The ESD Co-Ordinators Guide to Static Control 2006

TBA Electro Conductive Products

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Scope

The intention of this document is to provide pointers and ideas for establishing an Electrostatic Protected Area (EPA) in accordance with the principles of BS IEC 61340.

1. Why should we bother with static control?

To save money, reduce defects and increase business. It has been long established that electronic components are easily damaged by electrostatic discharges as small as 30-50V, with increased miniaturisation this problem will get worse.

We become aware of static when fields of around 20kV (20000V) are present, for instance opening a door and receiving an electric shock would occur at around this potential. Given the frequency of these events it is easy to understand that smaller potentials well in excess of 50 – 100V can be generated all the time without operatives being aware of the damage being caused to company profitability and quality reputation.

2. What kind of damage occurs?

Electrostatic Discharge (ESD) causes destruction or degradation of the conductive paths within Electrostatic Discharge Sensitive Devices (ESDSs) e.g. ICs, transistors etc. More frequently degradation occurs, this makes the problem worse as damaged product is likely to pass QC tests but have a shortened product life in use. It is therefore more likely that it is your customer who discovers that inadequate electrostatic precautions are being taken.

3. How is static generated?

Static is generated by a process known as tribo-charging, this occurs when two or more insulative surfaces are rubbed together.

As ESDSs are a mixture of insulative and conductive materials they can act as the source of the problem.

4. What can be done?

Introducing systems compliant with BS IEC 61340-5-1:2001, Protection of electronic devices from electrostatic phenomena into the manufacturing process mitigates the effects of Electrostatic Discharge (ESD).

5. What does the standard cover?

The standard is comprehensive and covers the following aspects: signs, configuration of EPA, field work, packaging, purchase, receipt, storage, training and quality responsibilities.

6. Where do I start?

Appoint an ESD co-ordinator! It is the responsibility of this individual to drive the implementation of BS IEC 61340-5-1:2001.

The standard is meant to run alongside Quality Assurance systems such as ISO 9002 etc. Therefore a prospective ESD Co-ordinator should have knowledge of internal quality systems and procedures, more importantly the co-ordinator should have an intimate knowledge of the manufacturing process as ideally the ESP system should add value to that process.

The value is added through cleaner working, better handling, improved flow etc.

Once a co-ordinator has been appointed senior management responsibility does not end there, the co-ordinator will be bringing about changes to established working practices so continued support will be needed, both financial and moral. Remember the changes being introduced will benefit the organisation at many levels.

7. What next?

Before purchasing Electrostatic Protection product, it is important to instigate an internal training and awareness programme. Unless all staff understand why they are being asked to work new systems, implementation will prove unsuccessful. Additionally suppliers should be contacted and informed of the new electrostatic protection requirements and what they will be expected to do.

8. Supplier obligations

Obviously to be using BS IEC 61340-5-1 internally, however the visible effect of this to you the customer is that all ESDSs you receive will be packaged correctly as per the standard and marked as per the standard. Typical markings are on pages 32 – 35 of the standard or on page 2 of our catalogue.

It is important to make every visible effort to get suppliers of ESDS to comply with the standard, if you are receiving damaged product your own good efforts are being undermined.

Particular attention should be given to sub-contract assemblers; these are likely to be working with components of many different types - ESDSs and non-ESDSs - and to their own quality system. You must ensure that their ESP precautions are adequate – remember it is your company logo on the finished product not theirs.

9. How is an EPA established?

To decide on the best equipment look at where EPAs are needed. A good approach to making this decision is to think through the product's journey through the factory from goods receiving to final despatch. An EPA may take the following forms:

- a bench
- a store
- an area of work
- a field work area
- a work station and equipment (for example, a solder flow machine)

Once the number of EPAs required has been established thought can be given to the equipment required within.

To establish an EPA it is necessary first to define its boundaries, obviously existing physical boundaries such as walls etc. will assist in this. Then it is simply a case of suitable entry and exit signs on the doors. In a larger open area it may be more convenient to mark the EPA off using for example floor marking tape or paint.

10. What equipment do I need?

The equipment required breaks down into several areas that must be considered, these are as follows:

- work surfaces
- floors
- seating
- grounding/personnel
- ionisation
- tools and machinery
- trolleys/carts/storage

10.1. What type of work surface?

The standard definition of a work surface includes bench tops, shelves, storage racks, trolleys and carts.

