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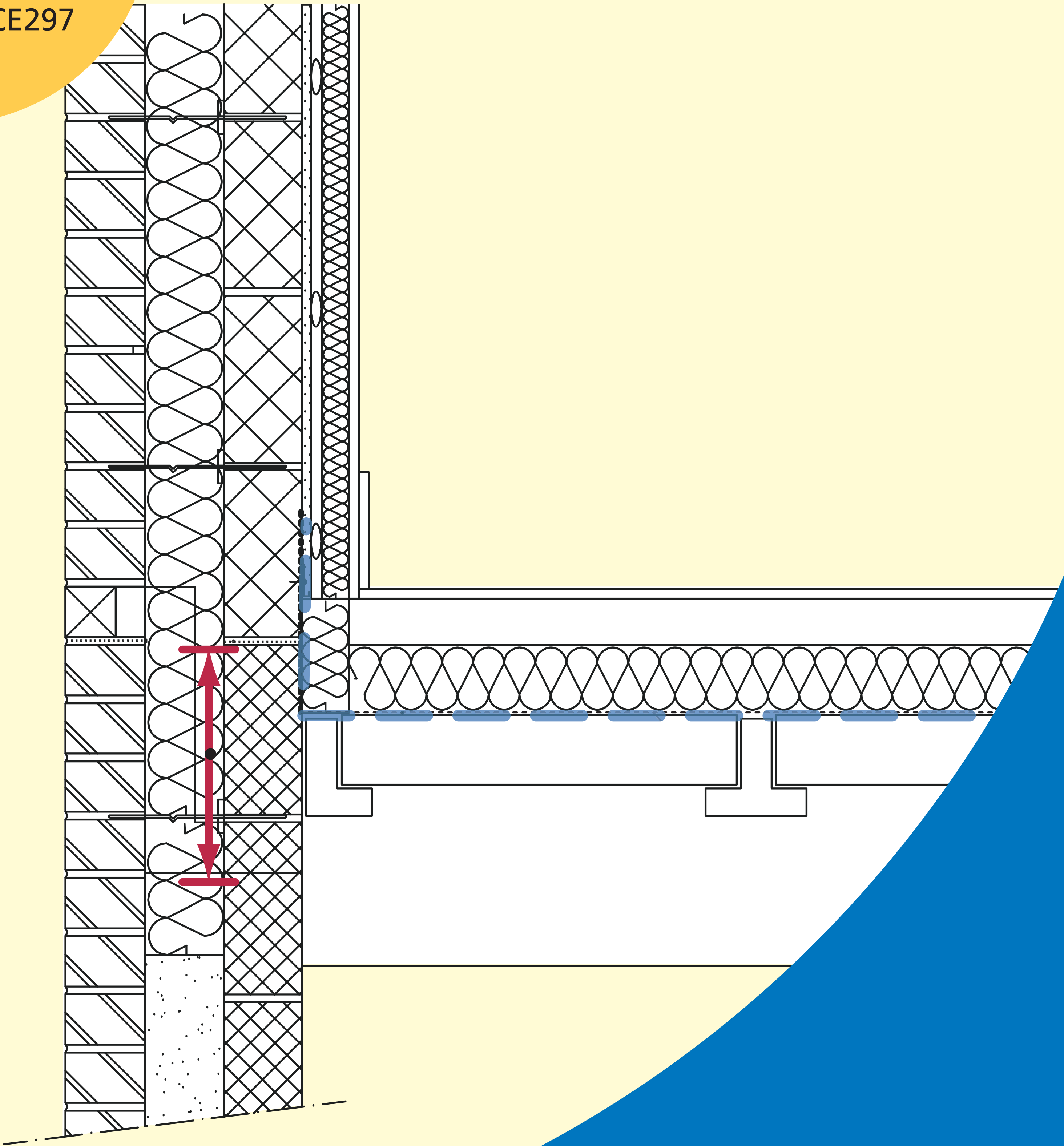

Enhanced Construction Details: introduction and use

energy saving trust®

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Executive summary

This guide describes how to use the Energy Saving Trust Enhanced Construction Details. It aims to help housing designers, specifiers and builders gain credit for reducing heat loss through the non-repeating thermal bridges that occur between building elements, at corners and around openings.

