Electromagnetic Susceptibility of Process Control Instrumentation

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FOREWORD

This Foreword is supplied for informational purposes, only, and is not part of Electromagnetic Susceptibility of Process Control Instrumentation.

Standards are adopted in the public interest and are designed to eliminate misunderstandings between the manufacturer and the purchaser and to assist the purchaser in selecting and obtaining without delay the proper product for his particular need.

Existence of a Standard does not in any respect preclude any member or non-member from manufacturing or selling products not conforming with the standard.

Most electronic equipment is in some manner affected by electromagnetic radiation. This radiation is frequently generated by the small hand-held radio transceivers that are used by maintenance and security personnel. The susceptibility of Process Control instrumentation to the radiation of the hand-held transceiver is the primary concern of this standard. However, there are other sources of electromagnetic radiation of concern, such as fixed station radio and television transmitters, vehicle radio transmitters and various industrial electromagnetic sources.

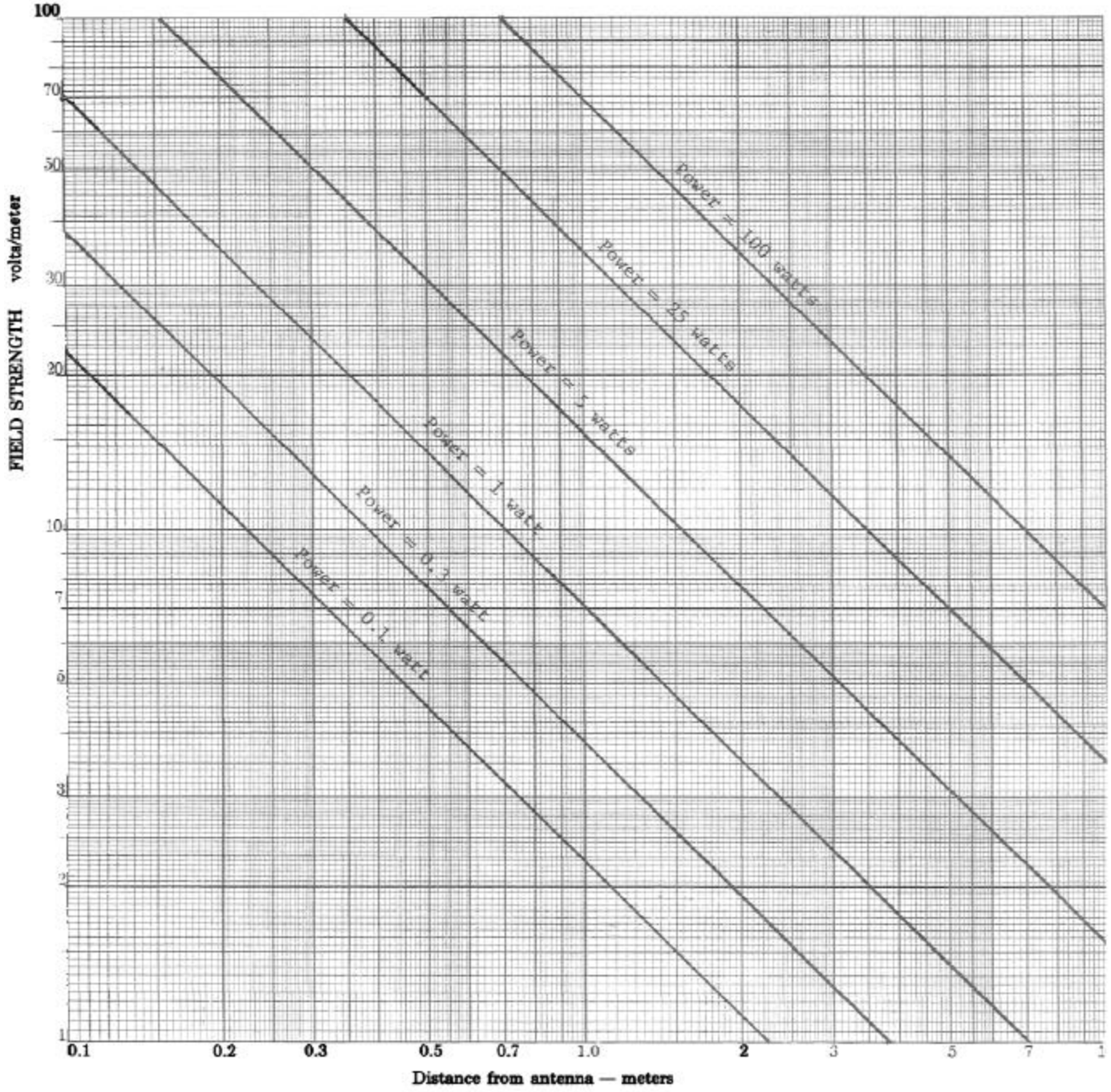
In addition to the continuous forms of electromagnetic energy deliberately generated, there are also spurious radiations caused by devices such as welders, contactors, motors, etc. It is recognized that these sources can cause difficulties in the operation of equipment but they are beyond the present scope of this standard; however, methods employed to prevent effects from continuous radiation will normally also reduce the effects from these sources.

