SIERRA ENERGY PROFESSIONALS

Building Envelope Test – Straw Bale Construction, Nevada City CA

Presented By:
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Millette Residence

19480 Chalk Bluff Rd.
Nevada City, CA 95959

Building Envelope Test Report, October 16, 2010

Introduction:

Sierra Energy Professionals, David Arkin, Jim Seely and Eric Millette collaborated to conduct a test on the tightness of the building envelope of this residence. The system was analyzed by using a testing method known as a Blower Door. The house was shut off to the exterior and pressurized, which allowed for inefficiencies to be identified with a pressure meter, infrared camera, and a fog machine.

History:

The residence is located at 19480 Chalk Bluff Rd. Nevada City, CA and was completed about a year ago. It is a hybrid construction with wood framing used for the bathroom and straw bales for the rest of construction. The roof was constructed using Structurally Insulated Panels (SIP's). The house has aluminum framed windows, all double paned. No areas of discomfort are reported and all systems function well.

Building Envelope Testing:

Figure 1: Blower Door setup.

Depressurization: A Blower Door test **(Figure 1)** was set up on the front door, with the fan set to depressurize the interior of the house to negative 50 Pascals(Pa) relative to the exterior. This approximates a 20 mph wind hitting the house on all sides and causes air to infiltrate from the exterior to the interior living space.

When the house pressure was at a 50 Pa difference relative to the exterior, the flow of air infiltrating from outside into the building envelope was measured to be **617 cubic feet per minute (CFM)**. This is the **equivalent of an 81 square inch (less than 1 square foot)** window being open on a flat wall all the time. This is a very low number and no improvements are seen as necessary in this area. The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) suggest a minimum natural ventilation of 950 – 1,200 CFM for a house of this size. This house is tighter than ASHRAE suggests without mechanical ventilation but occupant knowledge and behavior surpasses any need for that.

Building Envelope Infrared Inspection

Figures 2 – 28 show air and thermal infiltration. Infrared images will be on the left and visual images on the right. Green and blue represent cooler temperatures while orange/red/yellow/white represent the temperature getting hotter. From the exterior the lighter colors represent heated air from the interior escaping. From the interior darker/bluer colors represent cold air infiltrating from the exterior.

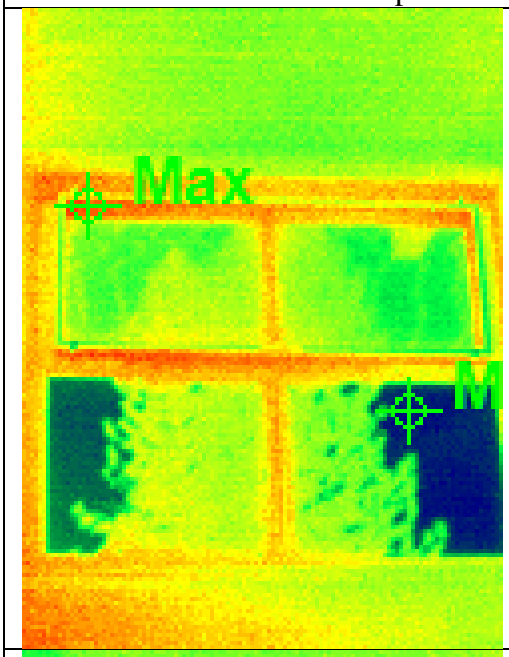

Figure 2a: Infrared Image Windows on south side of house above sliding glass door from exterior. Only thermal movement is from bridging across frame. Very well sealed window.

Figure 2b: Visual Image

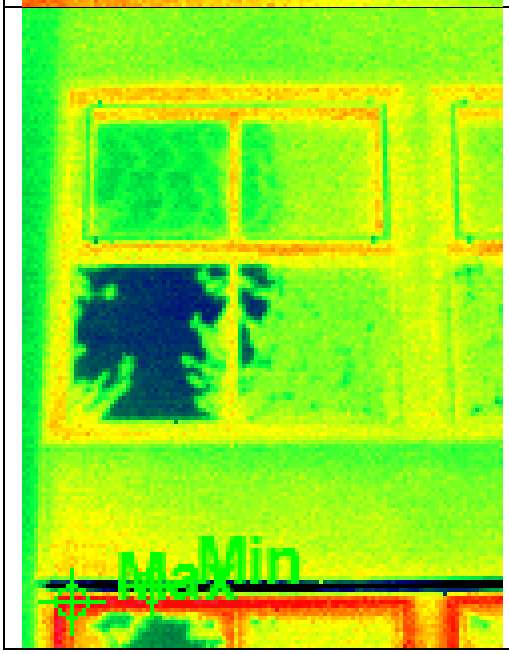

Figure 3a: Infrared Image windows to right of sliding glass door. No air leakage.

Figure 3b: Visual Image

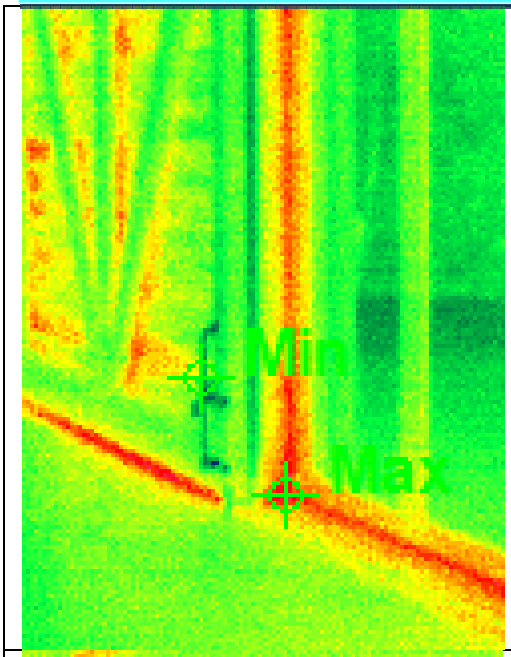

Figure 4a: Infrared Image sliding glass door. Minor air movement around edges especially left side. Other thermal movement due to radiant heat.

