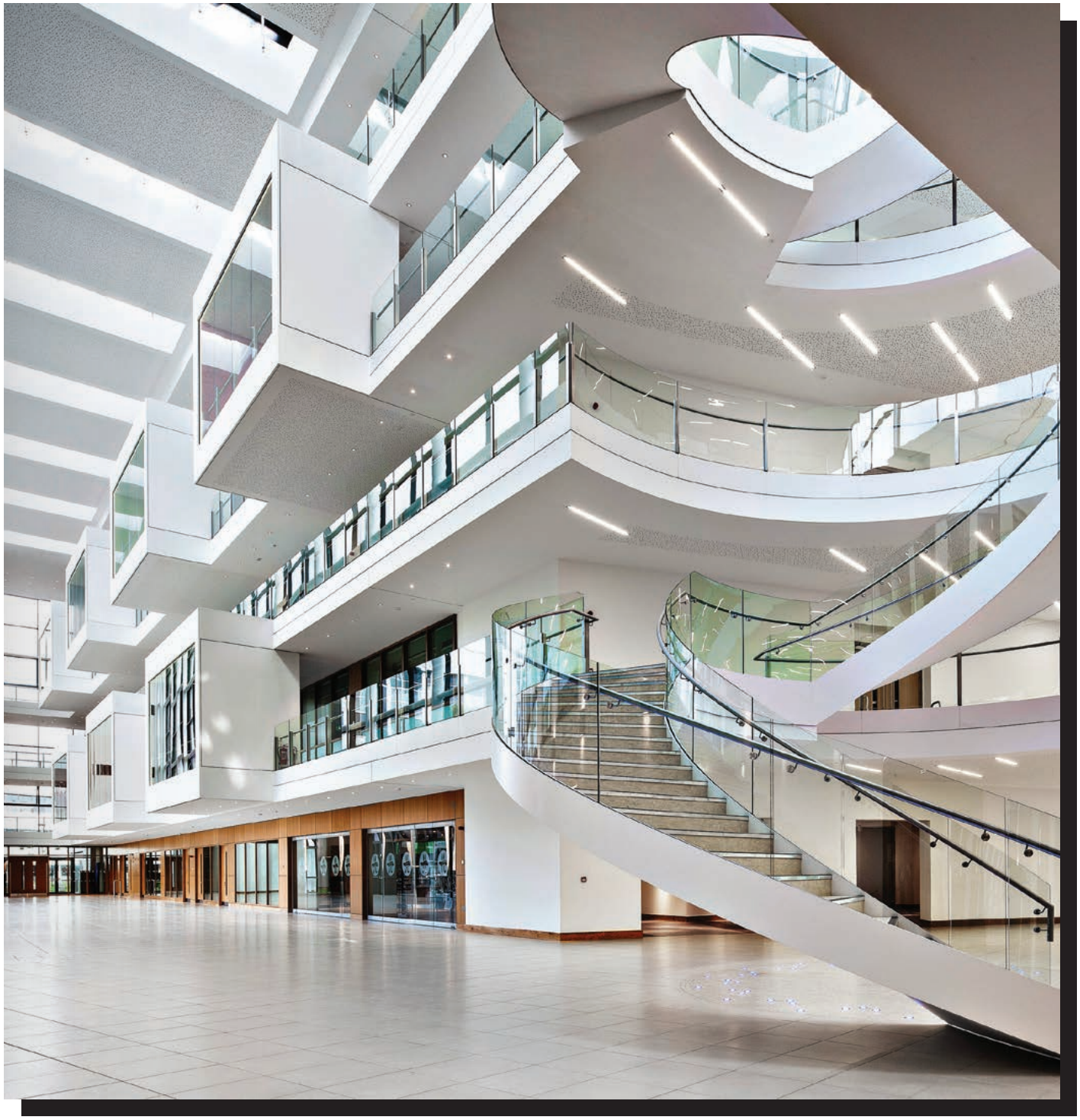
FIS

FINISHES & INTERIORS SECTOR

BEST PRACTICE GUIDE

# INSTALLATION OF DRYLINING



www.thefis.org

FINISHES & INTERIORS SECTOR

# BEST PRACTICE GUIDE
# INSTALLATION OF DRYLINING

First edition published April 2015
This edition published August 2018

ISBN 978-0-9565341-6-3



Published by FIS



Supported by

This project has been delivered with support from CITB, which aims to ensure that the construction industry has the right people, with the right skills, in the right place, at the right time and is equipped to meet the future skills demands of the industry.

# CONTENTS

# FOREWORD 1

This guide has been developed by FIS to promote best practice in the installation of drylining.

Drywall partitions are an integral part of many fit outs, offering fire, acoustic and structural performance, as well as making a major contribution to the overall appearance and quality of the finished space. However, for the completed drywall to meet the legitimate expectations of the building owner, occupier, design professionals and construction team, the selection and installation process must be carefully considered and understood by all parties.

Drylining is a finishing trade and requires installation by specialist contractors. The specialist contractor will provide the high levels of management, operative skills and resources essential to delivering a high-quality product. Their considerable experience on similar projects will be of significant assistance to the construction team.

System manufacturers design and produce drywall systems, which are then tested to meet the requirements for various environmental and performance levels. The provision of a whole range of design solutions is part of the responsibilities taken by manufacturers, who have a key role to play in drywall design.

FIS has grown over the past 50 years to become the leading trade association for the finishes and interiors sector of the construction industry, representing companies involved in the manufacture, supply and installation of all aspects of finishes, interior fit out and refurbishment. Its members can provide optimum solutions for installing interior elements.

This FIS best practice guide to the installation of drylining is not intended as a definitive technical manual, as the manufacturers' recommendations must always be followed, but as a guide to the construction team of best practice. FIS encourages all its members to follow the principles set out in this guide.

# INTRODUCTION 2

This guide is primarily concerned with the design and installation of internal, non-loadbearing drylining constructions using gypsum plasterboard on rigid metal framework. However, it also includes descriptions of other non-plasterboard, such as calcium silicate board, which are also used in drylined systems. This guide includes drylined partitions, linings and fire protection. Drylined ceilings are covered in the FIS Best Practice Guide – Installation of Suspended Ceilings.

Drylining systems are able to provide high levels of fire protection, fire resistance, sound insulation and thermal insulation. The correct design and installation are essential to ensure these performances are achieved.

The relative weight of drylined systems compared with blockwork, the speed of erection, fire, acoustic and thermal performance and the versatility of the systems make drylining a popular choice in all sectors of the industry. As such, they are used in all sectors, including residential, commercial, retail, medical and educational building types.

This guide provides useful information on a variety of disciplines involved in the design, management and installation of drylining systems, such as architects, engineers, main contractors, subcontract supervision and operatives.

The installation and design of the proprietary drylined systems will vary from one manufacturer to another, so reference should always be made to the manufacturer's technical literature for current methods of installation.

## 2.1 SCOPE

This best practice guide provides guidance for the design, selection and installation of non-loadbearing systems only, which comprise a rigid metal frame enclosed by boards that are not subjected to loading from the structure in which it is installed. Drylining systems can be subjected to an imposed load, such as tiling or mounted TVs. Full guidance should be obtained from the relevant manufacturer regarding the maximum loads drylined systems can facilitate.

Loadbearing constructions such as structural framing systems (SFS) or structural timber frame may use the same boards as for the non-loadbearing systems. Guidance for these systems should be sought from the relevant manufacturers.

# RECOMMENDATIONS FOR TENDERING AND MEASUREMENT 3

To enable the interior contractor to submit a realistic tender, it should be informed of the items given below. Tenders should normally be submitted on the basis that the work is to be carried out continuously. Should more than one visit be anticipated, the tenderers should be informed accordingly.

Construction (Design and Management) Regulations 2015, designed to reduce the risk of harm to those who have to build, maintain and demolish structures, should always be observed.

**www.hse.gov.uk/construction/index.htm**
**www.legislation.gov.uk/uksi/2015/51/contents/made**

## 3.1 CONTRACT CONDITIONS

The form of contract – for example, JCT, NEC or bespoke form – should be stated and the relevant sections of those contracts completed (contract particulars/contract data), which will include the following particulars:

- Confirmation as to whether it is a lump sum or remeasurable contract
- Payments (ideally a list of due dates and final dates for payment)
- Retention (if applicable)
- Discounts (it is preferable to have contracts placed on a nett of discount basis)
- Insurances
- Liquidated damages
- Defects liability period (now called rectification period under JCT11)
- Programme (duration and likely commencement date, possibly also number of visits to site and any milestone dates)
- Ascertainment of prices for variations
- Basis of day work charges (including actual rates for labour and percentage uplifts for plant and materials)
- Responsibility for design
- Requirements for bonds, warranties and parent company guarantees
- Waste management

### 3.1.1 Basis of measurement

The basis of measurement may take one of the following forms:

- Standard Method of Measurement 7th edition (SMM7)
- New Rules of Measurement (NRM)
- Quantities taken off drawings by the interior contractor and expressed as a lump sum (plan and spec) or an inclusive price per square or linear metre
- Site survey by specialist contractor
- Contractors' design proposal (CDP)

### 3.1.2 Programme

In addition to the information given in 3.4, as much information as is available should be given to the tenderer regarding the main contractor's building programme. If the main contractor has been appointed, ideally the partitioning tenderer should be given the dates of the work, together with details of sequencing.

## 3.2 MAIN CONTRACTOR (ATTENDANCES)

Attendances, together with services and facilities, should be clearly defined before entering into final contract agreement. Both main contractor and specialist contractor should clarify in writing what they have allowed for. Good practice is to agree a schedule provided by either party on what each is providing, so that the situation is clear. Items that should be covered include responsibility for providing toilets, hutting, cabins, lock-ups, skips, adequate and appropriate lighting, setting out and levels and datums, protection of the works, and security.

### 3.2.1 Specialist scaffolding

When the provision of specialist scaffolding is the responsibility of the main contractor, it should be provided, erected and dismantled free of any charge and conform to current regulations. It should be erected to the specialist contractor's requirements within the agreed programme and in advance of the specialist contractor's work. It should not be dismantled before satisfactory completion of the work.

If special scaffolding is the responsibility of the specialist contractor, it is assumed that the cost is included as a separate item in the tender. The main contractor should provide sufficient space for free movement of scaffolding and a suitable floor surface to properly support the scaffolding.

### 3.2.2 Unloading / distribution / hoists

Unloading the specialist contractor's material and plant and dist¬ributing it safely to the exact work locations should be defined as either being the responsibility of the main contractor or the specialist contractor. If the former, it will be at the cost of the main contractor; if the latter, the cost is deemed to be included in the specialist contractor's tender. If the specialist contractor's operatives are offloading material, they will assume that the ground works are complete to allow easy ingress into the site.

### 3.2.3 On-site storage

When storage of specialist contractors' material, plant etc is the responsibility of the main contractor, free use of a suitable secure, dry, covered area of sufficient size for stacking on a flat base should be provided **(see also 3.2.4)**. In the case of the specialist contractor being responsible for storage, the cost should be included in its tender.

### 3.2.4 Storage and handling

Once a full survey and assessment of site has been carried out, coordination with the project team with regard to site delivery, building access, lift or stairwell access and designated storage area is vital.

All materials and components should always be stored in accordance with manufacturer/supplier recommendations.

### 3.2.5 Temporary lighting and power

The responsibility for the provision of adequate and suitable lighting and suitable power supply should be stated. These must be in accordance with current safety regulations. Lighting levels should be designed to allow the installation and, importantly, the finishing of the drywall to be completed to the level of quality expected.

### 3.2.6 Working space

Sufficient space should be provided at floor level, free from traffic and interruption, for the specialist contractor to carry out the cutting of steel and panels, the cutting down of doors and the preparation of the surface as part of the normal process of the work. Consideration should be made to ensure that material can be moved around the site in a safe and efficient manner.

### 3.2.7 Waste management

The responsibility for clearing and removing waste material should be clearly defined pre-tender. During the installation process, there can generally be the following types of waste removal:

- The main contractor provides waste segregation skips/bins for items such as plasterboard, steel, aluminium, mineral wool, wood and glass. The interior contractor would place waste material in the relevant skip/bin. The main contractor then takes responsibility for removal from site to a local recycling centre.
- The specialist contractor is asked to take responsibility to remove segregated waste, as detailed above, to the local recycling centre. To do this a 'waste carrier licence' is required. Without one, a suitable authorised company will need to be appointed to collect the waste and transport to the local recycling centre.
- Recycling waste plasterboard back to the manufacturer for recycling in the manufacturing process is an option, providing there is reasonable volume. Consultation with the relevant manufacturer is advised.

More information about handling and managing plasterboard/gypsum being a controlled waste can be found at **www.gov.uk/managing-your-waste-an-overview** and **www.plasterboardpartnership.org/pages/recycling.htm**

## 3.3 DESIGN REQUIREMENTS

While in many cases the design and product selection is carried out by the specifier to the client's requirements, design input is being increasingly sought from the main contractor, the specialist contractor and the manufacturer. So in the very early stages, clarification of any design input required is needed by all parties and confirmed in writing.

### 3.3.1 Drawings for tender enquiry

a) Layout drawings should be provided, indicating the various areas covered by the enquiry, cross-referencing any changes in height and junctions between any different systems. A minimum scale of 1:100 should be used, but preferably 1:50 or better if possible.

b) The following information should be included:

- Detailed drawings to support design and installation
- Level of ceiling membrane above finished floor level
- Indication of any panels that should be accessible
- Indication of any intrusions in the floor to ceiling height
- Abutment and head details
- Junction and corner details
- Cable management
- Gradient of floor

### 3.3.2 Specification

The specifier might wish to consider specifically how any mock-ups or prototypes might be covered at this stage, to allow a more detailed final specification to be written.

A specification written in partnership with a manufacturer can ensure that key issues and details are considered in the design process. If however a performance specification is going to be produced, then the specifier should ensure that evidence can be provided that areas of performance can be met. This is normally in the form of tests carried out by an independent laboratory accredited by UKAS. Any test evidence should reflect the system

and details proposed and, where applicable, sight of the test report and not just the certification should be made possible (although copies may not be left for confidential reasons).

Specifiers, building operators and facility managers should not accept any substitution of materials from the test report without assessments. In fire, acoustic or applied line load (crowd pressure on an escape route) assemblies, any alteration of materials may cause a failure. In line with the National Building Specification (NBS) K10, the design criteria should be given under the following headings (where applicable), with outline details of layout:

- System manufacturer
- System type/product reference
- Location
- Layout
- System performance:
  - Fire resistance – BS 476-22: 1987 or BS EN 1364-1: 1999
  - Fire propagation – BS 476-6: 1989 +A1: 2009
  - Spread of flame – BS 476-7: 1997 or BS EN 13501-1: 2007 +A1: 2009
  - Acoustic insulation – BS EN ISO 10140-2: 2010) / BS EN ISO 140-3 :1995
  - Structural – duty rating BS 5234-2: 1992
  - Strength – to BS 5232-2: 1992
- Partition height:
  - Floor to ceiling (mm)
  - Deflection allowance (±mm)
- Panel type – module types
- Solid panels – finish/colour, joint treatment, cover trims
- Junctions
- Skirting

NBS Create will replace these standard clauses in due course.

## 3.4 BUILDING OWNER INVITING TENDER

When the owner of an existing building is inviting tenders, the following information should be given in addition to specification and design details:

- Location of site and access
- New building, existing building or extension
- Availability of lifts (including size) and stairs in existing buildings and use of power and hoists (including size) for bringing materials and plant into the building
- Function of building
- Main contractor's programme and building owner's stipulation affecting the sequence and working hours of the works
- Limitations imposed by occupancy on construction work
- Payment terms

# CONTRACT PLANNING 4

Crucial to the success of a partitioning installation is the planning and co-ordination that precedes the work. The aim of this planning should be to establish:

| | |
|---|---|
| EXACTLY WHAT IS TO BE DONE | **SPECIFICATION** |
| HOW IT IS TO BE DONE | **METHOD** |
| WHEN IT IS TO BE DONE | **PROGRAMME** |

These steps are inter-related and it is preferable not to discuss them separately. However, identifying them will assist a methodical approach to contract planning.

All three items should have been clearly stated before tendering and indeed should have formed the basis of the tender. However, after entering into a contract it is necessary for the specialist contractor to confirm specification, method of working and programme.

The first action by the specialist contractor must be to establish the date by which materials must be ordered to meet programme requirements. This will set a limit to the time available for receipt of contract drawings, the production of specialist working drawings (if required) and checking and approval by the client. Where special sizes, sections, materials or finishes are involved, this lead time can be considerable. It is often underestimated, with serious consequences if contracts are delayed, leading to claims against the specialist contractor.

Next, the detailed programme of work must be agreed with the main contractor. This will include start and completion dates for the subcontracted work or specific phases of the work and will be closely related to the activity of other trades whose work can be expected to interact with the partitioning.

A period of notice should be agreed for confirming or amending delivery dates.

The specifier should issue contract drawings that clearly detail the specification required and all partitioning-related services. These drawings should include and detail any interfaces with mechanical, electrical and related components that relate to the partitioning plane. This is to allow all services and penetrations to be considered. Drawings should be checked on receipt to ensure that requirements are fully understood on how this might affect the fire or sound performance of the partitioning.

