School of Industrial Engineering & IT

ESD PROTECTION STUDY AND IMPROVEMENT PROPOSALS IN BSH ESQUIROZ

Bachelor's Degree in Industrial Technologies Engineering

Final Degree Project

Laura Razquin Echarte

Eugenio Gubía & José Luis Castillo

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Abstract

This project has been carried out in the agreement of internship inside an enterprise, in the process-engineering department of BSH Home Appliances (Navarre). The ESD (Electrostatic Discharge) damages the electronic components of the products manufactured (dishwashers and refrigerators) and implies additional costs for the company as well as a reduction in quality and product reliability, due to a failure in the home appliance. The objective is to improve the current ESD protection in the entire factory, during all the life cycle that the electronic components follow. To do that, a previous ESD study has been carried out making measurements and observations, and the consequent improvement proposals have been stated. With the implementation of these improvement proposals, that if not now they will be implemented in the future, BSH is aware that its protection against ESD will increase.

Abbreviations and key words

ESD – Electrostatic Discharge

HBV- Human Body Voltage

ESDS – Electrostatic device sensitive

EPA – Electrostatic protected area

Electrostatic field

Grounding

Rgp – Resistance to ground

Rpp- Resistance point to point

Ionizer

Product qualification

Dissipative

Charge

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1. Introduction and main purpose of the project

1.1 Introduction

Nowadays the companies are making more efforts to improve their productivity and reduce the costs due to quality problems. In this direction, the companies dedicated to the handling or manufacturing of electronic components have to deal with the problem of ESD (Electrostatic Discharge), a problem that sometimes is difficult to notice. The problems due to ESD started a very long time ago. For instance, in the XIX century, in May of 1937 a transatlantic zeppelin exploded in Hindenburg because of an electrostatic discharge caused by the charged atmosphere due to an electric storm. It wasn´t until the 80s when people assumed the real importance of the electrostatic discharges in the manufacturing of electronic components. Today, not all the companies dedicated to this manufacturing have a protection system for ESD.

The electrostatic discharges are present in our lives all the time, and we may notice them if the charge is high enough ,but in a production process the problem might be there and nobody could realize because the product passes the functional tests and is released to the market. Therefore, the problem appears later and is due to an electrostatic discharge that was produced in the factory. Any electronic device could be destroyed and be not functional because of a high electrostatic discharge. In particular cases, as where there is a risk of explosion, electrostatic charging could cause a spark and, consequently, a fire or even an explosion.

The ESD is determinant for the premature failure of the product, and means an additional cost for the company if the appliance is still in warranty when it fails, or a repair for the user, and thus the enterprise has a poor quality.

However, what is known is that if the ESD events are controlled, the impact will decrease if not be eliminated, and there will be a lower number of failures, it will benefit the company and so the client. A suitable ESD protection system helps to significantly reduce manufacturing costs and is an important element for the quality assurance and product reliability.

This project is carried out in BSH Home Appliances Esquiroz, manufacturer of dishwashers and refrigerators, with the collaboration of Jose Luis Castillo and other workmates such as heads of assembly lines, maintenance workmates, warehouse workers, and more personnel that have taken part in the project. In BSH Esquiroz, they are aware that before the year of 2012 the number of fails in the power module of the dishwasher was higher in comparison with 2013, when protection measures against ESD were carried out. In addition, they have found several fails with the LEDs of the refrigerator, because they are assembled in a plastic cube that is high charged. They know that the ESD events could be making them losses in the home appliances market and a correct ESD protection system shall be incorporated.

BSH Home Appliances is a German multinational enterprise, the largest manufacturer of home appliances in Europe and one of the leading companies in the sector worldwide. Today, BSH operates in 42 factories worldwide. Together with a global network of sales

and customer service firms, the BSH conglomerate today is made up of about 80 companies in 50 countries, with a total workforce of more than 61.800 people. In Spain, with a total number of 4.431 employees, BSH is the leader company of the home appliances sector.

One of the six plants that BSH has in Spain is located in Esquiroz, Navarra. The factory was found in 1985 and owned by SuperSer. It produces dishwashers, refrigerators and freezers, under the brands of Balay, Bosch and Siemens. Initially, there was a dishwasher factory in Estella, but it was moved to Esquiroz and therefore Estella was used as a storage for BSH Esquiroz. Also in Navarra, there are offices located in Huarte, as a center of corporative systems. In Esquiroz, there are four assembly lines for the refrigerators and one line for the dishwasher. However, with only one assembly line for the dishwasher the number of the appliances produced is similar to the one of the refrigerators because the production process is not that complex. The majority of the dishwashers that are produced are sent to China, around an 80 % of the production.

This factory is structured in several departments. The planning, maintenance departments, and the laboratories of quality are inside the production plant in the ground floor. The development department, in the ground floor too; and then in the first floor we could find the departments of engineering, purchasing, quality, controlling, logistics and personnel. This factory also has the competence center for the heat pump, which is in direct contact with the development center in Berlin.

As we can see in Figure 2, the factory of Esquiroz is pretty close to Pamplona; nearly it takes about 10 minutes to arrive to the factory. The offices that BSH has in Huarte are close to Pamplona too. In Figure 1, we can observe an aerial view of the factory. The building on the left is the audit section, and the bigger building on the right contains the plant and the several departments of the factory.

Figure 2. BSH Esquiroz Location

Figure 1 Air view of the plant of BSH Esquiroz

1.2 Main purpose of the project

The main purpose of this project is to do an ESD protection study and state the corresponding improvement proposals, but that main purpose could be divided into different specific objectives as it is followed:

- Do a previous study of all the information about ESD: search information about the topic, the way it damages the electronic components, read different ESD control programs of several companies, study the main norms for ESD protection and the BSH regulation as well. A previous training of the topic is necessary to carry out with success the project.

- Stablish guidelines for ESD protection: knowing all the information already mentioned, a control program should be stablished. Therefore, the main guidelines for this program have to be stated and followed during the entire project.

- Study the current protection against ESD in the factory: following the guidelines previously stablished, and with the help of an audit kit, it has to be studied how protected are the electronic components of the home appliances since they arrive to the factory at the warehouse until the final product is released, during their whole life cycle. Different measurements and observations have to be made in all the manufacturing process.

- Stablish improvement proposals: for each home appliance assembly line, the dishwasher and the refrigerator, different improvement proposals have to be stablished in order to ensure the protection for their electronic components against ESD.

- Implementation of improvement proposals: although this cannot be controlled because it depends on the company, it is an objective too.

Knowing all the objectives that this project involves, it has been structured into different chapters. There is a first chapter explaining the ESD, how it is produced, the damages and failures that may occur, the existing test simulations to know the sensibility of the electronic components to ESD, and the existing norms about this topic. This information has been very useful in the development of the project. In the second chapter, the guidelines for an ESD protection are defined as well as the methodology (audit kit) that has been used for the different measurements. In the third chapter, an ESD study in the electronic components life cycle for each home appliance (dishwasher and refrigerator) is carried out, with its specific improvement proposals. Finally, the budget needed for the well development of this project is calculated, to know how much will cost its implementation to the company.

2. Electrostatic Discharge (ESD): definitions, consequences and norms

2.1 Static electricity and ways in which it occurs

The word "static" means without movement. Therefore, the static electricity is an electric charge without movement, a stationary charge. The static charge happens when there is a disequilibrium between electrons and protons present on the surface of a material. This disequilibrium has consequently the creation of an electric field. Non-conductive materials and conductors not derived to ground have the capacity to absorb or retain a charge or a stationary electric potential. Some materials of common use can acquire thousands of volt during its handling.

The two basic mechanisms by which the materials can retain electric charge are the triboelectric effect and the polarization, explained below.

- **Triboelectric effect**

All the materials are made of atoms. The atoms are composed of a nucleus charged positively due to the protons, and electrons charged negatively surround it. Then, the atom is electrically neutral. However, not all the elements have the same affinity for the electrons, to catch or release them. When two different material elements are rubbed, the difference in the affinity makes that one of them catches electrons from the other and therefore one is charged negatively and the other positively, as we can see in Figure 3. For the happening of this phenomenon, is not necessary the rubbing, with the contact of two elements the transference of charge is carried out also. The contact and separation of two neutral materials without electrostatic charge makes an exchange of electrons from one surface to another, so they will retain certain level of electrostatic charge. However, with the rubbing the contact surface is bigger so the additional energy will make a wide exchange of electrons, causing a higher charge. The effect will increase if the rubbing is fast. The intensity of the charge is directly influenced by the relative humidity. With lower humidity, higher is the charge.

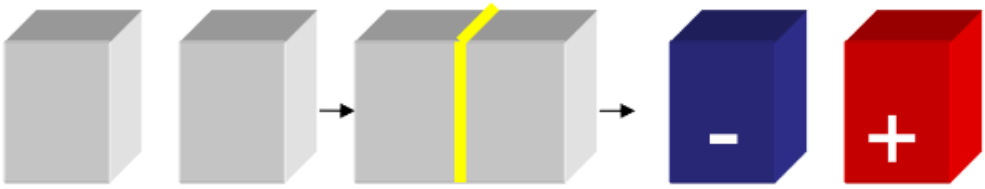

Figure 3 Way of charging

After getting in contact, there is a quimical link forming between some of the parts of the two surfaces, and the charges move from one material to another trying to equalize the electroquimical voltage. The nature of the materials that get in contact has a very important influence in the level of the charge. There is a classification that sorts the materials with regard to the capacity of electrostatically charging, it is called the triboelectric series, shown in Figure 4. [1]

Figure 4 Triboelectric series

Rubbing two materials of the previous list, the one in the higher position will be charged positively while the other in a lower position will be charged negatively. The more separated the materials of the list are, the higher is the intensity of their electrification. [1]

❖ **Polarization**

Every charged material is surrounded by an electromagnetic field. A conductor material connected to the ground under the influence of a magnetic field can retain a charge.

A conductor exposed to an electromagnetic field will redistribute those electrons of its outer layer attracted by the nucleus by a smaller force. If the object that emits the field is positively charged, the electrons will drift towards the nearest area of the object, which will leave the opposite end with electron deficiency (positively charged).

If, then, the negatively charged area of the conductor come into contact with the ground, the excess of electrons would drift to the ground, which would leave the conductor positively charged. The derivation to ground of the positively charged conductor would result in the instantaneous flow of electrons back to the

conductor, which would generate high temperatures and almost certain destruction of the conductor, if this were an electronic device. We can see this in Figure 5.

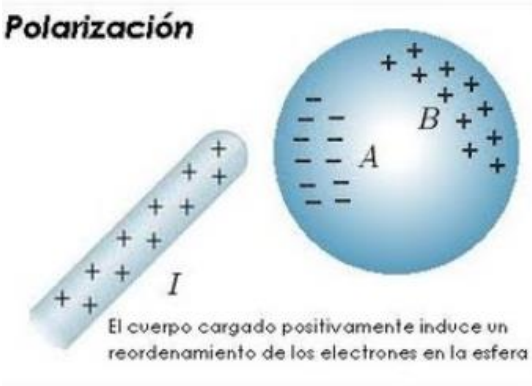

Figure 5 Polarization

When an electronic device containing semiconductors is exposed to an electromagnetic field, polarization occurs again, diverting electrons to the most positive area of the field. A potential difference can exist through the semiconductor and, if the difference is large enough, dielectric breakdown will occur. In certain occasions (high potentials) the dielectric will melt, with the consequent destruction of the device. In other situations, through the dielectric small burned holes will be produced, which will result in the degradation of the useful life, to an imprecise operation, or both.

Despite the static electricity is a stationary charge, it can affect the objects in the following ways taking into account the polarization and the triboelectric effect:

- *Electromagnetic induction*: A material or charged object has around it a stationary electromagnetic field that surrounds it, called EMI (Electromagnetic Interference). A conductor that travels through this field, or a field that travels through a conductor, induces the flow of an electric current through the conductor.
- *RF voltage:* When a charged material or object is discharged nearby, the resulting spark emits an electromagnetic field that moves and can cause irreversible damage. [1]

2.2 Electrostatic Discharge (ESD) and test simulations

The electrostatic discharge is an electrostatic phenomenon that causes a circulating current suddenly and shortly between two objects of different electric potential, such as the one that circulates through a lightning conductor after being reached by a lightning. Is the liberation of static electricity when two objects at different voltage get in touch.

The term is used in the electronics industry and other industries to describe momentary unwanted currents that can cause damage to electronic equipments.

When a material charged electrostatically gets in contact with an object connected to the ground the electrical charge is released reaching the electrical equilibrium again. This phenomenon is extremely fast, it happens in nanoseconds. The electrostatic discharges could happen during the fabrication, packaging, verification of the product or in another moment in which the device gets in touch with a person or a machine. To know the susceptibility of the device to ESD effects, there are used different models that simulate the real ESD events. The most common procedures or tests that are used are the Human Body Model (HBM), the machine model (MM) and the charged device model (CDM).

Human Body Model (HBM)

The human-body model (HBM) is the most commonly used model for characterizing the susceptibility of an electronic device to damage from electrostatic discharge (ESD). The model is a simulation of the discharge, which might occur when a human touches an electronic device. It is the transient pulse of current produced by the discharge from the tip of the human finger through an object connected to the ground (Figure 6). The model has a 100-pF capacitor that discharges through a 1.5 kΩ resistor and a switch into the device under test. A discharge from the tip of the finger can result in current peaks of up to 20 A; exclusively the resistance of the body determines the current intensity. For HBM tests, there is a simple series RC network to simulate the discharge from a human body. The waveform characteristics are shown in Figure 7. [2]

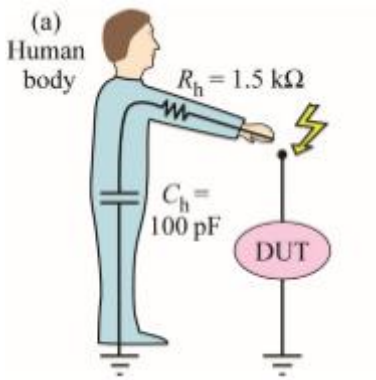

Figure 6 HBM model circuit

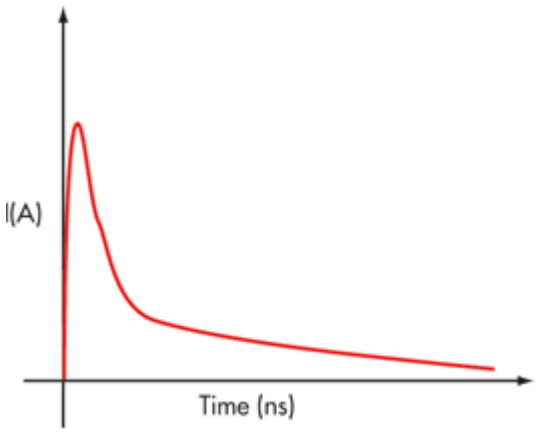

Figure 7 HBM waveform

Machine Model (MM)

The machine model represents the electrostatic discharge that a tool, a machine, or any production equipment with charge can cause in an ESDS (Electrostatic sensitive device). This requires metallic contact; so the resistance is lower than in the HBM. This results in a current 10 times bigger than in HBM. In the test setup, a high-voltage (HV) supply in series with a resistor charges a capacitor. A switch is used to remove it from the HV

supply and connect it to the inductor for discharging. The inductor produces an oscillatory current waveform.

MM uses the same basic test circuit as HBM, except R = 0 Ω and C = 200 pF (Figure 8) . A 200-pF capacitor, which represents a conductive object such as a metallic handler, is used with a 1-MΩ resistor for charging. A 0.5-µH inductor is used for discharging. The MM test is less commonly used than the HBM test. The MM current characteristic waveform consists of both positive and negative sinusoidal peaks that decay exponentially, that are shown in Figure 9. [2]

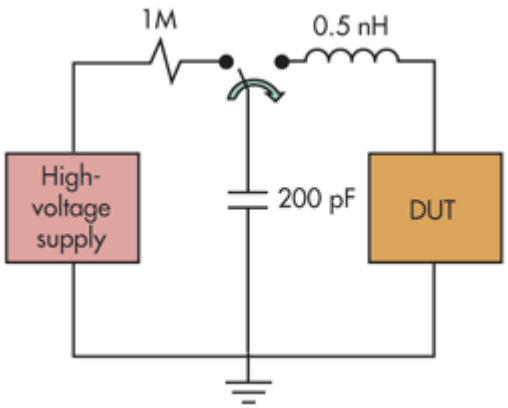

Figure 8 MM model circuit

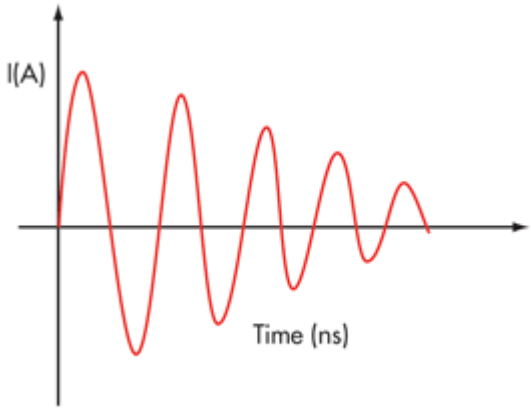

Figure 9 MM waveform

Charged Device Model (CDM)

This model is very different from the others. The event that tries to simulate is when an electronic component retains static charge and tends to discharge it to the ground. Therefore, the electronic component is the one that sends and receives the specific charge. It simulates a device charged either directly by triboelectric effect or indirectly by electrostatic induction and static charge stored in a part's body that discharges in an outside environment.

This test is used to simulate situations that happen in manufacturing environments such as mechanical device handling where devices slide down shipping tubes or test handlers that build up a charge that is subsequently discharged to ground. When an external ground touches the DUT pin of the charged device, the stored charge will be discharged from the device to the outside ground. In the CDM test, the device is kept on its back, facing upward on a test fixture.

CDM currents are higher than HBM currents because there is no current limiting resistor in the path to limit the discharge. In Figure 10 it is shown the CDM ESD test and typical current waveform. [2]

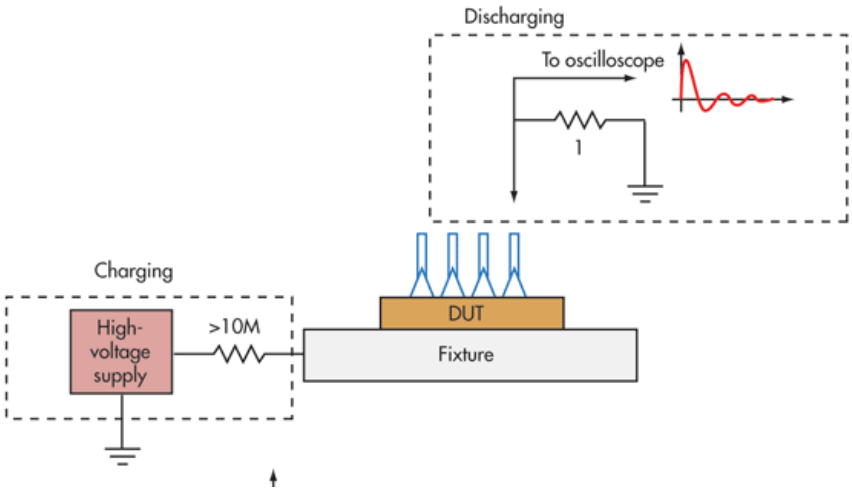

Figure 10 CDM model circuit and waveform

Similar rise times and total duration for HBM and MM cause comparable joule heating that results in similar failure mechanisms for both models. The failure signature and discharge processes of the MM test are generally the same as that of the HBM test. Thus, the HBM test could guarantee MM ESD robustness. Usually, the stress level of MM ESD is approximately 10 times lower than that of HBM ESD. In addition, the protection voltage level for HBM typically is 2 kV while for MM it is 200 V and for CDM it is 500 V. CDM is completely different from HBM and MM, so there is no correlation between them. Therefore, CDM and HBM tests are commonly used to test ESD protection circuits. The Figure 11 shows current waveforms characteristics for HBM, MM, and CDM. [2]

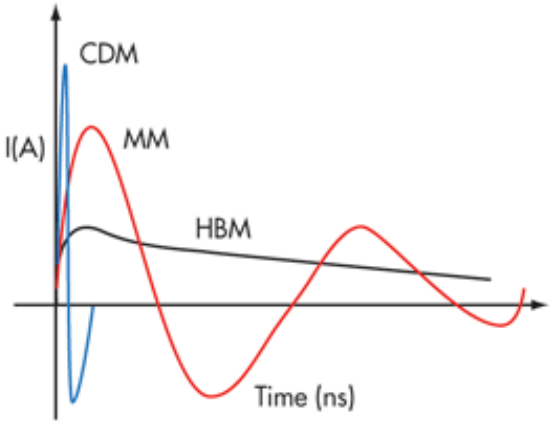

Figure 11 Comparison of the three models waveforms

The ESD sensitivity of a device can be defined as the highest ESD test voltage it supports and the lowest ESD test voltage it fails. Each model has its own classification for categorizing devices according to their ESD sensitivity. The classifications for HBM, MM and CDM are shown in Table 1, Table 2 and Table 3.

TABLE 1: ESD IMMUNITY CLASSIFICATION FOR HBM	
Class	**Voltage range**
Class 0	<250 V (fails for ESD pulse of 250 V)
Class 1A	250 V to <500 V (passes 250 V and fails 500 V)
Class 1B	500 V to <1000 V (passes 500 V and fails 1000 V)
Class 1C	1000 V to <2000 V (passes 1000 V and fails 2000 V)
Class 2	2000 V to <4000 V (passes 2000 V and fails 4000 V)
Class 3A	4000 V to <8000 V (passes 4000 V and fails 8000 V)
Class 3B	≥8000 V (passes 8000 V or above)

Table 1 ESD withstand voltage classification HBM

TABLE 3: ESD IMMUNITY CLASSIFICATION FOR MM	
Class	**Voltage range**
M1	<100 V (fails for ESD pulse of 100 V)
M2	100 V to <200 V (passes 100 V and fails 200 V)
M3	200 V to <400 V (passes 200 V and fails 400 V)
M4	≥400 V (passes 400 V or above)

Table 2 ESD withstand voltage classification MM

TABLE 2: ESD IMMUNITY CLASSIFICATION FOR CDM	
Class	Voltage range
C1	<125 V (fails for ESD pulse of 125 V)
C2	125 V to <250 V (passes 125 V and fails 250 V)
C3	250 V to <500 V (passes 250 V and fails 500 V)
C4	500 V to <1000 V (passes 500 V and fails 1000 V)
C5	1000 V to <1500 V (passes 1000 V and fails 1500 V)
C6	1500 V to <2000 V (passes 1500 V and fails 2000V)
C7	2000 V (passes 2000 V)

Table 3 ESD withstand voltage classification CDM

2.3 Types of failures and damages caused by ESD in electronic components

Although there are many types of failure due to ESD and very diverse, we can divide them into three groups:

- **Destruction**: the very high voltages and instantaneous currents cause the fusion of the metallic oxides and other components. Therefore, the device is no longer useful.

Then we have other types of failure called “latent damage” because the device fails but time after being exposed to electrostatic discharges. We can see two groups here:

- **Degradation of the useful life**: The unforeseen current flow may not be strong enough to destroy the device but may cause premature failure of the device. A part of what is called infant mortality of the components may be nothing other than the damage caused by ESD.

- **Inaccurate component operation**: Transient currents induced and polarization can affect the regime parameters of the device causing it to work unexpectedly or outside of tolerances expected.

The destruction of the device can be seen if the company has tests stations or verification areas for ESD. However, a latent damage could be classified as good device and pass the functional tests, and logically, the failure will be detected in the hands of the client, and the cost will be higher.

When the failure happens during the production process and could be detected there, the consequences are additional costs and repairs. Nevertheless, when the product is released to the market and the failure cannot be detected during the production process, the consequences are failure in client, product withdrawal, warranty, and loss of reputation. We can see the classification of failures in Figure 12.

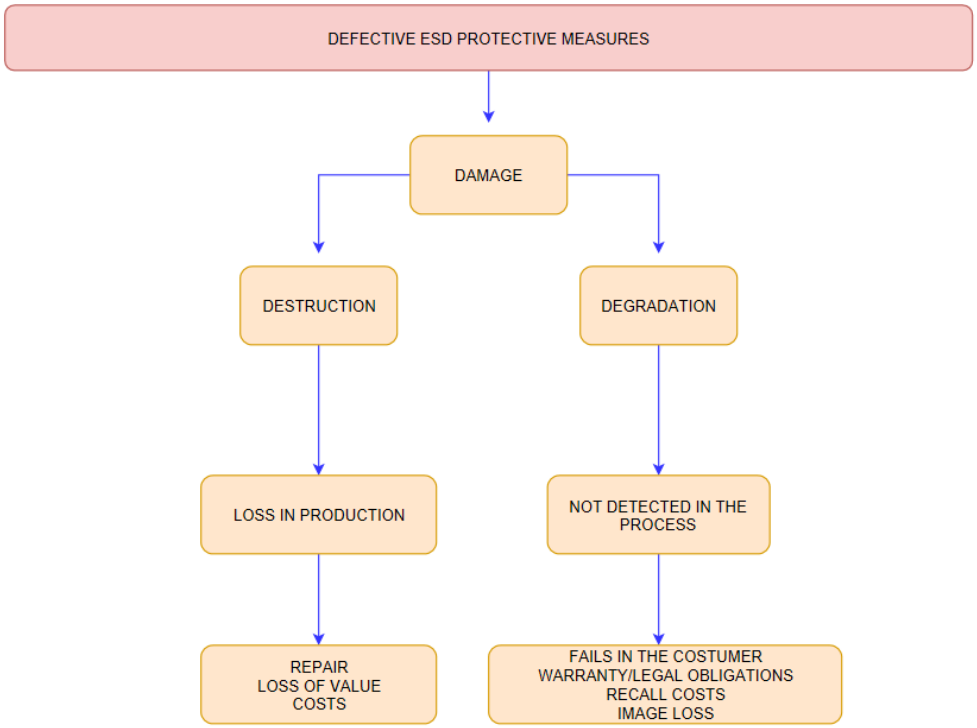

Figure 12 Types of failure caused by ESD

Now, after knowing the types of failure that we can have in every factory with electronic components, it is going to be exposed the kinds of damage that can occur in an electronic component due to an electrostatic discharge. They depend on the type of discharge (current, voltage, time of discharge) and on the typology of the component affected.

- **Oxide or dielectric breakdown:** Dielectric or oxide punch through refers to the ESD mechanism involving a voltage pulse that is large enough to break an oxide or dielectric layer. This problem is prevalent in MOS circuits because the thin oxide isolating the gate and the channel of the MOS transistor (Figure 13) can easily be 'punched through' by large voltage spikes. Trends in new fabrication processes that lean towards thinner oxide layers also aggravate the occurrence of this mechanism. We can see the oxide breakdown in Figure 14. [3]

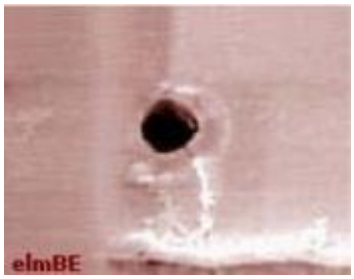

Figure 14 Oxide breakdown

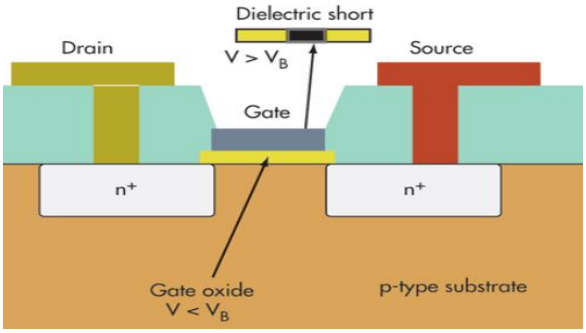

Figure 13 N-Mos transistor

- **Junction damage:** Junction damage or burnout, shown in Figure 15 refers to the destruction of a p-n junction due to joule heating caused by the ESD event, resulting either in the junction's being open- or short-circuited. This type of damage also involves joule heating, and is more prevalent in bipolar devices. Hot spots arise in the junction when it undergoes joule heating, especially in parts where there are non-homogeneities and geometrical shifts. Silicon where these hot spots arise become intrinsic in nature, whereby its resistivity goes down as temperature goes up. The reduction in resistivity further sinks more current, increasing the temperature further. This cycle continues, resulting in a thermal runaway that eventually melts the silicon with the hot spot when its temperature exceeds the melting point of silicon. The silicon meltdown often creates a short across the junction, although high-energy transient ESD events can also result in open junctions. [3]

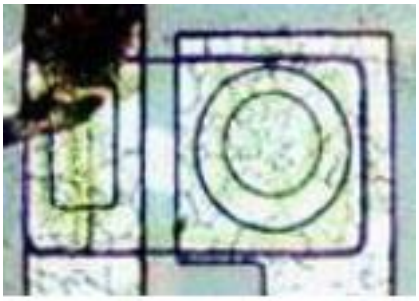

Figure 15 Junction damage

- **Metal melt:** When an electrostatic discharge occurs on a metal or a resistance, if the power dissipated by Joule effect is high enough, it can melt this component. This phenomenon usually occurs in thin metal interconnections, resistors thin and poly silicon resistors. This dissipated power will be I_{ESD}^2xR; where I_{ESD} is the intensity of the electrostatic discharge, and R the resistance of the metal. If the power is high enough, it can heat the metal above its melting temperature. Metal fusion is commonly observed in integrated circuits subjected to HBM models since the energy dissipated due to this model is, in reality, higher than in other models. Normally the fusion of a metallic element

of a circuit is completed causing an open circuit that supposes a non-functioning of the circuit. On the other hand, it is possible that the energy of the discharge only partially melts the metal resulting in a variation of the resistance of the affected part, that is to say a latent failure. We can see the difference between before and after the metal melt in Figure 16 and Figure 17. [3]

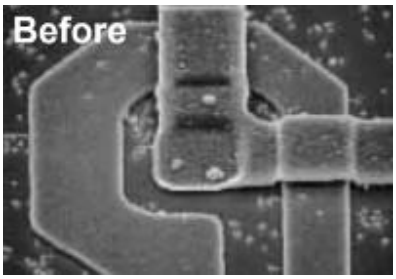

Figure 17 Before

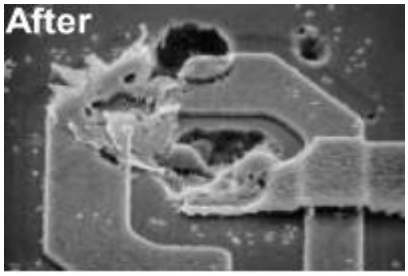

Figure 16 Metal melt after

2.4 Relative Humidity Influence in the ESD events

Relative humidity is a very important parameter to control electrostatic discharge. In fact, on days when the level of relative humidity is lower than usual, it can be observed how the "sparks" one receives when the car plate touches, the doorknob... increase.

The characteristics of the materials are sensitive to relative humidity. The resistance of the materials is one of these variable parameters depending on the humidity. Materials with high resistance will increase their resistance with the decrease in humidity. In other words, for non-conductive objects a low relative humidity supposes a decrease in the conductivity. The explanation for this phenomenon is as follows: the presence of environmental humidity results in the creation of a thin layer of moisture in the objects that behaves as a conductive medium.

If this moisture layer is created in an electrostatically charged object, the result is that the opposite electrical charges can be distributed freely, neutralizing the overall load of the object.

The following Table 4 shows the electrostatic charge that an object can store at different levels of relative humidity.

MEANS OF GENERATION	10-25% RELATIVE HUMIDITY	65-90% RELATIVE HUMIDITY
Walking across carpet	35,000V	1,500V
Walking across vinyl tile	12,000V	250V
Worker at bench	6,000V	100V
Poly bag picked up from bench	20,000V	1,200V
Chair with urethane foam	18,000V	1,500V

Table 4 Humidity influence

From the data presented, is deduced that humidity control automatically translates into danger control of ESD damage.

2.5 Norms

Nowadays, there are different documents and norms about ESD protection, there is a lot of information about this event and it is disperse, also in some cases incomplete. To define the concrete control program or ESD protection system that is going to be applied in BSH Esquiroz, it has been taken into account the international norm IEC-61340-5.1. However, there are a lot more norms about ESD, as we can see in Table 5.

AEE	Asociación Electrotécnica Española
ANSI	Instituto de normalización nacional de U.S.A.
BS	Prescripciones británicas
CENELEC	Comité europeo para la normalización electrotécnica
DIN	Normas alemanas para la industria
IEC	Comisión electrotécnica internacional
JIS	Prescripciones japonesas
NEMA	Asociación de fabricantes de productos eléctricos U.S.A.
UNE	Una norma española
UTE	Asociación electrotécnica francesa
VDE	Asociación electrotécnica alemana
CNE	Código Nacional de Electricidad (Perú)

Table 5 Norm's classification

For the ESD events, there are norms of ANSI (United States), for instance, the N.A.S.A has very good control programs based in this norm, also DIN (Germany), UNE (Spain) and IEC (International Electronic Commission). It is going to be chosen the last one mentioned, because is the most used in Europe, as well as the BSH Regulation for ESD protection, which is also based in the norm IEC 61340-5-1.

The BSH Regulation was designed to reduce the risk of failures caused by ESD in the BSH locations (factories and warehouses). It applies to activities that: manufacture, process, assemble, install, package, label, service, test, inspect, transport or otherwise handle electrical and electronic parts, assemblies and equipment. This standard does not apply to the development of the electronic components and modules.

The risk of harmful influence on modules caused by ESD depends primarily on the integration of the modules. Electronic sensitive modules can get protection by:

- Housing or integration in a subassembly
- Suitable packaging

It must be ensured, that all ESD relevant components are marked, to identify them accordingly. Due to the risk classification, at least all "A" and "B" materials must be marked as ESD sensitive. The marking has to be part of the BSH documentation. The classification can be seen in Table 6.

The protection level should be defined according environmental conditions, accessibility (people and material), and personnel protection. [5] The levels classification is in Table 7.

Protecction class	Description	Examples	ESD symbol
A(High risk)	Susceptibility to ESD ≤ 2kV or when it is easy to have a direct discharge trough the PCBA (typical situation of PCBA w/o housing)	Electronic PCBs w/o housings and higher complexity (electronic components and contacts are not reachable during handling), typically SMD, microcontroller, CMOS components	yes
B(medium risk)	Susceptibility to ESD > 2kV and ≤ 6kV, not easy to get in direct contact with the PCBA	Typically PCBA only with THT assembly.	yes
C(low risk)	Susceptibility to ESD > 6kV, PCBA is protected in order to avoid the direct contact with PCBA	Analog pressure sensors, temperature sensors	no

Table 6 Electronics classification

Level	Description	Equipment
1	ESD protected zone with automatic access control	ESD floor and ESD complying equipment Access control for verification of personal protection equipment
2	ESD protected zone without automatic access control	ESD floor and ESD complying production equipment (workplace, seats, tools, ...) Verification of personal protection equipment (e.g. wrist-straps) must be ensured by suitable means
3	Particular ESD protection	Typical “upgrade” situation of initially unprotected zones; use of ESD-mats and other local protection solutions Must include protection solutions for the workplace and t he worker Verification of all protection equipment (e.g. wrist-straps) must be ensured by suitable means
4	No specific ESD protection	Only possible for C class electronics. It must be ensured, that the electronic is left in the protected environment (e.g. housing). Not acceptable for technical analysis!

Table 7 EPA classification levels

It must be ensured, that all materials/components, classified as ESD sensitive, are also delivered/stored in suitable packages.

Inside and outside EPA's, the packaging must effectively limit electrical charging and provide shielding from electrostatic fields and discharges.

Outside the EPA, ESDS is to be enclosed inside supplier packaging. Before ESDS is transported outside the EPA it should be enclosed in such packaging that is low charging, conductive/dissipative and having the ESD control property of shielding. Unpacking of ESDS is only allowed in an EPA. The rules for packaging are shown in Table 8. [5]

Item to be packed	EPA		UPA	
	Intimate	Proximity	Intimate	Proximity
ESDS	Electrostatic conductive or dissipative [a]	Electrostatic conductive or dissipative	As for inside EPA and electrostatic discharge shielding [b]	Electrostatic discharge shielding
a For battery operated ESDS, the selection of the material or the design of the packaging should ensure that the battery does not become discharged. b Electrostatic discharge shielding property is only needed when proximity packaging is not electrostatic discharge shielding.				

Table 8 Packaging

All employees handling ESDS must receive proper training, too. The refresher instruction is held once a year. The corresponding manager should organize the training.

The controlled items (workplaces, trolleys, shelves, chairs…) should be labeled (Figure 18) in order to easily identify that they are safe to use with ESD sensitive components.

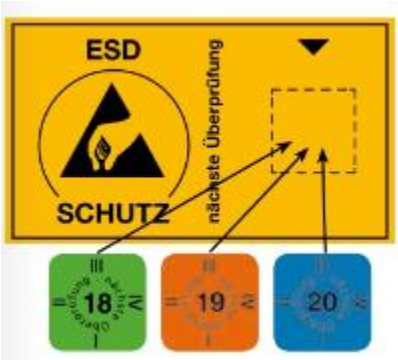

Figure 18 Control label

Internal ESD audits should be performed to verify the efficiency of the technical protection measures as well as the awareness of the staff. Therefore, ESD protection is checked during already existing BSH-internal factory audits as well as further audits (e.g. Q-audit). Additionally, executing factory-internal audits is highly recommended. Moreover, in the ramp-up of new products and systems, as well as changes in the plants, it is necessary to ensure the compliance of the necessary ESD protection.

The IEC-61340-5.1 norm stablishes the general requirements for a correct ESD protection system. It applies to activities that: manufacture, process, assemble, install, package, label, service, test, inspect, transport or otherwise handle electrical or electronic parts, assemblies and equipment with withstand voltages greater than or equal to 100 V HBM,200 V CDM and 35 V for isolated conductors. ESDS with lower withstand voltages may require additional control elements or adjusted limits. This standard does not apply to electrically initiate explosive devices, flammable liquids, gases and powders. The purpose of this standard is to provide the administrative and technical requirements for establishing, implementing and maintaining an ESD control program. IEC TR 61340-5-2 provides guidance on the implementation of this standard. Inside the IEC norm are subclauses useful for ESD protection [6]:

IEC 61340-2-3, Electrostatics – Part 2-3: Methods of test for determining the resistance and resistivity of solid planar materials used to avoid electrostatic charge accumulation

IEC 61340-4-1, Electrostatics – Part 4-1: Standard test methods for specific applications – Electrical resistance of floor coverings and installed floors

IEC 61340-4-3, Electrostatics – Part 4-3: Standard test methods for specific applications – Footwear

IEC 61340-4-5, Electrostatics – Part 4-5: Standard test methods for specific applications – Methods for characterizing the electrostatic protection of footwear and flooring in combination with a person

IEC 61340-4-6, Electrostatics – Part 4-6: Standard test methods for specific applications – Wrist straps

IEC 61340-4-7, Electrostatics – Part 4-7: Standard test methods for specific applications – Ionization

IEC 61340-4-9, Electrostatics – Part 4-9: Standard test methods for specific applications – Garments

IEC 61340-5-3, Electrostatics – Part 5-3: Protection of electronic devices from electrostatic phenomena – Properties and requirements classification for packaging intended for electrostatic discharge sensitive devices

The organization shall prepare an ESD control program plan that addresses each of the requirements of the program. Those requirements are:

- Training
- Product qualification

- Compliance verification
- Grounding/bonding systems
- Personnel grounding
- EPA requirements
- Packaging systems
- Marking

The plan is the principal document for implementing and verifying the program. The goal is a fully implemented and integrated program that conforms to internal quality system requirements. The plan shall apply to all applicable facets of the organization's work.

For the product qualification, the organization shall qualify all ESD control items that are selected for use as part of the ESD control program. All personnel shall be grounded or equipotentially bonded according to the requirements below when handling ESDS. When personnel are seated at ESD protective workstations, they shall be connected to ground via a wrist strap system. For standing operations, personnel can be grounded via a wrist strap system or by a footwear-flooring system. The technical requirements for the personnel grounded are shown in Table 9. [6]

Technical requirement	ESD control item	Product qualification		Compliance verification	
		Test method	Limits[b]	Test method	Limits[b]
Personnel grounding	Wrist straps (bands and ground cords)	IEC 61340-4-6	$R < 5 \times 10^6\ \Omega$ or user defined value	See wrist strap system	
	Wrist band resistance	IEC 61340-4-6			
		– interior	$\leq 1 \times 10^5\ \Omega$	Not applicable	
		– exterior	$> 1 \times 10^7\ \Omega$	Not applicable	
	Wrist strap system[a]	Not applicable		IEC 61340-4-6 Wrist strap continuity test	$R < 3{,}5 \times 10^7\ \Omega$
	Footwear	IEC 61340-4-3[c]	$R \leq 1 \times 10^8\ \Omega$	See person/footwear system	
	Person/footwear /flooring system	IEC 61340-4-5	$R_g < 1{,}0 \times 10^9\ \Omega$ and absolute value of body voltage < 100 V (average of 5 highest peaks)	IEC 61340-4-5	$R_g < 1{,}0 \times 10^9\ \Omega$[d,f]
	Person/footwear system	Not applicable		See Annex A[e]	$R_{gp} < 1{,}0 \times 10^8\ \Omega$

[a] For situations where an ESD garment is used as part of the wrist strap grounding path, the total system resistance including the person, garment and grounding cord should be less than $3{,}5 \times 10^7\ \Omega$.

[b] Symbols used in this table: R_g refers to resistance to ground, R_{gp} refers to resistance to groundable point

[c] For the product qualification of footwear, the environmental conditions for testing, using IEC 61340-4-3 should be (12 ± 3) % RH and 23 °C ± 2 °C.

[d] A periodic body voltage generation test should be done to verify the voltage is less than 100 V

[e] The resistance limit applies to measuring each foot one by one, not two in parallel.

[f] The required limit of $< 1{,}0 \times 10^9\ \Omega$ is the maximum allowed value. The user should establish an upper limit from the resistance values that were measured for product qualification for the footwear and the floor to comply with the < 100 V body voltage generation and use these resistances for compliance verification.

Table 9 Technical requirements

A compliance verification plan shall be established to ensure the organization's fulfilment of the requirements of the plan. Process monitoring (measurements) shall be conducted in accordance with a compliance verification plan that identifies the technical requirements to be verified, the measurement limits and the frequency at which those verifications shall occur. Compliance verification records shall be established and maintained to provide evidence of conformity to the technical requirements.

EPA areas

ESD protected areas are called EPAs. An EPA can, for example, consist of a building, an entire room or a single workstation. Handling of ESDS (electrostatic sensitive device) without ESD protective covering or packaging shall be performed in an EPA. The boundaries of the EPA shall be clearly identified as EPA boundaries. Access to the EPA shall be limited to personnel who have completed appropriate ESD training. Trained personnel while in an EPA shall escort untrained individuals. The technical requirements for an EPA can be seen in Table 10. [6]

EPA requirements	ESD control item	Product qualification[a]		Compliance verification[b]	
		Test method	Limits[c]	Based on test method	Limits[c]
	Working surfaces, storage racks and trolley[g]	IEC 61340-2-3	$R_{gp} < 1 \times 10^9\ \Omega$ $R_{p\text{-}p} < 1 \times 10^9\ \Omega$[f]	IEC 61340-2-3	$R_g < 1 \times 10^9\ \Omega$
	Wrist strap bonding point				$R_g < 5 \times 10^6\ \Omega$
	Flooring	IEC 61340-4-1[d,e]	$R_{gp} < 1 \times 10^9\ \Omega$	IEC 61340-4-1	$R_g < 1 \times 10^9\ \Omega$
	Ionization	IEC 61340-4-7	Decay (1 000 V to 100 V and –1 000 V to –100 V) < 20 s Offset voltage < ± 35 V	IEC 61340-4-7	Decay (1 000 V to 100 V and –1 000 V to –100 V) < 20 s or user defined Offset voltage < ± 35 V
	Seating	IEC 61340-2-3 (resistance to groundable point measurements)	$R_{gp} < 1 \times 10^9\ \Omega$	IEC 61340-2-3 (resistance to ground measurements)	$R_g < 1 \times 10^9\ \Omega$
	Static control garments	IEC 61340-4-9 or user defined method	$R_{p\text{-}p} < 1 \times 10^{11}\ \Omega$ or user defined limit	IEC 61340-4-9 or user defined method	$R_{p\text{-}p} < 1 \times 10^{11}\ \Omega$ or user defined limit
	Groundable static control garments	IEC 61340-4-9	$R_{gp} < 1 \times 10^9\ \Omega$	IEC 61340-4-9	$R_{gp} < 1 \times 10^9\ \Omega$

[a] For product qualification, the environmental conditions for testing should be (12 ± 3) % RH and 23 °C ± 2 °C. When not specified in the referenced IEC standard, the minimum environmental conditioning time for product qualification should be 48 hours.

[b] The test methods in the compliance verification column refer to the basic test procedure only. It is not expected that the test method will be followed in its entirety.

[c] Symbols used in this table: $R_{p\text{-}p}$ refers to point to point resistance. R_g refers to resistance to ground and R_{gp} refers to resistance to groundable point.

[d] The maximum test voltage allowed for measuring ESD flooring that should be used for an ESD program complying with this standard is 100 V.

[e] If flooring is used for grounding personnel that handle ESDS refer to the system requirements in Table 2.

[f] In situations where charged device model (CDM) damage is a concern, a minimum point to point resistance limit of $1 \times 10^4\ \Omega$ is recommended.

[g] Worksurfaces are defined as any surface on which an unprotected ESD sensitive item is placed.