Figure 4b: Visual Image

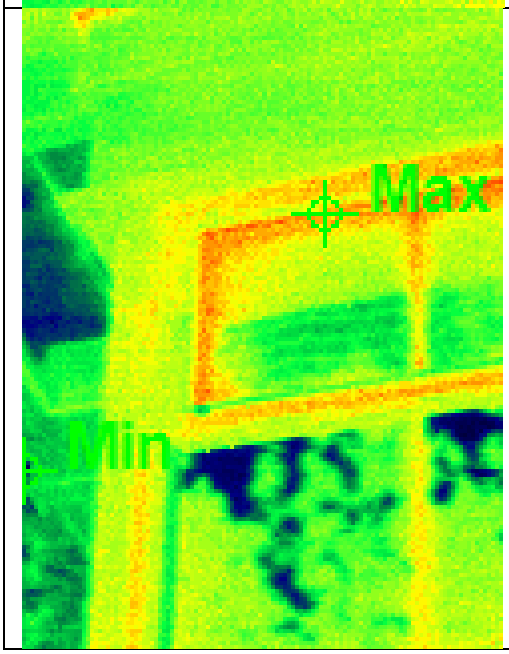

Figure 5a: Infrared Image exterior corner of "bed nook". Looks very good basically no leakage

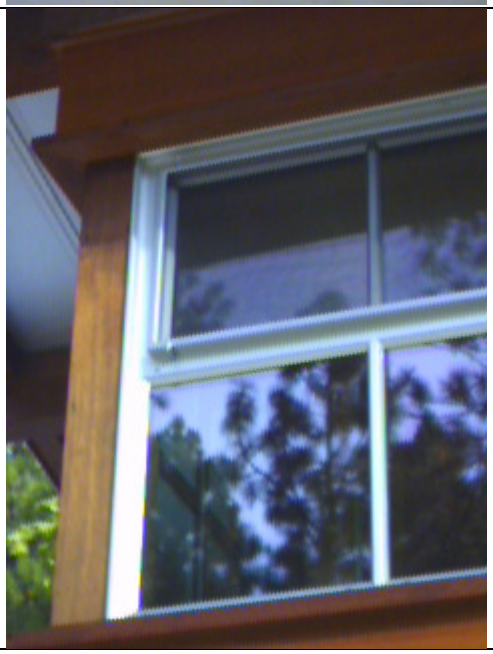

Figure 5b: Visual Image

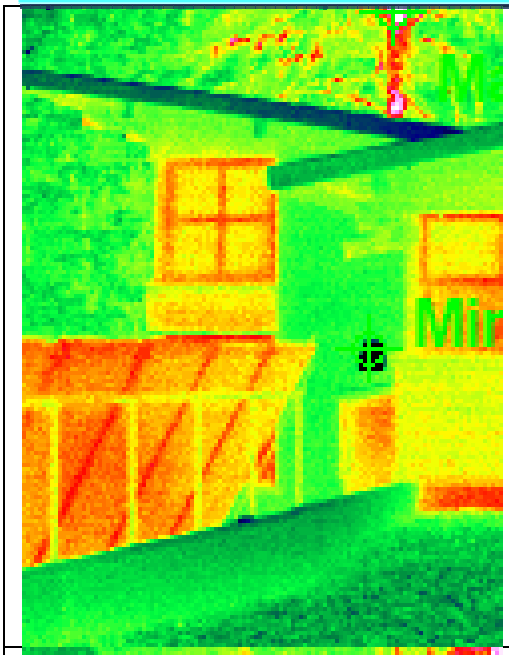

Figure 6a: Infrared Image exterior of house looks very good. Possible leakage or bridging in bottom right from foundation connection of bathroom.

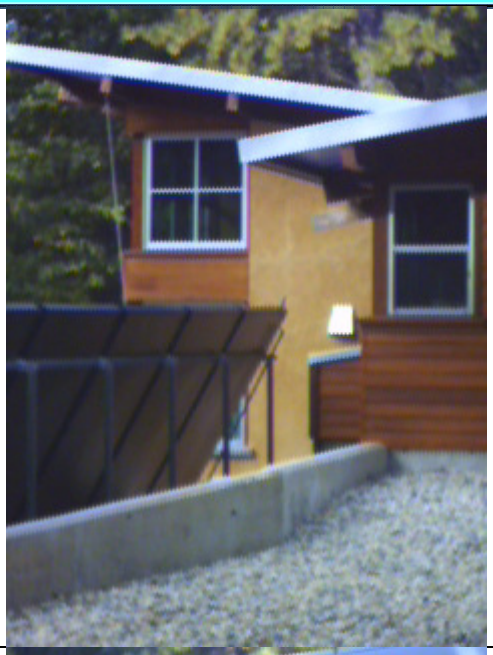

Figure 6b: Visual Image

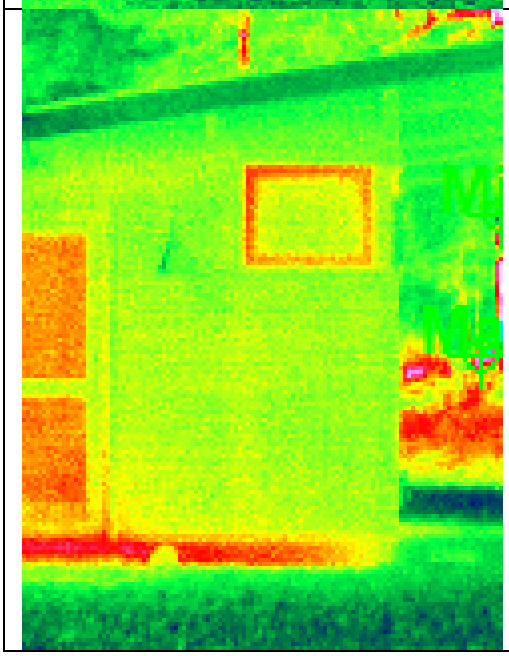

Figure 7a: Infrared Image bathroom no air leakage just bridging from foundation.

