# RESISTANCE TO ELECTROMAGNETIC DISTURBANCES, IRRADIATED TYPE, OF ELECTRONIC SYSTEMS INSTALLED ON A VEHICLE



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## 1 SCOPE

Define the test procedure and the equipment to use for testing the vehicle, in all conditions of use, for immunity of the electronic systems installed on the vehicle to the electromagnetic fields radiated by the external environment, owing to the presence of radio frequency repeaters and transmitters in the immediate vicinity.

## 2 OBJECT

This standard is valid for apparatus installed on “Otto”/”Diesel” cycle internal combustion engine vehicles with 12 V or 24 V electrical system and electrical or hybrid traction.

## 3 GENERAL TEST CONDITIONS

LThe tests should be carried out on systems whose electronic components have already passed the functional checks referred to in the IVECO STD. 18–2252 general specification sheet and in the specific specification sheets.
This standard is used at the Technical Decision, Qualification and Type Approval stages of the vehicle.

### 3.1 Test environment

a) In order to reproduce a standardized and more controlled environment, it is necessary to put the vehicle inside an anechoic or semi–anechoic chamber to carry out the tests at frequencies ranging from 10 kHz to 18 GHz.

b) For frequencies ranging from 10 kHz to 20 MHz the open field is accepted.
For vehicles longer than 12 m, the open field is accepted for the whole test range with maximum generatable fields of 30 V/m.

### 3.2 Vehicle position

The vehicle can be placed on rollers or alternatively held up by an isolating support such as to allow rotation of the drive axle.

Where suitable, the transmission shafts can be disengaged.

| Edition | Date | Description of modifications | Group |
|---|---|---|---|
| 1 | 12.09.1989 | New. | |
| 2 | 24.04.1992 | Completely revised. | |
| 3 | 03.09.1993 | Following points amended: 2.8 (Classes C and D), 2.9.1, 2.9.2, 2.11. | |
| 4 | 01.12.1993 | Point 1 added, point 1.2 eliminated, point 3.7.3 amended (Schedule I) and numbering of chapters and Figures changed. | |
| 5 | 28.08.1999 | Following points amended: 3.4.6, 3.7.3, (Schedule I, and diagrams added), 3.9.1, 3.9.2. | **PEL** |
| 6 | 06.08.2001 | Following points amended: 2, 3.2, 3.3, 3.4.1, 3.4.3, 3.4.6, 3.6, 3.6.2, 3.7, 3.7.1, 3.7.3, 3.11; Schedule I and Figures 1, 2, 4, 5, 6. Point 4 and Figure 3 added. | |
| 7 | 17.03.2006 | Completely revised to conform to EC Directive 2004/104 and adapt to Technical Progress ISO 11451–1 and 11451–2. | |
| 8 | 27.10.2006 | Figure 3 and Table 4 amended. | |

## 3.3 Test instruments and environments

### 3.3.1 Shielded anechoic / semi–anechoic chamber

It must be large enough to contain the electromagnetic field generating antennas and the vehicle under test.
It must also have the following characteristics:

a) The minimum shielding attenuation as regards the electromagnetic field must be the following:

| | | |
|---|---|---|
| – electric fields: | 10 kHz – 100 MHz | 100 dB |
| | 100 MHz – 20 GHz | 100 dB |
| – magnetic fields: | at 10 kHz | 60 dB |
| | at 200 kHz | 80 dB |
| | at 1 MHz | 100 dB |

b) The minimum reflection coefficients of the anechoic material must be the following:

| | |
|---|---|
| – 25 dB or better | at 30 MHz |
| – 35 dB or better | at 200 MHz |
| – 50 dB or better | at 1 GHz |

c) Field uniformity, measured on the end points of a volume of 6 x 2.5 x 2.5 m, must be $\leq$ 10 dB.

d) The reference environmental characteristics during the test must be:

| | |
|---|---|
| Temperature: | 20 ± 2 °C |
| Relative humidity: | 45 – 70% |
| Atmospheric pressure: | 860 – 1060 mbar |

e) Electromagnetic field:
the strength of the electromagnetic field that can be generated in the test frequency bands must be at least E = 100 V/m in the chosen calibration site.
If it is not possible to reach this level for certain frequencies, supply the transmitting antenna with the maximum power value delivered by the radio frequency amplifier.

f) Transmitting antennas:
must allow you to obtain, in the test frequency band, the electromagnetic field strength and uniformity specified in the preceding points.
Typical antennas for test frequency bands are the following:

| | |
|---|---|
| 100 kHz – 20 MHz | E/H Wire antenna |
| 20 MHz – 200 MHz | Log–Periodic antenna |
| 200 MHz – 1 GHz | Log–Periodic or Double Ridged antenna |
| 1 GHz – 18GHz | Horn antenna |

g) If present, the double roller bed must have technical features that will meet the functional features of the vehicle under examination, without altering the required attenuation and uniformity limits.

3.3.2 **Parallel plane antenna (P.P.L.)**

It must be large enough to contain the vehicle under test and must have the following characteristics:

– Electromagnetic field:
the strength of the electromagnetic field that can be generated in the test frequency band must be at least E = 100 V/m. If it is not possible to reach this level for certain frequencies, supply the P.P.L. antenna with the maximum power value delivered by the radio frequency amplifier.

– Frequency band: 10 kHz – 20 MHz.

– Field uniformity, measured at the end points of a volume of 6 x 2.5 x 2.5 m, must be ≤ 10 dB.

3.3.3 **Isotropic electromagnetic field meters**

They must make electromagnetic field measurements greater than 200 V/m in the frequency range between 10 kHz and 18 GHz, with a measurement precision of at least ± 3 dB.
They must be powered by internal batteries and equipped with optical fibre outputs for remote display.
They must allow remote reading of the electric field module (geometric mean of the three Cartesian axes), through digital or analogue display.
They must be equipped with optical fibre output for the necessary electric uncoupling.

3.3.4 **Systems for monitoring the devices under test**

– They must allow correct operation of the system under test in normal conditions of use, as envisaged by the supplier or the relevant specification sheet.

– They must be able to interface correctly with the sensors and actuators of the system under test, without altering their functional and electrical characteristics (impedances).

– They must be insensitive to the electromagnetic fields radiated during the test.

In order to satisfy the abovementioned points, the systems must be built as follows:

– unit for transmitting the signals of the diagnosis lines KL ISO 9141 and the CAN busses, for monitoring the functionality state of the system under test with electro–optical conversion.

– Reception unit with electro–optical conversion of the signals and the KL diagnosis lines and the CAN bus for monitoring the functionality state (in the control room).

– Optical fibres connecting transmission unit and reception unit.

– Monitoring instruments (in the control room).

One (or more) closed circuit TV cameras must also be installed on the vehicle, with optical connection to the receiving unit (monitor) located in the control room.

3.3.5 **Radio frequency generation/control system to be placed outside the shielded anechoic chamber and the P.P.L. antenna.**

a) Signal generators:
they must be able to generate sinusoidal signals in frequency bands from 10 kHz to 18 GHz modulated in amplitude with variable modulation index from 0% (no modulation) to 80%, with modulating (sinusoidal) frequencies of 400 and 1000 Hz for amplitude modulation and with variable duty cycle for pulse modulation.

b) Radio frequency power amplifiers:
they must have the following technical features:

– minimum frequency bands
from 10 kHz to 18 GHz.

– The generated power must be sufficient to obtain the electromagnetic field levels required in points 3.3.1 and 3.3.2.

– Harmonics:
at least 15 dB lower than the amplitude of the fundamental, for the whole operating band (6 dB for frequencies higher than one GHz).

– Input power to obtain the maximum output power (sensitivity):
1 mW (0 dBm) on a load of 50 Ω.

c) Radio frequency wattmeters, with 2 measurement channels,
must have the following technical features:

– minimum frequency bands:
from 10 kHz to 18 GHz and in any case such as to cover the band used by RF amplifiers.

– Measurement accuracy in the test frequency band:
at least ± 0,5 dB.

– The accepted incoming power must be compatible with the power leaving the directional couplers.

d) Directional couplers
must meet the following technical requirements:

– minimum frequency band such as to cover the band used by RF amplifiers.

– Accepted incoming power:
must be compatible with the maximum power generated by radio frequency power amplifiers.

– Attenuation of the measured signal such as to allow the radio frequency heads of the wattmeter to read the direct and reflected power leaving the amplifiers.

– Measurement accuracy:
± 0,5 dB in the respective frequency bands.

e) Control and switching unit:
must pilot the signal and power switchers and the radio frequency amplifiers, in consistency with the required test frequency bands.

f) Electric field repeater:
with optical fibre input and indication, through digital or analogue display, of the measured quantity.

