

Building Air Leakage & Thermal Bridging

Why a Bigger HVAC System May Not Make You Comfortable

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When it is difficult or impossible to maintain comfort in a building, the majority of building owners call their HVAC contractor to correct the situation. This solution may not only leave you uncomfortable, it may cost you money with limited or no results. The above is true not only in existing buildings, but new buildings as well. I have become involved in numerous building projects where the HVAC contractor and/or mechanical engineer were called on to solve comfort problems but have had limited success. So what is the problem? Well, I look at the problem as a process. It begins in the pre-design phase of many projects when items are eliminated to save money.

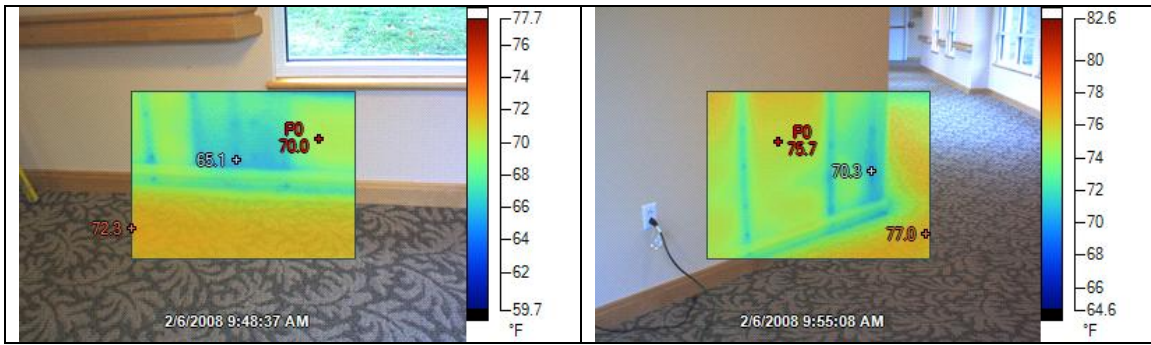
The first thing I usually notice is the scope of the commissioning, if the building is being commissioned at all. The scope typically covers the dynamic systems (HVAC, lighting, VFD's, BAS, etc.) but rarely encompasses any static systems such as the building enclosure. I find this to be true even on sustainable (e.g LEED) building projects. Most parties involved, including design team, owner, LEED project manager, etc. seem to always minimize or overlook altogether the building enclosure. This is a costly mistake in many cases.



The images and photos used in this article are all from a recent project. The building was new construction and there were numerous problems from the onset. First, the sprinkler system pipes froze and split the first winter. The second winter led to additional complaints concerning the inability to heat the building. The owner had placed portable electric space heaters throughout to try to heat the building.

Our investigation and evaluation of the building revealed some very serious problems in both the design and construction of the building. First, we knew that the building was framed with steel studs. This requires some additional thought and calculation during the design phase of the building. The photo shows fiberglass batt insulation between studs which has fallen, leaving little to resist heat flow at the exterior wall.

The first part of our investigation was to perform a thermographic analysis of the building enclosure to determine where the potential for problems was occurring. The results of the thermographic analysis were astounding. The images below show the extent of the thermal bridging and air leakage which we discovered. In some locations, we found a 20+ degree F. difference in surface temperature from the studs to the center of cavity.



This told us that the potential for condensation was significant. We needed to have a better understanding of the building enclosure design and construction. Further evaluation of both the drawings and specs and the building revealed some very significant shortcomings which would be hard to correct.



First, the installation of the sheathing and exterior insulation was not done properly, leaving uncontrolled airflow into the building and unacceptable resistance to heat

flow. The steel stud wall construction exacerbated the problems even further. The joints in the polystyrene insulation and the sheathing were aligned and neither had the joints sealed. This allowed for air to flow into the wall cavity and create what is known as “wind-washing” in the wall cavities. The R-values of all exterior walls were extremely compromised. In some areas, the interior wall surfaces were 15-20 degrees F. colder within an area of a few feet. The thermal images below show the extent of the thermal bridging which was taking place. Modeling of the wall (see below) revealed an effective R-value of less than 5.



