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Guide to the use of FILON GRP Rooflights to meet
2002 UK Building Regulations for Conservation of Fuel and Power

Keywords : - Roof Finishes - Overlapping Sheets - Reinforced Plastics

Introduction

There is a worldwide requirement to reduce the production of greenhouse gases and the British Government is committed to undertake major changes in building design and build specification over a period of 10 years to bring about the changes needed to achieve the worldwide goal. The 2002 Part L (England and Wales) and Part J (Scotland) are a first step in this process in the consideration of the design and installation of the building structure.

In principle buildings are required to be better insulated, built to a higher standard to reduce air loss and provide more efficient heating and ventilation systems. Well designed and natural daylight is also a requirement to offset unnecessary energy consumption.

The Regulation Documents

Two documents apply which came in to effect in the early part of 2002.

- **The Building Regulations 2000 (England and Wales) Approved Document L**
  - L1 Conservation of Fuel and Power in Dwellings.
  - L2 Conservation of Fuel and Power in Buildings Other than Dwellings.
- **The Building Standards (Scotland) Regulations 2001**
  - Regulation 22 Part J: Conservation of Fuel and Power

There are some variations between the two Regulations and generally the specification for England and Wales are more onerous. Where it is relevant the differences are indicated.

For the purposes of this document - dwellings will not be considered and thus any reference will be to Part L2 or Regulation 22 Part J.

Natural Daylighting

The Regulations now recognise that natural daylighting is essential to save fuel on heat and power and now specifically requires that natural daylight will be a designed into the building.

- **Para L2 1.14 states** "special care needs to be given to confirm that levels of daylight are adequate"
- **Para L2 1.55 states** "Where it is practical the aim of lighting control should be to encourage the maximum use of daylight and to avoid unnecessary lighting during the time when spaces are unoccupied."

Minimum levels of natural daylighting are specified :

- **Para 1.45** "that for any office, industrial and storage building, a daylight space is defined as any space within 6m of a window wall, provided that the glass area is at least 20% of the internal area of the window wall. Alternatively, it can be roof lit with a glazing area at least 10% of the floor area. The normal light transmittance of the glazing should be at least 70%, or if below this the glazing area could be increased proportionately but subject to a maximum daylight areas given below."

Thus for any building which is more than 6m wide, or 12m wide if windowed on both walls, rooflighting to a minimum of 10% of the floor area is a basic requirement.

Maximum Glazed Areas

Since the insulation value of the glazed areas will be less than that of the opaque areas surrounding them, the Regulations state a maximum glazed area in accordance with **L2 Para 1.12 Table 2. This is shown below as Table A**

Table A : Maximum Glazed Openings Unless Compensating Measures are Taken

Building Type	Windows and Doors as % of area of exposed walls	Rooflight as a % of area of roof
Places of Assembly,Offices and Shops	40	20
Industrial and Storage	15	20

Note that the areas of glazing can be exceeded if it can be shown that the heat loss has been compensated for in some way by using products with greater insulation value.

Daylight Design

Although the Regulations define maximum and minimum glazed areas they do not define the glazing levels that would be suitable for different building usage between these two parameters. To assist designers to determine the correct level of natural daylighting, the following information will be of assistance.

Natural Daylighting Benefits

Natural daylight makes you feel good. The eye and brain functions respond better in natural daylight, thus work is done more safely and efficiently. In hospitals patients recover quicker in wards with windows than those without. In the winter months in the northern hemisphere some people suffer from SAD (Seasonal Affective Disorder), a clinically diagnosed condition where lack of sunlight makes people feel ill. In extreme northern climates this can lead to suicide.

Whereas bread and butter feeds the stomach, natural daylight feeds the brain. Never deny people the opportunity to work in a daylit space unless it cannot be avoided.

Natural Daylighting Energy Efficiency

As well as providing the feel good factor, natural light includes the passage of infa-red light frequency which provides passive solar gain and therefore a free source of energy. With good design of rooflights facing South, coupled with thermal mass in the form of solid floors and walls that can store up the heat gain during the day and dissipate this heat in the evening and night, considerable energy savings can be made.