Table 10 EPA requirements

Grounding systems

In order to eliminate ESD damage, it is necessary to eliminate differences in potential between ESDS and other conductors that ESDS might come into contact with, such as personnel, automated handling equipment, fixtures and mobile equipment. All items that come into contact with ESDS and are capable of conducting electricity shall be connected to ground or electrically bonded in order to eliminate differences in potential. The first and preferred ESD ground is protective earth if available. The second acceptable ESD ground is achieved with a functional ground; this conductor can be a ground rod, stake or a separate wiring system that is bonded to the AC ground at the main service panel. In order to eliminate differences in potential between protective earth and the functional ground system, the two systems shall be electrically bonded together where possible. In the event that a ground facility is not available, ESD protection can be achieved by connecting all of the ESD control items together at a common connection point. [6]

Packaging and marking

ESD protective packaging and package marking shall be in accordance with customer contracts, purchase orders, drawing or other documentation. When the contract, purchase order, drawing or other documentation does not define ESD protective packaging, the organization shall define ESD protective packaging requirements for ESDS within the plan based on IEC 61340-5-3. Packaging, when required, shall be defined for all material movement within EPAs, between EPAs, between job sites, field service operations and to the customer.

ESDS, system or packaging marking shall be in accordance with customer contracts, purchase orders, drawing or other documentation. When the contract, purchase order. drawing or other documentation does not define ESDS, system or packaging marking, the organization, in developing the ESD control program plan, shall consider the need for marking. If it is determined that marking is required, it shall be documented as part of the plan. [6]

3. Guide lines for ESD protection and methodology

3.1 Guide lines

Taking into account the norm that I have summarized before and the limits stablished in that norm, I am going to define the steps of the control program for ESD protection that could be applied in all the manufacturing process of any factory.

You may question whether it is necessary a control program or not. The decision is not easy to make because it is the implementation of a program that tries to eliminate a failure that is hard to be detected. In addition, it requires an economic effort, and can cause a rise in the price of the product. Therefore, there should be an explanation important enough to implement this program, and that explanation is the quality. The quantities of the products failed will be reduced, as well as the warranty costs for the clients. To avoid the damages in the electronic components by ESD events, it is not only enough with the protection in the workstations; the protection against ESD should go in parallel with the product in all the life cycle.

Sensibility of the electronic components

The first step is to determine the sensibility of the product that we are working with. The purpose of this determination is to know if it is necessary an implementation of an ESD control program. For each new project it will be necessary a study of ESDS. A beginning point could be stablishing the category of the product. For example, knowing the withstand voltage as it follows in Table 11.

Component	Withstand voltage (V)
MOSFET	10-100
CMOS	200-3000
VMOS	30-1800
NMOS	60-100
JFET	140-7000
OP AMP	200-2500
SCHOTTKY DIODES	300-2500
FILM RESISTORS	300-3000
BIPOLAR TRANSISTOR	380-7000
EPROM	100-2500
SCR	500-1000
ECL	500-2000
TTL SCHOTTKY	200-2500

Table 11 Withstand voltage classification

The suppliers now more often give information about the technical description and the sensibility against ESD that the products they provide have. We can say that technologies based in MOSFET, CMOS, EPROM, are high sensible to ESD events.

Life cycle

The life cycle of the electronic components in the manufacturing process is very important for a correct ESD protection. When a new product is industrialized, a study of the sources of creation of static electricity shall be carried out. The flux process allows the creation of a map of the path that all the components do. With the knowledge of the sensibility of the components about ESD, a list of ESDS (Electrostatic sensitive device) should be done and a study of their particular flux process has to be done for each of them. We can see a general life cycle in Figure 19.

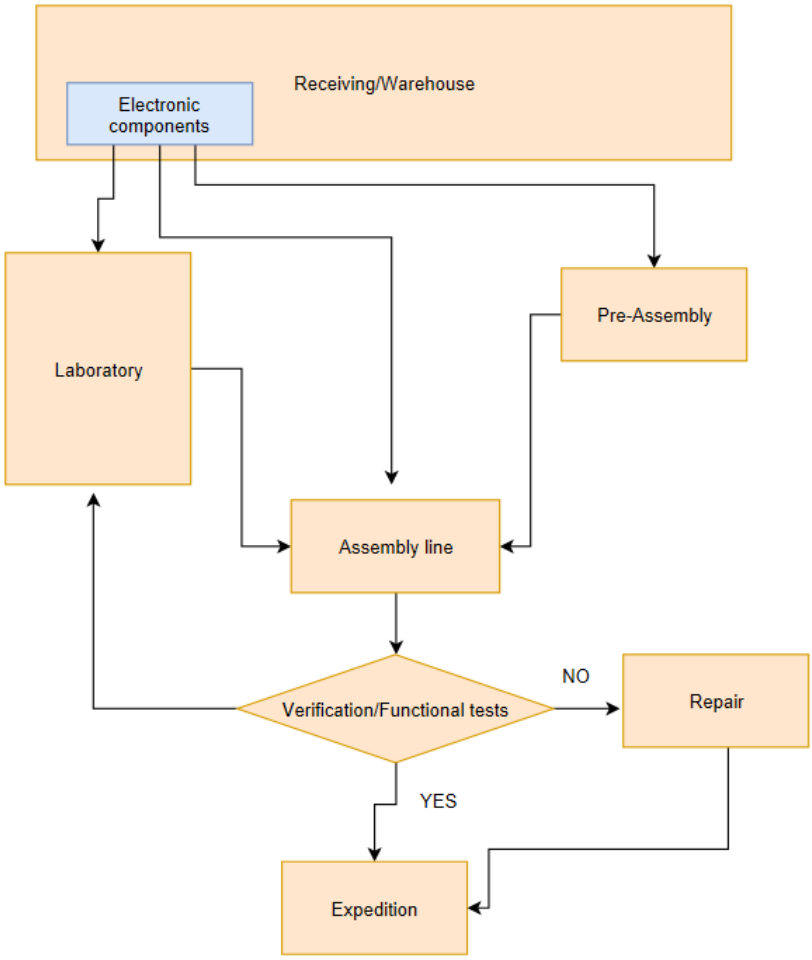

Figure 19 Life cycle

In addition, we have to be aware of the main sources of static electricity that are present. A source of static electricity is defined as any element that consequent to their movement can retain static charge. We could divide the sources in three main groups:

- Environment
- People
- Materials

Product Qualification

Every company that wants to ensure the protection against ESD events has to carry out a proper product qualification. How the electronic components are purchased, received and manipulated is an important factor for the ESD protection.

When electrostatic sensitive components (ESDS) are bought, this characteristic should be reflected in the order so that the manufacturer and the intern controller of the factory will know the right packaging of the component.

For components that are not ESDS and are going to be used inside an EPA area, the purchasing department must ensure that the packaging is of low charge generation.

The receiving of the material is going to be made outside an EPA area, in the warehouse. In this point, the inspection and identification of the ESDS shall be carried out. If the components are received in an inappropriate packaging, this should be informed to the head of the purchasing department to evaluate the return to the supplier.

The electrostatic sensitive components should be in their original packaging, and delivered to the workstations in that specific original package. If the time that an ESDS spends in the warehouse is considered long enough, so that the packaging has exceeded its useful life, it has to be packaged again properly.

The shelves where the ESDS are going to be placed should be dissipative; they have to ensure that they could dissipate the generation of electrostatic energy. They should be as well connected to the ground.

Transport and Packaging

When the ESDS have to be transported outside the EPA to another place of the factory, this should be done in a package that has the property of shielding. In shielding, the electrostatic charges and discharges take the path of least resistance. The charge will be either positive or negative; otherwise, the charge would balance out and be no charge.

Like charges repel and so the electrostatic charge will reside on the outer surface. A Faraday Cage effect can protect ESDS contents in a shielding bag, or other container with a shielding layer. This Faraday Cage effect (Figure 20) protects people in real life when a lightning bolt strikes an airplane or automobile with the charge residing on the outer metal fuselage or car body.

To complete the enclosure, make sure to place lids on boxes or containers, and closed shielding bags (Figure 21). Packaging with holes, tears, or gaps should not be used as the contents may be able to extend outside the enclosure and lose their shielding as well as mechanical protection. [8]

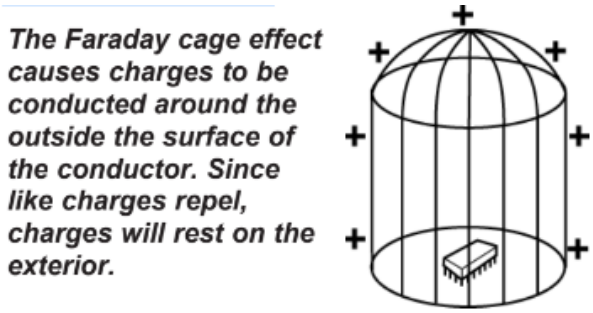

Figure 20 Faraday cage

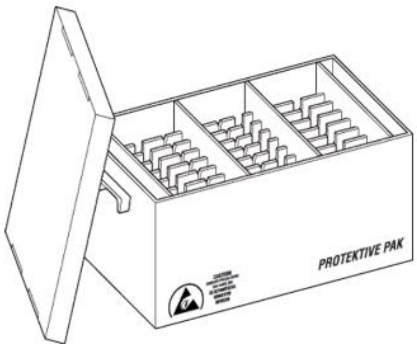

Figure 21 Shielding box

When ESD sensitive items are unpackaged from shielding bags or other containers, a grounded operator at an ESD workstation should handle them.

With regard to the material packaging, it is considered any material in which the ESDS is packed for transport or storage including bags, boxes, drawers, wrapping materials, protective materials, separators, foams, fillers, and so on.

The packaging makes an important function in terms of the protection of the products against different external agents such as, for example: bumps, friction, humidity, etc.

Characteristics of the packaging

- Low charge generation: packaging materials must guarantee the minimization of any load generation. It is convenient to use this name instead of antistatic since there are different meanings and misinterpretations can be created.
- Electrostatic shielding: packaging materials must protect ESD-sensitive devices from external electrostatic fields and electrostatic discharge.
- Conductor
- Dissipative
- Insulative

The different classification of materials according to the superficial resistance is shown in Figure 22.

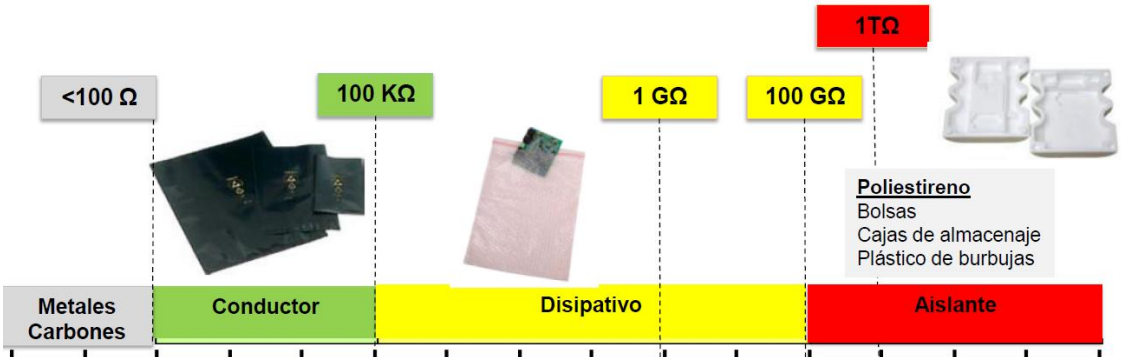

Figure 22 Materials classification

Ω

All material that generates electrostatic charges, such as plastics, foamed material, synthetic fibers or untreated adhesive tapes shall be prohibited as intimate or proximity packaging materials.

Personnel grounding

All the employees that work in contact with electrostatic sensitive components must be grounded. There are special items that allow the drainage of the electrostatic charge to the ground, such as heels and wristbands.

Wristband is defined as the one that is placed around the wrist making good contact and the cable that connects the operator to the point of connection to earth. When the use of a wristband is required, a work post must have a properly identified ground connection point. The connection cables must be long enough so that their placement and use is comfortable but short enough so that their length does not imply a considerable increase in resistance.

Wrist guards provide a perfect means of protection for people who are in a static workplace; because when the operator leaves the workstation, he is no longer grounded.

The maximum resistance value is determined so that the static charge generated does not create a voltage higher than 100 V that can cause damage to ESD devices.

The most comfortable, economical and usual solution is the use of heel cups. The heel cups are straps that are normally made using neoprene layers and that are perfectly adjustable to the footwear. There are also single-use heel pockets specially indicated for visits.

The use of heel or footwear as ESD protection means is not effective if there is no contact with the ground, therefore it is necessary to consider and study in detail the efficiency in jobs in which the operators are sitting in chairs.

For the correct operation of the heel cups as means of grounding the static charge, the following instructions must be followed:

- Place the heel poles when entering the EPA since the use of them outside of protected areas causes them to accumulate dirt. Dirt greatly reduces the ease of discharge through the heel.
- The heel should fit correctly to the foot and ensure that the contact with the ground is perfect.
- The conductive strip must make contact with the skin directly.

Ionizers

Ionization is a complementary method to the grounding and shielding systems used in the EPA area. It does not eliminate the need to use the other methods.

Its use is limited in the areas where the manufacturing products contain insulating materials that cannot be eliminated and where the earthing has no effect on the discharge of the charged insulating products.

Air is a mixture of gases, including nitrogen, oxygen, carbon dioxide, water vapor and other gases (nitrogen oxide and methane), each or more of which can be ionized. Sometimes a diatomic gas molecule, such as nitrogen or oxygen, can gain or lose an electron. Sometimes

it could be a more complex gas like carbon dioxide. In any case, when the molecules of one or more gases in the air gain or lose electrons the result is what we conventionally call "air ions".

In normal unfiltered air, "air ions" are molecular groups composed of approximately 10 molecules of neutral gas around a molecule of oxygen, water or nitrogen. These are called small "air ions" and are relatively mobile to quickly find ions of opposite polarity or a surface connected to earth, at which point they lose their charge and return to neutral molecules again. Small "air ions" have a life span of a few seconds to a few minutes in clean air.

In the market there are many types of ionizers, fan, bar, nozzles, gun, boxes, etc. In all cases, the ionization systems are recommended to have a self-balance system, to alert acoustically and visually to the worker that for one reason or another the system is malfunctioning.

An ionizer creates great numbers of positively and negatively charged ions. Fans help the ions flow over the work area. Ionization can neutralize static charges on an insulator in a matter of seconds, thereby reducing their potential to cause ESD damage.

A fundamental principle of ESD control is to neutralize process essential insulators with ionizers. In addition, if a conductor is not grounded, it is an isolated conductor, and an ionizer is the only way to neutralize ElectroStatic charges on it. We can see the way of performance of an ionizer in Figure 23.

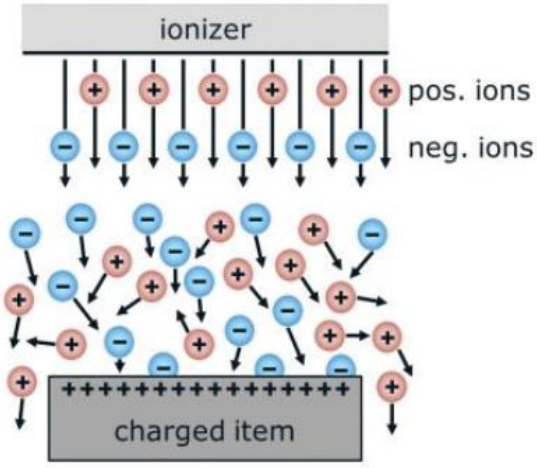

Figure 23 Ionizer way of performance

Types of ionizers

- **Nuclear**: Nuclear ionizers use a radioactive source (Polonium 210) to produce ionized air. The particles emitted by the radioactive source ionize the air near the ionizer. They should be used near the surface to be ionized.

- **AC ionizer**: Alternating current ionizers take advantage of polarity changes in the supply voltage to create positive and negative ions. The frequency of generation of these ions is the same as that of the feed (50 Hz), a high frequency that causes rapid recombination

of these ions. Each ion creates an electric field, and the succession of ions of different polarity causes a variable electric field to be created that can give problems of electromagnetic compatibility. For these two reasons, these ionizers are used at the exit of a ventilation system (to avoid recombination of ions) and away from ESD-sensitive devices (to avoid magnetic polarization problems).

- **DC ionizer**: have two separate ion emitters, one positive and one negative. As the emitters are separated, the recombination is much lower than that presented by the AC ionizers; therefore, they require a lower airflow. This separation of the emitters should not be excessively large since it could polarize sensitive components near the ionizer.

Applications

- **Local ionization:** Sometimes it is interesting to control the static electricity in a small and concrete area. This is the case of interiors of production equipment or mini-environments. For these functions you can use guns that work with compressed ionized air or compressed nitrogen.

- **Work surface ionization**: For this type of surfaces in which there is no airflow that allows using the ionization methods described above, local blowers or suspended ionizers incorporating fans can be used.

Signaling and ESD marking

The markings and signs are very useful to recognize and identify ESDS, protected areas, protection materials, etc. It is recommended to use the internationally recognized symbology shown in IEC-63140-5-1.

The entrance and exit of a protected area against ESD must be identified as such by means of signs that must be fully visible. The purpose of this signaling is:

- The entry to an EPA should be informed to remember that appropriate protection measures should be taken.

- The departure of an EPA should be reported, in case the person transports ESDS devices, remember that from that point the devices are unprotected against ESD.

In case of access to the EPA has wrist and / or shoe testers, it must be informed that verification is mandatory as in Figure 24.

Figure 24 Warning signal

Any device defined ESDS according to the provider's prescription or because it is defined in the corresponding study of sensitivity to ESD must be identified as such. If the size, nature of the device does not support this identification, the containers, or containers in which they are stored will be indicated as in Figure 25(not protected) or Figure 26(protected).

Figure 26 ESD not protected

Figure 25 ESD protected

It is the same symbol that identifies the sensitive devices but adding the arc that represents the protection.

Protected Area against ESD (EPA)

ESD Protected Area or EPA is defined as the area in which devices that are sensitive to electrostatic discharges can be manipulated with the minimal risk of degradation because of a discharge, or the electrostatic fields associated with them.

No element or activity present in an EPA must represent a potential hazard capable of causing damage to ESD-sensitive devices.

An EPA can be of any size and, depending on the needs; the decision can be taken to protect a job or a complete industrial facility. As a general guideline, it is advisable to integrate all ESD protection measures into a global EPA.

An EPA might be one ESD workstation, an area that has been established to effectively control ESD. At an ESD workstation, we attempt to limit electrostatic charges by grounding all conductors (including people), removing all insulators (or substituting with ESD protective versions), or neutralizing process essential insulators with an ionizer.

There are certain requirements for an EPA area stablished in the IEC 61340-5.1 norm that should be fulfilled. These requirements include the resistance limits and conditions as well as grounding connections for floors, shelves, storage racks, worksurfaces, ionizing equipments,

environmental conditions inside the EPA, definition of boundaries, seating, and so on. We have an example of what an EPA would be in Figure 26.

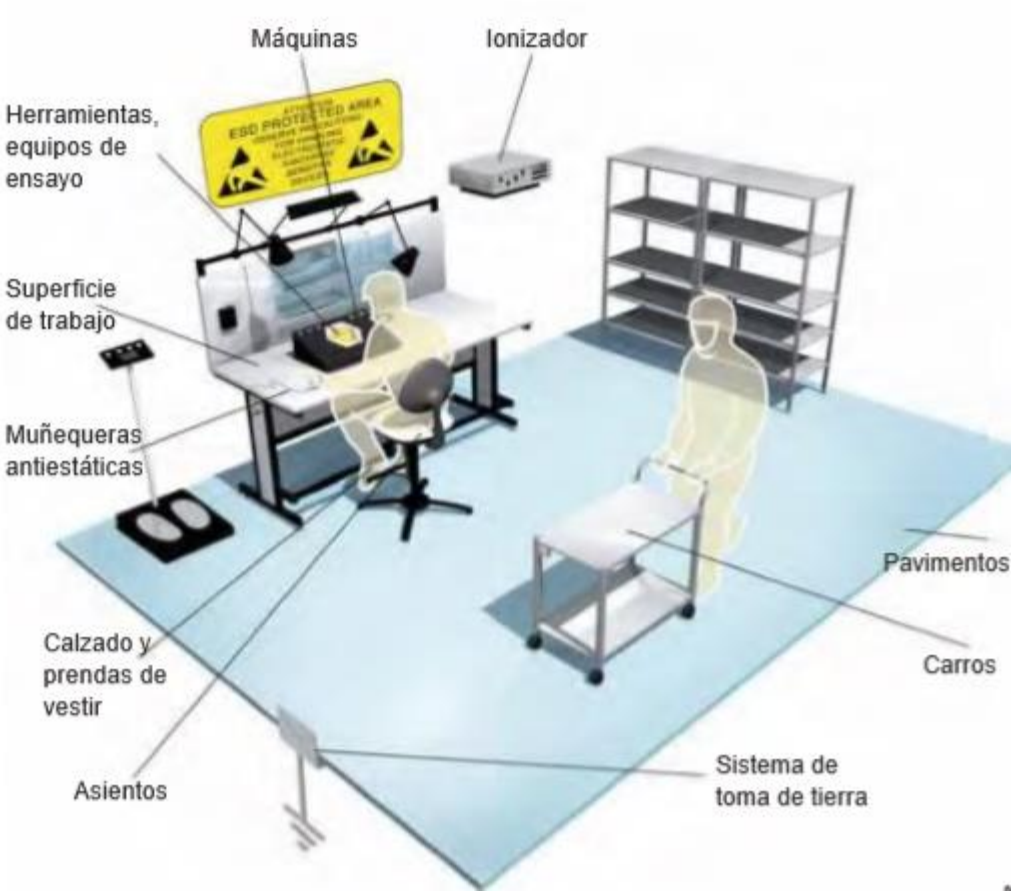

Figure 27 Example of EPA

3.2 Methodology used

For carrying out all the measurements needed for a proper ESD control program or to do an internal audit as well as external, there is an appropriate equipment for the user. Many companies sell this kind of equipment, but I am going to explain the one that I have used and that may be used in the internal audits. The audit kit is from the German company Wolfgang Warmbier, as we can see in Figure 28 and Figure 29.

Figure 28 Metriso 3000 audit kit

Figure 29 Electrostatic field meter audit kit

Metriso 3000 - High Ohmic Resistance Tester for resistance point-to-point, resistance to ground, surface and volume resistance measurements

Although the metriso 3000(Figure 31) is the one that comes with the audit kit, I have used the *Metriso 2000(*Figure 30*)*, which was owned by the maintenance department, because the metriso 3000 did not have a charger and it broke. The different values that the metrisos could measure (Rgp of a person, Rpp of a surface, Rgp of a surface) are shown in Figure 32.

Figure 31 Metriso 3000

Figure 30 Metriso 2000

Figure 32 Types of measures with metriso 2000

Both of them have a very similar way of use. They are useful for measuring the resistance to ground of the shelves, worksurfaces and people. As well as the resistance of the own floor. With the two resistance probes that we can find in the two kits, we place the two probes on the floor and connect them to the device to measure resistance point to point (Rpp), or just one probe and the other cable goes connected to the ground to measure the resistance to ground (Rgp).

Electrostatic field-Meter EFM 51

As its name says, this device is used to measure the electrostatic field of the electronic components that we may find. It measures the field in V/m x 2 cm. Placing the device 2 cm far from the electronics that you want to measure you will obtain your results. The device and its range of measurement are shown in Figure 33 and Table 12 respectively.

Figure 33 Electrostatic field meter

Range:

Distance:	Range:	Max. resolution
1 cm	0 - 8 kV	1 volt
2 cm	0 - 16 kV	2 volts
5 cm	0 - 40 kV	10 volts
10 cm	0 - 80 kV	10 volts
20 cm	0 - 160 kV	20 volts
E-Field mode	0 - 800 kV/m	100V/m
CPS mode	± 1.000 to ± 100 volts	0,1 sec.

Table 12 Electrostatic field meter range

Surface resistance meter

With this device (Figure 34), we are able to know the kind of material we have in the packaging or in worksurfaces. You just have to place it on the material you want to measure and it gives you the value by pressing one button (Figure 35). It has integrated a temperature and humidity sensor. The classification of materials according to the value obtained is shown in Table 13.

Figure 34 Surface resistance meter

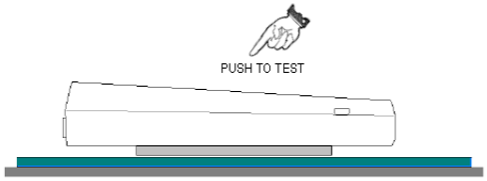

Figure 35 Way of measure

LED	Measuring range	Definition
Green	$< 1x10^3\ \Omega - 9x10^4\ \Omega$	Electrostatic conductive
Yellow	$1x10^5\ \Omega - 9x10^{10}\ \Omega$	Electrostatic dissipative
Red	$\geq 1x\ 10^{11}\ \Omega$	Electrostatic insulating

Table 13 Surface resistance meter Measurement of materials

Walking test kit 7100.WT5000

Since the people has an important impact for the ESD events, this device allows us to know how much they are charged in the working floor that they are every day(Figure 36). We have to connect the device to the ground and to the laptop by USB. The person

that we want to measure picks a metallic probe that is also connected to the device. Then, the values of the measurements are displayed in the screen of the laptop. We can have the graphics and the values of the measurements that we are making. There are two scales for the device, the maximum value that the measurement could go is shown in Table 14.

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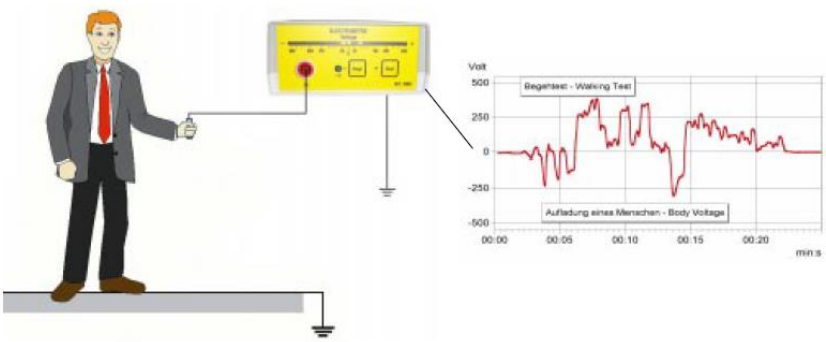


Figure 36 Walking test meter

Range	Output	Multiplier
± 500V	± 5V	100
± 5000V	± 5V	1000

Table 14 Walking test meter range

To see the measurement in the laptop, a software called "Digilliscope" must be downloaded. There are two ranges available with the software Digilliscope. If the voltage exceeds 5000 V then we are not able to see the measurement.

Charge plate Set EFM51.CPS

Using the same electrostatic field meter as in Figure 37, we can measure the time of discharge that an ionizer has, because it is very important that this time is very low. In order to do this, it is available a charge plate set, that consists in a parallel plate that we charge to the value of 1000 V. Then, we turn on the ionizer and see in the electrostatic field meter in how much time the 1000 V decrease to 100 V.

Figure 37 Charge plate set

Measurement for footwear and wristband

For the workers, there are several platforms of footwear tester as in Figure 38 placed in the factory. For the dishwasher assembly line, they have to measure themselves in this platform every day and report it. In the refrigerator, assembly lines there are as well this kind of platforms but the results are not reported. The platform measures the resistance a person has to the ground, by touching with your hand the metallic contact and staying on the metallic shoe prints.
The test result is indicated with audible and visual signals (A relay with a dry contact provides the connection to a door opening system). Wrist strap, right and left shoe testing is simultaneously possible by separate measuring circuits. The limit for the resistance to ground is:

$$Rgp \leq 3.5x10^{7}\ \Omega$$

Figure 38 Footwear tester

4. ESD protection study in BSH Esquiroz

As it has been mentioned before, a proper ESD study for both home appliances, the dishwasher and the refrigerator, is going to be made. Starting with the dishwasher and finishing with the refrigerator and the electronics laboratory. The electronic components should be protected during all their life cycle from an electrostatic discharge. In Figure 39 we can see the different sections of the factory where the electronic components are going to be studied.

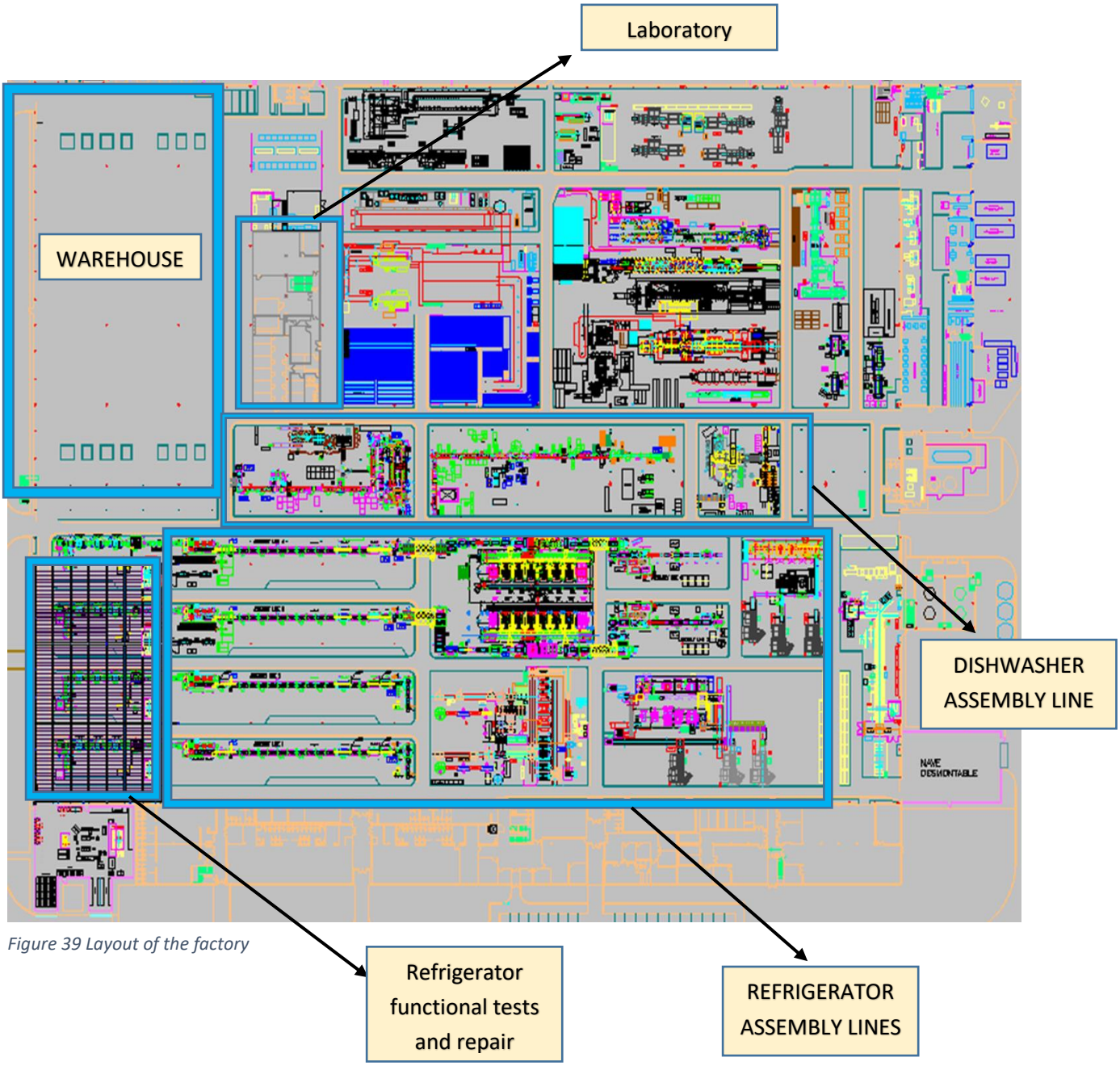


Figure 39 Layout of the factory

4.1 Dishwasher

In the following Figure 40 we can observe the dishwasher assembly line, in pink color, beginning from right to the left. The represents the workstations where there is risk of ESD.

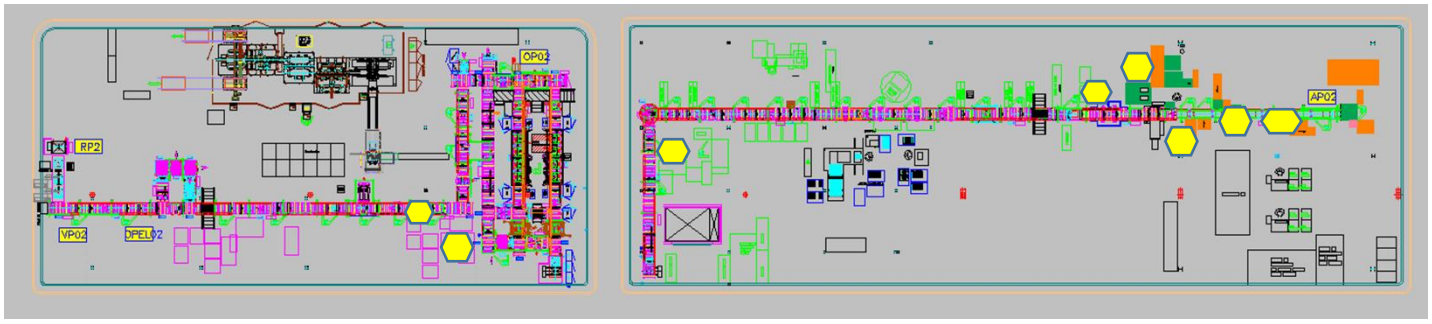


Figure 40 Dishwasher Assembly line

4.1.1 Electronic components and description

For the manufacturing of the dishwasher, six main electronic components are used. In total, the number of components is nine, because of the variety of control modules that the company has for the dishwasher models.

Nowadays there are two models in production for the dishwasher, the “Table Top”, also called TT, and the “Built In”, called BI. The tabletop is of free placement and the built has the dimensions of an oven and goes in a closet.

The most complex electronics we can find in the dishwasher are the PCB (Printed Circuit Board) for the power module and control module. Then, we have different smaller PCBs for the sensors and the LEDs.

- **Power module (PM):** is the brain of the dishwasher. In this component is all the information for the correct performance of the home appliance, and is from where we connect the appliance to the electrical network. All the connections between the electronics are made with the power module. The module is programmed in the assembly line depending on the model that BSH is manufacturing in that moment.

- **Control module (CM):** is the module with which the client interacts with the home appliance. There are different types of control modules for the “Table top” and the “Built in” models. Usually they have a display control and other information that is important for the user.

- **Aqua sensor:** is the electronic component that measures the dirt of the water. According to its measurements, the washing cycle will adjust for a good result and the lowest energy consumption.

- **Salt sensor:** is the sensor that goes inside the softener circuit. It is necessary to inform the user when the salt deposit is empty and it needs to be filled.

- **Door sensor:** this sensor is in the top of the door device, and it is used to know whether the door is closed or not. In that way, the home appliance won`t start washing if the door is opened.

- **Emotion light:** is a set of two lights only for integrable devices. When the door of the dishwasher opens, the leds allow the interior lighting.

In the following Table 15 we can observe the classification of the electronics that the dishwasher contains:

ESDS COMPONENT	PICTURE	CLASS	VARIANT GV550	WORKSTATIONS
Power module (PM)		**A**	All of them	Assembly PM Connection wiring harness Repair functional tests
Control module Siemens (CM)		**A**	BI Siemens	Assembly CM Connection CM Repair functional tests
Control module Bosch (CM)		**A**	BI Bosch	Assembly CM Connection CM Repair functional tests
Control panel without display (CM)		**B**	TT	Assembly CP Connection CP Repair functional tests
Control panel with display (CM)		**B**	BI 550.2	Assembly CP Connection CP Repair functional tests
Salt sensor		**C**	All of them	Assembly aquasensor Assembly softener
Door sensor		**C**	All of them	Assembly on dishwasher door
Aquasensor		**C**	All of them	Assembly water switch circuit
Emotion light		**C**	BI 5502.3	Assembly on dishwasher

Table 15 Dishwasher electronics classification

4.1.2 Productive process and life cycle

For the dishwasher, as we have said before, there is only one production line. The dishwasher model that is produced is called GV550, and it has two submodels. The first one has a smaller cube, of 45 cm, and the other is bigger with a 60 cm cube (Figure 42). The first is designed to go inside furniture as an oven; while the second is free to be placed wherever we want. Using two submodels there are produced many variants of different brands.

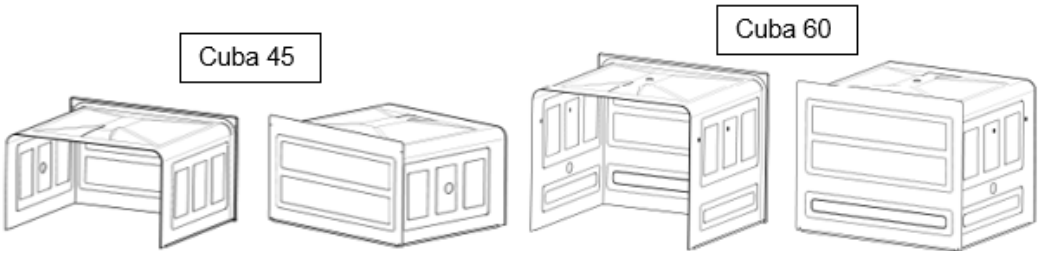


Figure 42 Dishwashers range

The layout of the dishwasher productive process is less complex than the refrigerator process so it has less workstations to study. We can observe the life cycle that the electronics follow in the manufacturing process of the dishwasher in Figure 43.

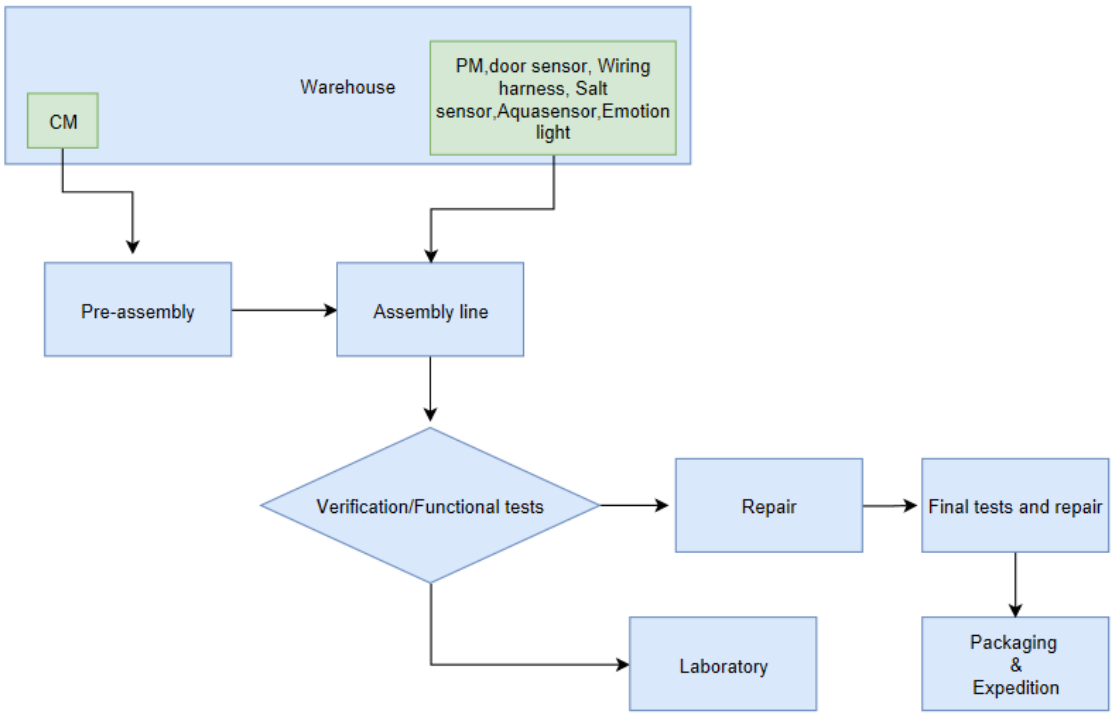


Figure 45 Dishwasher electronics life cycle

Press and cube construction

The first step of the dishwasher manufacturing is the creation of the cube. Four presses allow doing so (Figure 46). The stainless steel is pressed into the models of the envelope, the backside, and the frame. After we have those three components, they are taken to an automated line with robots (Figure 48) that put them together by capacitive welding. Before putting them together forming a cube, first in the envelope and the back-side it is placed a material on the steel that gives stiffness when is heated, so in that way the dishwasher is not like a drum when water is running inside it. When the cubes are finished, they are taken in a lift truck to a conveyer belt that goes through the top of the shed for drying, because it is still hot, until the cube is needed in the assembly line, when is lowered to the specific workstation(Figure 47).

Figure 46 Press

Figure 47 Cube transportation

Figure 48 Cube forming

Pre-Assembly of control modules

Before bringing the control panels to the assembly line, they are pre-assembled in specific workstations, as we can see in Figure 49. The control module of the model BI Bosch and Siemens are pre-assembled in the ground floor, next to the assembly line, and then carried to the line in specific trolleys. However, the control module of the models TT (without display) and BI 550.2(with display) are pre-assembled in the first floor in two workstations. Then, the control panels are carried to the assembly line in the same specific trolleys using an elevator.

Figure 49 Pre-assembly control modules

Assembly line

The wash tray is first placed into the production line. During the assembly line, the power module and the other electronic components such as the control panel and the sensors are connected. In addition, the circulation and the drain pumps are mounted, as well as the water entry system, as we can realize in Figure 50. The softener with the salt sensor is connected and tested before assembling on dishwasher. After all these connections and before lowering the cube to the assembly line, a vision robot verifies if the connections of Figure 51 have been done correctly. If not, then the worker changes it manually. Later, the cube is lowered and assembled automatically, the against doors are mounted, and finally the door sensor and the control panel are assembled, before the functional tests.

Figure 50 Connection of the water circuit

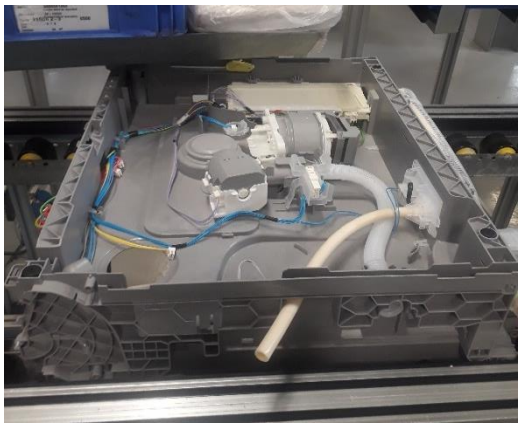


Figure 51 Connections made until the vision robot

Functional tests and repair

After all the assembling's and connections, the dishwasher proceeds to the functional tests; where a robot reads the bar code of the dishwasher and charges the specific program of the dishwasher depending on the model, we can see it in Figure 52. Then the program is carried out and checked. There are two parallel lines where the program of the dishwasher is tested. If the test fails, then it goes to the repair workstation (Figure 53) where a worker makes the appropriate changes of connections or electronic components damaged. If it performs correctly, it continues with the final assembly steps.

Figure 52 Functional tests

Figure 53 Repair of functional tests

Final verification and repair

Before the final verification, the upper and lower basket are mounted, as well as the cube blanket. For some models, the emotion light LEDs are connected after the functional test verification. The final verification is carried out automatically (Figure 54), without any worker. This is the final step before packaging the dishwasher. The final verification is compulsory for all factories, but here there are done two tests including the final. If the final test goes wrong, there is a repair workstation for assembling electronic components or verifying manual programming of doubtful power modules, as well as wiring connections, see it in Figure 55.

Figure 55 Repair final tests

Figure 54 Final tests

Packaging

Final step before the release to the warehouse of the finished dishwasher, in Figure 56. The assembly of mechanical and esthetic components is made here, as well as the general assembly. The basket with all the accessories that goes inside the dishwasher is mounted. Finally, the packaging is carried out.

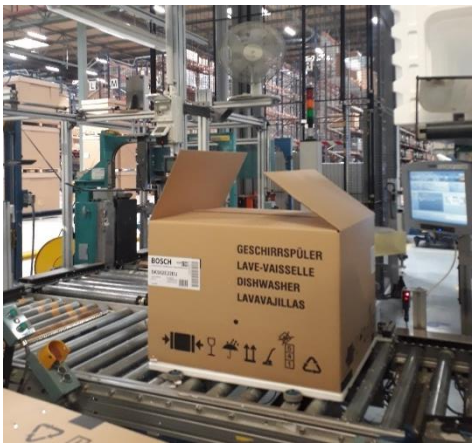


Figure 56 Packaging

4.1.3 ESD study

Knowing the life cycle that the electronic components follow in the productive process of the dishwasher, different aspects have been studied for the ESD protection.

Product qualification

First, I had to know how the electronic components arrived to the factory at the warehouse and how they were delivered to the specific workstations.

All the electronic components that the dishwasher contains, mentioned before, come to the warehouse in cardboard boxes. The warehouse is built of metallic painted shelves that are screwed to the ground, as in Figure 57. The superficial resistance of the cardboard is measured giving a value of approximately SR=1x10^{10}Ω, which is a correct value because, is a dissipative packaging. Some of them come in black trays that are ESD protected with a SR=5x10^{4}Ω.

In some cases, the cardboard boxes are placed on wooden pallets, which is also dissipative, or in a metal mesh, as well as in nylon wheel rails with a metallic support at the end of them. The nylon is an Insulative material so the electronic components could not be discharged when they are placed here.

Figure 57 Warehouse

The control modules with and without display are not stored in the warehouse. When they arrive, they are carried to the workstation of the pre-assembly of the control panel. There, they are stored in metallic painted shelves, with nylon wheel rails. The shelves have a metallic support at the end of them. We can observe this in Figure 59 and Figure 58.

Figure 59Shelving CM

Figure 58 Metal support shelves

The same happens with the boxes that contain the Aqua sensor and the door sensor, they are brought to a metallic shelf in the assembly line.

