Energy Saving Trust
Report

ENERGY SAVING TRUST

Product Performance Verification

Report updated August 2019

Client: Safeguard Europe Ltd
Address: Redkiln Close, Horsham, West Sussex, UK, RH13 5QL

This report constitutes an evaluation of the performance of the products:

Stormdry Masonry Protection Cream

hereinafter referred to as **the Product**.

Manufactured and Distributed by:

Safeguard Europe Ltd, Redkiln Close, Horsham, West Sussex, UK, RH13 5QL

hereinafter referred to as **Safeguard Europe**.

The Energy Saving Trust, 30 North Colonnade, London, E14 5GP, hereinafter referred to as **EST**, author the report**.**

CONTENTS

1. Background

The Energy Saving Trust (EST) is the UK's leading independent and impartial organisation in the domestic energy sector. Our internationally renowned services are underpinned by the very best evidence, research and evaluation, and delivered by highly skilled and experienced specialists in the field.

We have an outstanding record of accomplishment for delivery, whether leading programmes on behalf of UK wide governments, the European Commission or working alongside businesses.

EST offers a range of services relating to the evaluation and verification of the performance of energy efficiency and renewable technology. EST Product Verification is a bespoke service, designed to assist businesses in communicating the energy and performance benefits of their products. The process involves the independent verification of a product's performance characteristics followed by the development of factual, informative, consumer-facing claims for use in promotional marketing materials.

EST carried out a desk evaluation of the Product's waterproofing behaviour and impact on thermal performance based on evidence supplied by Safeguard Europe.

Safeguard Europe requested product performance verification from EST on the basis of the evidence submitted that the Product:

- prevents the ingress of moisture into masonry and reduces the moisture content of that masonry
- improves the thermal and energy performance of buildings, and reduces running costs
- offers other advantages such as a low upfront cost and preservation of the existing building aesthetic (no impact on appearance of the building)

This report represents the outcomes this independent of the development of consumer-facing claims, based on the verification findings, for use in marketing materials, with relevant supporting caveats.

2. Product Description

STORMDRY

Stormdry External Waterproofing Coating is an external wall waterproofing product manufactured by Safeguard Europe. The product claims to enhance water resistance and energy performance by creating a breathable water-repellent barrier on the masonry surface. It is asserted that increased moisture levels of masonry wall directly correlates to a lower thermal resistance.

3. Supporting evidence and evidence review

Safeguard Europe supplied a range of product performance data, including laboratory testing, field trial data and calculations of thermal performance. The documents provided and reviewed are as follows:

1. Giraffe: brief evaluation of water repellent surface protection for masonry, and potential energy requirements in space heating. Giraffe Innovation Dr Sibylle Frey and Mark Dowling, 17 October 2011
2. Estimates of Energy Saving with Stormdry: Laboratory report 9th December 2009
3. James MacMullen et al (2011) Brick and mortar treatment by cream emulsion for improved water repellence and thermal insulation, Energy and Buildings 43 (2011) 1560–1565
4. CLR Case Study 1A+B: Hydrophobic Brick Cream on Solid Wall + IWI (Internal wall insulation)
5. British Board of Agreement (BBA) test report No 53232
6. Paper for submission for "Retrofit 2012" prepared by Dr. Eric Rirsch (Safeguard) and Dr Zhongyi Zhang (University of Portsmouth) Energy Saving from Water Repellents
7. Heat Loss Savings from the Treatment of Masonry with Water Repellents - Feasibility Study: Stormdry Laboratory report April 2008
8. Tests on Stormdry Such Mur Icopal and Dryzone Suchy Mur Icopal products for Technical Recommendation purposes
   Phase I Report on tests on the product Stormdry Suchy Mur Icopal for Technical Recommendation purposes

3.1 Evidence A

Test report reference:	A brief evaluation of water repellent surface protection for masonry, and potential energy requirements in space heating.
Dated:	17 October 2011
Laboratory name:	Giraffe Innovation Ltd
Laboratory address:	Unit 5, Tungsten Building George Street Portslade Brighton BN41 1RA
Laboratory accreditation and date:	N/A
Test standard(s):	N/A

This report contains a peer review of selected literature, results of a SAP CO_2 model for a "typical house", a high-level life cycle carbon assessment of the Product's production and an estimate of the carbon savings arising from lower space heating requirements.

