THE DESIGN AND CONSTRUCTION OF FLOORING IN GOWNING AND ASSOCIATED AREAS

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The vast majority of contamination found within cleanroom facilities is introduced by humans. The human contamination problem can be reduced with good house-keeping practices, although the problem of cleanroom contamination is better addressed at source. On a dry day the average person carries approximately 0.1g of debris on their footwear when entering a building from the street. Therefore for every 1000 personnel entering a building, 100g of debris is tracked in with them (Fig.1). A particulate count of this magnitude would be almost impossible to estimate.

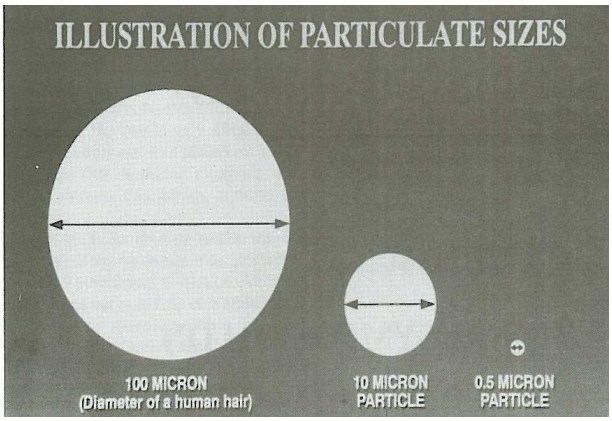

Fig 1: Illustration of Particulate sizes

Introduction

In a perfect world, i.e. with no budgetary restrictions, contamination control is dealt with in a sequential or cascading manner immediately staff enters the building. Personnel are first subjected to ergonomically design and specially textured *walkways* this allows for the minimal ingress of debris beyond the entry point, making its subsequent removal from footwear easier. Textile covered or carpeted foyer and corridor areas again address gross contamination. Footwear is submitted to a final contamination process at the entry points to sensitive or controlled areas. This may take the form of a chemically pre-treated *barrier mat*.
Having discussed the general flooring requirements outside the controlled areas, attention should now be given to the flooring within the gowning area.

Before looking at specific flooring types, there are other considerations to be taken into account. The *colour aspect* of the flooring in the gowning areas should not be overlooked. Cleanroom personnel are encouraged to think of the gowning process as a transferral from "black", i.e. dirty, through "grey" to "white" – a clean state. The psychology applied is enhanced by the colours of the floor. Cleanroom designers can offer customers a wide variety of contrasting colours. The area before the step over bench is usually dark, followed by a lighter colour over the barrier, with perhaps a pastel shade used in the cleanroom itself. White should be avoided in the cleanroom as it has been found to be stressful to personnel.
The choice of the specific flooring type in the gowning area is fundamental to the operation of the cleanroom, although due consideration to the potential cross-contamination problem is seldom given.

The gowning area provides the means of transferring contaminated and contaminating personnel and equipment from their "dirty" surroundings and preparing them for their ultimate transfer into the "clean" environment. Within the gowning area, functional, passive flooring or active, contamination control flooring can be chosen.
The first to consider in the passive section is vinyl flooring.

Functional, Passive Flooring
Vinyl Flooring (Fig. 2)

A large percentage of gowning area floors are made from high quality sheet vinyl. The optimum thickness is 2 mm. The material must be durable and abrasion material must be durable and abrasion resistant, thus a material with increased vinyl content is desirable so that the resultant material contains less filler. Sub-floor preparation is of utmost importance, as a rough or uneven surface will "telegraph" through the vinyl layer giving a poor appearance as well as providing undulation and ridges where contamination can accumulate. The general rule is that the sub-floor should contain less that 5% moisture and incorporate a damp proof membrane. The uppermost layer of the sub-floor should have a floor screed set and cement in a latex lattice. Having let the screed set, a polychlorophene contact adhesive provided a strong, water-tight method of installing the vinyl sheet flooring.
Having installed the flooring, the sharp junction between floor and wall, a potential dust trap, must be eliminated (coving is essential for all flooring to wall junctions). This can be achieved by use of vinyl coving which has an arc of approximately 100 mm. In some installations- particularly pharmaceutical cases- the vinyl sheet is rolled directly up the walls to provide a continuous, joint-free interface. The provision of rolled and coved edges is also made use of when step over barriers are a permanent feature.

