The Business

- new, innovative venture that aims to reduce the energy use and greenhouse gas emissions of Australian dwellings using the latest air leakage analysis and thermal imaging technologies.
- These technologies are unique within the Australian energy auditing sector and allow us to collect valuable data on the energy efficiency of Australian construction.
- 40-50% of household energy use in Canberra is for heating/cooling.
- Air sealing and properly insulating can reduce heating/cooling costs by 50%.
- Most cost-effective energy efficiency measures: simple and cheap to fix once you've located the problem spots.
- Potential to reduce annual CO_2 emissions by 3-6 tonnes per Canberra household.

The Gap

According to the Australian Government Department of the Environment, Water, Heritage and the Arts (in the 4th Edition of *Your Home: Design for Lifestyle and the Future, Technical Manual*, published in 2008):

Overseas standards and research recognise that the weather proofing or draught sealing of houses is the most effective method of achieving direct energy savings, whilst maintaining indoor air quality. It is estimated that Australian buildings leak 2-4 times as much air as North American or European buildings, suggesting a tremendous opportunity for energy savings in Australia.

In Australia, households produce around 20 per cent of our total annual greenhouse gas emissions, of which heating and air-conditioning account for around 38 per cent. Draughts can account for up to 25% of heat loss from a home.

According to the Mobile Architecture and Built Environment Laboratory there are currently no scientific programs on air leakage performance for Australian residential construction and the challenge is to identify where weather sealing can be improved and to develop appropriate methods of construction, repair and detailing.

Energy Imaging hopes to fill this research 'gap' with their pilot energy efficiency study: *Plugging the Gaps in Canberra Homes*. The study aims to assess the effectiveness of sealing air leaks and filling insulation gaps – detected using our technologies – in terms of: air leakage reduction; energy use; cost; greenhouse gas abatement; and resident comfort levels.

The Directors

Long term Canberra residents, Jenny Edwards and Andrew Cleary, both have strong scientific backgrounds and a keen interest in energy efficiency and the environment. Their tertiary training and experience encompasses the fields of: science, communication, environmental health, IT, business management and building thermal performance assessment.

Air Leakage & Insulation Assessment

Background

Overseas research shows, and standards recognise, that air leakage control is the most effective method of achieving direct energy savings. The Australian Government's *Your Home: Technical Manual* (2008) estimates that Australian buildings leak 2-4 times as much air as North American or European buildings, suggesting a tremendous opportunity for energy savings in Australia.[1] Our 2008-2009 testing program shows that Canberra houses leak 3-6 times more than North American buildings. Leakage rates in Canberra are equal to 2-4 complete air changes per hour… in winter that means 'goodbye heated air' (energy and money) every 15-30 minutes!

- Air leakage can account for 30% or more of a building's heating and cooling costs.[2]
- 40-50% of the energy used in Canberra homes is for heating and cooling.
- Reducing infiltration can significantly cut energy bills and reduce greenhouse gas emissions.[3]
- Insulating materials, such as batt or loose fill products, do not seal against air leakage.[4]
- Uncontrolled air leakage compromises the effectiveness of other, more expensive, energy efficiency measures such new heating systems, window dressing and double glazing.
- Starting with the simple and cost effective approach of air sealing will have the greatest impact on your energy use… and the least impact on your wallet!

Don't get us wrong — insulation is *very* important. We believe improving your building envelope by air-sealing and insulating, *together*, is the most effective thing you can do to reduce your energy use. Installing insulation, *without air sealing*, just doesn't make sense and isn't good practice.

Air leakage, ventilation & indoor air quality

Air leakage is the uncontrolled movement of air into and out of a building (infiltration), which is not for the specific and planned purpose of exhausting stale air or bringing in fresh air (ventilation).

Controlled ventilation is the key for energy efficiency, indoor air quality and building durability. It is achieved by: physically opening windows, doors or other sealable air vents; switching on specially positioned exhaust fans; or using larger and more complex mechanical ventilation systems (standard practice in modern homes in the cold climates of Europe and North America). Random infiltration, or air leakage, should not be considered acceptable natural ventilation because it is not controlled or filtered.

Causes of air leakage

Air moves from areas of higher pressure to areas of lower pressure (air pressure is measured in units called Pascals, Pa). There are three main forces that drive air leakage:

1. wind — exerts constantly-changing pressures on buildings (high on the windward side and low on the leeward, roughly 150-1500 Pa differences).
2. the stack effect — rising warm air causes pressure differences within buildings (lower pressures at the top, higher pressures near the floor, around 5-10 Pa differences).
3. mechanical heating and ventilation systems — create pressure differences within buildings as they heat, cool and move air (5-10 Pa differences).

Any one of these driving forces, or a combination of all three, will lead to air leakage through any cracks or gaps in the building envelope. This leads to cold external air moving into the building, and warm internal air moving out of the building.

[1] Australian Government DEWHA (2008), *Your Home: Technical Manual* www.yourhome.gov.au/technical/fs47.html
[2] US Department of Energy, Office of Building Technology apps1.eere.energy.gov/buildings/publications/pdfs/building_america/26446.pdf
[3] US Department of Energy (2005), *A Consumer's Guide to Energy Efficiency and Renewable Energy* apps1.eere.energy.gov/consumer/your_home/insulation_airsealing/index.cfm/mytopic=11240
[4] US Department of Energy (2005), *A Consumer's Guide to Energy Efficiency and Renewable Energy* apps1.eere.energy.gov/consumer/your_home/insulation_airsealing/index.cfm/mytopic=11250

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Impact of air leakage on energy use (& in relation to R values)

It does not matter how thermally resistant a building material is (low U value) or well insulated it is (high R value), if air is able to flow through gaps between building materials then energy efficiency is lost and durability compromised. It is widely accepted in Europe and North America that there is little point in improving the effective U or R (R = 1/U) value standards required for buildings unless levels of uncontrolled air leakage are significantly reduced. For example in the UK, the significant energy loss caused by uncontrolled air leakage has been recognised within amendments to their Building Regulations of 2006. These amendments introduce maximum envelope Air Leakage Standards for domestic and non domestic buildings.

Other impacts of air leakage

As well as direct energy loss, other problems associated with air leakage include:

- discomfort for residents due to drafts
- degradation of building materials due to moisture (carried by warm rising air) condensing within the building envelope, eg. in wall and ceiling cavities
- poor indoor air quality due to fumes and dust entering the building
- potential sites for ember entry during bush fires
- difficulties in balancing air conditioning and ventilating systems

Air leakage testing with a blower door & thermal camera

A blower door is a diagnostic tool designed to measure the airtightness of buildings and to help locate air leakage sites. It includes four components: a calibrated fan, an expandable door-panel system, a sensitive gauge to measure fan flow and building pressure, and tailored computer software.

The fan is sealed into an exterior doorway with the door-panel system and then used to draw air out of the building, creating a pressure difference between inside and outside. This pressure difference causes air from outside, at higher pressure, to move into the building through all the gaps in the building envelope.

The tighter the building (eg. fewer gaps and cracks), the less fan speed needed to create a change in building pressure. The pressure gauge and computer are used to regulate, and record, air flow and pressure differences.

Using a blower door, many large leaks will be detectable by simply feeling with your hands. However, the ideal technique for locating areas of air leakage is to use an infrared or thermal imaging camera in combination with the blower door. This involves performing two infrared scans from inside the building; one before turning on the blower door and one after the blower door has been depressurising the building for about 10 minutes. As long as the air being drawn in through the leaks is warmer or cooler than the interior of the house, the area surrounding the leakage path will change temperature and show up on the thermal image. Even if there is little temperature difference between inside and outside, an infrared scan can be still effective as sub-floor spaces are generally cooler, and roof spaces generally warmer, than the external air temperature. This technique allows you to find significant, and otherwise undetectable, leaks without having to enter the roof or floor space.

Thermal imaging lets you view infrared energy (basically the heat radiating from an object) which is not visible to the naked eye. The warmer an object is the more infrared energy it radiates. The thermal camera captures images of the infrared energy given off by the surfaces in your home and shows where temperatures vary by displaying different temperatures as different colours.

Checking insulation with a thermal camera

Independently of the blower door system, a thermal camera can be used to rapidly determine where insulation is missing or improperly installed. Just small gaps in insulation can reduce its effectiveness by 50%.[5] Our testing in Canberra suggests gaps in insulation totalling 5% or more are common.

