Fundamentals of Static and Dust – 1

1. Introduction

At the painting process of automobile body and plastic parts like bumpers as well as home electrical appliances, workers are fighting with dust day in and day out. And operators in the field of Liquid-crystal, Plasma, and Flat-panel display TV's such as Organic EL TV are also fighting day and night with foreign materials typified by dust, since they require a very severe quality control over the foreign material's adherence seen at their sheet and film manufacturing process.

The typical defects related to foreign materials originate in static and the dust adsorbed by it. That is to say, the static is the biggest cause of those foreign material related problems.

Here we inquire into the principles of the static and make clear various phenomena and problems caused by the static at production sites. We also bring up an established antistatic measure and disclose its shortcomings or limitations of these conventional devices. Then, from our actual experiences, we introduce new anti-static and anti-dust measures for manufacturing sites that were developed based on the new idea we had worked out.

2. Problems arising from static electricity

Because static is generated easily when more than two materials contact, are rubbed, and break away from each other, or are pressed to one another, it is generated anywhere those materials exist. So, the industrial companies actually or potentially troubled by static are infinitely wide. Although there are the fields like copy machines where they make use of static, most industries hate it as a cause of various problems.

Problems arising from static are those listed below.

1. Break-down on semi-conductors
2. Troubles caused by static's physical force (attraction/repulsion)
3. Adherence of dust or foreign materials
4. Electric shock
5. A fire

These problems arising from static are outlined below in due order.

2-1. Break-down on semi-conductors

The microscopic circuit patterning and wiring incorporated in semi-conductors are subject to meltdown when static causes a little current to flow through them. The latest technique accelerates miniaturization on semi-conductors so much as to reach to 30 nm (nanometers) in line thickness, and as a result the meltdown of the microscopic patterning and wiring comes to occur more frequently.

On the other hand, semi-conductors are losing their dielectric strength as a miniaturization progresses, and a dielectric breakdown could occur even with a faint change in voltage caused by static. For example, the semi-conductor sensor has been advanced toward ultimately thinner membrane to increase sensibility eventually to be as thin a laminate as contains only an atom, thereby to the extent that it hates most a disturbance by static.

A tendency like this becomes more and more apparent as the semi-conductors are miniaturized to increase integration and sensibility, and to be sped up as well. The advance in technology is fast-evolving, and our demand level grows more severe with it. But, since electronic devices are so easily destroyed by static, it appears that the age has come for antistatic measures to be taken to meet these problems.

So, not only has an antistatic measure taken for the semiconductors to be strengthened in their designing process for increased resistance, but also a technique for antistatic measures and devices has to be improved in the production site to meet these requirements.

2-2. Troubles caused by static's physical force (attraction and repulsion)

Another problem caused by static is its physical force such as attraction and repulsion.

For example, in the field of paper and resin products, we often see the case that a machine to convey film and sheet materials winds its way due to static attraction and repulsion finally to let the process inoperative. Moreover, when they are processed piece by piece from a pile, they would not split asunder due to static. The adsorption by static is powerful, and the process to align them properly to one side fails if the materials are not split asunder.

On the other hand, recently in the electronics field the electronic parts are supplied in a chip style with each arranged and attached on a strip of tape by suppliers. Because the size of chips has become smaller to 0.4mm by 0.2mm as is often called "0402," they get easily to jump out of the tape due to the static induced on the tape and adhere to surrounding places or stand on end. This chip separation eventually interferes with a picking motion of equipments like the surface mounting machine. Equipments to process these chips are mainly the taping machine and the chip mounter (surface mounter). Since both machines use plastic tapes, they cannot avoid the static generated when the tape's top cover is peeled off, and the management has been worried too much about countermeasures.

2-3. Adhesion of dust and foreign substances due to static

One of the biggest concerns in current industrial fields is adhesion of foreign substances to products and outbreaks of defective products caused by the dust or foreign substances adhering to each raw material due to static.

These are not only limited to the paint defects caused by dust adhesion at the painting process, the defects of resin film or sheet for the LCD TV related to the adhesion of foreign substances, and the defects of semi-conductors in the electronics field due to adhering dust, but spread widely almost all industries. That is, a common problem across every field coming with various shape.

Particularly in the electronics field, as semi-conductors and other components used in there become hyperfine, they have now become closer to the same size as dust and foreign substances. And the serious issue that had not been discussed before comes up to the surface.

2-4. Electric shock

An “electric shock to the human body” has long been the issue caused by static. In either case of when the static built up in objects is discharged toward the human body or when the static built up in the human boy is discharged toward objects, the human body receives an electric shock. Depending on the magnitude of its current or the region of body, it involves human lives. And the case that an electrician working on the power pole falls off with an electrical shock could also happen collaterally.

2-5. A fire accident

When a spark discharge occurs inside the environment where flammable gases or fine particles exist, it can become a source of ignition for a fire or explosion accidents. In these dangerous areas, it is absolutely necessary for static not to build up or to be removed at once if built up in objects.

In the above paragraphs, we have discussed of the problems arising from the static, and from here onward we sum up of “static fundamentals.”

3. Static fundamentals

3-1. What is static?

3-1-1. Static electricity and dynamic electricity

We sometimes hear a word of “dynamic electricity” as against “static electricity.” In fact, some books say that static is the electricity which does not move or stay still, and dynamic electricity is the one which moves around. But, practically there is the case where we cannot distinguish things correctly with this definition

3-1-2. Electron explains everything clearly

Both dynamic electricity and static electricity are nothing more than electricity, but electron explains everything. Let’s discuss of phenomenon of electron being divided into three groups based on the difference in electric conductivity.

[1] Low conductivity where electrons look like as if they remain stationary.
These are ones on an insulator.
[2] Medium conductivity where electrons look like moving one step at a time.
These are ones on a semi-conductor.
[3] High conductivity where electrons flow almost freely.
These are ones on a conductor.

Taking the electron in this way, you will see it's a bit unreasonable to sort out things between dynamic electricity and static electricity.

3-1-3. Integration of static into electricity

Therefore, we'd better not to define the static by constraint, but rather to consider as common electricity. On the contrary, attempting to distinguish static from the common electricity would make it difficult to understand things.

3-1-4. Three-dimensional circuit

If we dare to distinguish them, the difference between "static" and common electricity can be explained like; though the common electricity passes through electric circuit, the static flows on the surface of insulator where there is no electric circuit. So, the "static" flows in the resistive element having much higher resistance, which is just the same phenomenon in theory as an electric current flows in electric circuit.

In the world of the static, one can consider that "it acts on the stage of the three-dimensional electronic-circuits that includes an insulator." And,
[1] Its circuit has a tremendously large resistance,
[2] It has a extraordinarily high tension voltage, and
[3] Its current varies from several microamperes to several amperes.
Then, how is it generated?

3-2. Generation of static

Static is generated by the following physical operations and manipulations.

3-2-1. Friction

Rubbing two materials together causes a static. Electrons are transferred between two materials, and the one which receives the electrons becomes positively charged and the other which releases the electrons becomes negatively charged. In the real situation, however, since these two materials part from one another after rubbing, they are to eventually be in a phenomenon of abruption. Therefore, generally the static generated by friction is considered to be added up with the static caused by a succeeding abruption.

3-2-2. Abruption

When two attached materials are separated or broken away, a static is generated. Electrons are transferred between two materials, and the one which receives the electrons becomes positively charged and the other which releases the electrons becomes negatively charged. A static generation by abruption is simpler in operation than that of friction, and comparatively more reproducible and understandable because of its simpler electrical condition and steadiness. In the case that an electric leak is almost negligible right after abruption, the static generated and its electrification is seemingly larger. Thus the static building-up problem caused by abruption is more observable in the actual working site.

3-2-3. Compression

Generally, a static is generated when materials are compressed. A typical example of the material whose electric generation performance is enhanced is the piezoelectric element, called PZT. Since the static with a high voltage is generated with a little compressive force, it is used for an igniting power source of the cigarette lighter and the like.

3-2-4. Static elimination by static ionizer

Readers of this text might doubt instantly their ears hearing that the static ionizer, which is a tool to eliminate static, generates a static itself. But it is true.

When the static ionizer produces low quality ions and sprinkles them on an object, static is built up on the object. The low quality ions mean ions with a poorly controlled ion balance. This static built up by the static ionizer is the phenomenon taking place more or less in real working sites, but has been unknown to the public. For example,

[1] On a popular alternate current (AC) type static ionizer, an ion balance pulsates at about ？ 13V, 50/60Hz around the object whose static is to be eliminated. This, in turn, charges the object at AC13V, 50/6oHz. You might not believe it, but it is true. And,

[2] On a pulse type static ionizer (Pulse AC and Pulse DC types), one needs care for the fact that an object is often charged at more than？ 500V. Ion balance on the pulse type static ionizer is much worse than others. Particularly, if it is used to eliminate a static on the object which incorporates electronic components like semi-conductors (PCB, LCD, or the like), the semi-conductors are subject to breakdown. So care must be taken for the use.

Well, why does such a dangerous state happen?

The reason is simple. On the pulse type static ionizer, positive and negative ions are sprinkled on the object alternatively and charge it positively and negatively in the same sequence. And because the frequency is about 1Hz to 30Hz, the object results in being charged with ？ 500V, 1 to 30Hz. On the other hand,

[3] On a direct current (DC) type static ionizer, the ion balance does neither vary nor pulsate like the AC and Pulse types. So, it is controlled as low as ？ 1 to 3V.

For this reason, the DC type is the best to eliminate the static charged on vulnerable electronic components precisely.

Readers who have learnt the fact mentioned above might wonder why a big discrepancy exists between the explanation given by ionizer makers and the actual performance shown by their products. The reason is simple.

The pulsation of ion balance was not visible on the obsolete Charge Plate Monitor (CPM). It displayed the numeric value on its monitor and people watched an average amount of pulsing ion balance.

On the current CPM, however, it displays measured value graphically and even a subtle operational behavior becomes visible quite distinctly. As a result, people have recognized an unbelievable pulsation of ion balance particularly on the pulse type static ionizers and startled at the fact. This is the story happening in the current static ionizer's world. Especially, in the field of semi-conductors, they would try to adjust their pulse type static ionizers to get a static value under ？10V to meet the ESD (Electrostatic Discharge) standard using the obsolete CPM. But what actually happened was that it had been more than ？500V if an actual pulsation was added up. Under this circumstance the semi-conductor, all static on which had been supposed to be eliminated, was actually charged to more than ？500V, 1 to 60Hz and could have possibly been suffered with a electrostatic discharge damage.

So the situation we face now is such that those who noticed these facts have been bewildered by the revelation on static ionizers.

3-2-5. The static charged by the charger

A charger is the device that literally charges an object with static. It radiates monopole ion onto the surface of the object. At the same time, it applies to its reverse side a high voltage with a reverse polarity or a ground potential. Then the ion adheres on the surface to have static charged on it. In practice, the charger is used at the process where a protective film is attached to the glass panel charged with static. This device has a powerful static generating capability.

In the above paragraphs, we mentioned a static generation on insulating materials. Now, what about the conductive materials?

3-3. Static generation on conductive materials

Static builds up on conductive materials as well. But it is hard to observe the phenomenon. The reason is that there is no stable electrification even if static is generated on conductive materials. The static generated is transmitted momentarily and does not remain on a certain place of materials.

However, to be more accurately, sometime static remains on the conductive material. It is the case that the material is not grounded. But, in this case, the capacitance of conductive material is large enough to neglect the static potential, and measuring the amount is not possible.

In the next and the following serials, we discuss a polarity of static.

Serialization
No.2

Fundamentals of Static and Dust ? 2

In the last number, we wrapped up the problems and difficulties caused by static, and studied the followings as fundamentals of static;

[1] What is static?

[2] Generation of static, and

[3] Static generation on conductive materials.

In this number, we continue fundamental items of;

[4] Polarity of static, and

[5] Elimination of static.

3-4. Polarity of static

3-4-1. Behavior of electron

As we studied previously, static builds up as a result of electron's behavior. An excess of electrons on the surface of object make it charged negative, and a lack of electrons makes it charged positive. Between the two materials which are rubbed together or disunited, polarity of the static built up and charged on them are determined by the degree how one material is more likely to accept or release the electrons than the other.

3-4-2. Triboelectric Series

There is a long-established table called Triboelectric Series which arranges materials experimentally in the order of an electron's tendency. Two contiguous materials are charged with static when they are rubbed together or disunited. And when an upper ranked material in the table is rubbed against or disunited from a lower ranked material, the upper is charged positive while the lower is charged negative. The degree of static charges tends to be less if the two materials are closer in the table, and more if they are farther apart.

Table 1　Triboelectric Series

Positive polarity
Glass
Cellulose
Nylon MXD6
Acrylic
Wool
Silk
Polystyrene
Polyurethane
Natural rubber
Polyester
Polypropylene
Polyethylene
Polyvinyl chloride
Teflon
Negative polarity

This is, so to say, a table that arranges materials from easy-to-be positively charged to easy-to-be negatively charged order, enabling us to understand that which polarity of and about how much of the charge on each material is destined to have when they are rubbed or disunited. Generally plastic tends to be charged negatively. Teflon and Polyvinyl chloride tend to be charged negatively as shown in the table, and Acrylic tends to be charged positively.

However, actual experiments often show an unmatched result with the table perhaps due to the following reasons; unevenness in quality of the surface of two materials, foreign materials have already adhered to the surface before the experiment because someone touched it, or surface condition is so complicated and not even if viewed microscopically. Therefore, it would be better to regard the Triboelectric Series just as a reference.

3-4-3. Complicated phenomenon of electrification

An actual phenomenon of electrification is complicated. There is no chance that one whole material is static-charged uniformly, but the charges vary depending on its part (location). One particular part is charged much, while other part is little. Also, one particular part is charged positively, while other negatively. There are many cases that are unmatched with the Triboelectric Series. The actual cases are that complicated.

So, it is a difficult and also important point that how we can ionize these complicated and unsteady static charges and bring steadily them to as close to zero as possible.

3-5. Methods to eliminate static

The method to eliminate the static charged on an object varies depending on the working site and field it is located, but there are those which are used generally;

[1] Grounding with a lead wire
[2] Wiping with a conductive cloth
[3] Mixing conductive materials into raw material
[4] Applying surface-active agents onto material's surface
[5] Wiping surface with a wet cloth
[6] Humidifying
[7] Eliminating static a static ionizer

Each item is explained in due order below.

[1] Grounding with a lead wire

a. In case that an object is conductive material

In case that the object from which static is to be removed is a conductive material or the surface of which is plated or deposited so that it is conductive, or it is damped with some kind of liquid so as to have some conductivity, the static charged on it flows into the earth if it is grounded with a copper lead wire.

a-1. Static elimination on machine plant

The housing or chassis used on machine plant has to be grounded with a copper wire. This is not only an anti-static measure to dissipate the static built up on the machine plant but an anti-leak (leak protection) measure. If the electric equipment installed into the machine plant should cause an insulation failure for some reason, an electric leak would occur from the electric equipment to the housing of machine plant. And an operator is subject to electrical shock if he touches the machine. Grounding the housing or chassis in advance with a copper wire could prevent electricity from flowing into operator's body.

a-2. Static elimination on work piece (product)

Also in the case of a product being made of conductive materials, static charge can be removed by grounding it. This is to let the electrode (conductor), which is grounded, touch the product. If the product is stationary, it can be grounded by way of jigs attached to it. If it is in motion, it should be grounded through a terminal. However, if it is likely to get bruised from the terminal or damaged, this method cannot be applied.

b. In case that an object is insulator

In case that an object is made of insulator, the static charged on only a part of it where the ground wire touches is removed. So, it is not possible to eliminate all the static charged on it. The grounding is not a proper method if the object is insulator.

[2] Wiping with a conductive cloth

This is the same method in principle as the grounding wire described above. The static charged on the surface of an object where a conductive cloth touches can be removed even if the object is insulator. But, strictly speaking, on the area where the cloth does not touch, static remains unremoved. So this can eliminate static partially but cannot dissipate thoroughly the static charged all over the surface.

Moreover, the cloth causes anew static to build up when it touches and breaks apart from the object, that is, by rubbing together and disuniting (abruption) as explained earlier. So again this cannot eliminate the static completely. On the other hand, the static built up in the cloth instantly dissipate through human body to the earth.

[3] Mixing conductive materials into raw material

This is a method of mixing conductive materials such as a carbon into raw material of an object to make it electrically conductive. Since this makes insulator to be conductor, the static generated flows into the earth when the object is seated on the earth. If not seated, the static dissipates all over the surface. Thought it is too small to measure its voltage using the static tester, it stays there. And a level of distribution of the static dissipated depends on the circumstance where the object is situated.

This method of mixing conductive materials makes material specifications of product changed, and a practical use is limited. The typical application is for the transferring tray used for semi-conductors.

[4] Applying surface-active agents onto object surface

This is a method of applying surface-active agents onto the surface of an object. In this method, the object surface is slightly made conductive, and the static generated flows to dissipate to all over the surface. If the object is grounded, the static flows into the earth. Though it is too small to measure using the static tester, it is not removed from the surface but stay there. This is same as the case on conductor.

However, applying the surface-active agent is just applying foreign material onto the object, and cannot be used for the products which require cleanliness. In addition, the surface-active agent deteriorates as time goes by, or wears out or falls off when the product collides or is rubbed with other objects to reduce conductivity.

Therefore, this could not be a permanent anti-static masseur, but could be the one used as a tentative step.

[5] Wiping surface with wet cloth

This is a method of wiping the object with water-immersed cloth. Water is more of less electrically conductive if it is not pure, so static flows through it. Except for those objects which can be wiped with water,like water containers, this method cannot be applied generally.

[6] Humidifying

Humidifying is a static eliminating method used from old times? and has been used for dissipating the static spread in the vast air space in the factory.

When the air is humidified over 65% RH, the surface of object gets to sweat and becomes electrically conductive. The static charged flow out through the moist to vanish. However, effectiveness varies depending on materials. In case of nylon, for example, experimentation showed that static was found to remain inside even if the humidity was raised up to 80%. So this method has to be carefully chosen for the purpose depending on the object.

On the other hand, controlling humidity to be uniform in the space is so hard. If not well controlled, a dew condensation would take place here and there. And once the condensation should occur, many problems listed below would follow.

Painting leaves unevenness on a finish at painting process.
Sticky moist surface catches dust.
Mold growing on textiles and papers.
Machinery gets rusty.
Molding dies get rusty.
Semi-conductors get damaged.
Contact points of electronic parts (connecter and relay) get damaged.
Papers loose crispy and mold grows.
Sticky papers cause a feeding problem on printing machine.
Moisture helps grow bacteria in food factories.

To avoid these problems, a dew condensation has to be prevented. Because it forms where temperature is low, the air in every corner inside the factory has to be stirred about to get a constant temperature distribution. However, stirring air results to raise dust, and accelerates all the more dust failures.

Thus and so, though the humidifying method is so hard in handling and controlling, it is used even today in the limited case where there is no alternative static eliminating method available.

[7] Eliminating static with static ionizer

A method of eliminating static using an instrument called “Static Ionizer.”
The static ionizer ionizes the air to produce ions under a high tension voltage and cover object with a lot of ions. The ions are induced in both positive and negative polarities. Positive static charge absorbs the negative air ion to dissipate, and negative static charge absorbs the positive air ion to dissipate. In other words, this phenomenon is explained in this way; an ionized air turns to be a semi-conducting state, and by enwrapping the object with the ionized air, the static charged on the surface flows into the air to vanish.

This is a principle of the static elimination using the static ionizer. And details of the static ionizer are explained in the next numbers.

Serialization
No. 3

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Fundamentals of Static and Dust ? 3

Up to the last number, we wrapped up problems and obstructions caused by static, and then, as the fundamentals of static we explained, **[1] what is the static? [2] Generation of static, [3] Static generation on conductive material, [4] Polarity of static, and [5] Elimination of static.** To continue the fundamentals, we explain regarding types of static ionizers below.

3-6. Types of static ionizers

There exist the following types of static ionizers.

1. Corona discharge type
    - [1] AC (alternate current) static ionizer
        - (1) Power-frequency type
        - (2) Pulse type
            - (2)-1 Pulse AC type
            - (2)-2 Pulse DC type
        - (3) High-frequency type
    - [2] DC static ionizer
    - [3] Static-free Space TRINC
    - [4] Self-discharge type static ionizer
2. Other discharge type static ionizers
    - [5] Glow discharge type
    - [6] Plasma discharge type
3. Energy line type static ionizer
    - [7] Soft X-ray type
    - [8] Laser beam type
    - [10] Radiation type

Each item above is instructed in due order below.

[1] AC static ionizer

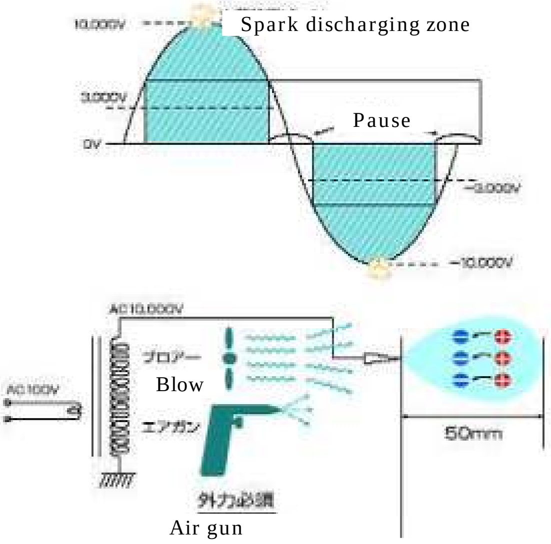
(1) Power-frequency type

The commercial AC power source with 50 or 60Hz is stepped up directly to get a high voltage of about 10,000 V using a step-up transformer. This is then led to electrodes where a corona discharge is induced to generate atmospheric ions (aero ionization). Because the positive and negative ions gravitate toward each other then to be canceled out to vanish, its effective area (to eliminate the static charge on the object) is limited only to 50mm or so. Therefore, using fan or compressed air blowing is indispensable to convey these ions to the object. Since this type uses 10,000V, the insulating materials used are subject to deterioration. In fact a lot of accidents of electric leak and electric shock have taken place.