The SAP CO_2 emissions modelling is prepared for one sample home. The model estimates that a home treated with the Product will demonstrate a 23% saving in CO_2 emissions compared with an untreated home. EST cannot comment on the validity of these claims based on the evidence submitted as only the results are provided in this report. These are based on modelling in "Safeguard laboratory report no.18".

The report gives the carbon footprint of the production and use of Stormdry as 0.73 kg CO_2e per meter square treated.

EST cannot comment on the validity of these results as the methodology for calculating this has not been provided.

3.2 Evidence B

Test report reference:	Estimates of Energy Saving with Stormdry
Dated:	9 December 2009
Laboratory name:	Safeguard Europe
Laboratory address:	Redkiln Close Horsham West Sussex, UK RH13 5QL
Laboratory accreditation and date:	N/A
Test standard(s):	N/A

This report shows the inputs and results from the SAP modelling of two modelled homes, located at 1 Safe Street. The worksheets show that the home was modelled using SAP 2005 for a semi-detached house with a floor area of 73.6 sqm and a gas boiler with SEDBUK efficiency of 83%. These are reasonable and conservative assumptions to use when modelling the energy use of a typical semi-detached home in Great Britain.

To calculate energy saved, the paper compares the energy use of the same dwellings, but varying the U-value of the external walls from 3.16 $Wm^{-2}K^{-1}$ to 1.91 $Wm^{-2}K^{-1}$. Effectively this assumes a 40% reduction in heat loss through the walls. No justification is given in the report as to how these U-values were chosen. RdSAP recommends a U-value for solid walls of 2.1 $Wm^{-2}K^{-1}$ significantly lower than the assumed U-value in the base case.

No definitive statements about the amount of energy a whole house can save were made based on these claims.

3.3 Evidence C

Test report reference:	Brick and mortar treatment by cream emulsion for improved water repellence and thermal insulation, Energy and Buildings 43 (2011) 1560–1565
Dated:	28 February 2011
Laboratory name:	Advanced Polymer and Composites Research Group
Laboratory address:	Department of Mechanical and Design Engineering University of Portsmouth Portsmouth, Hampshire, PO1 3DJ, UK

Laboratory accreditation and date:	Unknown
Test standard(s):	BS EN 771-1: 2003 Specification for masonry units. Clay masonry units. BS EN 828: 1998 Adhesives. Wettability. Determination by measurement of contact angle and critical surface tension of solid surface

This journal article presents results from a laboratory test whereby a small model "house" was built from 2 courses of 4 bricks (8 bricks in total), placed inside an environmental chamber. A lightbulb, acting as a heater and thermostatic control, was placed inside the house. Recordings of electricity consumption of the bulb measured the energy required to maintain the internal temperature of the house. Further recordings measured the electricity consumption after changing external humidity and temperature, with Product applied and not applied to the external brickwork.

A secondary laboratory test measured the change in the mass of Frogged London Bricks and mortar, following test procedure *BS EN 828: 1998 Adhesives. Wettability. Determination by measurement of contact angel and critical surface tension of solid surface*. Measurements of the absorbency of the material were recorded after submerging in a tank of water for 24 hours with and without application of the Product.

The results demonstrated that substrates with the Product applied, where the external humidity was 10% relative humidity, reduced thermal conductivity of the substrate. It follows that reducing the energy used in the model house to maintain the internal temperature at 20 °C by 55.8-48.9% in wet conditions when the external temperature was -5 and 5 °C respectively. It showed energy reduction of 2.4% at -5 °C externally in dry conditions and 5.4% at 5 °C.

As noted in the report, the savings from this modelled house can in no way be directly extrapolated actual homes in-situ. For various reasons the model house does not reflect the conditions of a real home with varying heating demand throughout the year experiencing variable precipitation and humidity. A major difference is the ratio in the model home of the heated volume to the heat loss area. As estimated in the two figures below, the model house has approximately 18 times the relative heat-loss-wall to volume area compared to the 3-bedroom semi-detached house modelled in SAP.

Model lab house		
Internal width:	150	mm
Internal wall height	204	mm
*Internal wall area (*4)*	0.12	sqm
Internal volume	0.005	cubic meters
surface area to volume ratio:	26.7	/m

Model SAP scale house		
External wall area:	108.21	sqm
Volume:	73.6	cubic meters
surface area to volume ratio:	1.47	/m

This report indicates that brick treatments can reduce heat loss through "Frogged London Brick" walls.

