SAE The Engineering Society For Advancing Mobility Land Sea Air and Space® INTERNATIONAL

400 Commonwealth Drive, Warrendale, PA 15096-0001

SURFACE VEHICLE STANDARD

SAE J1113-21

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Electronmagnetic Compatibility Measurement Procedure for Vehicle Components—Part 21: Immunity to Electromagnetic Fields, 10 kHz to 18 GHz, Absorber-Lined Chamber

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1. ***Scope***—This part of SAE J1113 specifies test methods and procedures for testing electromagnetic immunity (of vehicle radiation sources) of electronic components for passenger cars and commercial vehicles. To perform this test method, the electronic module along with the wiring harness (prototype or standard test harness) and peripheral devices will be subjected to the electromagnetic disturbance generated inside an absorber-lined chamber. The electromagnetic disturbances considered in this part of SAE J1113 are limited to continuous narrowband electromagnetic fields.

Immunity measurements of complete vehicles are generally only performed at the vehicle manufacturer. The reasons, for example, are high costs of a large absorber-lined chamber, preserving the secrecy of prototypes, or the large number of different vehicle models. Therefore, for research, development and quality control, a laboratory measuring method shall be applied by the manufacturers.

Part 1 of SAE J1113 specifies the general, definitions, practical use, and basic principles of the test procedure.

2. *References*

2.1 Applicable Publication—The following publication forms a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply.

2.1.1 SAE PUBLICATION—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1113-1—Electromagnetic Compatibility Measurement Procedures and Limits for Vehicle Components (Except Aircraft) (60 Hz to 18 GHz)

3. ***Measurement Philosophy***—The objective of an absorber-lined chamber is to create an indoor electromagnetic compatibility testing facility which simulates open-field testing. The shielded chamber is lined with absorbing material on as many surfaces in the chamber as possible to minimize reflections and resonances. The design objective is to reduce the reflectivity in the test area to –10 dB or less.

Typical application for this test method is recommended for frequency range of 10 kHz to 18 GHz. At frequency 10 kHz to 200 MHz, a parallel-plate antenna is used and only shielded room is required. Testing below cutoff can be accomplished using customized antennas and other specialized methods as listed in other parts of SAE J1113.

4. *Test Conditions*

4.1 Test Temperature and Voltage—The ambient temperature during the test shall be 23 °C ± 5 °C.

The supply voltage during the test shall be 13.5 V ± 0.5 V for 12-V electrical systems and 27 V ± 1 V for 24-V electrical systems.

If other values are agreed to by the users of this document, the values used shall be documented in the test report.

4.2 Frequency Range—The frequency range of the test is 10 KHz to 18 GHz.

4.3 Modulation—The device under test (DUT) determines the type and frequency of modulation. If no values are agreed between the users of this document, the following shall be used:

a. No modulation (continuous wave)
b. 1 kHz sine-wave amplitude modulation (AM) 80%

4.4 **Dwell time—**At each frequency, the DUT shall be exposed to the test levels for the minimum response time needed to control the DUT. In all cases, this minimum time of exposure shall be:

$$t\ min = 2\ s \quad \text{(Eq. 1)}$$

4.5 **Frequency steps—**The test will be conducted with the following maximum frequency step sizes:

TABLE 1—FREQUENCY STEPS

Frequency Band	Maximum Frequency Step Size
10 kHz to 100 kHz	10 kHz
100 kHz to 1 MHz	100 kHz
1 MHz to 10 MHz	1 MHz
10 MHz to 200 MHz	2 MHz
200 MHz to 1000 MHz	20 MHz
1 GHz to 18 GHz	200 MHz

Alternatively, logarithmic frequency steps, with the same minimum number of frequency steps in each frequency band, can be used. The values, as agreed by the users of this document, shall be documented in the test report.

NOTE—If it appears that the susceptibility thresholds of the DUT are very near the chosen test level, these frequency steps have to be reduced in the concerned frequency range in order to find the minimum susceptibility threshold.