Around 30% of the total heat lost through a building's fabric can be as a result of thermal bridging. And research shows that a dwelling's annual CO_2 emissions can be reduced by up to 10% with better detailing and improved airtightness.

The design principles used in this document can improve the performance of Accredited Construction Details such as lintels, wall-to-floor junctions and ceiling-to-gable-wall junctions by over 85%. Non-repeating thermal bridging is specifically included in SAP 2005 and therefore forms part of building regulations compliance in England, Wales, Northern Ireland and Scotland.

Using the Energy Saving Trust Enhanced Construction Details – whilst also ensuring that all remaining details are at least as good as Accredited Construction Details – will allow for a value of $y = 0.04\ W/m^2K$ to be used in SAP 2005.

This document introduces the Enhanced Construction Details (ECDs) and their use. The ECDs themselves are available to download via the helpful tools section on our website.
See www.energysavingtrust.org.uk/housing

This publication (including any drawings forming part of it) is intended for general guidance only and not as a substitute for the application of professional expertise. Any figures used are indicative only. The Energy Saving Trust gives no guarantee as to levels of thermal transmittance or heat loss, the reduction of carbon emissions, energy savings or otherwise. Anyone using this publication (including any drawings forming part of it) must make their own assessment of the suitability of its content (whether for their own purposes or those of any client or customer), and the Energy Saving Trust cannot accept responsibility for any loss, damage or other liability resulting from such use.

So far as the Energy Saving Trust is aware, the information presented in this publication was correct and current at the time of the last revision. To ensure you have the most up to date version, please visit our website: www.energysavingtrust.org.uk/housing. The contents of this publication may be superceded by statutory requirements or technical advances which arise after the date of publication. It is your responsibility to check latest developments.

Enhanced Construction Details: introduction and use

1. Introduction

Home energy use is responsible for over a quarter of UK carbon dioxide (CO_2) emissions which contribute to climate change. To help mitigate the effects of climate change, the Energy Saving Trust has a range of technical solutions to help UK housing professionals build to higher levels of energy efficiency.

To achieve overall energy efficiency, our housing guidance promotes high levels of insulation and airtightness in new dwellings as part of an integrated approach to housing design embracing the building fabric, heating and hot water systems, ventilation and lighting. All our information is available from www.energysavingtrust.org.uk/housing

The Energy Saving Trust developed the Enhanced Construction Details (ECDs) with an industry working group to improve on the existing Accredited Construction Details (ACDs), and enables designers and developers to achieve further reductions in heat losses from dwellings.

This guide is intended for housing designers, specifiers and builders with previous knowledge of:

- Approved Document L1 – Conservation of fuel and power, in England and Wales[1].
- Technical Booklet F1 – Conservation of fuel and power, in Northern Ireland[2].
- Section 6: Energy, of the Domestic Technical Handbook, in Scotland[3].

It sets out how to use the ECDs and how to gain credit in SAP 2005 for the improved thermal performance they deliver.

2. The significance of detailing

Traditional design and construction practice has concentrated on insulating exposed walls, floors and roofs of buildings in order to reduce their thermal transmittances (U-values). Until recently there has been little attention given to the heat losses that occur at the junctions between construction elements and around openings – or because of uncontrolled air leakage. Unless measures are taken to limit thermal bridging at junctions and improve the airtightness of the building fabric as a whole, the proportion of the total heat loss attributable to these causes is likely to increase as standards of insulation have improved.

For typical dwelling designs built to meet the 2006 Building Regulations, heat losses from thermal bridging at junctions, corners and around openings account for around 30% of the total fabric heat losses. Paying attention to construction detailing has therefore become increasingly important in order to achieve appropriate standards of overall energy efficiency. Simply assessing heat losses through the main areas of walls, roofs and floors by calculating U-values is no longer sufficient. The building regulations for England and Wales, Northern Ireland and Scotland now recognise the importance of considering the additional heat loss from construction details and recommend the use of ACDs (or similarly performing details) in new dwellings and extensions.

3. Dwelling energy assessments

Non-repeating thermal bridges are taken into account in the Government's Standard Assessment Procedure for Energy Rating of Dwellings (SAP 2005). They therefore have an influence on the Dwelling CO_2 Emissions Rate (DER) used to demonstrate compliance with the building regulations in England, Wales, Northern Ireland and Scotland.

