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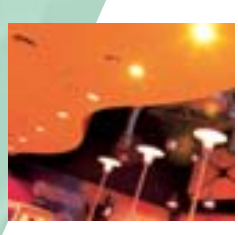
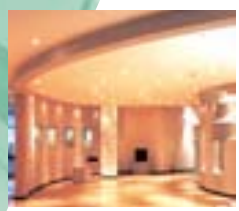
August 2005





THE DRYWALL MANUAL

LAFARGE PLASTERBOARD

The Lafarge Drywall Manual, August 2005
supersedes The Drywall Manual, July 2003,
January 2001, June 1999 and March 1998

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Designed and produced for Lafarge Plasterboard by NBA Tectonics

The Drywall Manual

This manual introduces Lafarge Plasterboard, explains the way we support sustainable construction and provides a comprehensive guide to the company's products and services. It incorporates the detailed technical information required to assist the user in selecting and specifying the correct drywall systems for applications ranging from the domestic environment to the most demanding of commercial and industrial installations.

It has been designed in tandem with our on line information systems and all of the data incorporated is also available by logging on to www.lafargeplasterboard.co.uk.

Above: The Lafarge Plasterboard zoned home web page
Top right: Lafarge Customer Services department
Below: The Lafarge Cormet metal framing systems can be used to create whatever shape the designer requires – and conceal the services
Below right: Dramatic curved surfaces can be achieved using Lafarge Contour wallboard

The introduction to the manual offers a broad overview of the products and systems available. These are then covered in detail in individual sections including: drawings, performance data, sitework details and all the information needed to prepare full specifications which meet a broad range of practical and design challenges and ensure effective installation.

If you cannot find a standard system to match your concept, contact our technical advice service, Technical Enquiryline, which will work with you to develop a bespoke solution.

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Email: enquiryline@lafarge-gypsum.lafarge.com.

Lafarge – a world leader

Lafarge is a world leader in the manufacture and supply of construction materials. It holds top-ranking positions in each of its four divisions: gypsum, cement, concrete and aggregates, and roofing. It is active in 75 countries and employs some 77,000 people.

The Group's global strength has been built on over 160 years of experience and innovation in manufacture, materials, design and methodology.

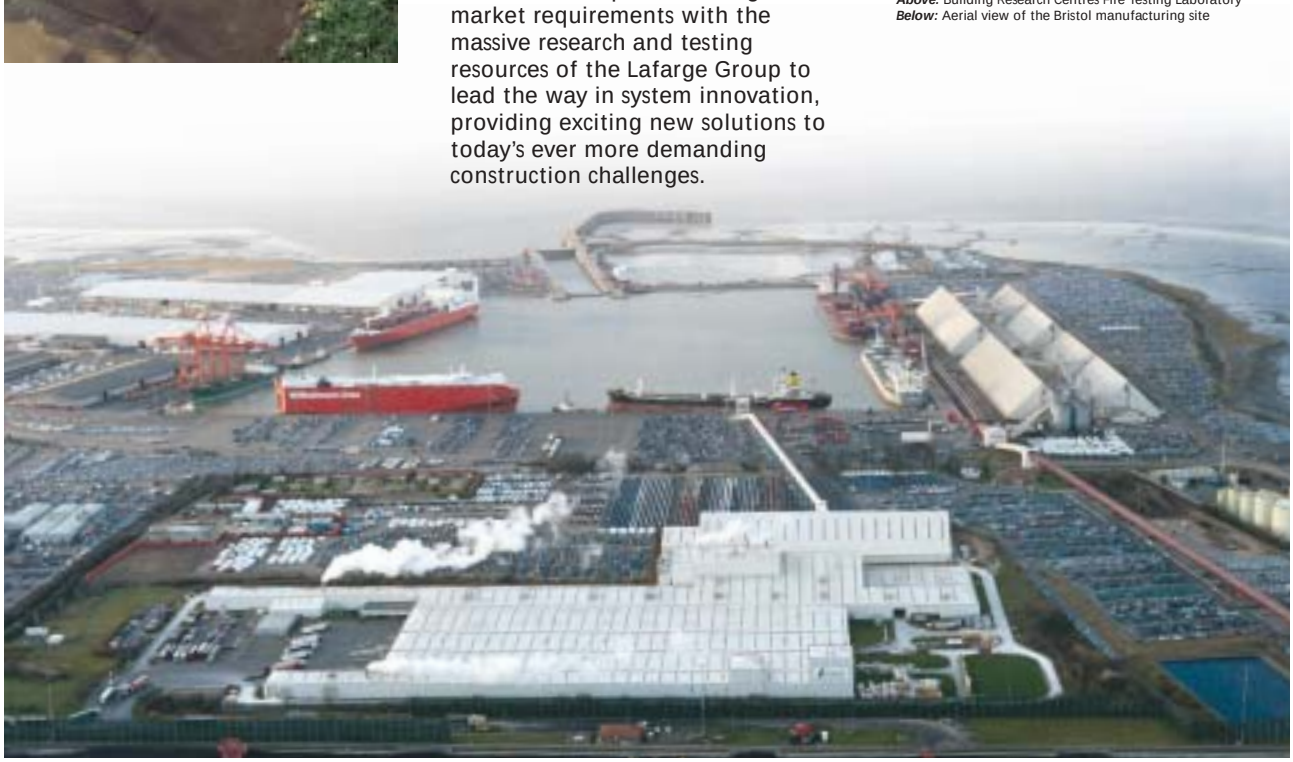
Business objectives go hand in hand with a commitment to respecting the communities within which we work and minimising the environmental impact of our operations. Lafarge's comprehensive environmental policy covers all aspects from the extraction of raw materials to recycling and the life cycle impacts of individual products. It includes the way we work with suppliers and the protection of wildlife habitats.

Lafarge Plasterboard is a member of the Group's gypsum division. It was established in the UK in 1987 and has its principal manufacturing facility on the outskirts of Bristol. This plant is among the most technically advanced drywall production units in the world. It has the capacity to supply in excess of 50 million square metres of plasterboard a year.

Lafarge have a number of distribution centres which enable fast and effective national distribution of all their products.

The company's development team combines in-depth knowledge of UK market requirements with the massive research and testing resources of the Lafarge Group to lead the way in system innovation, providing exciting new solutions to today's ever more demanding construction challenges.

Top: Lafarge Gypsum's Technical Development Centre
Above: Building Research Centres Fire Testing Laboratory
Below: Aerial view of the Bristol manufacturing site



The metal systems increasingly used in conjunction with wallboards introduce an added element of 'factory control' on-site, readily accommodate building services and avoid the problems sometimes associated with traditional timber studs drying out over time.

In refurbishment work, Lafarge Cormet metal systems provide a convenient means of creating true and flat surfaces over the must uneven of substrates.

