



ESD CONTROL SURVEY - REPORT

Survey at:

Address:

For:

Survey Date:

Report Date:

Prepared by:

Copy to:

SUMMARY

..... has made a strong commitment to improve the overall quality of their ESD control program. An important component to an effective and consistent program is management support and the establishment of an ESD committee, with representation from all departments within an end user organization. An effective ESD control program can only be achieved and maintained if there is complete buy-in from the entire organization. An effective ESD committee will help to address and deal with existing and new ESD concerns as the needs of the organization change.

..... has taken important positive steps in the process by developing a comprehensive program, implementing and enforcing it. Further improvements will optimize the program and to fully comply with IEC 61340-5-1 minimum recommendations and acceptable industry practices. are congratulated on their commitment to improve overall quality, productivity and customer satisfaction.

PURPOSE

Thank you for providing Charleswater, the opportunity to assist in the evaluation of your ESD program. Over more than twenty years, Charleswater has developed a reputation for providing valuable quality products and technical assistance to help improve your quality, productivity, and customer satisfaction. As your partner in optimizing your ESD program, our goal is to turn ESD control into a competitive advantage for you.

An ESD survey was performed to accomplish the following:

1. Assess the current level of the ESD control program.
2. Identify appropriate ESD protective products or improved methods to satisfy IEC 61340-5-1 and upcoming audits.
3. Make suggestions on how to improve ESD control program in general.

Charleswater primarily uses IEC 61340-5-1 and its User Guide IEC 61340-5-2 as the basis for performing ESD Surveys. The general title of IEC 61340 is Electrostatics. Part 5-1 is "Protection of electronic devices from electrostatic phenomena - General requirements". Part 5-2 is "Protection of electronic devices from electrostatic phenomena - User guide". IEC 61340-5-1 and this user guide are aimed purely at electronics. It states "Where no ESD handling precautions are taken, a high proportion of electronic apparatus failure can be attributed to ESD damage. This figure could in theory be reduced to zero by adopting the precautions described in IEC 61340-5-1 in all areas."

Per IEC 61340-5-2 paragraph 1.1 "This technical specification is intended to cater for electronic components, assemblies and subassemblies with a sensitivity of 100 V or greater (human body model (HBM), and as such covers most items available. There are on the market a few items which may suffer damage at lower levels. Where these are used, additional or alternative methods should be used. The HBM has been chosen as the major criteria, as damage from human contact is still the most common source even in today's automated society."

INTRODUCTION

Some of the effects of static electricity have been known for several thousands of years. In more recent times, their properties have been understood and have been used to advantage in many applications. Unfortunately some properties of static electricity cause problems, particularly in the electronics industry. Many electronic components and assemblies used in high technology products can be damaged or degraded by the sudden exchange of static electrical charges. This release of stored energy is called **ElectroStatic Discharge** or is most commonly referred to as **ESD**. Components that have a susceptibility to damage from electrostatic discharge are called **ESD Sensitive** or **ESDS**. These included transistors, diodes, laser diodes, electro-optical devices, precision film resistors, capacitors and an ever-increasing variety of integrated circuits. Susceptibility of devices to ESD is increasing with the drive to miniaturize electronic devices and increase operating speeds. Devices are subject to ESD damage at every stage of production from wafer fabrication to a populated circuit board assembly.

The most common electrostatic generator is triboelectric charging. This is caused when two materials come into contact or are rubbed together and then separated. Such actions allow electrons to move from one surface to another, creating a charge imbalance between the materials. Common sources of ESD include personnel, items made from common polymeric materials, and processing equipment. ESD can damage parts by direct contact with a charged source or by electric fields emanating from charged objects that induce a charge on grounded sensitive items.

PREREQUISITE

A particular written ESD control plan should be based on the device and item susceptibility or voltage sensitivity of the most sensitive components used in the facility. Examples of ESDS parts are microcircuits, discrete semiconductors, thick and thin film resistors, hybrid devices and piezoelectric crystals. Typically, the easiest way to establish the ESD susceptibility of ESDS items

in your facility is to refer to the Reliability Analysis Center “V-ZAP” data book rac.iitri.org/cgi-rac/ProdDescription?VZAP-95

A prerequisite of ESD control is the accurate and consistent identification of ESD sensitive items. When the voltage sensitivity of your most sensitive device is not known, we will assume a 100 volt human body model sensitivity level.

FUNDAMENTAL ESD CONTROL PRINCIPLES

The fundamental ESD control principles are:

- All conductors, including personnel, must be electrically connected and attached to a known ground. This attachment creates an equipotential balance between all items and personnel. Electrostatic protection can be maintained at a potential above a “zero” voltage ground potential as long as all items in the system are at the same potential.
- Ionization systems provide neutralization of charges on process necessary insulators and isolated conductors.
- Packaging of ESD sensitive items outside an ESD Protected Area should limit tribo-electric charging, provide shielding against electrostatic fields and discharges, and be capable of providing charge drainage to EPA ground when brought into an EPA. All non-ESDS items brought into an ESD Protected Area shall be packed in low charging, dissipative ESD packaging.

PERSONNEL SAFETY

- The ESD control program can in no way replace or supersede any requirements for personnel safety.
- Ground fault circuit interrupters (GFCI) and other safety protection should be considered wherever personnel might come into contact with electrical sources.

ESD CONTROL PROGRAM

- Per IEC 61340-5-2 ESD damage is very real, but as much of the damage takes place below the levels where the human senses can detect discharge, the awareness factor is vital. Training is one of the best means of achieving this awareness and should be included as an essential part of any structured handling procedure.
- A written ESD control Plan should establish, document, implement, maintain and verify the compliance of the Program in accordance with the requirements of IEC 61340-5-1.
- The ESD control plan should provide for electrostatic control and protection during design, production, inspection, test, storage, shipment, installation, use, maintenance, replacement and repair functions.
- Tailoring is acceptable and requirements may be added, modified or deleted. Tailoring decisions, including rationale, should be documented in the ESD Control Program Plan
- The ESD control plan should cover training, compliance verification, technical requirements, and should include a listing of the specific type of ESD protective materials and equipment used in the program.
- The ESD control plan should ensure that suppliers of ESD sensitive components and assemblies have established and implemented a Program in accordance IEC 61340-5-1.

Training Plan Requirement

- Initial and recurrent ESD awareness and prevention training shall be provided to all personnel extending beyond the employees who actually handle ESDS, designers, associated supervisors and managers. It should include personnel in purchasing and planning roles.
- The training shall include an objective evaluation technique to ensure comprehension and adequacy. It is the responsibility of the ESD co-ordinator to be satisfied that the level, quality and style are adequate, to set the intervals for refresher training, and to ensure that retraining

within the specified interval is carried out. A register of trained personnel should be maintained.

Compliance Verification Plan Requirement

- A Compliance Verification Plan should be established and audits be conducted.
- Subclause 10.1 of IEC 61340-5-1 calls for periodic audits, and intervals of not more than 12 months between these audits are recommended. Additionally, random audits should be held so that precautions are not tightened up periodically when audits are expected.
- Test equipment shall be selected to make measurements of appropriate properties of the technical requirements that are incorporated into the ESD program plan.
- See IEC 61340-5-1 Table 3 – Example of audit report.

SURVEY SUMMARY

Area of Facility:

Main Flight Cleanroom G16

ESD Protected Area Clearly Identified using signs, aisle tape & EPA bonding points labeled.

The area is clearly identified as an EPA.

IEC 61340-5-1 paragraph 4.3 Signs for ESD protected areas (EPA) ESD sensitivity symbol "Sign(s) ...shall be clearly visible to personnel before they enter the EPA and, where applicable, from inside the EPA. Where applicable, signs ... shall mark the EPA boundary." Paragraph 4.4 Marking of EPA bonding points (EBP) "All EBP shall be marked or labelled." Per IEC 61340-5-2 paragraph 5.1.1 "The boundaries of the EPA need defining and will vary between different types of EPA, but will typically have coloured (but not electrostatic generative) markings on the floor."

Access to ESD Protected Area controlled

Access to this area is strictly controlled.

IEC 61340-5-1 paragraph 5.5 EPA working practices "All persons, including visitors, entering the EPA shall comply with the requirements of this subclause" [grounded via wrist strap or ESD footwear, properly wearing ESD garments, paperwork in static dissipative document holders].

Working Surfaces and storage racks, Rp 10^4 to 10^9 ohms, Rg $7,5 \times 10^6$ to 1×10^9 ohms.
ESD Mat Cleaner used.

The work surfaces in this area are laminate with static dissipative matting placed on top. Random testing of the static dissipative mats was carried out with the following results noted:

5.7×10^7 Rp

6.9×10^7 Rg

The storage racks in this area are metal and grounded.

IEC 61340-5-1 paragraph 5.2.2 Working surfaces and storage racks "All working surfaces and storage racks on which unprotected ESDS may be placed shall be capable of being connected to EPA ground and shall have a point-to-point resistance and resistance to EPA ground in accordance with table 1 [Rp greater or equal to 1×10^4 , less than or equal to 1×10^9 ohms, and Rg greater or equal to $7,5 \times 10^5$ to less than or equal to 1×10^9 ohms]." Conductive materials conduct electricity too rapidly and a discharge may occur. Dissipative materials will drain the charges off an ESDS device at a slow enough rate to minimize the occurrence of discharges. Dirt & cleaners containing silicone are insulative and a dissipative ESD worksurface cannot fulfil its function if covered by insulative material

ESD Floors, Rg less than or equal to 1×10^9 ohms. If primary means of grounding personnel, Rg $7,5 \times 10^5$ to $3,5 \times 10^7$ ohms. Floor clean.

