

# ENVIRONMENTAL CHALLENGE TO AIRBORNE ELECTRONIC EQUIPMENT MAINTENANCE

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## Abstract

*In the paper, the challenge of technology progress and environment to airborne electronic equipment maintenance is discussed. With the VXI automatic test equipment and the equipment fault tree, maintenance technology and test method are studied. Finally, the application field of the study is analyzed.*

## 1 General Introduction

Presently, the increasing complexity of airborne electronic equipment, new task requests and high failure rate caused by special environment conditions put forward higher demands on airborne electronic equipment maintenance. The technology progress brings new techniques, new crafts, new materials and new equipment. This make failure forms more and more. In fact, just the rising of equipment system complexity will shorten the mean time between failure - MTBF. Whereas the avionics failures aroused by bad environment do not decreased, and the temperature, humidity, air pressure, vibration and the other environmental factors are constantly affect the electronic equipment. Because the flight situation is getting more complex and the global weather is getting bad the environment influence to electronic equipment is becoming more serious, and the demands on maintenance technique and process are more severe.

Combining with the devised VXI bus automatic testing equipment, the demands of technology progress on maintenance are discussed. The fault tree of the electronic equipment effected by environment is studied, and the adopted maintenance method and the

safeguard process such as dehumidification, dust elimination and real-time performance regulation are analyzed. The study on the failure mechanism of electronic equipment aroused by environment can be used to the realization of MFOP (Maintenance Free Operating Period) and the failure prediction technique so as to determine and replace the unit on the edge of failure, reducing failure false-alarm rate and error removing rate, and realizing balanced maintenance.

## 2 Environmental Challenge to Airborne Electronic Equipment Maintenance

### 2.1 Environment

The bad environment will result in the increasing of the failure of airborne electronic equipment. For example, high temperature, strong shake, salt fog, humidity, sand blown by wind is one of the dominating reason lead up to fault of electronic equipment [1].

#### 2.1.1 High temperature and high humidity.

There are some serious problems in high temperature and high humidity. They are organic materials (such as canvas, felt, liner and gasket, etc.) mildewing and materials (such as insulator and cable, etc.) performance depravation for rotting and going mouldy.

Mildew making materials corroded and its intension lowered, and some rubber such as soft waveguide cannot resist mildew. The fault statistics refer table 1. Even plating, painting, anode treating and some else surface processing are adopted to resist corrupt, any protection layer become cracked for aging or flake off in

bad climate and environment, such as the protection layer flake off from the metal waveguide.

Absorbing moisture make the rubber parts intumesce and deform, electric performance get bad, and structure destroyed. For example, the soft waveguide, made of rubber, intumesce on its surface.

### *2.1.2 High temperature and sand blow by the wind*

High temperature can make a lot of airproof-gasket in transformer and capacitor get bad so as to disable. The capacitance of some capacitor will change greatly when the temperature get over 120 C. Fault statistics refer table 2.

Relays and switch equipment are sensitive to the sand blow by the wind. The sand blow by the wind can make serious harm to precision parts or lubricant surface.

### *2.1.3 Low temperature, rain and snow*

Firm snow entering a part of equipment can clag its motion or freeze to ice lump after melt in the equipment. Melt snow will led to circuit short, rust or organic material decompose when the equipment run and get heat.

The influence below zero in temperature are as follows: rubber, synthetic rubber, plastic even metal all lose flexibility and get rigid and crisp so as not to stand strike. Capacitance, inductance and resistance increase so that the main circuit has to be readjusted. Fault statistics refer table 1.

### *2.1.4 Vibration*

Vibration make resistor appear flaw, porcelain stick rupture, circuit board occur short circuit, open circuit or intermittent open and shut, and integrate circuit wear, scratch and shell split.

### *2.1.5 Low air pressure*

Low air pressure result in isolation resistance reducing, "electric conduction pathway", flashover, and break in for isolation material performance going bad.

