APPENDIX B

ELECTROSTATIC DISCHARGE INFORMATION

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ELECTROSTATIC DISCHARGE

The following document is a collection of Electrostatic Discharge information from various vendors. It provides further information on the causes and the types of devices that are sensitive to ESD. It also provides methods of controlling ESD.

1) From FlightSafety International

A precaution in handling electronic hardware has continued to increase in importance with the broad application of electronic devices (CMOS, etc) used in FSE simulators. The broad application of such devices, coupled with increased hardware costs and repair of same, has quickly made it cost-effective to educate our technician staff in the handling of this equipment and to invest in electrostatic discharge devices for equipment protection. All FSI personnel handling such equipment whenever the equipment is outside an electrostatic protective covering (re Bulletin No. SSD-14-06-84-5-L) should be trained in proper handling and protection of equipment subject to damage from electrostatic discharge.

SSD is proceeding to install static grounding wrist straps at each equipment bay for convenience of the technicians, as they are required to handle PC cards.

Attached to this Bulletin is a good article from P-E re the subject.

It is essential each Center emphasize training of technicians in this area due to the broad introduction of microcomputer hardware in FSE simulator subsystems.

We also urge the Centers to invest in appropriate equipment for proper handling of micro equipment. We suggest use of such devices as grounding pads when handling micro equipment on the work bench with wrist strap for grounding and use of a grounded wrist strap for use in the vicinity of all micro equipment in the area of equipment cabinets, host computer, etc.

Please contact FSI-ILS if we can be of assistance.

2) From Perkin-Elmer

INTRODUCTION

The purpose of this FIB is to familiarize field personnel with the problems caused by electrostatic discharge. In addition, this FIB outlines the procedure field personnel should use to control static electricity. Special attention is given to the types of devices that are sensitive to damage from electro-static discharge.

Currently, extensive efforts are being made at the factory in Oceanport and the National Repair Center at Ocean to ensure that damage from electrostatic discharge (ESD) is prevented prior to shipment of equipment. These efforts include the installation of static control equipment, establishing static-free workstations and special care and handling (including shipping) of all devices and equipment that are sensitive to ESD. In Quality Assurance Bulletin number 283, issued on 3/13/84, all devices listed below are classified as sensitive to ESD.

All devices in the following part number categories:

- 19-xxx
- 20-xxx
- 21-xxx
- 23-xxx
- 31-xxx

In addition, the following devices are considered to be ESD sensitive:

24-040	24-063	24-108
24-064	24-065	
24-066	24-106	

No doubt many more devices will be added to this list as time goes on.

CAUTION

ALL ASSEMBLIES CONTAINING ANY DEVICES IN THE ABOVE-MENTIONED CATEGORIES SHOULD BE HANDLED IN SUCH A WAY TO PREVENT DAMAGE FROM ELECTROSTATIC DISCHARGE.

You will note that the above mentioned categories considered to be ESD sensitive include all integrated circuits, transistors, resistors, diodes, and solid-state relays. Although the degree of ESD sensitivity varies from device to device, Perkin-Elmer Quality Assurance considers all devices in these categories to be ESD sensitive. All assemblies containing any of these parts must be handled with care to prevent damage from ESD.

One further point should be noted. That is, integrated circuits and similar devices are sensitive to damage from ESD even when mounted on printed circuit boards. Therefore, it is essential to

properly handle printed circuit assemblies to prevent damage from ESD. The handling techniques are covered later in this FIB.

ESD PROBLEMS

This section covers the common problems caused by the generation of static electricity. The build-up of static electricity can cause three different problems. The first problem is the destruction of an ESD sensitive device when it is zapped by someone or something that has a static electricity charge. Most of the time, this type of failure is not identified as on ESD caused failure and is routinely replaced without regard to the real cause (ESD) of the problem.

The second type of problem caused by static electricity is that an ESD sensitive device is degraded when zapped by a static discharge. When this happens, the device may, and often does, perform acceptably for a while. However, a slight change in operating conditions such as a power supply variation, operating frequency or a change in operating temperature will cause the device to be over-stressed. The result may be occasional soft errors, intermittent operation, or a hard failure. This occurs even though the operating conditions are still well within the specifications of the device. However, the device does not operate correctly because of the degradation caused by the electrostatic discharge earlier. Usually when a device is degraded by ESD, it prematurely fails completely. This creates a problem in that the real cause of the failure, the electrostatic discharge is seldom suspected as the cause unless the failed device is thoroughly tested in a failure analysis laboratory.