4.6 **Test Severity Levels—**The user should specify the severity level(s) for the field strength over the frequency range. An example of test severity levels are included in Appendix A (Figure A1) of this document.

These suggested test severity level(s) are expressed in terms of the equivalent root-mean-square (RMS) value of an unmodulated wave.

Tests are generally performed in both horizontal and vertical polarizations over the test frequency range. Any exceptions to this practice shall be specified in the test plan.

5. Test Instrument Description and Specifications**—**The test consists of generating radiated electromagnetic fields by using antennas with radio frequency (RF) sources capable of producing the desired field strengths over the range of test frequencies. The fields are monitored with small probes to ensure proper test levels. To reduce testing error, the DUT operation under test is usually monitored by optical couplers.

5.1 **Absorber-Lined Chamber and Shielded Room—**The size, shape, and construction of an absorber-lined chamber can vary considerably. The chamber shape is a function of the types of tests to be performed, the size of DUT to be tested, and the frequency range to be covered. Basically, an absorber-lined chamber consists of a shielded room with absorbing material mounted on its internal reflective surfaces (optional: floor excepted). The shielded room must be capable of attenuating the generated electromagnetic energy such that it would not introduce an unacceptable level of emissions to the outside environment. The minimum size of the room is determined by the size of the test region needed, the size of the field generation device, and the clearances needed between them and the largest DUT that is to be tested. To create the test region, the absorber, field generation system, and chamber shape are selected to reduce the amount of extraneous energy in the test region below a minimum value which will give the desired measurement accuracy. The objective of an absorber-lined chamber is to create an indoor electromagnetic compatibility testing facility which simulates open-field testing. The chamber is lined with absorbing material on as many surfaces in the chamber as possible to minimize reflections and resonances. The design objective is to reduce the reflectivity in the test area to –10 dB or less.

5.2 Instrumentation

5.2.1 FIELD-GENERATING DEVICE—The field-generating device shall be an antenna. Any commercially available antenna set (including high-power baluns, if appropriate) which is capable of radiating the specified field strength at the DUT or reference point with the available power may be used.

5.2.2 DUT MONITOR—Test equipment, hardened to the test power levels, required to monitor the operation of the DUT shall be coupled to the control center by fiber-optic links or high-resistance leads.

5.2.3 FIELD PROBES—Field probes should be isotropic, electrically small. The transmission lines from the probes should be either very high resistance or fiber-optic links.

5.3 Test Set-Up

5.3.1 INSTALLATION OF THE DUT—The test configuration is shown in Figures 1 to 4. The DUT with standardized test wiring harness and actual or simulated loads shall be used in the test. The DUT, test harness, and other peripherals which are part of the test are to be placed on a test bench. The length of the test harness shall be 1.5 m ± 0.075 m. The wiring type is defined by the actual system application and requirement.

The faces of the DUT shall be located at a minimum distance of 100 mm from the edge of the ground plane. All leads and cables shall be a minimum of 100 mm from the edge of the ground plane and the distance to the ground plane (from the lowest point of the harness) shall be 50 mm +10/–0 mm above the ground plane.

DUT shall be placed at 100 mm ± 5 mm from the longitudinal line of the wiring harness.

Power shall be applied to the DUT via a 5 µH/50 W artificial network.

