ORIGINAL RESEARCH ARTICLE

Secret of radiation protection and anti-static clothing

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ABSTRACT

In the current era, electromagnetic radiation is everywhere. Every day electromagnetic radiation and static electricity caused by a variety of hazards. So, anti-electromagnetic radiation and anti-static awareness gradually enjoys popular support, more attention are gained by people on the anti-electromagnetic radiation and anti-static. This caused radiation protection and anti-static clothing industry's rise by the day. Radiation protection and anti-static clothing will enter various households to provide a certain amount of protection to the people's health. We discuss two parts in this paper, specifically from the effects of the electromagnetic radiation and electrostatic effects which started on radiation clothing and anti-static clothing. The main contents of this paper are as follows: The first part of the definition of electromagnetic radiation and its brief introduction, while explaining the types of electromagnetic radiation and electromagnetic radiation sources in daily lives, followed by the emphasis of serious harms on electromagnetic radiation on human health It is precisely because of electromagnetic radiation on people's lives have serious threat, that makes the development of radiation protection. This follows the basic introduction of the radiation suit and the development of radiation protection clothings. The development of radiation protection suits is an established industry. Materials made of radiation protection are constantly changing, but their basic working principle has not changed. Followed by the introduction of the basic principles of radiation protection clothings, we theoretically present specific analysis and demonstration. However, the theoretical analysis and practice is often consists a certain gap, so we highlight a few actual situations on the impact of radiation protection clothings. Finally, we present a simple discussion on wide range of applications of radiation protection clothings. The thought process of second part is similar as the first part, respectively, we introduce the health hazards and the impact on people's lives of electrostatic effect and static electricity . Followed by that it is the basic principles, relevant analysis and discussion of anti-static clothing Finally, we provide the detailed explanation of the application of anti-static clothing.

KEYWORDS: electromagnetic radiation, static electricity, radiation protection, anti-static clothing

1. Introduction

With the rapid development of the information industry, every corner of the world today can access a variety of different information channels to tell the story of the whole world. Every household has no doubt has the installation of a wide range of home appliances: air conditioners, refrigerators, LCD TVs, making our life more convenient and varied, while the mobile phone computer are integral in our lives. These developments brought us an unexpected convenience and joy. However, while these electronic and information products continue to improve the quality of our lives, at the same time they also caused a serious threat to our lives. 'Electromagnetic radiation', a term that cause fear to the masses , is virtually becoming a new threat to people living environment as electromagnetic pollution. This type of pollution have different hazards on different people, with children and pregnant women is more 'electromagnetic pollution' sensitive. Long-term exposure in the electromagnetic pollution of children will cause pediatric mental retardation, poor resistance, decreased vision, hematopoietic dysfunction and even increasing incidence of cancer. Pregnant women exposed are prone to fetal malformations, congenital disease or stillbirth. At the same time, static and electromagnetic pollution caused serious harm as well as human health and to experimental equipment. Static electricity lead to infant arrhythmia, and subsequently causing diseases such as bronchitis and asthma. Impact of static electricity on the elderly include increasing cardiovascular disease, ventricular arrhythmia and other arrhythmias. It is precisely because of electromagnetic pollution and electrostatic pollution has such a serious threat on human life and physical health, radiation suits and anti-static clothing came into development, as a solution. Radiation and anti-static garnered more and more attention. This article will be a specific exposition of working principle of radiation protection and anti-static clothing specific, their types, application areas and other issues, opening up the mystery of radiation clothing and anti-static clothing.

2. Electromagnetic radiation and radiation protection clothing

2.1. Electromagnetic radiation

2.1.1 Introduction to electromagnetic radiation

Interaction of electric field and the magnetic field caused electromagnetic waves. Electromagnetic waves radiating or leakage to the atmosphere are the phenomenon called electromagnetic radiation. Electromagnetic radiation is a kind of invisible, intangible form of material. Electromagnetic radiation, also known as electrical smoke, is the common transfer of electrical energy and magnetic energy through the space, composed by energy generated via charge movement. It has an oscillation of electric field and magnetic field component, which propagates energy in two mutually perpendicular directions. Electromagnetic radiation is divided into different types according to the frequency or wavelength of the waves. These types include (in increasing frequency): radio waves, microwave, terahertz radiation, infrared radiation, visible light, ultraviolet rays, X-rays and gamma rays.

