BUILDING ENERGY CODES: Creating Safe, Resilient, and Energy-Efficient Homes

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BRITT MAKELA GROUP, INC.

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Abstract

Building energy codes establish minimum requirements for the elements within a building that impact energy consumption. The obvious benefit of buying a new home built in compliance with current energy codes is the energy cost savings for the homeowner. However, there are other significant benefits that come with the purchase of a home built in compliance with current building energy codes. These benefits have impacts on everything from the safety of the air the occupants breathe to the prevention of fire spreading through draft openings. A house is a system that derives its characteristic, good or bad, from the interactions of its essential parts, and adhering to the energy code helps to keep these interactions positive.

Complying with energy codes has lasting positive impacts for building occupants. Provisions within the energy code touch most aspects of residential construction including the building envelope and the heating and cooling system. Increased durability, reduced potential for premature equipment failure, and a more comfortable environment for the occupant—these things all add to assisting builders with meeting other health/life safety requirements, and are just a few of the added benefits of complying with the energy code. As with any code, workmanship and attention to detail are necessary to ensure that efficiency features are installed properly to receive the true benefit of code requirements.

Introduction

Building energy codes establish minimum requirements for the elements within a building that impact energy consumption. The obvious benefit of buying a new home built in compliance with current energy codes is the energy cost savings for the homeowner. However, there are other significant benefits that come with the purchase of a home built in compliance with current building energy codes. These positive occurrences are due to building physics. A house is a system that derives its characteristic, good or bad, from the interactions of its essential parts.

This includes increased durability of the building, less condensation on interior surfaces, and mold prevention as compared to a house that is not compliant with the same code. Complying with current energy codes will also allow easier compliance with the residential fire requirements of the building codes. This paper will address those benefits and provide case studies where non-compliance with energy code requirements led to construction defects.

1. Building Energy Codes

Building energy codes establish minimum requirements for the elements within a building that impact energy consumption. These elements include insulation, windows, doors, air sealing, heating, ventilation, air conditioning equipment, service water heating, and lighting. When adopted by a state or local government, these requirements are considered law and they impact new construction as well as additions and alterations to existing buildings. The International Energy Conservation Code (IECC), developed by the International Code Council, is the most widely adopted energy code for residential construction. The majority of state and local governments in the U.S. have adopted some version of a building energy code. When local governments enforce the current energy code, they are providing a valuable service to their citizens by ensuring they get a quality home free of defects.

2. Benefits of Building Thermal Envelope Compliance

The building thermal envelope includes basement walls, exterior walls, floors, roofs, and any other building element that separates conditioned space from unconditioned space. Each component of the building thermal envelope has to meet the minimum insulation requirements prescribed by the code. In addition, there are also minimum requirements for windows and doors. Finally, the building thermal envelope must also be sealed to prevent indoor air from escaping and outdoor air from entering.

The building thermal envelope is the most critical aspect of the energy code.

The building thermal envelope is the most critical aspect of the energy code. Failure to meet the requirements of the energy code can lead to ice damming (in colder climates), mold and moisture problems, and indoor air quality issues. Meeting the requirements of the code can increase durability of the building envelope, increase indoor air quality, and assist the builder in complying with health/life safety codes.

By complying with the energy code, builders prevent their future homebuyer from enduring the cost and headache of dealing with ice dams and potential call-backs to address the problem.

2.1 Ice Dams

Obviously the issue of ice dams is unique to cold climates, but in those climates it is a major cause of insurance claims filed by homeowners. According to the Insurance Information Institute, "water damage and freezing" is the second most frequent homeowner's insurance claim and accounts for 20—25 percent of all insurance losses. The average cost of each claim is $6,965.

Ice dams are caused by warm indoor air escaping the "conditioned space" of a home and warming the attic and underside of the roof; causing snow to melt and then re-freeze when it reaches the colder roof eave. The simple solution to this costly problem is air sealing and properly insulating the ceiling assembly. By complying with the energy code, builders prevent their future homebuyer from enduring the cost and headache of dealing with ice dams and potential call-backs to address the problem.