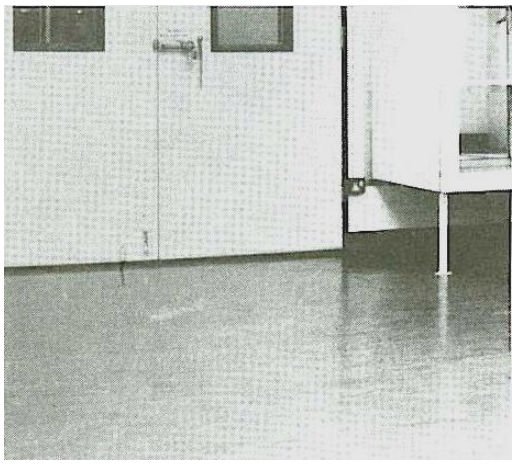

Fig 2: Vinyl Flooring

Vinyl flooring maintains its popularity due to its availability and its ability to retain its cleanliness and appearance; this is due to the presence of a wear layer incorporated into the top coat of the vinyl. This tough resilient layer can resist abrasion and soiling, making subsequent cleaning operations easy.
Joints in vinyl sheets must be sealed by chemical bonding or more commonly heat welding, creating an essential monolithic floor. Seams are potential dirt traps therefore they should be kept to a minimum (this is true of all flooring types). The high level of activity encountered in the gowning areas will cause dispersion of dirt trapped in the seams into the air and ultimately into the cleanroom. One of the drawbacks of vinyl floor installations is that when spilled organic solvents are lefty in contact they cause plasticiser extraction with the associated problems of shrinkage and embrittlement. Cleanroom operators that employ the use of organic solvents, for instance the printing and photographic industries, avoid vinyl flooring, preferring to opt for one of the following alternatives.

Epoxy, Polyester and Polyurethane Flooring

A popular choice of flooring, employed especially by the food industry, is produced by combining epoxy, polyester and polyurethane resins with inorganic aggregates such as silica sand and marble. It is possible to produce a wide variety of compositions suitable for the seamless surfacing of gowning area floors. Such flooring can be applied at any desired thickness depending upon the traffic through the area.

This system is physically hard wearing and has good chemical resistance, as well as being structurally very strong and impact resistant. The composition can be odourless and solvent free, thus its popularity with the food industry. Damaged areas can produce particulate, though repairs in situ are not difficult- a specific area can be removed and the repair instated.

Tiled Flooring (Fig. 3)
Tiles can be used for the surfacing of gowning are as, commonly tiles that are pre-cast and are composed of marble chippings bonded together with a hard wearing polymer resin. The tiles can be laid on traditional sand a cement base, or fixed with an acrylic adhesive.

Fig. 3: Tiled Flooring

Finally grout is applied between the tiles providing a flat, continuous surface. It is important that the grouting material is non-particulating and applied so that the finish is continuous with the tile surfaces. If this is not the case, a concavity occurs at the interface allowing dirt and debris to accumulate. Tile floors have the advantages of chemical and abrasion resistance and damaged areas can easily be repaired by the selected removal of the offending area, thus keeping down-time to a minimum. Care must be taken, however, to ensure that the grouting between the tiles is of the required standard.

Active Contamination Control Flooring
Having discussed functional, passive flooring it is important to remember that personnel not only carry and disperse contaminants bodily, but that also create turbulence that can re-disperse particulate gathered at floor level. (Fig. 4).
The following active flooring techniques avoid particulate re-dispersion.