2.1.2 Electromagnetic radiation around us

The most common source of electromagnetic radiation around us is countless. For example, handphones will have a certain state of radiation. During dialing, listening to music, when the radiation will be stronger. Microwave ovens at home during work strong electromagnetic waves will be leaked out. Usage of computer every day, its radiation is very high. In addition to the above, there are a lot of radiation sources, high voltage lines, substations, radio stations, television stations, radar stations, electromagnetic wave towers, all kinds of electronic equipment, medical equipment, office automation equipment, etc. These are the largest source of radiation of our daily life.

2.1.3 Harms of electromagnetic radiation

It is most likely one of the causes of childhood leukemia. Medical studies have shown that long-term exposure of high electromagnetic radiation in the environment, will cause change on the blood, lymph and cell protoplasm. Italian experts believe that the country each year more than 400 children suffering from leukemia, and the main reason is too close to the high voltage line, which has been a serious source electromagnetic pollution.

Electromagnetic radiation can induce cancer and accelerate the proliferation of human cancer cells. Electromagnetic radiation pollution will affect the human circulatory system, immune, reproductive and metabolic functions. It can also cause severe cancer and accelerate the proliferation of cancer cells. Swiss research data pointed out that around the high-voltage line through the residents of the residents, the probability of breast cancer are 7.4 times higher than ordinary people. The Texas Cancer Medical Foundation's sampling test for patients exposed to electromagnetic radiation showed that workers working near high-voltage lines had higher cancer cell growth 24 times faster than the average person.

The impact of electromagnetic radiation on human reproductive system for men, is reduction of the quality of sperm. While for pregnant women the causes are spontaneous abortion, fetal malformations, giving birth to children with intellectual disabilities. According to the latest survey shows that China's there are 350,000 defects from annual birth of 20 million children, of which 250,000 for the mental disability. Some experts believe that electromagnetic radiation is one of the factors. The World Health Organization believes that computer, television, mobile phone electromagnetic radiation has a negative impact on the fetus.

It affects people's cardiovascular system, manifested as palpitations, insomnia, some women menstrual disorders, bradycardia, reduced stroke volume, sinus heart rate irregularities, leukopenia and decreased immune function. If a patient with a pacemaker is living in a high-voltage electromagnetic radiation environment, it will affect the normal use of the pacemaker.

It also have a negative impact on people's visual system. As the eyes of the human body is sensitive to electromagnetic radiation organs, excessive electromagnetic radiation pollution can cause vision loss, cataracts and so on. High-dose of electromagnetic radiations will also affect and disrupt the body's original biological current and biological magnetic field, causing abnormalities in the original body of the electromagnetic field. It is noteworthy that ability to withstand electromagnetic radiation are different across individual and age. The elderly, children, pregnant women are sensitive to electromagnetic radiation.

2.2. Radiation protection clothing

2.2.1 Development of radiation protection suits

Radiation clothing industry in the 20th century begin in China during the late nineties, has since experienced more than a decade the development of with the likes of Kangfang Square, Tim Hong and more other outstanding brands, as the industry matures.

The early radiation protection clothing mainly are metal fiber blending, this material radiation protection clothing are on 10-3000Mhz electromagnetic wave, have shielding rate of 15DB or more, with some are up to 30DB. Metal fiber content are of more than 25% for the best proportion. Silver fiber radiation suit appeared in 2002, in addition to a good role in radiation protection, silver fiber fabric has a certain role in antibacterial maintenance. Silver fiber according to the different content is divided into half silver and all silver fiber. In addition, there are metal-plated and multi-ion fabric, but because of airtightness, unfavorable maintenance, unstable shielding performance and other reasons, it is not widely used and has been eliminated by most enterprises.

The first generation of radiation protection products used spray technology, with the metal paint sprayed on the textile fabric, forming of sheet-like shield. The advantages are good shielding effect up to 60DB or more. The shortcomings are, radiation protection is airtight, cannot bend, and more bulky like a thin iron. In can only be used as inner layer, usage of such radiation suit for too long likely cause skin allergies and other side effects.

The second generation of radiation protection coating used coating process. The metal particles are attached to the textile raw materials between the latitude and longitude intersection, to form a point-like shield. The radiation shielding value is up to 50DB above, with a certain degree of permeability, but this anti-radiation clothing metal particles are easy to peel off and cannot be washed and scrubbed. The shielding value will drop over long time usage and this radiation suit is not suitable for direct contact with the human body.

