Estimates of Uncertainty in Multi-Zone Air Leakage Measurements

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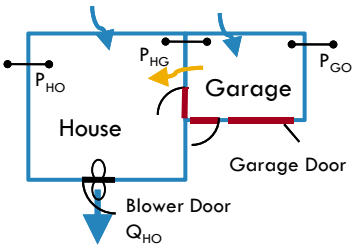
Determining Leakage Between Adjacent Zones



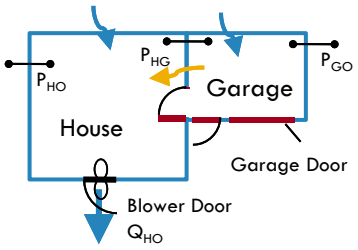
Leakage between a house and attached garage is typically small relative to leakage to-outside.

	House-Garage leakage area / House-Outside leakage area, C_{HG}/C_{HO}	House-Garage leakage area/ House & Garage-Outside leakage area $C_{HG}/(C_{GO}+C_{HO})$
This study N=6	0.05+/-0.16 min=0.02, max = 0.45	0.03+/-0.02 min=0.01, max = 0.06
Emmerich et al. (2003) N=5	0.14+/-0.17 min=0.04, max = 0.49	0.10+/-0.07 min=0.02, max = 0.21
Offerman (2009) N=105		0.055+/-0.035 min = 0, max = 0.18
CMHC (2001) N=25	0.14 min = 0.01, max = 0.43	
Batterman et al. (2007)		0.065+/-0.053 (fraction of house air from garage from PFT study)

Interzonal leakage is regularly measured, but are measurements accurate?

No standardized method

- Multiple methods exist to use a blower door for set of tests
- Accuracy, versatility not well known
- Inter-zone interface small
- Wind fluctuations complicate measurements



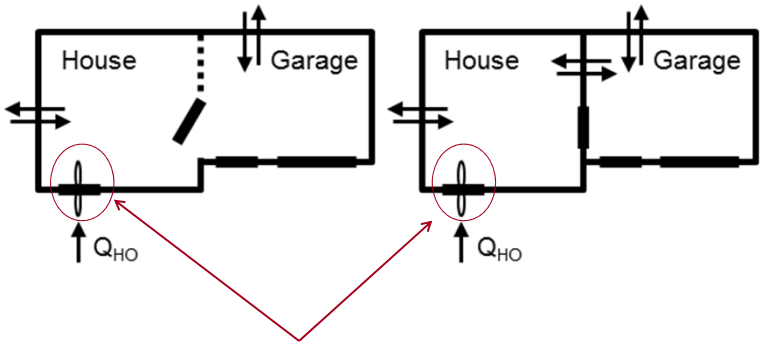
Key Questions:

- Can the inter-zone leakage be determined accurately?
- What is the best method to determine inter-zone leakage?

Approach:
Simulate leakage testing between adjacent zones

- House-garage measurements in 6 homes
  - Characterize leakage
  - Apply multiple test methods
- Monte Carlo Simulations
  - Include measurement uncertainty
  - Explore different assumptions in simplified test procedures
  - Compare different test strategies
- Identify the most versatile procedure

Most common single blower door test method

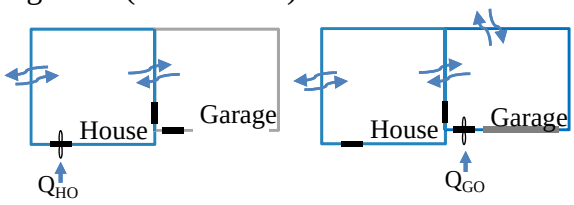


Blower door stays at the same location in both tests.