Figure 7b: Visual Image

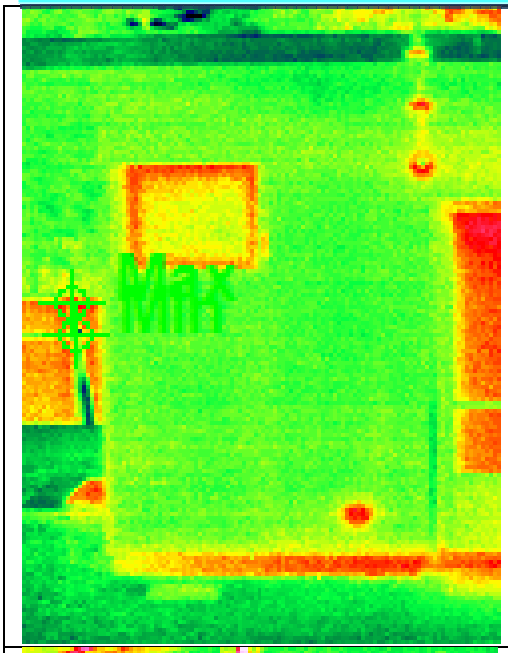

Figure 8a: Infrared Image front door. Possibly some leakage from penetration to upper left of door. Everything else good.

Figure 8b: Visual Image

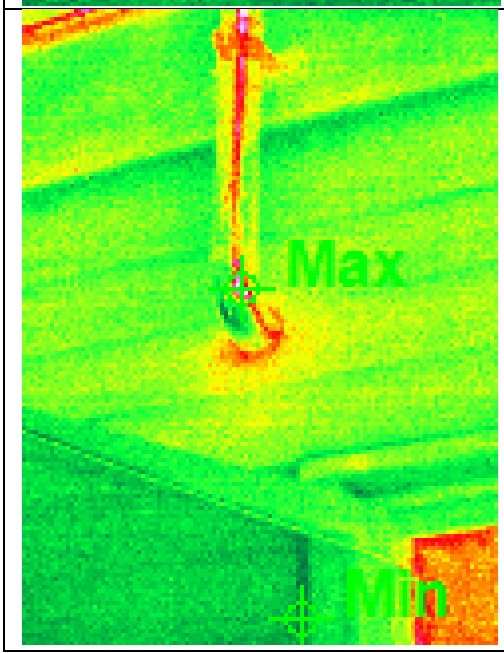

Figure 9a: Infrared Image pipe penetration above front door. Probably residual heat from venting, could be minor infiltration issue.

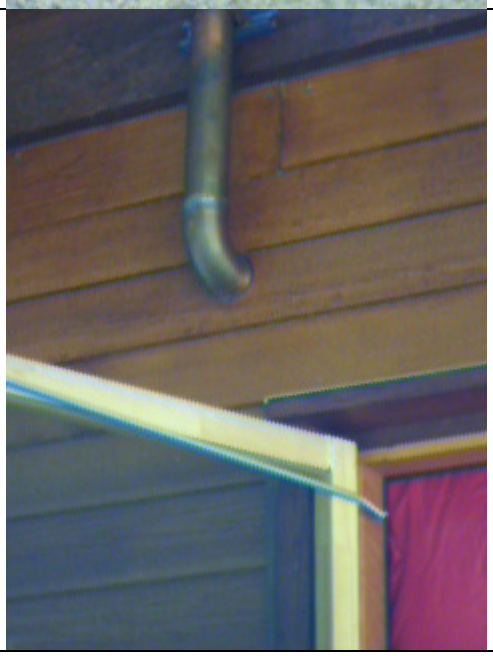

Figure 9b: Visual Image

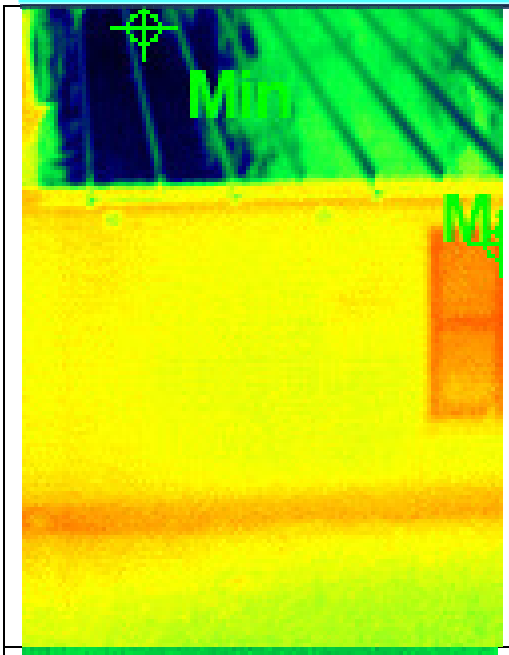

Figure 10a: Infrared Image north wall looks good. Note lack of bridging at foundation.

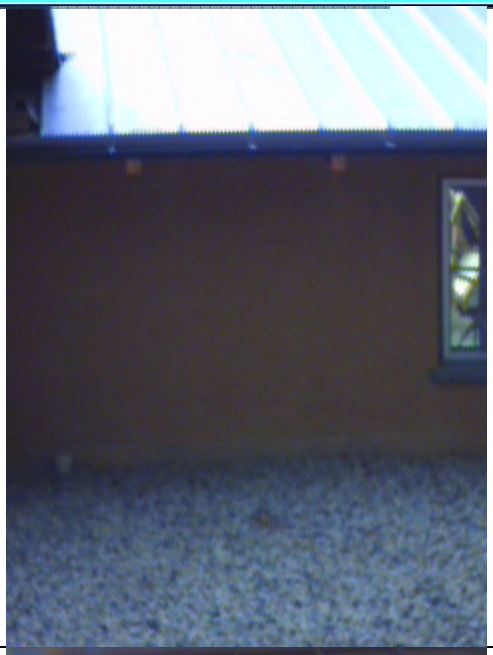

Figure 10b: Visual Image

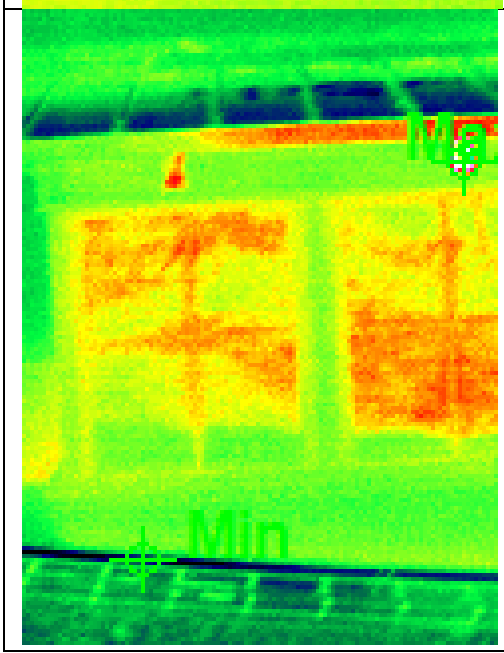

Figure 11a: Infrared Image west side of house. Red up higher is heat gain from the sun.

