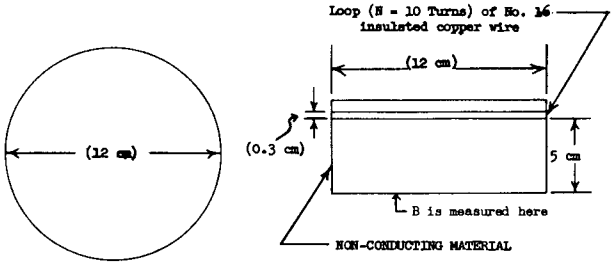
ANTENNAS FOR MIL-STD-461

MIL-STD-461A is quite explicit in its specification of antennas which are to be used for radiated emission (RE) and radiated susceptibility (RS) tests. These requirements are covered in Para. 5.2 of MIL-STD-461A for Air Force and Navy procurements, and in Notice 3 of MIL-STD-462, Para. 4.2.2.1 for Army procurements. Although MIL-STD-461B does not explicitly discuss antennas, the test methods of MIL-STD-462 still apply as does the antenna requirements.

The following information pertains to Navy and Air Force procurements. The requirements are similar in many areas for Army procurements, except that MIL-STD-462, Notice 3 contains a list of approved antenna and antenna factor curves. Users are advised to refer to Notice 3 of MIL-STD-462 when selecting antennas for Army procurements.

30Hz to 30 kHz. For magnetic field emission measurements a loop having the following specifications shall be used:

(1) Diameter = 13.3 cm.
(2) Number of turns = 36.
(3) Wire: 7-41 Litz.
(4) Loop shall be electrostatically shielded. The effective height of this loop is shown on Figure 1.



NOTE 1: $B = 5 \times 10^{-5} \frac{\text{Tesla}}{\text{Amp}}$ at 5 cm from wire turns.

NOTE 2: LOOP SELF RESONANT FREQUENCY SHALL BE GREATER THAN 100 kHz.

FIGURE 1

LOOP USED FOR RADIATING MAGNETIC FIELDS.

For radiating magnetic fields during susceptibility measurements, the loop shown on Figure 2 shall be used.

14 kHz to 25 MHz. For emission measurements, a 41-inch rod antenna (electrical length = 0.5 meter) and an appropriate matching network, as required, with a square counterpoise whose side measures 60 cm shall be used. For measurements on electric hand tools this antenna shall be used up to 30 MHz.

For radiating fields up to 1 Volt/meter, the 41-inch rod antenna and appropriate matching networks may be used. When fields greater than 1 Volt/meter are required, the antenna and general procedure shall be described in the test plan.

The 41 inch rod antenna need not be used for susceptibility testing for Air Force procurement. Antennas such as parallel plates; long wires, et cetera, are preferred. The antenna used and general procedures shall be described in the test plan.

20 to 200 MHz. Emission measurements in the frequency range of 25 to 200 MHz shall be performed using the biconical antenna. The maximum antenna factors for this biconical antenna are shown on Figure 3, and the measurement procedure for determining these antenna factors is shown below. The antenna factors shall be determined by the antenna manufacturer for each antenna and furnished with the antenna. These factors shall be used for calculating field strengths.

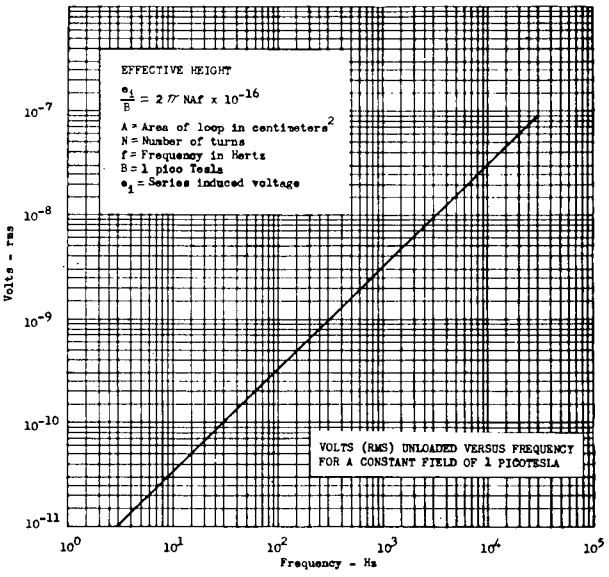


FIGURE 2

MAGNETIC FIELD EMISSION LOOP CONVERSION FACTOR.

