

The General Idea of Constructing Complex Electromagnetic Environment in Conventional Shooting Range

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Abstract. In order to assess and appraise the electromagnetic environment adaptability of informationized weapon, some ideas about the construction requirements of complex electromagnetic environment of shooting range are proposed in this paper. Starting from the two general standards in the field of electromagnetic environment and the common intentional interference signals, this paper analyses what kind of electromagnetic environment should be built in the shooting range.

Introduction

It can be concluded that in the long future, information weapons will still be an important factor in deciding the victory or defeat of war. In the future battlefield, the complex, dynamic and intensive electromagnetic environment will seriously affect and restrict the operational performance of information weapons [1,2]. Therefore, the shooting range needs to assess whether the information weapon can adapt to a specific electromagnetic environment and what kind of electromagnetic environment it can adapt to. This requires that the shooting range can reproduce the given complex electromagnetic environment as authentically as possible, and can generate various forms of electromagnetic stress to test the sensitive characteristics of the subjects. [3]. In this paper, starting from the mission nature of the range and the technical characteristics of the weapon, according to the relevant standards and electronic countermeasures technology, the construction technology of complex electromagnetic environment in the range is preliminarily discussed.

Construction Requirements of Complex Electromagnetic Environment in Shooting Range

The purpose of building complex electromagnetic environment in shooting range is to assess and appraise the electromagnetic environment adaptability of the weapon tested. That is, to appraise whether the weapon system can withstand the electromagnetic stress and how much the extreme value of the electromagnetic stress can be adapted by applying some electromagnetic stress to the weapon system tested. This is different from the complex electromagnetic environment construction in the exercise. The complex electromagnetic environment in the exercise is basically constructed according to the combat scenario. The purpose is to verify whether the weapon system can be used or not in the electromagnetic environment, but it does not explore the sensitivity of the weapon system to the signals in the complex environment. Of course, when the combat scenario is given, the shooting range should be able to construct the complex electromagnetic environment of the combat scenario [3]. Therefore, for the purpose of weapon equipment appraisal, the shooting range should have three kinds of electromagnetic signal construction capabilities, namely: According to the regulations of GJB151B-2013, electromagnetic signals are constructed, and electronic countermeasures signals are constructed according to GJB1389A-2005 "Requirements for System Electromagnetic Compatibility".

Constructing Electromagnetic Signal According to GJB151B-2013

In recent years, our country has formulated a series of military standards of electromagnetic compatibility and electromagnetic environment, and stipulated the electromagnetic compatibility and electromagnetic environment suitability of various weapons and equipment. These standards are the basic basis for argumentation, design, development, production and identification of weapons and equipment. Therefore, the shooting range should have the ability to construct the electromagnetic environment required by military standards. Among them, GJB151B-2013 "Requirements and Measurement of Electromagnetic Emission and Sensitivity of Military Equipment and Subsystems" is more general and important. The standard specifies 14 requirements and test methods for conduction and radiation sensitivity at equipment, subsystem level[4]. Although the 14 sensitive tests specified in GJB151B-2013 are all aimed at the equipment and subsystems installed before the weapon system, the signal patterns specified in the military standard still need to be constructed when the electromagnetic environment adaptability test of the weapon system is carried out in the shooting range. The reason is that even if the equipment and subsystems inside the weapon system have passed 14 sensitive tests before being installed, the equipment and subsystems may be subjected to multi-channel from inside and outside of the weapon system due to their installation location, grounding, shielding performance and electrical connection with other equipment subsystems after being installed into the weapon system. The disturbed state of diameter electromagnetic interference is quite different from that of equipment and subsystem level test. At this time, although the equipment and subsystems passed the EMC test before loading, it can not guarantee that the weapon system will not be sensitive after loading. It is quite possible that all the equipment and subsystems meet the requirements of GJB151B-2013 before they are installed into the weapon system, but when they are installed inside the weapon system, the sensitive phenomena of the equipment and subsystems will occur, which shows that the weapon system is sensitive. Therefore, it is necessary to apply the electromagnetic signal pattern prescribed by the military standard, and take the whole weapon system as the test object, and conduct the sensitive test again. Specifically, the shooting range should have the ability to construct the following signal patterns.

