Lessons from a decade of Passive House airtightness

Paul Jennings, Air Leakage Specialist, Aldas, 7th November 2018
Paul Jennings:

- Testing buildings for airtightness since 1987
- From the UK’s first Passive House & EnerPHit projects:

  - **Y Foel, Machynlleth**
  - **DVFP, Machynlleth**
  - **Grove Cottage, Hereford**

  **0.3 AC/hr @ 50 Pa**
  **0.3 AC/hr @ 50 Pa**
  **1.0 AC/hr @ 50 Pa – June 19th 2010**

Both tested 29th August 2008
Getting to now:

Erneley Close (32)
Cropthorne Autonomous House
Lancaster Co-Ho (44)
Totnes PH B&B
Mayville Community Centre
Camden
Machynlleth (West Wales) PH Projects: + 10 years

- Retested on October 18th

Y Foel, detached house

0.4 AC/hr @ 50 Pa

Hyddgen School

1.6 AC/hr @ 50 Pa
UK’s first certified Passive House dwelling

- 2-storey timber-framed, detached house, 99.5 m² TFA
- Sealed with Pro-Clima airtightness products
- Over 10 years, went from 0.3 to 0.4 AC/hr @ 50 Pa
- Monitoring information at: http://passivebuild.co.uk/
Y Foel leaks

- Leakage at top of window to door joint
- Leakage around poorly sealed penetration
Hyddgen School Details:

- Use changed from public sector office to school
- Major IT change, extra cooling load – leaky services

Leakage around extract fans through de-glazed window

Server Room

Leakage around poorly sealed future duct penetration
Major Projects

Wilmcote House, Portsmouth

EnerPHit: 113 Maisonettes & flats in 3 linked 11-storey blocks

Phase 1A, Agar Grove, London

Newbuild PH: ~40 Maisonettes & flats off 2 stair cores & individual entrances
Wilmcote House Details

• Large Bison REEMA concrete panel construction
• Built 1968
• 11 storeys, 3 linked blocks
• 100 x 3-bed maisonettes & 7 x 1-bed flats (increased to 13)
• Initially tested 2012, part of developing EnerPHit package
• Still testing (Nov 2018)
• “Europe’s largest EnerPHit failure”
• Couldn’t verify sealing
• Can’t measure airtightness
Wilmcote Co-Pressure Results

- No's 104 (9<sup>th</sup>), 98 (7<sup>th</sup>) & 92 (5<sup>th</sup>) – vertical line
- Depressurisation test on No. 98
- Leakage through risers to 104 & 92 ‘balanced out’
- With windows sealed, 98 down to 1.0 AC/hr @ 50 Pa
Wilmcote Issues:
Design Optimisation

Pre-tender airtightness design

- Much less complex
- Single airtightness tape
- No need for priming of masonry
Wilmcote issues – vertical leakage

- Co-pressure testing of 3 maisonettes showed major leakage on risers
- Not included within original works specified
- Issues with effectiveness of sealing
- Recording of fire collar installations found lacking
- Many boarded-up risers re-opened to check
Wilmcote HRV problems:

- Cannot remove filter due to position of controls
- Supply registers poorly installed
- Commissioning clearly invalid
- Leakage found through HRV ductwork, despite being sealed on the filters
Agar Grove Details

Marine will be discussing at length, so, briefly:

- ~40 Maisonettes & flats off 2 stair cores & individual entrances
- Designed to be certified as a PH block
- No internal airtightness between units
- Co-pressure tested on 27th March 2018
- 8 sets of door fan equipment operating in parallel
- Took most of the day to set up, and several hours to take readings
Delivering Airtightness

Conclusions:

• Good airtightness doesn’t happen by chance;
• Achieving a good level of airtightness is a process, and needs a plan;
• For PH projects, airtightness is key;
• Get the design right, use the right products
• Ensure skilled users – training & monitoring

Management, management, management
Excellent Airtightness?

Somewhere between:

- **0.07 AC/hr @ 50 Pa**
  - Best measured personally

- **≤ 0.2 AC/hr @ 50 Pa**
  - Best result in refurbishment

- **≤ 0.6 AC/hr @ 50 Pa**
  - Passive House Standard - newbuild
Projects with Excellent Airtightness

Best measured personally

Best result in refurbishment
Timings

• Good airtightness takes longer;
• Cannot muddle through;
• Fundamental cause of many problems on major UK low-energy projects to date is:

program steamrollers
12 Steps to Airtightness

• Developed over a decade of working on leading-edge UK low energy projects;
• Because UK volume housebuilders build down to a price, not up to a standard;
• Hence they find delivering PH very challenging

12-Step program because most UK volume house builders are

…………… addicted to building rubbish!
12 Steps - Documentation

- Aldas 7-page detailed explanation of 12 Steps to Airtightness approach
- Provided as pdf alongside presentation
- Contact me for further information
- E-mail: doorfanman@Hotmail.com
- Mob: +44 7866 948200
Air Barrier Strategy (Step 2) – Wilmcote House EnerPHit

What forms the airtightness barrier for each of the different elements?

