

Cleanroom ESD Flooring Installation

Options for installing ESD flooring in an existing operational facility with minimal impact on contamination and production

Many facility planners, concerned about contamination or potential scheduling delays, once dismissed the thought of installing electrostatic discharge (ESD) safe tile in operational clean spaces. Rather than risk tearing their buildings apart and losing valuable production time, many companies chose alternative methods to ESD flooring to be ANSI/ESD S20.20-1999 compliant. ESD industry control practices may include the combination of wrist straps, grounding cords, floor mats and “Faraday Cage” material handling protocols. Until recently, installing a new ESD floor most often included the difficult task of removing the old floor first.

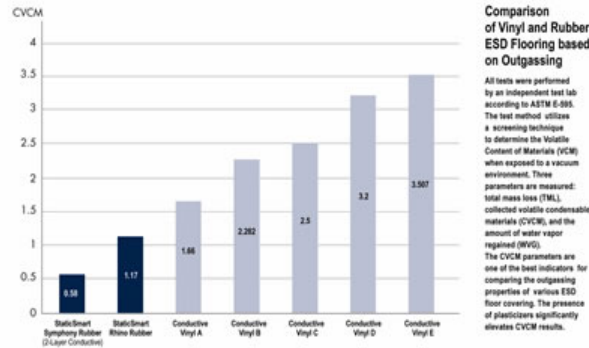
Ripping up old flooring, grinding concrete, and pouring epoxies and leveling compounds in a functional cleanroom would be a production manager’s worst nightmare. As one defense electronics facility manager put it, “Even though we absolutely need a conductive floor in our cleanroom, we can’t afford contaminating our HVAC system with dust and odors from flooring installation processes like shotblasting, concrete repair and skim coating. We’d have to build a back-up cleanroom before we would even consider installing a new floor.”

The alternative is a temporary production shutdown during flooring demolition and installation which may pose an even worse proposition. Horror stories abound about companies expecting a one week installation schedule for shutting down manufacturing and moving equipment into rented trailers, only to watch one week become 10, 15, and even 20 days. For these reasons, space planners with an eye on risk management are asking for installation methods that will neither disrupt production nor potentially corrupt their controlled environments.

Reasons for Installing ESD Flooring in Occupied Areas

Let us start with the reasons why a functioning cleanroom facility manager might want or need to replace a floor. Regardless of the issues involved, one does not replace an existing floor unless it is absolutely necessary. Floors are only replaced when

the existing flooring, usually a seamless epoxy or tile, becomes incompatible with ongoing needs. In a



cleanroom or clean manufacturing facility, there are four main reasons why this happens:

- 1) The existing floor, while conductive, may not meet increasingly stringent cleanroom criteria. Some PVC/vinyl tile is known for outgassing and plasticizer migration. The material loss from the floor can contaminate electro-optics or giant magnetoresistive (GMR) head manufacturing processes (see Figure 1).
- 2) The existing flooring material is improperly bonded to the concrete and has become a safety or maintenance problem. This problem could be the result of any number of issues including vapor drive (commonly referred to as moisture problems), alkalinity from the concrete subflooring or poor installation of the original floor.
- 3) The existing floor is cleanroom compatible, but it has no static control properties. It may not meet the recommended minimum requirements of an ESD prevention program like those described by the ESD Association documents ANSI/ESD S20.20-1999 [Protection of Electrical and Electronic Parts, Assemblies and Equipment] and ANSI/ESD STM7.1-2005 [Resistive Characterization of Materials—Floor Materials]. For example, the present floor may generate over 100 volts when people wearing conductive footwear walk from one place to another or the floor and footwear system resistance may exceed 35 Megohms to ground.
- 4) The current floor does not meet minimum standards for static control without the use of ESD waxes or dissipative floor finishes. ESD floor finishes are invisible and exhibit temporary characteristics. Because they are indistinguishable from standard floor finishes, waxes and other maintenance-sensitive ESD solutions, verification requires testing the floor on a regular basis using an ANSI/ESD STM7.1-2005 complaint resistance system. Relying on these maintenance chemicals for ESD control can give

customers, particularly those who demand rock-solid quality control, the impression that their supplier has little concern for quality. Quality-sensitive customers fear that their parts might be compromised any time their supplier's janitorial department fails to wax a floor that might be losing conductivity between maintenance intervals.

ESD Flooring Options for Cleanrooms

In any of the four replacement scenarios above, before any serious plans are made or dismissed, it makes sense to start with a broad evaluation of various ESD flooring alternatives. Any thoughtful evaluation should begin with an investigation involving process compatibility, and then an examination of the risks/rewards of installing a new floor based on successfully dealing with obstacles such as shutdowns, equipment movement, loss of production, contamination, odor containment and other considerations. At this point it is usually advisable to create a decision matrix or at least give a cursory glance at ESD flooring solutions. Of course most of the options will be quickly dismissed based on contamination control parameters or unsatisfactory electrical properties (point to point resistance, and resistance to a groundable point). Below is a reasonable list of possible flooring materials:

Various ESD flooring options:

