NSR Noise Suppressors - Wirewound Resistors

By Antonio Paolillo and James Ryba

APPLICATIONS

Noise suppressors are wirewound resistors which are specially designed to be implemented in automotive ignition systems to reduce Radio Frequency Interference (RFI) caused by electrical discharges. The resistors can be placed in the rotor of the distributor, the spark plug leads, as well as in the spark plug caps itself.

GENERATED NOISE IN IGNITION SYSTEMS

High-frequency electromagnetic interference (EMI), commonly referred to as Radio Frequency Interference (RFI), generated by a gasoline engine ignition system, comes primarily from the high-voltage side of the circuit. Ignition systems produce sparks at the coil where the battery voltage is converted into high voltage pulses, at the distributor where the high voltage is channeled to the proper plug, and at the spark plug itself where the spark ignites the controlled burning of the gasoline/air fuel mixture in the combustion chamber (diesel engines compress fuel to ignite it in a process that produces negligible “noise”). These pulses have a very rapid current change (dI/dt) which generates an electromagnetic field around the ignition system. Electricity bounding through air causes ionization of some of the atoms in the molecules it passes through. When these atoms “de-ionize” they release a tremendous number of radio waves. The frequencies are random and come and go in fractions of a second, but almost every electronic device that is installed can be affected by them to some degree. These disturbances can disrupt engine and ABS control electronics and can interfere with radio and telephone communications. In communication systems, this interference sounds like a convention of crisps and crackles or as a rattle in radio receivers.

LEGISLATION

According to international legislation, these disturbances must be reduced to an acceptable level. “Limitation of radio interference” means a reduction of radio interference in the sound-broadcasting and television frequency bands to a level such that there is no appreciable interference with the functioning of receivers not carried on the vehicle itself; this condition is fulfilled if the level of interference remains below the limits laid down.

The RFI damping characteristic is described in the Interference Suppression Regulations (like VDE 0874 to 0879, C.I.S.P.R. or Council Directive 72/245/EEC for Europe) and can be different from country to country. See pages 5 to 9.

REFERENCE LIMITS (TYPICAL FOR EUROPE)

The radiation limits (noise suppression) based on quasi-peak measurements shall be 50 mV/m (dB) in the 40 MHz to 75 MHz frequency band and 50 mV/m (dB) to 120 mV/m (dB) in the 75 MHz to 250 MHz frequency band, this limit increasing linearly with frequencies above 75 MHz.

PREVENTION

By tracking down the sources of this “noise” and either limiting it at its source or filtering it out before it reaches the instruments, you can minimize disruptive interference and assure that the instruments and electronics are working properly. The best prevention is to install resistive spark plugs, resistive spark plug leads or suppression ignition resistors. It contains internal impedance that dampens unneeded emissions from the ignition system. Other ways are redesigning the grounding circuit or installing bypass/feed-through capacitors.

Installing wear-dependent or loose components will not guarantee continuous prevention, since the customer may not replace the right kind of components in case of repair.

SPARK PLUG LEADS

Conventional spark plug leads carry a resistance of 6 kΩ to 15 kΩ per meter, which makes them poor transmitters of electrical noise. However some electronic ignition systems are sensitive to varying resistance in the spark-plug leads caused by different lengths which can give mixed signals to the control module. Therefore solid-core wire with a noise suppressor resistor screwed onto brass fittings at the end of the wire maintains an equal resistance on each cylinder.

NOISE SUPPRESSORS

One of the best solutions for reducing RFI is the use of noise suppressors. The resistor can be designed for the particular ignition system with the finest damping characteristics without disturbing the ignition pulses.

The resistors can be placed in the rotor of the distributor, the spark plug leads as well in the spark plug caps itself.

