



AEROSPACE INFORMATION REPORT

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METHODS OF ACHIEVING ELECTROMAGNETIC COMPATIBILITY OF GAS TURBINE ENGINE ACCESSORIES, FOR SELF-PROPELLED VEHICLES

1. INTRODUCTION

This Aerospace Information Report (AIR) is a description of methods to be employed to achieve Electromagnetic Compatibility (EMC) of gas turbine engine accessories. Its primary objectives are to aid those system designers of gas turbine assemblies who are employing commercial accessories, which are not always EMC designed, and to outline methods of achieving EMC employing readily available test instrumentation.

- 1.2 Electromagnetic Compatibility (EMC) as defined for this AIR is the ability of all engine accessories to perform within their specified capabilities when subjected to an electromagnetic environment generated by adjacent engine accessories.

2. EMC CLASSIFICATION OF ACCESSORIES

2.1 Classification of Emission Accessories:

- 2.1.1 An emission accessory is one which will either conduct or radiate electromagnetic energy to an external medium. The conducted emission may be present on the accessories power lines or on its interconnecting control and signal lines. If levels of conducted emission are present, these lines can become radiators to nearby lines and accessories by either magnetic or electrostatic coupling.
- 2.1.2 Any accessory, where energy is released in the form of a rate of change of current or voltage with respect to time into its input and output impedances, should be considered a probable emission accessory.
- 2.1.3 Example of such engine accessories are switches, (both mechanical and solid state), relays, solenoids, ignition systems and power control circuits.

2.2 Classification of Susceptible Accessories:

- 2.2.1 A susceptible accessory is one which will deviate from its accepted performance parameters when exposed to a level of either conducted or radiated electromagnetic energy. This deviation in performance is of such a nature as to adversely affect the function of the accessory.
- 2.2.2 Examples of such susceptible engine accessories are low level circuits employed in temperature and vibration monitoring, amplifiers, especially if their input or output impedance is high and circuits employing solid state and integrated circuit components. These circuits can encompass such items as fuel control and injection components, speed sensors, governors, and automatic sequencing and multiplexing components.

2.3 Dual Classifications:

- 2.3.1 The above classifications of accessories are, at times, not always clearly delineated as either emission or susceptible accessories, as some can be classed as both.

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2.3.2 For example, a converter circuit may emit electromagnetic energy and in turn be caused to deviate from its performance specifications by induced electromagnetic energy.

3. ANALYTICAL APPROACH TO SYSTEM EMC

3.1 Charting:

3.1.1 The complete turbine engine accessory system should be charted similar to that shown in Figure 1.

3.1.2 Separating the more clearly defined emission and susceptible accessories in this chart form assists the system designer in the following areas with respect to electromagnetic interference (EMI):

- a. Define those interconnecting power and/or control signal lines that are either emitters or receivers of EMI.
- b. Define those accessory housings that, if not properly shielded, may emit or receive EMI.
- c. Serve as a guide as to future wiring layouts to achieve maximum separation of accessories and wiring to reduce EMI influences on the overall system.
- d. Serve as a guide as to the application of a minimum number of filters to achieve system EMC at a minimum cost.

3.2 Mathematical:

3.2.1 A study of both current and voltage waveforms from those items classified as emission accessories, with respect to level, risetime, falltime and duty cycle, can be performed with rough estimates of EMI levels derived. The frequency spectrum of any pulse can be defined in sinusoidal waveforms by employing Fourier analysis.

3.2.2 A knowledge of the frequency spectrum and levels from the emission accessories when applied to a study of the susceptible accessories will allow the designer to develop reasonable test methods and limits to apply to suspected susceptible accessories.

3.3 Empirical:

3.3.1 This AIR takes into account the possibility that EMI measuring equipment may not be readily available to the designer. It does assume that items such as oscilloscopes, voltage and current probes, magnetic pickup loops, and signal generators capable of a frequency response of at least 30 MHz are available. EMC problems above 30 MHz can exist, but if adequate suppression below 30 MHz is accomplished, high frequency problems in many cases will also be minimized.

3.4 Emission Studies:

3.4.1 Photographs of voltage and current waveforms employing oscillographic techniques should be performed on all lines entering or leaving a suspected emission accessory.

3.4.2 In order to perform a mathematical study of these waveforms, care in obtaining rise and fall times of pulses should be exercised. The complete risetime of the measuring system, including probes and oscilloscope plug-ins, should be calculated to prevent errors in risetime measurements. (The total risetime capability of any measuring system is equal to the square root of the sum of the squares of each measuring component's risetime). Figure 2 shows typical engine accessory waveforms and a simplified method of calculation to determine EMI magnitudes in the frequency domain.

3.5 Susceptibility Studies:

- 3.5.1 Signal generators and commercial power amplifiers can be employed to establish susceptibility threshold levels on suspected susceptible accessories. A starting point for these levels and also the frequency spectrum can result from the previous Fourier study of the emission accessories.
- 3.5.2 The susceptibility levels, previously determined, if coupled inductively into all power, control and signal lines for all suspected susceptible accessories should result in a worst case condition. This method duplicates, by test, the possibility of the highest emission level present from the accessory system being introduced directly into a susceptible accessory.

4. METHODS OF ACHIEVING TURBINE ENGINE EMC

- 4.1 A study of the calculated emission and measured susceptibility levels should result in the designer's ability to apply analysis to the chart and allow him to question the following trade-offs with respect to cost versus accessory placement and wiring. The bibliography in paragraph 6. lists books and articles which offer much more detailed information in EMC Design Methods. The following are only some of the more obvious trade-off considerations.
 - 4.1.2 The emission interconnect wiring and the susceptible wiring must be separated and spaced as far as is practical from each other to minimize inductive and capacitive coupling.
 - 4.1.3 Where wires must cross each other, they should cross at right angles.
 - 4.1.4 Where it is impossible to separate wiring, twisted pairs should be attempted in a problem solution and as a last resort the more costly approach of shielded wiring may have to be employed.
 - 4.1.5 The shielding offered by the housings of the accessories should be of adequate shielding thickness, and R.F. gaskets should be used where access ports are employed.
 - 4.1.6 EMI filters when employed must be properly bonded to the engine frame and the filters input and output wires isolated to be totally effective. Feedthru capacitors are much more effective as filter suppressors than wire termination type capacitors.
 - 4.1.7 Bonding of engine components where vibration isolators are employed should be accomplished with copper bond straps whose length to width ratio is less than 5 to 1. Braid and wire pigtail bonds should be avoided.

5. SUMMARY

- 5.1 This AIR is directed towards EMC and its relationship with the turbine engine accessories.
- 5.2 However, proper EMC design to minimize the above relationship will also minimize the possibility of emission escaping the turbine engine to other surrounding mediums.
- 5.3 These techniques will also minimize the possibility of the engine accessories being susceptible to electromagnetic energy received from a medium external to the turbine engine.

6. BIBLIOGRAPHY

- 6.1 The following bibliography, which by no means can be considered all inclusive, does give information that is easily understood and of a practical nature. Most items listed below may be obtained from their source or from State and University Library Systems.
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