[5] US Building Performance Institute (2007), *Effective R-values for Batt Insulation*
http://www.bpi.org/documents/Yellow_Sheet.pdf

Plugging the gaps in Canberra homes

– a pilot energy efficiency study

Aim of the Study

1. Assess the effectiveness of sealing air leaks and filling insulation gaps – detected using blower door and thermal imaging technology – in terms of

- air leakage reduction
- energy use
- cost
- greenhouse gas abatement
- resident comfort levels

2. Assess the energy efficiency potential of the houses using:

- second generation House Energy Rating software (FirstRate 5)
- the Green Loans Home Sustainability Assessment method

Key Steps in the Study

1. Collect data[1] on:
    - house design, construction & energy efficiency characteristics
    - key energy using appliances[2] and lighting[3],
    - historical energy usage data from energy bills, ideally over a 3 year period
2. Test using:
    - blower door (fan pressurisation method[4]) equipment to measure the air leakage rate and identify the main causes and locations of air leakage
    - thermal imaging to locate gaps/problems with insulation

    2b. Calculate the energy efficiency of the house in its initial state, and after hypothetical implementation of energy efficiency opportunities, using:
    - FirstRate 5 software assessment (house design and alteration)
    - Home Sustainability assessment (appliances and behaviour)
3. Seal air leaks using a variety of strategies*
4. Test with blower door as air sealing measures are progressively implemented
5. Physically inspect insulation to determine if more than remediation (gap filling) of existing insulation would be beneficial*
    - remediation and thermal imaging, or
    - installation of new insulation & thermal imaging
6. Compare winter 2009 energy use and resident comfort levels with previous years. Calculate the effectiveness (cost and greenhouse gas abatement) of the air sealing and insulation measures used and compare with the hypothetical energy efficiency opportunities identified by the FirstRate 5 software and the Home Sustainability assessment.

[1] House plans, energy bills (and if available EER reports, HEAT energy audit reports, building inspection reports) requested
[2] water heater, heating and cooling systems, refrigerator/freezer, clothes washer, clothes dryer, dishwasher, televisions and computer equipment.
[3] type and wattage of lighting used in each room
[4] international standard test method ASTM E 779-03
* Homeowners will be provided with information outlining suggested rectification measures and costs. They will choose which air leakage or insulation improvement measures they wish to implement.

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Recommendations to the Standing Committee on Climate Change

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1. Raise awareness of the effectiveness ($, GHG & comfort) of reducing air leakage and properly installing insulation; and provide incentives for households and builders to implement air sealing measures and improve the installation of insulation.

    a. Make air leakage testing a requirement of building certification (set a maximum air leakage standard). Audit new, certified buildings for air leakage and quality of insulation.

    b. Include comprehensive draft sealing as a measure eligible for rebate under the ACT Energy Wise home audit program

2. Collect valuable data (and provide an auditing function) by pre- and post-testing public housing stock retrofitted under the 'Weathering the Change' strategy ($20 million over 10 years) to assess the effectiveness of draft sealing and the quality of insulation installation.

3. Ban the use of halogen globes in downlights and require the installation of covers to prevent air leakage and allow proper insulation.

4. Legislate the proper sealing of all ceiling penetrations such as exhaust fans and cooling and heating ducts.

5. Require EER assessors of new and existing ACT housing stock to be trained and nationally accredited in second generation software.

6. Regularly audit the EER scheme for both existing and new housing stock.

7. Centralise electronic storage of EER data to:

    a. allow analysis of the effects of legislative changes and government spending measures;

    b. provide an auditable data repository.

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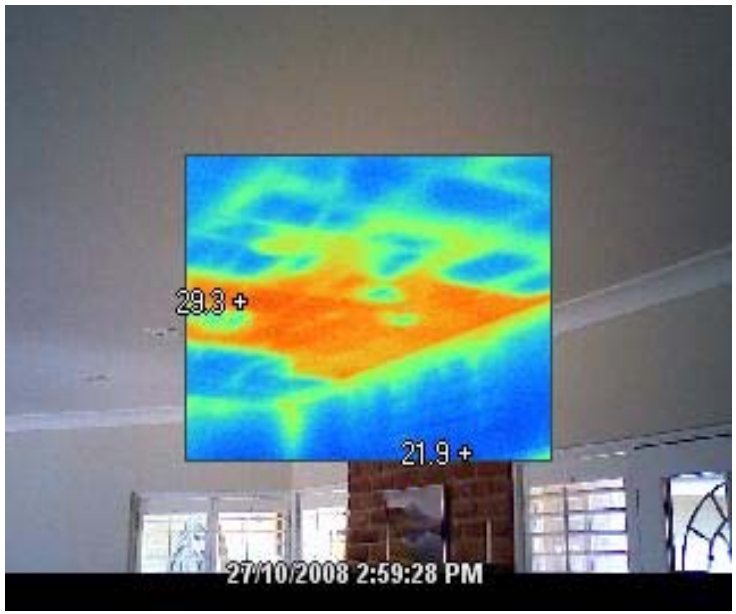

+

= wasted energy and money

= GHG emissions

= low cost way to improve energy-efficiency

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- Aim to cost-effectively reduce GHG emissions in domestic and small commercial buildings

Buildings present single largest opportunity for GHG abatement (4th IPCC)

- We measure and locate energy losses via the building envelope using technology unique to the Australian energy auditing sector

Your Home: Design for Lifestyle and the Future, DEWHA 2008

"*OS standards and research recognise that the draft sealing of houses is the most effective method of achieving direct energy savings*"

- 40-50% of energy use in ACT is heating/cooling
- Draft sealing and insulating relatively low cost
- Potential heating/cooling savings 30-50%
- Potential GHG reductions 3-6 tonnes/house/year

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What is Air Leakage?

Uncontrolled air movement, into and out of a building (infiltration), which is not for the planned purpose of exhausting stale air or bringing in fresh air (ventilation)

- Controlled ventilation is the key for energy efficiency, indoor air quality and building durability

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Testing with a Blower Door & Thermal Camera

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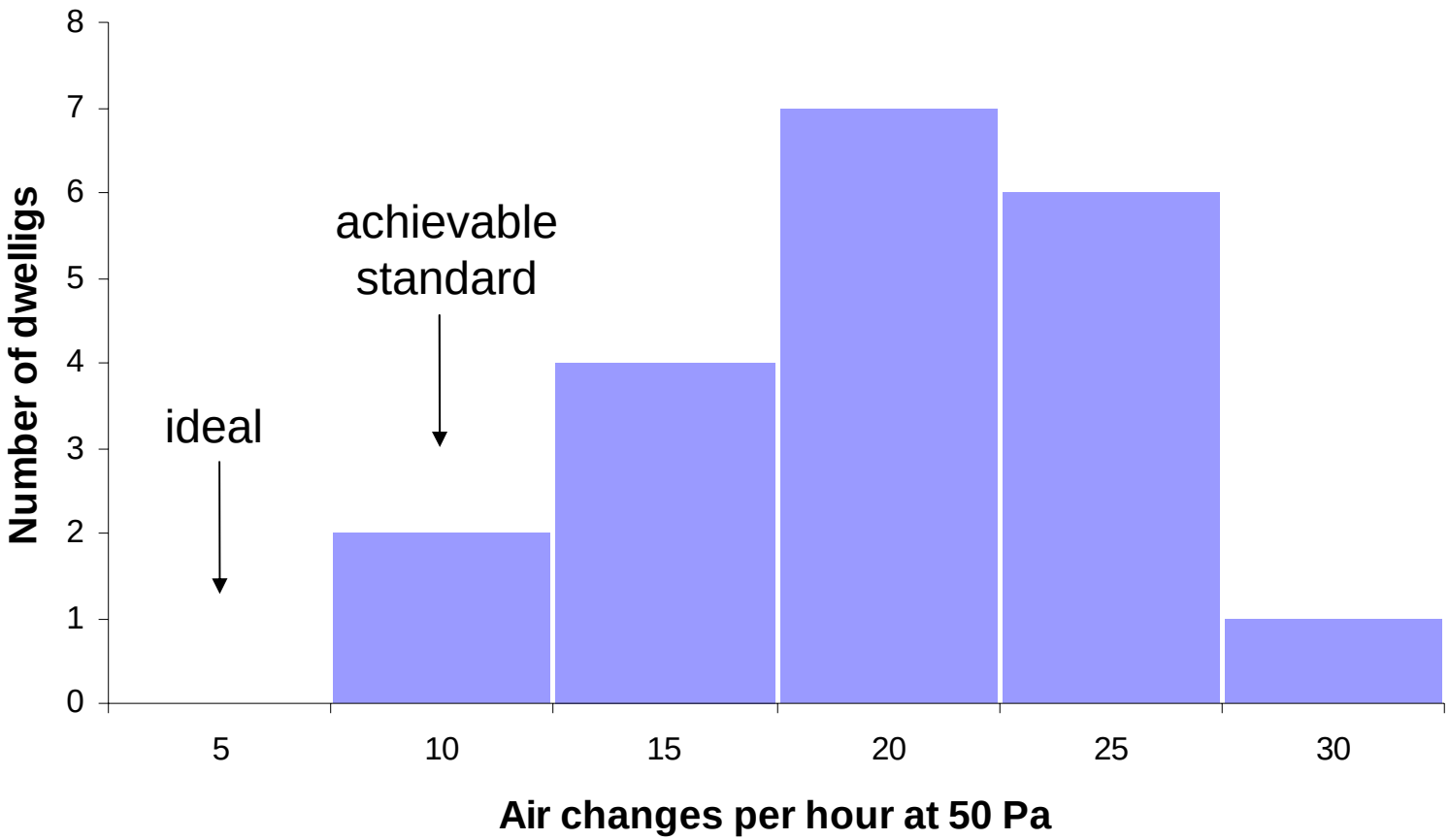
Canberra House Results