APPLICATION NOTE

For technical questions, contact: ww2aresistors@vishay.com

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FUNCTION

A noise suppressor is a wirewound resistor where the resistive wire is wound on a core and can be compared with a coil. Therefore the resistor has, besides an ohmic (R) value, also a self-inductance (L) which influences the frequency response by changing the impedance |Z|. The self-inductance depends on the number of windings and the relative magnetic permeability, the length and the diameter of the core. The formula for the impedance can be given by:

$|Z| = \sqrt{(R^2 + XL^2)}$

The formula for XL can be given: $X_L = 2\pi fL$

The impedance is responsible for the damping of the disturbing. The ohmic value gives overall impedance at the whole frequency range. A higher self-inductance increases the impedance at a certain frequency. Therefore the self-inductance value gives you a better specification about the working (damping) of the resistor than the ohmic value, although there is a relation between the two (see attached an example of an investigation report).

An engine runs from 1000 rpm to 10 000 rpm which gives an ignition frequency from 16.7 Hz to 167 Hz (base frequency). Due to the higher harmonics of the base frequency, electromagnetic pulses between 0.5 MHz and 200 MHz are being created, which is the same frequency range as many receivers. The ignition voltage pulses are around 40 kV. For a proper working of the ignition system the noise suppressor may not change these base pulses. Therefore the ohmic value and the self-inductance may not be chosen too high. Typical ohmic values are between 1 kΩ to 15 kΩ and the selfinductance between 10 µH to 1 mH.

RESISTOR DESCRIPTION

The resistor element is a resistive wire which is wound in a single layer on a fiber glass core. The end-caps or electrodes are crimped to the ends of the resistive body to assure a good mechanical and electrical contact. The design of the noise suppressors depends on the application and the car ignition system, therefore the resistors are custom made and all types are developed under request.

RESISTOR RANGE

The Rn-value is decided by the ignition characteristics of the engine and varies from model to model. However the ohmic value is not critical and the range can go from 1 kΩ to15 kΩ. The ohmic value reduces the pick voltage during discharge, therefore the resistance value may not be chosen too high.

RESISTIVE WIRE

Basically two different resistive wires are being used: Nickel-Copper (NiCu) and Nickel-Chrome alloy (NiCr). Normally the Nickel-Copper wire is used for low values (≤ 5K), Nickel-Chrome wire is used for high values (≥ 5K). However it is possible to make a value of 5K with NiCu wire but this gives special requirements on the dimensions of the suppressor, because of the different resistance specifications of the wire. The distance between the windings should be big enough to avoid flashes between the windings.

TOLERANCE

Because of the wide value range, a low tolerance of the product is not really necessary. A tolerance of 10 % to 20 % will do in most of the applications. This gives a lower production costs, which results in a better purchasing price.

POWER

The resistor is only exposed to repetitive exponential pulses and not to continuous current, therefore the pulse load behavior of the resistor must be considered. The power dissipation depends on the current waveform and frequency, which comes from the ignition coil. The current in the ignition circuit occurs only during discharge. Although the ignition voltage is quite high (40 kV), it does not make any sense to specify the power rating of the noise suppressor because most of the dissipation factor will depend on the mass of the final application assembly and encasing material.

TEMPERATURE COEFFICIENT

Is not critical. An average of ± 250 ppm/°C is more than enough.

COATING

The noise suppressor is protected by a coating against moisture, for isolation and to fix the windings on the core. The coating must be air-bubbles free to avoid interrupting of the wires by corona. The lacquer can be Poliesterimid or Silicone. Both have the same moisture protection specifications, however Poliesterimid can withstand higher temperatures. This is advisable specially when the resistors are being molded into rotors or spark plug caps.

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DIMENSIONS

The size of the resistor depends on the design of the used components (rotors, spark plug caps, etc.) from the car ignition system. Dimensions (designs with caps) from 10 mm length and Ø 3.15 mm are possible. However, small noise supressors can be a disadvantage for the hot spot temperature and handling high voltages (flashes).

TEMPERATURE

An operating temperature range from - 40 °C to + 155 °C will do in most of the applications. However, there are special designs for working under extreme conditions The permissible body temperature is around + 300 °C; this is necessary when the resistor is being molded into rotators, connectors or spark plug caps.

CONNECTIONS

The connections at the end of the resistor core can be with end-caps or electrodes.