2.2 Air Barriers

Complying with the air sealing requirements in the energy code increases the durability of the building, prevents potential moisture, mold, and rot problems, improves indoor air quality…

Airflow through and within building components is driven by three primary components: stack pressure, wind pressure, and pressure differentials induced by mechanical pressures that include fan pressure, interior door closure, and duct leakage. Air leaks through the building envelope can have the most damaging effect on a home's durability. Uncontrolled airflow through the building envelope can carry moisture into framing cavities. Moist indoor air that comes in contact with a cold surface can condense, causing moisture issues within framed cavities that can lead to mold growth, rot, and damage to the building envelope. Air leaks into the house can also bring contaminants, e.g. exhaust from a car parked in a garage and other pollutants that are stored outside of the conditioned space. Complying with the air sealing requirements in the energy code increases the durability of the building; prevents potential moisture, mold, and rot problems; improves indoor air quality; and prevents the financial and health issues that can be associated with these problems.

2.3 Condensation on Windows

Moisture can condense on inefficient windows if warmer moist air comes in contact with the cold surface of the glass or the frame during the winter. Typically, windows using standard glass with no low-E coating and aluminum frames can cause moisture to condense out of the air if the window and frame surface is colder than the dew point of the air next to the windows. If the surface temperature is below freezing, frost can form on the windows. Condensation can damage wall and ceiling materials and, if prolonged, can promote the growth of mold and mildew if mixed with dirt and other nutrients. Complying with energy code requirements to install efficient windows that will perform well in the climate zone they are specified for can significantly reduce these condensation issues.

Complying with air sealing and insulation requirements of the energy code not only increases the efficiency of the house but also helps meet the fire blocking requirements of the IRC by requiring that insulation be installed in exterior wall and that all penetrations be sealed between conditioned and unconditioned space.

2.4 Fire Blocking and Combustible Construction

In wood-framed residential construction, the code requires that fire blocking be provided to cut off all concealed draft openings (both vertical and horizontal). The fire blocking must also form an effective fire barrier between stories, and between a top story and the roof space. Fire blocking is required in concealed spaces of stud walls and partitions, and at intersections between concealed space, (e.g. between soffits, dropped ceilings, and at openings around vents, pipes, ducts, cables, and wires at ceiling/floor levels). To meet the requirement, the International Residential Code (IRC) allows the use of wood products in addition to different types of insulation that are approved for use as a fire block. Complying with air sealing and insulation requirements of the energy code not only increases the efficiency of the house but also helps meet the fire blocking requirements of the IRC by requiring that insulation be installed in exterior walls and that all penetrations be sealed between conditioned and unconditioned space. Concealed spaces are also required to be sealed off from each other to prevent air leakage.

2.5 Slab-on-Grade and Mold and Mildew

Slab-on-grade floors built in cold climates are typically very cold, especially if they are not insulated properly. During cold parts of the year, the surface temperature of an uninsulated slab perimeter can go below the dew point of the interior air for a significant period of time. Warm and moist air that comes in contact with the slab surface can condense. A carpeted slab, which is typical in residential construction, can add food necessary for mold and mildew growth, fungal growth, dust mites, and other pests. The best way to prevent the slab from getting cold and to reduce the potential for condensation is to insulate the slab edge. Energy codes require slab edge insulation in most climate zones, which reduces the risk of condensation on the surface of the slab and the potential growth of mold, mildew, and other unwanted pests.

2.6 Issues With Rim Joists

Complying with energy codes can increase the durability of wood framed construction.

Wall assemblies can be insulated and air sealed to increase their resistance to moisture intrusion. This is important in all climate zones but can be critical in cold climates where cold framing members can become condensing surfaces, increasing the potential of mold and mildew growth. The rim or band joist is a framing member that is relatively easy to insulate but difficult to air seal. These framing members are located between conditioned floors, at the top of basement walls, or on top of stem wall in an unvented crawlspace. These cold surfaces may be insulated with insulation that allows air movement through it (air permeable). Warm air passing through the insulation will condense on the rim joist during the heating season and be held against the surface. The moisture can cause mold growth and eventually can lead to rotting out the rim joist. Energy codes focus specifically on the rim joists to ensure they include an air seal and are properly insulated. Complying with energy codes can increase the durability of wood framed construction.

