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# Floors for Indoor Sports

## Introduction

From a playing perspective, the sports floor surface is probably the most important item of equipment in any sport facility. It is a fundamental matter that should be considered from the outset of any project when the overall objectives are being set.

This guide discusses the range of floor surfaces available for indoor sports facilities and offers guidance on selection. It covers the various requirements of different sports and the extent to which some surfaces may be considered as 'multi-sport' surfaces, together with design, cost and construction implications.



**BS 6399: Part 1** requires sports floors to withstand a distributed load of  $5\text{kN/m}^2$  and a  $3.6\text{kN}$  short-term concentrated load.

*From a playing perspective, the sports floor surface is probably the most important item of equipment in any sport facility.*

## Key Issues

### Prioritise Sporting Use

For some 'specialist' single sport facilities it may simply be a question of selecting the ideal surface for that sport.

More often economic, climatic and programming factors require some degree of multi-use that makes the selection of the playing surface far more complex. There will be a need to consider carefully the range of sports, levels of play, extent of use and the objectives and proposed programming of the new facility.

### Potential Non-Sporting Use

Social or commercial activities may also need to be considered and care must be taken to ensure that sporting requirements are not compromised to an unacceptable level. The surface must meet an appropriate sports standard if it is to be used for playing sport.

Additional activities that may need to be accommodated in an indoor sports facility include:

- dance and discos
- concerts
- school assemblies
- examinations
- exhibitions
- community activities

Sport England recommends that Sports Halls should not be used for catering/dining.

### Internal Visual Environment

The floor surface is a major visual element in the sports facility and will have a significant impact on the internal environment. The colour, reflectance and other characteristics of the surface material need to be carefully considered in order to create an attractive internal environment that gives maximum enjoyment to all users.

### Load Bearing and Wear Requirements

Sports floors must be capable of safely withstanding the loadings from users and

equipment. BS 6399-1 1996 defines the minimum requirements for areas with physical activities. It also deals with the additional loadings of temporary spectator seating. This can have a significant influence on the selection of a sports floor surface and its supporting structure. Additionally, 'resistance to wear' requirements for sports such as roller skating and 'impact damage' from equipment are important factors to be borne in mind.

***No one sports surface will suit all indoor sports - a careful compromise is required between safety, performance and operational factors.***

### Risk of Physical Injury

Contact with the floor surface can cause a range of physical injuries - bruising, friction burns, bone fracture as a result of severe body impact - muscle fatigue, strain from repeated foot impact, - twisting of joints from restricted foot movement.

Prolonged and intensive use of the sports floor requires optimal surface characteristics to minimise the potential for injury while allowing maximum sports development. This can generally be achieved through moderate levels of friction, surface deflection and force reduction appropriate to the activities taking place on the floor.

Generally, surfaces that are classified as 'area elastic' or 'combined elastic' are regarded as giving the highest levels of protection in that they allow high levels of force reduction without problems of excessive deformation and poor energy restitution. But the selection needs to be balanced against the playing requirements of particular sports and standards of the sporting activity. (see appendix 1).

### Stable Environmental Conditions

Many sports flooring systems are susceptible to changes in temperature and relative humidity, and it is essential that any environmental variations likely to occur in the facility are identified and controlled to prevent possible

irreparable damage or changes in the playing characteristics of the floor surface.

### Operational Issues/ Health & Safety

The new Construction (Design and Management) Regulations 2007 places additional duties on designers to eliminate or reduce hazards and risk during design, and to advise on those risks that remain. The term 'designer' is used broadly and may include a client, contractor and anyone involved in the preparation and modification of a design or giving instructions to others.<sup>1 2</sup>

The composition, construction requirements and the lifecycle implications of flooring products needs to be understood. In addition, analysis and discussion of the 'in use' health and safety implications of various sports floor products will be required with end users, operators and the client. See later sections on legal implications and risk analysis.

For example:

- The health implications of sanding and resealing hardwood floors say every 5 years, or the disposal of a vinyl based floor product at the end of its life of say 25 years.
- The importance of establishing the correct maintenance regime and using appropriate cleaning products.

Manufacturers and flooring suppliers should be asked to supply full 'in use' operation and maintenance information on their products.

Additionally, the floor must be:

- Hygienic and free from dust or vapour
- Easy to clean and maintain
- Resistant to accidental damage.

BS 6263 gives advice on cleaning and maintenance. Manufacturer's recommendations should be closely followed since the playing characteristics of factory applied finishes can be dramatically altered by using inappropriate cleaning products.

<sup>1</sup> <http://www.opsi.gov.uk/si/si2007/20070320>

<sup>2</sup> <http://www.hse.gov.uk/pubns/books/l144.htm>

The grade of manufacture and surface texture of materials such as linoleum can influence the cleaning regime.



Sports floors must be suitable for the range of body contact appropriate to the particular sport.



Roller skating can cause high loadings and wearing conditions.

### Environmental Sustainability

It is important to ensure that the flooring product and the cleaning and maintenance requirements do not involve harmful materials and generally have a 'green' profile. For example:

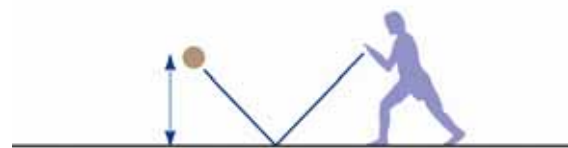
- Use materials that are non hazardous and can be recycled.
- Use timber from traceable and sustainable sources (European PEFC certificate).
- Minimise the use of hardwoods with engineered boards with hardwood veneers.
- Use naturally occurring materials such as linoleum where conditions allow.
- Minimise transport distances.
- Consider the energy profile for the product through its life cycle.

Refer to the Sport England publication 'Environmental Sustainability' for further details.

Refer to the BREEAM assessment tools for low environmental impact. <http://www.breeam.org>

### Sport Performance

The sport performance qualities required of the floor surface vary from sport to sport and relate to the interaction of the ball and/or the player to the surface. The analysis can be extremely complicated, involving the measurement of different physical characteristics with specialist scientific equipment and comparison with agreed standards. The subject can be summarised as follows:



The levels of vertical and angular rebound and spin characteristics must be appropriate for the proposed sport(s).



All sports require the surface to be sufficiently flat, level and consistent so that play is unaffected by floor surface.



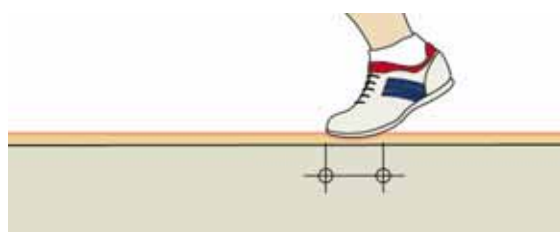
For most sports the degree of friction between the player's shoes and the surface needs to be high enough to prevent slipping, but not so high as to restrict foot movement either in a continuous direction or when turning, or prevent the controlled sliding of the foot that is required in some sports.



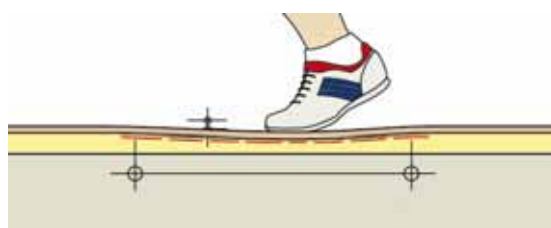
The surface deformation, shock absorbency, and the energy returned to the player and the

ball are critical characteristics: they influence the risk of injury to an athlete, the extent of fatigue and the fundamental playing qualities of a surface. Previously, the general terms ‘sprung floors’ or ‘semi-sprung floors’ has sometimes been used for floors that have such characteristics.