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The Numbers

- Typical ACT house > 20 ACH at 50 Pa
- Aim for < 10 ACH and potentially reduce
  - heating costs by 30-50%
  - annual GHG by 3-6 tonnes per household
- Cost-effective way to achieve major reductions in GHG emissions in the ACT

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Air Leakage & Insulation

- Most effective way to improve building thermal performance is to seal and insulate the envelope
- 5% gaps in insulation = 50% drop in effectiveness
- Gaps in ceiling insulation >5% are typical
- Cavity wall insulation variable, often poor
- Uncontrolled air leakage negates insulation benefits
- Need air leakage standards + R value standards

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Air Leakage and EER

RATING SUMMARY for: 2/9 CURTIN, 4 THORN PL, CURTIN

Assessor's Name:

Net Conditioned Floor Area: 151.2 m²

Feature						Points		
						Winter	Summer	Total
CEILING						10	1	11
Surface Area:	7	Insulation:	5					
WALL						-5	-1	-7
Surface Area:	-7	Insulation:	4	Mass:	-3			
FLOOR						0	-1	0
Surface Area:	3	Insulation:	-3	Mass:	0			
AIR LEAKAGE (Percentage of score shown for each element)						3	0	3
Fire Place	0 %	Vented Skylights	0 %					
Fixed Vents	0 %	Windows	31 %					
Exhaust Fans	0 %	Doors	24 %					
Down Lights	0 %	Gaps (around frames)	45 %					

