Improving static control awareness

Electrostatic discharge (ESD) has killed more semiconductor products than any destructive tests. But the awareness is now high and the products to suppress static are legion

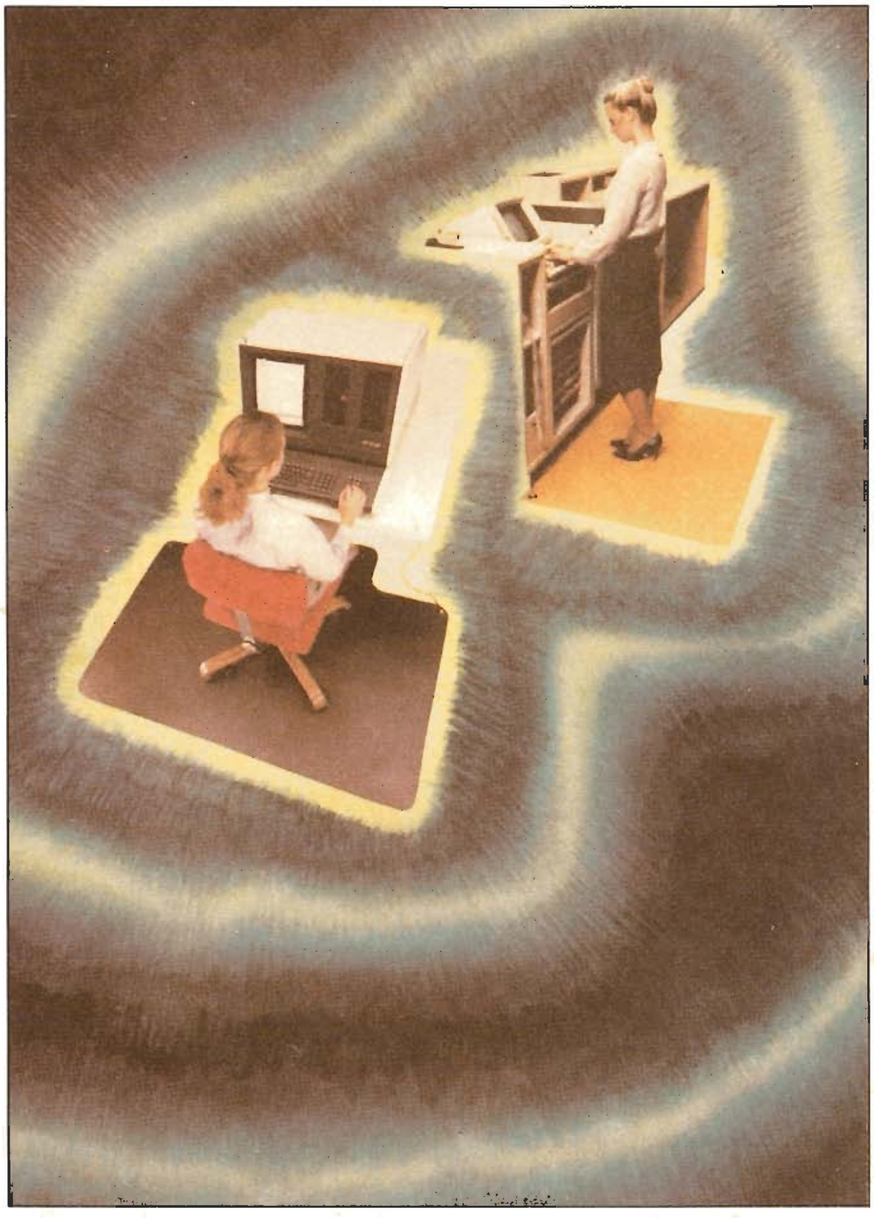
By Peter Green, Market Manager, Static Control Systems, 3M Canada Inc.

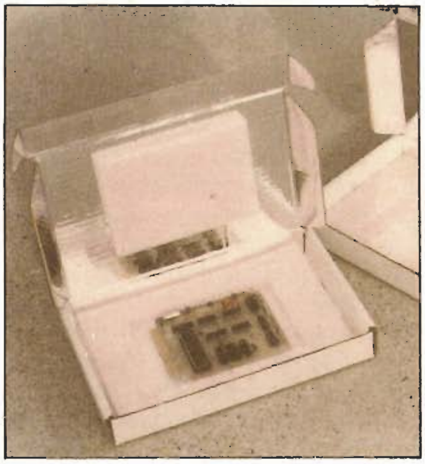
The effect of static charges on microelectronic components is no longer a matter of speculation. Device manufacturers, printed circuit board assemblers, equipment manufacturers, and to some extent equipment users, have all become aware of the tremendous losses associated with damaging static charges.