Similarly if natural light levels are adequate during the day, the artificial lights need not be turned on, and how often do we forget to turn them off!

Natural Light Quality - Direct or Diffused

Designers need to consider the type of quality of light needed for the building in question. Direct clear light has the advantage that people can see out and feel in touch with their environment. Thus vertical glazing will almost always be clear. For rooflights there is not the same need to see clouds float by but it is important that the work area at ground level is evenly and generally well lit. With only 10-20% of the roof space providing natural light, it is important that this glazing does not provide shafts of light illuminating only 10-20% of the floor area. The better solution is to provide diffused roof glazing so that the light at ground level covers 100% of the floor space with an even level of daylight. Filon GRP rooflights, which have diffusing agents added during manufacture are ideal to provide even and constant daylighting at floor level.

Amount of Light Determinations

The designer must design adequate natural daylight within the building to satisfy its intended use. Designers should also consider that buildings may have a change of use in the future and design to a potentially higher standard of daylight requirement.

The light levels required are measured in Standard Maintained Illuminance (Lux), and the recommended levels of Lux for each building usage is given in **Table B**.

Table B: Examples of Activities/Interiors Appropriate for Each Maintained Illuminance

Standard Maintained Illuminance	Characteristics of Activity/Interior	Representative Activities/Interiors
50-100	Interiors used occasionally, with visual tasks confined to movement, limited perception of detail.	Corridors, Bulk Stores
150-200	Continuously occupied interiors, visual tasks not requiring perception or detail.	Loading Bays, Plant Rooms
300-500	Moderately difficult visual tasks, colour judgement may be required.	Packing, General Offices, Engine Assembly, Retail Shops
750-1000	Difficult visual tasks, accurate colour judgement required.	Drawing Offices, Chain Stores, General Inspection, Electronic Assembly, Supermarkets
1500-2000	Visual tasks extremely difficult.	Precision Assembly, Fabric Inspection

In determining the Lux levels for the building, consideration should be given to whether to measure in the horizontal or the vertical plane. For most office and factory operations the horizontal plane would be used but in storage and warehousing the vertical plane could be more appropriate.

Rooflight positioning should also be considered to provide the correct Lux levels in the appropriate areas.

To convert these Lux levels into meaningful values for rooflight design, the National Association of Rooflight Manufacturers (NARM) have instigated research to be done by the Institute of Energy and Sustainable Development, De Montfort University, and their conclusions are published as **Daylighting and Solar Analysis for Rooflights** and **Guidance on Specifying Rooflights to Comply with Revisions to Part L2**.

Their research has concluded that the selection of required rooflight area depends on the level of natural light desired, the percentage of a working year that lower natural light levels are acceptable, and the level of use of auxiliary lighting which is acceptable.

Tables C and **D** below show the recommendations from this research and assumes the light transmission of rooflights to be 67%. If the light transmssion is better or worse, adjustment should be made accordingly.

Table C : Recommended Minimum Rooflight Area for Desired Illuminance Level (Horizontal)

Illuminance Level Required in the Horizontal Plane (Lux)	Recommended Min. Rooflight Area (% of Floor Space)
100	10
200	10
300	13
500	15
750	17
1000+	20

Table D : Recommended Minimum Rooflight Area for Desired Illuminance Level (Vertical)

Illuminance Level Required in the Vertical Plane (Lux)	Recommended Min. Rooflight Area (% of Floor Space)
100	10
200	14
300	17
500+	20

General Design

There are three methods of design allowable to demonstrate that reasonable provisions have been made for the conservation of fuel and power.

1. Elemental Method

This method considers the performance of each element of the building. To comply, a minimum level of performance should be achieved in each of the elements. Some flexibility is provided for trading off between different elements of the construction, and this is particularly relevant to rooflights where considerable advantage can be gained by trading up the rooflight design to generate heat credit that can be offset in other areas.

2. The Whole Building Method

Considers the performance of the whole building. This method can not be used for industrial and warehouse/storage buildings, but can be applied to offices, schools and hospitals.

3. Carbon Emmisions Calculation Method

This considers the whole building performance where the annual carbon emission is compared with a Notional Building of the same size that fills the criteria determined under the Elemental Method.

