Particle Shedding from Tacky Mats

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Abstract

This report describes the measurements made on particle shedding from tacky mats during the process of removal of the used mat from the stack attached to the floor. The measured data show that Rolamat removal technique introduces less dust into the surrounding atmosphere than the conventional ways of mat removal. The dust introduced to the cleanroom atmosphere was between 10 and 20 times less with the Rolamat technique, than with standard removal techniques. Also reported are some preliminary electrostatic measurements.

In this report we use the word “Rolamat” to describe the technique for removal of a tacky mat from the package of mats, as distinct from the brand of mats, which are being used. The purpose of this report is to compare the technique for removal; obviously, the technique requires a mat with a tapered end and centre-located adhesive tab. What is actually being tested is the technique as applied to a specific mat. This technique is being compared to standard methods for removing several brands of conventional tacky mats.

It should be noted that there are no professional society “recommended practices” for the kind of measurements described in this report. We have tried what we think are reasonable techniques; however, we are open to suggestions as to improved ways for comparing mats.

1.0 Experimental Design

The difficulty with this experiment was that there was no prior “standards” or recommended practices for selection of representative contamination, measuring particle shedding, determining when a tacky mat is due to be replaced, or for applying a known amount of powder to a mat. There is not even a historical protocol or standard procedure for changing mats. In essence fab personnel change mats, say, at the beginning of each shift, each day or perhaps when they “look dirty”. Thus, these data should be considered preliminary.

1.1 Particle Measurement Technique

In these experiments, the mats were placed in the UA test tower (sub-Class 1) and particles released to the down flowing air stream were counted downstream by an airborne particle counter.

1.2 Choice of Powder to Simulate Dust

Two powders were examined, commercial talc (Smith’s baby powder) and a printer’s starch provided by Clean Line Corporation. After experimenting with and characterizing each, the talc was selected as the “dust of choice.”

Scanning electron microscope photographs on the next three pages show, for different magnifications, respectively, the contamination on an actual tacky mat in our laboratory, the talc, and the starch powder. The starch tended to be more uniform and homogenous, and it also in the SEM, exhibited “shiny areas” characteristic of electrostatic charging in the microscope. The talc exhibited considerable dispersion in particle size, and was closer to real floor dirt that was starch. Also, the engineers noticed that the starch tended to diffuse everywhere in the cleanroom, again indicative of its ability to charge electro statically. Thus, it was felt that talcum powder was more representative of real contamination than was the starch. The size dispersion of the two could not be readily characterized by our particle counter, as its range extended from 0.19um to “greater than” 5.0 um. The maximum size detected by this counter is of order 10-15 um. The particle counter recorded the talc as being mostly in the size range 0.3 um to 3 um. The SEM photographs give an excellent visual description of the various size dispersions.