The third generation of radiation protection clothing used metal fiber and cotton fiber blending process, that is, the metal made into a filament and knitted in the fabric to form a network structure. The advantages of this radiation suit is breathable, washable, and shielding effect will not be reduced, no side effects on the human body. This radiation shielding of this clothing are above 30DB and suitable for long term wearing.

The fourth generation of radiation protection products is a multi-ion fabric. This radiation protection using the principle of absorption and transformation by absorbing and converting the harmful electromagnetic waves into heat dissipated, to avoid secondary pollution. This is the most advanced electromagnetic shielding technology. While the fabric is rich in a large number of metal cations, it can play the role as deodorant with help the body microcirculation of the skin. This radiation suit is also anti-static, anti-X-ray, anti-ultraviolet, and with other functions. Moreover, this radiation protection fabric are soft and comfortable, washable, making it the most suitable for civilian protective materials, but in a higher price.

The fifth generation of this radiation suit is metal fabric, made by electrolysis method with copper, silver to the fabric of the fiber surface, making the fiber looking like a wire fabric. This radiation protection has a high radiation protection capability up to 80DB. Though it cannot be washed, only can be dry cleaned.

2.2.2 Working principle of radiation protection clothing

Most of the current radiation protection is mainly against longer wavelength, low energy, non-ionizing radiation produced by the electrical appliances. As the current knowledge is not comprehensive, following only the basic theory of electromagnetic fields, we provide brief analysis of the principle of radiation and electromagnetic shielding principle, mainly from three aspects: wave absorption, wave reflection, energy attenuation of electromagnetic waves due to multiple reflections within the material.

Firstly, the wave absorption angle. The electromagnetic wave is operating by phase oscillation perpendicular in the form of wave movement, with the propagation direction perpendicular to the electric field and the magnetic field of the plane, effectively transferring of energy and momentum in line with the right hand rules. Then it can be said that the electromagnetic wave is composed of two parts of the electric field and magnetic field, but I think, during the electromagnetic waves in the interaction with the material mainly the electric vector is at work, altering the state of the electrical vector causing electromagnetic waves to have a variety of polarization state. Hence study of electromagnetic waves can be mainly studied through electric vector. The propagation of electromagnetic waves does not require any media, but in different media, its propagation characteristics will also change. For sine-changing harmonic electric field, in different media, the propagation parameters may also be a function of angular frequency. According to this principle, it can be divided into two kinds of media, dispersion media (loss of media) and non-dispersion media. Here the study the anti-radiation clothing, is using the principle of electromagnetic waves in the media dispersion and frequency change of electromagnetic parameters:

E = ε '-jε' '

M = μ '-jμ' '

As the hysteresis effect of permeability and conductivity are changed into plural, and by

$$\nabla \times \mathrm{H} = j\omega\left(\varepsilon' - j\frac{\sigma + \varepsilon''}{\omega}\right)\mathrm{E};$$

$$= j\varepsilon_f \mathrm{E}$$

Define the equivalent complex permittivity:

$$\varepsilon_f = \varepsilon' - j\frac{\sigma + \omega''}{\omega}$$

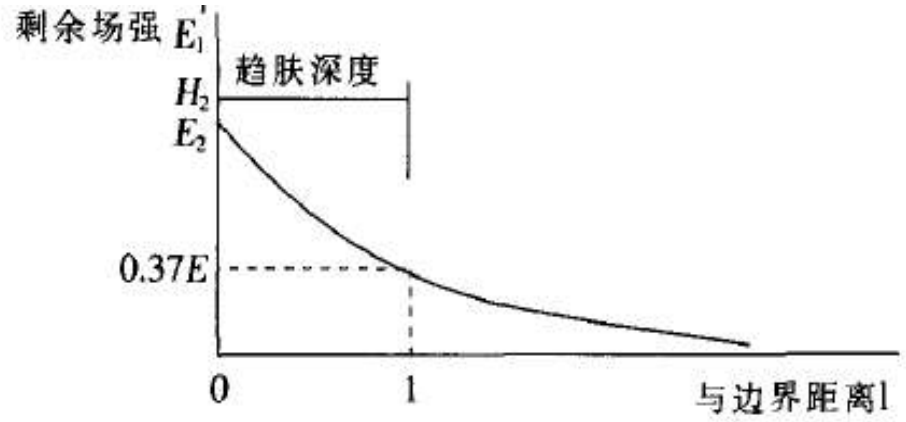
$$\frac{|\sigma \mathrm{E}|}{j\omega' \mathrm{E}} = \frac{\sigma}{\omega'}$$