This area has a static dissipative floor which measured 5.6×10^8 which is within spec. However, the floor should not be relied upon as the primary means of grounding personnel.

IEC 61340-5-1 paragraph 5.2.3 Floors "All floor surfaces shall have a surface-to-EPA ground resistance in accordance with table 1. Table 1 NOTE 2 - When the footwear/floor systems are used as the primary means of grounding personnel, the resistance of the combination shall be determined by the ESD co-ordinator, and is recommended to be between $7,5 \times 10^5$ ohms and $3,5 \times 10^7$ ohms." IEC 61340-5-1 paragraph 5.5 EPA working practices "When the use of a wrist strap system is impractical, the [ESD] floor and [ESD] footwear shall be the primary means of ESD control." Dirt is typically insulative and a dissipative ESD protected floor cannot fulfil its function if covered by insulative material.

ESD Seating, Rg less than or equal to 1×10^{10} ohms. If ESD floor grounding, minimum of two paths-to-ground.

ESD safe seating is used in this area. When measured it had an Rg of less than 1×10^{10} which is within specification.

IEC 61340-5-1 paragraph 5.2.4 Seating "The resistance from all areas of seating which may have human body contact when in normal use, to either a floor contact point or a groundable point, shall be as specified in table 1 [Rg less than or equal to 1×10^{10} ohms]. When the floor is used as part of a grounding system, a minimum of two wheels or two feet shall provide a path to EPA ground."

ESD Protective Smocks used to cover arms and torso, Rg less than or equal to 1×10^{12} ohms. Charge decay to less than 10% of original value (maximum 1,000 V). ESD Smocks marked with ESD protective symbol and properly fastened.

Cleanroom clothing is used.

IEC 61340-5-1 paragraph 5.2.5 Garments "Coats, jackets, smocks and overalls shall completely cover all clothing in the area of the arms and torso. There shall be electrical continuity between all parts of the garment. Garments shall have characteristics on the outward facing surface in accordance with table 1 [Rp less than or equal to 1×10^{12} ohms; Charge decay to 10% of initial value (maximum 1 000 V) in less than 2 s]. Garments complying with ESD requirements shall be clearly marked. NOTE - Marking with the ESD [protective] symbol ... is recommended." IEC 61340-5-1 paragraph 5.5 EPA working practices "When used, garments in accordance with 5.2.5 shall be worn and shall be properly fastened at all times."

ESD Gloves and Finger Cots, Charge decay to less than 10% of original value (maximum 1,000 V).

Two styles of gloves are used in this area. To meet the European specification, gloves should charge decay to less than 10% of the original value. The white coloured gloves meet the specification, however, the yellow coloured gloves were seen to carry a charge in excess of 5,000 volts which it retained and didn't dissipate even after a lengthy period of time.

IEC 61340-5-1 paragraph 5.2.6 Gloves and finger cots "Gloves and finger cots, as worn, shall be in compliance with table 1 [Charge decay to 10% of initial value (maximum 1 000 V) in less than 2 s]."

Wrist Straps with current limiting resistor worn and grounded. Tested daily to $R_g 7,5 \times 10^5$ to $3,5 \times 10^7$ ohms.

Wrist Straps are used at all times and are tested before entry into the clean area.

IEC 61340-5-1 paragraph 5.5 EPA working practices "The primary means of grounding personnel shall normally be by a wrist strap connected to an EBP." Paragraph 5.2.7 "The wrist strap shall consist of a band that fits snugly around the wrist and a cord to connect the band to an EBP. The wrist strap shall incorporate a quick release connection. The cord shall have a termination compatible with the EBP and shall incorporate at least one insulated current-limiting resistor. The total resistance from hand to EBP shall be in accordance with table 1 [$R_g 7,5 \times 10^5$ to $3,5 \times 10^7$ ohms]. IEC 61340-5-2: Paragraph 5.1.1 General "A nominal 1 megohm resistor is commonly used in wrist straps and to ground work surfaces. In the event of an operator touching an energized conductor, for the normal mains electricity supplies this resistor will limit the current flowing through the person to less than 0,5 mA. Current limiting or cut-off devices should also be considered and in some areas may be demanded by legislation."

Foot Grounders used in conjunction with ESD Floor touch tested daily prior to entering EPA. R_g be between $7,5 \times 10^5$ ohms and $3,5 \times 10^7$ ohms.

Each person wears two foot grounders, which are tested prior to entry into the cleanroom.

IEC 61340-5-1 paragraph 5.2.8 "Footwear shall be constructed in such a way that for each item, the resistance to EPA ground from wearer shall be in accordance with table 1. Table 1 NOTE 2 - When the footwear/floor systems are used as the primary means of grounding personnel, the resistance of the combination shall be determined by the ESD co-ordinator, and is recommended to be between $7,5 \times 10^5$ ohms and $3,5 \times 10^7$ ohms." IEC 61340-5-1 paragraph 5.5 EPA working practices "When the use of a wrist strap system is impractical, the [ESD] floor and [ESD] footwear shall be the primary means of ESD control." Per IEC 61340 5-1 Daily checks, paragraph 9.6.3 Non-permanent footwear "All wearers shall check that their heel and toe straps meet requirements. The check shall be made before entering the EPA."

Ionizers to reduce charges on insulators to less than 100 volts in less than 20 seconds.

Ionisers are not used as they are not considered necessary in this area. However, during my visit I was asked to test some Kapton tape for charge generation. The tape was found to generate in excess of 13Kv during unwinding, even after about 30 seconds it was found to still be holding in excess of 4Kv. The potential for damage to components is very big when the tape is applied to the back of a PCB. The charges on the tape can be neutralised using an Ioniser. You should also consider using a low charging Kapton tape.

IEC 61340-5-1 paragraph 5.2.9 "Ionizers shall enable either polarity of charge on items to be brought down and maintained to less than 100 V in accordance with table 1 [To decay from 1 000 V to 100 V in 20 s maximum]."

Check Ground to EPA ground bonding point (EBP) and EPA ground facility; recommend hard ground less than 2 ohms.

Mains earth is used as the EPA ground facility.

IEC 61340-5-1 paragraph 5.3.2 "The EPA ground facility shall be connected to EPA ground and provide a low resistance path to EPA ground (<2 ohms). When available, the mains protective earth shall be used. Paragraph 5.3.3 "An easily accessible dedicated EBP [EPA ground bonding point] for the wrist strap shall be established adjacent to each working area, or working surface. A sufficient number of EBP shall be provided for operators and visitors." Paragraph 5.3.4 "EPA ground cords shall be used to make electrical connections between groundable points and the EPA ground facility."

Paperwork in static dissipative Document Holders.

Paperwork and build instructions were scattered over all the workbenches. All paperwork that is on the workbench needs to be inside a static dissipative document holder.

IEC 61340-5-1 "Paperwork inside the EPA shall either be kept in containers conforming to the requirements of table 2 or shall not generate a field in excess of that specified in paragraph 5.3.5 [ESDS should not be exposed to electrostatic fields in excess of 10 kV/m]." Insulative paper, placed upon ESD protected worksurface, can easily interrupt path-to-ground.

For Packaging Outside EPA, use Shielding Bags or other ESD packaging for transportation or storage of ESD sensitive items.

All ESD sensitive items are transported around the facility in static shielding bags and conductive boxes.

IEC 61340 5-1 paragraph 6 Protective packaging states "The primary functions of protective packaging outside the ESD Protected Area are to: limit tribo-electric charging, provide shielding against electrostatic fields and discharges, [and] the packaging shall be capable of providing charge drainage to EPA ground when brought into an EPA. Per paragraph 4.1.2 "identified with ESD packaging symbol, manufacturer, and batch identification number". IEC 61340-5-1 Table 2 "Intimate: Either low-charging and electrostatic conductive or low-charging and electrostatic dissipative (for powered ESDS only low-charging and electrostatic dissipative above 1×10^8 ohm shall be used). Proximity: Electrostatic discharge shielding."

For Packaging Within EPA: 1) non-ESD items in low charging & ESDS [even if defective] in low charging & dissipative packaging 2) non-ESD packaging prohibited.

All ESDS are stored in this area in either static shielding bags or conductive boxes.

Note: Per IEC 61340 5-1 paragraph 7.3 "ESDS found to be faulty shall be protected in the same manner as any other ESDS up to the time of disposal." All non-ESDS items brought into an ESD Protected Area shall be packed in low charging, dissipative ESD packaging. "The outer surface of all proximity packaging brought into an EPA shall not be insulating." "Non-ESD protective packaging material shall not be taken into an EPA."

IEC 61340-5-1 paragraph 5.5 EPA working practices "All non-ESDS items brought into EPA shall be packed in accordance with table 2 which is minimum of "low-charging." Packaging per Table 2 for ESDS brought into EPA is "Intimate: Either low-charging and electrostatic conductive or low-charging and electrostatic dissipative (for powered ESDS only low-charging and electrostatic dissipative above 1×10^8 ohm shall be used). Proximity: Low-charging and Electrostatic discharge shielding or low-charging and electrostatic conductive or electrostatic dissipative."

Area of Facility:

Solar Panel G39

ESD Protected Area Clearly Identified using signs, aisle tape & EPA bonding points labeled.

This area was not clearly identified as an EPA

IEC 61340-5-1 paragraph 4.3 Signs for ESD protected areas (EPA) ESD sensitivity symbol "Sign(s) ... shall be clearly visible to personnel before they enter the EPA and, where applicable, from inside the EPA. Where applicable, signs ... shall mark the EPA boundary." Paragraph 4.4 Marking of EPA bonding points (EBP) "All EBP shall be marked or labelled." Per IEC 61340-5-2 paragraph 5.1.1 "The boundaries of the EPA need defining and will vary between different types of EPA, but will typically have coloured (but not electrostatic generative) markings on the floor."