- End-Caps: Brass polished or steel-nickel (FeNi) endcaps are common and acceptable and are pressed over the core ends.
- Electrodes: Customized electrodes can be brass polished, steel with coating, die casting, etc. The design of the electrodes depends on the component from the ignition system in which the resistor is being used. Noise suppressors with electrodes are mainly molded into the rotor of the distributor. However, there are electrode designs which can be screwed into the ignition coil, wires or spark plug caps.

TYPICAL QUICK REFERENCE DATA

DESCRIPTION	NOISE SUPPRESSOR
Resistance range/value	1 kΩ to 15 kΩ
Resistance tolerances	± 10 %, ± 15 %, ± 20 %, + 20 %/- 10 %
Number of windings tolerance	± 10 %
Maximum dissipation at Tamb = 70 °C	NA
Temperature coefficient	≤ + 250 ppm/°C
Maximum permissible voltage (DC or RMS)	50 kV
Inductance (100 kHz)	10 µH to 1 mH
Hot spot temperature (maximum body temperature)	250 °C
Operating temperature	- 40 °C to + 155 °C
Climatic category (IEC 60068)	40/155/56
Body dimensions	Application dependent
Basic specifications	IEC 115-1 and 115-2

TYPICAL QUICK REFERENCE DATA

PART	USED MATERIAL
Core	Fiber glass
Resistive wire	Nickel-Copper (NiCu) or Nickel-Chrome alloy (NiCr)
Coating	Poliesterimid or silicone
Caps	Brass polished or steel nickel finish
Electrodes	Brass polished, steel with coating, die casting, etc.

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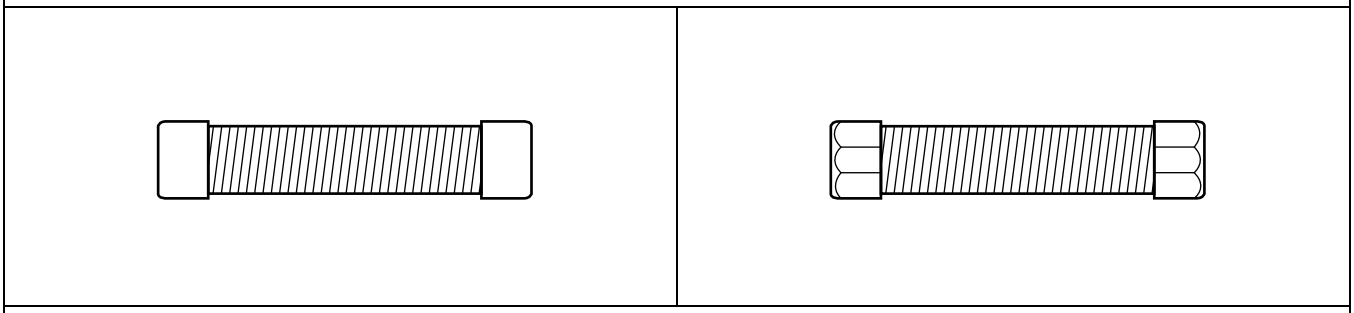
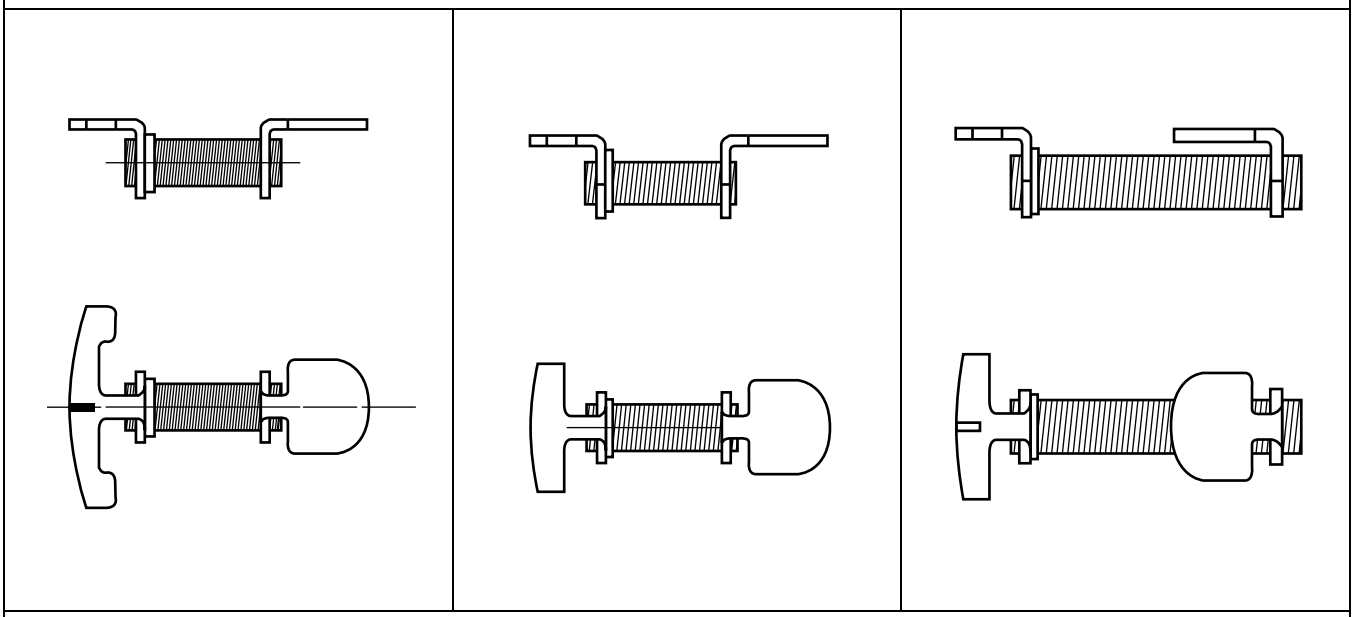
MECHANICAL DATA