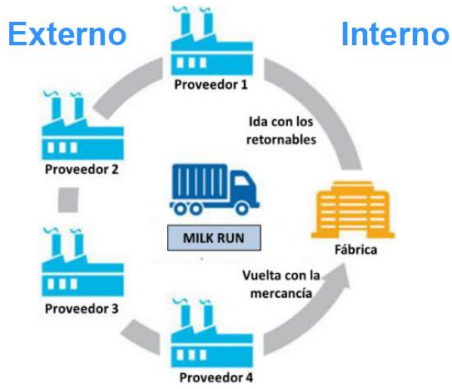
The electrostatic field is also measured with the electrostatic field meter for each component. Since the boxes come closed, they were opened to carry out the measurements, to know if the components came with charge from the supplier. The environmental conditions are taken into account every time a measurement is made.

The boxes are delivered unopened to the workstation using the milk run, with the exception of the salt sensor, which comes in big boxes and the trays are taken out of the boxes and delivered to the workstation. The delivery flow of the dishwasher is carried out in jumps of 24 units for all the components.

The milk run is a metallic painted train with rubber wheels, which allows a cyclic supply; which is a method to deliver the correct components in the quality and quantity required, in the correct

Figure 60 Internal and external milk run process

moment and place. Only the consumed material is replaced, reducing the stock. It reduces the path to follow because in one time it delivers or picks everything from the workstations. It can be used to supply either external raw materials of plants or internal supply of manufacturing process. We can see its process in both external and internal in Figure 60.



During the process from the warehouse to the workstation, the components are not grounded because the milk run has Insulative rubber wheels. If the boxes are closed there should not happen any problem. There could be some issues with the salt sensors because in the trays they are accessible to the worker or any other object.

When the components are in the workstation it is studied how they are stored. Some of the shelves inside an EPA area were connected to the ground to allow the flow of the charge from the electronic components to the ground, and some of them not. The electrostatic field was measured and it was not very high in all of them, but with the exception of the display control modules. They come with a high charge of 900V and 1050 V. They can put up with a high voltage, but the purchasing department should talk with the supplier. In addition, the wiring harness sometimes gives a value of 300 V.

There is shown an example of the product qualification report that has been made for all the electronic components in Table 17.

WORKSTATION	ASSEMBLY POWER MODULE	
ESDS Component	**Power module (PM)**	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	Boxes are closed and stocked on wooden pallets in metallic shelves screwed to the concrete floor The metallic shelves are built with nylon rollers with a metallic support at the end. SR wooden pallet= $6x10^9$ Ω - Dissipative	
Measurements **23 ºC** **41 % RH**	SR(Superficial Resistance) carbdoard=$1x10^{10}$ Ω Electrostatic field(V/m x 2 cm)= 50 V -82 V- 150 V	
Milk run delivery	Boxes are closed and delivered unopened to the EPA using a metallic painted milkround with rubber wheels	
Check	**OK**	
RECEIVING		
Supply packaging	27 units per box Cardboard box with cardboard divisors	
ESD label in the packaging	YES	
Standards	IEC 61340-5-1	
Limits	$1x10^4$ Ω ≤ Rpp ≤ $1x10^{11}$ Ω	
Measurements **22 ºC** **54 % RH**	SR(Superficial Resistance) carbdoard=$1x10^{10}$ Ω Electrostatic field(V/m x 2 cm)= 42 V - 58 V- 60 V	
Material packaging	Dissipative	
Check	**OK**	
ASSEMBLY SHELVING		
Assembly workstation	Direct assembly on dishwasher	
Assembly line shelving	Metalic shelf fixed to the ground with nylon sliding wheels and metal support at the end of the shelf The ESDS is manipulated from the EPA floor	
Connection to ground	YES	
Assembly line storage	NO STORAGE	
Connection to ground	N/A	
ESDS ground label	NO	
Check	**OK**	

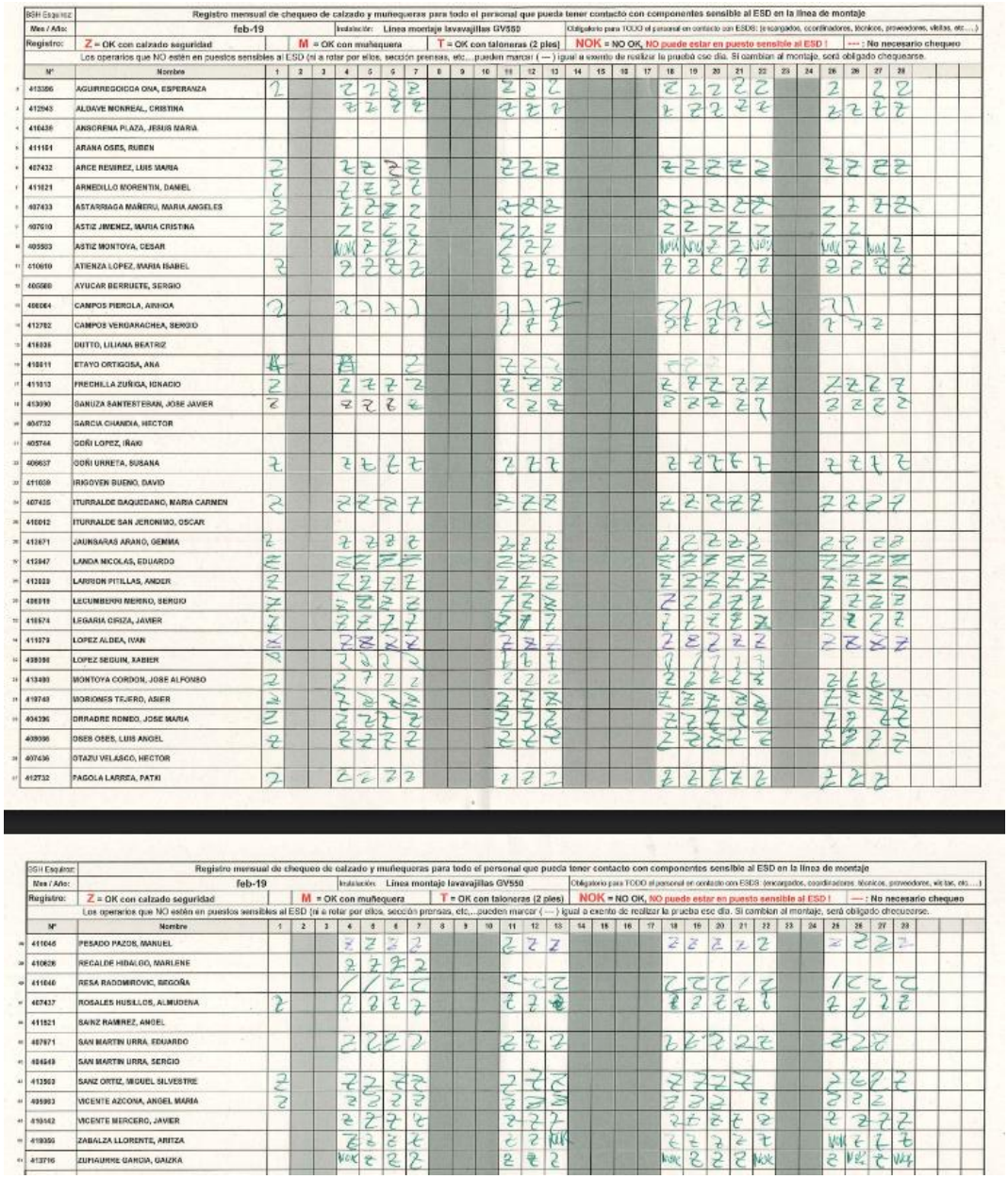
Table 17 Product qualitifaction report dishwasher

Personnel grounding

The grounding of the personnel that is in touch with electrostatic sensitive components is very important. They have to be completely discharge to ensure the ESD protection. With the footwear measurement, they can know every day if the value of the Rgp (Resistance to ground) they have is appropriate, and report it in a worksheet. I looked at the reports of January, as they are in Figure 61, February and March to know who got the worst results in their resistance and measure their voltage and the Rgp of all the workers. All of them should wear the ESD compatible safety shoes to be discharged in an EPA area. The report of the personnel grounding is shown in Table 18.

PERSONNEL GROUNDING		
Standards	61340-5-1	
Option **Wrist straps/Footheels**	Available in case the footwear test is NOK	
Limits	R < 5 x10^6 Ω or user defined value	
Standards	61340-5-1	
Clothing	FDCE complete uniform >60% to 100 % cotton	
Limits	Rpp< 1x10^{11} Ω	
Standards	61340-5-1	
Footwear	Standard Safety Shoes ESD compatible SR=1x10^3 Ω - Conductor	
Limits	R ≤ 1 x10^8 Ω	
Standards	61340-5-1	
Gloves	Standard Assembly gloves	
Limits	Rgp< 1x10^{11} Ω	
Checking regularity	Wrist straps - Daily	
	Clothing - Regularly	
	Footwear - Daily All the worker's footwear is checked in the tester and they have to report the result obtained	
	Gloves - Before using	
Check	**OK**	

Table 18 Personnel grounding dishwasher



BSH Esquiroz — Registro mensual de chequeo de calzado y muñequeras para todo el personal que pueda tener contacto con componentes sensible al ESD en la línea de montaje

Mes / Año: feb-19 — Instalación: Línea montaje lavavajillas GV550 — Obligatorio para TODO el personal en contacto con ESDS: (encargados, coordinadores, técnicos, proveedores, visitas, etc....)

Registro: Z = OK con calzado seguridad — M = OK con muñequera — T = OK con taloneras (2 pies) — NOK = NO OK, NO puede estar en puesto sensible al ESD ! — --- : No necesario chequeo

Los operarios que NO estén en puestos sensibles al ESD (ni a rotar por ellos, sección prensas, etc,...pueden marcar (—) igual a exento de realizar la prueba ese día. Si cambian al montaje, será obligado chequearse.

Nº	Nombre	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
413366	AGUIRREGOICOA ONA, ESPERANZA	Z			Z	Z	Z	Z				Z	Z	Z					Z	Z	Z	Z	Z			Z		Z	Z
412043	ALDAVE MONREAL, CRISTINA				Z	Z	Z	Z				Z	Z	Z					Z	Z	Z	Z	Z			Z	Z	Z	Z
410436	ANSOREMA PLAZA, JESUS MARIA																												
411161	ARANA OSES, RUBEN																												
407432	ARCE REMIREZ, LUIS MARIA	Z			Z	Z	Z	Z				Z	Z	Z					Z	Z	Z	Z	Z			Z	Z	Z	Z
411621	ARNEDILLO MORENTIN, DANIEL	Z			Z	Z	Z	Z																					
407433	ASTARRAGA MAÑERU, MARIA ANGELES	Z			Z	Z	Z	Z				Z	Z	Z					Z	Z	Z	Z	Z			Z	Z	Z	Z
407610	ASTIZ JIMENEZ, MARIA CRISTINA	Z			Z	Z	Z	Z				Z	Z	Z					Z	Z	Z	Z	Z			Z	Z		
409503	ASTIZ MONTOYA, CESAR				NOK	Z	Z	Z				Z	Z	Z					NOK	NOK	Z	Z	NOK			NOK	Z	NOK	Z
410610	ATIENZA LOPEZ, MARIA ISABEL	Z			Z	Z	Z	Z				Z	Z	Z					Z	Z	Z	Z	Z			Z	Z	Z	Z
409080	AYUCAR BERRUETE, SERGIO																												
408084	CAMPOS PIERGOLA, AINHOA	Z			Z	Z	Z	Z				Z	Z	Z					Z	Z	Z	Z	Z			Z			
412782	CAMPOS VERGARACHEA, SERGIO											Z	Z	Z					Z	Z	Z	Z	Z			Z	Z	Z	
416836	DIUTTO, LILIANA BEATRIZ																												
410811	ETAYO ORTIGOSA, ANA	A			A			Z				Z	Z	Z					Z										
411513	FRECHILLA ZUÑIGA, IGNACIO	Z			Z	Z	Z	Z				Z	Z	Z					Z	Z	Z	Z	Z			Z	Z	Z	Z
413090	GANUZA SANTESTEBAN, JOSE JAVIER	Z			Z	Z	Z	Z				Z	Z	Z					Z	Z	Z	Z	Z			Z	Z	Z	Z
404732	GARCIA CHANDIA, HECTOR																												
405744	GOÑI LOPEZ, IRAKI																												
409637	GOÑI URRETA, SUSANA	Z			Z	Z	Z	Z				Z	Z	Z					Z	Z	Z	Z	Z			Z	Z	Z	Z
411039	IRIGOYEN BUENO, DAVID																												
407435	ITURRALDE GAQUEDANO, MARIA CARMEN	Z			Z	Z	Z	Z				Z	Z	Z					Z	Z	Z	Z	Z			Z	Z	Z	Z
410012	ITURRALDE SAN JERONIMO, OSCAR																												
412671	JAUNSARAS ARANO, GEMMA	Z			Z	Z	Z	Z				Z	Z	Z					Z	Z	Z	Z	Z			Z	Z	Z	Z
412847	LANDA NICOLAS, EDUARDO	Z			Z	Z	Z	Z				Z	Z	Z					Z	Z	Z	Z	Z			Z	Z	Z	Z
412828	LARRION PITILLAS, ANDER	Z			Z	Z	Z	Z				Z	Z	Z					Z	Z	Z	Z	Z			Z	Z	Z	Z
408019	LECUMBERRI MERINO, SERGIO	Z			Z	Z	Z	Z				Z	Z	Z					Z	Z	Z	Z	Z			Z	Z	Z	Z
410574	LEGARIA CIRIZA, JAVIER	Z			Z	Z	Z	Z				Z	Z	Z					Z	Z	Z	Z	Z			Z	Z	Z	Z
411079	LOPEZ ALDEA, IVAN	Z			Z	Z	Z	Z				Z	Z	Z					Z	Z	Z	Z	Z			Z	Z	Z	Z
408096	LOPEZ SEGUIN, XABIER	A			Z	Z	Z	Z				Z	Z	Z					Z	Z	Z	Z	Z						
413480	MONTOYA CORDON, JOSE ALFONSO	Z			Z	Z	Z	Z				Z	Z	Z					Z	Z	Z	Z	Z			Z	Z	Z	
419748	MORIONES TEJERO, ASIER	Z			Z	Z	Z	Z				Z	Z	Z					Z	Z	Z	Z	Z			Z	Z	Z	Z
404396	ORRADRE ROMEO, JOSE MARIA	Z			Z	Z	Z	Z				Z	Z	Z					Z	Z	Z	Z	Z			Z	Z	Z	Z
408096	OSES OSES, LUIS ANGEL	Z			Z	Z	Z	Z				Z	Z	Z					Z	Z	Z	Z	Z			Z	Z	Z	Z
407436	OTAZU VELASCO, HECTOR																												
412732	PAGOLA LARREA, PATXI	Z			Z	Z	Z	Z				Z	Z	Z					Z	Z	Z	Z	Z			Z	Z	Z	

BSH Esquiroz — Registro mensual de chequeo de calzado y muñequeras para todo el personal que pueda tener contacto con componentes sensible al ESD en la línea de montaje

Mes / Año: feb-19 — Instalación: Línea montaje lavavajillas GV550 — Obligatorio para TODO el personal en contacto con ESDS: (encargados, coordinadores, técnicos, proveedores, visitas, etc....)

Registro: Z = OK con calzado seguridad — M = OK con muñequera — T = OK con taloneras (2 pies) — NOK = NO OK, NO puede estar en puesto sensible al ESD ! — --- : No necesario chequeo

Los operarios que NO estén en puestos sensibles al ESD (ni a rotar por ellos, sección prensas, etc,...pueden marcar (—) igual a exento de realizar la prueba ese día. Si cambian al montaje, será obligado chequearse.

Nº	Nombre	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
411046	PESADO PAZOS, MANUEL				Z	Z	Z	Z				Z	Z	Z					Z	Z	Z	Z	Z			Z	Z	Z	Z
410826	REGALDE HIDALGO, MARLENE				Z	Z	Z	Z																					
411040	RESA RADOMIROVIC, BEGOÑA				/	/	Z	Z				Z	Z	Z					Z	Z	Z	/	Z			/	Z	Z	Z
407437	ROSALES HUSILLOS, ALMUDENA	Z			Z	Z	Z	Z				Z	Z	Z					Z	Z	Z	Z	Z			Z	Z	Z	Z
411521	SAINZ RAMIREZ, ANGEL																												
407871	SAN MARTIN URRA, EDUARDO				Z	Z	Z	Z				Z	Z	Z					Z	Z	Z	Z	Z			Z	Z	Z	
404449	SAN MARTIN URRA, SERGIO																												
413503	SANZ ORTIZ, MIGUEL SILVESTRE	Z			Z	Z	Z	Z				Z	Z	Z					Z	Z	Z	Z				Z	Z	Z	Z
409903	VICENTE AZCONA, ANGEL MARIA	Z			Z	Z	Z	Z				Z	Z	Z					Z	Z	Z		Z			Z	Z	Z	
410442	VICENTE MERCERO, JAVIER				Z	Z	Z	Z				Z	Z	Z					Z	Z	Z	Z	Z			Z	Z	Z	Z
419059	ZABALZA LLORENTE, ARITZA				Z	Z	Z	Z				Z	Z	NOK					Z	Z	Z	Z	Z			NOK	Z	Z	Z
413716	ZUPIAURRE GARCIA, GAIZKA				NOK	Z	Z	Z				Z	Z	Z					NOK	Z	Z	Z	NOK			Z	NOK	Z	NOK

Figure 61 ESD footweear report dishwasher of February 2019

What the footwear tester measures is if the resistance to ground is lower than $3.5x10^7$ Ω. The IEC 61340-5.1 stablishes the limit value to Rgp=$1x10^9$ Ω. Therefore, all the workers were measured (Table 19) to know if this was verified. They were measured in an EPA floor (dissipative). Some of them got a wrong result and a high resistance.

The high resistance could be due to a huge variety of reasons. The worker could have the feet dry and then it is not grounded. The feet have to be a little sweaty to allow the conductivity of the charge to the ground. In addition, if the shocks are made of an insulative material then the worker is not grounded neither, or if they wear templates, it depends on the material of the template.

For the grounding point, it has been used the electrical ground or any screw of the shelves in the ground, as well as any point of the assembly line, which is grounded as well.

Rgp WORKERS GV550 ASSEMBLY LINE			
Limit	Rgp≤1x10^{9} Ω		
Nº	NAME	VALUE(Ω) 21ºC 34,4 % RH	VALUE(Ω) 22,3 ºC 35,2 % RH
1	ESPERANZA AGUIRREGOICOA	3,01x10^{7} Ω	
2	LUIS MARIA ARCE	6,41x10^{8} Ω	
3	ASTARRIAGA MARIA ANGELES	1,41x10^{9} Ω	1x10^{9} Ω
4	CESAR ASTIZ	2,51x10^{9} Ω	3,91x10^{8} Ω
5	SERGIO AYUCAR	2,26x10^{10} Ω	2,04x10^{8} Ω
6	AINHOA CAMPOS	3,27x10^{9} Ω	2,16x10^{8} Ω
7	SERGIO CAMPOS	1,11x10^{8} Ω	
8	ANA ETAYO	8,24x10^{7} Ω	
9	IGNACIO FRECHILLA	2,77x10^{8} Ω	
10	JOSE JAVIER GANUZA	8,51x10^{8} Ω	
11	SUSANA GOÑI	3,97x10^{7} Ω	
12	DAVID IRIGOYEN	4,9x10^{7} Ω	
13	GEMMA JAUNSARAS	4,16x10^{7} Ω	
14	EDUARDO LANDA	8,71x10^{7} Ω	
15	ANDER LARRION	3,74x10^{7} Ω	
16	SERGIO LECUMBERRI	1,24x10^{8} Ω	
17	JAVIER LEGARIA	6,76x10^{8} Ω	
18	JOSE ALFONSO MONTOYA	4,31x10^{8} Ω	
19	ASIER MORIONES	1,01x10^{8} Ω	
20	JOSE MARIA ORRADRE	4,54x10^{9} Ω	2,11x10^{8} Ω
21	PATXI PAGOLA	4,19x10^{8} Ω	
22	SERGIO SAN MARTIN	6,65x10^{7} Ω	
23	ANGEL MARIA VICENTE	7,16x10^{9} Ω	
24	JAVIER VICENTE	2,70x10^{8} Ω	
25	ARITZA ZABALZA	1,43x10^{7} Ω	
26	JON PAGOLA	2,80x10^{8} Ω	
27	ALFREDO TORRES	4,20x10^{8} Ω	
28	IVAN ASTIZ	2,12x10^{6} Ω	
29	MOISES RODRIGO	8,81x10^{9} Ω	1,96x10^{8} Ω
30	MIGUEL SANZ	3,7x10^{10} Ω	2,9x10^{8} Ω
31	XABIER TEJERO	4,85x10^{8} Ω	
32	ALFREDO IBERO	3,19x10^{9} Ω	

Table 19 Rgp workers dishwasher Assembly line

Using the walking test meter, I have measured the voltage generated by the workers that give a bad value in the report. The norm IEC 61340-5.1 says that the Human Body Voltage in absolute value should be less than 100 V. I told the workers to walk a little and then stop. The measurements were carried out in a dissipative floor. If when they stopped, the value decreased to less than 100 V or stablished in that range, then it is correct.

The following measurements of Figure 63, Figure 62, Figure 66 , Figure 64 and Figure 67 were made at 21 ºC and 33.5 % RH. Five people were measured. We can see that in EPA floor the workers discharge quickly than in non EPA (Figure 62), in which the voltage at the same time is 1000 V and in EPA is nearly 200 V(at 14 seconds). We also can observe the different scales of measurement in the walking teste meter for both floors (500 V and 5000 V). Most of the workers are gradually discharged when they stop walking, but there is one (Figure 64) that has a voltage of nearly 1000 V at the ending in EPA floor.

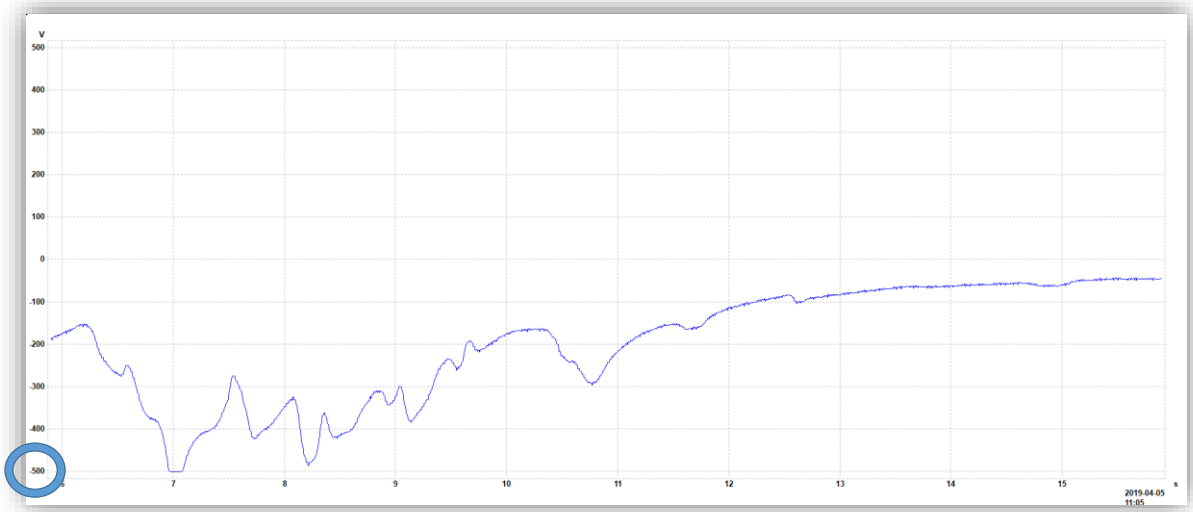


Figure 63 Measurement 1 EPA floor HBV

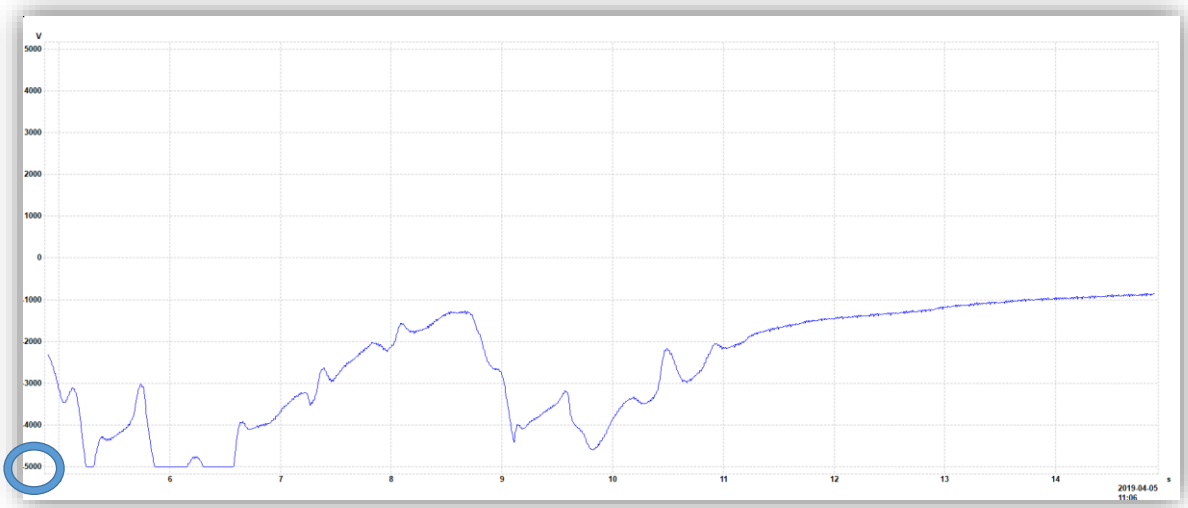


Figure 62 Measurement 2 non EPA floor HBV

In the following Figure 65 we can see the charge difference between a measurement made in an EPA floor and in a non-EPA floor. Comparing the two scales, we can realize that when workers are not grounded their charge is really high, in just a matter of seconds they acquire such a great amount of charge.

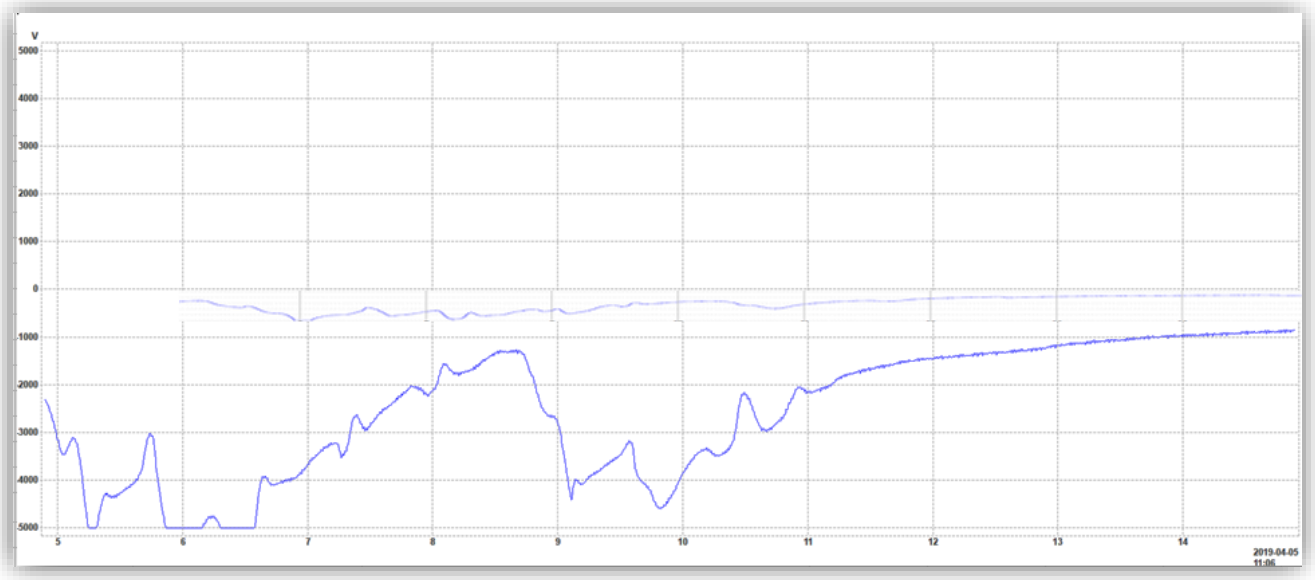


Figure 65 Comparison between Measurement 1 and 2 HBV

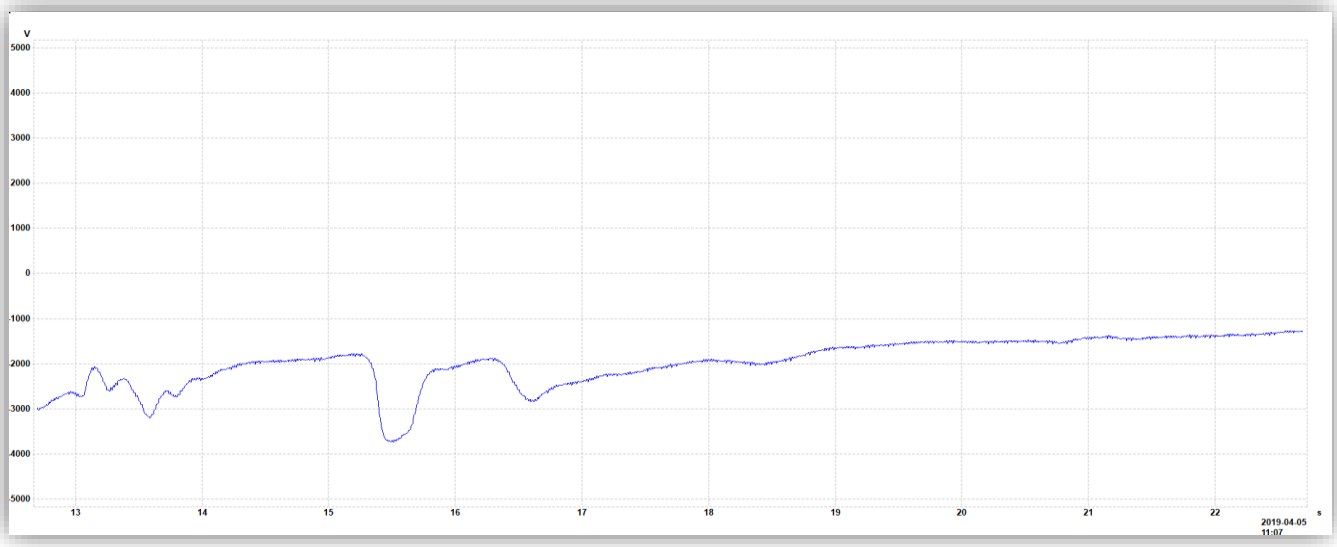


Figure 64 Measurement 3 HBV

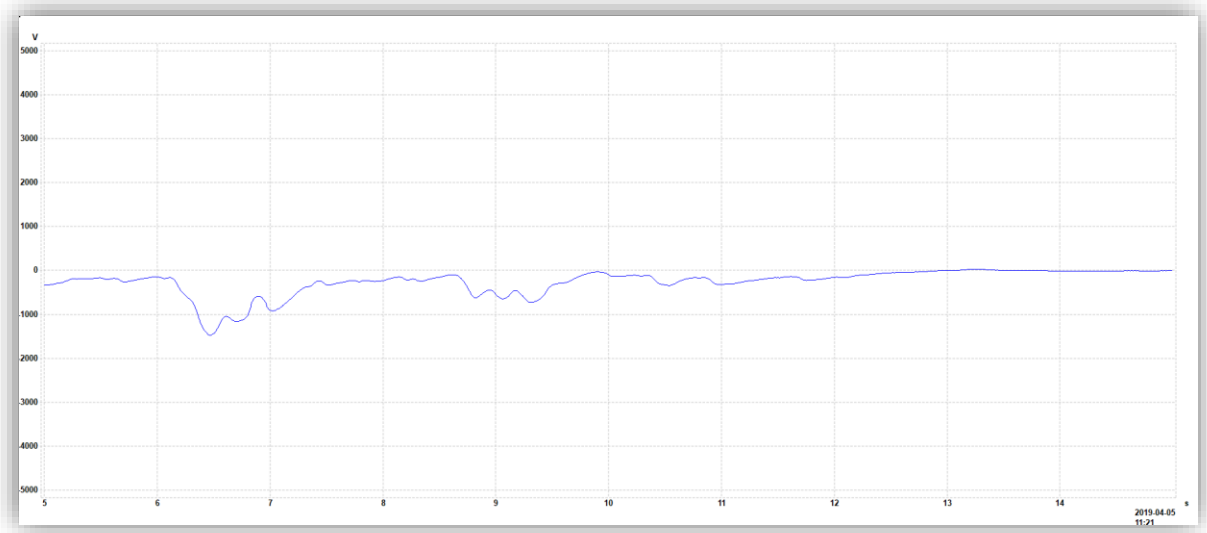


Figure 67 Measurement 4 HBV

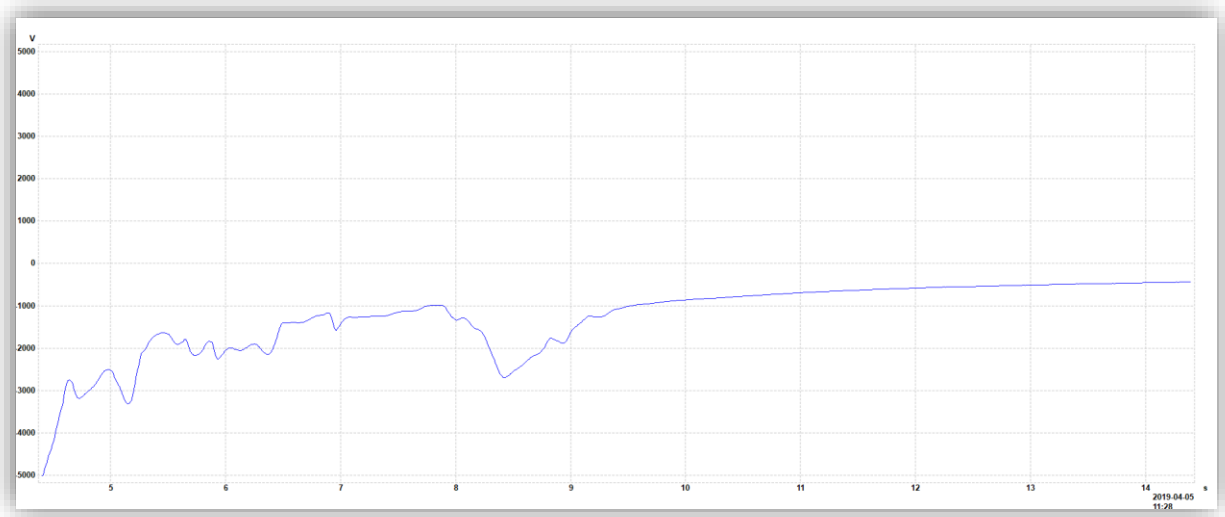


Figure 66 Measurement 5 HBV

In the following graphics of Figure 68 we can see the Human Body Voltage of the five different workers measured, at the beginning of the measurement when they started walking. We can realize that the second measuremeent is the one that starts with the highest voltage.

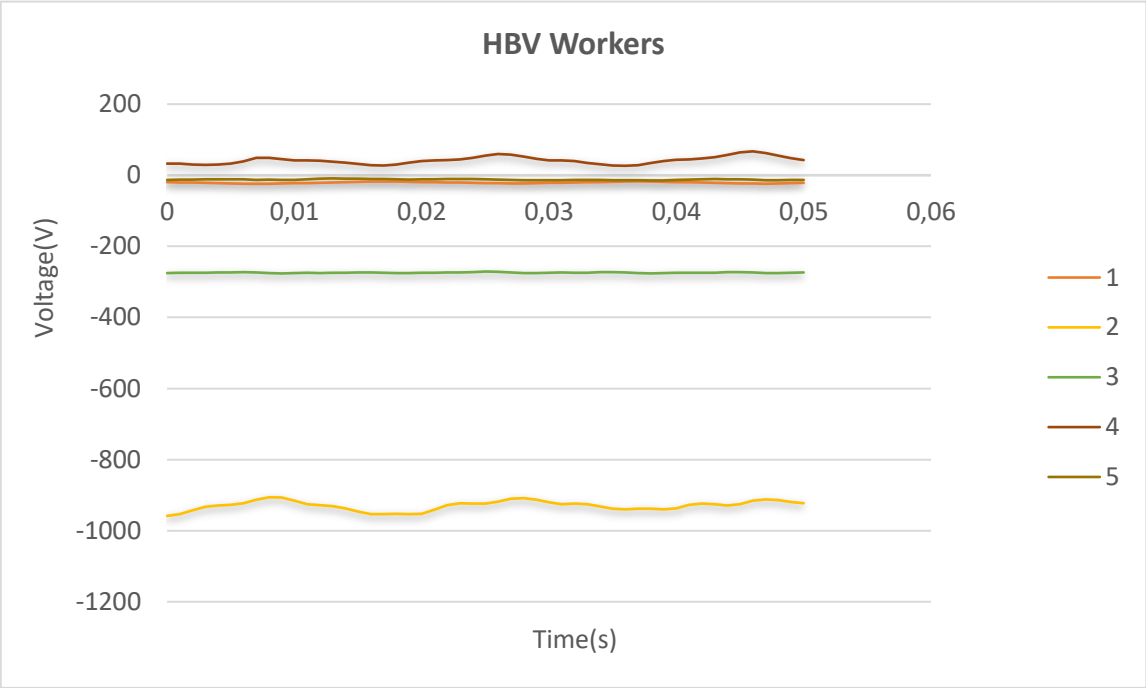


Figure 68 HBV at the beginning of the measurements

We realize that all the workers are charged at the beginning of the measurement, when they are talked to walk through the floor. The highest charge they reach at the beginning is -1000 V, but while they walk, more they increase the value of the charge, as we will see soon. The walking test meter gives us the exact values of the voltage every second of the measurement. Therefore, we can realize how charged the worker starts, the maximum point of charge it reaches and the value it goes when stopping. The charge that the people measured had at each moment(beginning, maximum point of charge, and ending when they stopped) are shown in Figure 69, Figure 71, Figure 70, Figure 72 and Figure 73.

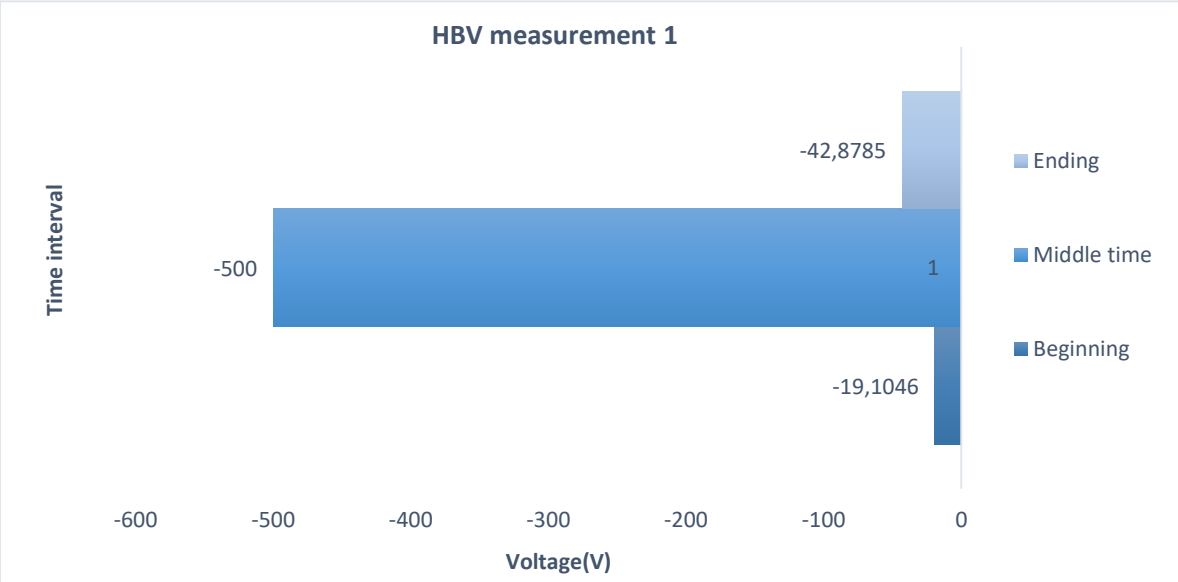


Figure 69 Time charging measurement 1

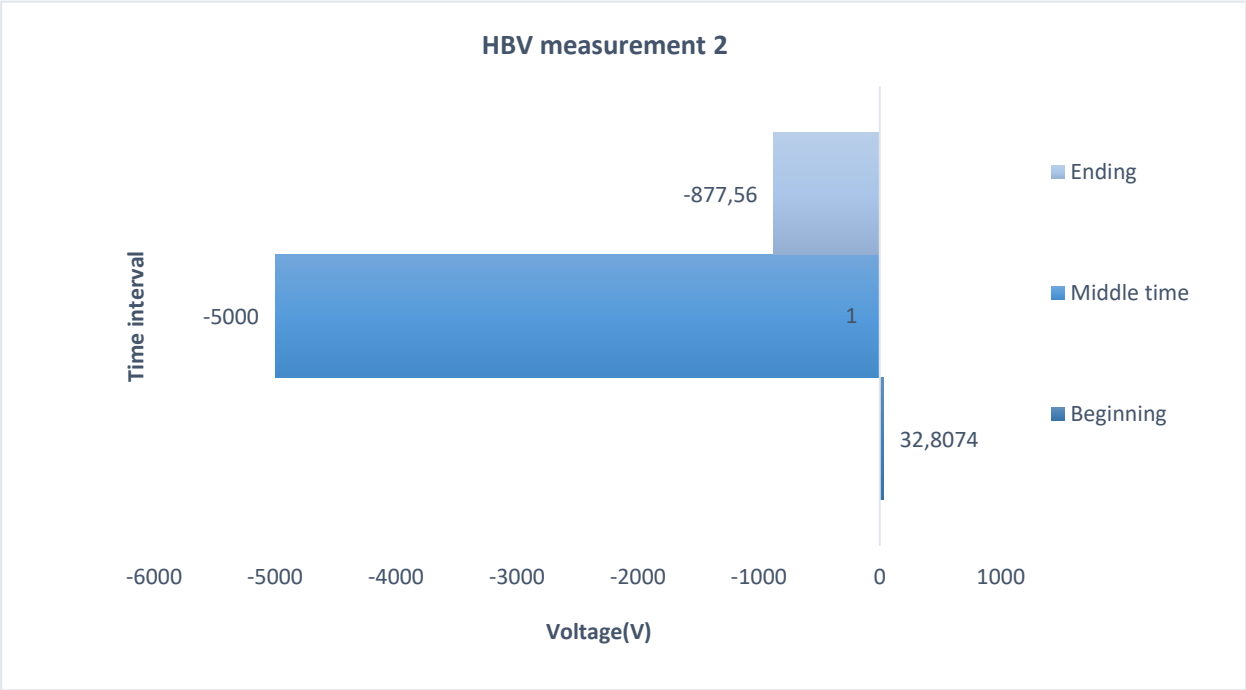


Figure 71 Time charging measurement 2

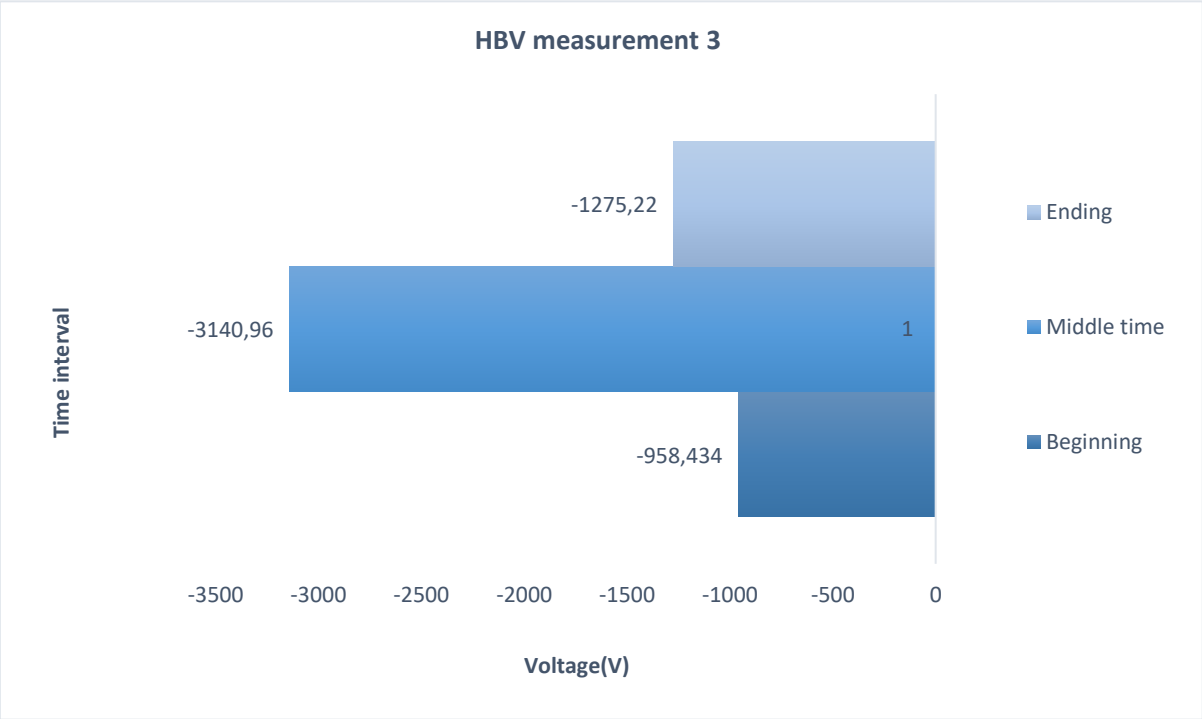


Figure 70 Time charging measurement 3

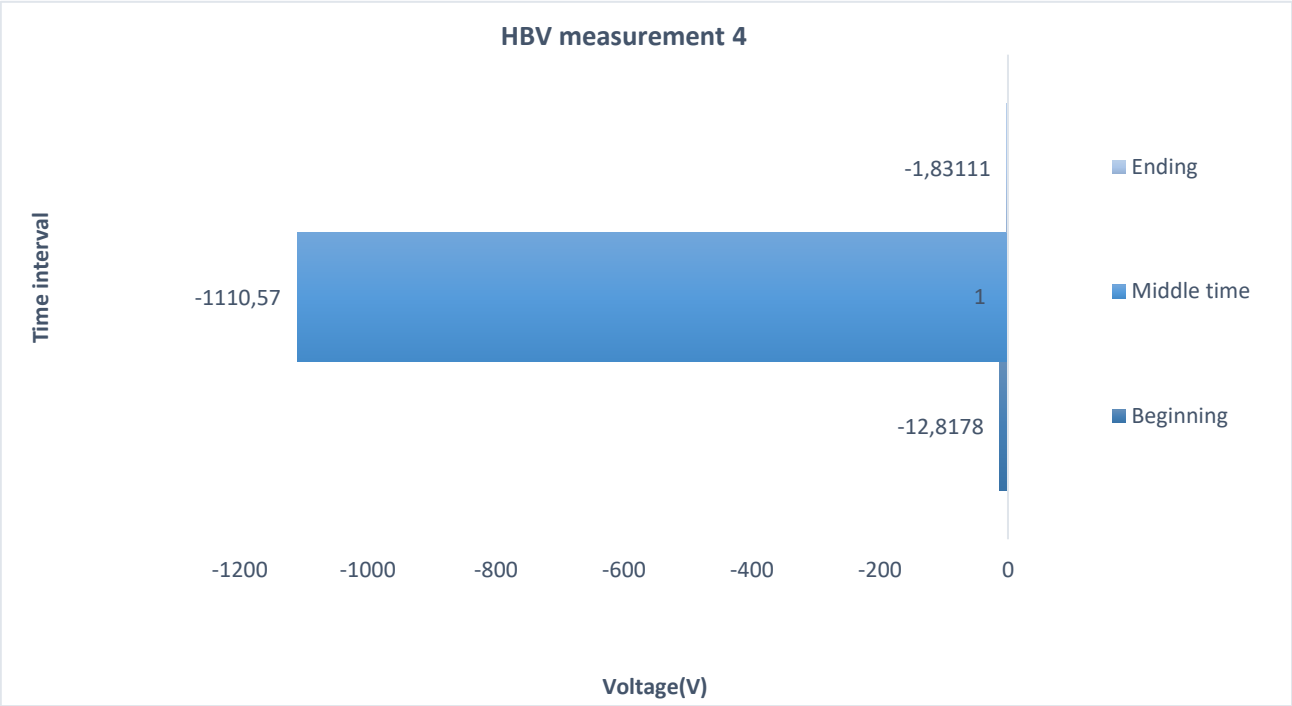


Figure 72 Time charging measurement 4

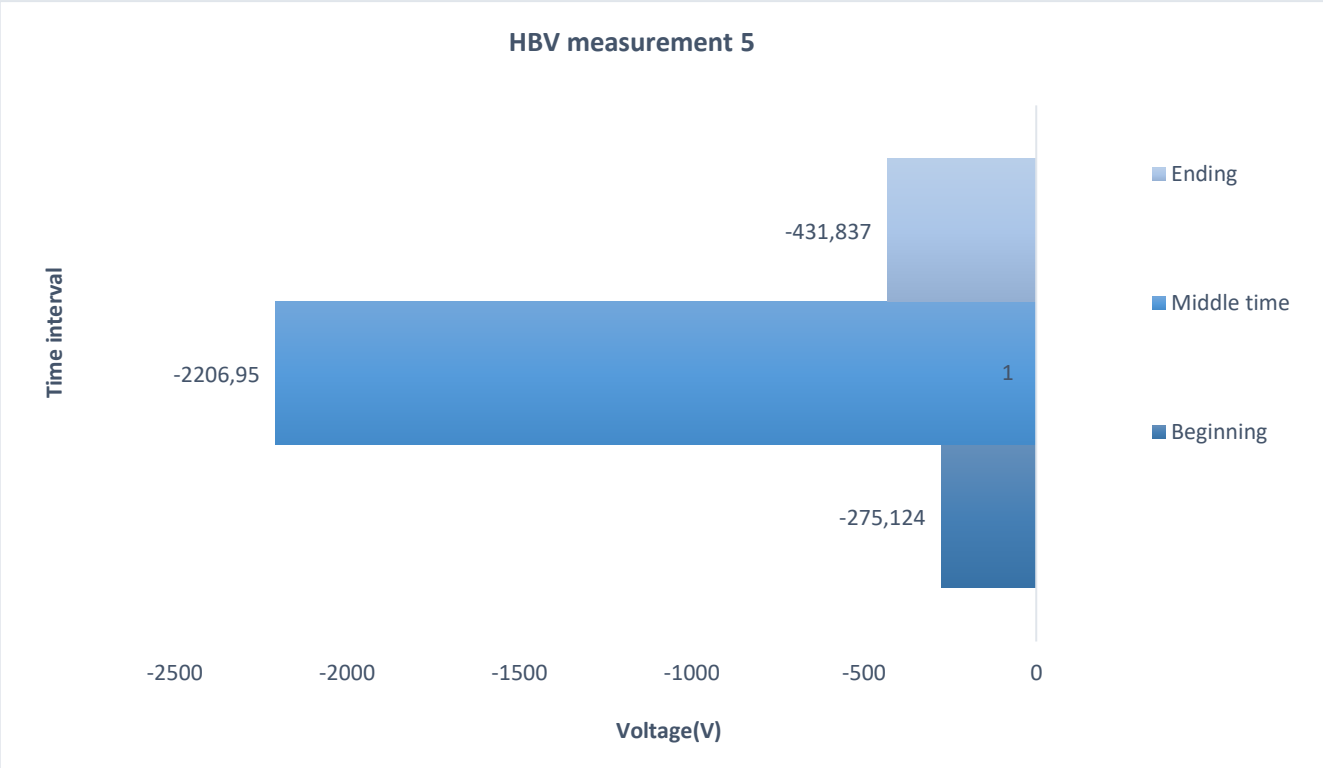


Figure 73 Time charging measurement 5

We can observe that in all the measurements that they reach a maximum value of 1000-5000 V, which is a high charge, but they are discharged to 1-1000 V. The measurement 3 is the less discharged, corresponding to the previous waveform shown of the walking test meter, with a final value of 1275 V. Then, it is followed by the measurement 2, made in non EPA area, with 877 V. The third measurement takes more time to discharge than the others that are made in an EPA area as well.

