Protecting the Assembly – EOS/ESD and Other Handling Considerations

The following topics are addressed in this section.

3.1 EOS/ESD Prevention

3.1.1 Electrical Overstress (EOS)
3.1.2 Electrostatic Discharge (ESD)
3.1.3 Warning Labels
3.1.4 Protective Materials

3.2 EOS/ESD Safe Workstation/EPA

3.3 Handling Considerations

3.3.1 Guidelines
3.3.2 Physical Damage
3.3.3 Contamination
3.3.4 Electronic Assemblies
3.3.5 After Soldering
3.3.6 Gloves and Finger Cots

3.1 EOS/ESD Prevention

Electrostatic Discharge (ESD) is the rapid transfer of a static electric charge from one object to another of a different potential that was created from electrostatic sources. When an electrostatic charge is allowed to come in contact with or close to a sensitive component it can cause damage to the component.

Electrical Overstress (EOS) is the internal result of an unwanted application of electrical energy that results in damaged components. This damage can be from many different sources, such as electrically powered process equipment or ESD occurring during handling or processing.

Electrostatic Discharge Sensitive (ESDS) components are those components that are affected by these high-electrical energy surges. The relative sensitivity of a component to ESD is dependent upon its construction and materials. As components become smaller and operate faster, the sensitivity increases.

ESDS components can fail to operate or change in value as a result of improper handling or processing. These failures can be immediate or latent. The result of immediate failure can be additional testing and rework or scrap. However the consequences of latent failure are the most serious. Even though the product may have passed inspection and functional test, it may fail after it has been delivered to the customer.

It is important to build protection for ESDS components into circuit designs and packaging. In the manufacturing and assembly areas, work is often done with unprotected electronic assemblies (such as test fixtures) that are attached to the ESDS components. It is important that ESDS items be removed from their protective enclosures only at EOS/ESD safe workstations within Electrostatic Protected Areas (EPA). This section is dedicated to safe handling of these unprotected electronic assemblies.

Information in this section is intended to be general in nature. Additional information can be found in IPC J-STD-001, ANSI/ESD-S-20.20 and other related documents.

3.1.1 EOS/ESD Prevention – Electrical Overstress (EOS)

Electrical components can be damaged by unwanted electrical energy from many different sources. This unwanted electrical energy can be the result of ESD potentials or the result of electrical spikes caused by the tools we work with, such as soldering irons, soldering extractors, testing instruments or other electrically operated process equipment. Some devices are more sensitive than others. The degree of sensitivity is a function of the design of the device. Generally speaking, higher speed and smaller devices are more susceptible than their slower, larger predecessors. The purpose or family of the device also plays an important part in component sensitivity. This is because the design of the component can allow it to react to smaller electrical sources or wider frequency ranges. With today's products in mind, we can see that EOS is a more serious problem than it was even a few years ago. It will be even more critical in the future.

When considering the susceptibility of the product, we must keep in mind the susceptibility of the most sensitive component in the assembly. Applied unwanted electrical energy can be processed or conducted just as an applied signal would be during circuit performance.

Before handling or processing sensitive components, it is important to be sure that tools and equipment will not generate damaging energy, including spike voltages. Current research indicates that voltages and spikes less than 0.5 volt are acceptable. However, an increasing number of extremely sensitive components require that soldering irons, solder extractors, test instruments and other equipment must never generate spikes greater than 0.3 volt.

As required by most ESD specifications, periodic testing may be warranted to preclude damage as equipment performance may degrade with use over time. Maintenance programs are also necessary for process equipment to ensure the continued ability to not cause EOS damage.

EOS damage is certainly similar in nature to ESD damage, since damage is the result of undesirable electrical energy.