## 3.4 Preparation of the vehicle under test

The vehicle must be prepared in the following way:

a) Body:
must have no additional metal masking, in order to avoid alteration of the shielding power of the vehicle body.
Masking with non–metal materials is allowed.

b) Electronic devices and electrical wiring of the vehicle:
must be in the final version or as near as possible to it and in any case in conformity with what is prescribed in the drawing or relevant specification sheet.

c) Pneumatic remote control for starting and switching off the combustion engine.
Additional stimuli of the on–board systems through pneumatic and/or optical actuators.

d) Monitoring of the electronic devices under test:
for each electronic device under test, the signal cables for checking the correct operation of the device under test must be identified and marked on the wiring.
Suitable quick–connect terminals, to which to connect the electrical–optical signal measurement and transmission system, must be inserted on these cables.

### 3.4.1 Sheet accompanying the vehicle for EMC tests

The system to be tested on the vehicle must arrive at the test centre accompanied by the briefly identified data of the system, vehicle and electronic set–up, according to the tables below.

#### 3.4.1.1 Concise description of the vehicle

**TABLE 1**

| **Vehicle specifications** | **Specific data – Notes** |
|---|---|
| **Vehicle model** | |
| **Engine type** | |
| **Chassis no.** | |
| Length | |
| Width | |
| Height | |
| Wheel base | |
| Front overhang | |
| Rear overhang | |
| Minimum height from ground | |
| Steering diameter | |
| Tare | |
| Special chassis materials, if any | |
| Special cabin materials, if any | |

3.4.1.2 **Concise description of the systems to be specifically subjected to the test on the vehicle**

**TABLE 2**

| For each system/component under test | Specific data – Notes |
|---|---|
| **Control unit** | |
| **Supplier** | |
| **IVECO drawing no. and/or Supplier** | |
| Hardware release of component under test | |
| Software release of component under test | |
| Hardware release planned for the range | |
| Software release planned for the range | |
| Connections with other systems, if any | |
| Communication protocol (CAN) | |
| Diagnostic tools (hardware–codes) | |
| Location on vehicle (engine, chassis, cabin, dash-board) | |
| Use of special cables (twisted, shielded) | |
| Documentation of specific wiring | |
| Wiring routingConformity as regards the EMC sugge-stions contained on the I.S. 10–4156 | |
| ECU material (insulating, conductive) | |
| ”House” electrical connection requirements (insulated or connected to earth; connected by cable, braid, mechanical fixings) | |
| Type of GroundingChosen earth points consistent with the suggestions contained on the I.S. 10–4157<br>– subdivision of earthing according to the magni-tude of the current<br>– use of braids for equipotentiality between struc-tures | |
| Supplier documentation of EMC/EMI conducted at the bench (self–certification) | |

3.4.1.3 **Concise description of the systems to be specifically subjected to the test on the vehicle**

**TABLE 3**

| Other control units present | Supplier | Drawing no. |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

3.5 **Testing methodology**

To establish the electromagnetic field conditions, the so–called "*substitution method*" is used. There will therefore be two stages, one a calibration stage in the absence of the vehicle, the other a test stage when the vehicle is put in the test installation and is suitably positioned.

3.5.1 **Calibration of test areas in the absence of the vehicle**

Anechoic chamber:
two calibration points regarding front/rear radiation and side radiation must be chosen.

Antenna:
must be oriented so that the maximum field level is read on the sensor, and its distance from the vehicle must be such as to guarantee good field uniformity inside its positioning volume.

3.5.1.1 **Point S1:**
will be positioned at a distance of 1 ±0,2 m inside the point of junction, between the windscreen of the vehicle under examination and the body on the longitudinal axis of the vehicle (Point I).

The height of this point from the ground will be:

– For front radiation:

**S1** 1 m for vehicles with total height ≤ 3,00 m.

**S2** 2 m for vehicles with total height > 3,00 m.

– For rear radiation: 1 m

3.5.1.2 **Point S2:**
will be positioned at a distance of 1 ± 0,2 outside the point of junction, between the windscreen of the vehicle under examination and the body on the longitudinal axis of the vehicle (Point I).

The height from the ground will be 2 m for both front and rear radiation.

3.5.1.3 **Point S3:**
will be positioned longitudinally at the chassis centre and equidistant between the two most distant wheel axles with tolerance of ± 0,2 m.

The height from the ground will be 1 m. This height is used for both right and left side radiation.

**Figures 1** and **2** illustrate examples of the calibration points on the following types of vehicle:

a) Vehicles with total height ≤ 3 m with front engine (Type A).

b) Vehicles with total height > 3 m with:

– Front engine and forward cab (Type B).

– Front engine and set–back cab (Type C).

– Rear engine (BUS) (Type D).

– Front engine and devices projecting beyond the front of the cabin (Type E).

The electric field sensor must be positioned at the above–described points in horizontal position, on the longitudinal axis of the transmitting antenna.

- P.P.L. antenna (10 kHz – 20 MHz)

Given the characteristics of this radiating element, we considered a single calibration point that coincides with point **S3** of the anechoic chamber.

**Figure 3** illustrates examples of calibration points for the test > 1 GHz

- Horn antenna (1 GHz – 18 GHz)

3.5.1.4 **Point S4:**
Arrange the Horn transmitting antennas (typically in quantities of 4 antennas) from their connection point towards the rotating table in the direction of the field meter.
Given the characteristics of the radiating system, for all the antennas, calibration will be carried out with the field meter positioned at a distance of 2500 mm from the tip of the antenna. The height of the field meter from the top of the rotating table will be 1000 ± 50 mm.

