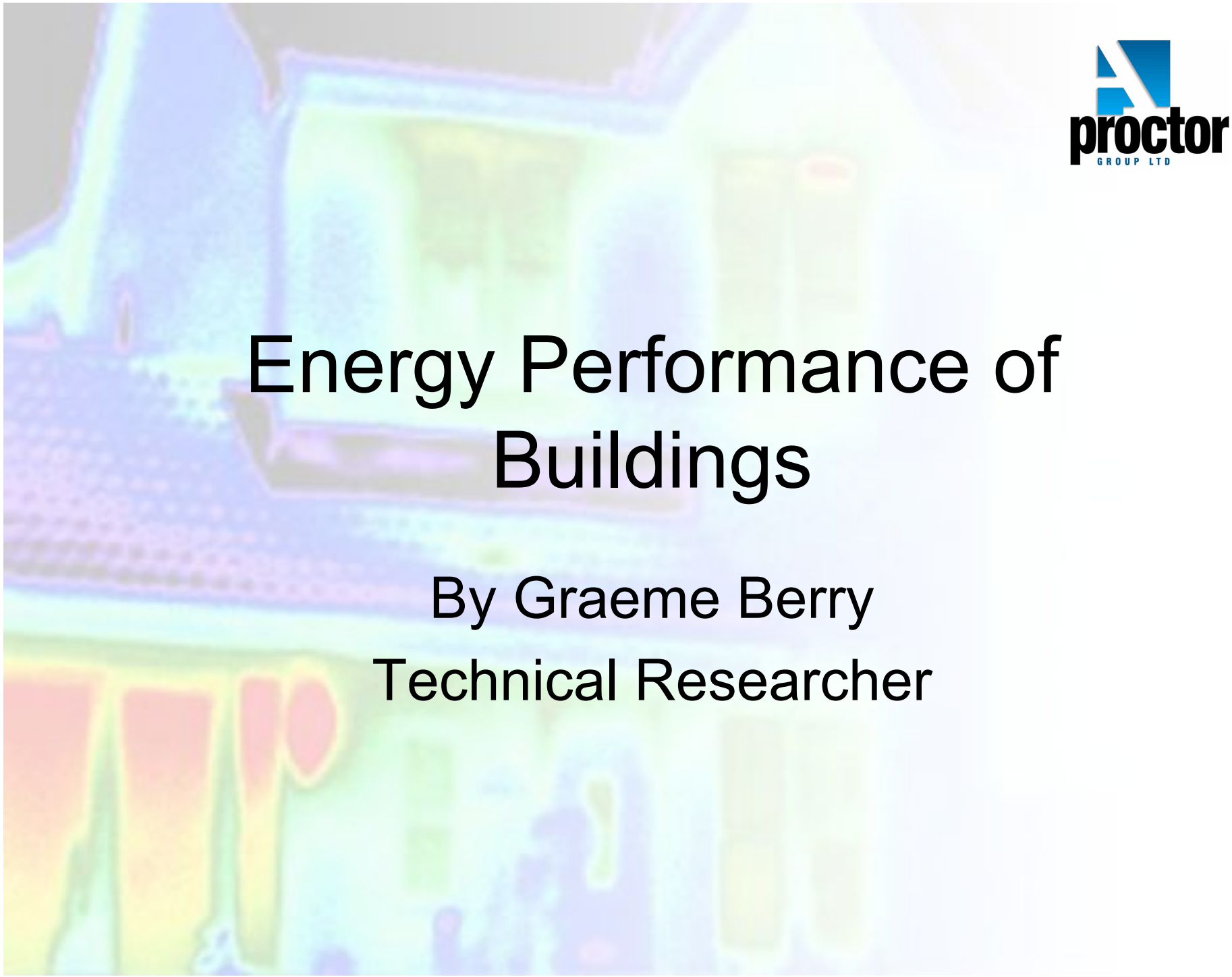


Energy Performance of Buildings

By Graeme Berry
Technical Researcher

About Us

- Head Office: Blairgowrie, Perthshire
- 75000ft² Manufacturing Space in Blairgowrie
- 15000ft² in Rugely, Staffordshire
- Currently >100 Employees

APG Divisions

- Acoustics
- Construction Membranes
- Exterior Products
- Geoengineering
- Thermal Insulation

Aims

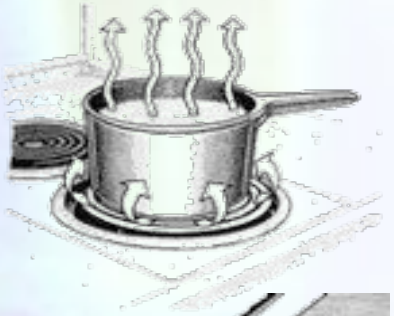
- Insulation Basics
- Insulation Materials Overview
- Wall Insulation Solutions
- Case Study: Restenneth Drive, Forfar