3.1.2 EOS/ESD Prevention – Electrostatic Discharge (ESD)

Table 3-1 Typical Static Charge Sources

Work surfaces	Waxed, painted or varnished surfaces Untreated vinyl and plastics Glass
Floors	Sealed concrete Waxed or finished wood Floor tile and carpeting
Clothes and personnel	Non-ESD smocks Synthetic materials Non-ESD Shoes Hair
Chairs	Finished wood Vinyl Fiberglass Nonconductive wheels
Packaging and handling materials	Plastic bags, wraps, envelopes Bubble wrap, foam Styrofoam Non-ESD totes, trays, boxes, parts bins
Assembly tools and materials	Pressure sprays Compressed air Synthetic brushes Heat guns, blowers Copiers, printers

Table 3-2 Typical Static Voltage Generation

Source	10-20% humidity	65-90% humidity
Walking on carpet	35,000 volts	1,500 volts
Walking on vinyl flooring	12,000 volts	250 volts
Worker at a bench	6,000 volts	100 volts
Vinyl envelopes (Work Instructions)	7,000 volts	600 volts
Plastic bag picked up from the bench	20,000 volts	1,200 volts
Work chair with foam pad	18,000 volts	1,500 volts

The best ESD damage prevention is a combination of preventing static charges and eliminating static charges if they do occur. All ESD protection techniques and products address one or both of the two issues.

ESD damage is the result of electrical energy that was generated from static sources either being applied or in close proximity to ESDS devices. Static sources are all around us. The degree of static generated is relative to the characteristics of the source. To generate energy, relative motion is required. This could be contacting, separation, or rubbing of the material.

Most of the serious offenders are insulators since they concentrate energy where it was generated or applied rather than allowing it to spread across the surface of the material. See Table 3-1. Common materials such as plastic bags or Styrofoam containers are serious static generators and are not appropriate in processing areas especially static safe/ Electrostatic Protected Areas (EPA). Peeling adhesive tape from a roll can generate 20,000 volts. Even compressed air nozzles that move air over insulating surfaces generate charges.

Destructive static charges are often induced on nearby conductors, such as human skin, and discharged into conductors on the assembly. This can happen when a person having an electrostatic charge potential touches a printed board assembly. The electronic assembly can be damaged as the discharge passes through the conductive pattern to an ESDS component. Electrostatic discharges may be too low to be felt by humans (less than static 3500 volts), and still damage ESDS components.

Typical static voltage generation is included in Table 3-2.