A third and often overlooked problem caused by static electricity is that of contamination. The more static electricity present in an environment, the greater the likelihood of contamination problems. This is especially true of magnetic recording media and other similar items. Thus, it is extremely important that all work and equipment areas be kept as clean as possible. A statically charged contaminant particle will be attracted to any material with an opposite charge. That material might be something that must be kept clean to work properly.

STATIC CONTROL

This section covers the factors relating to static control in a field environment. There are two factors that are most important in ensuring effective static control in a field environment. The first concern is environmental conditions. Of special significance are the cleanliness of the work and equipment areas and the relative humidity of the work and equipment areas. The second concern is the work habits of personnel working on and around the equipment. It is essential that both of these concerns be given careful consideration in order to effectively control static problems in the field.

Cleanliness in and around the equipment and work areas is essential to control static. Two factors of cleanliness are significant. The first is that the area be kept free of dirt, dust, and other contaminants as much as possible. This is necessary because one of the problems caused by static electricity is that contaminant particles will settle on surfaces such as read/write heads and magnetic recording media.

The second cleanliness factor is that the work and equipment areas be kept free of static generating materials. Some of the more prevalent static generating materials that are found in work areas are white/yellow and blue foam, clear poly bags, Styrofoam and nonconductive plastics and tools. In

addition, synthetic fabrics such as clothing items are static generators. Every effort should be made to ensure that the work and equipment areas are kept free of these items.

The relative humidity of the work and equipment areas will have a significant effect on how much static electricity is generated by a given activity. This problem is complicated by the fact that the relative humidity level has the inverse affect on ESD of what it has on other problems. That is, humidity levels are usually reduced to prevent such problems as discomfort to personnel, corrosion, dimensional changes, and moisture build-up. However, as the relative humidity is reduced, the effect of ESD is increased. See Table 1.

TABLE 1

MEANS OF STATIC GENERATION	ELECTROSTATIC VOLTAGE GENERATED	
	10% TO 20% RELATIVE HUMIDITY	65% TO 90% RELATIVE HUMIDITY
Walking Across Carpet	35,000	1,500
Walking Over Vinyl Floor	12,000	250
Worker At Bench	6,000	100
Vinyl Envelopes For Work Instructions	7,000	600
Common Poly Bag Picked Up From Bench	20,000	1,200
Work Chair Padded With Polyurethane Foam	18,000	1,500

As you will note, the level of static electricity generated is significantly reduced at higher humidity levels. However, as noted earlier, when the humidity level is raised too high, it causes other serious problems. Thus, a compromise must be achieved. Most computer systems are designed to operate most reliably in an environment of 40-60% relative humidity. Thus, the actual electrostatic voltage generated in most computer system environments will be somewhere between the two levels shown in Table 1. This will still allow for considerable problems from ESD.

Table 2 shows the range of ESD susceptibility (in volts) of various types of devices. You will note that several types of devices can still be damaged by ESD, even at very high humidity levels.

TABLE 2

ESD SUSCEPTIBILITY OF VARIOUS ELECTRONIC DEVICES	
DEVICE TYPE	**RANGE OF ESD SUSCEPTIBILITY (VOLTS)**
VMOS	30 to 1800
MOSFET	100 to 200
GaAsFET	100 to 300
EPROM	100
JFET	140 to 7000
SAW	150 to 500
OP AMP	190 to 2500
CMOS	250 to 3000
Schottky Diodes	300 to 2500
Film Resistors (Thick, Thin)	300 to 3000
Bipolar Transistors	380 to 7000
ECL (PC Board Level)	500 to 1500
SCR	680 to 1000
Schottky TTL	1000 to 2500

It should be noted that as chip geometry's decrease and circuitry density is increased, this problem will become even greater. Likewise, as circuit speeds increase, the susceptibility to ESD will continue to increase.

The second major area of concern in the control of static electricity is the work habits of personnel in the field. To help personnel working on equipment in the field, the Hardware Planning Group at Pine Street has specified an ESD Field Service Kit to be included in the CE's tool kit. This kit can be folded to a size only slightly larger than a standard set of hex wrenches. The part number for the kit is 45-lllF24, and may be ordered from National Logistics in Ocean Township, New Jersey.