Any queries must be raised with the specifier or main contractor without delay and be prepared to produce detailed drawings if requested. Details that commonly require such attention include:

- Fixing of the partition to a suspended ceiling – the need for pattresses behind the ceiling panels, lateral bracing to meet load requirements or acoustic treatment either on top of the partition or as a barrier fixed between the partition head and the soffit
- Type of floor and any fixing restrictions that prevail
- Type of abutting walls and any fixing restrictions that prevail

Where moveable walls are being installed, there will be a need to construct suitable framing behind the suspended ceiling to carry the necessary weight and load requirements of the wall.

## 4.1 SEQUENCE OF INSTALLATION

When the partitioning specification and integration with the building services are established, the sequence of installation and the method of working should be considered.

## 4.2 MATERIALS MANAGEMENT

For building construction to be efficient and economical, the management of materials must be efficient from the point of specification to incorporation in the works. Orders must be placed with suppliers or manufacturers to allow time for manufacture or procurement. This is particularly important for special sizes or special components when relatively long lead times are likely.

Building programmes are commonly disrupted for a variety of reasons – for example, bad weather, industrial disruption affecting delivery of major components, changes of policy by clients. It is important that suppliers are kept informed of possible delays in the building programme, which may require delay in delivery to site. Materials delivered too early to a site are likely to be damaged. Inadequate notice of delay may invoke charges from suppliers, particularly if products ordered are being bespoke manufactured for the project.

The specialist contractor must arrange with the main contractor for satisfactory receipt and storage of their materials. All must be aware that partitioning materials are generally fragile and require careful handling and storage **(see also 3.2.4)**.

To minimise handling, storage zones should be clearly identified adjacent to working areas, together with a time period for their use. Clear gangways and access to lifts and staircases should be available, with sufficient width to accommodate the safe handling of materials, and cleared of all obstacles to avoid tripping.

Consideration should be given to whether any floor protection is required and if so, who bears the cost. Likewise, where appropriate, the cost of protection against damage to core/existing areas is normally covered by others.

## 4.3 SITE CONDITIONS

It cannot be too strongly emphasised that drylining is essentially a finishing trade and therefore the building should be in a proper condition with regard to cleanliness, humidity and temperature before drylining can be installed. The building should be fully enclosed, and all wet work completed and dried out.

The manufacturer's recommended site conditions for the installation of their materials should be followed but generally conditions should be similar to those that will prevail when the building is occupied.

Drylining work is normally carried out in one operation. If this is not possible, it will add to the cost of the installation.

Where mobile platforms are used, areas required for installation should be clean and clear of the equipment and materials of other trades to provide an adequate and safe working space. The specialist contractor should leave these areas in a clean state after installation of the drylining.

### 4.3.1 Lighting

As the general level of lighting will have a critical effect on the appearance of a finished surface, higher levels of lighting are often required. It is essential to have good levels of lighting to achieve the highest quality of workmanship. Where there is a low level of natural lighting, this must be supplemented using artificial lighting.

The temporary lighting conditions provided on site should simulate the same or higher lighting conditions as the final lighting scheme and should be fully adjustable due to the angle of illumination. The specialist contractor should familiarise themselves with the lighting on the project and the temporary lighting should simulate or exceed the lighting conditions.

The contractor is to allow for sufficient lighting standards to achieve the correct quality. The contract documentation should specify if the final permanent lighting of any surface is to fall at glancing angles.

## 4.4 PROGRAMME

Realistic programming requires great care and depends on the professionalism and integrity of the various parties involved. In a building designed with a high concentration of services, the various trades involved depend on every member of the building team maintaining the correct rate of progress.

It is important that the drylining contractor works in harmony with any associated trades, such as suspended ceilings, partitioning, electricians and lighting, to ensure that all elements are built with a minimum of disruption for all concerned.

### 4.4.1 Acceptance of the works

CONTROL SAMPLES

It is recommended for the drylining contractor to install a control sample of various elements of the drylined systems. It is imperative that this is carried out and that the control sample is maintained in an area where it can be referenced throughout the contract. This will be invaluable in the case of any dispute over the quality of the installation. Early discussions regarding the location of the control samples are recommended.

DECORATING DRYLINING

It is generally considered good practice for the painting contractor to be a member of a recognised painting and decorating trade body. Trade bodies require members to abide by a strict code of practice, which requires members to advise on items such as any apparent shortcomings that may exist in the specification, make recommendations on alternatives and ensure that all work is executed by competent workmen and apprentices under proper supervision.

The additional advantage to both the specialist contractor and the client is that by being a member of a trade body, some can provide a client with an advisory service, including conciliation and arbitration arrangements to help resolve any disputes that arise between member firms and their clients.

## 5.1 INSTALLATION TOLERANCES AND QUALITY OF THE INSTALLATION

Where manufacturers state the use of BS 8000 or BS 8212, the systems will be deemed to be installed in accordance with the tolerances stated in section 3 of the standards.

In section 3 of BS 8212: 1995 Code of practice for drylining and partitions using gypsum plasterboard, section 3.3.3 describes the deviations and tolerances with regard to the finished surfaces of partitions and independent linings. Tolerances are also described in BS 8000-8: 1994 Workmanship on building sites – code of practice for plasterboard partitions and linings, and these are the same as the BS 8212 requirements.

It is common for these requirements to be amended when a higher standard of workmanship tolerances is required and it will be necessary to use enhanced methods of setting out, installation and checking when this is specified.

The specific wall tolerance clauses are as follows:

### 5.1.1 Setting out of partitions and independent linings

Where the framework of a partition or a lining is independent of the structure, the deviation from the setting out positions should be within the following tolerances:

- The offset on plan from an agreed line or position, measured at the setting out level (ceiling or floor) **±3mm**
- The offset from vertical, measured above or below the setting out position (ceiling or floor) **±5mm**

### 5.1.2 Finished surfaces of partitions and independent linings

The deviations in the position of a finished surface of a partition or lining from the straight line connecting end points of the partition should be within a band of 10mm **(see figure 1)**.

The measurements should be taken at approximately 600mm above finished floor level and should be accompanied by measurements of the partitions or linings vertically at the measuring points and should be within the 10mm band.

### 5.1.3 Localised build-up of the surface

CROWN OF JOINT: (TAPE AND JOINTING)
The maximum increase should not exceed 3mm when measured using a 450mm straightedge **(see figure 2)**.
EXTERNAL ANGLES (TAPE AND JOINTING)
The maximum increase should not exceed 4mm projection from either face.
INTERNAL ANGLES (TAPE AND JOINTING)
The maximum increase should not exceed 5mm projection from either face **(see figure 3)**.

### 5.1.4 Boxed studs

The increased thickness of the partition should be not more than 4mm around openings (door heads, access panels etc).

The above build-up tolerances are specific to tape and jointing, where noted. For plastered skim coat tolerances, reference should be made to BS EN 13914-2:2005 Design, preparation and application of external rendering and internal plastering – Part 2: Design considerations and essential principles for internal plastering for these tolerances.

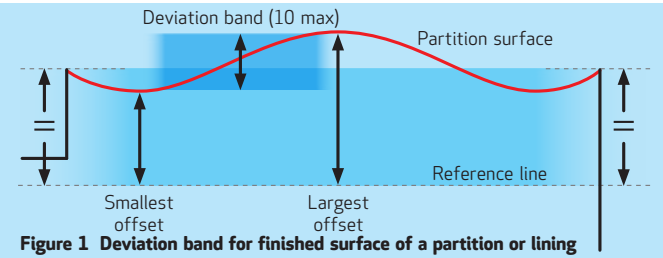


**Figure 1 Deviation band for finished surface of a partition or lining**

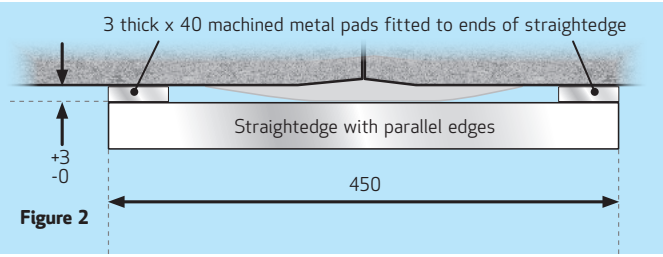
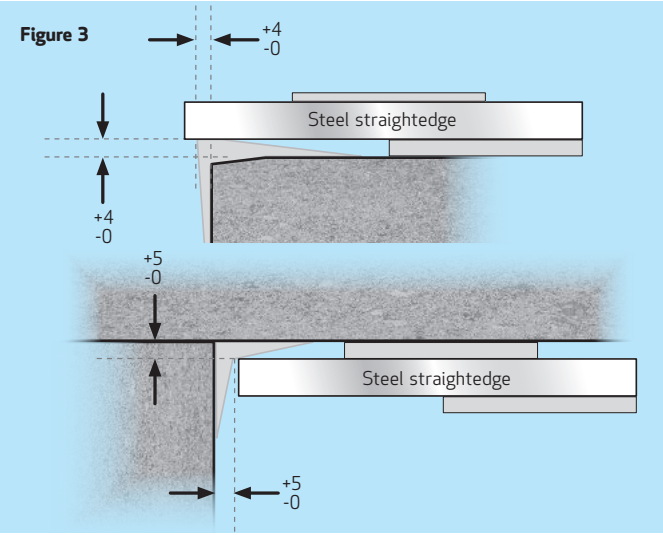


**Figure 2**



**The main standards that provide recommendations for the design and installation of internal, non-loadbearing constructions lined with gypsum plasterboard that has been manufactured in accordance with BS EN 520**

**BS 8212 1995**
Code of practice for drylining and partitioning using gypsum plasterboard

**BS 8000 part 8 1994**
Workmanship on building sites, Code of practice for plasterboard partitions and drylinings

**BS 5234 1992**
Specification for performance requirements for strength and robustness

**Figure 4**

The installation of non-gypsum board types are not covered within BS 8212 and BS 8000 and are defined in the section entitled Types of board used in construction of this guide **(see section 6.13.3)**.

## 6.1 DETERMINING THE CORRECT MATERIALS

A number of factors will need to be known when selecting the correct materials and drylined system to be used. Such factors are fire protection, fire resistance, acoustic performance, thermal performance, stability and the environment to which the finished products will be subject. Other factors, such as duty ratings and maximum height, will also be an important factor when determining the correct system **(see section 6.2)**.

Before commencing works, the site conditions for the construction of the works should be watertight, weatherproof and dry and the correct materials specified. Plastering and taping and jointing should only take place in dry conditions and where the minimum temperature can be maintained above 5ºC.

It should be noted that plaster and plasterboard will be damaged if subjected to temperatures in excess of 49ºC – for example, adjacent to open or closed multi-fuel burners – and alternative finishing methods should be employed.

## 6.2 CHECKLIST FOR THE SELECTION OF PARTITION SYSTEMS

BS 8212 states a number of factors that can influence the choice of a drylining system and these should be considered. This guide uses these factors and includes some additional factors to be considered in this revised list:

- Fire protection, fire resistance required
- Sound insulation
- Thermal insulation
- Current legislation
- Building type, occupancy and use
- Maximum height of the system
- BS or BS EN fire test standards
- Thickness of the drylined system
- Provision of services
- Loadings to be carried by the system
- Loading of the system on the structure
- Building deflection and movement
- Exposure to knocks and abrasions (durability)
- Decoration
- Temperature and humidity conditions
- Tolerances of the background structure
- Programming and sequence of the works
- Space utilisation (optimum use of space)

All of the above factors should be understood by the designer. In addition, consulting with the manufacturer literature when specifying the works should advise which products are suitable for the various applications.

## 6.3 KEY LEGISLATIVE AND GUIDANCE DOCUMENTS

The selection and specification of internal non-loadbearing partitions will be influenced by one or a combination of the following key legislative and guidance documents:


**Figure 5**

### 6.3.1 Fire resistance and fire protection

Approved Document B (AD B) of the national Building Regulations for England and Wales stipulates certain periods of fire resistance for structures and compartments. It is divided into five sections:

- B1 Means of warning and escape
- B2 Internal fire spread (linings)
- B3 Internal fire spread (structure)
- B4 External fire spread
- B5 Access and facilities for the fire service

Drylining systems can meet the requirements of AD B by providing surfaces that minimise the spread of fire. Constructions should have a specified period of fire resistance and the project-specific fire strategy drawings/reports should fully identify the requirements. Drylined systems are capable of providing a variety of fire resistances combining both integrity and insulation performances. It is important to note that some systems may not provide the full insulation requirements, such as shaft walls, and the designers should be aware of this and consult with the relevant manufacturer. This may require dispensations from the regulatory body.

AD B makes reference to publications produced by the Association for Specialist Fire Protection (ASFP) – the ASFP Red Book, Yellow Book, Grey Book and Blue Book. ASFP has since produced a Purple Book for Fire Resisting Partitions not referenced in Approved Document B. This is a valuable reference regarding all matters relating to the fire resistance of partitions.

The Purple Book defines a partition as 'an interior wall that is present to sub-divide space into multiple rooms or areas, but does not contribute to the support structure of the building'.

Always consult with the manufacturer for guidance of the effect if a load is applied to a fire resistance partition.

In Scotland the fire resistance requirements for buildings are contained in Regulation 12 of the Building Standard (Scotland) Regulations – Part D2 of the technical standards: structural fire precautions.

In addition to Regulation 12, the Technical Handbook 2013 – Domestic (section 2: Fire) and Technical Handbook 2013 – Non Domestic (section 2: Fire) should be referenced.

**www.gov.scot/Resource/0039/00397457.pdf**

It is not necessary to follow the requirements of the technical standard if it can be proved that an alternative method meets the provision of the functional standard.

**www.gov.scot/Topics/Built-Environment/Building/Building-standards/publications/pubtech**

In Northern Ireland Technical Booklet E: 2005 – Fire safety is used and this follows Approved Document E closely. There is no obligation to follow the methods set out within the technical standard. If preferred, other methods of meeting the requirements of the Building Regulations can be adopted but this will need to be demonstrated that those requirements are met through other means.

**www.dfpni.gov.uk/br-booklet-fire2005**

There are primarily two types of fire protection – passive and active.

Passive systems such as drylining are based on the principles of containment where the compartments of a building are built, so that fire will be restricted to one area, or as fire protection to structural steel.

Active fire protection systems may detect fire or extinguish fire with water sprinklers of inert gases. Active systems are not covered in this guide.

There are currently two methods of fire testing drylined systems within the UK (including ceilings and fire protection to structural steel). They can be tested using the principles of BS 476 series of tests (BS 476; Parts 20 to 23) or BS EN 1364-2:1999, 1365-2:2014 and 1364-1:1999. To allow a better free trade across Europe, the Construction Products Directive (CPD) was produced to reduce the technical barriers to trade across the EU member states and this directive introduced the European test standards. The methods of testing vary between the two standards and as a result there are differing constructions and performances achieved from the EN and BS tests. Generally, the results of the fire tests of the BS 476 and the BS EN test methods cannot be compared directly.

Using the BS EN methodology, reaction to fire and fire resistance are measured differently in Europe. The fire curve is the same for both the BS and EN test, although the method of recording temperature rise is different. This will typically lead to an earlier EN failure compared with BS, making the EN tests more onerous. In addition to the EN tests, the standard imposes rules regarding the use of the tests to cover specific end use scenarios (field of application). This means that it has an effect on the height of partitions where partitions above 4m may need to have enhanced levels of fire resistance. The impact of this can be reduced heights permissible in the EN tests over the BS tests and additional board layers required to achieve the same fire resistances. Calculation methods can be used to extend the heights of partitions above 4m.

The approach of the current BS 476 series of tests is that the height of the partition in a fire condition is not considered and if, for example, the partition passes the fire test at a particular height – for example, 3m – then it would be considered acceptable in a fire for any height permitted for the cold state height of the partition.

It is essential that all fire tests are carried out by a United Kingdom Accreditation Service (UKAS)-accredited test facility.

UKAS is a third-party accreditation body that ensures testing and calibration laboratories, inspection and certification bodies have been assessed against internationally recognised standards to demonstrate their competence, impartiality and performance capability. Never assume that systems have been tested using UKAS-accredited bodies and always ask to see evidence of this by asking to see a copy of the certificate and, where necessary, including the detailed construction details that apply to the certificate, such as where a deflection head may be included. This should be requested before the materials are procured and any work commences on site. It is also acceptable to produce assessments in lieu of specific fire resistance test results. See the Passive Fire Protection Federation's Guide to undertaking assessments in lieu of fire tests. An assessment is an opinion of the likely performance of a component or element of structure if it were subjected to a standard fire test.

Assessments may be provided for the following reasons:

- Where there has been a modification to a construction that has already been tested.
- When there is a requirement to interpolate or extrapolate the results of a series of fire test results or utilise a series of fire tests to evaluate a range of variables in a construction design or a product.
- Where it may not be possible to subject a construction or product to fire tests for various reasons, such as size or configuration.

**www.pfpf.associationhouse.org.uk**

Consideration should be given to the fire resistance or protection properties of the system. Properties may include the following:

- Reaction to fire – The manufacturer will be able to provide the Euroclass of the products used to construct the system and relevant materials will be selected to satisfy particular requirements.
- Fire resistance – The system that is selected should fulfil all of the fire requirements required by the legislative documents and the particular building fire strategy.
- Cavity barriers and closures – To prevent the spread of fire and smoke in cavities, cavity barrier closures will be required and should be considered by the designer.
- Fire stopping – Fire stopping should be installed to seal any imperfection of fit between fire-resisting systems and other elements, such as adjoining structure and services.
- Smoke control – Smoke stopping should be installed to seal any imperfection of fit between fire-resisting systems boarding and other elements, such as adjoining structure and services.