Figure 11b: Visual Image

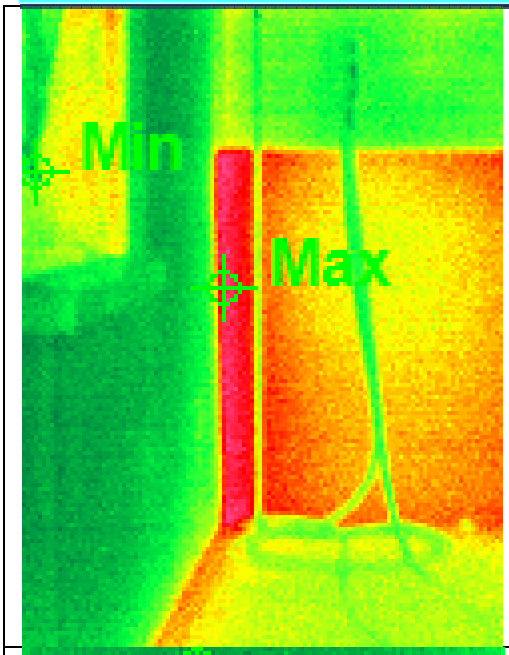

Figure 12a: Hot water distribution visible in wall behind hot water solar panels. Mechanical room on other side pumps hot water down that corner.

Figure 12b: Visual Image

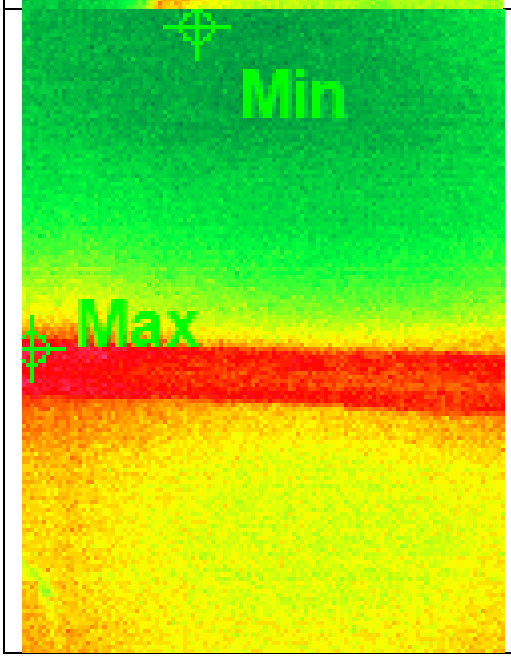

Figure 13a: Infrared Image heat escaping through the foundation slab. Even though it is insulated from the hydronic section it still provides a thermal bridge to the exterior.

Figure 13b: Visual Image

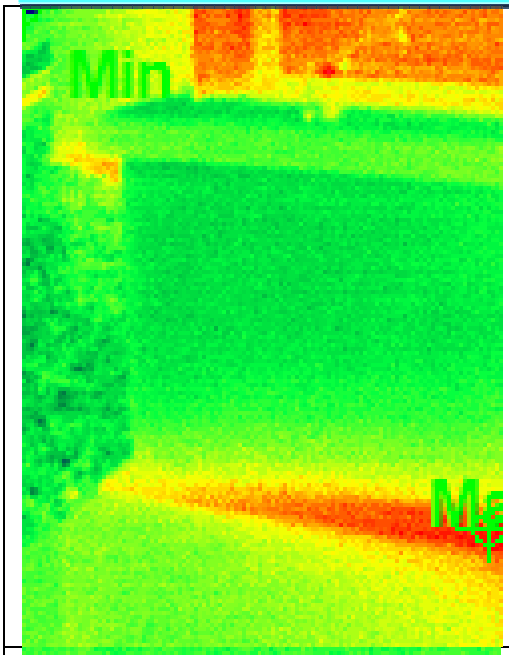

Figure 14a: Infrared Image of corner by "bed nook". Note foundation bridging.

Figure 14b: Visual Image

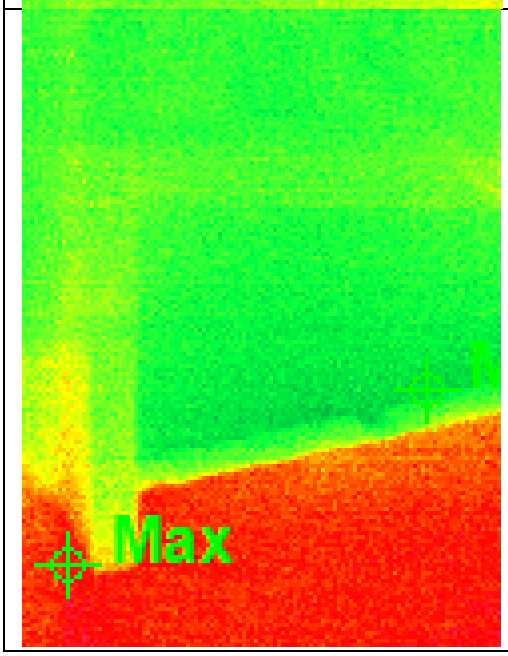

Figure 15a: Interior floor edge by refrigerator. No bridging from floor to exterior foundation visible, but not exposed on exterior like other areas.