Fields for susceptibility measurements shall be radiated from 20 to 200 MHz using the biconical antenna.

200 to 1000 MHz. Emission and susceptibility measurements (except for harmonic and spurious outputs in the open field) shall be performed using the conical logarithmic spiral antenna constructed in accordance with Drawing 62J4040. The measurement procedure for determining these antenna factors is shown below. The antenna factors shall be determined by the antenna manufacturer for each antenna and furnished with the antenna. These factors shall be used for calculating field strength.

1 to 10 GHz. Emmission and susceptibility measurements (except for harmonics and spurious outputs in the open field) shall be performed using the conical logarithmic spiral antenna constructed in accordance with Drawing 62J4041. The antenna factors shall be determined by the antenna manufacturer for each antenna and furnished with the antenna. These factors shall be used for calculating field strengths.

200 MHz to 40 GHz. Harmonic and spurious output measurements shall be performed with the following antennas:

(a) 200 to 1000 MHz—Cavity-Backed spiral antenna.
(b) 1 to 12 GHz—
  (1) Cavity-backed spiral antenna, AEL Model ASN-116 or equal.
  (2) Cavity-backed spiral antenna mounted in a 3-foot dish.
(c) 12 to 40 GHz—(Drawing ES-DL-201090)
  (1) 12 to 18 GHz—Horn antenna feeding an 18 inch diameter dish.
  (2) 18 to 26 GHz—Horn antenna feeding a 12 inch diameter dish.
  (3) 26 to 40 GHz—Horn antenna feeding a 12 inch diameter dish.

Antennas other than those specified can be used if described in the test plan and approved by the procuring activity. Antenna factors used shall be those published by the antenna manufacturer, measured in accordance with SAE ARP-958 or other approved procedure.

If the equipment under test is designed properly, it is likely that it will be impossible to establish the required amplitude at the power line input without using excessive energy or, possibly, damaging the equipment. Thus, the method described in MIL-STD-462 should be followed, first by establishing the transient across a 5 ohm resistor, and then by not letting the generator setting exceed that need with the resistor.

Floating Limit

Although it is not referred to as a "floating limit," the conducted emission limits in Parts 4, 5, 6 and 7 of MIL-STD-461B actually vary as a function of input power current. For instance, the CE01 limit on DC power leads for Navy procurements is shown in Figure 3 (excerpted from Figure 4-1 of the spec).

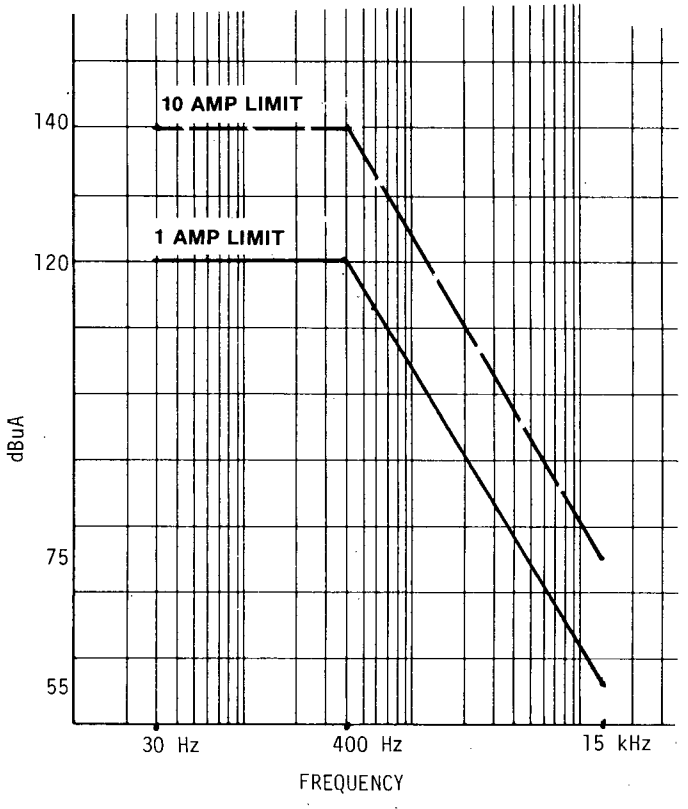


FIGURE 3

CE01 LIMIT FOR DC LINES ON NAVY PROCUREMENTS

The limit applies, provided that the DC current is one ampere or less. In the event the current exceeds one ampere, the entire limit is relaxed by the following relationship:

$$\text{dB relaxation} = 20 \log \frac{\text{(load current)}}{\text{1 amp}}$$

Assuming a 10 ampere load current, the applicable limit is shown in Figure 3 with the broken line.