There are different fire requirements and guidance documents for the variety of building types:

RESIDENTIAL

AD B stipulates the requirements for residential property and comprises two sections: Volume 1 – Dwellinghouses and Volume 2 – Buildings other than Dwellinghouses. A dwelling is defined as a unit of residential accommodation occupied by a single person or people living together as a family and not blocks of flats. Residential buildings often contain a variety of ages of occupants, including disabled and infirm, and are buildings where people sleep. The fire-resisting construction design is therefore essential for the life safety of the occupants.

England

**www.planningportal.gov.uk/buildingregulations/approveddocuments**

Northern Ireland

**www.dfpni.gov.uk/index/buildings-energy-efficiency-buildings/building-regulations/br-legislation.htm**

Scotland

**www.gov.scot/Topics/Built-Environment/Building/Building-standards**

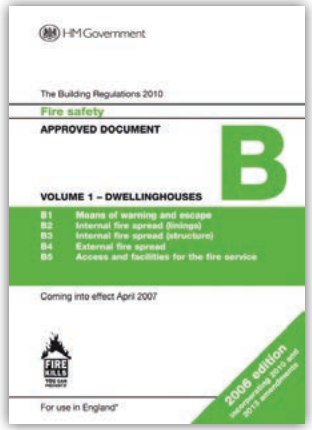
Wales

**www.gov.wales/topics/planning/buildingregs/publications/?lang=en**

In additional to AD B the Local Government Group has produced guidance entitled Fire safety in purpose-built blocks of flats. This guide includes reference to the Regulatory Reform (Fire Safety) Order 2005 (RRO), which came into force in October 2006.

**www.legislation.gov.uk/uksi/2005/1541/contents/made**

**Figure 6**




COMMERCIAL

In 1999 the Loss Prevention Council (LPC) produced The design guide for the fire protection of buildings – commercial and industrial. This document provides guidance on the general principles of passive fire protection with reference to AD B. It is a design guide and has been prepared to allow architects

and designers to take into account business risk management issues in relation to the fire protection of buildings.

Following the production of this document, the Fire Protection Association (FPA) and RISCAuthority combined to produce Approved Document B: Fire Safety (Volume 2), Buildings other than dwellinghouses, incorporating insurers' requirements for property protection. This document uses the text from AD B: Fire Safety (Volume 2) and includes additional text, tables and diagrams to cover relevant property protection and business interruption issues.

**www.riscauthority.co.uk**

**www.thefpa.co.uk**

HEALTHCARE

Health Technical Memorandum 05-02 (HTM 05-02), Guidance in support of functional provisions (fire safety in the design of healthcare premises) 2014 edition, is a code of practice and contains specific guidance to meet the requirements of AD B. In addition to the requirements of AD B, HTM 05-02 aims to ensure that everyone concerned with the management, design, procurement and use of healthcare facilities understands the requirements of fire safety in order to ensure optimum safety for all who are present in the building. Like residential buildings, hospitals and healthcare buildings contain large numbers of bedbound patients and the guidance considers factors such as the dependency of patients, the availability of adequately trained staff, the fire hazards in the building and the policies of management.

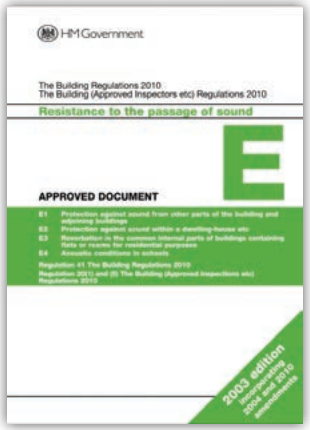
**www.gov.uk/government/uploads/system/uploads/attachment_data/file/308846/HTM_05-02_2014.pdf**

EDUCATIONAL

The design of fire safety in schools is covered in the Building Bulletin 100: Design for fire safety in schools (BB100). BB100 provides fire safety guidance for schools in England and Wales, primarily for designers, fire engineers, building control officers and fire safety officers.

### 6.3.2 Acoustic performance

Figure 7




Plasterboard systems can provide both sound absorption and sound insulation properties. Absorption is generally achieved by using a perforated grade of plasterboards backed with a sound-absorbing matting/material, while insulation is provided by the mass of the drylining system.

Systems are acoustically tested in a laboratory and the manufacturer's literature will provide the weighted sound index ($\boldsymbol{R}_w$), which is measured in decibels (dB). In general these tested systems will not contain perforations (imperforate) and will be fully sealed and have tape and jointed surfaces. However, some manufacturers have tested plasterboard wall systems containing perforated plasterboards on either one or both sides of the wall. The tests are carried out using a range of controlled frequencies and this will provide a good range and indication of the systems capability of resisting the passage of airborne sound.

Once the systems are constructed on site, they will not be able to replicate the same acoustic performance as that of the laboratory tests. Therefore a different method of standardised level difference is used. This is referred to as $\boldsymbol{D}_{nf,w}$. These site figures will be lower than the laboratory tests and will be affected by the surrounding structure and the junctions at wall and floor abutments – for example, flanking conditions. It is possible that the systems will be penetrated by services penetrations. Part E of the Building Regulations addresses occupant use in properties (residential, student accommodation), which takes into account low frequency noise with a correction factor of $\boldsymbol{C}_{tr}$.

Site test measurements on room-to-room airborne sound reduction (separating elements) within residential developments will have the $\boldsymbol{C}_{tr}$ correction factor applied: $\boldsymbol{D}_{nT,w} + \boldsymbol{C}_{tr}$ = site test result.

Manufacturers' systems will cover laboratory test conditions for sound tests stated as $\boldsymbol{R}_w$ and $\boldsymbol{R}_w + \boldsymbol{C}_{tr}$. It is important to note that an $\boldsymbol{R}_w + \boldsymbol{Ctr}$ sound test figure will need to be a minimum of 4-7dB higher in performance depending on the system to realise a site test $\boldsymbol{D}_{nT,w} + \boldsymbol{C}_{tr}$ figure.

The inclusion of various thicknesses of acoustic quilt within a cavity of a partition can increase the sound insulation values. (This insulation can also contribute to better thermal insulation values.)

It is important that this is considered by the designer when selecting the drylining system.

Due to potential work practices and flanking around adjacent elements, systems will not necessarily be able to replicate the same acoustic performance.

According to Approved Document E (AD E) of the national Building Regulations and other documents, there are a variety of requirements depending on the type of building:

RESIDENTIAL

Party walls and floors, partitions and ceilings require special detailing and specification to ensure the quality of life to occupants of residential buildings is not impaired.

There are two approaches to ensure the requirements of acoustic performances in residential buildings are met:

- Pre-completion testing where a percentage of the completed works are tested (1 in 10) in accordance with AD E.
- Use of the pre-approved details from Robust Details Ltd. There are limitations to the Robust Details method in that it can only be used for new build houses and apartments. It should be noted that the details provided by Robust Details are for compliance with Part E only and may not be suitable to comply with Part B.

The Robust Details scheme is the alternative to pre-completion sound testing for satisfying Part E of the Building Regulations. Using the scheme avoids pre-completion testing.

**www.robustdetails.com**

COMMERCIAL

AD E is not used for commercial buildings. FIS's Guide to Office Acoustics was developed to promote best practice in the design and installation of acoustic solutions in offices.

**www.thefis.org/publications/a-guide-to-office-acoustics-click-picture-to-view**

HEALTHCARE

The design of acoustic performance in healthcare is covered in the Health Technical Memorandum 08-01 (HTM 08-01). This document aims to help designers ensure the acoustic requirements are met and to give healthcare professionals a better understanding of the acoustic requirements. HTM 08-01 sets out the criteria for the design but does not provide the solutions to achieve this. This will be the responsibility of the designers.


**Figure 8**

**www.gov.uk/government/uploads/system/uploads/attachment_data/file/144248/HTM_08-01.pdf**

EDUCATIONAL

Section 8 of AD E is concerned with schools. In essence, the requirements set out in this section are that the way of satisfying Requirement E4 will be to meet the values of sound insulation, reverberation time and internal ambient noise given in section 1 of Building Bulletin 93, Acoustic design of schools (BB93).

The BB93 2015 standards are available to download at:

**www.gov.uk/government/uploads/system/uploads/attachment_data/file/400784/BB93_February_2015.pdf**

### 6.3.3 Thermal performance

Plasterboards can be combined with other low-conductive materials to provide a variety of thermal insulation performances.

The insulation can be bonded to the back faces of the boards, be concealed within the cavities of partitions and within roof or floor voids.

The positioning of the insulation will be vital to the performance of the system and can be used to reduce cold bridging and the effects of condensation, both surface and interstitial.

The insulation will be bonded onto the back of a variety of plasterboard types and the insulation types can be:

- Glass mineral wool
- Expanded polystyrene
- Extruded polystyrene
- Phenolic foam
- Rigid PIR.

RESIDENTIAL

There are two Approved Documents that concern thermal performance in residential buildings: L1A Conservation of fuel and power in new dwellings and L1B Conservation of fuel and power in existing dwellings.

These documents are concerned with the conservation of fuel, based on the fact that a considerable amount of power is consumed heating buildings in this country. These documents ensure that adequate thermal insulation standards are achieved and that the efficient controls of energy use are provided in both new and existing buildings.

COMMERCIAL, HEALTHCARE AND EDUCATIONAL

There are two Approved Documents that concern thermal

| GRADE | CATEGORY OF DUTY | EXAMPLES |
|---|---|---|
| **Light duty (LD)** | Adjacent space only accessible to persons with high incentive to exercise care. Small chance of accident occurring or of misuse | Domestic accommodation |
| **Medium duty (MD)** | Adjacent space moderately used primarily by persons with some incentive to exercise care. Some chance of accident occurring and of misuse. | Office accommodation |
| **Heavy duty (HD)** | Adjacent space frequently used by the public and others with little incentive to exercise care. Chances of accident occurring and of misuse. | Public circulation areas, industrial areas |
| **Severe duty (SD)** | Adjacent space intensively used by the public and others with little incentive to exercise care. Prone to vandalism and abnormally rough use. | Major circulation areas, heavy industrial areas |

**Figure 9 Extract from BS 5234 Part 2: 1992 Partitions (including matching linings) - Part 2: Specification for performance requirements for strength and robustness including methods of test.**

performance in non-residential buildings, L2A Conservation of fuel and power in new buildings other than dwellings and L2B Conservation of fuel and power in existing buildings other than dwellings.

## 6.4 DUTY RATING PERFORMANCE

It is important to understand the various duty ratings that are applicable to partitions. These are defined in **figure 9**. However, the actual requirements are not always considered and heavier duty ratings are commonly specified when a lesser rating would suffice.

Clients and customers could be dissatisfied with the lower duty ratings despite the descriptions in **figure 9**. Industry practice has improved but the duty standard has not. In our opinion, light duty should be avoided.

BS 5234-2 specifies performance requirements for the strength and robustness of partitions regardless of the materials and form of their construction, when tested by the methods stated in the standard.

The tests carried out on the partitions are designed to test the resistance to damage, both structural and visual from a range of load applications and impacts.

Certain board types used will limit the duty ratings of a partition by the nature of the board type/thickness and the board's performance in the hard body perforation test. For example, a single layer of standard 12.5mm wallboard will only be able to achieve a maximum rating of Medium.

When heavy and severe duty ratings are specified, this will impact other detailing of the partition. For example, when looking to achieve Heavy and Severe Duty ratings, the door details may need to be reinforced, otherwise too much deflection will be experienced and damage caused during the door slam tests.

There are specific gypsum plasterboards that have been manufactured with higher density cores and with other additives to provide greater impact resistance. The manufacturers of the drylined systems can provide guidance on properties of the various board types and the duty ratings the partitions can achieve.

## 6.5 MAXIMUM PARTITION HEIGHTS

The maximum height of partitions is determined using a widely adopted system in the partition industry, where an amount of deflection is given under uniformly distributed load (UDL) measured in pascals (Pa).

The most common of the limiting deflections is L/240, where L is the height of the partition and a partition is loaded to 200Pa.

The heights stipulated in the main performance tables of the various manufacturers provide the different stud centres and maximum heights, generally with a limiting deflection of L/240.

The manufacturers should always be consulted to determine the maximum heights of partitions, given differing allowable deflections and air pressure (Pa).

An example of where greater limiting air pressures may be experienced is in lift shafts.

The heights of partitions can be increased by reducing stud centres, boxing studs and the selection of stud type, size

and gauge – for example, I stud and C stud. Depending on the test evidence, additional maximum heights for fire-resisting partitions will only be applicable for partitions tested to BS 476: Part 22 unless a UKAS-accredited test laboratory is used to determine increased heights when working to BS EN 1364-1:1999.

It may be necessary to increase the stiffness of a partition for other reasons, such as when stone systems are applied to drylined systems, depending on the thickness, load of the stone etc – for example, from L/240 to L/360. Specialist advice can be sought from the stone federation.
**www.stonefed.org.uk**

When stud centres are reduced for specific reasons, such as the application of tiles, stud centres are generally reduced to 400mm max centres. This will stiffen the partition but can have a detrimental effect on the acoustic performance of the system. Any potential reduction in acoustic performance due to the stiffening of a partition can be counteracted by other measures, such as the introduction of acoustic quilt into the partition cavities. Advice on this would be available from the manufacturers or an acoustician.

## 6.6 ENVIRONMENTAL CONDITIONS

Another factor that may determine the selection of the materials is the condition of the site during construction. For example, it may be necessary to construct works prior to a building being watertight. While this is generally not recommended within BS 8212 and BS 8000, there are systems on the market that are capable and designed for these types of applications.

If the partition is installed with a gap between the board and the floor slab to elevate damage whilst there is a risk of water ingress then any gaps must be filled with a gypsum-based product or sealant, as approved by the manufacturer, to ensure that the performance of the partition is maintained. The use of expanding foam is not recommended.

## 6.7 AIR TIGHTNESS

Drylined systems can contribute to and provide air tightness and this could be required for areas such as mechanically assisted opening ventilator (MAOV) risers (where these must be fully smoke sealed), pressurised lift shafts, Passivhaus buildings, clean rooms and for air permeability within residential properties. Specialist detailing and sealing will be required and guidance can be obtained from the relevant plasterboard system manufacturer.

## 6.8 CORRECT SELECTION OF PERFORMANCE-RELATED PRODUCTS

Materials used in various systems will be specified by the manufacturer. Some manufacturers produce the full systems, metal, board, fixings and finishing products; others only manufacture parts, such as the metal components, not the boards etc. Where non-system alternatives are used it is imperative that the fire, acoustic, thermal etc properties are fully detailed.

You cannot assume that two fire-rated products from different manufacturers will provide the same performance. Clarification/certification should be confirmed from the supplier in writing prior to purchasing materials.

### 6.8.1 Material tolerances

Each material in a drylined system is manufactured within a tolerance and this will be factored in when designing a system to be used.

The overall tolerances of a finished system should comply with the requirement stipulated in the tolerances section of the British Standards, and CE marked where steel studs are manufactured in accordance with EN 14195 and plasterboards are manufactured in accordance with EN 520 When installing systems where studs are boxed the overall partition thickness can increase up to 2mm depending on the manufacturers stud profiles.

### 6.8.2 Metal stud and timber stud

There will be differing tolerances depending on whether metal or timber studs are used. The use of metal studs will generally produce more consistent material tolerances over timber stud.

When specifying drylined systems the manufacturers' stated performances should be referred to in terms fire resistance and the acoustic performance as well as the duty rating of the wall.

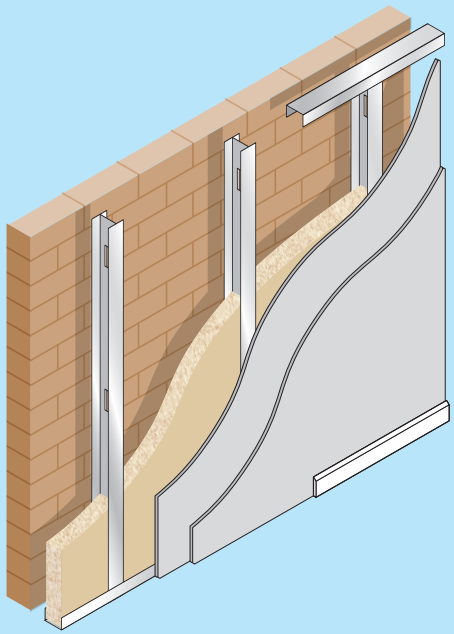
## 6.9 CATEGORIES OF DRYLINING SYSTEMS

### 6.9.1 Wall linings

There are two types of wall linings available either attached to the substrate or independent from the substrate. Where linings are attached to the structure, they can use a metal system or they can be adhesively fixed or use a combination of metal furrings and adhesive.

