ESD control-ESD control during manufacture

Principles of ESD prevention

ESD damage during manufacture can be prevented by adopting the following strategy:

- sensitive components are only handled in an ESD Protected Area (EPA)
- outside the EPA, components are protected by ESD packaging
- inside the EPA, electrostatic fields and voltages are maintained at a low level.

These principles lie at the heart of all ESD damage prevention standards.

All personnel and visitors must, without exception, comply with ESD requirements unless prevented by safety considerations.

If some part of a manufacturing process is subcontracted out, it is extremely important that ESD prevention measures are maintained throughout transport and the subcontractor's facility and processes. If parts are received in non-compliant packaging or have been handled in a non-compliant manner, they should be rejected, because they may be damaged.

Damaged or failed components that may be subjected to failure analysis must be packaged as usual for sensitive devices, or subsequent ESD damage may confuse the failure analysis results.

Keeping electrostatic fields and voltages to a low level

An ESD protected area (EPA) has the objective of keeping all electrostatic fields and voltages to an insignificant level. EN 61340-5-1 aims to protect devices down to 100V HBM sensitivity and recommends that electric fields are kept below 10kV/m, and voltages below 100V.

Minimisation of electric fields and voltages depends on the following strategies;

All non-essential insulating materials are excluded from the EPA

All conducting items are grounded – especially people!

Essential insulators are treated according to ESD risk. Often they may be neutralised by use of ionisers.

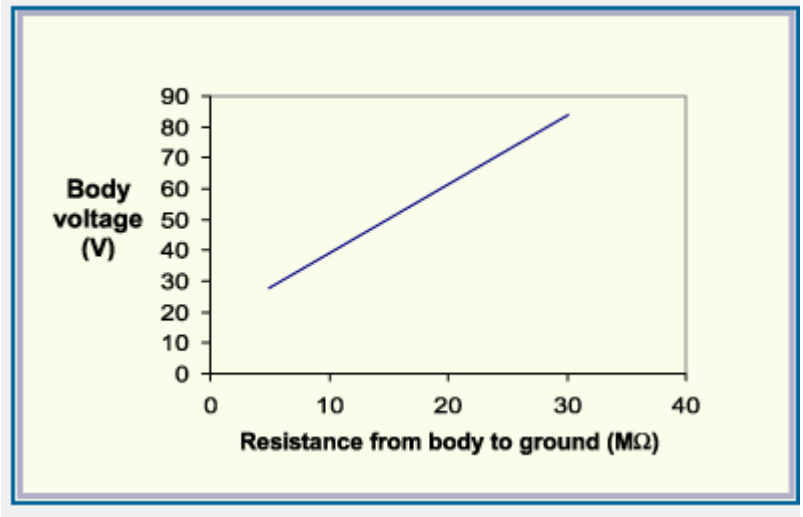
People and ESD

People are a primary source of damaging ESD. This is the reason that the human body model ESD is the main method of assessing ESD withstand voltage of components. It follows that it is of primary importance to maintain the electrostatic voltage developed on the operator's body at a low level within the EPA .

Providing a ground path to dissipate charge controls the operator's body voltage. Body voltage developed during everyday activity is a function of the body-to-ground resistance (Figure 1). EN 61340-5-1 gives two methods of achieving this ground path:

- through wrist straps
- through footwear and ESD flooring

Figure 1: Body voltage experience in daily activity as a function of the resistance between body and ground



EN61340-5-1 requires that when grounding a person by either of these methods, a resistance less than 35MΩ is maintained from body to ground. The 35MΩ upper limit is chosen to ensure body voltage remains below 100V. If more sensitive devices are handled, this upper limit of resistance must be reduced accordingly. A minimum of 750kΩ is recommended for safety.

In practice, wrist straps are the preferred method of grounding personnel and are essential for seated operators (seated personnel regularly take their feet off the floor!). Grounding via footwear and flooring is preferred when the operator must stand during their normal work.

A wrist strap must fit snugly and comfortably and make good contact with the skin of the wrist. Some people have a dry skin and high skin resistance – they may need to use a special lotion to promote contact between the wrist and the strap.

Foot straps must be worn in the correct way to make contact with the foot as well as the ground. Straps are required on both feet.