3. Benefits of Mechanical and Water Heating System Compliance

The IECC covers requirements for programmable thermostats, duct insulation, duct sealing, duct leakage testing, service hot water systems, mechanical ventilation, and equipment sizing. These provisions address the efficient use of energy for the heating, cooling, and ventilation of a home. Failure to comply with the mechanical system provisions can lead to several unintended consequences that impact more than just energy consumption. Complying with the provisions of the energy code can lead to better indoor air quality, reduced potential for premature equipment failure, and a more comfortable environment for the occupant.

3.1 Duct Leakage

Air leakage in supply and return duct systems can have a negative impact on the air quality within a building and may also lead to backdrafting of combustion appliances. Backdrafting becomes a very real issue when gas furnaces are located in a conditioned space (e.g. a basement) adjacent to other gas appliances like water heaters. If supply ductwork connected to the furnace is located in a vented attic and is very leaky, there may not be adequate air available to return to the furnace. In attempting to "find" an adequate amount of air to return to the furnace, the ductwork will pull in air through leaks in the building envelope and will also potentially pull in air through the water heater vent, causing the water heater to backdraft. Leaky return ducts located in the basement containing a water heater can also cause backdrafting by depressurizing the space. The negative pressure (suction) can draw air down vents and flue pipes.

Ductwork formed by framed cavities can also cause indoor air quality issues. These cavities are negatively pressurized and will want to draw air into the space for adjoining framed cavities (e.g. wall cavities) and bring in contaminants that may be located in the cavities. Also, a negatively pressurized cavity can pull in moisture from the exterior in hot-humid or warm-humid climates and cause the potential for condensation when the air conditioning is on. Complying with energy codes by ensuring that all ducts are sealed, ducts located outside of the conditioned space are tested, and the use of framed cavities as ductwork is prohibited will significantly reduce the potential for moisture issues and backdrafting due to leaky duct systems.

Complying with the provisions of the energy code can lead to better indoor air quality, reduced potential for premature equipment failure and a more comfortable environment for the occupant.

3.2 Cooling System Sizing for Humid Climates

Oversizing cooling systems in humid climates can lead to humidity issues in residential construction and to premature wear on the cooling systems. Oversized systems cycle on and off more than "right sized" cooling systems, reducing the effectiveness of dehumidifying the air. Proper dehumidification requires a higher percentage of run time, during which the coil is operating at its coldest temperature

Properly sizing the systems may lead to a reduction in humidity issues and longer life for the cooling system, reducing homeowner costs

and allowing more condensation to form and flow out of the system. More starts and stops accelerate wear and tear on the equipment, which can lead to premature failure. Energy codes require that an Air Conditioning Contractors of America (ACCA) Manual J heating and cooling load calculation be conducted to size the cooling system. In addition, the energy code requires that cooling equipment be selected based on the methodology described in ACCA Manual S. Properly sizing the systems may lead to a reduction in humidity issues and longer life for the cooling system, reducing homeowner costs.

3.3 Hot Water Piping Insulation

Leaving hot water piping uninsulated can lead to an increase in residential water usage in addition to an increase in energy usage. As hot water sits in a plumbing line between uses, the water cools to a temperature that is not desirable for the homeowner. The hot water faucet is typically turned on and left to run in order to get water to the desired temperature, which increases the water use of the house. If the pipe has multiple hot water draws within a period of 10—60 minutes, as may happen in a kitchen, there is a signifant amount of water that can be wasted. The IECC requires that most hot water runs be insulated to not only save energy but to also reduce water use in the house.