There is also a fundamental problem that the fan or air blow raises dust to promote dust-related failures even if static charges are eliminated. On the other hand, blowing the air (supplied by the air compressor) forms a mist due to adiabatic expansion at the nozzle. This, too, tends to cause an electric shock. The system using this type has also a demerit of its size being big and heavy since it uses heavy components like the transformer, while its electronic circuit is simple.

Because this type uses commercial power source, its ion balance pulsates at 50 or 60Hz with about 10V. Consequently, it is hard to control the ion balance as precisely as it is required for a high precision type static ionizer. Besides, if the object is brought closer to ionizer's electrodes, it will get an electrostatic induction, and objects like semi-conductors are subject to destruction by the electrostatic induction.

AC type



(2) Pulse type

Both AC and DC types are available for pulse type static ionizer.
The Pulse AC type discharges positive and negative ions alternately from the same electrode, while the Pulse DC type has a pair of electrodes each of which discharges a positive or a negative ion alone. Both types discharge positive and negative ions alternately, but viewing from the electrode level, the Pulse AC type has a common electrode for positive and negative ion discharging, while the Pulse DC type has two different electrodes each for positive and negative ions respectively. The pulse frequency varies from 1 to several dozen Hz.

Like the Power-frequency type, this pulse type, too, has their positive and negative ions gravitated toward each other and canceled out to vanish, its effectual area is limited to only about 50mm. So it needs to use a fan or air blow to convey these ions to the object.

Particularly, since the Pulse AC type uses extraordinary high voltage for electrode, the insulating materials tends to deteriorate, which could lead to an electrical leak and reduce durability. In fact, the system has often caused smoke and fire accidents. There are also other problems that one system which uses a fan air raises dust and dust related failures become more noticeable, while the other system which uses compressed air causes a dew condensation due to an adiabatic expansion eventually to cause an electric shock and system breakdown.

Since the pulse type uses a low frequency, its ion balance fluctuates largely on the time axis. It can pulsate even at ？ 500V or more depending on circumstances, and in the semi-conductor field the use of it can be dangerous. In addition, when the object, specifically a semi-conductor, comes closer to a static ionizer, it receives a strong influence of the electric field around its electrodes and is subject to damages due to the static induction.

Summing up the above, the Pulse type static ionizer requires care for both a fluctuation of the ion balance and a possible demolition of semi-conductors due to the static induction if it is placed to much closer to it.

(3) High-frequency type

This type uses the piezoelectric transformer to generate high tension voltage. Its frequency is actually not as high as it is named, but in several dozens KHz. Static ionizer industry calls it a “high-frequency type” only because that they had started with and been familiar with the frequency of the commercial AC power source, and even today they call it high frequency though it is a mere several dozens KHz.

A characteristic feature of this type static ionizer is its ions being not easily dissolved even inside conductive materials, and the ions produced at the electrode can be transferred to relatively a distant area through the pipe made of conductive material, and also the static ionizer itself can be made smaller.

On the other hand, as a negative point the amount of ozone produced is greater. Because the ozone has a propensity to deteriorate rubber parts, use of this type at the area where there is the instrument which uses the rubber “O” ring and bushing has to be avoided. Moreover, though depending on the brand, this type does not generally tolerate a vibration, and is not good to use in the place where a greater acceleration is applied.

[2] DC type static ionizer

A DC type static ionizer impresses a DC high tension voltage on its two separate electrodes to generate positive and negative ions respectively, and emit them to the object to remove the static charged on it.

A static ionizer like the “No-wind TRINC” (the static ionizer with no air blow), which emits ions outward not using a fan or a compressed air blow but making use of a Coulomb’s repulsive force, uses this DC system. Because it can remove the static without air blow thereby without raising dust, it is the best suited anti-dust and anti-foreign materials measures. As a matter of fact, the PCB maker which had replaced their conventional type static ionizers (air blow type) with this No-wind TRINC could achieve to make the failure rate a half. There are so many cases similar to this.

An effective static ionizing range (ion reaching distance) without air blow can stretch as far as 700mm, but the practical distance taking the decay time into consideration is form 200 to 300mm. On the other hand, the No-wind TRINC does not use the compressed air, which could form a mist around the nozzle due to adiabatic expansion and cause an electric leak through it. So it also realizes a feature of no-leak construction as well, “No-leak TRINC.” Because of this synergistic effect, troubles have been dramatically reduced and product’s lifetime is extended overwhelmingly, and maintenance’s man-power and cost cutting are also very much improved.

Here, let us make a slight digression, there are liquid crystal makers that have faced a static ionizer’s maintenance problem, only because they employed the static ionizer using air blow, i.e. they have become annoyed with a lot of electrical leaks. With a heavy burden of high maintenance cost on their shoulders, they established an own maintenance company to have it dedicated to all the maintenance jobs of those static ionizers. The company staff said with a serious looks that “If we lose the maintenance job (by replacing them with more sophisticated static ionizers), we cannot make a living.” It surely is a deep problem for them, too, but---.

Furthermore, it should be also stressed that because No-wind TRINC does not use air blow, a drastic cost cutting on electricity can be made as a subordinate effect of it. We were startled to see the cost calculation of the currently available static ionizer using air blow consuming electricity in the cost of US$1,200 a year even for smaller sized model but US$3,000 for a larger sized model. In other words, it requires almost the same running cost for the air per year as the cost of one static ionizer. Have you ever noticed this fact?

Generally, when assessing static ionizer’s performance, people speak of their ion balance. But for ordinary static ionizers which use air blow, they suffer so many electric leak problems and actually are situated beyond a discussion of their ion balance. Thus, speaking of these electric leak and ion balance issues, the reliability of No-wind TRINC is far improved than any other types beyond comparison.

Of course, DC type static ionizers are able to utilize a fan and air blow in the same way as other conventional types. When dust on the object is needed to blow off, they apply air blow. And when ions are forcibly sent in a recess or shaded section of the work piece, a fan is used to blow the air. But, generally the air blow is not required for the purpose of removing static, but rather harmful for maintaining a clean environment in many cases.

Well then, why have there been so many static ionizers using a fan and air blow since early times? The answer is because the ion generating system in the old static ionizers couldn’t make ions travel further distance. That is, the system had a structure for the ions generated at electrodes to get to recombine just in front of the electrodes to vanish. Consequently, a mistaken common knowledge had been wide spread that “A static ionizer is required to send the air to bring ions to the work piece.”

On the other hand, there was the operators' psychology that they felt uneasy without the air from static ionizers because ions were invisible and insensible to them. On the contrary, most people then were mistaken that “no” air from ionizer meant “no” ions from it. (In reality, there were so many cases that ions did not come out even if the air came out.) Thus a mistaken common knowledge began to spread combining the circumstances of ionizer makers and the need of customers.

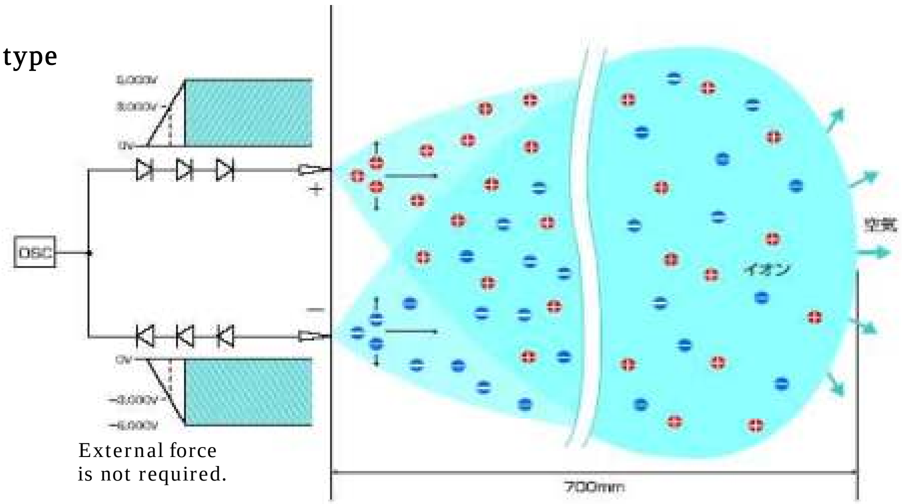
Next, we give an account of an ion balance of DC type static ionizers.

Unlike AC type and Pulse type static ionizers, the DC type has the feature that the ion balance does not fluctuate on the time axis and is precise. Because of no fluctuation on the ion balance and easier control of it, high precision static ionizers have been brought to realization. In fact, there are those which realize the ion balance of ？ 3V or less (some say even ？ 1V in their catalog).

With the AC type and the Pulse type, it is impossible to realize a high precision static ionizer such as this, because the ion balance of these ionizers is disturbed by their own pulsation. That is, the magnitude of their pulse is such high (? 10V on the AC type and ？ 500V on the Pulse type) that a higher precise ionization is not possible.

However, there is also a demerit for the DC type. The ion balance is likely to vary in reference to the place the static ionizer is situated. That is, it differs from place to place. Of cause, this disadvantage has been improved by technological innovation. TRINC has developed a technique called “Local ion generation” and overcome the problem of the ion balance varying place to place.

DC type



[3] Static-free Space TRINC

This is a new type static ionizer invented by TRINC. A special feature of this system is that static charges in an extraordinary wide space, as compared to conventional static ionizers, are all eliminated quietly without the use of air blow. An actual effective static-ionizing area per one unit is 36m² (9m x 4m) maximum, but by extending multiple units in series both horizontally and vertically and synchronizing them the space can be infinitely expanded. Thus a wider factory space than 100m² can be made a static-free environment.

In the past, there was no other method than humidification available to eliminate static charges inside a wide space, but in place of the humidification the Static-free Space (SFS) TRINC has come onstage as a new static eliminating device.

When the humidity grows excessively to be supersaturated condition, the liquid bridge force (an adhesive force caused by surface tension of the liquid) is created to accelerate product defects due to dust adhesion. Consequently, there has been the case that the humidification system introduced into the factory to avoid the dust adhesion becomes adversely a system to accelerate the dust failures.

The SFS TRINC is a new system to solve this problem at radical level. Irrespective of humidity, it creates an ideal environment of no static charges existing even under dry circumstances.

The SFS TRINC is also named as “Room-less Clean Room.” Inside the space filled with ions that SFS TRINC creates, dust loses its force to adhere to the object. So it embodies an environment like the clean room where product failures by foreign materials (dust) are minimized. This is the grounds where the name “Room-less Clean Room” comes from. We will detail the clean room in later part.

Besides, the SFS TRINC actualizes “the age of wrist strap being of no use” in electronics factories. The “anti-wrist-strap” (discussed in earlier numbers) has now become possible.

The SFS TRINC is a proposal for a new formation in denying the conventional electrostatic discharge (ESD) standard. Inside the space influenced by the SFS TRINC ions are flying about and the static charged on human bodies or work pieces are all dissipated into the air. It sets working sites free from the conventional way that requires conductive floors, conductive shoes, and wrist straps to be worn inside the factory. This is a new arm to support a so-called “Production innovation” and “Sell production system.” We will also detail this issue in later part.

Seeing from another viewpoint, the SFS TRINC is also capable of practicing a “completely dust-free ionization.” Generally, a static ionizer is situated upstream in the air flow made in the “clean room” space. For example, it is situated right under the HEPA filter so that the ions generated are carried along the down flow to reach the object. Setting it upstream, however, embraces a big problem. A static ionizer is essentially a dust generator, because it generates a high voltage thereby inherently to hold both dust collecting and dust generating functions. The electrode produces metal-oxide dust as well as separates out an ammonium nitrate to result in dust release. Particularly, the static ionizer using air blow scatters around these debris, ammonium nitrate and xylonic acid separated out from the electrode. So to say, a dust generator is situated upstream inside the clean room.

The SFS TRINC has solved this fundamental contradiction, because it is not required to locate upstream and, instead, a pair of ion bars is installed onto both sidewalls of the room and radiates ions from both sides to center part. Besides, because no air is blown from it, the down-draft which is an essential to the clean room is not disturbed at all. An air disturbance is another problem in clean room.

Owing to these unprecedented functions, the static ionization freed completely from the dust generation becomes possible. We call it "Perfect no-dust-generation TRINC"

In this chapter, we explained the outline of the SFS TRINC. It is really the arm having an epoch-making functions and features that innovates a conventional common sense. We will detail further about the SFS TRINC in the later part.

[4] Self-discharge type static ionizer

An operational principle of the self-discharge type static ionizer is to let the static charged on the object discharge making use of the static charge of its own. Practically, when a hair-like thin conductive material is laid closer to the object, the surface of which is charged with static, the electric field around the thin conductive material is distorted strongly, and the corona discharge begins eventually. The ions generated by this corona discharge are attracted by the static charged on the object and collide to neutralize it. It is generally called as the static ionizing brush. And because it operates without the power source, it can be made compact and cheap. So it is generally used for eliminating the static charged on the papers for copying machine for example.

[5] Glow discharge type

This is the one that generates ions using the glow discharge instead of the corona discharge set forth above. From its characteristic traits, the glow discharge is capable to operate even inside the environment close to vacuum and produce a little ozone, but on the other hand, it has a demerit that the tip of its electrode wears out rapidly to result in debris production. This is the technology still under development and has not been practically used yet.

[6] Plasma discharge type

This ionizer generates ions using the plasma discharge instead of the corona discharge, and uses the electrode having a sheet or special configuration as a discharge electrode. The ozone generated is almost double. Though it features no needle type electrode and thereby no troublesome cleaning, it requires a cleaning to its special electrode, which does not offer a merit to customers. There are also other concerns like durability of the electrode and dust production from the electrode. This is the technology still under development.

We will explain the Soft X-ray and other types in the next number.

Fundamentals of Static and Dust ? 4

Until the last number, as fundamentals of static we explained, **[1] what is the static? [2] Generation of the static, [3] Static generation on the conductive material, [4] Polarity of the static, [5] Elimination of the static,** and as **[6] Types of static ionizers** we studied until item 2 of the following list. In this number we start discussing from item 3 [7] Soft X-ray type onward.

1. Corona discharge type
   - [1] AC (alternate current) type static ionizer
     - (1) Power-frequency type
     - (2) Pulse type
       - (2)-1 Pulse AC type
       - (2)-2 Pulse DC type
     - (3) High-frequency type
   - [2] DC type static ionizer
   - [3] Static-free Space TRINC
   - [4] Self-discharge type static ionizer
2. Other discharge type static ionizer
   - [5] Glow discharge type
   - [6] Plasma discharge type
3. Energy line type static ionizer
   - [7] Soft X-ray type
   - [8] Ultraviolet type
   - [9] Laser beam type
   - [10] Radiation type

[7] Soft X-ray type static ionizer

This type uses an X-ray to generate ions; specifically a soft X-ray with a comparatively longer frequency. Making use of the phenomenon that air molecules on the trajectory the X-ray passed through are ionized, static on the object is neutralized to disappear.

Unlike other systems, this system does not induce corona discharge around the electrode exposed into the air, nor is debris released from the electrode. So a clean static ionization becomes possible. Besides, as it does not require a fan or air blow to carry ions, a clean environment can be maintained.

Since the X-ray itself is harmful to human body, shielding completely to prevent the human body from exposing to the radiation is required. But as a plastic-make shielding of several mm thick can block it efficiently, it is regarded to be highly safe.

Notwithstanding, however, in actual working site workers have a strong sense of resistance against the radiation from their safety mind for working environment, and persuading workers is another hard challenge in no room for quibbling. In fact, we have heard that a LCD-films production factory which introduced the Soft X-ray had to give up its use because workers did not accept it. From worker's standpoint, they would rather resign the company than impair their health.

And a service life is another problem of the Soft X-ray system. The X-ray tube is a kind of vacuum tube. Atop of the glass tube a window made of the Beryllium that emits the X-ray is provided. The cathode is heated up to emanate electrons, which are then sucked in by the high voltage to collide against the anode to generate a high energy X-ray. Since it is structurally a complicated vacuum tube, a guaranteed life is as shot as 1,000 hours. If it is used at the working site on 24 hours operation like in the semi-conductor plant, it will last only one month. And yet as it is a hand-crafted equipment, the cost goes up to several thousands dollars per unit.

In consequence, a high running cost piles up, and virtually countermeasures like to switch on and off frequently to reduce the cost and prolong the life become necessary. But, to the contrary, the frequent switching on and off results in shortening the life of the X-ray tube. So this system has been used in the limited area such as the field where a clean environment is specially required and the area of no human involvement or the safety against the radiation exposure being guaranteed.

[8] Ultraviolet type static ionizer

This type uses an ultraviolet to generate ions. Making use of the fact that air molecules on the trajectory the ultraviolet passes through are ionized, it neutralizes the static on the object.

Unlike other systems, this system does not induce the corona discharge around the electrode exposed into the air and has no problem of debris being released from the electrode. Besides, as it does not require a fan or air blow to carry ions, a clean environment can be maintained.

Though the ultraviolet static ionizer is safer than the X-ray type, it has a shortcoming of an ozone production being relatively high. Also since the ultraviolet is attenuated quickly in the air, the effectual ionizing area is shorter. Resultantly, the use of the ultraviolet type is limited only to the special field where conditions, that an ozone emission in not questioned but a clean environment is required as well as an effective ionizing area is narrower, are met. From these conditions, it has almost not been put into a practical use.

[9] Laser beam type static ionizer

This system illuminates the object with the laser beam to eliminate static charges from it. In order to ionize the air around the surface of the object, a powerful laser beam to produce a considerably high energy density is required. But a too much density could result in burning out the object. Because a laser essentially condenses light to increase its energy density thereby to form a spotlight, the object’s surface has to be scanned with it to eliminate the static charges. Accordingly it becomes a time consuming operation and is not suitable for a high speed static ionizing.

Besides, it has a safety problem and a safety precaution has to be made for a possible burning injury of human body or damage on eyes of creatures. There is an experimental report which claims a successful static ionizing on the PBC but has not been practically used.

[10] Radiation type static ionizer

This system uses the radio isotope radiation to generate ions. Making use of the fact that air molecules on the trajectory of the radiation are ionized, it neutralizes the static charged on the object to disappear. Of course, as the radiation is harmful to the human body, it is necessary to block it out completely with a sealing board. Practically it has almost not been used, but is limited to a very special case.

So far we have introduced an outline of static ionizers, and will explain further in detail of their useful applications in later part.

4. Fundamentals of dust (its behavior and propensity)

From now on we discuss “fundamental knowledge of dust.” The dust we speak of here is “foreign particles or substances floating in the air” to be more precise.

4-1 Classification of dust

The mechanism for dust to adhere to things is explained in the following three cases;

[1] Attraction by static

[2] Attraction by liquid bridge force

[3] Attraction by Van Der Waals force in microscopic world

In this paragraph, concentrating on the static attraction which is the biggest cause of dust adherence, we go ahead with explanation from the viewpoint of anti-static and anti-dust measures.

“Dust,” or “foreign particles floating in the air,” is classified into 2 kinds;

<1> Activated dust

The dust charged with static holds adhesion (force) to things.

<2> Inactivated dust

The dust not charged with static holds no adhesion to things.

4-4-1 Activated dust

I, the present writer, named the dust charged with static “activated dust” for easier understanding. The charge can be either + (positive) or ? (negative) and also a part of the dust can be charged with + while other charged ?. “Active” means a propensity that the charge (on the dust) induces the electric flux line to take on either an influence toward outside or receive an influence from outside. In actual working site, this sort of dust adheres to products to make them defective. So, it denotes that the activated dust is a “problematic dust” or “wrongful dust.”

Next, what about the possibility for the activated dust to adhere to the object? The question is answered in the following simple equation;

Simplified equation for dust adherence

$$P = kWD$$

here, P : Possibility for dust to adhere the object
k : Coefficient
W : Adsorbing force of the object
D : Adhering force of the dust

That is to say, P (possibility for the dust to adhere to the object) is the product of;
W : force of the object to adsorb the dust
and
D : force of the dust to gravitate toward the object

The equation can be detailed further in the followings.

Equation for dust adherence

$$F = q_1E \qquad E = q_2 / 4\ 6_0r^2$$

here, F : Force affecting between q_1 and q_2
q_1, q_2 : Charges
E : Electric field of q_2 affecting q_1
6_0 : Dielectric constant of the air
r : Distance between q_1 and q_2

That is to say, the attracting force (gravitation) acting on the dust is in proportion to the product of the strength of electric flux force from the charge on the object at a point where the dust is located and the charge of the dust.

At the working site in Japan, sometimes workers express the look of dust being gravitating toward products as “dust is rushing.” For example, it was the case seen at an auto repair shop where they were repainting a door using the paint spray gun. They paid attention to the dust which would appear out of nowhere to adhere the painting area, since even one small particle could spoil all works. Then, a piece of string came out of operator’s cloth. The string hovering at first in the air was then gravitated to the door. The closer it came to the door, the more it sped up, and it was adsorbed momentary to the door. This momentary adsorption is what the above equation represents. That is, since the gravitation “F” is in inverse proportion to the square of the distance “r,” the closer the string comes to door, the stronger the gravitation grows.

From the above, it is apparent that the dust adherence is a work of the static.

4-4-2 Inactivated dust

Contrary, the present writer named the dust not charged with static “inactivated dust.” “Inactivate” means that there is no static charge or, even if so, it is too small to recognize its influence. In other words, it is the dust which does not react with external force. In the actual working site, as the inactivated dust does not adhere to products and yield defects in the products, it is “harmless dust” and “good dust.”

In the end of the “Classifications of dust” we have covered above, I raise a question;

Conventionally, when measuring or speaking of cleanliness of the space, people use the particle counter to count how many particles (floating foreign materials) exist inside a cubic feet space. However, from a viewpoint of “static and dust,” there is almost no problem if floating particles in the working site are the “inactivated dust” because they do not adhere products so bad as to make them defective. Generally, as what actually becomes issue is the activated dust, it is necessary to count the activated dust. No matter how high the value of particle counter is, it would be no problem for the process if most of them are the “inactivated dust.”