3.4 Evidence D

Test report reference:	CLR Case Study 1A+B: Hydrophobic Brick Cream on Solid Wall + IWI (Internal wall insulation)
Dated:	11 August 2016
Laboratory name:	n/a
Laboratory address:	n/a
Laboratory accreditation and date:	n/a
Test standard(s):	n/a

This evidence reports the measurements over a four-year period of moisture levels on a solid wall, insulated in situ with an open cell PUR foam sprayed between timber battens.

An issue of concern is that the insulation reduces heat flow to the external walls from inside the building, allowing more water vapour to condense within the masonry. This may lead to structural issues related to damp. The report presents analysis of moisture sensors installed in the brick work where half of a west facing wall was treated with an unspecified hydrophobic brick treatment, the other half remains untreated.

It is noted in the report that a limited number of sensors were in place due to funding constraints, caution is required when drawing conclusions.

The report concludes that the unspecified hydrophobic brick cream appears to reduce rain load. It also states that the interface between the brick and the insulation is about 12% WME in the treated area compared to 18% in the untreated area, but again notes that the microwave survey shows a fair amount of variation so may not be completely representative.

The report does not confirm that the hydrophobic brick treatment is the Product. The result is that no definitive claims about the Product were made because of this report.

3.5 Evidence E

Test report reference:	British Board of Agrément (BBA) test report No 53232
Dated:	17 December 2014
Laboratory name:	British Board of Agrément
Laboratory address:	Bucknalls Lane, Garston Watford, Hertfordshire WD25 8BA

Laboratory accreditation and date:	UKAS 0357: ISO 17025:2005 16 November 2018
Test standard(s):	BS EN 12572 : 2001 Hygrothermal Performance of Building Materials and Products – Determination of water vapour transmission properties BS EN ISO 4892-3 : 2000 Plastics – Methods of exposure to laboratory light sources

This report presents the results of tests undertaken by the British Board of Agrément (BBA) on the Product. The test assessed two key product aspects, namely:

1. Water vapour transmission; Water absorption coefficients by partial immersion for various substrates treated and untreated by the Product. The tests also assessed the depth of penetration of the Product into the materials and the drying time of the bricks after saturation. The masonry substrates tested were:

- Beestone blocks (red sand stone)
- Concrete
- Mortar
- Mortar with repointing additive
- Milton Buff brick

2. The performance of the Product to inhibit absorption of water after prolonged exposure to UV and post freeze-thaw conditioning.
   Milton Buff brick was used as the substrate for both conditioning.
   There was a significant reduction in water absorption, and even after exposure to UV, the increase in water absorption was small. The results demonstrate that the Product slows the rate at which the bricks dry.
   There was a significant reduction in water absorption, and even after exposure to freeze-thaw cycles, the increase in water absorption was small. The results demonstrate that the Product slows the rate at which the bricks dry.

This report shows that the Product can inhibit the absorption of water into red sand stone, concrete, mortar and Milton Buff bricks. It suggests that the Product can also inhibit the drying of saturated bricks.

This report further demonstrates that the Product is resistance to freeze-thaw and UV exposure.

3.6 Evidence F

Test report reference:	Paper for submission for "Retrofit 2012" prepared by Dr. Eric Rirsch (Safeguard) and Dr Zhongyi Zhang (University of Portsmouth) Energy Saving from Water Repellents
Dated:	n/a
Laboratory name:	n/a
Laboratory address:	n/a
Laboratory accreditation and date:	n/a

Test standard(s):	EN ISO 15148:2002 (E)

This paper contains a compilation of results from various reports. It shows evidence that the moisture content of masonry affects its thermal conductivity. It shows absorptivity test results of the Product across various substrates:

- Fletton brick
- West Hoathley brick
- Mortar (new and old)
- Blaxter sandstone
- York sandstone
- Sheffield sandstone
- Portland limestone
- Concrete paving
- Granite

In all of these samples, the Product test results demonstrate reduction in absorption, and this is of considerable amounts with the exception of Portland Limestone where the reduction is only marginal and granite, which is practically non-absorbent to begin with. It also shows the estimated energy savings modelled in SAP for homes with varying wall U-values.