The electrical requirement is straightforward, surface resistance has to be less than or equal to $10^{10}\Omega$/sq. and greater than or equal to $10^{4}\Omega$/sq., the lower limit being a safety requirement rather than an electrostatic requirement.

Material selection however has many more parameters than just electrical performance. Some of the alternatives are outlined below.

ECP 1500 series matting is a range of flexible rubber work surfaces that can meet the requirements of a variety of problems. Easily cut to size these products can be used to convert existing non-static safe surfaces to BS IEC 61340 compliant surfaces. Typical applications would be bench tops, shelving, conveyor pallets, trolley tops etc.

Furthermore this range of matting can be used in conjunction with dissipative laminate tops to provide physical protection of the tops from operator vandalism, damage from solder irons, spillages and possible damage from sharp edges, screws etc. during production. Additionally these surfaces are non-slip and prevent sliding of assemblies during production.

If required it is possible to supply these products as a bonded worktop.

ECP 1580 series dissipative laminate worktops offer an easy to clean, hardwearing surface.

10.2. Do I need a conductive floor?

Obviously it is best to have a floor area as large as possible that complies with the requirements of the standard as this gives greater flexibility on grounding and material handling options.

The only requirement for a floor is that the resistance to ground from any point should be less than $10^9\Omega$. However, if electrostatic dissipative footwear is to be used as the primary means of grounding personnel then the resistance of the combination of operative/footwear/floor should be between 0.75MΩ and 35MΩ, again the lower limit is a safety requirement.

The most cost effective method of providing a large floor area that meets the requirements of BS IEC 61340 is to use ECP 525 or ECP 526 static dissipative and conductive epoxy floor paints. These are hard wearing, easy to clean products that can be easily applied to new cement floors or existing painted areas. Being volume conductive, only one grounding spot is necessary.

For local areas, ECP 1500 series matting is again suitable used as cut mats. They can be used in conjunction with ECP 525 or 526, as they could be used to prolong the life of the paint in high use areas e.g. near the bench, or they can be loose laid on existing flooring such as carpeting etc.

For operatives who are required to stand for long periods there are ECP 1535 conductive anti-fatigue mat tiles.

10.3. Are conductive chairs really necessary?

Standard seating is a source of static as tribo-charging occurs between the seat and operative. By opting for conductive seating not only is this problem eliminated but also provides additional grounding options.

TBA's ECP 1470 series is a range of chairs that not only complies with the electrostatic dissipation requirements of the standard but provides ergonomic solutions as well.

10.4. What are the best methods for grounding personnel?

There are several ways of grounding people: footwear, wristbands and coily cords or through seating. From an Electrostatic Protection perspective it is best practice to use at least two (preferably all three) of the options to protect against cord failure for example.

When considering which methods to use thought should be given to the manner of activity carried out by the operatives, are they mobile or stationary? Are they stood up or sat down? In addition to this it is necessary to think about the specification of the existing EPA - does it have static safe flooring covering the whole floor area or does it rely on local floor mats, if there is a static safe floor at all?

It must be remembered that wristbands and coily cords restrict mobility. If operatives are required to regularly leave their workstation the cord will have to be disconnected before leaving and reconnected upon return, obviously this provides scope for cords to become redundant either through forgetfulness or perceived inconvenience. That said a wristband and cord assembly represents the most certain means of grounding an operative.

The standard requirements for the band and cord as worn are as follows $7.5 \times 10^5\Omega \leq Rg \leq 3.5 \times 10^7\Omega$. In isolation the requirements for the band are that from the inner conductive surface of the band to the connecting stud on the buckle the resistance should be $\leq 1 \times 10^5\Omega$, whilst the cord should have a resistance end to end of $7.5 \times 10^5\Omega$ to $5 \times 10^6\Omega$. Electrical resistance is incorporated into the system for safety reasons the lower limit being associated with mains and the upper for high voltage areas.

Apart from the electrical requirements there are several other features of a band and cord assembly that are important. Comfort and ease of adjustment of the band, possible allergic reactions to materials such as steel that can be used as a conductor, retractability of the cord, the quality of the stress relief etc.