Access to ESD Protected Area controlled

Access to this area is strictly controlled.

IEC 61340-5-1 paragraph 5.5 EPA working practices "All persons, including visitors, entering the EPA shall comply with the requirements of this subclause" [grounded via wrist strap or ESD footwear, properly wearing ESD garments, paperwork in static dissipative document holders].

Working Surfaces and storage racks, R_p 10^4 to 10^9 ohms, R_g $7,5 \times 10^6$ to 1×10^9 ohms.
ESD Mat Cleaner used.

The work surfaces in this area are not fitted with ESD safe surfaces. Historically no ESD sensitive equipment was handled in this area, however, boards containing ESDS are now being handled here. All workbenches where handling of ESDS takes place must be established as EPA's.

IEC 61340-5-1 paragraph 5.2.2 Working surfaces and storage racks "All working surfaces and storage racks on which unprotected ESDS may be placed shall be capable of being connected to EPA ground and shall have a point-to-point resistance and resistance to EPA ground in accordance with table 1 [R_p greater or equal to 1×10^4 , less than or equal to 1×10^9 ohms, and R_g greater or equal to $7,5 \times 10^5$ to less than or equal to 1×10^9 ohms]." Conductive materials conduct electricity too rapidly and a discharge may occur. Dissipative materials will drain the charges off an ESDS device at a slow enough rate to minimize the occurrence of discharges. Dirt & cleaners containing silicone are insulative and a dissipative ESD worksurface cannot fulfil its function if covered by insulative material

ESD Floors, R_g less than or equal 1×10^9 ohms. If primary means of grounding personnel, R_g $7,5 \times 10^5$ to $3,5 \times 10^7$ ohms. Floor clean.

This area has a static dissipative floor which measured 9.9×10^9 which is not within spec. The floor in this area is measuring too high and would benefit from a thorough clean which would probably reduce the resistance level. The floor should not be relied upon as the primary means of grounding personnel.

IEC 61340-5-1 paragraph 5.2.3 Floors "All floor surfaces shall have a surface-to-EPA ground resistance in accordance with table 1. Table 1 NOTE 2 - When the footwear/floor systems are used as the primary means of grounding personnel, the resistance of the combination shall be determined by the ESD co-ordinator, and is recommended to be between 7.5×10^5 ohms and 3.5×10^7 ohms." IEC 61340-5-1 paragraph 5.5 EPA working practices "When the use of a wrist strap system is impractical, the [ESD] floor and [ESD] footwear shall be the primary means of ESD control." Dirt is typically insulative and a dissipative ESD protected floor cannot fulfil its function if covered by insulative material.

ESD Seating, R_g less than or equal to 1×10^{10} ohms. If ESD floor grounding, minimum of two paths-to-ground.

ESD seating is not used in this area.

IEC 61340-5-1 paragraph 5.2.4 Seating "The resistance from all areas of seating which may have human body contact when in normal use, to either a floor contact point or a groundable point, shall be as specified in table 1 [R_g less than or equal to 1×10^{10} ohms]. When the floor is used as part of a grounding system, a minimum of two wheels or two feet shall provide a path to EPA ground."

ESD Protective Smocks used to cover arms and torso, R_g less than or equal 1×10^{12} ohms. Charge decay to less than 10% of original value (maximum 1,000 V). ESD Smocks marked with ESD protective symbol and properly fastened.

Cleanroom clothing is used.

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Wrist Straps with current limiting resistor worn and grounded. Tested daily to $R_g 7,5 \times 10^5$ to $3,5 \times 10^7$ ohms.

Wrist Straps are not used in this area.

IEC 61340-5-1 paragraph 5.5 EPA working practices "The primary means of grounding personnel shall normally be by a wrist strap connected to an EBP." Paragraph 5.2.7 "The wrist strap shall consist of a band that fits snugly around the wrist and a cord to connect the band to an EBP. The wrist strap shall incorporate a quick release connection. The cord shall have a termination compatible with the EBP and shall incorporate at least one insulated current-limiting resistor. The total resistance from hand to EBP shall be in accordance with table 1 [$R_g 7,5 \times 10^5$ to $3,5 \times 10^7$ ohms]. IEC 61340-5-2: Paragraph 5.1.1 General "A nominal 1 megohm resistor is commonly used in wrist straps and to ground work surfaces. In the event of an operator touching an energized conductor, for the normal mains electricity supplies this resistor will limit the current flowing through the person to less than 0,5 mA. Current limiting or cut-off devices should also be considered and in some areas may be demanded by legislation."

Foot Grounders used in conjunction with ESD Floor touch tested daily prior to entering EPA. R_g be between $7,5 \times 10^5$ ohms and $3,5 \times 10^7$ ohms.

Foot grounders are not used in this area.

IEC 61340-5-1 paragraph 5.2.8 "Footwear shall be constructed in such a way that for each item, the resistance to EPA ground from wearer shall be in accordance with table 1. Table 1 NOTE 2 - When the footwear/floor systems are used as the primary means of grounding personnel, the resistance of the combination shall be determined by the ESD co-ordinator, and is recommended to be between $7,5 \times 10^5$ ohms and $3,5 \times 10^7$ ohms." IEC 61340-5-1 paragraph 5.5 EPA working practices "When the use of a wrist strap system is impractical, the [ESD] floor and [ESD] footwear shall be the primary means of ESD control." Per IEC 61340 5-1 Daily checks, paragraph 9.6.3 Non-permanent footwear "All wearers shall check that their heel and toe straps meet requirements. The check shall be made before entering the EPA."

Ionizers to reduce charges on insulators to less than 100 volts in less than 20 seconds.

Lots of high charging plastic packaging materials around

IEC 61340-5-1 paragraph 5.2.9 "Ionizers shall enable either polarity of charge on items to be brought down and maintained to less than 100 V in accordance with table 1 [To decay from 1 000 V to 100 V in 20 s maximum]."

Trolleys / equipment grounded; $R_p 10^4$ to 10^9 ohms, $R_g 7,5 \times 10^6$ to 1×10^9 ohms.

Metal racking is used in this area for storage.

IEC 61340-5-1 paragraph 5.2.11 Trolleys and carts "When used for transporting unprotected ESIDS or as portable work surfaces, they shall conform to the requirements of 5.2.2 [Working surfaces and storage racks 'All working surfaces and storage racks on which unprotected ESIDS may be placed shall be capable of being connected to EPA ground and shall have a point-to-point resistance and resistance to EPA ground in accordance with table 1 [R_p greater or equal to 1×10^4 , less than or equal to 1×10^9 ohms, and R_g greater or equal to $7,5 \times 10^5$ to less than or equal to 1×10^9 ohms]' and shall contain a groundable point.

Area of Facility:

AIT G4

ESD Protected Area Clearly Identified using signs, aisle tape & EPA bonding points labeled.

The area is clearly identified as an EPA.

IEC 61340-5-1 paragraph 4.3 Signs for ESD protected areas (EPA) ESD sensitivity symbol "Sign(s) ... shall be clearly visible to personnel before they enter the EPA and, where applicable, from inside the EPA. Where applicable, signs ... shall mark the EPA boundary." Paragraph 4.4 Marking of EPA bonding points (EBP) "All EBP shall be marked or labelled." Per IEC 61340-5-2 paragraph 5.1.1 "The boundaries of the EPA need defining and will vary between different types of EPA, but will typically have coloured (but not electrostatic generative) markings on the floor."

Access to ESD Protected Area controlled

Access to this area is strictly controlled.

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Working Surfaces and storage racks, Rp 10^4 to 10^9 ohms, Rg $7,5 \times 10^6$ to 1×10^9 ohms.
ESD Mat Cleaner used.

The work benches in this area are laminate with static dissipative matting placed on top. Random testing of the static dissipative mats was carried out with the following results noted:

5.8×10^8 Rp

6.7×10^8 Rg

The storage racks in this area are metal and grounded.

Two mats in the lower section of this area when tested had a surface resistance of $>10^{10}$ and should be replaced.

In the centre of the room are a number assembly stations which whilst all the metal work is linked and grounded the laminate surfaces are not ESD safe.

IEC 61340-5-1 paragraph 5.2.2 Working surfaces and storage racks "All working surfaces and storage racks on which unprotected ESDS may be placed shall be capable of being connected to EPA ground and shall have a point-to-point resistance and resistance to EPA ground in accordance with table 1 [Rp greater or equal to 1×10^4 , less than or equal to 1×10^9 ohms, and Rg greater or equal to $7,5 \times 10^5$ to less than or equal to 1×10^9 ohms]." Conductive materials conduct electricity too rapidly and a discharge may occur. Dissipative materials will drain the charges off an ESDS device at a slow enough rate to minimize the occurrence of discharges. Dirt & cleaners containing silicone are insulative and a dissipative ESD worksurface cannot fulfil its function if covered by insulative material

ESD Floors, Rg less than or equal 1×10^9 ohms. If primary means of grounding personnel, Rg $7,5 \times 10^5$ to $3,5 \times 10^7$ ohms. Floor clean.

The floor in this area looked the same as the floors in the other cleanrooms. The same test was conducted on this floor as the others, but with very different results. This floor measured $>10^{12}$ which is out of spec. The test was repeated at numerous points throughout the area with the same result every time. A HBM (Human Body Model) test was conducted whilst wearing two foot grounders, a voltage in excess of 4Kv was registered, further proof that the floor is not an ESD safe floor. The floor in this area should not be relied upon for grounding of personnel. This floor can be made ESD safe with the application of a static dissipative floor finish.