EPA areas

Regarding to the norm and BSH Regulation, we know the requirements that an EPA needs. All the working surfaces, shelves, and so on, must be connected to the ground. Then, the floors of all the EPAs have to be dissipative; it could be with a dissipative painting or with an ESD dissipative mat. If any electronic component is handled outside an EPA, the floor has to be dissipative; the worker has to be grounded, as well as the worksurface. The resistances Rpp of the floors are measured using the metriso 2000, and the Rgp of the tables, shelves and worksurfaces too. A report for every EPA needed conditions is carried out for each workstation where the electrostatic sensitive components are handled.

Since there are nine electronic components plus the functional tests workstation and wiring harness assembly, there are eleven main EPA areas. However, the control modules are pre-assembled in a different workstation, so in total there are thirteen EPA areas taking into account the workstations where the control panels are assembled. Most of the floor of the assembly line of the dishwasher is made of dissipative painting, but the most critical workstations that are designed as an EPA are the ones that contain electronic components. We can see the distribution of EPA areas in the dishwasher in Figure 74 and Figure 75.

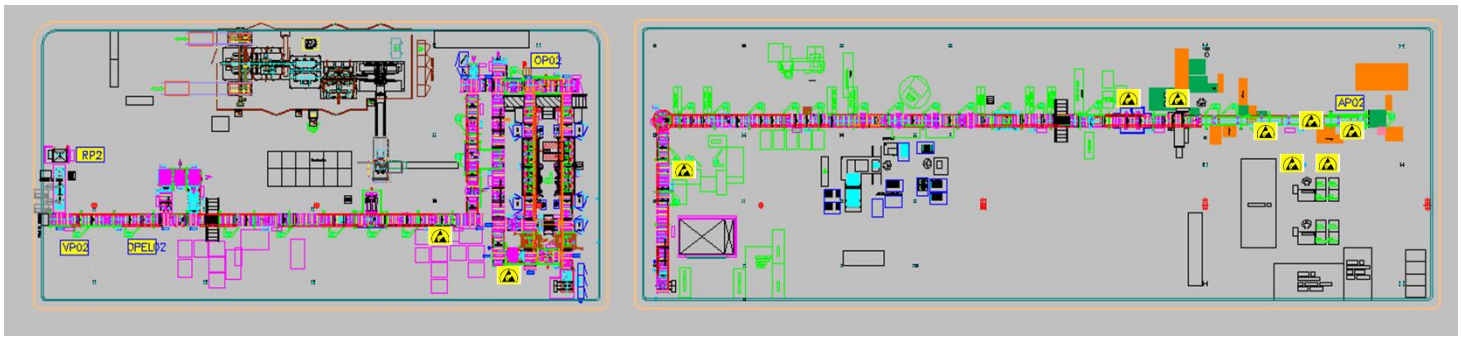


Figure 74 Location of EPA areas dishwasher

-EPA symbol

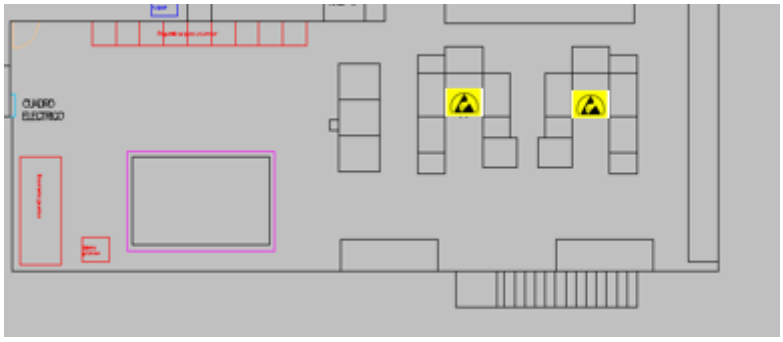


Figure 75 Location EPA control module pre-assembly dishwasher

If any electronic component is transported outside the EPA to other workstation, it has to be in an appropriate packaging. In the dishwasher assembly line, for the control modules, it is used a trolley that the inner part is made of a dissipative material. The outer material is tarpack, which is insulative, $1x10^{12}$ Ω, but the box has a metal support in the bottom of it, that makes contact with the conductor metal of the shelf and then the charge goes to the ground through the shelf. The trolley where theses boxes are transported also has a metallic chain, that when gets in contact with the dissipative floor it allows the discharge. The trolley is shown in Figure 76.

Figure 76 ESD trolley

Other components, like the aqua sensor or the door sensor; are transported in small boxes. The door sensor is placed in small ESD protected boxes, with a SR=$1x10^3$ Ω, because it is cut outside its workstation. The Aquasensor is placed in small insulative boxes.

It has been made a report of the requirements for an EPA for each workstation considered an EPA in the dishwasher assembly line, shown in Table 20.

In the following graphics that we have in Figure 77 we can observe the electrostatic field that the electronic components had during the study, measured several days at good conditions of relative humidity and temperature. They were measured once they were placed in the workstations for the assembly process. We can realize that most of the components have a charge below 400 V, which is acceptable, but with the exception of the control module, which is pre-assembled in the first floor, where the temperature is higher, there are ventilators that with the friction could charge the components, and that they were measured in the shelves directly placed from the warehouse and the charge was high, so there might be a problem with respect to the supplier. However, these electronics are type B, so they can support 2000 V.

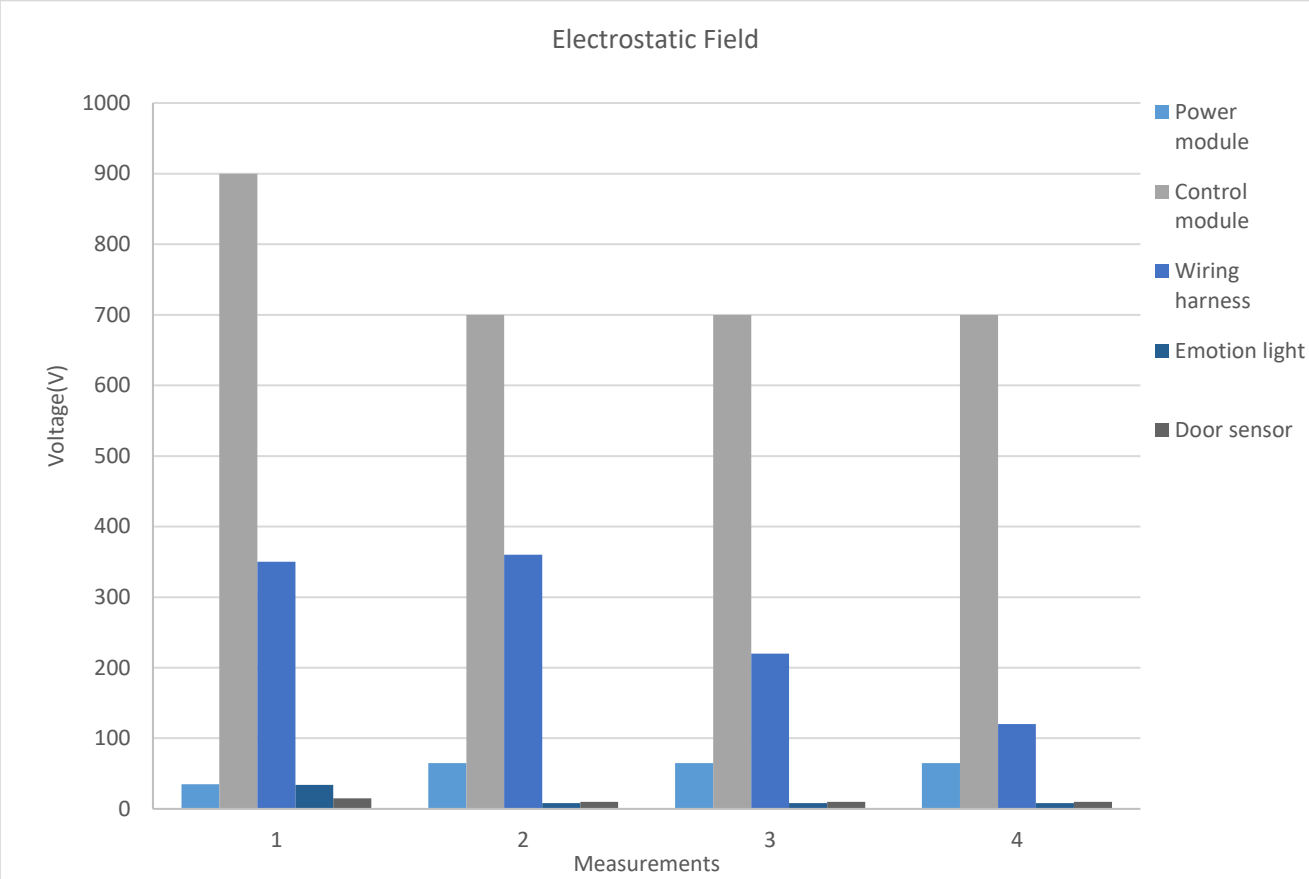


Figure 77 Electrostatic field in the electronic components

WORKSTATION	ASSEMBLY POWER MODULE
EPA REQUIREMENTS	
FLOORING	
Standards	61340-5-1
Limits	Rgp < $1x10^9$ Ω
Measurements 21,5 ºC 35 % RH	Rgp= $2,82x10^6$ Ω
Type of floor	Dissipative
Checking regularity	Once a year
Ground label/yellow connectors	YES
Check	OK
WORK PLACES	
Standards	61340-5-1
Grounding connection with ESD label or yellow ESD connectors	YES
Connection for wrist straps	YES
Tables and worksurfaces inside workstations connected to ground	YES
Checking regularity	Once a year
Check	OK
SHELVING/STORAGE RACKS	
Standards	61340-5-1
Limits	Rgp < $1x10^9$ Ω
Measurements 21,5 ºC 35 % RH	Rgp=$2x10^8$Ω
Connection to ground	YES
Ground label/yellow connectors	YES
Check	OK
MACHINERY AND EQUIPMENT	
Standards	61340-5-1
Limits	Rgp < $1x10^9$ Ω
Measurements 21,5 ºC 35 % RH	
Connection to ground	YES
Ground label/yellow connectors	YES
Checking regularity	Once a year
Check	OK
SEATING	
Standards	61340-5-1
Limits	Rgp < $1x10^9$ Ω
Checking regularity	Once a year
Existence of seating	NO
IONIZING EQUIPMENT	
Standards	61340-5-1
Limits	Decay time (from ±1000 V to ±100 V)< 20 seconds Offset voltage: -35 V<U0<+35 V
Existence of equipment	YES 
Measurements 21,5 ºC 35 % RH	Tdecay=8 sec
Performance	Manual switch on the ionizer, light for ON
Orientation	Fixed position. Oriented to the power module. Accesible to the worker
Distance and influence area	Optimal distance.
Balance	Theoric: +/- 50 V
Cleanness	No light alarm of cleanness. Depends on the worker
Checking regularity	Once a year
Check	OK
TRANSPORT	
Standards	61340-5-1
Limits	Rgp < $1x10^9$ Ω
ESDS transported in ESD conform containers	YES
ESDS stored in controlled conditions outside EPA	YES
ESD label in containers	YES
Checking regularity	Once a year
Check	OK

Table 20 EPA area report dishwasher

4.1.4 Improvement proposals and implementation

With all the observations that have been made as well as the measurements, some actions are proposed to improve the current protection that the electronic components of the dishwasher have. The improvement proposals were communicated to the production department and the head of the dishwasher team in order to know if it was possible to carry them out. They gave us the okay so we spoke with the maintenance department to do the changes. Iñaki Gaston, responsible of the dishwasher maintenance, led me to a technician to who I explained all the changes that had to be done. Most of the changes are connections to ground by means of hanging metallic chains and swapping nylon wheels with metallic ones, yellow connectors, or with ESD mats.

Warehouse improvement proposals

All the components were well arrived to the warehouse (Figure 79) and carried to the workstations in their original packaging. With the exception of the salt sensor, whose trays are taken out and carried to the workstation, like in Figure 78.

Proposal – My first and foremost proposal for the salt sensor is to bring the original packaging to the workstation, which is an EPA; place the boxes in a shelf next to the workstation(Figure 80) and open them inside the EPA. Once opened there, the trays can be taken out because there is no risk.

Figure 79 Salt sensor in the warehouse

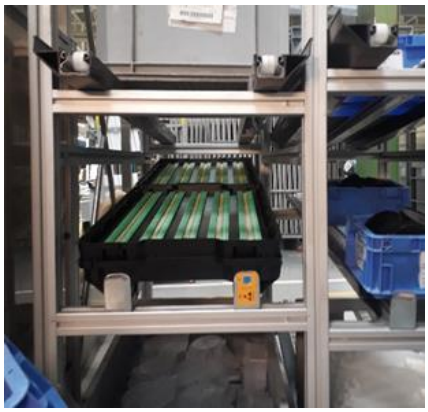


Figure 78 Salt sensor in the workstation

Figure 80 Shelf next to the workstation for the storage of the salt sensor

Meanwhile, the trays that contain the salt sensor are still being taken out of the boxes in the warehouse, so I proposed to change the shelf where they are placed. The shelf was grounded with a metallic chain and swapping two frontal nylon wheels with two metallic ones, we can see it in Figure 82 and Figure 81.

Figure 81 Hanging metallic chain

Figure 82 Metallic wheels

Assembly line improvement proposals

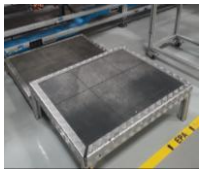
With the exception of the salt sensor, the rest of the components of the dishwasher were brought to the workstations in their original packaging, but some changes needed to be done in their specific workstation, as we can realize in Table 21.

The main purpose was to ground all the shelves that contained electronic components, as well as worksurfaces. If the shelf had wheels, then the best way to ground it is using a hanging metallic chain that gets in contact with the dissipative floor of the EPA and then the charge flows through the chain to the floor. In addition, to allow the flow of this charge, if the shelf had nylon wheels, two frontal nylon wheels had to be swapped with metallic wheels, because the nylon is an insulative material and the charge will not flow through it. What usually is placed on the wheels is a cardboard box, which is dissipative, or a conductive tray. If the shelf does not have wheels, then the way to ground it is using yellow grounding connectors, as in the case of the pre-assembly of the control module with/without display or the shelf in the functional tests workstation.

The boxes used for transporting the ESDS components do not have a shielding property because they do not have a lid. The best boxes I found in the Wolfgang Warmbier catalogue were the ones shown in Figure 83.

Art.-Nr.	Außenmaße mm (L x B x H)	Innenmaße mm (L x B x H)
5351.3204.390.992	300 x 200 x 69	260 x 160 x 39
5351.3208.397.992	300 x 200 x 110	260 x 160 x 95
5351.3213.397.992	300 x 200 x 154	254 x 154 x 139
5351.4304.397.992	400 x 300 x 63	354 x 254 x 58
5351.4308.397.992	400 x 300 x 110	354 x 254 x 95
5351.4313.397.992	400 x 300 x 154	354 x 254 x 139
5351.4320.397.992	400 x 300 x 221	354 x 254 x 206
5351.4326.397.992	400 x 300 x 287	354 x 254 x 272
5351.6408.397.992	600 x 400 x 111	554 x 354 x 95
5351.6413.397.992	600 x 400 x 155	554 x 354 x 139
5351.6420.397.992	600 x 400 x 221	554 x 354 x 206
5351.6426.397.992	600 x 400 x 288	554 x 354 x 272

Figure 83 ESD boxes

WORKSTATION	ACTION	PICTURE
Assembly power module	Swap two nylon front wheels of the shelf with metallic wheels Connect a hanging metallic chain to the shelf	
Connection of the wiring harness to the power module	Swap two nylon front wheels of the shelf with metallic wheels Connect a hanging metallic chain to the shelf	
Assembly softener circuit	Swap two nylon front wheels of the shelf with metallic wheels Connect a hanging metallic chain to the shelf	
Assembly emotion light in control panel	Swap two nylon front wheels of the shelf with metallic wheels Connect a hanging metallic chain to the shelf Put an ESD groundable mat above the rubber in the platform and connect it to the ground with a hanging metallic chain	
Pre-cut door sensor workstation	The door sensor should be cut in an EPA area Move the pre-cut area to an appropiate place or put an ESD dissipative mat in the floor next to the table where the sensor is cut	
Assembly door sensor/control panel	Connect a hanging metallic chain to the shelf where the sensor is handled or a yellow connector to the ground Connect a hanging metallic chain to the shelf containing the control panels. Swap two nylon wheels with two metallic wheels.	 
Pre-assembly control module with/without display	Connect with yellow connectors to the ground the metallic shelves where the control modules are placed	 

Assembly of the control panel	The shelf where the trolleys with the control panel are placed should have a hanging metallic chain to the ground and exchange two front nylon wheels of the shelf with metallic wheels	
Assembly water switch circuit	Connect a hanging metallic chain to the shelf Swap all plastic insulative baskets with ESD conductive baskets	 
Functional tests repair	The shelf where the return components are placed should be connected to the ground and the components placed inside ESD conductive baskets with lid The table where the repairs are made should be connected to the ground with a hanging metallic chain	 
Functional tests repair	The door sensor and the salt sensor are in an insulative box. They should be in an ESD conductive container for an appropiate protection	 

Table 21 Improvement proposals for the dishwasher

Most of the improvement proposals stated have been implemented, as we can see in Table 22. The ones that have not been implemented are the purchase of conductive ESD protected boxes (Figure 84) instead of insulative, shown in to carry in them the Aquasensor, the damaged electronic components verified in the functional tests, or any other sensible component and the placement of an ESD mat in the area where the door sensor is pre-cut and the Aquasensor is taken out from the original packaging. There are being changes in the layout in that area so later this proposal might be carried out.

Art.-Nr.	Außenmaße mm (L x B x H)	Innenmaße mm (L x B x H)	Nutzhöhe (mm)
5351.2108.007.992	200 x 150 x 100	155 x 106 x 96	83
5351.2113.007.992	200 x 150 x 145	155 x 106 x 142	129
5351.3208.007.992	300 x 200 x 100	254 x 154 x 96	83
5351.3213.007.992	300 x 200 x 145	254 x 154 x 141	128
5351.4304.007.992	400 x 300 x 53	354 x 254 x 49	40
5351.4308.907.992	400 x 300 x 100	354 x 254 x 96	83
5351.4313.907.992	400 x 300 x 145	354 x 254 x 141	128
5351.4320.007.992	400 x 300 x 212	354 x 254 x 208	195
5351.4326.007.992	400 x 300 x 278	354 x 254 x 274	262
5351.4332.007.992	400 x 300 x 320	354 x 254 x 317	303
5351.6404.617.992	600 x 400 x 55	554 x 354 x 41	28
5351.6408.007.992	600 x 400 x 100	554 x 354 x 95	83
5351.6413.007.992	600 x 400 x 145	554 x 354 x 141	128
5351.6420.007.992	600 x 400 x 212	554 x 354 x 208	195
5351.6426.007.992	600 x 400 x 278	554 x 354 x 273	260
5351.6432.007.992	600 x 400 x 320	554 x 354 x 316	303
5351.6440.007.992	600 x 400 x 412	554 x 354 x 407	393

Figure 84 Boxes for Aquasensor

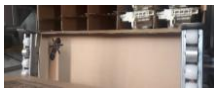
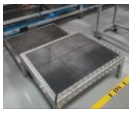
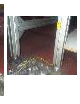
WORKSTATION	ACTION	PICTURE	CORRECTION
Assembly power module	Swap two nylon front wheels of the shelf with metallic wheels Connect a hanging metallic chain to the shelf		 
Connection of the wiring harness to the power module	Swap two nylon front wheels of the shelf with metallic wheels Connect a hanging metallic chain to the shelf		 
Assembly softener circuit	Swap two nylon front wheels of the shelf with metallic wheels Connect a hanging metallic chain to the shelf		 
Assembly emotion light in control panel	Swap two nylon front wheels of the shelf with metallic wheels Connect a hanging metallic chain to the shelf Put an ESD groundable mat above the rubber in the platform and connect it to the ground with a hanging metallic chain		  
Pre-cut door sensor workstation	The door sensor should be cut in an EPA area Move the pre-cut area to an appropiate place or put an ESD dissipative mat in the floor next to the table where the sensor is cut		
Assembly door sensor/control panel	Connect a hanging metallic chain to the shelf where the sensor is handled or a yellow connector to the ground Connect a hanging metallic chain to the shelf containing the control panels. Swap two nylon wheels with two metallic wheels.	 	
Pre-assembly control module with/without display	Connect with yellow connectors to the ground the metallic shelves where the control modules are placed	 	   
Assembly of the control panel	The shelf where the trolleys with the control panel are placed should have a hanging metallic chain to the ground and exchange two front nylon wheels of the shelf with metallic wheels		 
Assembly water switch circuit	Connect a hanging metallic chain to the shelf Swap all plastic insulative baskets with ESD conductive baskets	 	
Functional tests repair	The shelf where the return components are placed should be connected to the ground and the components placed inside ESD conductive baskets with lid The table where the repairs are made should be connected to the ground with a hanging metallic chain	 	 
Functional tests repair	The door sensor and the salt sensor are in an insulative box. They should be in an ESD conductive container for an appropiate protection	 	

Table 22 Implementation of the improvement proposals in dishwasher

4.2 Refrigerator

In the following Figure 85 we can observe the refrigerator assembly line, with the preassembly lines on the right, then the foaming stations and the assembly lines on the right. The ⬡ represents the workstations with risk of ESD.

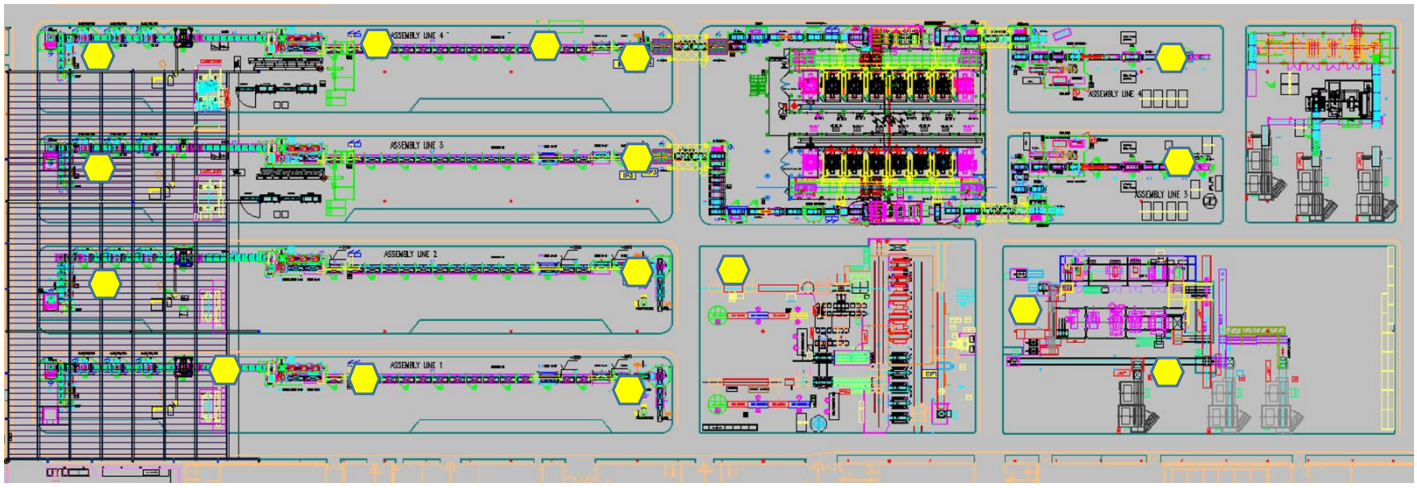


Figure 85 Refrigerator Assembly line

4.2.1 Electronic components and description

Talking about the refrigerator, we can find six main electronic components. All of the home appliances carry with them the LED, control panel, door sensor and fan. However, some variants have also a display control in the door, or an inverter.

There are five different models of refrigerators, and inside these five models, we could find 200 submodels, in which it varies the efficiency or the electronics or small aesthetic details.

Here are the main five models of refrigerators, shown in Figure 86:

- KDN: Combined two-door refrigerators (freezer / refrigerator) with the freezer on top.
- KGN: Combined two-door refrigerators (freezer / refrigerator) with the freezer on top. Within this group, they may have chill or not.
- KSV: One-door refrigerators without chill.
- KSF: One-door refrigerators with chill.
- GSN: Freezers of one door.

Figure 86 Refrigerators range

Inside these models, the refrigerator could be divided depending on the type of project, electronics, measurements, benefits, energy efficiency (A+, A++, and A+++).

All the electronic components of the refrigerator are PCB (Printed Circuit Board). The simplest ones are that of the LED lights and the most complex ones are that of the control panels.

- **LED light:** there are four different types of leds. The purpose of the led in the refrigerator is to provide light in the interior.

- **Control panel (CP):** same as in the dishwasher, the control panel controls everything in the refrigerator and allows the interaction with the client. Sometimes this interaction is made with the display control.

- **Display control (DC):** for some models, there is a display assembled in the door to control the temperature of the refrigerator, or both the refrigerator and freezer. With this model, energy is saved because the door doesn´t need to be opened to change the temperature.

- **Inverter:** for the A+++ variants. The inverter technology is based on electronic power converters. It regulates the voltage, current and frequency of an appliance. It allows achieving a stable temperature at all times because the speed of the compressor adapts

to the cold that will be necessary. Therefore, the inverter adapts the power of the compressor to the needs.

- **Door sensor:** most of the control panels have the door sensor integrated in them. However, for the freezer it is needed a door sensor to know if the door is closed or opened. It is a magnetic field sensor.

- **Fan:** it distributes the cold air in a homogeneous way; moisture does not condense and prevents frost on walls and food. It also increases the airflow to improve heat exchange. There are two types of fan. The type for the A+++ models comes with three output cables and a PCB to have a control PWM of the velocity of the fan.

In the following Table 23 we can observe the classification of the electronics that contain the refrigerator:

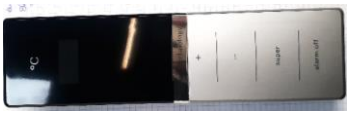
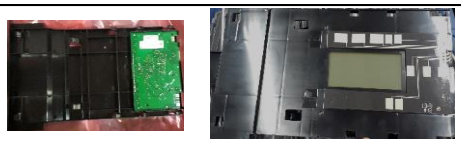
ESDS COMPONENT	PICTURE	CLASS	VARIANT	WORKSTATIONS
LED light		**A**	All of them	Assembly LED light
Display control		**B**	NF16 NF16 Added Value	Door assembly
Display control glassdoor		**A**	Glassdoor	Glassdoor assembly
Control panel		**A**	All of them	Assembly control panel
Door sensor		**C**	All of them	Assembly door sensor & control panel
Fan		**C**	A+++	Assembly evaporator set
Inverter		**B**	A+++	Assembly compressor

Table 23 Refrigerator electronics classification

4.2.2 Productive process and life cycle

The productive line of the refrigerator is carried out through a huge number of workstations. However, the mainly steps are shown and explain below. In the Figure 87we can observe the life cycle process the electronics follow in the case of the refrigerator.

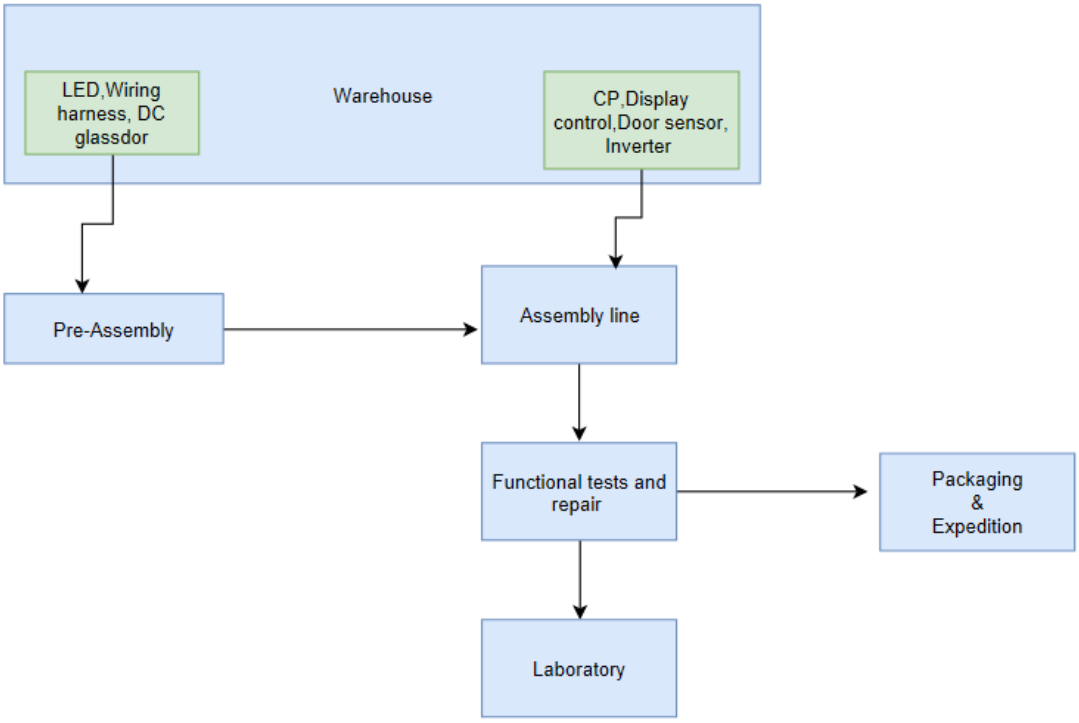


Figure 87 Refrigerator electronics life cycle

Pre-assembly line

The first steps in the manufacturing process of the refrigerator occur in the pre-assembly line. This part begins with the transformation of small granules of ABS, a very impact resistant plastic, into flat sheets, as we can see in Figure 88. These granules are made of new material as well as recycled materials coming from useless cubes. For this process, plastic injection screws are used at high temperatures, obtaining sheets with a plastic nature, which are later cooled and cut according to the necessary measures of each refrigerator.

Figure 88 Plastic sheets

Once the ABS sheets are obtained, they are introduced into a machine that heats them through a series of resistances. These resistances have different values according to the shape and dimension of the tank that is going to be made. With the sheets still hot, a cold wind blow is carried out that gives form to the cube of the refrigerator; we can observe it in Figure 89.

Figure 89 Cube forming

Then, each cube in each pre-assembly line, is die cut and its perimeter is fixed. This could be done with a machine or with a collaborative robot, which contains a laser to do the cuts. The next step is the assembly of the LEDs, and the placement of the evaporator in the back of the tank by means of a fixing press. Once it has finished with the press, a worker places the top support "Top", the wiring harness and the probe, shown in Figure 90. In the upper support a drawer is fitted where the electronics will be housed and another tank to locate the ventilator.

Figure 90 Wiring harness and evaporator assembly

With both sides of the refrigerator placed, the compressor plastic supports, the injection crosspiece and the drain are introduced. Subsequently, a screwing is carried out because until now the apparatus does not have anything screwed.

To finish the pre-assembly, the refrigerator continues to an oven, where is heated at high temperatures to be able to later perform the foaming of the body.

Said foaming consists in a chemical reaction between the polyol and the isocyanate, with which the polyurethane foam forming the insulation of the apparatus is obtained. The foaming is the last step of the pre-assembly line. Then, the refrigerators are brought to the assembly line process. The machinery in charge of the foaming is shown in Figure 91.

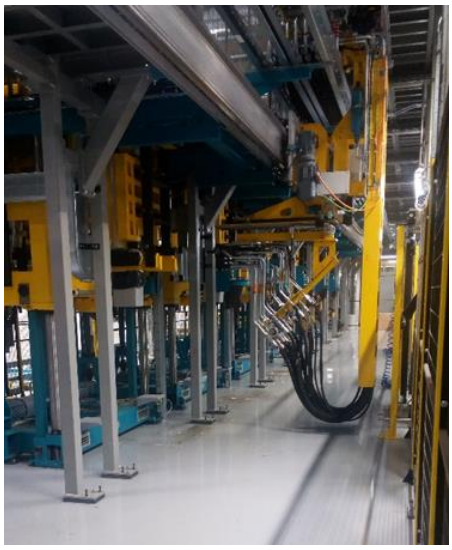


Figure 91 Foaming

Assembly line

Before starting this phase, a general verification of the appliance is made, where possible polyurethane leaks are eliminated. In the first workstation of the assembly line, the corresponding electronics are connected (Figure 92), which is the control panel, and its specific

program is charged manually by the worker. If an additional door sensor is needed, is connected at this point as well. Later, the fan, the trays and the drawers are assembled in the refrigerator.

Figure 92 Control panel assembly

Continuing with the process, the door must be assembled. To do this, we take the aluminum sheet, previously folded, and place the upper and lower sides. Next, the foaming between said sheet and the inner part of the door is made. Once foamed and by means of a collaborative robot, the rubber seal and the handle doors are assembled, as in Figure 93.

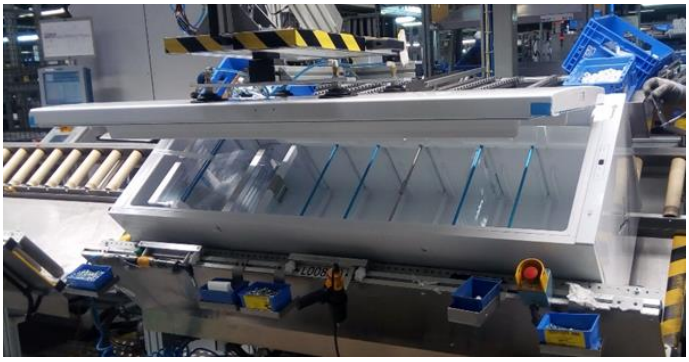


Figure 93 Door assembly

Approaching the last steps, with the help of a collaborative robot, the compressor is assembled into the lower gap of the backside of the refrigerator, we can see it in Figure 94. The same worker that assembles it, also makes the necessary connections so that said motor works correctly. Next, the bottle racks and the condenser are placed. The condenser occupies the entire length of the refrigerator's backside, as the evaporator. With all the elements introduced, the different tubes are welded to finish the refrigerator´s cooling circuit, and a visual inspection is carried out as the logo is placed on the door. If the refrigerator model includes an "Inverter", is assembled at this point of the assembly line, in the same workstation of the compressor assembly.

Figure 94 Compressor assembly

If there are any visual mistakes that the worker may find, they are repaired before going to the functional tests in the upper floor.

Functional tests and repair

Finally, the refrigerator is brought using a lift truck to the first floor called the "platform" of the plant to proceed with the functional tests and repairs. In an area, the refrigerators are charged with the refrigerant and tested at a normal daily performance. If there are any failures, leaks, electronic performance problems, the refrigerators are taken to the repair area, where a worker is in charge of the repairing. They reprogram the electronics if the problem came from it, or swap it with another one picking it from the assembly line. The last step of the manufacturing process is the packaging and the release of the appliance. We can observe the repair tests area in Figure 95.

Figure 95 Repair of Functional tests

4.2.3 ESD study

As in the case of the dishwasher, an appropriate ESD study has been done in the refrigerator and its four assembly lines. The study process have been similar, but there are problems in the case of the refrigerator because the cube is made of plastic and it is high charged, so when it arrives the pre-assembly line the voltage of the cube is really high and can damage the electronic components of the refrigerator.

Product qualification

Since there is a huge variety of electronic components, at least in the case of the control panels, there are many variants. It was decided to watch which electronic components were assembling in each assembly line and several references were taken to go to the warehouse and look for them. The entry inspection was visited to know the location of the electronic components in the warehouse.

There were found some irregularities in the way in which the electronic components are brought to the warehouse and carried to the workstations. In the case of the display controls of the glass door and other control displays, they were taken out from the original package and put in insulative boxes. The same happened with the LEDs, they were placed in an insulative box.

In other cases, the inner packaging of the electronic components is not appropriate for the ESD, because I measured the value of the superficial resistance and I obtained $1x10^{11}$ Ω and $1x10^{12}$ Ω, the values were in the border between insulative and dissipative. The foam tray in which the LEDs are placed is also insulative.

Some electronic components such as control panels, come from Tasubinsa, and they are packaged in a very bad manner, in a tarpack box with tarpack divisors, therefore the panels come with a high charge.

All the electronic components are taken in their original package, the one that comes to the warehouse despite is a wrong way of package, with the exception of the door sensor. The door sensor comes in a cardboard box with cardboard trays, and these trays are taken out from the box and put in insulative boxes, which is a mistake.

In addition, some of the components come from other warehouse called “TAF”, and for instance the wiring harnesses that come from there, come hanging in metallic trolleys, not in a cardboard box.

The electronics are carried to the workstations using the milk run as in the dishwasher, but in the refrigerator, the flux is done in every 24 units.

Then, in every workstation, containing an electronic component it was studied how they were stored and the electrostatic field they contained. Many irregularities were found taking into account the ones at the warehouse, and improvement proposals for every assembly line and the warehouse were stated.

The report that has been made for all the electronics of the refrigerator in the product qualification, is shown in Table 24.

WORKSTATION	ASSEMBLY CONTROL PANEL	
ESDS Component	Control panel Siemens & Bosch	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	The control panels are inside a cardboard box closed in a metallic shelf screwed to the ground.	
Measurements 23 ºC 41 % RH	Electrostatic field(V/m x 2 cm)= 3 kV	
Milkround delivery	Boxes are closed and delivered unopened to the EPA using a metallic painted milkround with rubber wheels	
Check	OK	
RECEIVING		
Supply packaging	Cardboard box with tarpack divisors between the panels and pink blanket divisor between each control panel's tier	
ESD label in the packaging	YES	
Standards	IEC 61340-5-1	
Limits	$1x10^4\ \Omega \leq Rpp \leq 1x10^{11}\ \Omega$	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) tarpack= $1x10^{[illegible]}\ \Omega$ SR(Superficial Resistance) carbdoard=$7x10^9\ \Omega$ SR(Superficial Resistance) pink blanket=$3x10^{10}\ \Omega$ Electrostatic field(V/m x 2 cm)= 44 V	
Material packaging	Cardboard-Dissipative Tarpack divisor-Insulative	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Direct assembly on refrigerator	
Assembly line shelving	The control panels are inside a cardboard box on a milkround's wagon outside the EPA area and not connected to the ground	
Connection to ground	NO	
Assembly line storage	N/A	
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

Table 24 Product qualification report refrigerator

Personnel grounding

The rule that has to be fulfilled in the refrigerator is the same as in the dishwasher. All the staff that is going to handle electronic components has to be grounded in an appropriate way and tested every time they are going inside a workstation that contains electrostatic sensitive devices.

What was found was that there were footwear testers placed in the plant, but any report was there showing the daily results of the workers. If we want to have a control on ESD, a report for every assembly line is needed. The personnel grounding report is shown in Table 25.

COMPLIANCE VERIFICATION		
PERSONNEL GROUNDING		
Standards	61340-5-1	
Option **Wrist straps/Footheels**	Available in case the footwear test is NOK	
Limits	R < 5 x10^6 Ω or user defined value	
Standards	61340-5-1	
Clothing	FDCE complete uniform >60% to 100 % cotton	
Limits	Rpp< 1x10^{11} Ω	
Standards	61340-5-1	
Footwear	Standard Safety Shoes ESD compatible SR=1x10^3 Ω - Conductor	
Limits	R ≤ 1 x10^9 Ω	
Standards	61340-5-1	
Gloves	Standard Assembly gloves	
Limits	Rgp< 1x10^{11} Ω	
Checking regularity	Wrist straps - Daily	
	Clothing - Regularly	
	Footwear - Daily All the worker's footwear is checked in the tester but there aren't any reports of the results of the daily tests The footwear tester is only placed in lines 2 and 4.	 
	Gloves - Before using	
Check	NOK	

Table 25 Personnel grounding report refrigerator

Since there is not available a report showing how the tests are performed, I could not know who got a wrong result. Therefore, it was decided to measure the people of some workstations that do not rotate too much.