In Scotland calculations are done by the Heat Loss Method.

For the purposes of this technical brochure, we will only consider satisfying the Regulations via the Elemental Method, which will be the normal route for the majority of large industrial and commercial buildings.

L2 para 1.16(c) states that no more than half of the allowable rooflight area can be converted into increased areas of windows (vertical) and doors. There is no provision for converting vertical openings into increased rooflight areas in the roof.

L2 para 1.16(b) states that if the area of the rooflights is less than the values shown in Table A, the respective U-values of the roof, wall and floor cannot exceed the appropriate values given in Table E by more than 0.02.W/m²K. Thus however much notional heat loss saving is made by reducing the rooflight area, the U-value of the insulated roof cannot exceed 0.27W/m²K.

Elemental Method Standard U-values

To show compliance the building envelope has to provide certain minimum levels of insulation. This will be achieved by stating standard U-values for each construction element as shown in **Table E**.

Table E : Standard U-values of Construction Elements

Exposed Element	U-values
Roofs with Integral Insulation	0.25W/m²K
Walls	0.35W/m²K
Walls (Part J Scotland)	0.30W/m²K
Rooflights	2.20W/m²K
Windows (Translucent Wall Area)	2.00W/m²K

Thus the Notional Building under the Regulations will be prescribed as having 20% rooflight area - **Table A**, and U-value of 2.2W/m²K - **Table E**.

Rooflight Trade Off

L2 para 1.14 allows for greater design flexibility to be introduced in respect of windows and rooflights, such that the area of daylighting can be increased or decreased with a corresponding compensation of insulation value, such that the heat loss from the daylight area is no worse than the notional value achieved when calculating heat loss from the value given in **Tables A** and **E**. This therefore means that with Trade Off the rooflight area can be greater or less than 20%, subject to achieving an appropriate rooflight U-value as shown in **Table F**.

Table F : Maximum Rooflight U-value per Roof Area

Opaque Roof Area at U-value 0.25W/m²K	Rooflight Area	Rooflight U-value W/m²K
70%	30%	1.5
75%	25%	1.8
80%	**20%**	**2.2**
85%	15%	2.8
88%	12%	3.5
90%	10%	4.1

Constraints to Trade Off

L2 para 1.14 states that care must be taken to confirm that levels of daylight are adequate. If the rooflight area is to be reduced below 20%, the designer must ensure that natural daylight levels are sufficient for the building purpose.

Filon Rooflight U-values

The U-values given below in **Table G** relate to the typical Filon Rooflight designs which can be seen in detail in the relevant **Filon product brochures**.

Table G : Filon Multiskin Rooflight U-values

Type of Construction	U-Value W/m²K	f-value (Minimum)
Site Assembled Double Skin $	3.1	0.69
Factory Assembled Double Skin	3.0	0.69
FILON Fermacore Site Assembled $	2.0	0.80
FILON Factory Assembled Triple Skin	1.9	0.80
FILON Factory Assembled Quadruple Skin	1.5	⩾0.80 *
FILON Monarch Double Skin Barrel Vault	3.3	0.69
FILON Monarch Double Skin Barrel Vault with Under Liner	2.2	0.80

* Figure awaiting confirmation from the BRE.

$ Site Assembled liners are assumed to have a profile depth of no more than 20mm. Deeper profile liners will adversely affect the U-value.

Thus we can conclude from **Table F** and **Table G** that **FILON Double Skin GRP Rooflights**, with a U-value of 3.1, are compliant with the Regulations at an area of 12%, and that **FILON Triple Skin GRP Rooflights**, with a U-value of 2.0, are fully compliant at 20% roof area.

However it should be noted that there is a very strong recommendation from the ODPM (Office of the Deputy Prime Minister), the BRE and NARM (National Association of Rooflight Manufacturers), that rooflights should be specified with 3 layers to achieve a U-value of 2.2, or better, regardless of the percentage of roof area and generate heat credit wherever possible.

Air Leakage

Air leakage requirements do not apply to Building Standards (Scotland) Part J, only reasonable provision is required.