3.1.3 EOS/ESD Prevention – Warning Labels

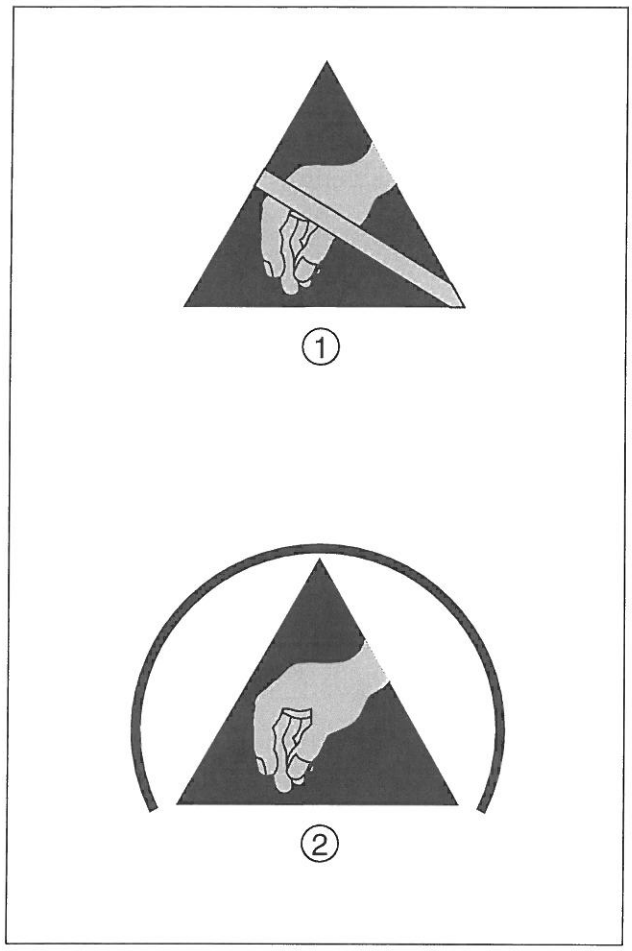

Figure 3-1
1. **ESD Susceptibility Symbol**
2. **ESD Protective Symbol**

Warning labels are available for posting in facilities and placement on devices, assemblies, equipment and packages to alert people to the possibility of inflicting electrostatic or electrical overstress damage to the devices they are handling. Examples of frequently encountered labels are shown in Figure 3-1.

Symbol (1) ESD susceptibility symbol is a triangle with a reaching hand and a slash across it. This is used to indicate that an electrical or electronic device or assembly is susceptible to damage from an ESD event.

Symbol (2) ESD protective symbol differs from the ESD susceptibility symbol in that it has an arc around the outside of the triangle and no slash across the hand. This is used to identify items that are specifically designed to provide ESD protection for ESD sensitive assemblies and devices.

Symbols (1) and (2) identify devices or an assembly as containing devices that are ESD sensitive, and that they must be handled accordingly. These symbols are promoted by the ESD association and are described in EOS/ESD standard S8.1 as well as the Electronic Industries Association (EIA) in EIA-471, IEC/TS 61340-5-1, and other standards.

Note that the absence of a symbol does not necessarily mean that the assembly is not ESD sensitive. ***When doubt exists about the sensitivity of an assembly, it must be handled as a sensitive device until it is determined otherwise.***

3.1.4 EOS/ESD Prevention – Protective Materials

ESDS components and assemblies must be protected from static sources when not being worked on in static safe environments or workstations. This protection could be conductive static-shielding boxes, protective caps, bags or wraps.

ESDS items must be removed from their protective enclosures only at static safe workstations.

It is important to understand the difference between the three types of protective enclosure material: (1) static shielding (or barrier packaging), (2) antistatic, and (3) static dissipative materials.

Static shielding packaging will prevent an electrostatic discharge from passing through the package and into the assembly causing damage.

Antistatic (low charging) packaging materials are used to provide inexpensive cushioning and intermediate packaging for ESDS items. Antistatic materials do not generate charges when motion is applied. However, if an electrostatic discharge occurs, it could pass through the packaging and into the part or assembly, causing EOS/ESD damage to ESDS components.

Static dissipative materials have enough conductivity to allow applied charges to dissipate over the surface relieving hot spots of energy. Parts leaving an EOS/ESD protected work area must be overpacked in static shielding materials, which normally also have static dissipative and antistatic materials inside.

Do not be misled by the "color" of packaging materials. It is widely assumed that "black" packaging is static shielding or conductive and that "pink" packaging is antistatic in nature. While that may be generally true, it can be misleading. In addition, there are many clear materials now on the market that may be antistatic and even static shielding. At one time, it could be assumed that clear packing materials introduced into the manufacturing operation would represent an EOS/ESD hazard. This is not necessarily the case now.

Caution:

Some static shielding and antistatic materials and some topical antistatic solutions may affect the solderability of assemblies, components, and materials in process. Care should be taken to select only packaging and handling materials that will not contaminate the assembly and use them with regard for the vendor's instructions. Solvent cleaning of static dissipative or antistatic surfaces can degrade their ESD performance. Follow the manufacturer's recommendations for cleaning.