In the following Figure 97 and Figure 96 we can observe the HBV measurements that were made in the workstation of the assembly line 3 and 1. These workstations were measured because a worker of the production department informed that these workstations had workers without rotations in the workstations. Therefore, they were told to walk for 10 seconds and stop at the end, and we can realize that the charge in both cases decreases to 100-200 V with time, so we can conclude that the workers are well grounded.

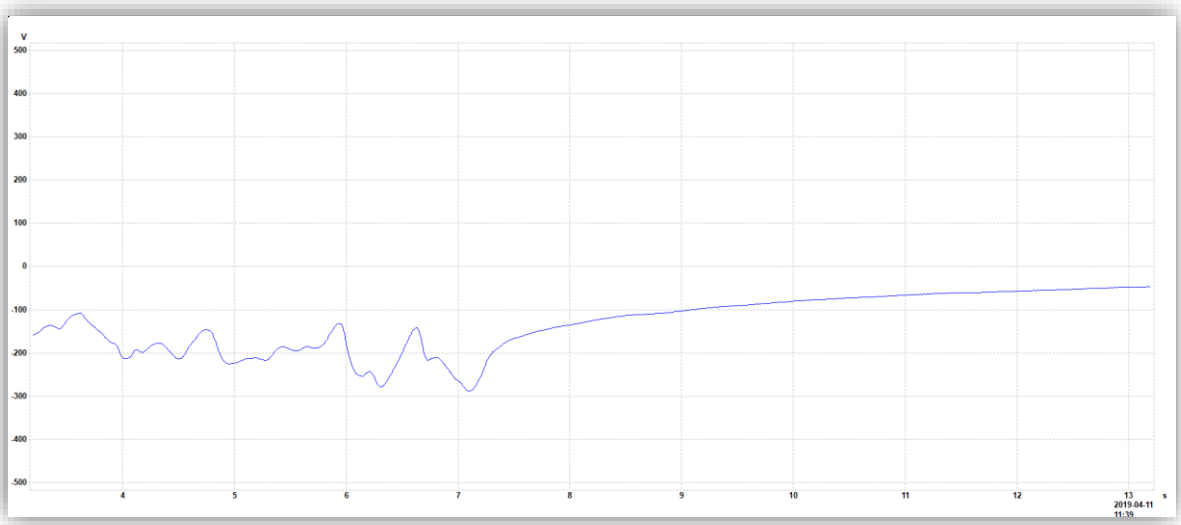


Figure 97 Control panel line 3

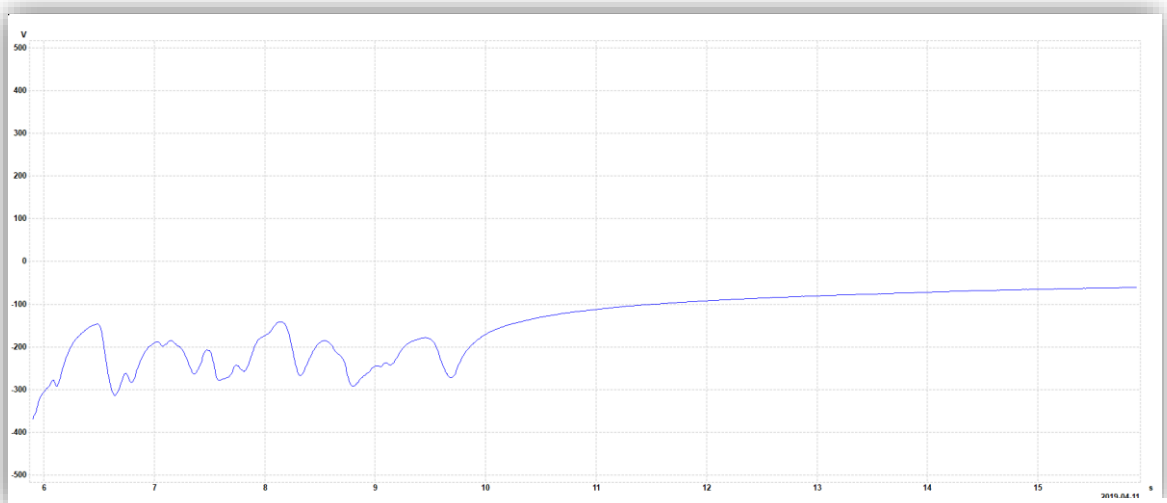


Figure 96 Control panel line 1

EPA areas

Each workstation containing ESDS are considered an EPA, as well as the repair of functional tests, where electronic components are also handled. Each pre-assembly line have two workstations for the assembly of the LEDs and wiring harness, then the assembly lines have one workstation for the control panel, and some of them for the control display. At the end of some assembly lines, there is a pre-assembly workstation for the inverter connections, and one for the assembly of the inverter. All the EPAS are shown in Figure 98 and Figure 99.

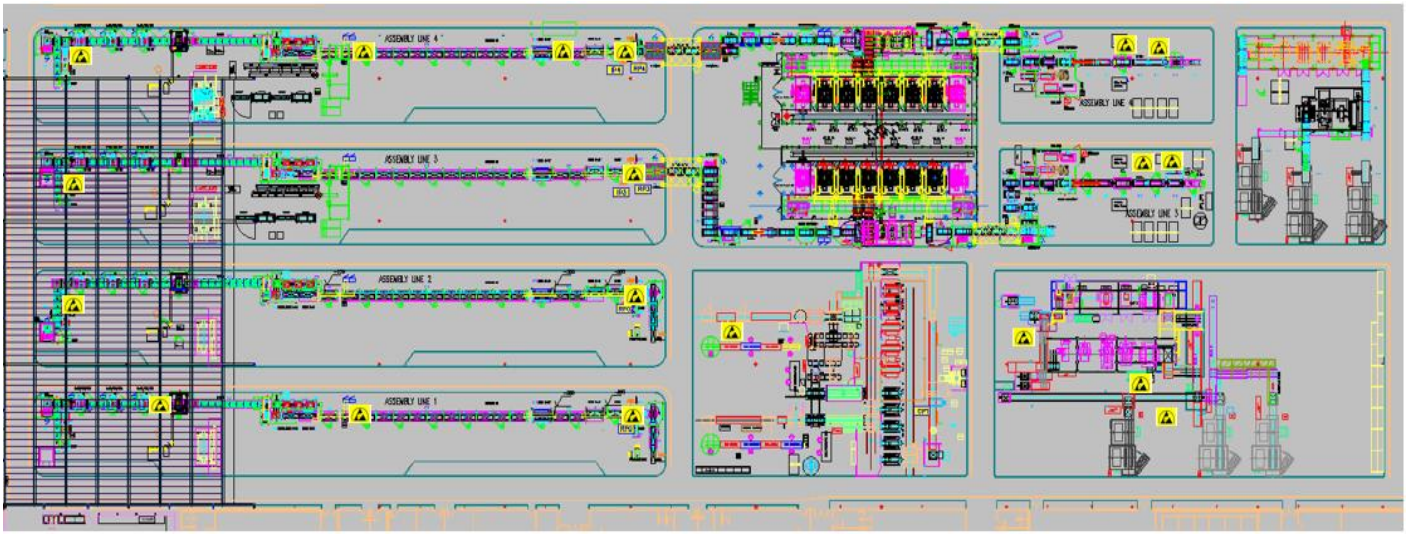


Figure 98 EPA areas refrigerator Assembly lines

-EPA symbol

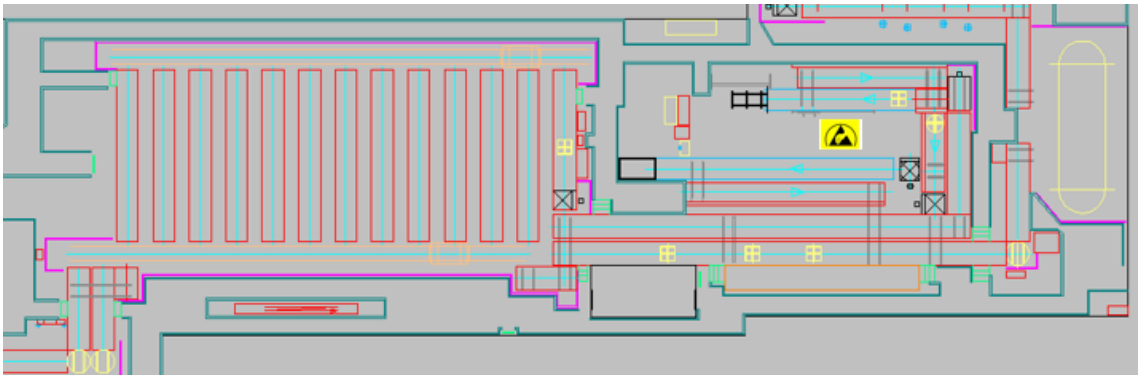


Figure 99 EPA area repair of Functional tests

It has been made an EPA report for each workstation considered as so, in every assembly line, as shown in Table 26.

WORKSTATION	ASSEMBLY CONTROL PANEL
EPA REQUIREMENTS	
FLOORING	
Standards	61340-5-1
Limits	Rgp < $1x10^9$ Ω
Measurements **21,3 ºC** **35,8 % RH**	Rgp= $1,05x10^6$ Ω
Type of floor	Dissipative
Checking regularity	Once a year
Ground label/yellow connectors	NO
Check	**OK**
WORK PLACES	
Standards	61340-5-1
Grounding connection with ESD label or yellow ESD connectors	NO
Connection for wrist straps	NO
Tables and worksurfaces inside workstations connected to ground	NO
Checking regularity	Once a year
Check	**OK**
SHELVING/STORAGE RACKS	
Standards	61340-5-1
Limits	Rgp < $1x10^9$ Ω
Measurements **21,5 ºC** **35 % RH**	Rgp=$5,37x10^{10}$ Ω
Connection to ground	NO
Ground label/yellow connectors	NO
Check	NOK
MACHINERY AND EQUIPMENT	
Standards	61340-5-1
Limits	Rgp < $1x10^9$ Ω
Measurements **21,5 ºC** **35 % RH**	Rgp=$1x10^3$ Ω
Connection to ground	YES
Ground label/yellow connectors	YES
Checking regularity	Once a year
Check	**OK**
SEATING	
Standards	61340-5-1
Limits	Rgp < $1x10^9$ Ω
Checking regularity	Once a year
Existence of seating	NO
IONIZING EQUIPMENT	
Standards	61340-5-1
Limits	Decay time (from ±1000 V to ±100 V)< 20 seconds
Existence of equipment	NO
Measurements	N/A
Performance	N/A
Orientation	N/A
Distance and influence area	N/A
Balance	N/A
Cleanness	N/A
Checking regularity	Once a year
TRANSPORT	
Standards	61340-5-1
Limits	Rgp < $1x10^9$ Ω
ESDS transported in ESD conform containers	YES
ESDS stored in controlled conditions outside EPA	YES
ESD label in containers	YES
Checking regularity	Once a year
Check	**OK**

Table 26 Example of report EPA line 1

4.2.4 Improvement proposals and implementation

By doing the ESD study in the assembly line, many necessary improvement proposals were stated in the four pre-assembly and assembly lines of the refrigerator, as well as in the warehouse.

The purchase department should speak with the supplier because some electronic components come in a bad way of packaging, like tarpack divisors, tarpack boxes, insulative foam trays, insulative inner packaging bags, which is not an appropriate way to prevent the electronics from an electrostatic discharge. We can observe the improvement proposals in Table 27.

WAREHOUSE		
ITEM	**ACTION**	**PICTURE**
LED light	The LEDs come in cardboard boxes in foam trays that are insulative. The trays should be dissipative.	
Control panel	Control panels that come in tarpack boxes from Tasubinsa should be changed for cardboard boxes. Control panels that come in insulative pink bags should be changed for dissipative bags. Control panels that come in cardboard boxes with tarpack divisors should be changed for cardboard divisors.	  
RECEIVING IN WORKSTATION		
ITEM	**ACTION**	**PICTURE**
LED light	The foam trays are taken out of the boxes and placed in blue insulative boxes. The boxes should be brought to the workstation as they come.	
Display control	The display controls come in cardboard trays or dissipative trays. But they are taken out of the box and placed in an ESD box. The display controls have to be carried to the workstation in their original package.	
Door sensor	The cardboard trays with the door sensors are taken out of the box and placed in an insulative blue box. The sensors should be carried to the workstation in the original package.	

Table 27 Improvement proposals Warehouse and receiving

Several measurements of the electrostatic field in the electronic components in each assembly line were made, as we can realize in the graphics of Figure 100, Figure 101, Figure 102 and Figure 103. For the measurements, each time different components of a same electronic were measured and the maximum value was taken into consideration.

We saw that in the first assembly line, the control panels had a high voltage, with a maximum of 4000 V some of them. This could be due to the inner packaging of the electronics, because usually they had tarpack divisors, or they could come with that charge from the supplier. In addition, the shelf is not a shelf (milkrun wagon) and is not connected to the ground.

The same happens in the line 2, where the control panel has a high voltage, as well as the inverter, with a maximum of 1500 V in the control panel and 2000 V in the inverter. The storing of control panels in line 2 is similar to line 1. The inverter is preassembled in this line in a not grounded area, and the plastic shell of the inverter was opened to measure the voltage of the PCB and we found high voltages.

For the control panels in line 1 and 2, an improvement proposal that further will be explained is proposed.

We can realize as well that in the line 4, the inverter has a high voltage of 1200 V. The area of preassembling is grounded (the floor is dissipative) but the shelves are not grounded. In lines 3 and 4 they have high voltage in the control panels, lower than in the first two lines, because the control panels come in cardboard boxes but the inner packaging is an insulative pink bag.

Therefore, knowing all the voltages that the electronic components of the refrigerator have in the assembly lines, the main improvement proposals were to ground all the shelves and worksurfaces that were not grounded in some workstations. By connecting a hanging metallic chain in the majority of them because they were movable shelves, or with yellow connectors. Some floors of what should be an EPA area did not have a dissipative floor, so it was proposed to place ESD mats in all the cases.

For two workstations, the ones of control panels in the 1 and 2 line, it is proposed to place a shelf for the storage of the control panels with an ionizer. We will see later that for the cubes area there have been proposed some actions to be implemented in order to decrease the charge they own. We can see these actions in Table 28, Table 29, Table 30 and Table 31.

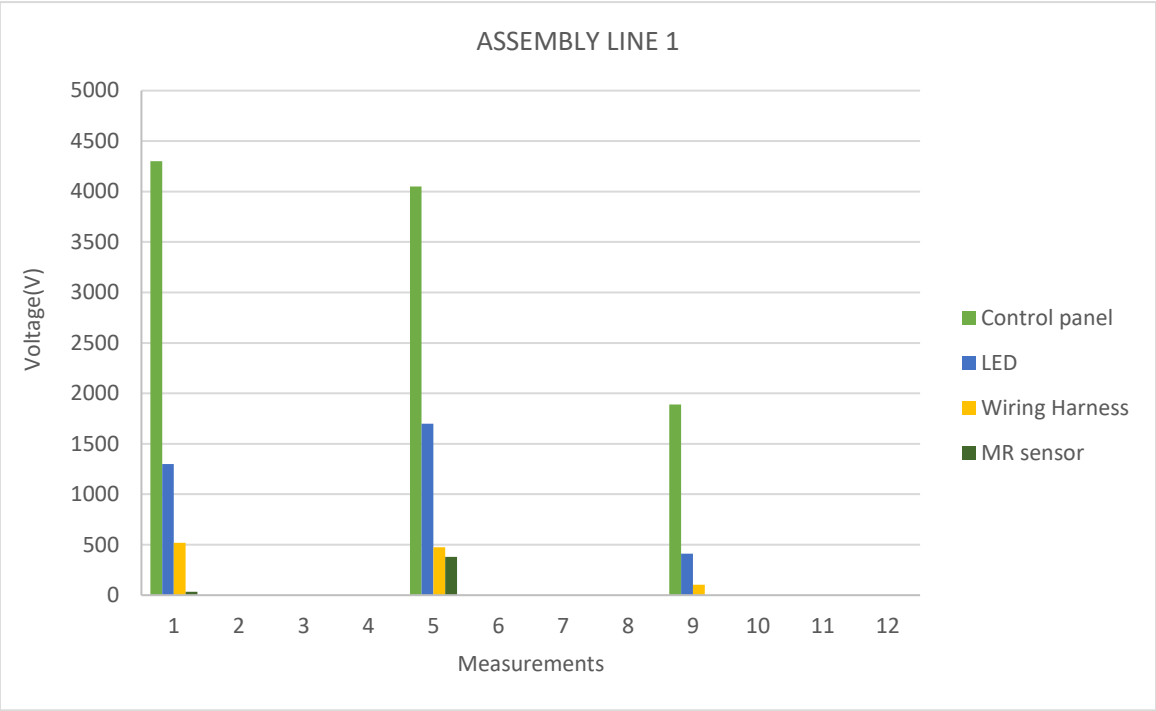


Figure 100 Electrostatic Field line 1

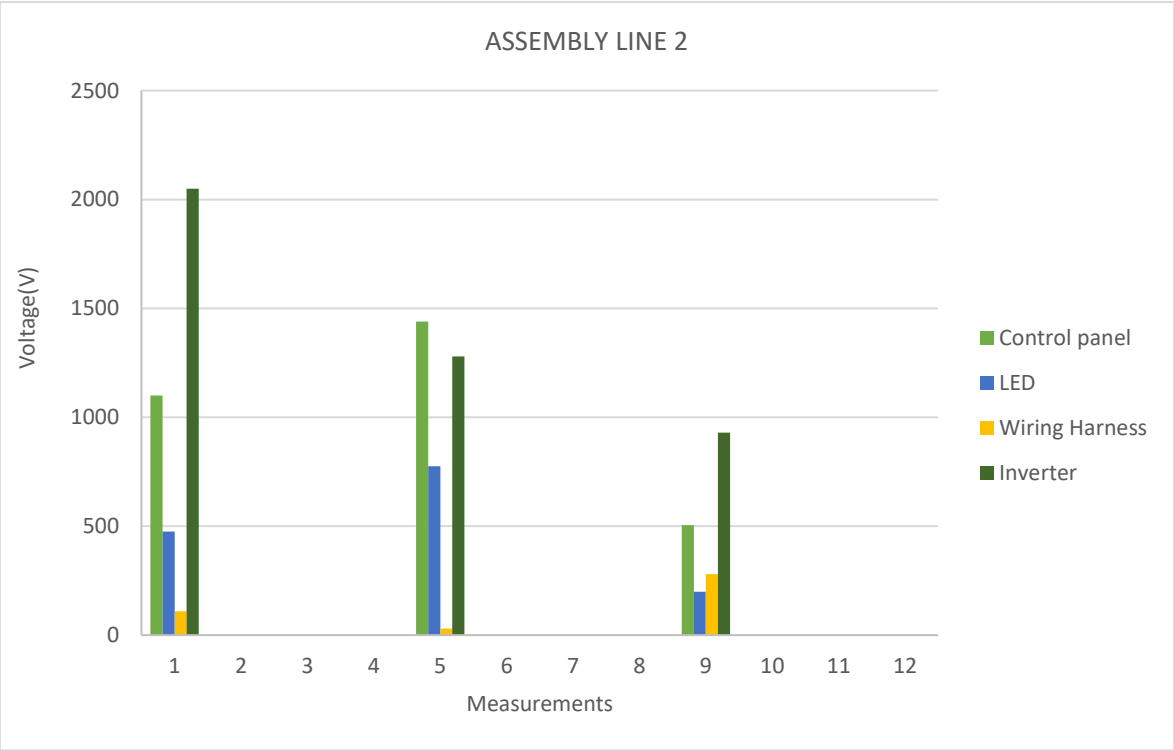


Figure 101 Electrostatic Field line 2

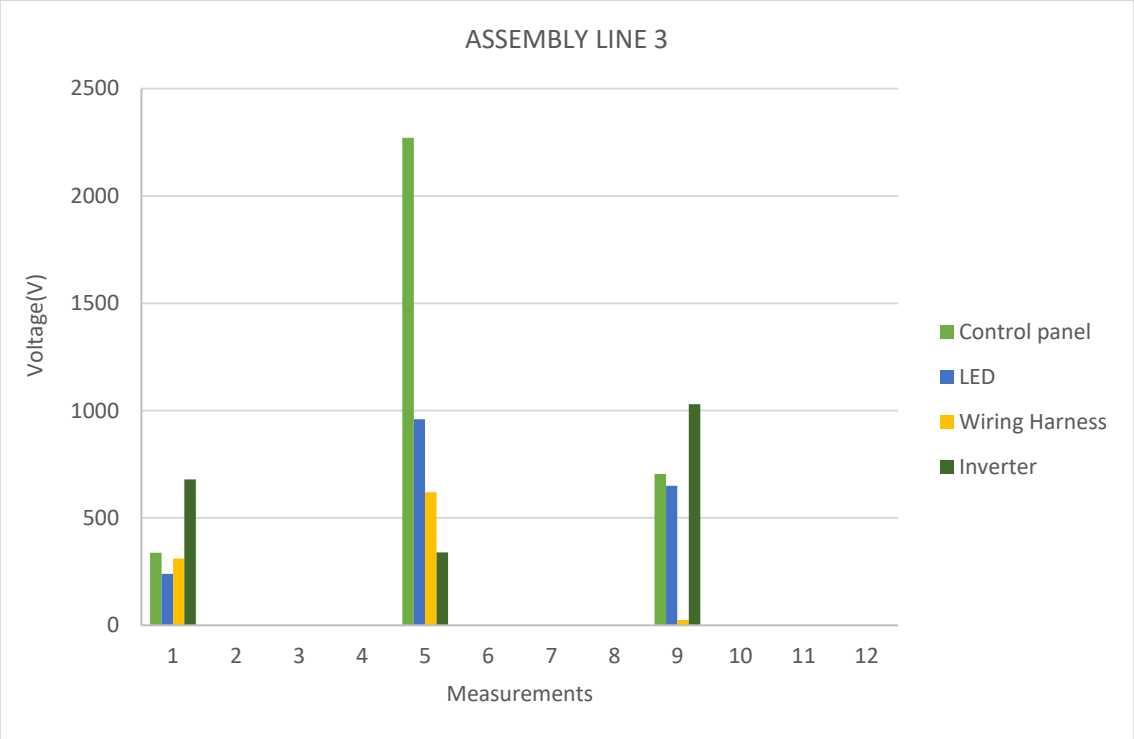


Figure 102 Electrostatic Field line 3

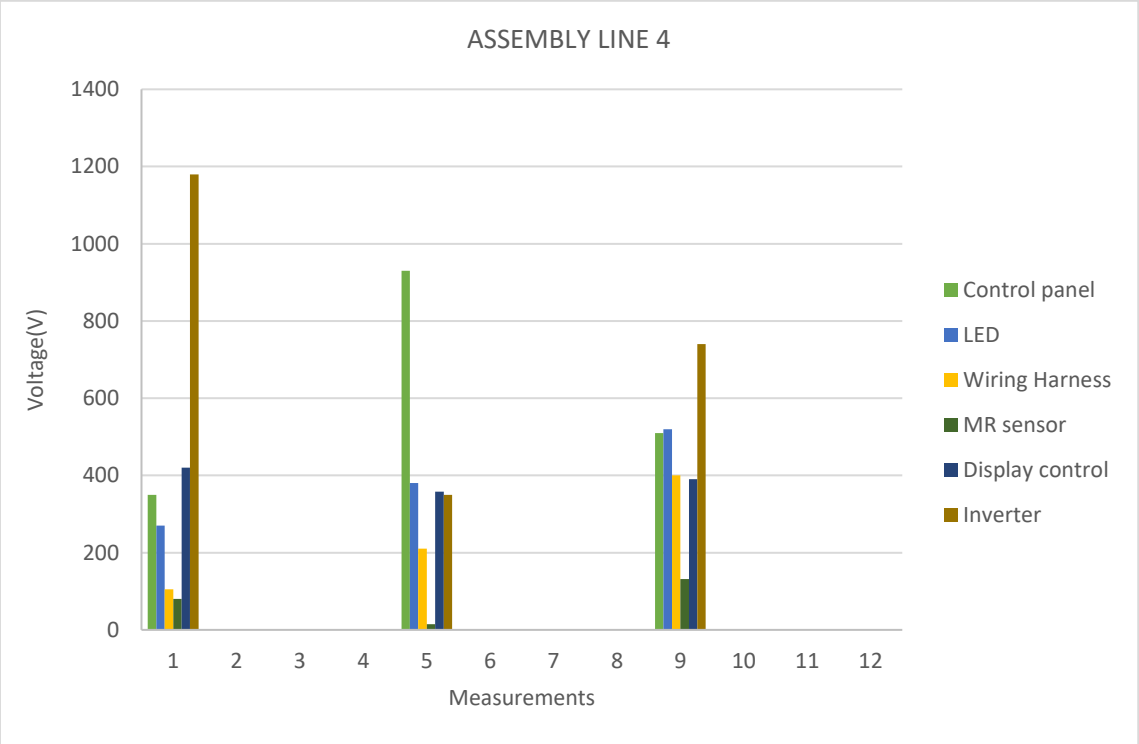


Figure 103 Electrostatic Field line 4

PRE-ASSEMBLY LINE 1		
WORKSTATION	**ACTION**	**PICTURE**
Assembly LED light	Connect a hanging metallic chain to the shelf that is in the workstation with the LED boxes, to be the shelf connected to the ground.	
Storage LED lights - "LED HOUSING"	Bring the LEDs in cardboard boxes with ESD trays closed. Store them closed until they are brought to the shelf in the workstation. Swap two nylon wheels with two metallic wheels. Put an ESD mat connected to the ground under the shelf where the LEDs are stored outside the workstation and connect a hanging metallic chain to the shelf.	
Assembly wiring harness	Connect to the ground the worksurface where the wiring harness is assembled. Put an ESD dissipative mat below the place where the trolleys are placed in the workstation.	
ASSEMBLY LINE 1		
WORKSTATION	**ACTION**	**PICTURE**
Assembly control panel	Put a metallic shelf connected to the ground for the boxes with the panels in the workstation, instead of a milkround wagon that is not connected to the ground.	
Assembly of the inverter	Connect a hanging metallic chain to the shelf where the inverters are placed.	
Assembly Display Control	Connect a hanging metallic chain to the movable shelf where the boxes with the display controls are placed inside the EPA.	

Table 28 Improvement proposals for Assembly line 1

The control panel in the Line 1 was brought in the milkrun and they left the milkrun wagon there, not connected to the ground. Therefore, I proposed to place a metallic shelf of Bosch profile made of Aluminum connected to the ground by yellow connectors. The same happened with the case of the control panel in Line 2. It was designed the shelf using SolidWorks with similar dimensions to the milkrun wagon, and I placed an upper bar to place an ionizer because the control panels came high charged because of the tarpack boxes(Line 2) and tarpack divisors(Line 1).

PRE-ASSEMBLY LINE 2		
WORKSTATION	**ACTION**	**PICTURE**
Assembly LED light	Place a bigger ESD dissipative mat in the floor where the LED is connected to the refrigerator cube or stablish that area as an EPA area. Actually there is an ESD mat not connected to the ground. Connect a hanging metallic chain to the table where the cardboard box is located. Exchange that table (insulative surface) with other dissipative or metallic.	 
Assembly wiring harness	Connect to the ground the worksurface where the wiring harness is assembled. Put an ESD dissipative mat below the place where the trolleys are placed in the workstation and connect it to the ground. The workstation is not an EPA area and it should be.	
ASSEMBLY LINE 2		
WORKSTATION	**ACTION**	**PICTURE**
Assembly control panel	Put a shelf connected to the ground for the boxes with the panels that are going to be opened on that shelf, instead of a milkround wagon that is not connected to the ground. Put the door sensors in an ESD box, not in a blue insulative box.	 
Pre-assembly inverter	The connections to the inverter are made in a non EPA area. There should be placed an ESD mat and the shelves and worksurfaces connected to the ground.	

Table 29 Improvement proposals for Assembly line 2

In the case of the pre-assembly of the inverter in line 2, it is carried out in an area that is not an EPA, and since there connections are made to the PCB of the inverter, there could be a risk that an electrostatic discharge occurs.

We can observe in the Figure 104 the shelf that was designed in SolidWorks for both assembly lines 1 and 2. These two shelves will be connected to the ground (to the dissipative floor). The ionizer will be placed in the middle point of the upper bar focusing on the electronics it has below. For the ionizer, it was the possibility of purchasing the aerostat 7500 XC shown in Figure 106 or the aerostat FPD shown in Figure 105. The action area for each ionizer is shown in Figure 107 and Figure 108.

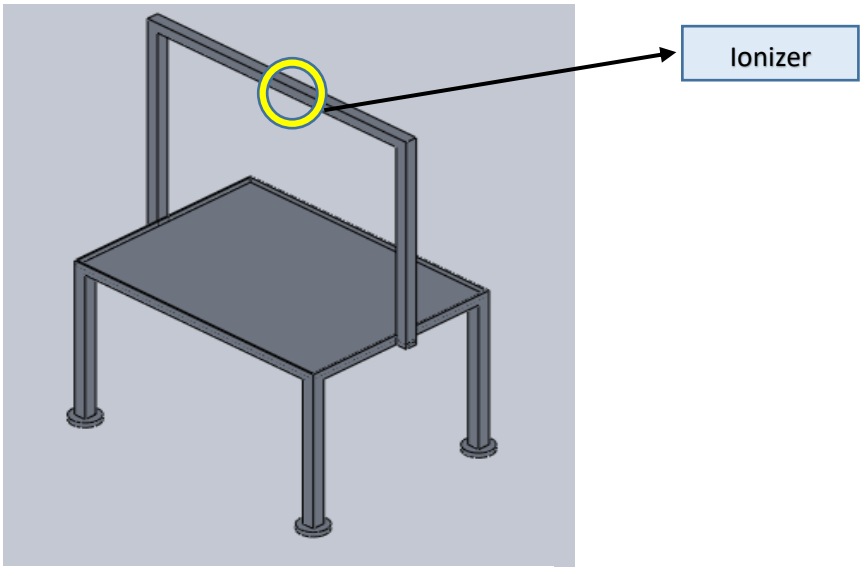


Figure 104 Designed shelf for line 1 and line 2 control panel workstation

Figure 106 Ionizer aerostat XC

Figure 105 Ionizer aerostat FPD

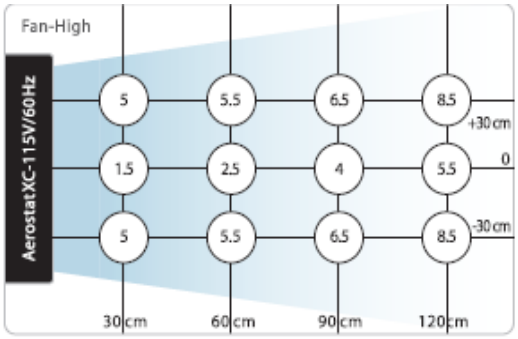


Figure 108 Action area aerostat XC

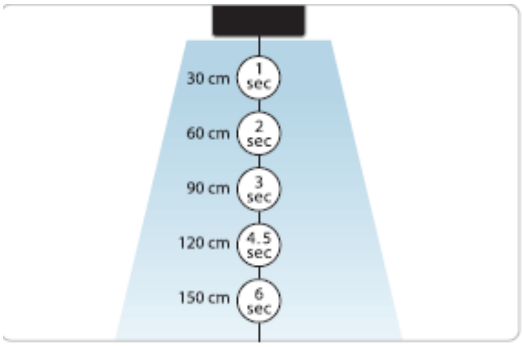


Figure 107 Action area of aerostat FPD

Since the ionizer aerostat XC covers more area of discharging, and is cheaper, it was chosen for the use in the shelf of lines 1 and 2.

For the third line of the refrigerator in the factory, the main proposal is to ground all the shelves and worksurfaces. The problem is that if, for instance, the shelf containing the LEDs is grounded, the effect will not make any difference because the LEDs are stored in an insulative box with insulative trays and the charge will remain in the LEDs. The same happens in the assembly line four.

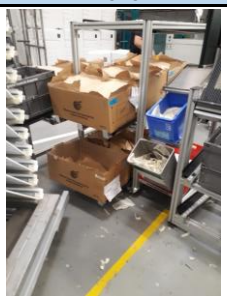
PRE- ASSEMBLY LINE 3		
WORKSTATION	**ACTION**	**PICTURE**
Assembly wiring harness	Swap two nylon wheels with two metallic wheels of the shelf. Connect the shelf to the ground with a hanging metallic chain. To do so put an ESD mat below the shelf and connect it to the ground because the EPA floor is not big enough.	
Assembly LED light	Swap two nylon wheels with two metallic wheels. Connect the shelf to the ground with a hanging metallic chain.	
ASSEMBLY LINE 3		
WORKSTATION	**ACTION**	**PICTURE**
Assembly control panel	Swap two nylon wheels with two metallic wheels. Connect the shelf to the ground with a hanging metallic chain	
Pre-assembly inverter	Connect the shelf where the inverters are placed to the ground with a hanging metallic chain as well as the worksurface where the connections are made	

Table 30 Improvement proposals for Assembly line 3

PRE- ASSEMBLY LINE 4		
WORKSTATION	**ACTION**	**PICTURE**
Assembly wiring harness	Swap two nylon wheels with two metallic wheels. Connect the shelf to the ground with a hanging metallic chain. To do so put an ESD mat below the shelf and connect it to the ground.	
Assembly LED light	Swap two nylon wheels with two metallic wheels. Connect the shelf to the ground with a hanging metallic chain	
ASSEMBLY LINE 4		
WORKSTATION	**ACTION**	**PICTURE**
Assembly control panel	Swap two nylon wheels with two metallic wheels. Connect the shelf to the ground with a hanging metallic chain	
Assembly Display Control	Connect a hanging metallic chain to the movable shelf where the boxes with the display controls are placed inside the EPA.	
Pre-assembly inverter	Connect the shelf where the inverters are placed to the ground with a hanging metallic chain as well as the worksurface where the connections are made between the control panel and the inverter	

Table 31 Improvement proposals for Assembly line 4

Glass door workstation

There is a variant in the refrigerator manufacturing in which the door is made of glass. In Esquiroz, the glass is not manufactured; it comes directly from the supplier. In a workstation apart from the assembly lines, there is a door foaming station for the assembly of the glass door.

If the variant of the glass door comes with electronics, it is mounted here. However, this workstation is not prepared as an EPA. We received a notification from the quality department, that there were happening problems with the electronics of the glass door. Therefore, it was studied quicker the workstation and made measurements.

In the workstation, three workers rotate their role. One of them picks the door from the machine with an automatic tool and places it in the ground to assemble the electronics in a gap that is in the upper part of the door.

I went there and measured the Rgp and HBV (Human Body Voltage) of the workers with them standing up in the small ESD mat that was there. In addition, I measured the Electrostatic Field of the electronics, which sometimes came in insulative boxes from the warehouse because they took them out from the original package, the gap connection, the foamed door and the glass. We can observe the measurements in Figure 109 and Table 35.

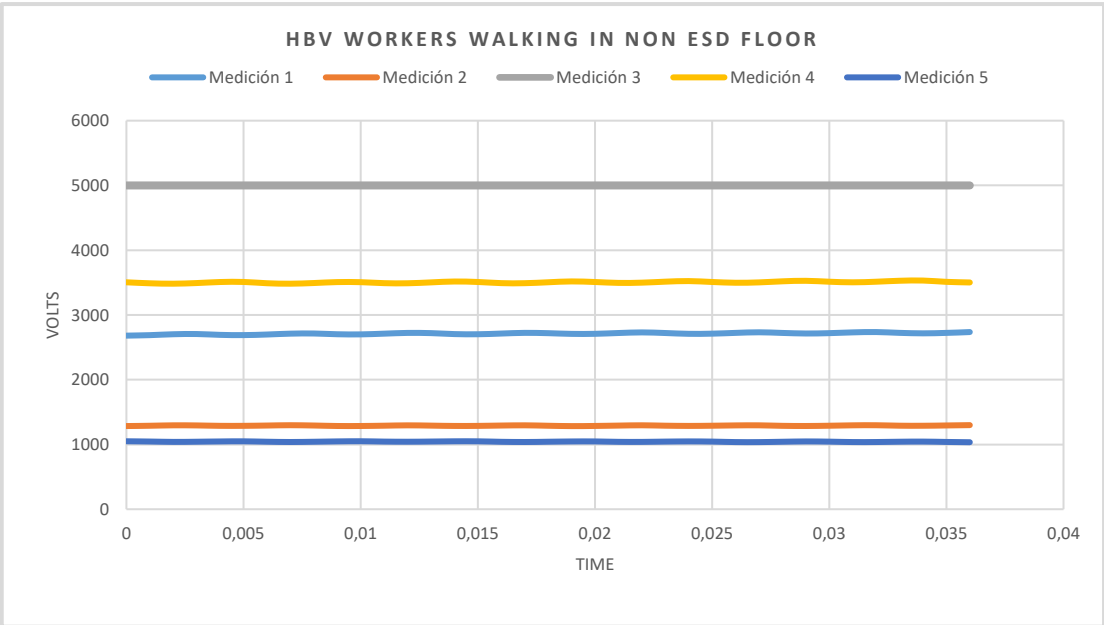


Figure 109 HBV workers in glass-door workstation

Rgp WORKERS GV550 ASSEMBLY LINE at 22ºC 38 % RH		
Limit	**Rgp≤1x10^{9}**	
Nº	**ESD footwear**	**VALUE(Ω)**
1	YES	1,68x10^{9} Ω
2	YES	5,44x10^{8} Ω
3	NO	8,99x10^{8} Ω

Table 35 Rgp workers glass-door workstation

The next step was to measure the glass door electronics voltage to know how charged they were. It was found that the electronics were high charged as well as the wiring gap connection where the electronic is assembled. We can observe the different voltages of the different items of the workstation measured in Figure 110.

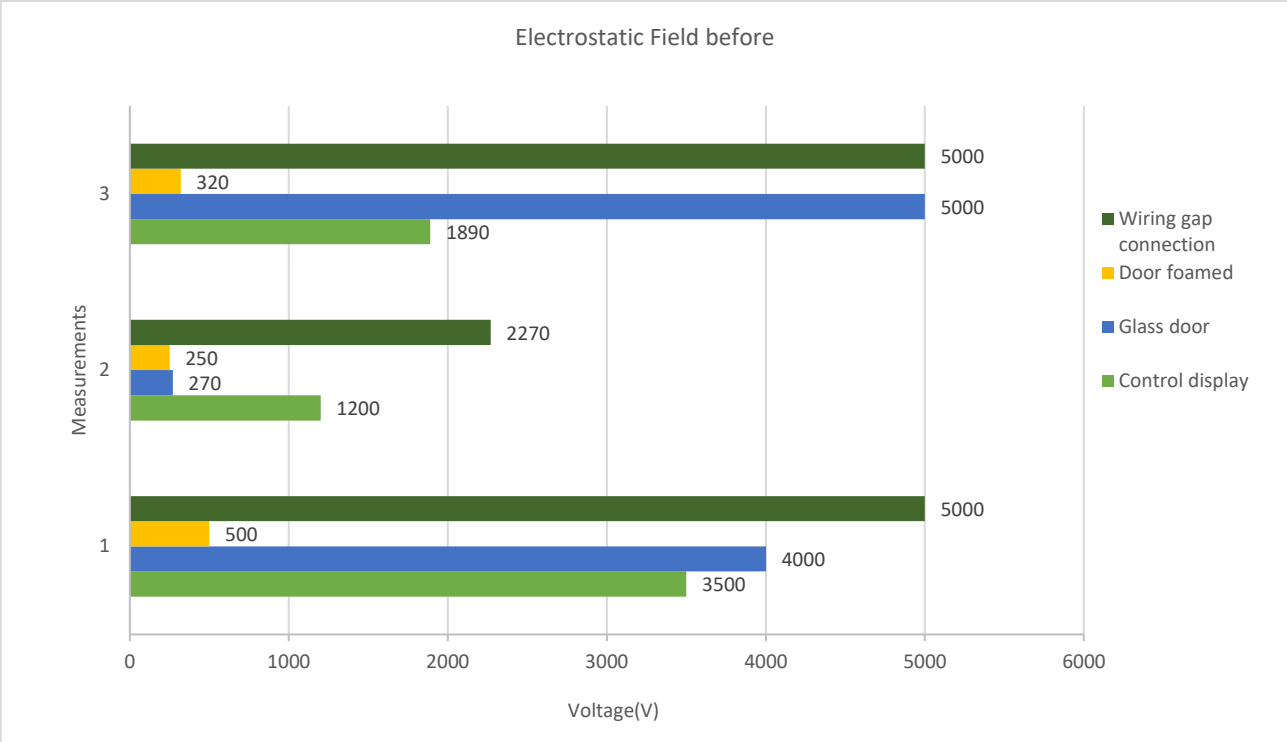


Figure 110 Electrostatic field before the changes

Knowing the high voltages of the wiring gap connection and the control display, some improvement proposals were stated as it follows:

- Place a bigger ESD mat in the floor where the electronics is assembled, because it might occur that the worker is not assembling with the feet on the mat and therefore not grounded.

- Connect to the ground the shelf where the electronics are stored and the ESD mat.

- Place an ionizer in the automatic tool focusing to the wiring connection gap, which has a high charge.

It was chosen a nozzle type ionizer called IZN10 from the SMC catalogue, as we can see in Figure 111 and Figure 112.

Figure 112 Ionizer SMC IZN10-01P06

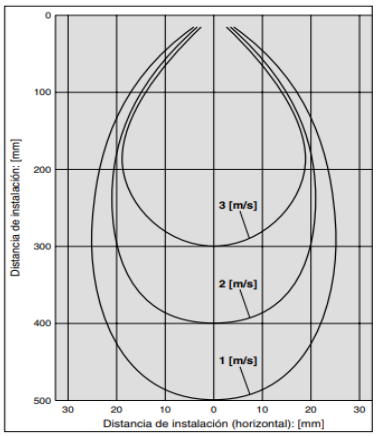


Figure 111 Action area IZN10

Some changes were made immediately, like placing a bigger ESD mat, and then the shelf and the mat were connected to the ground by a copper pike screwed to the ground. However, instead of placing the IZN10 ionizer focusing to the wiring gap, it was placed an aerostat XC ionizer focusing on the electronics that were placed in the shelf in the workstation. Therefore, since the electronics are inside dissipative pink bags, the ionizer only acted when they were taken out from the bags, and the wiring gap was still charged.

We can see the differences between before and after the implementation of the improvement proposals in the workstation in Table 36 and the changes in the voltage in Figure 113.

BEFORE	AFTER
	

Table 36 Situation of the Workstation before and after the changes

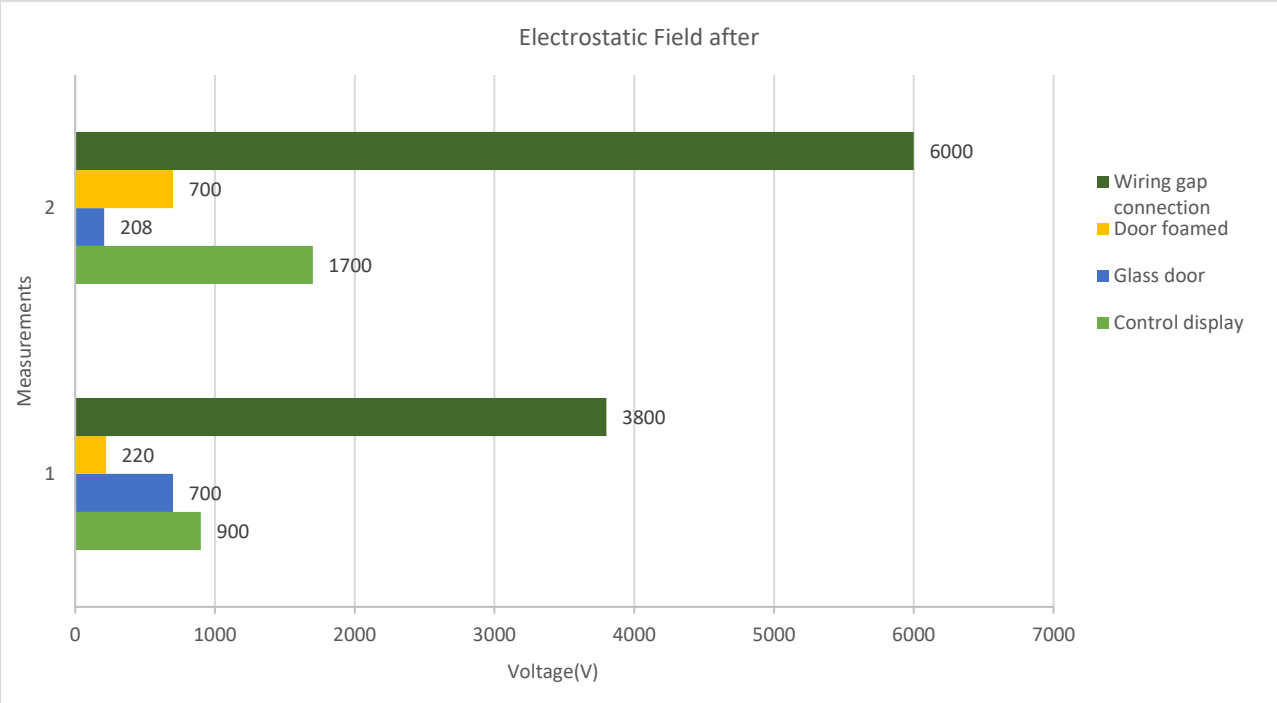


Figure 113 Electrostatic field after the changes

Cubes area in the assembly lines

As I have explained before in the production process, the cubes are made from an impact resistant plastic. The granules of ABS are transformed into sheets, that later are heated and transformed into what we call the cube. All the process of manufacturing until the cube is released to the assembly lines; the plastic is constantly acquiring charge because of the continuous contact and separation of the suckers, and the friction with the rollers. I measured the electrostatic field of the cubes when they were released to the first workstation of each assembly line and I found a voltage of 20000 V. We can see the areas that release the cube in each assembly line in Table 37.