### 6.9.2 Independent wall linings

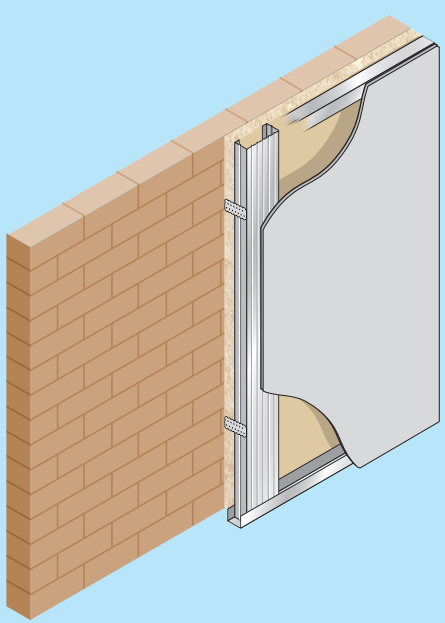
Figure 10



Independent wall linings (IWL) are, as the name implies, independently supported from the background structure. They will be fixed at the head and base in a similar manner to a partition and be boarded on only one side. Because these wall types are not symmetrical about their axis, they tend to be constructed using an I stud instead of a C stud. C studs may be used but will generally need to be braced back to the structure at mid-height or at centres recommended by the system manufacturer. Seek the manufacturer's advice where C studs are used in place of I studs, as this may affect the performance of the lining system.

### 6.9.3 Metal studs on brackets

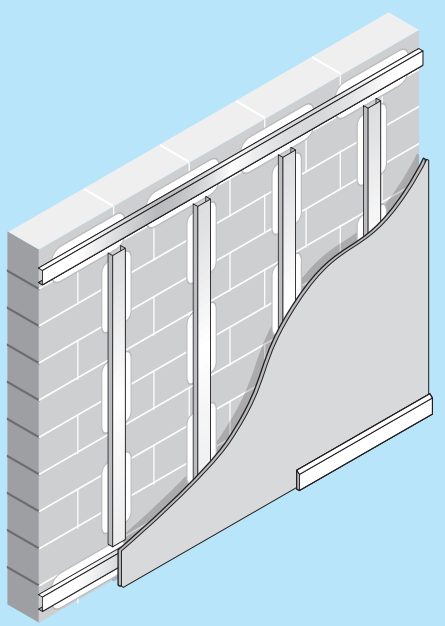
Figure 11



This type of lining employs the use of a shallower stud that is fixed back to the structure by the manufacturer using metal brackets at specified centres. A floor and head channel is used to retain the studs and is fixed in the same manner as floor and head channels for partitions. It should be noted that if deflection is required for this type of lining, special details will be required from the manufacturer. These types of lining can be constructed with smaller cavities than IWL.

### 6.9.4 Metal furring and adhesive

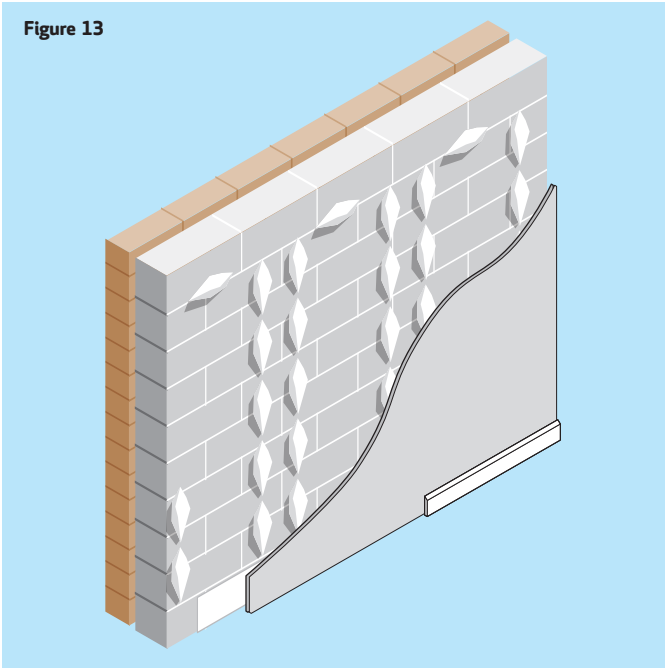
Figure 12



This system uses the same bonding adhesive used with the direct bonding system (dot and dab), although metal furrings are bonded to the substrate to allow the screw fixing of the boards. This system allows minimal cavities behind the board and has the advantage over the direct bonding system in that it allows the unfixing of boards if required prior to finishing.

### 6.9.5 Direct bonding

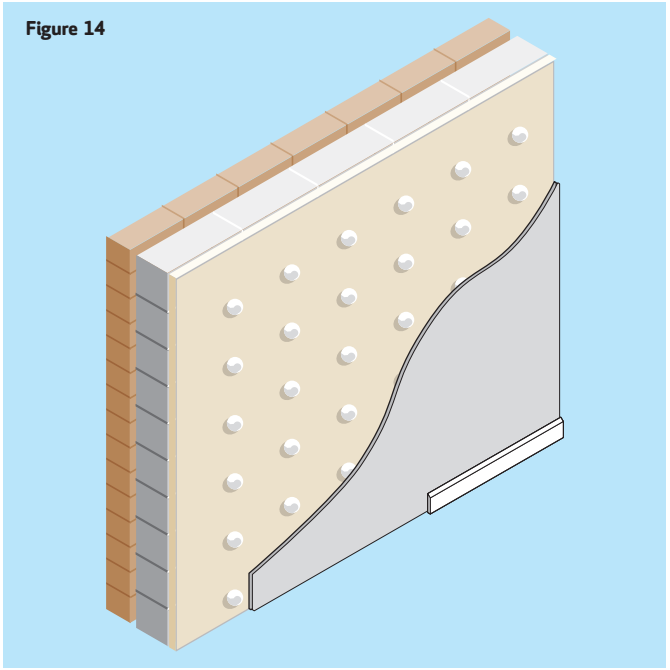
Figure 13



This is commonly referred to as dot and dab, and often used to dryline masonry or concrete walls. Plasterboard is fixed to the substrate using a gypsum-based adhesive to provide a smooth, level lining surface. Care should be taken to ensure the dabs are the correct size and spaced to the correct centres. Continuous dabs are applied at skirting, ceiling and around window and door openings to prevent distortion of boards when skirting and architraves are fitted and for minimising airflow/heat loss. This is important in new build residential, where air pressure tests are carried out under Part L 1A of the Building Regulations. Metal-framed linings utilise sealant to apply perimeter seals.

### 6.9.6 Sealant bonded

Figure 14

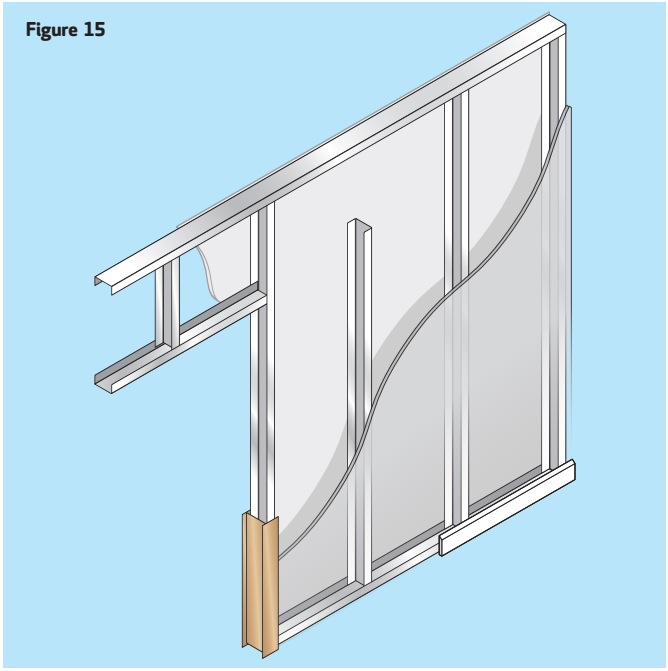


There are systems that allow the sticking of boards to backgrounds using drywall sealant. These tend to be for refurbishment.

## 6.10 PARTITION TYPES

### 6.10.1 Partitions

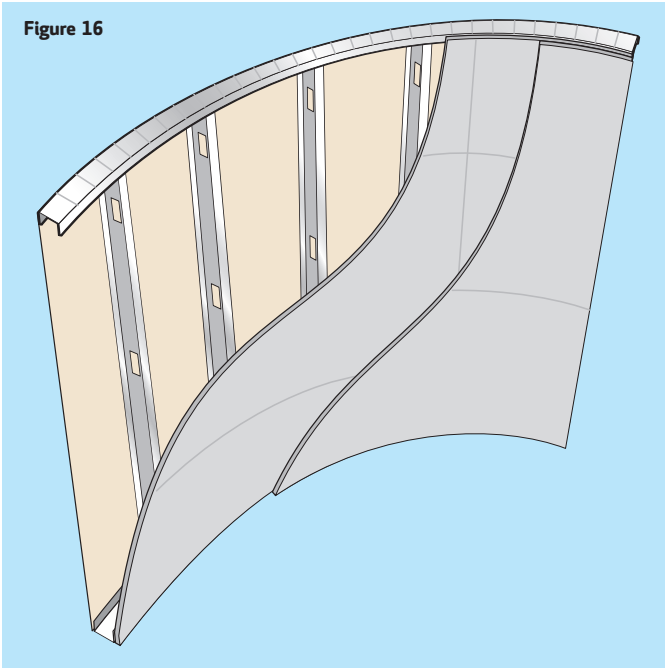
Figure 15



Partitions are constructed using both C studs and I studs and variations of these such as acoustic profiled studs. Partitions are able to provide a vast range of fire, acoustic and robustness performances. They can be single boarded or boarded with multiple layers of board. Because of the large number of variations in partition construction, the manufacturer should be consulted for the specific detailing of the required performance criteria.

### 6.10.2 Curved partitions

Figure 16

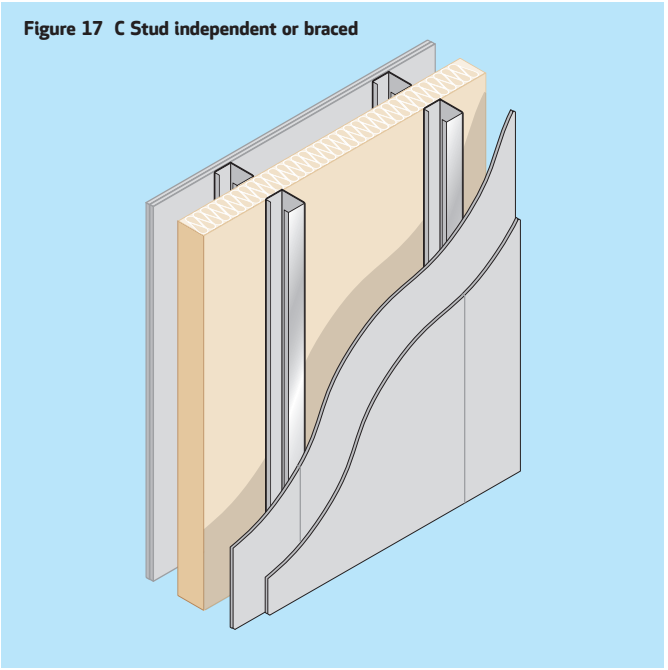


These are similar to standard straight partitions, although the head and floor channels are pre-cut to allow the curve to be formed. The fixing centres are generally reduced to 300mm to ensure sufficient fixing to maintain the curve.

Depending on the radius to be formed, this will determine the type of board required to form the curve. This may require the use of thin and flexible plasterboards, glass-reinforced gypsum or other specialist boards.

### 6.10.3 Twin frame

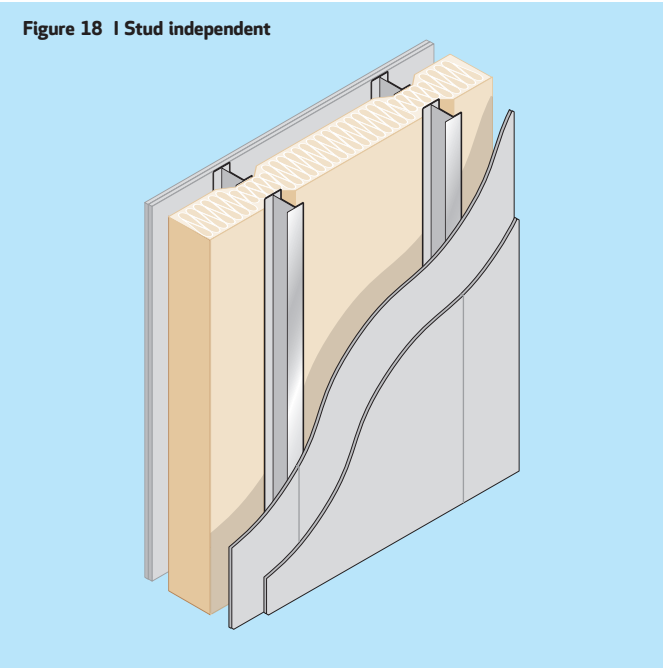
Figure 17 C Stud independent or braced



This type of partition is most commonly used for wall systems that require very high levels of sound insulation. These can either be a twin-frame C stud type, which may be required to be braced together, or two rows of independent I stud.

Because of the nature of the twin rows of studs, these systems offer very good acoustic isolation. This is due to the increased cavity widths possible, the inclusion of thicker acoustic quilt and the isolation from one side of the partition to the other. All of this will contribute to higher acoustic insulation performances.

Figure 18 I Stud independent



Braced C stud options can also be used for greater maximum partition heights over 6m. Specific maximum heights will be subject to the manufacturer's information.

This makes them a popular choice for residential partitions between apartments and in cinemas.

**Figures 19 and 20** overleaf illustrate the two typical installations using C and I stud.

Twin frame stud partitions offer very high levels of sound insulation.

Figure 19 C stud twin frame

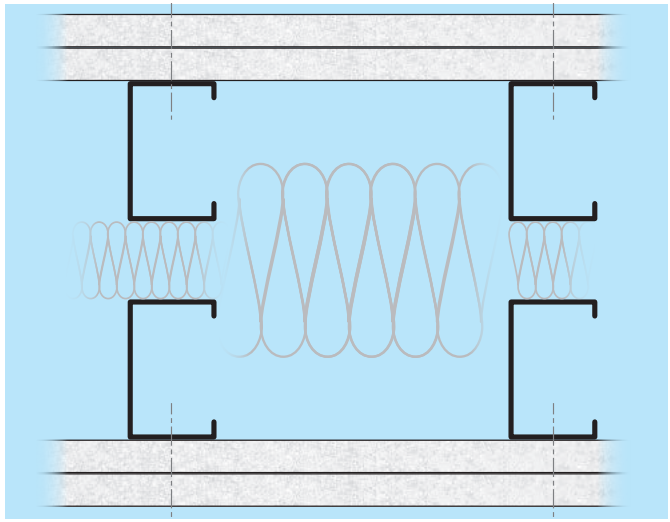
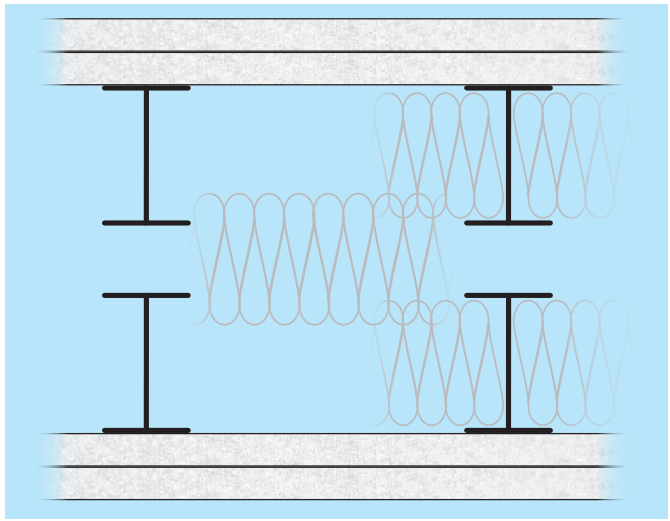
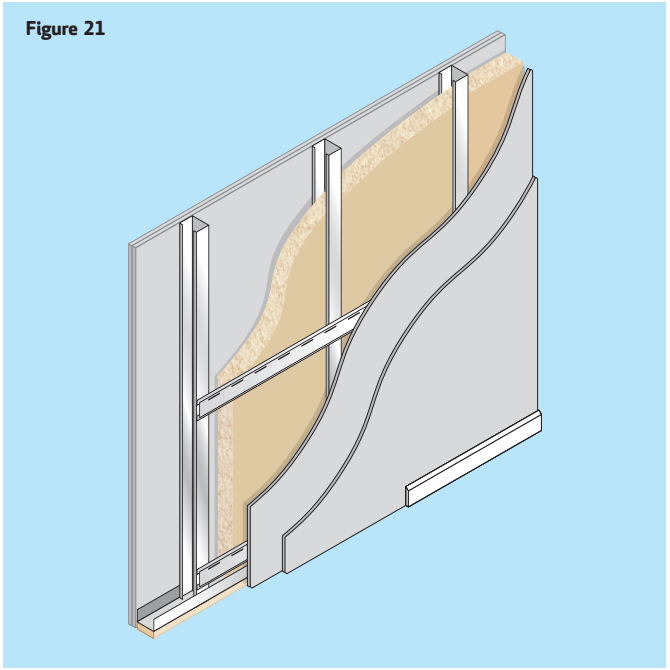


Figure 20 I stud twin frame



### 6.10.4 Resilient bar

Figure 21

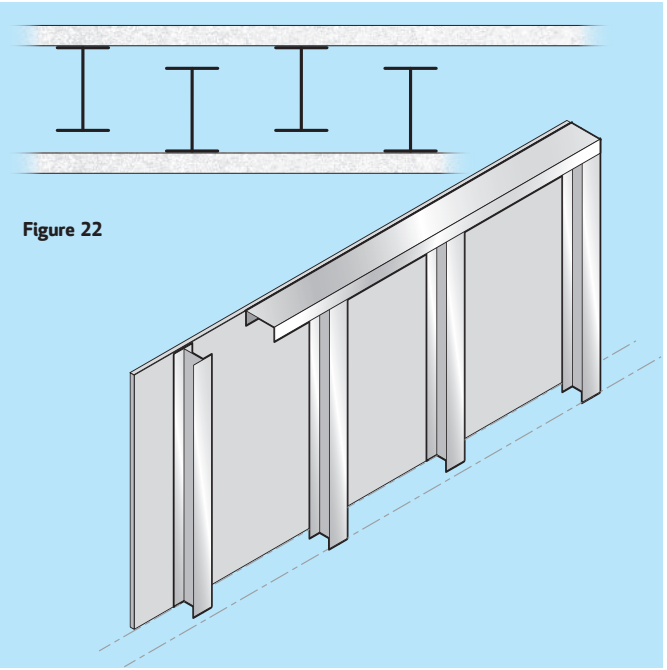


These types of partitions are constructed as standard partitions, with the exception that horizontal resilient bars are fixed to one or both sides of the studs.