### *2.1.6 Salt fog*

Salt fog make metal eroding accelerate, material chemical quality change, insulator eroding increase, metal material and the plating layer

erode, structure intensity reduce, hollow dot appear in the surface, insulator surface resistance and the electric current intensity can be insisted cut down. For example, the metal waveguide rust for the protecting layer falling off.

For the electronic equipment faults caused by environment, table 1 gives the every instance of disabled electronic parts. The statistics shows that the disabled rate caused by high temperature and high humidity is the highest (percentage of 66.6). More severe demands for maintenance are put forward.

## **2.2 Technology progress's challenge to airborne electronic equipment maintenance**

Today, the electronic equipment structure is complex and the automatization degree is high. This is the combing of every high-tech. Because the test and repair are difficult, the repairers must grasp the basic theory and information technic. Else, the increasing of the fine extent of maintenance presents more severe demands on maintenance equipment. For instance, the VXI test equipment (devised by us) not only should solve the technical problem such as parameter testing occur in the course of the tested equipment operation, but also should solve the problems of the maintenance self such as system configuration, programme, hardware interface, etc. The users are required to be trained.

### *2.2.1 VXI bus summarize and characteristic*

VXI bus test system (VMEbus-extensions for instrumentation), having the VME computer's characteristic of high speed, real time and portable, represents the development direction of the future apparatus.

The block diagram of the VXI bus test system is shown in Fig.1. The tested equipment is connected with the system through adapters. The signal voltage and signal waveform of the tested equipment are transmitted to the digital oscillograph through HP1466A matrix switch, and are measured by it. The RF signal of the equipment, which is switched by RACAL1260-67 microwave switch, enters HP4407B spectrum analyzer, HPE1416A power meter and

Table 1 Fault Statistics Table

environment	fault parts	Phenomena (times of fault parts)	reasons
high temperature and high humidity	1. waveguide	1.soft waveguide cranny ( 13 )	mildew
		2.oil paint on metal waveguide surface craze , corrugate or peel ( 46 )	
	2.self-check oscillator	power get down ( 7 )	aging
	3.VCO	frequency drift ( 7 )	aging or attenuation
	4.resistor	1.open circuit . ( 13 )	erode, electric corrosion, oxidation
		2.ill contact ( 3 )	electric corrosion
	5. cotton canvas used in heat preservation	go moldy ( 13 )	erode
	6.TWT	insulation damage ( 7 )	break in
		gas leak ( 7 )	
	7.capacitor	1. open circuit ( 30 ) .	oxidation
		2.short circuit ( 5 ) .	pollute and electrolyte decompose, erode
	8.semiconductor	1.pole open circuit ( 43 )	aging, pollute
		2. parameter drift ( 23 )	electric corrosion
9.integrate circuit	1.pole open circuit or ill contact ( 3 ) .	electric migration, corrosion or pervasion	
	2.pole short-circuit ( 10 ) .		
10.relay	high resistance in connector point ( 12 ) .	flare, electric corrosion and mote drift and pollute.	
low temperature and rain and snow	1.rubber, synthetic rubber	rigid and friable, not stand strike. ( 13 ) .	
	2.plastic		
	3.cable	short-circuit ( 3 )	melt snow
	4.capacitor, inductance and resistor	marked change in their values ( 5 )	

microwave detector, and the spectrum and power of the RF signal and the video signal outputted by detector are measured. The excited microwave signal needed in testing is outputted by HPE83732B microwave signal source.

The system finishes the measuring of 42 parameters such as AC and DC voltage, AC and DC current, power, waveform, spectrum, etc. the

output signals are as follows: RF signal, modulating signal and equipment simulation signals (such as pulse, pulse series).microwave signal needed in testing is outputted by HPE83732B microwave signal source.