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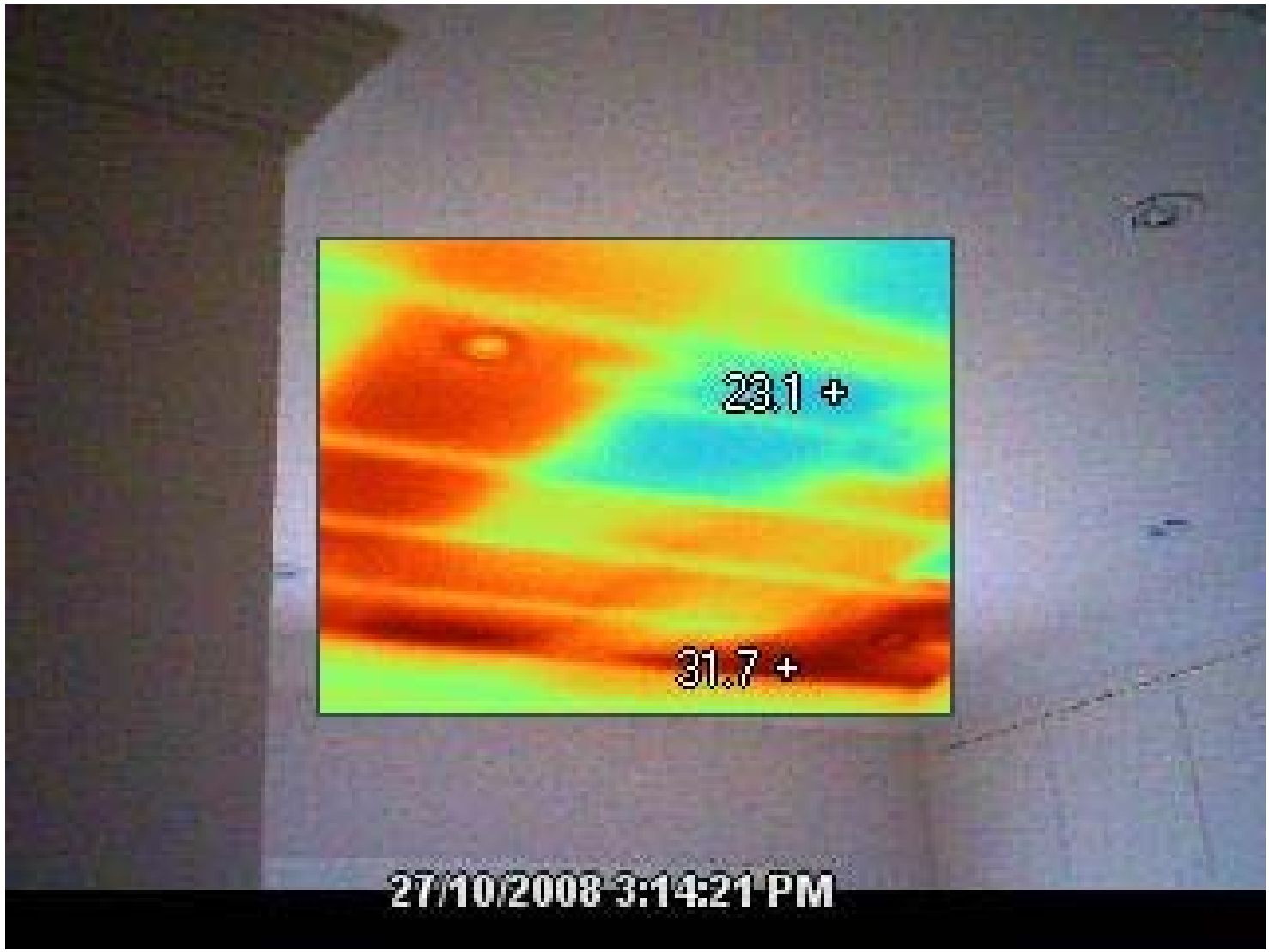
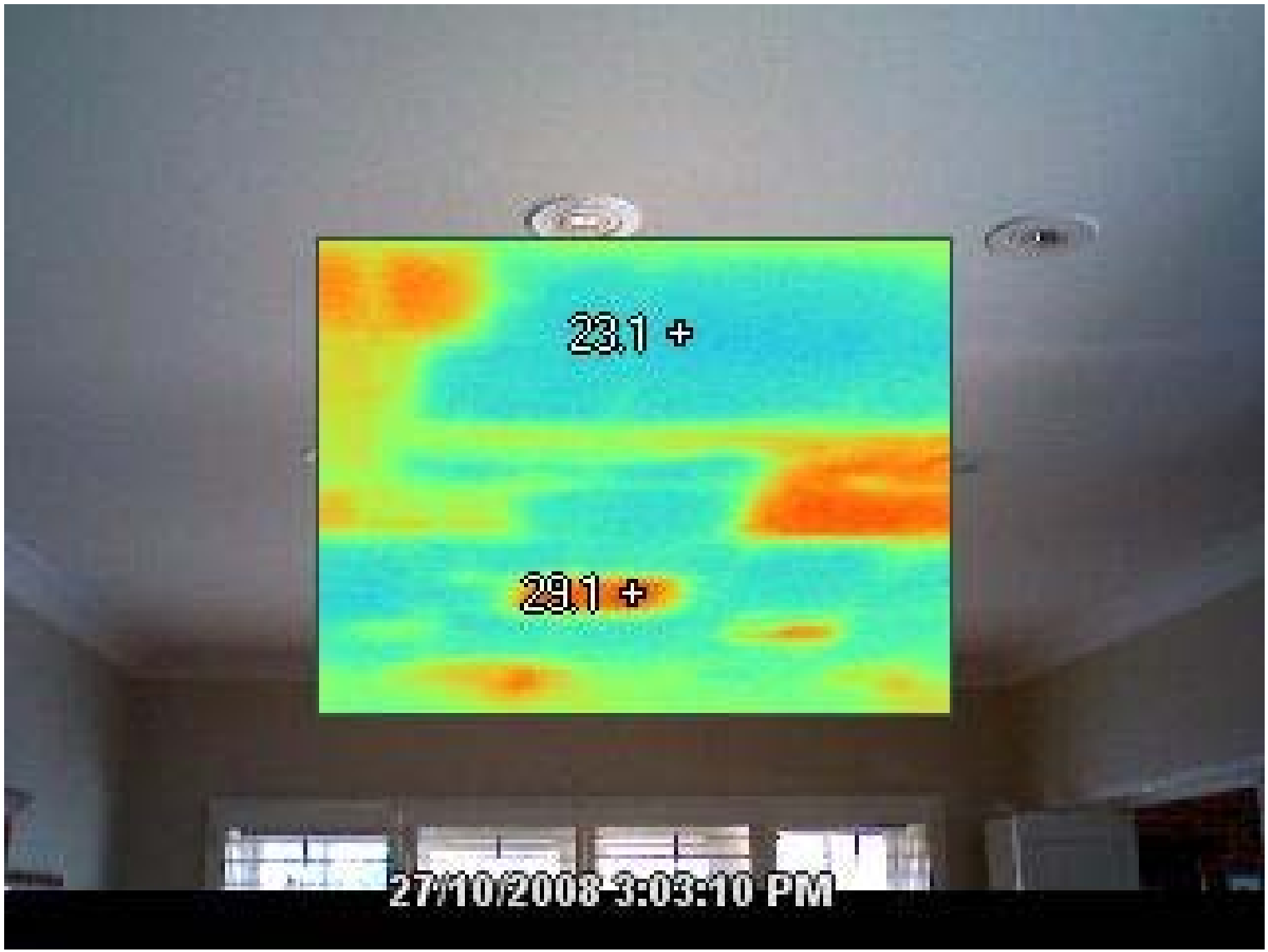
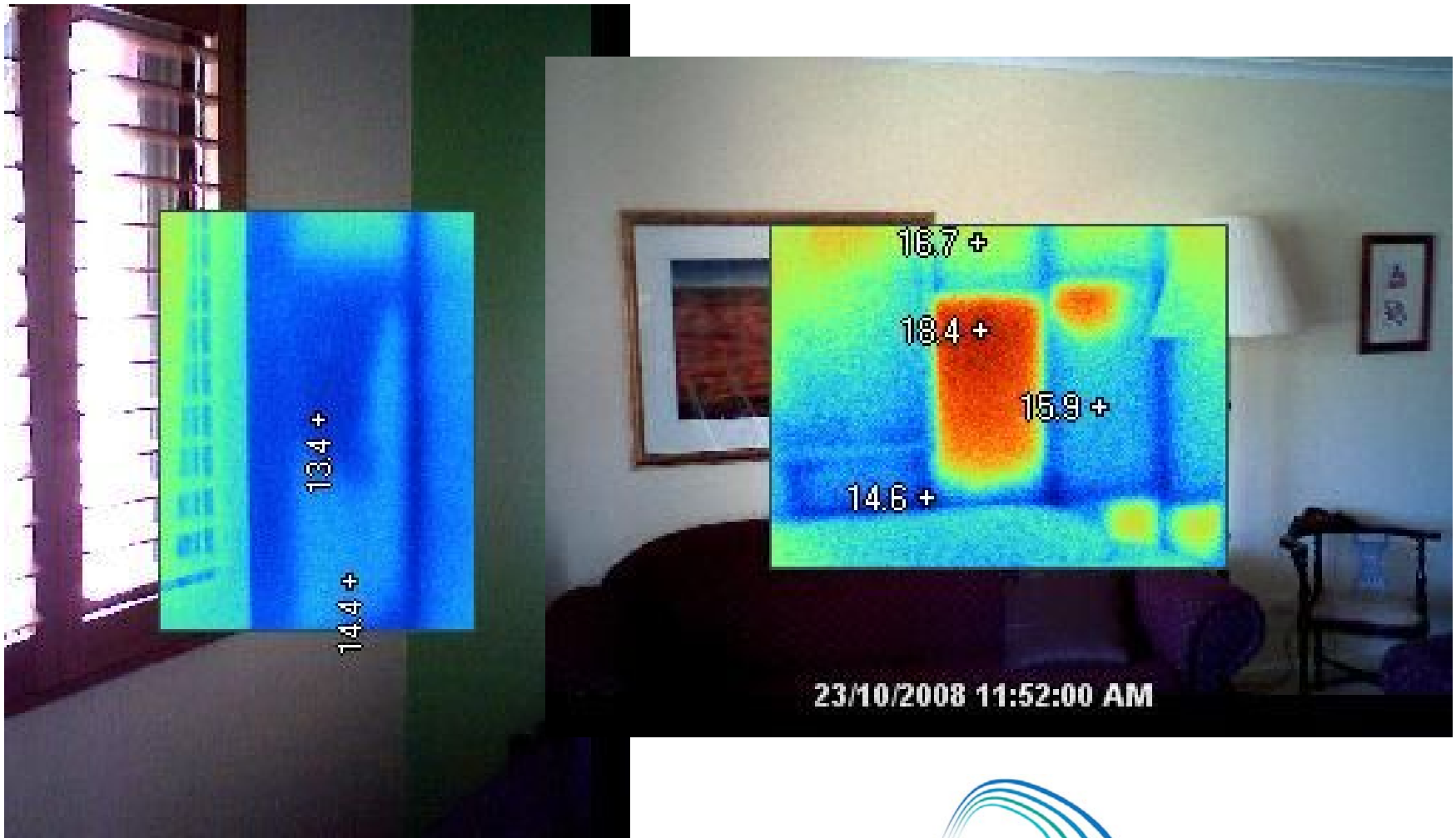
Gaps in Ceiling Insulation