Pages 5 and 6 show two primary ways to assess the effect of this additional heat loss in a specific dwelling.

1. England and Wales: The Building Regulations 2000, Conservation and power, are detailed in Approved Document L1A (2006 Edition). See www.planningportal.gov.uk

2. Northern Ireland: Building Regulations (Northern Ireland) 2000, are detailed in Technical booklet F1 2006, Conservation of fuel and power in dwellings. See www.dfpni.gov.uk

3. Scotland: Section 6: Energy, of the Domestic Technical Handbook outlines possible ways of complying with the Building (Scotland) Regulations 2007. See www.sbsa.gov.uk

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1. When known, the Ψ-value for each detail in the dwelling design can be multiplied by its length ($\ell \times \Psi$) to establish the rate of heat loss through that specific bridge. The heat loss of the dwelling due to all thermal bridges (H_{TB}) is then the sum of ($\ell \times \Psi$) for all the construction details that include thermal bridges, as defined in the following equation:

$$H_{TB} = \sum(\ell \times \Psi)$$

Total heat loss due to non-repeating thermal bridges – known as thermal bridge transmission heat loss

Sum of heat loss through all individual non-repeating thermal bridges

If the design uses ACDs[4], or ACDs (Scotland)[5], a set of default Ψ-values (table 1) can be used. Alternatively, if ACDs are not being used, the calculation of their Ψ-values and temperature factors should be determined from numerical modelling (in accordance with BR 497)[6] or from measurement.

Table 1: Default values of Ψ for junctions in wall constructions in Accredited Construction Details

Junction detail in external wall	Default Ψ-value (W/m²K)
Steel lintel with perforated steel base plate	**0.50**[3]
Other lintels (including other metal lintels)	**0.30**
Ground floor	**0.16**
Balcony between dwellings[1] [2]	0.04
Eaves: insulation at ceiling level	0.06
Eaves: insulation at rafter level	0.04
Gable: insulation at ceiling level	**0.24**
Gable: insulation at rafter level	0.04
Corner: normal	0.09
Corner: inverted	-0.09
Party wall between dwellings [1]	0.06

(1) For these junctions half of the Ψ-value is applied to each dwelling.

(2) This is an externally supported balcony (i.e. the balcony slab is not a continuation of the floor slab) where the wall insulation is continuous and not bridged by the balcony slab.

(3) Details in **bold** are the worst performing details and have been improved in the set of ECDs.

4. Further details regarding ACDs for England and Wales can be found on the Planning Portal. See www.planningportal.gov.uk

5. Further details regarding ACDs for Scotland can be found on the Scottish Building Standards Agency website. See www.sbsa.gov.uk

6. Tim Ward and Chris Sanders 'Conventions for calculating Linear thermal transmittance and Temperature factors' BR497 BRE Press, Watford. Available from www.brebookshop.com

2. If the lengths or Ψ-values for each detail are unknown, a default heat loss coefficient for junctions can be used. This uses a fraction, known as the default y-value, to estimate the heat loss due to thermal bridging. This is defined in the following equation:

$$H_{TB} = y x \Sigma A_{exp}$$

Total heat losses through non-repeating thermal bridges

y = 0.08 If all details are Accredited Construction Details (or calculated to be equivalent following numerical modelling)