The Static-free Space TRINC is a device that Trinc has developed focusing attention on this point. The Static-free Space TRINC features in neutralizing mainly the static charged on the “dust floating in the air,” which is the rare feat made possible from the reason that it is the no-air-blow ionization (No-Wind TRINC) incorporated. The floating dust adsorbs floating ions in the same space to dissipate the static charged on it without a help of air blow. The dust lost the static is then transformed to the “inactivated dust” and has no longer adhesion to anything. Consequently, the dust does not adhere to the product and no defective products are produced. That is, even if the dust is floating in the air of the production space, no defective products are produced. Accordingly it has the same effectiveness as the clean room. Hence we name the Static-free Space TRINC the “Room-less Clean Room.”

Fundamentals of Static and Dust – 5

Until the last number we explained, **1. Problems caused by the static** and **2. Fundamentals of static,** and as **3. Fundamentals of dust** we gave an account of the classification of dust. To continue to study the issue of dust, we discuss dust adherence and dust elimination in this number.

4-2 Dust adherence

The attraction force (gravitation) induced for dust to adhere to the object was explained in the previous number to be the followings;

[1] Attraction by static
[2] Attraction by liquid bridge force
[3] Attraction by Van Der Waals force in microscopic world

In general, the most powerful and influential gravitation among three is the static attraction. The force arising from static is detailed in later part.

The liquid bridge force is the gravitation related to the surface tension of water, which appears under humid conditions and yet is a special force exerted when dust comes closer to water. People often experience the liquid bridge force as a phenomenon of sticky dust adhering to human body in a high humidity environment.

The Van Der Waals force is the one acting between microscopic particles. Though it is very small, it could become so greater a force as not to be negligible if compared to the mass of particles, since the more microscopic the particle becomes, the smaller the mass of it becomes.

As explained above, generally the force induced by static is by far the most troublesome. In this sense, particularly, when the new system "Static-free Space TRINC," detailed later, is used as an antistatic measure in place of humidification, a factory can get rid of a humid condition and a resultant dry environment causes the liquid bridge force to disappear. It also makes various problems caused by damp air often seen on the paper-made products to disappear.

Now the force induced by static is the last one we need to discuss here. The dust adherence as one of problems caused by static is detailed below.

When discussing the behavior of dust, it could be easier to understand if the dust is classified into two kinds, "activated dust" and "inactivated dust," as detailed in previous number. An activated dust is the one charged with static thereby to get to possess an adhesion to the object. And an inactivated dust is the one not, or slightly, charged with static thereby to possess no or a slight (almost negligible) adhesion to the object.

When we discuss the principle of dust adhesion, we also have to classify it into two cases as well;

4-2-1 In case of the object being insulator

Static charges both on the surface of the object and the dust interact to attract or repel each other. If the two have the same polarity, they repel each other and as a result the dust is repelled from the object. If they have a reverse polarity to each other, they attract and the dust is adsorbed to the object.

Here, the dust in question is charged with static so to be an activated dust. Contrary the dust that is not or slightly charged with static is an inactivated dust, which does not adhere to the object and is hovering in the air and finally drops down on the floor. So it is not the dust that causes defective on products but harmless dust. Once again we quote here the equation for static gravitation;

$$F = q_1\, q_2 / 4\ \ 6_0 r^2 \text{ ------------------------------- } (1)$$

here, F : Static gravitation acting between q_1 and q_2
q_1, q_2 : Charges on insulator and dust
: Circle ratio
6_0 : Dielectric constant of the air
r : Distance between q_1 and q_2

and

$$E = q_2 / 4\ \ 6_0 r^2 \text{ ---------------------------------- } (2)$$

here, E: Electric field intensity induced by charges on insulator at the point of dust being located.

therefore,

$$F = q_2 E \text{ -- } (3)$$

That is to say, the attracting force (gravitation) acting on the dust is the product of "charge on the dust" and "electric flux force by the charge on the insulator at a point of the dust being located."

This equation is practically interpreted into;
"The larger the charges on the surface of the insulator and the dust are, the greater the gravitation between them grows. And, the closer the dust comes to the insulator, the stronger the adhesion becomes." This agrees with our common sense about dust adherence and is very understandable theory.

4-2-2 In case of the object being conductor

Generally speaking, conductors are not charged with static. But, strictly speaking, they are charged, but in most cases it is invisible and immeasurable. If only they are grounded somewhere, all the static charges leak through to the ground at once.

However, if a question of “Doesn’t <u>dust</u> really adhere to conductive materials?” is asked, the answer is no. It adheres to the conductive material handsomely.

The reason is; when the dust charged with static comes closer to a conductor, a reverse polarity to the dust is induced on the conductor. That is, when a positively charged dust comes near, a negative charge is induced on the surface of conductor. To the contrary, when a negatively charged dust comes near, an electron hole with a positive charge appears on the surface of conductor. So the conductor has always a reverse polarity to the dust, the static gravitation is induced between the two and eventually the dust is pulled toward the conductor. The charge induced on the surface of conductor is called “image charge” and static gravitation is called “image force.” It is called so because a reverse charge always appears on the conductive material just as if they are mirrored.

What you understand in the explanation above is that a conductive material not even being charged with static attracts dust to adsorb it on the surface. The writer recalls someone said; “Every time I measured static charges on the product (a conductive material), it showed none. But dust kept on adhering to the product, and I couldn’t understand why this happened. To me, it had been nothing short of a mystery. But now I see an answer to the question I have kept for 20 years.”

A mechanism of the dust adhering

(1) Adhering to insulator (plastic or the like)

? $I BSHFPO XPSL
? Charges on dust
? "UUSBDUF PQQPTJUF DI BSHF BMPOF

Repulsion
? Dust adherence

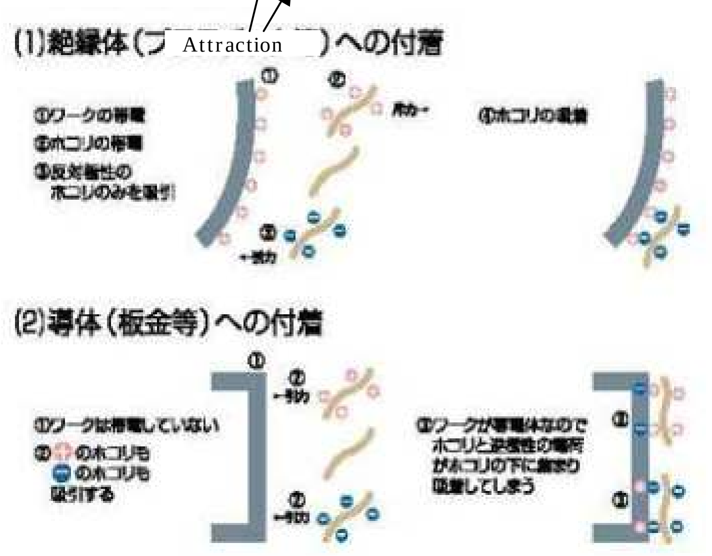
Attraction

(2) Adhering to conductive material (ion plate or the

? Work not charged
? Work attracts both ? and ? charged dust

? The work made of conductor collects the opposite charges beneath dust and adsorb it.

Attraction



: adherence we discussed
: this issue into two cases;

ect and duct attract each

other to adhere by static gravitation between charges on both sides. To remove the dust, generally air is blown while ions are sprinkled over the object by the static ionizer. By doing so, the static charged on the area of object, where no dust adheres and is exposed to the air, is neutralized first. But, on the remaining area both the positive and negative static each charged on the inside of insulator and dust are balanced to keep attracting each other, so it looks like as if there are no static charges staying there. That is to say, since no force to pull in ions from outside is exerted, they are not dissipated even if ions are sprinkled, and the dust can not be removed. If more air is blown powerfully, the dust loses the power to withstand if and is eventually blown off. The remaining static charges after the dust has been blown off pull in ions and disappear. The point on the dust removal from the insulator is to blow air powerfully.

4-3-2 In case of the object being conductor

The dust that induces the "image charge" on the conductor by the static charge of its own is adsorbed to the conductor. In this case, too, removing dust is generally done by blowing air while sprinkling ions by the static ionizer in the same way as the insulator. But the image charge induced by the dust tends to move along with the move of the dust from air blowing, so that the dust are hardly released from the bond of gravitation of the image charge. Therefore, unlike the case of insulator dust removal on the conductor is not made easily even air is blown. The dust moves just sideways and does not fly away. After all, the dust hides away in to the stagnation made while air is blown. But the hiding dust would come back again to the surface of products, and cause it to be defective.

Dust removing (blowing off) mechanism

(1) In case of insulator (plastic)

? 4UBUJDPOJ[JOH
(Sprinkling
Ions)

Ions

? 4UBUJD
JPOJ[FS

? Static charges
exposed to the
air disappear.

? "JSCMPXJOH

?
? and ?PGGTFU
NBLFT DIBSHF
DPOEJUJPO

?
"JSCMPX

? %VTUPWFT
XJUIBJSCMPX

Since connection
of ? and ?JT
SFEVDFEOPF
QBSUJDMF DPNFT
MPPTF EVTUDBO
CMPXBXBZ

Blown away

? %VTU
moves

Air
blow

Air
Blow

OK, good!!

(2) In case of conductor (metal panel, etc.)

?
When sprinkling
ions, the static
charges only on
back of dust
exposed to the air
disappear.

?
When air-blowing,
dust moves over
dragging charges
on the conductor.

? Moving

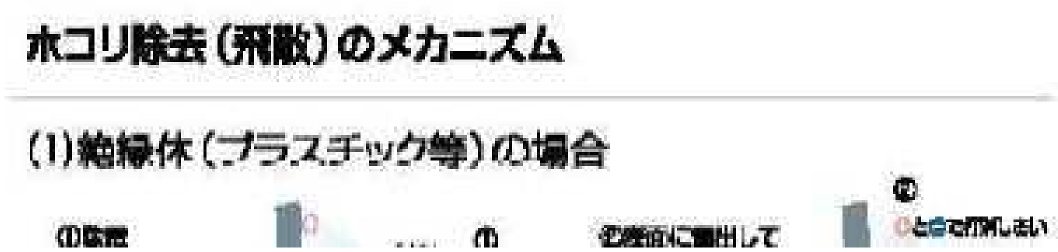
Air blow

?
Does not fly
off.

?
Dust moves over,
but does not fly
off.

I did every
thing I could,
but dust still
clings to the
panel!!

Air blow



Fundamentals of Static and Dust – 6

Until the last number, we covered item **2 Problems caused by the static** and **3 Fundamentals of the static.** And in item **4 Fundamentals of dust**, we gave an account of **[1] Classification of dust, [2] Dust adhesion, and [3] Dust removal**. To continue the study, we discuss here **5 Fundamentals of antistatic and anti-dust measures**.

5 Fundamentals of antistatic and anti-dust measures

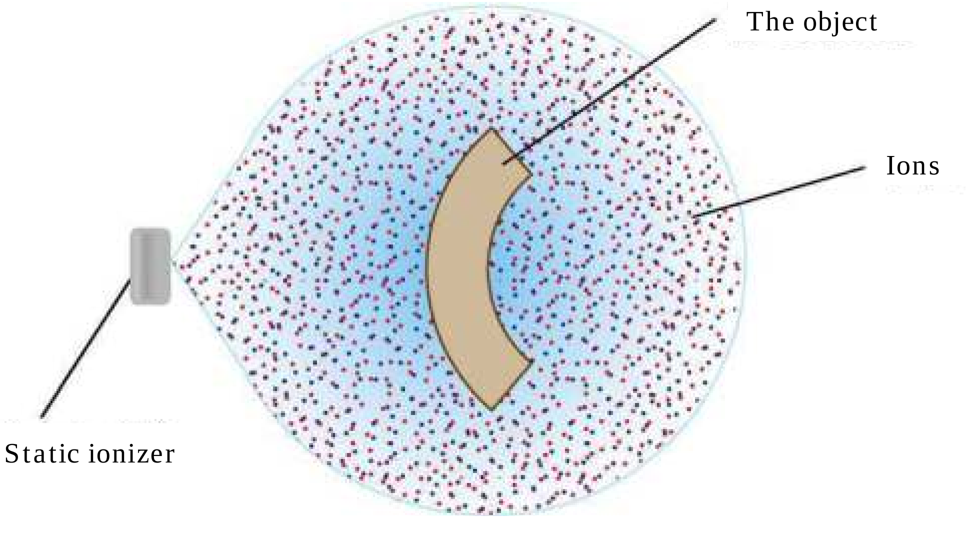
5-1 Antistatic measure

There are various methods available for antistatic measures like grounding the object, humidifying environment, and so on. But they all have their own weaknesses and cannot be used commonly in every field except specific purposes. The instrument that can be used uniformly for every field is a static ionizer.

5-1-1 Static elimination by static ionizer

5-1-1-1 Principle

A static ionizer is the device to generate atmospheric ions (or simply ions) by impressing a high tension voltage onto electrode/s to ionize the surrounding air. The ions produced are basically controlled to be in equal amount of positive and negative polarities. When these ions are sprinkled over the object charged with static, it becomes as if it is covered with air of semi-conducting state. The static charged on the object dissipate from its surface through the semi-conducting state into the air. This is the principle of the static ionizer.



5-1-1-2 Ions traveling along electric flux lines

To help readers understand the electric flux lines and the Coulomb's force, the writer likes to begin with their fundamentals. The electric flux lines are imaginary lines and used to visualize an electric field. They diverge from a positive charge and converge at a negative charge. Since the ion is a kind of charge, a positive ion diverges the electric flux lines and negative ion converges them on itself. When the electric flux lines are formed between positive and negative charges, the attraction (gravitation) is induced between them. When the electric flux line diverging at a positive charge collides head-on with that from another positive charge, they repel each other, and as a result the repulsion is induced between two positive charges. The same applies to two negative charges, and these attraction and repulsion are called Coulomb's force.

The ions generated by the static ionizer have also the electric flux lines and travel in the air being interfered with the electric flux lines existing in the air (such as those mentioned in the table below). That is, the positive ion travels along the existing electric flux lines and the negative ion travels against them. In other words, the positive ion travels being repelled by the positive charge, but at the same time being attracted by the negative charge.

Now, what is the "electric flux lines in the air" that affects ion's travel made up of?

	Charges in the air	Sort of electric flux line
1	Static ionizer	Electric flux lines generated at electrode/s
2	Ion	Electric flux lines emanated from ion itself
3	Charges existing in the air	Electric flux lines emanated from various charges in the air space where ions travel around.
4	Charges on the object	Electric flux lines emanated from the static charged on the object.
5	Image charge	Electric flux lines emanated from the various image charges existing in the air space.

The ions produced by the static ionizer travel being affected to decide their own trajectories by these various electric flux lines.

Particularly, the No-wind (No-blow) TRINC that Trinc advocates as an ideal static ionizer sends out ions without a fan or an air blow, so their traveling trajectories are all decided by these electric flux lines in the air. So the place to set up the static ionizer has to be decided considering the electric field and the electric flux lines accompanied. But in the real world, these charges in the air (environment) is far less influential as compared to the ions produced by the static ionizer, those ions travel almost straight to the object. On the other hand, since the conventional static ionizers using fan or air blow to send out ions forcibly by the air, it is less affected by these various electric flux lines. As a result, it can be set up without considering these factors.

Well, although the topic veers away a bit, the writer would like to add the following story as it is considered very important.

A fatal problem that conventional static ionizers connote inherently is in the "air blow" purposed to convey the ions they produce. The fan air blow or compressed air on which the ions travel raises dust that would otherwise stay calm on the bottom, and creates the dust related problem in production. A not-laughable reality, which the static ionizer introduced to eliminate dust related problems turn out to be the one that promotes dust-defective products, is absurd but has become a common issue in all countries.

The conclusive method to solve this basic problem is the "No-wind (No blow) TRINC. This is the new type static ionizer that delivers ions to the object without using a fan or compressed air. It has paid off greatly in the cutting off defect in many industrial fields.

5-1-1-3 Ion balance

An ion balance is the one that indicates the proportion of positive (+) ions and negative(?) ions contained in the total ions generated by the static ionizer and is shown in voltage. When the volume of positive ion surpasses the other, it is expressed "an ion balance of plus X volt." When the negative ion surpasses, it is "an ion balance of minus Y volt." To remove static charges effectively, the ion balance is required to be as close to 0 volt as possible.

Particularly in the semiconductor industrial field, the ion balance is required to be as close to 0 volt as possible, because a larger deviation could incur a higher risk of IC destruction. To the contrary, in the other fields not involving the semiconductors like the plastic industry, the ion balance is less questioned.

To win the better understanding of readers, the writer calls the ions having the ion balance closer to 0 volt "high quality ion." If we use the high quality ions, we can remove the static boundlessly to 0. Contrary, if we use poorer ions, we cannot remove the static thoroughly, and the residual static charge equal to the imbalance level remains unremoved.

For example, if the ions of ion balance +100V are sprinkled on the object charged with the static having more than + 100V, a + 100V of static still remains in the object as a residual static voltage. In this sense, the ions whose ion balance is controlled to as close to 0V as possible is preferable.

Practically, the ion balance varies depending on the type of static ionizing systems and models, a high-precision DC type shows ? 1V to 3V, a popular DC type 10V to 100V, an AC type ? 12V to 100V, and a Pulse type ? 100V to 600V as listed below.

	Ionizer type	Specification	Ion balance	Application
1	DC type	High precision	? 1V to 3V	Semi-conductor
2	DC type	Popular	? 10 to 100V	Semi-conductor and others
3	AC type		? 12 to 100V	Semi-conductor and others
4	Pulse type		? 100 to 600	Plastic and other fields

As seen in the table above, the Pulse type stands out from others for the ion balance sometimes measured as large as ? 500 to 600V. This indicates that the ion balance is pulsing largely, as often is expressed "being swinging." The lower the pulse frequency is, the larger the swing shows up.

Consequently, use of the Pulse type static ionizer is obviously dangerous under the circumstance where the object itself or surrounding instruments incorporate semiconductors. In other fields like textile, paper, and resin industries, the ion balance is not the one that is too much worried.

Serialization
No. 7

TRINC.ORG

Fundamentals of Static and Dust – 7

Until the last number, we gave an account of **2 Problems caused by the static**, **3 Fundamentals of the static**, **4 Fundamentals of dust**, and **5 Fundamentals of antistatic and anti-dust measures.** We continue on **5 Fundamentals of antistatic and anti-dust measures** in this number.

5 Fundamentals of antistatic and anti-dust measures

5-1-1-4 Static ionizer with a sensor

There are a various types of static ionizers equipped with a sensor as listed below.

[1] Static ionizer with an ion balance sensor
[2] Static ionizer with a static potential sensor
[3] Static ionizer with an ion current sensor

Each has a different type of sensor as detailed below.

[1] Static ionizer with an ion balance sensor

This is the system intended to keep an ion balance of the ions generated always at "0." It monitors always the ion balance generated and corrects it immediately if it veers either to "+" or "?" side.

*Uoperates stably without being swayed by the condition of the object or environment factors. It also removes static uniformly from the objects of not only a small size but also a wide surface like a liquid crystal grass. Unlike the other systems explained later, it does not induce hunting so as to make it in the uncontrollable condition or damage semiconductors and liquid crystals.

From these reasons, the system has a high stability and a high reliability, and is so to say is the device of going the highroad of the static ionizer.

[2] Static ionizer with a static potential sensor

Recently some makers have marketed the "static ionizer with a sensor" as a new type static ionizer. But since the static ionizers having a built-in sensor have existed as mentioned previously, it is by no means a "new static ionizer." Well then, why do they appeal it as a "new" static ionizer? The answer would be because the sensor they use is different from the conventional. They use the "static potential sensor" in place of the "ion balance sensor" normally used in the past. Truth to tell, however, the fundamental issue is hidden here. The system claimed does not stand up theoretically. It surely induces a hunting phenomenon and brings itself into an uncontrollable condition.

The makers selling these static ionizers explain the function as follows;

(1) The system measures static potential of the object.
(2) Then ionizer sprinkles the ion having a reverse polarity to the static measured

over the object.

(3) As a result high speed ionization (static elimination) becomes possible.

The explanation seems logical but contains the following two basic contradictions to make it work out;

Contradiction-1

The system oscillates to fall in uncontrollable condition when a power is put on.

Generally, in the field of automatic controlling system, this oscillation is referred to as a hunting phenomenon. Once this phenomenon occurs, far from eliminating static, it radiates positive and negative ions alternately at an interval of a few seconds thereby to charge the object with plus and minus static alternatively. Therefore, if this system should be used in the field of semiconductor ande liquid crystal industries, the products including the electronic boards or the crystal panels get to have the plus and minus current induced to run inside these components, and the system would rather create an awful situation to destroy the product.

Actually, a production engineer of the company manufacturing the chip resistor in Gifu-Prefecture, Japan, who introduced this system into their factory attested in a vivid description;

"As soon as I switched the power on, a lamp monitoring the state of ionizing turned from "red" to "green" then back again to "red" to continue the cycle. I got scared and switched off abruptly. The lamp that was supposed to turn from the 'red' indicating the object being charged to the 'green' indicating static elimination being completed and keep staying in 'green,' but it started spinning the cycle instead."

As proven in this attestation, the system that claimed to be "new" contradicts altogether theoretically and results in a very unstable and less-reliable static ionizer.

What is wrong with it, then?

The answer is simple; it is because the essential "static potential sensor" gets to lose track of self-generated ions. So, the ionizer system that is kept operating with this malfunctioning sensor becomes out of control and oscillates.

In reality, the static ionizers with such incomprehensible sensor applied have been sold and used in many places. Customers were fascinated with the ad that says "the static ionizer has a static potential sensor." As a matter of fact; one of those makers has stopped using this sensor and started to sell the product with the different controlling system with new name applied. And again, it, too, uses an odd theory.

After all, because static and ions are invisible and a static ionizer is the device not familiar to the ordinary customers, those products with odd systems have been sold unchallenged. And perhaps there is no way but to believe that designing engineers themselves of these makers are considered not to understand the theory. Or should they know it, it could be a big fraud.

Customers have to be careful in choosing new static ionizers. Even with a plausible technical description, they should not take everything in faith but assess the truth behind them. Otherwise, these might give a big damage to the products. In this connection, there had not been those evasive products having a theoretical contradiction in the past, but with an increase of new entry from different field into the static ionizer industry, these amateurish products have come into the market.