4. Conclusion

Complying with energy codes has lasting positive impacts on residential construction. Provisions within the energy code touch most aspects of residential construction, including the building envelope and heating and cooling system. Increased durability and healthier indoor air quality, in addition to assisting builders with meeting other health/life safety requirements, are just a few of the added benefits of complying with the energy code.

As with any code, workmanship and attention to detail are necessary to ensure that efficiency features are installed properly to receive the true benefit of code requirements. The appendix provides case studies that demonstrate what can happen if provisions of the code are not met and how construction practices were changed to mitigate issues that affected durability and indoor air quality.

References

Info-408 Critical Seal (Spray Foam at Rim Joist)

Building Science Corporation

9/17/2009

http://www.buildingscience.com/documents/information-sheets/critical-seal-spray-foam-at-rim-joist/?searchterm=Rim%20Joists

Info-513 Slab Edge Insulation

Building Science Corporation

5/14/2009

http://www.buildingscience.com/documents/information-sheets/slab-edge-insulation/?searchterm=slab-on-grade

RR-0403: Air Barriers

Joe Lstiburek, Building Science Corporation

6/08/2008

http://www.buildingscience.com/documents/reports/rr-0403-air-barriers/view?searchterm=Air%20Barriers

Efficient Windows Collaborative

Benefits: Reduced Condensation

http://www.efficientwindows.org/condensation.php

Whole Buiding Design Guide, National Institute of Building Sciences

HVAC Design for Humid Climates

David MacPhaul, P.E. and Christy Etter, P.E.

CH@M Hill

7/6/2010

http://www.wbdg.org/resources/hvac_humidclimates.php

Energy Efficient Homes: Air Conditioning
University of Florida IFAS Extension
Wendell A. Porter, Hyun-Jeong Lee, and Kathleen C. Ruppert
Publication # FCS3262
http://edis.ifas.ufl.edu/fy1026

2012 International Residential Code
International Code Council, Inc. May, 2011
Section R302.11

2012 International Energy Conservation Code
International Code Council, Inc. May, 2011
Section R302.11

Appendix

Case Study 1

Montana House: Excessive Moisture Issues Caused by Improperly Sealed Duct System, Poor Air Sealing, and Insulation Practices

Issue Statement

Improper air sealing, duct sealing, and lack of attention to detail in installing the vapor barrier on the crawlspace floor can lead to mold growth, degradation of insulation, and rotting of structural members.

Description

A homeowner in Montana was experiencing excessive moisture problems with their house. The Montana Department of Environmental Quality (DEQ) was contacted and asked to assist in solving the excessive moisture problems in the house that included frost covering the interior of the attic and extending out from the gable end vents during the winter. The homeowner stated the doors and windows would ice shut at times and that the ceiling had fallen in twice. To remedy the problem, extensive house repairs were made that included adding more vents to the crawlspace, removing the attic insulation, and repairing parts of the water-damaged ceiling. However, the problems persisted after the repairs were complete.

During the investigation, DEQ found that the major source of moisture entering the home was from the ground in the crawlspace. Moisture was entering the house from multiple paths that could have been eliminated through compliance with the energy code.

Duct Sealing. A framed floor joist cavity located in the crawlspace was used as a return air duct for the heating system. This was missing an end panel (approximately 18 inches by 10 inches) and was pulling moisture-laden air into the heating system and distributing the air into the house. There were several other areas of duct leakage in the return duct.

Air Sealing. The leaky return air duct was causing the upper floors of the house to be pressurized, forcing the moisture-laden air into the attic through ceiling-recessed light fixtures; into the exterior wall through the electrical outlets; into the window and door weather stripping; and into other openings to the exterior. The ice build-up in the weather-stripping and locks prevented the opening of doors and windows. There was also ice build-up on the roof sheathing in the attic.

Rim Joists. The rim joists in the crawlspace were insulated with fiberglass batts. The insulation was wet and there was mold staining on the rim joists in a few locations.

Crawlspace Vapor Retarder. DEQ found that moisture from the ground was the major source of moisture entering the house. A vapor retarder was installed on the floor of the crawlspace but the 6-mil poly vapor retarder was not sealed, allowing moisture to enter into the crawlspace.