Industry was initially slow to recognize the need to control ESD, but the trend to smaller, faster microelectronic devices that consume less power has caused static control to become an area for critical concern. It has become so important in the manufacturing sector that it may become a limiting factor in the drive to achieve greater packaging densities and combine functions on single chips.

Arriving at this level of awareness has not been easy. Static charge levels needed to damage most components are below the threshold of human perception *(Table 1)*. Conducting the research and gathering the data needed to identify and quantify the results of electrostatic damage has been a difficult and lengthy task.

Even today, new research is helping





The RSC or regular slotted carton when shielded provides both physical protection and static shielding.

to establish better control of the ESD phenomenon. New and better shielding methods and materials, better testing procedures and more critical circuit and component design are being used to wage the battle on many fronts.

Static can be costly

There is good reason for concern. 3M static control analysts point out that a 0.5% device failure rate becomes a 40% system failure rate on systems with five boards containing 20 devices each. This results in escalating costs to repair and replace at the field level, and perhaps a corresponding loss of credibility in a competitive marketplace, *(Table 2)*.

The hard or catastrophic failure of a microelectronic component is easy to isolate and repair. However, soft or latent degradation is far more difficult to identify. Some manufacturers claim there are 10 degraded components for every one damaged to immediate failure. And it should be noted that 90% of the ESD problems in field applications are the result of component degradation, rather than a hard failure.

A recent study of various devices showed that voltage strikes at 25% of the device's rated destructive level, can seriously soften the "knee" of the current/voltage characteristic. (MIL-STD-883C, Test Method 3015-2).

Systems approach

Many companies are finding that success in dealing with electrostatic discharge depends on adopting a systems approach to the problems. This involves making sure that the various static control products being used complement each other and that all elements of the organization are equally effective. Any one product might have impressive technical specifications, but it is very important that it work well in conjunction with other products in order that it perform to the fullest extent of its capabilities.

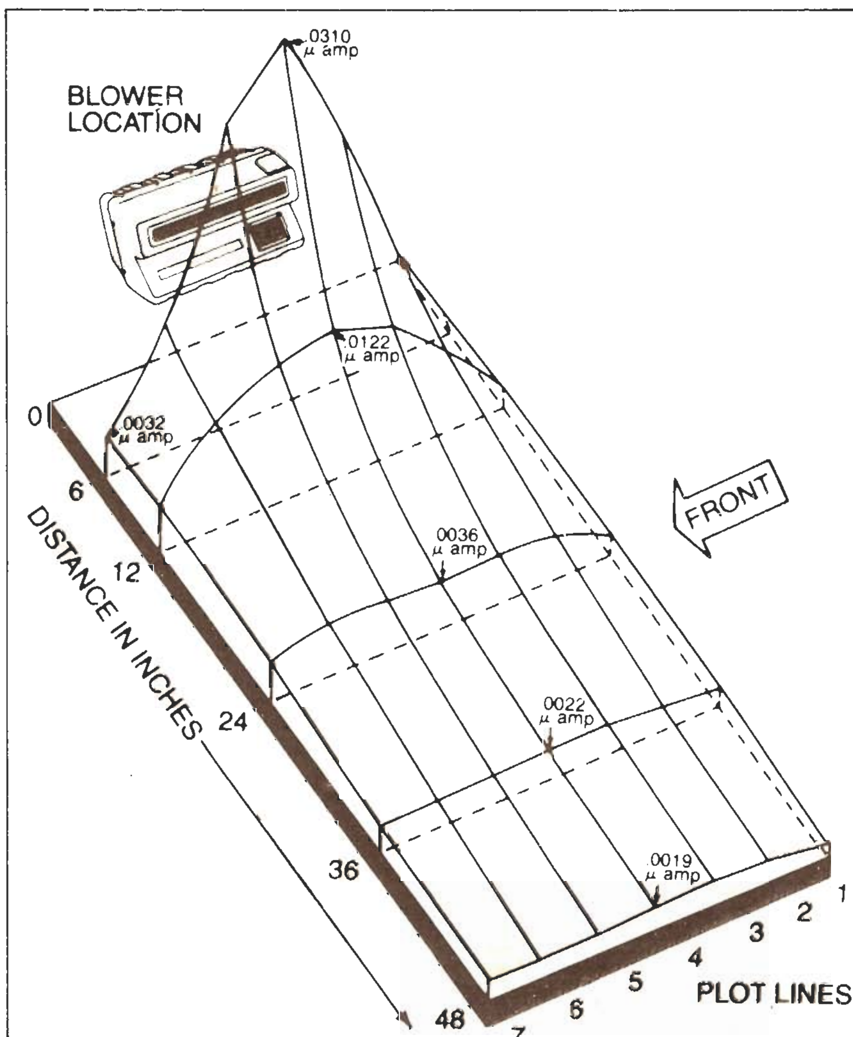
It is, of course, important to control static charges on non-conductive surfaces as well as conductors. Paper, plastic and styrofoam are examples of non-conductors found in abundance. Technology to manage this has been used for many years. The printing, plastic film and sheet fabricating, and the photoprocessing industries are examples of those who have applied the methods successfully.