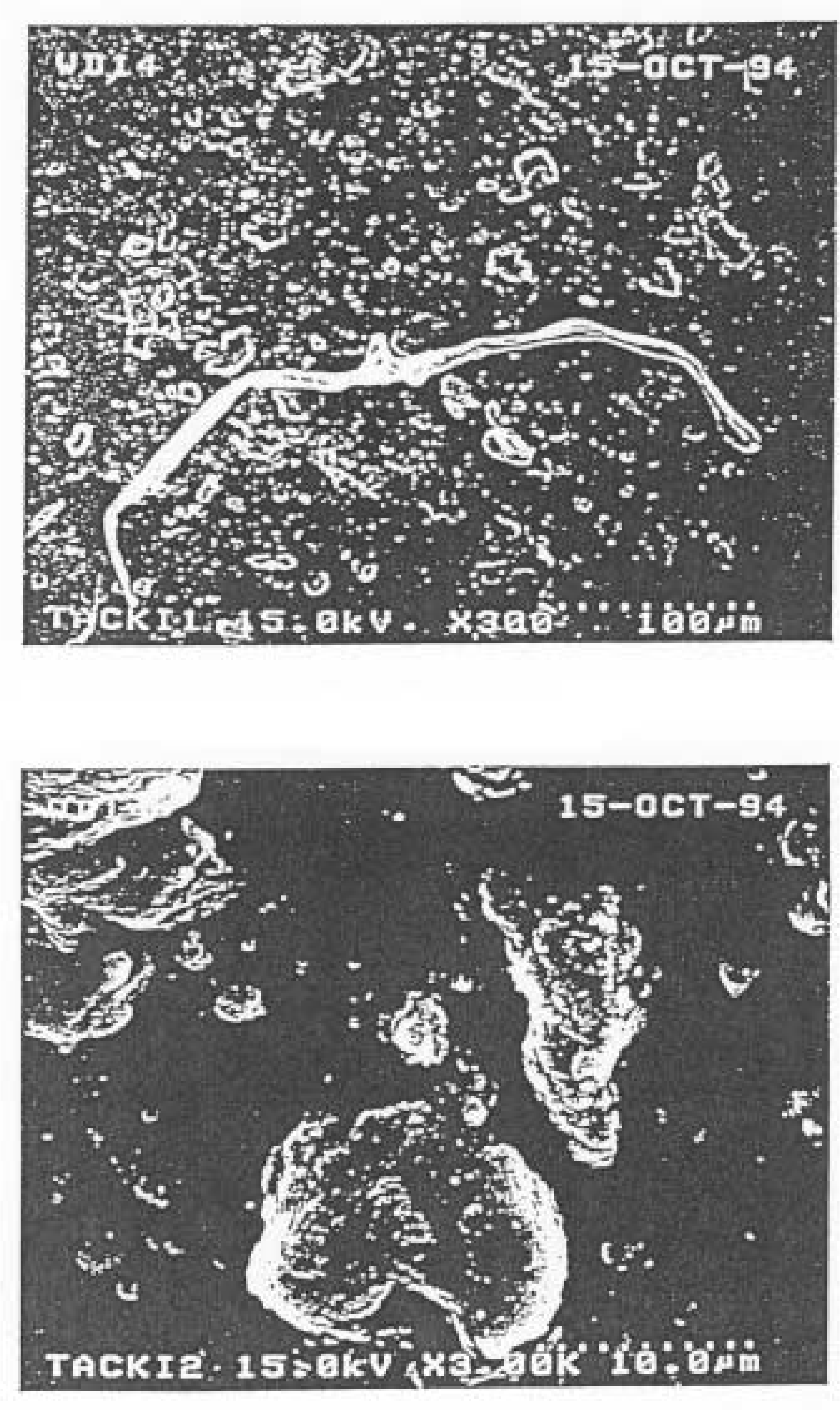
1.3 Powder Quantity

Two sets of experiments were performed, one set in which the mats were over saturated, and one in which they were under saturated. See sections 2.0 (over saturated) and 3.0 (under saturated).

1.4 Powder Application Technique

In the over saturated study, talc was applied by a foam covered roller after rolling in a tray of talc dust. In the under saturated study, a mat outside the Test Tower was saturated with talc, a person walked on the saturated mat, then walked on the tacky mat being studied. The details are given in the respective experimental sections.

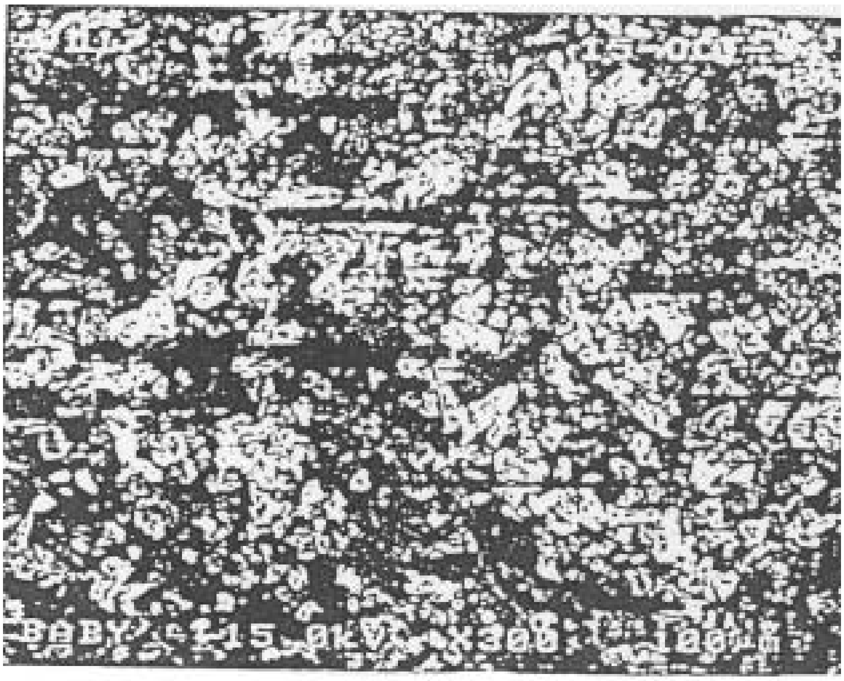
(A)

