ELECTROMAGNETIC COMPATIBILITY OF TRAINING DEVICES

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INTRODUCTION

Whenever a training device containing electronic equipments is operated in its intended operational environment, at designed levels, without degradation due to interference, it is called electromagnetically compatible. This paper will give some background history on interference specifications, their application to training devices, several problems that have occurred, present status of trainer EMC, and a forecast of what contractors may expect in the EMC (Electromagnetic Compatibility) area in the future.

BACKGROUND OF INTERFERENCE SPECIFICATIONS

The earliest electromagnetic interference specifications were written 25 years ago to control interference to voice communication receivers from aircraft electrical systems. In 1954, the Bureau of Ships, made revision to a draft of MIL-STD 225 and issued it as MIL-I-16910. The "C" version of this specification was dated 26 October 1964 and contained the radiated and conducted interference limits and test procedures to be used for Navy shore and shipboard electronic equipments. The Navy Bureau of Aeronautics generated another version of the proposed MIL-STD-225 which resulted in MIL-I-6181. In August of 1968, MIL-STD-461, "Electromagnetic Interference Characteristics Requirements for Equipment" was issued and superseded the general Army, Navy and Air Force interference specifications, including MIL-I-16910C which the Naval Training Device Center was using. The MIL-STD was a coordinated document containing interference test limits. The test procedures were documented in MIL-STD-462, "Electromagnetic Interference Characteristics, Measurement of," dated 31 July 1967. These Standards were meant to be used as a source for tailoring the interference requirements to meet the needs of the equipments being procured.

NAVTRADEVCEN INTERFERENCE CONTROL BACKGROUND

The Naval Training Device Center EMI philosophy prior to 1968 was to reference MIL-I-16910 directly in the trainer specification or indirectly through MIL-T-23991. Testing was occasionally performed. In 1968 MIL-STD-461 requirements began appearing in major training device specifications. The Electromagnetic Interference Control Plans became part of contractor submitted documentation. Some testing was required.

In an effort to avoid some of the less-than-desirable practices in cabling and grounding viewed in the field, MIL-T-23991C, dated October 1968, had new sections devoted to these areas. Additionally, the Air Force Handbook on Electromagnetic Compatibility was referenced as a design guide for meeting the electromagnetic interference suppression requirements appearing in the trainer specifications.

The detail specifications began having paragraphs requiring that elevated floor systems be incorporated into the overall grounding system, using MIL-STD-1310, "Shipboard Bonding and Grounding Requirements for Electromagnetic Compatibility" as a guide in the electrical bonding area. Crosstalk and signal-to-noise ratio requirements for audio communications systems were also included to eliminate these problems in future systems.

PAST PROBLEMS

A survey of recorded past interference problems revealed that trainers have not been a source of interference to other systems. Training devices also have been relatively free of being troubled by electromagnetic wave radiating systems (radar, TV). Interference that has been troublesome from external sources has usually entered the training device through the prime power leads. These have been of a transient nature such as large loads either going on or off the line and lightning effects.

It was revealing, however, to find that the majority of interference problems are self-induced. The following five cases are a small sampling of self-incompatibilities that have occurred:

Case 1 - An interference problem on a Sonar Tactics Trainer that required significant time and manpower to remedy was reported, with slight changes, as:
The 400 Hz and 60 Hz interference problems in the Sonar Systems have reached an unsatisfactory level. The major source interference appears to be topside in the cabling. One of the sonar receiving sets has 400 Hz interference internally as well. The interference problem from the cables appears in the audio circuits and also on the Scan Presentation. This interference appears at certain bearings only and these bearings can be made to change by rearranging the cables. It is felt that the following list of discrepancies have contributed to this problem:

Intermixing of signal cables and 400 Hz and 60 Hz power cables in the cable runs

Failure to shield signal cables and power cables sufficiently

Many of the cables are too long and have been doubled back or coiled rather than cut to the proper length.

The grounding system has in many cases been wired such that ground loops are possible.

After the installation of a Torpedo Modification, the interference seemed to increase. It is felt that the installation crew disturbed the cable runs under the Attack Center.

Case 2 - The following problem is associated with a Weapon System Trainer located in a van:

At present there is an intolerable amount of feed-through from the pilot's ICS to the sonar ICS and vice versa. When independent hops are given, there is confusion when trainees start to talk on both ends at the same time. Maintenance intercom also feeds into the trainees' ICS system. Background noise when selector buttons are pushed is too loud.

Case 3 - Some discrepancies on a Flight Portion of a Weapon Systems Trainer read as follows:

a. ICS too noisy
b. UHF Comm (Main) noisy (intermittent)
c. Computer stops for unknown reason, requires master clear and start to resume operation
d. Computer stops, program is destroyed, requires re-load of program to resume operation.