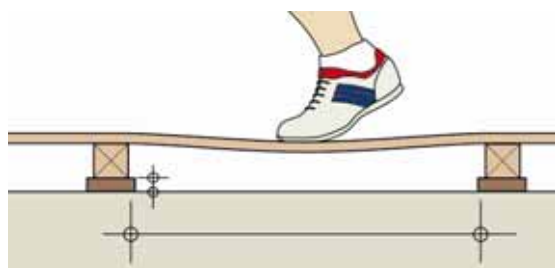
There are 4 categories of flooring systems in BS EN 14904, these are:



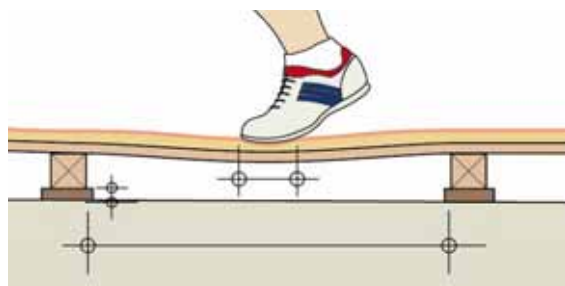
**Point Elastic (Type P).**



**Mixed Elastic (Type M).**



**Area Elastic (Type A).**



**Combined Elastic (Type C).**

For further technical details relating to flooring systems under BS EN 14904: 2006 ‘Surfaces for Sports Areas – Indoor surfaces for Multi-sports use- Specification’ refer to appendix 1.

### Performance Standards

The selection of sports floor products can be problematic. There are strong traditions in some sports to use particular manufacturers or types of flooring. Commercial pressures encourage manufacturers to continually update and develop their product ranges. The development of reliable testing methods and universally agreed performance standards has been a slow process that is often perceived as over-complex.

***The use of performance standards and testing methods remain the only objective way to specify sporting requirements and ensure compliance.***

Since the introduction of the new European standard BSEN 14909: 2006 the situation has been further complicated by some confusion over the status of existing British Standard BS 7044 and the German standard DIN 18032: Part 2. Some manufacturers quote all three in their product literature. In addition there are the standards that are produced by individual Sports Governing Bodies.

Appendices 2 & 3 gives an over view of sports played in multi-sport and dedicated facilities in England.

### **British Standard BS EN 14904: 2006 ‘Surfaces for Sports Areas – Indoor Surfaces for Multi-Sports Use- Specification’**

First published by the British Standards Institute (BSI) in June 2006 as the official English language version, BS EN 14904: 2006 has been the result of a long process to unify standards across Europe in the interest of free trade. All national standard bodies in the European Community, (such as BSI in the UK) are obliged to publish the standard and withdraw existing standards that might ‘conflict’ by February 2008.

This standard defines ‘multi-sport’ use as when more than one sport is played on the same floor

surface, and makes reference to Handball, Basketball, Volleyball, Five-a-side-Football, 'Physical education' and rather vaguely, 'other' sporting activities. Tennis halls are specifically excluded.

The standard had been heralded in Britain as the replacement for BS 7044 part 4 but there are a number of issues including:

- The lack of explanatory guidance.
- The definitions of 'physical education' and 'other' sporting activities.
- The absence of references to:
  - Risk of damage to an athlete caused by impact. (As in DIN 18032: Part 2)
  - Athlete fatigue (as in DIN 18032: Part 2)
  - The weight of users (i.e. children/adults)
  - The flatness of the sport surface (as in BS 7044: Part 4 which specifies  $\pm 6$ mm).
  - The energy restitution of a sports floor.
- The greater range of values now given in BS EN 14904 that allows the use of flooring systems in the P1 and P2 that would not have been classified as 'impact energy absorbing' under BS 7044: Part 4 and would therefore have been considered unsuitable in some situations.

See Appendix 1 for further details.

Some manufacturers do not yet have test results and appropriate certification for the new standard. There also appears to be a low level of awareness and understanding of the new standards.

### **British Standard 7044: 'Artificial Sports Surfaces, Part 4 - Specification for Surfaces for Multi-Sports Use'.**

This standard is 'co-existent' with BSEN 14904 until February 2008. It aims to compromise between the optimal conditions for sports performance and the reduction of injuries and resistance to wear and ageing. It has been regarded as a minimum requirement for multi-sports surfaces in Britain, based on the premise that prolonged and extensive training and varying levels of competition are best accommodated on sports floors that have a 'critical' level of energy absorption.

It contains a classification for 'impact energy absorbing' surfaces. However, the 'pass or fail'

nature of this classification has caused anomalies with sport-specific standards. For example, in the case of Cricket the ball bounce and pace might not be acceptable on an 'impact energy absorbing' floor even with the use of a mat. Whilst for other sports such as Netball there is a strong preference for 'harder' indoor surfaces to replicate the playing qualities of an outdoor court.

### **Other National Standards**

The German industrial standard (DIN 18032: Part 2) is also 'co-existent' with BS EN 14904 until February 2008<sup>3</sup>. It governs the performance and quality control of sports floors. The standard is derived from a construction point of view rather than from the sports' requirements and there can be problems with interpretation. However, the standard does aim to ensure high levels of athletic performance, injury prevention and durability.

Many other countries have their own performance specifications and care must be taken when evaluating imported products that they comply with BS EN 14904 which has become the minimum standard for multi-sports floors in the European market.

### **Generally, refer to BS EN 1490: 2006 in place of BS 7044: Part 4**

#### **Plus:**

- **Governing Body for Sports requirements.**
- **Test results from flooring manufactures/suppliers.**
- **Limits of impact and fatigue on the human body in DIN 18032: Part 2.**
- **Flatness requirement in BS 7044.**

<sup>3</sup> Or 2010 if the DIN application for an extension is successful.

## Sport-Specific Standards

Specific performance standards have been developed for many sports, including athletics, association football, bowls, basketball, cricket, hockey and tennis. It may be appropriate for these sport-specific standards to take precedence over BS EN 14904 in specialist facilities or where one sport is given priority in a multi-sports hall.

For further information refer also to Appendices 1 and 2.

## Approval Systems for Products

Some sports organisations such as the World Bowls Board and the International Hockey Federation operate approval schemes: for specific products based on their compliance with relevant performance standards. See appendices 2 and 3.

## Legal Implications

Recent revisions to the Construction (Design & Management) Regulations place additional responsibilities on designers to consider the safety of buildings in use and for places of work. See earlier references page 2.

It is advisable that the designer / specifier and project sponsor make careful reference to the objectives of the project to ensure that the sports floor is appropriately specified. Test results<sup>4</sup> of the product(s) and justification of the product selection should be covered in the 'health and safety file' and 'residual risks' explained to the future client, operator or designers. Where possible include assessments of similar completed installations.

Particular attention should be given to the use of products that comply with BS EN 14904 and the requirements of the governing bodies.

Compliance testing after the floor is installed should also be considered to demonstrate that the correct qualities are achieved. In an increasingly litigious world, on-site testing and compliance with standards might be used in

<sup>4</sup> References to test result for a particular standard in manufacturer's product literature may not indicate that a product complies with the full range of test for that particular standard.

personal injury claims and the compliance with appropriate standards should be regarded as the minimum requirement to defend such a claim.

## Risk Assessment

No sporting activity is totally without risk of injury. Indeed one of the attractions is the development of skills and physical control of ones body in relation to specific equipment and /or other persons. Quantifying the risks is extremely difficult because they are likely to differ from sport to sport and a wide range of factors. For example the participant's age, experience, natural talent, level of supervision and competition. All parties in sport have a responsibility under health and safety legislation and appropriate risk assessment should be cared out to ensure safe judgement on how a sport floor is used.



A typical squash court with a hardwood area elastic floor surface.

**Designers should make careful reference to the objectives of the project to ensure that sports floors are correctly specified for their intended use.**

### Materials Used For Floor Surface

#### Timber Flooring

Timber is one of the most widely used materials in the construction of sports floor surfaces. It is available in a variety of 'area elastic' systems with hardwood strips, veneers on engineered softwood boards, or composite tiles bedded on composite sheets all suspended on various forms of resilient pads.

Timber also acts as a versatile material for the supporting system or undercarriage of 'combined elastic floors': using plywood sheets, joists or battens, with or without a resilient layer or pads attached to the underside of the battens to create energy absorption. Such supporting systems may have other sheet or in situ finishes laid on top.

Timber can be laid over a cellular plastic sheet in the form of a floating floor. It can be laid in an unfinished state, be supplied from the factory with a surface finish or be sealed on-site.

Hardwood should be of 'selected' quality to achieve uniformity of colour and stability. Commonly, species such as beech, maple and oak are chosen for their light colour and hardness.

Timber is durable but not naturally water-resistant. When laid over a sub-floor, directly or suspended, timber floors must be protected from moisture in the sub-floor by a damp-proof membrane (DPM) additional to that required by the building regulations. Lateral movement in the timber floor arising from varying humidity levels must be addressed by provision of a perimeter expansion gap, even at positions such as doorways.