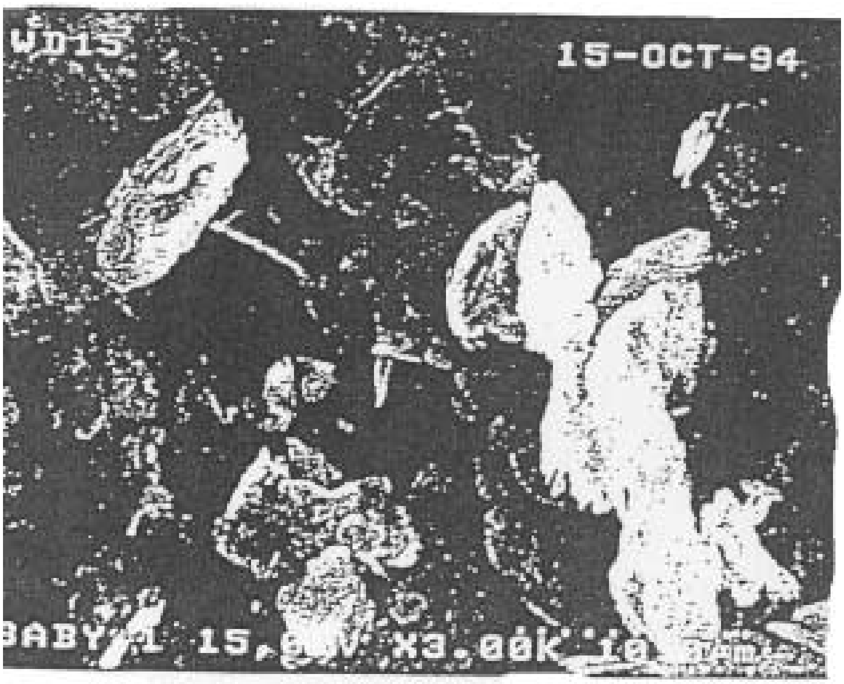


(B)

Figure 1.
Typical tacky mat contamination: (A) 100 um, and (B) (10 um magnification.

(A)