Solutions to Issues

Several of the issues could have been mitigated through compliance with the energy code.

Duct Sealing. The IECC requires that all ducts be sealed. The 2012 IECC requires that no framed cavities be used as a duct system. DEQ recommended that the current return duct system be sealed and that the cardboard return duct be replaced with metal ducting and all seams and gaps be sealed. Sealing the duct system would have prevented moisture from entering the system and also prevented the pressurization of the house with moisture-laden air.

Air Sealing. The IECC requires that all penetrations in the building envelope be caulked, gasketed, or otherwise sealed to prevent infiltration and exfiltration. The energy code also requires that recessed can lights be air tight and Insulated Contact-rated, with the gap between the sheetrock and the can light sealed. DEQ recommended sealing all penetrations in the building envelope and installing recessed light inserts that would reduce air flow through the existing fixtures.

Rim Joists. The energy code requires that the rim joists be sealed and insulated. DEQ recommended that all wet rim joist insulation be removed and that the rim area be allowed to dry.

Any stained areas were recommended to be cleaned and allowed to dry. It was also recommended that the rim joists should be insulated with spray foam or insulated with techniques shown in the DEQ Montana Energy Savers Guidebook, which includes sealed-in-place foam board insulation.

Crawlspace Vapor Retarder. Energy codes require that the floor of the crawlspace be covered by a Class I vapor retarder (0.1 Perm or less) and that the vapor retarder be sealed to the crawlspace wall and any penetrations. DEQ recommended repairing or replacing the vapor retarder with one that was sealed to footing or foundation wall and with all seams sealed, including sealing around any obstruction in the crawlspace. In addition it was recommended that the IRC be followed for providing conditioned air to the crawlspace at a rate of 1 cfm per 50 sq. ft of crawlspace.

References

Paul Tschida, Program Specialist. Montana Department of Environmental Quality. Helena, MT.

Case Study 2

Potential for Mold and Mildew, Odors, Allergic Symptoms, and Respiratory Discomfort for Occupants

Issue Statement

Oversizing air conditioning systems in hot-humid climates can lead to mold and mildew growth, unpleasant odors, allergic symptoms, and respiratory discomfort for the occupants in the house.

Description

There are several misconceptions concerning sizing air conditioning systems for warm-hot humid climates. Oversizing cooling systems is a common practice that can lead to higher humidity rates inside a home. When it is hot and humid outside, the air entering the building is cooled. But unless the moisture in the air is removed, the indoor relative humidity increases—making a home feel damp and uncomfortable. Air conditioners remove some moisture from the air (latent load), but in order to remove a significant amount of moisture the air conditioner must run long enough for the water that condenses on the coil to run off the coil and down the condensate drain.

Warm air can hold more water vapor than cool air—so as hot air is cooled, the humidity of the air increases if the cooling process doesn't allow for dehumidification. Air must be blown across the cooling coil in the air handler for an extended period of time in order for the hot-humid air to be cooled and dehumidified. Oversized air conditioning systems will satisfy the temperature that the thermostat is set at (sensible load) fairly quickly and then shut the system off, not running long enough to allow for dehumidification. The compressor in the air conditioning system should run for at least 13 minutes to start the humidification process. Most compressors run for less than 10 minutes because they are oversized and this can lead to systems cycling on and off and the cooled air feeling damp. Typically, most people feel comfortable when the air temperature is between 68—76°F and the humidity levels are between 40—50 percent relative humidity.

Increased humidity levels can lead to the growth of bacteria, viruses, fungi, and mites. Higher humidity levels can also lead to rhinitis and asthma. Oversized cooling systems can also lead to premature compressor failure due to increased cycling on and off. It will also increase the first cost of installing the system because an oversized system will require larger ducts to properly distribute the cooled air in addition to a larger outside condensing unit and air distribution fan. The system will also be more costly to operate.