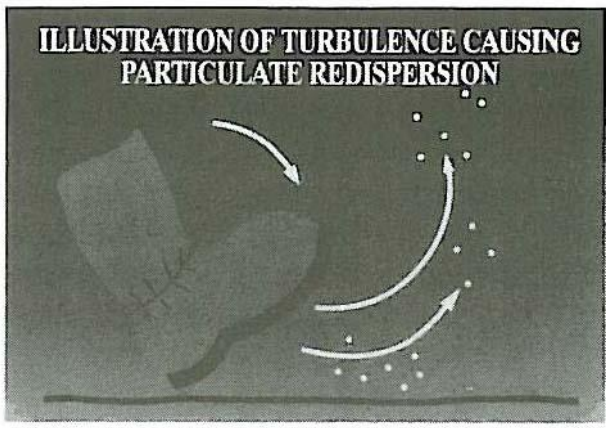

Fig. 4: Illustration of Turbulence Causing Particulate Redispersion.

Raised Perforated Flooring (Fig.5)
Raised perforated flooring in a gowning area is the ultimate in the defence against particulate contamination. The downward laminar airflow carries particulate through the perforations allowing it to be captured in filters before the air is re-circulated.
Due to the great expense associated with the system, raised perforated floors are only found in high class cleanroom change areas, typically class 100 or better. A further limitation of the system is its inability to deal with liquid spills.

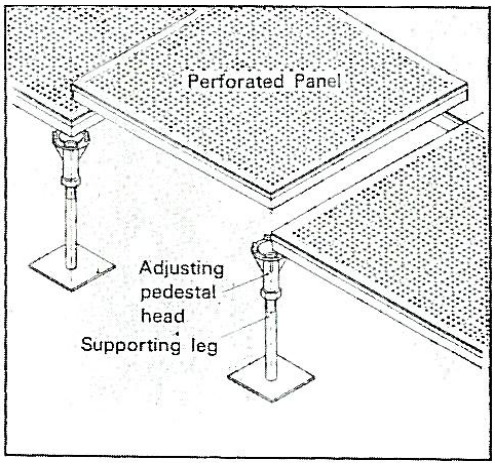

Fig. 5: Perforated Flooring.
Tacky Flooring (Fig. 6)

Tacky flooring is used not only to de-contaminate footwear and trolley wheels, but also to hold airborne particulate that has settled at floor level. Particulate is therefore prevented from re-circulation and possible entry into clean areas.
Tacky flooring works on the principle that a contaminated shoe or wheel has low adhesive forces compared to that of the flooring; therefore contaminants are transferred to and retained on the tacky flooring.
There are two systems – the disposable, peel-off mat and washable, polymeric flooring. Looking at the *disposable version* first, it is only available in a mat form which consists of layers (usually 20 to 30) of adhesive-coated sheets. Once the top layer has become contaminated it is peeled off to reveal a new, clean sheet.
The peel-off mat has proved popular because of this ease of use, however its limitations should be considered.
The adhesive layer may rapidly become saturated with contaminants and therefore show reduced efficiency and need frequent peeling. The act of peeling off a sheet from the mat can also create problem; particulate is re-dispersed form the sheet and the act of peeling off a sheet generates both static-electricity and turbulence. The method of disposal of the contaminated sheets also needs to be considered. From a cost point of view, based on average usage, it would only take ten to twelve weeks to spend as much on a peel-off mat as much on a peel off mat as on a comparable size of washable tacky flooring which would last you two to three years. What is more, in using just a single mat, the mat is very often walked around or only one foot placed on it. Several mats can be placed alongside each other, however this greatly adds to the expense.

Washable, tacky flooring (Fig.6)
Works on the principle of a soft compliant surface with a very high co-efficient of friction. After the surface has become fully contaminated it is cleaned by sponging with a detergent solution and "squeegeeing" dry. This washing procedure is usually accommodated in the routine cleaning schedule.