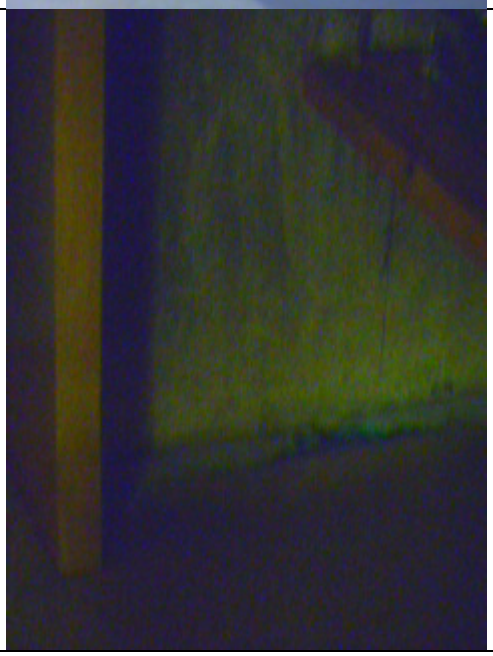

Figure 15b: Visual Image

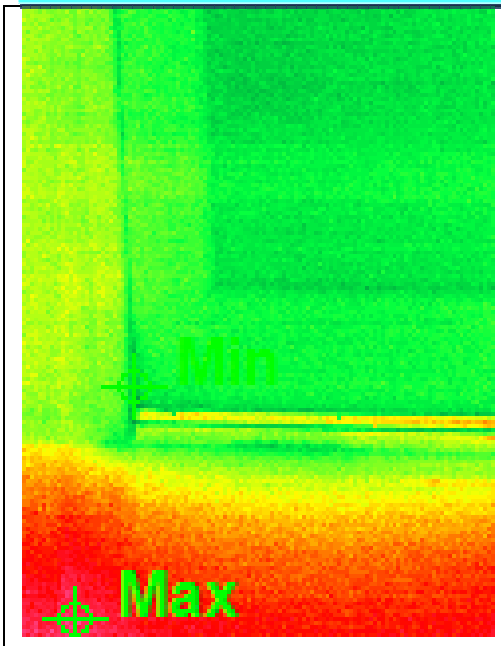

Figure 16a: Infrared Image door from bathroom to exterior before Blower Door test.

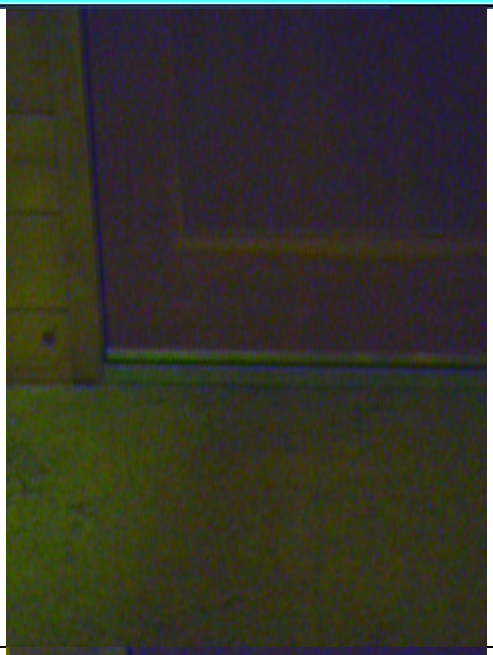

Figure 16b: Visual Image

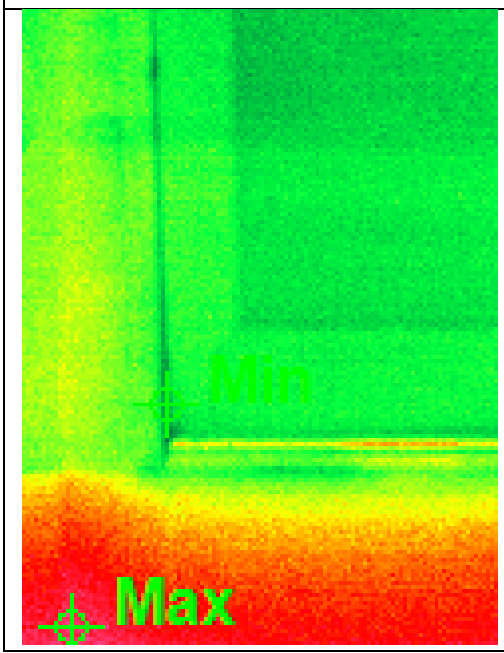

Figure 17a: Infrared Image bathroom door at very start of Blower Door test.

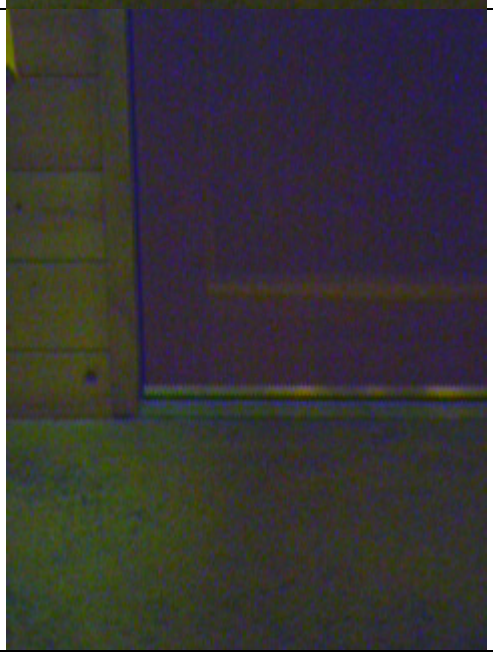

Figure 17b: Visual Image

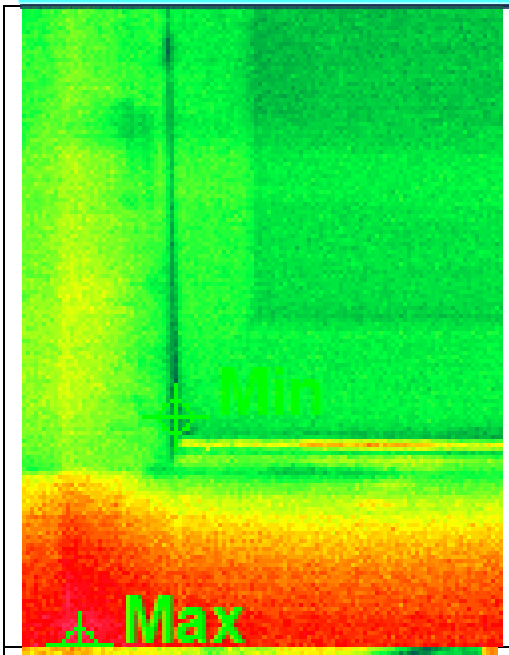

Figure 18a: Infrared Image bathroom door after 5 minutes of Blower Door testing. Note very slight growth of blue line on left side of door, this is a well sealed door.