LINE 1	LINE 2
	
LINE 3	**LINE 4**
	

Table 37 Cubes areas

The lines 3 and 4 carry out the die cutting of the cube by a collaborative robot that contains a laser, and in the lines 1 and 2, a machine cuts the perimeter and does the die cutting. Measurements were made three different days for the cubes in each assembly line, and it was found the following in Figure 114.

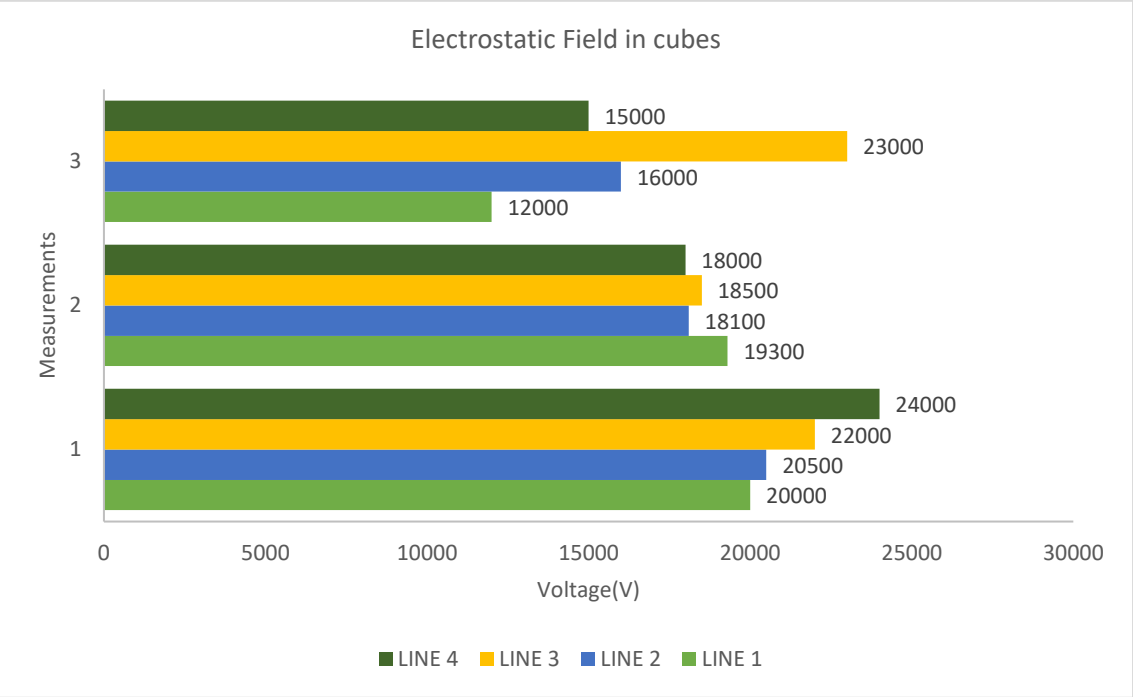


Figure 114 Electrostatic Field in cubes

Since the cube is made of plastic, the only way of discharging it is using an ionizer. A very powerful ionizer because in just a few seconds it has to be discharged.

If the cube has this high charge, it could be transferred to the wiring harness and since it is connected to all the electronics of the refrigerator, there is a high possibility of damaging, at least in the pre-assembly phase, because before the assembly line it is carried out the foaming and the charge decreases.

Therefore, what I propose for this problem found is the following:

- **Line 1**: place an ionizer below the rollers when the cube is released, with a sheet below the ionizer so that the air goes directly to the volume of the cube. The problem is that the cubes are taken directly from the release; there is no stop between to allow the discharge process. I suggest to make a stop before the LEDs are assembled.

- **Line 2**: since the cubes descend to the assembly of the LEDs by a ramp, I propose to place a very powerful ionizer below the ramp, focusing in the cubes and discharging them. I designed how the hole in the ramp would be in that case. The design for the ramp is shown in Figure 115.

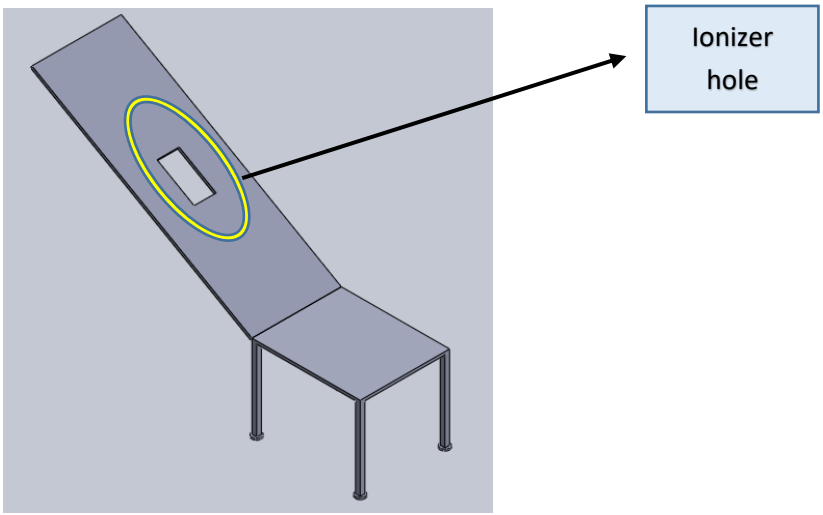


Figure 115 Gap design in the ramp of the cubes for the ionizer

- **Lines 3/4**: in this assembly line, there is a hot melt workstation where the cube is stopped for some time, so it could be used the same ionizer in line 4, with a sheet below and removing some rollers so that the ionizer only acts in the cube.

Since the cubes contain a high charge of 20 kV, it is needed a powerful ionizer that in just a few seconds can discharge more or less totally the cube. Therefore, it was chosen the ionizer volumION, from the "electrostatica" company catalogue, which is made of a double turbine and three eliminator bars; powered with a high voltage transformer. We can see this ionizer in Figure 116 and Figure 117.

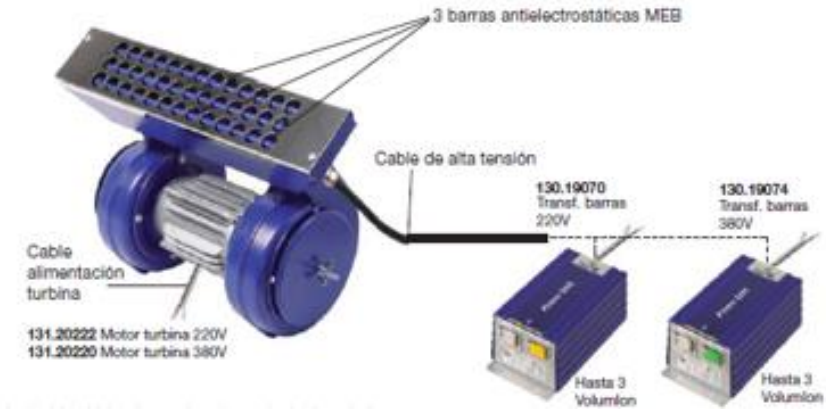


Figure 116 Ionizer volumION

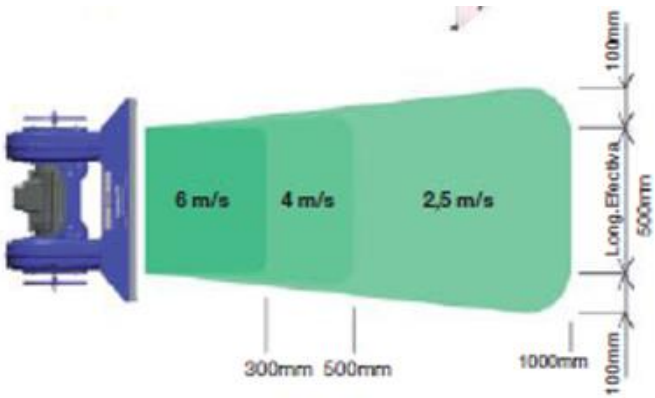


Figure 117 Action area of the ionizer volumION

4.3. Laboratory ESD study

There is a quality laboratory in the factory where they mainly simulate the electronics performance of the refrigerator and they see which problems they have.

In the laboratory it is analyzed the components that have came from the market, damaged as it is told by the technical service, and components that usually fail in the assembly line.

If they fail in the assembly line, first they are reprogrammed in the same workstation and if they continue not working then they are taken to the laboratory.

In the case of the dishwasher, there is available the equipment for the testing of the power module but they are not doing it yet. If there is a failure in the functional tests in the assembly line of the dishwasher, they try to solve it there and if they cannot, the power modules are taken for the future test or as scrap.

The laboratory is composed of one table with its specific equipment, where they test the refrigerator electronics. There are two ionizers placed high above the table. The electronics are stored in cardboard boxes in the floor, or on an ESD mat in the floor.

There is a footwear tester where the worker should be tested before handling with the electronics. However, there is no available report of the results. In the laboratory, now, there is only one worker, but the result should be reported. I measured the worker and the charge (HBV) she had was nearly 0 V as we can realize in Figure 118.

I think that the two ionizers the laboratory has, are too far from the electronics and won't act very efficiently. I propose to place them closer to the table. In Table 38 we can see the distribution of the laboratory.

LABORATORY


Table 38 Laboratory

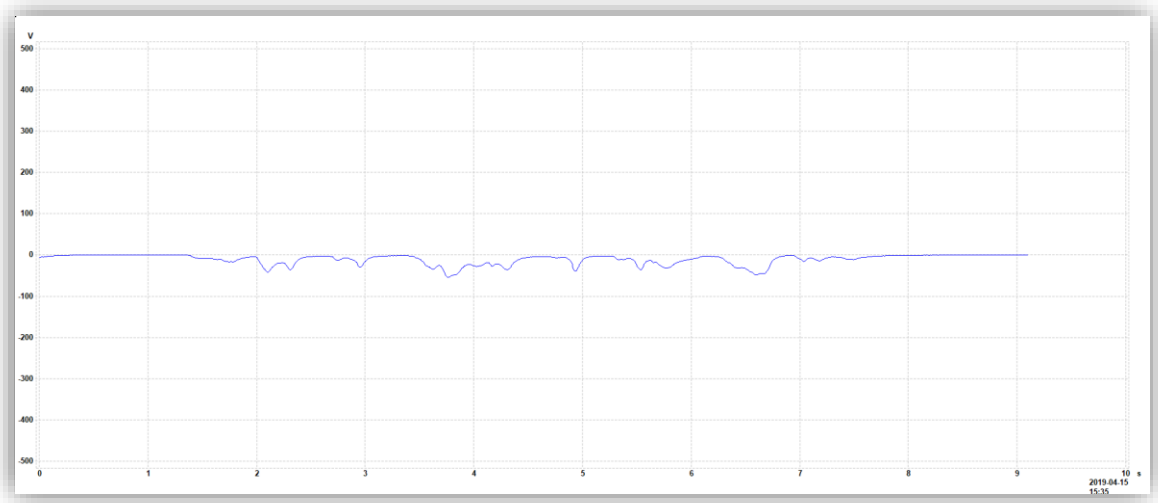


Figure 118 HBV worker laboratory

Some measurements with regard to the workstation resistances were made, such as shelves and worksurfaces. It was found that all of them were dissipative; but the tables of the fridge and the refrigerator are in the limit between dissipative and insulative. A good option would be to replace them for ones that are surely dissipative, or place dissipative mats in the tables.

The electrostatic field of some electronic components was also measured, finding a maximum value of 139 V, so we can conclude that there is no risk of discharge if the personnel is grounded. We can observe the measurements made in Table 39 and Table 40.

Measurements at 21,3 ºC 36,2 %		
Resistance	**Item**	**Result**
Rgp	Fridge worksurface	$7{,}74 \times 10^{9}$ Ω
Rgp	Dishwasher worksurface	$2{,}06 \times 10^{10}$ Ω
Rpp	ESD floor mat	$2{,}5 \times 10^{7}$ Ω
Rpp	Floor	Dissipative

Table 39 Rgp and Rpp laboratory

Measurements at 24 ºC 46 %		
Resistance	**Item**	**Result**
SR	Fridge table	1×10^{10} Ω
SR	Dishwasher table	2×10^{10} Ω
Electrostatic Field	**Item**	**Result**
1	Control panel 1	32 V
2	Control panel 2	5 V
3	Control panel 3	88 V
4	Control panel 4	139 V
5	LED	3 V

Table 40 SR and EF laboratory

5. Budget

The development of this project of ESD protection will succeed if the improvement proposals are good, but also if the changes are cheap and do not imply a high budget for the company. Therefore, to know how much money is needed to carry out the changes for improving the protection, it is going to be estimated a budget for the project.

As I have said before, the mechanical changes (connections to the ground of shelves, dissipative floors…) is done by a technician of the maintenance department. For each assembly line in which changes are going to be made, a work report is opened, as we can see in Figure 119.

Orden	Clase de orden	Fe.inic. extrema	Texto breve	Equipo	Denominación	Cst.tot. reales	Status sistema
547545437	PM07	20190222	Puesta tierra estanterías por ESD	4035103	CADENA MECHANICA GV	197,09 €	CTEC NOTP IMPR KKMP NLIQ PREC

Orden	Clase de orden	Fe.inic. extrema	Texto breve	Equipo	Denominación	Cst.tot.reales	Status sistema
547604905	PM07	20190509	Acciones prevención ESD	4016425	CADENA DE MONTAJE Nº1	0,00 €	LIB. IMPR KKMP NLIQ PREC

Orden	Clase de orden	Fe.inic. extrema	Texto breve	Equipo	Denominación	Cst.tot.reales	Status sistema
547604904	PM07	20190509	Acciones prevención ESD	4016435	CADENA DE MONTAJE Nº2	0,00 €	LIB. IMPR KKMP NLIQ PREC

Orden	Clase de orden	Fe.inic.extrema	Texto breve	Equipo	Denominación	Cst.tot.reales	Status sistema
547604903	PM07	20190509	Acciones prevención ESD	4049361	CADENA DE MONTAJE Nº3	13,88 €	LIB. NOTP IMPR KKMP NLIQ PREC

Orden	Clase de orden	Fe.inic.extrema	Texto breve	Equipo	Denominación	Cst.tot.reales	Status sistema
547604901	PM07	20190507	Acciones prevención ESD	4049359	CADENA DE MONTAJE Nº4	20,10 €	LIB. NOTP IMPR KKMP MOVM NLIQ PREC

Figure 119 Work reports

We have to say that the total costs that involve the time working of the technician, are so low in the refrigerator assembly lines because they are carrying them out now.

To calculate the total budget of the project, it has been taken into account the needed material resources, the workforce that involves the technicians of the maintenance department to do all the changes, and the labor of the worker in the process-engineering department to carry out the project. For the worker, it has been taken into account the medium salary of an industrial engineer [13].

In the following Figure 120 and Figure 121 we can see in more detail the data from the costs that the technicians have supposed to the company in the dishwasher assembly line and the glass door workstation, and that we will take into account for the total cost of the project. For the four assembly lines of the refrigerator, the changes are being implemented at the moment so the cost will be speculated.

Orden 547545437 Puesta tierra estanterías por ESD
Clase de orden PM07 Modific.-Constr. medios de fabricación
Centro 5211 BSH Electrodomést. España FRFE

Versión plan 0

Datos acumulados
Valoración legal
Moneda de sociedad/objeto

Cl.coste	Clase de coste (Texto)	Σ	Plan total	Σ	Tot.csts.reales	Σ	Desv.plan/real	Mon.	Ce.coste	Mater...	Tp. orig...	ClAct	Σ	Pl.fjo	Origen (Texto)	Ce.coste
85112000	FACTURACION MANTENIMIENTO		0,00		30,59		30,59	EUR	CM8502...		KL	POT		0,00		MANTEN...
85112000	FACTURACION MANTENIMIENTO		0,00		166,50		166,50	EUR	CM8502...		KL	POT		0,00		MANTEN...
		▪	**0,00**	▪	**197,09**	▪	**197,09**	**EUR**					▪	**0,00**		
83221000	LIQUIDACION ORDENES MANTENI...		0,00		30,59-		30,59-	EUR	CM8502...		KL	POT		0,00		MANTEN...
83221000	LIQUIDACION ORDENES MANTENI...		0,00		166,50-		166,50-	EUR	CM8502...		KL	POT		0,00		MANTEN...
		▪	**0,00**	▪	**197,09-**	▪	**197,09-**	**EUR**					▪	**0,00**		
		▪▪	**0,00**	▪▪	**0,00**	▪▪	**0,00**	**EUR**					▪▪	**0,0...**		

Figure 120 Work report technician dishwasher

Orden 547579928 Informe ESD, montaje puertas cristal
Clase de orden PM02 Orden de mantenimiento preventivo
Centro 5211 BSH Electrodomést. España FRFE

Versión plan 0

Datos acumulados
Valoración legal
Moneda de sociedad/objeto

Cl.coste	Clase de coste (Texto)	Σ	Plan total	Σ	Tot.csts.reales	Σ	Desv.plan/real	Mon.	Centro coste	Mater...	Tp. orig...	ClAct	Σ	Pl.fjo	Origen (Texto)	Ce.coste
62200000	Reparación y conservación equipo ...		39,05		39,05		0,00	EUR						0,00	(sin origen)	
85112000	FACTURACION MANTENIMIENTO		0,00		374,64		374,64	EUR	CM850201		KL	POT		0,00		MANTEN...
		▪	**39,05**	▪	**413,69**	▪	**374,64**	**EUR**					▪	**0,00**		
83121000	LIQUIDACION ORDENES MANTENI...		0,00		39,05-		39,05-	EUR	K950403					0,00	(sin origen)	PUERTA...
83221000	LIQUIDACION ORDENES MANTENI...		0,00		374,64-		374,64-	EUR	CM850201		KL	POT		0,00		MANTEN...
		▪	**0,00**	▪	**413,69-**	▪	**413,69-**	**EUR**					▪	**0,00**		
		▪▪	**39,05**	▪▪	**0,00**	▪▪	**39,05-**	**EUR**					▪▪	**0,0...**		

Figure 121 Work report technician glass door refrigerator

In Table 41 and Table 42 we can find the cost that the necessary material resources to carry out the improvement proposals have involved. In Table 43 we have the total cost of the money that the company has paid to the technicians in charge of making the changes.

Material resources			
Component	**Price (€)**	**Quantity**	**Total cost (€)**
ESD box with lid (400x300x185mm)	30	4	120
ESD box (300x200x125mm)	7,71	30	231,3
Aluminum chain/yellow grounding connectors GV+FR	1,25 €	35	43,75 €
Aluminum wheel GV+FR	1,25 €	22	27,50 €
Ionizer volumION double turbine 380 V	1220,1	4	4880,4
U. power supply 7kV 230V 50Hz UL	482	4	1928
Ionizer SMC IZN10-01P06, 24V dc, 0 ven	500,44	1	500,44
Ionizer AEROSTAT XC	615	2	1230
Yellow grounding connectors GV+FR	0,5	7	3,5
	Total(€)		**8964,89**

Table 41 Material resources cost

Surface components cost			
Component	Price (€)/ m2	Surface(m2)	Total cost (€)
ESD mat GV emotion light	35,46	1,278	45,32
ESD mat GV cut area door sensor+aquasensor	35,46	1,14	40,42
ESD mat FR wiring harness line 2	35,46	0,612	21,70
ESD mat FR pre-assembly inverter line 2	35,46	1,644	58,30
ESD mat FR functional tests	35,46	1	35,46
Aluminum sheet	5	4	20,00
	Total(€)		221,20

Table 42 Surface material resources cost

Maintenance workforce	
Type	Price (€)
Workforce GV	197,09
Workforce FR	1202,05
Total(€)	1399,14

Table 43 Maintenance workforce cost

For the cost that the worker involve, we have taken into account the total salary per year that a common industrial engineer receives, which is 26378, and we have counted the hours dedicated to the project, see it in Table 44. Taking into consideration the social insurance cost, and the hours dedicated, the worker cost is shown in Table 45.

Time invested by the worker	
Task	Time(h)
Previous study of the topic	32
Analysis of the current situation	64
Making measurements and studying	160
Stablish the plans of actions	87
Total hours	343

Table 44 Amount of time invested in the project by the worker

Salary of the worker + Social Insurance	
Salary/year (€)	26378
Social insurance (32%)	8440,96
Total(€)/year	34818,96
Total(€)/month	2901,58
Total(€)/hour	18,13
Total(€) -hours invested in the project-	6220,26

Table 45 Worker cost

Summing all the costs of the different part that the budget of the project contains, we found a total budget for the project of **16805, 49 €.** The cost for the project is lightly expensive, due to the ionizers, and the workforce of the engineer, which have the greatest contribution to the budget.

6. Conclusions and future lines

6.1 Conclusions

The ESD protection is very important for the industries that manufacture the electronic components, because without a proper protection, their products would fail and they will not have any benefit. In other factories that manufacture other products with electronic components, it is also important the protection in the whole manufacturing process.

Since the electrostatic discharges damages could not be seen with the human eye, when the product fails after being released to the market, sometimes it is said to be due to ESD. In addition, the ESD protection involves a high cost for the company, for instance, the dissipative painting costed to BSH Esquiroz around 5000 €, only to paint the floors, and the ionizers are also very expensive devices, with the budget calculated for this project we can conclude that is an expensive measure. The benefit that this protection could give is not given immediately, but there is evidence that when the protection increases, the losses in the market decrease. Therefore, if a company contains electronic components in its manufacturing process, that usually are the brain of most of the manufactured products, and wants to maintain a high quality and product reliability, the ESD protection should be implemented.

We can say that this project answers the main objectives that were mentioned at the beginning. A complete previous acquisition of knowledge about ESD has been made, stablishing guidelines that could be used in the future by any worker that wants to do an internal audit or study in BSH or a new study about the topic in other factories. Later, an ESD study for all the electronic components that are handled in this factory was carried out, identifying the weaknesses points that it has in ESD protection, and consequently several improvement proposals have been stated and communicated to the company.

Moreover, some improvement proposals have been implemented in the assembly lines, such as grounding connections, done by the maintenance department. If all the improvement proposals are done in the future, the ESD protection will increase for BSH Esquiroz, but all of them need to be done, because one proposal implies the other. For instance, a shelf can be grounded but if the packaging of the electronic component in that shelf is insulative, then almost nothing will change because the discharge will not happen. Everything needs to be controlled to reduce the risk for an electrostatic discharge.

Finally, from the point of view of my own learning, I did not know much about how an electrostatic discharge was produced and the damages that could have in an electronic component. By now, I can say that I feel up to study any manufacturing process with respect to ESD and quickly know the changes that are necessary to be made.

6.2 Future lines

To continue with this project, the study could be extended if the factory had an ESD laboratory, and the failed products from the technique service were studied there to know if the reason of failure was ESD. In addition, the different test simulations (HBM, MM and CDM) could be done there to know the sensibility of the electronic components used in the manufacturing process. However, this laboratory is very expensive and only a few manufacturing companies of electronic components have it.

On the other hand, I only could measure the human body voltage in the refrigerator for two workstations, because of the limited time. I would like to have measured people working in the inverter pre-assembly area, the LED and wiring harness assembly, control display assembly and in the functional tests area. All those workstations can have an influence in the damaging of the electronics. In addition, next to the building of the plant, certain quantity of dishwashers and refrigerators is brought to another building called the audit area, where their performance is tested. I would like to evaluate whether the actions there have an influence for ESD or not.

The improvement proposals that have not been implemented yet are the ones that included the volumION ionizer for the high charge present in the cubes of the refrigerator, and the shelf construction for lines 1 and 2. However, I designed how it would be the design for the shelf and how the ionizers should be placed in all the cases; and I can say that in the future these proposals would be carried out in all likelihood because BSH Esquiroz is aware of the importance that the ESD may have in the market failures that they have.

Moreover, the ESD due to the static electricity is not a problem reduced to the electronic components themselves. The plastic sheets from which the cubes are made, have a high static electricity and they attract the dirty, which is why some sheets when they are stored in shelves, the first ones of the piles have small black points. In the case of the dishwasher, the glass of a panel had a lot of dust due to the static electricity and the display could not be seen properly, a quality problem too. I think a good idea would be to study these facts, search solutions for them and learn more about the static electricity problems in the whole factory.

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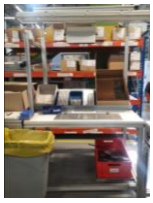
INDEX ANNEX

1.ANNEX I – PRODUCT QUALIFICATION DISHWASHER

WORKSTATION	ASSEMBLY POWER MODULE	
ESDS Component	Power module (PM)	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	Boxes are closed and stocked on wooden pallets in metallic shelves screwed to the concrete floor The metallic shelves are built with nylon rollers with a metallic support at the end. SR wooden pallet= $6x10^9$ Ω - Dissipative	
Measurements 23 ºC 41 % RH	SR(Superficial Resistance) carbdoard=$1x10^{10}$ Ω Electrostatic field(V/m x 2 cm)= 50 V -82 V- 150 V	
Milk run delivery	Boxes are closed and delivered unopened to the EPA using a metallic painted milkround with rubber wheels	
Check	OK	
RECEIVING		
Supply packaging	27 units per box Cardboard box with cardboard divisors	
ESD label in the packaging	YES	
Standards	IEC 61340-5-1	
Limits	$1x10^4$ Ω ≤ Rpp ≤ $1x10^{11}$ Ω	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) carbdoard=$1x10^{10}$ Ω Electrostatic field(V/m x 2 cm)= 42 V - 58 V- 60 V	
Material packaging	Dissipative	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Direct assembly on dishwasher	
Assembly line shelving	Metalic shelf fixed to the ground with nylon sliding wheels and metal support at the end of the shelf The ESDS is manipulated from the EPA floor	
Connection to ground	YES	
Assembly line storage	NO STORAGE	
Connection to ground	N/A	
ESDS ground label	NO	
Check	OK	

WORKSTATION	PRE-ASSEMBLY CONTROL MODULE	
ESDS Component	Control module Siemens(CM)	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	Boxes are closed and stocked on wooden pallets in metallic shelves screwed to the concrete floor The metallic shelves are built with nylon rollers with a metallic support at the end. SR wooden pallet= $6x10^9$ Ω - Dissipative	
Measurements 23 ºC 41 % RH	SR(Superficial Resistance) carbdoard=$4x10^9$ Ω Electrostatic field(V/m x 2 cm)= 30-50 V	
Milk run delivery	Boxes are closed and delivered unopened to the EPA using a metallic painted milkround with rubber wheels	
Check	OK	
RECEIVING		
Supply packaging	100 units per box Cardboard box with cardboard divisors	
ESD label in the packaging	YES	
Standards	IEC 61340-5-1	
Limits	$1x10^4$ Ω ≤ Rpp ≤ $1x10^{11}$ Ω	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) carbdoard=$4x10^9$ Ω Electrostatic field(V/m x 2 cm)= 305 V	
Material packaging	Dissipative	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Control module pre-assembly on design factory Fascia panel preassembled are delivered to assembly line workstation	
Assembly line shelving	Metal support connected to a table worksurface that is connected to the ground ESDS manipulated from the EPA area Boxes are brought to the worksurface closed	
Connection to ground	YES	
Assembly line storage	Cardboard boxes in metallic painted shelves not screwed to the ground outside the EPA as well as on pallets with SR = 6x109 Ω - Dissipative The legs are made of metal and the shelves of a cardboard rubber with SR=4x1010 Ω (23ªC,50%) Boxes should me moved from the shelves to the EPA closed	 
Measurements 22 º C 41 % RH	Shelf electrostatic field(V/m x 2 cm)= 350 V-410 V-50 V Pallets electrostatic field(V/m x 2 cm)= 415 V - 180 V- 360 V	
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

WORKSTATION	PRE-ASSEMBLY CONTROL MODULE	
ESDS Component	Control module Bosch(CM)	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	Boxes are closed and stocked on wooden pallets in metallic shelves screwed to the concrete floor The metallic shelves are built with nylon rollers with a metallic support at the end. SR wooden pallet= $6x10^9$ Ω - Dissipative	
Measurements 23 ºC 41 % RH		
Milk run delivery	Boxes are closed and delivered unopened to the EPA using a metallic painted milkround with rubber wheels	
Check	OK	
RECEIVING		
Supply packaging	66 units per box Cardboard box with cardboard divisors	
ESD label in the packaging	NO	
Standards	IEC 61340-5-1	
Limits	$1x10^4$ Ω ≤ Rpp ≤ $1x10^{11}$ Ω	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) carbdoard=$1x10^{10}$ Ω Electrostatic field(V/m x 2 cm)= 825 V	
Material packaging	Dissipative	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Control module pre-assembly on design factory Fascia panel preassembled are delivered to assembly line workstation	
Assembly line shelving	Metal support connected to a table worksurface that is connected to the ground ESDS manipulated from the EPA area Boxes are brought to the worksurface closed from shelves outside the EPA	
Connection to ground	YES	
Assembly line storage	Cardboard boxes in metallic painted shelves not screwed to the ground outside the EPA The legs are made of metal and the shelves of a cardboard rubber with SR=$4x10^{10}$ Ω (23ªC,50%) Boxes should me moved from the shelves to the EPA closed	
Measurements 22 º C 41 % RH	Electrostatic field(V/m x 2 cm)= 305 V	
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

WORKSTATION	PRE-ASSEMBLY CONTROL PANEL WITH DISPLAY	
ESDS Component	Display Control module	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	Boxes are closed and stocked on wooden pallets in metallic shelves screwed to the concrete floor The metallic shelves are built with nylon rollers with a metallic support at the end. SR wooden pallet= $6x10^9$ Ω - Dissipative	
Measurements 23 ºC 41 % RH		
Milk run delivery	Boxes are closed and delivered unopened to the EPA using a metallic painted milkround with rubber wheels	
Check	OK	
RECEIVING		
Supply packaging	56 units per box Cardboard box with plastic trays	
ESD label in the packaging	YES	Outer packaging  Inner packaging(tray) 
Standards	IEC 61340-5-1	
Limits	Rpp ≤ $9x10^4$ Ω	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) plastic tray= $5x10^4$ Ω SR(Superficial Resistance) carbdoard=$1x10^{10}$ Ω Electrostatic field(V/m x 2 cm)= 815 V	
Material packaging	Plastic tray - Conductor	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Control module pre-assembly on design factory Fascia panel preassembled are delivered to assembly line workstation	
Assembly line shelving	Metallic shelf not connected to the ground ESDS manipulated from the EPA area Boxes are brought closed to the worksurface	
Connection to ground	Workstation shelf- no Worksurface - yes	
Assembly line storage	Cardboard boxes in metallic shelves outside the EPA not screwed to the concrete ground Boxes should me moved from the shelves closed Shelves built with nylon rollers and metallic strip at the end of the rollers	 
Measurements 22 º C 41 % RH	Electrostatic field(V/m x 2 cm)= 180 V- 250 V-700 V-900 V SR metallic painted shelf= 1 $x10^{12}$ Ω - Insulative	
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

WORKSTATION	PRE-ASSEMBLY CONTROL PANEL WITHOUT DISPLAY	
ESDS Component	Control module	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	Boxes are closed and stocked on wooden pallets in metallic shelves screwed to the concrete floor The metallic shelves are built with nylon rollers with a metallic support at the end. SR wooden pallet= $6x10^9$ Ω - Dissipative	
Measurements 23 ºC 41 % RH		
Milk run delivery	Boxes are closed and delivered unopened to the EPA using a metallic painted milkround with rubber wheels	
Check	OK	
RECEIVING		
Supply packaging	56 units per box Cardboard box with plastic trays	
ESD label in the packaging	YES	Outer packaging  Inner packaging(tray) 
Standards	IEC 61340-5-1	
Limits	Rpp ≤ $9x10^4$ Ω	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) plastic tray= $5x10^4$ Ω SR(Superficial Resistance) carbdoard=$1x10^{10}$ Ω Electrostatic field(V/m x 2 cm)= 815 V	
Material packaging	Plastic tray - Conductor Cardboard - Dissipative	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Control module pre-assembly on design factory Fascia panel preassembled are delivered to assembly line workstation	
Assembly line shelving	Metallic shelf not connected to the ground ESDS manipulated from the EPA area Boxes are brought closed to the worksurface	
Connection to ground	Workstation shelf where boxes are placed- no Worksurface - yes	
Assembly line storage	Cardboard boxes in metallic shelves outside the EPA not screwed to the concrete ground Boxes should me moved from the shelves closed Shelves built with nylon rollers and metallic strip at the end of the rollers	 
Measurements 22 º C 41 % RH	Electrostatic field(V/m x 2 cm)= 650 V- 680 V- 900 V SR metallic painted shelf= 1 $x10^{12}$ Ω - Insulative	
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

WORKSTATION	ASSEMBLY SOFTENER CIRCUIT	
ESDS Component	Salt Sensor	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	Boxes are closed and stocked on wooden pallets in metallic shelves screwed to the concrete floor The metallic shelves are built with nylon rollers with a metallic support at the end. SR wooden pallet= $6x10^9$ Ω - Dissipative	 
Measurements 23 ºC 41 % RH	SR(Superficial Resistance) plastic tray= $3x10^4$ Ω SR(Superficial Resistance) carbdoard=$1x10^9$Ω Electrostatic field(V/m x 2 cm)= 15 V	
Milkround delivery	Trays are taken out of the box in the warehouse and delivered to the shelf in the EPA using a metallic painted milkround with rubber wheels	
Check	OK	
RECEIVING		
Supply packaging	Cardboard box with plastic trays 2000 sensors per box	
ESD label in the packaging	YES	Outer packaging 
Standards	IEC 61340-5-1	
Limits	Rpp ≤ $9x10^4$ Ω	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) plastic tray= $3x10^4$ Ω SR(Superficial Resistance) carbdoard=$1x10^9$Ω Electrostatic field(V/m x 2 cm)= 25 V	
Material packaging	Plastic tray - Conductor	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Direct assembly on dishwasher	
Assembly line shelving	Metallic shelf not connected to the ground with metal support at the end ESDS manipulated from the EPA area Placed in a metal support over the worksurface connected to the ground	 
Connection to ground	NO	
Assembly line storage	NO STORAGE	
Connection to ground	N/A	
ESDS ground label	YES	
Check	OK	

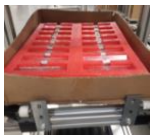
WORKSTATION	ASSEMBLY CONTROL PANEL	
ESDS Component	Door sensor	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	Boxes are closed and stocked on wooden pallets in metallic shelves screwed to the concrete floor The metallic shelves are built with nylon rollers with a metallic support at the end. SR wooden pallet= $6x10^9$ Ω - Dissipative	
Measurements 23 ºC 41 % RH		
Milk run delivery	Boxes are closed and delivered unopened to the work place where the sensors cards are cut using a metallic painted milkround	
Check	OK	
RECEIVING		
Supply packaging	5760 units per box Cardboard box with plastic paper divisors	
ESD label in the packaging	YES	
Standards	IEC 61340-5-1	
Limits	Rpp ≤ $9x10^4$ Ω	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) plastic paper= $2x10^5$ Ω SR(Superficial Resistance) carbdoard=$3x10^{10}$ Ω Electrostatic field(V/m x 2 cm)= 44 V	
Material packaging	Plastic paper - Dissipative Cardboard - Dissipative	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Manual precut of the sensor Direct assembly on dishwasher	
Assembly line shelving	The door sensors are placed in the worksurface inside an ESD conductive basket with SR=$1x10^4$ Ω (23 ºC, 50 %)	
Connection to ground	NO	
Assembly line storage	Door sensors are cut from packaging boxes that are in metallic storage racks with wheels in a non EPA area and then carried to the workstation in an ESD conductive basket	
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

WORKSTATION	ASSEMBLY EMOTION LIGHT	
ESDS Component	Emotion light	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	Boxes are closed and stocked on wooden pallets in metallic shelves screwed to the concrete floor The metallic shelves are built with nylon rollers with a metallic support at the end. SR wooden pallet= $6x10^9$ Ω - Dissipative	
Measurements 23 ºC 41 % RH	SR(Superficial Resistance) carbdoard=$7x10^9$ Ω Electrostatic field(V/m x 2 cm)= 20 V - 81 V	
Milk run delivery	Boxes are closed and delivered unopened to the EPA using a metallic painted milkround with rubber wheels	
Check	OK	
RECEIVING		
Supply packaging	48 units per box Cardboard box with cardboard divisors	
ESD label in the packaging	NO	
Standards	IEC 61340-5-1	
Limits	$1x10^4$ Ω ≤ Rpp ≤ $1x10^{11}$ Ω	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) carbdoard=$7x10^9$ Ω Electrostatic field(V/m x 2 cm)= 34 V	
Material packaging	Dissipative	
Check	OK	
PRE-ASSEMBLY/ASSEMBLY		
Assembly workstation	Direct assembly on dishwasher	
Assembly line shelving	Movable metalic shelf, with nylon sliding wheels and metal support at the end of the shelf The ESDS is manipulated from a rubber platform with metallic legs that is connected to ground	
Connection to ground	NO	
Assembly line storage	NO STORAGE	
Connection to ground	N/A	
ESDS ground label	NO	
Check	OK	

WORKSTATION	ASSEMBLY POWER MODULE	
Component	Wiring Harness	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	Boxes are closed and stocked on wooden pallets in metallic shelves screwed to the concrete floor The metallic shelves are built with nylon rollers with a metallic support at the end. SR wooden pallet= $6x10^9$ Ω - Dissipative	
Measurements 23 ºC 41 % RH	SR(Superficial Resistance) carbdoard=$1x10^{10}$ Ω Electrostatic field(V/m x 2 cm)= 50 V	
Milk run delivery	Boxes flaps are cut in the warehouse and delivered to the EPA using a metallic painted milkround with rubber wheels	
Check	OK	
RECEIVING		
Supply packaging	Cardboard box with cardboard divisors	
ESD label in the packaging	NO	
Standards	IEC 61340-5-1	
Limits	$1x10^4$ Ω ≤ Rpp ≤ $1x10^{11}$ Ω	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) carbdoard=$1x10^{10}$ Ω Electrostatic field(V/m x 2 cm)= 48 V- 28 V	
Material packaging	Dissipative	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Direct assembly on dishwasher	
Assembly line shelving	Metalic shelf fixed to the ground with nylon sliding wheels and metal support at the end of the shelf	
Connection to ground	YES	
Assembly line storage	NO STORAGE	
Connection to ground	N/A	
ESDS ground label	NO	
Check	OK	

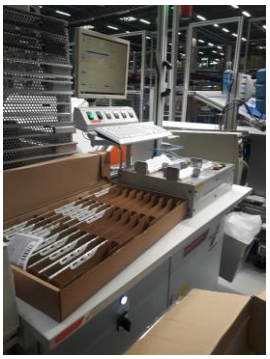
WORKSTATION	ASSEMBLY WATER SWITCH CIRCUIT	
ESDS Component	Aquasensor	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	Boxes are closed and stocked on wooden pallets in metallic shelves screwed to the concrete floor The metallic shelves are built with nylon rollers with a metallic support at the end. SR wooden pallet= $6x10^9$ Ω - Dissipative	
Measurements 23 ºC 41 % RH	SR(Superficial Resistance) carbdoard=$1x10^{10}$ Ω Electrostatic field(V/m x 2 cm)= 50 V -82 V- 150 V	
Milk run delivery	Boxes are closed and delivered unopened to the EPA using a metallic painted milkround with rubber wheels	
Check	OK	
RECEIVING		
Supply packaging	1200 units per box Cardboard box with dissipative pink bags	
ESD label in the packaging	NO	
Standards	IEC 61340-5-1	
Limits	$1x10^4$ Ω ≤ Rpp ≤ $1x10^{11}$ Ω	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) carbdoard=$2x10^{10}$ Ω SR(Superficial Resistance) pink bag =$3x10^{10}$ Ω Electrostatic field(V/m x 2 cm)= 30-40 V	
Material packaging	Dissipative	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Direct assembly on dishwasher	
Assembly line shelving	Metalic movable shelf not connected to the ground with nylon sliding wheels and metal support at the end of the shelf The ESDS is manipulated from the EPA floor	 
Connection to ground	NO	
Assembly line storage	Aquasensors are in a cardboard box in metallic storage racks with wheels in a non EPA area and then carried to the workstation in an insulative plastic basket	
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

2.ANNEX II: PRODUCT QUALIFICATION REFRIGERATOR LINE 1

WORKSTATION	ASSEMBLY LED LIGHT	
ESDS Component	LED light	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	The leds come in an insulative foam tray inside a cardboard box and are taken out of the box and placed in a plastic box. The boxes are in metallic shelves screwed to the ground.	
Measurements 23 ºC 41 % RH	SR(Superficial Resistance) carbdoard=7x10^{9} Ω Electrostatic field(V/mx2cm)= 50-120 V	
Milkround delivery	Boxes are closed and delivered unopened to the EPA using a metallic painted milkround with rubber wheels	
Check	OK	
RECEIVING		
Supply packaging	240 per box Cardboard box with the flaps cut and black plastic trays inside or pink foam trays	 
ESD label in the packaging	YES	Outer packaging packaging(black tray)  Inner 
Standards	IEC 61340-5-1	
Limits	1x10^{4} Ω ≤ Rpp ≤ 1x10^{11} Ω	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) tray= 8x10^{5} Ω SR(Superficial Resistance) carbdoard=7x10^{9} Ω SR(Superficial Resistance) foam=1x10^{12} Ω Electrostatic field(V/m x 2 cm) foam= 30 V Electrostatic field(V/m x 2 cm) black tray= 50 V	
Material packaging	Tray and cardboard- Dissipative Foam- Insulative	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Direct assembly on refrigerator	
Assembly line shelving	Metallic shelf with rubber wheels outside the EPA area and not connected to the ground. The ESDS are taken from the EPA area. The led is introduced into a white plastic that is inside an insulative blue box.	
Connection to ground	NO	
Assembly line storage	There is a metallic shelf outside the EPA a few meters away from the workstation, called "LED HOUSING" where the LEDs are placed. The shelf is not connected to the ground	
Measurements 22 ºC 54 % RH	Electrostatic field(V/m x 2 cm) black tray= 400-500 V Electrostatic field(V/m x 2 cm) white plastic where the LED is placed= 700 V	
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

WORKSTATION	ASSEMBLY CONTROL PANEL	
ESDS Component	Control panel Siemens & Bosch	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	The control panels are inside a cardboard box closed in a metallic shelf screwed to the ground.	
Measurements 23 ºC 41 % RH	Electrostatic field(V/m x 2 cm)= 3 kV	
Milkround delivery	Boxes are closed and delivered unopened to the EPA using a metallic painted milkround with rubber wheels	
Check	OK	
RECEIVING		
Supply packaging	Cardboard box with tarpack divisors between the panels and pink blanket divisor between each control panel's tier	
ESD label in the packaging	YES	
Standards	IEC 61340-5-1	
Limits	$1x10^{4}$ Ω ≤ Rpp ≤ $1x10^{11}$ Ω	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) tarpack= 1x10[illegible] Ω SR(Superficial Resistance) carbdoard=$7x10^{9}$ Ω SR(Superficial Resistance) pink blanket=$3x10^{10}$ Ω Electrostatic field(V/m x 2 cm)= 44 V	
Material packaging	Cardboard-Dissipative Tarpack divisor-Insulative	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Direct assembly on refrigerator	
Assembly line shelving	The control panels are inside a cardboard box on a milkround's wagon outside the EPA area and not connected to the ground	
Connection to ground	NO	
Assembly line storage	N/A	
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

WORKSTATION	ASSEMBLY WIRING HARNESS	
ESDS Component	Wiring harness	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	The wiring harnesses come in the metallic trolleys from the warehouse TAF	
Measurements 23 ºC 41 % RH		
Milkround delivery	Boxes are closed and delivered unopened to the EPA using a metallic painted milkround with rubber wheels	
Check	OK	
RECEIVING		
Supply packaging		
ESD label in the packaging	NO	
Standards	IEC 61340-5-1	
Limits	$1x10^4$ Ω ≤ Rpp ≤ $1x10^{11}$ Ω	
Measurements 22 ºC 54 % RH	Electrostatic field(V/m x 2 cm)= 700-900 V	
Material packaging		
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Direct assembly on refrigerator	
Assembly line shelving	The wiring harnesses are hanging in a metallic movable shelf not connected to the ground outside the EPA close to the workstation	
Connection to ground	NO	
Assembly line storage	The wiring harnesses are hanging in a metallic movable shelf not connected to the ground outside the EPA a few meters far from the workstation	
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

WORKSTATION	ASSEMBLY CONTROL PANEL	
ESDS Component	Control panel	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	The control panels are in a closed cardboard box in a metallic painted shelf screwed to the ground.	
Measurements 23 ºC 41 % RH	SR(Superficial Resistance) carbdoard=7x10^9 Ω Electrostatic field(V/mx2cm)=280-300V	
Milkround delivery	Boxes are closed and delivered unopened to the EPA using a metallic painted milkround with rubber wheels	
Check	OK	
RECEIVING		
Supply packaging	Cardboard box with cardboard divisors	
ESD label in the packaging	YES	
Standards	IEC 61340-5-1	
Limits	1x10^4 Ω ≤ Rpp ≤ 1x10^{11} Ω	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) carbdoard=7x10^9 Ω Electrostatic field(V/m x 2 cm)= 380 V	
Material packaging	Dissipative	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Direct assembly on refrigerator	
Assembly line shelving	The control panels are inside a cardboard box on a milkround's wagon outside the EPA area and not connected to the ground. The panels are taken from the EPA area.	
Connection to ground	NO	
Assembly line storage	N/A	
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