Advice must be obtained from flooring companies regarding the need for ventilation to any under-floor space and recommendations for cleaning the floor must also be fully understood.

Some authorities claim water penetration to be the most common cause of all sports floor failures.



Hardwood veneers on plywood on alternative undercarriage systems can also be used to give appropriate force reduction and surface deformation characteristics.

***Do not decide upon a sports floor product without play-testing it first.***

***A user group could be set up to help with this process.***

#### Polymeric and Sheet Flooring

Vinyl, linoleum, rubber and composites are widely used materials for sports floor surfaces. They are usually in sheet form with a foam backing that achieves a 'point elastic' or 'mixed elastic' floor. Alternatively, sheet materials can provide the top wearing surface in a 'combined elastic' system. Without a foam backing or supporting system they rely heavily on the quality of the undercarriage on which they are laid and care must be taken to avoid showing irregularities in the underlying surface.

The foam backing can enhance the feeling of softness which may be an advantage where close contact is required, such as barefoot activities, lying on the floor or involving young children. However such floors can limit opportunities for activities such as roller skating that need a stiff surface without drag.





**Contrasting colours facilitate court markings and contribute to a bright environment.**

Alternatively, there are a group of polymeric materials that can be mixed on-site and form a continuous playing surface without joints. The underlay can be a cellular plastic, prefabricated sheet or in situ resin-bonded material. The polymeric coatings are then applied as a 'wet-poured' application in various thicknesses to build up the final surface.

The final surface, which can range from 1-4mm thick, usually has a matt finish and is available in a wide range of colours. Surfaces with a thickness of 4mm may be suitable for use with spiked shoes.

This type of surface is usually considered 'point elastic' but synthetic mesh material can be integrated into the under layers to achieve a measure of 'mixed elastic' performance.

There is a range of thin polymeric finishes available in sheet or acrylic spray paint forms that are used for tennis. These are generally outside the BS EN 14904-1 standard, unless laid on an undercarriage. See International Tennis Federation web site. <http://www.itftennis.com/technical>



**A seamless polyurethane sports floor finish constructed from two 1 mm-thick layers over a reinforcing mesh on top of resilient prefabricated granulated rubber sheets that are bonded to the subsurface. The playing surface is given a matt finish and court markings are applied with polyurethane paint.**

The other approach, as with sheet materials, is to use an in-situ polymeric surface layer as the surface over an undercarriage to give a combined elastic system. All resilient sheet floors should be laid in accordance with BS 8203: 2001.



**Removable section in polymeric floor for volleyball posts**

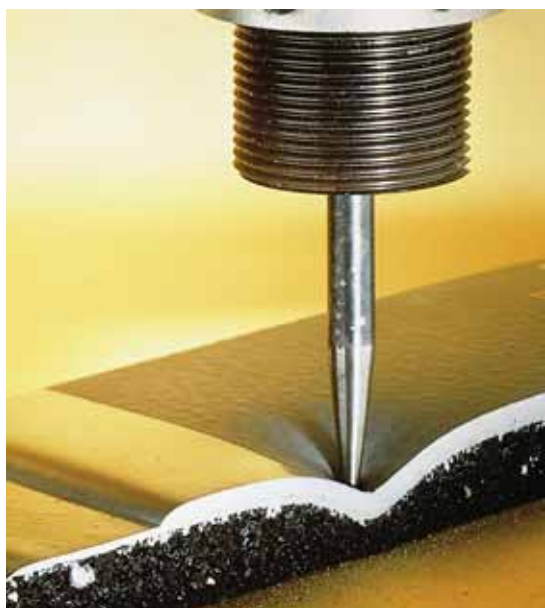
### Textile Flooring

Textile floor surfaces are available in a range of material including:

- Heavy woven fabric
- Felt
- Flock
- Velour

- Fibre-bonded, needle-punched and fine pile carpet
- Knitted, woven or tufted carpet.

The characteristics of textile surfaces vary considerably dependent on the material and construction used particularly durability and friction qualities such as slip-resistance and ball roll.



**Spike resistant point elastic material under a test**

Textiles tend to be used more as specialist than multi-sport surfaces and lend themselves to use as temporary surfaces. Additionally, their warmth and tactile qualities make them suitable for activities such as gymnastics and aerobics and for weight training areas, whilst the sound absorption qualities are an advantage in teaching situations.

		Timber flooring	Polymeric flooring	Textile flooring
Point Elastic	(P)		✓	✓
Mixed Elastic	(M)		✓	
Area Elastic	(A)	✓		
Combined Elastic	(C)		✓	✓

**Overview of types of elastic flooring under BSEN 14904 against groups of materials used as the playing surface**

### Construction Features



**Plywood decking fixed to battens suspended on rubber pads to conform to the force reduction and deformation limits of an area elastic or combined elastic floor to BSEN 14904**

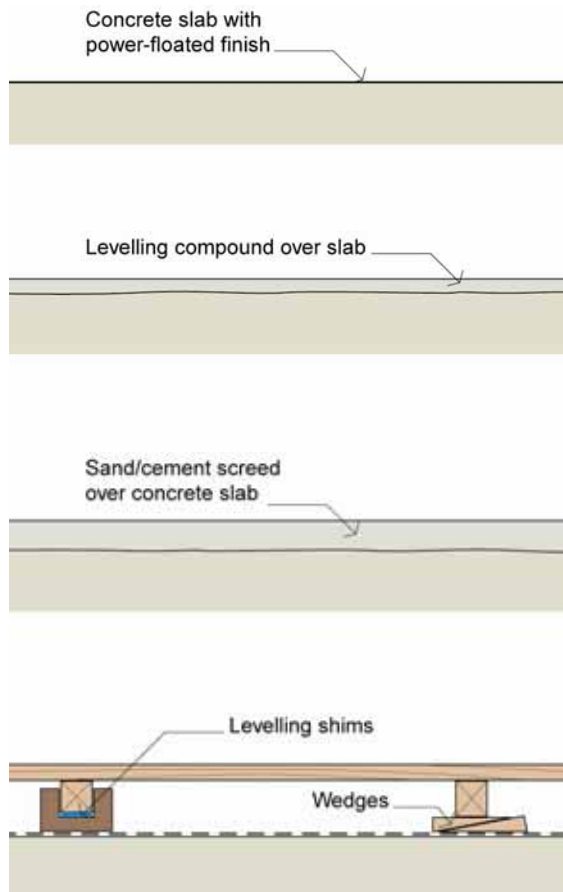
***In-situ compliance testing should be undertaken for new floor installations - a common practice in Europe and for outside synthetic pitches.***

### Sub-Floor

Sub-floor requirements for different floor finishes need to be established at an early stage in the selection and design process. Some products require a screed finish over the structural floor-slab, while others can be laid directly on the slab. The thickness of the floor finish, the degree of evenness and flatness together with standards of workmanship will all be key factors.

Generally, the finished sports floor must be flat

with a deviation no greater than  $\pm 6\text{mm}$  from datum at any point (BS 7044: Part 4), and with an evenness of not more than 2mm under a 300mm straight edge and 6mm under a 3m straight edge ( BS EN 14904). Some 'area elastic' and 'combined elastic' sports floorings have a system of levelling shims and cradles that can compensate for an uneven sub-floor.



### Levelling techniques

### Surface Treatments

Chemical hardening solutions, curing membranes and power-floating/trowelling directly finished concrete can affect adhesion. Where a floor finish is to be bonded directly onto a concrete slab advice on the surface preparation, tolerances and adhesive should be sought from the manufacturer.

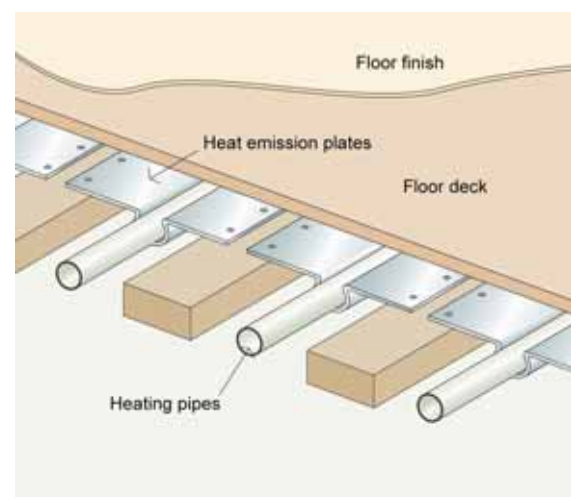
### Underfloor Heating and Other Services

Some flooring systems may accommodate underfloor heating pipes and other services within the voids beneath the playing surface.