Building Envelope

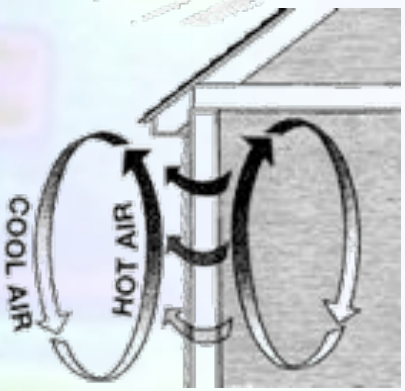
- Whole building approach to energy
- Heat loss rate (U-Value)
- Fabric heat storage (Thermal mass)
- Airtightness
- Cold Bridging
- Condensation risk

Heat Transfer

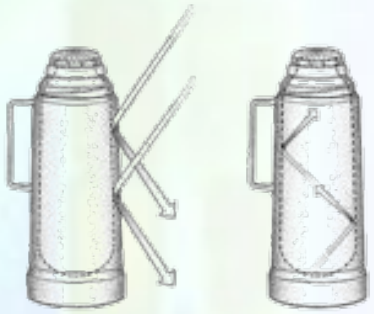
- **Conduction**



- **Convection**



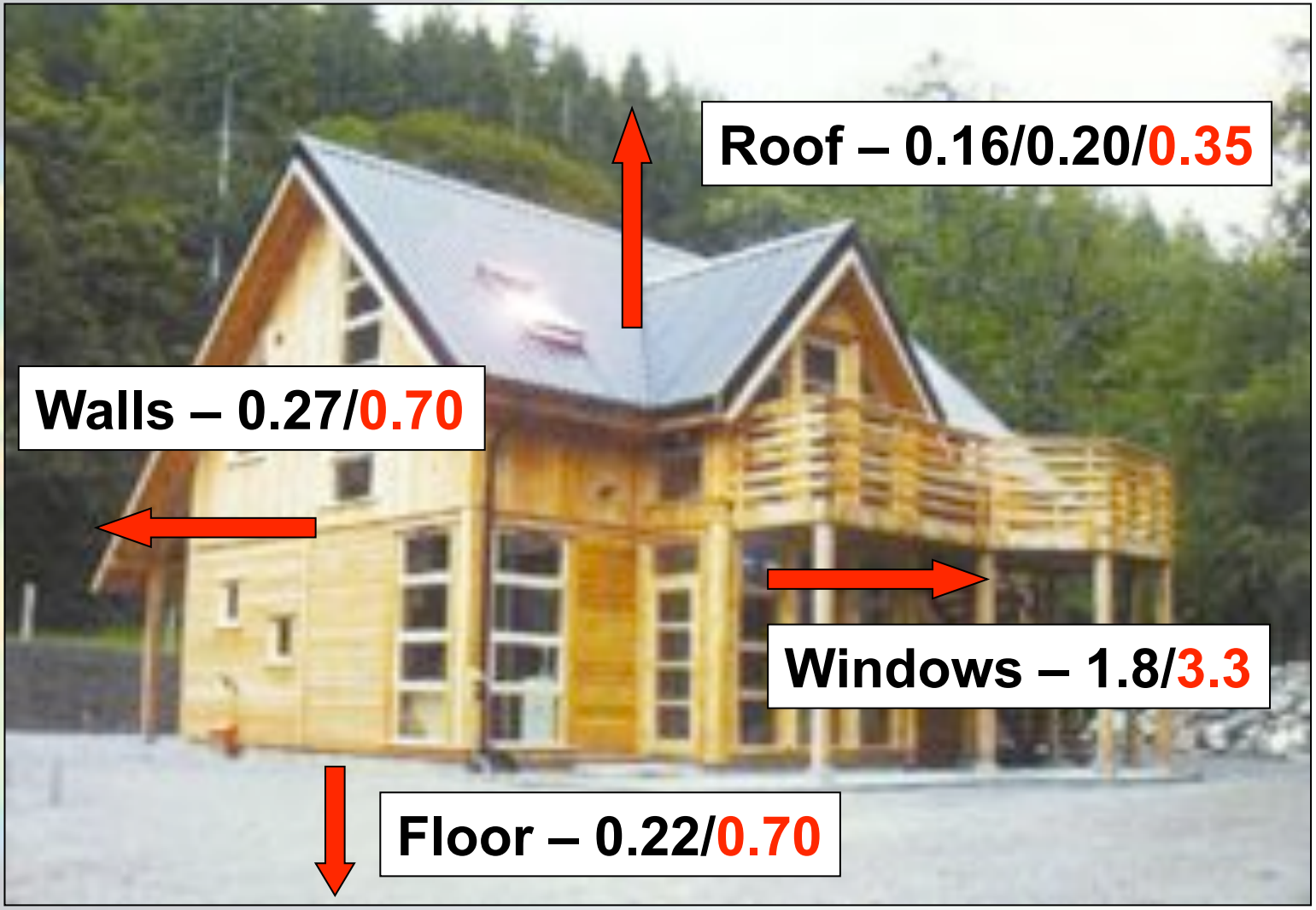
- **Radiation**



Ks, Rs & Us

- Thermal Conductivity (k-factor / λ) - W/mK
  - 90/90 to EN12267
- Thermal Resistance (R-value) - m^2K/W
  - thickness/tc
- U-Value is the rate of heat loss - W/m^2K
  - $U=1/\Sigma R$

U-Value Guidance (Sect. 6)



Fabric Heat Storage