The same type of relaxation or "floating limit" also applies for CE03. However, the full relaxation is only applied at the lowest frequency (15 kHz), and is reduced to the existing limit at 2 MHz. This is illustrated in Figure 4, (which has been excerpted from Figure 4-3 of the spec.)

A more complicated application of the floating limit applies to AC power limits, as shown in Figure 4-2 of the spec. Unfortunately, there is not enough space in this issue of *ITEM* to explain Figure 4-2. However, it is recommended that the figure be broken down and redrawn for each application.

Commercial and GFE Requirements

In order to minimize costs, the government often procures or requires commercial off-the-shelf equipment as part of a system. Whether or not this commercial equipment must meet MIL-STD-461B depends upon how the equipment is selected.

If the government specifies a specific equipment by manufacturer and model number, the contractor responsibilities are limited. The contractor must integrate the specified equipment into the system and perform the required EMC tests. In the event the system fails to meet the requirements because of the commercial equipment, the contractor must so advise the government and recommend what further action is required to achieve compliance. The contractor's responsibility ends there, and it is the government's responsibility to authorize further action, if desired.

In the event the contractor selects the commercial equipment and as a result the system fails to meet the EMI requirements, it is then the contractor's full responsibility to implement whatever action is required to achieve compliance.

When government furnished equipment is provided as part of the system, the contractor should treat this in the same manner as described above for government specified commercial equipment.

Notice 1 to MIL-STD-461B in Process

Although it seems as though MIL-STD-461B has just been released, it actually has been in effect for over eight months. Notice 1 to the Standard now is under preparation and a draft will be circulated during the first calendar quarter of 1981.

The obvious content of the first notice will include the correction of typographical errors which are contained in the basic document. These errors include the reversal of the time sign for the transient durations (they all should be "less than or equal to") and a correction to the note which appears on Figure 10-1. Persons using MIL-STD-461B now should be familiar with the floating limit concept. In Figure 10-1, the relaxation at the 50 kHz end point of the limit should be derived by a factor of 20 log (load current divided by 10).

Of more major significance will be the introduction of an additional conducted susceptibility test, probably notated as CS10. This new requirement is based upon EMP requirements and will require the injection of a PIN current at 10 amps and at 1000 volts. This requirement will be applicable to ships, and, possibly, ground systems. A Notice 5 to MIL-STD-462 is anticipated in order to provide the appropriate test method.

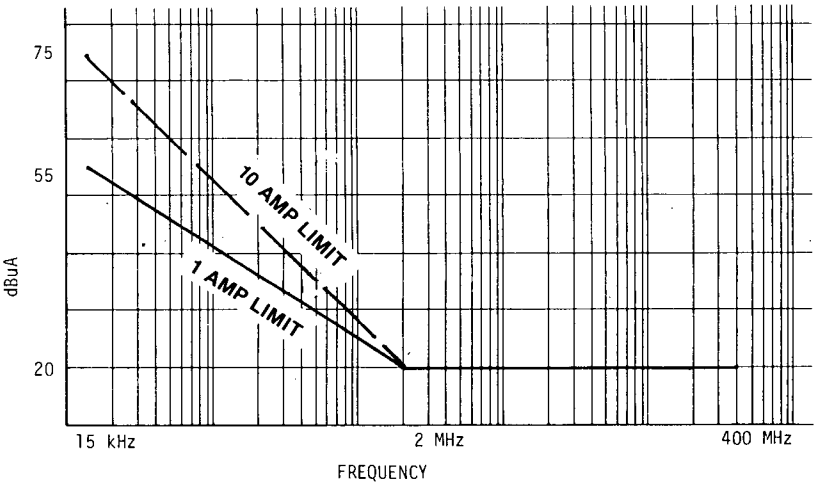


FIGURE 4

CE03 LIMIT FOR DC LINES ON NAVY PROCUREMENTS

*This article has been exclusively prepared for **ITEM** by Robert D. Goldblum, President, EMC Science Center.*