G|PRO

MECHANICAL
WEB RESOURCES

CHAPTER 3: Indoor Air Quality & Ventilation

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- Underfloor air distribution (UFAD) systems

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- **Air Quality In Retrofits**:
  Renovation and retrofits can be a major cause of poor indoor air quality, and these projects often take place while a building is occupied. Four potential problems to avoid during retrofitting and renovation activities are:
  1. Demolition that releases toxic materials (e.g., lead, asbestos, mold)
  2. Construction dust and fumes
  3. Interference with ventilation infrastructure
  4. Off-gassing from new building materials and products (i.e., VOCs)

  Generally, it is the contractor's responsibility to mitigate these problems. Your job is to confirm that the contractor complies with the building's rules, to relay complaints to the contractors (or to management if the contractor is unresponsive), and to help the contractor devise and implement solutions. If you are doing the retrofit work, you have more responsibility over mitigation. Here are some tips from the U.S. EPA to help protect residents during renovations:

  Testing: Before performing any demolition, check for lead-based paints and asbestos. Samples should be sent to laboratories for analysis. Any paint from buildings built before 1978 may have lead in it, and asbestos can be found in older boiler and pipe insulation and cement that holds down vinyl floor tiles. In April 2010, the U.S. EPA enacted a rule requiring all contractors dealing with paint likely to contain lead to be trained to follow lead-safe work practices.

  Timing: When possible, perform work at times when occupants are least likely to be in the building, such as vacation breaks, weekends, or evenings.

  Distance: Keep building occupants as far from renovation activities as possible. The greater the distance between pollutants and occupants, the less concentrated the pollutants will be upon reaching the occupants.

Barriers: Install temporary barriers (e.g., plastic sheeting) to seal the work areas from the occupied areas. Cover all supply and return air grilles if the HVAC system in the renovation area also serves occupied areas. Directly exhaust air from the construction area to the outside so construction pollutants cannot flow into the occupied areas.

Containment: Keep pollutants confined to as small an area as reasonably possible. Examples of containment techniques include wet sanding or vacuum sanding drywall to prevent the spread of dust, misting asbestos with water so it doesn't become airborne, and keeping containers of chemicals (such as solvents, adhesives, and paints) closed as much as possible. Do not operate the heating/cooling equipment when work is causing dust to be visible in the air.

Cleanup: At least daily, construction debris, dust, and scraps should be adequately cleaned up to lessen the chance that these pollutants will enter occupied areas. See a list of construction and demolition (C&D) materials to clean up.

Whenever possible, avoid the use of products with high levels of volatile organic compounds (VOCs). As concern over VOCs has grown, manufacturers have developed low- or no-VOC product alternatives, including paints, sealants, adhesives, and caulking and sealing materials.

- **Improved Controls To Reduce Emissions:**
  All boilers require some form of active control to determine when they should fire and for how long. For a variety of reasons, most controls currently in use are quite primitive compared to available technologies, and improving controls is one of the most straightforward ways to reduce fuel use and emissions. The building's heating system maintenance company should perform an annual combustion efficiency test, which shows whether the heating and hot water system is operating at maximum efficiency. The following devices should be installed in a building:

  Permanent stack thermometer: Boiler efficiency can be monitored through daily stack temperature readings with the help of a permanent stack thermometer. High stack temperatures are an indicator of inefficient combustion. For every 40ºF rise in stack temperature, fuel consumption increases by 1%.

  Make-up water meter: If the water level in the boiler is not stable and a lot of make-up water is needed, steam is leaking.

  Domestic hot water temperature sensor: Avoid overheating domestic hot water to prevent scalding accidents and save fuel.

  Modulating aquastat OR "reset" system (for hot water boilers): A modulating aquastat controls the temperature of the water in the boiler. A modulating aquastat senses the outdoor ambient temperature and adjusts boiler water temperature accordingly. Modulating aquastats can lower annual fuel costs by approximately 10%, depending on heating needs.

  Programmable thermostats: Programmable thermostats can save up to 15% in fuel consumption. A thermostat monitors the temperature of one or more areas within a building and initiates or terminates boiler operation, depending on heating needs. A programmable thermostat allows the building owner to specify multiple set points that can vary by time of day. These systems can be used in single-family homes, multifamily homes, and small apartment buildings. They may not be practical in very large apartment buildings.

Boiler controls (in small buildings): Boilers in most smaller buildings are controlled by simple thermostats that turn the boiler and circulation pumps on and off to maintain internal temperatures within a degree or two of a set-point temperature. Significant savings can be achieved in these buildings by installing a programmable thermostat, which can be set to lower temperatures at times when the building is not occupied or people are sleeping.

Boiler controls (in large buildings): Boiler controls and energy management systems (EMS) in larger buildings can save approximately 15% in fuel consumption. An EMS costs from $8,000 – $20,000 and produces savings of at least 10%, and often more, resulting in payback periods of 1 – 5 years on the basis of fuel savings alone (depending on building size).

Heating system balance issues: Even with an EMS or BMS providing improved control, building operators frequently find that some spaces will always be overheated, and others underheated. Since this usually results in substantial overheating to keep the coldest spaces comfortable, significant savings can be realized by improving the system balance. Balance can only be addressed by using thermostatic radiator valves (TRVs) and zone controls.

