Photo Courtesy BSRIA

WHOLE-BUILDING AIRTIGHTNESS TESTING:

THE TIME IS NOW

Agenda

- A performance standard for whole-building air leakage
- Compliance ensured by measurement after completion of the building
- Air Leakage and its control in buildings
- The UK Experience with regulating whole-building airtightness
- Conclusions

It's time for tested performance of building envelopes

- Traditionally, there are few quantified aspects of performance for buildings
- We have difficulty in maximizing the performance of the building envelope because we don't measure the performance
- We need to focus more on envelope performance for energy and CO2 emissions reasons
- An easy place to start is envelope air leakage

What is Air Leakage ?

- Exchange of air between conditioned space and the outdoors
- UNPLANNED
- UNCONTROLLED

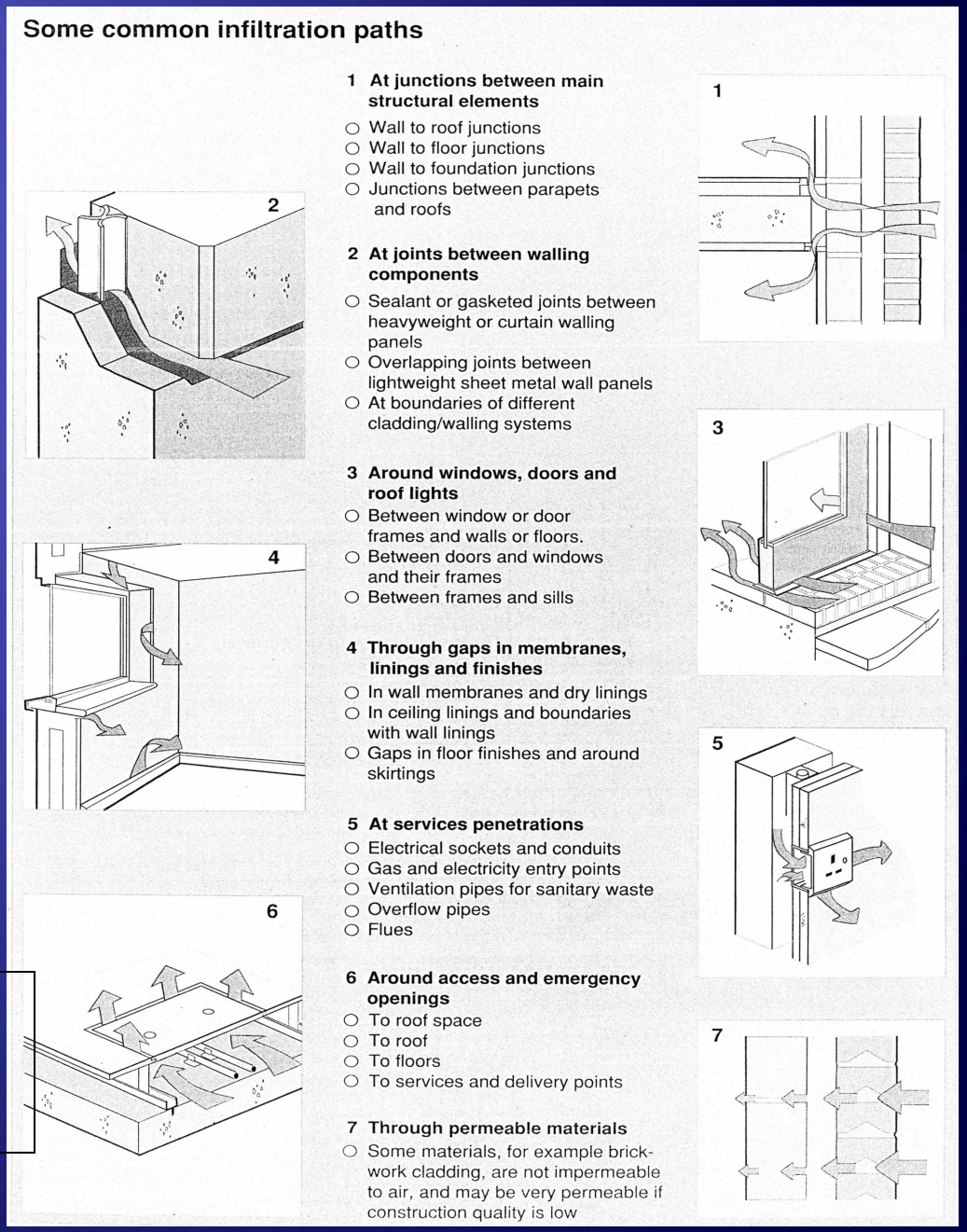
How does it happen ?