Customer Engineers should use this portable workstation when working on any equipment in the field. Although newer equipment will probably contain more devices that are considered ESD sensitive, even older processors such as the 7/32 and the 8/32 have many ESD sensitive devices. Reports from both those at the factory and the National Repair Center indicate that many chips have been damaged or destroyed by working on these processors without using static control procedures.

The ESD Field Service Kit consists of a foldable 24" by 24" work surface, a ground cord for the work surface, an elastic wrist strap and a coil ground cord for the wrist strap. The kit is designed to provide the maximum latitude of movement and the most possible comfort to the Customer Engineer while using it.

NOTE

A one-megohm resistor is included in both ground cords to ensure safety for personnel using the ESD Field Service Kit.

In addition to using the ESD Field Service Kit, personnel working on equipment in the field should keep their work areas clean and free of static generating items. Some of the common static generating items that are found in work areas are discussed in the section titled ESD PROBLEMS.

COMMON MISCONCEPTIONS ABOUT ESD

One of the reasons why ESD causes so much damage is that we all have many misconceptions about ESD. The purpose of this section is to help allay some of these misconceptions in order that we all can better deal with potential problem areas regarding ESD.

Probably the most damaging misconception is the idea that ESD is a problem with only a few commonly used devices. However, as noted earlier in Table 2, this is not true. Far more devices are susceptible to ESD damage than most people think. Thus, the wise choice is to treat all devices with care by using static control procedures when working on any equipment in the field.

Another misconception is that there is a tendency to think that static electricity cannot be the cause of a problem if we do not see it (i.e. a spark), feel it (i.e. a shock), or hear it. However, this is not so. The typical person is not sensitive to static electricity until the voltage level reaches about 4,000 volts. Furthermore, we will not see a spark or hear an arc until the voltage level exceeds 10,000 volts. As can be noted in Table 2, many devices can be damaged at much lower voltage levels.

An additional misconception is that since we cannot identify problems as being specifically caused by ESD, the problem does not exist. However, again this is a fallacy. To illustrate this point, let me give you the following example. Several years ago, 3M, a leader in the static control industry, intentionally destroyed 100 devices by ESD. When these devices were sent to an independent testing lab, only 40 of the failures were attributed to ESD. Keep in mind that this lab used all of the primary methods of failure analysis and yet was only able to attribute 40% of the failures to ESD.

A final misconception about ESD that creates problems is the idea that a device cannot be damaged by ESD once it is installed on a printed circuit board. While it is true that the surrounding circuitry may provide additional protection, the truth is that the printed circuit board offers little or no additional protection to most devices. This is true because most of the auxiliary circuitry to an ESD sensitive device is not designed to protect against static discharge. In fact, sometimes the auxiliary circuitry also is susceptible to ESD damage.

HANDLING PROCEDURES

This section outlines the procedures for handling components and assemblies in the field to prevent damage from ESD. Careful adherence to these procedures will help ensure that handling in the field does not damage these components and assemblies.

The first step is to ensure that all components and assemblies are kept in a static shielded or conductive container until ready for installation. This will guarantee that the parts are not damaged by ESD while in transit. It is essential that this be done, as failure to do so may cause the part to be damaged even before we open the package.

The second step, upon arriving at the work area, is to unfold the ESD Field Service Kit. This will give you a conductive work surface to place parts on. This will ensure that all items being installed or removed can be maintained at ground potential via the work surface ground cord.

The next step before beginning any work is to put on the wrist strap and connect its ground lead to ground. The wrist strap should be put on before any work is started, including removing covers or doors, etc. A good rule to follow regarding the wrist strap is:

FIRST ON, LAST OFF

A ten-foot coil cord, which gives an extension of about twelve feet, is provided for the wrist strap ground. This should provide sufficient freedom of movement in most cases so that once the ground cord has been connected. It will not need to be removed. However, if it does become necessary to remove the wrist strap, it should be put on again before beginning any additional work.

Next, the work area should be cleared of all non-conductive items as much as possible. Of special concern are coffee cups, paper wrappers, scotch tape, and vinyl or plastic items. One special hazard should be noted.

CAUTION

VINYL COVERED MANUALS ARE NOTORIOUS STATIC GENERATORS. THEREFORE, THEY SHOULD BE KEPT AS FAR AS POSSIBLE FROM ALL COMPONENTS AND ASSEMBLIES.