Zone controls: Often there are large discrepancies in heating needs for different parts of a building, especially between the south and north sides of a building on sunny winter days. The best way to control for this is to break the heat distribution system into "zones" and send heat only where it is needed. Ideally a large building will be divided into four or six zones, all controlled by an advanced EMS with multiple temperature sensors. Zone controls can be used with either steam or hydronic distribution systems and with or without TRVs.

- **Thermostatic Radiator Valves And Shut-Off Valves:** Thermostatic radiator valves (TRVs) allow heat to flow into individual radiators only when the room temperature falls below an adjustable set point, yielding fuel savings of 3 – 20%. TRVs are quite effective when installed in two-pipe steam systems and in hydronic systems that are plumbed with parallel pathways, which prevents the valve on one radiator from turning off the hot water supply to all the other radiators. TRVs are also available for one-pipe steam systems, in which case they replace the sir valve and do let air out of the radiator unless the room temperature is below the set point.

  TRVs come in two styles. In the first type, either the temperature sensor or dial is directly attached to the valve when there is no radiator cover. If the radiator is enclosed, it is recommended to mount the temperature sensor on a nearby wall and connect it to the valve by a thin tube. The second type, known as "remote actuator," is better under all circumstances and must be used if radiator covers are present, because it is important that the actuator senses room temperature rather than radiator temperature.

- **Air Sealing And Duct Sealing In Retrofits**
  Stack effect: In cold weather, a tall building acts like a chimney. The warm air inside is lighter than the cold air outside and tends to rise, pulling cold air in through any openings near the ground and discharging heated air through any openings on or near the roof. In most buildings, this flow of air is much greater than that needed for adequate ventilation and increases the load on the heating system. Professionals can use a variety of

techniques to identify and isolate leaks, ranging from smoke pencils that track drafts to blower doors that pressurize entire small buildings. Even without this information, however, active steps to reduce infiltration are well worthwhile. Because many aspects of construction contribute to infiltration, there are many measures to reduce it.

Air Sealing In Retrofits: Repairing leaking ducts can yield big improvements in energy efficiency. Duct sealing contractors often find many leaks: duct tape decays and falls away; ducts may have been torn or crumpled by other trades during installation; and poorly hung ducts can have bends and kinks that prevent proper air flow. It is also not uncommon to find one or more ducts completely disconnected from their registers. If return ducts in the heating and air-conditioning system have holes, they can draw in hot attic air or cold outside air. As a result, the system must work harder and use more energy to heat and cool the inside of the house. This added stress on the system increases energy use in heating and cooling the building interior.

Ensure Duct System Integrity: A heating and cooling equipment contractor may:

- Inspect the duct system, including the attic and crawlspace.
- Evaluate the system's supply and return air flow.
- Repair damaged and disconnected ducts.
- Seal all leaks and connections with mastic (a thick sealant painted on duct joints).
- Seal all registers and grills to the ducts.
- Insulate ducts in the unconditioned areas (like attics, crawlspaces, and garages) with duct insulation that has an R-value of 6 or higher.
- Replace the filter as part of any duct system improvement.
- Retest air flow after repairs are completed.
- Ensure there is no backdraft of gas- or oil-burning appliances, and conduct a combustion safety test after ducts are sealed.

- **Thermal Imaging And Insulating In Retrofits**

Thermal imaging: In addition to visual inspection, thermal imaging can identify areas with large heat loss and find uninsulated areas that a visual inspection may miss. Thermal imaging offers a cost effective way to visualize and assess BTU loss from missing, lost, damaged, or improperly installed mechanical insulation. With advances in technology, thermal cameras and guns have become cheaper and more accurate.

The fact that a system has insulation does not ensure that it was properly designed and installed. Thermal imaging helps remedy this uncertainty by providing a tool to distinguish between properly installed insulation and defective insulation. Thermal images locate voids in the insulation, which cause unwanted heat loss or gain. The technology is capable of revealing not only insulation deficiencies in building features visible to the human eye, but also temperature losses on mechanical systems hidden behind walls and structures.

The applications of infrared thermometers or thermal imagers extend even further. They can be used to inspect fuses, circuit breakers, and many other types of electrical equipment, loads, and panels. Thermal inspections may uncover both electrical problems, such as poor power quality, and mechanical problems, such as bad bearings in motors. Water and steam leaks in walls and below ground can also be identified.

Wall and pipe insulation: Insulating all exposed pipes in the boiler room and throughout the building is an essential step. The boiler itself should also be wrapped in insulation material to minimize heat loss, and in general, everything that feels warm to the touch should be insulated. Any time a resident or the building owner performs repairs requiring the walls to be opened up, the building management should use the opportunity to insulate all pipes carrying steam or hot water, pushing insulation up and down into the adjoining floors.

Air-sealing measures, such as high-endurance caulking and spray-foam applications, further reduce energy use, lower expenses, and improve interior building comfort. In addition to air flow, heat leaks out of buildings by conduction through walls, windows, and any other surface in contact with the outdoors. Blowing insulation into the walls of wood-frame structures is a cost-effective measure. It is not usually practical for masonry or steel-frame buildings, but it can be effective in filling a roof cavity. In large buildings with radiators, a substantial part of the heat released by the radiator is directed into the wall behind it, a sizeable portion of which is then lost to the outdoors. If esthetically acceptable, a slab of insulation between any radiator and the wall behind it will be a very cost-effective intervention.