This can be an alternative to providing heating elements within the screed. If the under floor heating approach is to be considered, the implications of differential heating, curing and ageing must be thoroughly investigated with manufacturers and suppliers. Sports performance characteristics of floors may change with temperature. Some sports floor manufacturers strongly advise against this approach.

Generally temperatures of component materials should not be subjected to temperatures above 27°C<sup>5</sup>.

Other more conventional methods of heating sports halls include warm air systems or overhead radiant tubes/panels. Both have potential advantages in terms of quick response times to changing climate and usage factors.

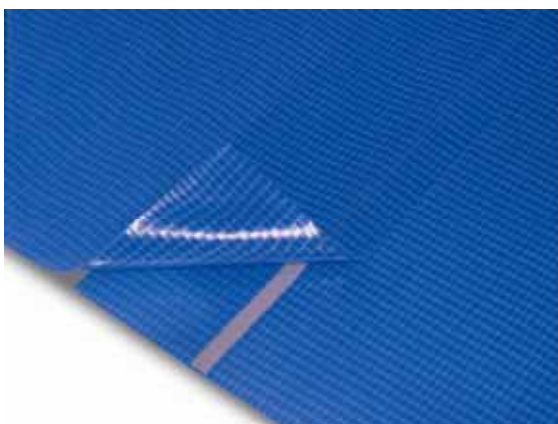


One method of under floor heating

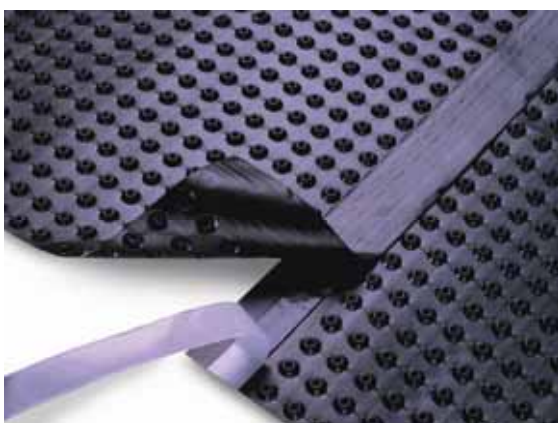
### Programming & Environmental Conditions

Sub-floors must incorporate an effective damp proof membrane (DPM) laid in accordance with BS 8204. The building programme must ensure sufficient drying time to achieve a level of relative humidity less than 75% or as required by the flooring manufacturer.

<sup>5</sup> Refer to CFA Guide to contract flooring for experience of past problems and interpretation of standards.  
[www.cfa.org.uk](http://www.cfa.org.uk)



Reinforced moisture barrier with glued joints



Continuous glued joint in a heavy-duty moisture barrier with studded air gaps to allow ventilation to the perimeter.

Dependent on the thickness of the screed or slab, a concrete floor can take from two months to one year to dry out sufficiently. At the design stage, consider the use of a surface DPM if timescales do not allow sufficient drying time or when the use of a sandwich DPM is inappropriate.

However, surface DPM's cannot generally be used with underfloor heating and the construction program must allow sufficient time for the UFH system to be commissioned and used to dry the subfloor in a controlled manner before the installation of the floor finish.

Before the sports floor is installed it is essential to ensure the building is weather-tight, ventilated and all wet trades, including plumbing, have been completed and tested. The floor manufacturer must be consulted on the precise details but, as a general guide, the following conditions should be in place:

- The temperature must be stabilised at not less than 13°C.
- The moisture content of walls must not exceed 8%.
- The moisture content of the sub-floor must not exceed 2.5% (CM Test) or 75% RH (Hygrometer Test)



Section of sports floor perimeter allowing for variance in expansion and contraction.

### Site-specific risks

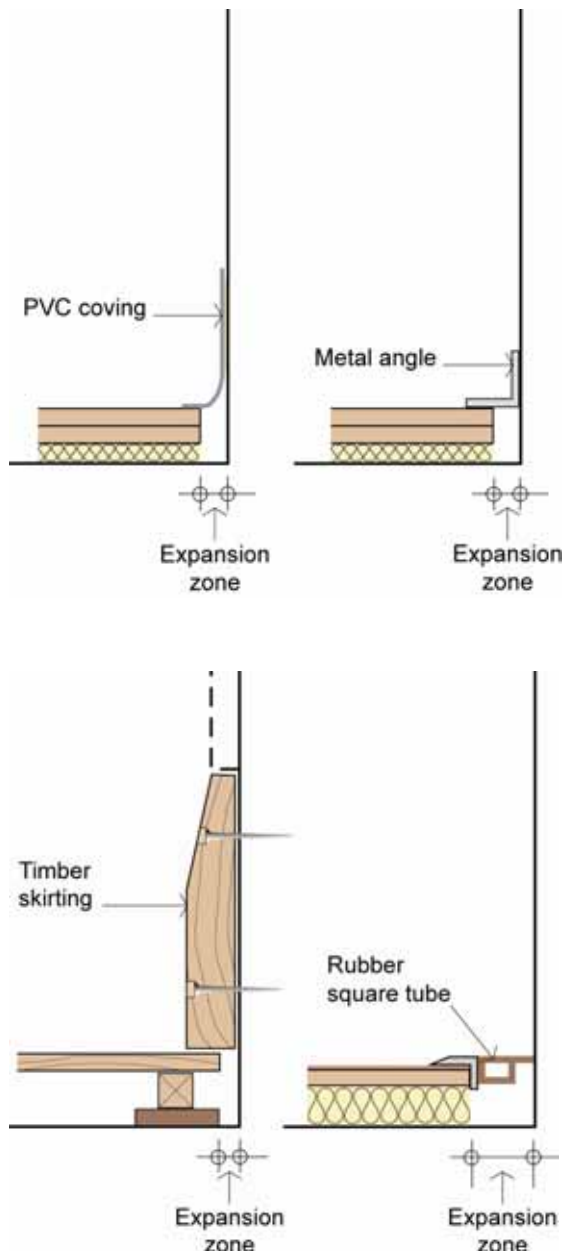
The location of the sports building may pose specific risks that influence the selection of the floor surface and the detailing of the floor and associated elements. For example, the building may be in a flood plain; or an area with a high water-table where the floor level should be elevated; or vulnerable to mining subsidence.

***The floor manufacturer must be consulted for the detailed installation requirements for the particular product.***

### Skirting details

Most floor systems, particularly those using timber-based materials, need an expansion joint around the perimeter to allow for movement caused by changes in temperature or moisture

levels. A cover-piece or skirting board will usually be required as shown in the details below.



When sports such as roller skating and hockey are proposed, the skirting board component can also provide some protection against impact damage. An angle on the top of timber skirtings or the sharp upper edge of metal skirtings can cause hockey balls to fly into the air and must be avoided if hockey is a priority sport.

## Key Features

A range of materials can provide good multi-sports floors: various timbers such as beech, maple or oak, either solid or veneer, and various composition and synthetic materials. Key required features can be summarised as follows:

- The sports floor surface should conform with the appropriate performance standards for the priority range of sports to be accommodated. (BSEN 14904 or a sports specific standard).
- The structural loading must accommodate special features such as bleacher seating or roller skating.
- The positions of fixed and portable sports equipment and their floor sockets should be integrated into the design.
- The floor colour should be considered in order to create an integrated design with wall reflectance and lighting scheme. (The walls should have a 40-50% light reflectance)
- Mats should be provided for sports that cannot be accommodated on the chosen sports floor.