2.2.2 Demands of the personnel quality

Because the electronic equipment is the concen-

Table 2 Fault Statistics Table

environment	fault parts	Phenomena (times of fault parts)	reasons
high temperature and sand blow by the wind	1.waveguide transform switch	cannot transform ( 3 )	lube drying, sand entering
	2.capacitor	open circuit ( 5 )	airproof-gasket invalid
	3.Relay	can't shut up ( 8 )	sand entering
vibration	1.TWT	1.filament open circuit ( 3 )	
		2.gas leak ( 7 )	
	2. plug-in-unit	Short circuit, open circuit, wire break or ill contact ( 8 )	
	3.semiconductor	1.pole open circuit ( 8 )	
		2. shell cranny ( 8 )	
	5.integrate circuit	1.pole short circuit ( 8 )	something from extra
2. abrasion, scratch and shell cranny ( 8 )			
6.resistor	body flaw, scratch and porcelain-stick rupture ( 8 )		
low air pressure	TWT	break in, damage ( 8 )	insulation resistance get down, "electric conduction pathway" and flashover
salt fog	metal waveguide	cuppy occur on the surface ( 18 )	metal material and coating erode.
		protecting layer peel, surface go bad and rusty. ( 18 )	resist-electricity strength of insulator and surface resistance get down

trate of various high technologies, and the safeguard adopt new test technology, the operators are demanded to be familiar with the computer, instrument, parameter character, etc. The demands of the operators' quality are enhanced obviously.

The technology progress brings forward higher demands to maintenance, this is said, the failure diagnosis technique is more complex, the maintenance range is more expand and the maintenance depth is deeper.

**3 Electronic equipment maintenance method in bad environment**

Table 1 shows that aircraft environment result in devices failure, especially in the condition there are no moistureproof and heat-emanation measures. Therefore, we must study maintenance method of electronic equipment in bad condition.

The fault tree of a certain electronic equipment affected by environment is shown in Fig.2. The reasons of power abnormality are that bad environment result in TWT(in end power-amplifier of preamplifier) filament short circuit, gas leak and inefficient. Vacuum tube of self check oscillator aging and power get down even no output result in equipment self check abnormality. The IC, especially CMOS chips, have strict demand to environment. Electromagnetism jamming, voltage fluctuating,

high temperature and high humidity, vibration, result in integrate circuit fault whose form is voltage abnormality.

Actually, when a function is abnormality, first we should examine whether aeration and dehumidify are made. In high temperature and

high humidity, aeration must be last adjusting is finished, such as voltage drift adjusting, power drift adjusting, etc. These measures can effectively eliminate the equipment faults form-

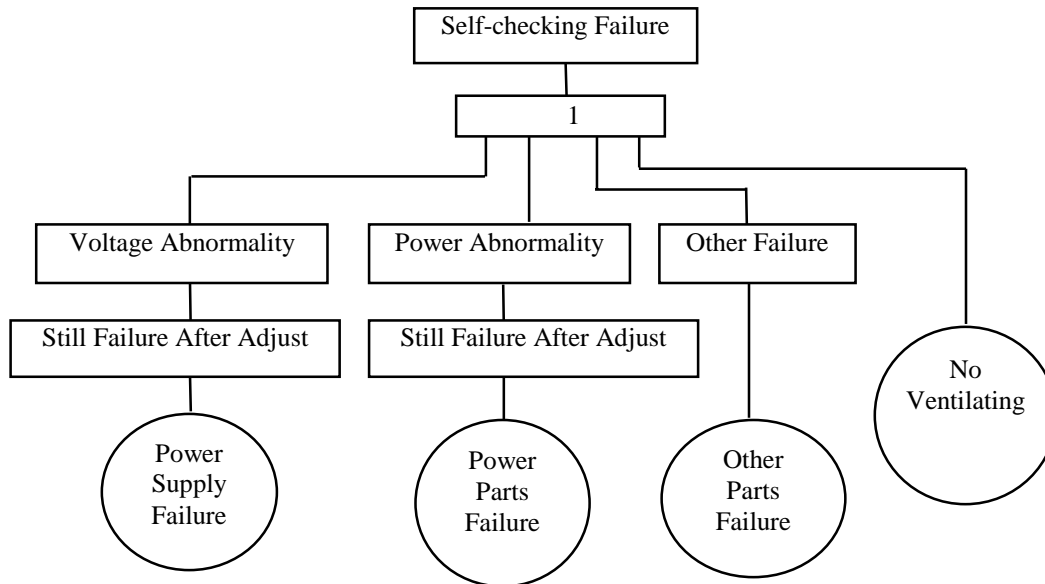


Fig.1 Testing Block Diagram Of VXI Automatic Test Vehicle For A Certain Equipment