Neutralizing the static charges is achieved by production of free positive and negative ions from a nuclear or high voltage electrical source. Usually a non-turbulent airflow is used to distribute the ionized environment. The same principle can be used to combat charges on non-conductors in the electronic manufacturing workplace. An ionizing air-blower installed at a workstation, for example, can complete the ESD control system here, and in addition contribute to worker comfort with a gentle, warm airflow at the same time.

Next priority

Even 100% static control during manufacture does not mean an end to the problem, however. Protective measures must extend beyond assembly

Ionized air blower effectively sweeps static away. Illustration shows ionization current pattern. The unit relating to these characteristics is a 3M 911 with nuclear static eliminator element.



to encompass transport, storage, shipping, field service work and end use.

Preventing static damage from occurring after manufacture, along with ESD-related field failures, becomes the next priority. To achieve this, the same level of awareness must be promoted among field service organizations and equipment operators alike. Material suppliers and electronic equipment manufacturers can each benefit from this process.

Protect during shipment

Often overlooked is the protection that should be afforded the ESD-sensitive components while they are being transported from the manufacturing facility to the next step in the distribution chain.

Protection must be both physical and static shielding. The former can be accomplished in a number of standard types of shipping containers. By far the most frequent method, regular slotted cartons (RSC) usually provide physical protection from puncturing. Some form of interior wrapping also is required to reduce the damage from vibration.

Triboelectronic charge damage can be easily prevented by using some form of antistatic or conductive wrapping or filler. Care must be taken to ensure that the material used is conductive enough to provide true antistatic properties.

Two other forms of electrostatic damage, direct current discharge or voltage field effects, need another form of protection—a static shield or Faraday cage. To achieve this, a conductive shielding material can be coated or laminated to the carton surface. Alternatively, the ESD-sensitive components can be simply shipped in the same static shielded bag that was used to transport them from the assembly area.

Some companies are considering the use of a static shielding bag inside a shielded shipping container lined with antistatic foam. Although some may consider this double or even triple protection, consideration should be given to the handling procedure at the destination. ESD-sensitive components remain so always, regardless of the point reached in the distribution cycle. As a result, protection must be afforded in case the component is removed from its shipping container before reaching a static-safe work area.

Large field service industry

The majority of electronic equipment purchased in this country is imported, and maintaining and repairing it has become in itself a large Canadian industry. Many companies have their own captive service departments, a good example being the telephone operating companies. Others are contracted to service certain equipment on an exclusive basis. Numerically, the largest group are the independent field service organizations.

In every case, field service can either help or hinder the effort to prevent ESD-failure. If static control procedures are not implemented here, original efforts by the manufacturer can be nearly neutralized. On the other hand, simple precautionary measures can enhance manufacturers' ESD programs and significantly reduce prema-

The static-safe work area is capable of controlling static charge on conductive objects, non-conductive objects and people

ESD Susceptibility of Various Electronic Devices

Device Type	Range of ESD Susceptibilty (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

Source: Dow Chemical

Table 1

Typical Discharge Times

Object centered in 2′ x 4′ work area

Object	Capacitance (pico farads)	Voltage (kilovolts)	Neutralization Time (seconds)
Coffee cup (styrene)	10	3	8.3
Plastic box (2″x3″x⅞″)	4	5	5.6
Cardboard box (2″x5½″x¾″)	4	5	11.1

Table 3. *Typical discharge times using an ionized air blower for non-conductive objects. Watch for those styrene coffee cups!*