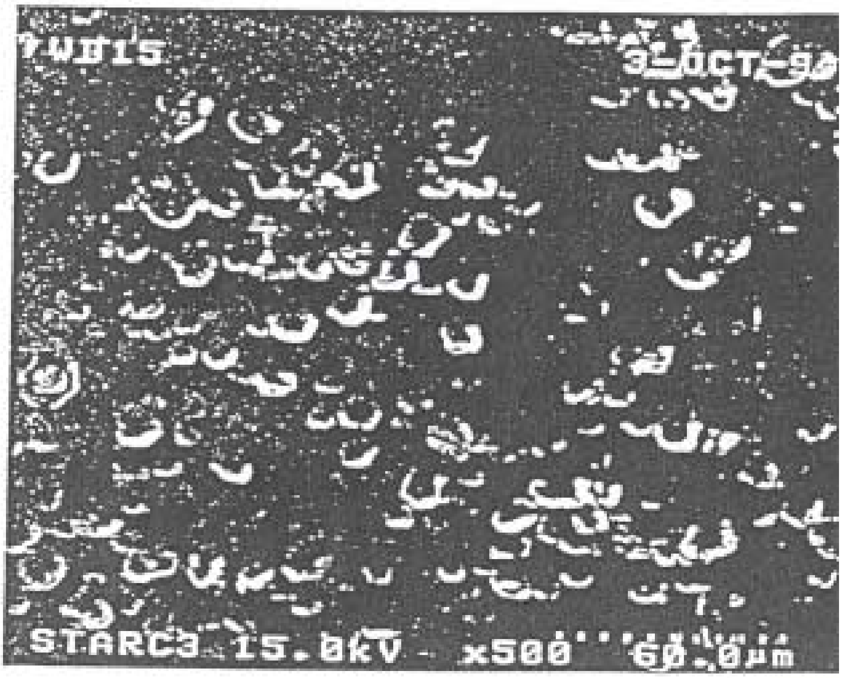


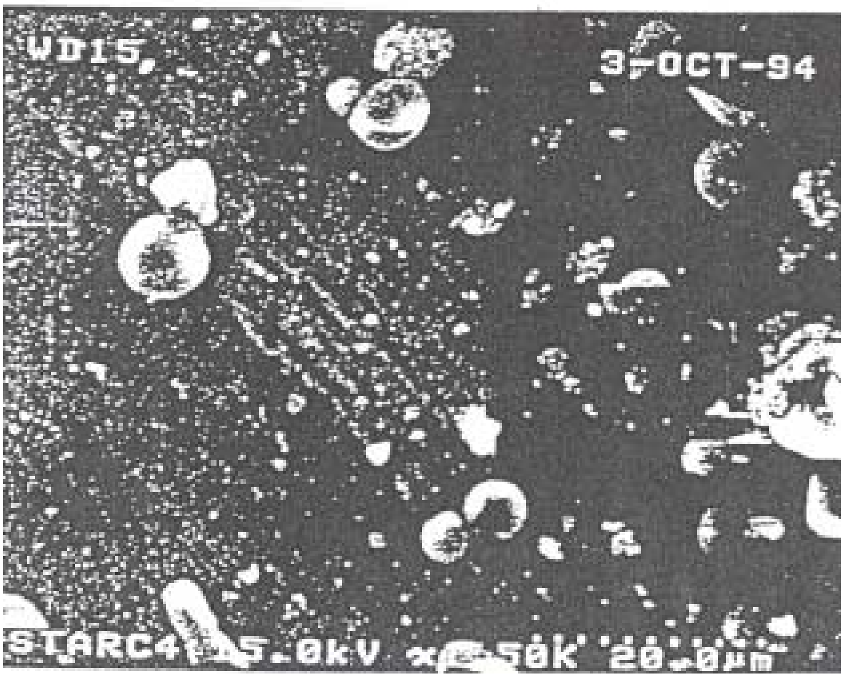


(B)

Figure 2. Talc Particles: (A) 100 um, and (B) 10 um magnification.

(A)





(B)

Figure 3. Printer’s starch particles: (A) 60 um, and (B) 20 um magnification.

2.0 Experimental Test Method 1: Overly Saturated Mats

In this section we describe the first experimental set-up and test data taken by completely, in fact overly saturating, the mats. It will be noted that the test was the same on all mats, with the exception of the mats, which used the Rolamat removal procedure. The procedure was altered slightly for the Rolamat removal technique, as those mats were masked for two inches on each edge in order to provide a clean, tacky area for the roller to grip. Without doing this they would not roll as described, when saturated with talc to this degree.

2.1 Test Tower Set-Up

The test tower was thoroughly cleaned and the mats were placed in the (4' x 4') tower approximately 6 inches from the outside wall. See Figure 4. The end of the mats was placed as close to the door as possible without contact. The first tab was turned up slightly to ensure timely removal of one mat only. For Rolamat removal only, a clean sleeve was placed on the Rolamat roller and three clean mats were rolled onto it to secure the clean sleeve tightly against the roller, preventing slippage. The roller was placed against the opposite wall of the test tower.

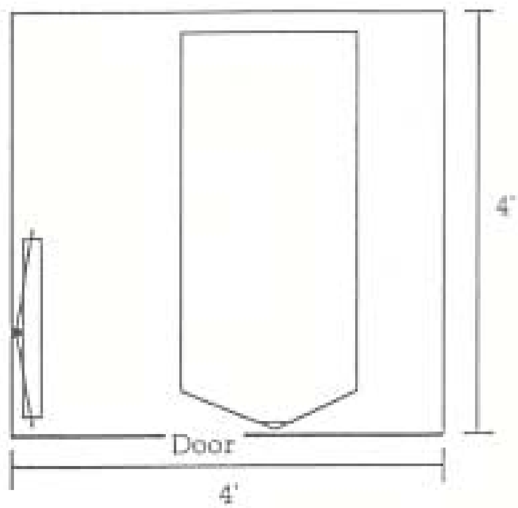


Figure 4. Layout of Test Tower Floor.