- Thermally massive materials retain heat
- Adds “inertia” to thermal system, stabilising temperature fluctuations
- Generally Speaking:
  - Heavy = Good Heat Store
  - Light = Poor Heat Store
- Position of insulation can affect heat storage

Thermal Mass?

Airtightness

- Can dramatically affect energy performance
- Simple to to achieve
  - in theory
- Service voids/reflective insulation
- Can improve SAP Rating/DER
- Requires careful consideration of controlled ventilation

Airtightness

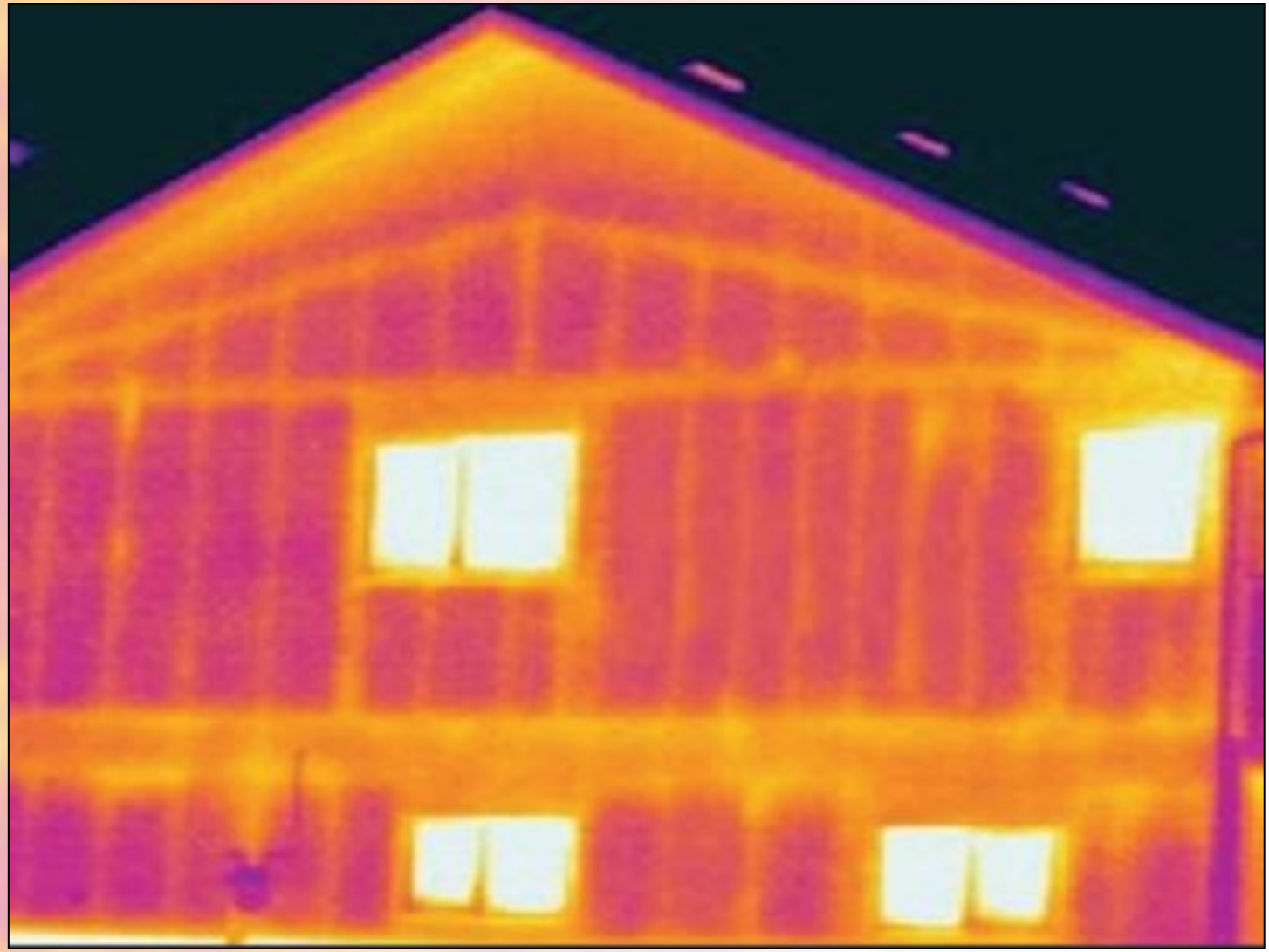
Air Permeability	10	7	3	7
Wall U-Value	0.27	0.27	0.27	0.23
Kg/CO2/m2	20.43	19.9	19.42	19.43