Solutions to Issues

Oversizing of air conditioning systems can lead to increased levels of humidity in hot and humid climates, but can be solved through compliance with the energy code. The IECC requires that residential heating and cooling loads be calculated in accordance with the Air Conditioning Contractors of America (ACCA) Manual J. In addition, once the load calculations are complete the IECC requires that ACCA Manual S be used to size the heating and cooling system. This process helps the HVAC contractor ensure that the system that is selected will have enough capacity to handle the sensible load of the house and also the latent load. The overall result will be an air conditioning system that is sized properly and that will run for longer periods of time to satisfy the loads but will be less expensive to install and operate over the life of the system.

References

Proctor, John. January, 2005. *Smart and Cool - The Art of Air Conditioning: Common misconceptions can contribute to a home environment that is too cold, too hot, or too humid*. Home Energy.

Akers, Dwayne. October 2004. *Air Conditioning for Humid Climates.* Journal of Light Construction

International Code Council, Inc. May 2011. *2012 International Energy Conservation Code.*

Case Study 3

Damage from Ice Dams on Residential Buildings

Issue Statement

Ice dams can cost homeowners several thousand dollars in repair costs due to water intrusion into building assemblies. The time to prevent ice dams is when the house is being built and through compliance with energy and other building codes.

Description

A news report from Hermantown, Minn. discussed a homeowner's issue with an ice dam on a residence that occurred after they received 6-8 inches of snow and then temperatures of 35—40^{o}F. The homeowner cited the cause of the ice dam as heat inside the house. Another story reported by CBS Minnesota cited ice damming issues in Minneapolis that caused water to seep into homeowner's kitchen. The ice dam caused damage to the exterior wall and roof in addition to causing water to seep into the kitchen cabinets. The homeowner hired a contractor to remove the ice and sweep roof, which was viewed as a short term solution. The overall estimate of damage was $300, which is significantly less than the average homeowner's insurance claim for water damage and freezing—which was $5,896 in 2007, according to the Insurance Information Institute.

Ice dams occur when the outside temperature is below freezing, the roof deck temperature is above freezing, and there is snow on the roof. The heat from the roof deck causes the snow in contact with the roof deck to melt and the water runs down the roof to the cold edge of the roof where it freezes. Over time the ice builds up and forms a dam, causing water to build up behind it. The pooling water can then seep back under the roofing material and into building assemblies, e.g. attics and exterior walls. Ice dams can also cause a build-up of icicles than can be potentially dangerous.
Ice dams are caused when heat from the attic melts the snow on top of the roof deck. The heat can come from a variety of different sources:

1. Warm moist air that leaks into the attic through penetrations in the ceiling assembly.

2. Heat moving through poorly insulated ceiling assemblies which typically occur at the exterior of the wall near the eaves of the roof.
3. Heat given off by heating ductwork located in the attic between the insulation and the roof deck that is either poorly insulated or not insulated—note that heat also comes from the air leaks in the duct system that is installed in the attic.
4. Inadequate attic ventilation that doesn't remove the heat generated from the items listed above out of the attic.

Ice dams have been addressed using approaches that don't adequately address the issues raised above. Section R905.2.7.1 of the 2012 International Residential Code (IRC) requires that an ice barrier be installed in the perimeter of roof systems to protect against moisture intrusion due to ice damming. In some areas of the country, heating cables are installed on the perimeter of the roof system to prevent ice from forming. Eliminating the problem during the construction phase is the best soulution.

Solutions to Issues

There are several provisions within the International Energy Conservation Code (IECC) than can be used to reduce the occurrence of ice damming and that address the issues raised above.

Air Leakage Requirements. The IECC requires that the building envelope be sealed. This includes the requirement for sealing all penetrations in the roof/ceiling assembly and conducting and air leakage test. Recessed lighting installed in the building envelope, e.g. the ceiling, are required to be rated for contact with insulation (IC rated) and also have a maximum air leakage rate (air tight) to reduce infiltration. The code also requires that the can light be sealed to the drywall. Penetrations in the top plate of all wall systems are also required to be sealed to reduce leakage.