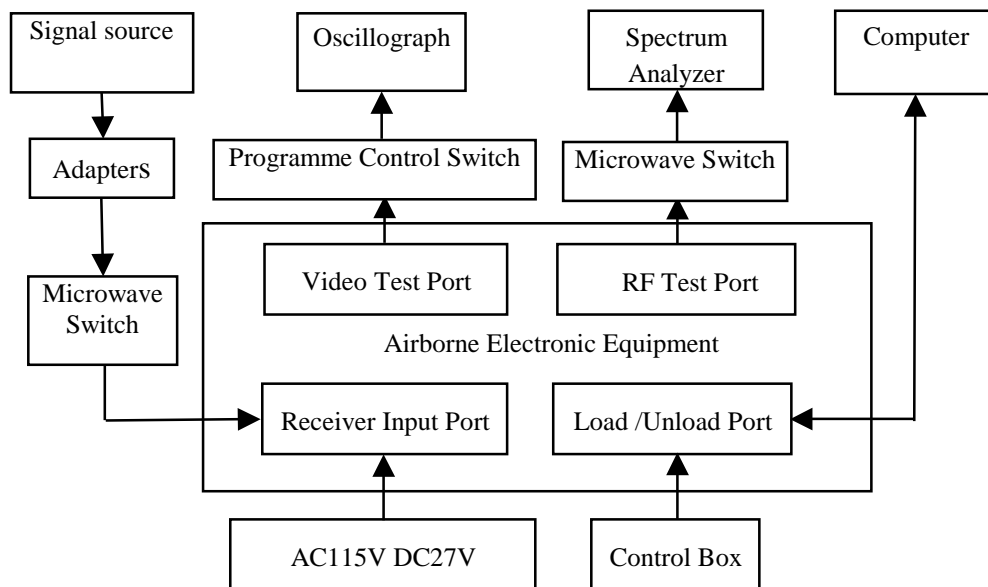


Fig.2 A Certain Electronic Equipment Fault Tree

ed for long-term storage or damp.

In addition, drainage hole, groove in frame and rail can prevent the equipment from damp and accumulating water.

The technology progress brings forward higher demands to maintenance, this needs computer experts, electronic engineers, aviation experts, communication engineers and other professionals become the main body of electronic equipment maintain force. The field which safeguard participate in is more and more expended, their action is more and more outstanding out, and the demand for training is more and more strict.

## 4. Application

### 4.1 Realizing balanced maintenance.

Collecting and analyzing every part's status and performance data are the basics of maintenance work. Premeditating the exceptional circumstance of environment, changing the methods depend on repeated replacing LRU by hand to location fault and reducing false alarm probability in BIT detecting can be used in failure prediction technique, determining and replacing unit on the edge of failure and reducing failure false alarm probability and error removing rate, so as to realizing balanced maintenance.

### 4.2 MFOP

MFOP is the using period that product can finish all specific tasks. In the time, it needn't any maintenance[2]. Therefore, we must study the reasons of equipment failure earnestly, and cannot tolerate the failure whose reasons are unknown, so as to improve the design and making, enhance the equipment inherent reliability, realize long MFOP.

According to the character of equipment failure aroused by environment, this paper studied the products failure mechanism, and provided the foundation for reliability design. Using the relative data, the various factors bring fault can be eliminated. Apply to MFOP, the maintenance workload will be reduced, and the cost of maintenance will be cut down.

## References

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