Particles released from the mats are carried downward in the test tower's vertical laminar flow, where they turn a corner, pass through mixing vanes, and are sampled by a counter. Each particle counted equates to 340 particles released in the test tower. Large particles will not make it "around the corner" to the detector at the base of the test tower.

2.2 Application of Particles to Mats

Materials

- 2 bottles of Smith’s talcum powder
- 1 foam roller (18” wide). For application to Rolamat, the roller was cut to 14” wide.

- 1 aluminium tray (Auto Trends drip pan)

- 2 sheets black poster board

The tray was placed on two overlapping sheets of poster board. Baby powder was sprinkled on the tray. The tray was lightly shaken to distribute the baby powder as evenly as possible. The roller was rolled forward then backwards across the tray to saturate it with powder. Then it was gently tapped once on the poster board to remove excess particles, and carried to the test tower. The roller was placed on the tacky mat and rolled to the end of the mat and back to the beginning. For the Rolamat removal technique, the roller was placed about 2 inches from the tapered ends. This left enough sticky surface for the mat to adhere to the Rolamat roller for removal. Also, only for the Rolamat removal, the 14” wide roller was used, leaving two inches on each side for the fresh tack to grip the roller. If this was not done, the mats were so saturated that the roller would slide.
See Sketch in Figure 5.

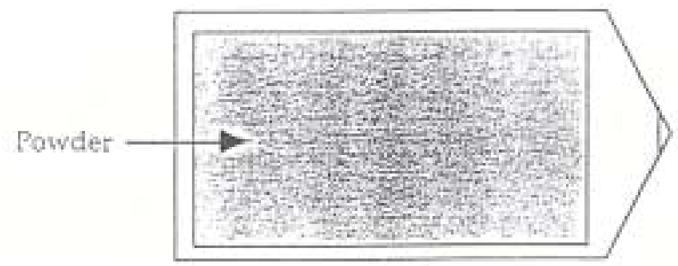


Figure 5. Powder application: Rolamat Illustrated.

Foe each test, the powder was applied to a mat following this procedure. Powder that was spilled onto the poster board was poured back into the tray. Additional powder was added as needed.

2.3 Mat Removal Procedures

Conventional mats were removed by two procedures: slow and fast. In the “slow” method recommended by cleanroom maintenance personnel, the corner of the mat is folded toward the centre, next the opposite corner is folded toward the centre, and the procedure is repeated until the mat is completely removed.

For the “fast” method, the mat is ripped off the floor and crumpled up while in the tower and placed in the waste container upon exit.

The Rolamat removal technique, obviously, was different. Because of the size of the test tower, 4’ x 4’, the Rolamat technique was further modified in the following manner.

The operator was unable to stand in front of the mats during removal; instead, the operator stood facing the mat at its side. “See Figure 6. Configuration for removing mat with Rolamat tool.” Given the start signal, the operator turned, picked up the roller, and placed it on the mat about 1 inch from the tapered edges. See Figure 6.