IEC 61340-5-1 paragraph 5.2.3 Floors "All floor surfaces shall have a surface-to-EPA ground resistance in accordance with table 1. Table 1 NOTE 2 - When the footwear/floor systems are used as the primary means of grounding personnel, the resistance of the combination shall be determined by the ESD co-ordinator, and is recommended to be between $7,5 \times 10^5$ ohms and $3,5 \times 10^7$ ohms." IEC 61340-5-1 paragraph 5.5 EPA working practices "When the use of a wrist strap system is impractical, the [ESD] floor and [ESD] footwear shall be the primary means of ESD control." Dirt is typically insulative and a dissipative ESD protected floor cannot fulfil its function if covered by insulative material.

ESD Seating, R_g less than or equal to 1×10^{10} ohms. If ESD floor grounding, minimum of two paths-to-ground.

Seating is not used in this area.

IEC 61340-5-1 paragraph 5.2.4 Seating "The resistance from all areas of seating which may have human body contact when in normal use, to either a floor contact point or a groundable point, shall be as specified in table 1 [R_g less than or equal to 1×10^{10} ohms]. When the floor is used as part of a grounding system, a minimum of two wheels or two feet shall provide a path to EPA ground."

ESD Protective Smocks used to cover arms and torso, R_g less than or equal 1×10^{12} ohms. Charge decay to less than 10% of original value (maximum 1,000 V). ESD Smocks marked with ESD protective symbol and properly fastened.

Cleanroom clothing is worn.

IEC 61340-5-1 paragraph 5.2.5 Garments "Coats, jackets, smocks and overalls shall completely cover all clothing in the area of the arms and torso. There shall be electrical continuity between all parts of the garment. Garments shall have characteristics on the outward facing surface in accordance with table 1 [R_p less than or equal to 1×10^{12} ohms; Charge decay to 10% of initial value (maximum 1 000 V) in less than 2 s]. Garments complying with ESD requirements shall be clearly marked. NOTE - Marking with the ESD [protective] symbol ... is recommended." IEC 61340-5-1 paragraph 5.5 EPA working practices "When used, garments in accordance with 5.2.5 shall be worn and shall be properly fastened at all times."

ESD Gloves and Finger Cots, Charge decay to less than 10% of original value (maximum 1,000 V).

Three styles of gloves are used in this area. To meet the European specification, gloves should charge decay to less than 10% of the original value. The white coloured latex gloves meet the specification, however, the yellow coloured laytex gloves were seen to carry a charge in excess of 5,000 volts which it retained and didn't

dissipate even after a lengthy period of time. The white cotton type gloves also meet the specification.

IEC 61340-5-1 paragraph 5.2.6 Gloves and finger cots "Gloves and finger cots, as worn, shall be in compliance with table 1 [Charge decay to 10% of initial value (maximum 1 000 V) in less than 2 s]."

Wrist Straps with current limiting resistor worn and grounded. Tested daily to R_g $7,5 \times 10^5$ to $3,5 \times 10^7$ ohms.

Wrist straps are available for use. Wrist straps in this area as with the other cleanrooms are left in the clean area and are not subject to testing before entry into the area. Wrist straps must be tested at least daily to ensure that they are working properly. As the floor was shown not be grounding the personnel in this area it is essential that the wrist straps are tested and proved to be working, as this is the only means of grounding personnel handling ESDs in this area.

IEC 61340-5-1 paragraph 5.5 EPA working practices "The primary means of grounding personnel shall normally be by a wrist strap connected to an EBP." Paragraph 5.2.7 "The wrist strap shall consist of a band that fits snugly around the wrist and a cord to connect the band to an EBP. The wrist strap shall incorporate a quick release connection. The cord shall have a termination compatible with the EBP and shall incorporate at least one insulated current-limiting resistor. The total resistance from hand to EBP shall be in accordance with table 1 [R_g $7,5 \times 10^5$ to $3,5 \times 10^7$ ohms]. IEC 61340-5-2: Paragraph 5.1.1 General "A nominal 1 megohm resistor is commonly used in wrist straps and to ground work surfaces. In the event of an operator touching an energized conductor, for the normal mains electricity supplies this resistor will limit the current flowing through the person to less than 0,5 mA. Current limiting or cut-off devices should also be considered and in some areas may be demanded by legislation."

Foot Grounders used in conjunction with ESD Floor touch tested daily prior to entering EPA. R_g be between $7,5 \times 10^5$ ohms and $3,5 \times 10^7$ ohms.

Each person working in this area wears two foot grounders which are tested before entry into the area. Whilst the foot grounders are tested and approved for use they are not grounding the personnel as the floor is insulative.

IEC 61340-5-1 paragraph 5.2.8 "Footwear shall be constructed in such a way that for each item, the resistance to EPA ground from wearer shall be in accordance with table 1. Table 1 NOTE 2 - When the footwear/floor systems are used as the primary means of grounding personnel, the resistance of the combination shall be determined by the ESD co-ordinator, and is recommended to be between $7,5 \times 10^5$ ohms and $3,5 \times 10^7$ ohms." IEC 61340-5-1 paragraph 5.5 EPA working practices "When the use of a wrist strap system is impractical, the [ESD] floor and [ESD] footwear shall be the primary means of ESD control." Per IEC 61340 5-1 Daily checks, paragraph 9.6.3 Non-permanent footwear "All wearers shall check that their heel and toe straps meet requirements. The check shall be made before entering the EPA."

Check Ground to EPA ground bonding point (EBP) and EPA ground facility; recommend hard ground less than 2 ohms.

Mains earth is used for grounding via an EBP plug. We noted a few very old green EBP plugs which when tested were shown not to be working and should be replaced.

IEC 61340-5-1 paragraph 5.3.2 "The EPA ground facility shall be connected to EPA ground and provide a low resistance path to EPA ground (<2 ohms). When available, the mains protective earth shall be used. Paragraph 5.3.3 "An easily accessible dedicated EBP [EPA ground bonding point] for the wrist strap shall be established adjacent to each working area, or working surface. A sufficient number of EBP shall be provided for operators and visitors." Paragraph 5.3.4 "EPA ground cords shall be used to make electrical connections between groundable points and the EPA ground facility."

Paperwork in static dissipative Document Holders.

Paperwork and build instructions were scattered over all the workbenches. All paperwork that is on the workbench needs to be inside a static dissipative document holder.

IEC 61340-5-1 "Paperwork inside the EPA shall either be kept in containers conforming to the requirements of table 2 or shall not generate a field in excess of that specified in paragraph 5.3.5 [ESDS should not be exposed to electrostatic fields in excess of 10 kV/m]." Insulative paper, placed upon ESD protected worksurface, can easily interrupt path-to-ground.

For Packaging Outside EPA, use Shielding Bags or other ESD packaging for transportation or storage of ESD sensitive items.

All ESD sensitive items are transported around the facility in static shielding bags and conductive boxes.

IEC 61340 5-1 paragraph 6 Protective packaging states "The primary functions of protective packaging outside the ESD Protected Area are to: limit tribo-electric charging, provide shielding against electrostatic fields and discharges, [and] the packaging shall be capable of providing charge drainage to EPA ground when brought into an EPA. Per paragraph 4.1.2 "identified with ESD packaging symbol, manufacturer, and batch identification number". IEC 61340-5-1 Table 2 "Intimate: Either low-charging and electrostatic conductive or low-charging and electrostatic dissipative (for powered ESDS only low-charging and electrostatic dissipative above 1×10^8 ohm shall be used). Proximity: Electrostatic discharge shielding."

For Packaging Within EPA: 1) non-ESD items in low charging & ESDS [even if defective] in low charging & dissipative packaging 2) non-ESD packaging prohibited.

All ESDS are stored in this area in either static shielding bags or conductive boxes.

Note: Per IEC 61340 5-1 paragraph 7.3 "ESDS found to be faulty shall be protected in the same manner as any other ESDS up to the time of disposal." All non-ESDS items brought into an ESD Protected Area shall be packed in low charging, dissipative ESD packaging. "The outer surface of all proximity packaging brought into an EPA shall not be insulating." "Non-ESD protective packaging material shall not be taken into an EPA."
IEC 61340-5-1 paragraph 5.5 EPA working practices "All non-ESDS items brought into EPA shall be packed in accordance with table 2 which is minimum of "low-charging." Packaging per Table 2 for ESDS brought into EPA is "Intimate: Either low-charging and electrostatic conductive or low-charging and electrostatic dissipative (for powered ESDS only low-charging and electrostatic dissipative above 1×10^8 ohm shall be used). Proximity: Low-charging and Electrostatic discharge shielding or low-charging and electrostatic conductive or electrostatic dissipative."

Area of Facility:

RF Lab G01

ESD Protected Area Clearly Identified using signs, aisle tape & EPA bonding points labeled.

The area is clearly identified as an EPA, but would certainly benefit from a few more awareness signs being placed in the area.

IEC 61340-5-1 paragraph 4.3 Signs for ESD protected areas (EPA) ESD sensitivity symbol "Sign(s) ... shall be clearly visible to personnel before they enter the EPA and, where applicable, from inside the EPA. Where applicable, signs ... shall mark the EPA boundary." Paragraph 4.4 Marking of EPA bonding points (EBP) "All EBP shall be marked or labelled." Per IEC 61340-5-2 paragraph 5.1.1 "The boundaries of the EPA need defining and will vary between different types of EPA, but will typically have coloured (but not electrostatic generative) markings on the floor."

Access to ESD Protected Area controlled

Access to this area is strictly controlled.