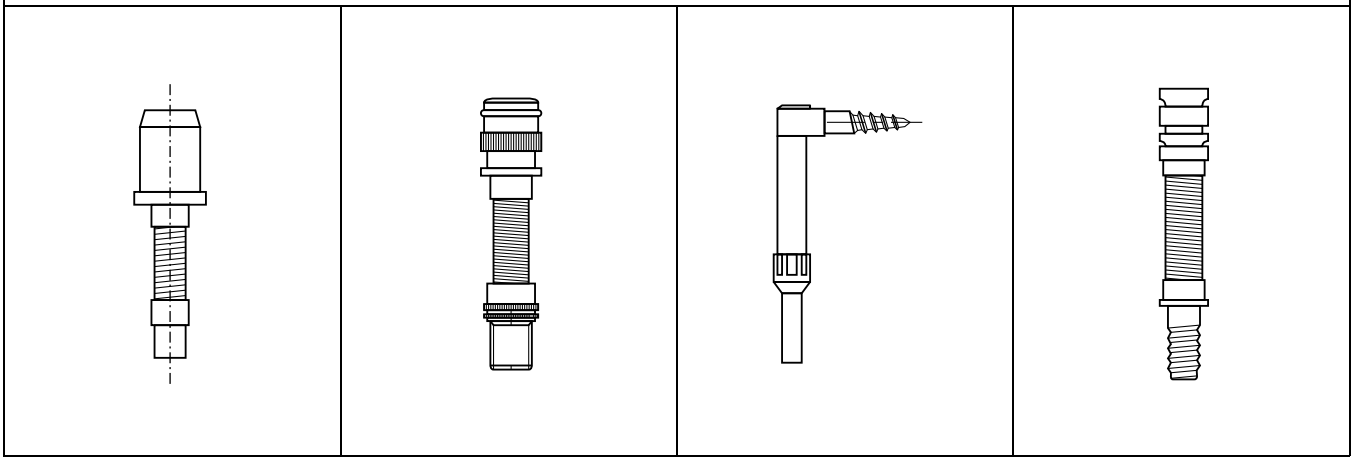
Type I, with caps for mounting into spark plug connector