Case 4 - Another problem on an Operational Flight Trainer:

Random erroneous signals are inputed to the computer whenever the air compressor in the trainee station cycles on or off.

Case 5 - A problem on a Radar/MAD Trainer

Interference from a 60 to 400 Hz frequency converter used in the system was causing noise to appear on the radar land-mass displays.

Most of the above problems have been taken care of, leading us to the present status of EMC at the Naval Training Device Center.

PRESENT STATUS

EMC field problems of the Case 1 magnitude do not currently exist. Field problems are becoming more scarce due to improved interference design practices and the contractor's awareness and ability to locate and rectify them prior to device acceptance. The "sore thumb" that needs medication now is the reduction of noise and crosstalk in the trainer audio systems.

GROUNDING, BONDING AND CABLING

Grounding systems are being improved. Elevated floors of the bolted stringer type are being used as an essential part of the trainer grounding systems.

In the area of electrical bonding practices, some contractors now have standard practices and procedures that are documented as company standards and have been found to be satisfactory. Not all contractors have had the opportunity to establish such practices and such matters are left to the individual expertise of the mechanical or electrical designers at the time of the particular trainer design.

An area which has been vastly improved in the past three years is cable categorization and separation. The planned routing and grouping of power and signal cables, according to interference producing capability and susceptibility to cable coupled interference in conjunction with improved grounding system, has probably done more for solving difficult problems than any other single item. Cabling installations are being designed in a fashion analogous to laying out the signal connections on a multilayer printed circuit board.

INSTALLATION SITES

Installation sites are studied in an effort to define risk areas to the local environment due to the probable emissions from the trainer and the risk areas of the environment to the trainer. As new buildings are planned to house training devices, electrical prints are reviewed to ensure that the grounding systems will be satisfactory for electronic equipment grounding and lightning protection.

MIL-STD-461 INPUTS

From a MIL-STD-461 viewpoint, the major training devices (that are closed systems (non-antenna type)) usually have three design requirements in the specification to control susceptibility due to transients on the prime power lines, conducted emissions being generated by the trainer and going out on the prime power lines and radiated emissions from the training system. Commercial off-the-shelf equipments such as computers are not required to be shielded. However, there is concern for the radiated emissions from the cables since they may become fairly efficient radiators and the location of many of the trainers are near operational equipments. The current specification input often has the following appearance:

> Electromagnetic Interference Suppression
>
> All electronic equipment other than off-the-shelf equipment to be furnished by the contractor shall be designed to meet the following requirements of Class 1C equipment listed in table 2 of Mil-Std-461: CE03, RE02, and CS06. Commercial off-the-shelf equipment shall be modified, if necessary, to meet the requirements of CS06 for power inputs and RE02 for cabling external to the equipment enclosures.

TESTING

Experience has indicated that the cost-effectiveness of testing to the electromagnetic interference suppression requirements is a variable determined by the installation environment. The current philosophy is to do as little testing as possible. Testing may be limited to checking the grounding system to ensure separation of the various categories of grounds and the electrical resistance across electrical bonding joints. Interference in the intercoms is and has been such a nuisance that it has been singled out for special attention. A general specification for communication systems for training devices (MIL-C-29025 TD) was issued 14 September 1971.

FORECAST FOR THE FUTURE

To extinguish the intercom interference fire, it is expected that intercom systems will be required, as a minimum, to meet the background noise, signal-to-noise and crosstalk levels prior to device acceptance. It is expected that a document on grounding and bonding will be written to standardize the techniques and the hardware for training device systems. The EMI Control Plan will be required to be submitted on major training devices. Its use is expected to diminish over the next five years as the Center's contractors become experienced in interference control design.

MIL-STD-461 is undergoing a change to make it more effective. It is expected that NAVTRADEVCEN specification will contain the "design to meet" requirement unless installation environment necessitates the "shall meet" requirement. When the "shall meet" clause is used, the specification will also have testing requirements.

Facility requirements will continue to be viewed with the purpose of ensuring that the training system and the facility will have a high probability of being compatible. Areas of interest will be existing cabling, grounding systems, power distribution and interference risk areas from transmitting systems.

SUMMARY

The Naval Training Device Center has had its share of interference problems, particularly in the area of self compatibility. Although the random type problems are being eliminated through improved electrical grounding and cabling techniques, power line transient and, particularly, audio communication interference problems continue to exist. Efforts are being directed to ensure their non-reoccurrence through improved specification requirements, design monitoring and contractor education.

SESSION V

Thursday, 17 February 1972

Chairman: Mr. Victor G. Hajek
Head, Air-Warfare Department (ASW/Environmental)
Naval Training Device Center