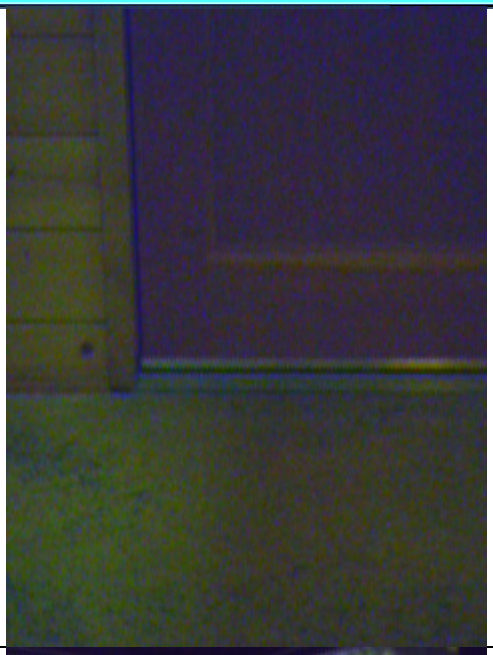

Figure 18b: Visual Image

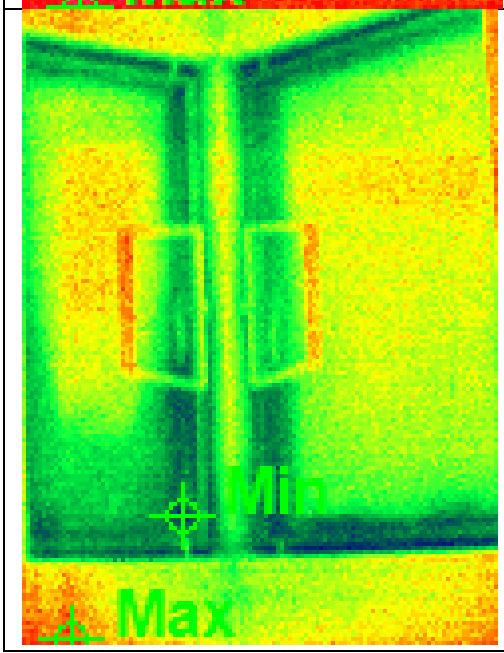

Figure 19a: Infrared Image entryway windows no apparent leakage just thermal bridging.

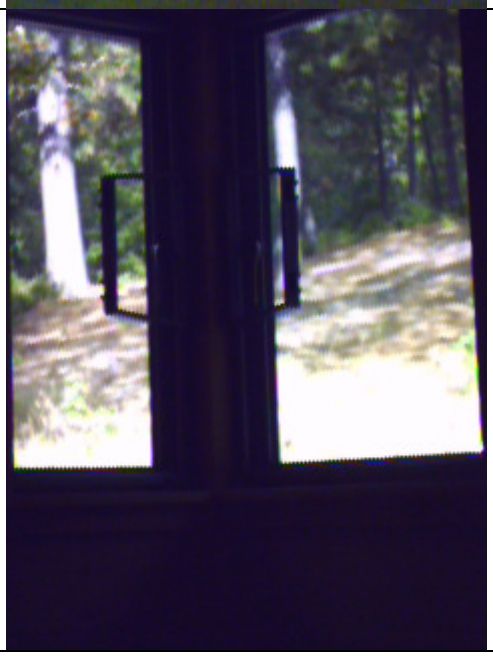

Figure 19b: Visual Image

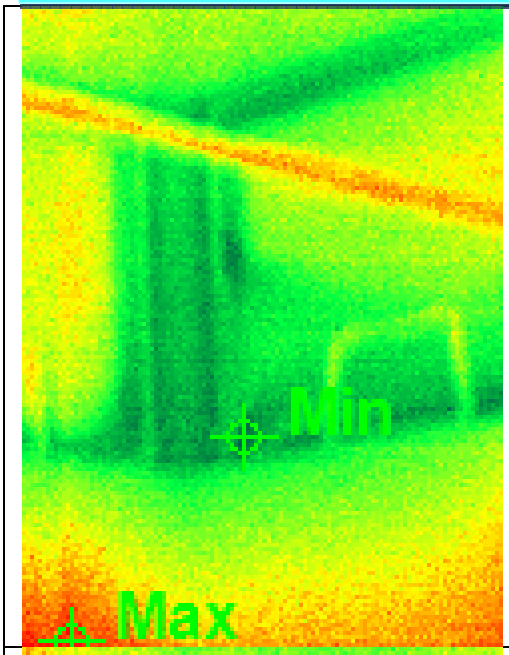

Figure 20a: Infrared Image bathroom windows. Look good no infiltration.

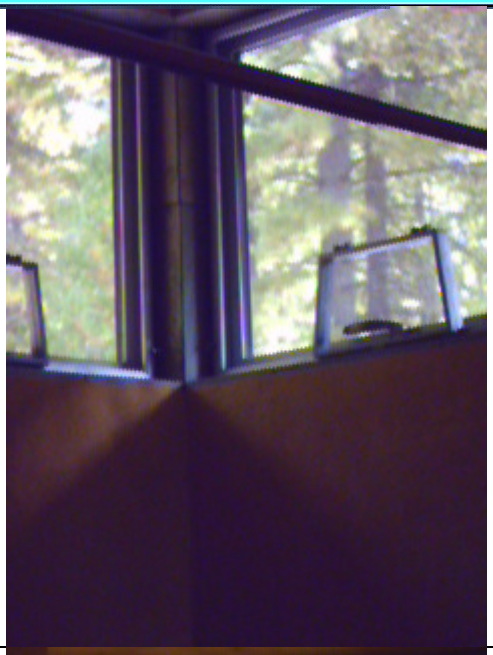

Figure 20b: Visual Image

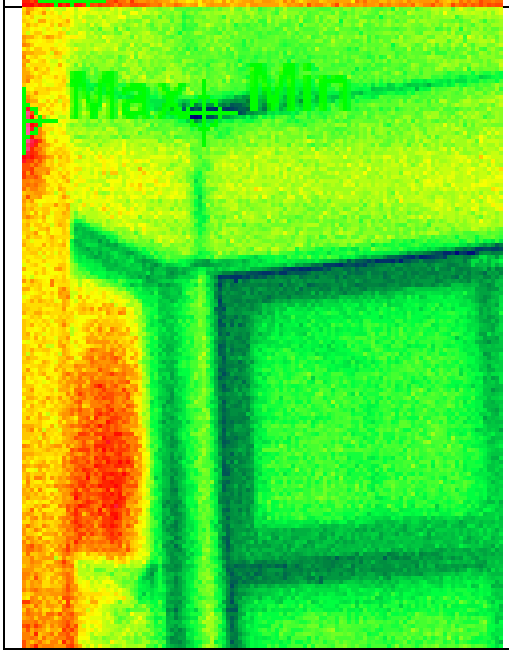

Figure 21a: Infrared Image loft windows. Note area of infiltration in top left corner. A gap was seen on close visual inspection.