Type II, with electrodes for molding into rotator



Type III, with electrodes for mounting into spark plug connector



APPLICATION NOTE

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INVESTIGATION REPORT: PHILIPS DEVELOPMENT PASSIVE COMPONENTS RECIFE

- Objective:

  A) Verify the typical frequency response of the NS – product: 5 kΩ (req. 27/99)

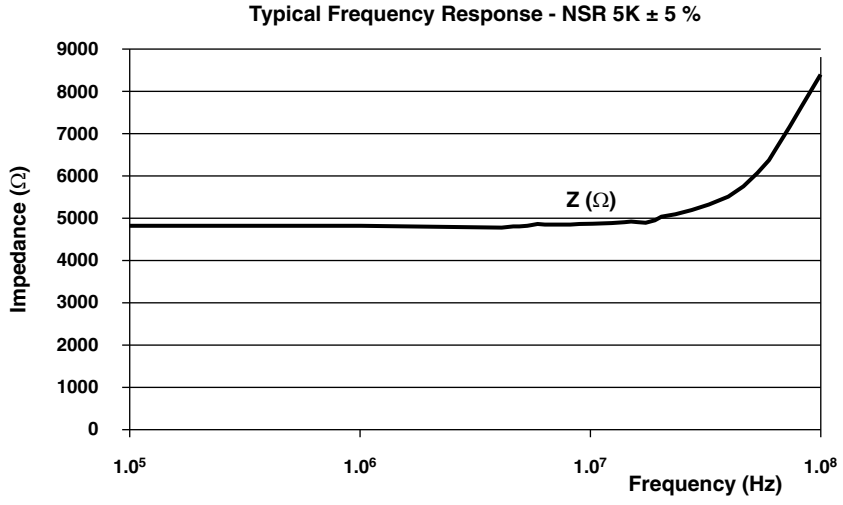
- Procedure:

  A) Verify the typical resistance and inductance values as an average from five samples (measuring at 1 MHz impedance analyzer HP4192A).

  B) Calculate the equivalent R + L series impedance (Z) for a range of frequencies.

SAMPLE	VALUES AT 1 MHz	
	R (Ω)	L (µH)
A	4.865	11.3
B	4.616	9.6
C	4.787	10.8
D	4.821	11.2
E	4.902	11.5
Average	4.789	10.9

F (Hz)	100 kHz	1 MHz	10 MHz	20 MHz	50 MHz	100 MHz
R (Ω)	4.789	4.789	4.789	4.789	4.789	4.789
L (µH)	10.9	10.9	10.9	10.9	10.9	10.9
XL (Ω)	7	68	684	1.367	3.418	6.836
Z (Ω)	4.789	4.799	4.847	4.989	5.891	8.352



APPLICATION NOTE

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COMMUNITY LEGISLATION IN FORCE

(From Internet site eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31972L0245:EN:HTML)

Document 372L0245

Directory chapters where this document can be found: [13.30.10 - Motor Vehicles]

372L0245

Council Directive 72/245/EEC of 20 June 1972 on the approximation of the laws of the Member States relating to the suppression of radio interference produced by spark-ignition engines fitted to motor vehicles

Official Journal L 152 , 06/07/1972 p. 0015 to 0024
Danish special edition: Series-I 72(II) p. 609
English special edition: Series-I 72(II) p. 637
Greek special edition: Chapter 13 Volume 1 p. 250
Spanish special edition: Chapter 13 Volume 2 p. 117
Portuguese special edition: Chapter 13 Volume 2 p. 117
Finnish special edition: Chapter 13 Volume 2 p. 104
Swedish special edition: Chapter 13 Volume 2 p. 104

Amendments:

Amended by 389L0491 (OJ L 238 15.08.89 p.43)
Incorporated by 294A0103(52) (OJ L 001 03.01.94 p.263)
Amended by 395L0054 (OJ L 266 08.11.95 p.1)

Text:

COUNCIL DIRECTIVE of 20 June 1972 on the approximation of the laws of the Member States relating to the suppression of radio interference produced by spark-ignition engines fitted to motor vehicles (72/245/EEC)

THE COUNCIL OF THE EUROPEAN COMMUNITIES,

Having regard to the Treaty establishing the European Economic Community, and in particular Article 100 thereof;

Having regard to the proposal from the Commission;

Having regard to the Opinion of the European Parliament;

Having regard to the Opinion of the Economic and Social Committee;

Whereas the technical requirements which motor vehicles fitted with a spark-ignition engine must satisfy pursuant to national laws relate, inter alia, to the suppression of radio interference produced by such vehicles;

whereas those requirements differ from one Member State to another; whereas it is therefore necessary that all Member States adopt the same requirements either in addition to or in place of their existing requirements, in order, in particular, to allow the EEC type approval procedure which was the subject of the Council Directive of 6 February 1970 1 on the approximation of the laws of the Member States relating to the type approval of motor vehicles and their trailers to be applied in respect of each type of vehicle;

Whereas it is desirable to follow the technical requirements adopted by the UN Economic Commission for Europe in its Regulation No 10 (Uniform provisions concerning the approval of vehicles with regard to radio interference suppression), which is annexed to the Agreement of 20 March 1958 concerning the adoption of uniform conditions of approval and reciprocal recognition of approval for motor vehicle equipment and parts 2;

HAS ADOPTED THIS DIRECTIVE:

Article 1

For the purposes of this Directive, “vehicle” means any motor vehicle fitted with a high-voltage ignition system, intended for use on the road, with or without bodywork, having at least four wheels and a maximum design speed exceeding 25 km/h, with the exception of vehicles which run on rails, agricultural tractors and machinery, and public works vehicles.

Article 2

No Member State may refuse to grant EEC type approval or national type approval of a vehicle on grounds relating to the radio interference produced by the electric ignition systems of its propulsion engine or engines if such vehicle is fitted with an interference suppressor meeting the requirements set out in the Annexes.

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Article 3
The Member State which has granted type approval shall take the necessary measures to be informed of any modification of a part or characteristic referred to in item 2.2 of Annex I. The competent authorities of that State shall determine whether fresh tests should be carried out on the modified prototype and a fresh report drawn up. Where such tests reveal failure to comply with the requirements of this Directive, the modification shall not be approved. 1OJ No L 42, 23.2.1970, p. 1. 2 >PIC FILE = "T0010807">

Article 4
The amendments necessary for adjusting the requirements of the Annexes so as to take account of technical progress shall be adopted in accordance with the procedure laid down in Article 13 of the Council Directive of 6 February 1970 on the type approval of motor vehicles and their trailers.

Article 5
1. Member States shall put into force the provisions needed in order to comply with this Directive within eighteen months of its notification and shall forthwith inform the Commission thereof.
2. Member States shall ensure that the texts of the main provisions of national law, which they adopt in the field covered by this Directive, are communicated to the Commission.

Article 6
This Directive is addressed to the Member States.

Done at Luxembourg, 20 June 1972.
For the Council
The President
J.P. BUCHLER

ANNEX I 1 DEFINITIONS, APPLICATION FOR EEC TYPE APPROVAL, MARKINGS, EEC TYPE APPROVAL, SPECIFICATIONS, TESTS, CONFORMITY OF PRODUCTION

(1)