The electromagnetic environment is determined by the strength of the electromagnetic field (field strength in volts per meter). The field strength is not easily measured without sophisticated instrumentation nor is it easily calculated by classical equations and formulae because of the effect of surrounding structures or the proximity of other equipment that will distort and/or reflect the electromagnetic waves.

The graph on page 2 is provided as a guideline of what the field strength may be in the proximity of a source of electromagnetic radiation from a 1/2 wave dipole antenna in an isotropic space in the far field. Because of the factors listed above it should only be used as an approximation and tests should be conducted on the installed equipment to insure that the desired effects have been achieved.

Test methods are defined in the standard for measuring the effect that electromagnetic radiation has on the instrument of concern. The test methods defined are structured for the primary objective of establishing repeatability of results at various test sites. However, electromagnetic radiation will be affected and distorted by the proximity of conductive objects, including the walls of the test chamber. Therefore, there will undoubtedly be some differences in results if tests are conducted at various sites. These differences must be taken into account when verification testing is conducted.

This standard is written for those knowledgeable of electromagnetic interference problems and methods of analyzing and limiting the effect. It is not intended to be a tutorial standard. Tutorial information can be obtained by referring to the bibliographical references.



Approximate Field strength in the far field from a dipole antenna as a function of antenna power based on equation $E = \frac{7.02}{d}\sqrt{P}$ for $d \geq \frac{\lambda}{2\pi}$

(d = distance from antenna in meters, P = radiated antenna power)

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1. SCOPE

This standard applies to the susceptibility of industrial and process control instrumentation to radiated electromagnetic energy. This standard establishes a classification of environments for anticipated electromagnetic fields and defines test methods for evaluating the instrumentation when used in these electromagnetic environments.

2. PURPOSE

The purpose of this standard is to establish a common reference for evaluating the performance of industrial process control instrumentation when subjected to electromagnetic fields such as generated from portable radio transceivers (walkie-talkies), or any other device that will generate continuous wave radiated electromagnetic energy.