5.3.2 LOCATION OF FIELD-GENERATING DEVICE

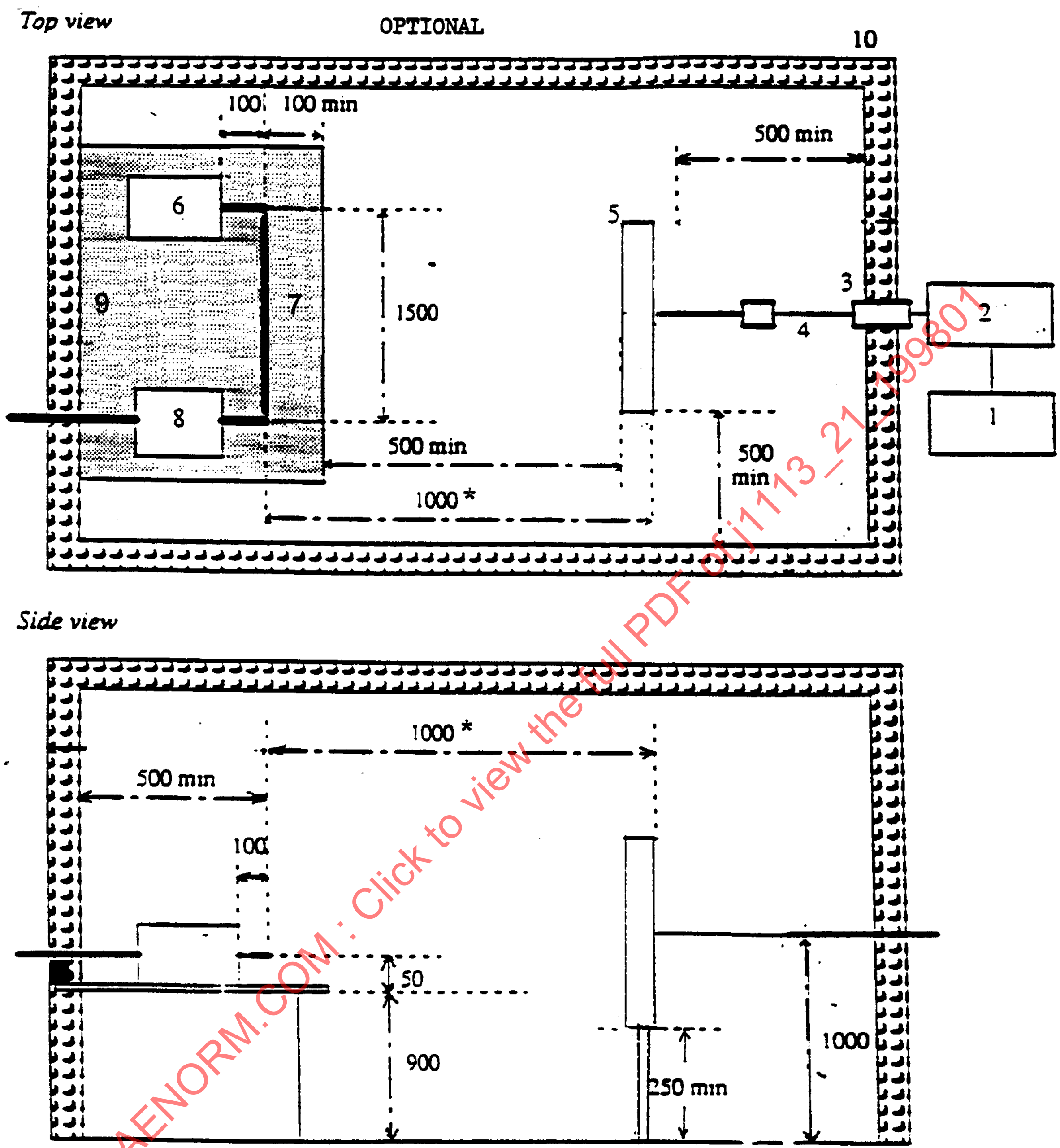
5.3.2.1 Height and Distance of Measurement—The phase center of any antenna shall be 1 m above the floor.

No part of any antenna radiating elements shall be closer than 0.25 m to the floor.

5.3.2.1.1 Antenna Location—The radiating elements of the field-generating devices shall not be closer than 0.5 m to any absorbent material and shall not be closer than 1.5 m to the wall of the enclosed facility.