**FIGURE 1**

**Calibration points for Type A and Type B vehicles**

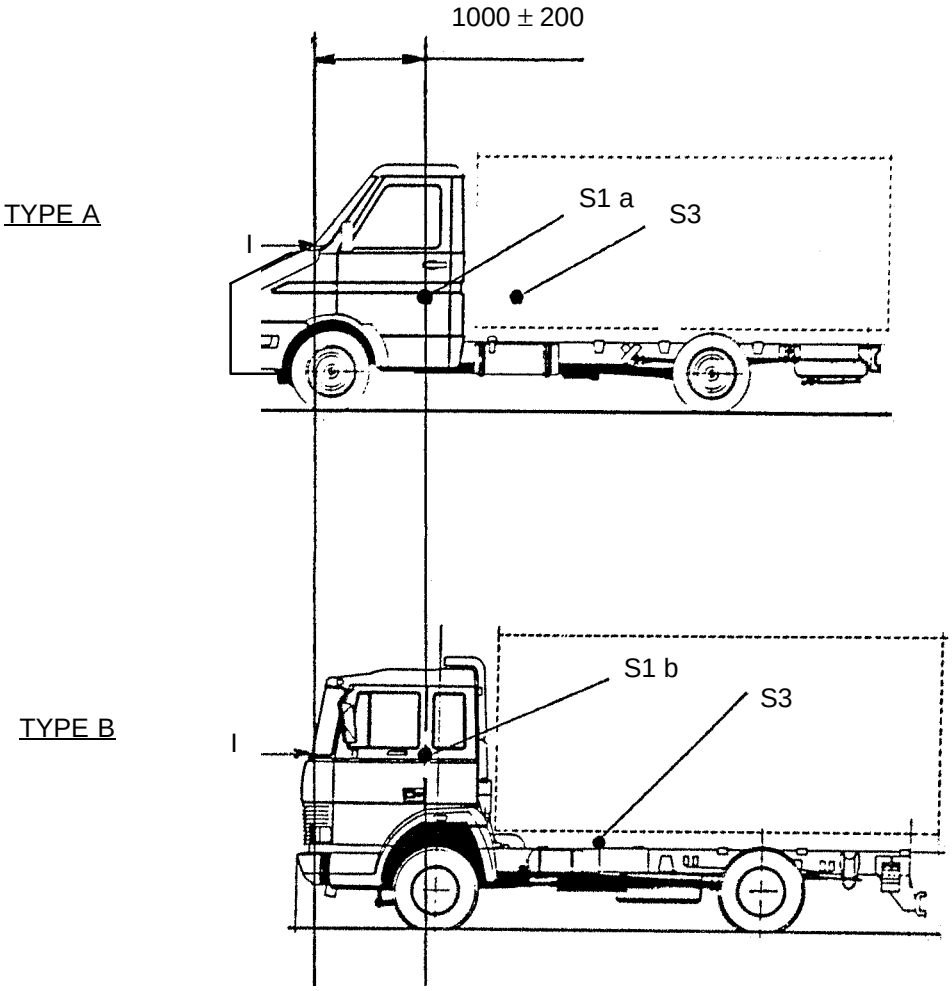
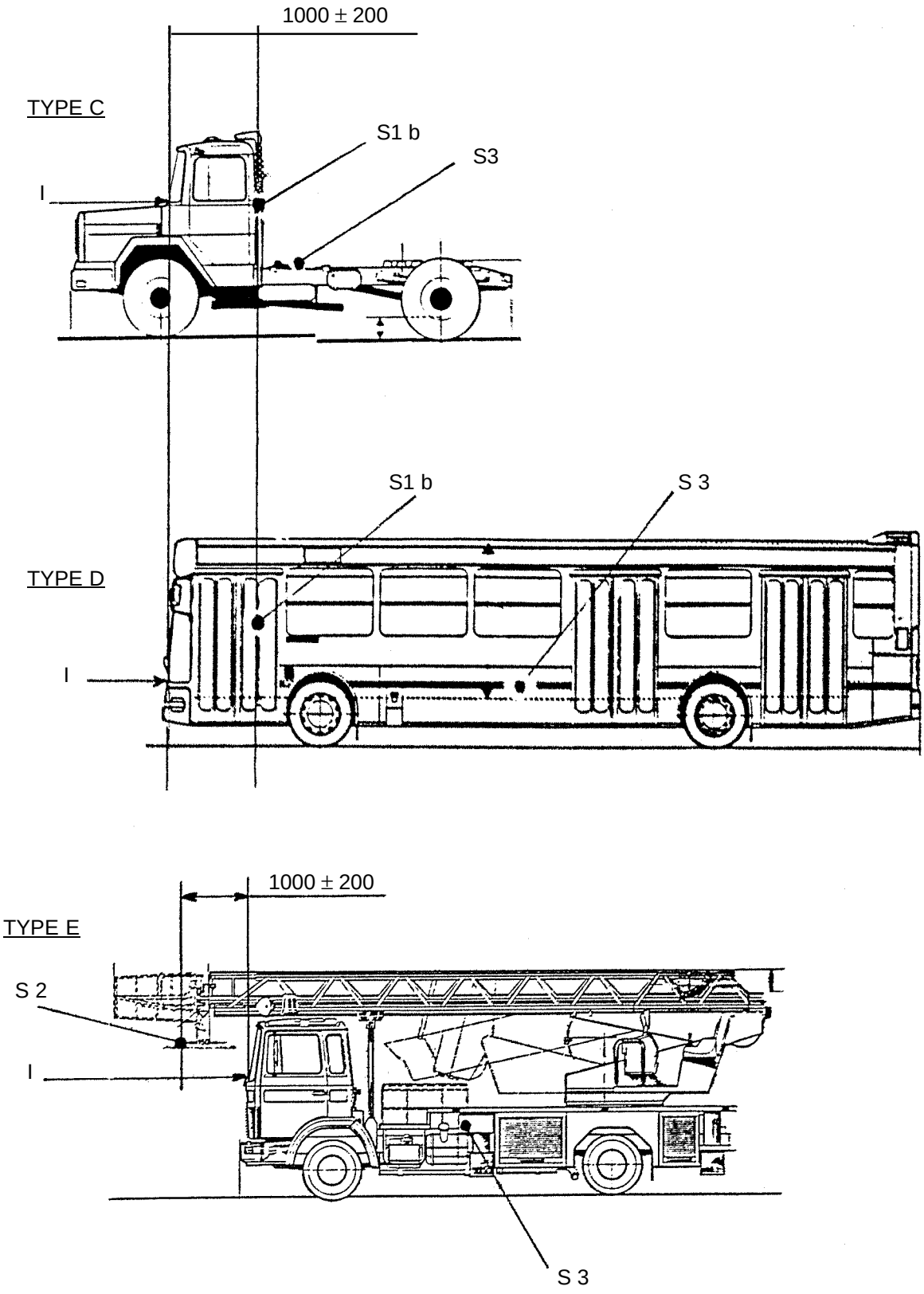


**FIGURE 2**

**Calibration points for Type C, Type D and Type E vehicles**



3.5.2 **Calibration procedure**

This consists of acquiring the power curve radiated by the transmitting antenna (direct power) necessary for generating, at the chosen measurement point, an electric field of known and constant strength in the whole frequency band that is to be used to carry out the test.
During the tests on the vehicle, and provided that it is in the same radiating conditions, this reference curve allows the ”unloaded” electric field value to be found by means of just the radiated power reading.
Normally the term ”control in power” indicates the retroaction procedure applied to the calibration curve.
The calibration must be carried out according to the ”substitution method” in the absence of modulation (CW), according to the methods described by ISO 11451–1 and ISO 11451–2 standards for both the polarizations of the vertical/horizontal transmitting antenna.

3.5.2.1 For ranges 10 KHz to 20 MHz and 2 GHz to 18 GHz, arrange the transmitting antenna and the field sensor as indicated in **Figures 3** and **4**.
The reference point for the calibration, is the reference point of the vehicle indicated in **Figures 1** and **2**.