## Equipment & Access Covers

Most sports hall equipment is either free standing or suspended from walls or ceilings. However, some equipment requires the installation of permanent sockets in the floor that must be covered with a flush non-slip access panel when not in use. Examples include:

- Rebound boards
- Volleyball posts
- Gymnastics equipment
- Anchors for fencing pistes
- Golf practice nets
- Power sockets
- Computer/data points



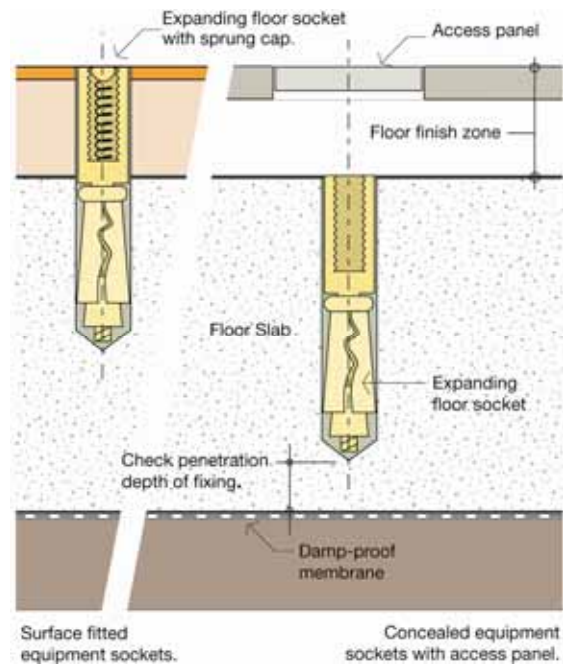
Sports hall layout showing contrasting walls and floors.



Typical access panel to underfloor services and sockets for sports equipment and rebound boards.

Potential damage to under floor heating systems must be borne in mind. Consider court layouts at an early stage in the design process so that the socket position can be established and proper allowance made in the detailing. Additionally, allow for thermal and moisture movement when detailing the floor sockets.

***The requirement to integrate fixed equipment into the sport floor should be identified early in the design process.***

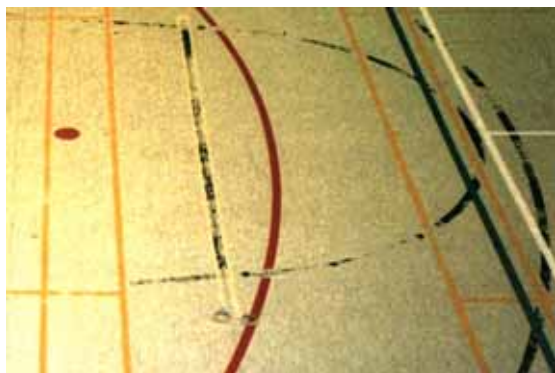


Section through floor slab: typical equipment anchor sockets set into sports floor.

It may be necessary to thicken the sub-floor to accommodate the sockets which usually need to be drilled at least 150mm into the slab - care must be taken to avoid damaging the DPM

### Colour and Court Markings

The colour of the sports floor must be chosen in the context of the overall colour scheme and lighting requirements. The light reflectance value should be between 40-50%<sup>6</sup> and visual contrast with the wall surface and court markings is required<sup>7</sup>. A matt finish is preferable to avoid glare from light fittings. Court marking lines are painted on most sports floors. PVC tape is not usually used, except for temporary courts, whilst inlaid lines are an option for a limited number of sports floor products. These techniques can be combined, with permanent inlaid or painted marks being used as guides for tape markings or, alternatively, permanent markings can be applied for the facility's most popular sports activities.



**Paint and surface preparation must be matched with the surface type to avoid wear.**



**Painted line markings.**

<sup>6</sup> A darker reflectance range is quoted for floors in some specialist facilities: Badminton (20-40%) and Table Tennis (20-30%)  
[http://www.sportengland.org/sportshalls\\_design.pdf](http://www.sportengland.org/sportshalls_design.pdf)  
<http://www.sportengland.org/badminton-4.pdf>

<sup>7</sup> See part M of Building Regulation

Paint should be selected and tested to suit the type of floor. Manufacturers will supply or recommend a proven paint and give guidance on its use. Two-part polyurethane is often used because of its durability. All lines should be masked out to a high standard prior to painting. Line widths must be  $\pm 2$ mm and overall dimensions within 0.1 %.

Most sports require white lines for major competitions although yellow is used for handball and, sometimes, hockey and basketball. For multi-sports halls a range of colours is required to avoid confusion.

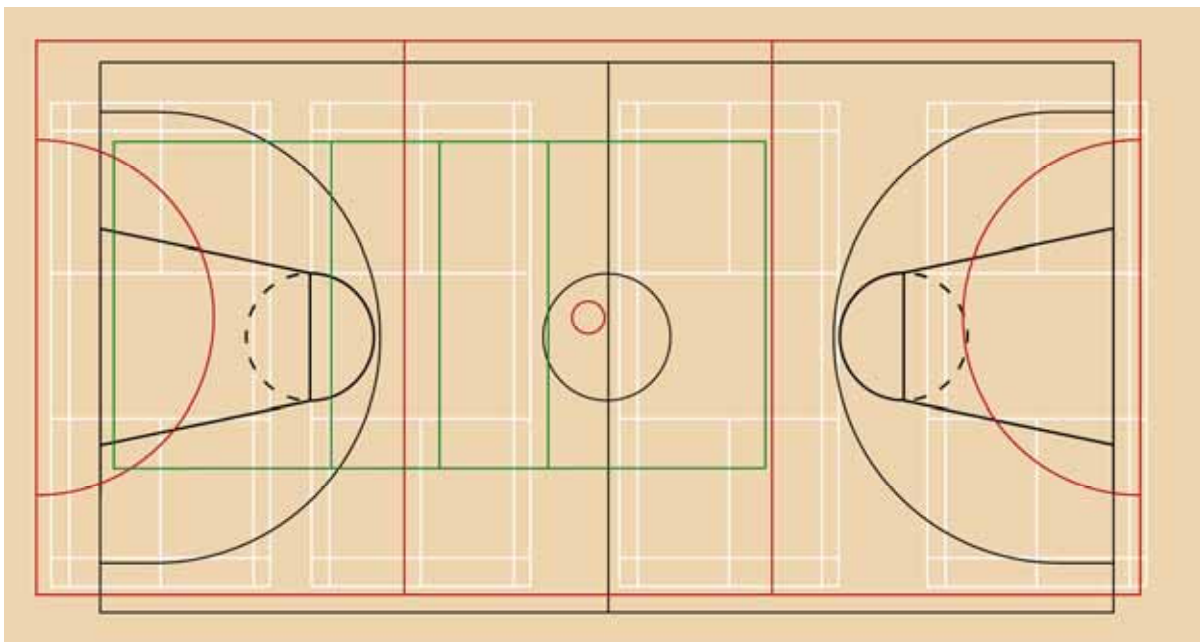
Sport	Line Colour	Width
Hockey	Blue or Other	50mm
Indoor Hockey	Light Blue	50mm
Netball	Red	50mm
Volleyball	Green or Other	50mm
Five-a-side football	Other	50mm
Basketball	Black	50mm
Tennis	Yellow	50mm
Badminton/ Short Tennis	White	40mm

### Recommended court marking line colours & widths.

The layout of court markings needs to be considered carefully to avoid line markings being too close to each other or coinciding. Manufacturers can usually recommend specialist firms to undertake this work or may include it as an element of the floor installation. Computer-drawn layouts can be useful aids when deciding the details of the court layout.



**Floor markings should be carefully planned to avoid overlapping lines.**



Typical 33 x 18m multi-purpose hall layout showing Computer Aided Design drawing of multiple court layouts for client approval prior to installation work. See <http://www.sportengland.org/sportshalls.pdf>

**Portable Sports Surfaces**

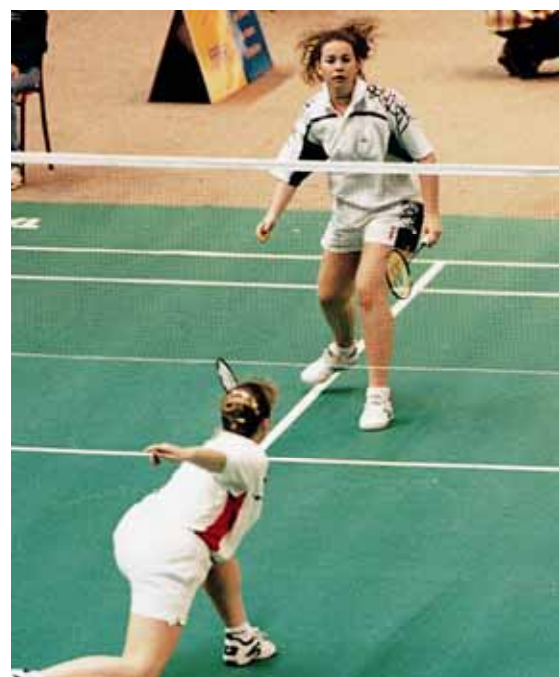
Sports such as indoor cricket have requirements that might be difficult to achieve within a multi-sports specification (BS EN 14904) or conflict with the requirements of other sports that may be regarded as a higher priority.