Under Part L2 buildings should be reasonably airtight to avoid unnecessary space heating and cooling demand. There is a requirement that the permeability of the envelope (which includes the total area of the perimeter wall, roof, and ground floor area) should be no worse than 10m³/h/m² at an applied pressure of 50 Pascals. All buildings exceeding 1000m² of gross floor area must be air tested on building completion to show compliance.

The Filon Fermacore Panel in between the two Outer skins

Filon Fermacore fitted over Filon Liners (unseen), with Filon SupasaFe outer skin fitted over the Three Skin Assembly

Buildings less than 1000m² gross floor area will be deemed compliant providing evidence that appropriate design detail and construction techniques have been used.

Provided that FILON rooflights are correctly fixed and sealed in accordance with FILON recommendations, then the rooflight assemblies will usually comply easily with this requirement. Filon Products strongly recommend that Roofing Contractors take considerable care in the fixing and sealing of rooflights, since air test failure will generally require extensive remedial work which could run in £1000's and possibly the replacement of the sheeting at contractors cost. Areas to be particularly mindful off is misaligned and/or sagging purlins and rails, and the detailing at the eaves and ridge. Sagging purlins are a specific area of concern as the building envelope has increased in dead load due to increased insulation levels.

Buildings in the range of 1000m² to 3000m² are particularly vulnerable to failing the air pressure test, the smaller the building the greater the attention to detail is required.

Thermal Bridging, Linear Heat Loss Ψ value and f-factors

Thermal Bridging

The building fabric should be constructed so that there are no significant thermal bridges. All FILON Inplane Rooflights are such that of themselves they do not provide a cold bridge. FILON Monarch Barrel lights may provide a cold bridge via the aluminium or steel upstand frames and careful design should be given to this specific area.

For site assembled rooflight systems, care should be taken to insulate the internal support structure to minimise the cold bridge.

Linear Heat Loss Ψ(psi)-value

Part L refers to BRE IP17/01 and MCRMA Technical Report No.14. They detail how thermal bridges and linear heat loss should be assessed and designed by the use of robust details.

Heat loss at linear junctions between the various elements of the building envelope require special detailing and are calculated by computer designed systems. This linear heat loss is called Ψ(psi). Detailing at gutters/eaves, around windows/doors, and at junctions with floor and ducts, are the areas requiring most attention.

Heat credit generated from the use of higher specification rooflights can be used to offset linear heat loss to achieve compliance. This detail is shown below under **Total Building Heat Loss α (alpha) value**.

Temperature factor or f-factor

The multi-dimensional heat flow that occurs through rooflights also lowers the internal surface temperature giving rise to a risk of surface condensation in high humidity environments. This risk is quantified in the Regulations using Minimum Surface Temperature Factor or f-factor. The f-factor is a property of the structure and not the assumed conditions.

The Regulations require that the f-factor should be kept above the following values at all points as shown in **Table H**.

Table H : Minimum f-value Requirements

Building Type	Minimum Rooflight f-value
Storage Buildings	0.30
Offices, Retail Shops	0.50
Sports Halls, Kitchens, Canteens	0.80
Swimming Pools, Laundries	0.90

FILON Rooflight systems will be compliant with the above requirement by reference to the f-factors given in **Table G**.

Total Building Heat Loss - α (alpha) value

Designers and builders are required to determine the total heat loss of the building and compare this to the Notional Building of the same size. The Notional Building heat loss allowance will be a summation of all heat losses of all external components using the specific U-value allowance for each component. The linear losses at the junction must not be more than 10% of this Notional Value and is defined by the equation :

$$\alpha \text{ (alpha)} = \frac{\Sigma\, \Psi \times L}{\Sigma\, U \times A} \leq \mathbf{0.1}$$

This may be rewritten :

$$\text{Total Building Heat Loss} \leq \Sigma U_{(notional)} \times A \; +10\%$$

Rooflight Heat Credit Trade Off

The Regulations allow that any heat credit from the use of better insulated rooflights or notional U-value rooflights used to a lesser area, the heat credit generated can be used to offset linear heat losses. This can have a major impact on resolving design problems to achieve the correct α (alpha) value for the complete building.