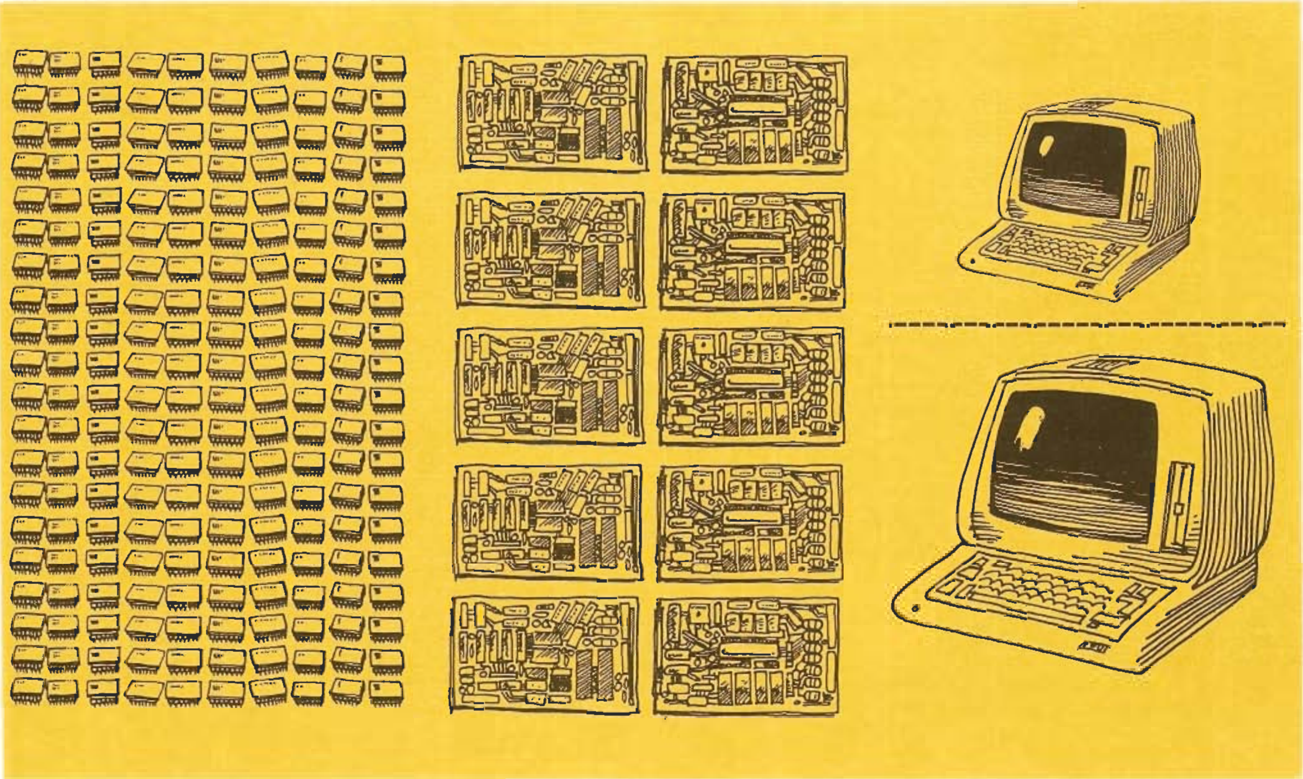


Table 2. *How a respectable 0.5% device failure rate can become a 40% disaster. S. Russell of Teradyne has presented this mathematical probability, based on standard attitudes on acceptable quality levels and realistic failure rates caused by static discharge. He observed that if you allow static to degrade just 0.5% of the devices going through an assembly area and are installing 20 devices per board, the potential board failure rate is 10%. But with five boards per typical system, the likelihood of premature board failure reaches 40%.*

ture field failures. Reduction of service calls alone can make an organization more effective and more profitable. If necessary, custom static control field service kits can be produced to ensure that technicians can use the correct materials and procedures in their own workplace. In any case, the investment required to achieve this level of precaution is small when compared to the potential savings.

The end user link

Equipment users are spread throughout all segments of the commercial, industrial and consumer sectors. Governments, financial and insurance institutions, education, retailing, hotels and restaurants, general industry, and individual homeowners are all consumers and operators of a variety of sophisticated electronic equipment.

Although the equipment itself is diverse, all of it is sensitive enough to electrostatic damage to potentially cause breakdowns, interruptions and errors in everyday situations. Electronic typewriters, telexing and telecommunications equipment, word processing and all forms of computing equipment, electronic cash registers, numerical controls, security systems, graphic processors, electronic automotive systems—the list seems neverending.

To complicate the issue, most users are unaware that they, as human beings, are the biggest generators of static electricity and that they personally present the greatest danger to microprocessor-driven equipment. Creating an understanding of this fact and instituting simple control procedures should be a high priority.