The Drywall Advantage

Drywall systems provide an economic, high performance option to meet a broad range of construction requirements. They are ideally suited to today's fast-track construction schedules which must control costs whilst maintaining the highest quality standards.

Use of these products removes the drying time associated with wet trades and so aids co-ordination between contractors, whilst at the same time contributing to overall build programme speed.

Top: Lafarge Drywall systems providing a fast track solution in Andover
Top right: Live in Quarters, London: POD manufacture
Above: A cinema in Yeovil exploiting the drywall advantage
Left: The Lafarge Dryliner system is ideal for solid walls – no wet trades and eliminates the risk of moisture penetration damaging decorations

Product Range

Lafarge offers a comprehensive range of drywall systems to meet the practical and performance needs of both new build and refurbishment projects in the domestic, commercial, industrial, leisure and public sectors. The range is complemented by design orientated systems that offer the architect and specifier huge scope in translating exciting visual concepts into reality on-site.

Today, there is a cost-effective drywall solution to virtually every wall lining, partition, ceiling and flooring challenge whether the requirement is for flat and true durable surfaces, eye-catching curves or stunning creative detailing as offered by Lafarge profiles.

The range is constantly reviewed to ensure products meet changing construction needs and reflect modifications in Building Regulations. The focus is on the provision of systems that combine ease of installation with the highest performance standards.

Top: An exciting use of Lafarge systems at Century Cinema Cardiff
Right: Part of the range of Lafarge wallboards
Bottom left: Lafarge wallboard and coving create a comfortable home

Plasterboard, jointing and associated products made in the United Kingdom by Lafarge Plasterboard are manufactured in accordance with management systems certified to BS EN ISO 9001: 2000 (quality) and BS EN ISO 14001:2004 (environment) and verifies their conformance with appropriate British and International Standards.

Boards

Construction practice and Building Regulations call for a family of boards to match specific installation needs.

Lafarge wallboards are complemented by high performance products specifically designed for thermal and acoustic applications, and to provide impact, moisture, vapour and fire resistance.

Design-orientated Products

Coving and decorative **Fresco** panels, that re-create the traditional appearance of panelled walls and ceilings, make light work of adding luxury to interior design.

The '**Profiles**' range of aluminium extrusions enables features such as bullnose corners, uplighters and reveals, recesses, accent lines, shadowgap grooves, curved and rebated corners, stepped cornices, architraves, skirtings and mouldings to be incorporated with ease.

Metal Systems

Lafarge has developed a complete range of metal systems for use in combination with its boards. From non-load bearing metal studs to purpose-designed partitions and from traditional metal furring ceilings to intricate curves. There's a drywall solution to meet the needs of all the design professional requirements.

To complement its range for standard drylining, partitions and ceilings, Lafarge offers specialist systems such as **Shaftwall** for lift shafts. It is important that system specifications are not compromised by mixing metals and boards from different manufacturers. To provide total peace of mind, Lafarge Plasterboard has introduced the "**Cormet**" brand covering all the company's metal systems for lining, partition and ceiling applications. Cormet brings together the highest standards of design, innovation, manufacture, quality control and technical support to provide complete, fully warranted drywall solutions.

Finishes

A number of finishing options are available offering a choice between taping and jointing, skim plastering and decorative textured coatings.

The latest **Taping and Jointing** systems make use of two-coat compounds for bedding, joint filling and finishing. This reduces the time needed to complete the jointing process and avoids the additional labour and drying time associated with skim plastering.

Encasements

Drywall provides one of the most cost-effective means of providing fire protection to steel columns and beams. Lafarge systems combine simple installation with long term performance and the capability to achieve up to 180 minutes fire protection.

Top right: Lafarge Fresco adds distinction
Above left: Lafarge aluminium profiles
Above right: Specialist Lafarge systems were used extensively at the Open University building
Right: Jointing a tapered edge wallboard
Left: The components used in the Lafarge Encasement system

The Deco Range

The **Deco** range of colour matched board systems is designed to provide a consistent white finish. The paper face of the wallboard is factory sealed and combined within the system are a range of **Deco Joint Cements** that have been specially formulated to both colour match and offer the same paint absorption characteristics as the wallboard.

Megadeco

A versatile and high performance wallboard, which combines the characteristics of **Firecheck** (fire resistance), **dBcheck** (acoustic) and **Toughcheck** (high impact resistance) with the additional benefit of the Deco pre-sealed finish applied to the face of the paper.

Thicknesses available: 12.5, 15mm

Hydrodeco

Designed for applications where **Moisturecheck** (moisture resistance) is required, with the Deco pre-sealed finish applied to the face of the paper.

Thicknesses available: 12.5mm

Predeco

Alternative to **Standard** wallboard with the Deco pre-sealed finish applied to the face of the paper.

Thicknesses available: 9.5, 12.5, 15mm

Predeco Joint Filler*

Setting compound used for bedding, filling and for external corners within the taping and jointing process.

Deco Joint Cement*

Air drying lightweight ready mixed compound which can be used for bedding, filling and finishing within the taping and jointing process.

Deco Machine Joint Cement*

Air drying lightweight ready mixed compound specially formulated for easy application when used in conjunction with **Premier** range of Automatic Taping Machines.

Suitable for bedding, filling and finishing within the taping and jointing process.

Note:

* **Deco** joint compounds, defined above, are the only jointing compounds that should be used within the **Deco** system.

Decoration

Lafarge Plasterboard does not recommend the use of gloss, eggshell, silk or sheen paints in line with the code of practices of BS 6150: 1991 *Painting of buildings* and BS 8212: 1995 *Dry lining and partitioning using gypsum plasterboard*.

However, should you choose to use such finishes, Lafarge Plasterboard recommend the use of an additional coat of **Lafarge Universal Sealer** when using the **Deco** system. The **Deco** system is not suitable for plastering.

Above: Great Western Hospital, Swindon
Below: A fire test at BRE
Bottom: Lafarge Thermalcheck being installed

Fire, Acoustic & Thermal Solutions

Fire Protection

All Lafarge Plasterboards are Class 0. The gypsum cores are classified as non-combustible. The range includes boards that allow fire resistance from 30 to 180 minutes to be achieved with ease.

Sound Insulation

Drywall products offer a lightweight construction technique capable of offering excellent insulation against the transmission of airborne and impact sound in applications ranging from domestic properties to hospitals and digital multiplex cinemas.

Thermal Performance

Lafarge products and systems are available with a range of polystyrene and phenolic foam laminates and can also be used in conjunction with mineral wool insulation to achieve the highest standards of thermal resistance.

www.lafargeplasterboard.co.uk provides on line access to all of the information within the Drywall Manual. The web site additionally includes the latest news from Lafarge Plasterboard, and email links to key contacts within the company.