The resilient bar installation offers isolation between the stud frame and plasterboard. The resilient bar profile provides minimal contact with the plasterboard, which inheritably improves the sound reduction of the system. As a result, these partitions can provide very high levels of acoustic performance.

### 6.10.5 Staggered stud

Figure 22



Staggered stud partitions offer very high levels of sound insulation and are similar to a partition except that the I studs used in the partitions are a smaller size than the head and floor channels. This also reduces impact sound transmission through the partition.

### 6.10.6 Shaft walls

Shaft walls were traditionally designed to form the enclosures to lifts, stairs and risers where access was available on one side only. These particular partitions may not provide integrity and insulation because the studs are exposed on the riser side.

Some manufacturers have special requirements regarding fixing the centres of the head channels. Due to the nature of the environment during the installation of lift shafts, moisture and fire-resistant board types are used.

Shaft wall can be used in alternative situations to shafts. Manufacturers may have solutions for installing shaft wall at a higher level if there is obstruction from M&E services, to allow boarding to be at one side. The partition can then revert to boarding on either side of the I stud framework at a lower level.

### 6.10.7 Firewalls

Typically the maximum fire resistance of plasterboard partitions is 120 minutes, but when higher fire resistance is required, up to 240 minutes is possible. Calcium silicate partition systems are also capable of high levels of fire resistance up to 240 minutes.

When the maximum fire resistances are required for all board types, the cavities of the partitions may need to be filled with insulation material or additional layers of board, depending on the manufacturer's requirements.

### 6.10.8 Bomb blast walls/security walls

Bomb blast walls are common in commercial buildings in areas deemed to be sensitive, such as post rooms and lecture theatres. While some board manufacturers have their own systems in place, more often bomb blast walls are a specialist area and the specifications are detailed by specialist security consultants. It is imperative that these walls are installed strictly in accordance with the consultant's details to ensure they perform as designed.

There may be requirements to install additional security measures to partitions and this is becoming more common in residential schemes to party walls separating the various plots/apartments. There are a number of ways of achieving this but the two most common are a blockwork core between the two wall linings or the introduction of a security mesh fixed between the board layers. Advice should be obtained from the system manufacturer regarding the correct installation of the mesh. It will be necessary to bed the mesh in acoustic sealant to prevent any 'rattling' of the mesh.

### 6.10.9 Encasements

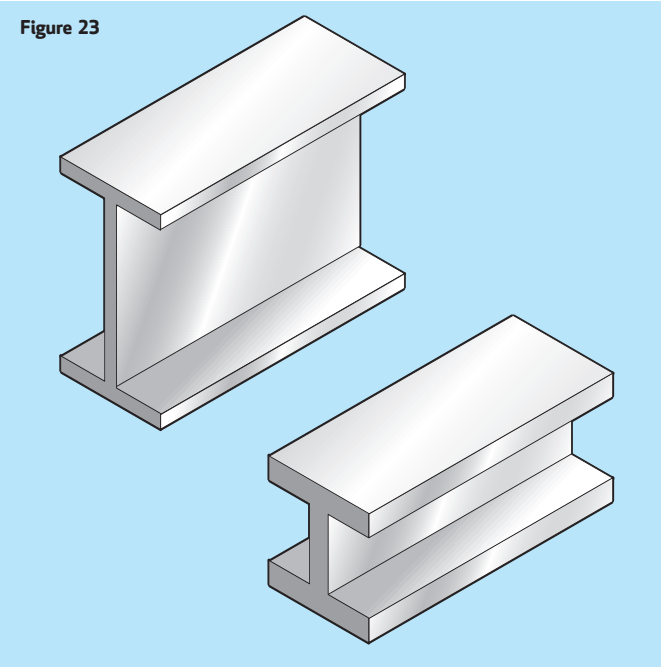
These can be framed or frameless and will provide up to 240 minutes' fire resistance to both column and beams, depending on the board selection. When selecting the correct board thicknesses/types for the fire protection of steelwork, it is necessary to establish the section factor of the steel, which is expressed as A/V (Hp/A) for the steel section.

The Hp is the perimeter of the steel that is exposed to the flames and the A is the cross sectional area of the steel section. Standard section sizes and the A/V can be found in the ASFP Yellow Book, (Fire protection for structural steel in buildings, 5th edition).

Beams with openings should be protected with the same thickness of material as that applied to the solid beam plus 20%. For cellular and castellated beams, the section factor is calculated as 1400/t, where t is the thickness of the web in mm. (Where the web thickness varies, the bottom web thickness should be used.)

It is possible to provide fire protection to steelwork utilising the cavity of a metal stud or I stud twin-frame partition. This can be achieved by upgrading the board to a fire grade board.

Figure 23



Where castellated or cellular beams are used, the thickness for the fire protection material should be 20% more than the thickness determined from the section factor of the original uncut section for board protection.

It will also be necessary to know the limiting temperatures for the fire protection. Traditionally this was 550°C for columns and 620°C for beams. However, this is now considered far too simplistic and manufacturers can now offer tables for thicknesses of boards for structural steel at a series of temperatures. Limiting temperatures are not fixed and will vary according to two factors: the temperature profile and the

load. This information should be provided by the structural engineer or fire engineer.

When it is necessary to provide fire protection to historical steelwork such as cast iron, wrought iron or steel, specialist expertise may be required by a fire engineer, for example, who can provide guidance for this work.

## 6.11 HOW TO ASSEMBLE METAL STUD AND FIX THE PLASTERBOARD

**Figure 24**


Although each manufacturer has specific fixing requirements, a series of rules can generally be applied to drywall systems.

It is important to fully understand the manufacturer's specific fixing requirements and these should be followed closely.

### 6.11.1 Metal stud partitions

The locations of the partitions will be set out on the floor and the lines plumbed up to the soffit using a plumb line, laser or optical equipment. Where greater than British Standard tolerances are specified, it may be necessary to use optical equipment with a greater accuracy than laser equipment.

Floor and head tracks are fixed to the various substrates and it is important that these are fixed at the correct centres with fixings appropriate for the substrate.

The type of substrate will have an impact on the design and method of installation of the head and floor channels. The manufacturer of the drylining system should be consulted for specialist guidance.

Examples of the various substrates are concrete (in situ, post-tensioned, pre-tensioned), intumescent painted beams and columns, board protected beams and columns, hollow pot floors and soffits, wood wool floors and soffits, and spray-applied protection to beams and columns. The types of fixings used will be selected based on the type of substrate.

When partitions abut the underside of metal profile decking, the method of sealing the profile must be considered and the detailing will depend on the fire and acoustic performance of the drylining. Scribing plasterboard into the profiles can be very difficult and therefore a specialist acoustic and fire pre-cut material can be installed to the profile of the deck.

Where partitions exceed specific heights identified by the system manufacturer, the type and size of floor and head tracks can often alter – for example, a deeper floor track may be required.

The heights of a partition will also have a bearing on the type of stud to be used. Generally speaking, the higher the partition, the wider the stud required.

There may be specific fixing requirements for wider head and floor tracks, depending on the manufacturer, and it could be a requirement to install two rows of staggered fixings in the floor and head channels – for example, when greater than 72mm head and floor channels are used.

The fixings into floor and head channels should be no greater than 50mm from the ends of the channels, as stated in BS 8212: 1995 Code of practice for drylining and partitioning using gypsum, or as specified by the manufacturer.

Depending on the partition's performance, there will be a requirement for either acoustic or fire sealants or both between the tracks/fire stops and the substrate. This should be installed strictly in accordance with the manufacturer's details.

A deflection head will be required when there is any movement of the structural slabs that may crush, stretch or otherwise damage the partition. There are various methods of constructing deflection heads, depending on the manufacturer and system selected, although the principles of the deflection head are similar.

Because deflection heads allow movement, achieving an airtight seal will be more difficult than with a fixed head. Any air leakage will have a potentially detrimental effect on the acoustic performance of any partition. To reduce the effect on acoustic performance, additional measures may need to be taken, such as the installation of metal angles or insulation.

The choice/depth of the head channels will depend on the maximum amount of deflection specified, the minimum engagement of the studs into the head channels and whether the deflection is downward only or a plus and minus deflection. A full understanding of the precise requirements of deflections is strongly recommended, using clear guidance from the specifier or structural engineer to ensure the requirements are interpreted correctly.

Where there are deflection heads, there are often requirements to fix boards of various types and numbers between the head channel and the soffit to ensure there is no passage of fire through the thin gauge metal. An example of a typical +/- 15mm deflection head is illustrated in **figure 25**, showing the

**Figure 25 A partition prior to deflection**

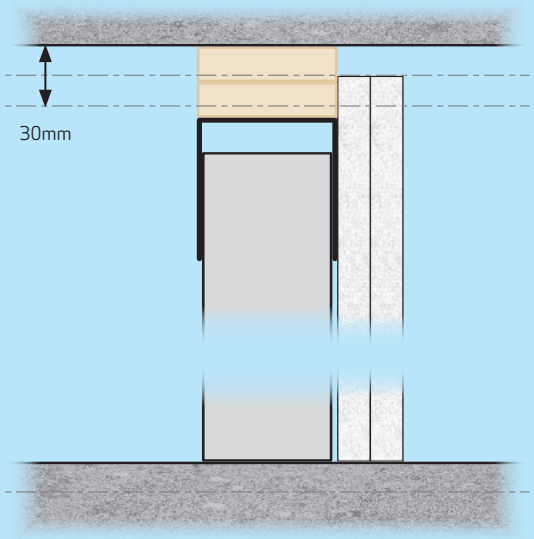



**Figure 26 Floor deflecting downwards**

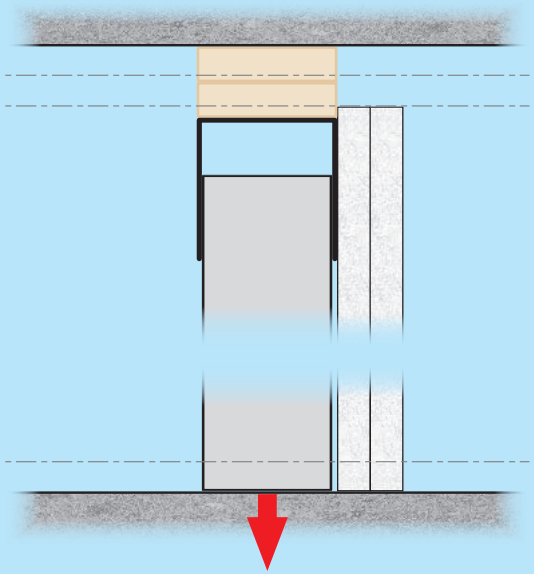
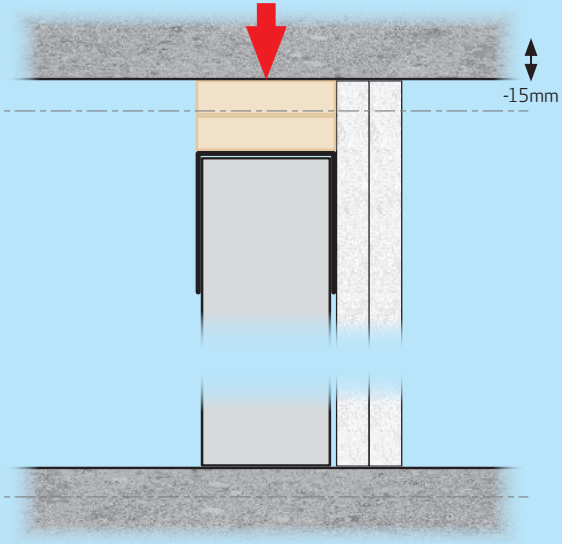


**Figure 27 Soffit deflecting downwards**




movement of the slab and the effect on the partition.

Just as the board types used for higher fire-resistant partitions will change, so will the method of constructing deflection head detailing. For example, additional fire-resisting materials and components will be required for 120 minutes fire-resistant partitions over that of lesser rated partitions. This could be cloaking angles, mineral wool, additional boarding etc. The specific manufacturers' details will illustrate this.

Where there are deflection heads, a flat plate or fixing channel may be required to provide fixings for the boards at the heads of walls depending on the system. This will be fixed into the studs or positioned between the board layers on multiple board systems. The precise locations of the plates will depend on the manufacturer's requirements. These are positioned in specific locations in relation to the head channels, depending on the deflection requirement, to ensure the uppermost fixings can be fixed into the flat plate and not into the head channels, which would negate the deflection.

Flat plates and fixing channels will also be required at any horizontal board joints to ensure the boards can also be fixed at a maximum of 300mm centres. Like the deflection heads, these can be fixed directly to the studs or between board layers on multiple board systems and will depend on the manufacturer's requirements **(see figures 25, 26 and 27)**.

Once the floor and head channels are installed, there will be a requirement to install abutment studs (often referred to as starter channels), which will generally be fixed to the structure. Where the starter studs abut a substrate with a movement deflection – for example, in curtain walling – this movement will need to be considered. Where a direct fixing into a substrate is not possible, it may be necessary to reinforce the starter studs to stiffen the section to reduce possible movement. Consultation with the system manufacturer should be made. These studs/channels are fixed at specified centres of 600mm in general and again should be fixed within 50mm of the ends. There may be a requirement to install an acoustic sealant on partitions prior to boarding to provide optimum performance requirements.

Studs are cut to length less the deflection requirement, ensuring that service cut-outs do not coincide with the head or base channel, and inserted into the floor and head channels at the required centres. This will be at multiples of the board widths. It is good practice to allow at least 150mm of solid stud above and below service cut-outs in the studs.

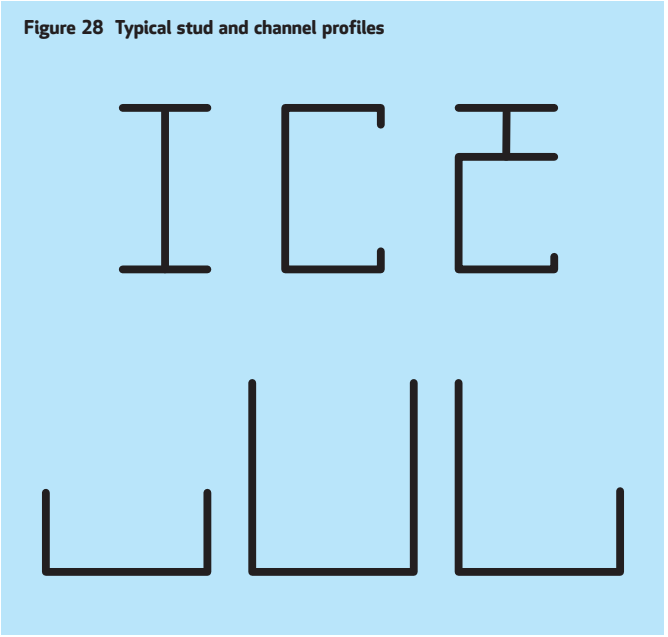
If there is no deflection requirement, studs should be cut 5mm shorter for installation and expansion as required by the manufacturer to ensure there is a minimum of 20mm of stud engaged into the head channel.

The stud centres installed will depend on the height, the stiffness and any loads applied to the partition. It is important to install the studs to the specified centres and not to match the board widths. For example, studs are typically installed at 300mm, 400mm and 600mm centres. Plasterboards are manufactured to a tolerance – for example, a 1,200mm width board could be up to 3mm narrower. If the stud centres are set out to suit a particular batch of board widths, this can cause potential issues when applying further layers of boarding from other batches of boards of differing widths, especially during second fixing of partitions. This can result in the board joints not being centered on a stud and result in non-compliant screw fixing.

Studs may be fixed to the floor channel. However, where there are deflection heads, the studs must not be fixed into the head channels – and this includes crimping of the stud to the head channel. Crimping studs will not allow for the deflection of the head channel.

Studs can be spliced when the height of the partition exceeds the maximum height of the partition, and boxed when the strength of the stud needs to be increased. It is relatively easy to box or splice C studs as these are designed to be interlocked, ensuring that the minimum length of splicing is used. However, splicing of I studs is more difficult as each manufacturer has a specific method for splicing I studs. It is recommended that a minimum of 600mm overlap is provided for the stud splices, although this may be larger depending on the heights of the systems. The studs are connected together using the fixings and centres recommended by the manufacturer.