WORKSTATION	DOOR ASSEMBLY	
ESDS Component	Display control	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	The display controls are in a cardboard box in black plastic trays.	
Measurements 23 ºC 41 % RH		
Milkround delivery	Boxes are closed and delivered unopened to the EPA using a metallic painted milkround with rubber wheels	
Check	OK	
RECEIVING		
Supply packaging	30 units per box Cardboard box with plastic trays	
ESD label in the packaging	NO	
Standards	IEC 61340-5-1	
Limits	$1x10^4\ \Omega \leq Rpp \leq 1x10^{11}\ \Omega$	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) carbdoard=$7x10^9\ \Omega$ SR(Superficial Resistance) black plastic tray=$1x10^9\ \Omega$ Electrostatic field(V/m x 2 cm)= 160 V	
Material packaging	Dissipative	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Direct assembly on refrigerator	
Assembly line shelving	The boxes are placed in a metallic movable shelf outside the EPA that is not connected to the ground.	
Connection to ground	NO	
Assembly line storage	N/A	
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

3.ANNEX III: PRODUCT QUALIFICATION REFRIGERATOR LINE 2

WORKSTATION	ASSEMBLY LED LIGHT	
ESDS Component	LED light	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	The leds are in a closed cardboard box in a metallic painted shelf that is screwed to the ground.	
Measurements 23 ºC 41 % RH	SR(Superficial Resistance) cardboard=$1x10^9$ Ω Electrostatic field(V/m x 2 cm)= 20-40 V	
Milkround delivery	Boxes are closed and delivered unopened to the EPA using a metallic painted milkround with rubber wheels	
Check	OK	
RECEIVING		
Supply packaging	Cardboard box with cardboard divisors	
ESD label in the packaging	YES	
Standards	IEC 61340-5-1	
Limits	$1x10^4$ Ω ≤ Rpp ≤ $1x10^{11}$ Ω	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) cardboard=$1x10^9$ Ω Electrostatic field(V/m x 2 cm)= 380V-400V	
Material packaging	Dissipative	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Direct assembly on refrigerator	
Assembly line shelving	The boxes with the LEDs are placed on a table with an insulative surface. The table is in a non EPA area and is not connected to the ground.	
Connection to ground	NO	
Assembly line storage	The boxes are closed and placed in blue plastic supports in a metallic shelf near the workstation. Not connected to the ground and in a non EPA area.	
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

WORKSTATION	ASSEMBLY CONTROL PANEL	
ESDS Component	Control panel	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	The control panels are in closed tarpack boxes with tarpack divisors in the warehouse	
Measurements 23 ºC 41 % RH		
Milkround delivery	Boxes are closed and delivered unopened to the EPA using a metallic painted milkround with rubber wheels	
Check	OK	
RECEIVING		
Supply packaging	Tarpack box with tarpack divisors	
ESD label in the packaging	NO	
Standards	IEC 61340-5-1	
Limits	$1x10^4\ \Omega \leq Rpp \leq 1x10^{11}\ \Omega$	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) tarpack= $1x10^{12}\ \Omega$ Electrostatic field(V/m x 2 cm)= 700 V - 900 V	
Material packaging	Insulative	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Direct assembly on refrigerator	
Assembly line shelving	The control panels are inside a tarpack box on tarpack's pallet in a milkround's wagon outside the EPA area and not connected to the ground	
Connection to ground	NO	
Assembly line storage	N/A	
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

WORKSTATION	ASSEMBLY WIRING HARNESS	
ESDS Component	Wiring harness	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	The wiring harnesses come in the metallic trolleys from the warehouse TAF	
Measurements 23 ºC 41 % RH		
Milkround delivery	Boxes are closed and delivered unopened to the EPA using a metallic painted milkround with rubber wheels	
Check	OK	
RECEIVING		
Supply packaging	The wiring harnesses come directly to the workstation hanging in the metallic movable shelf.	
ESD label in the packaging	NO	
Standards	IEC 61340-5-1	
Limits	$1x10^4$ Ω ≤ Rpp ≤ $1x10^{11}$ Ω	
Measurements 22 ºC 54 % RH	Electrostatic field(V/m x 2 cm)= 160 V -380V-500 V	
Material packaging		
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Direct assembly on refrigerator	
Assembly line shelving	The wiring harnesses are hanging in a metallic movable shelf not connected to the ground outside the EPA a few meters far from the workstation. The wiring harnesses are handled from the EPA floor.	
Connection to ground	NO	
Assembly line storage	N/A	
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

WORKSTATION	ASSEMBLY COMPRESSOR	
ESDS Component	Inverter	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	The inverters are taken directly to the pre-assembly workstation and stored there.	
Measurements 23 ºC 41 % RH		
Milkround delivery	Boxes are closed and delivered unopened to the EPA using a metallic painted milkround with rubber wheels	
Check	OK	
RECEIVING		
Supply packaging	16 per box Cardboard box with cardboard divisors	
ESD label in the packaging	NO	
Standards	IEC 61340-5-1	
Limits	$1x10^4\ \Omega \leq Rpp \leq 1x10^{11}\ \Omega$	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) carbdoard=$7x10^9\ \Omega$	
Material packaging	Dissipative	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Pre-assembly of the ground connector and the network wire into the inverter. This connections are made in a non EPA area. The flaps of the inverter boxes are cut. Assembly of the inverter in the refrigerator. The boxes with the mounted inverters are placed in a metallic shelf not connected to the ground, where the compressor is assembled	 
Assembly line shelving	Once the connections to the inverter are finished they are stored in cardboard boxes with the flaps cut in a metallic shelf with rubber wheels not connected to the ground and outside an EPA area	
Measurements 20 ºC 33,1 % RH	Electrostatic field(V/m x 2 cm) inverter in flaps's cuted box= 280-370 V Electrostatic field(V/m x 2 cm) mounted inverter in flap's cut box= 150-200-400 V	
Connection to ground	NO	
Assembly line storage	The cardboard boxes with the inverters are brought closed to the floor next to the workstation on a wooden pallet.	
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

WORKSTATION	ASSEMBLY CONTROL PANEL	
ESDS Component	Control panel	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse		
Measurements 23 ºC 41 % RH		
Milkround delivery	Boxes are closed and delivered unopened to the EPA using a metallic painted milkround with rubber wheels	
Check	OK	
RECEIVING		
Supply packaging	Tarpack box with tarpack divisors	
ESD label in the packaging	NO	
Standards	IEC 61340-5-1	
Limits	$1x10^4\ \Omega \leq Rpp \leq 1x10^{11}\ \Omega$	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) tarpack= $1x10^{12}\ \Omega$ Electrostatic field(V/m x 2 cm)= 500 V - 800 V	
Material packaging	Insulative	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Direct assembly on refrigerator	
Assembly line shelving	The control panels are inside a tarpack box on a milkround's wagon outside the EPA area and not connected to the ground	
Connection to ground	NO	
Assembly line storage	N/A	
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

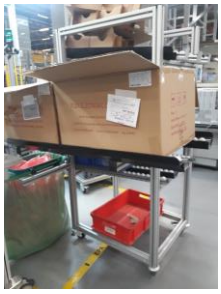
WORKSTATION	ASSEMBLY CONTROL PANEL	
ESDS Component	Control panel	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	The control panels are in a closed cardboard box in a metallic painted shelf screwed to the ground.	
Measurements 23 ºC 41 % RH		
Milkround delivery	Boxes are closed and delivered unopened to the EPA using a metallic painted milkround with rubber wheels	
Check	OK	
RECEIVING		
Supply packaging	Cardboard box with cardboard divisors	
ESD label in the packaging	YES	
Standards	IEC 61340-5-1	
Limits	$1x10^4\ \Omega \leq Rpp \leq 1x10^{11}\ \Omega$	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) carbdoard=$7x10^9\ \Omega$ Electrostatic field(V/m x 2 cm)= 380 V	
Material packaging	Dissipative	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Direct assembly on refrigerator	
Assembly line shelving	The control panels are inside a cardboard box on a milkround's wagon outside the EPA area and not connected to the ground. The panels are taken from the EPA area.	
Connection to ground	NO	
Assembly line storage	N/A	
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

4.ANNEX IV: PRODUCT QUALIFICATION REFRIGERATOR LINE 3

WORKSTATION	ASSEMBLY LED LIGHT	
ESDS Component	LED light	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	The leds come in an insulative foam tray inside a cardboard box and are taken out of the box and placed in a plastic box	
Measurements 23 ºC 41 % RH	SR(Superficial Resistance) carbdoard=7x10^{9} Ω Electrostatic field(V/mx2cm)= 1,2 kV	
Milkround delivery	Boxes are closed and delivered unopened to the EPA using a metallic painted milkround with rubber wheels	
Check	OK	
RECEIVING		
Supply packaging	Blue plastic box with pink foam trays with compartments	
ESD label in the packaging	YES	
Standards	IEC 61340-5-1	
Limits	1x10^{4} Ω ≤ Rpp ≤ 1x10^{11} Ω	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) foam tray= 1x10^{12} Ω SR(Superficial Resistance) plastic box=1x10^{12} Ω Electrostatic field(V/m x 2 cm)= 280V-400V-150V	
Material packaging	Insulative	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Direct assembly on refrigerator	
Assembly line shelving	Metallic shelf made of sliding nylon wheels and with rubber wheels outside the EPA area and not connected to the ground. The led is introduced into a white plastic that is inside an insulative blue box.	
Connection to ground	NO	
Assembly line storage	N/A	
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

WORKSTATION	ASSEMBLY WIRING HARNESS	
ESDS Component	Wiring harness	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	The wiring harnesses are in closed boxes stored in the warehouse	
Measurements 23 ºC 41 % RH		
Milkround delivery	Boxes are closed and delivered unopened to the EPA using a metallic painted milkround with rubber wheels	
Check	OK	
RECEIVING		
Supply packaging	Cardboard box with cardboard divisors	
ESD label in the packaging	YES	
Standards	IEC 61340-5-1	
Limits	$1x10^4\ \Omega \leq Rpp \leq 1x10^{11}\ \Omega$	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) carbdoard=$7x10^9\ \Omega$ Electrostatic field(V/m x 2 cm)= 200 V	
Material packaging	Dissipative	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Direct assembly on refrigerator	
Assembly line shelving	The flaps of the boxes are cut. Stored in metallic shelf made of nylon sliding wheels and with rubber wheels in their legs, outside the EPA area and not connected to the ground. The ESDS are taken from the EPA area. The led is introduced into a white plastic that is inside an insulative blue box.	
Connection to ground	NO	
Assembly line storage	N/A	
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

WORKSTATION	ASSEMBLY COMPRESSOR	
ESDS Component	Inverter	
INBOUND MATERIAL		
Warehouse	The inverters are taken directly to the pre-assembly workstation and stored there.	
Measurements 23 ºC 41 % RH		
Milkround delivery	Boxes are closed and delivered unopened to the EPA using a metallic painted milkround with rubber wheels	
Check	OK	
RECEIVING		
Supply packaging	16 per box Cardboard box with cardboard divisors	
ESD label in the packaging	NO	
Standards	IEC 61340-5-1	
Limits	$1x10^4\ \Omega \leq Rpp \leq 1x10^{11}\ \Omega$	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) carbdoard=$7x10^9\ \Omega$ Electrostatic field(V/m x 2 cm)= 200-400-500 V	
Material packaging	Dissipative	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Pre-assembly of the ground connector and the network wire into the inverter. This connections are made in an EPA area. The flaps of the inverter boxes are cut.	
Assembly line shelving	Once the connections to the inverter are finished they are stored in cardboard boxes with the flaps cuted in a metallic shelf with rubber wheels not connected to the ground and outside an EPA area. Boxes handled from the EPA area.	
Measurements 20 ºC 33,1 % RH	Electrostatic field(V/m x 2 cm) inverter in flpas's cuted box= 150-170-200 V Electrostatic field(V/m x 2 cm) mounted inverter in flpas's cuted box= 80-90-140 V	
Connection to ground	NO	
Assembly line storage	The cardboard boxes with the inverters are brought closed to the floor next to the workstation on a wooden pallet and stored in the metallic shelf closed.	
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

WORKSTATION	ASSEMBLY CONTROL PANEL	
ESDS Component	Control panel	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	The control panel is in a closed cardboard box in a metallic shelf screwed to the ground.	
Measurements 23 ºC 41 % RH		
Milkround delivery	The boxes are delivered to the workstations.	
Check	OK	
RECEIVING		
Supply packaging	Cardboard box with pink bags in which the panels are inside.	
ESD label in the packaging	NO	
Standards	IEC 61340-5-1	
Limits	$1x10^4$ Ω ≤ Rpp ≤ $1x10^{11}$ Ω	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) carbdoard=$7x10^9$ Ω Electrostatic field(V/m x 2 cm)= 70 V	
Material packaging	Cardboard-Dissipative Inner packaging- Insulative	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Direct assembly on refrigerator	
Assembly line shelving	The cardboard boxes are in aa metallic movable shelf, with sliding nylon wheels and not connected to the ground.	
Connection to ground	NO	
Assembly line storage	N/A	
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

5.ANNEX V: PRODUCT QUALIFICATION REFRIGERATOR LINE 4

WORKSTATION	ASSEMBLY LED LIGHT	
ESDS Component	LED light	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	The leds come in an insulative foam tray inside a cardboard box and are taken out of the box and placed in a plastic box	
Measurements 23 ºC 41 % RH	SR(Superficial Resistance) carbdoard=7x10^{9} Ω Electrostatic field(V/mx2cm)= 1,2 kV	
Milkround delivery	The leds are delivered to the workstation in the blue plastic boxes.	
Check	OK	
RECEIVING		
Supply packaging	Blue plastic box with pink foam trays with compartments	
ESD label in the packaging	NO	
Standards	IEC 61340-5-1	
Limits	1x10^{4} Ω ≤ Rpp ≤ 1x10^{11} Ω	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) foam tray= 1x10^{12} Ω SR(Superficial Resistance) plastic box=1x10^{12} Ω Electrostatic field(V/m x 2 cm)= 280V-400V-150V	
Material packaging	Insulative	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Direct assembly on refrigerator	
Assembly line shelving	Metallic shelf made of sliding nylon wheels and with rubber wheels outside the EPA area and not connected to the ground. The led is introduced into a white plastic that is inside an insulative blue box.	
Connection to ground	NO	
Assembly line storage	N/A	
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

WORKSTATION	ASSEMBLY WIRING HARNESS	
ESDS Component	Wiring harness	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	The wiring harnesses are in closed boxes stored in the warehouse	
Measurements 23 ºC 41 % RH		
Milkround delivery	The boxes are deliverred to the workstation.	
Check	OK	
RECEIVING		
Supply packaging	Cardboard box with cardboard paper divisors.	
ESD label in the packaging	NO	
Standards	IEC 61340-5-1	
Limits	$1x10^4$ Ω ≤ Rpp ≤ $1x10^{11}$ Ω	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) foam tray= $1x10^{12}$ Ω SR(Superficial Resistance) plastic box=$1x10^{12}$ Ω Electrostatic field(V/m x 2 cm)= 280V-400V-150V	
Material packaging	Dissipative	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Direct assembly on refrigerator	
Assembly line shelving	The flaps of the boxes are cut. Stored in metallic shelf made of nylon sliding wheels and with rubber wheels in their legs, outside the EPA area and not connected to the ground. The ESDS are taken from the EPA area. The led is introduced into a white plastic that is inside an insulative blue box.	
Connection to ground	NO	
Assembly line storage	N/A	
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

WORKSTATION	ASSEMBLY CONTROL PANEL	
ESDS Component	Control panel	 
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	The control panel is in a closed cardboard box in a metallic shelf screwed to the ground.	
Measurements 23 ºC 41 % RH		
Milkround delivery	The boxes are delivered to the workstations.	
Check	OK	
RECEIVING		
Supply packaging	Cardboard box with cardboard divisors. The control panels are in the divisors inside pink insulative bags.	
ESD label in the packaging	NO	
Standards	IEC 61340-5-1	
Limits	$1x10^4\ \Omega \leq Rpp \leq 1x10^{11}\ \Omega$	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) cardboard= $1x10^9\ \Omega$ SR(Superficial Resistance) pink bag= $1x10^{12}\ \Omega$ Electrostatic field(V/m x 2 cm)= 280V-350 V	
Material packaging	Cardboard-Dissipative Inner packaging- Insulative	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Direct assembly on refrigerator	
Assembly line shelving	The cardboard boxes are in aa metallic movable shelf, with sliding nylon wheels and not connected to the ground.	
Connection to ground	NO	
Assembly line storage	N/A	
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

WORKSTATION	DOOR ASSEMBLY	
ESDS Component	Display control	 
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	The display controls are originally in a cardboard box in cardoard trays with divisors. But are taken out the trays and placed in an ESD protective box.	
Measurements 23 ºC 41 % RH	SR(Superficial Resistance) cardboard = $1x10^9$ Ω SR(Superficial Resistance) ESD black box = $1x10^3$ Ω Electrostatic field(V/m x 2 cm)= 80 V	
Milkround delivery	The cardboard trays are delivered to the workstation.	
Check	OK	
RECEIVING		
Supply packaging	Cardboard box with cardboard divisors	
ESD label in the packaging	YES	
Standards	IEC 61340-5-1	
Limits	$1x10^4$ Ω ≤ Rpp ≤ $1x10^{11}$ Ω	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) cardboard = $1x10^9$ Ω Electrostatic field(V/m x 2 cm)= 80-130 V	
Material packaging	Dissipative	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Direct assembly on refrigerator	
Assembly line shelving	Metallic movable shelf not connected to the ground. The touch door electronics are taken from the EPA floor.	
Connection to ground	NO	
Assembly line storage	N/A	
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

WORKSTATION	PRE- ASSEMBLY INVERTER & CONTROL PANEL	
ESDS Component	**Inverter & Control panel**	 
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	The inverters are taken directly to the pre-assembly workstation and stored there. The control panels are in closed cardboard boxes in the warehouse in a metallic painted shelf screwed to the ground.	
Measurements **23 ºC** **41 % RH**		
Milkround delivery	The boxes with the control panels and inverters are delivered to the metallic shelves in the workstation where the inverter is pre assembled.	
Check	**OK**	
RECEIVING		
Supply packaging	Cardboard box with cardboard divisors	 
ESD label in the packaging	Inverter -NO Control panel - YES	
Standards	IEC 61340-5-1	
Limits	$1x10^{4}$ Ω ≤ Rpp ≤ $1x10^{11}$ Ω	
Measurements **22 ºC** **54 % RH**	SR(Superficial Resistance) cardboard = $1x10^{7}$ Ω Electrostatic field(V/m x 2 cm) control panel= 170 V Electrostatic field(V/m x 2 cm) inverter= 400-500 V	
Material packaging	Dissipative	
Check	**OK**	
ASSEMBLY SHELVING		
Assembly workstation	Direct assembly on refrigerator	
Assembly line shelving	The boxes are placed in a metallic shelf, with the flaps cut. The shelf is not connected to the ground.	
Connection to ground	NO	
Assembly line storage	N/A	
Connection to ground	NO	
ESDS ground label	NO	
Check	**OK**	

WORKSTATION	ASSEMBLY INVERTER & CONTROL PANEL	
ESDS Component	**Inverter & Control panel**	
PRODUCT QUALIFICATION		
INBOUND MATERIAL	The control panel is assembled with the inverter and stored in the workstation	
RECEIVING		
ASSEMBLY SHELVING		
Assembly workstation	Direct assembly on refrigerator	
Assembly line shelving	Metallic shelf with sliding nylo wheels not connected to the ground. The set is handled from a dissipative ESD mat.	
Connection to ground	NO	
Assembly line storage	The finished set inverter & control panel is stored in metallic shelves outside the EPA and not connected to the ground. They are in cardboard boxes with the flaps cut.	
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

WORKSTATION	ASSEMBLY DOOR SENSOR	
ESDS Component	Door sensor	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	The door sensor comes in cardboard trays inside a carboard box. But the trays are taken out from the box and places in blue plastic boxes.	
Measurements 23 ºC 41 % RH	SR(Superficial Resistance) cardboard tray= $1x10^{9}$ Ω SR(Superficial Resistance) cardboard box= $1x10^{10}$ Ω Electrostatic field(V/m x 2 cm)=45-60 V	
Milkround delivery	The blue plastic boxes are carried to the workstation an placed in a metallic shelf.	
Check	OK	
RECEIVING		
Supply packaging	Carboard trays	
ESD label in the packaging	YES	
Standards	IEC 61340-5-1	
Limits	$1x10^{4}$ Ω ≤ Rpp ≤ $1x10^{11}$ Ω	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) cardboard tray= $1x10^{9}$ Ω Electrostatic field(V/m x 2 cm)= 240 V	
Material packaging	Dissipative	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	Direct assembly on refrigerator	
Assembly line shelving	Small metallic shelf connected to the assembly line. The sensors are taken from an EPA floor. Metallic shelf connected to the assembly line in the control panel assembly workstation.	 
Connection to ground	YES	
Assembly line storage	The cardboard trays are stacked together inside an insulative blue box in a metallic shelf not connected to the ground. In the control panel assembly they are stored in a metallic shelf not connected to the ground.	 
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

WORKSTATION	ASSEMBLY EVAPORATOR SET	
ESDS Component	Fan	
PRODUCT QUALIFICATION		
INBOUND MATERIAL		
Warehouse	The fans are stored in a metallic shelf screwed to the ground, in a cardboard box with cardboard divisors but without lid.	
Measurements 23 ºC 41 % RH	SR(Superficial Resistance) cardboard box= $1x10^9$ Ω Electrostatic field(V/m x 2 cm)= 169 V	
Milkround delivery	The cardboard boxes are delivered to the workstation.	
Check	OK	
RECEIVING		
Supply packaging	Cardboard box with cardboard divisors	
ESD label in the packaging	NO	
Standards	IEC 61340-5-1	
Limits	$1x10^4$ Ω ≤ Rpp ≤ $1x10^{11}$ Ω	
Measurements 22 ºC 54 % RH	SR(Superficial Resistance) cardboard box= $1x10^9$ Ω Electrostatic field(V/m x 2 cm)= 240 V	
Material packaging	Dissipative	
Check	OK	
ASSEMBLY SHELVING		
Assembly workstation	The fan is connected to the evaporator set and then directly assembled on the refrigerator.	
Assembly line shelving	The fans are in a metallic shelf not connected to the ground, on nylon sliding wheels. The fans are taken from an EPA floor.	
Connection to ground	NO	
Assembly line storage	N/A	
Connection to ground	NO	
ESDS ground label	NO	
Check	OK	

6.ANNEX VI: IONIZERS CHARACTERISTICS

Turbina doble ionizadora Volumion

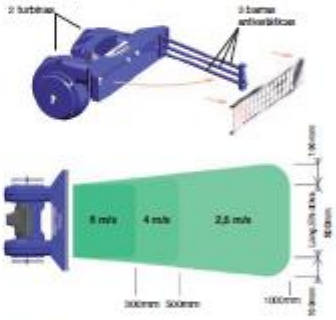
La turbina Volumion es ideal para todo tipo de industria gracias a su robustez y capacidad ionizadora, al contar con tres barras eliminadoras tipo MEB que se alimentan con un transformador de alta tensión.

El volumen de iones generado por las barras es propulsado por una turbina doble, disponible en dos versiones 220V ó 380V, cuyas tapas laterales actúan de regulador de caudal.

El equipo permite incorporar filtros, recomendados en entornos muy sucios o cuando se desea aumentar su intervalo de limpieza.

CARACTERÍSTICAS
- Cobertura máx. 500 x 1500 mm
- Material: Acero pintado.
- Tiempo de neutralización: 0,6 s (alta vol.)
- Material Barra: PVC
- Cable motor: 3m (neoprene)
- Cable barras: 3m apantallado
- Peso: 11 Kg
- T° de funcionamiento: 0-50 °C
- Nivel de ruido: 77 dBA (a 1 metro)
- Volumen de aire: 600 m3/h
- Tensión del primario: 400 VCA, 50/60 Hz
- Consumo: 140W
- Capacidad max. U. Alim: 3 Volumion
- Dim. 296 ancho x 455 largo x 235 alto [mm]
- Opcional: Filtro clase EU3 (DIN 24185)

Fácil de limpiar



Código	Accesorios y repuestos
130.19073	7kV - 220 V con alarma y 1/0 remoto
131.20225	Rpto. Set barras 131.20220+3m CableSHD
131.20226	Soporte + filtro
131.20227	Rpto. Filtro
131.20228	Rpto. Motor 400V
131.20229	Rpto. Conducto Apantallado PVC

Código	Versión estándar: 380V turb. /220 barras
131.20220	Turbina con motor 380V
130.19070	Transf. barras antielec. 220 V (Máx. 3 u)
Código	**Versión 220V**
131.20222	Turbina con motor 220V
130.19070	Transf. barras antielec. 220 V (Máx. 3 u)
Código	**Versión 380V**
131.20220	Turbina con motor 380V
130.19074	Transf. barras antielec. 380 V (Máx. 3 u)

** Ver pág.10 para información U. Alimentación*

Extrusionado de film

A Ionizador

Es un proceso que genera mucha carga electrostática que luego presenta problemas en la confección e impresión, así como calambres en el personal. Para solucionarlo recomendamos instalar un soplador Blowion o una Barra Thundarion (ver pág.15). Entre otras ventajas reducen costes operativos, al no recurrir a aire comprimido y permiten retirar el equipo sin parar la máquina al ser un único soplador del ancho de la banda, a diferencia de otros sopladores de menor ancho.

IZN10-TFL07ES-A

SMC

Manual de instalación y mantenimiento
Ionizador tipo boquilla
Serie IZN10

CE

1 Normas de seguridad

- Este manual contiene información fundamental para la protección de usuarios y terceros contra posibles lesiones físicas y daños en el equipo.
- Lea este manual antes de utilizar el producto para así garantizar la utilización correcta del mismo. Asimismo, lea los manuales de los aparatos relacionados antes de utilizarlos.
- Conserve este manual en un lugar seguro para poder consultarlo en un futuro.
- Estas instrucciones indican niveles de riesgo potencial mediante las etiquetas "**PELIGRO**", "**ADVERTENCIA**" o "**PRECAUCIÓN**", seguidas de información importante en materia de seguridad que debe respetarse rigurosamente.
- Para garantizar la seguridad del personal y del equipo, deberán observarse las instrucciones de seguridad incluidas en este manual y en el catálogo de productos, así como cualquier otra práctica habitual en materia de seguridad que sea pertinente.
- Este producto es un equipo de clase A destinado para su uso en un entorno industrial.

⚠ **PELIGRO**	PELIGRO indica un peligro con un nivel alto de riesgo, que si no es evitado dará muerte o a alguna lesión seria.
⚠ **ADVERTENCIA**	ADVERTENCIA indica un peligro con un nivel medio de riesgo, que si no es evitado podría dar lugar a muerte o a alguna lesión seria.
⚠ **PRECAUCIÓN**	PRECAUCIÓN indica un peligro con un nivel bajo de riesgo, que si no es evitado podría dar lugar a alguna lesión de poca importancia o moderada.

1.1 Recomendaciones generales

⚠ ADVERTENCIA

- **La compatibilidad de los equipos es responsabilidad exclusiva de la persona que diseña los sistemas o decide las especificaciones de los mismos.**
  Puesto que los productos aquí especificados pueden ser utilizados en diferentes condiciones de funcionamiento, su compatibilidad para un sistema determinado deberá basarse en especificaciones concretas o en la realización de análisis y/o pruebas en función de los requisitos específicos. Aquellas personas que decidan la compatibilidad del equipo deberán asumir la responsabilidad de garantizar la seguridad y rendimiento inicial del sistema. Configure el sistema tras haber revisado todas especificaciones pertinentes en la versión más reciente del catálogo o documentación disponible, considerando, además, las implicaciones derivadas del posible fallo de cualquier pieza o equipo.
- **La maquinaria y los equipos deberían ser manipulados únicamente por personal cualificado.**
  Este producto genera altas tensiones eléctricas, por lo tanto, su utilización por parte de un operario que no estuviera familiarizado con el mismo podría ser peligrosa. Las operaciones de montaje, manipulación y reparación de sistemas deberán ser ejecutadas únicamente por personal que cuente con la debida formación y experiencia.
- **No realice reparaciones en máquinas/equipos ni trate de retirar ningún componente hasta haber confirmado la seguridad de la operación.**
  1) Las tareas de inspección y mantenimiento de máquinas/equipos deberán llevarse a cabo únicamente tras haberse confirmado la seguridad de las mismas, debiendo tenerse en cuenta aquellas áreas relacionadas con la puesta a tierra, prevención de electrocución y otros tipos de lesiones.
  2) Cuando sea necesario retirar algún equipo, confirme la seguridad del proceso de la manera mencionada anteriormente. Aísle el suministro de aire y alimentación eléctrica que abastece al equipo y evacue completamente el aire comprimido residual del sistema.
  3) Antes de volver a poner en marcha máquinas/equipos, asegúrese de que se han tomado todas las medidas necesarias para evitar cortocircuitos, etc.

1 Normas de seguridad (continuación)

- **No utilice el producto en las condiciones o entornos que se mencionan a continuación. En caso de que dichas condiciones o entornos sean inevitables, tome las medidas adecuadas y póngase en contacto con SMC.**
  1) Condiciones y entornos que no cumplen las especificaciones indicadas, o cuando el producto se usa al aire libre.
  2) Instalaciones o equipos relacionados con la energía nuclear, ferrocarriles, aviación, automoción, equipos médicos, alimentación y bebidas, equipos recreativos, circuitos de parada de emergencia, aplicaciones en maquinarias de prensa o equipos de seguridad.
  3) Aplicaciones que pudieran conllevar consecuencias negativas para personas, propiedades o animales, requiriéndose en este caso un análisis especial de seguridad.

1.2 Recomendaciones específicas

⚠ ADVERTENCIA

- **Este producto está previsto para ser utilizado en sistemas generales automatizados de planta.**
  En caso de utilizarse en otras aplicaciones (en particular, aquellas indicadas en la sección 1.1), póngase en contacto con SMC antes de proceder a su utilización.
- **Utilice el producto conforme al voltaje y límites de temperatura especificados.**
  La utilización de este equipo con un tipo de voltaje no especificado podrá causar un funcionamiento defectuoso, así como daños, electrocución y/o incendios.
- **Utilice únicamente aire comprimido y limpio como medio.**
  No utilice gases inflamables o explosivos como medios, ya que podrían causar un incendio o una explosión. Cuando vayan a utilizarse otros medios en lugar de aire comprimido, póngase en contacto con el representante de servicio de SMC.
- **Este producto no es resistente a explosiones.**
  No utilice este producto en zonas donde tengan lugar explosiones producidas por polvo o donde existan gases inflamables o explosivos, ya que esto también podría causar explosiones y/o incendios.

⚠ PRECAUCIÓN

- **Este producto no ha sido limpiado.**
  Cuando utilice este producto en un entorno de sala estéril, enjuague y confirme en el nivel de purificación del producto antes de proceder a su utilización.
- **Este producto está equipado con un electrodo muy afilado.**
  Cuando utilice o limpie el producto, procure no tocar el electrodo ya que podría lesionarse.

2 Condiciones de uso previstas

2.1 Especificaciones

Modelo de Ionizador		IZN10-□□ (NPN)	IZN10-□□P (PNP)
Tipo		Efecto corona	
Método de suministro de tensión		Tipo CA de alta frecuencia	
Salida de descarga [nota 1)]		2.500 V	
Equilibrio iónico [nota 2)]		±10 V máx.	
Generación de ozono [nota 3)]		0,03 ppm (0,05 ppm para boquillas de eliminación de carga para ahorro de energía)	
Purga de aire	Líquido	Aire (limpio y seco)	
	Presión de funcionamiento [nota 4)]	0,05 MPa ~ 0,7 MPa	
	Tamaño del tubo de conexión	ϕ6 mm y ϕ1/4 de pulgada	
Tensión de alimentación		24 VCC ± 10 %	
Consumo de corriente		80 mA (cuando no se utilizan señales de entrada o salida)	
Señal de entrada	Señal de parada de descarga	Tierra a conexión Consumo de corriente: 5 mA o menos	+24 V a conexión Consumo de corriente: 5 mA o menos
	Señal de reinicialización		
	Señal de inicio de mantenimiento		
Señal de salida	Señal de descarga	Corriente de carga máx. 40 mA Tensión residual: 1 V o menos (con una corriente de carga de 40 mA) Tensión máxima aplicada: 28 VCC	Corriente de carga máx. 40 mA Tensión residual: 1 V o menos (con una corriente de carga de 40 mA)
	Señal de error		
	Señal de mantenimiento		
Distancia efectiva de eliminación		20 ~ 500 mm	
Temperatura ambiente		De 0 a 55 °C	
Humedad ambiente		De 35 a 65 % de humedad relativa "RH" (sin condensación)	
Material		Carcasa: ABS, acero inoxidable Boquilla: acero inoxidable Aguja del electrodo: tungsteno	
Resistencia a vibraciones		Durabilidad 50 Hz Amplitud 1mm 2 horas en cada una de los sentidos de vibración X, Y, Z	
Resistencia a los impactos		10 G	
Peso		120 g	
Norma/directiva aplicable		Marcado CE	

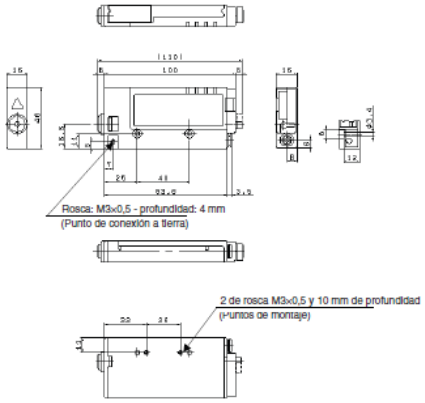
2 Condiciones de uso previstas (continuación)

Nota 1) Sonda de medición: 1.000 MΩ, 5 pF.
Nota 2) Distancia entre el objeto cargado y el ionizador: 100 mm, purga de aire: 0,3 MPa, cuando se utiliza una boquilla de eliminación de carga de ahorro energético.
Nota 3) Valor por encima del nivel de fondo, medido a 300 mm de la cara frontal de la boquilla.
Nota 4) Sin purga de aire, la eliminación de carga no estará disponible y aumentará la concentración interna de ozono, lo cual tendría un efecto adverso sobre el producto y el equipo periférico.

2.2 Esquema

IZN10-01 / IZN10-02

Boquilla de ahorro energético / Boquilla de gran caudal



3 Cómo efectuar pedidos

IZN10 - 01 P 06 Z - B1

Nombre de la serie

IZN10	Tipo CA de alta frecuencia

Forma de la boquilla

01	Boquilla de eliminación de carga para ahorro de energía
02	Boquilla de gran caudal

Especificaciones de la salida

Ninguna	NPN
P	PNP

Diámetro de la tubería

06	ϕ 6 mm: métrica
07	ϕ 6,35: 1/4 de pulgada
16	ϕ 6 mm: métrica (acodada)
17	ϕ 6,35: 1/4 de pulgada (acodada)

Cable de alimentación

Ninguno	3 m
Z	10 m
N	No se suministra

Soporte

Ninguno	Sin soporte
B1	Con soporte tipo L
B2	Con soporte basculante
B3	Con soporte de montaje en carril tipo DIN

3 Cómo efectuar pedidos (continuación)

Accesorios

Cable de alimentación

IZN10-CP	3 m
IZN10-CPZ	10 m

Soporte

IZN10-B1	Soporte en forma de L
IZN10-B2	Soporte basculante
IZN10-B3	Soporte de montaje en carril tipo DIN

Piezas de servicio

Aguja del electrodo

IZN10-NT	Conjunto de agujas de electrodos
IZS30-M2	Kit limpiador de agujas de electrodos

Opción

Conjunto de piezas de montaje del distribuidor
Incluye tornillos de cabeza tipo Allen, separador y tuercas hexagonales.
Tanto el ionizador como los soportes de montajes en forma de L y de carril tipo DIN deberán solicitarse por separado.

Piezas de montaje del distribuidor

IZN10 - ES 2

Intervalo de montaje — Número de estaciones

ES	17 mm

2	2 estaciones
3	3 estaciones
4	4 estaciones

4 Instalación

4.1 Entorno

⚠ ADVERTENCIA

1. **Utilice el producto dentro de los márgenes de temperatura ambiente y de funcionamiento del medio.**
   Los márgenes de temperatura ambiente y de funcionamiento del medio para el ionizador son de 0 a 55 °C. En aquellas áreas que sean propicias a cambios repentinos de temperatura, es posible que se forme condensación incluso cuando dichos cambios estén dentro de los márgenes de temperatura especificados. El ionizador no deberá utilizarse en dichas condiciones.
2. **No utilice este producto en espacios cerrados.**
   Este producto utiliza un método de funcionamiento mediante descarga por efecto corona y, debido a que este proceso genera pequeñas cantidades de ozono y NOx, el ionizador sólo deberá utilizarse en espacios abiertos y bien ventilados.
3. **Entornos a evitar**
   No utilice o almacene el producto en las condiciones que se indican a continuación, ya que podrían producirse fallos en el equipo:
   - Temperaturas ambiente que excedan de alguna manera el margen de entre 0 y 55 °C.
   - Humedad ambiente que exceda de alguna manera el margen de entre 35 y 65 % de RH.
   - Las zonas sujetas a cambios rápidos de temperatura pueden producir condensación.
   - Zonas donde se almacenen gases corrosivos, gases inflamables u otras sustancias inflamables y volátiles.
   - Zonas donde el producto pueda verse expuesto a polvo de tipo conductor, como por ejemplo polvo o limaduras de hierro, neblina de aceite, sal, disolventes orgánicos, así como virutas, partículas o aceite de corte procedente del mecanizado de piezas.
   - Colocado directamente en el flujo de aire de aparatos de aire acondicionado.
   - En espacios cerrados y poco ventilados.
   - Expuesto a la acción directa de los rayos solares y/o de calor radiante.

4 Instalación (continuación)

- Zonas donde se generen altos niveles de ruido electromagnético tales como potentes campos magnéticos y eléctricos, o picos repentinos de tensión en el suministro eléctrico.
- Zonas donde el producto pueda verse sometido a descargas electrostáticas.
- Zonas donde se generen interferencias de radiofrecuencia (RF).
- Zonas propensas a recibir descargas de rayos.
- Zonas donde el producto pueda recibir impactos o vibraciones directas.
- Zonas donde el producto pueda verse sometido a fuerzas o pesos que puedan producir deformaciones o distorsiones en el mismo.

En caso de que no sea posible evitar dichas condiciones, tome las medidas de protección adecuadas.

4. No utilice aire que contenga partículas en suspensión o polvo.
La utilización de aire que contenga partículas en suspensión o polvo puede reducir la funcionalidad del producto, así como hacer que sean necesarios unos ciclos de mantenimiento más frecuentes. Utilice un secador (serie IDF), filtro de aire (series AF/AFF) y separador de neblina (series AFM/AM) para obtener aire comprimido limpio.

5. El ionizador no es inmune a las descargas de rayos.
Deberá incorporarse en el equipo algún sistema de protección contra las subidas de tensión producidas por rayos.

4.2 Cableado y tuberías

⚠ ADVERTENCIA

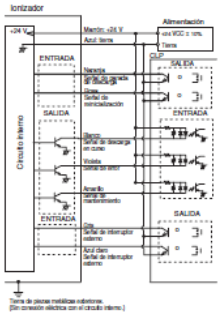
1. Conecte únicamente este aparato a circuitos externos de tipo SELV (tensión ultra baja de seguridad/independiente).
2. Antes de conectar el aparato, asegúrese de que la capacidad de la fuente de alimentación es suficiente y de que su tensión corresponde a la especificada.
3. Utilice siempre una fuente de alimentación homologada y reconocida por laboratorios certificados (UL). Ésta deberá pertenecer a la categoría 2 de fuentes de alimentación de 24 VCC y estar limitada a 2,1 A.
4. Para optimizar su rendimiento y evitar riesgos de electrocución, el producto deberá conectarse a una toma de tierra de protección conforme a las instrucciones indicadas en este manual.

5. Asegúrese de aislar completamente el suministro eléctrico cuando proceda a la corrección de los cables. Esto incluye la tarea de enchufar o desenchufar conectores, ya que de lo contrario podrían producirse daños en el equipo.
6. Compruebe que el cableado está bien conectado y es del tipo correcto y confirme la seguridad del circuito antes de activar el producto. La conexión o utilización incorrecta de cableado podría producir daños o el funcionamiento defectuoso del producto.
7. No tienda los cables del producto junto a cables de alimentación o de alta tensión. De esta manera, evitará posibles funcionamientos defectuosos debido a interferencias.
8. Enjuague las tuberías neumáticas antes de proceder a la instalación del producto. Asegúrese de eliminar cualquier residuo de polvo, gotas de agua, aceite, etc.,. antes de instalar la tubería.

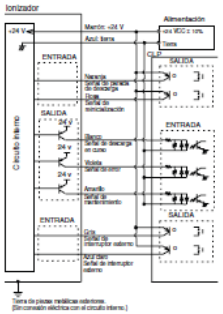
4.3 Conexiones eléctricas

1. Circuitos NPN y PNP

▪ NPN



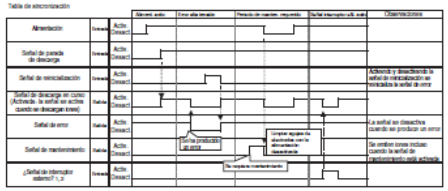
▪ PNP



4 Instalación (continuación)

2. Tabla de sincronización

Tabla de sincronización

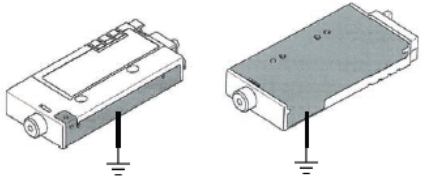


3. Tablas de identificación de cableado

N.º	Color de cable	Denominación de la señal	E/S	Conexión	Especificaciones
1	Marrón	Fuente de alimentación de +24 V	-	○	-
2	Azul	Conexión a tierra de la fuente de alimentación	-	○	-
3	Naranja	Señal de parada de descarga	Entrada	○	Cuando la señal está desactivada, se detiene la descarga.
4	Rosa	Señal de reinicialización	Entrada		Cuando se activa y desactiva la señal, se reinicializa la señal de error. Cuando la señal se desactiva, se reanuda el funcionamiento normal.
5	Blanco	Señal de descarga en curso	Salida		La señal permanece activada durante la descarga
6	Violeta	Señal de error	Salida		La señal se desactiva cuando se produce un error.
7	Amarillo	Señal de mantenimiento	Salida		La señal se activa cuando se requiere mantenimiento.
8	Gris	Señal de interrupt or externo 1	Entrada		Cuando se activa la señal, se detiene la descarga.
9	Azul claro	Señal de interrupt or externo 2	Entrada		Cuando se activa la señal, se detiene la descarga.

○ Número mínimo de conexiones necesarias para que funcione el ionizador.

- Además del cableado mencionado anteriormente, asegúrese de conectar la carcasa externa del producto (pieza metálica sombreada en gris en la ilustración) a una toma de tierra a modo de protección. De no conectarse a tierra o si ésta es insuficiente, la función de eliminación de carga especificada no estará disponible y la señal de mantenimiento permanecerá activada.



- Señal de entrada

NPN: La señal estará activada cuando el producto esté conectado a la toma de tierra de la fuente de alimentación (GND) y desactivada, cuando esté desconectado.

PNP: La señal estará activada cuando el producto esté conectado a una fuente de alimentación de 24 V y desactivada cuando esté desconectado de la misma.

- Señal de salida

NPN: La señal estará activada cuando se active un transistor de salida (mediante la toma de tierra "GND" de la fuente de alimentación en el interior del producto) y desactivada cuando se desactive dicho transistor.

PNP: La señal estará activada cuando se active un transistor de salida (mediante la conexión de 24 V de la fuente de alimentación en el interior del producto) y desactivada, cuando se desactive dicho transistor.

4 Instalación (continuación)

4.4 Montaje

⚠ ADVERTENCIA

1. Instale únicamente el producto donde haya espacio suficiente para realizar las tareas de mantenimiento, tendido de cableado y tuberías.
Cuando instale el conector eléctrico y el racor instantáneo neumático, asegúrese de dejar suficiente espacio para facilitar la inserción y desmontaje del cable eléctrico y tubo neumático.
No instale el cable o el tubo con ángulos demasiado cerrados. Teniendo en cuenta el radio mínimo de curvatura que se proporciona a continuación, asegúrese de que tanto las entradas de los cables como de los tubos están en posición recta y no someta los conectores eléctricos o racores neumáticos a una fatiga excesiva. Si los conectores eléctricos o racores neumáticos se someten a tensiones mecánicas, podrían producirse anomalías tales como rotura de cables, fugas de aire o incendios.
Radio mínimo de curvatura: Cable de alimentación eléctrica ·····35 mm
Nota: éste es radio mínimo de curvatura a at 20 °C. En caso de instalarse a una temperatura inferior a la indicada, los valores serán mayores. Consulte el catálogo correspondiente para informarse sobre el radio mínimo de curvatura del tubo neumático.

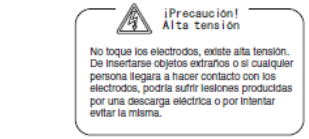
2. Instale el producto únicamente sobre una superficie plana.
Una superficie de montaje curva o irregular podría producir una tensión excesiva en el bastidor o la carcasa. Dicha tensión, así como cualquier impacto considerable (p. ej. si se deja caer el ionizador) podría producir daños y fallos.

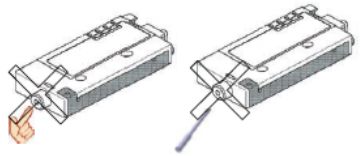
3. No utilice el producto en zonas sometidas a ruidos eléctricos.
Esto podría provocar un funcionamiento defectuoso, así como deterioro o daños en los componentes internos. Tome las medidas necesarias para evitar ruidos en su lugar de origen y procure que los cables de alimentación y de señal estén lo suficientemente apartados los unos de los otros.