To allow the use of footwear as a means of grounding it is necessary to for all the floor area of the EPA to be capable of being brought to ground. Providing this criteria has been met footwear provides a very flexible means of grounding personnel that does not act to restrict the daily work activities of the people using them.

There are two basic options: electrostatic dissipative shoes or electrostatic dissipative footstraps. Technically shoes are the best option; the entire area of the sole of the shoe is dissipative therefore regardless of posture some part of the shoe will be in electrical contact with floor.

However there are limitations, to prevent contamination entering the EPA from outside (this is particularly important for clean areas) it is necessary to change shoes upon entering and leaving and EPA area. Clearly in the case of shoes this is inconvenient and in reality unlikely to happen.

Additionally, there are other issues surrounding shoes e.g. those of style, fit and comfort. These problems are especially apparent when hiring temporary staff or in dealing with visitors.

Foot straps (heel straps or toe straps) are commonly used instead of shoes as they avoid all the above issues and are cheaper, though there is then the problem that only part of the foot is then capable of forming an electrical connection with a grounded floor. This can be mitigated by wearing a heel and a toe strap, instead of the usual pair of heel straps or pair of toe straps.

In a situation where the operative is likely to working in a single fixed position an electrostatic dissipative chair is an excellent means of grounding, however if the operative should stand up obviously they are no longer grounded if this is only means of grounding. A conductive floor is also required for chairs to function, however in the case of chairs a local floor mat will suffice.

Considering the pros and cons of each method of personnel grounding provides excellent reasons for adopting at least two of the methods to ground the users of your ESP systems.

10.5. Why should I spend on ionisation equipment?

Ionisation provides an excellent means of non-contact means of elimination of static electricity from an EPA. Although they are insufficient in isolation, as part of an integrated system they are extremely effective in eradicating static produced when peeling off protective film from LCDs for example. The static fields produced in such activities are significant and can result in high failure rates in production.

TBA ECP provides a range of ionisation solutions that meet the requirements of the standard as well as the varied demands and requirements of the user.

10.6. Are there requirements for tools and machinery?

Tools and machinery used within an EPA are required to be at least non-tribo-charging but preferably electrostatic dissipative. The static dissipating element is particularly important when the tools are likely to be in close contact with ESDSs, e.g. desolder guns, tweezers etc, it is for this reason that TBA ECP 1850 series desolder guns and ECP 1800/200 series cutters pliers and strippers are produced with ESD compliant versions.

10.7. Trolleys and Carts

If a trolley is intended for use as transport for ESDSs or as a portable work surface then it must meet the same requirements as a fixed bench or work surface. Obviously the surface resistance requirements are straightforward enough, but the resistance to ground requirement needs a little more thought.

There are a couple of options for grounding a trolley, either by means of a conductive chain/strap or using conductive castors, both of these options can be provided by TBA. However for these options to work a conductive or dissipative floor is required.

As for the construction of the rest of the trolley thought should be given to what is being carried and what activities are being carried out on the trolley when considering how best to ground the contents of the trolley. For example, if it is a quantity of picking bins then it makes sense to use ECP 1150 series trolley fitted with zinc plated louvred panels to provide electrical continuity from the bin through the trolley to earth. Alternatively if it is trays or boxes being handled ECP 1160 series trolleys provide a solution, with options on runner systems and worktops. All TBA trays can be supplied with ECP 534 static dissipative powder coating to provide a 100% ESP compliant system.

The way the standard is written implies that it is acceptable for ordinary trolleys to be used providing that they are not used for transporting ESDSs. However in practice operating two types of trolley would be impossible to control, therefore it is common sense that all trolleys should comply with the standard.

11. EPA Construction and Working Practice

11.1. What does an EPA look like?

Figures 11 and 12 of the standard provide a schematic showing a typical EPA using the equipment described in section 10 of this guide and the EPA grounding system.

11.2. What are the specific requirements for an EPA?

11.2.1. What is an EPA Ground Facility?

Effectively this is mains earth.

11.2.2. What is an EPA ground bonding point (EBP)?

This is typically either a 10mm stud or a 4mm socket; other alternatives are 4 and 7mm studs. The EBP is the means by which the wrist strap and other components of an EPA are ultimately connected to the ground facility. For example TBA product references ECP 1425 common reference plate or ECP 1409 grounding box, ECP 1440 straight ground cord and 1420 ESP bonding plug provides a suitable means for complying with this criteria.