Further installation details including photographic references and coverage rates are provided in the Lafarge Plasterboard *Installation Guide*.

left: Customer Service team member
above: Lafarge Plasterboard home page
below: Advice being given at the Lafarge Training Centre

Customer Services

The Lafarge customer service commitment combines constant monitoring of performance through the On Time In Full (OTIF) programme with a number of dedicated support departments.

The ***Customer Service*** and ***Sales Office*** teams process orders nationwide and provide comprehensive data on product availability, stockists and delivery schedules. See back page for contact information.

The ***Drywall Training Centre*** offers a range of courses to enable specifiers, merchants, contractors and supervisory staff to keep abreast of the latest drywall developments and installation techniques. It also develops bespoke training for individual customer needs. All courses are CITB approved and training can be integrated with National Vocational Qualification programmes. See back page for contact information.

The ***Technical Enquiryline*** provides expert advice on technical issues related to specification and installation. See back page for contact information.

Lafarge ***Literatureline*** provides a quick and efficient service in the supply of literature on company products. Next day delivery is guaranteed for all orders received before 3pm. See back page for contact information.

Lafarge Systems at a glance

The table below is designed as a quick reference to the principal Lafarge drywall products and systems and is coded to show the detail sections of the manual relating to them.

Product/System		Application	Section
Boards	**Megadeco**	White board, colour matched to joint cements – an alternative to Firecheck, dBcheck or Toughcheck, ideally suited for hospitals, schools and high traffic areas	8
	Hydrodeco	White board, colour matched to joint cements – an alternative to Moisturecheck	8
	Predeco	White board, colour matched to joint cements – an alternative to standard wallboards	8
	Toughcheck	For locations requiring additional impact resistance	8
	dBcheck	Where higher levels of sound insulation are needed	8
	Firecheck	For locations requiring improved fire resistance	8
	Echeck	Meets the performance standards for plasterboard in Approved Document E	8
	Acoustic Homespan	Achieves at least 40 dB sound resistance when used as part of the Acoustic Homespan Partition system	8
	Moisturecheck	Wherever protection from moisture ingress is required eg kitchens and bathrooms	8
	Vapourcheck	Wherever protection from moisture vapour is required eg kitchens and bathrooms	8
	Standard wallboard	General purpose board	8
Wall linings	**Direct bond**	Where boards are to be fixed directly to sound substrates	2
	Dryliner	Where it is advantageous to create a cavity up to 150mm between the lining and the substrate. Tackling the problems posed by very uneven substrates	2
	Timber frame	Fixing drywall products to traditional timber studs	2
	Independent	Wherever there is a requirement to construct a lining without any direct connection to the substrate	2
Partitions	**Acoustic Homespan**	Domestic partitions requiring higher levels of sound insulation	3
	Metal stud	All forms of partitions in domestic, commercial and industrial buildings	3
	High performance	Partitions in applications demanding exceptional performance, such as multiplex cinemas, auditoria, and very high partitions in industrial environments	3
Ceilings	**Timber**	Fixing drywall products direct to timber joists and trusses	4
	Dryliner	Where creating a true flat surface may otherwise be difficult	4
	Horizontal Shaftwall	Where exceptional levels of fire resistance are required	4
	Metal Furring	Wherever it is appropriate to create a ceiling void to accommodate services	4
Acoustic Floor	**Acoustic Floor**	Provides high levels of acoustic separation between storeys or dwellings in renovation projects	4
Fire Protection	**Shaftwall Column and Beam**	A speedy, reliable and effective system that is cost effective and practical to install	5
Finishing	**Deco System**	Colour matched, pre-sealed boards and joint cements for domestic, commercial and industrial locations	7
	Taping & Jointing	The quickest and most cost-effective way to joint drywall systems and achieve a flat surface ready for direct decoration	7
	Skim plastering	Where specifier preference is for a plastered finish	7
	Texture	Wherever a crack-resistant decorative texture surface is required	7

Fire

History

Gypsum-based products have long been used to protect against fire. The molecular structure of gypsum contains combined water molecules. The evaporation of this combined water absorbs a large amount of energy from the fire before the actual gypsum material is degraded and fire spread is therefore delayed.

Changing legislation

Historically, under Approved Document B of the current Building Regulations for England and Wales, all materials to be used in building construction are required to satisfy various levels of performance, under two main fields, ***Reaction to Fire*** and ***Fire Resistance***.

Reaction to Fire

Reaction to fire regulations are concerned with the contribution to any fire that a material is likely to make. This potential contribution has been evaluated by testing in accordance with British Standard 476: Parts 4 (Non-Combustibility), Part 5 (Ignitability), Part 6 (Fire Propagation) and Part 7 (Surface Spread of Flame). The well-known *Class O* classification is a combination of results from testing to Parts 6 and 7.

These tests are carried out on the basic materials themselves.

Under the above tests, most Lafarge Plasterboard products achieved results which enabled them to be classified as *Materials of Limited Combustibility* and to achieve the Class O classification.

In addition, there is the Core Cohesion test in British Standard 1230, which determines if a wallboard can be classed as a Type 5 (Fire Resisting) wallboard. BS 1230 is to be superseded by BS EN 520.

Fire Resistance

The fire resistance regulations are concerned with the length of time a construction can delay any fire from spreading from the compartment already involved in the fire into any adjoining compartment or property, or the length of time the construction can delay collapse of any building involved in the fire.

The delay in fire spread or building collapse provided by the construction is vital to allow evacuation or fire fighting to take place as well as limiting the extent of damage caused by a fire.

The contribution made by a construction has been determined by testing or assessment in accordance with British Standard 476: Parts 20, 21, 22, 23 & 24, and is measured in minutes, according to how long the construction satisfied the requirements of the appropriate standard.

Only a complete construction, as opposed to a material, can be evaluated for fire resistance.

New Legislation

The following is a statement from the Gypsum Plasterboard Development Association (GPDA) from 16th September 2004, Fire tests – The European Standard

"As a result of efforts to harmonise fire test standards throughout the European Union, British Standard fire resistance and reaction to fire tests will gradually be replaced by harmonised European Standards.

It is anticipated that the existing British Standard BS 476 will continue to be used for the time being, as there is currently no target for legislation to require the testing of products to the BS EN standard, BS EN 1363 and plasterboard manufacturers will continue to quote the BS in their technical literature. Gradually, however, specifiers will become familiar with the EN standard and the BS will become less used, and will eventually become obsolete.

It is anticipated that the gypsum wallboard manufacturers in Great Britain and Ireland will quote only EN fire test data in their literature from 1st January 2007."

It is to this end that Lafarge Plasterboard has taken this opportunity to start the process of informing our industry of the differing effect that the EN standard will have with regard to overall system performance.