Gaps in Ceiling Insulation



Gaps in Cavity Wall Insulation



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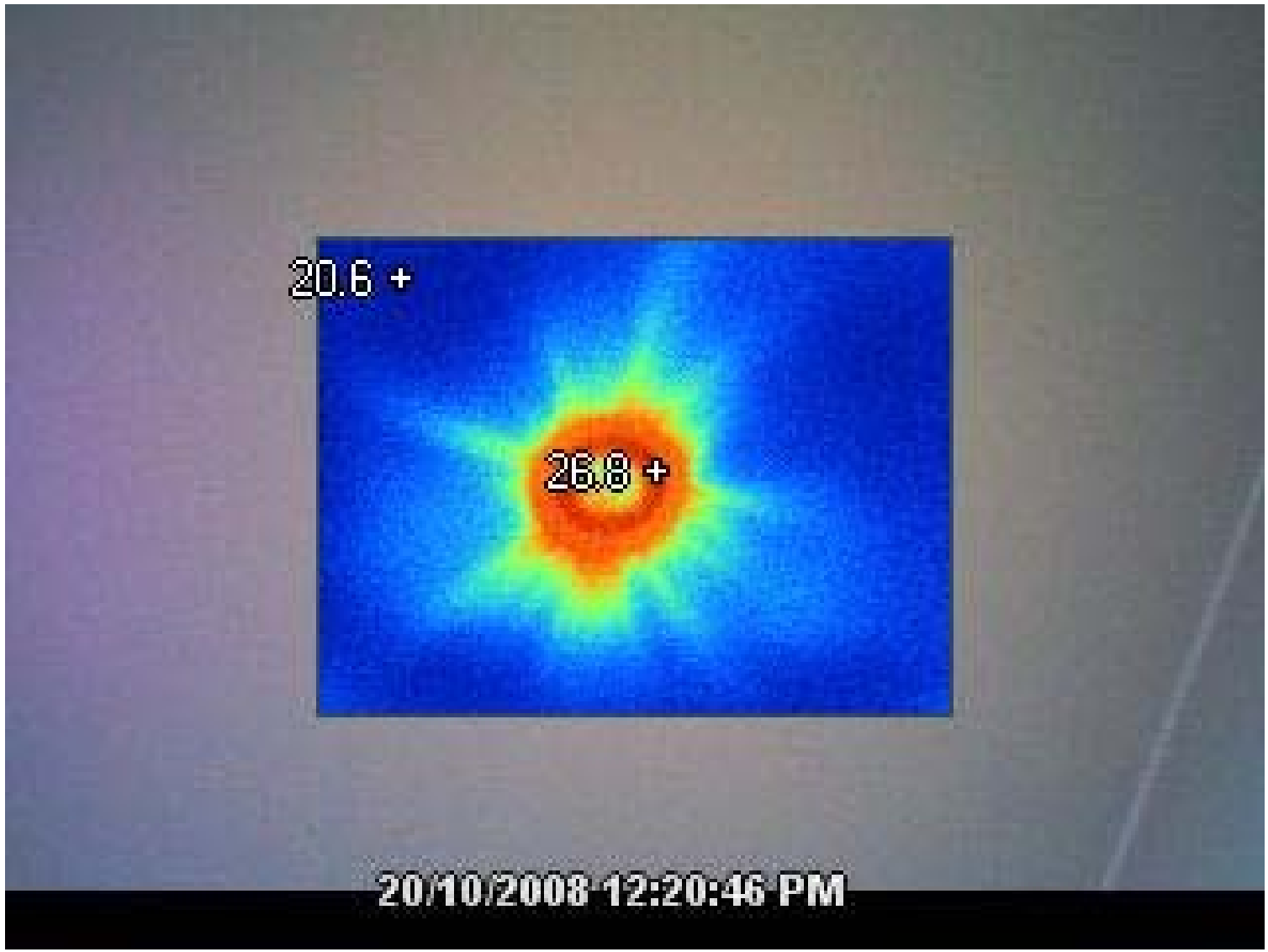
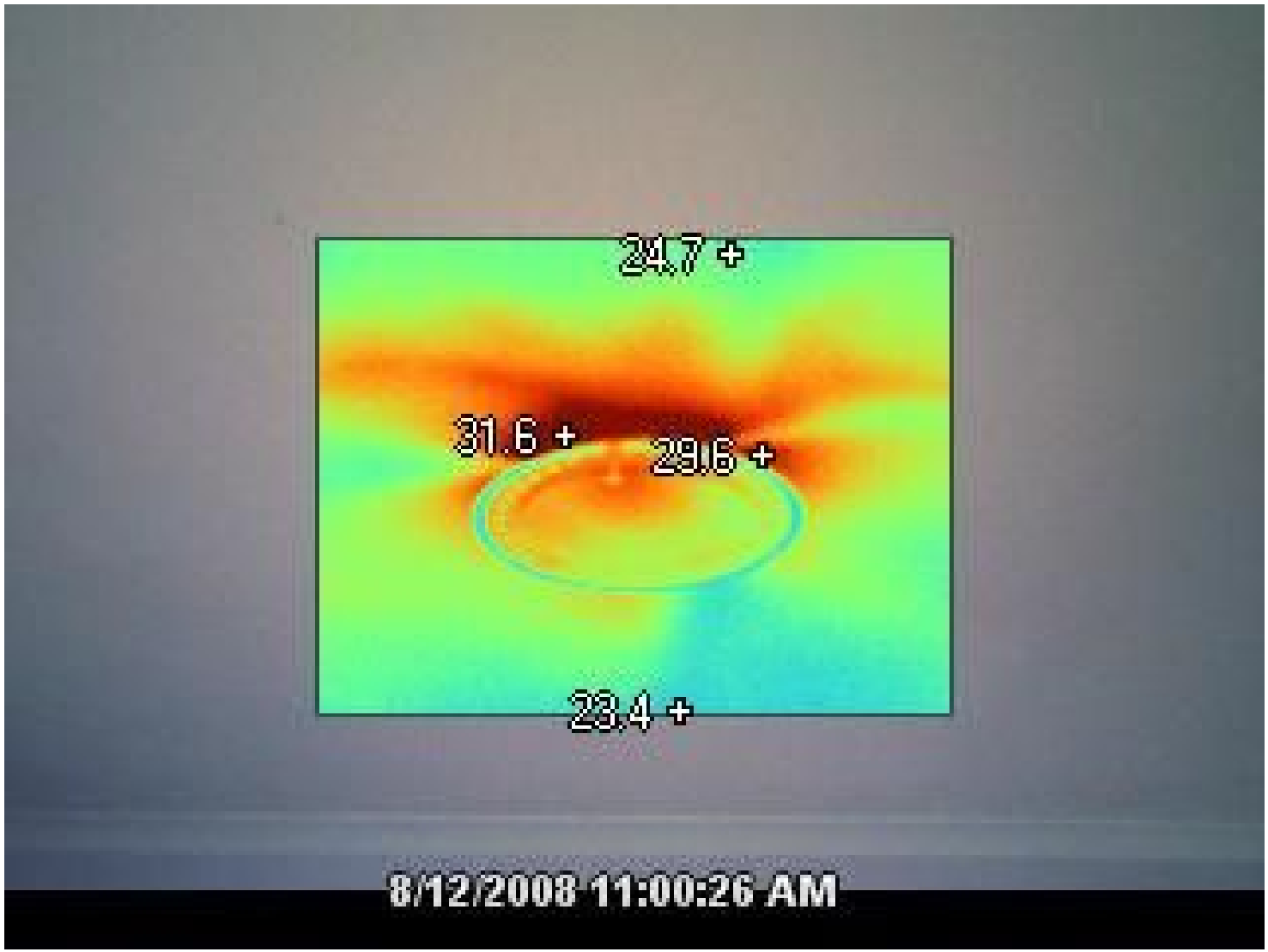
Air Leakage: Downlights