It is essential to check the wrist strap or the footwear before commencing work every shift (Figure 2). If a failure were to occur in the equipment, the operator would be ungrounded and ESD damage could occur until the fault is detected.

Figure 2: Checking personal grounding for effectiveness

Source: Nortel Telecom

Grounding of personnel and safety

Safety always takes precedence over ESD prevention measures, and local safety regulations must always be observed.

Wrist strap cords must contain a resistor in the cord at the wrist end, for safety. Commercially available cords incorporate this resistor in at least one end. The same style of cord is often used as a ground cord for other equipment – in this case the cord resistance must be at the ground end.

The recommended range of resistance-to-ground for personnel is designed to limit current through the body to a safe level, in the event the person accidentally touches a live conductor at voltage up to 250VAC or 500 VDC.

Grounding via wrist straps or footwear and flooring can be used where higher voltages are present, subject to safety regulations, but the minimum resistance-to-ground must be raised accordingly. EN 61340-5-1 specifies a minimum of 750kΩ per 250VAC or 500VDC. For example, in an area where 1000 VDC is present, a minimum resistance-to-ground of 1.5MΩ would be used.

EPA design and operations

An ESD protected area (EPA) can take a wide variety of forms, from a field service kit, to a single bench workstation, a storage area, or a complete manufacturing area. All EPAs must be carefully defined according to the processes and facilities in place: it is extremely important to have clear marked boundaries to the EPA, so that it is clear where special handling measures apply and sensitive devices may be safely handled. High voltage areas need special signs for safety reasons.

Requirements for EPA furniture, tools and equipment

Equipment for EPA use are designed to minimise charge generation, and reduce any charge generated to 10% of its initial value within 2 seconds. EPA equipment must be marked with a symbol to show it is compatible with EPA use.

All work surfaces within the EPA, and any surfaces that might be used to support ESDS including trolleys or carts, are made static dissipative and grounded. The resistance-to-ground is required to be below 109 W in order to dissipate charge as it is generated. A minimum resistance-to-ground of 750kW is recommended for safety and to prevent CDM ESD damage. ESDS are never placed on a metal surface as this would result in CDM ESD. Trolleys or carts should be grounded through a ground point or at least two wheels.

If seating is provided, the seat and back surfaces must be static dissipative and grounded, achieving a resistance-to-ground below 1010 W.

Tools used within the EPA must not generate or hold charge – a resistance below 1012 W is sufficient in this case. Tools, gloves and finger cots, and ESD garments, must dissipate charge to less than 10% of its initial value within 2 seconds. Gloves or finger cots used with hand tools must be conductive or static dissipative.

If ESD garments are required then they must cover the clothing of the upper torso and arms, and they must be grounded either by contact with the wearer's skin or via a connection e.g. to a wrist strap grounding point. Ordinary clothing must not be allowed to come into contact with ESDS.

EPA floors

While it is not mandatory to have an EPA specification floor surface, including this can significantly reduce ESD risk and make assembly handling easier. Two nearby EPA benches that are not linked via an EPA floor should be considered separate EPAs. A board transported between these is passing through an uncontrolled area and should be protected in shielding packaging.

Use of ionisers

- Sometimes insulating materials are unavoidable in the EPA. Electrostatic charges generated on such insulating materials can often be neutralised using an ioniser. An ioniser must be capable of reducing a charged surface of either polarity from 1000 V to 100 V in less than 20 seconds.

- Various types of ioniser are available and the type used must be suitable for the size of area to be protected. Typically protection performance reduces with distance from the ioniser, and can be seriously affected by draughts as the ions are transported by the airflow.

- Many ionisers produce ions using a high voltage corona discharge and can themselves be the source of high electric fields – in this case they must be sited sufficiently far away from ESDS.

- Maintenance and performance monitoring of ionisers is important as the ion sources can become unbalanced over a period of time. A neglected ioniser could actually charge up nearby objects!

Figure 3: An EPA installation

Source: Vermason Ltd

Good housekeeping

An important way in which EPA workers can make a strong contribution to ESD prevention is to maintain vigilance over the state of their work place. Non-compliant (insulating) materials must not be brought into the EPA, and if found should be removed. Visual checks on a daily basis form an important part of maintaining EPA effectiveness. Care should be taken not to take objects or clothing (lunch boxes, polystyrene cups, bags, coats, equipment etc.) that could generate electrostatic charges, into the EPA.