We have in this issue published both the BS 476 and EN 1363 results alongside one another with the view of only publishing the EN standard performance from 1st January 2007.

BS EN Reaction-to-Fire tests

Under the old UK system for classifying the reaction to fire performance of building products plasterboard falls into the Building Regulations defined category of 'Material of Limited Combustibility'. Under the new Euro classification system gypsum wallboards are classified after testing as Euroclass A2, the second highest performance level. In the consultation package published by DTRL (now ODPM) a material of limited combustibility is equated to Euroclass A2 and therefore is no change in the potential usage of wallboard on reaction to fire applications.

BS EN Fire Resistance Testing

Severity

The eventual introduction of the new European tests for fire resistance (The BS EN 1363 series) will have the effect of increasing the severity of fire resistance testing in the UK. The principle reason for the increase in severity of the test is the adoption of the *plate thermocouple*, the device used by test laboratories to measure the temperature inside the furnace. This new device gives a slower reaction to the actual temperature rise within the furnace and therefore requires more heat input in order to follow what is nominally the same time/temperature curve as specified in BS 476.

There are some further, minor, procedural changes that further increase the severity of the test. Back-to-back testing demonstrates that the increase in severity for tests on gypsum-based products will decrease the fire resistance period by 10-15%.

Structural Strength

Stud Partitions – Non-loadbearing

The strength of a partition is judged by its ability to resist deflection under load, or by the force needed to break through the partition when subjected to an impact by either a hard or soft body.

The factors which control these aspects of acceptability are:

- The bending strength of the frame
- The height of the frame
- The thickness of the wallboards
- The number of wallboard layers
- The rigidity of the head fixing
- The spacing of the studs
- The axial load (if any) from above
- The wind load - uniformly distributed load (UDL) if any
- Any temporary point load (if any) at mid height
- The stiffness of the wallboards
- The hardness of the wallboards
- The bending/breaking strength of the wallboards

It is not possible to write a mathematical equation which takes into account all these factors and which, when the physical properties of the materials are used to calculate, for example, height limit, gives a satisfactory relationship to practical acceptability.

Instead, over the years, gypsum board manufacturers have built up a dossier of knowledge which relates the main parameters to the acceptability of known generic systems. There is also a nucleus of testing data, to fall back upon, where this acceptability is in doubt.

Lafarge have carried out a great many tests in accordance with methods described in BS 5234: Part 2: 1990. The 5 main tests are:

- **Stiffness**
  – 500 N temporary pressure
- **Soft body impact**
  – 50 kg swinging bag
- **Hard body impact**
  – 5 kg swing hammer
- **UDL and crowd pressure**
  – 2.5m beam pressure
- **Door slamming**
  – 100 slams, 35 kg door for LD and MD
  – 100 slams, 60 kg door for HD and SD

From these tests it is possible to judge whether the partition is graded as

- Light duty LD
- Medium duty MD
- Heavy duty HD
- Severe duty SD

When testing for axial load, the partition is loaded from the top using hydraulic jacks pushing down on a spreader beam. This test is not included in BS 5234.

When testing for racking resistance, the partition is loaded both from above and from one top corner. This test is mainly applied to external wall panels, in steel and timber framed buildings, where the panel may also be subjected to wind loads, also not part of BS 5234.

The failure criteria for the tests under BS 5234 are shown in a table 7.1 taken from Part 1 of this document.

BS 5234 also covers tests for cupboard, shelf and wash/hand basin loads and pull-out strength of fixings.

The duty ratings are shown in the tables of performance, in subsequent chapters of the Drywall Manual.

Where duty ratings are not shown, or where a particular combination of boards and studs has not been tested or expertly assessed, it is possible to extrapolate the rating by comparing the nearest equivalent. The most important parameter controlling height limit is the overall thickness. The relationship between height and thickness is called the slenderness ratio.

$$\text{Slenderness ratio } Sr = \frac{\text{Height in mm}}{\text{Thickness is mm}} \quad \frac{h}{t}$$

As a rough guide, Sr should be less than 40, but for design purposes targeted at 30, when there is no suspended ceiling either side.

Example:
RMP 01 = 70mm studs,
1 x 15 Megadeco board each side
Max h = 3800mm
t = 100mm,
Sr = 38

For Severe Duty, this partition would, when tested to BS 5234, achieve:

- *Stiffness* – < 10mm deflection, 500 N temporary pressure
- *Impact, hard body* – no perforation 30 Nm hit
- *Impact, soft body* – < 1mm residual deflection 120 Nm hit
- *Beam or air bag UDL* – h/240 < 15mm deflection

Domestic partitions would be expected to be designed and tested to the LD standard.

In practice, LD has been shown to be too weak. These partitions are too 'flimsy' and not marketed by Lafarge Plasterboard Ltd.

Loadbearing partitions cannot be created from metal studs less than 70mm web depth and 1.2mm steel thickness. Timber studs should be at least 75mm x 44mm. In both cases, the maximum centre to centre spacing is 600mm. All the load has to be carried by the frame, typically, > 5 kN per stud. Gypsum wallboard linings will assist with overall stiffness of the partition, but cannot be relied upon to give support to crushing from overloaded frames. When fire testing loadbearing systems, it would be usual to expect to achieve only half the period of fire protection achievable from non-loaded partitions.

Load bearing stud capability is available by calculation, or from timber frame and steel stud frame manufacturers. Lafarge Plasterboard Ltd does not offer this service.

Wall Linings

Wall linings are usually fixed to a rigid support frame or masonry, via clips and brackets, or by plaster dabs.

The criteria under BS 5234 apply to board impact resistance but not deflection unless the board is very flexible. Where the lining is created from independent studs, all the same parameters as with partitions apply.

As a general guideline, wall linings using 12.5mm Standard wallboard will be Medium Duty, 15mm board Heavy Duty, 15mm Megadeco board Severe Duty. Any board combination using double layers gives Severe Duty. 12.5mm Toughcheck is also Severe Duty. 9.5mm wallboard is not rated.

Structural Strength

Ceilings & Floors

The spanning capability of floor joists whether steel or timber is well established from performance tables. Likewise concrete beams and in-situ reinforced concrete. This information is not available via Lafarge Plasterboard Ltd.

Under a structural floor the plasterboard lining is used to provide a cosmetic finish and to give added acoustic insulation and fire protection.

The ceiling systems within this manual will not support foot traffic. It is important that the stated loading in this manual is not exceeded, if in doubt please contact Technical Enquiryline.

When plasterboard is used as a suspended ceiling, with the Cormet Suspended Metal Frame system, it may also be required to support light fittings, lightweight services and insulation.

All of the ceiling systems in the Drywall Manual have been designed and tested so as to be capable of supporting a load, where the pull down safety factor is at least x 3, i.e. 3 times the weight of the ceiling, inclusive of the board weight.