3. DEFINITIONS, TERMINOLOGY, AND BIBLIOGRAPHY

3.1 Definitions and Terminology

Amplitude Modulation: The process by which the amplitude of a carrier wave is varied in accordance with a modulating wave.
Antenna: A transducer which either emits radio frequency power into space from a signal source, or intercepts an arriving electromagnetic field, converting it into an electrical signal.
Continuous Waves: (CW) Electromagnetic waves, the successive oscillations of which are identical under steady-state conditions, which can be interrupted or modulated to convey information.
Electromagnetic Interference (EMI): Any spurious effect produced in the circuits or elements of a device by external electromagnetic field.
Electromagnetic Wave: The radiant energy produced by the oscillation of an electric charge characterized by oscillation of the electric and magnetic fields.
Far Field: That region where the field from an antenna is self-propagating. For a dipole antenna this corresponds to distances greater than $\frac{\lambda}{2\pi}$, where λ is the wave length of the radiation.
Field Strength: The magnitude of the electromagnetic field, expressed as volts/meter.
Frequency Band: A continuous range of frequencies extending between two limits.
Isotropic: Having properties of equal values in all directions.
Octave: A frequency ratio of 2 to 1. 3.32 octaves equal one decade.
Polarization: A term used to describe the orientation of the electric-field vector of a radiated field.
Shielded Enclosures: A screened or solid metallic housing designed expressly for the purpose of isolating the internal from the external electromagnetic environments. The purpose is to prevent outside ambient electromagnetic fields from causing performance degradation and to prevent emission from causing interference to outside activities.
Sub-harmonic: An integer sub-multiple of a fundamental frequency.
Radiation: The propagation of a signal or interference from a source other than by conduction.
Span: The algebraic difference between the upper and lower range values.
Spurious Radiation: Any undesired electromagnetic emission from an electrical device.
Susceptibility: The characteristic of electronic equipment that results in undesirable responses when subjected to electromagnetic energy.
Sweep: A continuous traverse over a range of frequencies.
Transceiver: The combination of radio transmitting and receiving equipment in a common housing.

The above definitions were extracted from MIL-STD-463; IEEE Std 100-1972—ANSI C42.100-1972; SAMA PMC 20.1—1973; and ISA S51.1—1976, with modifications to fit the particular need of this standard.

3.2 Bibliography

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4. TEST CLASSIFICATIONS

4.1 The susceptibility tests have been classified according to field strengths and frequency bands. This is to allow the manufacturer or user to describe the susceptibility of instruments more accurately because susceptibility may vary with frequency as well as field strength.

4.2 The classes of field strengths are shown in Table 1; the frequency bands are shown in Table 2.

TABLE 1
CLASS OF FIELD STRENGTHS

Class	Field Strength V/m
1	3
2	10
3	As specified

Class 1 - Low level electromagnetic radiation environments, e.g.,local radio/television stations, low power transceivers.

Class 2 - Moderate electromagnetic radiation environments, e.g., portable transceivers or mobile transceivers that can be relatively close to the equipment but not closer than one meter.

Class 3 - Open class for situations involving very severe electromagnetic radiation environments. The level subject to negotiations between the user and vendor, or as defined by the manufacturer.

TABLE 2
FREQUENCY BANDS

Band	Frequency Range MHz
a	20-50
b	50-300
c	300-1000

The identifying nomenclature for the equipment is composed by stating the classes and bands followed by the numerical value of the maximum error of the instrument as shown by figure 1.

Example 1 — 1-c:0.5% Span.
This describes a device that has been tested for only class 1 (3 V/m) and band c (300 to 1000 MHz) and shows an error of not greater than 0.5% span.

Example 2 — 3-bc:1% Reading @ 50 V/m
This describes a device that has been tested for class 3 and bands b and c (50 to 1000 MHz) and shows an error of not greater than 1% of reading at specified level of 50 V/m.

Example 3 — 2-ab:0.75% span; 3-c:0.75% span @ 20 V/m
This describes a device that has been tested for class 2 (10 V/m) at frequencies of 20 to 300 MHz with an error no greater than 0.75% and class 3 at frequencies of 300 to 1000 MHz, with an error of no greater than 0.75% of span at specified level of 20 V/m.

Example 4 - 2-abc: Spec. 7P81.
This describes a device that has been tested for class 2 (10 V/m) over the full frequency range of 20 to 1000 MHz. The effect on the performance must be described in the product (or system) specification number 7P81.

5. TEST METHODS

5.1 TEST SET-UP

5.1.1 The procedure defined herein requires the generation of electromagnetic fields within which the test sample is placed and its operation observed. To generate fields that are useful for simulation of actual (field) conditions may require significant antenna drive power and the resultant high field strength levels. To comply with the Federal Communication Commission's regulations and to prevent biological hazards to the testing personnel, it is recommended that these tests be carried out in a shielded enclosure or room.