- Based on a standard detached timber frame house of:
  - 100m2 floor area, 200m2 wall area.
  - 90% Efficient Mains Gas Condensing Combi Boiler.
  - 1.8 U-Value Windows/Doors.

Cold Bridging

- Bridging elements increases u-value
  - structural elements, timber/steel
  - windows/doors/detailing
- Condensation can form at bridges
- Continuous insulation envelope
  - internal or external
- Insulation applied to bridging elements
- Cold bridging should be properly accounted for in calculations
  - Guidance given in BR443

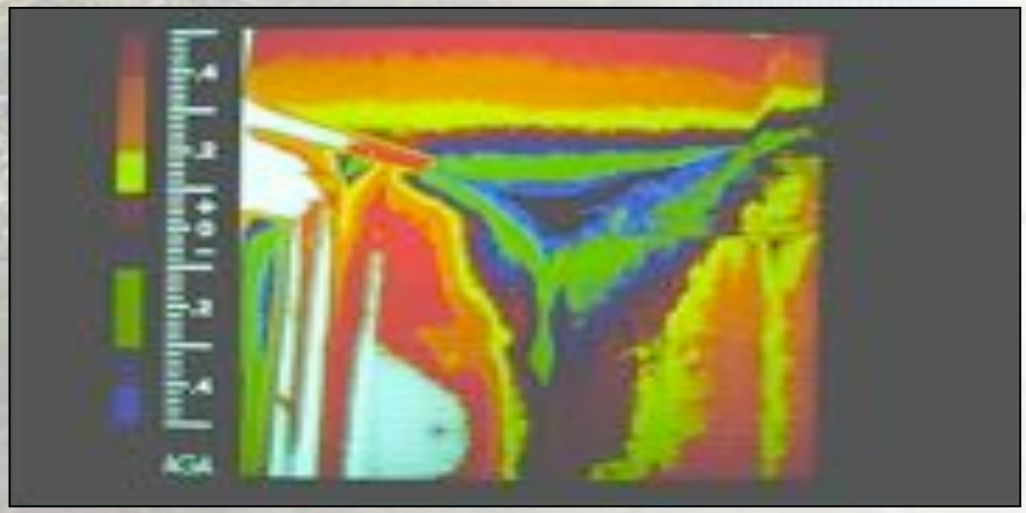
Cold Bridging



Condensation Risk

- Increased insulation changes temperature gradients
- Leads to cold interstitial boundaries
- Cool air retains less moisture
  - leads to condensation
- Consideration of vapour control
- Consideration of insulation permeability and positioning in structure

Mould and Temperature



Insulation Types

- Fibrous (Mineral/Cellulose/Fleece)
- Polystyrene Foam
- PUR/PIR/Phenolic Foam
- Reflective Insulation
- Silica Aerogel

Fibrous Insulation

- Thermal Conductivity 0.032-0.044
- Good fabric heat store
- High vapour permeability
- Low compressive strength
- Good acoustic performance
- Poor moisture resistance
- Can be low in embodied energy

Polystyrene (EPS & XPS)

- Thermal conductivity 0.025-0.038
- Low vapour permeability
- Very high compressive strength (XPS>EPS)
- High embodied energy
- Excellent moisture resistance
- Poor acoustic performance

PUR/PIR/Phenolic

- Thermal conductivity 0.020-0.026
- Low vapour permeability
- Average compressive strength
- Poor acoustic performance
- Medium embodied energy
- Good fire performance