Occasionally it is necessary to take equipment (e.g. test and measurement apparatus or equipment) that may not be EPA compliant, into an EPA for a specific purpose. In this case, the ESD Coordinator must make an ESD risk assessment and identify special measures required to avoid ESD damage, before the equipment is introduced.

Documents should not be brought into the EPA unless they are known not to generate significant electrostatic fields, or are kept within an appropriate EPA compliant protective bag or wallet. Paper can become highly insulating when dry, and can emerge from a photocopier or printer in a highly charged state!

Any cleaning materials or processes used must not impair the properties of surfaces or other ESD protective measures.

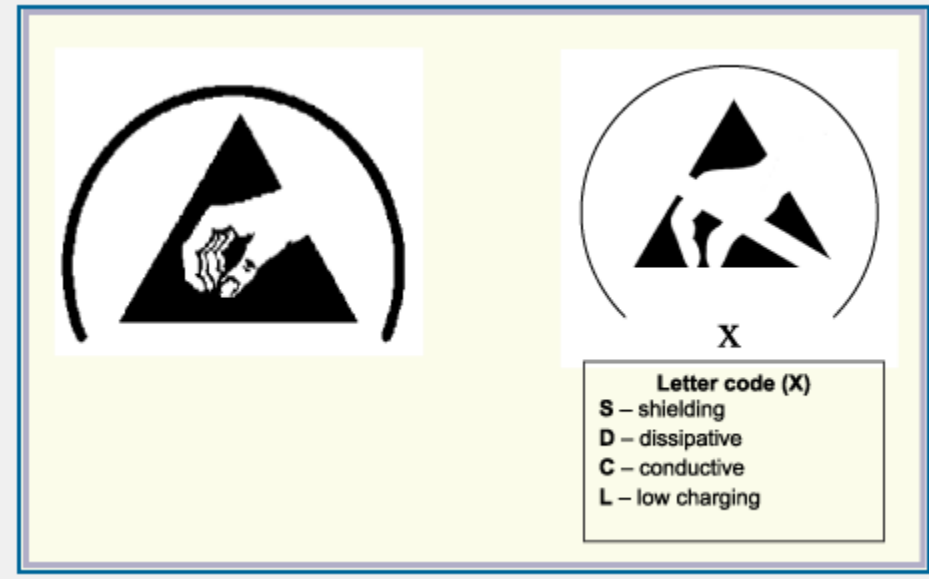
ESD protective packaging

Packaging principles

Sensitive devices must never be removed from their protective packaging unless within an EPA. Parts received (for example at Goods Inwards) in boxes, bubble wrap or other non-ESD outer packaging, must have this removed to the level of the ESD packaging, before they may be taken into an EPA.

ESD packaging may be recognised from the markings in Figure 4. If this mark is visible then the packaging can be taken into an EPA, but it must not be opened outside an EPA.

Figure 4: Symbols on ESD protective packaging



left: ESD Association specification, right: EN 61340-5-1 specification.

To be compliant with EN 61340-5-1, the packaging must also carry the manufacturer’s name or logo, and a batch number traceable to the date of manufacture.

Outer packaging, e.g. bubble wrap, cartons and polythene sheet that is necessary to protect items in transit, but must never be brought into the EPA, is called ‘secondary’ packaging.

ESD protective packaging suitable for use in the EPA

All surfaces of ESD packaging which can be brought into an EPA, must be low charging and either electrostatic dissipative or conductive. The definition of ‘low charging’ has no specific performance criteria but means that insignificant levels of static charge should arise on the surface during normal use.

Surfaces in contact with the ESDS are known as ‘intimate’ packaging. If the ESDS is powered (e.g. by an on-board battery) then only dissipative packaging with a surface resistivity over 108Ω should be used for intimate packaging.

An outer layer of packaging that is not normally in contact with the ESDS, is known as ‘proximity’ packaging. This must be low charging and either electrostatic dissipative or conductive, or a shielding layer.

Black carbon loaded bags and tote boxes are suitable for packaging ESDS within the EPA, but are not in themselves sufficient for protecting ESDS outside the EPA as they can conduct direct ESD through to the devices inside. Note that similar packaging is now available in other colours than black!

Black polythene is a very common material and is often not static dissipative or conductive – it is not safe to assume from the colour that black polythene is EPA compliant!

