A mat-ter of retention

Photo 1: Dycem mat loading after four hours of use

Retentive washable polymeric floor mats have particular use in the cleanroom sector but how well do they perform in terms or retention and potential carry-over? **Dick Gibbons***, specialist consultant, carried out tests to answer these concerns

Control of changing room floor particulate is an essential part of cleanroom discipline with retentive mats often used to control it. This article examines the performance of the Dycem washable polymeric floor mat in preventing a) the re-release of trapped particulate into the cleanroom air stream and b) shoe carry-over into the white zone.

It is generally accepted that debris carried on feet is a major source of cleanroom particulate. The extremes range between mud and road dust to fines and particles from adjacent processes. Both laminar and turbulent airflow systems easily redistribute this material onto garments and material with catastrophic result. Precautions taken to preclude it include shoe changes, shoe cleaners, shoe covers and retentive mats. This study was carried out to determine the capture and release behaviour of the Dycem variety of washable polymeric mat.

A key feature of the polymeric floor mat is its ability to embed particulate within its cellular structure rather than to bind it with surface adhesive as is done with the tear off tak mats (see Figures 1a & b on page 22). Thus the debris is locked into the material rather than bonded to its surface; pressure from passing feet forces the debris deeper into the material pores.

Furthermore there is no surface adhesive trying to pull off the overshoes of people walking over it. During cleaning these pores are expanded by the surfactant/water combination or a solvent, allowing the debris to move to the surface for removal.

While providing a much higher level of debris loading than the adhesive form, it does allow a high level of surface discolouring that is of concern to some users. There is also a perception that the debris is not fully retained and that it could easily become airborne or transferred to passing feet. This study examined both concerns, by using airborne and surface particle counters to establish debris and airborne release levels in a very harsh surrounding environment.

The facility selected for the tests was the Irish operation of the US-based Williams Advanced Materials – OMC Scientific. This ISO 6 cleanroom facility has been operational for several years providing a sputter mask refurbishing and cleaning process for the semiconductor industries. It was chosen because of the high level of material debris associated with this type of work.

Complex contamination

Ancillary work that includes abrasive blasting, chemical stripping and machining, generates a complex mixture of contamination over a wide particle size range. This results in heavily contaminated traffic routes around the cleanroom perimeter. Operators moving between these processes collect high levels of tramp debris on their feet, which must be removed before entry into the changing room. For example, Picture 1 (above) is a photograph taken during the testing of the Dycem system.

Current practice is to don disposable overshoes at the point of room entry; these

are then removed at the step over bench in the ISO 7 changing room and replaced with cleanroom shoes. A conventional tear-off adhesive mat is positioned outside the changing room entrance. Airborne particulate ingress is minimised by 15 Pascals of over-pressurisation and a 0.35 metre per second vertical airflow, maintained via HEPA filter on the entrance (grey) side of the room.

Two considerations were studied:

1) that the debris shown above would subsequently become airborne in the grey zone (the re-deposition theory); and

2) that mat particulate would be carried over on the overshoe into the white zone (the carry-over theory)

These considerations were examined by testing a 4m^2 section of Dycem polymeric material, fitted between the entrance door and the step over bench, as shown in Pictures 1 and 2 during eight hours of peak operation at OMC.

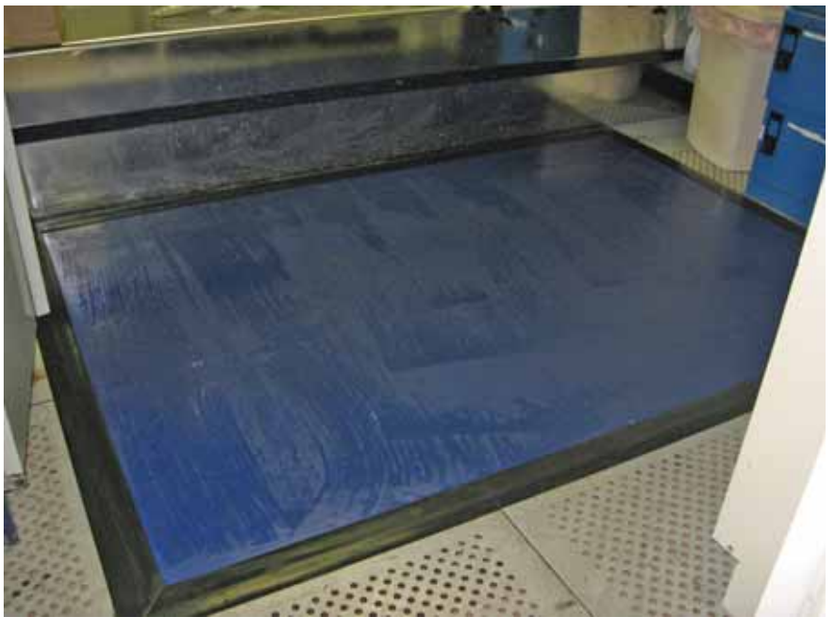

Photo 2: Showing the Dycem mat cleaned at mid test and the step over bench

High footprint areas

Four specific high footprint areas were identified on the mat and repeatedly measured for surface particulate every 30 minutes during the eight-hour shift. The mean value of these four readings was then compared with airborne particle counts taken at three different heights during each 30-minute interval (see Figure 2).