There are cases where the suspension hangers are further apart than 1200mm for example, where roof purlins are at 1500mm. In this case, special details and a stronger primary channel are needed. For this, please consult our Technical Enquiryline.

Lafarge do not accept responsibility for fixings into concrete, hot rolled structural steel beams and steel decking.

BS 5234 – Performance Tables

Table 4. Partition grades: Summary of requirements and principle test performance levels

Requirement & test method(1)	Units	Grade (See Table 3) LD	MD	HD	SD	Principal criteria
Stiffness (A)	mm	25	20	15	10	Maximum deflection
	mm	5	3	2	1	Maximum residual deformation
Small hard body impact:						
Surface damage (B)	N.m	3	3	6	10	Judgement of indent
Perforation (D)	N.m	(2)	5	15	30	No perforation of facing
Large soft body impact:						
Damage (C)	N.m	20	20	40	100	2mm maximum deformation
Structural Damage	N.m	60	60	120	120	No collapse or dislocation
Door slam (F)	No.	20	20	100	100	No damage and 1mm maximum displacement

(1) Test methods are shown by letters in brackets which relate to annexes in BS 5234: Part 2: 1992
(2) No requirements for this grade

Above: BS 5234 Impact test being carried out at BRE Testing Centre

Acoustics

Principles of Sound

Acoustics is a subject that describes all aspects of sound and falls into the fields of both science and art.

The science of sound envelops the technicalities of its generation, propagation and reception as well as objectively describing its qualities. In the artistic world, sound plays a large part in terms of the spoken word, music and other auditory experiences that give us pleasure. A well used acoustical term is noise, often described as unwanted sound. The sound that is generated by one party is noise to another party if they have no interest in it or are disturbed by it. For instance, the sound of classical music played by your neighbour is noise to you if either you hate that particular piece or it is so loud that you cannot concentrate on the calculation you are attempting to solve.

Airborne sound as its name suggests, is generated in the air by a vibrating object. Examples of airborne sound sources are:

- the human voice
- Hi-Fi playing through a loudspeaker
- musical instruments such as a violin (vibrating string) or a trumpet (vibrating air column)

The decibel

Sound travels away from its source through the air as a pressure wave fluctuating about the almost constant atmospheric pressure. The pressure fluctuations are very small compared with atmospheric pressure but the difference in pressure of a sound that can be just heard (threshold of hearing) and one that is excessive is more than a million times greater.

For this reason, sound is not measured in terms of its pressure.

The method used is to compare the pressure of a particular sound with the nominal threshold of hearing pressure and then use a logarithmic scale to compress the range.

This is called the decibel (dB) scale and allows the useful range of sounds to begin at 0 dB (threshold of hearing) and effectively end at 140 dB where hearing is likely to be irreparably damaged by a single short noise event.

Sound pressure level is the term used to denote the amount of sound present in decibels (dB).

The ear is the most common sound detector. In the absence of sound, the ear drum remains stationary held steady by atmospheric pressure of the air which reaches it on one side from the ear canal and on the other from the mouth. When a sound wave travels along the ear canal, the pressure fluctuation causes the ear drum to vibrate and a signal is sent to the brain. The level of sound heard by the ear can be evaluated subjectively and very small changes can be detected. A 5 dB change in sound pressure level is generally considered to be significant. For many reasons, everyone's hearing is not identical but for simplicity, we define 0 dB as the point where we begin to hear sound or the threshold of hearing.

Measuring sound

In order to obtain an absolute evaluation of sound pressure level, a sound level meter is used. This comprises a microphone with a diaphragm that vibrates on detection of the sound wave and a means of converting the vibration into an electrical signal that is processed to give a display in decibels.

Background noise can affect the assessment of a sources sound level. For instance, road traffic in the daytime may cause us to increase the radio's volume to a level which seems excessive during a quieter evening period. It can be difficult to measure the sound pressure level of a source if the background noise is less than 10 dB below the sound pressure level of the source itself.

Sound frequency

In addition to its variation in level sound has another important property called frequency or pitch. Sources vibrate at different rates giving the sound produced a quality that has a uniquely identified character. The rate of vibration is measured in cycles per second and its unit is named the hertz (Hz). Sound that can be heard by the human ear ranges from around 20 Hz to 20,000 Hz. The human ear has varying sensitivity to different frequencies being less sensitive at low frequencies and very high frequencies. A curve can be drawn which shows the variation of sensitivity with frequency rise to its optimum in the range 1000 Hz to 4000 Hz then falling away with increasing values. This is known as the "A" weighting curve.

Most sources produce sound which contains many different frequencies.

To obtain a more detailed objective analysis of a sound source, we can use a more sophisticated sound level meter that has the capability to evaluate frequency as well as sound pressure level.

Building Acoustics

Noise control as the name suggests, envelops the techniques used to minimise the effects of unwanted sound and thus optimise environmental conditions. In the construction industry, Building Acoustics is the term which covers this aspect of sound. Building Acoustics involves both the control of noise within an enclosed space and the reduction of noise between rooms or from either outside or inside a building.

Sound Absorption

Noise is generally controlled within a space using sound absorbing materials. Sound absorption relates to the percentage that effectively disappears when the sound wave hits a body or surface. Sound absorption is evaluated by measuring the reverberation time of a room. The reverberation time is defined as the time taken for the noise (sound pressure level) to fall to 60dB below its original level when a sound source ceases to operate. If the reverberation time is long then the room will be live and the conditions will be acoustically uncomfortable for most activities. If the reverberation time is too short then sounds such as music may appear flat and lack character.

Therefore where possible, we design a space to have an optimum reverberation time for its use.

The sound absorption properties of a specific material or system can be evaluated in a purpose built laboratory called a reverberation room. This comprises a large space (approximately 200m^3) that has hard reflective surfaces usually plastered masonry. The empty room has long reverberation times which are measured prior to installing about 10m^2 of the material under test. Measurements are made in third octave frequency bands from 100 Hz to 5000 Hz. Assuming that the material has greater sound absorption than the room surface on which it is installed, the reverberation times which are again

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measured will now be shorter than in the empty condition. The reverberation times in each condition can be used to calculate the sound absorption of the room and the difference between the two values gives the sound absorption of the installed sample. If we then divide the sound absorption of the sample by its area, the absorption/m^2 is obtained. In practice, this is a value between 0 and 1 and is called the *absorption coefficient*. A hard concrete surface has a very low sound absorption coefficient (less than 0.05 at most frequencies), whereas a thick carpet and underlay can approach 1.

Acoustic consultants use the absorption coefficients of materials to estimate the reverberation times of specific buildings. However, in many rooms for example small offices, it is sufficient to specify totally covering one or two surfaces with a good sound absorbing product such as carpet or a mineral fibre tile ceiling.