**Roll-down cricket wicket over multi-sports floor**

Placing a portable floor surface over a multi-sport surface is one way of accommodating occasional activities. They can also provide the conditions for major one off competitions. Standard portable equipment could be used successfully in association with portable courts for many sports with the exception of volleyball where posts need to be located in floor sockets.

The terms 'portable' and 'roll down' can be misleading due to the extent and weight of the surface. Laying, lifting and storing these surfaces can be laborious, time-consuming and expensive. If this approach is adopted it is important to consider the interaction between the existing and portable floors to ensure that the combination is stable and meets the same performance standards as the permanent floor.



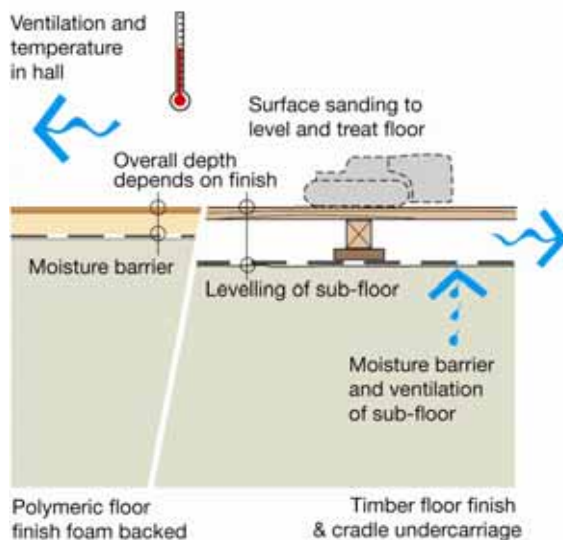
**Portable badminton court laid for a tournament.**



### Cost

Typically, the sports floor surface construction will be small proportion (say 3-5%) of the total construction costs of the sports hall (excluding floor structure). However, it is one of the most important elements in a sports hall and can influence the overall economics of a facility. The cost of the sports floor should be assessed against the overall objectives such as:

- Creating a suitable internal environment
- Attracting and maintaining users.
- Helping players to develop their skills and abilities.
- Balancing cost in use factors against income to maintain overall viability.



### Causes of additional costs

The cost of sports floors can be affected by fluctuations in international market conditions for materials, transport costs and labour rates. Very few flooring products are sourced entirely from within the UK.

The market strategies of individual suppliers will also come into play and in order to obtain best value for money, competitive tenders should be sought based on the performance specifications required by BS EN 14909 and any other appropriate references.

It is also essential that any other associated cost factors are considered so that the full cost picture is understood. Manufacturers should be asked to state:

- **Requirements for levelling the sub-floor:**

The costs of providing a levelling screed or applying a power-floated screed to the structural sub-floor can be expensive and time-consuming and must be allowed for in building contracts. Some area and combined elastic undercarriage systems can be levelled and height adjusted allowing screeds to be eliminated.

- **Requirements to achieve a specified moisture level in the sub-floor and other building elements before the commencement of installation work:**

It can take months for a structural sub-floor to fully cure and naturally dry out to the required moisture level. The time required must be allowed for in the original building programme to avoid extending the contract and incurring increased costs. Alternatively, a surface DPM should be used, or heating could be employed to speed up the process.

For systems using timber based products a damp-proof membrane is essential and in some cases this will require natural or forced ventilation.

- **Requirements for permanent heating and ventilation:**

Some flooring systems have specific requirements for heating and ventilation in order to maintain dimensional stability.

- **Requirements for installation work:**

The sequence and organisation of the installation work will vary from system to system.

- **Requirements for the storage of materials:**

The working conditions within the building may need to be precisely controlled. Flooring materials can require special storage conditions on-site in order to acclimatise to the building's internal environmental conditions.

- **Requirement for finishing off and cleaning:**

Some systems require heavy sanding of the surface before application of the final surface treatment. Methods of safely controlling dust and secondary cleaning must be fully understood.

- **Overall depth of system in relation to structural design:**

The depth of floor finish could have an influence on the economics of the overall design.

- **Requirements for movement joints.**

- **Requirements for cleaning and maintenance when the surface is in use.**

- **Life expectancy of the surface.**

- **Integration with line marking and installing fixed sports equipment**

Some suppliers provide a combined service in which line markings and fixed sports equipment are installed in the same package and therefore avoiding coordination problems.

*The sports floor is one of the most important elements in a sports hall and can influence the overall economics of a facility.*

*The cost of the sports floor should be assessed against the overall objectives of the project.*



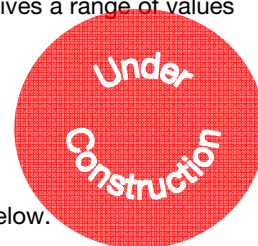
## APPENDIX 1 – Note on the New European Standard BS EN 14904: 2006

**BS EN 14904: 2006 'Surfaces for Sports Areas – Indoor Surfaces For Multi-Sports Use – Specification'** partially supersedes **BS 7044: 1990 Part 4**. This is the first of a package of standards, which when completed will lead to the entire withdrawal of BS 7044.

Key points to note about the new **BS EN 14904** are:

- 1 Some change in terminology.
- 2 A different approach to the classification of **shock absorption**: In contrast the 'pass' or 'fail' classification in BS 7044 part 4 for impact energy absorbing floors, an annex B to the new standard gives a range of values from 25%- 75% for different types of sport surface construction:
  - Point elastic - P
  - Mixed elastic - M
  - Area elastic - A
  - Combined elastic - C

The general characteristics are illustrated on page 4 and illustrated in the diagram A below.
- 3 An annex B gives a range of values for **vertical deformation** for different types of sport surface construction with a maximum being set at 5mm.
- 4 A range of values of 80-110 is given for **friction**, with emphasis on the degree of 'grip' between footwear and the surface being an important safety and sport performance issue.
- 5 Other characteristics covered by the standard include:
  - Vertical ball behaviour
  - Resistance to a rolling load
  - Resistance to wear
  - Reaction to fire
  - Formaldehyde emission
  - Content of pentachlorophenol
  - Specular reflection
  - Specular gloss
  - Resistance to indentation
  - Resistance to impact
  - Degree of evenness



### Issues around BS EN 14904

Issues relating to the new 'European' standard BS EN 14904 are mentioned on pages 4 and 5 - the absence of references that are included in existing 'national' standards, questions about interpretation and the extent that the new standard in its present form can only partially replace existing 'national' standards.

The transitional process being followed allows the new 'European' standard to 'co-exist' with existing 'National' standards for a period of time, and to supersede those parts that are in 'conflict'. It seems sensible therefore, at least for the time being, for Designers and Specifiers to refer firstly to the new 'European' standard, but to then look to the 'National' standards to fill the perceived 'gaps'. This is particularly so, when national standards are still referred to in some manufacturers trade literature and sports specifications. See the highlighted panel on page 5 and table below.

Issues not covered in BS EN 14904	Alternative references
Energy Restitution	[To be confirmed]
Protection to athletes against Impact damage	<ul style="list-style-type: none"> <li>• Referring to the peak deceleration standard in the BS 7044: Part 4.</li> <li>• German DIN Standard V 18032: Part 2: Clause 3.16 which gives limits of between 45 and 53% force reduction for different types and categories of sports floors.</li> </ul>
Fatigue	Limit athlete fatigue the German DIN Standard V 18032: Part 2: Clause 3.15 and Table 1 of DIN V 18032: Part 2.
Flatness of the surface	± 6mm standard within BS 7044: Part 4.

In addition the new standard does not differentiate between the needs of individual (or groups) of sports and by itself does not provide a basis for establishing the flooring characterises that are appropriate for a particular sports project. It is considered essential that the requirements of the sports to be accommodated in a project are fully understood. Appendices 2 and 3 provide additional information available from sports organisations.