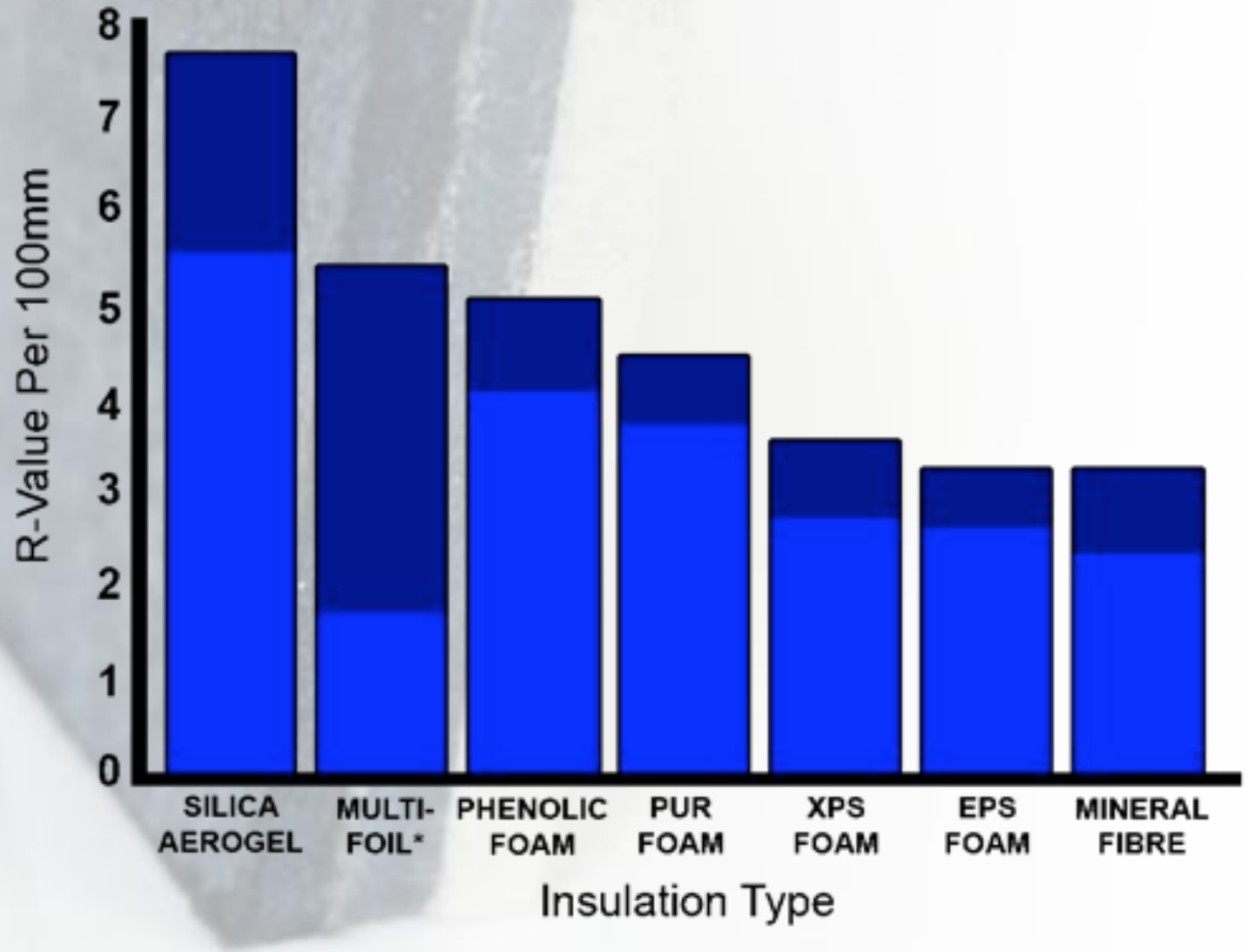
Reflective Insulation

- R-Values 0.34-5.25
- Insulates by reducing emissivity
- Utilises “dead space”
- Improves airtightness
- Very low thermal mass
- Reduces solar gains

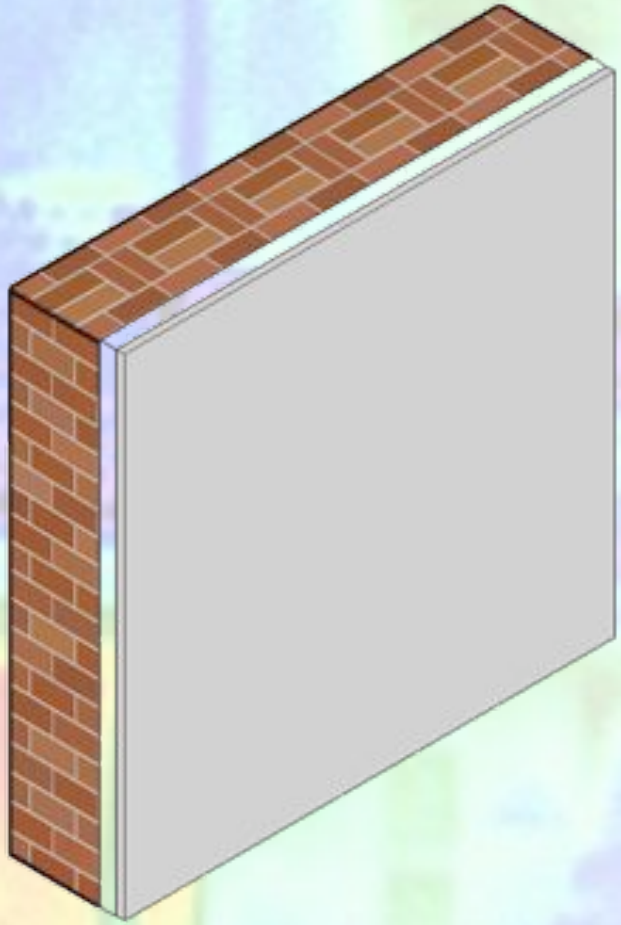
Silica Aerogel

- Thermal conductivity 0.013-0.018
- High vapour permeability
- Average compressive strength
- Hydrophobic & Mould Resistant
- Good acoustic performance
- Low embodied energy & co2