Sound Insulation

The reduction of noise through structures is called sound insulation.

Airborne sound insulation is the ability of a construction separating two rooms to resist the passage of airborne sound.

Sound passes from one room to another by travelling either through the dividing element or the surrounding structure (flanking transmission).

The evaluation of the sound insulation of a single building element, such as a partition, takes place in purpose built laboratories comprising a pair of rooms with an aperture into which the test structure is erected. In such a laboratory, flanking transmission is negligible and so the optimum sound insulation of the element is obtained. The sound insulation of a building element is related to the sound power reduction through the element and is termed the sound reduction index (*R*).

Site testing takes place between a pair of rooms in a building and the sound insulation of the integrated constructions (including flanking transmission) is obtained which is a function of both design and workmanship. The sound insulation value on site relates to the sound pressure level reduction between rooms and the reverberation time of the receiving room and is termed the Standardised Level Difference (D_{nT}).

The general testing method is as follows:

- Sound is generated through a loudspeaker in one room (source room) and the sound pressure level (L1) is measured using a sound level meter.
- The sound pressure level is also measured in the other (receiving) room (L2) so that the reduction can be calculated. The bigger the reduction is, the better the airborne sound insulation.
- In addition, reverberation time measurements (T) are made in the receiving room in order to normalise any sound absorption effects. The reason for this can be explained by considering a pair of empty rooms with a sound source such as a radio operating in one. The level of radio sound heard in the other room depends on the sound insulation of the dividing element and associated structure plus the amount of sound absorption in the room. If we now install a carpet and other furnishings in the receiving room, the sound pressure level will reduce due to the increased sound absorption thus resulting in apparently better sound insulation. Therefore in order to obtain the same sound insulation result in each case, we measure the reverberation time and compare this to a standard reverberation time (T_0 usually 0.5 seconds) in order to obtain a correction to add to the level difference.

The Standardised Level Difference (D_{nT}) is described by the equation:

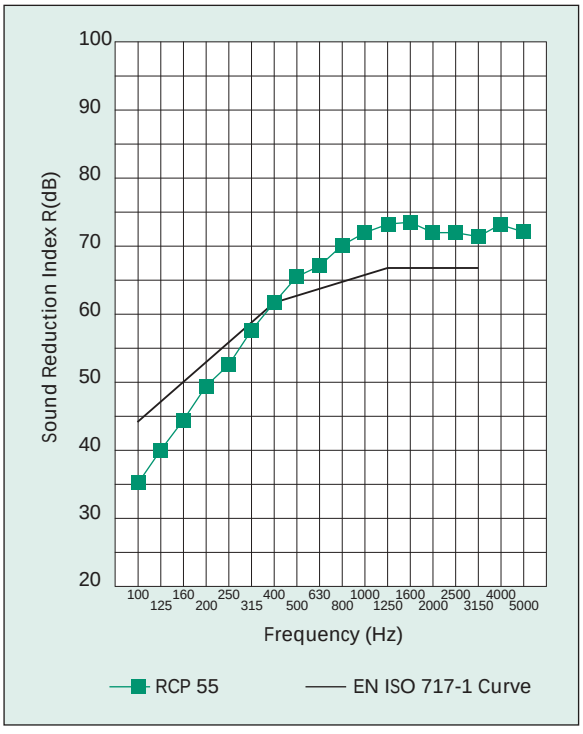
$$D_{nT} = L_1 - L_2 + 10\mathrm{Log}_{10}\frac{T}{0.5}$$

For both laboratory and site tests, measurements are carried out in one third octave bands generally over a frequency range between 100 Hz to 5000 Hz. This allows a graph of sound insulation verses frequency to be plotted which can be used for design purposes.

However, to simplify the presentation of data, a rating method has been devised which calculates a single figure from the sound insulation spectrum. The single figure is obtained by overlaying the measured sound insulation graph with a standard curve shape whose position can be shifted so that certain criteria are met. The single figure relates to the final position of the reference curve.

For laboratory tests, the single figure quantity is termed the Weighted Sound Reduction Index (R_w) and for site tests the Weighted Standardised Level Difference ($D_{nT,w}$). The graph below shows a typical sound insulation graph and the curve used to rate it.

Acoustic response curve



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The use of these values should be restricted to ranking constructions of the same type. The use of single figure ratings for design purposes is difficult because two different types of construction, for example a masonry wall and a metal stud partitions, may have the same value but totally different spectral performance.

To complicate the issue further, other single figures have been devised called *Spectrum Adaption Terms*. Spectrum Adaption Terms are values which are added to the single figure rating (eg $D_{nT,w}$) to take account of a particular activity which may be taking place in the source room.

C_{tr}, spectrum adaptor term, typically relates to urban road traffic or low frequency noise.

In the current Approved Document E the method of calculating airborne sound insulation has changed. It is now necessary to apply a correction factor (C_{tr} to all site test results) and it should be noted that the C_{tr} correction factor is always a negative figure.

For a C_{tr} calculation on any Lafarge system detailed, please contact our Technical Enquiryline, tel 01275 377789.

Impact Sound

Impact sound is generated when one object collides with another causing it to vibrate. Examples of impact sounds are footsteps and hammer blows.

Impact sound insulation is specific to floors and is an evaluation of the ability of the floor to attenuate the sound produced when an object strikes its walking surface. In an impact sound insulation test, sound is generated by a standard tapping machine that is placed on the walking surface. The tapping machine comprises five hammer heads all of the same dimensions and weight which are continuously dropped in turn onto the floor (ten impacts per second). The impact sound travels through the floor structure to the room below where the sound pressure level (L_i) is measured. The lower the sound pressure level is, the better the impact sound insulation.

The evaluation of the impact sound insulation of a floor element takes place in a purpose built laboratory and a value called the Normalised Impact Sound Pressure Level (L_n) is obtained.

On site, we evaluate the floor element and its surrounding structure and the result is called the Standardised Impact Sound Pressure Level (L_{nT}).

As for airborne sound insulation, this is a function of the reverberation time in the receiving room and is given by the equation:

$$L_{nT} = L_1 - 10\text{Log}_{10}\frac{T}{0.5}$$

The single figure ratings used to describe impact sound insulation in the laboratory and on site respectively are Weighted Normalised Impact Sound Pressure Level ($L_{n,w}$) and Weighted Standardised Impact Sound Pressure Level ($L_{nT,w}$).

The standards used to measure sound insulation are the BS EN ISO 140 series whilst single figure ratings are determined using BS EN ISO 717-1 and 2.

Sound Insulation Design

Designing for sound insulation purposes involves the selection of a suitable dividing element and then detailing the associated structure to be compatible.