Contradiction-2

The static charged on the products that have a wide surface area like a liquid crystal panel can not be eliminated.

A static potential sensor, depending on the model, is used to sense the static potential on the surface of the object by placing it face to face normally keeping off 10mm to 25mm, or sometimes 50mm from its surface. In these cases, the sensible range of the surface is limited from $10mm^2$ to $50mm^2$. Therefore, it is sensing nothing but a part of the big object like the liquid crystal glass. So, it has to be noted that even if the sensed value is a certain volt, the value has nothing to do with the whole glass.

What if a static ionizer controls its discharging ions depending only on the value measured at a point of the object? For example, if the value measured at a certain point is ?2KV and the static ionizer emanates the positive ions generated based on this value to sprinkle over the object to neutralize the minus static charge, the static at the certain point will be neutralized to 0KV. But if the static potential on surrounding areas is originally ?1KV, the static of these area can be charged to +1KV. Consequently, the static ionizer becomes a static charger instead of static eliminator.

Obviously the static ionizer of this type can not be used if the object is wider or longer than the size it can handle. But the static ionizers incorporating an incomprehensible system like this have been sold unchallenged. Customers have to be careful not to be mistaken.

[3] Static ionizer with an ion current sensor

Next, a “static ionizer equipped with an ion current sensor” has been marketed by certain makers. The operation of this system is described in their manual and ads as follows.

(1) The object absorbs ions with a reverse polarity to the static charge of its own.
(2) As the ions absorbed become thinner, more ions with the same polarity are supplied from the static ionizer to compensate it.
(3) To compensate the ions supplied and consumed, further ions with the same polarity is produced and supplied.

If so, this system has also following two principle contradictions;

Contradiction-1

Same as the above item [2], a static elimination control system oscillates and falls in an uncontrollable condition.

For example, if the object is charged with minus static, positive ions are consumed to eliminate the static. The more positive ions are supplied, the more the same are produced to make good. Eventually the positive ions are over supplied to make the object charged with plus static. This plus static absorbs in turn negative ions. To compensate the loss of the negative ions, more of it is generated and supplied. Eventually the negative ions become excessive, and the system supplies the positive ions.

In this way the control system repeats production of positive and negative ions to compensate the excessive ions supplied alternately. That is, the system oscillates and falls into an uncontrollable condition.

Contradiction-2

This system operates successfully only on close-up ionization.

An antistatic operation begins with the action that the object absorbs the ions having opposite polarity to the static charged on it. To sense the absorption of ions properly at an electrode of static ionizer, the electrode has to come face to face with the object at very close range (within several dozen mm). But, since normally people keep the static ionizer keeping 200 to 300mm off from the object, it cannot sense the signal of absorption of ions into the object.

Therefore, this system requires a close-up setting against the object, but keeping it close-up with the object (several dozen millimeters for example) could cause another big problem that electronic components fracture with an electric field of static ionizer itself. As a result, this system is unrealistic and not practically used.

Up until this end, we have studied about merits and demerits of each system adopted on those static ionizers sold in the market. The following Table 1 shows characteristics of those systems.

Table 1: Merits and demerits of various types of static ionizer system using a sensor

	Type of sensor applied to Static ionizer	Stability and reliability	Effective area	Accuracy
1	Ion balance sensor	High stability High reliability	Wide (whole)	Higher
2	Static potential sensor	Unstable Lower reliability Design ignoring a control theory Subject to	Narrow (partial)	Lower

		uncontrollable and dangerous condition		
3	Ion current sensor	Unstable Lower reliability Design ignoring a control theory Subject to uncontrollable and dangerous condition Unrealistic	Wide (whole)	Lower

Serialization
No. 8

Fundamentals of Static and Dust – 8

Until the last number, we gave an account of **2 Problems caused by the static**, **3 Fundamentals of the static**, **4 Fundamentals of dust**, and **5 Fundamentals of antistatic and anti-dust measures.** We continue on **5 Fundamentals of antistatic and anti-dust measures** in this number.

5 Fundamentals of antistatic and anti-dust measures

5-1-1-5 Static elimination on various objects done by a static ionizer

(A) Static elimination on conductive materials - conductors

Static electricity is generated on all physical substances. If a substance is made of conductive material, state of static charges varies according to a surrounding situation, and a method of static elimination also differs accordingly.

? In case that the other materials charged with static don't exist on the fringe of the conductive object;

a. If the conductor is not grounded, the static induced diffuses instantly into all around and becomes so subtle that measurement of surface potential with the static potential tester is not possible. Or even if one could measure it, the value must be so low. This is because the value measured depends on a static capacity of a substance, which is so big on the conductors.

b. If the conductor is grounded, the static induced flows instantly through the ground to earth, and the potential value measured is 0V.

? In case that the other materials charged with static exist on the fringe of it;

On the surface of the conductor situated closer to the charged material, an image charge is induced and remains there. That is, the image charge stands still being affected by the static charged on the other material.

Note: Image charge: The charge induced on the surface of conductor is called "image charge" and its static gravitation is called "image force." (Fundamentals of Static and Dust – 5, item 4-2-2)

Like this, as an electron can move freely in the conductor and is subject to receiving an influence from the surrounding environment, a so complicated phenomenon takes place on the static charge.

Then, how can the static be eliminated on the conductors?

? In case that a static-charged material stays away from the conductor;

The static induced on the conductor can be eliminated by sprinkling ions produced by a static ionizer onto the charged material.

? In case that a static-charged material contacts the conductor;
Because the ions produced by the static ionizer would not reach the static charges staying between the two materials, the static can not be eliminated.

(B) Static elimination on insulators in the shape of a three-dimensional or two-dimensional

In case that a physical substance is made of insulating materials, the static induced at a certain point would remain there. If it shapes three dimensional, a static elimination differs in speed and degree depending on the area the static is remaining, and care must be taken in handling it.

? Elimination of the static charged on the façade of the object (insulator);
When ions are sprinkled over a three-dimensional or a plane object, the static charged on its façade (front side) is eliminated first, then on the side, and finally on the reverse side. If the object is larger than the size of 150mm square, part of ions would disappear before they reach the reverse side and the static on the reverse side could possibly be left unremoved. But, unlike the liquid sprinkled using a normal spray gun, ions would go around even to the reverse side and eliminate the static remaining there. The reason for it is; since the ion particles discharged by a static ionizer are either ionized air molecules or electrons and are very small in the mass, they move quickly for one thing and the static charged on the surface of object attract them even to the reverse side for another.

? Elimination of the static charged on the hollow on the reverse side of the object;
In case that there is a hollow on the reverse side, the static charged in there is hardly eliminated particularly when the object is larger than 150mm square. The reason for it is that ions cannot get at there. In this case ions need to be sprinkled from reverse side, and generally it is practical to rotate the object instead of rotating the static ionizer around it.

(C) Static elimination on insulators piled up to three-dimensional shape

What if the object is a piled up to a three-dimensional insulator? For example, the case that plastic parts are piled up to the object on which static is taking place both externally and internally.

Since the static stays even inner parts, ions have to be sent deep inside the object to eliminate it. The method taken conventionally is a method to plunge ions into the inner areas by way of using a fan or a compressed air. But neither the air nor ions would sneak into such inner narrow space. Therefore, generally even if the static on the surface can be eliminated, the one inside remains unremoved.

A talked-of issue in this case is a static elimination on the work pieces placed inside the parts feeder. Principally the parts feeder is a device to transfer the works by having them flied with vibration, and a strong static is inevitably induced in them. The works gravitate to the parts feeder bowl by the static and are prevented from being transferred. That is, the device has become not the part feeder anymore.

In an attempt to overcome this problem conventionally, ions had been sprinkled over from the top of the bowl. But with this method, even if the static of top surface of the piled up works could be eliminated, the static on the works inside the pile and the surface of the bowl covered by the pile could not be eliminated. And the result was that the problem had been partially improved but not solved completely.

To cope with this fateful issue, our company has made it possible to solve it with a new technology. We leave out the details of this technology here, but they are available when calling up us directly.

(D) Static elimination on plane insulating material

There are so many demands for elimination of static on plane insulating objects like films and sheets. And these are widely spread to various conditions such as film itself as well as they are laminated, retained in the air, suspended, or rolled.

? When static elimination is required on the plane object like a not-laminated film, a sheet, or a plate, it is important to confirm that there are no other materials behind them. If other materials stay attached to the reverse side of the object, static elimination is almost impossible. The material behind the object can be an obstacle to ionization, whether it is a conductive material or an insulating material. But a conducting material is more influential.

? What if ions are sprinkled head-on while the reverse side of plane object is charged with static? The ion having a reverse polarity to that on the reverse side is actually adsorbed to the front face and the static seems as if it were eliminated. But it is not actually eliminated, which causes a problem later.

? When a plane object like film or sheet laps over, it is generally hard to eliminate the static staying inside, because ions cannot intrude deep inside. TRINC has developed a new technology against this issue. We leave out the details here. Please contact us for details if necessary.

(E) Static elimination on the compound material consisting of conductor and insulator

The last subject to be discussed is a static elimination on the compound material. As explained previously, the method of static elimination taken varies between the insulator and the conductor. Since the method for the compound material has to be the one combining the both, virtually it must be taken care of case by case base manner. The followings are typical cases;

? PCB (Printed Circuit Board)

Since the printed circuit part is a conductor, the method taken for conductor has to be applied. And since the base plate part is the insulator having a good insulation, the method for insulator has to be used. In this case, however, both parts contact so closely that the static charged in the insulator part induces an image charge in the circuit part and the electric flux line is closed there. Consequently the ions emanated by the static ionizer are hardly adsorbed and the static remains unremoved. When measured with the static tester, the static seems as if not existing, but it remains actually there. It is not easy to measure and remove it from the PCB.

? Automobile body with the undercoat already done

The inner boy metal is the conductor and outer coating is the insulator. This has complex characteristics of being both insulator and conductor. The thicker the coating grows, the more it gets to assume character of insulator. This is because the conductor gets away gradually from the surface.

? Patterning-processed liquid crystal panel

The patterning part is the conductor and the glass base plate is an insulator. In this case, the insulator part and conductor part are arranged so complicatedly that the image charge is induced on the conductor part, which balances out with the static on the insulator part. Therefore, the static can be neither seen on the tester nor measured for its potential. Even if it is measured, it would look like lower than the actual value. So, it behaves similar to the PCB case above.

The question we are often asked for at working sites is, “We were said by the liquid crystal maker that static should be kept lower than a certain level (volt), but how should we do?” This is the issue raised between two companies that do not understand a thing by its nature. A demand made by the maker that the static should be kept under a certain level was totally meaningless. The maker should understand that they cannot make even a conversation of such unless they specify the object and the specific area to measure.

We hear that in the liquid crystal industrial field they make a good use of cutting edge technologies but had a history of fighting with the process yield from the beginning to the end of it. Even among the field of cutting edge technologies, the meaningless conversation like this has been spoken in the world of static electricity. It started out with meaningless words, followed by incomprehensible conditions that were built up based on them, and finally customers were demanded to keep the conditions. It would have been a really big trouble for the customers, but notwithstanding, the things have been kept produced. I pray of nothing but having both makers and customers comprehend thoroughly a principle and practice of the static and build a correct and lean the process in their factory.

Serialization
No. 9

Fundamentals of Static and Dust – 9

Until the last number, we gave an account of **2 Problems caused by the static**, **3 Fundamentals of the static**, **4 Fundamentals of dust**, and **5 Fundamentals of antistatic and anti-dust measures.** We continue on **5 Fundamentals of antistatic and anti-dust measures** in this number.

5 Fundamentals of antistatic and anti-dust measures

5-1-2 Static elimination with other methods than static ionizer

This theme has already been explained in this serialization No.2; item 3-5 "Method of elimination of static," so we go over them here just roughly.

5-1-2-1 Static elimination by grounding

This is the method to leak the static charged on the object out through grounding. But its effect depends on weather the object is either an insulator or a conductor.

? Static elimination on insulator

Since the static remaining on the surface of the object can not move freely, only the static charged on the spot where ground wire is connected can be removed. But because microscopically an insulator has a bumpy surface, the wire will not come into contact with the whole area of the spot, so the static elimination is limited to a part of it.

This method can be applied to the case that the object will not be damaged even if the wire touches on its surface, but can not be applied to, for example, the optical film or the optical lens. Neither can it be applied to the meticulous work pieces because a touching of the wire cause a fine spark to jump on the surface and as a result a fine damage or hole is made.

? Static elimination on conductor

Since a conductor passes an electric current through it, grounding a part of the work piece makes a static elimination easy over its whole area. But a care must be taken when there is another charged object near to it. Although not generally known, since a conductor has the static induced by other charge sources, if there are other objects charged with static exist nearby, the static elimination can be made and at other times not depending on where the ground wire is connected. So, when a thorough static elimination on the work is expected, it is necessary to ground it under the circumstance of no other charged objects existing.

? Static elimination on semi-conductor

The insulators we handle in daily jobs are often not the perfect insulator even if they are claimed so. This is because the surface of them is often contaminated by a touch given by workers and becomes more or less conductive. These insulators are in the state of semi-conductor which acquires an intermediate property of both the insulator and the conductor explained above. Therefore, the method of the static elimination taken against them becomes different from the case of a pure insulator and the grounding taken for conductor is also effective. But as it takes a time before the static is thoroughly eliminated, it is not suitable for an instantaneous static elimination. Time-consuming is one thing for the factory to take notice.

5-1-2-2 Static elimination by conductive cloth or brush

Wiping the object with a conductive cloth or brushing with a conductive brush is another method to eliminate the static. But microscopically the surface of insulator is not flat and these cloth and brush would not touch every hollow of it, so the static elimination is limited to a part of it. Moreover, as a basic problem, a touch by the cloth or the brush causes anew static from these contact, friction and abruption. A thorough elimination of the static can not be expected actually.

This method can be applied to the case that object is not damaged from touching, but can not be applied to the optical film or the lens which prohibits any touch of other stuff. Also it can not be applied to a fine work pieces, because a touch may cause a fine spark to jump on the object surface and causes damages or makes a hole to it.

Though this is a general method widely seen in many cases, we can not recommend it for the problems involved.

5-1-2-3 Static elimination by mixing conductive materials in the work piece

This is a method to make an insulator conductive by mixing conductive materials into it. By doing so the work turns to be a conductor or a semi-conductor so that the static is dissipated immediately to become invisible, even if static is induced.

When the work is connected with a ground wire, the static charged on it flows through it. But when it sits on an insulator, the static remains unremoved. Since the work in which conductive materials are mixed has a larger capacitance, the static potential on it looks relatively smaller and invisible, but it is actually there. This must be taken notice of carefully.

As the conductive material to mix in, a carbon powder is mainly used. Therefore, it is limited to the use on the black colored products like just inner parts or functional parts which are not visible from the outside. So, it is not suitable for appearance-oriented products or optical parts, but widely used for the tray and containers carrying semi-conductors.

5-1-2-4 Static elimination by applying surface-active agents to the object

This is a method to convert the property of the object from insulative to conductive by spraying a surface-active agent to it. Depending on the characteristics of the agent used, the converted object is more like a semiconductor than a conductor because of its bigger surface resistance in general. The static charged on the surface dissipates through the agent. However, the static is not eliminated, but just dissipated on its surface and the question whether it is eliminated or not depends on surrounded circumstances in the same way as the case of the conductive material above.

The effectiveness by the surface-active agent is temporal and can not be expected for a permanent effect. In addition, needless to say, the surface-active agent itself is a foreign material so that it can not be applied on the work which is incompatible with foreign materials. An actual application of this system to the mass-production is limited because of the cost incurred and deterioration of products by spraying.

5-1-2-5 Static elimination by wiping the object with damp cloth

This is a method to wipe simply the surface of the insulator with a damp cloth. The static charged on the surface dissipates through water. In principle water contains impurities and has a slight conductive property to let the static flow through it. So, the pure water not containing impurities cannot be used. On the other hand, because in many cases a wiping with the damp cloth could help constituent materials or attachments to the object seep into the water to make it conductive, there is a case that the pure water can be used.

Generally the wiping with a damp cloth would deteriorate the product quality, so the use of this method is limited to the plastic canteen used for carrying water for example.

5-1-2-6 Static elimination by humidification

This is a method to humidify the environment where the object is place to eliminate the static charged on it. Humidification has to be done by splaying the pure water in the air. The water sprayed is then vaporized to raise the humidity.

This is the method which puts the phenomenon into practice that the surface of the work (insulator) gets wet to have a conductivity to let the static dissipate to either its surface or inner part, rather than that the humidity itself eliminates the static.

Consequently, the effectiveness of humidification varies much depending on the material used. For example, the object made of paper and wood are those which static elimination is easily accomplished by humidification, while that made of high insulative plastics is hard to expect the efficiency. Experimentation done by us proved that a nylon fabric has the static remaining at as high as 10KV even after 5 minutes in the 80% humidity which is the highest limit. This shows that high insulative materials would hardly loose its insulative property even if a mist of pure water sticks to them.

Generally, the humidity in this method is required to be more than 65%, but in most cases it is actually raised to 70% to 80% aiming for higher effectiveness. But under this condition, the atmosphere gets to be close to the saturated vapor pressure, a dew condensation would form even for a slight change in temperature. For example, the dew would form in the morning with the temperature still being low, but in daytime with the temperature going up the air becomes dry for static to be easily induced to the contrary.

Besides, to maintain the humidity at a constant level, it is required to keep the temperature at a constant level everywhere inside the environment. But to do so inside the wide space is so hard, and as a result, either a dew condensation or a dry air occurs depending on a location in the space.

As a matter of fact, it is very hard to keep the temperature at the window area and that of the center part of the factory always equal in winder time. Similarly it is so difficult to keep the temperature at the high ceiling part and at the floor level always to be equal.

To challenge this difficult problem, enormous efforts to keep the temperature always uniform in the factory are constrained at the work site. But no matter how highly the air temperature is controlled, it is almost impossible to keep it at a certain level every hole and corner of the factory, even though it is done properly at the limited point of the air. To bring the temperature at a certain level throughout the factory, it is the most important that the air inside it is stirred. But stirring the air brings another big problem that dust in the air is also raised, to result in a laughable story in a real world that the static has been eliminated but product defects with dust has grown bigger.

Serialization
No. 10

Static and Dust Fundamentals – 10

Until the last number, we gave an account of **2 Problems caused by the static**, **3 Fundamentals of the static**, **4 Fundamentals of dust**, and **5 Fundamentals of antistatic and anti-dust measures.** We continue on **5 Fundamentals of antistatic and anti-dust measures** in this number.

5 Fundamentals of antistatic and anti-dust measures

5-2 Anti-dust measure

Until the last number, we gave an account of the antistatic measure. From this number on we explain an anti-dust measure.

5-2-1 Prevention of dust adherence

As an instrument to prevent dust from adhering to products, the dustless environment facilities represented by the clean room, the clean bench and others have long been employed as a common sense against anti-dust measures. But TRINC has introduced an entirely new concept, the Static-free Space TRINC.

5-2-1-1 Converting existing facility into clean room or clean bench

In trying to prevent dust from adhering to products, the first thing one considers is to set up the clean room. If he preferred it to be a bit smaller size, either the clean booth or the clean bench was employed. If a further compact size was required, the instrument called the clean box was employed.

These conventional systems are basically common in sending the air containing dust forcibly to a filter to filtrate it then to be supplied to the clean space where only clean air was required. That is, they try to avoid any dust from getting in the space from outside. And to do so, they use a method of pressurizing the space to be a little higher than an outside so that the air always leaks out toward the outside.

However, these clean room and clean bench that have been considered to be a common sense for anti-dust measures have the following controversial points;

5-2-1-1-1 Controversial point 1

There is no technique to trap the dust which is either taken in from the outside adhering to the raw materials delivered in or comes off the clothing of workers operating there. In other words, there is no method to defuse the dust.

Inside the facility like an ideal clean room, the clean air is let out downward from the ceiling through its entire surface so that the contaminated air is all retrieved into the floor mesh fitted to its space (the wall-to-wall air inside flows all downward uniformly). In this state, the air is descending calmly and uniformly at a speed of 0.3m/sec. and the dust comes off the worker's clothing and the raw materials is taken away with the down-air-flow and retrieved into the suction holes provided at the floor. Since the ideal clean room like this involves a very high plant investment, it has not been used practically and instead in many cases the lower grade clean room mentioned below has been widely used.

The clean systems such as a low grade popular type or a downscale model let out clean air from a part of ceiling instead of its entire area, or retrieve contaminated air into a part of the floor instead of its entire area. On further low grade systems the contaminated air is retrieved into a ventilation hole on the wall.

What's happening inside the room of these popular or downscale types? The air does not flow along with the air down-draft but causes turbulence or crosswind. Consequently, they have no way of dealing with the dust coming out of worker's clothing or raw materials inside the room. These turbulence and crosswind deliver the dust to the production process at downstream creating the dust-related defective products.

So these low cost and downscale type clean rooms may protect the dust from coming in from the outside, but are helpless against the dust generated inside the room.

5-2-1-1-2 Controversial point 2

Another controversial point is in the filer. The filter maker says with confidence that dust is completely filtered out if filtered. But there is a basic question on the current filtration system and it is theoretically impossible to filter the dust completely. (The writer dare waive details of it here, but will respond to the requirement made to us.)

5-2-1-1-3 Controversial point 3

The high power consumption on the clean room is the 3rd biggest issue. Recently, not only in the domestic market but in China as well, we hear that there are many outsourcers who do not outsource goods to the company having no clean rooms. The companies which have no clean rooms are considered to lag behind others in a quality control system. It is said that the possession of the clean room becomes preconditions without any study of whether the outsourced job requires indeed the clean room or not.

For this reason, subcontractors are making a high equipment investment to build up first the clean room. But once it is operated, they become aware of its maintenance cost going up as high as several hundred dollars a month. And as it presses heavily management, they actually keep operating the business with it switched off. And only when the outsourcer visits the company, they operate it.