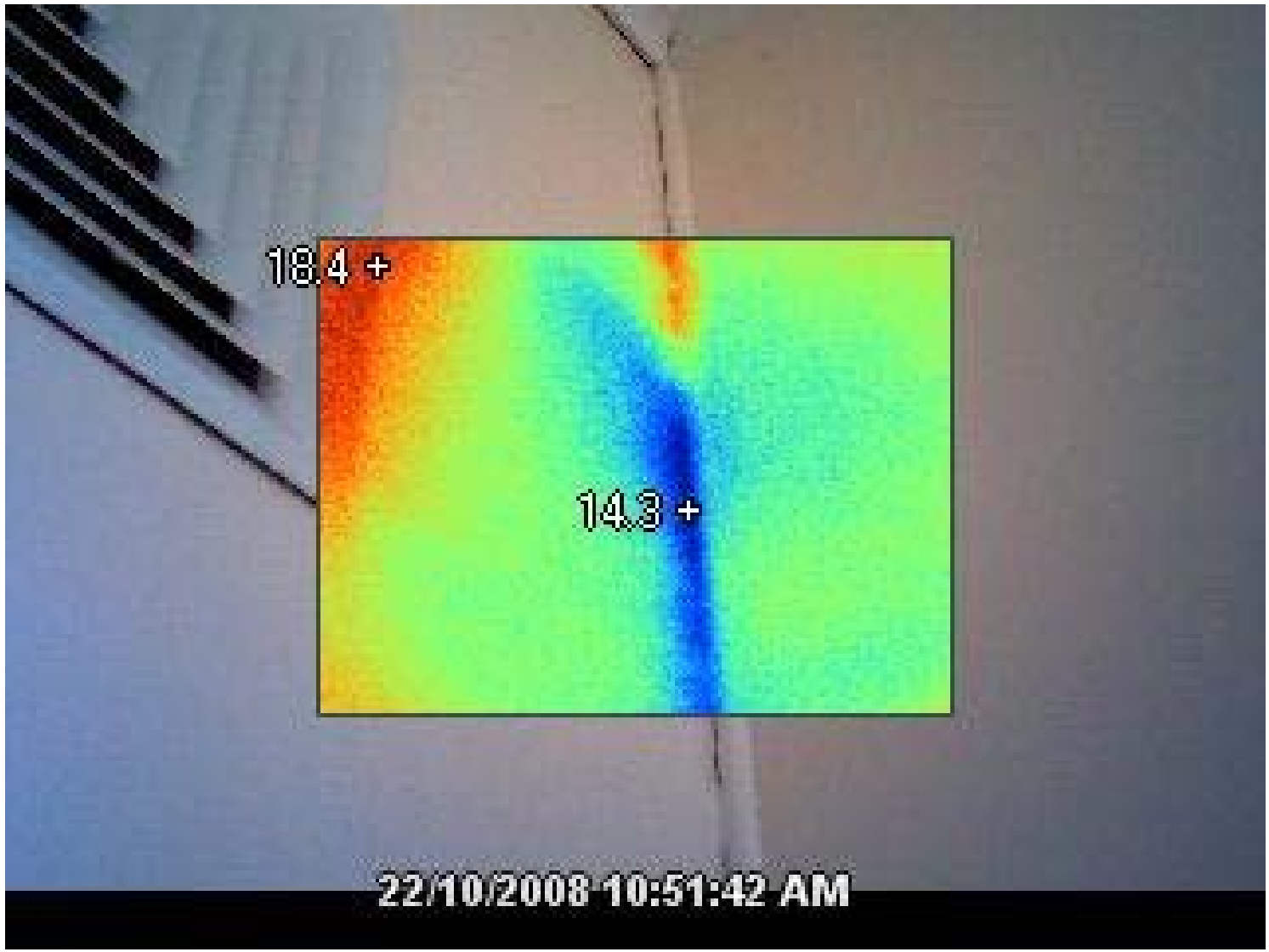
Air Leakage: Standard Lights



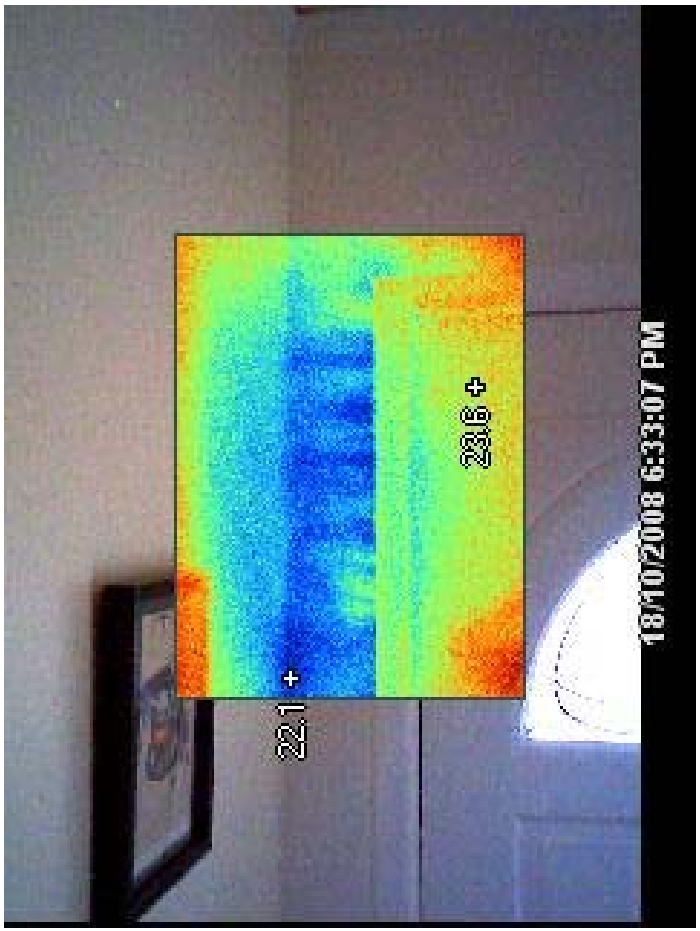
Air Leakage: Floor/Wall

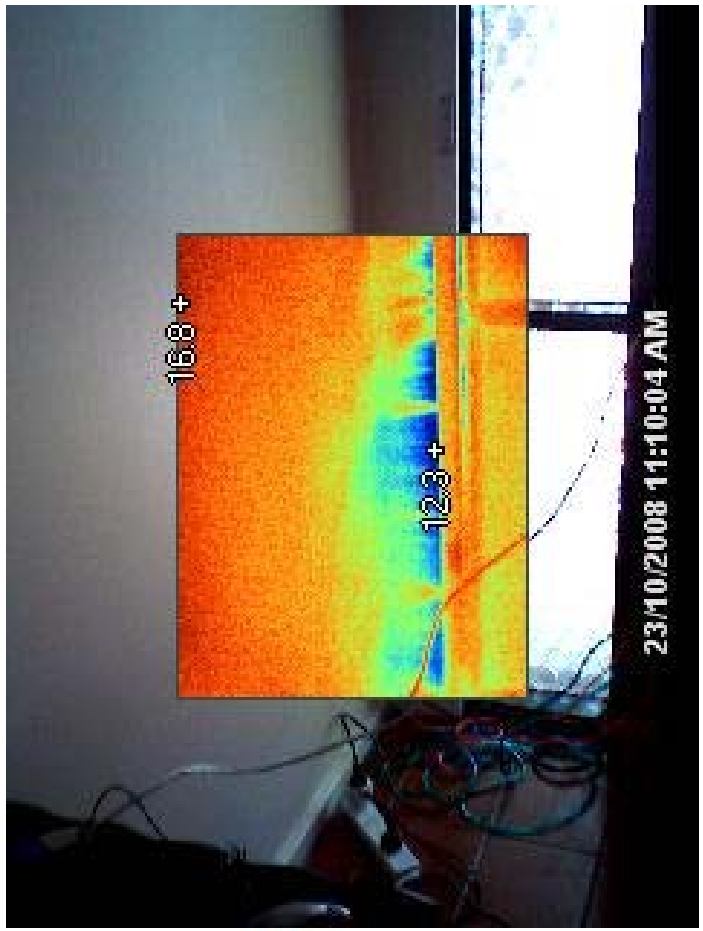
Air Leakage: Floor/Wall

Air Leakage: Wall/Wall