The distance between the antenna and the wiring harness shall be 1 m ± 0.01 m. This distance is measured from:

a. The center of the parallel-plate antenna
b. The phase center of the biconical antenna
c. The nearest part of the log periodic
d. The nearest part of the horn antenna

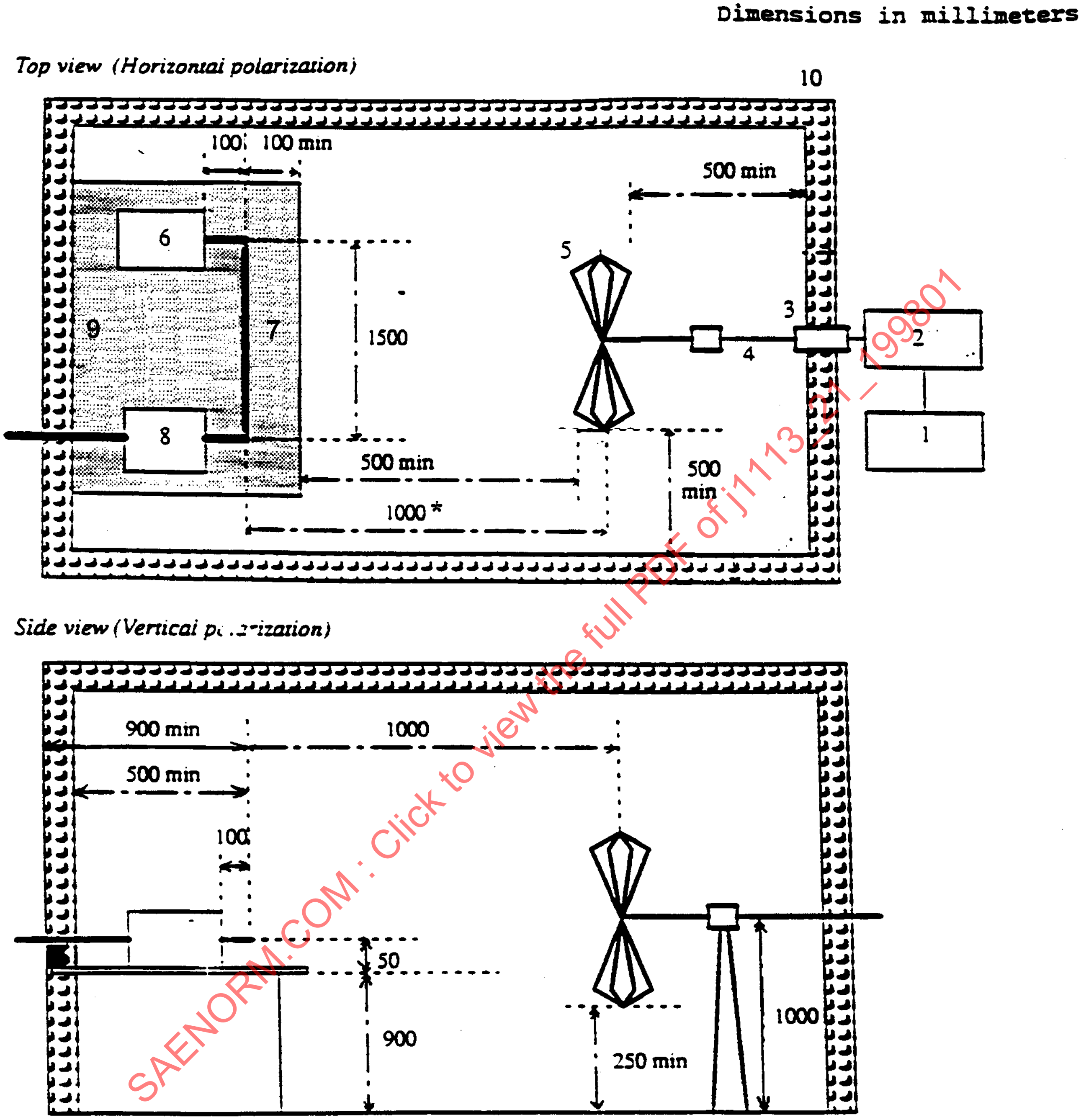


LEGEND

1. Signal Generator
2. Amplifier
3. Bulkhead Connector
4. Double shielded coaxial
5. Antenna
6. DUT
7. Wiring harness (power and signal lines)
8. Artificial network (power lines)
9. Test Bench
10. Typical RF absorber - optional