3.2 EOS/ESD Safe Workstation/EPA

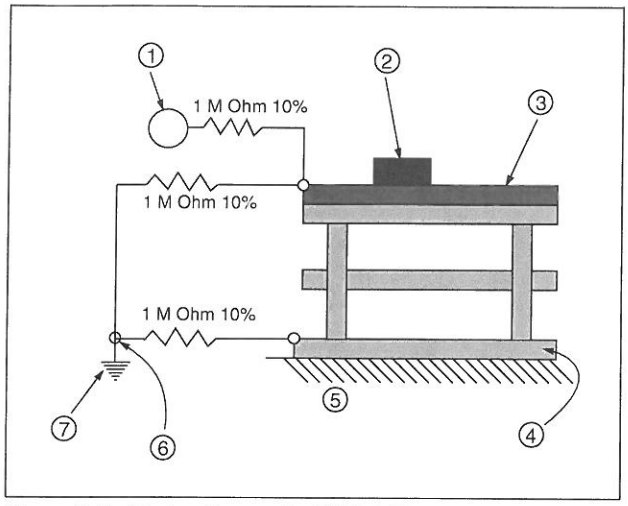

Figure 3-2 Series Connected Wrist Strap

1. Personal wrist strap
2. EOS protective trays, shunts, etc.
3. EOS protective table top
4. EOS protective floor or mat
5. Building floor
6. Common ground point
7. Ground

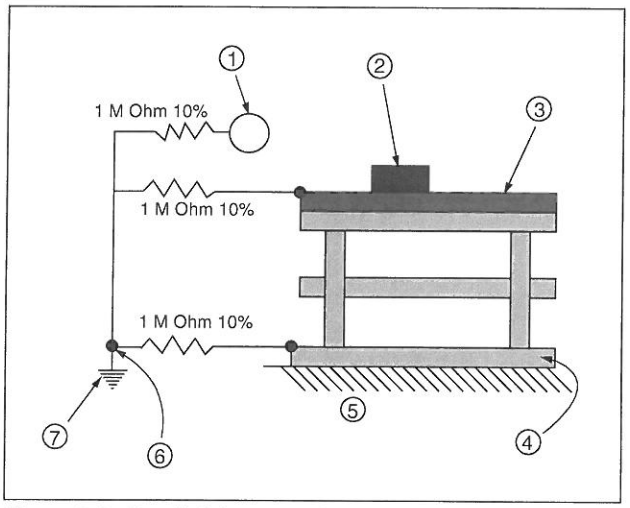

Figure 3-3 Parallel Connected Wrist Strap

1. Personal wrist strap
2. EOS protective trays, shunts, etc.
3. EOS protective table top
4. EOS protective floor or mat
5. Building floor
6. Common ground point
7. Ground

An EOS/ESD safe workstation prevents damage to sensitive components from spikes and static discharges while operations are being performed. Safe workstations should include EOS damage prevention by avoiding spike generating repair, manufacturing or testing equipment. Soldering irons, solder extractors and testing instruments can generate energy of sufficient levels to destroy extremely sensitive components and seriously degrade others.

For ESD protection, a path-to-ground must be provided to neutralize static charges that might otherwise discharge to a device or assembly. ESD safe workstations/EPAs also have static dissipative or antistatic work surfaces that are connected to a common ground. Provisions are also made for grounding the worker's skin, preferably via a wrist strap to eliminate charges generated on the skin or clothing.

Provision must be made in the grounding system to protect the worker from live circuitry as the result of carelessness or equipment failure. This is commonly accomplished through resistance in line with the ground path, which also slows the charge decay time to prevent sparks or surges of energy from ESD sources. Additionally, a survey must be performed of the available voltage sources that could be encountered at the workstation to provide adequate protection from personnel electrical hazards.

For maximum allowable resistance and discharge times for static safe operations, see Table 3-3.

Table 3-3 Maximum Allowable Resistance and Discharge Times for Static Safe Operations

Reading from Operator Through	Maximum Tolerable Resistance	Maximum Acceptable Discharge Time
Floor mat to ground	1000 megohms	less than 1 sec.
Table mat to ground	1000 megohms	less than 1 sec.
Wrist strap to ground	100 megohms	less than 0.1 sec.

