Hospital flooring – why is that an issue today?

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Abstract: Control of electrostatics has been considered important in hospitals since the advent of anesthesia chemicals for surgical procedures. Now that anesthetics are for the most part not flammable, hospital designers in the United States are rarely considering electrostatics. Since flammable situations are much less likely in hospitals, the US organization, the National Fire Protection Association (NFPA), has removed any mention of electrostatic control from the Health Care Facility Standard, NFPA 99[1]. This document had always been important for consideration in hospital design, especially surgical suites. The elimination of a requirement for conductive flooring and appropriate footwear have brought about serious consequences regarding electrostatic charge generation and accumulation. Accumulated charge has led to discharge issues resulting in personal injury, electronic equipment damage and loss of significant amounts of data. Figure 1 is an example of recorded voltage on a person while pushing a metal cart in the hospital discussed in Incident three below.

1. Introduction
NFPA 99 – Health Care Facilities standard in the United States (formerly NFPA 56), originally had a section that discussed hospital surgical suite flooring requirements. Flooring was required to have a resistance to ground of <1 megohm. Footwear and shoe coverings were also required to maintain a resistance to ground from a person from 500 kohms to 1 megohm. Numerous other requirements for controlled resistance of materials used in the surgical suite were also listed. In about 2003, the information regarding electrostatic control requirements was moved to an informational Annex. It is unlikely that hospital architects took the Annex seriously since it was likely considered just
information and not a set of requirements. When looking at possible flooring choices, the conductive versions usually have increased material and installation costs, so that makes the decision to choose some other floor more likely. It is also very unlikely that any hospital in the USA will be able to have control of shoes worn by medical staff and other personnel working in a hospital. That means special care is needed in the selection of the flooring to ensure minimal charging, regardless of the shoes. The following incidents were evaluated by the author independently or as part of a team of investigators. The names of the hospitals and locations are omitted to maintain confidentiality.

2. Incidents

In the winter months, the northern tier states in the United States, often have cold and dry conditions. Humidity control in most commercial buildings is limited to rudimentary humidification by adding some water to a forced air heating system. The interior humidity can often reach single digits at normal room temperatures and will surely be less than 30% for several months. The manifestation of electrostatic charge and discharge becomes more noticeable in these low humidity conditions, especially when there is no consideration for mitigation of electrostatic charge.

2.1 Incident 1

A new tablet computer data acquisition and recording system was employed in a northern tier US hospital. During the summer months, very few computer related problems were reported and those that were reported were mostly due to human error. As the colder fall and winter months arrived, multiple doctors and nurses and other health care personnel carrying tablet computers throughout the day lost all their collected data when they returned to offices, workstations and their desks and connected their tablets to their computer docking stations. Various mitigation strategies were tried by the tablet computer supplier with little positive effect on the situation. By early spring of the next year, the hospital management was almost to the point of terminating the tablet computer installation. The hospital facility management requested outside assistance.

The ensuing investigation consisted of hundreds of measurements of electrostatic voltage on personnel as they moved around the hospital doing their various tasks. The discharge of tablet computers at their docking stations was observed and the level of discharge required to lock-up or cause data loss was estimated. A voltage on personnel resulting in a 1-2 kV discharge was considered a hazardous level for the tablet computers as designed. At the end of the investigation, a design change in the mating connectors between the tablet computer and the docking station to contact ground first added a significant increase to the robustness of the system by discharging the tablet case to ground before connecting the operating system of the tablet to the docking station. The addition of a grounded dissipative mat or grounded “touch me first” strip of mat material in front of the docking station also helped by providing a place for personnel to touch and discharge their body voltage before docking. This of course required training of personnel to assure they would use this ancillary device properly and routinely.

Figures 2-5 represent some of the voltage measurements recorded on personnel in the hospital investigation. The activities include walking, sitting and rising from a chair, and touching a grounded surface.

Figure 2: Personnel voltage in office area

Figure 3: Walking and sitting/rising from chair
After implementing the mitigation suggestions, the loss of data dropped to near zero, at least from electrostatic discharges.