And according to the size of the media classification, for the radiation of the material, usually act as good conductor at this time and the hysteresis effect can be ignored, then there are $\varepsilon'' = 0$, in the loss of media, according $\frac{\sigma}{\omega'} > 1$ to Helmholtz homogeneous equation:

$$\nabla^2 \mathrm{E} + \mathrm{K}_f{}^2 \mathrm{E} = 0(\nabla \bullet \mathrm{E} = 0)$$

$$k^2 = \omega^2 \mu_f$$

We can deduce the propagation equation of the plane wave: $\mathrm{E} = \mathrm{E}_0 e^{-jk_f r}$ (Here it may be assumed that the wave vector is along the Z direction), because the medium is detrimental, and there is a hysteresis effect, then K_f as a complex number, with K_f = β jα, and assume that β, α is the same direction, this can also be written as: K_f =(β-jα) n ; $\mathrm{E} = \mathrm{E}_0 e^{-\alpha z} e^{-j\beta a}$; From the above equation, and assuming that the medium is a good conductor (conductivity σ >> ω', $\varepsilon'' = 0$), α and β can be obtained with α = β = $\sqrt{\pi f \sigma}$, if α> 0, the intensity E of the electrical vector increases with Z, will be exponentially decreasing, as shown



This means that electromagnetic waves propagate in the medium will have space constraints, so you can define δ for penetration depth, that is, the propagation distance of the Z direction when E_0 reduced to E_0. That is to say: for $\delta = 1/\alpha$, as long as α is large enough, then the attenuation will be fast, then also to a certain extent, can be considered, electromagnetic waves are blocked and achieve the protection of electromagnetic radiation. Of course for good conductors

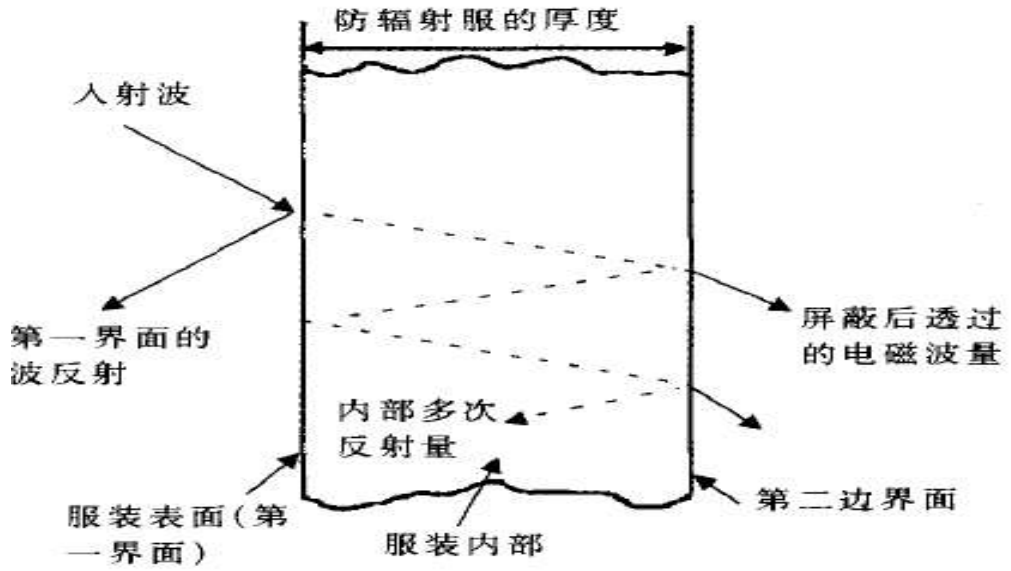
$$\delta = \frac{1}{\alpha} = \frac{1}{\sqrt{\pi f \mu \sigma}}$$

In the case of f, the greater the conductivity σ, the depth of penetration will be small, and for high-level electromagnetic waves, the electromagnetic field will only exist in the conductor surface of a thin layer, and high-frequency current will only focus on the thin layer conductor , which is the electromagnetic waves in the loss on media through spreading effect. Hence, in the design of radiation protection clothing, the choice of materials should be a good conductor, and with smallest conductivity This makes pregnant women radiation protection clothing using metal fibers, and even with expensive silver.

Ag：$\sigma = 6.3 \times 10^7 S/m$,

So for the general electrical radiation of electromagnetic waves and wireless communication of electromagnetic waves, the frequency range of tens of Hz to several hundred MHz, calculated penetration depth are lesss than 2cm. Hence we can see that the electromagnetic wave in the conductor material caused rapid attenuation of radiation.