- Conductive paint
- ESD floor finish or conductive wax
- Conductive/dissipative carpeting and carpet tile
- Raised flooring with panels covered with options 7 or 8
- Conductive/dissipative seamless flooring including epoxies, urethanes and quartz floors
- Strategically located conductive mats and runners
- Conductive/dissipative vinyl tile and vinyl sheet flooring
- Conductive/dissipative rubber tile and rubber sheet flooring

Properly installed and adequately maintained, any of the eight options will provide some level of static protection in an electronics handling application. However, electrical performance is only one variable within the decision matrix. Options 1, 2, and 3 can be eliminated purely based on inherent contamination control liabilities such as most ESD paint flakes, delaminates and, because they are usually somewhat porous, ultimately generate dust. ESD waxes and floor finishes generate dust and fine particulates from abrasion caused by traffic and

standard janitorial practices like buffing. Also, waxes require temporary shutdowns during periodic stripping and maintenance. Any carpet or textile-based flooring, option 3, will naturally capture and accumulate particles and eventually become a dirt generator.

Although option 4, the raised floor, is the defacto standard in most wafer fabrication areas, it is probably an expensive overkill for many cleanroom applications, other than offering access to wires and cables and air exchange; otherwise, there is little advantage to a cleanroom raised floor system.

Option 5, resinous flooring (epoxy or urethane) is rarely installed in occupied spaces due to odors, drying times and dust generated during floor preparation. After installation, epoxies and urethanes must cure for 24 to 72 hours which may make them undesirable flooring materials in any occupied space that must be turned over quickly. Epoxies are also difficult to repair in a cleanroom without closing off the area with plastic shrouds and air exhausts during grinding and reapplication process.

Floor mats and runners, option 6, are usually used as stop-gap solutions until a more permanent flooring material is identified. Floor runners offer limited protection because they are able to ground static charges on people or carts only if and when the latter are in direct physical contact with the runner or mat. This limitation means that the cleanroom will lack contiguous grounding. The resulting islands or zones of ESD protection force a continued reliance on expensive shielded packaging of static sensitive (ESDS) parts. Ensuring continuous ESD protection also requires redundant grounding through the combination of wrist straps and ground cords (which inhibits mobility). Wrist straps must be connected and disconnected every time parts are removed from packaging or transported through ungrounded areas. So through a process of elimination, let us explore the real benefits of using option 7 and 8 in this article.

VARIOUS ESD FLOORING OPTIONS:	
1.	Conductive paint
2.	ESD floor finish or conductive wax
3.	Conductive/dissipative carpeting and carpet tile
4.	Raised flooring with panels covered with options 7 or 8
5.	Conductive/dissipative seamless flooring including epoxies, urethanes and quartz floors.
6.	Strategically located conductive mats and runners
7.	Conductive/dissipative vinyl tile and vinyl sheet flooring
8.	Conductive/dissipative rubber tile and rubber sheet flooring

Will Conductive Footwear Be Required?

Most ESD floors are purchased with the assumption that conductive footwear will be used judiciously. However, an ESD prevention program, like any

comprehensive control process, is only as good as its weakest link. In the case of ESD prevention, the weak link almost always involves compliance or the failure of personnel to adhere to rigid policies. Thus, it would be reckless to make assumptions regarding compliance without first conducting a serious reality check. For instance, will every employee actually wear conductive footwear while he or she is physically present in the ESD protected cleanroom?

This compliance issue is particularly important when comparing the performance of ESD vinyl with conductive rubber. Previous testing [1] has documented that without the use of conductive footwear, conductive vinyl floors offer little or no benefit. People wearing uncontrolled footwear on conductive or dissipative vinyl flooring will generate static just as they would on any standard insulative vinyl floor. Walking body voltages (WBV) in excess of 3000 volts [2] can be measured on people walking on conductive vinyl when conventional footwear is worn without heel straps. If compliance to ESD process controls is in doubt, it may be prudent to install a conductive rubber floor; some rubber grades exhibit both conductive and antistatic properties; whereas, vinyl can only be made conductive, not antistatic. Although employees should always wear controlled footwear in the ESD Protected Area (EPA), conductive rubber floors inhibit the generation of static charges regardless of footwear.

RESILIENT FLOORING OPTIONS FOR CLEANROOMS		
Flooring Option	Performance - Should be tested per requirements of ANSI/ESD 20.20	
	With Conductive Footwear	Without Conductive Footwear
Dissipative Vinyl	Great Variations in Performance Based on Manufacturer	No Static Mitigation Properties
Conductive Vinyl	Usually Excellent	Limited Antistatic Properties
Dissipative Rubber	Usually Excellent	Good Antistatic Properties
2-layer Conductive Rubber	Excellent Static Mitigation Properties Usually Best in Class	Extremely Antistatic

Understanding Moisture Problems

The most dreaded words a flooring contractor can say to a client are “you have a moisture problem.” In laymen’s terms a moisture problem means that water vapor is passing from the ground below the building through the concrete subflooring. These vapors combine with the chemistry of concrete and over time will destroy and undermine the bond between flooring materials and concrete. Unfortunately, this type of moisture is not visible in the form of a puddle of water on the floor.