The modelling shows that the heating requirement for a semi-detached home with U-values of 3.16 $Wm^{-2}K^{-1}$ to 1.91 $Wm^{-2}K^{-1}$. It would appear that this refers to the modelling shown in "Estimates of Energy Saving with Stormdry: Laboratory report 9th December 2009". Some justification for the conductivity value used for an exposed wall and a non-exposed wall, though the u-value of 3.16 $Wm^{-2}K^{-1}$is not evidenced entirely. As the paper states in reference to space heating requirements "it is difficult to model accurately". The paper also provides results from the paper: "Brick and mortar treatment by cream emulsion for improved water repellence and thermal insulation" discussed above.

No additional EST verified claims were determined from this report.

3.7 Evidence G

Test report reference:	Heat Loss Savings from the Treatment of Masonry with Water Repellents - Feasibility Study: Stormdry Laboratory report April 2008
Dated:	April 2008
Laboratory name:	N/A
Laboratory address:	N/A
Laboratory accreditation and date:	N/A
Test standard(s):	N/A

This paper was put together by Safeguard Europe in 2008 bringing together information from 4 reports, including ones produced by Fraunhofer and BRE Scotland, in order to model the energy savings achievable by having a waterproofing agent on the walls. The report explains the different ways that heat loss is affected by moisture, including graphing the relationship between conductivity and moisture content from a Portsmouth university report and the influence of latent heat of vaporisation. Savings estimates are provided, but these are crude as noted in the paper and could not be used for the purpose of consumer savings.

No additional EST verified claims were determined from this report.

3.8 Evidence H

Test report reference:	Tests on Stormdry Such Mur Icopal and Dryzone Suchy Mur Icopal products for Technical Recommendation purposes Phase I Report on tests on the product Stormdry Suchy Mur Icopal for Technical Recommendation purposes
Dated:	January 2012
Laboratory name:	Institute of Construction Technology (ITB)
Laboratory address:	Construction Materials Centre Ul. Filtrowa 1 00-611 Warsaw Poland
Laboratory accreditation and date:	PN-EN ISO/IEC17021 PKN-ISO/IEC TS 17021-2
Test standard(s):	PN-EN 1504-2:2006 Products and systems to protect and repair concrete structures. Definitions, requirements, quality control and suitability assessment.

PN-EN 1504-2:2006 Products and systems to protect and repair concrete structures. Definitions, requirements, quality control and suitability assessment.

This test programme included determination of the following technical and use properties of cement mortar, ordinary brick and natural sandstone after impregnation
of their surface with the Product: depth of product impregnation, water vapour permeability, water permeability, adhesion (separation resistance), resistance to the action of frost on a substrate made of cement mortar via cyclical freezing and unfreezing in de-icing salt.

The substrates tested were cement mortar, ordinary brick and natural sandstone, with and without application of the Product.

The results were as below:

	Depth of product impregnation (mm)	Diffusion resistance to water vapour (m)	Water permeability co-efficient ($kg/m^2 \cdot h^{0.5}$)	Adhesion (tear resistance) (MPa)
Cement mortar (untreated)	N/A	0.12	0.86	1.9
Standard brick (untreated)	N/A	0.18	2.9	1.5
Natural sandstone (untreated)	N/A	0.15	2.2	1.1
Cement mortar (treated with Product)	7	0.14	0.04	2.3 (2.1*)
Standard brick (treated with Product)	10	0.2	0.02	1.8
Natural sandstone (treated with Product)	1	0.17	1.9	1.6

* This result was recorded after 20 freeze-thaw cycles using de-icing salt. Surface appearance remained unchanged (no cracking observed)

The results demonstrate that the Product inhibits water ingress into the substrates, with minor impact on water vapour permeability. The results also demonstrate that the Product is resistant to frost impact with presence of de-icing salt.

It should be noted that application of the Product to natural sandstone did present a decrease in water permeability; but not by the significant levels demonstrated in cement mortar and standard brick.

4. EST Review of Quality Assurance Documentation

The scope of the EST Verification project for Safeguard Europe's Stormdry product included a document review to establish that a suitable Quality Management System (QMS) is in place, covering the manufacture of the product.

Quality Management Standard	ISO 9001:2015
Certificate Number	FM 01937
Date of Issue	15 February 2019
Date of Expiry	14 February 2022
Accrediting Body	BSI Assurance UK Ltd, 389 Chiswick High Road, London, W4 4AL, UK
Manufacturing Site	Safeguard Europe Ltd, Redkiln Close, Horsham, RH13 5QL, UK

The accrediting body for the certificate is BSI, and covers the Quality Management System implemented by Safeguard Europe who manufacture the Product.