Once the work area has been cleared, the actual work can begin. All assemblies should be immediately placed on the conductive work surface. As much as possible, try to work without having items being worked on coming in the proximity of non-conductive items. When all work has been completed, remove the wrist strap and the work surface ground cord. Only by following these steps can you be assured that you are not damaging the equipment you are working on by electrostatic discharge.

NOTE

These handling procedures should be used when working on any equipment in the field.

ESD TRAINING

Currently an ESD Awareness videotape is being produced by the Training Center. This videotape will be available soon for all field offices. It is recommended that all Customer Engineers view this tape when it becomes available. In addition, efforts are being made to incorporate a brief presentation on ESD into the New Hire CE course. Furthermore, it is intended that a special course on Environmental Issues, including ESD, be offered at the Training Center in Neptune, New Jersey. This course would be designed for regional and district support personnel to provide insight into the various environmental issues that affect the operation of our equipment in the field.

3) From McDonnell Douglas Corporation

1-82. ELECTROSTATIC SENSITIVE DEVICES.

CAUTION

SERIOUS DAMAGE MAY RESULT FROM THE DISCHARGE OF ELECTROSTATIC BUILDUP IF THE ELECTROSTATIC SENSITIVE DEVICES ARE NOT HANDLED PROPERLY DURING SHIPPING AND WHEN MAINTENANCE IS BEING PERFORMED ON THEM. THE FOLLOWING STEPS MUST BE PERFORMED IN SEQUENCE TO ENSURE THE SAFETY OF THE EQUIPMENT.

1-83. Electrostatic Sensitive Devices (ESD) are electronic components or circuits that can be damaged by the discharge of static electricity. Static electricity is generated by the rubbing together of two dissimilar materials such as the nylon of a carpet and the material other than nylon of shoe soles or the material of an electronic module and the unlike material of a work bench surface. The magnitude of the accumulated static charge depends in part upon the relative humidity of the surrounding environment. Since the leakage of static from the surface of a material is slower with low humidity, the accumulation of electricity is greater when the surrounding air is dry. Under certain conditions, the static charge generated by friction between shoe soles and carpet can be as much as 39,000 volts. More often, this charge is about 4,000 volts, but the usually unnoticed static charge of 1,000 volts is very common. Yet, an ESD can be damaged by less than 100 volts. Therefore, certain precautions are required in the handling of these ESD to prevent damage. The VITAL system ESD is listed in Table 1-3.

TABLE 1-3

ELECTROSTATIC SENSITIVE DEVICES	
PART NUMBER	**DESCRIPTION**
H06G1705	RBOS Occulter Circuit Card Assembly, A2A1/A5
H06G1706	RBOS Occulter Control Circuit Card Assembly, A2A6
H06G1708	RBOS D/A Circuit Card Assembly, A2A8
H06G1713	RBOS Z Computer Circuit Card Assembly, A2A13
H06G1718	Signal Receiver Circuit Card Assembly, 5A4
H06G1719	Geometry and Gain Correction Circuit Card Assembly, 5A1
H06G1720	Focus Function Circuit Card Assembly
H06G1726	TASC Intensity/Defocus Circuit Card Assembly, A1A6
H06G1727	TASC Intensity and Output Buffer Circuit Card Assembly, A1A7
H06G1911	Landing Light Shader Circuit Card Assembly, A2A12

1-84. Maintenance on the ESD must be performed on a grounded workbench, which consists of a grounded conductive work surface with a wrist strap attached through a one-megohm resistor. The grounded conductive surface prevents the accumulation of static electricity on both the surfaces of the workbench and on tools and equipment on the workbench, while the grounded wrist strap prevents the accumulation of static electricity on the technician. The one-megohm resistor protects the technician from accidental shock hazard by providing a high resistance path to ground. Proceed as follows:

1. Attach wrist strap to wrist.
2. Connect wrist strap ground lead and resistor to wrist strap.

CAUTION

WRIST STRAP MUST FIT SNUGLY, CONTACT THE SKIN AREA OF THE WRIST AND BE WORN AT ALL TIMES WHEN HANDLING AN ESD.

3. Verify conductive work surface is connected to ground lead.

CAUTION

OBSERVE THE FOLLOWING WHEN PERFORMING MAINTENANCE ON AN ESD.

a. Place all tools not in use on the conductive workbench surface.

b. Handle all ESD by other than electrical leads and connections.

c. Short ESD connector contacts with conductive tape, conductive foam, or a shorted mating connector.

d. Perform all maintenance operations on the grounded conductive work surface.

e. Use soldering iron only with isolation transformer and electrostatic shield.

f. Place completed assemblies in conductive packages identified with proper label.