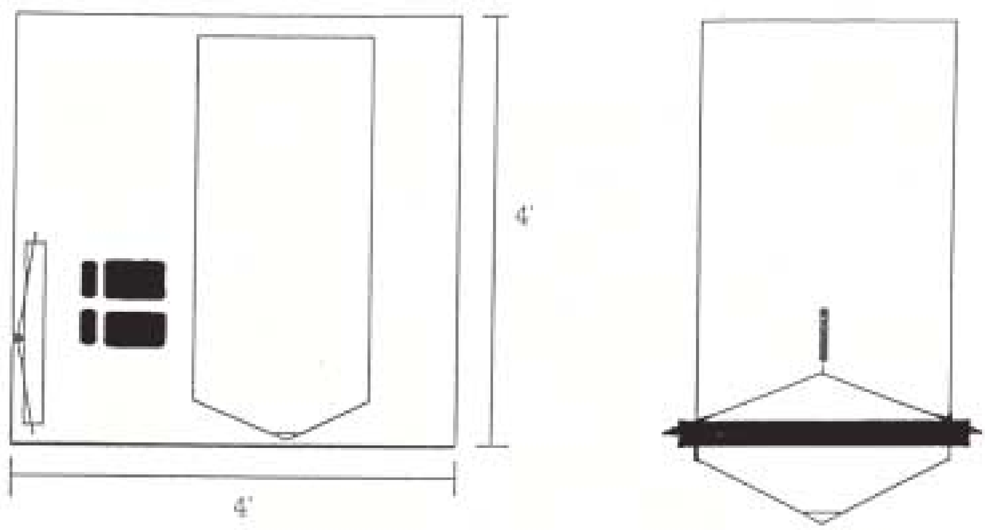


Figure 6. Configuration for removing mat with Rolamat tool.

Holding the handle, see Figure 7 on page 8, in the right hand, the operator firmly pressed the body of the roller onto the mat with the left hand. When the mat was secure, the operator pulled the tab of the soiled mat, removing the mat up to the roller. The free portion of the mat was stretched across the roller, and any excess was placed onto the soiled mat and pressed down firmly. See Figure 7 on page 8. Because the position of the mat was so close to the door, the angle 0 with respect to the floor was nearly 90^{o}. Thus, it was very difficult to set the roller in motion. Therefore, the left hand applied downward pressure on the body of the roller and began pushing it along the mat until momentum allowed the right hand to finish the motion. The actual tests required 2-3 of these “assistive” pushes. As the roller proceeded down the mat, the angle 0 gradually decreased to about 70^{o} and kept fairly constant through the remainder of the pull. The roller was pushed until it was completely off the mat. Then it was set back against the wall from which it was originally located.

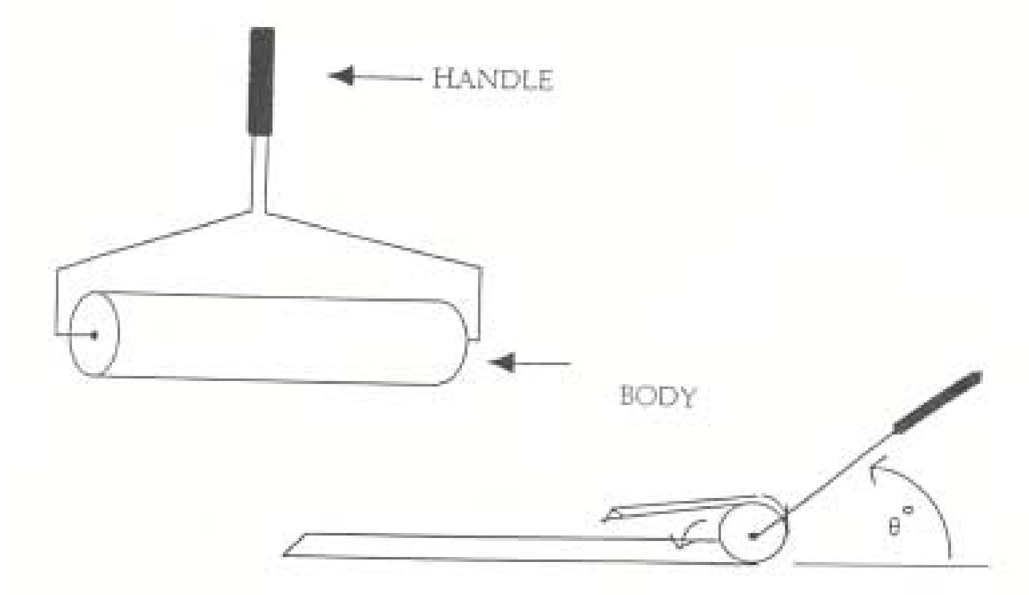


Figure 7.Rmoval technique

2.4 Problems and variations

During the course of the tests various problems were encountered. Because these problems occurred frequently and were minor, the tests were not redone. Instead, those problems and the procedural variations taken to remedy are mentioned in this section.