Insulation Comparisons

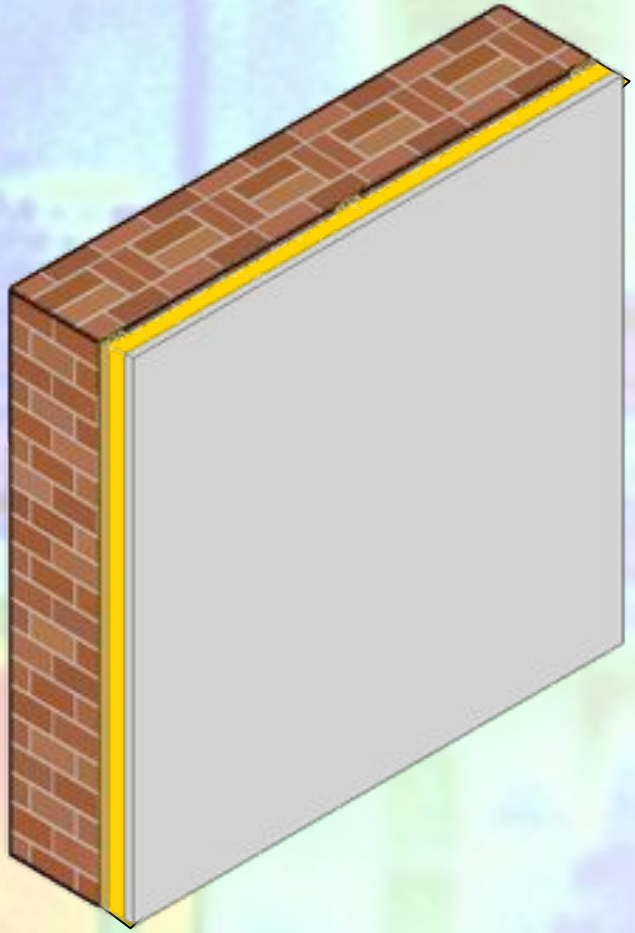


Internal: Direct Fix



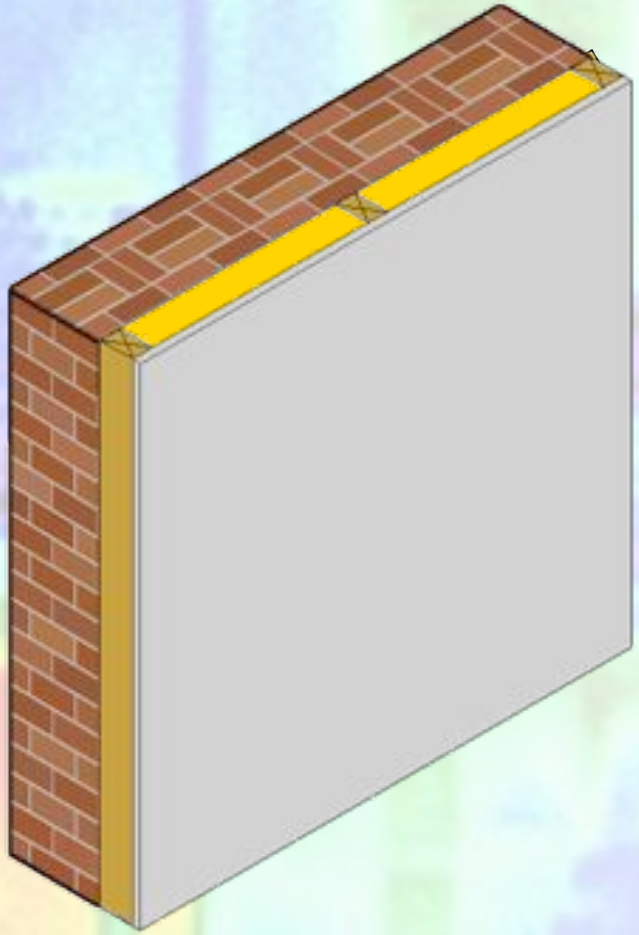
- Continuous: Limits cold bridging effect
- Thin, no “wasted” thickness
- Faster Installation
- Not all insulation types suitable
- Requires reasonably level surface to fix to