* CAN BE REDUCED TO ACHIEVE HIGHER FIELD STRENGTH

FIGURE 1—EXAMPLE OF TEST CONFIGURATION—PARALLEL PLATE ANTENNA

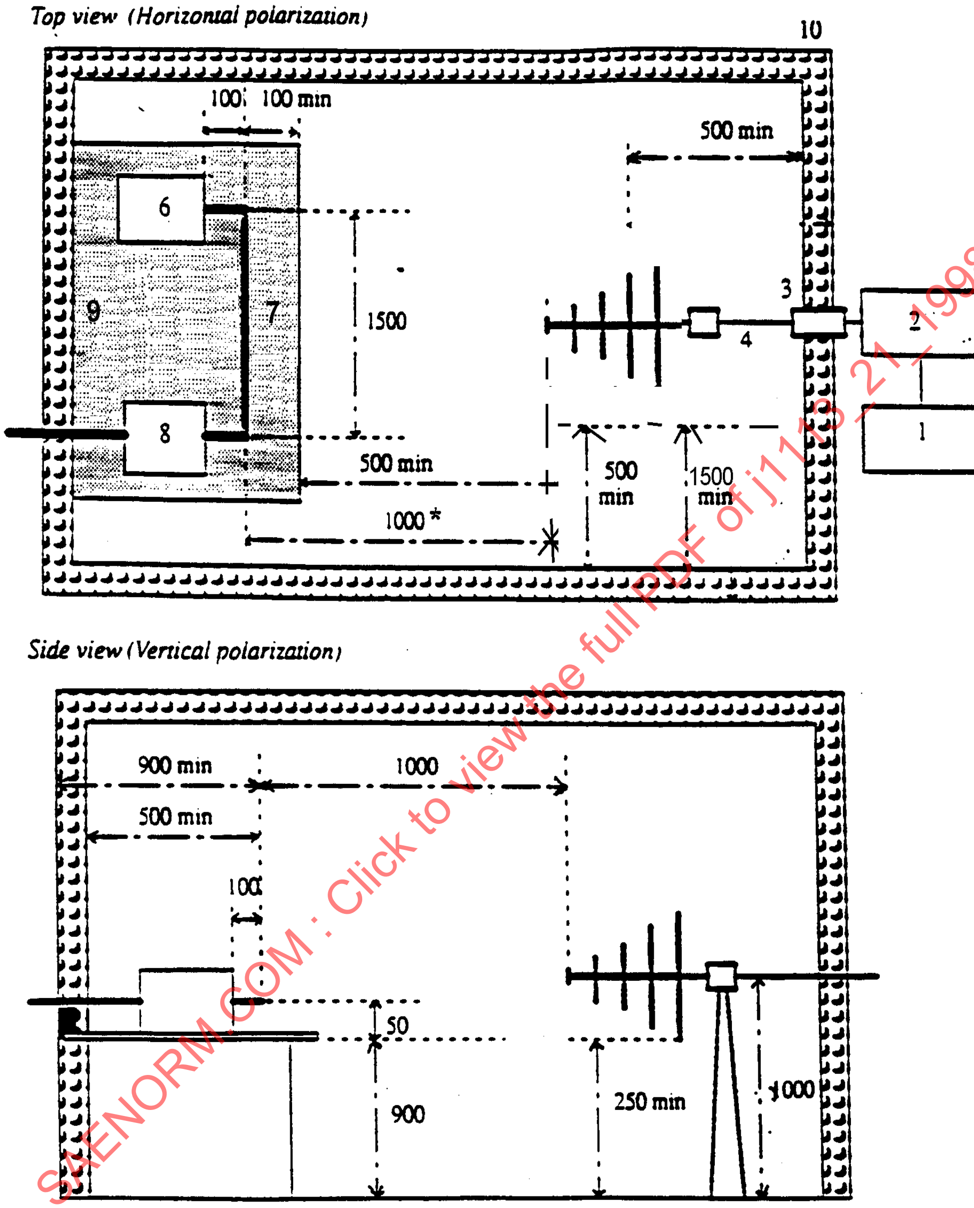


LEGEND

1. Signal Generator
2. Amplifier
3. Bulkhead Connector
4. Double shielded coaxial
5. Antenna
6. DUT
7. Wiring harness (power and signal lines)
8. Artificial network (power lines)
9. Test Bench
10. Typical RF absorber - optional