- Air moves from one place to another if:
  - There is a pressure difference between the two locations and…
  - There is an open or air-permeable path between the two locations
- Nobody designs or builds air leakage paths into a building – it results from incomplete or defective work

Examples of Air Leakage Paths

- Joints
  - Between different materials
  - At changes of geometry or plane
  - Construction or expansion
- Service Penetrations
  - Pipes
  - Wires
  - Vents

Diagram Courtesy BRE



How Does it Affect Buildings ?

- Affects the ability to supply ventilation air comfortably, in the quantities required at the times and locations required
- Imposes a negative potential for comfort and indoor air quality
- Imposes an energy penalty
- Imposes a requirement for extra heating and cooling capacity

Minimizing Air Leakage

- NOT Rocket Science !!!!
- But requires a detailed design…
- AND greater attention to quality control during construction
- Our current designs show and label an "air barrier" or "plane of airtightness"
- …which is continuous through all construction sections, details, joints, and penetrations

Construction Quality Control

- Most of our construction quality control is via visual spot-check inspection during construction
- WRT Water leakage, we have gone further
- … To setting performance standards for installed assemblies, and testing (some of) them
- But we have no similar confirmation of air leakage performance in a newly-constructed building

Air Leakage Testing

- Is quick and easy to do !
- …in most building types
- Install large fan to create known pressure difference across building envelope
- Measure the airflow through the fan
- Normalize the airflow to the surface area of the building envelope
- Compare with performance standard

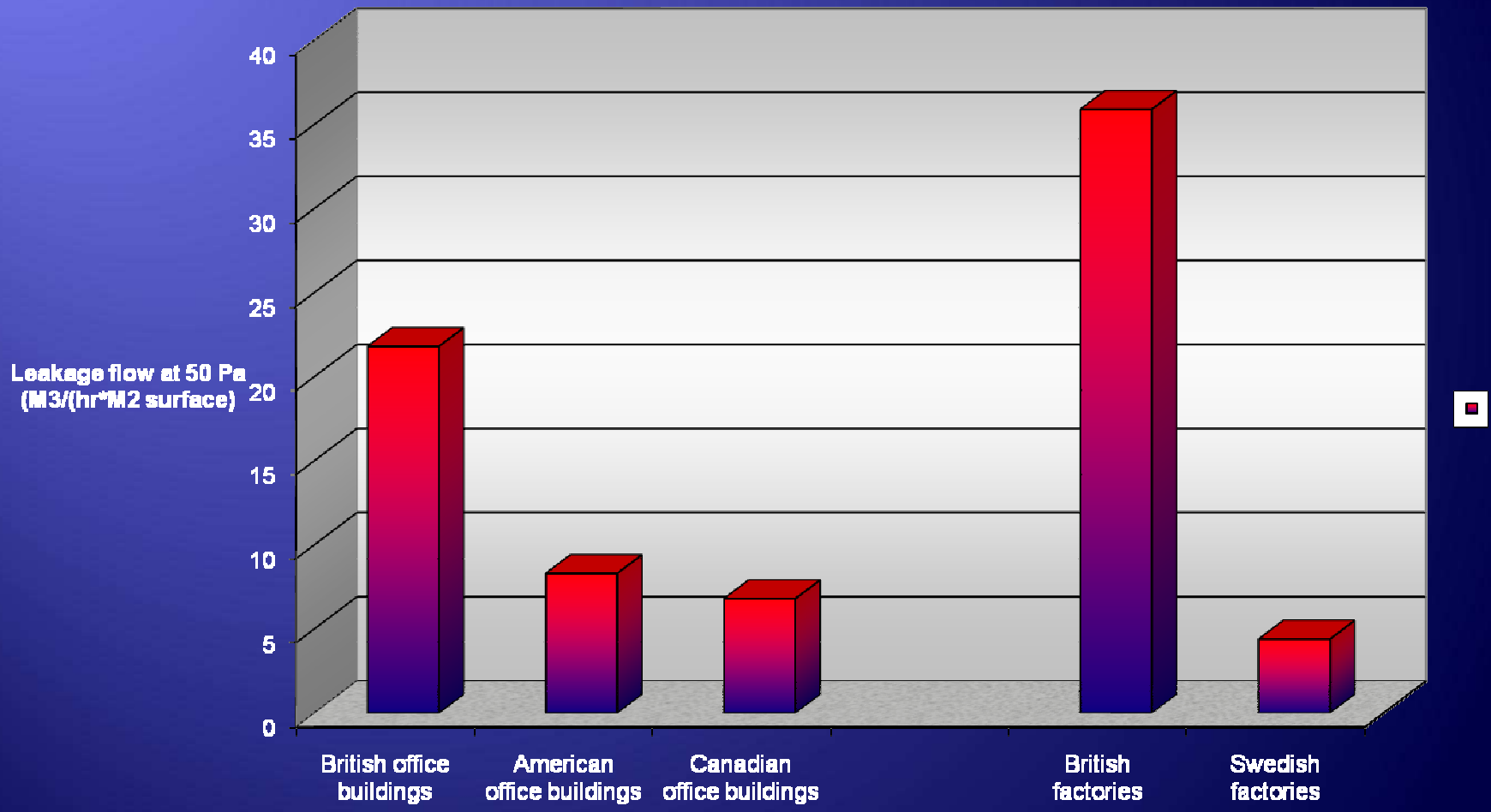
Airtightness testing at the Centre for Mathematical Sciences, University of Cambridge (Photo Courtesy Building Services Journal)