Constructing Electromagnetic Signals in Accordance with GJB1389A-2005 "Requirements for System Electromagnetic Compatibility"

GJB1389A-2005 is a top-level system-level electromagnetic compatibility index standard established to ensure the electromagnetic compatibility of China's weapon systems to meet the requirements of combat applications in complex electromagnetic environment. It is basically the same as the text of MIL-STD-464A-2002 "Requirements for System Electromagnetic Environmental Effects". GJB1389A-2005 "Requirements for System Electromagnetic Compatibility" stipulates the adaptability requirements of weapon system to external electromagnetic environment, lightning protection requirements, electrostatic protection requirements, etc[5]. From the point of view of shooting range electromagnetic environment construction, GJB1389A-2005 stipulates four kinds of electromagnetic environment, which are: External radio frequency electromagnetic environment, lightning, electromagnetic pulse, static electricity.

External Radio Frequency Electromagnetic Environment. The standard stipulates that the system should be compatible with the specified external RF electromagnetic environment in order to meet the requirements of the system performance. External radio frequency electromagnetic environment includes (but is not limited to) electromagnetic environment from platforms such as aircraft flying in formation, ships navigating in formation with frigates and adjacent ground command systems, friendly transmitters and enemy transmitters. The data of external electromagnetic environment varies according to the platform. When constructing the external radio frequency electromagnetic environment, the data of measurement or prediction analysis agreed by the orderer should be preferentially used in the shooting range[6]. Only when there is neither measured data nor predictive analysis data can the data specified in the second section be used. If the

system is exposed to more than one specified electromagnetic environment, the combination of the most harsh conditions applicable to the electromagnetic environment should be adopted.

Lightning Environment. The standard stipulates that for the direct and indirect effects of lightning, the system should meet the requirements of its performance[7,8]. When the ordnance is exposed, subjected to a nearby lightning strike, or to a direct lightning strike in storage, the ordnance shall meet its performance requirements. Ordnance should be safe during and after direct lightning strikes under exposed conditions.

EMP Environment. After enduring the electromagnetic pulse environment, the system should meet its performance requirements. When making this request, the orderer shall give the acceptance and test waveform of EMP environment. If not, the EMP environment specified in the standard can be used. The waveform in this standard is exactly the same as the waveform specified in the radiation sensitivity of RS105 transient electromagnetic field in GJB151B-2013. If the orderer does not give the pattern and repetition frequency of electromagnetic pulse, the electromagnetic pulse interference can be applied to the weapon system under test according to the signal pattern specified in RS105.

DC Magnetic Field Environment of Warship. The standard stipulates that the performance of subsystems and equipments should not be reduced when they work in DC magnetic field environment (such as the environment specified in GJB 1446.41). Therefore, the shooting range should have the ability to construct the DC magnetic field environment, such as the environment specified in GJB 1446.41, which can be used to check the equipment, subsystems or systems working in the DC magnetic field environment according to the relevant standards or the requirements of the subscriber.

Electrostatic Discharge Environment. The system should control and eliminate the accumulation of electrostatic charges caused by deposition electrostatic effect, liquid flow, air flow, waste gas flow, human activities, vehicles (including pre-launch status) and space vehicle movement, as well as other charge generation mechanisms, in order to avoid igniting fuel and harmful ordnance, preventing personnel from electric shock hazards and preventing the performance degradation or damage of electronic products [9]. For shooting range, the following three ESD environments are needed:

1) Electrostatic Discharge Environment for Vertical Lifting and Air Refueling

The standard stipulates that when the system undergoes 300 KV ESD, it should meet its performance requirements. This standard applies to helicopters, any aircraft refueling in flight, and systems suspended or transported from outside the helicopter. The test method is to discharge a 1000pF capacitor to the system through a resistor with a maximum of 1 ohm.

2) Deposited Electrostatic Discharge Environment

When an aircraft is flying in the air, electrostatic deposition will occur on its fuselage. The standard stipulates that in order to ensure that the system's performance meets the requirements, the system should control the interference of electrostatic deposition on receivers mounted on the system or on the main platform. The system should prevent the breakdown of structural materials and protective layers and the impact hazards of accumulated charges.