**FIGURE 3**

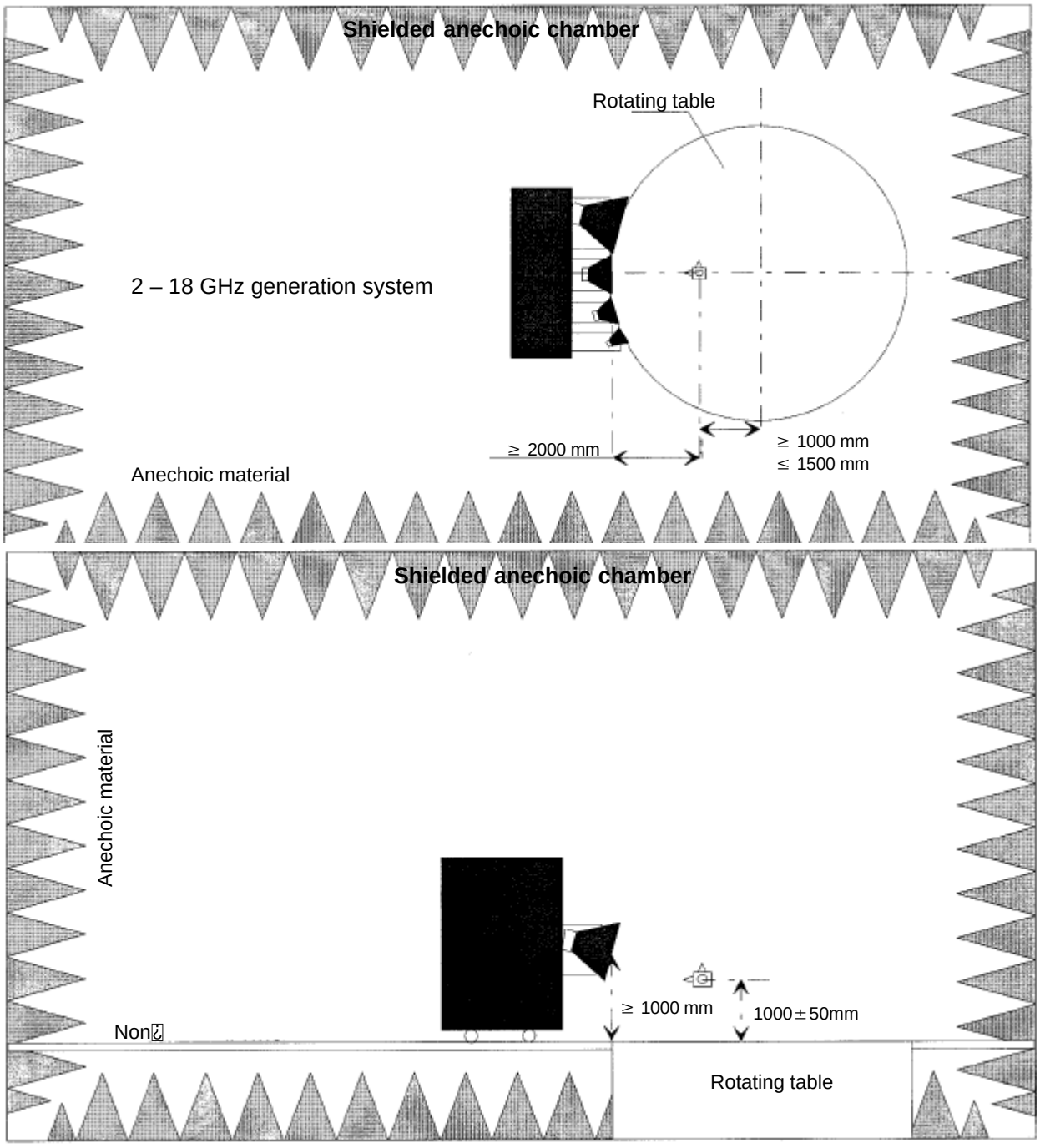
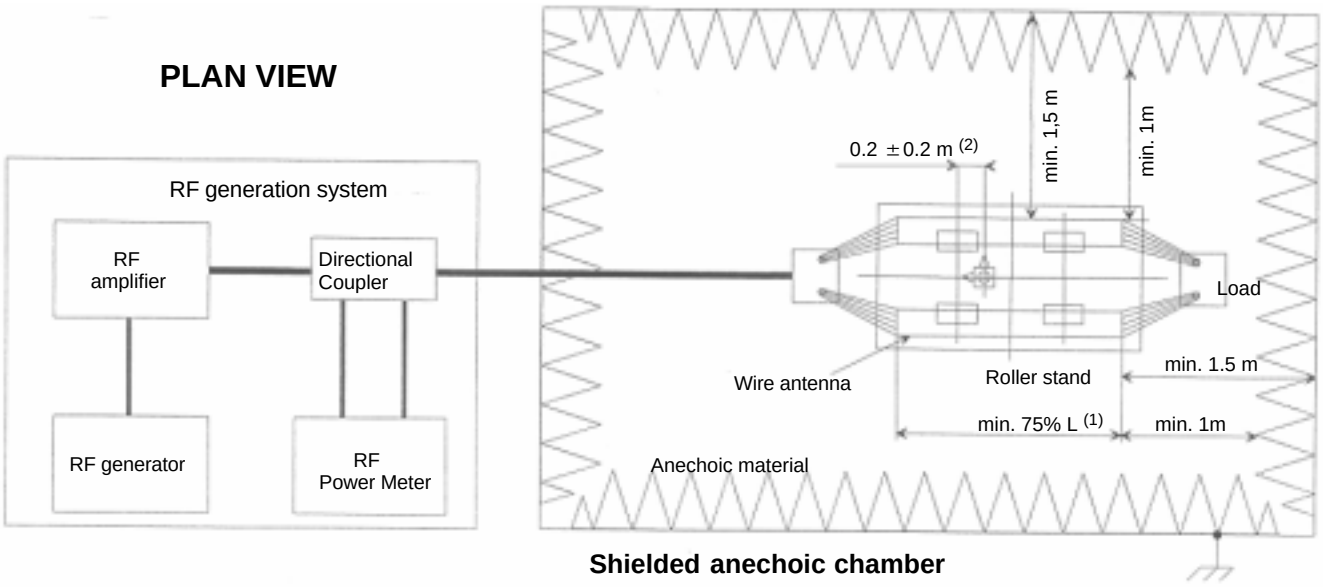
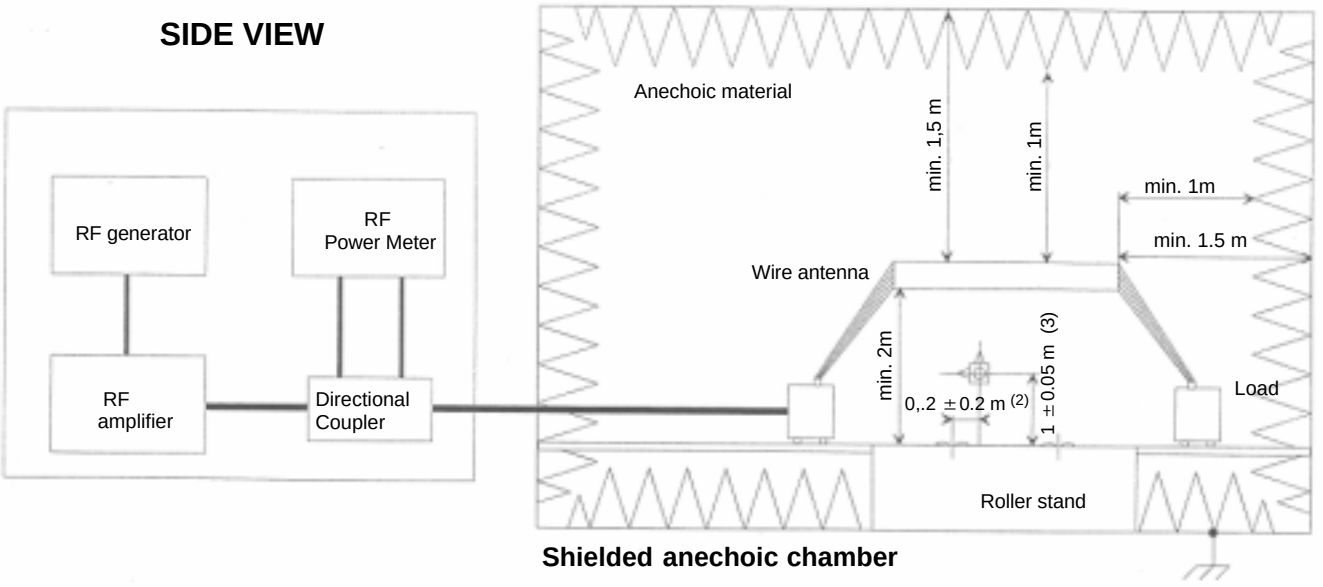


**FIGURE 4**

**Set–up for test site calibration (10 KHz – 20 MHz)**




(1) L tested vehicle length
H tested vehicle height

(2) 1,0 ±0,2 m ehind the intersection point between the windscreen and the engine bonnet if the latter reference point is close to the antenna.

(3) 2,0 ±0,05 m if vehicle height: > 3 metres.

3.5.2.2 For each point in frequency defined by **Table 4** (shown below), apply to the antenna a power such as to read the desired value on the RMS field meter.

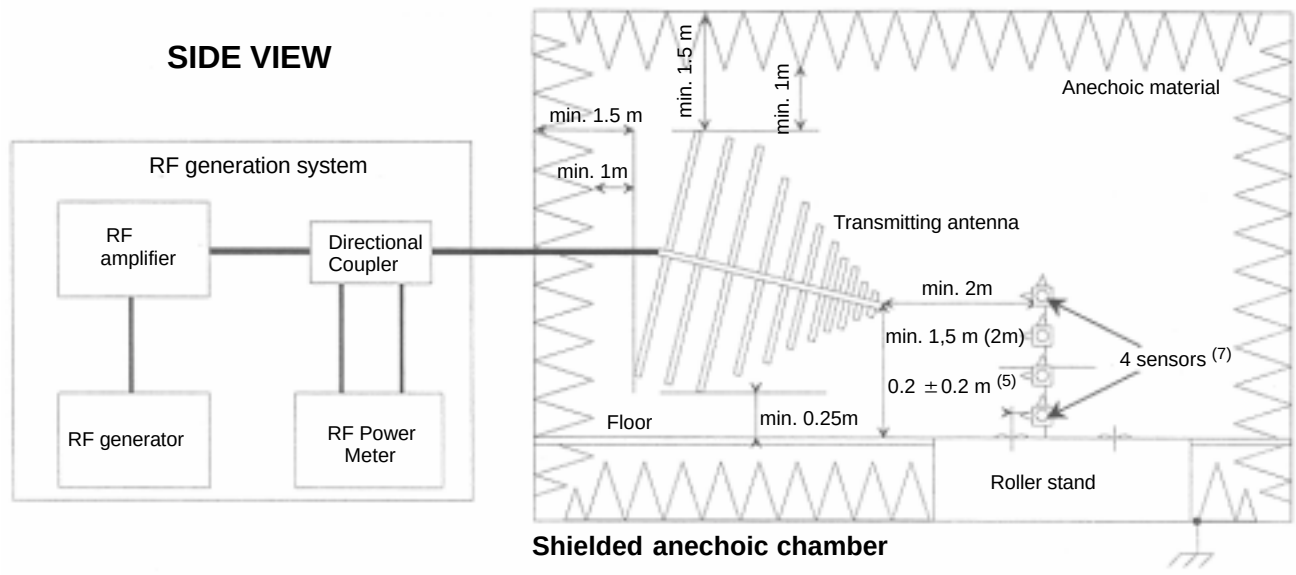
3.5.2.3 Measure and store the value of the direct power and its RF signal to be set on the generator for each frequency point.