The Dividing Element

The airborne sound insulation of a solid building element is largely governed by its surface mass. The Empirical Mass Law is a rule devised by plotting the surface mass against "mean" sound insulation for many solid structures. It shows that the mean sound insulation increases by 4 to 5 dB each time the surface mass is doubled. Using this principal alone we see for example that a single layer of plasterboard having a sound insulation of 27 dB can be combined with another layer to achieve 32 dB and two further layers to reach 36 – 37 dB. However, experience has shown that using practical building methods such as the Lafarge Cormet System, two layers of 12.5mm dBcheck wallboard each side of a CS70/R Cormet metal stud and a 25mm glass mineral wool have a Weighted Sound Reduction Index of 56 dB (see RSP 11 page 73). This is achieved by a combination of mass and discontinuity. The thin gauge metal stud allows each pair of wallboards to act as semi-independent linings, the resulting sound insulation being much better than predicted from the mass alone.

This and other principals to achieve high levels of sound insulation in a practical and economical way can be simply explained as follows:

- A single light gauge metal stud frame lined with one layer of wallboard gives a sound insulation of at least 5 dB more than predicted by the Empirical Mass Law due to the separation and discontinuity provided by the stud. The main limitation is the air in the cavity which acts as a "spring" connection between the plasterboard leaves.
- A glass or rock mineral wool infill which effectively damps the air spring in the cavity, improves this value by at least 5 dB.
- Double layers of wallboard give a further 8 to 10 dB because they are now operating as semi-independent linings.
- Fixing resilient bar to one side of the metal stud frame creates virtually independent linings and gives about 6 dB improvement.
- Twin independent frames not only give structural discontinuity but allow the wall width to be increased which optimises the "airspring" discontinuity and results in good low frequency improvements. Acoustic cross braces are available to optimise the maximum partition heights achievable.

The levels of sound insulation that can be ultimately achieved, allow metal stud systems to be used exclusively in one of the most onerous situations, that of multi-cinema separation.

These principles can be applied to other forms of construction to optimise sound insulation.

- The Dryliner system provides virtually independent wall linings to improve the performance of solid and cavity masonry walls. A glass or rock mineral wool infill optimises the levels achieved.
- The M.F. and Dryliner ceiling systems or resilient bar provide discontinuity in timber, steel frame and concrete floors.
- 15mm dBcheck wallboard over glass or rock mineral wool provides a floating floor base onto which a chipboard walking surface is laminated in platform timber and steel joist systems or over concrete bases.

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Sound insulation on-site

Having selected a suitable dividing element, the next step is to consider how this should be constructed with the associated building structure in order to obtain the required sound insulation on site.

Generally due to flanking transmission, the sound insulation achieved on site will be less than that found in the laboratory. However, the shortfall is by no means a constant value.

For instance, if cost and practical restraints did not exist and every step was taken to make flanking transmission negligible, the laboratory value could be achieved. However at the other extreme, a continuous air duct connecting the two rooms could result in a catastrophic reduction in sound insulation.

The following list though not exhaustive, gives pointers towards good sound insulation design.

- **Perimeter sealing of metal stud partitions/plasterboard linings**

  In order to optimise the sound insulation of metal stud partitions, it is imperative that all perimeters are sealed. It is not uncommon to find that a high performance wall is apparently giving poor sound insulation on site purely due to the lack of a seal at base level, the loss can easily be 10 dB worse than that expected.

  The gap at the bottom of the lining is generally hidden by a skirting board but prior to fitting this, it should be totally filled with Lafarge Acoustic Sealant. This flexible acrylic mastic will accommodate movement and cracking so that a satisfactory acoustic seal can be maintained.

  The quality of the sealing treatment is important and so prior to application, dust should be swept from the floor and the mastic should be "gunned" into the joint resulting in a complete fill. This treatment is applicable anywhere where a partition terminates against masonry and standard paper tape jointing treatments are not possible.

- **Services in metal stud partitions**

  Thought must be given to the method of installation of electrical sockets, TV and other similar outlets in order to optimise sound insulation and preserve fire resistance properties. With correct detailing, it is feasible to overcome potential difficulties.

- **Services passing through partitions**

  Services such a ducts, cable trays and pipes which pass through partitions can have a detrimental effect on sound insulation and fire resistance. For high levels of sound insulation, it is necessary to "shield" the services by installing a plasterboard ceiling in each room.

- **Deflection heads in metal stud partitions**

  When non-loadbearing partitions are installed beneath floors or roofs, it is often necessary to incorporate a detail to accommodate deflection. Whilst methods are available which reduce the effect of sound leakage, optimum performance is again achieved by the provision of a suspended plasterboard ceiling in each room of equivalent mass to the partition.

- **Metal stud partition junctions**

  Where a separating wall terminates at an internal partition or corridor wall, it is imperative that the bi-passing partition linings are broken in order to minimise flanking transmission. With careful detailing, it is possible to virtually eliminate flanking transmission at this point.

- **Metal stud partition junctions with timber/steel joist floors**

  Sound insulation can be catastrophically reduced if partitions are built directly off continuous floor boarding or beneath continuous ceilings. In order to overcome these problems, it may be necessary to consider the use of independent floating floors and "broken" ceilings fixed on resilient bars.

- **Metal stud partition junctions with concrete floors**

  Building partitions off non-bonded screeds, floating screeds or lightweight concrete floors can result in undesirable flanking transmission. The optimum design is to build directly off the structural floor and then install floating screeds or timber floating floors in each room.

  Continuous concrete floors bi-passing above a separating wall can have similar effects. Suspended plasterboard ceilings can again be used to good effect.

- **Metal stud partition junctions with masonry walls**

  When a metal stud partition meets a continuous masonry leaf, the partition including its linings should be installed prior to the masonry wall linings. In order to minimise flanking transmission, consideration should be given to installing independent linings such as the Dryliner system in each room.

- **Metal stud partitions meeting window mullions**

  The use of continuous glazing systems incorporating narrow or hollow lightweight window mullions at which partitions are terminated is not conducive to achieving good levels of sound insulation. Where this detail is considered necessary for architectural purposes, details may be available which minimise the problem.

- **Inadequate masonry walls**

  Inadequate masonry walls can be successfully upgraded using independent linings such as the Dryliner system. In such situations, it will also be necessary to consider flanking transmission paths at floor / ceiling level and also the use of independent linings on masonry leaves which the separating wall abuts.

- **Doors in partitions**

  For practical and economical reasons, it is not generally possible to maintain the sound insulation of a partition in which a door is installed. Where this results in privacy or annoyance problems, the use of lobbies / double doors can often prove effective.

  For school classrooms, hotels and hospital wards there is a requirement to fit heavy doors with seals built into the door frame set. This is known as a 30 dB door system.

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Site Testing

Building Regulations Approved Document Part E originally proposed on-site testing of all sound resisting separating walls and floors between dwellings, flats and rooms for residential purposes. These include not only flats and houses constructed in-situ but also 'factory-built' modules transported to site in a complete or partially built state.