ECP 1425 provides up to four EBPs, these can be used for the operative wrist strap, supervisors, visitors and bench mat. ECP 1420 provides the connection with the EPA ground facility whilst ECP 1440 provides safe electrical connection between the other two components.

All EBPs shall be clearly marked.

11.2.3. EPA ground cords

Obviously these are the means by which the individual components of an EPA are electrically connected to the ground facility; they will be either straight or coiled. Coiled cords usually being connected to a dynamic part of the EPA e.g. the operative and a straight cord to a static component e.g. a bench top.

If a single safety resistor is being used this has to be located near the groundable point. To guarantee compliance with this requirement it makes sense to have a safety resistor in each end of a cord, in this case a resistor of a minimum resistance value of one half the total shall be located near the groundable point. The electrical resistance requirements for EPA ground cords are summarised in table 1 (page 28) of the standard or on the table given on page 31 of TBA's Static Control Solutions catalogue.

Without ground cords being connected works surfaces, wall panels, shelving etc cannot be grounded making them redundant and useless in terms of Electrostatic Protection. It is surprising how often this is overlooked.

11.3. Why do we need a Certificate of Conformance for an EPA?

This is essentially a procedural requirement, however there are benefits

- it makes the system more obvious to internal staff and external visitors.
- it helps provide discipline to the ESP system.
- shows management commitment.

11.4. Are the requirements for fieldwork different?

No. All temporary EPAs established during fieldwork shall comply with the same requirements as a permanent EPA with respect to the following:

- material quality
- training
- labelling
- packaging
- personal responsibilities

Providing training is of even greater performance in the field work arena as service/installation engineers are outside of an ESD co-ordinators individual control. Therefore to ensure engineers use the equipment provided they must fully understand the need to do so. Issuing an EPA Certificate of Conformance for the customer to sign would be a useful and visible means of ensuring compliance with the standard in a field situation.

The use of suitable ESD protective packaging is of paramount importance in a field situation (see packaging section of this guide)

TBA provides a variety of solutions in this area from light mini kits (ECP 1555/MINI) to portable workstations (ECP 1550 series).

11.5. General EPA Work Practice.

All persons, including visitors, entering an EPA shall comply with the requirements of the standard. In other words a little brief training, particularly for external visitors and sub-contractors should be given and they should be issued with equipment, garments, footwear etc meeting the requirements of your own system.

Faulty ESDSs shall be protected in the same manner as any other ESDS. This maintains consistency in approach from all operatives and the results of any fault-finding investigation will be more meaningful.

All non-ESDS items brought into the EPA shall be packed in accordance with table 2 of the standard. This as stated previously, is to prevent them acting as a source of static that may damage ESDSs.

All paperwork inside the EPA shall either be kept in containers (ECP 1112 conductive letter tray) conforming to the requirements of table 2 or shall not generate an electrostatic field. In the right conditions, e.g. high relative humidity, paper is static dissipative. However in a low humidity environment, air conditioned rooms for example, paper is an excellent source of static potential.

Only cleaning materials or processes that do not degrade the properties of the ESD protective items shall be used. Some static dissipative materials can have their properties affected by using water; additionally some cleaning materials can leave a film behind that shields the conductive properties of the item. Care should be taken then when identifying suitable cleaning materials, ECP 539 is an example of a good cleaning fluid in that it is effective at cleaning but also leaves behind a dissipative finish. It is the responsibility of the ESD co-ordinator to specify suitable materials.

12. Packaging

12.1. What should be packaged in ESP packaging?

The standard is very clear! Within an EPA **everything** should be in an ESP container of some description. This is to prevent items such as enclosures tribo-charging and damaging ESDSs. It is false economy to try and use cheaper non-ESP packaging for items not deemed to be static sensitive, the result will be to damage ESDSs at a greater cost to the business in scrap, returns, lost customers etc.

Outside an EPA only ESDSs need be packaged. Outside an EPA, packaging has to be to a higher specification than inside an EPA. The primary functions of packaging outside the EPA are to provide shielding against electrostatic fields and discharges plus limiting tribo-charging.