The Quality Manual overseeing the Quality Management System has also been reviewed.

Additional supporting documents were submitted to EST for review, summarised as follows:

- BBA Assessment of Production, document reference 97/3363 AQP 18-09-2017
- Internal procedure "Stormdry colour check", document reference QC 20 dated 23.4.13
- Internal procedure "Stormdry Re-Pointing Additive No.1 Solids Test", document reference QC 32, dated 2.11.15
- Internal procedure "Stormdry Viscosity Test", document reference QC 10, dated 24.8.16

Having reviewed this documentation EST have concluded that Safeguard Europe maintains an appropriate QMS, subject to ongoing audit by both BSI and the BBA.

5. Conclusions and verification of performance claims

Moisture has an adverse effect on thermal performance of walls. Moisture typically travels through walls in two ways:

1. As water vapour from inside, due to the high concentration of water vapour created in the home.
2. As liquid water from outside, due to exterior weather conditions.

Water ingress can increase heat loss through walls, with the amount of heat loss dependent on wall construction, physical characteristics, background moisture content and the amount and frequency of ingress.

Preventing water ingress by applying a super hydrophobic exterior coating can therefore reduce heat loss through certain wall constructions. To function effectively, these coatings need to be sufficiently vapour permeable to allow water vapour to pass through the wall. This helps prevent build-up of moisture in the wall.

Safeguard Europe have provided independent test data in support of the performance claims of the Product, comprising independent test data and academic reports. EST can verify three claims outlined below, based on the evidence submitted.

All statements are correct as of August 2019 and valid for 12 months, subject to the terms and conditions of the *Energy Saving Trust Verification Licence Agreement*.

Please follow application guidelines.

Water resistance

Claim
The Product can inhibit the absorption of water into red sand stone, concrete, mortar and Milton Buff bricks, which could help prevent high moisture level in walls.

Caveat
The extent of which the Products could maintain lower levels of moisture content in walls will be determined by wall material construction, physical characteristics and the pre-existing water content.

Explanation
3.5 Evidence E This report presents the results of tests undertaken by the British Board of Agrément (BBA) on Stormdry Masonry Protection Cream. The test assesses water vapour transmission; Water absorption coefficients by partial immersion for various substrates treated and untreated by Stormdry. The tests also assessed the depth of penetration of Stormdry into the materials and the drying time of the bricks after saturation. The masonry substrates tested were: Beestone blocks (red sand stone), concrete, mortar, mortar with repointing additive and Milton Buff brick.

3.8 Evidence H provided supporting evidence to this claim, with substrates cement mortar, standard brick and natural sandstone. Application of the Product to cement mortar and standard brick demonstrated inhibition to water absorption into the substrate, although it must be noted that application of the Product to natural sandstone did not reduce water permeability of the substrate to acceptable levels. Therefore, wall material construction, physical characteristics and pre-existing water content should be determined before application of this Product.

Longevity/durability

Claim
The Product will continue to inhibit water ingress despite exposure to severe weather, including sunlight exposure and freezing temperatures.

Caveat
The Product did not demonstrate any loss to performance when one substrate was conditioned under UV exposure and freeze-thaw cycles. The extent of which this claim can be made across other substrates would be determined by the wall material construction, and other exposure factors may influence water content.

Explanation
The masonry substrates tested were Milton Buff brick.

The Product satisfies the requirements *of BS EN 12572: 2001 Hygrothermal Performance of Building Materials and Products*, as per the results of *3.5 Evidence E*. The tests reviewed the performance of the Product to inhibit absorption of water after prolonged exposure to UV and freeze-thaw cycles. Very minor negative effects were demonstrated after extended UV exposure, and no noticeable trend to performance of the Product was demonstrated after freeze-thaw cycles.

Supporting evidence presented in *3.8 Evidence H* demonstrated similar results after freeze-thaw conditioning.

Heat loss

Claim
To follow on from the water resistance claim:
This could help reduce heat loss in many wall constructions, leading to lower heating requirements.

Or as a stand-alone claim:
The Product can inhibit the absorption of water into many wall constructions, which can help improve the energy efficiency of dwellings by reducing heat loss, leading to lower heating requirements.