- **Roof:** Top floor, heat loss: concrete slab. Membrane over
- **Walls:** Road-side facades: existing concrete panel
- **Walls:** End walls: existing concrete panel
- **Walls:** Party walls: non-heat loss: concrete
- **Walls:** Garden-side facades: new insulated wall, membrane & tape

**Interfaces:** Around windows & doors, tape sealed

**Floor:** Non-heat loss: concrete

**Penetrations:** Prepare list, identify appropriate tape or grommets for each type
Step 3: Air Barrier Drawings

- Detail the air barrier plane in plans & sections
- Identify materials & means of sealing, work packages

Abertay University, Scotland: The Kydd Building – Courtesy of Gaia Architects

- Controlled document, variations must be tracked

Red line – airtightness at the level of window openings;

Green line – below the window openings
Performance Spec (Step 4)

• A critical document
• Identify airtightness packages & sections they affect
• Air barriers to be:
  • Impermeable to air
  • Continuous
  • Robust
• Air barriers should be clearly identified & labelled
  • After a satisfactory preliminary airtightness test: PROTECT
• Subsequent penetrations must be rigorously managed and effectively sealed
Performance Spec (Step 4)
Performance Spec (Step 4)

Air Barrier Drawings:
- Air Barrier Strategy by ALDAS
- Implemented & issued by Cre8 Architects
- Plans, elevations & sections

- Basement level: Slab above (red/green);
- Slab below (unshaded);
- Walls – external, red; fire separation, blue

Key to Air Barrier Drawings:
- Red: Denotes extent of external fabric requiring to be sealed for airtightness purposes.
- Green: Denotes extent of external fabric requiring to be sealed to prevent the ingress of dust and other contaminants.
- Blue: Denotes extent of internal partitions requiring to be intumescently sealed for fire protection/ separation purposes.
- Magenta: Denotes extent of external fabric to the slab / roof above requiring to be sealed for airtightness purposes.
- Green: Denotes extent of the floor slab / roof above requiring to be sealed to prevent the ingress of dust and other contaminants.
- Blue: Denotes extent of the floor slab above requiring to be sealed to prevent the spread of fire (in addition, refer to note below).

Explanatory Notes:
- Specific Notes linked to particular elements
- Summary of the Air Barrier Plane
- Areas where a survey is required
- Doors requiring draughtseals and mastic sealing to frame

Creating the Seal: Presentation to the Canadian PH Conference 2018
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Airtightness Champion’s role (Step 7)

Simplified into 12 areas of work & responsibility:

1. Understand & communicate the air barrier strategy. Ensure it’s adoption by ALL.
2. Know where the Air Barrier Plane is & what forms it. Supervise or check all relevant works.
3. Ensure Site Inductions emphasise Air Leakage Testing & the necessity to avoid leaks.
4. Manage relevant variations, which can often compromise the Air Barrier.
5. Operate an inspection checklist for key elements, interfaces and penetrations.
6. Ensure all materials which form part of the Air Barrier Plane are correctly stored & used.
7. Use a Leakchecker fan or similar to check the effectiveness of sealing works
8. Liaise with the air leakage consultant/ testers to organise visits for Audits & Tests, ensure all necessary preparations are complete
9. Verify that weather conditions are satisfactory for testing
10. Ensure that leaks identified in Air Leakage Audits are sealed as necessary
11. Determine test schedule, which groups of dwellings need to be tested, when
12. Ensure the envelope area & volume for each dwelling type is traceably calculated
Erneley Close EnerPHit, Manchester:

- UK’s first major EnerPHit project
- 32 maisonettes in 2 blocks
- Very successful airtightness champions team of 4
- Very satisfied residents

- Post-completion, tenants concerned that meters weren’t going round!
Recently PH failures

- Rural newbuild, near London – 2 pairs of semis
- Investigation: airtightness tests & thermographic survey
- Took off internal linings, new floor & new membrane throughout
- Urban newbuild, Bristol – terrace of 4 PH townhouses on much larger site
- Started with airtightness tests, then managing remedial sealing overseen by specialist contractor
- All 4 achieved <1.5 AC/Hr @ 50 Pa late 2016. Major cost-overrun:
Tools for Airtightness:

- Most important tool: Thinking, planning, preparing, managing
- NOT assuming!

- Second tier tools: those that make taping effective & robust
  - Pressfix & rollers (to ensure adhesion)
  - Brush (removing dust)
  - Primer (to stick to masonry)
Tools for Quality Control of Sealing Works

- Training & Trust
- Looking – if sealing looks poor, it often is

Localised checking of sealing
- By hand
- Using a hair drier (2 people)
Leakage checking under pressure:

- Searching for leaks
- By hand
- With (non-toxic) chemical smoke
- Using an anemometer, vane or hot wire
- By thermographic imaging
Leakchecker Fans

- Uncalibrated fans used to check for leaks
- Apply to sections of a PH build - room, floor, wing
- Fitted with a magnahelic pressure gauge
  - to ensure > 25 Pa applied
- Large or small depending upon scale of build

Large fan being used for leakage checking on an EnerPHit refurb

Front & back views of small fan usually used for leakage checking on PH newbuilds
Airtightness Training Aids

- Used in training courses
  - e.g. Airtightness Champions Training
  - Training for PH Site Management
- Sealing of cables
- Sealing of ducts and pipes
Airtightness Demonstrators

Inside-out house            Practicing sealing    Builders merchant’s
d - good & bad seals        of windows          demo room

• For developing awareness & checking skills

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Lessons from 10 years of PH Airtightness:

At base, about attention to detail & effective management
- during design
- on site

Apply a robust approach, and plan for things going wrong
- key staff sick or leaving
- missing materials and late deliveries
- last minute changes in design or detailing

Provide training & get buy-in from everyone on site

*Please, please, think about how the building will be tested*