Internal: On Straps



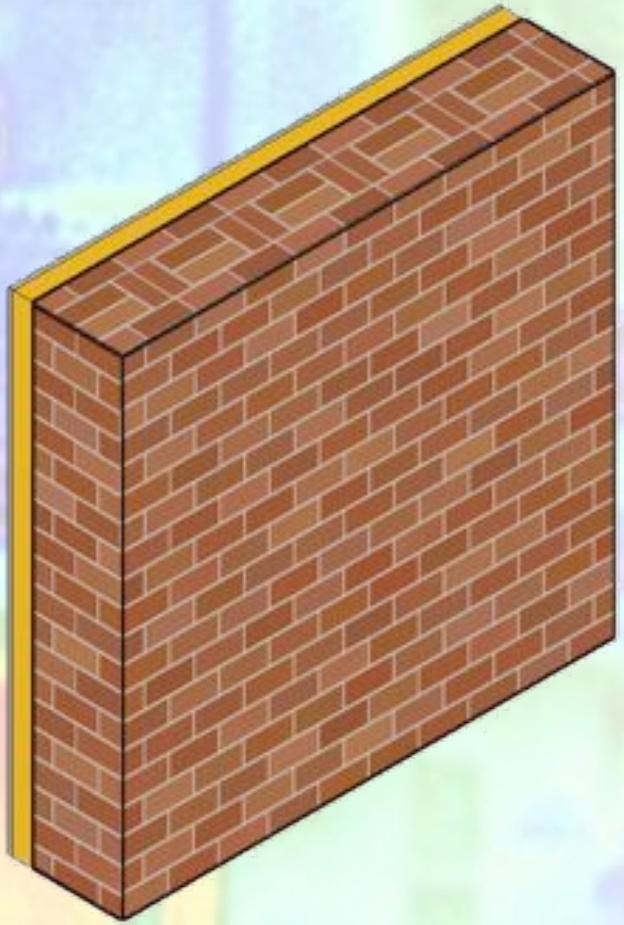
- Most types of insulation suitable
- Provides service void for cables etc
- Continuous insulation avoids cold bridging
- Allows some degree of levelling
- Requires more depth to accommodate battens

Internal: Between Studs



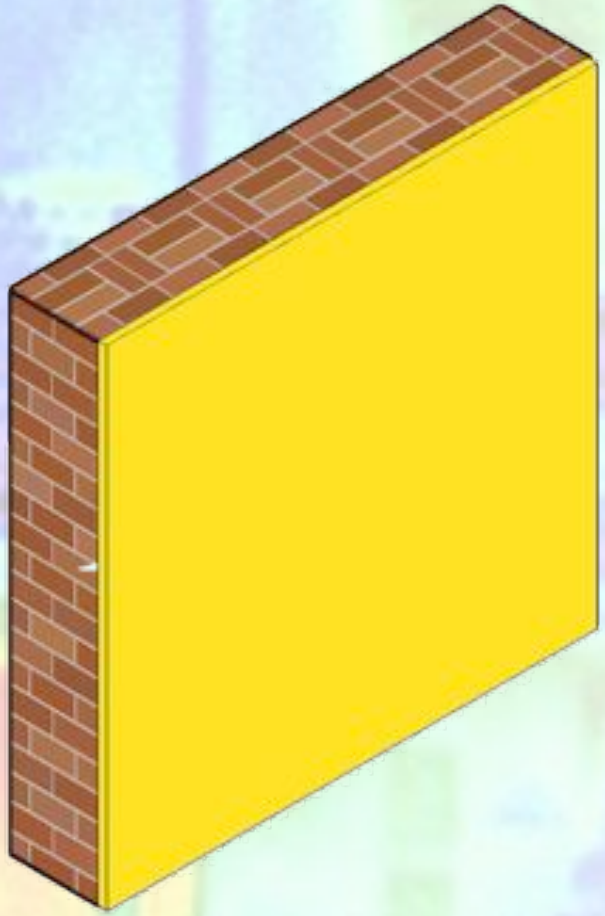
- Accommodates very uneven base walls
- Can improve acoustic insulation
- Most insulation types suitable
- Cold bridging increases thickness considerably