Sound testing is not required for internal walls and floors within dwelling houses and flats.

Robust Details (RD)

In order to ease the burden of testing, whilst maintaining standards, a series of Robust Details (RD's) have been devised for separating/party walls and floors. These are industry standard construction designs, which are automatically accepted by Building Control through a registration system via the company, Robust Details Ltd, that has been set up in conjunction with the ODPM. This scheme grants approval in advance on behalf of Building Control and undertakes limited pre-completion acoustic testing nationally to ensure continued compliance with the Regulations. Note that registration and plot fees must be done in advance of works being started.

The Robust Details cover standard floor and wall constructions and numerous elements within them such as junctions, sockets, flues and downlighters. RD's have been developed specifically for new build houses and flats by the Housebuilders Federation, working in conjunction with leading acoustics specialists at Napier University, Edinburgh.
30 on-site tests of the relevant design had to be successfully completed and independently tested, in order for each detail to be accepted as an RD. To meet the stringent requirements set, each detail must demonstrate sound insulating performance 5 dB greater than the lowest performance requirement to meet the level of adequate sound insulation required in Approved Document E.

Robust Details Limited opened for business in May 2004 and allows builders and designers to obtain copies of the RD handbook, to register plots and fee payment in advance of the start of building work. RD registered solutions or pre-completion acoustic testing became mandatory from 1st July 2004, within Approved Document E for England and Wales.

Scotland and Northern Ireland

Regulations currently remain unchanged and are therefore not affected by the England and Wales acoustic changes defined within Approved Document E.

Effects of sound reduction values on audibility

R_w	Noise Level
30dB	Normal conversation can be distinguished
35dB	Loud conversation can be distinguished
40dB	Loud conversation can be heard but not distinguished
45dB	Loud conversation can be heard
50dB	Shouting can be heard but not distinguished
55dB	All speech is totally unheard with a high level of privacy from other domestic noise
60dB	High level of privacy including noise from Hi-Fi and digital television

Performance standards for separating walls, separating floors, and stairs with a separating function

	Airborne sound insulation $D_{nT,w} + C_{tr}$ (dB minimum requirement)	Impact sound insulation $L_{nT,w}$ (dB maximum requirement)
Purpose built dwelling-houses and flats		
Party walls	45	–
Separating floors and stairs	45	62
Dwelling-houses and flats formed by a material change of use		
Party walls	43	–
Separating floors and stairs	43	64
Purpose built residential rooms		
Partitions	43	–
Separating floors and stairs	45	62
Residential rooms formed by a material change of use		
Partitions	43	–
Separating floors and stairs	43	64

Laboratory values for new internal walls, partitions and floors

	Airborne sound insulation R_w (dB minimum requirement)
Internal walls and partitions	40
Internal floors	40

Thermal

Thermal Advice – Part L

There is a massive need to reduce greenhouse gas emissions. In 1997, the UK played a leading role in the negotiations that led to the Kyoto agreement and as part of that commitment, set its CO_2 target beyond that of the agreement. The aim of the changes is to significantly improve the energy efficiency of all new buildings, extensions and alterations to existing buildings.

A guide to the implications of Approved Document L

Approved Documents L1 and L2 of the Building Regulations came into effect on 1st April 2002.

Main objectives

- Reduce Carbon Dioxide (CO_2) emissions
- Improved design flexibility within the building process
- Minimised technical risk
- Avoidance of excessive cost

Compliance

There are three methods of compliance:

- The Elemental Method
- The Target U-value method
- Carbon Index Method

After introduction all house designs should be upgraded to conform to the new regulations. The most challenging area will be in refurbishment, where it is most likely, due to the inability to radically alter the existing design, the Elemental Method of compliance will be used.

Thermal Advice - External Walls

Building Regulations place greater emphasis than ever before on the thermal insulation performance of walls and partitions in domestic properties. Part L is designed to assist in reducing Carbon Dioxide emissions, provide improved flexibility within the build process, minimise technical risk and avoid excessive cost. Adoption of thermally efficient drywall constructions can make a major contribution to achieving these objectives. The advantages of opting for a drywall solution include:

- Availability of a range of thermal laminates to suite different specification needs
- The ability to fix wall lining and insulate in a single operation
- Fully-filled, partially filled and clear cavity design options
- Effective means of upgrading solid wall constructions
- Insulation is located on the inner leaf, giving a better 'response' to changing temperature requirements

Lafarge Thermalcheck wallboards include boards bonded to expanded polystyrene, extruded polystyrene and phenolic foam with or without vapour barriers, to meet a wide range of performance requirements. There are many different forms of construction, combinations of materials and methods of application. The prescribed methods of calculating thermal efficiency are complex and generally are undertaken with the aid of computer software. In this manual we show constructions for several common types of traditionally built wall. Drywall systems are equally well suited to use in conjunction with timber frame and metal frame constructions.

Future Regulation changes

The ODPM have produced a draft paper with the view to changing the Approved Document L Regulations from 1st January 2006.

The draft proposals are a fundamental change in the method of the thermal calculation which, when adopted, will no longer allow Elemental or Target U-value demonstrated compliance but will require a "whole building" calculation, such as SAP 2005, in all new build and extensions of a size equal or greater than 100m².

U-values (W/m²K) for the Elemental Method

Element	Central heating with required SEDBUK value	Other heating systems(1) (Scotland only)
Pitched roof with insulation between joists	0.16	0.16
Pitched roof with insulation between rafters	0.20	0.18
Flat roofs	0.25	0.22
Walls	0.35 (England & Wales)	–
	0.30 (Scotland)	0.27
Floors	0.25	0.22
Windows/doors/rooflights		
In wood or PVC frames *(area weighted average)*	2.0	1.8
In metal frames *(area weighted average)*	2.2	1.8

(1) Other gas or 'central' heating systems, or any electric heating system or solid fuel central heating system or undecided – these U-values are applicable only to Scotland

Case Study

Ster Century cinema, Cardiff

Cardiff's new Ster Century multiplex cinema is a 14 screen complex designed to exacting sound insulation standards. It provides an impressive 73 dB sound reduction between auditoria and 60 dB Rw for the external envelope. Some 85,000 square metres of Lafarge Plasterboard systems have been used to achieve the sound and fire protection criteria set for the project which abuts the Cardiff Millennium Stadium. Partitions are built on two 90mm metal studs and faced with three layers of boards - 19mm plank, 15mm dBcheck and 15mm Firecheck. A unique acoustic brace is used to brace the studs and provide an effective sound break.

Client: Ster Century

Drywall contractor: Ultimate Finishing Systems

Main contractor: Taylor Woodrow

LAFARGE PLASTERBOARD