Note: The selection of resistance values is based on the available voltages at the station to ensure personnel safety as well as to provide adequate decay or discharge time for ESD potentials.

Examples of acceptable workstations are shown in Figures 3-2 and 3-3. When necessary, air ionizers may be required for more sensitive applications. The selection, location, and use procedures for ionizers must be followed to ensure their effectiveness.

3.2 EOS/ESD Safe Workstation/EPA (cont.)

Keep workstation(s) free of static generating materials such as Styrofoam, plastic solder removers, sheet protectors, plastic or paper notebook folders, and employees' personal items.

Periodically check workstations/EPAs to make sure they work. EOS/ESD assembly and personnel hazards can be caused by improper grounding methods or by an oxide build-up on grounding connectors. Tools and equipment must be periodically checked and maintained to ensure proper operation.

Note: Because of the unique conditions of each facility, particular care must be given to "third wire" ground terminations. Frequently, instead of being at workbench or earth potential, the third wire ground may have a "floating" potential of 80 to 100 volts. This 80 to 100 volt potential between an electronic assembly on a properly grounded EOS/ESD workstation/EPA and a third wire grounded electrical tool may damage EOS sensitive components or could cause injury to personnel. Most ESD specifications also require these potentials to be electrically common. The use of ground fault interrupter (GFI) electrical outlets at EOS/ESD workstations/EPAs is highly recommended.

3.3 Handling Considerations

3.3.1 Handling Considerations – Guidelines

Avoid contaminating solderable surfaces prior to soldering. Whatever comes in contact with these surfaces must be clean. When boards are removed from their protective wrappings, handle them with great care. Touch only the edges away from any edge connector tabs. Where a firm grip on the board is required due to any mechanical assembly procedure, gloves meeting EOS/ESD requirements may be required. These principles are especially critical when no-clean processes are employed.

Care must be taken during assembly and acceptability inspections to ensure product integrity at all times. Table 3-4 provides general guidance.

Printed circuit boards and commonly used plastic components absorb and release moisture at different rates. During the soldering process heat causes expansion of the moisture that can damage the ability of the materials to perform as required for the product requirements. This damage (crack, internal delamination, popcorning) may not be visible and can occur during original soldering as well as during rework operations.

To prevent laminate issues, if the level of moisture is unknown, PCBs should be baked to reduce the internal moisture content. The baking temperature selection and duration should be controlled to prevent reduction of solderability through intermetallic growth, surface oxidation or other internal component damage.

Moisture sensitive components (as classified by IPC/JEDEC J-STD-020 or equivalent documented procedure) must be handled in a manner consistent with IPC/JEDEC J-STD-033 or an equivalent documented procedure. IPC-1601 provides moisture control, handling and packing of PCBs.

Table 3-4 Recommended Practices for Handling Electronic Assemblies

1. Keep workstations clean and neat. There must not be any eating, drinking, or use of tobacco products in the work area.
2. Minimize the handling of electronic assemblies and components to prevent damage.
3 When gloves are used, change as frequently as necessary to prevent contamination from dirty gloves.
4. Do not handle solderable surfaces with bare hands or fingers. Body oils and salts reduce solderability, promote corrosion and dendritic growth. They can also cause poor adhesion of subsequent coatings or encapsulates.
5. Do not use hand creams or lotions containing silicone since they can cause solderability and conformal coating adhesion problems.
6. Never stack electronic assemblies or physical damage may occur. Special racks may be provided in assembly areas for temporary storage.
7. Always assume the items are ESDS even if they are not marked.
8. Personnel must be trained and follow appropriate ESD practices and procedures.
9. Never transport ESDS devices unless proper packaging is applied.

3.3.2 Handling Considerations – Physical Damage

Improper handling can readily damage components and assemblies (e.g., cracked, chipped or broken components and connectors, bent or broken terminals, badly scratched board surfaces and conductor lands). Physical damage of this type can ruin the entire assembly or attached components.