The photo to the left was taken from the soffit area at the exterior of the building. Note that the fiberglass batt insulation edge is exposed to outdoor airflow. This answered our questions about the frozen sprinkler lines. Our pressure assessment indicated that the building was under negative pressure with reference to the outdoors. This was partly due to an attached building which was exacerbating the uncontrolled airflow into the drop ceiling

where the sprinkler piping was located. The fiberglass baffles which were installed between rafters were not performing their intended function which is to

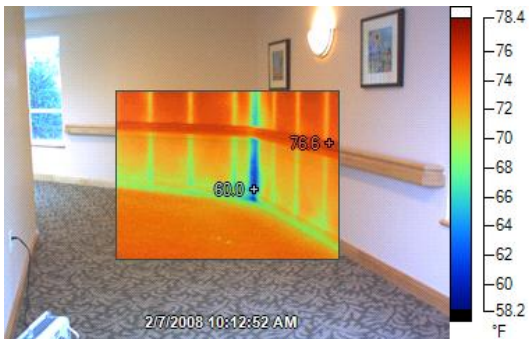
separate airflow from the insulation. This scenario greatly reduces the resistance to heat flow through the insulation.

On this particular project we utilized infrared thermography to detail the issues in the building. We performed scans from both interior and exterior and our findings were used to guide the investigation.



Thermal bridging through the steel stud wall construction was apparent when a thermal scan was performed from the exterior. A significant amount of heat loss is also apparent at the top of slab. This told us that further investigation of both air barrier and insulation/sheathing installation was warranted.

Below is an interior view of the same area. The extensive thermal bridging is made very evident using infrared thermography. This can save valuable time in directing an investigation.

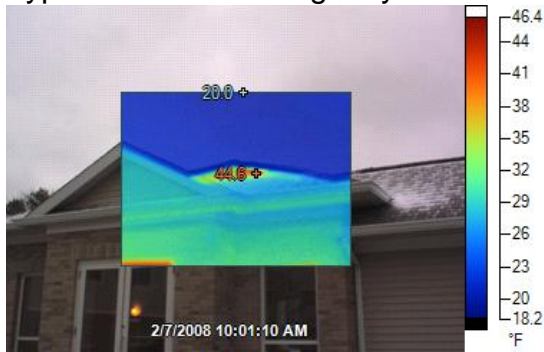


Note the anomaly which indicates air leakage at the change of direction in the wall. This is sometimes where architecture and building performance go their own ways. The plane of air tightness most often fails at these changes of plane in the wall. This is where additional attention in the design and installation is required to assure success.

In addition to air leakage issues in this building we found a few other areas where a closer evaluation during plan review would have spotted some other potential problems. One of these areas was the placement of the air handlers (2) in the attic. In addition to comfort complaints and frozen sprinkler lines, the owner complained of large ice buildup at the eaves. Our infrared thermography assessment revealed this almost immediately when the exterior was scanned. The image below shows that the roof above the area housing the air handlers was 44 degrees on a day when the outdoor temperature was in the 20's.

A trip up to the space used to house the air handlers revealed some significant problems including poor insulation, significant amounts of air leakage around the plenums and a disconnected supply duct. How do you spell RELIEF in such situations? COMMISSIONING!! The owners could have avoided many serious and expensive problems had they opted for some form of commissioning.

Typical commissioning may not have discovered the problems. This project shows the need for “total building commissioning”.



I have evaluated many building failures over the past 15 years. I have also performed numerous commercial energy assessments and tried to find solutions for numerous comfort complaints. Typically, by the time a building owner decides to call someone

like me, the issues have escalated to the litigation stage. That’s unfortunate. However, it is also very typical in our industry. Too often, the term building commissioning has been misapplied to mean air balancing. I am not saying that air balancing and diagnostics is a bad thing. To the contrary, I think it is an important piece of a larger puzzle which should include the air barrier, construction details and other design issues which can directly affect the performance of all systems.

In operating a consulting firm that specializes in total building commissioning and performance, one of the biggest difficulties I have encountered is breaking down what I call the mechanical system bias. Many of those I have employed or worked with come from the old school (HVAC only) school of commissioning and breaking that bias is a difficult undertaking. Most of the old school commissioning agents see all building condition and problems as being corrected through the HVAC systems. Of course, today we know this is not true. This is why the “INDEPENDENT THIRD-PARTY” concept was created. It allows for the rational assessment of building performance without a bias for selling services or equipment. It also allows for a higher ratio of success in correctly identifying and correcting building complaints.

Understanding the relationships between all building systems and how they affect overall performance is the direction of today’s building commissioning agent. The last page of this article shows a model of the wall in the building we have discussed. This model, if performed during design phase would have revealed some of the concern with the R-values in the walls. Some low cost changes could have been implemented and I would not be writing this. The model shows the R values of the wall would not perform well through a Northern, Ohio winter.

commercial construction settings and has been involved in projects ranging from small storefronts to nuclear power plants. AI is currently involved in sustainable building and has been involved with commissioning and/or retro-Cx for clients including Summit Metro Parks, NASA, numerous healthcare facilities, congregation buildings and industrial facilities. AI has also been involved in several LEED building projects.