**Figure 28 Typical stud and channel profiles**



Fixing wafer head screws into the head channels on either side of a stud to locate it prior to boarding to prevent movement of the studs when first fixing wall linings/party walls should be avoided as this will not allow boards to sit flush with the head channels. These fixings should be removed prior to boarding.

Two basic types of stud are manufactured for partitions: C studs and I studs. When C studs are used it is important that they face the same orientation so that the open ends are in the same direction. Because I studs are symmetrical, they will always be installed in the same orientation **(see figure 34)**.

There are a number of variations in the types of studs manufactured according to the specific partition type, such as shaft wall constructions. These can be in the form of a CT or CH stud **(see figure 28)**.

Types of boards used in drylining (only gypsum based plasterboards are all covered by BS 8212).

The stated performance of a drylined system will depend on the components used for the installation.

### 6.11.2 Insulation

Insulation may be installed within a drylined system to increase fire, acoustic or thermal performance. The insulation must remain in the intended position and not displace in any way. Where rigid slabs are used, a friction fit is generally acceptable. However, when roll quilts are used, it will be necessary to secure the quilt in position by fixing at the head or using proprietary clips as specified or approved by the system manufacturer. It is generally considered best practice to fix acoustic quilt into the slab or into the head channels using channels/battens/angles and allowing the quilt to hang within the cavity. The quilts should be continuous lengths and not made up from small sections that could displace in the cavity.

### 6.11.3 Types of boards

Drylining systems use a variety of board types:

GYPSUM PLASTERBOARD

Gypsum plasterboards are manufactured from a gypsum core encased in and bonded to paper liners. Gypsum is obtained from a number of sources: mining in quarries; manufactured using DS (desulphogypsum), a byproduct of flue gas desulphurisation from coal-fired power stations; and recycled from old gypsum products.

Plasterboard can have a high recycled content and is a recyclable, sustainable product.

Boards are available with both tapered edge and square edge and a thickness range from 6mm to 25mm. Lengths vary from 2.4m to 3.0m and widths of 600mm, 900mm and 1,200mm are available.

In some Scandinavian countries, 900mm wide boards are used for partitions, and there is evidence that some contractors in the UK are adopting 900mm wide boards to reduce the risk of musculoskeletal injury.

Contractors should ensure that relevant systems have been tested to ensure that performance can be maintained and that manufacturer recommendations for setting out and stud centres are adhered to.

Specialist gypsum-based boards may be suitable for use in areas exposed to temporary humidity, such as bathrooms and kitchens. However, in wet areas such as showers, the exposed surfaces of the boards must be protected against water and moisture. Standard plasterboards are not recommended in any regularly moist or humid areas and consideration should be given to using moisture-resistant boards in these areas.

SUBCATEGORIES OF BOARD MAKE-UP

Within the main gypsum-based board types above there are various subcategories of boards. These can include boards with:

- Vapour control layer on the back
- Greater impact resistance
- Greater density for higher acoustic performance
- Moisture-resistant properties
- Thermal insulation attached
- Perforations for sound absorption
- Other specialist treatments.

GLASS-REINFORCED GYPSUM PLASTERBOARD

These boards are manufactured in a similar way to gypsum plasterboard, with the addition of glass wool-facing membranes and/or glass reinforcement. They provide greater fire resistance to standard gypsum plasterboard.

CALCIUM SILICATE BOARDS

Calcium silicate boards are manufactured from a mix of lime, cement, silica and fire-protective fillers in combination with cellulose fibre.

CELLULOSE-REINFORCED CEMENT BOARDS

Cement-based boards are made from a mixture of cement and binders or reinforcing materials such as engineered wood filaments.

GLASS FIBRE-REINFORCED CEMENTITIOUS BOARDS

Cementitious boards are manufactured from Portland cement, lightweight fillers and binders. The boards may also contain alkali-resistant fibre in the form of mesh or random strands.

GYPSUM FIBRE BOARD

Gypsum fibre boards are manufactured from calcined gypsum and cellulose fibres produced from recycled paper, mixed with water but without the use of binders.

SPECIALIST CUT BOARDS

Board fabrication companies are able to provide boards cut to form specific profiles either for assembly on site or provided as a flat pack for site assembly. The process of cutting the boards only removes specific sections of the gypsum, such as a mitre, but retains the paper face. This eliminates the need for metal or paper angles, ensuring a crisp edge to the works. These are generally acceptable for areas requiring a more aesthetic appearance and will not necessarily be suitable for fire or acoustic performances unless specifically tested.

### 6.11.4 Implications of mixing and matching systems

It is imperative to install drylining and partitioning systems in accordance with the manufacturer recommendations.

The Gypsum Products Development Association (GPDA) offers the following guidance with regards to product compatibility:

"Each of the three main UK gypsum plaster and plasterboard manufacturers, British Gypsum, Knauf and Etex Building Performance, agree the following statement through the offices of their trade association the Gypsum Products Development Association.

"This statement refers to the compatibility of gypsum based finishing products from one or more of the above manufacturers.

"For the purposes of preparation for decoration, gypsum based finishing products (eg jointing compounds and finishing plasters) can be applied to the front face of plasterboard manufactured in accordance with BS EN 520 2004 A1+ 2009, provided the products are manufactured in accordance with the current, relevant standard, eg Finishing Plaster – BSEN 13279-1: 2008. Jointing Materials – BSEN 13963:2014, except where:

**1** Colour matching is required between plasterboard and jointing.
**2** Required by the manufacturer, moisture resistant plasterboard variants need to be primed prior to plastering.
**3** Specific finishing materials are required by the system warranty provider to maintain or achieve the system performances, for example, fire resistance and acoustic insulation.

"The following points should be noted when referring to the above:

- Products supplied by companies other than the companies listed above are not covered by this statement.
- The supplier of each product used must have indicated (either on the product or in product literature) that it is suitable for the purpose for which it is intended and that it conforms with any relevant British and European standards.
- Workmanship should be in strict accordance with any current relevant Code of Practice, Building Regulations and manufacturers' literature.
- This statement only applies to products manufactured in Great Britain (or produced by the three manufacturers with the same specification and imported for use in that market) and fixed in Great Britain."

### 6.11.5 Definitions

PROPRIETARY SYSTEMS

In the context of this statement, a proprietary system is a system from a manufacturer where a direct technical claim of performance is made by the manufacturer. The system's performance depends on the complete system using components supplied by only one of the above manufacturers. The substitution of any system component may prejudice the system's performance.

Examples of such systems are:

- Partitioning and ceiling systems based on plasterboard fixed to cold rolled metal sections
- Systems involving composite plasterboards
- Systems with fire, sound, thermal or impact performance claims.

NON-PROPRIETARY SYSTEMS

In the context of this statement, a non-proprietary system is a system where the specification is substantiated by a third party not related to the plasterboard manufacturer – for example, BSI, Robust Details, BRE – and is usually based on nominal product dimensions such as thickness and density. Examples include:

- Plasterboard defined by weight within Robust Details recommendations
- Plasterboard defined by thickness, as given in Guidelines for the construction of fire resisting structural elements (BRE 1988)
- Metal studs defined by thickness within Approved Document E.

### 6.11.6 Correct and accurate measurement and cutting of board and metal

It is possible to have boards and metal made to specific lengths to reduce wastage of materials on site and this can be particularly cost-effective on larger projects. Where there are deflection heads, firestops (dropped soffits) may be used on the head channels and these can also be pre-cut, providing more accurate installations and eliminating dust on site.

Boards have been traditionally cut using a tape measure and a knife. However, a number of main contractors are now insisting that knives with retractable blades are used to avoid the risk of cuts to hands. There are other products on the market that use a rolling blade above and below the board, connected via a strong magnet, which cut the board both front and back. Some boards will require the use of hand saws to cut them.

Light gauge metal can be cut with either metal snips, a hacksaw or a chop saw; heavy gauge metal with a hacksaw or a chop saw; and timber studs with a hand saw or timber chop saws.

It is recommended that any cutting of metal using a chop saw is carried out in a well ventilated area as the cutting process may emit gases hazardous to health. When light gauge metal is cut, this results in sharp edges. Care should be taken to ensure the correct personal protective equipment (PPE) is

worn when cutting and handling the sections.

The boards should be installed vertically and not horizontally (unless they have been specifically tested in that orientation). The boards are fixed to the studwork at the specific centres and with the types of screws specified by the system manufacturer. This will generally be 300mm in the field of the boards and at the board ends, and may be reduced to 200mm at the external corners and around doors as required by the manufacturer.

There are very specific guidelines for fixing gypsum-based plasterboards to metal and timber studs/sections where the screws must be installed no closer than 10mm from a bound edge and 13mm from a cut edge of the board **(see figures 30 and 31)**.

For boards other than plasterboards, refer to the specific manufacturer's installation guidelines, which may differ in certain aspects.

Drywall screws should be lightly depressed and should not break the paper face. Drywall screws have a characteristic bugle head, which allows fixing without breaking the paper face.

Drywall screws are supplied in varying lengths. There are specific screws made for both metal and timber applications and there may be different screws for the different board types. Some fire protection systems can be installed using staples. The correct length of fixing must be selected. The minimum engagement of a drywall screw into a metal stud/component is 10mm and into a timber stud 25mm. Longer screws may be used, provided they do not overpenetrate or interfere with other components.

Depending on the gauge of the metal, the type of drywall screw will vary from a self-drilling or self-tapping type **(see figure 29)**.

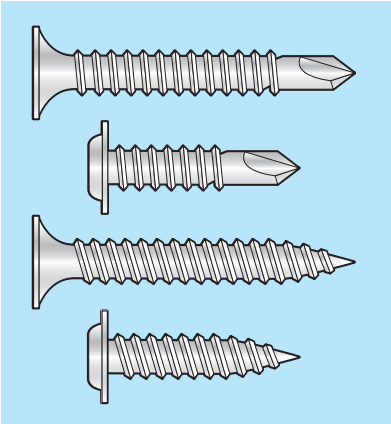
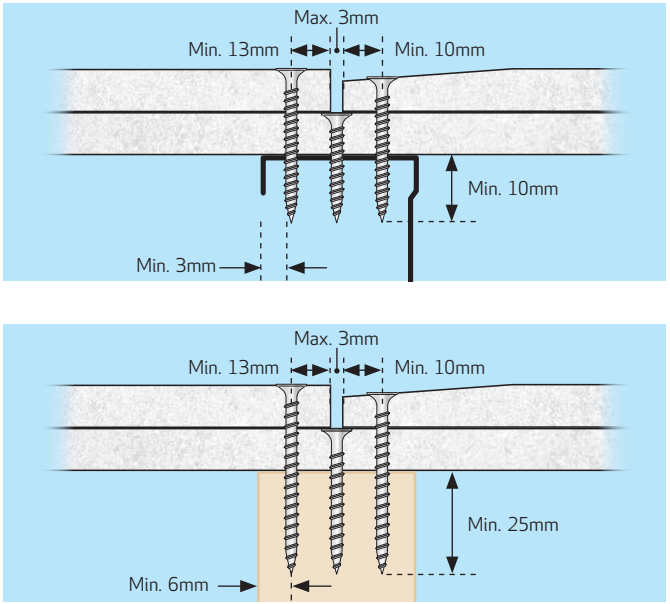


**Figure 29 Common types of drywall screws**

Self drilling screws are used for heavy gauge metal and self taping screws for light gauge metal. The manufacturers of the drywall systems provide guidance on the screw types to be used with specific metal gauges. In **Figure 29**, the screws from top to bottom are: a self drilling drywall screw for fixing boards to heavy gauge metal, a wafer head self drilling screw for heavy gauge metal to metal connections, a self tapping drywall screw for fixing plasterboard to light gauge metal and a wafer head self tapping screw for light gauge metal to metal connections.

Drywall screws will be supplied as zinc coated, black phosphate coated or even ceramic coated depending on the application and the manufacturer of the system.

It is imperative that the boards are correctly staggered from one side of a partition to the other and, where multiple board layers are used, that these layers are correctly staggered in accordance with the manufacturer's recommendations. This is for a number of reasons: the strength of the partition/lining and to maintain the fire and acoustic performance. **Figures 32 and 33** overleaf illustrate the requirements of BS 8212: 1995 Code of practice for drylining and partitioning using gypsum plasterboard and




**Figures 30 and 31 Edge distances screw fixings should be from bound and cut edges into timber and metal stud**

BS 8000 Part 8: 1994 Workmanship on building sites, code of practice for plasterboard partitions and drylinings. On multiple layer boarded systems, the inner layer of boarding can be square edge (S/E) or tapered edge (T/E).

Impact drivers are being increasingly used in the drylining industry to fix plasterboards to the metal framework, as opposed to using specific drylining screw guns. These impact drivers are not designed for the installation of plasterboard into metal framework and they rely on the fixers judging the correct torque to set the drywall screws to ensure the correct depth. Invariably this will be too deep and the screw head will break the paper face **(see figure 37)**. Drywall screw guns come

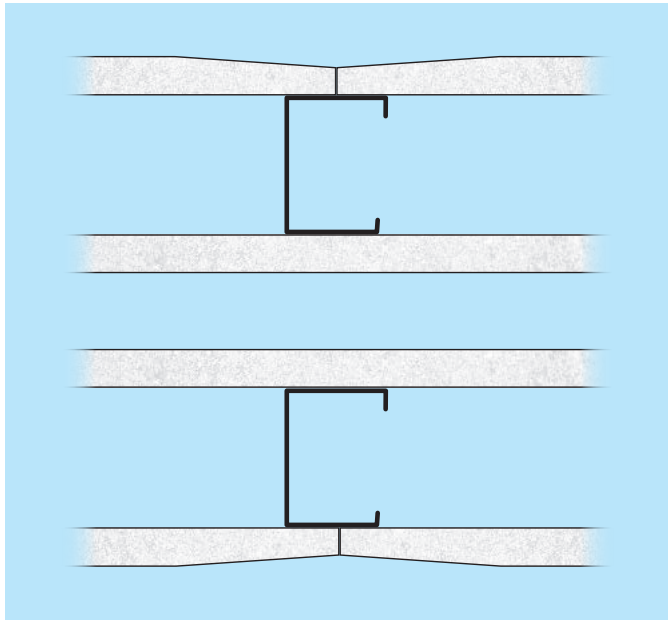


**Figure 32 Single layer system**

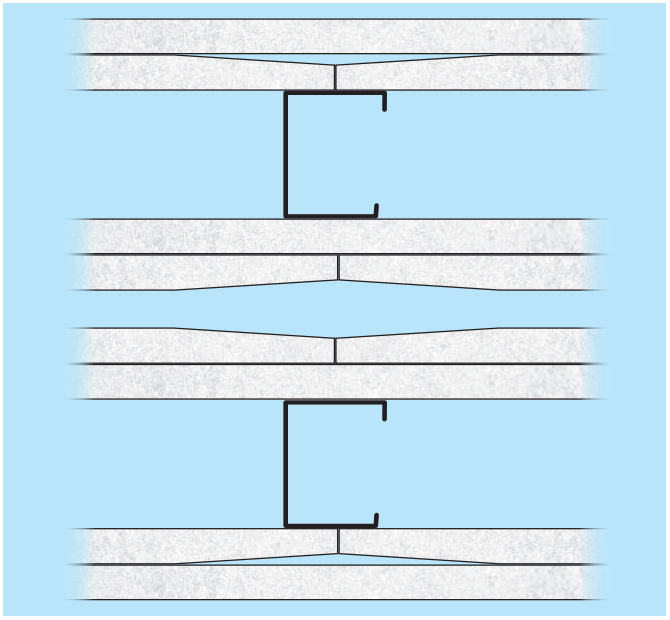


**Figure 33 Double layer system**

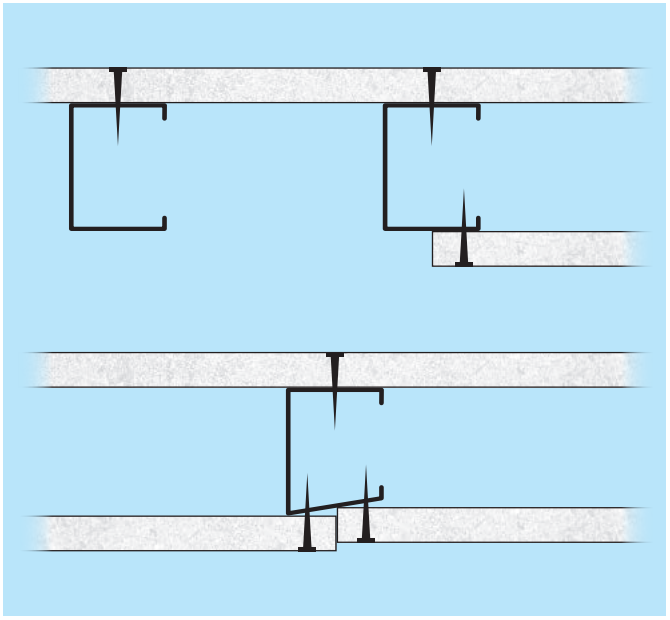


**Figure 34 Not recommended method of boarding**

in three types: battery, corded and auto feed. Each of these tools has a specific nose cone on the screw gun, which allows the operative to set the depth to which the screw will penetrate the plasterboard **(see figure 36)**.