3.3.3 Handling Considerations – Contamination

Many times product is contaminated during the manufacturing process due to careless or poor handling practices causing soldering and coating problems; body salts and oils, and unauthorized hand creams are typical contaminants. Body oils and acids can reduce solderability, promote corrosion and dendritic growth. They can also cause poor adhesion of subsequent coatings or encapsulants. Normal cleaning procedures may not remove all contaminants. Therefore it is important to minimize the opportunities for contamination. The best solution is prevention. *Frequently washing ones hands and handling boards only by the edges without touching the lands or pads will aid in reducing contamination. When required the use of pallets and carriers will also aid in reducing contamination during processing.*

The use of gloves or finger cots many times creates a false sense of protection and within a short time can become more contaminated than bare hands. When gloves or finger cots are used they should be discarded and replaced often. Gloves and finger cots need to be carefully chosen and properly utilized.

3.3.4 Handling Considerations – Electronic Assemblies

Even if no ESDS markings are on an assembly, it still needs to be handled as if it were an ESDS assembly. However, ESDS components and electronic assemblies need to be identified by suitable EOS/ESD labels, see Figure 3-1. Many sensitive assemblies will also be marked on the assembly itself, usually on an edge connector. To prevent ESD and EOS damage to sensitive components, all handling, unpacking, assembly and testing **shall** be performed at a static controlled workstation, see Figures 3-2 and 3-3.

3.3.5 Handling Considerations – After Soldering

After soldering and cleaning operations, the handling of electronic assemblies still requires great care. Fingerprints are extremely hard to remove and will often show up in conformally coated boards after humidity or environmental testing. Gloves or other protective handling devices may be used to prevent such contamination. Use mechanical racking or baskets with full ESD protection when handling during cleaning operations.

3.3.6 Handling Considerations – Gloves and Finger Cots

The use of gloves or finger cots may be required under contract to prevent contamination of parts and assemblies. Gloves and finger cots must be carefully chosen to maintain EOS/ESD protection.

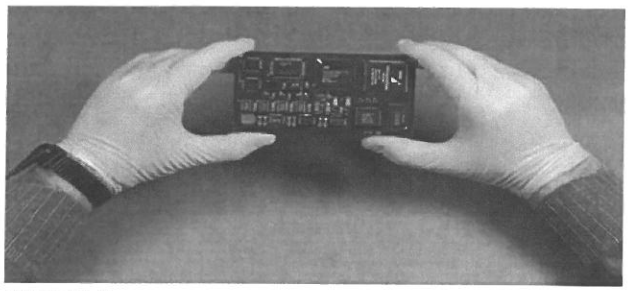

Figure 3-4

Figure 3-4 and 3-5 provide examples of:

- Handling with clean gloves and full EOS/ESD protection.
- Handling during cleaning procedures using solvent resistant gloves meeting all EOS/ESD requirements.
- Handling with clean hands by board edges using full EOS/ESD protection.

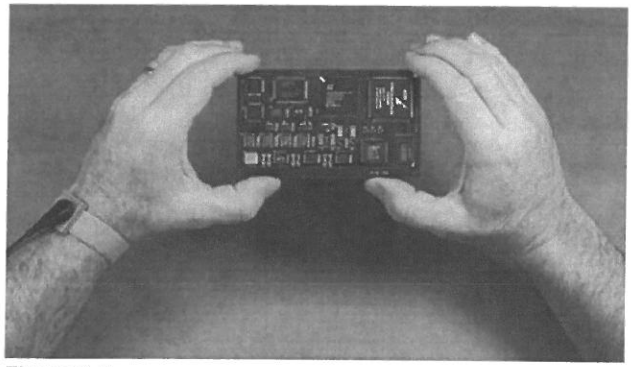

Figure 3-5

Note: Any assembly related component if handled without EOS/ESD protection may damage electrostatic sensitive components. This damage could be in the form of latent failures, or product degradation not detectable during initial test or catastrophic failures found at initial test.