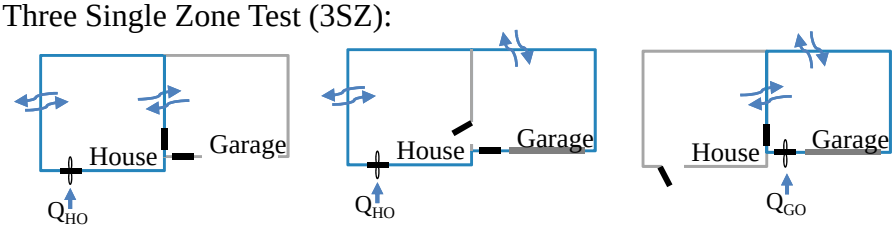
(Blasnik & Fitzgerald 1992; Offermann 2009)

Two test methods are recommended that require only a single blower door

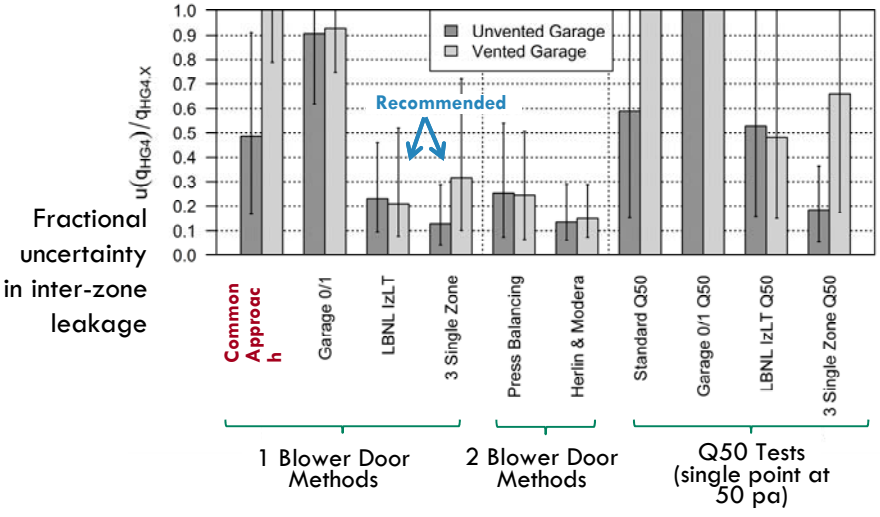
LBNL Inter-zone Leakage Test (LBNL IzLT):



Three Single Zone Test (3SZ):



Uncertainty varies significantly depending on test method.

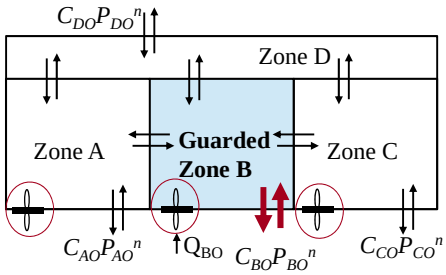


Uncertainty in Guarded Leakage Tests

Guarded Test: Pressurize Zones A & C to minimize flow to Zone B

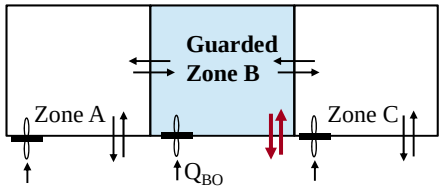
Does this test actually tell you the leakage to outside?

- Measurement errors (calibration, fluctuations)
- Some connected zones not pressurized (Zone D), e.g.: hallways, attic, wall cavities, crawl space, etc.



What is the uncertainty associated with measurement error?

- **Measurement errors**
  - Calibration error of 1% pressure
  - Pressure fluctuations of 0.5 Pa standard deviations
  - Calibration error of 3% airflow
- **Model assumptions**
  - 15-30% of infiltration is from other zones*
  - Leakage areas between A&B, B&C are each 10% of zone B to-outside leakage