12.2. What type of packaging should be used?

The standard characterises packaging in the following three ways:

- Intimate – these are packaging materials that will make direct contact with an ESDS e.g. foam, bags or picking bins
- Proximity – materials not making direct contact with an ESDS but instead is used to enclose one or more devices, e.g. a transit box or bag
- Secondary – packaging materials designed to give additional physical protection to proximity packaging or to contain a number of proximity packages e.g. a pallet, cardboard box etc. Secondary packaging can be either ESP or non-ESP

These types of packaging can then be used inside two environments; these are inside an EPA or outside an EPA.

The requirements for intimate packaging are the same for both environments, which keeps things simple. Packaging of this type is required to be either conductive ($\geq 10^2 \Omega$/sq. to $\leq 10^5 \Omega$/sq.) or static dissipative ($\geq 10^5 \Omega$/sq. to $\leq 10^{11} \Omega$/sq.). For powered ESDS intimate packaging has to be static dissipative above $10^8 \Omega$/sq.

However, there are two separate requirements for proximity packaging. These are:

- Within an EPA either electrostatic discharge shielding (i.e. material that limits current and attenuates energy from a discharge, in this case energy should not exceed 50nJ from a 1000V discharge), electrostatic conductive or electrostatic dissipative.
- Outside an EPA proximity packaging has to be electrostatic discharge shielding.

Beyond the electrostatic requirements outlined above for packaging/storage, it is also necessary to consider other features of packaging when deciding on the best option for a particular product.

For example, simple packaging is a conductive box with conductive foam (ECP 1000 series), the foam would be the intimate packaging in this case and the box the proximity package. The box would provide low level electrostatic discharge shielding, physical and environmental protection. In many cases this packaging solution will suffice, however in some cases there can be a necessity to improve the nature of the intimate packaging.

For instance the ESDS may include delicate pins, contacts etc making it susceptible to damage in transit or by handling. Therefore it may be worth considering custom cut foam inserts or vacuum forming as an option for producing intimate packaging, these methods provide improved security and location of the part resulting from the package shape being designed around the component as well as assisting in preventing operator damage through over-packing. In addition it helps with batching, avoids mixing of products in a box and improves presentation.

ECP has many years of experience of producing custom made packaging solutions that comply with the electrostatic requirements of the standard as well as meeting individual process and handling requirements of the customer.

ECP 2000 range of coloured static dissipative polymers provide for manufacturing containers that are capable of meeting the requirement for powered ESDS, as well as being suitable for cleanrooms or simply colour coding storage by customer, product, business centre etc.

12.3. Are there any requirements for identification?

All packages containing ESDSs have to be identified, the intention being to warn the user of the nature of the contents of a package so that they can take the necessary handling precautions to prevent damage.

Additionally all storage equipment should be identified as per figure 4 (page 33) of the standard as electrostatic shielding, electrostatic conductive, electrostatic dissipative or low charging. This ensures that packaging is used in the correct manner to suit environment and component type. It is insufficient, as many people do, to rely on a black bin being conductive – this is not true.

12.4. Are there any supplier obligations?

Yes. Suppliers of ESDSs should package as per BS IEC 61340-5-1, this must be stated on purchase orders. Again this goes back to the earlier point of working in partnership with the supplier to remove risk of damage through ESD.

12.5. What if ESDSs are supplied without the correct packaging?

The contents of such a consignment must be treated as non-compliant and treated in the appropriate manner as per your quality system. Action taken may be rejection, quarantine pending more detailed investigation or acceptance on concession.

If it is simply the secondary packaging that is not within specification then that is OK this simply has to be removed before going to the EPA.

12.6. When is it safe to open a package containing an ESDS?

Only within an EPA! When warning labels have been removed to obtain access these should be replaced with fresh labels to re-seal the container.

13. Training

In many ways training is the most important of the standard requirements and should not be done in a haphazard manner. Poorly trained or untrained staff will either not use the equipment provided or use it incorrectly or inappropriately. Therefore it is essential that before a training programme is implemented careful thought and planning should be given to it.

13.1. Who should be trained?

Anyone who is responsible for specification, procurement, design, marking or handling of ESDSs including those who manage and supervise them. Also do not forget sub-contractors, cleaners, temporary staff and visitors (especially if they are customers).