**TABLE 4**
**Frequency step for the calibration stage**

| | Range [MHz] | Step [MHz] |
|---|---|---|
| **B1** | 0,01 – 1,5 | 0,02 |
| **B2** | 1,5 – 2,0 | 0,2 |
| **B3** | 20 – 200 | 1 |
| **B4** | 200 – 400 | 2,5 |
| **B5** | 400 – 1000 | 5 |
| **B6** | 1000 – 1700 | 10 |
| **B7** | 1700 – 2000 | 5 |
| **B8** | 2000 – 18000 | 50 |

3.5.2.4 Place 4 sensors in the 20 MHz – 2 GHz range as shown in **Figure 5**

**FIGURE 5**
**Set–up for test site calibration (20 MHz – 2 GHz)**




(4) L tested vehicle length
H tested vehicle height

(5) 1.0 ±0.2 m behind the intersection point between the windscreen and the engine bonnet if the latter reference point is close to the antenna.

(6) 2.0 ±0.05 m if vehicle height: > 3 metres.

(7) Sensor height from ground:
– 0.5, 0.8, 1 and 1,2 if vehicle height: < 3 metres
– 1.2, 1.5, 1.8 and 2.1 if vehicle height: > 3 metres.

3.5.2.5 For each frequency point defined in **Table 4**, apply to the antenna a power such that the average of the values measured by the 4 RMS sensors corresponds to the desired field level value.

3.5.2.6 Measure and store the value of the direct power and its RF signal to be set on the generator for each point in frequency.

## 3.6 Test method

Put the vehicle in the test site and position it in consistency with the criteria that were adopted during calibration.

### 3.6.1 Positioning of the transmitting antenna (Figure 6, 7, 8)

The position of the antenna during the vehicle radiation test must be the same as when the calibration was done in the absence of the vehicle.
The minimum distance between antenna and metal part of the vehicle structure (d1, d2) and between antenna and the nearest anechoic element of the chamber (d3) must be at least 1 m.
The phase centre height of the antenna with respect to the surface on which the vehicle is standing must be:

– ≥ 1,5 m for points S1a and S3

– ≥ 2 m for points S1b and S2

The antenna must be inclined so that its axis passes through calibration points **S1**, **S2** and **S3**. The transmitting element of the P.P.L. structure must be placed at least 1 m above the metal surface of the vehicle.
The radiating element must extend for at least for the whole length of the vehicle under test.

### 3.6.2 Radiation of the vehicle

Depending on the place where the test system is installed, the vehicle will be radiated from the front, rear, passenger side or driver side with respect to the antenna, according to the methods prescribed in point 3.6.1, with the frequency bands and steps indicated in point 3.6.3 (**Schedule I**), over the whole test range.
As regards the band from 10 kHz to 20 MHz, the free–field test is allowed (P.P.L.) if it is not possible to carry it out in an anechoic chamber.

#### 3.6.2.1 Activation of the system under test

Prepare the system in the particular operating condition necessary (according to what is prescribed in the drawing or relevant specification sheet) for testing its correct operation.
If necessary, apply the signals necessary for operation of the system under test to the electrical inputs or physical sensors.

### 3.6.3 Method of carrying out the test and measurement

a) Automatic scan in frequency, at electric field levels, according to preset frequency steps and stay times as indicated in **Schedule I**.

b) The test must not be carried out at the resonant frequency of the anechoic chamber.

c) The tests with modulated signal, described in paragraphs 3.7.1 and 3.7.2, must be carried out adopting the ”peak conservation” principle, (as suggested and described in the ISO 11451–1 standard) according to which:
The peak value of the un–modulated signal, acquired during calibration and having RMS value equal to the desired level of immunity, and the peak value of the modulated signal generated during the test must be equal.

Repeat the following procedure for each point in frequency of the susceptibility curve that you wish to measure.

3.6.3.1 Select the correct setting of the control and switching system in keeping with the frequency of the EM field that you wish to generate.

3.6.3.2 Set the desired frequency on the RF signal generator.

3.6.3.3 Adjust the power of the signal coming from the signal generator so that the peak conservation principle is observed, namely:

$$P_{mod} = P_{cw} \frac{2 + m^2}{2\,(1 + m)^2}$$

with
$P_{mod}$ power of the modulated signal (AM),
$P_{cw}$ power of the un–modulated signal,
m depth of modulation.

To obtain a field value ”E” different from ”Er”, used as reference during calibration, the value $P_{cw}$ is given by the following equation:

$$P_{cw} = P_{cal} \left( \frac{E}{E_r} \right)^2$$

with
$P_{cal}$ equal to the calibration direct power.

3.6.3.4 Apply the modulation characteristics required for the field to the RF signal (CW, AM, GSM, etc.). If it is not possible to reach the required EM field strength, the highest possible field must in any case be obtained by using the maximum output power of the amplifier.

3.6.3.5 Check the correct operation of the device under test, in the particular operating condition tested by comparing the characteristic parameters of the signals supplied by the sensors with the reference parameters.

3.6.3.6 In the event of incorrect operation of the device, repeat the operations from point 3.6.3.3 to point 3.6.3.5) starting from a field level that will not cause malfunctioning and searching for the minimum field level for which the system stops working normally.

3.6.3.7 Write the field level reached at the current test frequency in the relevant table and try to highlight the malfunctioning points of the device under test compared to the correct operation points.

3.6.3.8 Repeat the operations from point 3.6.3.2 to point 3.6.3.7 until the frequency range under examination has been completed.

3.6.3.9 Draw the relevant susceptibility curve graph with the field levels measured in the frequency range under examination.

**SCHEDULE I**

| | |
|---|---|
| Frequency bands on each test frequency | BAND 1 : 0,5 – 20 MHz (8)<br>BAND 2 : 20 – 200 MHz<br>BAND 3 : 200 – 500 MHz<br>BAND 4 : 500 – 1000 MHz<br>BAND 5 : 1 – 2 GHz<br>BAND 6 : 2 – 5 GHz (8)<br>BAND 7 : 5 – 18 GHz (8) |
| Frequency interval on each test frequency | BAND 1 : logarithmic scan, 50 POINTS/DEC<br>BAND 2 : linear scan with pitch 1 MHz, or logarithmic scan with 100 points per decade.<br>BAND 3 : linear scan with pitch 2.5 MHz, or logarithmic scan with 100 points per decade.<br>BAND 4 : linear scan with pitch 5 MHz, or logarithmic scan with 100 points per decade.<br>BAND 5 : linear scan with pitch 10 MHz<br>BAND 6 : linear scan with pitch 50 MHz<br>BAND 7 : linear scan with pitch 100 MHz |
| Stay time on each test frequency | 2 sec or the time necessary for checking the correct operation of the device under test. |
| Strength of test electric field | 100 V/m<br>See point 3.9.2 |
| Polarization of the electric field | vertical<br>horizontal (if required) |
| Type of amplitude | modulation AM ( 500 KHz – 800 MHz )<br>modulation frequency of: 400 Hz – 1000 Hz<br>pulse modulation index 0 – 80 %<br>PM (rectangular wave) only in the 800 MHz – 18 GHz range<br>modulation frequency of: 200 Hz<br>modulation index: 100 %<br>Duty Cycle : 1/8 |
| Radiation of the vehicle | BAND 1 : perpendicular to the roof of the vehicle<br>BAND 2 : front, left side, right side, rear<br>BAND 3 : front, left side, right side, rear<br>BAND 4 : front, left side, right side, rear<br>BAND 5 : front, left side, right side, rear<br>BAND 6 : front, left side, right side, rear<br>BAND 7 : front, left side, right side, rear |
| Position of antennas | positioning towards the axis of the vehicle with direction of propagation according to the longitudinal axis of the vehicle.antenna–vehicle distance as described in point 3.6.1 |
| Calibration of the test area | in the absence of the vehicle with field sensor positioned at height H and distance D from the antenna and along the longitudinal axis of the chamber, as described in point 3.5.1. |
| Test method | automatic scan in frequency with closed loop control of radiated power on the basis of the calibration curve.<br>Manual search for susceptibility limit. |

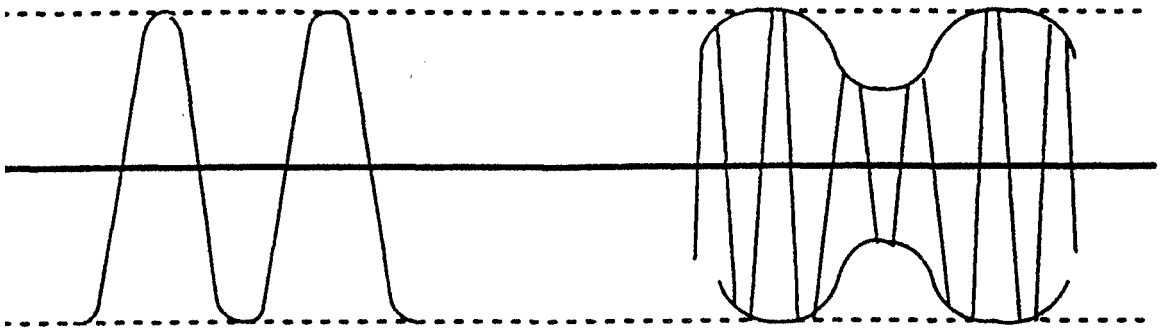
(8) Only if explicitly requested and for functional reasons from Product Specifications.

