[b)]</td><td>-</td></tr>
<tr><td>Measured SFP</td><td colspan="2">1.10</td><td>-</td></tr>
<tr><td rowspan="3">Balanced whole house mechanical ventilation, with heat recovery [a)]</td><td>No</td><td>1.70</td><td>1.40[b)]</td><td>-</td><td rowspan="3">0.9</td><td rowspan="3">0.8</td><td rowspan="3">0.5</td><td rowspan="3">0.25</td></tr>
<tr><td>Yes</td><td>1.60</td><td>1.25[b)]</td><td>-</td></tr>
<tr><td>Measured SFP</td><td colspan="2">1.10</td><td>-</td></tr>
<tr><td>Where default data from Table 4g has been used (all types)</td><td>-</td><td colspan="3">2.5</td><td colspan="2">0.7</td><td colspan="2">0.25</td></tr>
</table>

a) Use these values for data from the PCDB.
b) The values for rigid ducts also apply to semi-rigid ducts provided that the semi-rigid ducts are listed in the database.
c) Requirements to satisfy Level 1 insulated ducts definition:
   i) For supply (or extract, whichever is longer) duct lengths less than or equal to 2m, the duct system must be continuously insulated throughout to a minimum depth of 25mm with an insulant thermal conductivity of 0.04 W/m.K or less
   ii) For supply (or extract, whichever is longer) duct lengths greater than 2m, the duct system must be continuously insulated throughout to a minimum depth of 50mm with an insulant thermal conductivity of 0.04 W/m.K or less
d) The definition of Level 2 insulated ducts is where Level 1 is not satisfied or the insulation specification is unknown.
e) Duct system continuously insulated throughout to a minimum depth of 25mm with an insulant thermal conductivity of 0.04 W/m.K or less, as required by the Domestic Ventilation Compliance Guide.
f) Duct system insulation not meeting the requirements of d), i.e. insulation depth less than 25mm or not present.