Caveat
The extent of which the Product could achieve a reduction in heat loss via the walls will be determined by wall material construction, physical characteristics,

exposure and other factors influencing water content. The heating requirements of the building may further influence the extent of this claim.

Explanation
Appendix 1 provides a literature overview, documenting various evidence in support that moisture has an adverse effect of the thermal performance of walls.

Overview

The evidence provided about the Product demonstrates via independent testing that:

- Dry masonry has a lower thermal transmittance than wet masonry
- A non-specified water repellent can reduce heat loss through Masonry (frogged London bricks) when applied
- The Product can inhibit the absorption of water into red sand stone, concrete, mortar and Milton Buff bricks
- The Product may also inhibit the drying of saturated bricks

The results of the laboratory testing are supportive that the Products will reduce water ingress into masonry walls with minimal effect to the water vapour permeability of the materials.

It follows that, in certain cases, treating walls with the Product could lower heat loss through the walls.

It is noted that only two of the test reports from independent sources (*3.5 Evidence E and 3.8 Evidence H*) directly relate to Product, neither testing specifically for the energy performance of the product.

Finally, it should be noted that no situational testing results were available, explicitly demonstrating that the application of the Product improves the thermal performance of walls when applied to an actual dwelling with typical UK domestic heating requirements.

APPENDIX A: MOISTURE CONTENT AND THERMAL PERFORMANCE OF SOLID WALLS – LITERATURE REVIEW

Overview

This literature review explores the existing research and evidence around how the moisture content of walls/substrates affects their thermal performance. The review investigates the common sources of moisture in walls and looks at the impacts of external coatings.

Key conclusions:

- It is well documented that **moisture has an adverse effect on thermal performance** of walls.
- **Uninsulated solid wall properties have poor thermal performance**; almost a third of the UK housing stock is comprised of this property type.
- Although the effects of **moisture are accounted for in technical design guidance,** findings from field trials show that **solid walls have a lower heat loss rate** than predicted.
- **Local climate and the exposure or protection of the walls affects their thermal performance**. Driving rain is particularly prevalent across the North and West coasts of Britain.
- **Thermal performance is affected by physical properties** of the wall. These include the substrate material, mortar material, and wall construction type

Glossary of Terms

Thermal Transmittance (U-value) A measure of how effective a material is an insulator (W/m^{2}K). The lower the U-value is, the better the material is at stopping heat flow.

Thermal Conductivity (λ – value): The property of a material to conduct heat (W/mK). The lower the thermal conductivity is, the better the material is as a heat insulator.

Moisture affects the thermal performance of walls

Increased moisture content within masonry can increase heat loss through a wall[1].

Measurements of damp masonry have shown that heat loss is significantly higher than when it is dry. A test on London Bricks by the University of Portsmouth have shown that with 15% moisture content the U-value of the brick was approximately 1.4 $W/m^2.K$, compared to 0.6 $W/m^2.K$ at 0% moisture content[2]. This represents a heat loss reduction of over 50% (though this is not representative of real world situations, as 0% moisture content is not achievable in buildings). The laboratory tests found that waterproofing treatments resulted in different amounts of heat loss, depending on the substrate they were applied to.

Similarly, the School of the Built Environment and Engineering at Leeds Metropolitan University found a general correlation between wall moisture content and U-value. The experiment measured the U-values and moisture contents of the brick walls in a UK solid brick wall property. Moisture readings were grouped into dry (below 20% wall moisture content), medium (20-70%) and wet (70%). The study found that dry walls wall generally had lower U-values and that walls that had over 20% moisture content were less thermally efficient[3].

> *"The amount of moisture present in the fabric of a building has long been recognised as an important factor in influencing a U-value, and interpretation of a measured U-value is often accompanied by a measurement of moisture content"*
>
> *– Building Research Establishment*

[1] Solid wall heat losses and the potential for energy saving: Literature review. BRE, 2014

[2] Energy saving from water repellents. Rirsch, E. and Zhang, Z. University of Portsmouth.2012

[3] Comparison of moisture survey and U-values for a UK 220mm solid brick wall. Melanie B Smith. School of the Built Environment and Engineering, Leeds Metropolitan University

Moisture is accounted for in the technical guidance

The moisture levels of walls and its effect on thermal performance is accounted for in technical guidance, such as the CIBSE Environmental Design guide[4], the premier technical/reference source for designers and installers of building services. The CIBSE guide provides standard moisture contents for masonry and recommends thermal conductivity values for both 'exposed' and 'protected' bricks.

