Caterpillar, Inc.
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Environmental Assessment
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Environmental Assessment

Electromagnetic Compatibility (EMC) immunity testing involves illuminating a device under test (DUT) with an electromagnetic field of specified electric field strength. Industry and internal standards for Caterpillar earthmoving equipment require testing of electronic systems on machines at a field strength level of 100 V/m. Testing at this field strength often requires transmitter power in excess of 100 watts. Since the testing done under the terms of this experimental license is performed outdoors and not in a shielded room, this environmental assessment is required for this experimental license according to Table 2 of Appendix A of OET Bulletin 65.

Applicable Limits

The testing done under the terms of this license will be performed on Caterpillar property where access is tightly controlled. Only company employees and authorized contractors are allowed on the property. All personnel involved in EMC testing will receive training in RF exposure safety. Access to the immediate testing area will be limited to those personnel involved in testing. Therefore, the occupational/controlled maximum permitted exposure (MPE) limits will apply.

Caterpillar's experimental license authorizes transmissions in the frequency range of 20 MHz to 2 GHz. Therefore, the following MPE limits apply:

- From 20 MHz to 30 MHz, 824/f V/m (27.5 V/m at 30 MHz is lowest level)
- From 30 MHz to 300 MHz, 27.5 V/m
- From 300 MHz to 1500 MHz, f/1500 mW/cm^2
- From 1500 MHz to 2000 MHz, 1 mw/cm^2

While the dwell time on any given frequency is short, a full testing sweep may take more than six minutes, so power averaging over time will not be used in these calculations. Continuous exposure will be assumed, though it is recognized that this is a conservative assumption and actual exposure will often be less than what is calculated.

Calculations by Frequency Range

20 MHz to 300 MHz

In this frequency range, the worst-case antenna that could be used for testing (from an RF safety standpoint) is a biconical antenna, which, when vertically polarized, has an omnidirectional azimuth radiation pattern. Since electric field strength decreases with the

square of distance from the antenna, it is necessary for the antenna to be placed near the device under test to generate the necessary field without excessive amounts of transmitter power. A DUT to antenna distance of 1 meters is commonly used to generate a 100 V/m field strength. Since the biconical antenna is omnidirectional, a 100 V/m field strength exists at a 1 meter distance from the antenna in all directions. The equation for electric field strength in terms of EIRP and distance is:

$$E(V/m) = \sqrt{\frac{30 * P_t}{r^2}}$$

Where:

E = Electric Field Strength in volts per meter
Pt = Transmitted EIRP in watts
r = distance from the antenna in meters

We can calculate that in order to generate 100 V/m at a distance of 1 meter, 330 W of EIRP is needed. We can then calculate that if 330 W of EIRP is radiating from the antenna, the distance from the antenna to test personnel must be at least 3.6 meters in order to for the electric field strength to be under the limit of 27.5 V/m.

300 MHz to 1500 MHz

In this frequency range a broadband log periodic antenna is normally used. These types of antennas generally exhibit 3 dBi to 9 dBi of gain in the main lobe, depending on frequency. The rear lobe generally exhibits –3 dBi to –15 dBi of gain, again dependant on frequency. In some cases a broadband horn antenna may be used, in which case the main lobe exhibits even more gain and the rear lobe even less. Calculations will show that in all cases, the required distance from the transmitting antenna to personnel in order to comply with the MPE limits is less than the 3.6 meters calculated in the previous section.

1500 MHz to 2000 MHz

In this frequency range a broadband horn antenna is normally used. These types of antennas generally exhibit significant gain in the main lobe, and significant negative gain in the rear lobe (relative to an isotropic radiator). Calculations will show that in all cases, the required distance from the transmitting antenna to personnel in order to comply with the MPE limits is less than the 3.6 meters calculated in the previous sections.

Conclusions

This environmental assessment shows that if personnel are located at least 4 meters from the transmitting antenna while the transmitter is operational, the FCC limits for maximum permissible exposure will never be exceeded. With this in mind, the following RF safety guidelines have been developed and will be enforced during all EMC immunity testing performed under this license authorization.

1) At no time should personnel come between the transmitting antenna and the device under test while the transmitter is operational.
2) If the transmitting antenna is directional, all personnel involved in testing should be located outside of the main lobe of the antenna when the transmitter is operational.
3) All personnel should be located at least four meters away from the transmitting antenna when the transmitter is operational.

In addition, a portable electric field strength meter will be used to periodically check the areas where personnel are located during testing to ensure that the maximum permissible exposure limits are not exceeded.

Appendix A – Maximum Calculated and Permissible Exposure

The following chart illustrates the maximum calculated exposure based on a distance of four meters from the transmitting antenna and antennas that are commonly used for EMC immunity testing. The chart also shows the FCC's maximum permissible exposure limits for reference. This chart assumes that a field strength level of 100 V/m is being generated in the main lobe of the antenna at a distance of 1 meter, where the device under test is located.