IEC 61340-5-1 paragraph 5.5 EPA working practices "All persons, including visitors, entering the EPA shall comply with the requirements of this subclause" [grounded via wrist strap or ESD footwear, properly wearing ESD garments, paperwork in static dissipative document holders].

Working Surfaces and storage racks, Rp 10^4 to 10^9 ohms, Rg $7,5 \times 10^6$ to 1×10^9 ohms.
ESD Mat Cleaner used.

The work surfaces in this area are laminate with static dissipative matting placed on top. Random testing of the static dissipative mats was carried out with the following results noted:

4.1×10^7 Rp

3.2×10^7 Rg

The storage racks in this area are metal and grounded.

ESDS are also stored in metal cabinets.

IEC 61340-5-1 paragraph 5.2.2 Working surfaces and storage racks "All working surfaces and storage racks on which unprotected ESDS may be placed shall be capable of being connected to EPA ground and shall have a point-to-point resistance and resistance to EPA ground in accordance with table 1 [Rp greater or equal to 1×10^4 , less than or equal to 1×10^9 ohms, and Rg greater or equal to $7,5 \times 10^5$ to less than or equal to 1×10^9 ohms]." Conductive materials conduct electricity too rapidly and a discharge may occur. Dissipative materials will drain the charges off an ESDS device at a slow enough rate to minimize the occurrence of discharges. Dirt & cleaners containing silicone are insulative and a dissipative ESD worksurface cannot fulfil its function if covered by insulative material

ESD Floors, Rg less than or equal 1×10^9 ohms. If primary means of grounding personnel, Rg $7,5 \times 10^5$ to $3,5 \times 10^7$ ohms. Floor clean.

Floor measured 5.8×10^6 and is within spec.

IEC 61340-5-1 paragraph 5.2.3 Floors "All floor surfaces shall have a surface-to-EPA ground resistance in accordance with table 1. Table 1 NOTE 2 - When the footwear/floor systems are used as the primary means of grounding personnel, the resistance of the combination shall be determined by the ESD co-ordinator, and is recommended to be between $7,5 \times 10^5$ ohms and $3,5 \times 10^7$ ohms." IEC 61340-5-1 paragraph 5.5 EPA working practices "When the use of a wrist strap system is impractical, the [ESD] floor and [ESD] footwear shall be the primary means of ESD control." Dirt is typically insulative and a dissipative ESD protected floor cannot fulfil its function if covered by insulative material.

ESD Seating, Rg less than or equal to 1×10^{10} ohms. If ESD floor grounding, minimum of two paths-to-ground.

ESD safe seating is used in this area. When measured it had an Rg of less than 1×10^{10} which is within specification.

IEC 61340-5-1 paragraph 5.2.4 Seating "The resistance from all areas of seating which may have human body contact when in normal use, to either a floor contact point or a groundable point, shall be as specified in table 1 [Rg less than or equal to 1×10^{10} ohms]. When the floor is used as part of a grounding system, a minimum of two wheels or two feet shall provide a path to EPA ground."

ESD Protective Smocks used to cover arms and torso, Rg less than or equal 1×10^{12} ohms. Charge decay to less than 10% of original value (maximum 1,000 V). ESD Smocks marked with ESD protective symbol and properly fastened.

ESD protective smocks are not used in this area.

IEC 61340-5-1 paragraph 5.2.5 Garments "Coats, jackets, smocks and overalls shall completely cover all clothing in the area of the arms and torso. There shall be electrical continuity between all parts of the garment. Garments shall have characteristics on the outward facing surface in accordance with table 1 [Rp less than or equal to 1×10^{12} ohms; Charge decay to 10% of initial value (maximum 1 000 V) in less than 2 s]. Garments complying with ESD requirements shall be clearly marked. NOTE - Marking with the ESD [protective] symbol ... is recommended." IEC 61340-5-1 paragraph 5.5 EPA working practices "When used, garments in accordance with 5.2.5 shall be worn and shall be properly fastened at all times."

ESD Gloves and Finger Cots, Charge decay to less than 10% of original value (maximum 1,000 V).

Two styles of gloves are used in this area. To meet the European specification, gloves should charge decay to less than 10% of the original value. The white coloured gloves meet the specification, however, the yellow coloured gloves were seen to carry a charge in excess of 5,000 volts which it retained and didn't dissipate even after a lengthy period of time.

IEC 61340-5-1 paragraph 5.2.6 Gloves and finger cots "Gloves and finger cots, as worn, shall be in compliance with table 1 [Charge decay to 10% of initial value (maximum 1 000 V) in less than 2 s].

Wrist Straps with current limiting resistor worn and grounded. Tested daily to Rg $7,5 \times 10^5$ to $3,5 \times 10^7$ ohms.

Wrist straps are available for use and are tested daily with a log of the results kept.

IEC 61340-5-1 paragraph 5.5 EPA working practices "The primary means of grounding personnel shall normally be by a wrist strap connected to an EBP." Paragraph 5.2.7 "The wrist strap shall consist of a band that fits snugly around the wrist and a cord to connect the band to an EBP. The wrist strap shall incorporate a quick release connection. The cord shall have a termination compatible with the EBP and shall incorporate at least one insulated current-limiting resistor. The total resistance from hand to EBP shall be in accordance with table 1 [Rg 7,5 x 10⁵ to 3,5 x 10⁷ ohms]. IEC 61340-5-2: Paragraph 5.1.1 General "A nominal 1 megohm resistor is commonly used in wrist straps and to ground work surfaces. In the event of an operator touching an energized conductor, for the normal mains electricity supplies this resistor will limit the current flowing through the person to less than 0,5 mA. Current limiting or cut-off devices should also be considered and in some areas may be demanded by legislation."

Foot Grounders used in conjunction with ESD Floor touch tested daily prior to entering EPA. Rg be between 7,5 x 10⁵ ohms and 3,5 x 10⁷ ohms.

Foot grounders are not used in this area

IEC 61340-5-1 paragraph 5.2.8 "Footwear shall be constructed in such a way that for each item, the resistance to EPA ground from wearer shall be in accordance with table 1. Table 1 NOTE 2 - When the footwear/floor systems are used as the primary means of grounding personnel, the resistance of the combination shall be determined by the ESD co-ordinator, and is recommended to be between 7,5 x 10⁵ ohms and 3,5 x 10⁷ ohms." IEC 61340-5-1 paragraph 5.5 EPA working practices "When the use of a wrist strap system is impractical, the [ESD] floor and [ESD] footwear shall be the primary means of ESD control." Per IEC 61340 5-1 Daily checks, paragraph 9.6.3 Non-permanent footwear "All wearers shall check that their heel and toe straps meet requirements. The check shall be made before entering the EPA."

Trolleys / equipment grounded; Rp 10⁴ to 10⁹ ohms, Rg 7,5 x 10⁶ to 1 x 10⁹ ohms.

Trolleys are used in this area and are grounded and within spec.

IEC 61340-5-1 paragraph 5.2.11 Trolleys and carts "When used for transporting unprotected ESIDS or as portable work surfaces, they shall conform to the requirements of 5.2.2 [Working surfaces and storage racks 'All working surfaces and storage racks on which unprotected ESIDS may be placed shall be capable of being connected to EPA ground and shall have a point-to-point resistance and resistance to EPA ground in accordance with table 1 [Rp greater or equal to 1 x 10⁴, less than or equal to 1 x 10⁹ ohms, and Rg greater or equal to 7,5 x 10⁵ to less than or equal to 1 x 10⁹ ohms]' and shall contain a groundable point.

Check Ground to EPA ground bonding point (EBP) and EPA ground facility; recommend hard ground less than 2 ohms.

Mains earth is used for grounding via EBP plugs.

IEC 61340-5-1 paragraph 5.3.2 "The EPA ground facility shall be connected to EPA ground and provide a low resistance path to EPA ground (<2 ohms). When available, the mains protective earth shall be used. Paragraph 5.3.3 "An easily accessible dedicated EBP [EPA ground bonding point] for the wrist strap shall be established adjacent to each working area, or working surface. A sufficient number of EBP shall be provided for operators and visitors." Paragraph 5.3.4 "EPA ground cords shall be used to make electrical connections between groundable points and the EPA ground facility."

Paperwork in static dissipative Document Holders.

Insulative paper interfering with path to ground when ESDS placed upon paper and not ESD Mat. Instructions placed in dissipative document holders provide a path to ground.

IEC 61340-5-1 "Paperwork inside the EPA shall either be kept in containers conforming to the requirements of table 2 or shall not generate a field in excess of that specified in paragraph 5.3.5 [ESDS should not be exposed to electrostatic fields in excess of 10 kV/m]." Insulative paper, placed upon ESD protected worksurface, can easily interrupt path-to-ground.

For Packaging Outside EPA, use Shielding Bags or other ESD packaging for transportation or storage of ESD sensitive items.

All ESD sensitive items are transported around the facility in static shielding bags and conductive boxes.

IEC 61340 5-1 paragraph 6 Protective packaging states "The primary functions of protective packaging outside the ESD Protected Area are to: limit tribo-electric charging, provide shielding against electrostatic fields and discharges, [and] the packaging shall be capable of providing charge drainage to EPA ground when brought into an EPA. Per paragraph 4.1.2 "identified with ESD packaging symbol, manufacturer, and batch identification number". IEC 61340-5-1 Table 2 "Intimate: Either low-charging and electrostatic conductive or low-charging and electrostatic dissipative (for powered ESDS only low-charging and electrostatic dissipative above 1×10^8 ohm shall be used). Proximity: Electrostatic discharge shielding."