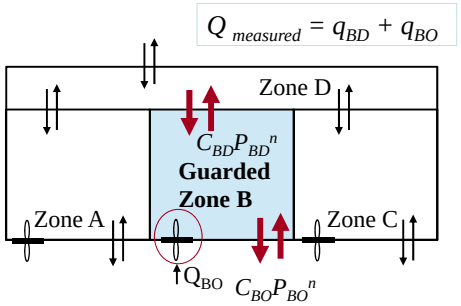


- **Result: 4% uncertainty in measured leakage to outside**
- If zones are more connected (e.g., interzonal leakage is 50% of leakage area to-outside), then uncertainty is 14%

* Francisco and Palmiter 1994; Bohac et al. 2007

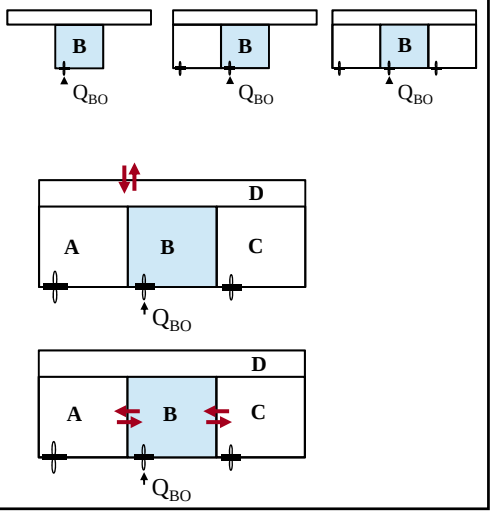
How important are interstitial (unguarded) zones?

- Leakage measured in guarded test includes flow to unguarded (UG) zones
- Leakage to UG zones is **not equivalent** to leakage to outdoors:
  - Energy implications are different – UG zones may be conditioned
  - UG zones are physically protected from outdoor winds
  - UG zones can be pressurized to some degree



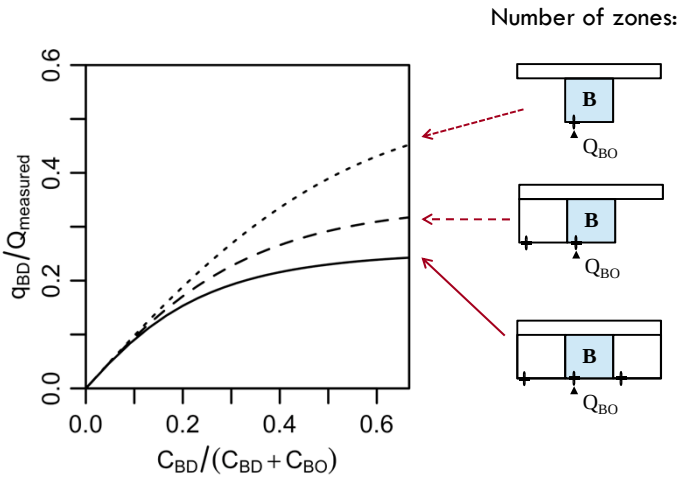
Approach: Estimate the possible impacts of interstitial zones by simulations

- **Model simulations**
  - 1, 2 and 3 adjacent zones connected to interstitial zone considered
  - Connectedness of interstitial zone to the outdoors varied
  - Leakage between adjacent zones varied



Of the measured flow in the guarded leakage test, what fraction goes to the interstitial (unguarded) zone?

Result: 20-40% of the measured flow reported in the guarded test may flow to the unguarded zone.



This assumes a relatively tight interstitial zone: $C_{DO}/C_{BO}=1$, but $q_{BD}/Q_{measured}$ increases with this ratio.

Conclusions

- Uncertainty in interzonal leakage measurements can be significant—choosing a recommended method can reduce uncertainty to 20%
- In the guarded test method, fluctuations due to wind and calibration error do not increase uncertainty substantially (5-10%)
- In the guarded test method, 20-40% of the measured leakage may flow to interstitial (unguarded) zones

Further information:

Hult, E.L., Dickerhoff, D.J., and Price, P.N. Measurement Methods to Determine Air Leakage Between Adjacent Zones, 2012. LBNL Report No: LBNL-5887E.