FIGURE 2—EXAMPLE OF TEST CONFIGURATION—BICONICAL ANTENNA

Dimensions in millimeters

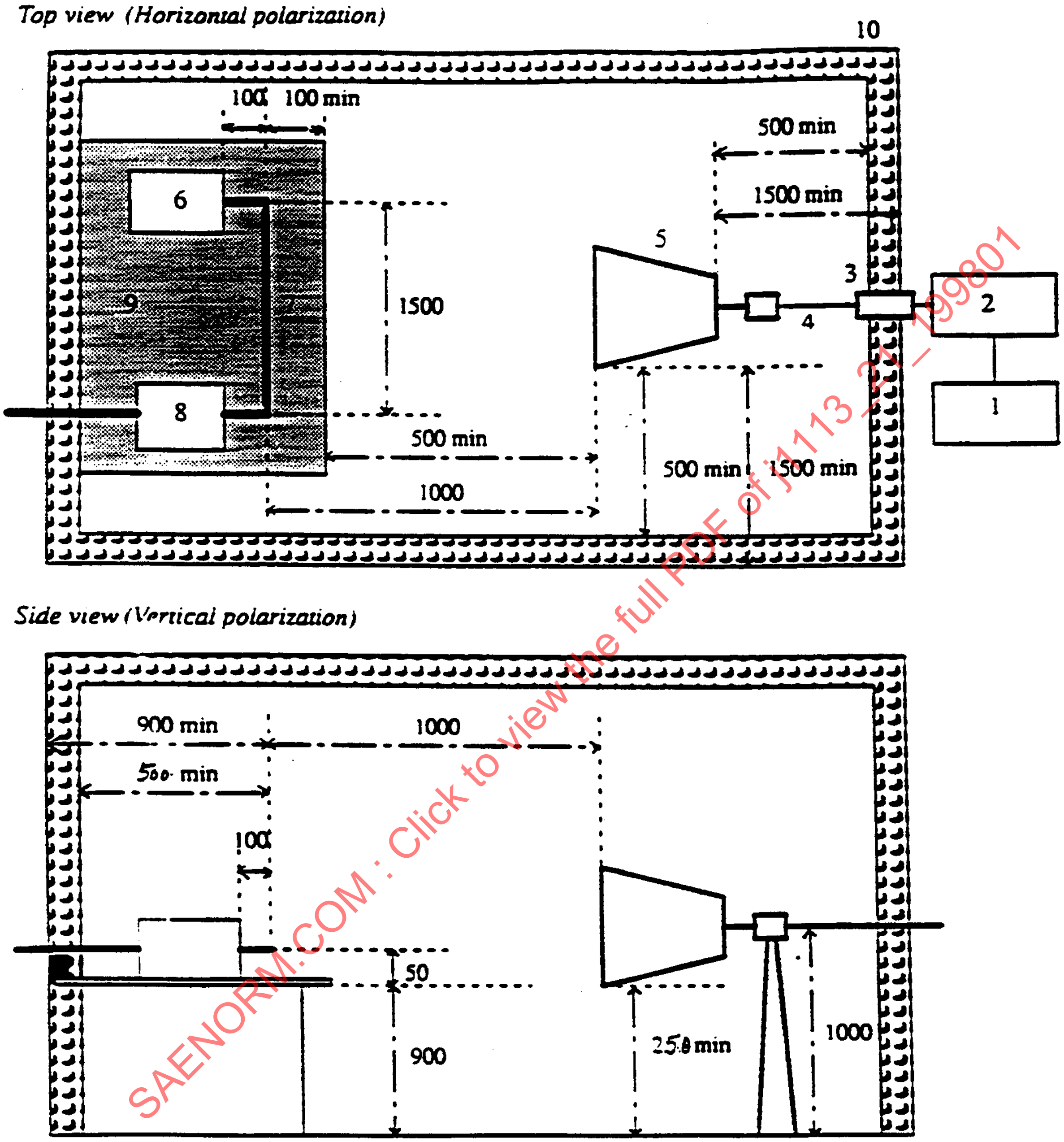


LEGEND

1. Signal Generator
2. Amplifier
3. Bulkhead Connector
4. Double shielded coaxial
5. Antenna
6. DUT
7. Wiring harness (power and signal lines)
8. Artificial network (power lines)
9. Test Bench
10. Typical RF absorber - optional