Ceiling Insulation. For cold climates the IECC requires high levels of ceiling insulation to reduce conductive heat loss through the roof/ceiling assembly. The code also allows a slight reduction in overall ceiling insulation if the insulation can be installed full height over the exterior wall plate line, using either an energy truss or raised heel truss system. This will reduce heat loss at or near the exterior wall plate line where ice damming occurs. The code also requires eave baffles to direct ventilation air up and over air-permeable insulation (i.e. blown insulation) installed in the attic.

Duct Work. The IECC requires that ducts be sealed to a maximum leakage rate that will reduce the quantity of warm air that can leak into an attic assembly. The code also encourages all duct work to be installed in conditioned space by eliminating the requirement for duct leakage testing but still requires that ducts be sealed with an approved sealing device. Ducts are required to be insulated to an R-8 for ducts that are located in a vented attic assembly which will reduce conductive heat gain into the attic. In addition, Chapter 16 of the IRC requires that supply and return duct work be designed to comply with ACCA Manual D. Proper sizing of supply and return duct work will help mitigate positively pressurized rooms that could result in pushing warm moist air up into the attic through penetrations in the ceiling assembly.

Resources

Insurance Information Institute. With Another Round of Ice, Snow and Wind Blanketing Much of the Country, the I.I.I. Offers Insurance Coverage and Claims Filing Information. NEW YORK, February 3, 2011.
http://www.iii.org/press_releases/with-another-round-of-ice-snow-and-wind-blanketing-much-of-the-country-the-iii-offers-insurance-coverage-and-claims-filing-information.html.

Northlands NewsCenter. March 20, 2013
http://www.northlandsnewscenter.com/news/local/199260441.html

CBS Minnestoa. *Homeowners Beware: Ice Dams Could Cost You. Rachel Slavik, WCCO-TV.* December 23, 2010.
http://minnesota.cbslocal.com/2010/12/23/homeowners-beware-ice-dams-could-cost-you/.

Building Science Corporation. *Building Science Insights. BSI-046: Dam Ice Dam.* Joseph Lstiburek Created: 2011/02/08.
http://www.buildingscience.com/documents/insights/bsi-046-dam-ice-dam/?searchterm=ice%20dams.

International Code Council, Inc. May, 2011. *2012 International Residential Code.*

International Code Council, Inc. May, 2011. *2012 International Energy Conservation Code.*

Case Study 4

Poorly Designed and Leaky Duct Systems Cause Issues with Residential Buildings

Issue Statement

Poorly designed and sealed residential heating and cooling duct systems have caused poor indoor air quality, backdrafting of combustion appliances, and degradation of the building envelope.

Description

Improper HVAC duct design for residential buildings—and supply and return duct leaks—can cause indoor air quality issues, force moisture into framed cavities, and increase energy use in the building. Spaces or ducts will always seek to be at neutral pressure so a positively pressurized space will want to push air out where as a negatively pressurized space will want to suck air in. Return air ducts that leak will try and pull in air and any contaminants that are in the air into the air stream where it will be distributed throughout the house. Using framed cavities for return air systems will negatively pressurize the cavity and will draw air through any cracks to try to alleviate the pressure difference. The return system will suck on the walls any contaminants that might be in the walls, and redistribute them to the living space. By negatively pressuring the walls in a hot-humid climate, warm-humid air could be drawn into the walls from the exterior, and condensation is likely to occur on the cooler air-conditioned surfaces.

Leaky supply ducts can also cause the house to go into negative pressure as the return duct system tries to find enough air to return back to the furnace. Rooms that are provided with supply air but are not provided a path for the air to get back to the return air for the furnace can become positively pressurized. If there is a moisture source in the room, e.g. a master bedroom suite with a shower, the pressure can push the moisture-laden air into unvented cavities in the building as the room attempts to reach a neutral pressure, which can condense on colder surfaces during colder months.

The examples that follow demonstrate the importance of sealing up supply and return ductwork.