As a matter of fact, the electricity required to send the air under pressure through the HEPA filter into the clean room is generally about 340W per square meter, so it consumes the electricity as high as 68KW on the small sized ideal clean room of 10m by 20m floor space. Even if its performance is reduced to a half, it still requires 34KW.

5-2-1-2 Static-free Space TRINC

The clean facility typified by a clean room involves a high plant and equipment investment. And yet, it takes a high running cost as mentioned above.

As an instrument to solve this problem, the writer offers the Static-free Space TRINC that Trinc invented.

Static-free Space TRINC radiates ions in every direction into space without the help of air blow. These ions neutralize the static charges on both the object placed in the space and the dust floating in the inside air. As the static charges existing in the space are all neutralized, the dust loses adhesion to the product and defective products caused by dust are no longer produced. So to speak, this embodies a function of the clean room.

The Static-free Space TRINC is named differently as the “Room-less clean room” and functions as a wall-less clean room. Of cause, it could not substitute for a full-featured ideal clean room, but serves as the economical or simplified mould clean room. For example, it meets a case that production process does not demand such high level as the ideal clean room at present, but requires the cleanliness to a certain extent.

The merit of the Static-free Space TRINC lies largely in 2 points.

First, it takes so low in the plant and equipment investment. The small sized clean room costs about several hundreds thousand U.S. dollars, while the Static-free Space TRINC costs only thirty five thousand dollar or less in converting the same size room into the room-less clean room. It results in about a tenth part of the plant and equipment investment required to set up the clean room.

Second, it offers a very cheap running cost. The Static-free Space TRINC consumes electricity of a mere 4.7W per unit, which is about the same consumption as the midget lamp lit while the fluorescent is switched off. For example, to create a small sized room-less clean room of about 10m by 20m, it consumes only 65.8W. If this is converted to an electric consumption per unit area, it is only 0.26W/m^2 as the effective area of the Static-free Space TRINC is 18 m^2 per unit.

As mentioned above, the Static-free Space TRINC consumes 0.0658KW as against 34KW to 68KW on the popular type small clean room, so it is a mere 1/517 to 1/1033. That is to say, if the room-less clean room is built up using the Static-free Space TRINC, running cost comes off with 1/500 to 1/1000 running cost.

This shows not only an enormous cost cutting, but a large reduction efficiency of CO_2 gas.

We have so far studied prevention of dust adherence. Next, the writer explains about the removal of the dust already adhered to the object.

5-2-2 Dust removal

To remove the dust adhered to the product, the following methods have been currently used.

5-2-2-1 Wiping off with damp cloth

The most primitive dust removing method is to wipe off with a damp cloth. The dust adhered to product can be removed by wiping off with the damp cloth to a certain extent. But, practically, the cleaning with the damp cloth can not be used on the operating process as it creates another fouling problem.

On the other hand, it is hard to clean the dust with a dry cloth. The reason for it is that the area wiped with the dry cloth is cleaned for the dust but charged anew with the static. Though this is the phenomenon commonly known and considered not necessary for us to explain here, but in many working sites the thing like this has still been practiced and operators are equally complaining “too many dust to deal with.”

Wiping the object causes the static to rise and to stay there. It is this static that attracts dust to adhere to it. The static performs as an adhesion bond. Wiping off the dust makes the object looked clean, but actually the invisible static is created anew. And as these static charges start attracting the dust to stick onto the object, it back to square one.

Serialization
No. 11

Static and Dust Fundamentals – 11

Until the last number, we gave an account of **2 Problems caused by the static**, **3 Fundamentals of the static**, **4 Fundamentals of dust**, and **5 Fundamentals of antistatic and anti-dust measures.** We continue on **5 Fundamentals of antistatic and anti-dust measures** in this number.

5 Fundamentals of antistatic and anti-dust measures

5-2-2-2 Adhesive roller

This is the way intended to adsorb the dust adhering to the object onto the adhesive applied on an elastic roller while rotating it on the object. In this case the roller can pick the dust away, but at the same time it induces the static to stay on the object. Since the static attracts to adsorb another dust right after that, the object which is supposed to have been cleaned is practically not cleaned. A fatal flaw of this method is that, even if visible dust disappears, the invisible static adheres to it.

As an actual application, the adhesive roller is often seen in field of the printed circuit board and plastic manufacturing, but antistatic measures have to be taken without fail at the time as the dust removing.

5-2-2-3 Air blow

This is a method of blowing air to remove the dust adhering to product. If the ionized air, the air mixed with ions, is used to blow off the dust, the efficiency is increased since it is done while the static charged on dust is being ionized, or removed.

A simple air blow makes the object charged further with the static, for the fine particles floating in the air strike the surface of the object to cause the static. And the static induced there adsorbs dust again from around the environment, so it is absolutely necessary to use an air gun having the function of static elimination (Gun TRINC) when blowing air.

Another point we shoud pay attention is a phenomenon of the dust flying out first but coming back to the reverse side of the object. Generally, when air is blown, the dust adhering to the object seems to be blown off to disappear, but it has just gone to stay in the stagnant air. That is; after ail blow the dust that has flown out comes back without fail to the reverse side and lurks in the stagnant air. After a while the dust would reappear on to the front side and a familiar yell starts “What happen? The dust should have been blown off.”

Until recently, this has been considered as an “unavoidable phenomenon” among workers. However, our “Static-free Space TRINC” detailed later part of this chapter has solved marvelously this problem.

Here, you see a good case example;
This is a story at the company who introduced the Static-free Space TRINC. A worker working under the working space being filled with ions generated by the Static-free Space TRINC blew off the dust piled up on the product. He did it in exactly the same way as he used to do before and tried to remove the dust from the reverse side and found no dust there. He couldn’t believe what happened before he was explained by his supervisor.

5-2-2-4 Suction with a vacuum

There is also a method of sucking in the dust adhering to the object with a vacuum instead of the air blow. Various types of vacuum suction units are available. As a compact unit for example, a vacuum tweezers which has a small hole for vacuum suction on one of the tip sucks the dust in through it. This is used in the field of the semiconductor manufacturing for removing fin dust.

On the other hand, as a mid-sized or a big-sized product, a vacuum cleaner type unit which sucks dust with a powerful vacuum is available. But, since in many cases dust would not be removed by a vacuum suction alone, they are generally equipped with a brush at the inlet hole area and operated for sucking dust while brushing. In this case, however, brushing causes the static to occur on the surface of the object and, though the dust on the surface appears to have once been removed, it attracts to adsorb the dust again right after brushing.

Accordingly, the equipment that brushes off the dust on the surface of the object while eliminating the static and then sucks the dust raised with a vacuum becomes effective. And here is the “Vacuum Cleaner TRINC” that TRINC has embodied this function ahead of the world. This is useful equipment to use in place of the adhesive roller and air blow explained above.

5-2-2-5 Adsorption with a sticky substance

This is a method of removing small pieces of dust one by one carefully using the tweezers or the like which has an adhesive on the tip in place of the adhesive roller. This is used particularly in the field of electronics industries where a fine dust removing work is required. In this case, too, the work is better made in the environment of ions drifting in the air using a static eliminating device, because a subtle static induced when removing the dust adsorbs again the dust. Of cause, the static ionizer should be of no-blow type (No-wind TRINC). If the static ionizer equipped with a fan or a compressed-air system is mistakenly used, it causes the dust to rise to accelerate product defects all the more.

5-3 “The static multiplied by dust” countermeasures

It has been generally recognized that an antistatic measure is to be handled by those specialists who deal with static-related jobs and an anti-dust measure is to be handled by those who deal with air-related jobs. By this reason, the static-related agents have taken just the antistatic measures without caring for the anti-dust measures. To the contrary, the air -related agents have dismissed the antistatic measures. As a result, both agents have influenced each other to adversely contribute in increased product defects as well as deteriorated process yield. The victims of this discrepancy have been always the customers.

TRINC has found out this problem and insisted to associate the two things and offer the countermeasure taken simultaneously.

5-3-1 Countermeasures against product defects by foreign substances

In order to keep down defective problems by foreign substances sticking to the products, the following 3 measures have to be taken simultaneously;

[1] A clean working space has to be achieved to prevent any foreign substances from coming in during operation.

[2] A static elimination from products has to be accomplished to avoid the static from attracting dust from around the environment.

[3] The static charged on dust has to be neutralized so that it does not adhere to the product.

But, what is the real world for these fundamentals;

For [1], the clean space is not created actually due to the mistaken countermeasures taken unconsciously.

For [2], the static elimination is exercised only on the product.

For [3], the neutralization is not done because it has not been established.

Well then, we detail them one by one in due order.

[1] A clean working space for any foreign substances not to come in during operation.

Practically this has not been done in most working sites. For example, the static ionization using a fan or air-blow is carried out inside the clean bench. Consequently, the laminar air flowing down inside the clean bench is disturbed to allow the dust brought in from outside to be tapped in the turbulence.

Generally, the air blowing from the fan and compressed air is prohibited to use inside the clean environment like the clean room or the clean bench. The reason for it is that the air disturbs the down flow and breaks the laminar air flow. Why is a fundamental like this ignored and a wrong practice carried our? The answer is because a “wrong handling practice” has been recommended in the catalog or the like from ionizer makers. After all, ionizer makers have educated customers to do a wrong way. Perhaps this was not caused intentionally by makers but rather by the fact that makers themselves had not understood it, though it was a grave situation.

[2] A static elimination from products to avoid it from attracting dust from around.

When speaking of a static ionization, one pictures that taken for the product. And antistatic measures for the products have been taken accordingly. But a fundamental problem is hidden here. That is about the air blow used to remove the static on the product. We call it the "static ionization with air blow (wind)" for convenience sake, in which the static ionizer generates ions and delivers them on the wind blown against the product. And a fan or the compressed air is required for this purpose. This is what the anti-dust measures abominate most and the dust-related problem is accelerated all the more by raising dust.

Unfortunately, this method has become the standard in the world. This, too, is the result from what the static ionizer makers have instructed customers. Take a look at the catalog or other information from them, you will find it everywhere or the way they instruct them.

[3] Neutralization of the static charged on dust so it does not adhere to the product

In the past, the world was not conscious of the static charged on dust contributing to the dust-related problems. TRINC pointed out it for the first time. Together with this advocacy, TRINC invented the "Static-free Space TRINC" as a countermeasure device and offered it to the world. It has been introduced into advanced user companies and has produced significant results in reducing dust-related problems.

5-3-2 No-wind (air blow) static ionizing is a must

Inside the clean environment, the down flow of air made through the HEPA filter prevents dust from coming into its stream beyond the bounds of air curtain. The air down flow forms a laminar air flow which must not be disturbed so carelessly as to cause turbulence in it. But just for the purpose of static elimination on the product the static ionizer equipped with a fan is situated inside this air steam and as a result the laminar air flow is disturbed. Or the static ionizer with a compressed air is situated in the same way. These are all don'ts. Static ionization has to be done under no air blow. The static ionizer makers who do not know even the fundamental common sense like this are educating customers to wrong direction.

5-3-3 Static-free Space static ionization is effective

Dust adheres to the product because the static charged on it attracts dust, and at the same time the static charged on the dust makes it adsorbed to the product. For this reason, the static charges on both product and dust have to be eliminated. Since dust rises with wind (air) and increases a cause of defective products, no air should be blown using a fan or a compressed air. That is, the static charged on the floating dust has to be neutralized with no air blown. The Static-free Space TRINC makes it possible to perform such magical task.

With this the static charged on the dust is neutralized, so is that on the product at the same time. As a result the force for dust to gravitate to the product no longer exists and product defects with foreign substances disappear.

This is an epoch-making technology TRINC has invented first in the world, and it is the famous story in the field that Toyota Motor was first to introduce it in all of their facilities. Canon Inc. in the field of electronics industry and other big companies supplying materials to the liquid crystal TV manufacturers are a few examples among many industry fields who have introduced Static-free Space TRINC.

We are now on the way to expand the market from domestic to world industrial fields, especially to American and European markets.

Serialization
No. 12

Static and Dust Fundamentals – 12

Until the last number, we gave an account of **2 Problems caused by the static**, **3 Fundamentals of the static**, **4 Fundamentals of dust**, and **5 Fundamentals of antistatic and anti-dust measures.** We give an account of **6 Antistatic and anti-dust measures of new age** in this number.

6 Antistatic and anti-dust measures of a new age

The common sense regarding antistatic and anti-dust measures believed for last 4 or 5 decades has stood in the way of today's various production fields. Readers may not be able to believe it suddenly. We need to look at it boldly from a different angle here.

For ordinary technicians, doubting the words and the practices taught from older members at work for long time since entering the company after graduation from school or, further, denying the international standard for a static management would surely be unimaginable. Even if they are positive, they might take great nerve to do so.

However, from the time Trinc developed new concepts, new techniques, and new devices and introduced them into the society, a new movement has started. From the feeling that the writer has gotten for nearly 10 years since then, those technicians who has less experience seems to accept them quickly perhaps from the less fixed and stereotype conception in their minds. And because they are not prepossessed with the theory, they understand faster. They have shifted gears to the new idea quickly and have gotten wonderful results.

Those who had more or less experiences with the static electricity in the past seem to be reluctant to accept the new techniques. But, if they are doubtful or reluctant about it here, they will do nothing but fall behind. Because what was not possible to embody before have become possible now, there is much difference between "before" and "after" the decision made for their acceptance. Including presidents and senior directors of big companies in Japan who have read the book "Static and Dust [Zero] Revolution" (English version: Supplier to the worldwide Toyota factories: MADE IN JAPAN), those who participated in a Trinc's presentation and observed or used the device are all expressing "I saw the light." This is a proof of the old common sense being wrong.

Well then, we give an account of both the old mistaken common sense and the Trinc's new idea in the following paragraphs.

There has long been a common sense that a static ionizer is the instrument which generates ions and carries them on the air (wind) from a fan or air compressor to the object. By the same token, many makers for pneumatic components have made recently a new entry into the static ionizer industry in unison. They might have considered and intended to sell the static ionizers along with their existing products line, trusting the mistaken common sense that pneumatic parts are essential for the static ionizers.

To the contrary, it becomes a standard of new common sense that "the fan air or the compressed air is rather inimical to a static ionization" than "they are of no or little avail to the static elimination." That is a story of a complete turn-around. And it is really a serious issue for those new entry makers to loose their foothold.

We take up the air issue first. A fan issue follows it.

6-1 Anti-air (An age demanding no air aid)

Generally people would picture the static ionizer as a box type device with the electric fan, but there are the bar and the gun types used widely. These normal bar and gun types utilize air blow without question and carry the ions generated over to the object on the air.

The structure and operation of these static ionizers are;

[1] They consist of mainly the high voltage source, corona discharge needles and the air passage.

[2] A high tension voltage is impressed to the needles to induce a corona discharge which in turn ionizes the air around them.

[3] A compressed air is sent out toward the needles from behind to carry the ions over to the object.

Here, there are 3 basic problems in this process.

(1) An electric leak and a fire take place.

On these static ionizers the compressed air emitted from its nozzle forms an air flow, on which ions travel to the object. When the compressed air is released into atmosphere, it expands instantly and simultaneously drops down its pressure having no time to absorb heat from around atmosphere. That is to say, the air expansion refraining from heat, "adiabatic expansion" occurs and air temperature drops down quickly. As a result, the moisture contained in the air is condensed to form a mist or dews.

The air containing the mist and dews is then sent to the needles which are impressed with a high voltage. Of course, the needles are held in the insulating material to avoid a leakage. However, since a high tension voltage is basically subject to leakage through the surface of the insulator if it is deteriorated, the mist and dews that reduce the insulation performance causes a leak in an instant. Once a leak occurs, it leaves the track burnt black on the surface. This means that the insulator gets burnt to produce a carbon. And since the carbon is a good conductive material, the leak current grows bigger at an accelerating pace, and eventually the high tension voltage gets lower to stop the corona discharge, and lastly the system catches a fire.

Those conventional bar and gun type ionizers are all equipped with the air blow system that causes the leak (Trinc named it "eclectic-leaky structure" for sake of easier understanding), and actually many famous liquid crystal and copy-machines factories who use them have caught fire. At an automaker's painting factory, they said that they had a smoking accident and scrambled to turn off the switch because the factory space was filled with a flammable paint thinner.

This dangerous situation has been left unchanged for more than 40 years until quite recently people realize that an awful engineering design has been applied for those products. This is the mistaken common sense long believed in the past. The writer instantiate a trouble occurred at the plastic mold manufacturer in Toyama-Prefecture, Japan.

We gave a presentation of our products at their office. After the presentation they invited us to their working site and requested us to give an advice, where the toner cartridges were being processed using conventional gun type static ionizers. They used them to remove dust from the toner cartridge before filling it with the toner. We conducted experimentation right away. By rubbing the test piece we built up the static on it and measured voltage. It was ?15 KV. Then we asked a worker to sprinkle ions from the gun type static ionizer they were using and measure the value, they were startled to see the result which showed ?17 KV. The static was increased rather than reduced. They mumbled that they bought the static ionizer just one week before. The device was found to be "eclectic-leaky" structure.

The writer has witnessed countless cases similar to this. As long as the conventional static ionizers built in the electric-leaky structure, the problem was a necessary consequence. Everybody has never doubted but accepted the fact.

There was a story even worse. One day the writer had a chance to talk to a general manager of the company who sells painting equipments that incorporate static ionizers. The writer told him that conventional static ionizers could cause an electric leak problem and a poor working efficiency. A response from him was that "We know that those static ionizers we have sold become ineffective after a while of use, but we turn a blind eye to it because we would be blamed of it if we had told of it to them."

After all, the static ionizers they could get at that time were all in this level and they had no other way but to sell them if they were requested by their customers, even if they knew they had a problem. The static ionizer makers who have supplied their dealers with defective products had to be primitively blamed for that. But, even today the static ionizers with this poor quality are sold openly as the brand name products. The writer has a feeling that a portion of the blame for this situation should also be on the part of customers. They should also be blamed for their blindly using those products. Why haven't they confirmed whether products are actually effective or not. If this situation were left untouched, the problem could never be corrected.

Well then, we introduce a Trinc new common sense.

Once Trinc discovered a fatal flaw, "electric-leaky-structure," on the conventional static ionizers, it became obvious that, if it had not been able to go beyond the bounds of such obsolete common sense, it would have been one of birds in a feather. So, it was placed to develop a new structure having no leak problem at all costs, and developed the no-leak-structure, "No-leak TRINC."

The idea used then was an often-cited "zero return." Trinc came back to the basic of the electric engineering and abided by the theory, "air and electricity should not cohabit with each other." And yet, since the static ionizer uses a high voltage, it must not be put together with the air which tends to contain water. Then Trinc developed a new structure that divides the air passage from the dangerous high voltage parts to have all these parts housed in the separated room. By doing so, the structure has no longer to do with the leakage. This is the "No-leak TRINC" that prolongs the service life amazingly from the conventionally said one week to 6 months to 90 months, that is, 15 to 360 times the conventional service life.

The second problem is;

(2) Air raises dust.

The air is normally produced by the air compressor. The compressor produces the air through the process of mechanical operation including friction between metals and lubricating system. Consequently, no matter how clean th e air is, various kinds of foreign bodies (debris and dust) are included into the air during its compressing process. So they have to use filers several times over to get rid of these debris and dust. And, as the air contains originally mist, it has to be filtered through the dedicated filter. But it is obviously impossible to filter those dust particles smaller than the mesh of the filters. And so, the mesh is tried to be made smaller and smaller, but in turn the compressor output has to be increased to let out the air through them.

And eventually, they have to be compromised at a certain level and part of dust which is not filtered remains in the air and sprayed to the object.

In addition, the filters require a periodical maintenance. If they are not maintained properly, more defective products are produced. Particularly, when the plant starts running after a long vacation, workers often observe the dust piled up inside the piping spraying out from the nozzle. It is extremely difficult to keep supplying a clean air for 24 hours throughout a year.

The third problem is given in the next number.

Serialization
No. 13

Fundamentals of Static and Dust – 13

Until the last number, we gave an account of **2 Problems caused by the static**, **3 Fundamentals of the static**, **4 Fundamentals of dust**, **5 Fundamentals of antistatic and anti-dust measures,** and **6 Antistatic and anti-dust measures of new age.** We continue on **6 Antistatic and anti-dust measures of new age** in this number.

6 Antistatic and anti-dust measures of new age

The Third problem resulting from the use of compressed air is;

(3) The dust raised by air creates product defects.

Most bar-type static ionizers use air, so not only an electric power source but an air supply is required. The air supplied from outside is used to send the ions produced at the needles (electrodes) out of the static ionizer as well as to carry them on it to the object. But, the air used originally for the purpose of carrying ions has a problem of raising the dust piled up on the object and surrounding instruments. And, even a partial air flow causes ambient air to circulate around the object if continuously blown, and the floating dust in the air eventually adheres to or piles up on the object again, resulting in more defective products.

Like this, the static ionizers using air blow has inherently a problem to increase the dust-related defects other than its original purpose of static elimination. Therefore, the antistatic and anti-dust measures of new age have to be achieved with the "No-wind TRINC" which does not use the air at all. With this, the factory management is surely released from the problem of dust-related defective products.

Note: No-wind TRINC is a generic term of Trinc's static ionizers that do not use air blow to carry ions to the object. Refer to Series No.11, item 5-3-2 for details.

The forth problem resulting from the use of compressed air is;

(4) High electric power consumption on the air compressor

Recently, at the factory working site supervisors become very nervous about air consumption. The reason for it is because electric power consumption for the air compressor is so high. Consequently, as a part of workers' education, they say, "When you hear a faint hiss of air leaking out, consider it that we incur waste as high as US $100 a month." It turns out to be $1,200 a year. So much electric power is consumed to get the compressed air.

What about the static ionizer using air blow? Taking a bar-type static ionizer for example, even a shorter ionizer of 500mm long has 10 electrodes over its entire length, and a longer one of about 2,000mm has 30 electrodes. Considering that air is let out at each electrode, the total air consumption becomes so high.