Pink polythene bags are best used for packaging non-sensitive devices or documents. Their static dissipative performance can be severely reduced by low humidity.

ESD protective packaging suitable for use outside the EPA

ESD protective packaging for use outside the EPA must protect the ESDS against electrostatic fields and possible direct ESD. The packaging can be taken into an EPA and therefore must have surfaces that are low charging and either electrostatic dissipative or conductive.

EN61340-5-1 also requires that a proximity layer with electrostatic shielding properties is included.

A shielding layer or package is designed to limit the passage of ESD current and attenuate energy resulting from an ESD event. When a 1,000 V HBM ESD is applied to the outside of such a package, the energy detected by a sensor, at the typical position of an ESDS, must be attenuated to less than 50 nJ.

At the time of writing (Feb 2002), the only packaging available on the market, tested to this specification, is the shielding bag. Shielding bag material contains a conductive layer that acts as a Faraday cage, shielding the contents from fields and direct ESD. An internal intimate packaging layer of dissipative material prevents direct conduction of ESD through to the contents.

A shielding bag must fully enclose its contents in order to be effective. Folded, crumpled, perforated or torn shielding bags are likely to have lost their shielding performance.

ESD protection in field work

It is often necessary to replace an ESD sensitive PCB or module in an uncontrolled environment such as a client's site. It is especially important to take care with ESD prevention measures in this situation – an ESD event could require a return visit and another replacement later on!

A simple field service kit, and careful preparation, provides adequate protection in this situation. A typical kit is shown in Figure 5. A typical working procedure is as follows;

The working area is cleared of insulating materials that could induce ESD events

Any secondary packaging is removed from the ESDS and discarded well away from the work area. The ESD must remain in its protective ESD shielding packaging

The portable work surface is earthed using the mains earthing plug and cord

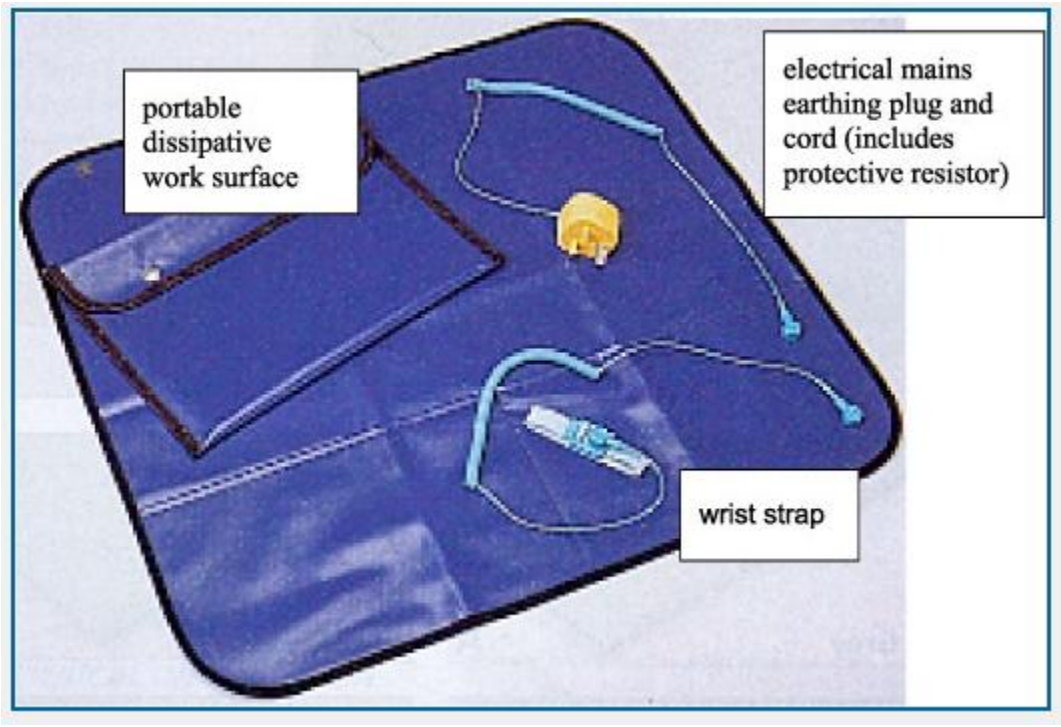
The engineers ground themselves using the wrist strap

The equipment covers may now be opened for access to the board to be replaced. The old board is removed and may be placed temporarily on the portable work surface

The replacement board is removed from its shielding packaging and inserted in the equipment. The old board may now be placed in the shielding packaging and sealed for return and failure analysis

The equipment housing covers are replaced.