Second, we discuss from the perspective of wave reflection. In fact, the above discussion of the principle is only from the perspective of the absorption of first wave. During the actual manufacturing, the principle of multiple reflection is also the focus of the researchers, which can be simplified as follows:



In the refraction and reflection theory of electromagnetic waves, we have the simplest vertical incidence as an example. According to the Fresnel principle, both the vertical polarized wave and the parallel polarized wave transmission coefficient are

$$T = \frac{2\eta_2}{\eta_2 + \eta_1}; T = \frac{2}{1 + \frac{\eta_1}{\eta_2}}$$

That is, from the level of this formula, the transmission intensity can be effectively reduced by reducing the characteristic impedance of the second medium, η . Of course, this is only a simplified model of the theory, in practice we also need to consider the direction of wave propagation, as well as the air impedance itself is not great, making reducing the characteristic impedance of the medium 2 not a big gap. The above is the two basic principles of anti-electromagnetic radiation and the basic principles of analysis of conductor material as a radiation protection materials.

2.2.3 Influencing factors of radiation protection

Although the theoretical analysis of radiation can be done perfectly, but actual situation is not so simple. Limited electromagnetic wave propagation direction is not fixed. Its spatial distribution is complex and varied, and the frequency of electromagnetic waves is also spans largely. The same material can not completely eliminate all the electromagnetic waves, and do not follow the laws of electromagnetic wave refraction and reflection. Hence there are many specific details of radiation protection that needs to be discussed. Here is a summary of the influencing factors of anti-radiation protection. The ideal condition will be having the human completely surrounded by metal conductors. Of course, this is not easy to achieve (making space suit a special case), so the design should be as close as possible to the ideal state.

(1) fabric coating should use metallic materials with large resistance.

(2) Clothing gaps, holes (collar, cuffs, buckle) will have a significant impact on radiation effects,

According to the information found, the gap of clothing should be reduced as much as possible to, because if the size of the gap is close to the wavelength, the gap will produce an antenna effect, making the garment an electromagnetic wave radiator, seriously affecting the clothing shielding effect.

(3) Presence of holes will produce electromagnetic waves leakage, once entered into the internals, because of the clothings are made to be shielding the electromagnetic wave are not easy to escape from the inside. The waves may be reflected multiple times, superimposed in the inner layer. But due to the law of conservation of energy, the energy of this type of electromagnetic wave should not be massive and not serious, and the leakage of electromagnetic waves

only in some specific direction, through the hole into the radiation clothing suit, such as the head, feet, and most of the side. Electromagnetic radiation can still be absorbed the shield, hence it is helpful to have a more sensible look at this disadvantage.

(4) Radiation protection clothing can be multi-layer shielding: based on the formula of penetration depth electromagnetic wave in the ideal conductor $\delta = \frac{1}{\alpha} = \frac{1}{\sqrt{\pi f \mu \sigma}}$, conductor has a good absorption effect on the high-frequency electromagnetic wave, but for low-frequency electromagnetic radiation, it is possible to use a multi-layer, high-conductivity metal material for effective shielding.

3. Electrostatic effects and anti-static clothing

3.1. Static electricity and hazards in life

In daily life, you can produce static electricity out of any two different material objects after contact and then separated,. When two different objects are in contact with each other, it causes an object to lose some charge, such as electrons to another object to be positively charged, while the other body gets some of the remaining electrons and is negatively charged. If the charge is difficult to neutralize during the separation process, the charge accumulates to cause the object to be statically charged. Hence, objects after the separation will possess static electricity. Usually stripping of a plastic film from an object is a typical 'contact separation' of static electricity. In daily life taking of clothes is an example of static electricity is 'contact separation'. Solid, liquid and even gas separated will produce static electricity. This is because they are composed of molecules and atoms. When the air flows, 'contact separation' between molecules and atoms will occur and produce static electricity. We all know that friction as a cause of static electricity and rarely heard of contact electrification. In fact, the friction is a kind of contact and separation caused by positive and negative charge imbalances. Friction is a constant contact and separation process. So, friction is essentially a contact-separation production of static electricity. Another common electrification is induction. When the charged object is close to the uncharged object, negative and positive charges are sensed at both ends. In dry and windy autumn, we often encounter this phenomenon, during at night, when undress to sleep, we often hear the sound of crackling in the dark, accompanied by blue sparks. When we meet and handshake, the finger just touch each other, will suddenly feel the spark. The hair will often 'floating' up when combing early in the morning, and hard to be tidied. Pulling the door handle and faucet will cause us to be 'electric shocked', often coming with snapping voice. These above are the phenomenon of the body as a result of the external static electricity 'discharge'.