The CIBSE Environmental Design Guide states a typical moisture content of 5% for 'exposed' brickwork and a typical moisture content of 1% for 'protected'

Table 3.2 'Standard' moisture contents for masonry

Material	Moisture content	
	Protected	Exposed
Brick (fired clay)	1% (by volume)	5% (by volume)
Brick (calcium silicate)	1% (by volume)	5% (by volume)
Dense aggregate concrete	3% (by volume)	5% (by volume)
Blast furnace slag concrete	3% (by weight)	5% (by weight)
Pumice aggregate concrete	3% (by weight)	5% (by weight)
Other lightweight aggregate concrete	3% (by weight)	5% (by weight)
Autoclaved aerated concrete	3% (by weight)	5% (by weight)

Note: % (by volume) = % (by weight) × density/1000

brickwork, as shown in Table 1. Please note that this is much lower than the moisture contents found in the experiment by Leeds Metropolitan University detailed above. The difference in moisture content is reflected in the thermal conductivity values stated by the guide. A thermal conductivity of 0.77 W/m·K is stated for 'exposed' bricks and 0.56 W/m·K is stated for 'protected' bricks. This indicated that protected masonry has lower heat loss.

This difference in thermal conductivity can have a significant influence on the U-value of a typical nine-inch solid wall. For instance, a typical exposed solid wall might be expected, using current calculation methods, to have a U-value in the region of 2.1 W/m²K, but if the same wall was considered 'protected' its U-value would be expected to drop to around 1.8 W/m²K. This represents a 14% decrease in thermal transmittance.

[4] CIBSE Guide A: Environmental Design

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Note: % (by volume) = % (by weight) × density/1000

Table 1: Standard masonry moisture contents, CIBSE Guide A: Environmental Design

Moisture primarily comes from outside

Lstiburek and Carmody[5] outline the four primary mechanisms of moisture transfer in buildings. These are air movement, vapour diffusion, liquid flow and capillary suction.

The first two mechanisms: air movement and vapour diffusion, deal with moisture as water vapour in the air. In cold climates, such as the UK, where the building is heated relative to the colder outside temperature, the natural movement of moisture in the air is from the building interior to exterior.

The final two mechanisms: liquid flow and capillary suction, deal with liquid water. They are the most significant factors in the wetting of building fabrics, and usually occur as water penetration by rainwater or groundwater. These mechanisms are particularly prevalent across the North and West coasts of Britain, exposed to the most severe driving rain[6], represented by the green shades in Figure 1.

The primary source of moisture in walls typically comes from rain penetrating the exterior surface through the mortar joints.

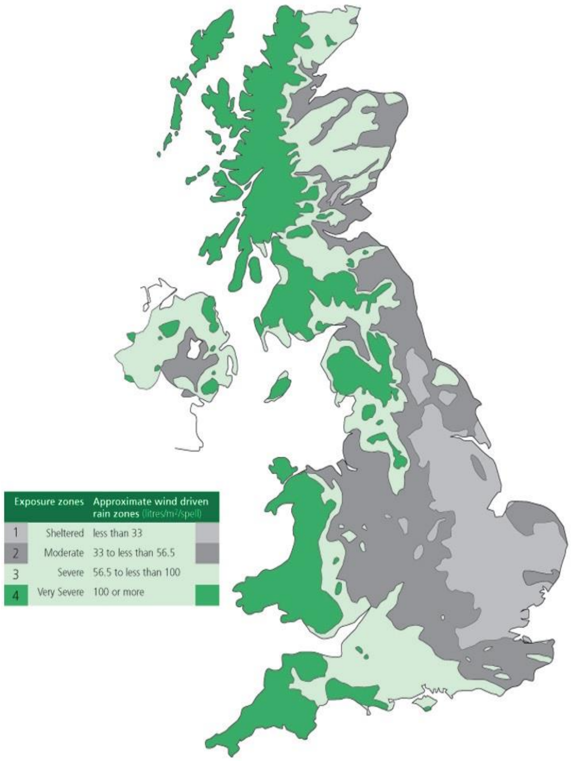

Figure 1: UK Exposure Zones

BRE Centre for Sustainable Design of the Built Environment in the Welsh School of Architecture at Cardiff University conducted a field trial investigating the effects of insulation on solid walls[7]. The trial monitored five buildings with thick stone walls before and after the application of various types of insulation. The main findings of this trial were that the primary source of moisture in the walls was from rain penetrating the exterior surface, and the main route for water through the wall was provided by the mortar joints between the stones.