y = 0.15 If any details are not Accredited Construction Details

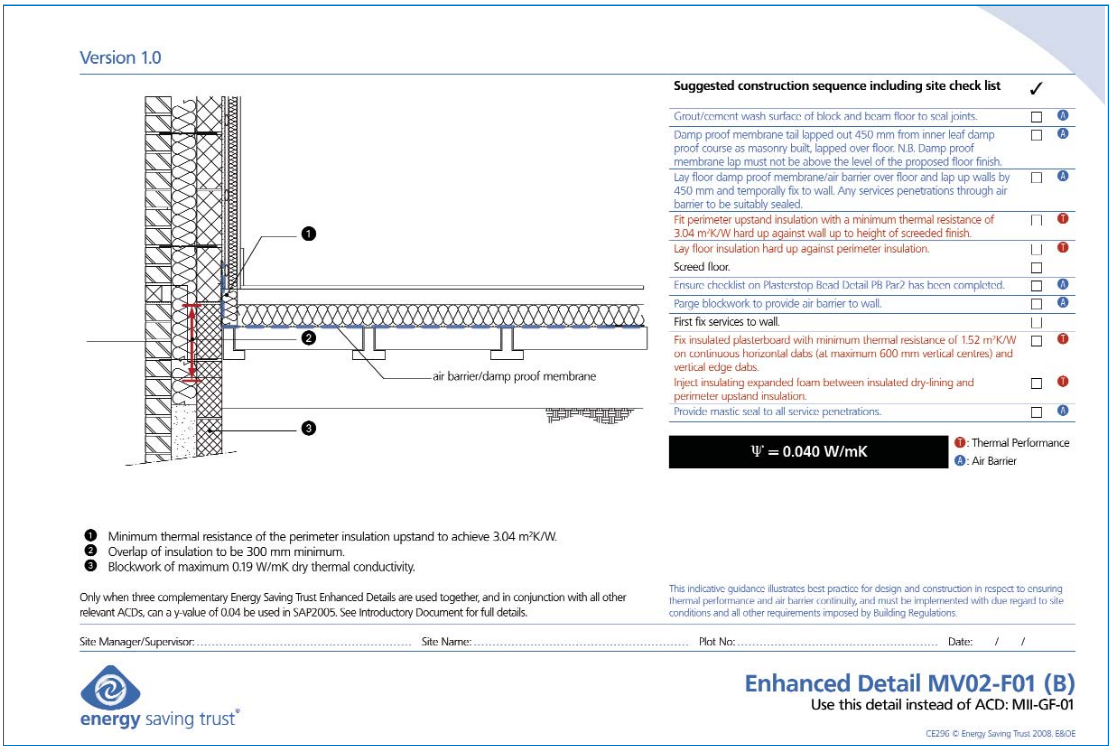
Sum of the area of all exposed elements

This second approach means that the heat loss due to thermal bridging can be estimated by simply using the y-value and the total area of exposed elements. Previously only two default y-values were available:

- y = 0.08 W/m²K when ACDs or ACDs (Scotland) are used; or
- y = 0.15 W/m²K when non-accredited details are used.

However from April 2008, it has become possible to enter a user-defined y-value in SAP 2005. The set of ECDs enables a designer to take advantage of using such a y-value appropriate for a design that conforms to specification. See figure 1 for a sample detail.

By using details that conform to the Energy Saving Trust ECDs and ensuring that all remaining details are at least as good as ACDs, you will be able to use a value of y = 0.04 W/m²K in SAP 2005.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Suggested construction sequence including site check list	✓	
Grout/cement wash surface of block and beam floor to seal joints.	☐	A
Damp proof membrane tail lapped out 450 mm from inner leaf damp proof course as masonry built, lapped over floor. N.B. Damp proof membrane lap must not be above the level of the proposed floor finish.	☐	A
Lay floor damp proof membrane/air barrier over floor and lap up walls by 450 mm and temporally fix to wall. Any services penetrations through air barrier to be suitably sealed.	☐	A
Fit perimeter upstand insulation with a minimum thermal resistance of 3.04 m²K/W hard up against wall up to height of screeded finish.	☐	T
Lay floor insulation hard up against perimeter insulation.	☐	T
Screed floor.	☐	
Ensure checklist on Plasterstop Bead Detail PB Par2 has been completed.	☐	A
Parge blockwork to provide air barrier to wall.	☐	A
First fix services to wall.	☐	
Fix insulated plasterboard with minimum thermal resistance of 1.52 m²K/W on continuous horizontal dabs (at maximum 600 mm vertical centres) and vertical edge dabs.	☐	T
Inject insulating expanded foam between insulated dry-lining and perimeter upstand insulation.	☐	T
Provide mastic seal to all service penetrations.	☐	A

Ψ = 0.040 W/mK

T: Thermal Performance
A: Air Barrier

1. Minimum thermal resistance of the perimeter insulation upstand to achieve 3.04 m²K/W.
2. Overlap of insulation to be 300 mm minimum.
3. Blockwork of maximum 0.19 W/mK dry thermal conductivity.