Air Leakage: Door/Wall





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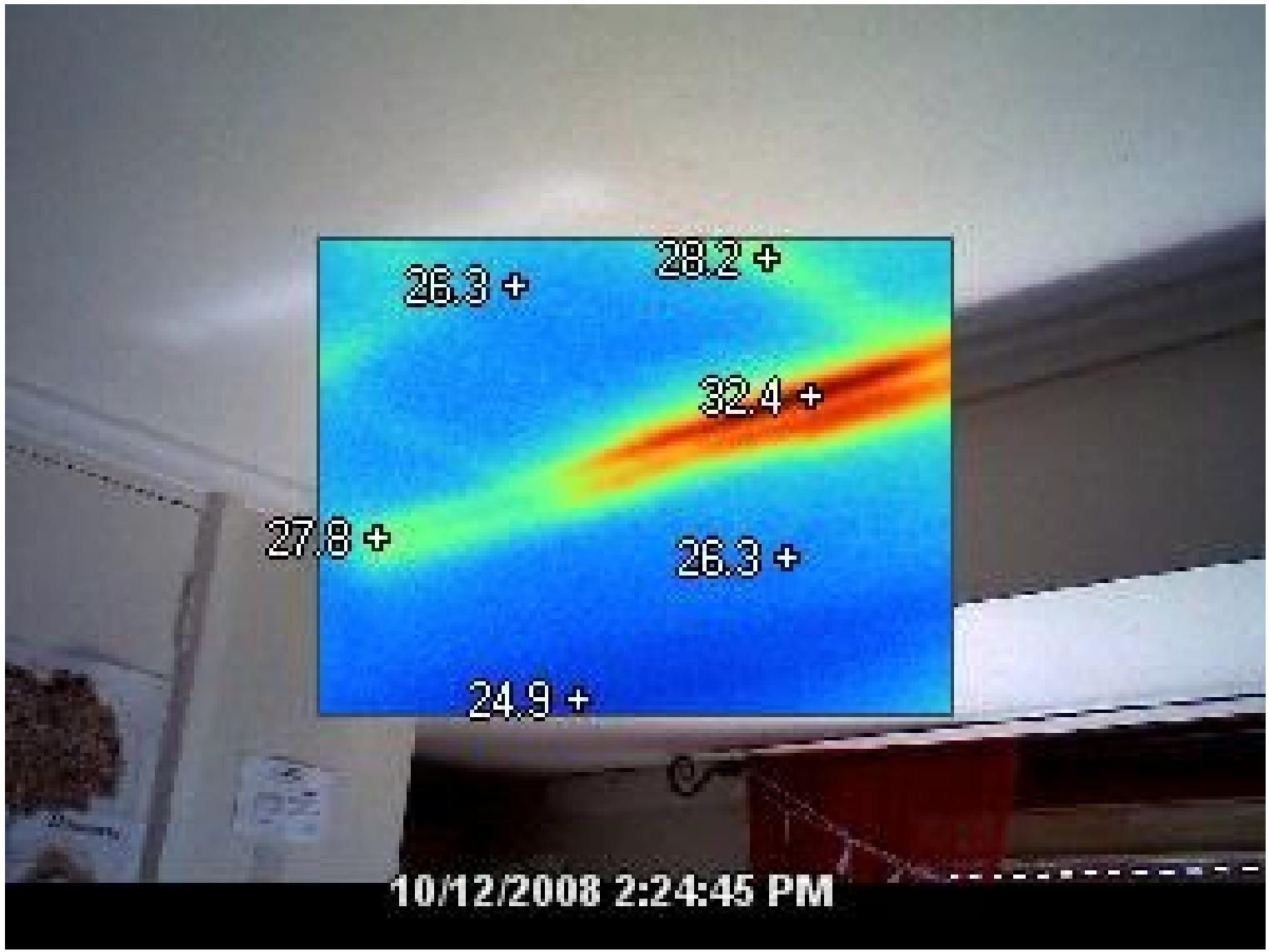
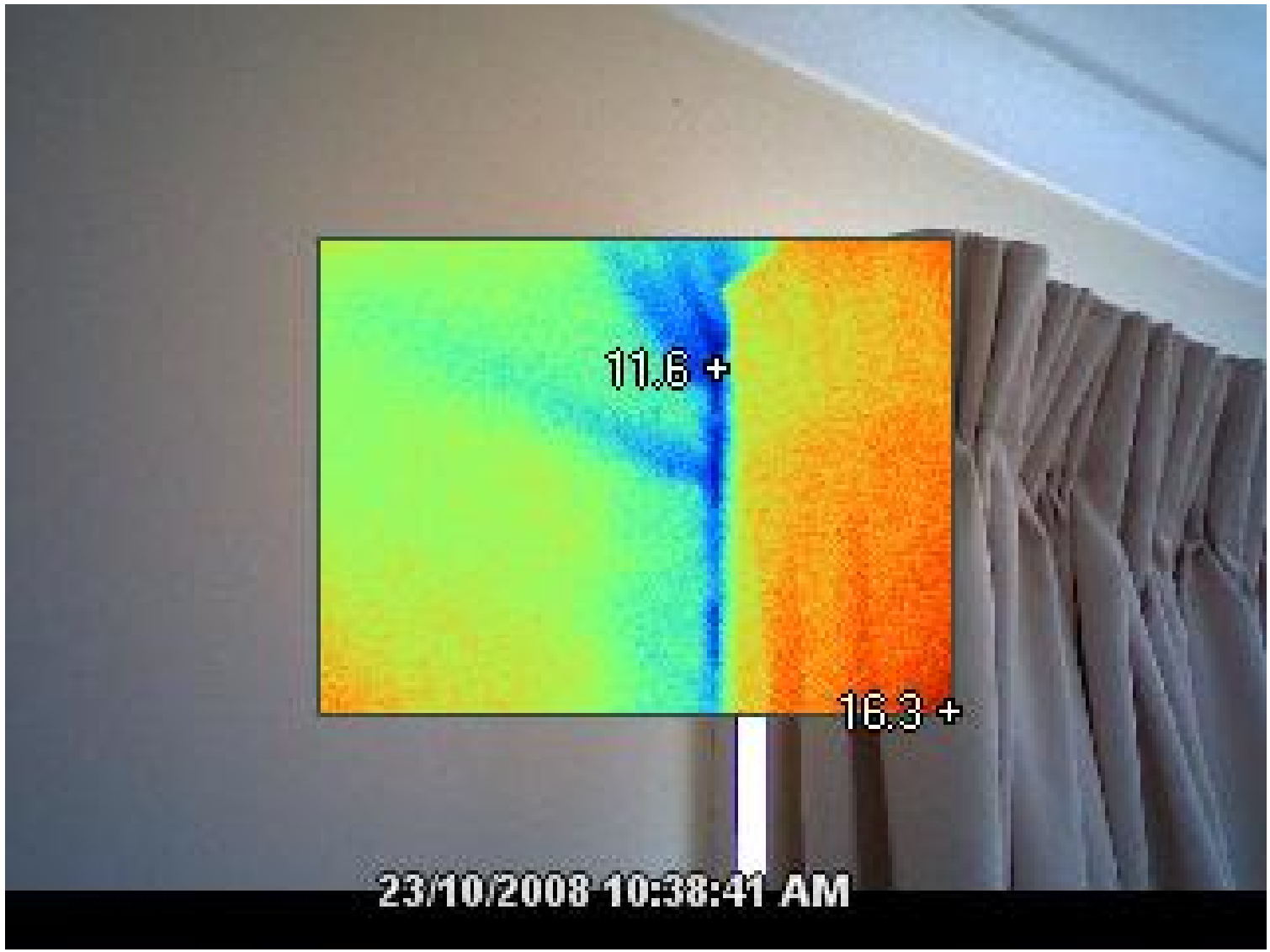
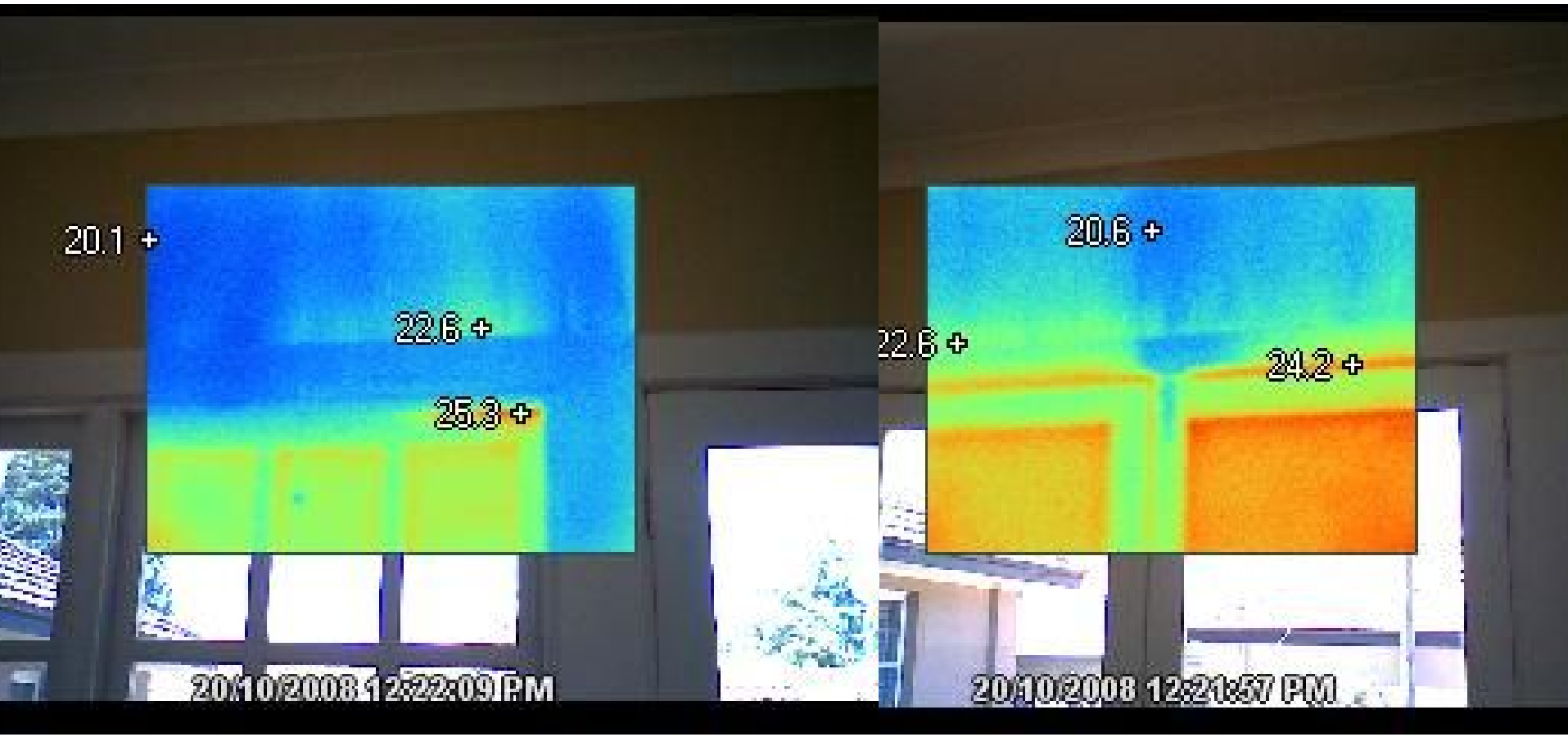
Air Leakage: Wall/Ceiling