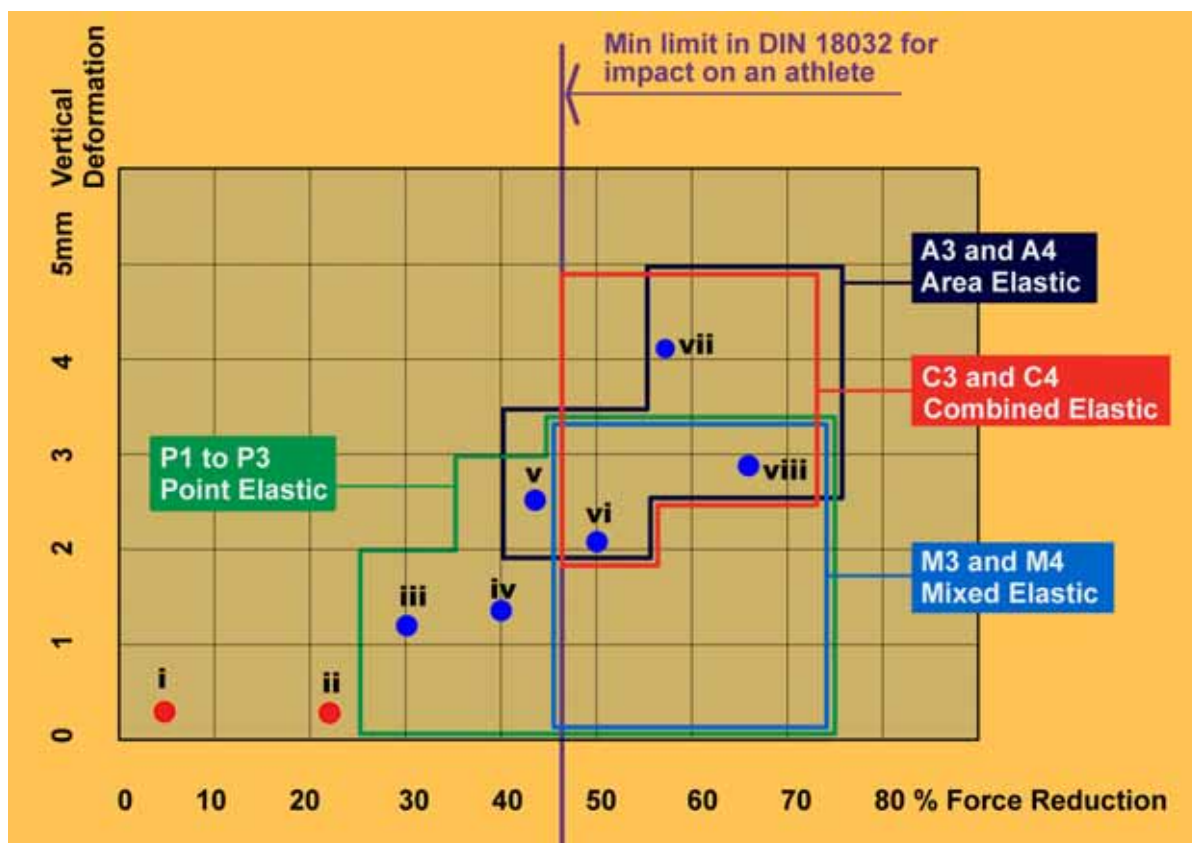


Diagram A

The graph of Force Reduction (%) against Vertical Deflection shows four interlocking coloured boxes representing the value limits for Point Elastic (P), Mixed Elastic (M), Area Elastic (A), and Combined Elastic (C) floor systems shown in Appendix B of BS EN 14904. Examples of typical floor products are also plotted on the graph in positions i- viii.

**Examples i and ii**

Represent systems outside the standard - likely to be sheet flooring products laid on a solid base. However they may be suitable for single sports applications (e.g. Tennis and Bowls).

**Examples iii and iv**

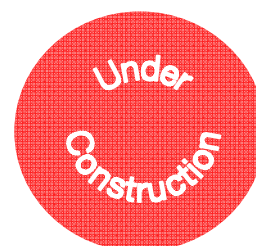
Represent systems within the standard (P1 or P2) and likely to be sheet products e.g. Polymeric/Rubber, with a foam backing layer giving greater shock absorption and allowing increased vertical deflection. This may give an increased sense of softness underfoot.

**Examples v and vi**

These may also be sheet systems with thicker foam backings (P3 or M3<sup>8</sup>). More typically these would be timber or sheet material on an undercarriage system (A3, or C3).

**Examples vii and viii**

Represent systems giving athletes maximum protection from injury due to impact (A4 or C4). These exceed the minimum limit in DIN 18032: Part 2 marked in purple. It is not possible to plot the limit for impact energy absorption as set in BS 7044 because it is based on different parameters. However, it could be approximately estimated<sup>9</sup> as 40% being the lower level for area elastic floors.



<sup>8</sup> Examples of 'mixed elastic' floors are not currently on the market.

<sup>9</sup> From test data of energy absorbing systems classified under BS 7044

**APPENDIX 2 - Sports Played in Multi-Sport Halls (England)**


This table is a draft under discussion with National Sport Governing bodies. The intention is to develop an overview of the critical flooring issues and sources of further information for each sports activity.

Sport/Critical Issues		Further information	BSEN 14904	References made in the standard.	Considered to be compatible
<b>Athletics (Sports Hall)</b>		<p>Recreational/fun level indoor athletics can take place on a multi-sport floor with appropriate grip and shock absorbency. Running lanes can be marked out with tape and angular turning boards, known as 'reversaboards' can be fixed to the floor and side wall to extend the distances. Protective mats can be used to protect the floor for throwing activities.</p>	<p><a href="http://www.ukathletics.net">http://www.ukathletics.net</a>                      Advice is available from UK Athletics.  <a href="http://www.sportshall.org/">http://www.sportshall.org/</a>                      See section on sports hall athletics in Sport England's Design Guidance Note 'Athletics'.  <a href="http://www.sportengland.org/athletics.pdf">http://www.sportengland.org/athletics.pdf</a></p>		
<b>Badminton</b>	<p>The level of friction between the players shoe and surface can be a critical and Badminton England's specification has a reduced range of values (80-100) for all levels of play.</p>	<p><a href="http://www.badmintonengland.co.uk">http://www.badmintonengland.co.uk</a>                      Badminton England provide advice on surface selection based on a combined elastic floor type C4 in BSEN 14904.</p>		✓	
<b>Boxing</b>	<p>Slip resistance when perspiration falls on to the floor can be critical.</p>				
<b>Bowls</b>	<p>Roll down mat required.</p>	<p><a href="http://www.eiba.co.uk">http://www.eiba.co.uk</a>                      Played to the same rules as the full sized game.</p>		✓	
<b>Short Mat Bowls</b>	<p>Roll down mat required.</p>	<p><a href="http://www.esmba.org.uk">http://www.esmba.org.uk</a>                      A short mat version of the game with separate rules. The governing body operates an approval system for the mats.</p>			
<b>Carpet Bowls</b>	<p>Roll down mat required.</p>	<p><a href="http://www.englishcarpetbowls.com">http://www.englishcarpetbowls.com</a>                      Carpet bowls is a further version of the game and is often played at a community level.</p>		✓	
<b>Basketball</b>	<p>Consistency of ball rebound across the surface is critical a high level of shock absorption is required for safety and comfort of players.</p>	<p><a href="http://www.englandbasketball.co.uk">http://www.englandbasketball.co.uk</a>                      English Basketball Association have a facility specification that requires playing surfaces for international level to be in accordance with DIN 18032: Part 2 and semi sprung for other competition. (i.e. a floor with shock absorption characteristics). FIBA operate a licensing system for approved floor products.  <a href="http://www.fiba.com">http://www.fiba.com</a></p>		✓	