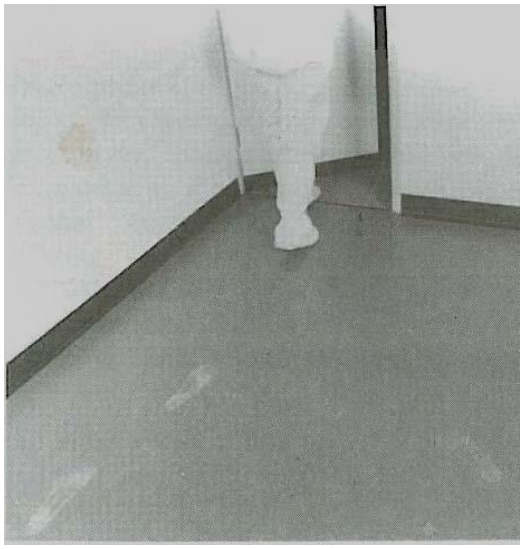

Fig. 6: Tacky Flooring.

The washable version is available either as a mat or as flooring. The flooring can be installed to cover any required area and a variety of mat sizes ensures that a number of footfalls are made on the mat, resulting in a complete decontamination of the shoe sole or wheel. Tests have shown that, on average, a large percentage of the larger particles are removed on the first footfall, however further footfalls are requires to remove the remaining contamination *(Fig. 7).*

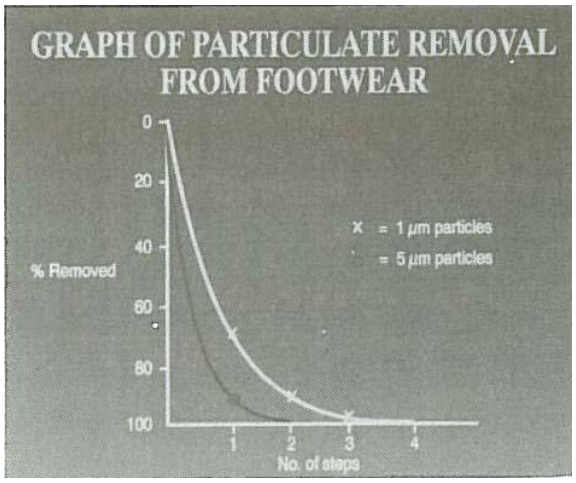

Fig 7: Graph of particulate Removal from footwear.

Such polymeric flooring will last a number of years on average and its effectiveness can be monitored by testing the tack level of the surface, thus providing an accurate guide to its lifespan.
Tacky mats can be placed on all change room floorings discussed; tacky flooring can also be installed on all change room floorings discussed; tacky flooring can also be installed in conjunction with all of the floorings discussed. The only exception is raised perforated floors where the perforations would be covered resulting in the laminar air flow.

Static-Dissipative Flooring
It is well documented that the movement and changing of clothes produces a state of electrostatic charge on the body. Consequently when an operator puts on cleanroom garments, particulate can be attracted to their surfaces and retained. Neutralisation in the ionised air system of a cleanroom will cause the particulate to shed, thus increasing the possibility of surface contamination.
The various flooring systems previously discussed can be manufactured incorporating degrees of static-dissipative

properties, namely a matrix of carbon fibres connected to a point of zero potential.
Raised, perorated flooring is the exception; as it is constructed from steel, it is inherently conductive.

Summary

The successful operation of a cleanroom depends solely on contamination control. The graded transition form "black" to "white" prior to entry to the cleanroom must be adhered to. Whilst operating a cleanroom facility the introduction of particulate must be minimised. Bearing this in mind, the flooring aspect of gowning areas should be considered as important as the air filtering for the clenroom, and the choice of cleanroom garments. Active flooring, be it either in the form of raised, perforated flooring, tacky mats or tacky flooring minimises the entry particulate if properly maintained. The cost effectiveness of a special floor system may not immediately be apparent; however it can be measure in terms of rejected production.

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With thanks for the photographs to: Morton International – Dynachem, Warrington, U.K.