Attaining this goal is a long process, but it will only be reached by a cooperative effort. Just as the electronics industry understand the eventual benefits, the purchaser of a piece of equipment should be made aware of the problems with ESD, and benefits accruing from control procedures. Emphasis must be given to *prevention* of ESD problems, rather than *detection* once a problem occurs.

For example, if a fault occurs on a piece of electronic equipment the normal procedure would be to call a technician to solve the problem. Many are intermittent and thus difficult to identify. If the fault happened to obliterate an important piece of data, the cost associated with reworking the data, the lack of productivity due to equipment downtime, plus the service call itself can be determined with reasonably accuracy. This cost in a single instance can easily be equivalent to, or greater than, the cost associated with adequate electrostatic prevention.

Consumer education vital

Despite the acknowledged necessity of using static control procedures at the manufacturing level, a purchaser is rarely told that the equipment has ESD-sensitive components. Beyond question, damage can occur with operator handling when static control floor mats or conductive keyboard pads are not used. Static control measures are gaining some acceptance among these users, but a greater effort from all industry segments would provide benefits for all.

Static

For example, equipment manufacturers and their associated component suppliers would benefit through reduced warranty costs and gain a greater market acceptance for the reliability of their products.

Service companies would be able to make sure that field calls were for problems other than ESD-related. It is even possible that a reduced-cost service contract could be offered to customers using static control procedures.

The consumer would undoubtedly benefit because there would be less equipment downtime, and fewer errors introduced to the system. Productivity savings would accrue.

In summary, awareness of the potential damaging effects of electrostatic discharges or microelectronic components is widely accepted. Greatest acceptance has come from the manufacturing sector but some field service organizations, and a small number of equipment users are also familiar with static control precautions.

The static control system is only complete when all elements are in place and utilized. ESD precautions should include control of both conductive and non-conductive surfaces during all phases, from receiving and storage through assembly and shipping to field and end use.

Education of the end user remains a key facet in the reduction of ESD-realted problems and their associated costs. CEE

The hardware of static protection

Static has been around ever since the ancient Egyptians, (or was it the Romans and Greeks?), stroked their pet cats on cold days. It also reoccurred when the first transistorized car radios were introduced because the first cold, dry day saw the input RF amplifier blow its base-emitter junction a microsecond after the car key was inserted in the door!

Now there's anti-static spray for the cat and a voltage dependent resistor plus a dissipative base-emitter diode to protect the NPN, PNP or IC in the car. But the advent of statically fragile field effect semiconductors, EPROMs and CMOS to the large-volume production floor means that even the parts tote boxes, the factory floor and the shipping wrap and containers need to be Faraday-caged and static proofed. And so, enter the static hardware specialists, still, to some extent, charged (pun intended!) with the requirement to convince the end-users that static is here to kill.

Buckhorn boxes

Anti-static conductive boxes are the bread and butter of Buckhorn Materials Handling Products Inc., of Mississauga, ON. Buckhorn's Jim Morrison says that at least eight sizes of these containers are made in Canada. Formerly known as Nestier, the company has two ranges of containers which can be made from polyethylene as well as from a proprietary brand of carbon loaded non-conductive plastic. The two styles are a Modubox, with adjustable dividers, a flat area for labels and/or bar code placement and a reinforced lip for automatic extraction and edge racking. The other style is a conventional open front bin.

Buckhorn keeps some $60 000 of anti-static containers on hand: time for development and tooling for custom containers is five to six months, though the US and Canadian operations have many standard sizes available off-the-shelf.

Current sizes are from .01 to 8.2 cubic feet.

Shocking carpet

Once upon a time, it was common to hand your associate a fully charged 10 microfarad capacitor and watch the facial contortions when it discharged across the palm of the hand. Tom Rennie, marketing manager of Badische Canada, has a similar toy that he uses to show the static-dissipative properties of Badische's patented Zeftron® nylonfiber. Rennie has his own high-voltage generator, battery operated with a high frequency oscillator, rectifier and charge capacitor. Charged, he puts the base plate on the carpet. The well-conducting carpet material leaves no charge on his probe, but your average carpet material still allows plenty of sparks to fly from the undischarged capacitor.

However, there are a couple of points in this connection: there's the electro static problem of human comfort and convenience, and there's the ESD of a lower potential for human discomfort, but one that kills chips and generates computer lies: garbage out can result not only from garbage in, but also from static in.

The voltages involved in electrostatic discharge (ESD) are high. Peo-