Figure 5: Typical field service kit



Source: Static Safe Environments Ltd

ESD management

ESD prevention standards

The main ESD damage prevention standards are currently EN 61340-5-1 in Europe, and ANSI/ESD 20:20 in the U.S.A. Although superseded by EN61340-5-1 during 2001, EN100015 is still commonly used in Europe. While these standards have very different approaches and may appear quite different, they are based on identical principles. It is possible to have an in-house ESD programme that conforms to both EN61340-5-1 and ANSI/ESD20:20. This may be documented in an in-house ESD Programme document.

The ESD programme

ESD management is achieved by implementing a suite of ESD prevention measures. These must be documented in an ESD Programme document that details:

the ESD programme and specific ESD measures

an ESD Training programme

ESD Audit procedures.

The EN 61340-5-1 standard provides all these elements. This standard is identical to IEC 61340-5-1. There is an associate User Guide.

EN61340-5-2 that gives a useful amount of additional recommendations to help implementation of the standard.

EN61340-5-1 requires that an ESD Coordinator is appointed for every site where ESD prevention measures are implemented. The role of the ESD Coordinator is to take day-to-day responsibility for, and implement, all ESD matters on the site, and to provide ESD information and advice for those who may need it. They must ensure that equipment, training and audit procedures are in place and maintained according to the ESD Programme.

Effective training programme

While people provide the greatest risk of ESD damage, an ESD aware person can be the primary defence against ESD, preventing and problems as they occur and providing prompt remedial action. It is the responsibility of all workers to do this, and if they cannot solve a problem themselves then they should bring it to the attention of the ESD Coordinator. EN61340-5-1 expects all personnel who work with ESD sensitive devices to;

recognise ESD threat

know what equipment to use, and how to use it

know the correct ESD procedures, and work to them

know how to check equipment

know which packaging to use

take corrective actions when required.

Clearly, these abilities depend on the provision of clear and effective training on ESD related topics relevant to their work.

EN 61340-5-1 requires that effective training is provided for everyone who specifies, procures, designs, marks, or handles ESDS, managers and supervisors, subcontractors, maintenance personnel, cleaners and temporary personnel. In other words, everyone who has anything to do with ESD sensitive devices or the facility where they are made or handled!

Training must be provided to employees as part of an induction course (before they work with the ESDS!) Regular refresher training is also required, and a register of trained personnel must be maintained. Training is expected to include;

theory and causes of electrostatic charging, and basic ESD understanding

handling procedures

knowledge of, use, and limitations of protective equipment

identification of ESDS, and understanding of ESDS sensitivity

Safety aspects and high voltage precautions

New techniques, processes, facilities and equipment before they are implemented

Awareness of the 61340-5-1 standard.

Specialist job specific training must be provided for personnel in areas such as assembly, purchasing, repair and field service.

Visitors to an EPA facility such as visitors, customers and contractors, must have basic awareness information and instructions on use of wrist straps and footwear, and appropriate instruction to prevent their taking non-compliant materials into the EPA.

Checks, tests and auditing

The ESD Programme must specify checks and Audit procedures in order to make sure that equipment remains in good condition, failed items are discovered and that procedures are correctly observed. EN 61340-5-1 requires;

Daily checks

Wrist straps and ESD footwear, before starting work

Visual check of ground connections

Make sure there’s no stray non-compliant items or packaging or charge generating materials in the workstation

Make sure ionisers are directed at the correct working area!

Monthly checks

On a sample basis, check earth bonding of work surfaces, floors, earth bonding points, chairs, trolleys, field service kits, and any other equipment.

Check functionality of ionisers.

Six monthly checks

Check electrostatic fields and voltages are within limits

Check signs and labelling are correct

Check garments

Check ESD shoes.

Periodic audit

A complete audit of facilities, practices and procedures is carried out at intervals not longer than a year. The results are documented in an audit report and circulated for corrective action.

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Source: http://www.ami.ac.uk/courses/topics/0216_esdcm/index.html