Only when three complementary Energy Saving Trust Enhanced Details are used together, and in conjunction with all other relevant ACDs, can a y-value of 0.04 be used in SAP2005. See Introductory Document for full details.

This indicative guidance illustrates best practice for design and construction in respect to ensuring thermal performance and air barrier continuity, and must be implemented with due regard to site conditions and all other requirements imposed by Building Regulations.

Site Manager/Supervisor: .... Site Name: .... Plot No: .... Date: / /

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Enhanced Detail MV02-F01 (B)
Use this detail instead of ACD: MII-GF-01

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Figure 1: Example of how the Enhanced Construction Details look

4. How to use Enhanced Construction Details improved thermal performance in SAP 2005

Within a SAP 2005 calculation, the improved thermal performance from using ECDs in a design can be realised in three ways:

1. With the full potential for using enhanced details realised in the design, plus all remaining details conforming to at least ACDs, an ECD y-value of 0.04 can be input as a user-defined y value to determine the total heat losses through the non-repeating thermal bridges H_{TB}. This avoids having to input Ψ-values and lengths into the SAP 2005 calculation.
2. With the use of some ECDs (or other enhanced details) plus all remaining details conforming to at least ACDs, the appropriate Ψ-values (see table 2) and lengths can then be input into the SAP 2005 calculation to determine the total heat losses through the non-repeating thermal bridges H_{TB}.
3. From the Ψ-values and lengths input at point 2 above, and the total area of exposed building elements, a user-defined y-value for a specific house type can be determined. If the fabric of the specific house type is unchanged (i.e. U-values and junction details are unchanged) then a single user-defined y-value can be input in subsequent SAP calculations, avoiding the need to input Ψ-values and lengths into the SAP 2005 calculation each time that house type is proposed.

5. Overall design principles and thermal modelling process

As can be seen from the list of Ψ-values contained in table 1 (the defaults for ACDs), apart from lintels, ground-floor/wall, and gable/ceiling junctions, all other junctions have Ψ-values that are less than 0.10 W/m^2K.

Consequently, the focus for producing ECDs was on designing lintel, gable and ground-floor details that brought significant reductions in their Ψ-values. Improving these details would clearly have a major impact on the subsequent default y-value for use in SAP 2005 calculations.

From an initial scoping study, it was determined that it was indeed possible to aim for a much lower ECD default y-value of 0.04, as long as the Ψ-values of lintels, ground-floor/wall, and gable/ceiling junctions could be limited to 0.07 W/m^2K or less.

The details themselves were developed and designed in association with an industry working group (consisting of house builders, designers, product manufacturers, and building physics theorists), with the aim of 'designing out' potential problems and developing 'buildable' details that the industry could readily incorporate into existing designs. This means that thermal bridging heat losses can be reduced without radically altering current designs.

Additionally, to focus the efforts of the working group, the construction forms were restricted to the

Table 2: Ψ-values for the Energy Saving Trust Enhanced Construction Details

Enhanced details – summary of Ψ-values					
Wall type	**Lintel**	**Gable**	**Slab on ground**	**Beam and block**	**Suspended timber**
MV01	0.010	0.057	0.075	0.074	0.048
MV02	0.007	0.049	0.037	0.048	0.032
MV03	0.004	0.040	0.043	0.047	0.029
TF01	0.024	0.045	-	0.034	0.016
TF02	0.025	0.050	-	0.037	0.021
SF01	-0.010	0.068	-	0.070	-

main construction types already familiar to users of the ACDs set i.e. for walls; cavity masonry (three variants), timber frame (two variants), and light steel frame, for floors; slab on ground, suspended block and beam, and suspended timber as can be seen in table 3.

Table 3 summarises the specification for the elements in the set of ECDs.

The junction details were modelled on building elements of wall, roof and floor which achieved the fabric U-values in table 4. These U-values are significantly lower than the suggested backstop values contained in the Energy Saving Trust Code Level 3 guidance and should be considered as being the target for building elements when using the ECDs.