When using C studs, It is recommended that the boards should be installed in the direction of the stud flanges so that the leading edge of the board is fixed to the web edge of the stud flange as shown in **figure 35**. This is a recommendation only and some fixers may install as per **figure 34**, however, if stepping is experienced, consider reverting to the method in **figure 35**.

Partitions will generally be first fixed where the metal studs and one side of the partition is boarded, to allow the services to be installed and any acoustic quilt included. The services should be fully co-ordinated with the drylining and the tested detailing installed as required to maintain the fire, acoustic and thermal performance of the systems.

Once the services and noggins etc are complete within the drylining and checked/signed off, the works will be second fixed where the opposite wall face will be boarded. The boards should be staggered from one side of the partition to the other as illustrated in **figures 32 and 33**.

It is imperative that any fire and acoustic solutions have been fully tested or assessed within a drylining system by a UKAS-accredited test facility.

Reference should be made to the ASFP Red Book when considering the selection of a fire-stopping system in a drylined system.

There may be full or partial penetrations on the drylining. The selection of the fire-stopping system should take into account not only the fire performance but also other performance requirements such as acoustic performance. There are fire-stopping products available that have been tested for their acoustic performance – for example, putty pads – and the manufacturer's technical literature and test evidence should be referenced.

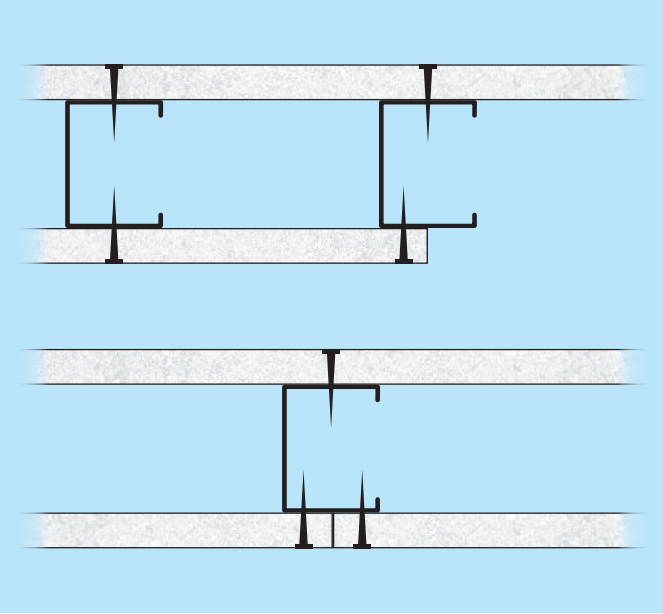


Figure 35 Recommended sequence for boarding

### 6.11.7 T junctions

When partitions abut at right angles to an adjoining partition, especially for higher performance partitions (50+dB $R_w$), the overall performance can be reduced due to flanking sound transmission. Flanking is where airborne and impact sound energy can have an effect on a rigid material, causing vibrations. These vibrations can carry along the material and radiate sound to adjoining areas, away from the original source.

To limit loss in overall performance due to flanking sound transmission, materials need to be uncoupled/ disconnected.

### 6.11.8 Façade interface, where partitions abut a single mullion

When partitions abut a façade, there are numerous configurations to this detail. Often there is a twin mullion arrangement with a non-visual glazing panel between. In these instances, it is common for the area to be boxed in with plasterboard and the subsequent partition abutting this. These junctions are usually high performing and for the best acoustic performance continuous board lines from one side to the other should be avoided. The method should be similar to the T junction details.

Where projects require maximum visual glazed areas in high-rise commercial and residential properties, this generally involves floor to ceiling glazing as well as wall to wall. In these instances, an internal partition would typically abut a single mullion. In residential developments, party wall interfaces will be more complex due to the added fire performance requirements.

While mullions may vary from 100mm-250mm deep, they are typically only 50mm-60mm wide. However, the abutting partition may be 120mm-175mm thick and this can create an interface problem. This has resulted in the use of narrow façade interface panels (FIPs) as a means of linking these two elements **(see figure 38)**.

This arrangement has the advantage of spacing the thicker internal partition away from the thinner mullion, allowing the glazing to be unobscured. It also reduces the visual impact of the stepped detail formed.

However, the thickness of this infill panel cannot normally exceed the thickness of the mullion. The thin nature of the

Figure 36 Typical drywall screw gun

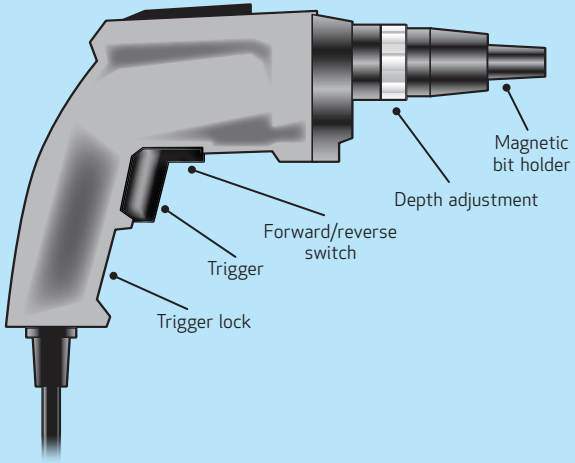
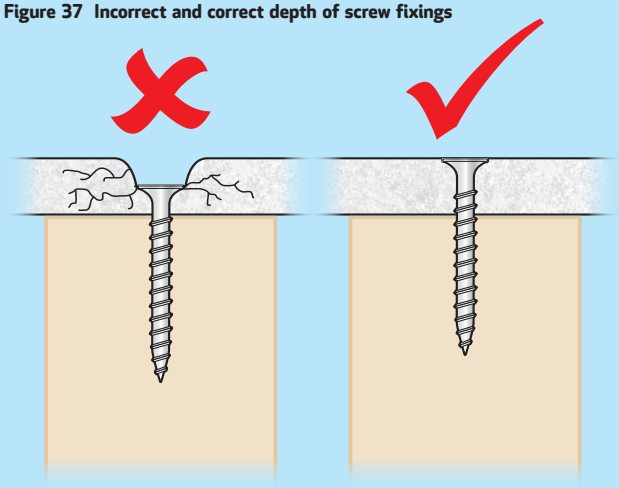



Figure 37 Incorrect and correct depth of screw fixings



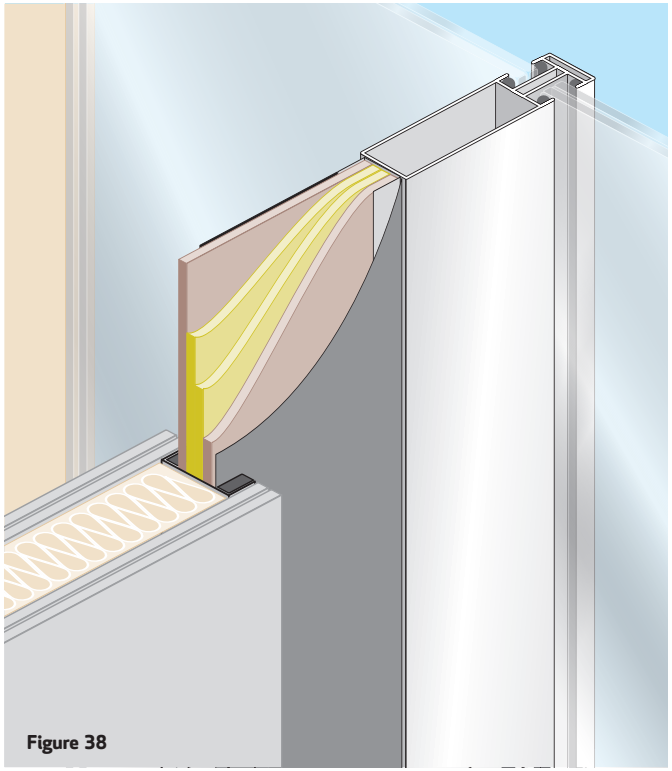


Figure 38

panel will result in a significant acoustic weakness, potentially limiting achievable room-to-room sound separation.

With the increased use of curtain wall façades used in multiple occupancy and residential properties, this has increasingly become a problem for both developers and occupants. To achieve maximum performance, specialist high-performance FIPs should be used with tested fire ratings and acoustic performances in excess of 45dB $R_w$ to ensure final compliance.

### 6.11.9 How to cut openings for other services

For the successful installation of drylined systems, it is important to predetermine the positions of electrical and mechanical services prior to the installation of the studs and boards. This will allow correct framing and boarding to maintain the wall's stability, fire performance and acoustic performance.

Some systems are easier to incorporate services into than others and particular attention should be made for shaft walls, resilient bar and staggered stud partitions. Additional non-standard detailing may be required from the manufacturers of these wall types.

### 6.11.10 Performance implications of altering the drywall

When considering altering any partition, it is imperative that the wall's performance is fully understood. Care should be taken to determine the fire acoustic and structural performance of the partition. Failure to do so could result in any alteration being detrimental to the system's performance.

### 6.11.11 Maintaining fire rating

A number of elements that can be incorporated into a partition may have an effect on the fire performance, such as doors, glazing, services penetrations and structural steel. Where these elements are incorporated into a partition, it should be proven by test that they will not adversely affect the partition's fire performance. They should always be tested in a drywall partition.

FIS and ASFP have launched a new labelling initiative to identify fire performance partitions to building owners, M&E contractors and facilities managers, and to highlight the risks of cutting holes in them for services.

One of the biggest issues facing M&E contractors employed to pass services through a building is that they may not be aware the partitions they need to pass through are fire rated. Any holes cut into them will negate the performance of the partition, which may allow smoke fumes and fire to pass from one compartment to another. This could lead to loss of life and extensive damage to the building and have huge impacts on the business.


This simple labelling scheme is designed to highlight that the partition is fire rated and where to go for advice before cutting holes through it.

The labels will be placed on the partitions at high level, where the penetrations are likely to pass through the partition and above the line of any suspended ceiling.

The labels are supplied on 60m rolls of self-adhesive tape and will be available through partitioning component distributors. FIS and ASFP both believe that this simple initiative is not only good practice but has the potential to save lives and property.

## 7.1 INSTALLING DOORS AND GLAZING IN DRYLINING

Door and window detailing in partitions will depend on the duty rating of the system.

The detailing of door openings will depend on the weight of the doorset to be installed and this information must be known at the design stage. Each drylining manufacturer has detailing for various door weights from lightweight doors of 25kg up to a heavyweight doorset of 100kg. Where door weights exceed 100kg, the manufacturer should be consulted. Specialist steel sections may be required within the partitions to increase the strength of the partition. The system manufacturer will provide suitable details for the various systems.

The widths of door openings will have an impact on the design and determine the transom details that are required. Often it is assumed that the same detailing for a 1,200mm wide door or window opening or builders' work hole (BWH) will be the same for larger spans. Specialist advice should be sought from the manufacturers. The details provided should use standard components and be tested.

When boarding walls to door openings, it has generally been the practice to oversail the opening and cut out the boarding in the opening. This has resulted in a considerable amount of board wastage as the boarding may simply be disposed of and not reused. There are a number of board-saving solutions from manufacturers, although consideration should be given to the robustness of the solutions. As with all new systems, is important that they are able to maintain the wall's performance.

Specific methods of installation of door details are currently under review by the GPDA and FIS as part of a designing out waste working party. Information on the approved methodologies will available in a separate document.

## 7.2 WATER VAPOUR CONTROL

There are two types of condensation to be considered; these are surface and interstitial condensation.

All of the forms of condensation can be reduced by suitably designing adequate insulation, adequately heating areas above the dew point, ventilation and the use of vapour control layers on the warm sides of the systems.

All of the above should be considered at the design stage and the manufacturers will be able to provide dew point calculations to ensure the correct installation of insulation and vapour control layers.

## 7.3 FIRE STOPPING IN DRYLINING

Unless the drylining or partition manufacturer provides the fire-stopping products, it will be the specifier's responsibility to determine the correct fire-stopping systems to be used (refer to the ASFP Red Book and Purple Book). The following guidance is provided by the ASFP:

CRITERIA FOR SELECTION OF THE FIRE-STOPPING PRODUCT/SYSTEM

In order to ensure the correct type of fire stopping is specified and/or installed, a number of key questions still need answering before final selection can be made:

- Is the fire stopping to be used in a wall or floor or a junction between fire-separating elements, and what type of materials are used to form each element?
- What fire resistance is required?
- How big is the gap or opening?
- Does the fire stopping have to cater for movement in the fire-separating element?
- What kind and type of services, if any, are penetrating the construction at the opening?
- How many services are there?
- What size is each service?
- How close are the services positioned to each other?
- How close are the services positioned to the edge of the opening?
- Is the fire-stopping system suitable for use with the intended elements of construction?

Fire-stopping products are used for sealing apertures and imperfections of fit or design tolerance between the fire-resisting fixed elements of a building to restrict the passage of fire and smoke. They continue to take up the imperfections of fit at all times and have the same fire rating as the fixed elements of which they form a part. In reaction to a fire condition they swell, spread or deform to achieve their performance or remain stable and resilient according to the type of product used.

Fire stopping requires special attention from the designer as it is frequently hidden once installed and therefore difficult to inspect after installation, handover and through the life of the building. The designer may not be able to indicate on drawings where there is a specific need for fire stopping. It should be

installed wherever needed to maintain the system's fire performance or fire compartmentation. Because it is an important element that is often accidentally missed out during construction, the responsibility for its installation and performance must be clearly identified.

Unless clearly defined, it is possible for an inexperienced or inappropriate subcontractor to be given the task of installing specialist fire-stopping systems. For example, where fire stopping is needed behind a cladding system at floor level, the responsibility may fall to the floor installer or the cladding contractor. Those who carry out the task must have the necessary expertise. The requirements and responsibilities for the provision of fire stopping must be clearly stated in the contract(s). Proprietary systems must be designed in accordance with the manufacturer's printed instructions.

Recommendations on the provision of fire stopping are given in Approved Document B.

## 8.1 FINISHING OF THE DRYWALL AFTER CONSTRUCTION

Depending on the system selected and the board types used, the two most common methods of finishing the drylining partitions are machine or hand jointing or plaster skimming by machine or hand.

The GPDA advises that it is possible to mix various manufacturers' finishing systems and this can be a personal preference of the installer **(see GPDA statement in section 6.11.4)**.

It should be recognised that there are advantages and disadvantages of using tape and jointing and/or plaster skimming. The level of finish of the works, programme of the works, site conditions, final lighting conditions etc can all have an impact on the decision to use plastering or tape and jointing. There are also plastering systems that can be spray-applied for speed of application. Plaster skimming will not require any sanding, unlike tape and jointing, and therefore produces less dust when installed.

## 8.2 WHAT IS TAPING AND JOINTING?

Taping and jointing is a trade designed for bringing plasterboard up to a standard that is ready for professional decoration.

It was originally designed as an alternative to plastering. The basic difference between plastering and taping and jointing, is that when plastering an area you apply tapes to all the joints in the boards and then skim coat the whole surface of the plasterboard with plaster. When taping and jointing the same area, you still tape all the joints but only apply two or three coats of jointing compounds to the joints only. Once these are dry, you sand down the jointing compound to a smooth surface.

THE ADVANTAGES OF TAPING AND JOINTING ARE:

**Speed** Although generally a three-coat process, the materials can dry much faster than plaster, making it a potentially faster process.

**Cleanliness** As the process of taping means material is only applied to the joints, only a fraction of the material is used compared with plaster skimming. This means less material dropped on floors and there is a reduction in material costs. Tapers and jointers can work in and cover more areas of a job site and need fewer scaffold towers, helping cut down job site clutter.

**Finish** Some believe tape and jointing can provide a better finish to plastering but this is always subjective and depends on the quality of the labour.

**Time** Plasterers need a large work area to themselves but tapers and jointers can work in unison with other tradesmen, such as carpenters, electricians and decorators. When there is a time constraint, all tradesmen can work together towards completion. The materials used for tape jointing set and dry quicker than traditional plasters, allowing for quicker decoration.

**Climate** Ambient and background temperature only needs to be above 2ºC, whereas for plaster it must be 5ºC. Tape and jointing can be used in areas of higher than normal humidity.

**Flexibility** It is possible to commence tape and jointing prior to completing an area, which can be an advantage – for example, if shadow beads cannot be completed on doors or if areas of work cannot be completed.

THE DISADVANTAGES OF TAPING AND JOINTING ARE:

- It has to be carried out over two to three visits.
- Joints can often be visible in glancing light conditions.
- A large quantity of dust is produced after sanding.
- When a plasterboard drylining system is tape and jointed there will be different porosity of the plasterboard and the jointing material.
- Because of this it is important to use a board primer/sealer. The use of a primer/sealer as a surface treatment will equalise the porosity across the joints prior to decoration.

## 8.3 WHAT IS SKIMMING?

Plaster skimming to plasterboards is a popular method of providing a smooth, seamless surface ready to receive decorative treatment. Skim plastering gives many of the advantages of a traditional solid plaster finish combined with quick turnaround on site. Surface preparation simply involves joint reinforcement and, if tapered edge board is used, flushing out the tapers. The plaster is applied to the wall or ceiling surface to a nominal 2mm thickness.

THE ADVANTAGES OF PLASTER SKIMMING ARE:

**Application** It is a one-visit application.

**Finish** Some believe plaster skimming can provide a better finish to plastering, although this is always subjective and depends on the quality of labour.