2. DEFINITIONS
For the purposes of this Directive,
(2.1)
2.2. "Vehicle type as regards radio interference suppression" means motor vehicles which do not differ in such essential respects as:
2.2.1 the shapes and constituent materials of the part of the body forming the engine compartment and the part of the passenger compartment nearest to it;
2.2.2 the type of engine (whether two- or four-stroke, number and capacity of cylinders, number of carburetors, arrangement of valves, maximum power and corresponding r.p.m.);
2.2.3 the position or model of the ignition circuit components (coil, distributor, sparking plugs, screening etc.);
2.2.4 the position of metal components housed in the engine compartment (e.g. heating appliances, spare wheel, air filter etc.);
2.3. "Limitation of radio interference" means a reduction of radio interference in the sound-broadcasting and television frequency bands to a level such that there is no appreciable interference with the functioning of receivers not carried on the vehicle itself; this condition is fulfilled if the level of interference remains below the limits laid down in item 6.2.2 below;
2.4. "Radio interference suppression equipment" means a complete set of components necessary for limiting radio interference from the ignition system of a motor vehicle. Radio interference suppression equipment also includes earthing strips and screening components incorporated specially for radio interference suppression; 1The text of the Annexes corresponds to that of Regulation No 10 of the UN Economic Commission for Europe; in particular the breakdown into items is the same; for this reason, where an item of Regulation No 10 has no counterpart in this Directive, its number is given in brackets as a token entry.
2.5. "Suppression equipment of different types" means sets of equipment which differ in such essential respects as:
2.5.1 that their components bear different trade names or marks;
2.5.2 that the "high-frequency" characteristics of a component are different or their components differ in shape or size;
2.5.3 that the operating principles of at least one component are different;
2.5.4 that their components are assembled differently.
2.6. "Suppression equipment component" means one of the individual constituent parts of the suppression equipment.

3. APPLICATION FOR EEC TYPE APPROVAL
3.1 The application for EEC type approval of a vehicle type with regard to radio interference suppression shall be submitted by the vehicle manufacturer or by his authorized representative.

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3.2 It shall be accompanied by the following documents in triplicate and by the following particulars:
3.2.1 a description of the vehicle type with regard to the items mentioned in item 2.2 above, accompanied by an exploded view or a photograph of the engine compartment. The numbers and/or symbols identifying the engine type and the vehicle type shall be shown;
3.2.2 a list of the components, duly identified' constituting the radio interference suppression equipment;
3.2.3 detailed drawings of each component to enable it to be easily located and identified;
3.2.4 particulars of the nominal value of the direct-current resistances, and, in the case of resistive ignition cables, of their nominal resistance per meter.
3.3 In addition, the application for EEC type approval shall be accompanied by a sample of the radio interference suppression equipment.
3.4 A vehicle representative of the vehicle type to be approved shall be submitted to the technical service responsible for the type approval tests.

4. MARKINGS
4.1 The radio interference suppression equipment components shall bear:
4.1.1 the trade name or mark of the manufacturers of the equipment and its components;
4.1.2 the trade description given by the manufacturer.
4.2 The markings shall be repeated on the radio interference suppression cables at intervals of not more than twelve centimeters.
4.3 These markings shall be clearly legible and indelible.

5. TYPE APPROVAL
(5.1)
(5.2)
5.3 A form conforming to the model in Annex IV shall be attached to the EEC type approval certificate.
(5.4)
(5.5)
(5.6)

6. SPECIFICATIONS
6.1 General specifications
The components of the radio interference suppression equipment shall be so designed constructed and fitted so as to enable the vehicle, in normal conditions of use, to Comply with the requirements of this Directive.
6.2 Specifications concerning radio interference 6.2.1 Method of measurement
The interfering radiation set up by the vehicle type submitted for approval shall be measured by the method described in Annex II.
6.2.2 Reference limits
6.2.2.1 The radiation limits based on quasi-peak measurements shall be 50 mV/m in the 40 MHz to 75 MHz frequency band and 50 mV/m to 120 mV/m in the 75 MHz to 250 MHz frequency band, this limit increasing linearly with frequencies above 75 MHz
6.2.2.2 If measurements are made with peak measuring equipment, the readings, expressed in mV/m, shall be divided by 10.
6.2.3 On the vehicle type submitted for approval in respect of radio interference suppression, the measured values shall be not less than 20 per cent below the reference limits.

7. TESTS
Compliance with the requirements of item 6 above shall be checked in accordance with the method shown in Annex II.