Table 3: Description of each construction type

Construction Type	Type Code	Brief Description
Cavity masonry	**MV01**	100mm block inner leaf internally plastered*. 150mm fully filled insulated cavity. Brick outer leaf.
	MV02	100mm block inner leaf, internally lined with laminated plasterboard on horizontal continuous dabs on parge coat. 100mm fully filled insulated cavity. Brick outer leaf.
	MV03	100mm block inner leaf, internally lined with laminated plasterboard on horizontal continuous dabs on parge coat. 100mm partially filled insulated cavity. Brick outer leaf.
Timber Frame	**TF01**	140mm fully filled timber frame, sheeted externally, air barrier/vapour control layer and insulated lining internally. Service void and plasterboard. Clear cavity with brick outer leaf.
	TF02	140mm fully filled timber frame, sheeted both sides, air barrier/vapour control layer. Service void and plasterboard. Partially filled insulated cavity with brick outer leaf.
Light Steel Frame	**SF01**	70mm fully filled light steel frame, air barrier/vapour control layer. Service void and plasterboard. Partially filled insulated cavity with brick outer leaf.
Ceiling	**-**	Attic trusses with insulation laid above, between and below, air barrier/vapour control layer. Service void and plasterboard.
Beam & Block	**F01**	Beam and block floor with insulation and air barrier above, with screeded finish.
Solid Slab	**F02**	100mm concrete slab on insulation on damp proof membrane/air barrier.
Suspended Timber	**F03**	Floor decking on insulation on air barrier on sheeting on suspended timber floor joists off joist hangers.

*NB. Internally plastered finish could be replaced by plasterboard on continuous horizontal dabs on parge coat.

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Table 4: Summary of modelled U-values

Energy Saving Trust Enhanced Construction Details - summary of U-values					
	Wall	**Roof**	**Slab on ground**	**Beam and block**	**Suspended timber**
MV01	0.22	0.11	0.15	0.14	0.15
MV02	0.20	0.11	0.15	0.14	0.15
MV03	0.22	0.11	0.15	0.14	0.15
TF01	0.22	0.11	-	0.14	0.15
TF02	0.19	0.11	-	0.14	0.15
SF01	0.18	0.11	-	0.14	-

6. Key features of Enhanced Construction Details

Contained within Energy Saving Trust ECDs is a set of thermal rules that must be followed to enable the user to claim either the ECDs y-value of 0.04, or the individual Ψ-values for a particular enhanced detail. Mostly, these rules are expressed as meeting a minimum thermal resistance for key insulation layers.

Following the modelling, a sensitivity analysis of the Ψ-values for the ECDs was conducted. The resulting y-value of 0.04 is considered to be valid for a limited range of U-values of the building elements, where individual elements can vary from the target U-values given in table 4 by ± 20%. This gives the following valid ranges for individual building elements:

Roof	**0.13 – 0.09 W/m²K**
Walls	**0.25 – 0.16 W/m²K**
Floors	**0.18 – 0.12 W/m²K**

Where two building elements have one U-value above its target while the other is below its target U-value, the aggregate percentage change from the respective target U-values in table 4 should not exceed 20%, i.e if for the (MV02) wall, the U-value was increased by 10% above the wall target U-value (from 0.20 to 0.22), then the roof U-value could be at most 10% below the roof target U-value (from 0.11 to 0.10), because the aggregate change would then be 20%.

6.1 Dealing with air leakage

The ECDs have a focus on methods and practices that reduce unnecessary air leakage. It is essential that a wet plaster finish or parged layers be applied to masonry, or that an appropriately located air barrier is included in timber and steel-frame constructions, as well as in all floor and ceiling constructions. These various air barriers must be incorporated into every design used on site.

6.2 Service voids

In an attempt to future proof construction and maintain the integrity of the insulation and air barrier layers, all service voids are also an essential part of these details. Their insulation layers and air barriers should not be breached by electrical cabling or pipework during the initial installation, or by any future alterations to these services. The width of the service voids depends on the design and the services that are provided. However, we believe that the service voids should not be reduced below 37mm, and in some cases (such as accommodating recessed down-lighters), they should be significantly larger. The service void should be wide (or deep) enough to ensure that the insulation and air barrier layers are both continuous but not compromised by the services they contain.

6.3 Ensuring continuity of the air barrier

Continuity of the air barrier is a significant factor in reducing uncontrolled air leakage through any thermal element. However, attention to air-barrier continuity is even more crucial at junctions between different elements, or where the material that forms the air barrier changes. Although it is relatively simple to tape joints – for example between foiled-backed insulation and vapour control layers – this is not necessarily the case between a wet plaster finish to a wall and a vapour control layer in a ceiling or floor.