2.2 Incident 2
A new northeastern US hospital installed a beautiful stone tile floor throughout all the public areas. Charge generation was significant, particularly on metal carts and other equipment rolling across the stone tile floors. Videos were provided to several consultants for discussion. The video evidence showed discharges up to 80 mm in length from the edge of metal carts to doorways. Several nurses and technicians reported painful shocks when touching door handles and light switch panels. Mitigation required routine treatment of the public area flooring with dissipative treatments that did not impact the appearance of the floor.

2.3 Incident 3
Another new northern tier hospital reported significant shocks to nurses when they touched door switches and door handles in one area of a surgical suite. The initial consultant called to investigate determined it would be necessary to install a series of grounded dissipative pads by the electronic door switches for personnel to touch before contacting the metal portions of the door opening devices. While this addition resulted in an immediate reduction of shock complaints, it did not reduce them to zero.

A second consultant (this author) was invited to visit the hospital and conduct a second evaluation. The visit took place during the spring, so the temperature and humidity were more moderate. Many measurements of electrostatic charging were recorded on personnel and moving equipment. Figure 1 shown earlier is one example of the voltage on a metal cart pushed by a person along a corridor in a surgical unit (hallway around a series of operating rooms). The floor was a sheet vinyl system with the intent to be electrically dissipative to ground. Resistance to ground measurements along the corridor resulted in less than half of the flooring resulting in a preferred resistance of $<1 \times 10^9$ ohms to ground. The rest of the floor measured $>1 \times 10^9$ ohms and up to $1 \times 10^{12}$ ohms. The walking and rolling equipment highest voltage measurements tended to occur at the locations of the higher floor resistance measurements.

Further investigation discovered that the highest resistance floor area was due to repairs that had been made to the concrete structure at an area where an addition to the building joined the original structure. The floor covering underlayment was not identical in this area to the rest of the corridor. As mobile equipment contacted the floor in this area, the charging propensity increased very rapidly. This was also the area where the significant shocks to nurses had occurred previously. The following charts show charging levels of personnel and mobile equipment approaching and moving through the area where the flooring had highest resistance to ground.
As shown in Figure 6, the charging level on the surgical bed was low along most of the corridor for approximately 25 meters until the area where the floor resistance increased. This occurred at about the 65 second mark of the bed movements along the corridor. The rapid increase in voltage was obvious and since the person pushing the bed was in contact with the metal frame, they were charged as well. If the person had touched the door opening switch at this point, they would have discharged the accumulated charge. During this experiment, the bed was pushed further down the corridor and most of the accumulated charge dissipated to the lower resistance floor in that area. A similar pattern was recorded on a metal cart as shown in Figure 7. The rapid increase in voltage occurred at the same part of the corridor. The moisture content of the air during these measurements was moderate so the charge accumulation was lower than would be expected in the low humidity winter months. It would be reasonable to expect the voltage levels to exceed 20 kV. The severity of shocks reported during interviews with the nurses involved indicated a discharge level of 20 kV or higher based on the physiological response of their bodies.

Based on the observations shown above and additional supporting measurements, the hospital management decided to replace the floor in the surgical unit. A floor meeting the original NFPA 99 specifications has been installed. No reports of significant issues with electrostatic shock have been made to this point (first winter since installation). In addition, the specifications for flooring in a new hospital wing were changed before construction to help avoid the electrostatic issues observed in the older part of the hospital.

3. Summary and Conclusions
In the United States, the lack of guidance or requirements from standards is causing electrostatic issues in hospitals. With no specific recommendations for control of flooring and footwear electrical specifications in hospitals today, there is significant cause for concern. It is hoped that the guidance presented in IEC61340-6-1[2] will be noticed by the US hospital designers, the NFPA and perhaps the ESD Association. Requests have been made to the ESD Association to start a working group to investigate the need for more stringent control of flooring in commercial spaces, with emphasis on hospitals. Existing standards are lacking or at least insufficient in this area in the USA.

References
[1] NFPA 99 – Health Care Facilities, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101, www.nfpa.org
[2] IEC61340-6-1 – Electrostatic control in health care facilities – International Electrotechnical Commission, 3, rue de Varembe’, Geneva, Switzerland, www.iec.ch