(8)

9. CONFORMITY OF PRODUCTION
(9.1)
9.2 When the conformity of a vehicle taken from the series is being verified, production shall be deemed to conform to the requirements of this Directive if the levels measured do not exceed by more than 25 % the limits prescribed in item 6.2.2.
9.3 If at least one of the levels measured on the vehicle taken from the series exceeds the limits prescribed in item 6.2.2 by more than 25 %, the manufacturer may request that measurements be made on a sample of at least six vehicles taken from the series. The results for each frequency band shall be interpreted by the statistical method shown in Annex III.

(10)

(11)

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ANNEX II METHOD OF MEASUREMENT OF RADIO INTERFERENCE PRODUCED BY HIGH-VOLTAGE IGNITION SYSTEMS

1. MEASURING APPARATUS
The measuring equipment shall comply with the requirements of Publication No 2 (first edition, 1961) of the International Special Committee on Radio Interference (CISPR) or with the specifications applicable to peak type measuring apparatus given in CISPR Publication No 5 (first edition, 1967).
Note: Where the available equipment does not fully meet all the CISPR specifications, discrepancies must be clearly stated.

2. EXPRESSION OF RESULTS >PIC FILE = “T0010808”>

3. MEASURING SITE
The measuring site shall be a level area free from appreciable wave-reflecting surfaces within an ellipse having a major axis of 20 m and a minor axis of 1773 m. The antenna and the center of the engine must be located on the major axis of the ellipse, the plane of symmetry of the vehicle being parallel to the minor axis. The antenna and the point of intersection of the side of the engine nearest to the antenna with the major axis must each be located at a focal point of the ellipse. The measuring set, or the test hut or vehicle, in which the set is located, may be within the ellipse but horizontally not closer than 3 m to the antenna, in a direction opposite to the vehicle being measured. Furthermore, the absence of any extraneous noise or signal which could materially affect the measurement must be ensured; a check is therefore made, with the engine stopped, before and after taking the measurements, which can be considered satisfactory only if the readings are at least 10 dB above the highest obtained at the pre- and post-measurement checks.

4. VEHICLE
4.1 Only the ancillary electrical equipment necessary for the running of the engine shall be operating.
4.2 The engine shall be at its normal operating temperature. During each measurement, the engine shall be operated as follows: >PIC FILE = “T0010809”>
4.3 Measurements shall not be made while rain is falling on the vehicle or within 10 minutes after rain has stopped.

5. ANTENNA
5.1 Height
The center of the dipole shall be 3 m above the ground.
5.2 Distance of measurement
The horizontal distance from the antenna to the nearest metal part of the vehicle shall be 10 m.
5.3 Antenna location relative to vehicle
The antenna shall be placed successively on the left- and right-hand sides of the vehicle, at two positions of measurement, with the aerial parallel to the plane of symmetry of the vehicle and in line with the engine. (See Appendix to this Annex.)
5.4 Antenna position
At each of the measuring points, readings shall be taken with the dipole in a horizontal and in a vertical position. (See Appendix to this Annex.)
5.5 Readings
The maximum of four readings shall be taken as the characteristic reading at the frequency at which the measurements were made.

6. FREQUENCIES
Measurements shall be made within the 40 MHz to 250 MHz range. A vehicle is considered as very likely to meet the required suppression limits over the whole frequency range if it meets them at the following six frequencies: 45, 65, 90, 150, 180 and 220 (± 5 MHz). (The 5 MHz tolerance for the six frequencies chosen should make it possible to avoid interference from transmissions operating on the nominal frequencies.)

Appendix ANTENNA DIRECTION RELATIVE TO VEHICLE >PIC FILE = “T0010810”>

ANNEX III STATISTICAL METHOD OF CHECKING RADIO INTERFERENCE SUPPRESSION

In order to ensure with an 80 % probability that 80 % of the vehicles conform to a specified limit L, the following condition must be satisfied: >PIC FILE = “T0010811”>
If a first sample of n vehicles does not meet the specification, a second sample of n vehicles shall be tested and the overall results assessed as coming from a sample of 2n vehicles.

ANNEX IV >PIC FILE = “T0010812”>