External



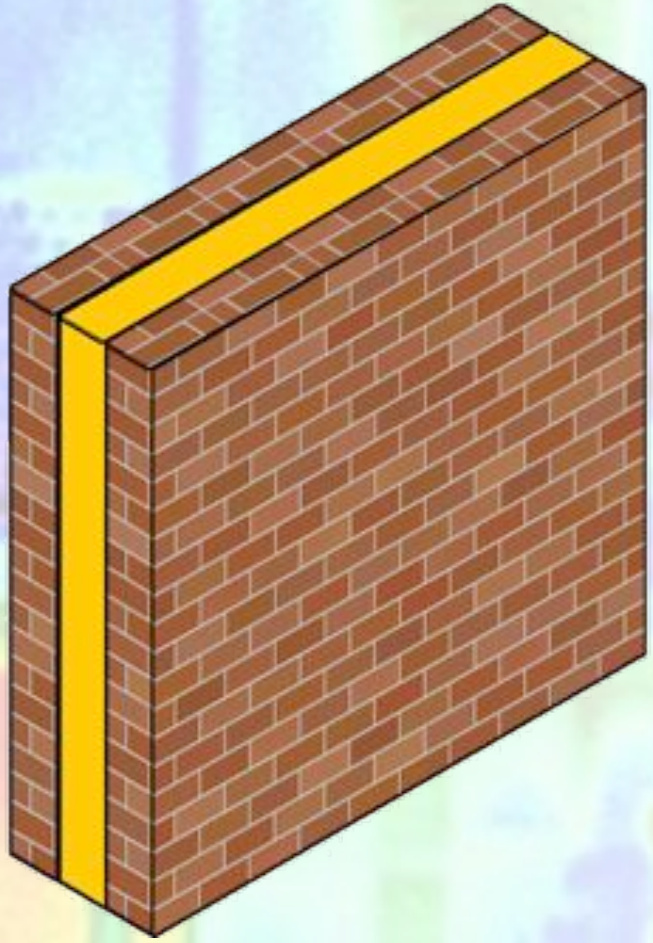
- Can improve weathertightness by reinstating external render
- No loss of internal space
- Maximised fabric heat storage
- Expensive, requires specialist contractors

Internal: Flexible Lining



- Simple to install
- Can deal with some degree of unevenness
- Minimum disruption to room sizes…..
- ….But also minimal thermal performance

Cavity Wall



- No loss of space
- No disruption to building appearance
- Can be done relatively quickly, and with no disruption to occupants
- Requires careful consideration of moisture
- Requires specialist contractors

Case Study:

54 Restenneth Drive, Forfar

Existing Stock: Problems

- Limited space to retrofit thermal insulation
- Existing insulation may be missing, patchy, saturated or otherwise ineffective, with significant cold bridging and air leakage
- Installation requiring scaffolding may cause disruption to access, traffic, neighbours
- Effective external insulation may be impossible due to presence of owner occupiers

Before with Cavity Fill

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Before Internal

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Case Study: Forfar

Bedroom Wall
Evidence of damp forming at cold spots

Variations in performance caused by damp and air leakage

Case Study: Forfar

- Spacetherm panels installed at 54 Restenneth Drive, Forfar in partnership with Angus Council
- Problems with continuity of the existing cavity fill missing in places and wet.
- Damaged external render led to damp inner wall surfaces
- Internal damp led in turn to cold spots and mould growth
- Cold bridging at door/window lintels

Case Study: Forfar

- 30mm Spacetherm Laminate board installed directly to damp inner leaf
- Internal lining so does not require scaffolding or relocation of signage/lighting etc…
- Does not require specialist contractors
- Isolation of thermal mass giving faster response to heating inputs
- Provides uniform, continuous insulation and restricts cold bridging
- Average u-value improved from 0.628 to 0.35
- Does not require upgrade of entire block at once

Case Study: Forfar

Case Study: Forfar

U-Value and Energy Savings from Installation of Spaceloft™ 9251*

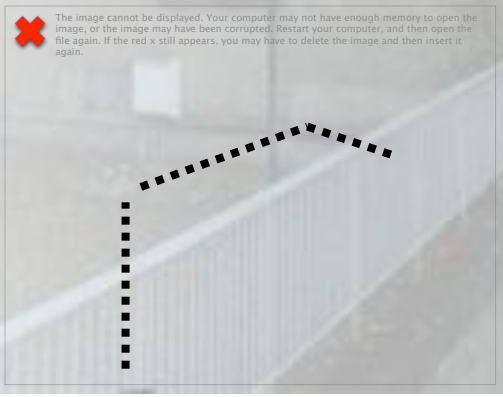
- U-value reduction: 0.28 W/m2k, (0.63 - 0.35 W/m2K), a 44% reduction
- Energy reduction: 900 kWhr/yr
- Carbon emmission reduction: 400 kg/yr

Case Study: Forfar

Gable Wall
Cavity wall with existing blown-in fibre insulation

Before : Average U-Value **0.628**
Poor performance from cavity fill
Significant cold spots

After : Average U-Value **0.35**
Increased performance and uniformity



Benefits: Summary

- Dramatically reduces thermal losses for minimal loss of space
- Improves insulation uniformity and reduces cold bridging
- Internal system minimises disruption and cost
- By warming the inner surface, the property will “feel” warmer
- Improves response to heating input when heated intermittently

Questions?

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