From Home Energy Magazine

A new home had an induced-draft furnace on a 4-inch vent. The furnace was made for either a bottom return or a sidewall return. The furnace installer had neglected to fasten and seal the bottom plate of the furnace under the circulating blower when the furnace was installed, resulting in a leak in the return air system. The leaky return depressurized the basement to over 9 Pascals (Pa), when the furnace was operating causing a complete flow reversal in the common furnace and water heater vent. The family that purchased the house began having respiratory problems as soon as they moved into their new home. This was potentially caused by nitrogen dioxide from the water heater and dust off the basement floor that was being pulled into the return air leak. After several attempts to identify and fix the problem by HVAC contractors, an energy auditor found the return air leak. Sealing the return leak stopped the contaminants and dust from entering the air stream and resolved the backdrafting issue.

As another example, the owners of a home complained that the pilot on their water heater continually went out. The furnace was a direct-vent, sealed-combustion furnace and the water heater was a natural-draft unit with a separate vent pipe. When the furnace blower operated, the basement was depressurized to 8 Pa and the water heater backdrafted. The negative pressure was caused by extremely leaky return ductwork located in the basement, inadequate return ductwork for the house, and closed off supply registers in the basement. Once the issues were addressed, the basement depressurization was 3 Pa and the water heater vented adequately.

Solutions to Issues

Complying with the energy code and with Chapter 16 of the International Residential Code (IRC) will solve many of the issues that arise with poorly designed and installed duct systems. The IECC requires that an ACCA Manual J heating and cooling load calculation be performed on all residential buildings. The IECC also requires that Manual S be complied with to ensure that the heating and cooling equipment proposed for the house is properly selected. Chapter 16 of the IRC then requires that the duct system be designed to ACCA Manual D to ensure that there is a proper amount of supply air to each space and that there is a path provided for the air to return back to the air handler so that rooms will be at neutral pressure.

The IECC also requires that ducts are sealed with an approved sealing device that complies with UL 181 for the applicable type of duct system. For example, sealing flexible air ducts and flexible air connectors must use a sealing device that complies with UL 181B and be marked “181B-FX” for pressure-sensitive tape or “181B-M” for mastic. If ducts are located in an unconditioned space they must be tested for a maximum duct leakage rate. This will ensure that supply or return ducts located in unconditioned space do not leak to the outside and cause pressurization issues inside the building. In addition, building framing cavities (e.g. studs, floor joists, and sheetrock) cannot not be used as duct material and the return air must be routed through an actual duct when passing through a framed cavity. This will reduce the potential for negatively pressurized framed cavities and pulling contaminants into the air system. In addition, the IECC requires that all HVAC air handlers meet maximum leakage requirements which will reduce air leakage into the space where the air handler is located.

Resources

Greiner, Thomas H. May/June, 1997. Carbon Monoxide Problems from New Furnaces. Home Energy Magazine Online.

International Code Council, Inc. May, 2011. 2012 International Residential Code.

International Code Council, Inc. May 2011. 2012 International Energy Conservation Code.

Info-801: What's Wrong With This Practice? Using Unsealed Wall Cavities or Panned Floor Joists as Return Plenum. January, 2011. Building Science Corporation.

About the Institute for Market Transformation (IMT)

The Institute for Market Transformation (IMT) is a Washington, DC-based nonprofit organization promoting energy efficiency, green building, and environmental protection in the United States and abroad. IMT's work addresses market failures that inhibit investment in energy efficiency and sustainability in the building sector. For more information, visit imt.org.

About Britt/Makela Group (BMG)

Britt/Makela Group, Inc. was formed in 2001 by Eric Makela and Michelle Britt to meet the growing need for independent code development, training, and analysis resources. Their complementary backgrounds encompass building energy, land use and transportation planning, and regulatory issues. BMG brings a combination of national and local experience, research and practice on best practices, new ideas, and lessons learned. BMG provides states and jurisdictions with expertise to develop the plans and programs best suited to the needs of their community. BMG is committed to fostering the changes needed so that one day energy efficiency and sustainability will be the norm. For more information, visit www.brittmakela.com.

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