Air Leakage Basics

• Air leakage in buildings is detrimental for many reasons
  – Energy performance (heating/cooling loads)
  – Occupant comfort
  – Contaminant transport
  – Noise (“whistling” from air movement, high frequency sound transmission)

• Air leakage is driven by differences in air pressure

• Air pressure differentials occur due to three phenomena
Wind Effect

Stack Effect
Mechanical Pressurization

Negative Pressure

Positive Pressure

Positive Pressure

Positive Pressure
Low vs. Mid/High Rise Buildings

• In low rise buildings, wind is the primary driver of air leakage
• A “leaky” low rise building will experience very little air leakage during calm conditions

• In mid-and high rise buildings, stack pressure and mechanical system operation are the primary drivers of air leakage
• In zero-wind conditions, mechanical system operation can result in significant air leakage

Mechanical Code Issues

• Most mechanical codes require ventilation for all spaces
  – Ventilation can be mechanical or natural

• Natural ventilation is often provided in lieu of mechanical due to lower construction costs, especially in mid- and high-rise residential buildings

• Natural ventilation is typically used in conjunction with mechanical exhaust. The systems can be balanced, but who will typically:
  – Open their windows in Boston in January?
  – Open their windows in Florida in August?
Typical Problems

- With windows closed, constant exhaust systems for bathrooms, dryers, kitchens, etc. creates negative pressure in spaces.
- Negative pressure exacerbates air infiltration and may lead to airflows between units or other interior spaces.
- Fresh air often provided via pressurized corridors
  - Technically not allowed by most building and fire codes, but commonly done
  - Can be used to balance out exhaust flows if properly designed

Exhaust Stacks in Tall Buildings

What you hope for

What usually happens
Exhaust stacks

- Straight / constant cross-section ducts often used for tall exhaust stacks due to low first cost
- Results in high flows nearest to fan, little to no flows at base of stack
- We investigated a project where imbalanced exhaust risers led to negative pressures of 60 to 80pa at top floor units
  - Pressures near ground floor were closer to neutral
  - 100+N force exerted on doors, making operation difficult
  - Noise complaints of whistling noises due to high air flow around doors

Internal/Unit-to-Unit Flows

- Poorly constructed air shafts (exhaust or supply) can lead to inter-unit flows and internal pressure differentials

- We reviewed a project where leakage around exhaust grilles allowed exhaust shafts in one stack of units to impact pressures in adjacent stacks as well
Gaps Around Exhaust Intake

Magnitude of Air Leakage

- Due to their relatively constant operation, mechanical exhaust systems can lead to significant, sustained airflows
- Even small differentials, when constant in nature, can produce air leakage much greater than due to wind alone
- For a sample high-rise residential building, we used Washington DC weather data to calculate air leakage and resulting heat loss, including losses from conduction alone
Magnitude of Air Leakage

- In terms of overall building air leakage, we used the same weather data and compared wind-driven air leakage to mechanically driven leakage at 10, 20, and 30 Pa.

- Results show even 10 Pa differential, when constant, results in significantly greater air leakage than from the intermittent effects of wind alone.
Conclusions

- Mechanical system operation, especially in taller buildings, can result in much greater pressure differentials than wind alone
- This results in higher sustained air leakage and heat losses/gains
- Balanced ventilation and exhaust are critical to reducing air leakage in tall buildings
- Cost is often the primary driver for system selection, resulting in poor design choices which lead to inefficient operation