## 3.7 Characteristics of the test signal to be generated

### 3.7.1 Amplitude modulation (A.M.)

When a test is required, use the module signal in amplitude instead of in CW conditions; the peak–peak value of the electric field must in any case be:

(CW peak) = E (AM peak)



CW AM

The relationships between the generated powers will be:

$$\frac{P\,(AM)}{P\,(CW)} = \frac{((1 + m^2)E^2)}{2} = \frac{E^2}{2} = \frac{(1 + m^2)}{2} \cdot \frac{E^2}{E^2} = \frac{(1 + m2) : 2}{(1 + m)^2}$$

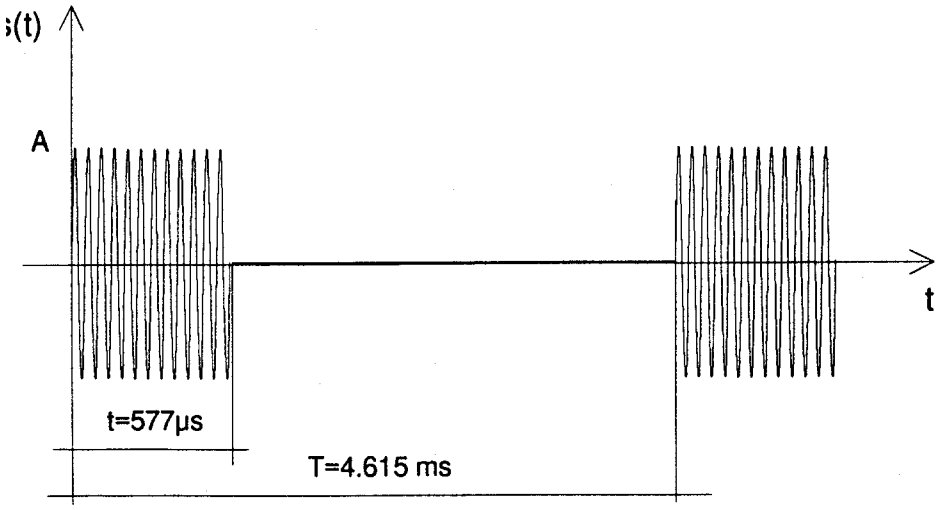
$$P\,(AM) = \frac{(2 + m^2)E^2)}{(2(1 + m)^2}\, P\,(CW)$$

for m = 0,8 (AM 1 KHz 80 %) we will have:

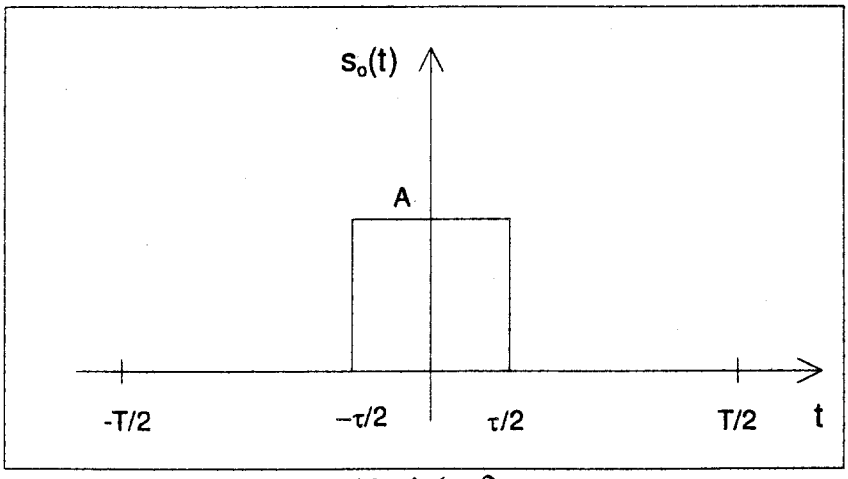
P (AM) = 0,407 P (CW).

### 3.7.2 Pulse modulation (P.M.)

In the test range where pulse modulation will have to be used.
The radiated RF signal, indicated with s(t), is a CW type packet signal (carrier in the 890–915 MHz band) of amplitude A, duratio $\tau$ = 577 $\mu$s and repetition frequency fr =217 Hz as indicated in the diagram below.



The envelope so(t) of s(t) is a rectangular wave with fundamental period T = 4.615 ms and duty cycle 1:8 as indicated in the following diagram.




$$S(f) = \frac{A\tau}{T} \sum_{n=-\infty}^{+\infty} \frac{\sin(\pi\tau f)}{\pi\tau f} \delta(f - nf_r)$$

As can be seen from the equation, the spectrum of the transmitted signal (in base band) consists of lines placed at frequency values as multiples of fr, whose amplitudes have a sin (x)/x type trend.

## 3.8 CLASSES

The operating states of the electronic devices during the EMC tests conducted can be referred to the following classes:

CLASS A: All the functions of the device meet the requirements both during and after the test.

CLASS B: All the functions of the device meet the requirements both during and after the test, but one or more of them can be out of tolerance within the limits prescribed by the specific Specification Sheet or the Product Specifications.
In any case, these functions return to specifications when the interference ceases.

CLASS C: A function of the device can be in failure but automatically returns to specifications when the interference ceases through an autoreset function that puts the device back in conditions that are consistent with the parameters present.

CLASS D: A function of the device can be in failure and does not return to specifications when the interference ceases until a reset is operated from outside.

CLASS E: One or more functions of the device can be in failure both during and after the test. These functions do not return to specifications when the interference ceases unless the device is repaired or replaced.

***NOTE*** **:** *The occurrence of faults on the devices under test, subjected to the maximum test level,* ***cannot be accepted*** *(Functional Class E).*

## 3.9 Classification of defects of the component/system and related test levels

### 3.9.1 Defect classification

**P**: Priority defect that affects the control of the vehicle and can be perceived by the driver or other road user, or produces alterations in its operation that could cause confusion to other road users.

**NP**: Non–priority defect that does not affect the control of the vehicle, or secondary function defect for the system under examination.

These classifications will be defined on the relevant product specifications.

3.9.2 **Test levels**

The test must be carried out at 100 V/m with amplitude modulation from 80 to 800 MHz and with pulse modulation from 800 MHz to 2 GHz.
The tests are optional above 2 GHz.

3.10 **Acceptability limits**

The functional class reached by the product (A – B – C – D – E) under examination during **electric field radiation** must be in conformity with, or better than, what is prescribed for all the test levels or by the relevant product specifications.
In the event of malfunctioning of the device, a manual search must be carried out for the minimum **electric field** levels at which the device starts to operate correctly again (search for susceptibility limits).

– From 0 to 35 V/m — no type of defect is accepted.

– From 36 a 50 V/m — it is accepted that some non–priority function of the device can be out of tolerance, but this must automatically return to specifications when the interference ceases.

– From 51 a 100 V/m — it is accepted that some non–priority function of the device can be out of tolerance and this function can return to specifications also through a manual reset when the interference ceases.

– From 75 a 100 V/m — it is accepted that some priority function of the device can be out of tolerance, but this must automatically return to specifications when the interference ceases.

– For priority defects, manual action carried out to restore possible anomalies occurring during the test is not accepted.

3.11 **PRESENTATION OF RESULTS**

**Electric field/frequency** diagrams of susceptibility curves and the associated functional class reached (A – B – C – D – E) must be shown for each test system, for each test condition and for each test level, and the types of anomaly found must also be indicated. The functions of the product under examination must be in conformity with what is prescribed in **Table 5** and **Table 6** shown below.

**TABLE 5**
**– For non–priority aspects –**

| LEVEL | CLASS REACHED | RESULT/NOTES |
|---|---|---|
| 0 – 35 V/m | A | No defect, either during or after the interference |
| 36 – 50 V/m | B | Non–priority defect, automatically re–settable when the interference ceases. |
| 51 – 100 V/m | D | Non–priority defect, manual resets are also accepted. |

**TABLE 6**
**– For priority aspects –**

| LEVEL | CLASS REACHED | RESULT/NOTES |
|---|---|---|
| 0 – 75 V/m | A | No defect, either during or after the interference |
| 76 – 100 V/m | B | Priority defect, automatically re–settable when the interference ceases. |

## 4 TYPE APPROVAL TESTING

For just type approval testing in the presence of the Motor Vehicle Test Centre Inspector, the systems installed on the vehicle must be tested with the method prescribed by the directive 2004/104 EEC in force since 01/07/2006, for new vehicles to be type approved, and summarized in **Schedule II**, which replaces 95/54/EC summarized in **Schedule III**.