An example of this heat credit is shown below :

Notional Building Heat Loss

80% Opaque Roof at 0.25W/m²K Heat Loss/m² = 0.20W/K

20% Rooflight at 2.2W/m²K Heat Loss/m² = 0.44W/K

Notional Building Roof Total Heat Loss/m² = 0.64W/K

Actual Building Designed with Heat Credit

88% Opaque Roof at 0.25W/m²K Heat Loss/m² = 0.22W/K

12% Rooflight at 2.0W/m²K Heat Loss/m² = 0.24W/K

Roof Total Heat Loss/m² = 0.46W/K

Heat Credit from total roof area with high specification rooflights that can be used to offset Ψ losses is **0.18W/m²K**.

It is strongly recommended that designers should always allow for **FILON Fermacore Site** or **Factory Assembled Insulating Rooflights,** with a U-value of 2.0W/m²K, such that if the area of rooflight used is less than 20% to meet the design requirements stated earlier, this will automatically generate heat credit which is likely to be of major importance in the total building heat loss calculation

Solar Overheating

Solar overheating requirements do not apply to Building Standards (Scotland) Part J.

Natural daylighting is beneficial to the conservation of fuel and power in that it provides daylight, saving the light bulb, and via the infra-red wavelengths it provides solar heat gain within a building.

However, excessive levels of glazing can generate solar over heating making the internal environment unpleasant.

To compensate for excessive solar overheating, designers can accommodate this by one or a combination of the following design criteria :

1. An appropriate specification of glazing.
2. Air conditioning without excessive cooling plant capacity.
3. Passive measures such as shading.
4. Exposed thermal capacity blocks plus night ventilation.
5. Limiting the amount of roof and wall glazing.
6. By calculation refer to Part L para 1.23

If only item **5** is adopted, the maximum glazing areas that can be incorporated into the building design are shown in **Table I** below.

Table I : Solar Overheating - Maximum Allowable Areas of Glazing

Orientation of Opening	Maximum Allowable Area of Opening
N	50%
NE/NW/S	40%
E/SE/W/SW	32%
Roofs Below 75^0	12%

Thus, if no other measures are taken to control solar gain for buildings in England and Wales, the maximum area of rooflighting is limited to 12% of the roof area. Designers need to satisfy themselves that daylight levels are adequate for the purposes of the building, by reference to the section on Daylight Design on **Pages 1 and 2**.

Avoidance of Solar Heating by Calculation Method

Part L Regulations state that where the rooflight area is less than 12%, solar overheating will not be a problem and no further action is required. Wherever higher rooflight areas are specified, it must be shown that solar overheating will not occur by calculation or adoption of alternative measures.

Independent research carried out by the Institute of Energy and Sustainable Development, De Montfort University, has been submitted to the Building Regulation Advisory Council and being considered for inclusion in future revisions to the Building Regulations, has predicted the levels of solar overheating which will occur inside typical large span buildings using the latest computer modelling techniques.

The Part L Regulations are met if the overall internal gain does not exceed 40W/m^2; they assume an internal gain of 15W/m^2; thus allowing a maximum solar load of 25W/m^2; but the research demonstrates this assumption does not apply to many large span buildings, depending on the building use.

For typical activities in large span buildings, the heat emitted per person (male) ranges from 140W (seated light work) to 256W (medium bench work). Standing, light work or walking produces about 160W of heat.

Table J (extracted from the independent research) shows the maximum rooflight area which will avoid solar overheating, from various levels of internal gain.

Table J : Maximum Rooflight Area to Avoid Overheating

Internal Gain (W/m^2)	Max Rooflight Area (% of floor area)
0	23
5	20
10	17
15	14
20	11

This table shows that where internal gains are 15W/m^2, rooflight area can be up to 14% of floor area without risk of causing solar overheating; where internal gains are lower then rooflight area can be higher.

For example, in storage buildings, occupant densities are generally very low and can often be ignored; the main gains are from artificial lighting, typically only 5W/m^2. It can be seen from **Table J** that rooflight areas up to 20% will not cause solar overheating.