13.2. What should people be trained in?

This obviously depends on who is being trained. A visitor's training requirements would not be as in depth as a production operative for example. However, the list below gives a few ideas of the sort of things that could be included in a training course:

- theory of the causes of charging
- some basic knowledge about electrostatic discharge
- special handling procedures
- protective items
- identification of ESS in equipment
- limits of the protection used
- ESDS sensitivity
- Personnel shall be trained in the use of new techniques, processes and equipment prior to implementation
- Conflicts with safety requirements
- High voltage precautions where EPA includes exposed conductors with a potential in excess of 250V AC or 500V DC
- Awareness of BS IEC 61340-5-1:2001

The list is by no means exhaustive nor would it be necessary to include all the items listed on an individual course.

Obviously all training given should be documented on an appropriate register and a forward plan of retraining should be devised.

Any training course should emphasise that the responsibility for meeting the requirements of an ESP system lies with everybody within the organisation.

14. Quality Responsibilities

14.1. What are the responsibilities of general management?

They are responsible for the effective implementation of all precautions set out in BS IEC 61340-5-1:2001, and for appointing an ESD co-ordinator.

They meet this requirement by ensuring that appropriate training is provided at regular intervals.

14.2. What are the responsibilities of all personnel?

People pose the greatest ESD threat to Electrostatic Sensitive Devices, therefore all personnel have the prime responsibility to take out the precautions described in BS IEC 61340-5-1:2001.

In addition it is their responsibility to be aware of the damage that can be done to electronic components by ESD. With this in mind it is up to all personnel to be pro active in informing the ESD co-ordinator of any aspects of electrostatic handling that they consider unsatisfactory.

14.3. What are the specific responsibilities of the ESD Co-ordinator?

The ESD Co-ordinator has four main areas of responsibility as listed below:

- listing all approved ESD items and equipment
- ensuring that training provision conforms to the requirements of this standard
- ensuring that the standard or an in-house procedure based on this standard is available to all relevant staff
- provision of assistance on ESD related problems.

15. Are there any requirements for procurement?

Yes. Obviously all electrostatic protective equipment should comply with the requirements of BS IEC 61340-5-1:2001.

Additionally, it is also necessary that suppliers of ESDSs or subcontractors handling ESDSs also meet the requirements of this standard. In effect this requirement has to be stated on all purchase orders.

16. What checks are required on the system?

Faults will occur with the materials in the system, it is therefore necessary to check and record checks of ESD protection equipment used in the system. Recommended frequencies of these checks are summarised below.

Item	Frequency	Requirement	Equipment
Visual	Daily	All EPA and packaging precautions are in apparent working order	N/A
Wrist Strap	Min. daily, for best practice it should be before and after use or continuously	When worn and used with ground cord. 0.75MΩ < Rg < 35MΩ	ECP 1600, 1601 or ECP 1601/Test kit ECP 1603
Non-permanent footwear e.g. heel straps, toe straps etc.	As above	If the heel strap is the primary means of grounding personnel 0.75MΩ < Rg < 35MΩ Otherwise 50kΩ < Rg < 100MΩ	ECP 1600, 1601 or ECP 1601/Test kit ECP 1603
Permanent footwear e.g. shoes	As above	If the shoe is the primary means of grounding personnel 0.75MΩ < Rg < 35MΩ (value includes the Rg of the floor) Otherwise 50kΩ < Rg < 100MΩ	ECP 1600, 1601 or ECP 1601/Test kit, ECP 1603
Earth Bonding – resistance to ground for benches, chairs, floors, racks etc.	Monthly sample	**Floors** ≤1000MΩ, unless there are safety requirements specifying minimum resistance or if heel straps are the primary means of grounding; in which case 0.75MΩ < Rg < 35MΩ **Chairs** ≤10GΩ **All other items** 0.75MΩ < Rg < 1GΩ	ECP 1602
Ionisation system	Monthly	Charge decay from 1000V – 100V in 20sec max.	ECP 1606
Electrostatic fields	Six monthly		ECP 1606
Signs and Labels	Six monthly	Location of signs must be correct	Visual
Garments	Six monthly	≤1000GΩ, charge decay 10% of initial value in 10 secs.	ECP 1602 + ECP 1606

The above checks should be backed up by regular and documented random checks on all aspects of the system in addition regular training should encourage all personnel to carry out their own individual checks on equipment and maintain a degree of vigilance with respect to the system.

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