These findings are supported by English Heritage's research[8] that found that poor thermal performance tends to be in cases where the wall has been saturated by prolonged rain ingress. English Heritage highlight the need to keep buildings in a good state of repair.

It should be noted that the amount of moisture ingress is likely to be affected by the substrate and type of mortar, there will be differences between brick and stone due to their different porosities.

[5] Lstiburek, J. & Carmody, J. (1991) Moisture Control Handbook: New, Low-rise, Residential Construction.
[6] BS EN 8104:1992 Code of practice for assessing exposure of walls to wind-driven rain.
[7] BRE Centre for Sustainable Design of the Built Environment in the Welsh School of Architecture at Cardiff University.
[8] Research into the Thermal Performance of Traditional Brick Walls. English Heritage, 2013.

Coated walls perform better than uncoated walls

Measurements taken by Historic Scotland Conservation Group on a garden bothy made of sandstone[14] found that internally coated walls had a better thermal performance than uncoated walls. The 600mm thick walls were finished with plaster on lath in nine locations, and one with dry lining. Resultant U-values ranged from 0.9 to 1.3W/m2.K. Measurement of the same wall without any finishes resulted in a U-value of 2.4W/m2K. The study determined that part of this differential was a result of changed moisture levels in the wall.

There have been similar findings from studies of external wall insulation. A field trial by BRE and Cardiff University[9] found that rain penetration and moisture content in the external wall diminished after external insulation was applied.

Supporting evidence indicating that exterior coatings can reduce moisture ingress has been provided. A comparative test of the Products applied to a wall constructed from Wienerberger Red Brick against an untreated section of the same wall. Following water spray testing on the exterior to simulate driving rain, the interior of the wall was demonstrably dryer that the untreated section of wall. Thermal imaging also showed that the wall was warmer on the inside.

The vapour permeability of exterior coatings is of importance. A non-permeable coating on the outside of a wall can trap moisture within the wall. To prevent deterioration of the substrate due to trapped water it is important to understand the moisture permeability of the wall with and without the coating[10].

[9] BRE Centre for Sustainable Design of the Built Environment in the Welsh School of Architecture at Cardiff University

[10] Goossens, E. L. J., Van der Zanden, A. J. J., & Van der Spoel, W. H. (2004). The measurement of the moisture transfer properties of paint films using the cup method. Progress in organic coatings, 49(3), pp. 270-274

Variables that affect energy performance of coatings

Substrate
Moisture absorbency depends on the physical characteristics of the substrate. Tests by Portsmouth University have shown that the application of water repellent coatings has varying impact on the absorption of moisture by different substrates[11]. This means that the effectiveness of a water repellent coating in terms of its energy saving potential would also be dependent on the type of substrate to which the coating was applied. The thermal conductivity of bricks is largely affected by the physical characteristics of the brick. Lower density materials performed better in thermal testing[12]. However, lower density brick can also absorb more moisture and displayed higher wet thermal conductivity than dense bricks.

Wall construction type

The percentage reduction in the heat-loss through a wall achieved by applying a waterproof coating would vary depending on the initial thermal performance of the walls to which they are applied. As with insulation, when applied to a wall with a good thermal performance, the percentage reduction in heat loss will be smaller than when applied to a wall with poor thermal performance. Additionally, application of a layer of insulation is likely to impact on moisture penetration of the wall in some way, depending on the characteristics of the materials used and their location within the wall structure.

Existing moisture content of the wall

The extent to which a waterproof coating can help reduce energy loss will depend on the propensity of the wall to contain high levels of moisture in the first place. As mentioned formerly, the CIBSE Environmental Design guide indicates typical moisture content varies depending on whether the brickwork is protected or sheltered. Moisture content will also vary both seasonally and by location, which is likely to affect product performance.

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[11] Energy saving from water repellents. Rirsch, E. and Zhang, Z. University of Portsmouth.2012
[12] Research into the Thermal Performance of Traditional Brick Walls. English Heritage, 2013.