For Packaging Within EPA: 1) non-ESD items in low charging & ESDS [even if defective] in low charging & dissipative packaging 2) non-ESD packaging prohibited.

All ESDS are stored in this area in either static shielding bags or conductive boxes.

Note: Per IEC 61340 5-1 paragraph 7.3 "ESDS found to be faulty shall be protected in the same manner as any other ESDS up to the time of disposal." All non-ESDS items brought into an ESD Protected Area shall be packed in low charging, dissipative ESD packaging. "The outer surface of all proximity packaging brought into an EPA shall not be insulating." "Non-ESD protective packaging material shall not be taken into an EPA."
IEC 61340-5-1 paragraph 5.5 EPA working practices "All non-ESDS items brought into EPA shall be packed in accordance with table 2 which is minimum of "low-charging." Packaging per Table 2 for ESDS brought into EPA is "Intimate: Either low-charging and electrostatic conductive or low-charging and electrostatic dissipative (for powered ESDS only low-charging and electrostatic dissipative above 1×10^8 ohm shall be used). Proximity: Low-charging and Electrostatic discharge shielding or low-charging and electrostatic conductive or electrostatic dissipative."

Area of Facility:

**G9 – G10 – Ground Station Lab
All the above areas have been reported together.**

ESD Protected Area Clearly Identified using signs, aisle tape & EPA bonding points labeled.

The area is clearly identified as an EPA.

IEC 61340-5-1 paragraph 4.3 Signs for ESD protected areas (EPA) ESD sensitivity symbol "Sign(s) ... shall be clearly visible to personnel before they enter the EPA and, where applicable, from inside the EPA. Where applicable, signs ... shall mark the EPA boundary." Paragraph 4.4 Marking of EPA bonding points (EBP) "All EBP shall be marked or labelled." Per IEC 61340-5-2 paragraph 5.1.1 "The boundaries of the EPA need defining and will vary between different types of EPA, but will typically have coloured (but not electrostatic generative) markings on the floor."

Access to ESD Protected Area controlled

Access to this area is strictly controlled.

IEC 61340-5-1 paragraph 5.5 EPA working practices "All persons, including visitors, entering the EPA shall comply with the requirements of this subclause" [grounded via wrist strap or ESD footwear, properly wearing ESD garments, paperwork in static dissipative document holders].

Working Surfaces and storage racks, Rp 10^4 to 10^9 ohms, Rg $7,5 \times 10^6$ to 1×10^9 ohms.
ESD Mat Cleaner used.

The work surfaces in this area are laminate with static dissipative matting placed on top. Random testing of the static dissipative mats was carried out with the following results noted:

**5.7×10^7 Rp
 6.9×10^7 Rg**

IEC 61340-5-1 paragraph 5.2.2 Working surfaces and storage racks "All working surfaces and storage racks on which unprotected ESDS may be placed shall be capable of being connected to EPA ground and shall have a point-to-point resistance and resistance to EPA ground in accordance with table 1 [Rp greater or equal to 1×10^4 , less than or equal to 1×10^9 ohms, and Rg greater or equal to $7,5 \times 10^5$ to less than or equal to 1×10^9 ohms]." Conductive materials conduct electricity too rapidly and a discharge may occur. Dissipative materials will drain the charges off an ESDS device at a slow enough rate to minimize the occurrence of discharges. Dirt & cleaners containing silicone are insulative and a dissipative ESD worksurface cannot fulfil its function if covered by insulative material

ESD Floors, Rg less than or equal to 1×10^9 ohms. If primary means of grounding personnel, Rg $7,5 \times 10^5$ to $3,5 \times 10^7$ ohms. Floor clean.

All the floors in these areas were tested, G10 and the Ground Station Lab floors were below 10^9 and within spec but should not be used as the primary means of grounding personnel. The floor in G9 measured 1.5×10^{10} which is out of spec and should be cleaned and re-tested.

IEC 61340-5-1 paragraph 5.2.3 Floors "All floor surfaces shall have a surface-to-EPA ground resistance in accordance with table 1. Table 1 NOTE 2 - When the footwear/floor systems are used as the primary means of grounding personnel, the resistance of the combination shall be determined by the ESD co-ordinator, and is recommended to be between $7,5 \times 10^5$ ohms and $3,5 \times 10^7$ ohms." IEC 61340-5-1 paragraph 5.5 EPA working practices "When the use of a wrist strap system is impractical, the [ESD] floor and [ESD] footwear shall be the primary means of ESD control." Dirt is typically insulative and a dissipative ESD protected floor cannot fulfil its function if covered by insulative material.

ESD Seating, Rg less than or equal to 1×10^{10} ohms. If ESD floor grounding, minimum of two paths-to-ground.

ESD safe seating is used in G9 and G10 and when tested is within spec. ESD safe seating is not used in the Ground Station Lab.

IEC 61340-5-1 paragraph 5.2.4 Seating "The resistance from all areas of seating which may have human body contact when in normal use, to either a floor contact point or a groundable point, shall be as specified in table 1 [Rg less than or equal to 1×10^{10} ohms]. When the floor is used as part of a grounding system, a minimum of two wheels or two feet shall provide a path to EPA ground."

ESD Protective Smocks used to cover arms and torso, Rg less than or equal 1×10^{12} ohms. Charge decay to less than 10% of original value (maximum 1,000 V). ESD Smocks marked with ESD protective symbol and properly fastened.

ESD protective smocks are not used.

IEC 61340-5-1 paragraph 5.2.5 Garments "Coats, jackets, smocks and overalls shall completely cover all clothing in the area of the arms and torso. There shall be electrical continuity between all parts of the garment. Garments shall have characteristics on the outward facing surface in accordance with table 1 [Rp less than or equal to 1×10^{12} ohms; Charge decay to 10% of initial value (maximum 1 000 V) in less than 2 s]. Garments complying with ESD requirements shall be clearly marked. NOTE - Marking with the ESD [protective] symbol ... is recommended." IEC 61340-5-1 paragraph 5.5 EPA working practices "When used, garments in accordance with 5.2.5 shall be worn and shall be properly fastened at all times."

Wrist Straps with current limiting resistor worn and grounded. Tested daily to Rg $7,5 \times 10^5$ to $3,5 \times 10^7$ ohms.

Wrist Straps are available for use and tested on a daily basis.

IEC 61340-5-1 paragraph 5.5 EPA working practices "The primary means of grounding personnel shall normally be by a wrist strap connected to an EBP." Paragraph 5.2.7 "The wrist strap shall consist of a band that fits snugly around the wrist and a cord to connect the band to an EBP. The wrist strap shall incorporate a quick release connection. The cord shall have a termination compatible with the EBP and shall incorporate at least one insulated current-limiting resistor. The total resistance from hand to EBP shall be in accordance with table 1 [Rg $7,5 \times 10^5$ to $3,5 \times 10^7$ ohms]. IEC 61340-5-2: Paragraph 5.1.1 General "A nominal 1 megohm resistor is commonly used in wrist straps and to ground work surfaces. In the event of an operator touching an energized conductor, for the normal mains electricity supplies this resistor will limit the current flowing through the person to less than 0,5 mA. Current limiting or cut-off devices should also be considered and in some areas may be demanded by legislation."

Foot Grounders used in conjunction with ESD Floor touch tested daily prior to entering EPA. Rg be between $7,5 \times 10^5$ ohms and $3,5 \times 10^7$ ohms.

Foot grounders are not used in these areas.

IEC 61340-5-1 paragraph 5.2.8 "Footwear shall be constructed in such a way that for each item, the resistance to EPA ground from wearer shall be in accordance with table 1. Table 1 NOTE 2 - When the footwear/floor systems are used as the primary means of grounding personnel, the resistance of the combination shall be determined by the ESD co-ordinator, and is recommended to be between $7,5 \times 10^5$ ohms and $3,5 \times 10^7$ ohms." IEC 61340-5-1 paragraph 5.5 EPA working practices "When the use of a wrist strap system is impractical, the [ESD] floor and [ESD] footwear shall be the primary means of ESD control." Per IEC 61340 5-1 Daily checks, paragraph 9.6.3 Non-permanent footwear "All wearers shall check that their heel and toe straps meet requirements. The check shall be made before entering the EPA."

Ionizers to reduce charges on insulators to less than 100 volts in less than 20 seconds.

In all areas insulative plastic containers were in evidence, which when tested were found to contain significantly high voltage levels. If these containers are essential any charges on the should be neutralised using ionisers.

IEC 61340-5-1 paragraph 5.2.9 "Ionizers shall enable either polarity of charge on items to be brought down and maintained to less than 100 V in accordance with table 1 [To decay from 1 000 V to 100 V in 20 s maximum]."

Check Ground to EPA ground bonding point (EBP) and EPA ground facility; recommend hard ground less than 2 ohms.

Mains earth is used for grounding via EBP plugs.

IEC 61340-5-1 paragraph 5.3.2 "The EPA ground facility shall be connected to EPA ground and provide a low resistance path to EPA ground (<2 ohms). When available, the mains protective earth shall be used. Paragraph 5.3.3 "An easily accessible dedicated EBP [EPA ground bonding point] for the wrist strap shall be established adjacent to each working area, or working surface. A sufficient number of EBP shall be provided for operators and visitors." Paragraph 5.3.4 "EPA ground cords shall be used to make electrical connections between groundable points and the EPA ground facility."

Paperwork in static dissipative Document Holders.

Paperwork and build instructions were scattered over all the workbenches. All paperwork that is on the workbench needs to be inside a static dissipative document holder.