When the electrostatic deposition occurs, the accumulated charge will generate a voltage relative to the surrounding air. When the voltage is high enough, the air at the tip of the aircraft surface (where the voltage is the highest) will be periodically broken down to form a sharp pulse discharge. The sharp pulse discharges will produce broadband radiation interference, which will degrade the performance of receivers with antennas, especially low-frequency receivers. When the pulse discharge is fast, the receiver will even be able to hear only hoarse and completely invalidate. The process of electrostatic deposition and discharge on aircraft surface can be equivalent to the process of charging aircraft with a certain current. Total charging current(I_t - μA) The size is determined by the charge current density.(I_c , Company $\mu A / m^2$), Weather condition, Frontal Surface Area of Aircraft(S_a , Company m^2) And the velocity of the aircraft (V, Unit mile) decision, It can be estimated as follows:

$$I_t = I_c \times S_a \times V / 600. \quad (1)$$

For cirrus clouds, I_c is 50 to 100 $\mu\text{A}/\text{m}^2$, Stratus clouds are 100 to 200 $\mu\text{A}/\text{m}^2$, Snow clouds are 300 $\mu\text{A}/\text{m}^2$, On very few occasions, 400 $\mu\text{A}/\text{m}^2$ had been observed. In order to eliminate electrostatic deposition, aircraft often adopt such measures as installing an electrostatic discharge device, conducting the surface of non-metallic parts (such as cockpit cover) and grounding. In order to verify the effectiveness of these measures, it is necessary to verify through experiments. Because the test method of electrostatic deposition environment is not given in GJB1389A-2005, and the test method is not given in the available U.S. military data. Based on the principle of electrostatic deposition and the equivalent relationship between electrostatic deposition process and charging current (1), a method of electrostatic deposition in aircraft is proposed in this paper.

Firstly, the I_t is calculated according to the parameters of the aircraft, and then the DC voltage source is used to charge the aircraft suspended in the air by the insulation device, and the voltage is gradually increased. If the voltage has risen to the air breakdown voltage without tip discharge, the anti-deposition electrostatic measures of the aircraft are qualified; otherwise, if a persistent tip discharge is observed during the boost process, the charging current is measured and recorded. If the charging current is greater than I_t at this time, the anti-deposition electrostatic measure of the aircraft is qualified, otherwise it is unqualified.

3) Human Electrostatic Discharge Environment

The anti-static requirement of the ordnance subsystem is emphasized separately in the standard. It is stipulated that the ordnance subsystem should not be accidentally ignited or dumb when it undergoes an electrostatic discharge of 25KV (note that this value is greater than the stipulation of CS112 in GJB151B-2013) caused by the operation of personnel. Conformity should be verified by tests (e.g. method 601 electrostatic discharge test in GJB 573A-1998). The test method is to discharge a 500pF capacitor through a 500 ohm resistor to an ordnance subsystem (e.g., electrical interface, housing and operating point).

Construction of Electronic Countermeasure Signal

Electronic countermeasure signal is an important component in complex electromagnetic environment, and its common characteristic is intentional interference signal[10]. From the point of view of jamming objects, ECM signals mainly include radar countermeasure signal, communication countermeasure signal, navigation countermeasure signal, fuze countermeasure signal and photoelectric countermeasure signal. Among them, fuze countermeasure signal is similar to radar countermeasure signal, navigation countermeasure signal is similar to communication countermeasure signal, and photoelectric countermeasure signal is beyond the scope of electromagnetic environment. These signals can be generated by active jammers, which will not be discussed in this paper.

Conclusion

Starting from two general standards in the field of electromagnetic environment and common intentional interference signals, the general idea of constructing complex electromagnetic environment in conventional shooting range is preliminarily sorted out in this paper. However, it is not enough to only know the signal pattern to construct the complex electromagnetic environment of shooting range, but also to study how to generate these signals. We also need to carry out the research work on parameter setting method and hardware implementation of complex electromagnetic environment in shooting range.

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