5.1.2 The use of a shielded enclosure, however, creates difficulties in establishing and maintaining the required field strengths due to reflections of the radiated energy from the walls of the enclosure. These reflections will cause enforcement and cancellation nodes to be established within the room.

5.1.3 The calibrated span and other operational adjustments of the test sample during the testing shall be stated by the manufacturer in his documentation.

5.1.4 All testing on instruments shall be performed in as close to installed conditions as possible. Wiring shall be consistent with the manufacturer's recommended procedures and the instrument shall be in its housing with all covers and access panels in place, unless otherwise stated. If the equipment is designed to be mounted in a panel, rack or cabinet it should be tested in this configuration.

5.1.5 A specific ground plane is not required. When a means is required to support the test sample it should be constructed of non-metallic material. However, grounding of housing or case of the instrument shall be consistent with the manufacturer's installation recommendations.

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Test Classifications

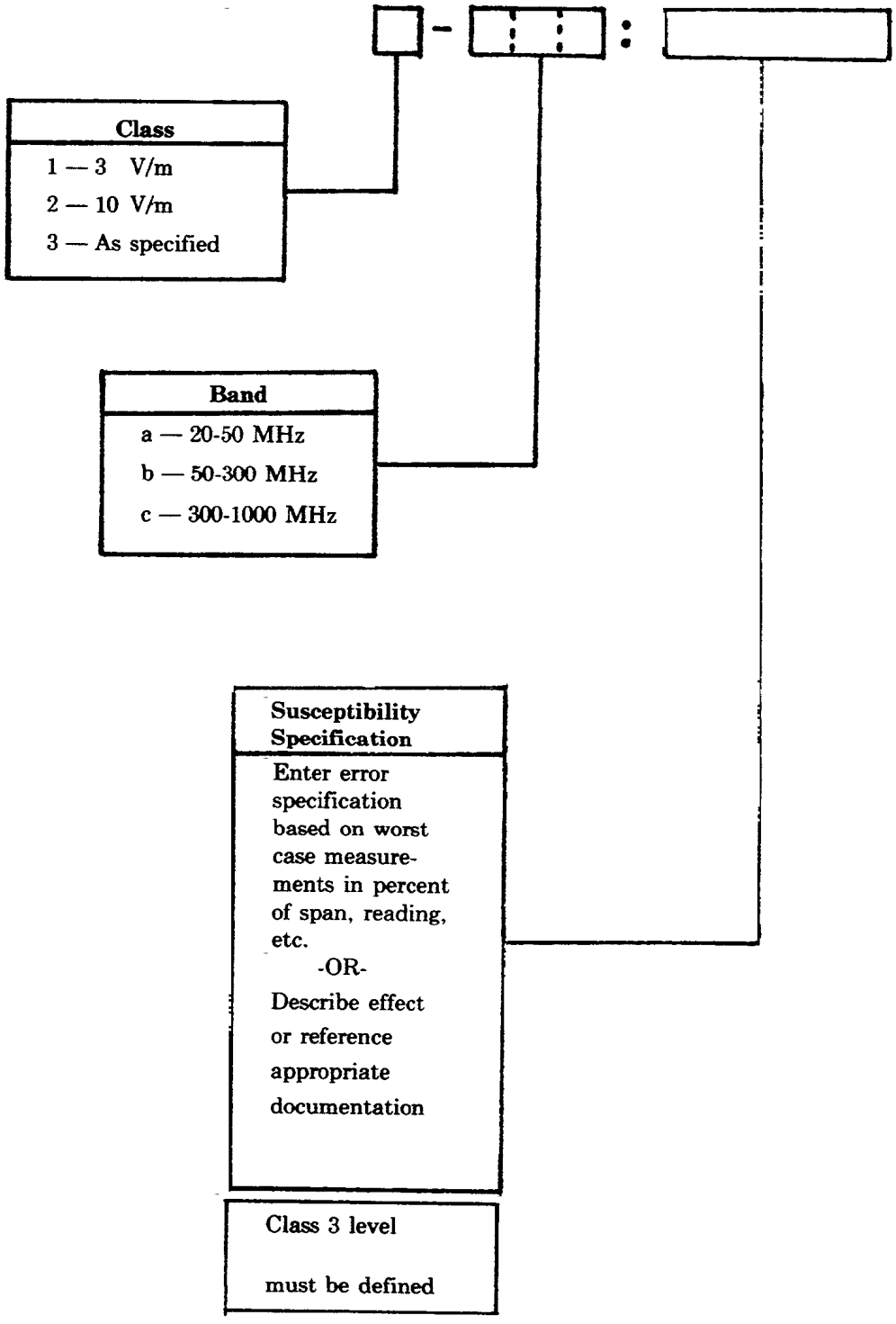

Figure 1 Specifying Test Classifications

5.2 TEST EQUIPMENT

5.2.1 The following test equipment is recommended. The use of other means of establishing and controlling the field is not ruled out and is acceptable providing the required conditions can be verified.

(1) Shielded Room—Size adequate to maintain distances shown by Figure 2.

(2) Signal Source—Signal generator(s) capable of covering frequency range with capability of amplitude modulation (if automatic sweep, sweep rate should be capable of achieving 0.005 octave/sec. (1.5×10^{-3} decades/sec.) or slower).

(3) Power Amplifier—To amplify signal and provide antenna drive if signal source is incapable.

(4) Antennas—Signal Source

a. Biconical
b. Conical Logarithmic Spiral

] See Manufacturer's Specifications

(5) Field Strength Monitor—Antennas with EMI Meter

(6) Associated equipment to monitor output and to establish operating power and signals for test sample.

5.3 TEST PROCEDURE

5.3.1 The test procedure assumes the use of biconical and log spiral antennas. Other methods of establishing the fields are acceptable providing the proper fields can be generated and verified.