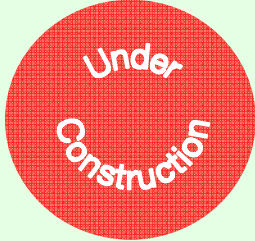
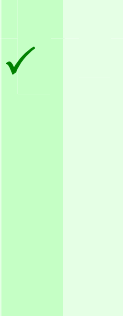
Sport/Critical Issues		Further information	BSEN 14904	References made in the standard.	Considered to be compatible
<p><b>Cricket Nets and Six-a-Side Cricket</b></p> <p>Floor surfaces, with or without rollout mats, should meet the requirements of the ECB performance standard for indoor cricket pitches. This is based on BS EN 14904.</p> <p>Ball bounce and surface friction are key requirements that determine the 'pace' of a pitch. These and other playing characteristics are influenced by the hardness/firmness of the underlying structure. A floor surfaces with a high level of force reduction can give a 'dead surface' that is unsatisfactory for cricket even with the addition of a mat.</p>		<p><a href="http://www.ecb.co.uk">http://www.ecb.co.uk</a></p> <p>The England and Wales Cricket Board (ECB) performance standard classifies levels of play into Club, Educational and Centres of Excellent, which embraces professional.</p> <p>The 'Performance Standard for Indoor Cricket Pitches' and ECB Guidance Notes TS3 – 'Indoor Sports Hall with Cricket Provision' can be obtained from the ECB Facilities and Funding Manager at Old Trafford Cricket Ground, Old Trafford, Manchester. M16 OPS</p>		✓	✓
<p><b>Five-a-Side Football/Futsal</b></p> <p>Played on a wide range of floor surfaces</p>		<p><a href="http://www.thefa.com">http://www.thefa.com</a></p> <p>Football Association (FA) publication: 'Guide to indoor and outdoor areas for small sided football, mini-soccer and futsal' refers to BS 7044<sup>10</sup></p>		✓	✓
<p><b>Fencing</b></p> <p>Portable piste required</p>		<p>No preference</p>		✓	✓
<p><b>Gymnastics</b></p> <p>Special mats required to protect participants from the force of falling.</p>				✓	✓
<p><b>Handball</b></p> <p>A high level of shock absorption for safety and comfort of players:            Combined Elastic minimum Shock Absorption 53%            Vertical Deformation &gt; 2.3mm            Ball Rebound min 90%</p>				✓	✓
<p><b>Hockey</b></p>		<p>No Standard</p>		✓	✓
<p><b>Korfball</b></p> <p>A high level of shock absorption is needed for the safety and comfort of players and this needs to be combined with consistency of ball bounce</p>				✓	✓

<sup>10</sup> Understood to be under review.

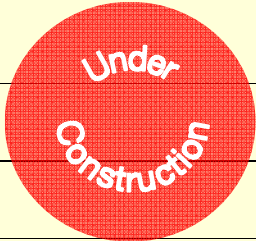
Sport/Critical Issues		Further information	BSEN 14904	References made in the standard.	Considered to be compatible
<p><b>Lacrosse</b></p> <p>Identified as an indoor sport in BS 7044 but not widely played in England.</p>		<p>Indoor version of the game is played in a modified form known as 'box' lacrosse or 'boxla' or 'boxcrosse'</p>			
<p><b>Movement, Dance &amp; Keep Fit</b></p> <p>Combined elastic floors with a stable surface that allows balance, slide, and turn on an energy absorbing undercarriage are regarded as most suitable.</p> <p>For multi-use community and school projects an easily cleaned 'point elastic' with a integrated energy absorbing backing can be satisfactory</p>		<p><a href="http://www.danceuk.org">http://www.danceuk.org</a></p> <p>Information sheet reference to Mark Foley's Handbook for Dance Floors is available from Dance UK. This refers to DIN 18032: Part 2 and the minimum force reduction level of 53%.</p>			✓
<p><b>Martial Arts</b></p> <p>Special mats required to protect participants from the force of falling.</p>					✓
<p><b>Netball</b></p> <p>Low force reduction levels preferred</p>					
<p><b>Roller Skating / disco / hockey</b></p> <p>High resistance to wear and indentation of dirt particles beneath wheels required. Low rolling resistance also important.</p>					
<p><b>Soft Play</b></p> <p>Mats required for some activities.</p>					

Sport/Critical Issues		Further information	BSEN 14904
<b>Table tennis</b>	<p>The vertical deformation of the sports floor is of particular importance, for the stability of the table, as is the grip between the surface and players shoes. In Multi-sports halls there is a preference for Type 3A or 3C FLOORS under BS EN 14904. Point elastic or mixed elastic floors are not recommended.</p>	<p><a href="http://www.englishtabletennis.org.uk">http://www.englishtabletennis.org.uk</a></p>  <p>Design advice on surface selection is available from the English Table Tennis Association (ETTA). <a href="http://etta.co.uk">http://etta.co.uk</a></p>	<p>References made in the standard. Considered to be compatible</p>
<b>Tennis / Short Tennis</b>	<p>Tennis is not usually played in multi-sports halls due to the difficulty in creating the suitable ball bounce characteristics. However, short tennis which is played with special balls is an option</p>	<p><a href="http://www.lta.org.uk">http://www.lta.org.uk</a></p> <p>Design advice on surface selection and mini tennis available from the Lawn Tennis Assoc (LTA). The LTA have adopted the ITFA Performance Standard for Tennis Court Surfaces</p> <p><a href="http://www.itftennis.com/technical">http://www.itftennis.com/technical</a></p>	<p>Specifically excluded</p>
<b>Tug of war</b>	<p>The friction of the floor is a key factor for recreation level and training. Mats used for competitive events.</p>	<p><a href="http://www.tugofwar.co.uk">http://www.tugofwar.co.uk</a></p> 	
<b>Trampoline</b>	<p>Surface indentation damage by the trampoline while being moved and in use can be an issue with some surfaces, particularly when the rolling resistance is high.</p>		



Sport/Critical Issues		Further information	BSEN 14904	References made in the standard.	Considered to be compatible
<p><b>Volleyball</b></p> <p>High levels of force reduction required to allow for players jumping and diving on the floor during play.</p>		<p><a href="http://www.volleyballengland.org">http://www.volleyballengland.org</a></p>			
<p><b>Yoga</b></p> <p>Usually undertaken on mats.</p>		<p><a href="http://www.bwy.org.uk">http://www.bwy.org.uk</a></p>			

## APPENDIX 3 - Specialist Facilities

Sport/Critical Issues	Further Information
<p><b>Athletics</b></p> <p>Specialist indoor training halls use spike resistant flooring to meet IAAF specifications and replicate outdoor tracks to give ideal training conditions. These surfaces can have surface textures that limit the scope for other sports. A range of activities such as 5-a-side football, badminton and keep fit can be played at a recreational level.</p>	<p>Details of International Amateur Athletics Federation (IAAF) certified products are on their web site. <a href="http://www.iaaf.org">http://www.iaaf.org</a> Advice based on the use of indoor athletic tracks is available from UK Athletics <a href="http://www.ukathletics.net/">http://www.ukathletics.net/</a></p>
<p><b>Bowls</b></p> <p>Purpose built centres require a surface built to higher dimensional tolerances than BSEN 14904</p>	<p>The Sport England Guidance Note 'Indoor Bowls' covers purpose built bowls halls.</p>
<p><b>Cricket</b></p> <p>Specialist cricket hall may have different surfaces at the batting and bowlers end and/or a range of mats to simulate different playing conditions.</p>	<p>See item Appendix 2</p>
<p><b>Cycling</b></p> <p>Special track, low friction and rolling resistance required.</p>	
<p><b>Ice Sports</b></p> <p>Special rink required</p>	
<p><b>Irish Handball</b></p> <p>Special court required</p>	
<p><b>Pelata</b></p> <p>Special court required</p>	
<p><b>Rackets</b></p> <p>Special court required</p>	
<p><b>Racketball</b></p> <p>Special court required</p>	
<p><b>Real Tennis</b></p> <p>Special court required</p>	
<p><b>Rugby Fives</b></p> <p>Special court required</p>	
<p><b>Riding and Equestrian</b></p> <p>Special floor required</p>	
<p><b>Skiing</b></p> <p>Special rink required</p>	
<p><b>Squash</b></p> <p>Special court required</p>	
<p><b>Tennis</b></p> <p>Special court required</p>	<p>Design advice on surface selection and mini tennis is available from the LTA. <a href="http://www.lta.org.uk">http://www.lta.org.uk</a> The LTA have adopted the ITFA Performance Standard for Tennis Court Surfaces <a href="http://www.itftennis.com/technical">http://www.itftennis.com/technical</a></p>
<p><b>Tenpin Bowling</b></p> <p>Special facility required</p>	

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## Information Prepared By:

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