When the body moves, friction between skin and the clothes and clothes and clothes will produce static electricity. With the increase in household appliances and chemical fiber clothing in winter wear, household appliances generated by the static charge will be absorbed and accumulated by the human body. Combined the fact that indoor walls and floors are mostly insulated and dry making houses more susceptible to electrostatic interference. Due to the factor of drier skin, aging of the cardiovascular system, anti-interference ability and other factors, elderly are more susceptible to static electricity. In older people, cardiovascular system has a variety of lesions, static electricity worsen the medical condition, induce more ventricular premature beats and other arrhythmias. Excessive static electricity often make the people more irritable, headache, chest tightness, difficult in breathing and coughing.

3.2. Anti-static clothing

3.2.1 Working principle

Anti-static clothing with dust and antistatic performance are suitable for electronics, optical instrumentations, pharmaceuticals, microbial engineering, precision instruments and other industries. The clothing is generally embedded with woven wire synthetic fiber fabric to prevent the accumulation of static electricity, suitable to be wore in electrostatic sensitive places or place with fire or explosion hazards. The anti-static fabric used in the production process is interwoven intermittently with roughly equal or evenly mixed with metal or organic conductive materials made of anti-static fiber or anti-static synthetic fiber. The anti-static fiber or anti-static synthetic fiber can be woven together.

(1) First, anti-static clothing for work is sewn with anti-static fabric to prevent the accumulation of static electricity on clothing during work. During weaving, conductive fibers or the antistatic synthetic fibers, or both are mixed and interwoven intermittently or evenly in the textile.

(2) Conductive fiber refers to the general or partial use of metal or organic conductive material or sub-conductive material made of fiber, with the volume resistivity ρ between 104 ~ 109Ω / cm. The conductive fiber is divided into three types: conductive composition homogeneous type, conductive composition covering type and compound conductive

composition type. It is depending on the distribution of the conductive component in the fiber. At present, the vast majority of anti-static fabric is made of conductive fiber, especially in the compound conductive composition type.
(3) Adding conductive fiber in the chemical fiber as the fabric for anti-static working clothing, based on the two mechanism of charge leakage and neutralization. When connected to the ground, the static electricity on the fabric in addition to the conductive fiber is neutralized through coronal discharge, but also through the conductive fiber release to the earth. When not grounded by the conductive fiber is discharged through weak coronal discharge.

3.2.2 Application of anti-static clothing

Due to the special function of anti-static clothing, its application is also very extensive. The main application areas such as the oil industry, mining and metallurgical industry, chemical industry, electronics industry with as strict control of the working environment. In addition, the industry worth to mention special industries such as: atomic energy, aerospace, weapons and so on. Static electricity is not allowed to let rage in the country's high-tech research sites which related to national security. Anti-static clothing is also used in other industries, such as: food, fireworks, medicine and so on.

4. Conclusion

As the information age continues to move forward, electronic products are increasingly developed, hidden electromagnetic radiation and the threat of static electricity is intensified. But with gradual garner of wide attention, radiation suits and anti-static clothing are produced to provide a variety of protection. The main contents of this paper are divided into several aspects as follows:

This paper begins with the definition of electromagnetic radiation, briefly introduces the types and sources of electromagnetic radiation, and emphasizes the serious impact of electromagnetic radiation on people's health in people's lives. It is precisely because of electromagnetic radiation on people's health has such a big harm, it leads to production of radiation protection suits. So an introduction to the radiation clothing are done starting from the development of radiation protection clothing, with several generations of radiation protection improvements, and finally to the latest fifth generation of suit. The birth of the fifth generation of radiation suits is an outstanding achievement. But what is the basic principle of radiation protection? Followed by the working principle of the radiation suit, from the basis of electromagnetic field we began to analyze and elaborate the content, combined with professional knowledge and thus completely discussing the working principle of radiation protection. But the theoretical analysis often have gaps with the practical situation. Hence we discussed the radiation protection effect of suits from actual production process, combining with several different factors impacting the efficiency of radiation protection as an explaination the current situation of radiation protection suits.

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