**Acoustic** Some manufacturers claim a higher acoustic performance with a plaster skim over performance taping and jointing.

THE DISADVANTAGES OF PLASTER SKIMMING ARE:

- Other trades usually cannot work in areas being plastered, potentially making programming more complex.
- Plasterers generally need a work area to themselves and can require a lot of scaffold, creating job site clutter.
- Plastering tends to be a more messy process.
- It is not suitable for very narrow works and usually has to be supplemented with tape and jointing.
- It is not suitable for areas of higher than normal humidity.
- The temperature must be 5ºC until fully dry.
- It is only suitable if large areas are available to plaster and areas are complete.
- A mist coat is essential to enable snagging.
- Reduced tile weights can only be applied to plaster skimmed areas – for example, 20kg/$m^3$ as opposed to 32kg/$m^2$ for tape and jointed areas.

## 8.4 QUALITY OF THE JOINTING

Eurogypsum has produced a guidance document entitled Drywall jointing and finishing, surface quality level classifications.
**www.eurogypsum.org**

This document acknowledged that traditionally the quality of the surface has been judged subjectively. The document provides clear definitions of the finish quality, advice on application and criteria to judge the result.

Eurogypsum has stipulated four quality levels:

**Q1** Quality Level 1 – The basic filling of boards where surfaces do not have any decorative finish requirements.

**Q2** Quality Level 2 – This level fulfils the basic level of jointing.

**Q3** Quality Level 3 – This is jointing to level Q2 plus additional enhancements, such as wider finishing of the joint. For matt and fine structured wall coverings and paint coatings.

**Q4** Quality Level 4 – Jointing as per level Q2 plus a complete surface-covering skim coat with a suitable material of a minimum thickness of 1mm. Suitable for smooth or textured glossy wall coverings, silk finish paints etc.

While the above are generally not specified, it is considered that this would be good practice in controlling quality and expectations of finish. For full details see the guidance document.

Once the required standard of finish has been achieved, this should be benchmarked and used when assessing the standard of finish in all locations.

When a plasterboard drylining system is tape and jointed, there will be different porosity of the plasterboard and the jointing material. Because of this, it is important to use a board primer/sealer. The use of a primer/sealer as a surface treatment will equalise the porosity across the joints prior to decoration.

To ensure the best quality painting and decorating, it is imperative that the painting subcontractor, their supervisor and operatives are suitably trained and qualified.

Where hand and pole sanders are used as opposed to mechanical vacuum methods, it is important to ensure the surface is cleaned down to prevent the risk of any blistering occurring once primers and sealers are applied.

## 8.5 PREPARATION

Well executed preparation of the surfaces is paramount in achieving a very high standard of finish.

Making good by filling and stopping should be carried out at the earliest opportunity. Prior to any decoration, the painting subcontractor should inspect the areas to be painted and any obvious areas requiring filling and stopping should be highlighted and made good. Any obvious defects in the background to be painted should be identified, such as damaged plasterboard. It is possible that filling products may shrink and cause variations in texture, which will be apparent in the finish. It is therefore imperative that the works are thoroughly snagged again at the mist coat stage or preferably at the primer/sealer stage.

Stopping (or stopping up) is defined in BS 6150:2006 as relating to nail and screw holes, open joints, cracks and similar local cavities and deep depressions.

Filling is defined as overall smoothing and levelling of shallow depressions and rough, open textured or coarse-grained surfaces.

If both stopping and filling are to be carried out, reference should be made to the relevant NBS specification for surface finishing; M52 for decorative papers/fabrics or M60 for painting/clear finishing, for the full requirements of preparation.

Before the application of each coat, the surface to be painted should be clean and dust free. Any nibs of dust that have adhered to the surface should be lightly abraded with a fine grade of abrasive paper, preferably part worn to avoid overscuffing the surface.

## 8.6 METHODS OF APPLICATION

The principle methods of paint application are:

- Brush
- Roller
- Paint pad
- Paint glove
- Spray

In this guide only brush and roller applications are described.

The operatives applying the paint to the surfaces should be skilled in the various applications.

The temperature will affect the paint application, so the temperatures on site must be in accordance with the manufacturer's recommendations. A temperature equal to or not less than 10ºC throughout the painting process is commonly required.

The correct sequence for the painting should be adhered to – for example, ceilings painted prior to walls. If this is not possible, additional checking should be carried out in the preparation of the walls where specs or runs of paint may be visible on the walls.

## 8.7 PRIMER AND SEALER

As soon as the jointing is dry, a dual-purpose pigmented primer should be applied by brush or roller to the drylined surface. Such a primer will reduce moisture absorption and the risk of discolouration. It will also equalise the suction, provide an even texture and facilitate the subsequent removal of wallpaper or fabrics. In view of the wide range of materials available as finishes, the manufacturer should be consulted as to the suitability of the above treatment.

Decoration should be applied to the face of the gypsum wallboard as soon as possible after jointing and should be in accordance with the recommendations of BS 6150.

It is worth considering that the painting and decorating contractor should apply the drywall primer or sealer in lieu of the drylining contractor. The purpose of this is to achieve a high standard of application of this background application.

## 8.8 TAPING AND SEALING OF ALL JOINTS AND IMPACT ON FIRE AND ACOUSTIC PERFORMANCE

When drylined systems are fire and acoustically tested, it is usual that a minimum of a taped joint is installed. It is imperative that the board joints are tape and jointed in line with the test data to ensure the systems performance is not impaired. It is typical for manufacturers to state that the fire and acoustic performance of the systems (partitions, walls and ceilings) is for imperforate and fully jointed (taped and filled) or plastered surfaces.

Substitution of the tapes to board joints with fire mastic is not acceptable unless this has been proved by test or approved by the manufacturer of the drylined system.

There are two types of tapes available for reinforcing joints for both tape and jointing and plaster skimming: paper tape and glass fibre mesh tape. Paper tape is recommended where the best resistance to cracking is required.

Some board systems can be jointed using tapeless systems, although these methods are specific to particular board types and guidance should be obtained from the manufacturer.

## 8.9 IMPACT OF APPLIED LOADINGS ON DRYLINING

Depending on the types of board used and the types and sizes of studwork, it is possible for loads to be applied to drylining systems, such as stone or timber panelling. The permissible weights on the systems would be determined by the manufacturer.

For example, it is accepted that tiles up to 32 kg/m$^2$ can be supported on a standard plasterboard. However, it should be noted that there is a requirement for partitions to have additional measures to provide a stiffer substrate where tiled. This could be by reducing stud centres from 600mm to 400mm. Other board types are capable of supporting greater weights than 32 kg/m$^2$ and the manufacturer should be consulted.

## 9.1 TRAINING

Initial and continuous training of all staff and operatives is essential and the following minimum standards of training must be obtained.

It should be expected that any person installing drylining systems should be adequately trained and working towards a minimum of NVQ level 2 diploma, interior systems: drylining.

The minimum qualification for a decorator would be QUA727 NVQ level 2, decorative finishing and industrial painting.

## 9.2 SUSTAINABILITY

The first principle of sustainability is to reduce waste, and this can be best achieved at the design stage. The Plasterboard Sustainability Partnership has produced a short e-learning module available at **www.constructionlibrary.co.uk/app/designoutplasterboardwaste_CPD**

It recommends the following points are considered:

TOP TEN WAYS TO REDUCE PLASTERBOARD WASTE

1. Order boards manufactured to size (or close to size).
2. Ensure plasterboards are correctly stored on site and are protected from damage.
3. Design door details using a minimum amount of plasterboard.
4. Consider using a single thickness of board throughout the project, so offcuts and surplus materials can be used on any part of the scheme and overall waste is reduced.
5. Consider single layer of board applications. Manufacturers will be happy to advise on alternative high-performance board options.
6. Agree a location on the site/floor where all plasterboard offcuts can be stored and used by other trades.
7. Agree positions and sizes for all service penetrations, then schedule the erection of the partition, including a prepared opening.
8. Carefully schedule window openings and reveals using offcuts.
9. Understand the true cost of waste – material, labour, skip, gate fees. See Plasterboard Sustainability Partnership – **www.plasterboardpartnership.org/pages/recycling.htm**
10. Reduce waste around columns by designing using one width of board per column.

A number of measures can be employed to control wastage of any drylined system. Having studs and boards manufactured to site-specific lengths can dramatically reduce the amount of wastage of materials on site. This is predominantly the approach taken on large projects, where the additional cost of having the boards or metal cut/made to specific sizes makes sense.

Firestops used on the head of deflection head details can also be manufactured to the correct width and this again reduces wastage on site. A number of details are available on the market that aim to reduce the amount of board wastage when forming door openings.

## 9.3 HEALTH AND SAFETY INCLUDING WORKING AT HEIGHT

The work at height regulations are properly recognised as the main legislation to consider when working at height, however the Construction (Design and Management) Regulations 2015 (CDM 2015) regulations also have a role to play for this type of activity.

WORKING AT HEIGHT

Working at height is the biggest single cause of fatal and serious injury in the construction industry and operatives have to frequently carry out work at height.

***Key legislation: Work at Height Regulations 2005***

All work at height should be risk assessed, which will determine the optimum equipment to be used for access and working. This equipment may include mobile elevating work platforms (MEWPs), podiums, scaffold towers, pop-ups, hop-ups, ladders or even stilts.

A host of guidance is available on all of the above and some have their own associations that provide training and further guidance – IPAF (International Powered Access Federation) for MEWPs, PASMA (Prefabricated Access Suppliers & Manufacturers Association) for podiums and towers, and NASC (National Access and Scaffolding Confederation) for scaffolds.

Anyone erecting or operating the above access equipment must be competent and trained in the relevant equipment.

Emergency plans for the recovery of people should be compiled where relevant.

## 9.4 USE OF POWERED SAWS

Powered saws such as skill saws, jig saws, reciprocating saws and chop saws are high-hazard items of equipment due to their potential to cause severe cuts/amputation injuries and their potential to create excessive noise and dust.

***Key legislation: Provision and Use of Work Equipment Regulations 1998 (PUWER)***

All tools and associated equipment should be inspected before use and should carry an in-date portable appliance test (PAT) sticker or tag.

Where practicable, benches should be constructed to allow items to be sawn at a comfortable height and clamped where necessary.

Abrasive wheels must only be changed by those certified in this activity.

## 9.5 USE OF GAS AND CARTRIDGE TOOLS

Gas and cartridge tools provide a method of fixing that is secure and minimises exposure to hand arm vibration. However, they remain a high-hazard item of equipment due to their potential to cause severe impact injuries.

***Key legislation: Provision and Use of Work Equipment Regulations 1998 (PUWER)***

Gas and cartridge tools should only be used by those trained and certified in their operation.

## 9.6 CUTS

Cuts to hands and arms are the most common 'minor' injury to drylining operatives – usually caused by the knives used to cut boards, from carrying metal studs or when working among services.

***Key legislation: Management of Health and Safety at Work Regulations 1999, regulation 3, risk assessment***

***Personal Protective Equipment Regulations 2002 and the Personal Protective Equipment at Work Regulations 1992 (as amended)***

CE-marked gloves should be worn with a minimum cut resistance of 3 when working with knives. When working among services or handling studs, arm protectors should also be worn.

## 9.7 MANUAL HANDLING

A report involving manual handling of plasterboard by the Health and Safety Laboratory for the HSE (An investigation into the use of plasterboard manual handling aids in the GB construction industry... by Tony Wynn, 2010) determined that drylining operatives have been shown to have one of the highest prevalence rates for musculoskeletal disorders (MSD) in the construction industry. It said that handling and installing plasterboard represents a moderate to high level of MSD risk. This is predominantly due to the weight and unwieldy nature of plasterboard.

***Key legislation: Manual Handling Operations Regulations 1992 (as amended 2004)***

The HSE's manual handling assessment chart (MAC tool) gives guidance on the risk from manual handling in a number of differing activities and risk factors. Where this tool shows there to be a moderate or high risk, a specific manual handling risk assessment should be carried out.

## 9.8 NOISE EXPOSURE

Noise monitoring has shown that construction site general noise levels can exceed both the lower and upper exposure action values. Individual tasks carried out by drylining operatives will also cause these values to be breached.

***Key legislation: Control of Noise at Work Regulations 2005***

Hearing protection with sufficient attenuation should be provided to all operatives and the wearing of this enforced where the upper exposure action value is exceeded. A record of issue of hearing protection, and training in its use, should be maintained.

## 9.9 DUST AND FUME EXPOSURE

A number of materials used in drylining have the potential to expose operatives to above workplace exposure limits stated in EH40.

***Key legislation: Control of Substances Hazardous to Health Regulations 2002 (COSHH)***

A COSHH assessment should be carried out on all materials that have the potential to breach the levels stated in EH40. Occupational hygiene monitoring should be carried out where necessary to determine actual levels. Where masks or other respiratory equipment are used as a control measure, these should be face-fit tested by a competent person for each individual.

## 10.1 BRITISH STANDARDS RELEVANT TO DRYLINING AND PARTITIONING

The following standards, regulations and documents are relevant to the design and specification of internal drylinings and plasters. The list below is not exhaustive but includes the main standards that would be used. Some of the standards are BS (British Standards), others are BS EN (British Standard European Norm) standards:

BS EN 520: 2004 Gypsum plasterboards. Definitions, requirements and test methods

BS EN 15283: 2008 Gypsum boards with fibrous reinforcement. Definitions, requirements and test methods

BS EN 13279-1: 2005 Gypsum binders and gypsum plasters. Definitions and requirements

BS EN 13963: 2005 Jointing materials for gypsum plasterboards. Definitions, requirements and test methods

BS EN 14496: 2005 Gypsum-based adhesives for thermal/ acoustic insulation composite panels and plasterboards. Definitions, requirements and test methods

BS EN 13658-1: 2005 Metal lath and beads. Definitions, requirements and test methods. Internal plastering

BS 8000 part 8: 1994 Workmanship on building sites. Code of practice for plasterboard partitions and dry linings

BS 8212: 1995 Code of practice for drylining and partitioning using gypsum plasterboard

BS 476: Fire tests on building materials and structures, parts 4, 6, 20, 21, 22 and 23

BS EN 1363: Fire resistance tests Part 1: General requirements

BS EN 1364: Fire resistance tests for non-loadbearing elements Part 1: Walls

BS EN 1365 : Fire resistance for loadbearing elements, Part 1 walls , part 3: beams, part 4: columns

BS EN 1366 : Fire Resistance of services installations, part 3: penetration seals, part 4: linear joint seals, part 5: service ducts and shafts

BS 5234 part 1:1992 Partitions (including matching linings). Code of practice for design and installation

BS 5234 part 2: 1992 Partitions (including matching linings). Specification for Performance requirements for strength and robustness including methods of test

OTHER DOCUMENTS OF INTEREST
Eurogypsum, Drywall jointing and finishing: surface quality level classifications

## 10.2 DEFINITIONS

**Background**
The building structure or elements to be drylined.

**Deflection head**
A special design feature at the head of the partition which allows integrity to be maintained while allowing movement, such as floor slab or deflection, to take place.

**Door assembly**
A complete assembly as installed, comprising door frame and one or more leaves together with essential hardware supplied from separate resources.

**Door frame**
Part of the door assembly in which the door leaf moves.

**Door set**
Complete units consist of a door frame and door leaf or leaves, supplied with a central hardware as a product from a single source.

**Drywall system**
PROPRIETARY SYSTEM
GPDA definition: This is a system where a direct technical claim of performance is made by the manufacturer. The systems performance is dependent on the complete system using components supplied only by one of the three GB gypsum plaster and plasterboard manufacturers.

NON-PROPRIETARY SYSTEM
GPDA definition : A non-propriety system is a system where the specification is substantiated by a third party not related to the plasterboard manufacturer, such as BSI, Robust Details or BRE, and is usually based on nominal product dimensions – for example, thickness or density.

**UKAS (United Kingdom Accreditation Service)**
The sole national accreditation body recognised by the British government to assess the competence of organisations that provide certification, testing and inspection and calibration services.

**Limiting temperatures**
The failure temperature of structural steel when it will retain 60% of its room temperature strength.

**FIS would like to extend its thanks to those FIS members and other professionals and specialists who gave generously of their valuable time and expertise to make this publication possible.**

**FINISHES & INTERIORS SECTOR**

FIS has grown over the past 50 years to become the leading trade association for the finishes and interiors sector of the construction industry. Representing companies involved in the manufacture, supply and installation of all aspects of finishes, interior fit outs and refurbishment, we work on behalf of our membership to raise awareness and increase the influence of the sector. We help members to make the most of opportunities through advice, training, technical support and dialogue with government and other bodies.

Quality and integrity lie at the heart of FIS's philosophy, our focus is on developing sector skills, driving technical competence and building our community. Each member is expected to act with the utmost integrity, and to exercise the highest standards of business practice and workmanship. At the same time, the Association seeks to continually raise, maintain and ensure the perpetuation of standards in order to remain a source of quality membership.

FIS membership is not automatic and applicants are subject to strict vetting procedures on application, as well as ongoing vetting. In the case of contractors, this includes inspection of recent contracts to assess workmanship standards.

**www.thefis.org**

FINISHES & INTERIORS SECTOR

# BEST PRACTICE GUIDE
# INSTALLATION OF DRYLINING

**FIS**
Olton Bridge
245 Warwick Road
Solihull
West Midlands
B92 7AH

+44(0)121 707 0077
info@thefis.org
www.thefis.org

ISBN 978-0-9565341-6-3