4. Apriete las fijaciones al par especificado.
Consulte la tabla que se muestra a continuación para informarse sobre los pares de apriete correctos. Si se excede el par de apriete, podrían romperse los tornillos y los soportes de fijación. Si el par de apriete aplicado no es suficiente, podrían aflojarse los tornillos y los soportes de fijación.

Tamaño de tornillo	Par de apriete recomendado (N•m)
M3	De 0,61 a 0,63

5. No toque los electrodos directamente con la mano o con una herramienta metálica.
El hecho de tocar los electrodos con la mano o con una herramienta metálica, no sólo se interferirá con la función y rendimiento especificados del ionizador, sino que también podrían producirse fallos de funcionamiento o accidentes.





6. No aplique cinta o sellador al producto.
En caso de que la cinta o sellador incorporara algún tipo de adhesivo conductor o pintura refrescante, sería posible que, debido al efecto dieléctrico, se produjera una acumulación de carga que provocara una descarga electrostática o fuga eléctrica.

4 Instalación (continuación)

7. Instale o ajuste únicamente el producto tras haber aislado el suministro eléctrico.

⚠ PRECAUCIÓN

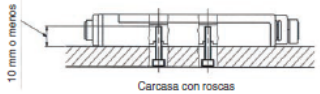
1. Mantenga un mínimo de espacio libre de 100 mm alrededor del ionizador para garantizar su funcionamiento, instalación y mantenimiento correctos.
Las paredes o cualquier otro objeto que estuviera presente dentro del espacio mínimo especificado podrían interferir con el funcionamiento del ionizador, reduciendo su eficacia para eliminar las cargas estáticas.

2. Asegúrese de comprobar el efecto de la eliminación de cargas estáticas después de completar la instalación.
La eficacia de la capacidad de eliminación de cargas estáticas varía en función de la instalación y de las condiciones de funcionamiento.

4.4.1 Instalación del ionizador

Localice aquellos lugares donde se producen problemas de estática, o donde los procesos y piezas generan descargas electrostáticas (ESD) y haga todo lo posible para proporcionar las condiciones adecuadas para una eliminación correcta de las cargas estáticas antes de proceder a la instalación del producto.
Cuando proceda al montaje del producto, utilice tornillos M3 de cabeza tipo Allen. El margen del par de apriete es de 0,61 a 0,63 N•m.

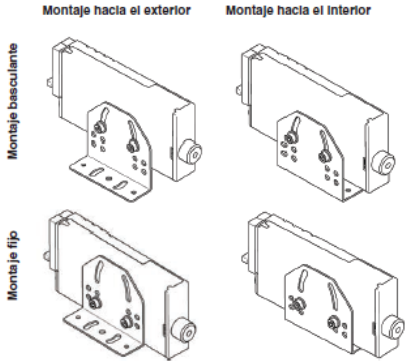
(1) Tipo de montaje para carcasa: Orificio roscado o pasante.
Consulte la ilustración que se muestra a continuación y monte el producto utilizando los tornillos de cabeza Allen de la longitud óptima.



Carcasa con roscas
Utilice tornillos con una penetración de rosca máxima de 10 mm

Orificios pasantes
Utilice tornillos de una longitud mínima de 12 mm

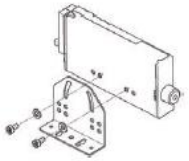
(2) Soporte en forma de L.
El soporte en forma de L puede instalarse de cuatro maneras diferentes tal y como se muestra en la ilustración inferior.



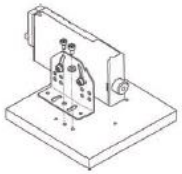
4 Instalación (continuación)

(3) Montaje hacia el exterior del soporte en forma de L.

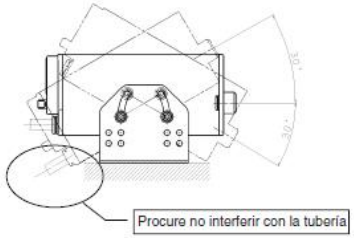
1. Utilice los tornillos de cabeza tipo Allen (M3 X 6) y las arandelas que se suministran con el producto y, a continuación, proceda al montaje del soporte en forma de L.



2. Ajuste el ángulo de la carcasa del ionizador para garantizar la correcta eliminación de las cargas estáticas y fíjelo en su sitio utilizando los tornillos de sujeción del soporte. Para el orificio ranurado, utilice la arandela que se suministra con el producto. Los tornillos de cabeza tipo Allen no están incluidos y deben adquirirse por separado.

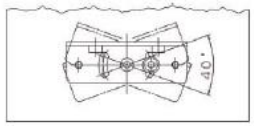


3. El ángulo de montaje del producto puede ajustarse dentro de los márgenes siguientes.



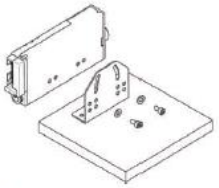
(4) Montaje hacia el interior del soporte en forma de L.

1. Antes de proceder al montaje del producto, instale el soporte en forma de L en el lugar donde vaya a instalarse el producto. El ángulo de montaje del soporte puede ajustarse dentro de los márgenes siguientes. Los tornillos de cabeza tipo Allen no se incluyen con el producto y deben adquirirse por separado.



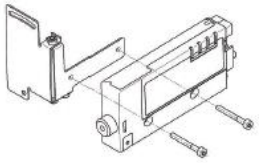
4 Instalación (continuación)

2. Monte el producto utilizando los tornillos de cabeza tipo Allen (M3 X 6) y las arandelas que se suministran con el producto. El margen del par de apriete es de 0,61 a 0,63 N•m.

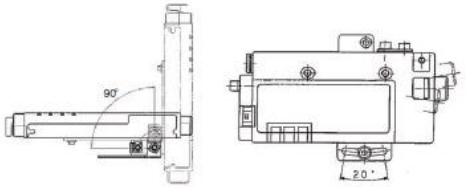


(5) Soporte basculante

1. Fije el soporte basculante al producto utilizando los tornillos de cabeza tipo Allen y las arandelas que se suministran con el producto. El margen del par de apriete es de 0,61 a 0,63 N•m.

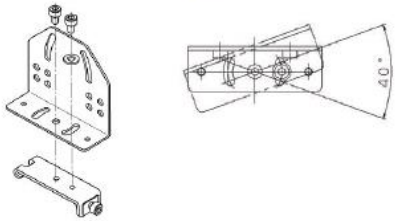


2. Ajuste el producto al ángulo de montaje deseado y fíjelo en su sitio.



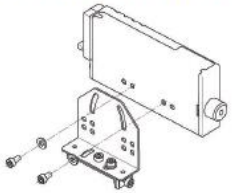
(6) Soporte de montaje en carril tipo DIN

1. Ajuste el soporte en forma de L al ángulo deseado y fíjelo en su sitio.

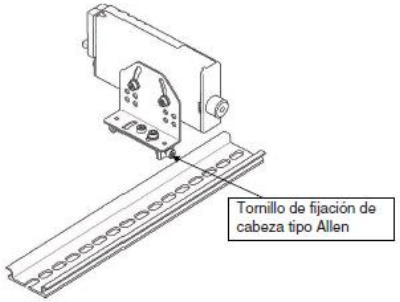


4 Instalación (continuación)

2. Fije el soporte en forma de L al producto utilizando los tornillos de cabeza tipo Allen (M3 X 6) y las arandelas que se suministran con el producto.



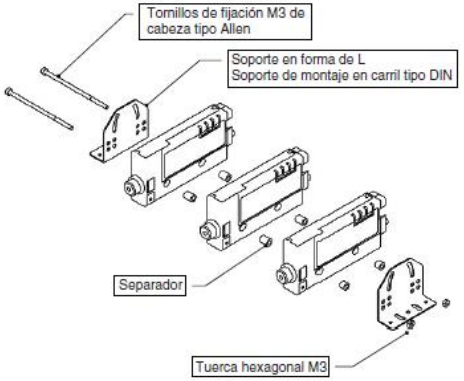
3. Monte el producto en el carril tipo DIN y apriete los tornillos de cabeza tipo Allen para fijarlo en su sitio.



(7) Montaje de múltiples ionizadores

1. Inserte los separadores entre los orificios achaflanados de la carcasa.
2. Fije el producto utilizando a cada lado del mismo soportes en forma de L y apriete los tornillos de cabeza Allen. El margen del par de apriete es de 0,61 a 0,63N•m.

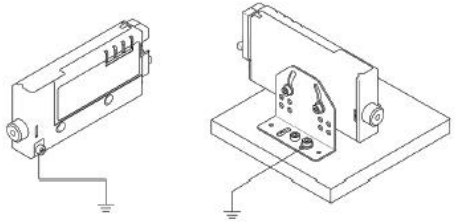
La ilustración inferior muestra la disposición correcta de las piezas si se desea conectar 3 ionizadores.



4 Instalación (continuación)

(8) Asegúrese de que el conductor del cable [azul] del suministro eléctrico está conectado a una toma de tierra a modo de protección.

De no conectarse a tierra dicho cable, el equilibrio iónico sería inestable y existiría riesgo de electrocución. Además, podrían producirse daños en el ionizador o en la fuente de alimentación conectada al mismo.



5 Descripción funcional

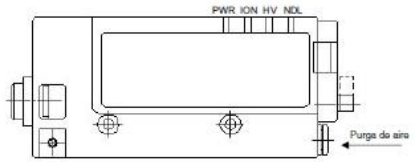
1. Detección de contaminación en el electrodo.

Durante el funcionamiento del aparato, se supervisa constantemente cualquier reducción en la capacidad de eliminación de carga debido a contaminación o desgaste del electrodo. Si fuera necesario limpiar el electrodo, el indicador LED de mantenimiento se iluminará en la pantalla del producto y se generará una señal de salida de mantenimiento.

2. Entrada de señal procedente de un interruptor externo.

Existen dos puertos para las entradas de señales de interruptores externos.
En caso de que se conecte un sensor electrostático o un interruptor de presión, podrá detenerse la descarga debido a una presión anormal o tras haberse completado la eliminación de la carga.

3. Denominación de los indicadores LED de la pantalla.



Denominación	Identificació	Color	Indicaciones
Alimentación	PWR	Verde	Iluminado cuando se activa la alimentación.
Descarga	ION	Verde	Iluminado cuando se está efectuando la descarga
Error alta tensión	HV	Rojo	Iluminado cuando fluye una corriente excesiva a través de la aguja del electrodo.
Mantenimiento	NDL	Naranja	Iluminado cuando se detecta contaminación o desgaste en la aguja del electrodo.

5 Descripción funcional (continuación)

4. Estado de los indicadores LED

Elemento	PWR	ION	HV	NDL	Observaciones
Funcionamiento normal (señal de parada de descarga activada)	•	•			Emisión de iones
Funcionamiento normal (señal de parada de descarga desactivada)	•				Descarga interrumpida
Detección de error de alta tensión	•		•		Descarga interrumpida debido a haberse detectado
Señal de interruptor externo 1	•				Descarga interrumpida debido a una entrada de señal
Señal de interruptor externo 2	•				
Detección de contaminación en la aguja del electrodo	•	•		•	Se emiten iones de forma continua incluso tras haberse detectado contaminación en la aguja

5. Datos de las alarmas

Descripción	Indicaciones	Cómo reinicializar
Error alta tensión	Informa que se ha producido un exceso de corriente (por ejemplo, una fuga de alta tensión) en la aguja del electrodo. El indicador LED "HV" se ilumina y se detiene la emisión de iones. La señal de error se desactiva cuando se produce un error.	Desactive la alimentación, localice y resuelva el error y, a continuación, vuelva a activar la alimentación. De haberse corregido el error, active y desactive la señal de reinicialización.
Mantenimiento de la aguja del electrodo	Informa sobre la necesidad de realizar operaciones de mantenimiento en la aguja del electrodo. El indicador LED "NDL" se ilumina y se produce una señal de mantenimiento en la salida del circuito.	Desactive la alimentación, limpie la aguja del electrodo y vuelva a activar la alimentación.

6 Mantenimiento

⚠ ADVERTENCIA

1. No deje caer el producto ni permita que golpee otro objeto o reciba un fuerte impacto (de 10 G o más) durante su manipulación. Aunque en su exterior parezca que el ionizador no está roto, es posible que se hayan producido daños internos que causen un funcionamiento defectuoso.

2. Al enchufar o desenchufar el cable, presione entre los dedos el clip elástico del enchufe modular e inserte o retire el enchufe en línea recta. Si se inserta o retira con una orientación incorrecta, podría dañarse la zona de montaje del conector modular y podrían producirse fallos durante el funcionamiento.

⚠ PRECAUCIÓN

1. Mantenga el electrodo limpio efectuando con regularidad las tareas de mantenimiento pertinentes.

Asegúrese de que el equipo funciona sin errores efectuando con regularidad las tareas de mantenimiento pertinentes. Tan sólo aquellas personas con los conocimientos y experiencia suficientes deberán efectuar trabajos de mantenimiento en el equipo. Cualquier contaminación que se adhiera al electrodo debido a periodos prolongados de funcionamiento, reducirá la habilidad del ionizador para eliminar la electricidad estática. Si después de limpiar el electrodo, el ionizador sigue sin recuperar su rendimiento correcto, deberá procederse a la sustitución del electrodo. Para mantener un rendimiento estable del producto, se recomienda efectuar un mantenimiento y una limpieza frecuentes del electrodo.

¡Precaución! Alta tensión

Existe instalado un circuito que genera alta tensión. Asegúrese de desactivar la tensión de alimentación antes de proceder a efectuar cualquier tarea de mantenimiento. No desmonte o modifique el producto, ya que podría reducirse la eficacia de sus funciones y causar lesiones físicas debido a descargas eléctricas o a fugas de corriente.

6 Mantenimiento (continuación)

2. El tubo y los racores deberán tratarse como piezas consumibles.

Es posible que el tubo y el racor que están conectados al puerto de conexión de tubería hembra del producto se deterioren debido al ozono y se requiera sustituirlos con frecuencia.

3. Deberá desconectarse la alimentación eléctrica cuando se vaya a proceder a la limpieza del electrodo o a la sustitución del cartucho del mismo.

Para evitar riesgos de descarga eléctrica, no toque el electrodo mientras que el ionizador reciba alimentación eléctrica.

4. Para evitar riesgos de electrocución, así como averías, incendios, etc., no efectúe reparaciones ni modificaciones en el producto.

No podrá garantizarse que aquellos productos no reparados por SMC o en los que se hayan efectuado modificaciones cumplan las especificaciones publicadas.

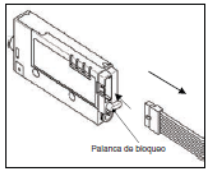
5. No manipule u opere el producto con las manos húmedas.

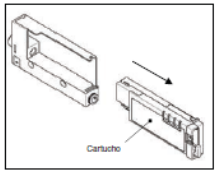
Existe peligro de electrocución.

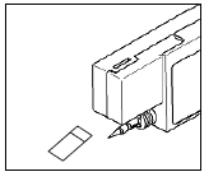
(1) Cómo llevar a cabo las tareas de mantenimiento en el electrodo.

Limpieza del electrodo.

1. Desconecte el cable del alimentación eléctrica.
2. Gire la palanca de bloqueo y tire hacia abajo del cartucho.
3. Limpie el electrodo.
4. Vuelva a montar el cartucho y el cable de alimentación eléctrica invirtiendo la secuencia de desmontaje para así completar el proceso de limpieza.







7 Limitaciones de uso

⚠ ADVERTENCIA

No exceda ninguna de las especificaciones indicadas en la sección 2 de este documento o del catálogo específico del producto.

8 Contactos

AUSTRIA	(43) 2262 62280	HOLANDA	(31) 20 531 8888
BÉLGICA	(32) 3 355 1464	NORUEGA	(47) 67 12 90 20
REPÚBLICA CHECA	(420) 541 424 611	POLONIA	(48) 22 211 9600
DINAMARCA	(45) 7025 2900	PORTUGAL	(351) 21 471 1880
FINLANDIA	(358) 207 513513	ESLOVAQUIA	(421) 2 444 56725
FRANCIA	(33) 1 6476 1000	ESLOVENIA	(386) 73 885 412
ALEMANIA	(49) 6103 4020	ESPAÑA	(34) 945 184 100
GRECIA	(30) 210 271 7265	SUECIA	(46) 8 603 1200
HUNGRÍA	(36) 23 511 390	SUIZA	(41) 52 396 3131
IRLANDA	(353) 1 403 9000	REINO UNIDO	(44) 1908 563888
ITALIA	(39) 02 92711		

SMC Corporation

URL: http// www.smcworld.com (Global) http// www.smceu.com (Europa)

Las especificaciones pueden estar sujetas a modificaciones sin previo aviso por parte del fabricante.

Part No. 7500.XC

Certified by DQS
ISO 9001:2008

Wolfgang Warmbier®
Systeme gegen Elektrostatik

♦ Untere Gießwiesen 21 ♦ 78247 Hilzingen ♦ Tel.: +49-7731-86880 ♦ Fax: +49-7731-868830

Aerostat® XC (Benchtop Ionizer)

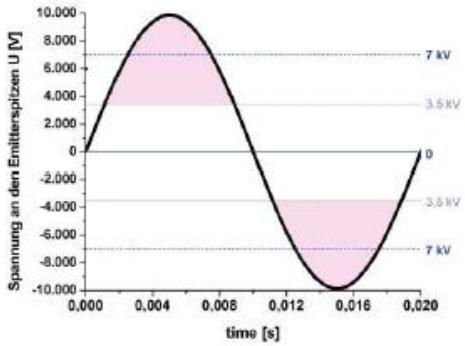
(Part No. 7500.XC)

SIMCO
An Illinois Tool Works Company

- Quickly neutralizes static charges
- Complies with IEC 61340-5-1 Ed. 1.0 (2007-08)
- Good coverage of the work area
- Patented emitter point cleaner
- Integrated 3-speed fan and heater (to warm-up the ambient temperature by 6-8℃)
- AC technology
- Easy maintenance

Applications:

- Manufacturing of PCB's with ESDS devices
- Pharmaceutical industry, electronic assembly and production
- Manufacturing of optical components



High voltage ionisation with emitter strip

V0211

Certified by DQS
ISO 9001:2008

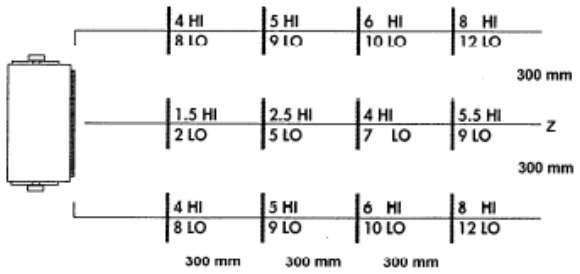
Wolfgang Warmbier®
Systeme gegen Elektrostatik
♦ Untere Gießwiesen 21 ♦ 78247 Hilzingen ♦ Tel.: +49-7731-86880 ♦ Fax: +49-7731-868830

Technical data:

Power supply:	230 V, 50 Hz
Input current:	min. 0,3 A (without heating)
	max. 1,8 A (with heating)
High voltage:	internal app. 7 kV
Emitter:	stainless steel emitter points
Offset voltage:	Inherently balanced to ± 5 V
Area of ionisation:	90 cm x 180 cm
Operating temp.:	0°C to 50°C
Dimensions:	39 cm x 11,4 cm x 20,63 cm (W x H x D)
Weight:	7,9 kg (steel housing)
Ozone generation:	<0,005 ppm (measured 15 cm in front of the unit)
	Complies with TRGS 900 (maximum value 200µg/m³ = 0,1ppm)

Airflow adjustable in three steps:

Step:	Airflow:	Noise:
low	2 m^3/Minute	52dB
medium	2,7 m^3/Minute	58dB
high	3,5 m^3/Minute	64dB



Decay time according to IEC 61340-4-7 FDIS (1.000 V to 100 V)

Time in seconds,
HI/LO = fan speed

CE

► 1 year limited warranty.

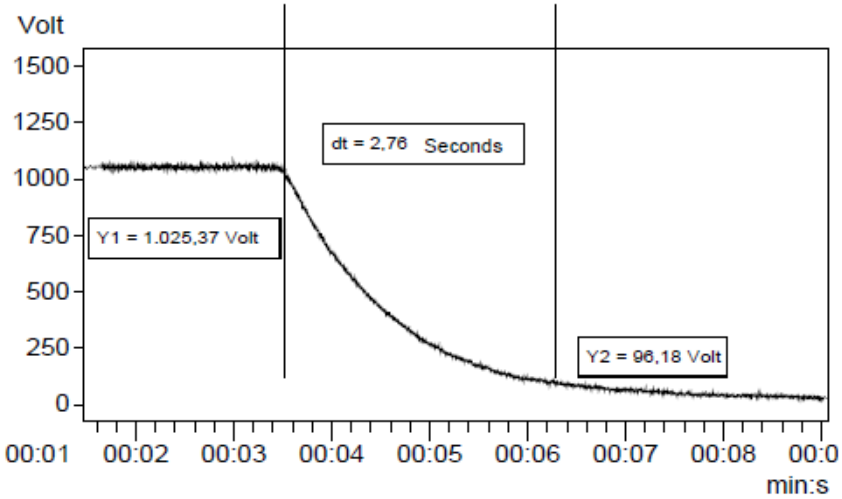
V0211

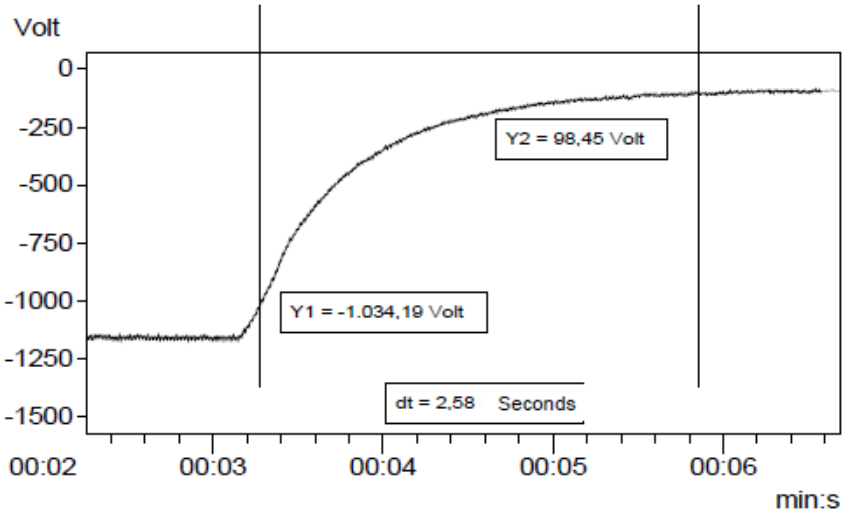
Part No. 7500.XC

Certified by DQS
ISO 9001:2008

Wolfgang Warmbier®
Systeme gegen Elektrostatik
♦ Untere Gießwiesen 21 ♦ 78247 Hilzingen ♦ Tel.: +49-7731-86880 ♦ Fax: +49-7731-868830

Typical decay time 1.000 V to 100 V
(Measurement according to IEC 61340-4-7 FDIS





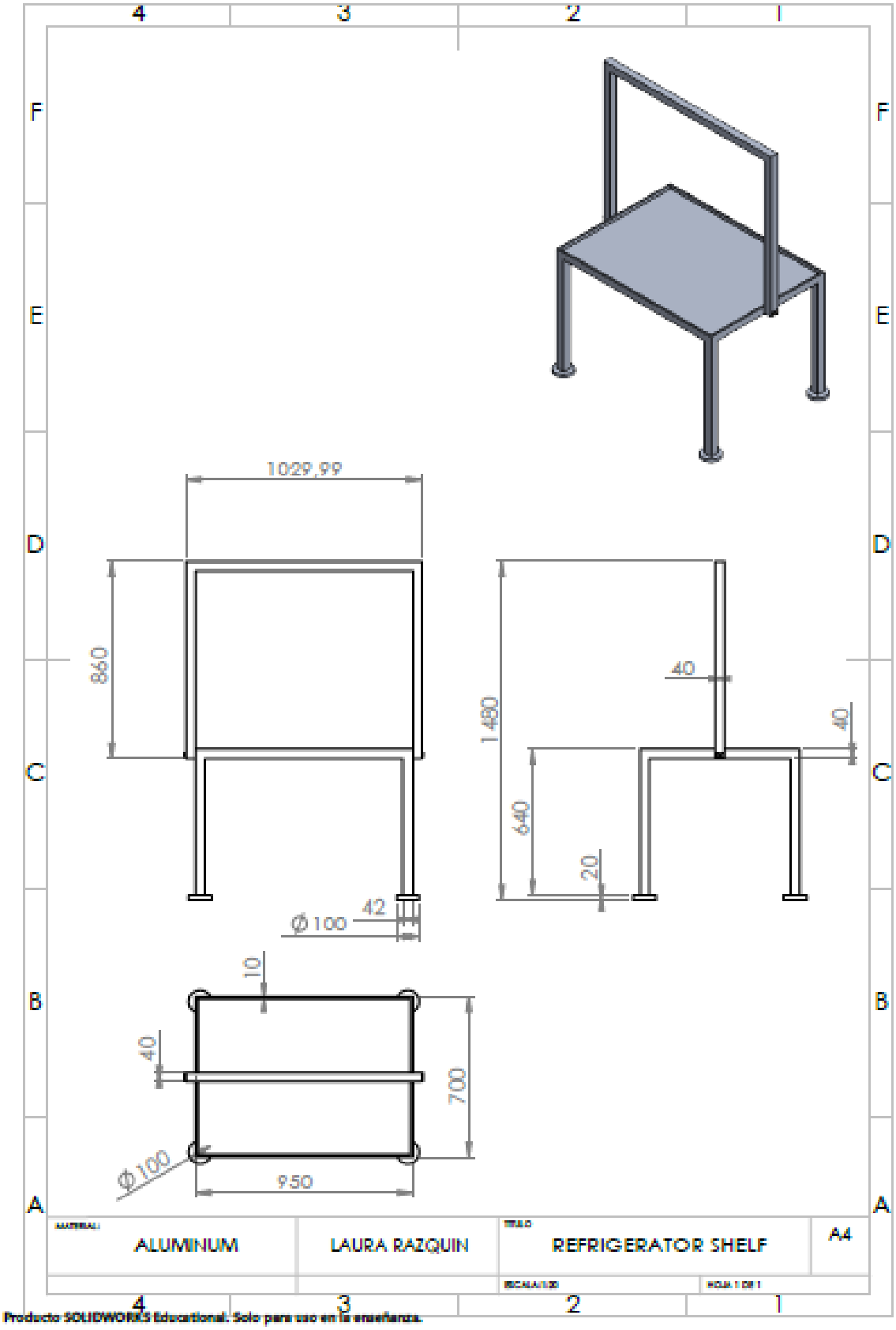
➢ Measured with a Charged Plate Monitor (CPM) Type EA-3 of SIMCO. (Fan speed „High").
Distance: 60 cm; **Relative Humidity**: 34 %; **Temperature:** 21°C

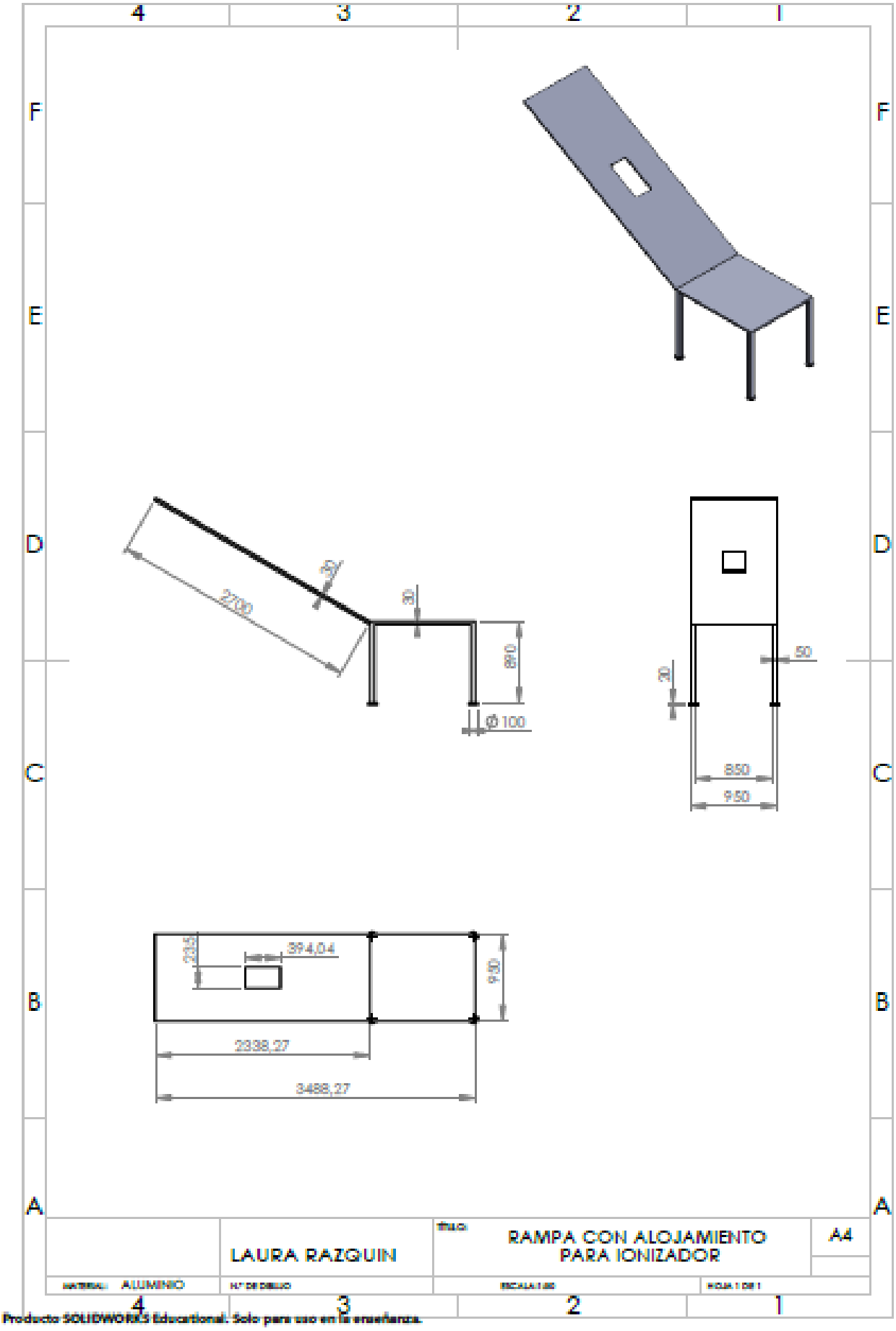
Accessories (optional):

7500.XC.F	Filter kit	

V0211

7.ANNEX VII: SOLIDWORKS DESIGN FOR FR ASSEMBLY LINE




2200
50
30
890
Ø 100
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850
950
235
394,04
950
2338,27
3488,27
LAURA RAZQUIN
RAMPA CON ALOJAMIENTO
PARA IONIZADOR
A4
ALUMINIO
Producto SOLIDWORKS Educational. Solo para uso en la enseñanza.

8.ANNEX VIII: CHARACTERISTICS OF DISSIPATIVE MAT AND PAINTING

Technisches Merkblatt

Seite 1 von 2

Artikel Nr.: 1250.47002.x

DQS-zertifiziert nach ISO 9001:2008

Wolfgang Warmbier®
Systeme gegen Elektrostatik

♦ Untere Gießwiesen 21 ♦ 78247 Hilzingen ♦ Tel.: +49-7731-86880 ♦ Fax: +49-7731-868830

ECOSTAT® DUO-2.0 PVC

(Artikel Nr.: 1250.47002.x)

- Basismaterial: Polyvinylchlorid
- Zweischichtiger Verbundbelag
- Elektrostatisch ableitfähiger Bodenbelag mit leitfähigem Rücken
- Entspricht Anforderungen nach DIN EN 61340-5-1
- Isolationswiderstand nach DIN VDE 0100-410 für Personensicherheit
- Seidenmatte Oberfläche
- Pflegeleicht
- Hervorragende Verschleißeigenschaften
- Zur losen Verlegung ohne Verklebung, multifunktional/Mehrfachnutzen
- Erdung z.B. über 10 mm Druckknopf
- Lieferform: Bahnenware / Zuschnitte

Leitfähiger Rücken

Farb-Nr. 47002

Produktqualifikation nach DIN EN 61340-5-1 (2008-07):

	Prüfmethode	Grenzwerte	Typische Werte
Widerstand zum erdungsfähigen Punkt R_{gp}	DIN EN 61340-4-1	$< 1 \times 10^9\ \Omega$	$10^6 - 10^8\ \Omega$
Systemwiderstand - Person / Schuhwerk / Boden R_g	DIN EN 61340-4-5	$< 3{,}5 \times 10^7\ \Omega$	$10^6 - 10^8\ \Omega$ abhängig vom Schuhtyp
Körperspannung (Begehtest)	DIN EN 61340-4-5	< 100 V	< 100 V abhängig vom Schuhtyp
Umgebungsbedingungen: 25 ± 3% rel. Feuchte und 23 ± 2°C (Konditionierung > 48 Std.)			

Elektrische Eigenschaften:

	Prüfmethode	Typische Werte
Punkt-zu-Punkt Widerstand (Leitfähige Rückseite) R_{p-p}	DIN EN 61340-2-3	$10^3 - 10^4\ \Omega$

V1109

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Technische Daten:

Eigenschaften	Prüfnorm	Anforderungen	Typische Werte
Gesamtdicke	EN 428		2,0 mm
Flächengewicht	EN 430		3000 g/m²
Lieferform	EN 426		Länge 10 m Breite 1,5 m
Isolationswiderstand R_i	DIN VDE 0100-610	$> 5 \times 10^4\ \Omega$ (Nennspannung bis 500 V)	$> 5 \times 10^4\ \Omega$
Stuhlrollenbeanspruchung	DIN 68131/EN 425		Geeignet, wenn Typ W nach DIN 68131
Maßänderung durch Wärmeeinwirkung	DIN 1817 / EN 434	± 0,4%	< 0,2%
Resteindruck	DIN 51955 / EN 433	≤ 0,1 mm	< 0,1 mm
Lichtechtheit	ISO 105 B02	Note 6	≥ 7
Trittschallverbesserungsmaß	ISO 140-8		ca. 2dB
Brandverhalten	DIN 4102	B2	B1
Verschleißverhalten	EN 660 Pt2		Gruppe T ≤ 2,0 mm³
Nahtfestigkeit	EN 684		≥ 400 N/50 mm
Wärmeleitfähigkeit			0,25 W/m K

Anmerkungen:

Produktionsbedingte Farbabweichungen (Chargen), technische Veränderungen, die der Produktionsverbesserung dienen, behalten wir uns vor. Typische Werte wurden in Anlehnung an oben zitierte Normen praxisbezogen ermittelt.

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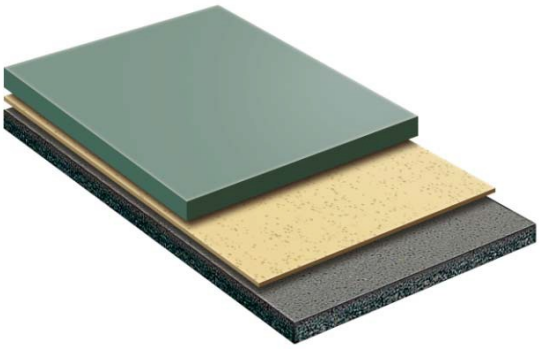

MasterTop 1278

Recubrimiento epoxy continuo con capacidad de puentear fisuras para cubetos de contención según § 19 WHG

Campo de aplicación: Pavimentos industriales, cubetos de contención expuestos a desgaste mecánico y químico.

- Clase de resistencia al deslizamiento Rd según UNE-ENV 12633: **1**
- Clase de reacción al fuego según UNE EN 13501-1: **Bfl-s1**.

			Consumo
	Imprimación	**MasterTop P 621** Resina epoxy bicomponente que no contiene disolventes	0,3 - 0,5 kg/m²
	Espolvoreo sobre imprimación	Arena **MasterTop F5** Espolvoreo ligero homogéneo. No aplicar en exceso	0,3 kg/m²
	Opcional: Imprimación espatulada	**MasterTop P 621** Mezclar con árido MasterTop F1 Relación de mezcla resina : árido 1:0,5	0,6 – 1,0 kg/m²*
	Capa base**	**MasterTop BC 378** Resina epoxy bicomponente pigmentada que no contiene disolventes (100% sólidos) con alta resistencia química	min. 2,5 kg/m²
	Espesor del sistema	**Mínimo 2,1 mm**	

Nota: Los consumos indicados pueden ser superiores dependiendo de la rugosidad, temperatura y rugosidad del soporte, así como las pérdidas generadas durante la aplicación.
* El consumo incluye el árido.
*** El espolvoreo de agregados es necesario para alcanzar la resistencia al deslizamiento.

BASF Construction Chemicals España, S.L.
Carretera del Mig nº 219
08907 L'Hospitalet de Llobregat
Barcelona (ESPAÑA)
Teléfono +34 93 261 61 00
Fax +34 93 261 62 19
E-mail basf-cc@basf-cc.es
Internet www.master-builders-solutions.basf.es

MASTER® BUILDERS SOLUTIONS

El sistema de pavimentos cumple, como requerimientos mínimos, las siguientes propiedades y datos técnicos determinados por ensayos internos y externos:

Aprobación técnica general **DIBt Z-59.12-194.**

EN 13813	SR-B1,5-AR1-IR4
Resistencia a tracción	11 N/mm^2
Resistencia al desgarro	35 N/mm^2
Resistencia a la abrasión Taber	87 mg/1000 R
Resistencia al tráfico	Neumáticos de aire, goma, goma vulcanizada y poliamida.
Resistencia química	Grupos de ensayo BPG (Building and test laws): 3, 3a, 3b, 4, 4a, 4b, 4c, 5, 5a, 5b, 6, 6a, 6b, 7, 7a, 7b, 8, 8a, 9, 9a, 10, 11, 12, 13, 14 Además: Ácido fosfórico al 85%, ácido sulfúrico al 90%, ácido láctico al 50%, ácido clorhídrico al 37%, hipoclorito sódico (13% de cloro activo), solución de amoniaco concentrado, ácido crómico al 50%, ácido acético en base agua al 30%, ácido nítrico al 30%, ácido fluorhídrico al 50%, ácido fórmico en base agua, peróxido de hidrógeno al 30% (para más información, consultar el documento Dibt).
Comportamiento al fuego según EN 13501-1	Bfl-s1 / DIN 4102-1 = B 2.
Capacidad de puente de fisuras	0,3 mm según BPG
Resistencia al deslizamiento	R9, R10
Campos de aplicación	Interior y exterior

Consultar el método de aplicación que se encuentra en la autorización de los organismos de construcción DIBt.

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08907 L'Hospitalet de Llobregat
Barcelona (ESPAÑA)
Teléfono +34 93 261 61 00
Fax +34 93 261 62 19
E-mail basf-cc@basf-cc.es
Internet www.master-builders-solutions.basf.es

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0679	
BASF Construction Chemicals España, S.L. Carretera del Mig, 219 08907 L'Hospitalet de Llobregat	
09	
127801	
EN 13813	
EN 13813: SR-B1,5-AR1-IR4	
Recubrimiento/revestimiento a base de resina sintética para uso en construcciones	
Comportamiento al fuego*	**Bfl – s1**
Emisión de sustancias corrosivas	**SR**
Permeabilidad al agua	**NPD**
Resistencia al desgaste	**< AR1**
Adherencia	**> B1,5**
Resistencia al impacto	**> IR4**
Aislamiento acústico	**NPD**
Absorción acústica	**NPD**
Resistencia térmica	**NPD**
Resistencia química	**NPD**
Resistencia al deslizamiento	**R9, R10**
Comportamiento de emisiones	**NPD**

NPD = Prestación no determinada

Comportamiento determinado para el sistema **MasterTop 1278**

Última edición: 02/05/2017

BASF Construction Chemicals España, S.L.
Carretera del Mig nº 219
08907 L'Hospitalet de Llobregat
Barcelona (ESPAÑA)
Teléfono +34 93 261 61 00
Fax +34 93 261 62 19
E-mail basf-cc@basf-cc.es
Internet www.master-builders-solutions.basf.es

MASTER® BUILDERS SOLUTIONS

Informe Técnico

Informe número:	**CS/B- 02/18**
Fecha del informe:	**18/01/2018**
Fecha de la visita:	**15/01/2018**
Productos:	**Sistema MasterTop 1278 AS**
Obra:	**BSH Electrodomésticos**
Lugar:	**Esquiroz (Navarra)**
Empresa aplicadora:	**GRANALLADOS DE NAVARRA**

BASF Construction Chemicals España, S.L.

Avd, Txori Erri 46
Pol Berreteaga Pab 6 Modulo D
48150 Sondika
Bizkaia

Telf. : +34 –94 – 453 10 21
Fax. : +34 –94 – 453 14 88

www.master-builders-solutions.basf.es

ÍNDICE

1. OBJETO

El objeto de este informe es el recoger los resultados de las medidas de conductividad realizadas en la planta BSH Electrodomésticos en Esquiroz (Navarra) el pasado día 15 de enero. El pavimento aplicado (Sistema MasterTop 1278 AS) se ha realizado en diversas áreas de la planta.

2. DESCRIPCIÓN ENSAYO Y NORMATIVA

Las mediciones de resistencia eléctrica sobre el pavimento MasterTop 1278 AS se efectuaron mediante equipo METRISO 2000 – KIT, con identificación M541C OK2444 y con certificado de calibración número ZEL-27073 emitido por Trescal Iberica De Calibracion S.L.

Los valores obtenidos según el ensayo, se han realizado tomando como base a la norma CEI 61340-4-1:2003 Electrostática. Parte 4-1: Métodos de ensayo normalizados para aplicaciones específicas. Resistencia eléctrica de recubrimientos de suelos y pavimentos instalados. La diferencia de potencial empleada fue de 100 V.

3. RESULTADOS

Condiciones ambientales durante las mediciones:

Tª: 20,9 ºC
Humedad relativa: 40 %

3.1 Zona espumado

ºResultados:

Punto de medida	Valor obtenido (Ω)
1	$1,93 \times 10^6$
2	$1,29 \times 10^6$

Valor medio: $1,610 \times 10^6$

3.2. Montaje Cadena 1:

º Resultados:

Punto de medida	Valor obtenido (Ω)
1	$1,25 \times 10^5$
2	$5,12 \times 10^5$
3	$6,67 \times 10^5$
4	$1,47 \times 10^5$
5	$1,87 \times 10^5$
6	$2,07 \times 10^5$
7	$2,26 \times 10^5$

Valor medio: $2,950 \times 10^5$

3.3. Pelapuertas Cadena 1:

º Resultados:

Punto de medida	Valor obtenido (Ω)
1	$3,63 \times 10^5$
2	$1,13 \times 10^5$

Valor medio: $2,050 \times 10^5$

3.4. Montaje Cadena 4:

º Resultados:

Punto de medida	Valor obtenido (Ω)
1	$7,49 \times 10^5$
2	$5,46 \times 10^5$
3	$1,23 \times 10^5$
4	$1,60 \times 10^5$
5	$5,18 \times 10^5$
6	$1,37 \times 10^5$
7	$1,97 \times 10^5$
8	$0,97 \times 10^5$
9	$0,76 \times 10^5$
10	$2,37 \times 10^5$

Valor medio: $2,840 \times 10^5$

3.5. Tambor Cadena 4:

º Resultados:

Punto de medida	Valor obtenido (Ω)
1	$0,83 \times 10^5$
2	$1,24 \times 10^5$
3	$0,81 \times 10^5$

Valor medio: $0,960 \times 10^5$

3.6. Pelapuertas Cadena 4:

º Resultados:

Punto de medida	Valor obtenido (Ω)
1	$4,04 \times 10^5$
2	$2,75 \times 10^5$
3	$0,34 \times 10^5$

Valor medio: $2,376 \times 10^5$

3.7. <u>Premontaje Cadena 4:</u>

º Resultados:

Punto de medida	Valor obtenido (Ω)
1	$5{,}20 \times 10^5$
2	$2{,}63 \times 10^5$
3	$1{,}16 \times 10^5$
4	$4{,}92 \times 10^5$
5	$3{,}74 \times 10^5$
6	$1{,}46 \times 10^5$
7	$1{,}47 \times 10^5$
8	$1{,}70 \times 10^5$

Valor medio: $2{,}785 \times 10^5$

4. CONCLUSIONES

Según el ensayo realizado en base a la norma CEI 61340-4-1:2003 (Electrostática. Parte 4-1: Métodos de ensayo normalizados para aplicaciones específicas. Resistencia eléctrica de recubrimientos de suelos y pavimentos instalados) todas las mediciones obtenidas de la resistencia eléctrica del pavimento se encuentran dentro de los valores declarados en la especificación técnica del sistema de pavimento **MasterTop 1278 AS** ($R_{gp} < 1 \times 10^9 \Omega$)**.**

Se adjunta Hojas de sistema y ensayo externo de caracterización del sistema en cuanto a su comportamiento electroestático.

5. NOTAS

Para completar la información y consultar las características de los productos citados será necesario consultar las correspondiente Fichas Técnicas y Hojas de Datos de Seguridad de los mismos.

Pueden ser necesarios ensayos complementarios o modificaciones del presente documento en base a informaciones que no han podido ser facilitadas a la realización del presente escrito.

Para más información sobre cualquiera de los materiales mencionados en este informe (DOP, datos técnicos…) se recomienda consultar la correspondientes fichas técnicas y documentación técnica adicional. Todas nuestras fichas técnicas pueden encontrarlas en nuestra página web:
www.master-builders-solutions-basf.es

BASF Construction Chemicals España, S.L.

Javier Vidaurrazaga Vidal
Servicio Técnico – Master Builders Solution

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