Surface particulate was measured using a Lighthouse surface particle counter type Solair 31000 at greater than 0.5µm for 20 seconds. This uses suction over a 35mm diameter air bearing head to remove loose particulate, passing it into a laser particle counter for sizing and counting at 1 cfm. Four critical zones on the mat were examined and the mean value taken to produce the data shown in Figure 3 and Table 1.

Airborne particle counts of 1 minute duration, greater than 0.5µm, were taken using a Hiac-Royco Particle 5320 airborne particle counter. This was running at 1.1 ft^3 per minute with its collection head mounted at the following heights:

– 50mm above the polymeric mat
– 800mm above the mat (knee high)
– 1,700mm above the mat (head height)

The results are shown in Figure 3, which plots the mean of the four surface tests against each height of the airborne measurement during the eight hour shift at OMC. The raw data is shown in Table 1.

This data shows that the mat readings ramp up rapidly during the shift but do not appear to influence the airborne readings, which remain reasonably constant at a mean value of 3,000 (particles larger than 0.5µm per ft^3 of air) This is well within the class limits of 10,000 at 0.5µm per ft^3 per minute for an ISO 7 changing room of this type and similar to the figure achieved at annual validation.

Variable readings

The 16:00 hour increase in airborne readings is attributed to an open door situation while equipment was being moved but is still well within the ISO 7 limit. Mat readings at this time were at their lowest during the day.

Surface loadings did reach very high levels, peaking at a maximum of 27,000 particles per cm^2 at critical points within the four-position average. However, wiping was remarkably effective in reducing these high levels to near zero for the afternoon shift.

The reduction in mat readings between 11am and 12am may be explained by shoe "carry-over" prior to cleaning, with carry-over seen to start at 18,000 particles per cm^2.

Build-up rate in the afternoon was much slower and represents a more typical build rate up for OMC rather than the excessive activity encouraged during the overnight and morning period.

As explained in the introductory section, solvent or surfactant expands the pores of the substrate allowing the debris to be squeezed out of the material. At OMC this was done by wiping with IPA-impregnated wipers, allowing the surface counts to reduce to near zero (see the measurements taken between 13:30 and 14:00 hours in Figure 3 and Table 1).

Shoe carry-over tests were performed by

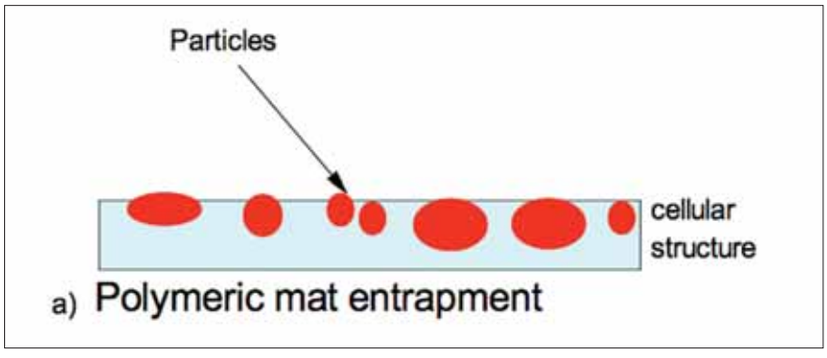

Fig 1a: A schematic of the method of polymeric mat entrapment

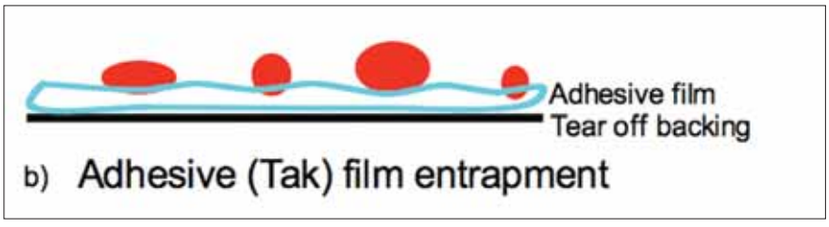

Fig 1b: A schematic of the method of adhesive entrapment

Table 1: 8-hour airborne v surface particulate trend using Dycem mat

Changing room mat tests									
	Surface counter 20 secs				Airborne 1 min				
	Particles > 0.5 microns				Particles > 0.5 microns				
Time	Posn 1	Posn 2	Posn 3	Posn 4	Avge	Avge x3	floor	knee	head
10:20:00	2723	10718	-	-	6721	20162	1489	5913	4384
11:20:00	2738	11768	1110	6200	4363	13090	4797	3973	2701
11:50:00	11635	48232	45687	1155	26677	80032	3304	2593	1043
12:30:00	5674	16943	19870	2273	11190	33570	1709	1551	1723
13:30:00	19002	6903	39511	7357	18193	54580	1158	796	423
Wiped down with IPA									
14:00:00	523	159	12	17	178	533	1218	975	281
16:00:00	890	1606	394	1978	1217	3651	2686	5768	3952
16:15:00	382	619	164	2541	927	2780	1305	895	351
17:00:00	8012	912	198	13324	5612	16835	808	613	317
	23748	14078	20646	6971	16361	49082			

NB: The mat had accumulated night shift debris before starting the experiment.
When plotting graph 4, the 20 second average from column 5 is used. Column 6 was introduced to convert the reading to a 1 min average but is then too large to show a graphical comparison.