Any large plant or process facility may produce considerable local heat gains. Where these are envisaged, it is recommended that localised heat extraction/removal and/or cooling is used to prevent overheating. Where these are known to be effective in eliminating the localised heat gain, the sources can be excluded from the internal heat gains for the assessment of overheating.

In retail outlets occupant density can be significant (typically around 4W/m^2), and retail outlets are usually well lit, with internal gains due to lighting around 15-20W/m^2. However, the period of highest solar gain is simultaneous with highest daylight illuminance, and provided rooflight area is sufficient, the internal gains due to electric lighting can be greatly reduced or eliminated by switching off the lights either manually or more reliably, by daylight-linked controls. Total internal gains may therefore be around 4W/m^2 and **Table J** again shows that rooflight areas up to 20% will not cause solar overheating.

Roof Repair and Exempt Buildings

Roof repair is exempt if single components are replaced or the complete roof is repaired. Strip and re-sheeting of a complete roof or the upgrading of part of the roof is regarded as a refurbishment and will be subject to compliance to the new Regulations.

Thus rooflights that have become damaged with time can be replaced without resorting to the new Part L Regulations.

Similarly over sheeting the entire roof with opaque **FILON Over-Roofing** to effect a repair does not need to comply with new Part L.

Buildings that are unheated or have a heating requirement of no more than 25W/m^2 are exempt from the Regulations. Typically agricultural buildings. For such buildings, single skin FILON rooflights are acceptable.

Buildings that are purpose designed for cold storage will require insulation but will be designed to meet operational needs.

Designers and builders should note that they should consider the possibility of **change of use** in the future and design their buildings accordingly. The ODPM are aware of abuse of the Regulations in this area and are likely to legislate that Planning Permission will not be granted for a change of use from a low insulated buildings to a general purpose building without a full upgrade on the building structure to meet the requirements of L2. The cost of upgrading will be far greater than the cost of building it to the required upgrade standard at the outset.

Conclusion on Energy Conservation

1. For unheated or low heat buildings **FILON Single Skin** rooflights are acceptable.

2. If rooflights are specified to a U-value of 2.2W/m^{2}K then **FILON Fermacore (3 skin) systems** must be used.

3. If rooflights are specified at 12% roof area then **FILON Double Skin Assemblies** with a U-value of 3.0W/m^{2}K will be compliant.

4. By using rooflights to a higher specification than notionally required ***Heat Credit*** can be created to offset heat losses though linear joints of the building. Thus for specified rooflight areas of 12%, the use of **FILON Fermacore** will provide a Heat Credit of 0.18W/m^{2}K. This specification is strongly recommended by the ODPM regardless of the rooflight area specified, and meets the intended spirit of the legislation.

5. All buildings are required to be designed to provide sufficient and adequate daylight to the working areas through windows and/or rooflights. Rooflight areas must be a minimum of 10% of the roof area.

6. For rooflight areas in excess of 14% **FILON Fermacore 3 Skin Assemblies** will be necessary.

7. Repairs to existing rooflights can be repaired or replaced without the need to comply with the new Regulations

Health and Safety

ALL rooflights and rooflight liners must be considered fragile until they are correctly fixed as recommended.

Roof works should be completed in accordance with the recommendations published in the Health and Safety Executive Guidance Note HS (G) 33 "Safety in Roof Work".

Many accidents occur during maintenance and cleaning. Very often work is carried out by those who have no experience or understanding of working at heights.

Roofs are dangerous places to work and it is recommended that the following information be included in the "**Health & Safety File**".

No person should have access to a roof unless under the direct supervision of an experienced roofer who should be sufficiently competent to assess any risks and take the necessary action to reduce such risks. Although designed to be ***non-fragile*** when installed, foot traffic on rooflights may damage and weaken the sheets and is likely to damage the UV resistant protective coating thereby reducing the life and translucent qualities of the sheet.

Do NOT walk on rooflights at any time, ALWAYS use crawling boards.

Design

To minimise risk to future maintenance personnel, it is recommended that rooflights should not be located adjacent to valley or boundary wall gutters or within 2m from exposed roof edges.

Technical Services

Technical and advisory services are available from Sales Area Managers or Filon Technical Services Department.

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