When attempting calculations, management would startle at the annual electric power consumption counting up to $1,200 on shorter and $3,000 on longer one. It is a quite absurd, but true like someone saying that the factory could afford to buy one more new static ionizer in half a year if the air blow were saved to 0. The running cost on the static ionizer using air blow is paid to this extent. However, in the real world no management has ever regarded seriously about this fact. It is probably because the obsolete common sense of "a static ionizer is the device that uses air-blow" has been widely believed. Please recall that the No-wind TRINC needs no air-blow.

At the last, as the fifth problem we raise the following issue;

(5) A large capital investment and an extravagant maintenance fee come along.

With higher air consumption, a larger and more expensive air compressor has to be prepared. In addition, because the air supplied for the static ionizer is required to be filtered more efficiently to avoid not only foreign substances but also damp, a higher filtering is required. Resultantly, a large capital investment becomes necessary and it will involve an extravagant maintenance fee as well.

Since the "No-wind TRINC" in antistatic and anti-dust measures of new age does not use air blow, factory management is surely released from these issuers of capital investment and maintenance fee.

Next, there is a fan-type static ionizer as another typical static ionizer. This, too, carries a basic fatal flaw in the same way as the bar-types mentioned above.

6-2 Anti-fan (fan of-no-use age)

Generally a static ionizer means either the "bar-type static ionizer" that uses compressed air or the "fan-type static ionizer" which uses a fan. We explained that the bar-type static ionizer has a fatal flaw, but the fan-type static ionizer, too, commits a basic error.

As detailed above, the No-wind TRINC is the means to rescue the bar-type static ionizer from its fatal flaw. The same applies to the fan-type static ionizer.

Problems on fan-type static ionizer are;

(1) Fan-type static ionizer sprinkles out dust to develop flaws

A fan has to be considered potentially one of sources of contamination. The dust piled up on the fan body is removed by its own air or vibration to scatter around. Its mechanical components such as the electric motor, bearings, and commutator brushes also produce and scatter debris. In addition, regardless of the fan-type or the bar-type, ionizer's electrodes produce a lot of waste materials such as, the dust piled up on them (the high voltage impressed on them attracts dust from the surrounding air), the crystallized ammonium nitrate, and the oxidized metal. So, various materials (dust) are produced and scattered by the fan-type ionizer.

In short, even if the fan-type static ionizer can eliminate static effectively, it helps increase the dust-related problems. Since this is a fundamental issue, it can not be used in the environment demanding the clean air condition.

The key to solve this troublesome issue is to use the “No-wind TRINC.” Because it blows no air, the foreign materials scattered from it are extremely low. Those dust and debris adhered to the electrodes and the crystallized ammonium nitrite produced on the electrodes are not blown off but stay unremoved until they are brushed off in the periodical cleanings, while the fan and bar type static ionizers using air blow let every kind of substances out of the ionizer by the blow. In this sense, the readers would understand of how many problems the fan-type static ionizer incorporates. Unfortunately, however, in the real world the majority still consider that the fan-type static ionizer is the very static ionizer.

(2) Fan-type static ionizer raises dust from surroundings to develop product flaws.

When the fan keeps blowing air, it creates a circulating air flow around the fan at the center (the air going out from the fan comes back again making a loop), similar to the compressed air blow. The dust raised by this air flow circulates to finally adhere to the product and causes product defects.

The only solution to this issue is to use the “No-wind TRINC,” for the devices using air-blow are basically harmful. This phenomenon of the air circulation caused by the fan-type static ionizer is developed even in the wide open space, but we often observe the case that the air circulation is developed intentionally inside much narrower space like the semi-conductor manufacturing unit. Operating the fan in such narrower space develops an intense air circulation and stirs dust even to convert the static ionizer into the flaw developing machine. We are amazed by the insensitiveness, but in fact almost all semi-conductor manufacturers in Japan are doing the same. What the writer witnessed in the memory manufacturing factories in Korea was that the most static ionizers were made in Japan and the same basic error was carried out.

This indicates that engineers of these static ionizers, who had less knowledge of the static and dust, paid more attention to the installation of the static ionizer into the machinery or equipment than its function and efficiency. It is true that; when the equipment (needed to produce electronic components for example) is to be introduced into the factory, it is required to incorporate the static ionizer in it. And the equipment is used to be accepted only if the static ionizer is installed without a question of how effective it is. So, the issue would not be improved unless both customers and makers become conscious of the antistatic and anti-dust measures.

(3) Customer mistakes an air-blow for an ion flow.

Those customers who are looking for antistatic and anti-dust measures have mistaken idea that a static elimination cannot be made without air-blow and the static is being removed if air is being blown from the static ionizer.

But there is no relation between these two things, and the air-blow does not necessarily mean that it contains ions. Contrary, ions can exist in the air and is delivered even without air-blow. All one can say that the air containing no ions can adversely charge the object with the static if blown to it.

What is important in use of the ordinary static ionizer is to check the static charged on the object periodically whether the air is blown or not. It is necessary to confirm that the static has been steadily eliminated from the object, because conventional static ionizers are fragile.

As the static ionizer uses a high tension voltage, an electrical leak occurs quite often and ions cease to be produced each time it occurs. But since ions are invisible to human, operators have had no way but to rely on the air coming out of the static ionizer, that is, they have regarded the air as a telltale of the ion being radiated.

Antistatic and anti-dust measures of the new age can be achieved by use of the No-wind TRINC, which assures a static elimination without blowing air.

? Continued to the next number ?

Serialization
No. 14

Fundamentals of Static and Dust – 14

Until the last number, we gave an account of **2 Problems caused by the static**, **3 Fundamentals of the static**, **4 Fundamentals of dust**, **5 Fundamentals of antistatic and anti-dust measures,** and **6 Antistatic and anti-dust measures of new age.** We continue on **6 Antistatic and anti-dust measures of new age** in this number.

6 Antistatic and anti-dust measures of new age

6-2 Anti-fan (An age demanding no fan aid)

In the previous numbers, we explained about;

(1) A fan type static ionizer increases product defects by spraying dust.

(2) A fan type static ionizer increases product defects by rising dust.

(3) Customers delude themselves by "the air blow is synonymous with ion sprinkle."

In this number, we continue on various shortcomings on the fan type static ionizer and various problems caused by its misuse.

(4) A fan type static ionizer consumes a large electric power.

Almost all the fan type static ionizers consume a large electric power. Their power consumption is about 30W as against 3W on the No-wind TRINC, a tenth part. This tenfold consumption is resulted from using the fan to send out an air.

Note: The No-wind TRINC is a generic term of the Trinc's static ionizers that require no air blow to carry ions they generate to the object. Refer to No.11, item 5-3-2 for details.

Further, they even sell the models incorporating an electric heater to accommodate a complaint from workers that they get a cold from the air blowing all day long. They consume more than 1KW which is more than three-hundredfold electricity of the No-wind TRINC. Sending out air makes workers feel cold, so adding a heater as a countermeasure. What a poor idea!

A trend toward the no-blow static ionizer increases the importance all the more for the device used all day long amid the calls for energy and CO_2 saving.

(5) AC and Pulse system fan type static ionizers pose a risk of damaging semi-conductors

AC and Pulse system static ionizers leak out from its frontal surface the strong alternate electric flux lines which damage the semi-conductors passing nearby or the electronic devices located closer to them.

These static ionizers have a structure of the electrodes arranged close to ion radiating holes. Since an alternative high voltage of about 10KV is impressed onto them, the strong electric flux lines grow out of them. Also a strong alternate electric field of 50/60 Hz on the AC type and from several to several dozen Hz on the Pulse type static ionizers is formed. It poses a risk of a possible damage to the electronic device including semi-conductors passing nearby and electric devices located closer to them.

This was a story actually happened in a famous Japanese major cell phone company plant in China. They had been worried about the cell phone memory data erased from time to time. On our inspection into their assembling line, it was revealed that the static ionizers were located as close to the cell phones as almost touching it. They said that they put them within easy reach in order to eliminate quickly the static built up on the liquid crystal (acrylic) window on the cell phone when peeling off a protection film from it. The problem had been caused by the electric field growing out from the static ionizer which induced current in the semi-conductor to erase the memory.

The writer pointed out the following two mistakes;
First, the static ionizer located too close to the product made the memory erased. And second, the "instantaneous static eliminating" was indeed a risky conception to lead to destroying the semi-conductor.

The person in charge said in reply to this that his company expert (director) recognized as a person creating excellent technique/products instructed him to do so and he couldn't deny it though he doubted it. The writer felt uneasy about its future.

(6) A fan type static ionizer used as an electric fan

When the writer visited a factory in the northern part of China, he saw that workers located the fan type static ionizer, the size of which was almost as large as their shoulder-width, just in front of them to use it as the electric fan. Hundreds of static ionizers, one for each worker, were being used as electric fans. On calculation it was found that all these static ionizers were heating up factory just like a 60KW heater was heating it. So workers were clinging to the breeze from the static ionizers. It was as thought they took a backseat to the function and efficiency of the static ionizer. It was beyond the question that hundreds of them were disturbing the air and rising dust inside the factory. The management said that they didn't care of product defects caused by dust. The writer was in doubt if the Japanese static ionizer maker instructed it.

(7) A static ionizer with a heater appears in the market to accommodate complaint that operators get a cold by the air coming out of it all day long.

As described briefly in item (4) above, there were unceasing cries at the working site for the bad physical condition that workers were suffering an ozone smelling breeze blown for 8 hours a day and sick to their stomach or shivered with cold. The maker for these conventional static ionizers simply considered that adding a heater would solve the problem and developed a "fan type static ionizer with a heater." Because the heater dried the ambient air, workers felt the temperature went down all the more. Eventually the factory was obliged to humidify the air. But while the humidified air was circulating inside the factory, it reached the place where temperature was low and formed a dew condensation. This condensation caused in turn far larger problems like an electrical contact failure at the contact point and a deterioration of semi-conductors.

This is the case happened in Japan having a milder climate. Though the electric fan was useless except summer, they could not stop it even in spring, autumn and winter as the fan type static ionizer carries ions to the work piece on the air from it. So they had no way but to add a heater, but as a result they fell in a bad cycle that they consumed electric power with a 1KW heater which in turn caused various other problems.

Here again, the writer would like to urge the readers to realize that an air blow (breeze of wind) is not required for static ionizing. A fan has been mistakenly used by an erroneous common sense. The “No-wind TRINC” relieves customers from the big discrepancy like this. Even today the situation is such that most customers are still using the static ionizers with a fan or a compressed air supply. The writer wishes for all customers to awake that the fan and compressed air are not useful but harmful.

(8) A fan type static ionizer scattering about a lot of dust

Electrodes of the static ionizer are easy to get fouled with dust. Being impressed with a high voltage, they not only attract dust from around ambient air, but also separate out a crystal of ammonium nitrate at the tip of the electrode as a byproduct from the corona discharge. As a result, the tip gets fouled to reduce the ion discharge and ionizing performance.

One of the static ionizer makers developed the fan type static ionizer which, in order to brush off the dust sticking the electrodes, has the propeller like brushes built in place so that it rotates with the air from the fan to brush off the dust. As everyone can imagine what happens, this idea scatters about always the dust brushed off of the electrodes. This maker would have had a thought that everything goes if they can remove static charges. Or they might have thought that, because customers didn’t clean the electrodes periodically and kept complaining that the static ionizer would not work, they’d better to adopt an automatic brushing device. And a propeller like brushes which rotate by the fan air would solve it.

Customers intend to eliminate the static charged on products to improve a process yield. But those static ionizer makers sensed that if the static is eliminated successfully they do not care about how dust is scattered about.

(9) Blowing off a tiny work piece (chip)

The conventional fan type static ionizer would blow off tiny chips. The chips used in the field of electronics industry have grown smaller to an ultra small size of 0.4 mm by 0.2 mm, which is almost not distinguishable from dust. When picking and placing this tiny chip inside the chip mounter, an ultraviolet beam is radiated to the tape to which chips adhere to have them lose adhesion. So the chips are in the state that they have no adhesion and are just arranged on the plastic tape. If the fan type static ionizer is used in this state, almost all chips are blown off with ease.

Here again, the fan air plays pranks on the chip mounting. The conventional fan type static ionizer has no longer been useful but harmful in this field as well, and a new age has come where only the “No-wind TRINC” can play a role.

Up until this stage, we have given an account of the importance of the Anti-fan scheme (An age demanding no fan aid) as Antistatic and anti-dust measures of new age over 9 items.

In the next number, we will explain **6-3 Anti-clean room scheme (An age demanding no clean room).**

Serialization
No. 15

Static and Dust Fundamentals – 15

Until the last number, we gave an account of **2 Problems caused by the static**, **3 Fundamentals of the static**, **4 Fundamentals of dust**, **5 Fundamentals of antistatic and anti-dust measures,** and **6 Antistatic and anti-dust measures of new age.** We continue on **6 Antistatic and anti-dust measures of new age** in this number.

6 Antistatic and anti-dust measures of new age

6-3 Anti-clean room (An age demanding no clean room aid)

First we point out various problems caused by a combination of the specification and performance of currently available clean rooms and their misuse. Then we would like to introduce the alternate methods taking place of the clean room.

There are various clean rooms available now from the high performance to the popular and simple models. Their installation prices vary widely. The clean rooms we target here are the popular or simple models. Listing their defects and problems in the functional and performance area, we want to offer the countermeasures and new thoughts.

6-3-1 A current air shower is in a malfunction condition

Generally, any personnel getting inside the clean room have to pass through the air shower first so that the dust adhering to their bodies is cleaned and not brought in the room. But actually, human bodies and materials coming in from outside bring in the dust into the room because of malfunction of the air shower.

The air shower is a device that blows off dust on the human body. But when the dust adheres to the body with static, blowing off it is not easy. The dust adhering on the front side of body where the air is brown from the nozzle is moved to leeward where the air is stagnating and adheres to there again. Like this, because the dust charged with static is always moved to the lee and adhere again, it is hardly removed. So the device is hardly recognized serving as the air shower.

The important thing here is to eliminate the static in addition to blowing off dust. Trinc has created a product called “Air shower TRINC,” which eliminates static inside the air shower, and succeeded to enhance the anti-dust performance.

It is obvious to every clear thinker that this has to be inherent function on the air shower, but has not for unknown reason only to conclude “a result of luck of common sense.” When seeing the conventional field from a new and different perspective, we perceive this kind of blind side.

6-3-2 A Current clean room is impotent against the dust produced inside the room

The clean room prevents dust from coming in from outside by increasing inner pressure. So dust intrusion from gaps or clearances made at doors or windows is nil, but what is problem is that it is almost impotent against the dust that is produced inside the room. That is, having no protection against the dust produced inside the room, it stands on the hypothesis that there must not be the dust produced inside the room. However, dust always falls off of the human body and materials brought in from outside. In addition, the mechanical equipments inside the room also produce dust or foreign particles during operation.

Though conventional clean rooms admit that they have no way for those dust or particles produced inside the room, there are ways to clear the problem. One way is to retrieve the dust quickly before they are scattered around, and the other is to prevent the floating dust from adhering to the products. In concrete terms, the use of our product “Static-free Space TRINC” does these jobs. As we also call it “Room-less clean room,” it literally realizes a clean room which has no walls. This device neutralizes all the static existing in the space so that the static charged on products as well as the floating dust is eliminated. In this way, a static attraction between them does no longer exist and the floating dust simply drops along with the laminar air flow. So it can be a real clean room not producing dust-related defects.

Summing up, the conventional popular and simple type clean rooms are unguarded or impotent against the dust produced inside the room, by the use of “Static-free Space TRINC” the product defects caused by dust and particles can be drastically reduced.

6-3-3 A current clean room has always a turbulence inside the room

A clean room should have essentially the function that a clean air is blown out through the HEPA filter in the ceiling, which forms a laminar down draft in the entire room. But the reality is that there are a lot of eddies to cause a turbulence and dust and particles circulate inside the room on the wind. These dust and particles should be dropped to the floor to retrieve at the dust collector and must not circulate inside the room, because they adhere to the products during circulation and yield product defects.

The countermeasure to this problem is also made by the Static-free Space TRINC. By setting it inside the clean room, it neutralizes the static charged on both products and floating dust quietly without letting air out of the device. So the dust floating in the air would no longer adhere to the products nor yield any product defects.

The problem, that the conventional popular and simple type clean rooms have a shortcoming of causing turbulence and product defects, can be solved by this device.

6-3-4 A current clean room has a crosswind blowing inside the room.

The ideal clean room should be filled with a laminar down draft in principle. But in reality the laminar air flow coming out of the filter turns in part to cross-wind causing some local areas to be windward and other areas leeward.

The problem occurs in the leeward. The dust and particles scattered at the windward fly on the crosswind and get to the leeward. There they adhere to the products. The clean room is intended to realize the clean space with no dust intruding into it, but realistically it is also true that the space can be turned into unclean space.

The answer to this problem is also the use of the Static-free Space TRINC. Since the static charged on both the products set inside the room and the dust floating inside the room is all neutralized, the dust would no longer adhere to the products and dust-related product defects are prevented.

6-3-5 A current HEPA and ULPA filters are in a malfunction condition

Generally the clean room has a system that particles contained in the fresh air are filtered out by the filter made of nonwoven fabric. But the particles which are smaller in size than the mesh of filter would not be filtered out. Those smaller particles contained in the air driven by the fan would pass through the fine mesh and jump into the room. While passing through the filter, they repeat friction and abruption between the filter fabrics and build up intensely static charges. Then the particles having opposite polarities cohere to grow bigger than the mesh of filter.

The filter blocks larger particles than limited size. But as they reunion and grow bigger after the filtration, it is the same thing that the particles that are supposed to be blocked out at the filter pass it freely. Whether this thing becomes trouble or not depends on its frequency and amount, but implies that the filtering system can not be an infallible measure from view point of the function of filtration.

To cope with this issue, either “Static-free Space TRINC” or “Bar TRINC” is useful. By installing it right under the filter, it neutralizes the static charged on these particles so that they lose the reunion force and ensures that any particle having a larger size than the mesh would not emerge in the room.

Thus we can realize a perfect filtering system using them, but we have to pay attention to the following points when they are actually installed into room; the static ionizer has to be “No-wind (blow) TRINC”---Trinc static ionizer sprinkles ions without the help of air blow---, but at the same time the location it is to be installed has to be decided carefully. Recognizing that a static ionizer is more or less a source of dust production, it has not to be installed inside the clean down draft of air from the filter. Particularly in the case where a high level cleanliness is required, the static ionizer has to be located apart from the clean down draft of air to radiate ions remotely.

Some static ionizer makers have marketed their products contradicting this principle and confused their customers. It is very important to pay attention to this when introducing the device.

So far we have covered the first half of “anti-clean room (an age demanding no clean room aid)” and its importance as a new age for antistatic and anti-dust measures. We will continue to give an account of the last half in the next numbers.

Serialization
No. 16

Fundamentals of Static and Dust – 16

Until the last number, we gave an account of **2 Problems caused by the static**, **3 Fundamentals of the static**, **4 Fundamentals of dust**, **5 Fundamentals of antistatic and anti-dust measures,** and **6 Antistatic and anti-dust measures of new age.** We continue on **6 Antistatic and anti-dust measures of new age** in this number.

6 Antistatic and anti-dust measures of new age

6-4 Anti-humidification (An age demanding no humidification)

A humidification has long been adopted as an effective instrument for antistatic measures. Because people do not perceive static electricity normally under a high humid air like in rainy season, they have come to know that static problems can be solved by creating a warm and humid condition and followed blindly it as common sense.

Even today the situation is such that the textile and paper factories are the typical fields that use regularly the humidification. Sometimes it can be seen in the printing factories. And even some electronic factories producing semiconductors appear to adopt the humidification against the static charge. But what amazes us most is that the humidification is still employed in the painting process of some automakers, which is supposed to be the field of cutting edge.

However, many of them have been using the humidification against their will because they have had no alternative. Well, why is it against their will?

They have recognized implicitly that various problems could have possibly been originated in the humidification, but considered that they can not help using it because there is no alternative. That is, they have resigned themselves to using it by not actively but passively or grudgingly accepting it as an unavoidable capital investment and running cost.

6-4-1 Problems arising from humidification

So, what kinds of problems are considered to be caused by humidification? Since the humidification has been used in various fields, they have a large variety of types;

? Molding dies get rusty.
Due to the dew condensation caused by the humidification, the plastic molding dies, sheet metal press dies, and dies for forging and die-casting get rusty.

? Mechanical equipments get rusty.
Housings and metal plates on mechanical equipments get rusty due to the dew condensation.

? Semiconductors are destroyed.
Metal parts of the semiconductors are eroded to cause solder jointing problems

due to the dew condensation.

? Electric contacts break down to be an uncontrollable condition.
  The contact points of relays and breaker are oxidized to create a contact failure due to the dew condensation.

? Materials change in quality.
  Optical components, like plastic lenses, change its nature of surface material to be a blur. The parts made of an organic EL (electroluminescence) come to have a shorter life due to humidity.

? Blemishes in the paint finish
  The dew condensation on the paint surface causes blemishes to appear.

? Defective products are produced.
  To prevent the condensation in the factory, humidity has to be kept always at a constant level and uniform everywhere inside it. But to do this the temperature inside the factory has to be kept constant and uniform, so they try to stir the air using fans. But these fans raise dust and make the matter worse for the quality of products with a dust adherence.
  Originally, they have had to humidify their factories to reduce the dust related defectives as an antistatic measure, but results have shown a reverse effect and increased defectives instead.

? Papers get jammed in printers.
  Papers lose a crispy touch due to humid air and get jammed or wrinkled in the printing machine.

? Fabrics and papers go moldy.
  A high temperature and humid air molds on fabrics and papers so bad as to reduce their quality.

? Foods become insanitary and deteriorated.
  A high temperature and humid air creates an environment for bacteria to grow fast and lets foods go rotten.

? Skin diseases get worse.
  Under the environment of a high temperature and humid air, the skin diseases get worse. At the floor level of the factory the temperature becomes lower than the ceiling area to form easily a dew condensation. It gives a bad environment for foot diseases.

? Capital investments run up.
  Cost of equipments and engineering works for water purification facilities, water pipes and atomizers runs up.

? Running cost at the factory runs up.
  A water purification facility requires a large expense regularly.
  Particularly, at the painting shop they have to ventilate the air regularly to exhaust the paint solvent. Because the ventilation dehumidify the factory, a further humidification becomes necessary. As a result the humidification and the dehumidification are fighting all the time to waist a lot of power.