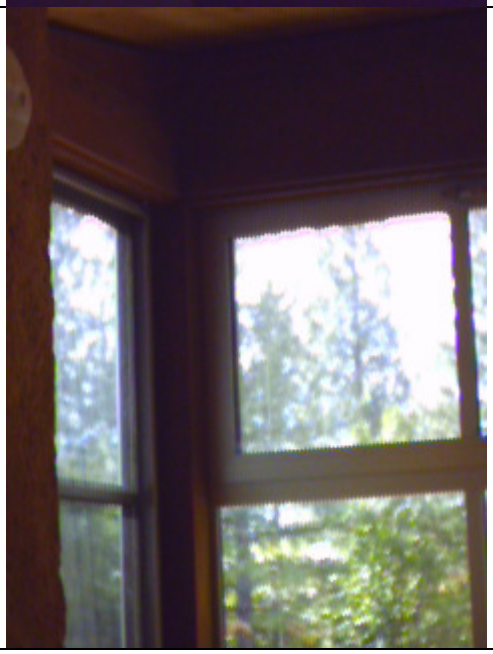

Figure 21b: Visual Image

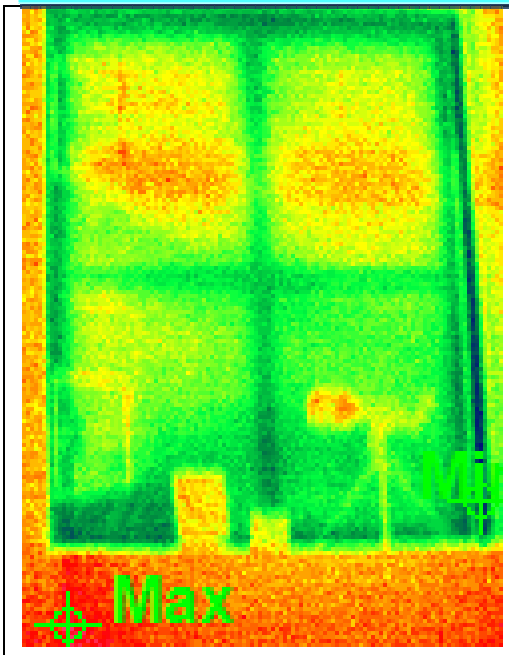

Figure 22a: Infrared Image living room window. All thermal bridging transfer.

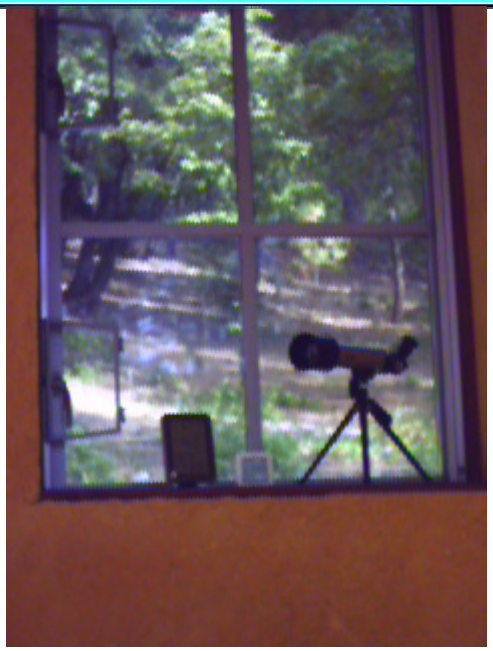

Figure 22b: Visual Image

Figure 23a: Infrared Image upper corner living room windows. Heat is due to sun warming. Note a bit of infiltration in upper corner at wall/ceiling interface.

Figure 23b: Visual Image

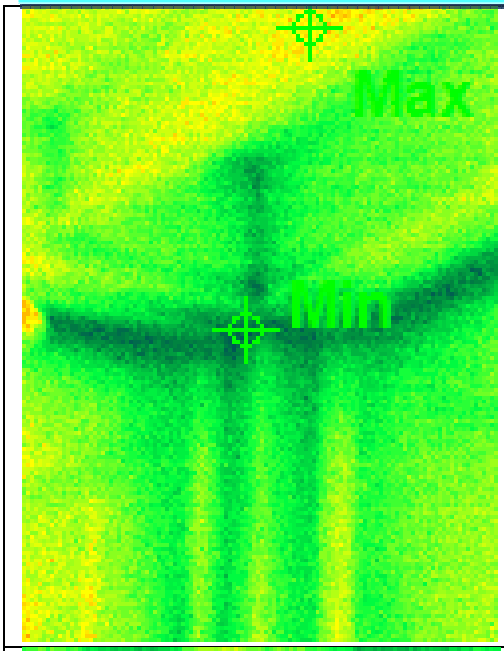

Figure 24a: Infrared Image upper corner kitchen windows. Possibly some leakage along joints and up into corner.