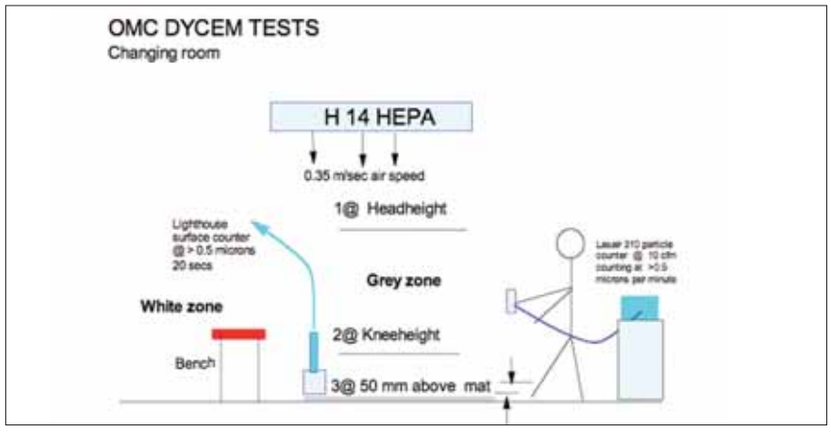

Fig 2: A schematic showing the heights at which airborne particulates were counted

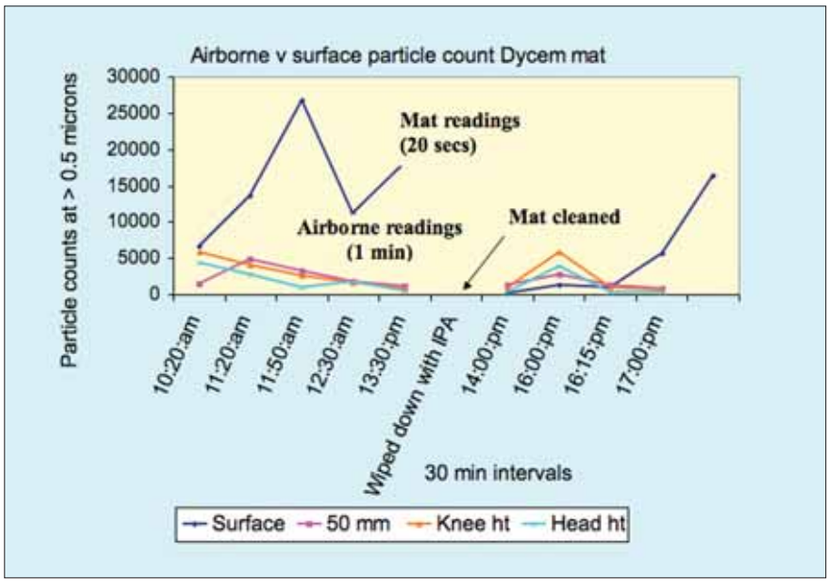

Fig 3: Graph of surface v airborne particulate > 0.5 microns at OMC

passing the Lighthouse surface counter over the sole of a disposable overshoe, before and after walking it over the mat. Clean shoe covers displayed readings of 400 0.5µm particles per cm^2 before passage over the mat into the white zone. This level was monitored until a significant increase (10%) was detected, corresponding to a mat floor loading of 18,000 particles per cm^2.

During the shift break, the mat was wiped clean, restoring its loading to zero, resulting in a reversion to the 400 level particle count on the shoe sole. Reference to Figure 3 indicates that the downturn from the 27,000 particles per cm^2 peak may have been due to carry-over on the overshoe.

The conclusions drawn from this study on the Dycem polymeric flooring are:

- Mat levels in excess of 27,000 per cm^2 do not influence the airborne readings at between 50mm and 1.7 metres above the mat in typical ISO 6/7 airflow conditions.
- Surface loadings up to 18,000 per cm^2 do not transfer on foot.
- Cleaning in this particularly harsh environment is recommended at intervals of four hours.

Recommendations

Although tested in a very hostile environment, the material proves to be capable of use in the most critical application. Novel applications are known to be for glove wiping in disc manufacturing plants, workstation particle retention and ESD sensitive regions.

Given this level of particulate retention, its application range could even be extended into medical device and pharmaceutical applications. CT

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