IEC 61340-5-1 "Paperwork inside the EPA shall either be kept in containers conforming to the requirements of table 2 or shall not generate a field in excess of that specified in paragraph 5.3.5 [ESDS should not be exposed to electrostatic fields in excess of 10 kV/m]." Insulative paper, placed upon ESD protected worksurface, can easily interrupt path-to-ground.

For Packaging Outside EPA, use Shielding Bags or other ESD packaging for transportation or storage of ESD sensitive items.

All ESD sensitive items are transported around the facility in static shielding bags and conductive boxes.

IEC 61340 5-1 paragraph 6 Protective packaging states "The primary functions of protective packaging outside the ESD Protected Area are to: limit tribo-electric charging, provide shielding against electrostatic fields and discharges, [and] the packaging shall be capable of providing charge drainage to EPA ground when brought into an EPA. Per paragraph 4.1.2 "identified with ESD packaging symbol, manufacturer, and batch identification number". IEC 61340-5-1 Table 2 "Intimate: Either low-charging and electrostatic conductive or low-charging and electrostatic dissipative (for powered ESDS only low-charging and electrostatic dissipative above 1×10^8 ohm shall be used). Proximity: Electrostatic discharge shielding."

For Packaging Within EPA: 1) non-ESD items in low charging & ESDS [even if defective] in low charging & dissipative packaging 2) non-ESD packaging prohibited.

All ESDS are stored in these areas in static shielding bags or conductive boxes.

Note: Per IEC 61340 5-1 paragraph 7.3 "ESDS found to be faulty shall be protected in the same manner as any other ESDS up to the time of disposal." All non-ESDS items brought into an ESD Protected Area shall be packed in low charging, dissipative ESD packaging. "The outer surface of all proximity packaging brought into an EPA shall not be insulating." "Non-ESD protective packaging material shall not be taken into an EPA."
IEC 61340-5-1 paragraph 5.5 EPA working practices "All non-ESDS items brought into EPA shall be packed in accordance with table 2 which is minimum of "low-charging." Packaging per Table 2 for ESDS brought into EPA is "Intimate: Either low-charging and electrostatic conductive or low-charging and electrostatic dissipative (for powered ESDS only low-charging and electrostatic dissipative above 1×10^8 ohm shall be used). Proximity: Low-charging and Electrostatic discharge shielding or low-charging and electrostatic conductive or electrostatic dissipative."

Area of Facility:

Sun Sensor

ESD Protected Area Clearly Identified using signs, aisle tape & EPA bonding points labeled.

This area is not clearly identified as an EPA

IEC 61340-5-1 paragraph 4.3 Signs for ESD protected areas (EPA) ESD sensitivity symbol "Sign(s) ...shall be clearly visible to personnel before they enter the EPA and, where applicable, from inside the EPA. Where applicable, signs ... shall mark the EPA boundary." Paragraph 4.4 Marking of EPA bonding points (EBP) "All EBP shall be marked or labelled." Per IEC 61340-5-2 paragraph 5.1.1 "The boundaries of the EPA need defining and will vary between different types of EPA, but will typically have coloured (but not electrostatic generative) markings on the floor."

Access to ESD Protected Area controlled

Access to this area is controlled

IEC 61340-5-1 paragraph 5.5 EPA working practices "All persons, including visitors, entering the EPA shall comply with the requirements of this subclause" [grounded via wrist strap or ESD footwear, properly wearing ESD garments, paperwork in static dissipative document holders].

Working Surfaces and storage racks, Rp 10^4 to 10^9 ohms, Rg $7,5 \times 10^6$ to 1×10^9 ohms.
ESD Mat Cleaner used.

The ESD safe mat in this area measured 1.7×10^8 and is within spec.

IEC 61340-5-1 paragraph 5.2.2 Working surfaces and storage racks "All working surfaces and storage racks on which unprotected ESDS may be placed shall be capable of being connected to EPA ground and shall have a point-to-point resistance and resistance to EPA ground in accordance with table 1 [Rp greater or equal to 1×10^4 , less than or equal to 1×10^9 ohms, and Rg greater or equal to $7,5 \times 10^5$ to less than or equal to 1×10^9 ohms]." Conductive materials conduct electricity too rapidly and a discharge may occur. Dissipative materials will drain the charges off an ESDS device at a slow enough rate to minimize the occurrence of discharges. Dirt & cleaners containing silicone are insulative and a dissipative ESD worksurface cannot fulfil its function if covered by insulative material

ESD Floors, Rg less than or equal 1×10^9 ohms. If primary means of grounding personnel, Rg $7,5 \times 10^5$ to $3,5 \times 10^7$ ohms. Floor clean.

The floor in this area measured $>10^{10}$ and is therefore not in spec.

IEC 61340-5-1 paragraph 5.2.3 Floors "All floor surfaces shall have a surface-to-EPA ground resistance in accordance with table 1. Table 1 NOTE 2 - When the footwear/floor systems are used as the primary means of grounding personnel, the resistance of the combination shall be determined by the ESD co-ordinator, and is recommended to be between $7,5 \times 10^5$ ohms and $3,5 \times 10^7$ ohms." IEC 61340-5-1 paragraph 5.5 EPA working practices "When the use of a wrist strap system is impractical, the [ESD] floor and [ESD] footwear shall be the primary means of ESD control." Dirt is typically insulative and a dissipative ESD protected floor cannot fulfil its function if covered by insulative material.

ESD Seating, Rg less than or equal to 1×10^{10} ohms. If ESD floor grounding, minimum of two paths-to-ground.

ESD safe seating is not used in this area.

IEC 61340-5-1 paragraph 5.2.4 Seating "The resistance from all areas of seating which may have human body contact when in normal use, to either a floor contact point or a groundable point, shall be as specified in table 1 [Rg less than or equal to 1×10^{10} ohms]. When the floor is used as part of a grounding system, a minimum of two wheels or two feet shall provide a path to EPA ground."

ESD Protective Smocks used to cover arms and torso, Rg less than or equal 1×10^{12} ohms. Charge decay to less than 10% of original value (maximum 1,000 V). ESD Smocks marked with ESD protective symbol and properly fastened.

ESD protective smocks are not used.

IEC 61340-5-1 paragraph 5.2.5 Garments "Coats, jackets, smocks and overalls shall completely cover all clothing in the area of the arms and torso. There shall be electrical continuity between all parts of the garment. Garments shall have characteristics on the outward facing surface in accordance with table 1 [Rp less than or equal to 1×10^{12} ohms; Charge decay to 10% of initial value (maximum 1 000 V) in less than 2 s]. Garments complying with ESD requirements shall be clearly marked. NOTE - Marking with the ESD [protective] symbol ... is recommended." IEC 61340-5-1 paragraph 5.5 EPA working practices "When used, garments in accordance with 5.2.5 shall be worn and shall be properly fastened at all times."

Wrist Straps with current limiting resistor worn and grounded. Tested daily to Rg $7,5 \times 10^5$ to $3,5 \times 10^7$ ohms.

Wrist straps are available for use but a wrist strap tester is not available for use.

IEC 61340-5-1 paragraph 5.5 EPA working practices "The primary means of grounding personnel shall normally be by a wrist strap connected to an EBP." Paragraph 5.2.7 "The wrist strap shall consist of a band that fits snugly around the wrist and a cord to connect the band to an EBP. The wrist strap shall incorporate a quick release connection. The cord shall have a termination compatible with the EBP and shall incorporate at least one insulated current-limiting resistor. The total resistance from hand to EBP shall be in accordance with table 1 [Rg $7,5 \times 10^5$ to $3,5 \times 10^7$ ohms]. IEC 61340-5-2: Paragraph 5.1.1 General "A nominal 1 megohm resistor is commonly used in wrist straps and to ground work surfaces. In the event of an operator touching an energized conductor, for the normal mains electricity supplies this resistor will limit the current flowing through the person to less than 0,5 mA. Current limiting or cut-off devices should also be considered and in some areas may be demanded by legislation."

Foot Grounders used in conjunction with ESD Floor touch tested daily prior to entering EPA. Rg be between $7,5 \times 10^5$ ohms and $3,5 \times 10^7$ ohms.

Foot grounders are not used.

IEC 61340-5-1 paragraph 5.2.8 "Footwear shall be constructed in such a way that for each item, the resistance to EPA ground from wearer shall be in accordance with table 1. Table 1 NOTE 2 - When the footwear/floor systems are used as the primary means of grounding personnel, the resistance of the combination shall be determined by the ESD co-ordinator, and is recommended to be between $7,5 \times 10^5$ ohms and $3,5 \times 10^7$ ohms." IEC 61340-5-1 paragraph 5.5 EPA working practices "When the use of a wrist strap system is impractical, the [ESD] floor and [ESD] footwear shall be the primary means of ESD control." Per IEC 61340 5-1 Daily checks, paragraph 9.6.3 Non-permanent footwear "All wearers shall check that their heel and toe straps meet requirements. The check shall be made before entering the EPA."

Check Ground to EPA ground bonding point (EBP) and EPA ground facility; recommend hard ground less than 2 ohms.

Mains earth is used for grounding.

IEC 61340-5-1 paragraph 5.3.2 "The EPA ground facility shall be connected to EPA ground and provide a low resistance path to EPA ground (<2 ohms). When available, the mains protective earth shall be used. Paragraph 5.3.3 "An easily accessible dedicated EBP [EPA ground bonding point] for the wrist strap shall be established adjacent to each working area, or working surface. A sufficient number of EBP shall be provided for operators and visitors." Paragraph 5.3.4 "EPA ground cords shall be used to make electrical connections between groundable points and the EPA ground facility."

Paperwork in static dissipative Document Holders.

Paperwork and build instructions were scattered over all the workbenches. All paperwork that is on the workbench needs to be inside a static dissipative document holder.