WARNING

USE ANTISTATIC COATING ONLY IN WELL-VENTILATED AREA.

g. Spray a thin coat of antistatic coating on plastic tools and molds for imbedding without contaminating assemblies with the coating.

h. Ground the outer metal case of all electrical equipment.

i. Use only power tools having ground through three-wire power cord connections.

j. Remove connector contact shorting material after conformed coating.

k. Keep circuit cards in conductive wrapping when not actually being serviced.

l. Do not probe ESD containing circuits with V0M or similar equipment.

NOTE

Manual tools are considered grounded when held by personnel wearing grounded wrist strap.

4. Remove wrist strap or disconnect ground lead and resistor from wrist strap when work on ESD is completed.

CAUTION

THE ESD MUST NOT BE REMOVED FROM THE BAG FOR MAINTENANCE ANYWHERE OTHER THAN ON THE GROUNDED WORKBENCH AND, IF MOVEMENT FROM THE WORKBENCH IS NECESSARY, THE ESD MUST BE REINSERTED INTO THE ANTISTATIC BAG. IF THE ESD MUST BE HANDLED WITHOUT THE WRIST STRAP OR ANTISTATIC BAG, IT MUST BE HELD ONLY AT THE EXTREME OUTER EDGES AND WELL AWAY FROM ALL CIRCUIT WIRING, LEADS, AND CONNECTOR PINS. IF AN ESD MUST BE LEFT UNATTENDED ON THE WORKBENCH, A RED CAUTION SIGN MUST BE PLACED ADJACENT TO THE UNATTENDED ESD TO PREVENT DAMAGE FROM INADVERTENT HANDLING.

4) From Microprocessors Unlimited, Inc.

MICROPROCESSORS UNLIMITED, INC.

IMPORTANT

The number one killer of Integrated Circuits or ICs is static electricity. So, read this carefully and BE CAREFUL.

Please DO NOT HANDLE ICs until you are installing them.

HANDLE DYNAMIC RAM's, EPROM's & CMOS ICs WITH EXTREME CAUTION:

1. Spread out a sheet of aluminum foil. Place both circuit board and ICs onto the foil. Before you touch the ICs touch the foil with one hand. Keep this hand in contact with the foil. Then use your other hand to pick up and install ICs into your circuit board.
2. Theory: Electricity, or electrons, flows between two points only when there is a difference in voltage between those two points. Thus, the ideal anti-static workstation should be conductive, so that every person and circuit board at the workstation becomes the same voltage.
3. When all three objects are touching the metal foil: you, the ICs, and the circuit board, are all the same voltage, and there is no way to zap the parts. This is called a "local ground".

WARNING

DO NOT CONNECT THE FOIL TO "ELECTRICAL GROUND" OR "EARTH GROUND".

DOING SO IS DANGEROUS!

4. A person should never be tied directly to "electrical ground" when there is the possibility of coming into contact with a lethal voltage such as 110 volts. People are killed this way.

CAUTION

DO NOT PLACE CIRCUIT BOARDS, WHICH HAVE A BATTERY, ON ALUMINUM FOIL. THE FOIL WILL SHORT OUT THE BATTERY AND RUIN IT.

If you cannot easily remove your circuit board from your computer case, perhaps do the next best thing: remove the 110-volt power plug from the wall socket outlet. Repeat: unplug the computer. Then contact or wrap the plug in a corner of the foil on your tabletop. The third prong on your power plug is electrically tied to your cabinet ground or chassis ground. DO NOT INSERT THE PLUG AND FOIL INTO THE POWER OUTLET! Once contact is made between the plug and the aluminum foil, slide ICs out of their packing tube onto the foil. Then, as before, touch the foil with one hand, keeping in contact with the foil or cabinet with the other hand.

Another Electro Static Discharge, or ESD, prevention technique:

1. With your left hand touch the IC container; keep your left hand on the IC container. Pick up an IC with your right hand.

2. With your left hand touch the target circuit board; keep it in on the board. With your right hand install the IC.

This procedure makes your body first become the same voltage as the IC container, then the same voltage as the circuit.

IF YOU ARE CONFUSED BY THE ABOVE, LET SOMEONE ELSE INSTALL YOUR ICs

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