? Maintenance cost of facility runs up.

Water leak problem start taking place everywhere inside the factory as the years go by and repair works become needed all the time to run up a maintenance fee.

As explained above, the humidification adopted as an antistatic measure runs into a lot of troubles. Among them there is a case that became a fatal trouble, like in the painting factory where the humidification adopted to reduce defectives on the paintworks has been proved to be actually a factor to increase them. But a reality is that most customers have been unconscious of the fact.

Undoubtedly, there hasn't been a useful method except a humidification as an antistatic measure to be taken in the entire factory. No matter how many problems it might produce, they had to use it. But finally we get around to a new method developed to outgrow the humidification. That is the Static-free Space (SFS) TRINC.

Note: The concept and the function of the Static-free Space (SFS) TRINC are detailed in the serial No.3, item (3). The effectiveness of the same is explained in the next paragraph.

6-4-2.The new method able to outgrow humidification

The SFS TRINC lets atmospheric ions travel in a wide space without air blow. These ions are controlled to be equal in amount for positive and negative charges, so that the static charges existing in the space are uniformly neutralized to dissipate. As a result, the static charged on products, their components and raw materials are all removed, but more importantly the static charges on floating dust are also neutralized to vanish. This is a significant improvement, considering that conventional static ionizers have just removed the static charged on objects, while that on dust have been left unremoved as an impossible thing.

The meaning of SFS TRINC's feature, "neutralizing the static on dust," is to reduce drastically the problems caused by foreign particles. A phenomenon of the particles adhering to objects occurs when the static charged on the object and floating dust attract toward one another. So, to reduce dust related defects it is indispensable to remove the static charged on both sides. In the past the static charged on dust has been left unremoved, because no one has ever noticed of it and there have been no such instruments.

Well, why is the SFS TRINC alone capable to neutralize the static charged on dust? If one attempts to neutralize the static charged on the floating dust using the conventional static ionizer, which blows air to send out ions by a fan or compressed air (we call it "air-blowing ionization"), he has to set it on the floor to send out the air upward. But, since the air reaches only about 1.5m radius at the most, a lot of static ionizers have to be used to cover the whole space. However, the worst thing is that they would blow up the dust in the space only further to increase a defection rate. Conventional ionizers are helpless against floating dust in the space.

The SFS TRINC produces ions and radiates them out into wide space through the use of ion's repulsion and attraction force. No air blowing used. It dissipates static on everything in its effective space without air blow. We named the operation or the system, "No-wind TRINC." Its ionization is powerful. For reference's sake, an experimental test was done to compare it with the humidification in terms of a static dissipation time (decay time) on the surface of nylon resin, the humidification could not remove the static even more than 5 minutes and the static over 10kV still remained, while the SFS TRINC completed perfectly in only 20 seconds with almost 0V on the tester.

The SFS TRINC has made the humidification unwanted. It has made it possible to realize a static-free environment even under the dry condition like that given in winter season. An antistatic-environmental-protection technology in the new era taking the place of the humidification that had been practiced for more than decades has newly been developed. A time of momentous change has come.

In this number, we have given an account of anti-humidification (an age demanding no humidification) as the antistatic and anti-dust measures demanded for a new age and its importance.

We continue onto the next number about an anti-wrist-strap (an age demanding no wrist-strap).

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Serialization
No. 17

Fundamentals of Static and Dust – 17

Until the last number, we gave an account of **2 Problems caused by the static**, **3 Fundamentals of the static**, **4 Fundamentals of dust**, **5 Fundamentals of antistatic and anti-dust measures,** and **6 Antistatic and anti-dust measures of new age.** We continue on **6 Antistatic and anti-dust measures of new age** in this number.

6 Antistatic and anti-dust measures of new age

6-5 Anti-wrist-strap (An age demanding no wrist-strap)

6-5-1 Wrist-strap

In the field of electronics industry, a wrist-strap has long been used as an antistatic measure. It has been considered as a standard tool to dissipate the static charged on human body. Practically there are two ways of using the strap, one is to dissipate the static through the skin of hand, and the other is through the skin of foot.

? Through the skin of hand
Static flows from the skin through the wrist-strap (wrist-band) to the earth.

? Through the skin of food
Static flows from the skin through the foot-strap to the earth.

In either case, it makes no difference in the sense that the static charged on human body is removed to the earth. So we will concentrate on the wrist-strap below.

6-5-1-1 Elements of wrist-strap method

(1) Human skin

The static charged on human body appears on the surface of body, on the skin. That is, the law of nature that a static appears on the surface of the materials applies to this case, too. The wrist-strap is a device to connect the ground wire to the skin to let static flow to the earth. But the contact resistance of skin varies depending on its conditions. On a dry skin, as the worst case, the situation that the antistatic device becomes useless even if it is worn in place could happen. To avoid it, in some factories they keep monitoring the workers' skin condition by measuring the contact resistance with the dedicated tester every morning when they enter the factory. For they need to apply a conductive cream onto their skin to reduce the contact resistance, if it is out of the rated value.

(2) Strap (Conductive cord)

The strap has the copper wire connected serially to a resistor (about 1 M ohm). Should an electric shock take place, it protects operator from being electrocuted.

(3) Ground wire

The ground wire is to lead the static flown from human body through the strap to the earth. Since it is very important element, it has to be grounded firmly.

(4) Ground

Finally a ground is made by connecting the ground wire to the earth that absorbs all charges. But the location where the wire is connected is important. The earth bar has to be dug deep into the earth soil with moisture to reduce the contact resistance so that a large capacity of current can be absorbed.

6-5-1-2 Good and bad points of wrist-strap

A wrist-strap system has been considered the most basic anti-static measure in the field of electronics. But it would be an interesting to see if this is still one and only system even at the present day where everything has evolved after 50 years of its history. Let us examine it;

Good points:

(1) It makes it certain that the static potential of human body drops to 0V, if the ground is made firmly.

(2) Comprehensible and visible
The static charged on human body is removed into the earth using a lead wire. The wrist skin is exposed to the air and the ideal part to hook the wire.

(3) Cheap and economical
It costs only about several dollars.

Bad points:

(1) A risk of the wrist-strap being not worn on

At the working site of semiconductors, workers are supposed to ware the wrist strap before touching products. But it occurs sometimes that they forget the rule and destroy them. There is also the case that they forget to wear again the wrist-strap after the bathroom and touch to destroy them hastily. And also as is often the case with assembling lines, a line supervisor who goes around inspecting and instructing workers forgets erroneously connecting his wrist-strap to ground wire to destroy them.

(2) A risk of the ground-wire-line cutting off or failing to ground

Taking the assembling line of electronics factory for example, all the wrist-straps worn by workers are connected to branch lines from the main wire grounded to the earth. The case occurred that the main wire was not secured at midstream and the grounding at each worker became imperfect. This was the typical case that the main wire had been disconnected once for construction works but forgotten connecting it again.

(3) The system relying on worker’s upbringing

This system requires that each worker wears the wrist-strap without fail. That is to say, it cannot be pursued effectively without worker’s good sense against antistatic measures. To this end, the company has to pay meticulous attention to the moral issue like demanding worker’s upbringing be improved in the daily jobs.

(4) The system standing in the way of industrial innovation

Recently various new manufacturing systems have been introduced in many factories to improve productivity and humanity. They are referred as either the cell production system or the industrial innovation system. In these systems workers move along with the product movement and work while moving. It is hard to ground them with the wrist-strap.

(5) Worsening industrial hygiene environment

A wrist-strap removes static charges to the earth through the conductive wire bound to the worker’s wrist. This in turn restricts them from a free movement. Placing workers under restrain by tying up their wrists can be a mental health issue and not a preferable thing.

Recently the writer had a chance to visit a consumer electronic maker in US. Workers there wore a strap on their ankles. They were tied up to the floor using the conductive wires. Since these workers are living in an advanced civilization and working in the cutting-edge semiconductor factories, the writer could not help but recall the history.

In the above paragraphs, we have reviewed the issues the wrist-trap inheres. In the next paragraphs, we introduce an antistatic measures taking place of the wrist-trap.

6-5-2 Anti-wrist-strap

The reason that static builds up in the human body and the object is because they are isolated from the earth. There is the case that the static is removed to the earth through the jig coming into contact with them. But what if the object is insulator? The static does not dissipate even if it is grounded with a wire.

How can the static charged on the isolated object (suspended electrically from the earth) be eliminated? The answer to it is to “make the surrounded air a semiconductor.” If the air is were semiconductor, all the static charged on the object, whether it is a conductor or an insulator, would leak through it to dissipate. The troublesome wrist-strap would be no longer needed.

To “make the air a semiconductor” – It is the Static-free Space (SFS) TRINC that has realized it.

Note: The concept and the function of the Static-free Space (SFS) TRINC are detailed in the serial No.3, item (3). The effectiveness of the same is explained in the No. 16, item 6-4-2.

The SFS TRINC radiates ions into a wide space to let them drift in the air, so that the air in the space turns to be a state of the semiconductor. By doing so, the static charged on human bodies and objects are all leak through it to dissipate. In other words, it changes a whole room into the space without static charges. And what attracts attention as an unprecedented new potency is an ability to neutralize the static charged on the dust floating in the air. By this both the object and the dust existing in the space come to lose all static so that the attracting Coulomb’s force exerted between them does not exist any more and the product defects caused by dust adhesion can be reduced drastically.

The SFS TRINC is clearly different from conventional static ionizers in its unique function of radiating ions without a help of air blow as well as much wider effective area. If multiple units are connected together in a daisy-chain pattern with coaxial cables, the effectual area can be expanded infinitely, which can make a wide area in the factory a static-free environment.

Conventional static ionizers are all using a fan or compressed air blow to sprinkle ions. The air (wind) raises dust from all around and make the matter worse – more product defects with dust. And their effectual area is limited to the distance of air blow of several centimeters to a meter.

The SFS TRINC solves all these conventional troubles.

And besides, it has established an innovation to the antistatic measure against moving objects like worker’s bodies and materials transferred inside the factory. Because the moving objects could not be grounded with a wire, the antistatic measures have been a headache. After all, the wrist-strap has been only the way applicable for human body.

Taking the place of the wrist-strap in the electronics field the SFS TRINC can prevent the static discharge damages on semiconductors, and constrain product defectives caused by dust in the field of the liquid crystal and its related material factories. It can constrain paint failures in the painting factory.

As explained in the above paragraphs, the wrist-strap employed as a antistatic measure against human body in the electronics field is a simple and economical method, but on the other hand holds a fatal problem. It has been a standard of the quality control against the static electricity, but it is inexplicable that it has not made any evolution for 50 years. The quality control criteria have specified so and this is a typical example of the criteria which has prevented the evolution.

Surely, there had been no other methods available for the antistatic measure in the electronics factories than the wrist-strap in the past. No matter how fateful problem it has, they have had no alternative methods. But, at last the new method with which they can outgrow the wrist-strap is invented, and that is the SFS TRINC. Let's do an anti-wrist-strap. It is crucial that particularly persons in charge of the quality control changes their way of thinking.

Now we have completed to cover the meaning and the importance of the anti-wrist-strap (an age demanding no wrist-strap) at the time we consider of antistatic and anti-dust measures of a new age.

We continue onto the next number about an anti-maintenance nightmare (an age demanding no maintenance).

Serialization
No. 18

Fundamentals of Static and Dust – 18

Until the last number, we gave an account of **2 Problems caused by the static**, **3 Fundamentals of the static**, **4 Fundamentals of dust**, **5 Fundamentals of antistatic and anti-dust measures,** and **6 Antistatic and anti-dust measures of new age.** We continue on **6 Antistatic and anti-dust measures of new age** in this number.

6 Antistatic and anti-dust measures of new age

6-6 Anti-maintenance-hell (An age demanding no troublesome maintenance)

6-6-1 Maintenance on the static ionizer

The maintenance is regarded as an inevitable accompaniment to static ionizers. Depending on the level of demand to what degree the ion quality is required, the interval of the needle cleaning maintenance varies like, from every day for the severest ion quality to once a week, once a month, once every 3 months, once a half year, and once a year.

Usually, it requires once a week or a month for the semiconductor-related products, and from once a month to once every 3 months for non-semiconductors and other fields.

6-6-2 Case examples of maintenance-hell

Let us introduce one example reported by a well-known liquid crystal maker. They had once introduced multiple air-blow type static ionizers of famous brand as a company-wide policy. Because their needles were fouled up heavily, workers had to clean tens of thousands of needles every week. Since they couldn’t clean one by one in the process of manufacturing, they prepared the spare needles in the same number and replaced the fouled with spares, so that they were cleaned in the solvent later in a lot. The needle was built into its holder having threads so that the replacement was done by screwing into the ionizer body. But this cleaning in a lot had other reasons which are explained later.

Eventually, this company had established an affiliate company specialized to do the maintenance for those static ionizers. Trinc had introduced the Maintenance-free TRINC (static ionizers) to them, but they refused since they would lose the job.

Well then, why is such a troublesome maintenance needed for static ionizers?

6-6-3 Why is maintenance needed?

There are two reasons; (1) an ion generation gets worse, (2) troubles occur.

(1) Maintenance needs because an ion generation gets worse.

The static ionizer generates ions by applying the high tension voltage to the needle and inducing a corona discharge around it, and ions are then carried to the object to eliminate the static charged on it. But production of the ions becomes less gradually due to the following two causes;

? Needle fouling

The needle fouling is also caused by the following 2 reasons;

a. Dust collection function of the needle

The needle impressed with a high tension voltage tends to collect dust. The tip of the needle is an essential part for producing ions, and dust adherence to it reduces an ion production.

b. Crystallizing of ammonium nitrite

A corona discharge at the needle tip causes oxygen and nitrogen in the air to produce the NOx, which then reacts with the water H_2O in the air to crystallize ammonium nitrite NH_4NO_3. The crystallized ammonium nitrite covering the needle tip weakens the corona discharge to reduce ion generation.

? Needle wear-out

A corona discharge makes the needle tip wear out. The blunt needle tip weakens corona discharge thereby to reduce ions production.

(2) Maintenance is needed otherwise troubles occur.

Generally, the widespread static ionizers are broken down easily to fail to produce ions. The cause of troubles is in either the ? electric leak, ? air leak, or ? ozone generation.

? Electric leak

a. Leakage around the needles

The static ionizer that uses compressed air causes particularly an electric leak around its needles. The reason for it is that the air blew out from the nozzles expands instantly to reduce its temperature (adiabatic expansion) and forms a dew condensation. When the dew condensation is formed on the insulator that supports the needle applied with high voltage, an electric leak occurs to reduce or stop the corona discharge and resultantly ion production. Once the leak occurs, the insulator (plastic) marks a black carbonized trace on it. To clean the trace is not easy, and a wire brush is generally used to scrape it off.

However, in the example mentioned above, the maker has been using the solvent to dissolve the carbonized plastic trace on the insulator. One of the “other reasons” adverted was that the ionizer they had introduced had needles set deep inside to avoid a dust adherence, which was absolutely a structural defect, so that the wire brush wouldn’t reach them at cleaning. That is, a ridiculous mistake brought by poor design caused the customer to use the solvent, which went against the tide of the times. And the second reason was that tens of thousands of needles had to be maintained weekly, which was too big job to do manually one by one.

Well then, going back to a fundamental point of view we need to know why things have fallen into the mess like this.

There is only one cause for it. It was caused by a leak-prone structure of the high voltage system and the air passage living there together. Neglecting the fundamentals in the electric engineering; “high voltage and air systems must not live together,” they had designed the ionizer to have an inevitable consequence as a structural failure.

To solve this problem the writer developed the “No-leak TRINC” and has relieved the ionizer customers from the “maintenance-hell” caused by the leak. This is the theme of this number titled “Anti-maintenance-hell.”

Summing up the idea, the air and high voltage systems have to be isolated from each other ? this is the base of the “No-leak TRINC.” With this, the leak is no longer at issue, and the rest is just a matter of how dust is removed from the needles. Since the dust is gravitated to the needle by static, it can be removed simply by brushing. No such troublesome work as wire-brushing to scrape the carbonized plastic away or dissolving it with the solvent is needed. Thus, the writer had implemented the new ideas using the “zero return” thinking and developed the unique one-touch cleaner and the automatic cleaner to eventually evolve them to the “Maintenance-free TRINC,” which makes customers even forget the existence of the ionizer.

b. Leakage inside the high voltage source

The static ionizer induces a corona discharge by using a high voltage. Some sort of ionizers has a design problem inside its power source to result in the break-down. Generally the corona discharge is induced by applying 3KV to 7KV, but some pulse type static ionizers generate ？ 14KV first then to synthesize it to ？ 7KV. Because they encage a high voltage of 14KV into the small container inside the ionizer and mold it with a resin, which has not enough tolerance to dielectric strength, the ionizer develops a leak soon after the use and breaks down. The other insulation materials are deteriorated gradually by the high voltage. Obviously the break-down is caused by the failure in the design that neglects these factors.

？ Air leak

The static ionizers that uses a compressed air tend to break down. This is because the moisture the air used to contain forms a condensation.

a. Air intrusion into the high voltage circuit

Almost all static ionizers using a compressed air have their structures conforming to one same pattern. The reason is that, when one company became successful in occupying the market with a high shear, competitors would follow suit for design in unison. They simply imitate the successor without examining if it is correct or not.

Then, what is wrong with its design?

That is in the basic structure having its high voltage part made crossing the air passage. Here, the high voltage part means the needle. Whenever maintenance is made on these ionizers, users replace the needle across flow of the air emitted from the nozzle. If they forget to turn the air off at the main and take off needles, the air gets into the high voltage circuit or the high voltage power source unit. They will certainly be posed a risk of an electric leak.

When they put on the needle, they also are subjected to seal up the air passage so securely that air doesn't leak into the high voltage part. The designer who designs such static ionizer uses a rubber seal for a perfect sealing. But when dust/debris adheres to the seal, it is impossible to seal off completely. On such static ionizer as has more than 20 needles, it is not possible to keep it airtight thoroughly even though its user is required to seal up them completely at the maintenance. Because the static ionizer tends to collect dust/debris on the needles and insulators around them, and the dust/debris get into sealing parts at the time of replacing needles. Once the air gets inside the high voltage parts, the static ionizer will break down. And yet, for the users who have multiple ionizers, it is extremely difficult for them to do the perfect maintenance on the countless needles every week. User should know of this fact.

b. Wasting air

This topic jumps the track of the air-leak issue, but is considered important to be added here. That is, the cost of electric power becomes tremendously high on those static ionizers that use air. The air used for one needle costs about 100 US dollars a month, and 12 thousand dollars a year. Have you ever imagined of the air cost up to 2 thousand dollars a mouth and 24 thousands a year on the static ionizer having 20 needles? Generally an ionizer used in the factory has more than 20 needles. What if several hundred or thousand ionizers of this sort are used in a big factory? This would not be allowed from a point of resource saving, as well.

? Ozone generation

a. Self-destruction with ozone

The static ionizer uses high voltage to generate ions by inducing corona discharge around the needles. The problem is the corona discharge that tends to occur on any sharp corner of the conducting material except the needles. To make the matter worse, once the corona discharge occurs it generates a slight amount of ozone as a by-product. Though it is a slight amount, it increases density gradually and corrodes the system.

On the ionizers broken down by erosion, their high voltage circuits are often revealed tattered. The sockets (holders) of the needles are tattered to result in a poor connection.

Like this, since poorly designed ionizers have their components eroded by the ozone they produce, they are borne to kill themselves. Readers may not believe, but it is true.

b. The connector that cannot be detached

As often observed on the conventional AC type static ionizers, the high voltage connector to connect the ionizer to the power source gets stuck in the power source unit.

Inside the connector, the corona discharge induced between the connect surfaces generates the by-product ozone which in turn erodes the surfaces and makes the connector detachable. Most static ionizer makers consider that the phenomenon is inevitable and the system has only to be replaced with new as a life time.

The writer cannot help but think that it is neglectful of maker’s duties. Because they think it inevitable, the technological advancement stops. The writer has an answer to this problem. But since we don’t have such type ionizers in our product line-up, I shouldn’t disclose the answer here.

In the above explanation, we have covered the meaning and importance of the “Anti-maintenance-hell” as the antistatic and anti-dust measures of new age. In the next number, we continue this issue.

Serialization
No. 19

Fundamentals of Static and Dust – 19

Until the last number, we had covered **2 Problems caused by the static**, **3 Fundamentals of the static**, **4 Fundamentals of dust**, **5 Fundamentals of antistatic and anti-dust measures,** and **6 Antistatic and anti-dust measures of new age.** We continue on **6 Antistatic and anti-dust measures of new age** in this number.

6 Antistatic and anti-dust measures of new age

The following items were explained in the last number.

6-6 Anti-maintenance-hell (An age demanding no troublesome maintenance)

6-6-1 Maintenance on the static ionizer

6-6-2 Case examples of maintenance-hell

6-6-3 Why is maintenance needed?

We continue to keep this theme for item 6 here.

6-6-4 Outrageous static ionizers

Up to this point, we have covered the issue why static ionizers require maintenance. We look further into this point in terms of their structure and controversial points between conventional and current static ionizers.

(1) Conventional static ionizers

A static ionizer (hereinafter ionizer) has a long history of almost 50 years. It was originally borne in the US and exported to Japan where it was copied to become commonly used. Like other commodities, it is the technology borne in the US. By that token, its basic patent has been held by Americans.

The basic structure of an ionizer is; it receives alternative voltage from an AC power source then to step up it to 10,000V by the transformer. The high voltage is led to electrodes to cause a corona discharge by which ions are produced. The ions are delivered to objects by either fan air or compressed air. So it is quite a simple structure of stepping up the AC power source by the transformer.

Well then, we will look at the controversial points inherent in the ionizer structure.

? They are designed so as to have an electric leak.