5.3.2 Basic Radiation Susceptibility Test

(1) Set up the test sample and the transmitting antenna in accordance with the distance restrictions of Figure 2 for the biconical and log spiral antennas. When using the biconical transmitting antenna, adjust it so the electromagnetic field is polarized vertically.

(2) Establish the field strength at all frequencies of interest by replacing the test sample with the EMI receiver antenna.

(3) Replace the receiving antenna with the test sample and sweep through the required frequency band plotting the test sample output vs. the radiation frequency. Automatic sweep rate will be at 0.005 octaves or less per sec. If manual sweep is utilized, data points should be taken at a rate of three (3) frequencies per octave. For frequencies below 50 MHz,the test shall be run with amplitude modulation of 90% with a 1000 Hz sine wave. (See 5.3.3 for digital equipment).

(4) Step 3 shall be repeated to expose the test sample in other planes. The front and the back of the panel, rack or cabinet mounted equipment shall be exposed. Field mounted equipment shall be exposed on all six (6) sides.

(5) When using the biconical antenna, change electromagnetic wave polarization to horizontal and repeat Steps 2, 3, and 4.

5.3.3 Digital Equipment Modulation Test

All digital equipment using a clock shall also be subjected to electromagnetic radiation that is 90% amplitude (pulse or square wave) modulated at a frequency close to 10 kHz but not phase locked with the digital clock frequency. This applies to all test classification frequency bands. The 1000 Hz sine wave modulation listed in Step 3 above may be omitted when the 10 kHz modulation test is performed.

5.3.4 Keying Test

Some equipment is susceptible to repeated operation of a transmitter. This test is to evaluate the instrument in this mode. To simulate keying of a transceiver the signal source shall be switched between 0 and 100% of the CW amplitude as defined by 5.3.2(3). The switched signal shall have an on and off duration of at least one second each and shall have rise and fall times of no greater than 50 micro sec. There shall be at least three keying cycles per frequency octave. If manual sweep is utilized the test shall be run at three frequencies per octave. Exposure shall be to the most susceptible side of the instrument as defined by 5.3.2. (4).