IEC 61340-5-1 "Paperwork inside the EPA shall either be kept in containers conforming to the requirements of table 2 or shall not generate a field in excess of that specified in paragraph 5.3.5 [ESDS should not be exposed to electrostatic fields in excess of 10 kV/m]." Insulative paper, placed upon ESD protected worksurface, can easily interrupt path-to-ground.

For Packaging Outside EPA, use Shielding Bags or other ESD packaging for transportation or storage of ESD sensitive items.

All ESD sensitive items are transported around the facility in static shielding bags and conductive boxes.

IEC 61340 5-1 paragraph 6 Protective packaging states "The primary functions of protective packaging outside the ESD Protected Area are to: limit tribo-electric charging, provide shielding against electrostatic fields and discharges, [and] the packaging shall be capable of providing charge drainage to EPA ground when brought into an EPA. Per paragraph 4.1.2 "identified with ESD packaging symbol, manufacturer, and batch identification number". IEC 61340-5-1 Table 2 "Intimate: Either low-charging and electrostatic conductive or low-charging and electrostatic dissipative (for powered ESDS only low-charging and electrostatic dissipative above 1×10^8 ohm shall be used). Proximity: Electrostatic discharge shielding."

For Packaging Within EPA: 1) non-ESD items in low charging & ESDS [even if defective] in low charging & dissipative packaging 2) non-ESD packaging prohibited.

All ESDS are stored in these areas in static shielding bags or conductive boxes.

Note: Per IEC 61340 5-1 paragraph 7.3 "ESDS found to be faulty shall be protected in the same manner as any other ESDS up to the time of disposal." All non-ESDS items brought into an ESD Protected Area shall be packed in low charging, dissipative ESD packaging. "The outer surface of all proximity packaging brought into an EPA shall not be insulating." "Non-ESD protective packaging material shall not be taken into an EPA."
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Area of Facility:

Goods In and Stores G37

ESD Protected Area Clearly Identified using signs, aisle tape & EPA bonding points labeled.

The area is clearly identified as an EPA.

IEC 61340-5-1 paragraph 4.3 Signs for ESD protected areas (EPA) ESD sensitivity symbol "Sign(s) ... shall be clearly visible to personnel before they enter the EPA and, where applicable, from inside the EPA. Where applicable, signs ... shall mark the EPA boundary." Paragraph 4.4 Marking of EPA bonding points (EBP) "All EBP shall be marked or labelled." Per IEC 61340-5-2 paragraph 5.1.1 "The boundaries of the EPA need defining and will vary between different types of EPA, but will typically have coloured (but not electrostatic generative) markings on the floor."

Access to ESD Protected Area controlled

Access to this area is strictly controlled.

IEC 61340-5-1 paragraph 5.5 EPA working practices "All persons, including visitors, entering the EPA shall comply with the requirements of this subclause" [grounded via wrist strap or ESD footwear, properly wearing ESD garments, paperwork in static dissipative document holders].

Working Surfaces and storage racks, Rp 10^4 to 10^9 ohms, Rg $7,5 \times 10^6$ to 1×10^9 ohms.
ESD Mat Cleaner used.

The work surfaces in this area are laminate with static dissipative matting placed on top. Random testing of the static dissipative mats was carried out with the following results noted:

6.2×10^8 Rp

5.9×10^8 Rg

The storage racks in this area are metal and grounded.

IEC 61340-5-1 paragraph 5.2.2 Working surfaces and storage racks "All working surfaces and storage racks on which unprotected ESDS may be placed shall be capable of being connected to EPA ground and shall have a point-to-point resistance and resistance to EPA ground in accordance with table 1 [Rp greater or equal to 1×10^4 , less than or equal to 1×10^9 ohms, and Rg greater or equal to $7,5 \times 10^5$ to less than or equal to 1×10^9 ohms]." Conductive materials conduct electricity too rapidly and a discharge may occur. Dissipative materials will drain the charges off an ESDS device at a slow enough rate to minimize the occurrence of discharges. Dirt & cleaners containing silicone are insulative and a dissipative ESD worksurface cannot fulfil its function if covered by insulative material

ESD Floors, Rg less than or equal to 1×10^9 ohms. If primary means of grounding personnel, Rg $7,5 \times 10^5$ to $3,5 \times 10^7$ ohms. Floor clean.

This area has a static dissipative floor which measured 5.6×10^8 which is within spec. However, the floor should not be relied upon as the primary means of grounding personnel.

IEC 61340-5-1 paragraph 5.2.3 Floors "All floor surfaces shall have a surface-to-EPA ground resistance in accordance with table 1. Table 1 NOTE 2 - When the footwear/floor systems are used as the primary means of grounding personnel, the resistance of the combination shall be determined by the ESD co-ordinator, and is recommended to be between $7,5 \times 10^5$ ohms and $3,5 \times 10^7$ ohms." IEC 61340-5-1 paragraph 5.5 EPA working practices "When the use of a wrist strap system is impractical, the [ESD] floor and [ESD] footwear shall be the primary means of ESD control." Dirt is typically insulative and a dissipative ESD protected floor cannot fulfil its function if covered by insulative material.

ESD Seating, Rg less than or equal to 1×10^{10} ohms. If ESD floor grounding, minimum of two paths-to-ground.

ESD safe seating is used and when tested were found to be within spec.

IEC 61340-5-1 paragraph 5.2.4 Seating "The resistance from all areas of seating which may have human body contact when in normal use, to either a floor contact point or a groundable point, shall be as specified in table 1 [Rg less than or equal to 1×10^{10} ohms]. When the floor is used as part of a grounding system, a minimum of two wheels or two feet shall provide a path to EPA ground."

ESD Protective Smocks used to cover arms and torso, Rg less than or equal to 1×10^{12} ohms. Charge decay to less than 10% of original value (maximum 1,000 V). ESD Smocks marked with ESD protective symbol and properly fastened.

ESD protective smocks are not used.

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Wrist Straps with current limiting resistor worn and grounded. Tested daily to Rg $7,5 \times 10^5$ to $3,5 \times 10^7$ ohms.

Wrist straps are used and tested daily.

IEC 61340-5-1 paragraph 5.5 EPA working practices "The primary means of grounding personnel shall normally be by a wrist strap connected to an EBP." Paragraph 5.2.7 "The wrist strap shall consist of a band that fits snugly around the wrist and a cord to connect the band to an EBP. The wrist strap shall incorporate a quick release connection. The cord shall have a termination compatible with the EBP and shall incorporate at least one insulated current-limiting resistor. The total resistance from hand to EBP shall be in accordance with table 1 [Rg $7,5 \times 10^5$ to $3,5 \times 10^7$ ohms]. IEC 61340-5-2: Paragraph 5.1.1 General "A nominal 1 megohm resistor is commonly used in wrist straps and to ground work surfaces. In the event of an operator touching an energized conductor, for the normal mains electricity supplies this resistor will limit the current flowing through the person to less than 0,5 mA. Current limiting or cut-off devices should also be considered and in some areas may be demanded by legislation."

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Check Ground to EPA ground bonding point (EBP) and EPA ground facility; recommend hard ground less than 2 ohms.

Mains earth is used for grounding.

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For Packaging Within EPA: 1) non-ESD items in low charging & ESDS [even if defective] in low charging & dissipative packaging 2) non-ESD packaging prohibited.

All ESDS are stored in these areas in static shielding bags or conductive boxes.

Note: Per IEC 61340 5-1 paragraph 7.3 "ESDS found to be faulty shall be protected in the same manner as any other ESDS up to the time of disposal." All non-ESDS items brought into an ESD Protected Area shall be packed in low charging, dissipative ESD packaging. "The outer surface of all proximity packaging brought into an EPA shall not be insulating." "Non-ESD protective packaging material shall not be taken into an EPA."

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Area of Facility:

G42 & Heavy Structures Lab

Neither of these areas are established yet although it is anticipated that both these areas will be used for handling ESDS. The same ESD handling protection system as used in the RF lab should be used in these areas when established. It was stated during my visit that the floor is to be painted in the Heavy Structures Lab if that is the case we recommend that you use a Conductive paint to make the floor ESD safe. We will obviously be willing to give our advice on what is required in these areas to make them safe for ESDS handling.

RECOMMENDATIONS:

We'd like to invite you to become a Charleswater T.E.A.M. account where you can expect to receive quarterly or more frequent support to help you optimize your ESD control program. Although, we require nothing in writing, our expectation is that, in return, you will designate Charleswater as your preferred supplier for ESD protective products and test equipment and establish a QPL (Qualified Product List) which we will be happy to discuss with you during our follow-up meeting to this Survey report.

Summary

An efficient and cost effective ESD Control program should be treated as an on-going process, like any good quality control system. As such, it should never be treated as an event.

All ESD Control costs should provide the user with improved quality (finished products that pass final test without rework) and increased reliability (few returned items). Through improved quality and reliability, the user should achieve a Return On Investment (ROI) for every dollar spent. Lucent reports a 95:1 ROI for ESD Control. The range from other companies reported in articles is for a low of 5:1 to 20:1.

Major companies like IBM and HP state that 25% of all unidentified failure to electronics is a result of ESD. To maximize your ROI, highest loss operations, areas and products should be identified first. Then a corrective plan should be developed and evaluated. Once the corrective plan is determined, the ESD controls should be implemented and the resulting quality monitored. The effectiveness of the plan should then be evaluated and the plan refined if necessary. This process should be repeated as necessary until quality and reliability are at a level deemed acceptable to the company and their customers.

By keeping ESD Control an on-going quality process, program costs and resulting ROI can be monitored so that the company can maximize total program value.

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