FIGURE 3—EXAMPLE OF TEST CONFIGURATION—LOG PERIODIC ANTENNA

Dimensions in millimeters



LEGEND

1. Signal generator
2. Amplifier
3. Bulkhead connector
4. Double shielded coaxial cable
5. Antenna
6. DUT
7. Wiring harness (power and signal lines)
8. Artificial network (power lines)
9. Test bench
10. Typical RF absorber

FIGURE 4—EXAMPLE OF TEST CONFIGURATION—HORN ANTENNA

5.3.3 TEST BENCH DESCRIPTION—The test shall be performed inside an absorber-lined chamber on a bench top with either metallic or nonmetallic surface as described as follows:

NOTE—ISO 1145-2 (ISO version of this test method) proposed to delete the use of nonmetallic table as an acceptable option (only test bench with metallic table top is allowed). The use of metallic or nonmetallic table may induce significant difference in test results. When parallel-plate antenna is used, nonmetallic table is recommended. The type of test bench used shall be specified in the test plan and documented in the test report.

5.3.3.1 Nonmetallic Table—The table shall be constructed with nonmetallic material. The table top shall be 0.9 m above the floor (either metallic or absorber-lined). The system under test shall not be connected to the chamber ground.

5.3.3.2 Metallic Table—The DUT shall be placed on top of a metallic table (or a table with a metallic top). The ground plane shall be constructed from either copper or brass or galvanized steel.

The minimum thickness of the metal ground plane is 0.5 mm. The dimension is 2.25 m^2 or larger in area with the smaller side no less than 0.75 m. The height shall be 0.9 m above the floor of the shielded enclosure.

The ground plane shall be bonded to the wall of the shielded room at least at every 300 mm interval. The bonding resistance shall be less than 2.5 mΩ.

5.3.4 TEST ACTUATORS AND MONITORS—The DUT shall be operated as required in the test plan by actuators which have a minimum effect on the DUT, e.g., plastic blocks on the push-buttons, pneumatic actuators with plastic tubes. Connections to equipment monitoring for electromagnetic interference reactions of the DUT may be accomplished by using fiber optics, or by high-resistance leads. Other types of leads may be used but require extreme care to minimize interactions. The orientation, length, and location of the latter leads must be carefully documented to assure repeatability of the test results.

6. Test Procedures

6.1 Test Plan—Prior to performing the tests, a test plan shall be generated which shall include interface tests points, DUT mode of operation, DUT acceptance criteria, and any special instructions and changes from the standard test. Each DUT shall be verified under the most significant situations, e.g., at least in stand-by and in a mode where all the actuators can be excited.

6.2 Test Method

CAUTION—HAZARDOUS VOLTAGES AND FIELDS MAY EXIST WITHIN THE TEST AREA. CARE SHOULD BE TAKEN TO ENSURE THAT THE REQUIREMENTS FOR LIMITING THE EXPOSURE OF HUMANS TO R.F. ENERGY ARE MET.

The field calibration can be performed according to one of the following two methods:

6.2.1 SUBSTITUTION METHOD—The substitution method is based upon <u>the use of NET POWER as the reference parameter used for calibration and test.</u>

Measurements using the substitution method can be affected by coupling between the antenna and the DUT as well as by reflected energy. During the test, the net power shall be maintained relative to the calibration point up to a limit of 2 dB increase in forward power.

NOTE 1—If the forward power has to be increased by 2 dB or more, this shall be indicated in the test report.