Our details suggest lapping a vapour control layer, foil, or a taped joint behind a plaster stop bead. Some typical enlarged lap details are included within the set of ECDs. It should be noted that to avoid risks to internal air quality and provision of fresh air, adequate ventilation must be provided where airtightness levels are improved to $5m^3/hrm^2$ @ 50Pa or below. Here, some form of whole-house ventilation will be needed. Using mechanical ventilation with heat recovery, together with the ECDs, compensates for extra energy used by the ventilation system, and further reduces the dwelling's CO_2 emissions. Additional guidance on whole- house ventilation systems can be found in the Energy Saving Trust publication 'Energy efficient ventilation in dwellings - a guide for specifiers (GPG268)'[7].

Figure 2: Even if proprietary systems are used to achieve airtightness when joist ends are built into the masonry, the potential for heat losses from thermal bridging or uncontrolled air leakage remains. Blocks have to be cut to fit between the joists, gaps have to be pointed up with mortar. (Photo from Stamford Brook report on airtightness – courtesy of Malcolm Bell, Leeds Met University.)

7. See www.energysavingtrust.org.uk/housing

6.4 The junction between timber floors and the inner leaf

Another major cause of excessive heat losses due to thermal bridging or uncontrolled air leakage is the junction between timber floors and the inner leaf of the external and separating walls. The spacing of floor joists built into the inner leaf inevitably leads to piecing/pointing up of the the blockwork between the joists (see figure 2).

Also, unless the floor joists are the same depth as the blocks used, or are coursed in the same way, then additional piecing/pointing up occurs above/below the joists. And because the joists move continuously, either because of the daily heating/cooling cycles, or short-term changes to loading, the joint formed around the floor joists deteriorates rapidly after the dwelling is built. For this reason, the ECDs show the use of joist hangers for all timber ground floor details.

We therefore recommend that all upper timber floors are also supported via joist hangers so that the inner leaf can be continuous both thermally and in terms of airtightness. Suitable restraint-type joist hangers should of course be used where lateral restraint in required.

6.5 Attic trusses

One last key feature is the use of attic trusses as shown on all ceiling/wall junction details. Additional credits are available in the Code for Sustainable Homes when the footprint of the building is reduced by making the roof space habitable. Although simply including attic trusses in a design does not achieve these additional credits, we believe that making it easy for the home owner to increase their living space is the most sustainable solution that can be incorporated into the initial design. This does not however prevent the use of traditional cold-vented roof voids formed by TRADA type trusses.

The ECDs are available to download via the helpful tools section on our website. See www.energysavingtrust.org.uk/housing

Further information

The Energy Saving Trust provides free technical guidance and solutions to help UK housing professionals design, build and refurbish to high levels of energy efficiency. These cover all aspects of energy efficiency in domestic new build and renovation. They are made available through the provision of training seminars, downloadable guides, online tools and a dedicated helpline.

A complete list of guidance categorised by subject area can be found in Energy efficiency is best practice (CE279). To download this, and to browse all available Energy Saving Trust publications, please visit www.energysavingtrust.org.uk/housing

The following publications may also be of interest:

- Energy efficiency and the Code for Sustainable Homes – Level 3 (CE290)
- Energy efficiency and the Code for Sustainable Homes – Level 4 (CE291)
- Energy efficiency and the Code for Sustainable Homes – Level 5 & 6 (CE292)
- Energy efficient ventilation in dwellings – a guide for specifiers (CE124/GPG268)
- Improving airtightness in dwellings (CE137/GPG224)

To obtain these publications or for more information, call 0845 120 7799, email bestpractice@est.org.uk or visit www.energysavingtrust.org.uk/housing

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- Tim Ward and Chris Sanders 'Conventions for calculating Linear thermal transmittance and Temperature factors' BR497 BRE Press, Watford, available from www.brebookshop.com
- The Government's Standard Assessment Procedure for Energy Rating of Dwellings, 2005 Edition, available from www.bre.co.uk/sap2005
- Stamford Brook report, deliverable 6 available from www.leedsmet.ac.uk/as/cebe/projects/stamford

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