Air Leakage Performance

- Large database of tests on single-family houses
- R-2000 program has required air leakage testing for over 20 years
- Energuide for Houses includes an air leakage test

- … But much less has been done in larger buildings

Measured Air Leakage of 1990s Buildings



The U.K. Experience

- In 2002, the UK Building Regulations were amended to include a whole-building airtightness requirement
- In 2006, this was extended to require an air leakage test to demonstrate compliance
- How has this affected the UK construction and building performance ?

The UK Objectives

- Reduce energy use in new buildings
- Reduce dependence on foreign and non-renewable energy sources
- Reduce carbon dioxide emissions to the atmosphere
- Do so in an efficient, fair, and objective way

More Benefits of Regulation…

- Ensures adequate level of performance at the start of the building's operational life
- Provides a feedback process to contractors and developers which encourages quality
- Provides a baseline measurement for comparison with future tests of the same building, and comparison with other buildings
- Creates a new industry of building airtightness testing and consultancy

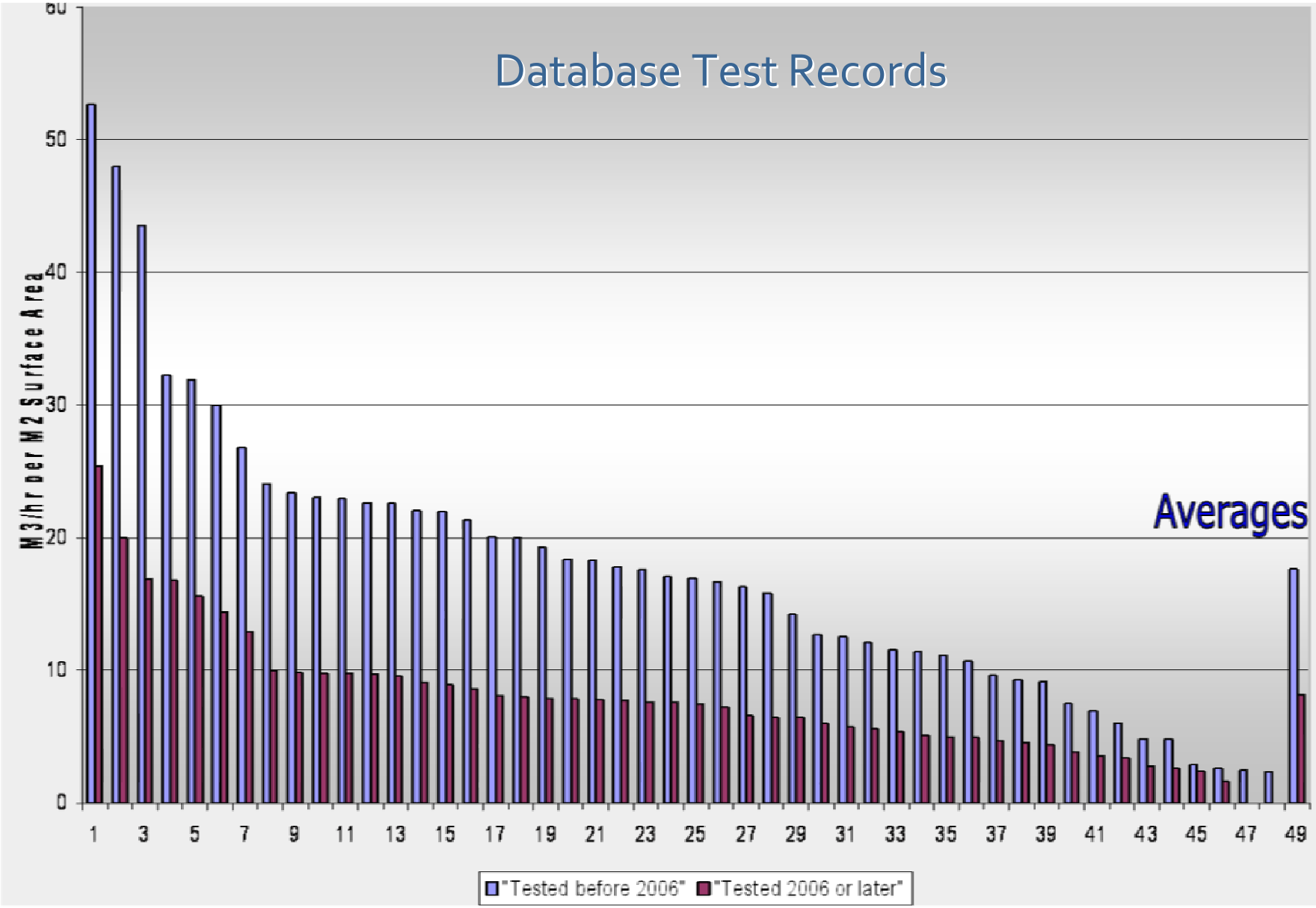
The UK Airtightness Testing Industry