2.4.1 Conventional Mats

A significant amount of dust was generated during the course of the experiments, and the tests had to be stopped several times, and the test tower completely cleaned. The talc deposits on the sub-floor of the test tower, underneath the raised floor, and its accumulations needed to be removed. It was noted that in six of the eleven tests, the lowest particle count occurred on the first pull, when the test tower was the cleanest.

2.4.2 Rolamat Removal Technique

Slipping was the most common problem. Although the sticky surface of the mats was exposed an inch on three sides, see “Figure 5. Powder application” on page 6, the mat did not always adhere to the Rolamat roller for the entire pull. Thus, the roller would slide across the mat and spread the powder instead of rolling up neatly. This was the result of two observed factors. One cause was powder build-up during the rolling process. As the mat was rolled, the forward motion pushed the loose powder ahead of the roll causing a slight build-up. As the mound grew, particles were pushed out the side and covered the area, which was to have remained “sticky”, causing the roller to slip.

Another factor was the physical shape of the roller. The mats were tapered at the beginning of the roll. Thus, for a whole circumference or more, the entire layer existed only in the centre of the roller. As the tapered edges were overcome, the layers evened out. However, the roller was thicker in the middle, and that made a bigger difference as more layers were added. Although the operator would apply a greater downward pressure, the ends of the roller were higher than the centre of the roller. Therefore, the sticky sides of the mat were not always able to attach themselves properly. The solution to this problem was to control the speed of the pull. As soon as a slip was felt, the operator stopped forward motion and pressed downward on the body of the roller while rolling. If the roller slipped for a distance, it was lifted slightly off the mat and pulled backward until the slack was gone. Then the operator pushed downward on the body of the roller and resumed the pull. The latter case did occur a few times, with the greatest slide distance being approximately 3 inches.

Loose finish was another frequent problem with the mats. As the pull was finished, the end of the mat did not always stick to the roller despite the sticky inch left on the mat. This was probably also due to the residual powder build-up that occurred through the rolling process. There were two remedies for the problem. One was tipping the roller slightly to one side and applying pressure so that the corner of the mat would stick to the roller. Then the mat was pulled off, whether or not the whole mat was actually sticking to the roller. If this did not work, the operator applied downward pressure on the body of the roller while it was lifted off the mat. This kept the mat on the roller and prevented it from unravelling. Loose ends were fixed with a patch of Scotch tape before reversing the roller.

Hitting the wall occurred as time progressed and the roller became thicker with mats. Because there were only a few inches from the edge of the mat to the back wall, the roller sometimes had too much momentum to stop completely before it contacted the wall. Particles were produced when the roller did contact the wall. This did not occur often or appear to raise the particle count. It is mentioned for consideration.

2.5 Particle Shedding Data

Ten sets of data were taken on each configuration, the “slow” pull, e.g., the way mats are intended to be removed, and the “fast” pull, which is how mats are often removed, especially when supervisory personnel are “not looking”. For Markel mats, a third entry is shown; those data describe the shedding results with the Rolamat technique. These data, given in Table 1, show the average, deviation, high and low counts. Shown in Table 1 are the average, high and low counts.

Table 1: Saturated Tacky Mat Particle Release Data(1)

Type of Mat	Type of Pull(2)	Average Particle Count(3)	Standard Deviation	High Count	Low Count
Alma	S	282,123	22%	324,946	200,924
	F	197,777	11.3%	216,075	171,468
Baxter	S	150,832	13%	165,606	126,335
	F	157,550	11.7%	176,211	139,240
CEC	S	231,262	16.6%	283,062	206,421
	F	147,823	20.9%	181,225	119,541
Liberty	S	148,515	10.2%	162,085	131,763
	F	149,562	24.6%	162,567	120,843
Markel	S	189,311	9.5%	204,868	168,850
	F	152,680	10.8%	168,458	135,368
	R(4)	41,077	87.4%	86,598	14,788

(1) Data taken according to talc "over saturated" loading conditions previously described in this section.

(2) Three different "pull" procedures were used:

a. S= Slow or proper pull, e.g., folding from corners
b. F= Fast/rapid pull, the way it is often done when "no one is looking."
c. R = Clean Line Corp. "Rolamat" brand roll pull apparatus

(3) All counts are cumulative or integral counts, that is the sum of all counts from 0.19 um and larger to over 5 um.