**SCHEDULE II**

Type approval testing in accordance with Directive 2004/104/EC

– Immunity tests –

| | | |
|---|---|---|
| Test range | | 20 MHz – 2 GHz |
| Modulation | | Da 20 MHz a 800 MHz<br>A.M. 1 KHz 80% |
| | | Da 800 MHz a 2 GHz<br>P.M. $t_{on}$ =577 µs $t_{off}$ =4600 µs |
| Electric field strength | | 30 V/m |
| Polarization of the electric field | | Vertical |
| Stay time on each frequency | | 2 seconds or the time necessary for checking correct operation |
| Calibration | | With 4 field sensors |
| Operating conditions of the vehicle | Operating conditions of the systems | Susceptibility criterion |
| 1) Speed of 50 km/h, rollers idle turned by the vehicle, or where suitable the transmission shafts can be disengaged, or the vehicle can be raised | Engine at constant speed | Speed variations greater than ±10% of the nominal speed |
| | Constant speed gear | Transmission ratio change that induces speed variations greater than 10% of the nominal speed |
| | Low beam lights on | Lights off |
| | Window wipers on at maximum speed | Window wipers completely still |
| | Driver side direction indicator on | Frequency change<br>(lower than 0.75 Hz or higher than 2.25 Hz) |
| | | Operating cycle variation<br>(lower than 25 % or higher than 75 %) |
| | Adjustable suspension in normal position | Significant variation |
| | Driver's seat and steering wheel in middle position | Unexpected variation greater than 10% of the total amplitude |
| | Alarm deactivated | Unexpected activation of the alarm |
| | Horn off | Unexpected activation of the horn |
| | Automatic closing of the doors | Unexpected opening |
| | Airbag and safety retaining systems operating; passenger airbag deactivated (where possible) | Unexpected activation |
| | Adjustable lever of the continuous brake in normal position | Unexpected activation |
| 2) Engine idling, gear in neutral, wheels stationary, brake pedal pressed at each frequency step | Braking system in normal braking conditions | Brake lights off during the cycle |
| | | Brake fluid warning light on with loss of function |
| | | Unexpected activation of warning lights and functions connected with the braking system |

## SCHEDULE III

**TYPE APPROVAL TESTING**
(Directive 72 / 245 / EEC amended by 95 / 54 / EEC)

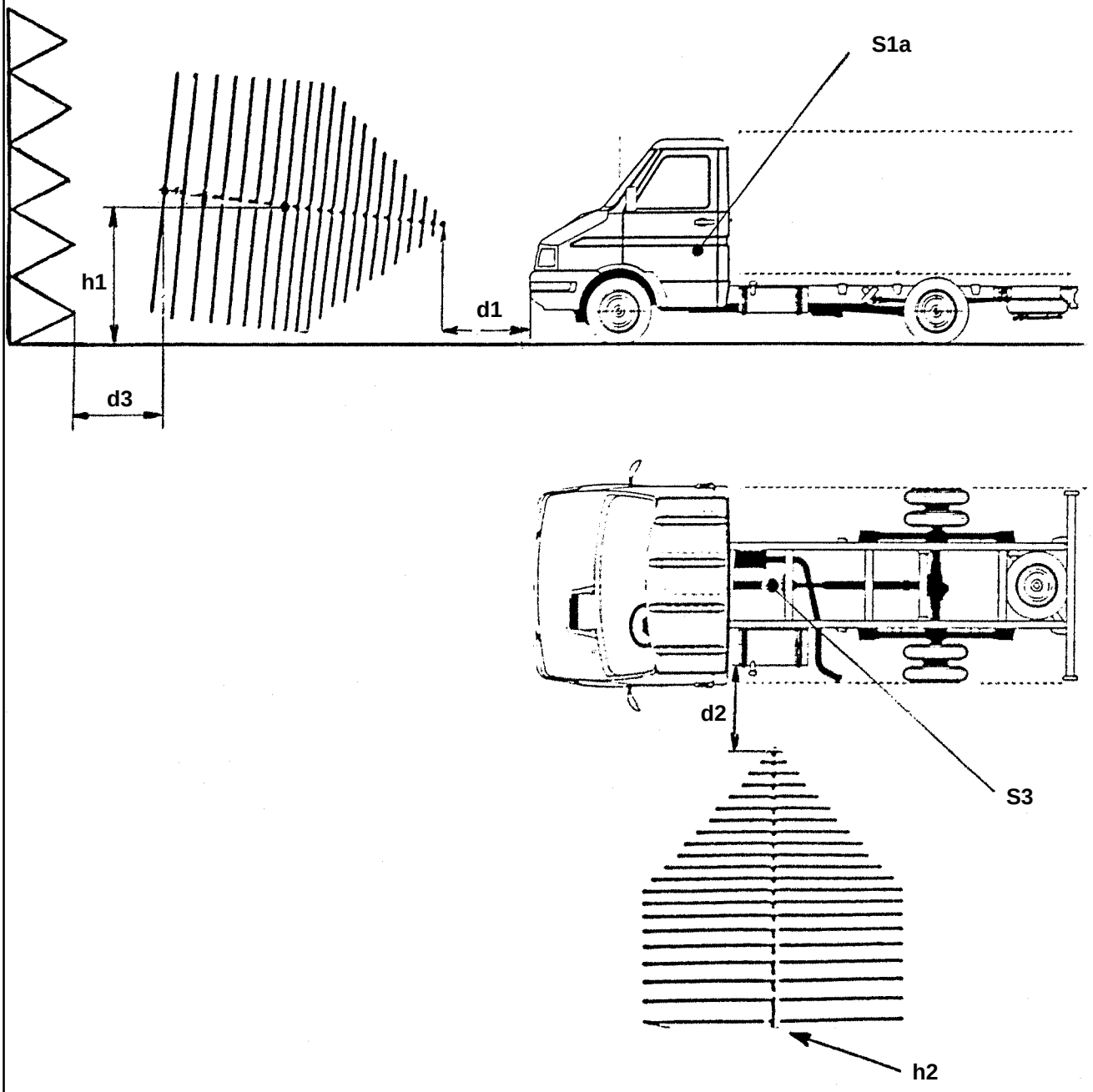
| | |
|---|---|
| Stay time on each test frequency | 2 sec, or the time necessary for checking the correct operation of the device under test |
| Strength of test electric field | Preliminary check 50 V / m<br>TYPE APPROVAL SESSION 30 V / m |
| Modulation | With AM 1 KHz 80% modulation |
| Polarization of the electric field | vertical |
| Position of the vehicle | – Normally the vehicle should be in front of the antenna |
| | – If most of the control unit are located near the back of the vehicle, the test must be carried out with the back of the vehicle facing the antenna |
| | – For long vehicles (excluding Vans and Tractors) if their control units with associated wiring are mainly at the centre of the vehicle, a point of reference can be determined on the right or left side surface of the vehicle.<br>This point of reference must be at the centre of a longitudinal line at the side of the vehicle or on a point of this line established by the manufacturer in accordance with the competent authorities. |
| Operating conditions of the vehicle | Speed of 50 km/h, rollers idle turned by the vehicle or, where suitable, the transmission shafts can be disengaged |
| Operating conditions of the system under test | – Low–beam headlights on |
| | – Right or left direction indicators operating |
| | – In the presence of electric windows, position a window halfway |
| | – Electric window operating in continuous slow position |
| | – In the presence of electronic air conditioner, activate the windscreen defrosting function |
| Parametri monitorati | – On board instruments through CCTV installed on the vehicle<br>– Devices outside the vehicle displayed through CCTV |

NOTES:

Malfunctioning criteria:

- Variations in vehicle speed greater than ±10%
- Spurious lighting of the failure warning lights of the engine control systems, automatic gearbox/clutch, suspensions, ABS, airbag, immobilizer, alarm
- Stopping or variation in speed of the window wiper
- Frequency change or other anomalies of the direction indicator
- Switching off of external lighting devices
- Non–requested movements (where electrical/electronic movement control systems are installed) of the driver's seat and external rear view mirrors
- Activation of alarm/anti–theft systems