Perhaps you are aware of a gun ionizer. It carries the ions produced by a corona discharge on the air to objects. The air used contains inherently dust, moisture and water. And yet it is released instantly into atmosphere inside the gun so that its temperature drops immediately due to adiabatic expansion thereby to form a mist (condensation). The electrode, which is supported by insulating materials, is impressed by high voltage to cause a corona discharge. If the condensation forms on the insulator, an electric leak occurs all at once. So to say, it has a structure of a high voltage and the air living together, which is basically a leak-induced design. It is originally a mistaken design. But the makers require customers to use a clean and dry air and take a position that customers are responsible for the problem caused by the condensation. Notwithstanding, as long as a compressed air is used, condensation is not inevitable. So, almost all gun ionizers using the air are actually in trouble with a leak. And as they do not produce ions any longer in this condition, they are just an air gun. Since the static charged on the object cannot be eliminated only with air blow. Instead, because the air blow raises static, it becomes rather a dust collector, which is totally the adverse effect.

? They are designed so as to have a connector hardly disconnected.

a. Since an AC-type static ionizer uses a high voltage of 10,000V, it produces ozone.

It steps up directly an alternative voltage from AC power source to 10.000V. So the part of conductor which is impressed with a high voltage and exposed to the air tends to induce a corona discharge and ozone at the same time.

b. A connector becomes inoperative.

Ozone is very oxidative and oxidizes surrounding metals, rubbers and resins. The connector used between electrodes and circuit boards is also oxidized by the ozone and becomes impossible to be taken apart.

(2) Currently developed static ionizers

Next, we look at constructional problems on currently used static ionizers. To be frank, the problems seen on the old types have not been solved yet on the current ones, and rather more new problems have been added up to corrupt further the situation.

These added new problems are as follows:

? They are designed so as to cause an electric leak.

a. Leak around electrodes

A leak occurs because both air and high voltage systems live together. The plastic parts used around electrodes are carbonized and maintenance for them becomes inevitable. The carbonized plastic is so hard that a wire brush has to be used for scraping off. But the area where the wire brush wouldn’t reach (because of space) has no ways to have it removed other than to dissolve the plastic material with solvent.

b. Inner parts of high-voltage generating unit are ruined by a leak.

A pulse-AC type static ionizer steps up voltage to as high as ？14kV. As it is beyond the capacity of insulating materials used, a leak occurs to ruin the inner parts.

? Wasting air

Power consumption of these static ionizer are 15W at most, but air consumption is enormous. It would be about 3KW if it is converted into electricity. So the true power consumption goes up to 3.015W. The power consumption claimed in its catalog (15W) is a tip of iceberg, a total power consumption is converted into about $3,700 US a year. This is the amount equal to buying a new static ionizer in a half year.

? Air leak

They have a basic problem in designing of air passage. They are not designed to have the system airtight. The air leaking out the air passage is going into a high-voltage circuit section and ruins the power source.

? Self-destruction by ozone generation

a. The conductors of the system leading high voltage are oxidized by ozone to ruin the system itself.

b. The connector between the high voltage generating unit and electrodes is also oxidized to ruin the system.

? Brushes driven by fan air ???

At last a strange static ionizer appears. The idea used is like this; ionizer's fan air drives the brushes which have fins so that they brush off electrodes while discharging ions from them. This is indeed a nonsense and irresponsible idea because it eliminates static but also scatters dust around. This is the very static ionizer that materializes the thought conventional makers would take that they don't care whatever happens if static can only be eliminated. The maker has not even realized that customers are struggling against problems of static and dust.

? A static ionizer whose maintenance cannot be done appears.

This is the case seen on a Pulse AC-type static ionizer, which encloses electrodes inside the narrow hollow of plastic sheath from the reason that the electrodes exposed to the air might be fouled by dust. But, since this static ionizer uses air to send out ions, surrounding plastic parts are subject to electric leak and carbonized black due to adiabatic expansion. The problem that customers have now with it is that they cannot brush the carbon off because the hollow is too narrow to use a brush. The engineers who designed it appeared to be ignorant about static ionizers.

6-6-5 Countermeasures

The writer would like to take it for granted that readers have understood that many new static ionizers (they say) have just taken over the old type without solving the basic problems and rather made more trouble by adding new problems. TRINC has developed new technologies to overcome them, which are explained below:

? Simplified maintenance by the use of one-touch cleaner

A one-touch cleaner has the function that all electrodes (needles) can be cleaned by just a one-touch operation. Each needle is combined with a brush inside the housing which is interconnected to one lever (grip) located at the end of the ion-bar, so that by turning it 90 degrees all needles are brushed off at once.

On the other hand, normal static ionizers are designed to have their needles taken out to brush off carbonized debris with a wire brush one by one to be replaced one by one.

The required man-hour on the one-touch cleaner system is the thousandth part of normal ionizers in case of multiple long bar type ionizers being used.

? Automated maintenance by an automatic cleaner

TRINC's automatic cleaner has the function, as explained above, driven by an electric motor instead of a manual one-touch operation. When switched on, all needles turn in unison to be cleaned by stationary brushes in mere 2 seconds. It is also possible to have it controlled remotely, which is extremely effective for the situation where the unattended operation using the automatic needle cleaner is made in such a highly clean space as no one being allowed to enter.

? Full automatization with Maintenance-free TRINC

TRINC's maintenance-free function uses a central control system that gets automatic needle cleaning done according to a preset schedule. Since all the static ionizers installed in factory are cleaned automatically according to the program, the factory is released from troublesome maintenance so much as they forget the existence of static ionizers.

? Making maintenance less needed with an ozone corrosion-free system

The ozone corrosion-free function TRINC applies prevents the ozone, which is produced as a by-product at the process of corona discharge being generated by static ionizers, from corroding and deteriorating surrounding metal, rubber, or resin components. General static ionizers corrode their own electrodes, high voltage circuits, and connectors with self-generated ozone to cause a short circuit or air leaks. But TRINC employs the structure that doesn't make these troubles occurred with an ozone corrosion-free system.

? Making air-leak free

TRINC's static ionizers are of the no-wind (blow-free) type coming out of a principle of ionizers. But even on those TRINC ionizers which have a dusting function with air, they have basically no-air leak structure.

With this structure, they would never cause a high voltage source breaking down by an air leak around it as often seen on normal static ionizers.

? Making electric-leak free

TRINC has developed a no-electric leak mechanism that doesn't allow any electric leak to take place on the static ionizer when in use. By nature air is apt to include a moisture and mist in it. And yet, when compressed air is released instantly into the air inside the static ionizers that are widely used in the market, it expands but is cooled down by adiabatic expansion to form dew condensation. When those components supporting the electrode that is applied with high voltage form the dew condensation, an electric leak takes place.

The no-electric leak structure TRINC employs has its air passage isolated from high voltage circuits so that the electric leak of this kind would never happen. So any type of air whatever it includes water, moisture or other materials can be used without fail.

To the contrary, normal static ionizers lead compress ed air to electrodes and carry the ions generated there away toward objects. That is, their structure lets both high voltage and air live together, so that it is made basically to induce electric leak. This is essentially a mistake at the stage of product designing, but the makers demand customers to use clean and dry air and handle the trouble, which comes from air quality, as customer 's responsibility.

? Making voltage lower

TRINC static ionizers are designed to suppress the voltage needed to generate a corona discharge to 5 KV (7 KV at the highest). So, they are designed on the safe side for insulation performance, and neither insulation breakdown nor troubles due to it occur.

To the contrary, Pulse AC type static ionizers use the voltage as high as 14 KV, from which they step down to 7 KV. But the problem is the high voltage inside the ionizers. The high voltage of this level could cause insulators to wear out to result in insulation breakdown.

In this chapter, the writer explained the meaning and importance of "anti-maintenance hell (An age demanding no troublesome maintenance)" as antistatic and anti-dust measures of new age

In the next number, the writer will explain "6-7. Anti-ozone smell hell (Improvement of work environment of too smelly to withstand)."

Serialization
No. 20

Fundamentals of Static and Dust – 20

Until the last number, we had covered **2 Problems caused by the static**, **3 Fundamentals of the static**, **4 Fundamentals of dust**, **5 Fundamentals of antistatic and anti-dust measures,** and **6 Antistatic and anti-dust measures of new age.** We continue on **6 Antistatic and anti-dust measures of new age** in this number.

6 Antistatic and anti-dust measures of new age

The following item was explained in the last number.

6-6 Anti-maintenance-hell (An age demanding no troublesome maintenance)

In this number we discuss regarding 6-7 Anti-ozone hell.

6-7 Anti-ozone hell

6-7-1 By-products yielded by static ionizers

Static ionizers produce atmospheric ions to neutralize the static charged on objects. At this stage, they produce the following materials as by-products.

(1) Ammonium nitrate
(2) Ozone
(3) Ultraviolet ray

Each by-product is detailed below;

(1) Ammonium nitrate

As already explained earlier, the corona discharge generated by static ionizers makes Nitrogen (N_2) and Oxygen (O_2) in the air react on each other to produce NO_x, This NO_x reacts with moisture (H_2O) in the air to produce Ammonium nitrate (NH_4NO_3). This reaction takes place wherever there are oxygen, nitrogen and moisture in the air and is inevitable.

Since ammonium nitrate separates out as crystal to cover a tip of electrode, the corona discharge is weakened and ion generation is reduced. This phenomenon occurs all the year around, but is enhanced when humidity gets high in rainy season.

On the conventional static ionizers that use compressed air or fan air, the overgrown crystal is blown out of the ionizers to cause debris-related problems as if ionizers are debris-emitting machines.

(2) Ozone

Also as explained earlier, the corona discharge generated by static ionizers makes one oxygen in the air react with others to produce Ozone (O_3). This ozone is very oxidative to corrode metals and harden or deteriorate rubbers. Also the ozone smell makes people sick.

(3) Ultraviolet ray

Static ionizers generate a slight amount of ultraviolet ray during the corona generation process. Generally it is negligible level, but possible to expose the high sensitive films from which static is required to eliminate. So, people need to device not to direct the films to ionizers or adopt some kind guards against the ultraviolet ray.

Here, the writer explain more about a harmful effect of by-product ozone.

6-7-2 Harmful ozone effect

Ozone causes the following harmful effects from its strong oxidative property.

? Working environment worsened by ozone smell

Generally, static ionizers are placed in front of workers across objects so that workers are kept receiving the ion wind (breeze) emitted by ionizers. The ion wind includes relatively strong ozone smell. Humans are quite sensitive to sense the smell, and become intoxicated with it. There are cases that workers have to switch off ionizers from this.

The limit of ozone density is regulated by the Industrial Safety Regulation. The limit is set to the level for humans to be free from any medical trouble, but workers seem to be more perceptive to feel sick than this level.

Though static ionizers are known to be devices they could worsen working environment, makers have done yet to overcome the problem. So, customers have only to choose the machines that produce less ozone.

Ultraviolent type static ionizer produces the biggest volume of ozone. This is because it is not of corona discharge but ray type. And to this reason, it is used generally in the nitrogen environment without oxygen.

Of all the normal corona discharge type static ionizers, the high frequency type produces the highest amount of ozone. The AC type comes next, then the pulse type, and the DC type has the least amount of ozone produced. This is because that amount of ozone increases in proportion to power frequencies, and the higher it goes, the more the ozone is produced.

? Erosion caused by ozone

(1) Erosion on conductors (metals)

The high voltage circuit used on static ionizers is eroded by ozone. Erosion in it causes a short circuit and stops ion production.

The high voltage connectors are also made of conductors and suffer as well to the extent that they cannot be detached or a poor contact takes place to shut off power.

Either case makes crucial damages to static ionizers. These damages are not easily imagined by customers, who, as a result of repeated experiences in the past, are force to consider simply that the static ionizer is the device inheriting them.

Practically, these problems are all caused by ignorance of makers, and can be avoided by designing the products properly.

(2) Erosion on rubber bushings

It is generally known that rubber products are hardened by ozone to cause a problem. For example, they are often used as sealing materials and become a source of leakage problems resulting from hardened rubber materials, apart from anti-ozone rubbers.

Many static ionizers use air blow to help ions travel more distance, and employ a number of sealing rubbers. A typical product of them uses 2 sealing rubbers (bushings) per one electrode chamber to keep out air, because the chamber crosses the air passage. When cleaning the electrode, these bushings are removed. But replacing them to the original position is made without watching them because of its structure. This model has 20 electrodes so that 40 bushings are supposed to be airtight completely, but there is no guarantee if they are positioned properly. When an air leak occurs, it causes an electric leak as explained earlier.

An electric leak is a fatal damage to the static ionizers. Because of these repeated damages, they have been widely recognized as an easy-to-breakdown device. However, improper designs have made so, and the static ionizer is a trouble free and reliable device if they are properly designed.

As explained above, the ozone produced by static ionizers causes various problems. The writer introduces an ozone-free static ionizer as a new device to overcome this problem.

6-7-3 Ozone-free static ionizer

Under the present circumstances, it is inevitable to avoid ozone production. To do with this, a static ionizer has to be designed to have self-protection from its designing process, but actually there are so many static ionizers having no self-protection sold in the market. As a result many of them break themselves down from the erosion on their incorporating components. That is, they kill themselves.

This is the phenomenon that the problems are caused by basic structural defects, but truth to tell, the product currently sold most in Japan is just as this phenomenon applies. Not only are designers in its product maker ignorant of the fact, but also the maker has sold so many improper products just because customers are not complaining (maybe customers are unaware of the fact). The mistaken common knowledge that static ionizers are easy-to-breakdown devices having not been blamed by customers, they have kept selling their products so as to sacrifice them.

Well then, what are the requirement that static ionizer has to fulfill?

(1) To hold down the ozone production
(2) To apply countermeasures against the ozone to avoid the erosion at high voltage circuits and connectors
(3) To prevent the ozone from leaking out of static ionizers

Each item is detailed below;

(1) To hold down the ozone production

Use of DC type is the best to hold down the ozone production. Since the DC type has a zero frequency, it is minimized. As explained above, the high frequency type has the highest level and the DC type comes to next.

(2) To apply countermeasures against the ozone

Since it is inevitable to avoid the ozone production, the use of metal and rubber inner components is minimized.

(3) To prevent the ozone from leaking out of static ionizers

The system that retrieves the ozone produced and transforms it into oxygen (O_2) is employed in static ionizers.

The static ionizers currently sold in the market are not equipped with these countermeasures, or, if equipped, insufficiently equipped. Because of this fact, the mistaken common knowledge that the static ionizers are easy-to-breakdown devices has been set in among customers.

For your information, our TRINC static ionizers have materialized these functions. If static ionizers have the designing which abide by basic theory, they wouldn’t be damaged in such way.

In the above, we covered meaning and importance of the “Anti-ozone hell” as “antistatic and anti-dust measures of new age.”

In the next number, we will discuss 6-8. “Anti-dust generation.”

Serialization
No. 21

Fundamentals of Static and Dust – 21

Until the last number, we had covered **2 Problems caused by the static**, **3 Fundamentals of the static**, **4 Fundamentals of dust**, **5 Fundamentals of antistatic and anti-dust measures,** and **6 Antistatic and anti-dust measures of new age.** We continue on **6 Antistatic and anti-dust measures of new age** in this number.

6 Antistatic and anti-dust measures of new age

The following item was discussed in the last number.

6-6 "Anti-ozone" hell

In this number we discuss regarding 6-8 "Anti-dust-generation" hell.

6-8 "Anti-dust generation" hell

Same as the item in the previous number, this topic may make readers doubt their ears, but there are static ionizers that generate dust. The basic function on static ionizers is to eliminate static. However, since there are static ionizers that generate dust, those which have been introduced into facilities now risk the failure rate of products related to foreign material adherence. We discuss this laughable fact below.

6-8-1 Some static ionizers generate dust.

Some sort of static ionizers generate foreign materials as listed below at the same time they eradiate ions.

(1) Crystal grains of ammonium nitrate
(2) Metal flakes or composites from electrodes
(3) Dust piled up on a fan motor
(4) Dust piled up on fan blades
(5) Dust piled up on chassis
(6) Dust from filters

Each dust above is detailed below;

(1) Crystal grains of ammonium nitrate

Static ionizers induce a corona discharge applying a high voltage on the electrodes. At this process, they separate out white crystal grains (ammonium nitrate) at the tip of electrodes as by-products, which grow gradually as time goes by. Some sort of static ionizers use the compressed or fan air that is blown directed to the tip of electrodes, and blow off these crystal grains one after another as they grow bigger. As a result, they are generating dust.

On the other hand, the static ionizers which don't use the air have not this kind of problem.

(2) Metal flakes or composites from electrodes

The electrodes used for static ionizers wear out and get shorter as time goes by. That is to say, the composites of electrodes separate out as fine grains and sent out of them along with the air blow. Though minute amount, they have to be watched out carefully for harmful contamination in the severely controlled process. Particularly in the semiconductors field, they should be dealt with carefully as chemical contamination. As long as static ionizers induce a corona discharge, it is inevitable to send out composites of electrodes. But to reduce the risk of failing products (semiconductors) as low as possible, the electrodes made of the silicon base materials are sometimes used.

It should be noted that use of the static ionizers which blow air from a fan or compressor in such circumstances as mentioned above diffuses positively these materials (ammonium nitrate and electrode composites).

As against the ones cited above, the TRINC's no-wind (air blow) static ionizer, which sends out ions without help of air blow, makes a dent in diffusing this debris. Besides, TRINC has developed a new static ionizer that holds down the debris diffusion completely. Details of this model will be introduced in a separated issue.

(3) Dust piled up on a fan motor

The electric motor to drive a fan is also a source of dust. Particularly the bearings used inside it generate dust or debris. This is an inevitable weak point in fan type static ionizers, but a sort of motor that designed to generate less dust is often used to avoid the problem.

On the other hand, TRINC's no-wind static ionizers do not use the motor.

(4) Dust piled up on fan blades

The fan used to generate a breeze to send out ions also generates dust. The composites of fan blade are spread out right after the use of the fan for the first time, but the problem is bigger on the dust adhered to blades after that. As they rotate a lot of dust piles up and also spread out all around. Though this is an inherent weak point in this type, but it is inevitable. On the other hand, with TRINC's no-wind static ionizers, this problem can be solved.

(5) Dust piled up on chassis

A chassis of static ionizers generates dust too. The dust gathered from around the chassis and released finally into the air is more problematic than the one coming out of its own materials. Since static ionizers include high voltage parts, they collect dust from the around air. Particularly, the chassis made of plastic turns gradually dark in the surface. But problem here is the air from a compressor or fan which scatters around the dust adhering on the chassis. To the contrary, the static ionizer which does not use air at all has no such problems.

(6) Dust in filters

The filter fitted to air-blow type static ionizers is a stowing container of dust for large sized dust. Although depending on circumstances they are used, it turns to be a whitish form as time goes by. It is so thin that you can faintly see through the thing beyond it, and its meshes are too rough to restrict fine dust. It has only a capacity to filtrate a relatively large fabric threads or something like that. That is, although it is called a filter, it has not an effective filtrating function for fine dust, but rather is a dust spreading device.

And yet, the dust piled up in the filter is peeled off and released in time as foreign materials or debris. Therefore, the filter is rather a harmful under the circumstances where many working sites require the clean environment. Static ionizers with air system are by contrast destroying the environment, and air blowing is a root of all evil.

The no-wind (no air blow) static ionizer is a measure to solve these problems. An obsolete common knowledge, "Static ionizers should use air to blow to judge if they are operative or not." In other word, it had been believed that blowing air is evidence if they are working. However, today it has been acknowledged that this story is wrong. Blowing air is a root of all evil and the no-wind static ionizer is a measure to solve all these problems.

Up to this point, we have discussed of the static ionizers that generate dust, but there are more problems. In the following items, we discuss the harmful static ionizers having other problems.

6-8-2 Harmful static ionizers

Harmful static ionizers are divided broadly into three categories; the ones with air blow, the ones involving electric leak problems, and the ones claimed to be of maintenance-free type. Each is detailed below.

? Static ionizers with air blow system

As explained above, these are all using the air from a compressor or fan to send out ions and almost all conventional ionizers fall under this category. Their side effects are;

(1) They spray objects with dust and foreign materials (debris)

There are 6 elements for the dust generation as detailed above, and the air contributes to spray dust and debris to objects. These dust and debris wouldn't fly about if they do not send the air out.

Moreover, the air they use includes various materials, such as oils, water, moisture, metals and resins, all of which mostly come out of a compressor and its tubing system. The air is usually filtered, but they wouldn't be removed properly if the maintenance to the filter is not done properly.

(2) They raise dust

Fan air or air from a compressor raises dust piled up on the desk or adhering to worker's clothing. The dust then adheres to products to cause product defectives. This is the reason that the static ionizers using air are designated as harmful devices. If they were no-wind (no-blow) static ionizers, they would complete the ionizing function without these reverse reactions.

(3) They have dust and debris forcibly adhering to objects

Adherence of dust and debris onto objects results from static attraction (Coulomb force).

Since this force varies in reverse proportion to the square of distance, the nearer the dust comes, the stronger it is generated. And the dust flying distantly from objects wouldn't adhere. However, the static ionizer that uses air raises the dust, and those which would not have come nearer to objects under ordinary circumstances could be flown closer and forcibly adsorbed to them. That is to say, the measure employed to avoid static and dust could in turn increase defects on products.

(4) They could be dust collectors and dust generators

As already explained, a static ionizers is the equipment using high voltage, and the electrode, chassis or whatever attract dust to adsorb from the circumference of it. Because the static ionizers using air spray out the dust onto objects, they could be dust collectors, dust generators, and tools to produce more dust-related problems.

? Static ionizer with potential electric-leak-hazard

This is the static ionizer that has structure to cause potentially a high voltage electric leak. That is, the one whose structure causes a leak inevitably because the electrode applied with a high voltage is always exposed to the air from a compressor. To our surprise, the conventional static ionizers that use air belong almost all to this type.

This type has following harmful adverse effects, too.

(1) When an electric leak occurs, plastic parts around electrodes get scorched to produce carbon. Normally they scorch black and carbon particles are released from the surface, but smoke is spewed out as gas-like carbon when the leak is too intense.

(2) The black carbon produced by the leak is required to scrape off with a wire brush or something like that. The debris of carbon scraped off is finally sent off through air as dust.

In the above items, the meaning of "'anti-dust generation' hell" and importance are explained, and we will continue this theme in the next number.