Air Leakage: Window/Wall



Air Leakage: Negating Double Glazing



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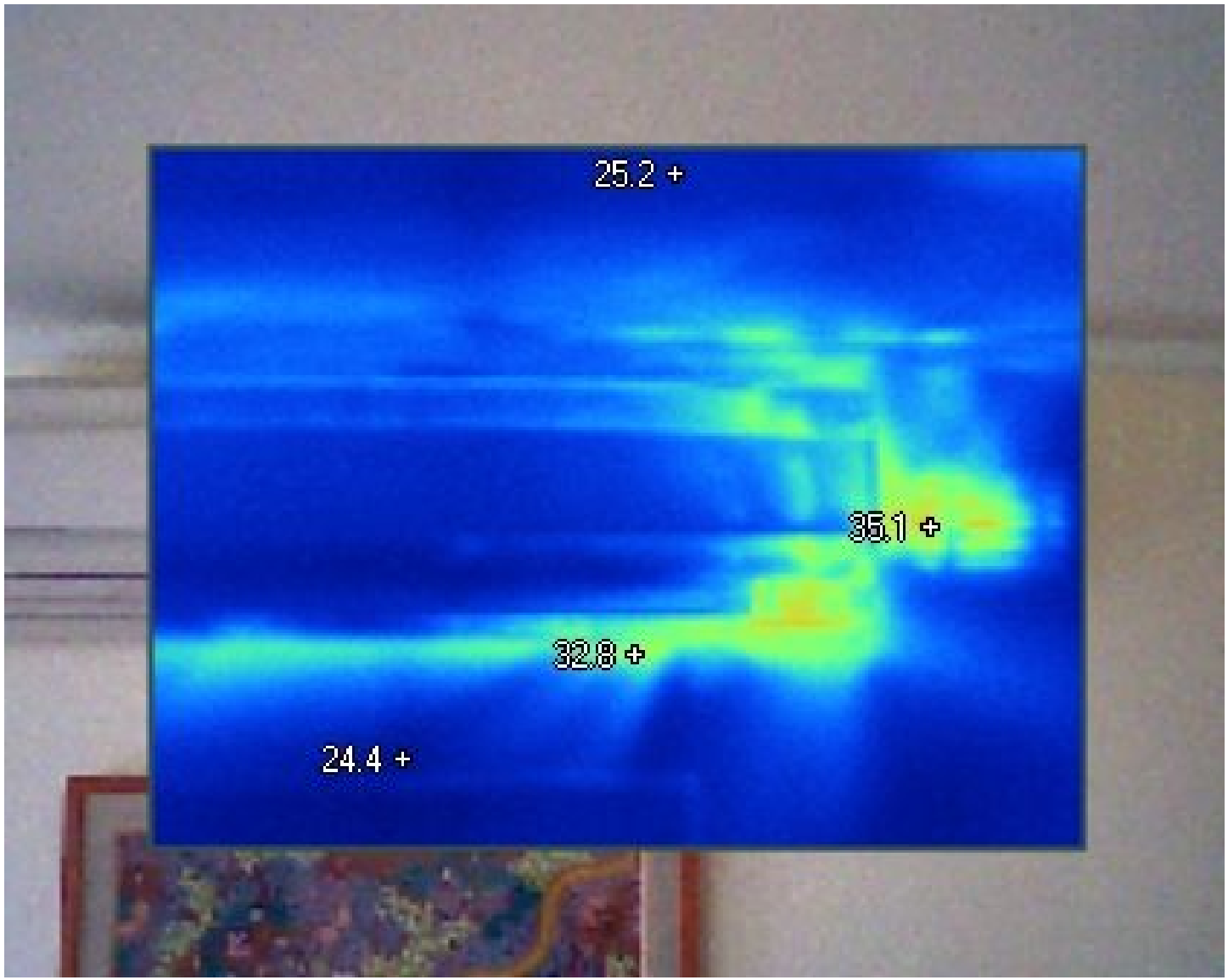
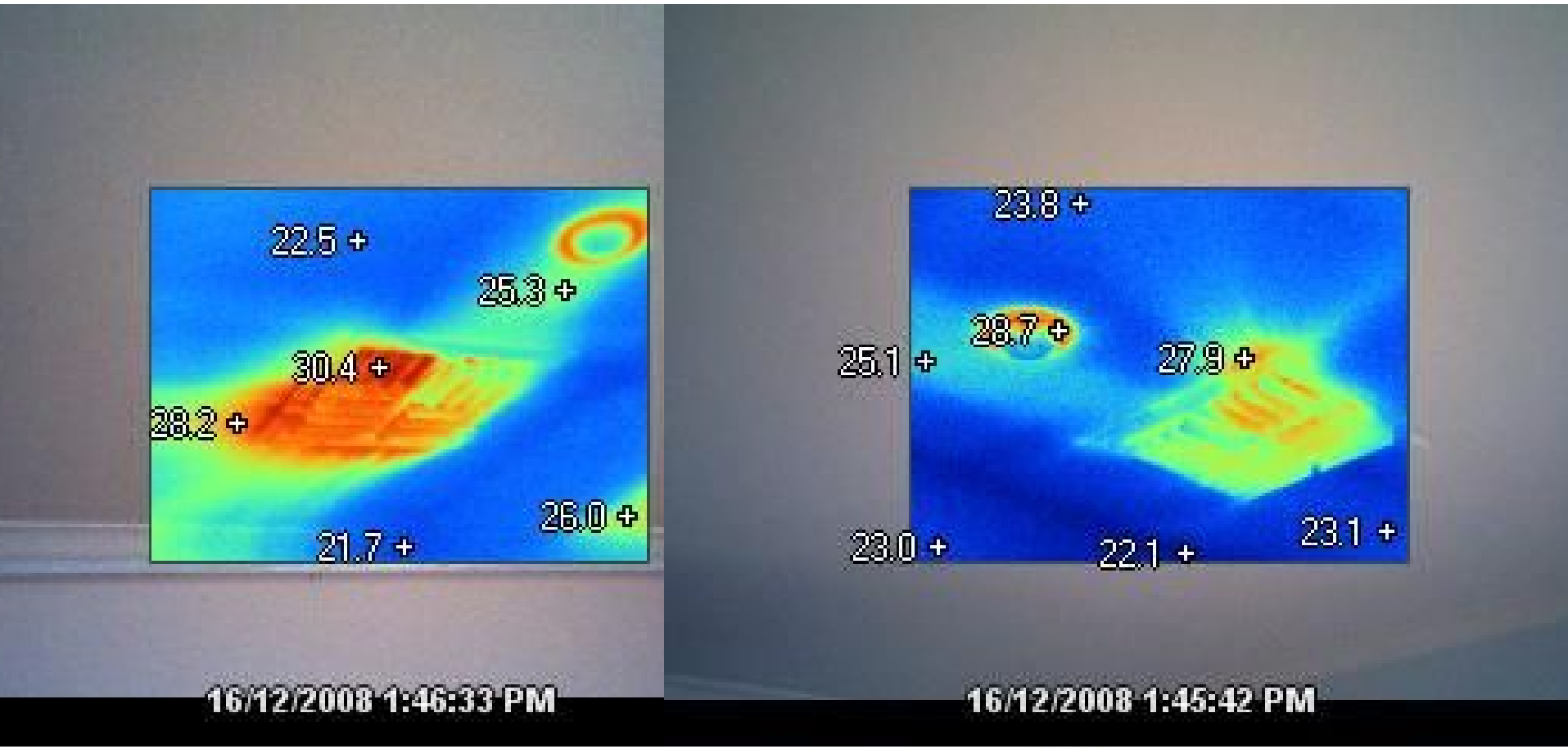
Air Leakage: at Heat Source



Air Leakage: at Heat Source



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Air Leakage: Manhole

Air Leakage: Bathroom Fans

Air Leakage

- Accounts for 30-50% heating and cooling costs
- Minimisation significantly cuts energy bills and GHG emissions
- Compromises effectiveness of other, more expensive, energy efficiency measures
- Simple and cost effective to control once located

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Recommendations

1. Raise awareness of the effectiveness ($, GHG & comfort) of reducing air leakage and properly installing insulation;

   and provide incentives for households and builders to implement air sealing measures and improve the installation of insulation.

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