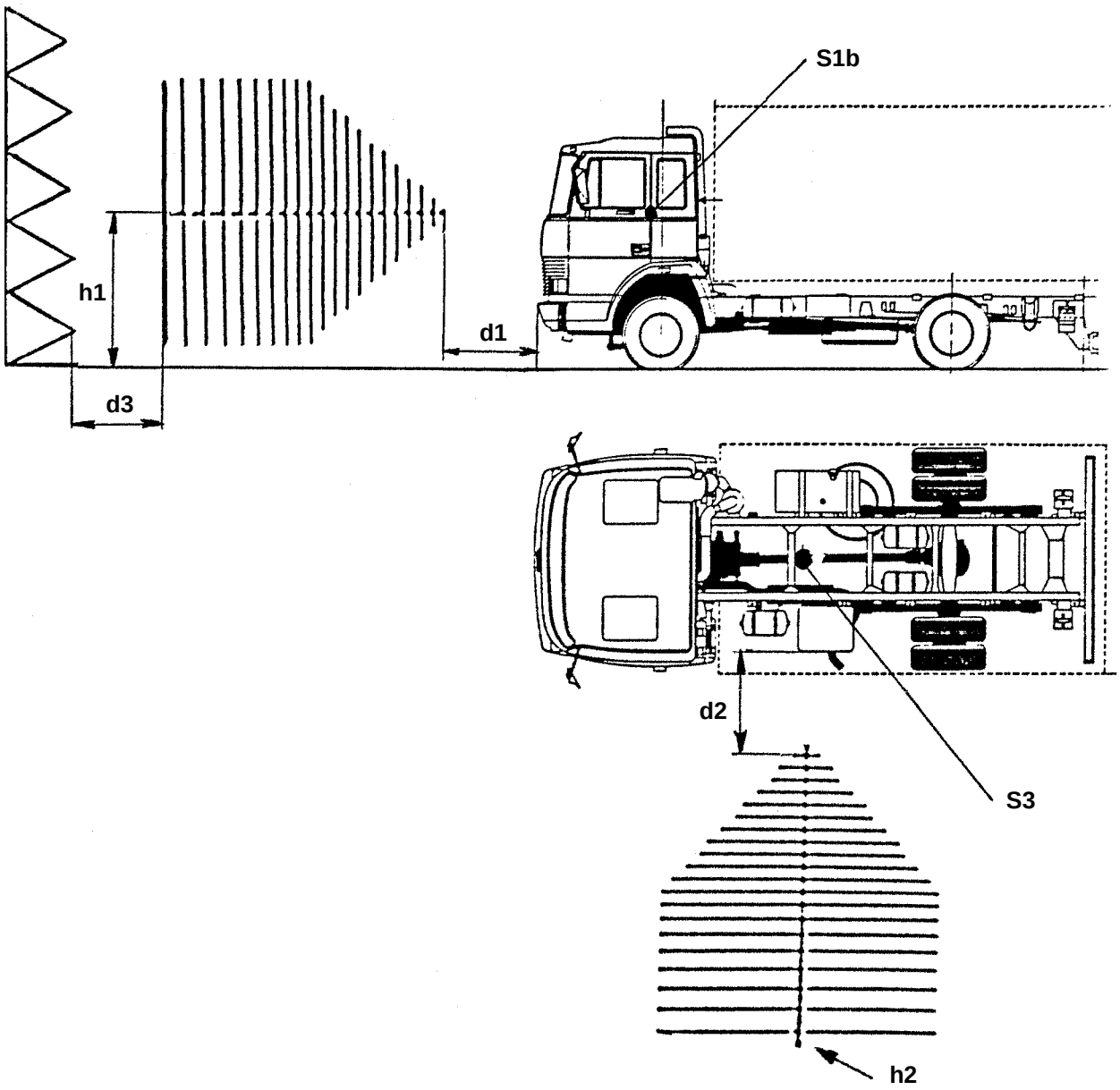
**FIGURE 6**
**Positioning of transmitting antenna**




For Type A vehicles

d 1 – d 2 – d 3 ≥ 1 m
h 1 – h 2 ≥ 1,5 m

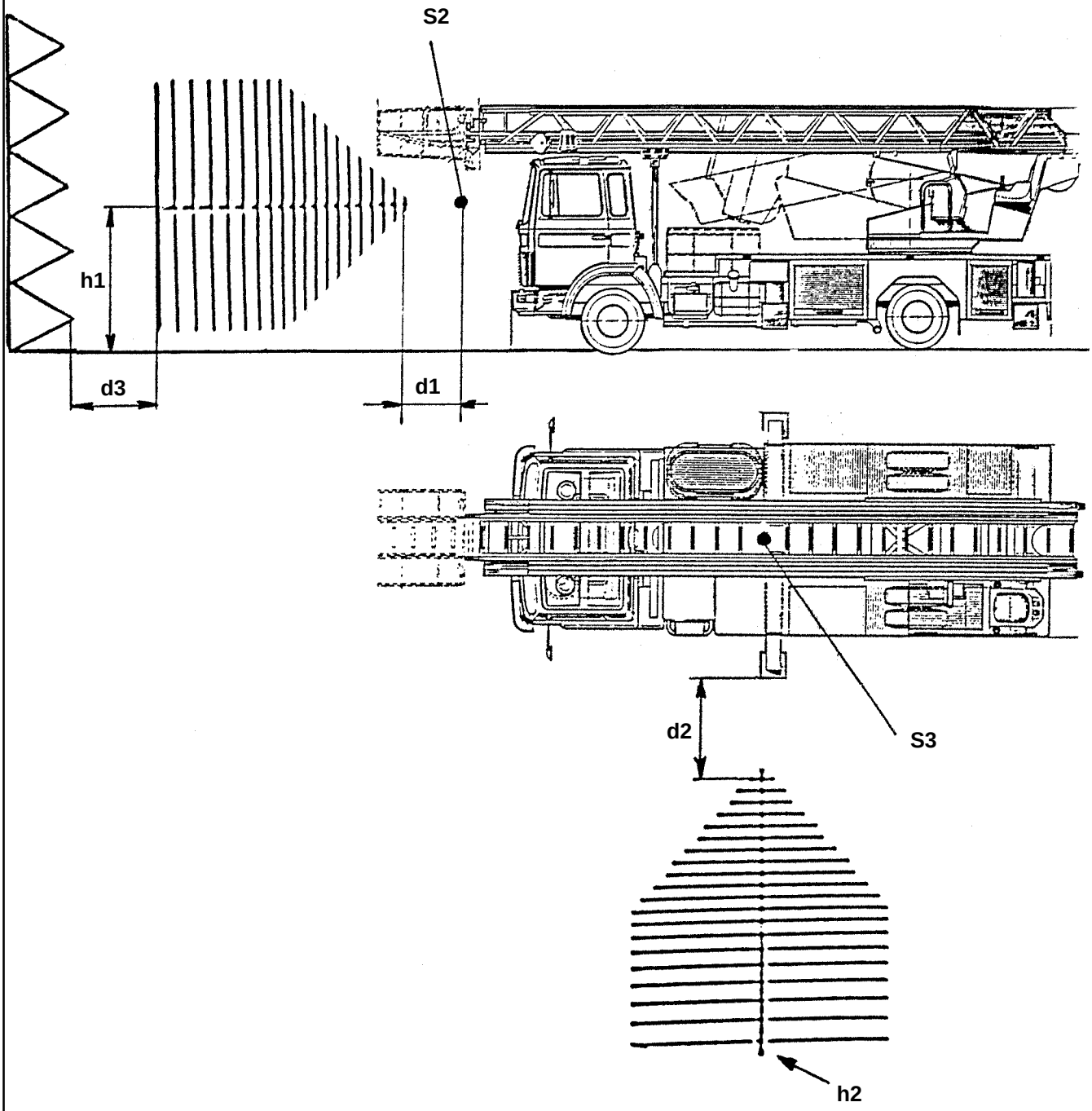
**FIGURE 7**
**Positioning of transmitting antenna**




For Type B – C – D vehicles

| | | |
|---|---|---|
| d 1 – d 2 – d 3 | ≥ 1 | m |
| h 1 | ≥ 2 | m |
| h 2 | ≥ 1,5 | m |

**FIGURE 8**
**Positioning of transmitting antenna**




For Type E vehicles

| | | |
|---|---|---|
| d 1 – d 2 – d 3 | ≥ 1 | m |
| h 1 | ≥ 2 | m |
| h 2 | ≥ 1,5 | m |

**STANDARDS QUOTED:**

**IVECO STD.:** 10–4156, 10–4157, 18–2252.

**ISO:** 11451–1 and 11451–2.

**Direttiva CEE** 2004/104, 95/54, 72/245.