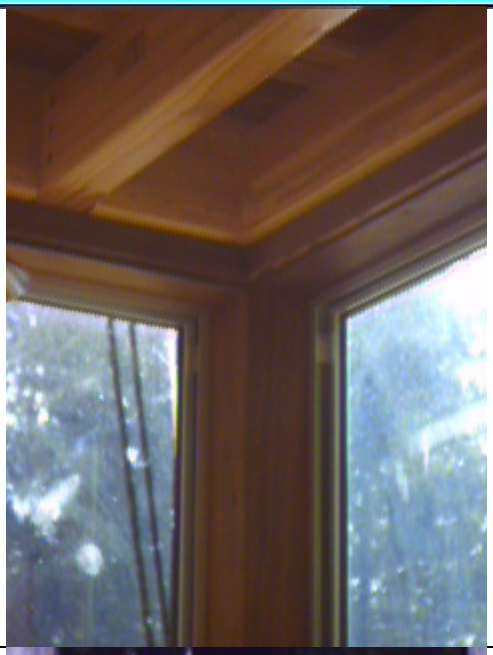

Figure 24b: Visual Image

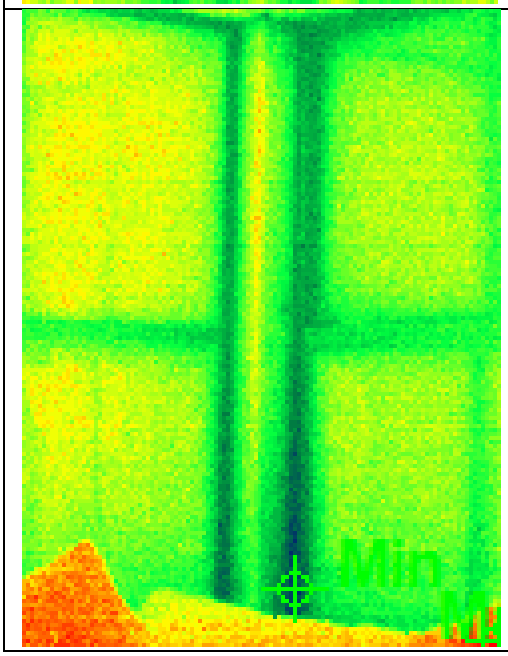

Figure 25a: Infrared Image "bed nook" windows. Look good.

Figure 25b: Visual Image

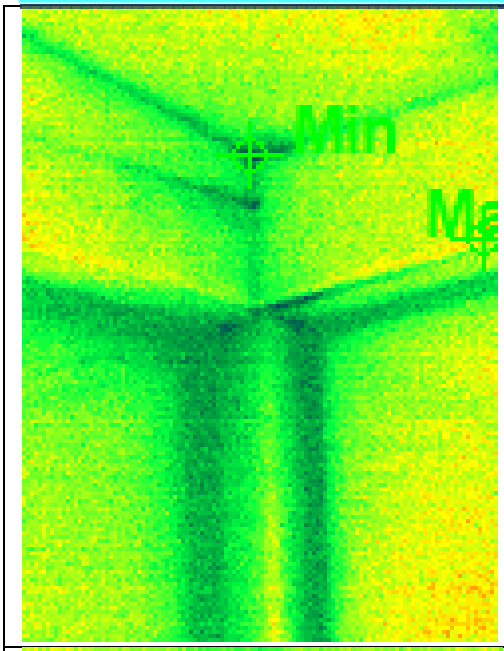

Figure 26a: Infrared Image "bed nook windows". Corner might show some infiltration.

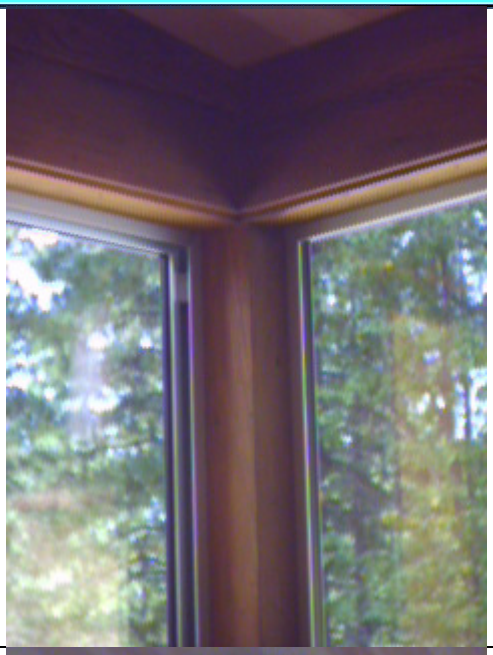

Figure 26b: Visual Image

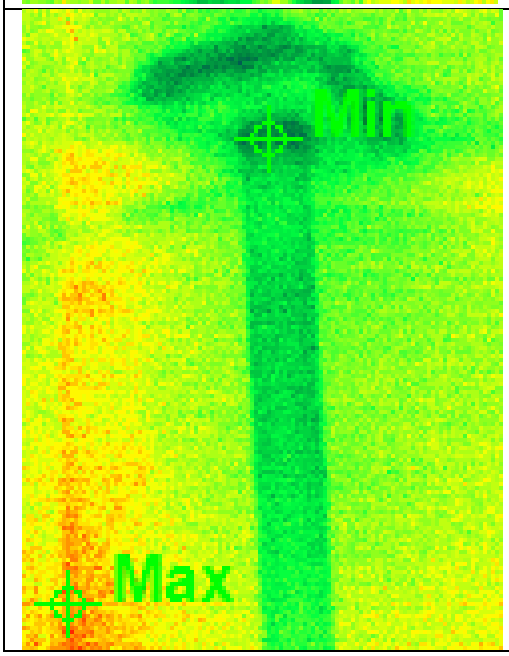

Figure 27a: Infrared Image well sealed chimney flashing some radiative transfer.

Figure 27b: Visual Image

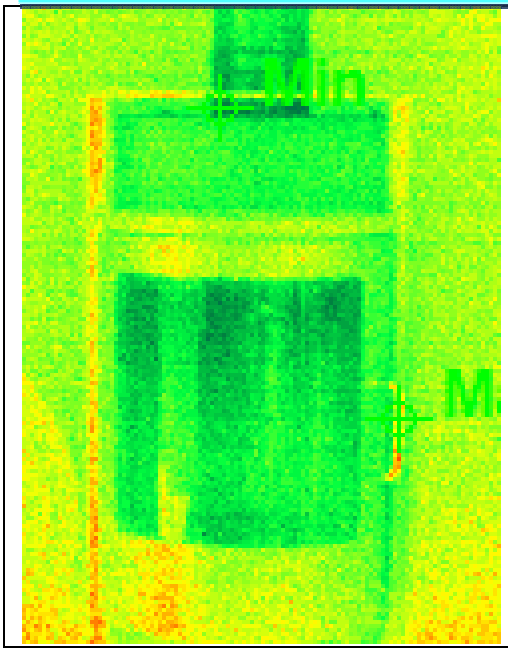

Figure 28a: Wood burning stove. Leakage from flue is basically unavoidable, good shielding at chimney helps.

Figure 28b: Visual Image

Figure 29: Very minor infiltration of fog in bottom right corner of right window during house depressurization.

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Figure 30: Visual illustration of fog entering through small leakage area of sliding glass door during house depressurization.