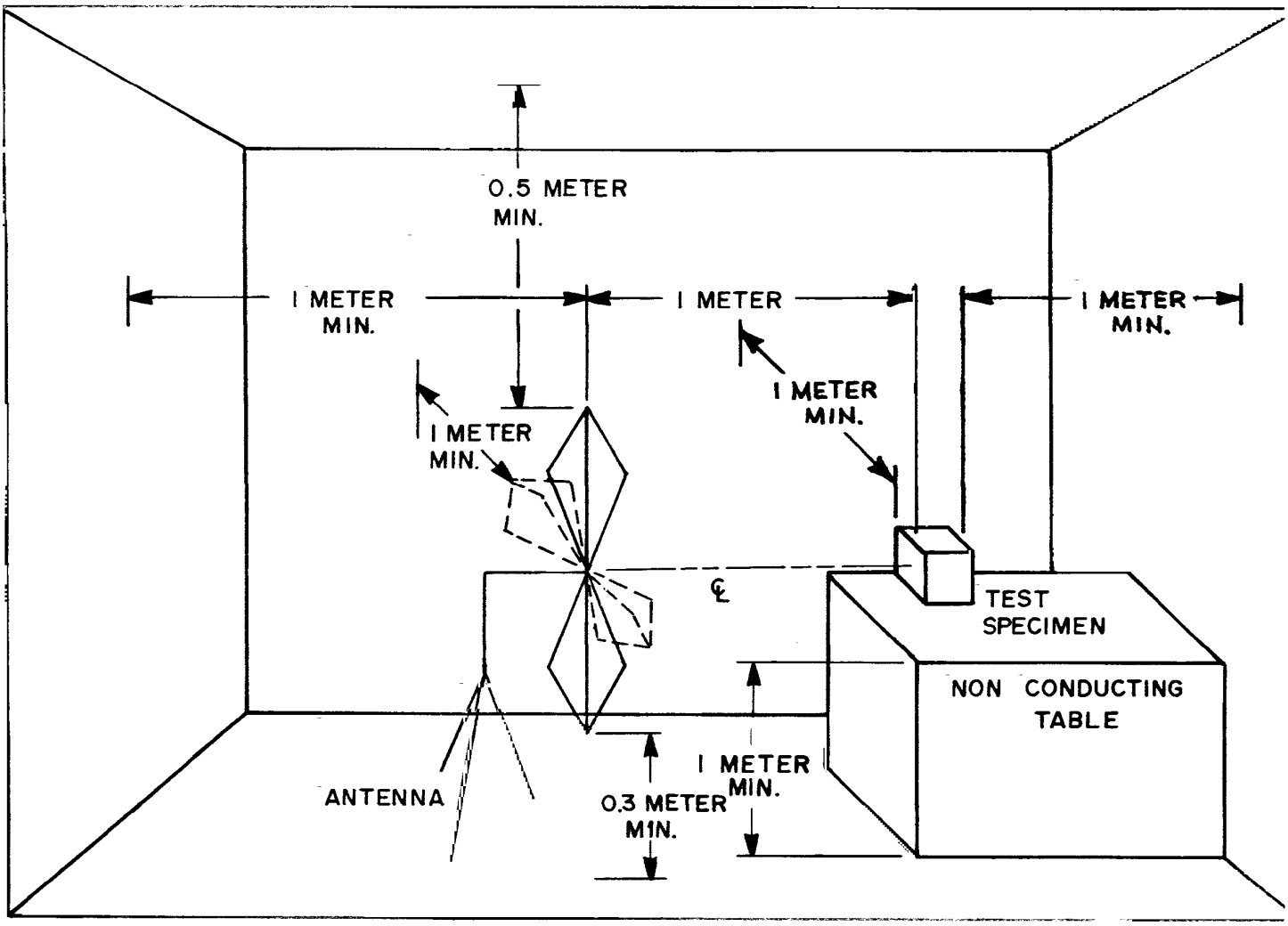

FIG. 2 TEST SET UP FOR RADIATED SUSCEPTIBILITY