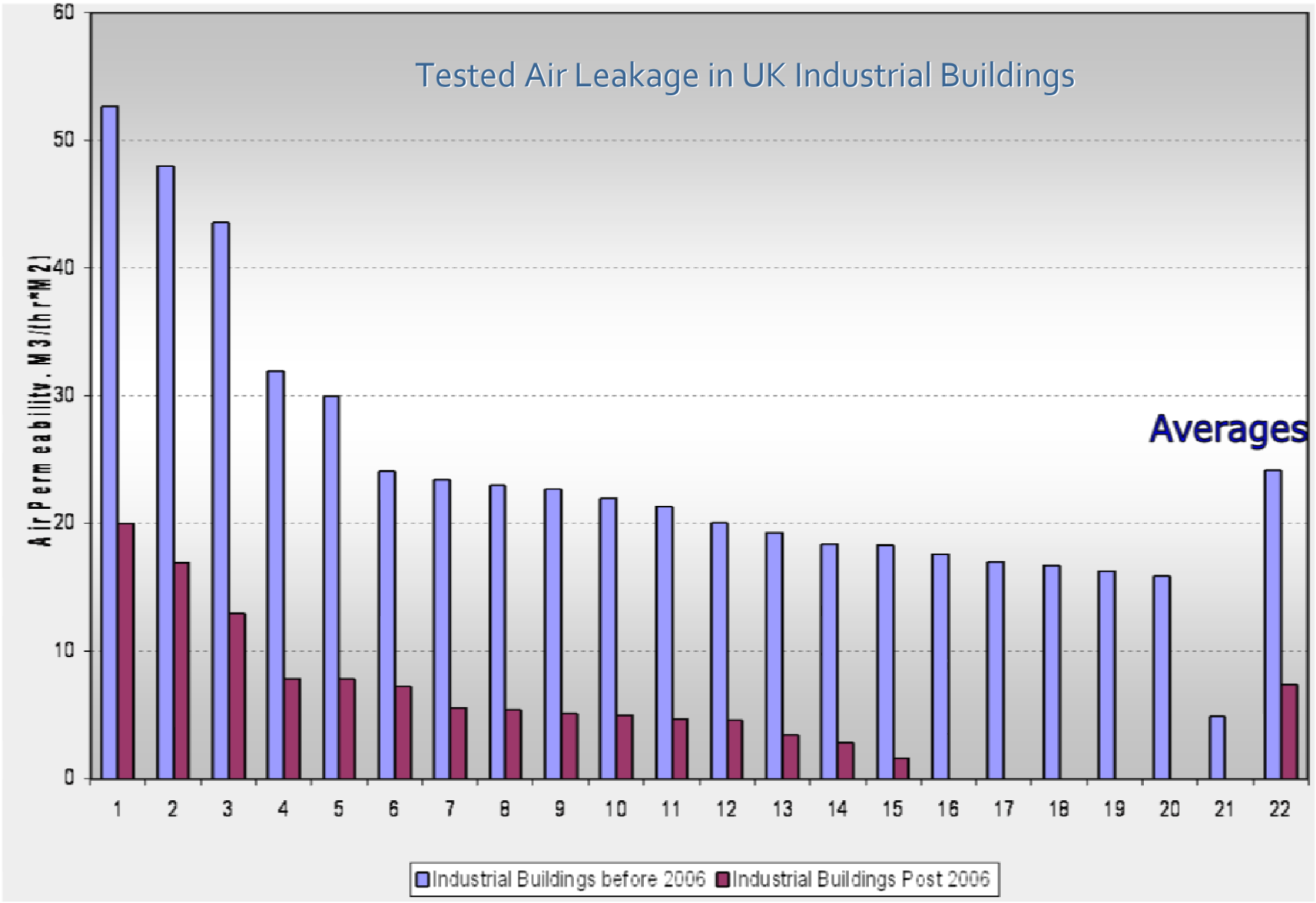
- Nine accredited firms; over 100 employees
- Market size around $15 million per year
- Demand for about 7000 tests per year
- Several unique test rigs for varying building sizes, power availability and flexibility
- Testing to UK standard can be completed in ½ day on typical small buildings

Effect on Building Airtightness

- Database of building airtightness tests developed
- Split evenly between tests before mandatory testing and after
- Buildings grouped by type and size
- Statistical measures of improvement calculated

Database Test Records




Tested Air Leakage in UK Industrial Buildings
Air Permeability, M3/(hr*M2)
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
Averages
Industrial Buildings before 2006
Industrial Buildings Post 2006

Air Leakage Reductions

	Average Leakage Before 2006 $M^3/(Hr*M^2)$ @ 50 Pa	Average Leakage After 2006 $M^3/(Hr*M^2)$ @ 50 Pa	Percentage of Pre-2006
All Buildings	17.7	8.2	46 %
Educational	9	8.25	92 %
Commercial	14	10	71 %
Industrial	24	7.4	31 %

Energy and Environmental Benefits

- Savings of approximately 0.8 % of UK gas consumption in these buildings each year
- Reduction of 140,000 tons of CO_2 emissions each year
- Improved comfort in large stores by reducing cold air entry at the doors
- Ability to control ventilation without need for fans

Problems

- 8 of 46 buildings in database failed to satisfy the standard on the first test
- Interviewees stated that
  - most failures were easily brought up to the standard
  - The learning curve for contractors was steep, with very few having more than one building fail the test
  - The rules of thumb regarding ventilation design would require revision as night cooling was not effective in an airtight building

Conclusions

- The UK experience with regulating whole-building airtightness has proven highly beneficial
- The greatest improvement has been seen in industrial, warehouse, and retail buildings
- The regulation did require the mandatory whole-building air leakage measurement to ensure compliance with the standard
- As the performance level required by the standard is not stringent, the industry found it relatively easy to implement

Conclusions

- A performance standard for Whole –building air leakage, with mandatory testing to prove compliance, will create major improvements to
  - building envelope energy efficiency
  - occupant comfort
  - Greenhouse gas emissions
  - Capital and operating costs
- An idea whose time has come !