(4) Rolamat, as used here, refers to the mechanism/method for removing the mats with the tapered ends. The mats used here were manufactured by Markel Industries.

2.6 Summary: Saturated Tacky Mats

The average number of particles for the fast pulls were about the same or less than that of the slow pulls. However, I believed that the fast pulls produced more loose particles than were counted. The most obvious evidence of this being that the particles were more visibly spread throughout the test tower both on the floor and on the walls. For the slow pulls, loose particles remained within 2-3 inches of the mat, as seen on the floor of the test tower. It is therefore felt that the slow pull is more effective in containing the particles than the first pull.

Overall the roll pull was the most effective. Although the standard deviation is the greatest of all the tests, the highest particle count was considerably lower than the average counts for the slow and fast pulls. The wide range of particle counts for the roll pulls could be explained by the fact that the roller did not always roll smoothly across the mat. Sometimes it would get stuck and sometimes it would roll perfectly.

3.0 Experimental Test Method 2, Unsaturated Mats

3.1 Test Tower Set-Up

The Test Tower was set-up in an identical manner, with the exception that the method of application required an additional mat outside the tower (see below).

3.2 Application of Particles to the Mats

During the course of the first set of experiments it became apparent that too much talc was being loaded onto the mats. We then decided on a procedure to deposit a much smaller quantity of talc, which would not saturate the mats. In this set of tests the powder was first rolled onto a mat outside the test tower, saturating the mat. Then, the operator stepped onto the saturated mat (four steps) and then directly onto the mat inside the Test Tower. The operator stepped on the mat in the Test Tower eight steps.

3.3 Mat Removal

After exiting the tower, the operator changed boots, and the test proceeded in the same manner as previous tests.

3.4 Problems and Variations

None of the problems with sliding or slipping of the roller, encountered in the earlier, saturated tests were a problem here. The mats rolled as they were designed.

A series of three mats of each brand were used in these tests. Hence, we give the average and not the standard deviation or max or min particle counts.

3.5 Particle Shedding Data

Table 2: Unsaturated Tacky Mat Particle Release Data(1)

Type of Mat	Type of Pull(2)	Average Particle Count(3)
Alma	S	19,751
	F	23,609
Baxter	S	25,225
	F	20,208
CEEC	S	14,199
	F	13,233
Liberty	S	10,464
	F	17,121
Markel	R(4)	1,948

(1) Data taken according to talc "unsaturated" loading conditions previously described in this section.

(2) Three different "pull" procedures were used:

a. S= Slow or proper pull, e.g., folding from corners
b. F= Fast/rapid pull, the way it is often done when "no one is looking."
c. R = Clean Line Corp. "Rolamat" brand roll pull apparatus

(3) All counts are cumulative or integral counts, that is the sum of all counts from 0.19 um and larger to over 5 um.

(4) Rolamat, as used here, refers to the mechanism/method for removing the mats with the tapered ends. The mats used here were manufactured by Markel Industries.

3.6 Summary

As can be seen from these data, the quantity of particles released was about an order of magnitude less than from those in the previous, saturated, experiments. The particle release data from mats removed by the Rolamat technique were about an order of magnitude less than from the conventional technique. The particle release data from the slow pull and the fast pull showed that the "slow" pull did not release consistently a lower number of particles, as compared to the "fast" pull.

4.0 Preliminary Electrostatic Charging Data

Preliminary data were taken with a Chubb Electrostatic Charging Meter. Unfortunately, we did not measure the initial charge on the top mat prior to its removal, and measurement of the residual charge on the next mat. Table 3. shows these initial data for the fast and slow pull.

Table 3: Preliminary Charging Data

Type of Mat	Fast Pull(2) (V)	Slow Pull (V)
Alma	−970	−231
Baxter	70	34
CEEC	608	928
Liberty	1,006	2,870
Markel	−149	−533

In a separate measurement at a later date, it was found that the initial measurements of mats, which were only moved to accommodate measurement, that the Alma mats showed a voltage on the top surface of 17V; Baxter, -38V; CEEC, -85V, Liberty, 357V, and Markel 190V.