Before fully cured concrete is covered or sealed, moisture vapor easily passes through without a problem. Moisture vapor typically remains undetected until it becomes trapped in the concrete subflooring when a non-permeable membrane like rubber, vinyl or epoxy flooring is installed. Over time, vapor pressure increases against the tile or epoxy until the

flooring breaks away causing delamination from the concrete. Despite the availability of moisture indicating test kits that can assist in predicting (and preventing) this difficult problem, moisture related issues are usually discovered after a flooring installation failure. In the case of cleanroom floors, “discovery” typically occurs months and sometimes years after installation when the room is fully occupied and cannot be shut down without severe consequences.

After small sections of flooring begin failing, the problem quickly spreads. The resulting mess can cripple a manufacturing operation. Tiles become loose, air entrainment bubbles develop in the tile or epoxy coatings followed by eventual black liquids oozing through cracks and seams. The failing floor becomes a safety hazard and traffic obstacle. Repairs are almost impossible because water vapor continuously rehydrates the repaired area, often before the new installation has had the opportunity to cure. After the problem first emerges, most companies that have experienced this problem find themselves replacing compromised sections on an ever increasing basis. The standard permanent “fix” for moisture problems usually does not get used since it would require a complete shutdown due to demolition and reinstallation of flooring. A permanent fix entails ripping up the failed floor, shot blasting the concrete, repairing imperfections, installing a moisture vapor barrier and then reinstalling new flooring. The cost for this cure could run as high as fifteen to twenty dollars per square foot depending on working conditions, this is exclusive of the cost of shutdowns, equipment moving and auxiliary support.



Floating subfloors like Smartdeck™ can be placed directly over old failing floors.

A Non-Invasive Installation Method

Despite the obvious costs of tile removal and reinstallation, facility managers are usually as concerned about meeting project deadlines as they are about maintaining budgets. One additional day of shutdown could potentially cost their company more dollars than the entire expense of new flooring and labor. It is well known that delays from unanticipated events are an everyday part of any construction project. In the case of flooring, demolition will often reveal invisible unforeseen problems like moisture vapor or damaged concrete that must be addressed before any new flooring can be installed. Improper handling of these problems could add days or even a week to an installation schedule that was already overly optimistic. These risks are the main reasons companies limp along with a marginal ESD prevention plan rather than take the chance of ripping up what could become their own Pandora's Box.

The single biggest obstacle in installing new flooring is dealing with the removal of old flooring. This issue is painlessly solved by leaving the failed floor in place and covering it with new subflooring. Interlocking subflooring like SmartDeck™ can be installed directly over almost any surface regardless of the root cause of the floor's failure. A floating subflooring system (see Figure 2) can be installed without the use of adhesives or chemicals. The only tools required are a rubber mallet, and a tile cutter. To avoid contamination, floating subflooring tiles can be cut outside of the cleanroom and then brought inside where they are snapped together. Once the subflooring is in place any resilient ESD flooring can then be installed on top.

The second most time consuming aspect in a flooring installation is waiting for adhesives to dry and cure before the new floor is fit for traffic and equipment movement. This 48 to 72 hour step can be eliminated by selecting flooring materials and cleanroom compatible adhesives that bond immediately. Conductive pressure sensitive adhesives are VOC free and they are now formulated without carbon or graphite. They can be spread directly over old well secured tile or on top of new floating subflooring. Since these adhesive dry and develop a high tack in one hour or less, the new ESD floor can facilitate foot traffic almost immediately after installation.

One large medical electronics manufacturer used conductive release adhesives to install small segments of ESD rubber flooring over old vinyl tile until the entire facility was covered. This installation occurred over a six week period until all 25,000 feet were covered with ESD flooring. The entire process was done without interrupting traffic or production and since the tile could be walked on right away, minimal labor was required for equipment movement. Larger pieces of equipment were moved just a few feet and then repositioned immediately after tiles were placed on the adhesive. And the best attribute of this installation method is the lack of smell, so the

installation was done during normal manufacturing hours.

Conclusion

No construction project should ever begin without a contingency plan that includes a thorough understanding of what could go wrong. In the case of flooring, the biggest problem is always the one not seen by the watchful eye, the one below the old floor. Often, even a failing floor will look perfectly fine, so one does not realize it has lost its bond with the concrete. The removal of old flooring should never be contemplated without at least allowing for time to overcome the more obvious potential disasters that may or may not be encountered once removal begins (moisture vapor, asbestos contaminated adhesive, crumbling or uneven concrete). Moreover, if an extended installation conflicts with production schedules and environmental conditions, it is wise to either cancel the project or proactively seek a creative alternative to the surprises demolition will surely bring.

References

- 1) Mil Standard 263B-1994, Appendix A, table IV
- 2) D. Long. "Choosing the Right ESD Floor for Laboratory and Technical Environments," Conformity Magazine, (May, 2005).

© 2006 Controlled Environments

David H. Long is the principle of StaticWorx, based in Newton, MA. He can be reached by phone at (617) 527-6299 or by e-mail at dave@staticworx.com. StaticWorx can be visited on the web at <http://www.staticworx.com/>.



t: 6170527.6299 f: 6170527.6220 www.staticworx.com