C22.4—No. 108-1947

CANADIAN STANDARDS ASSOCIATION
(INCORPORATED 1919)

CANADIAN ELECTRICAL CODE

PART IV

RADIO

CSA SPECIFICATION C22.4—NO. 108-1947

CONSTRUCTION AND APPLICATION OF SUPPRESSORS FOR RADIO INTERFERENCE

CANADIAN STANDARDS ASSOCIATION
OTTAWA

Specification C22.4 No. 108—1947

Construction and Application of Suppressors for RADIO INTERFERENCE

The attached revision slips cover editorial changes to Rules 303.6(b), 303.6(c) and 303.10 Table I, and you are asked to insert them in the appropriate places in your copy of this Specification.

December, 1948

Clause 303.6(b) — Revise to read:

(b) Conductors shall be of the flexible stranded type.

Revision No. 1 *C22.4 No. 108—1947*
December, 1948

Clause 303.6(c) Note — Revise to read:

Note: (1) Examples of leads suitable for from 0 to 300 volts are:

Type FF-32—Code-grade-insulation fixture wire.
Coil Lead Wire—Super-code-grade insulation.
Type CF—Heat-resisting wire with impregnated cotton insulation.
Type CTF—Thermoplastic insulation under a lacquered cotton braid.
Type TRB-32—Thermoplastic insulation under a treated cotton or fibre-glass braid.

(2) Examples of leads suitable for over 300 but not exceeding 600 volts are:

Type R—Code-grade insulation.
Type RH—Heat-resisting-rubber insulation.

(3) For over 600 but not exceeding 1000 volts:

Type R10—(Code-grade-insulation building wire) and
Type RH-10—(Heat-resisting-grade-insulation building wire) may be used.

Revision No. 2 *C22.4 No. 108—1947*
December, 1948

Clause 303.10 Table I — Revise to read:

In column 1, line 1 change "Less than 150" to "150 or less".

Revision No. 3 *C22.4 No. 108—1947*
December, 1948

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CANADIAN ELECTRICAL CODE

PART IV

RADIO

SUPPRESSORS FOR RADIO INTERFERENCE

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PREFACE

The purpose of CSA Specification C22.4—No. 108 is to set up requirements for the construction, application and installation of suppressors for radio interference.

The general theory of causes and means of suppression of radio interference is not given herein although some pertinent factors are outlined in a few cases. For detailed information regarding the theory of this subject reference should be made to the general specifications mentioned in the text.

The specification is divided into five sections. The first section outlines general principles of the application of suppressors to electrical circuits and apparatus. The second and third sections give details of the types, construction and installation of suppressors for use with existing apparatus and new apparatus respectively. The fourth and fifth sections deal with interference suppressors for internal combustion engines and electric railways.

The type of suppressors suitable for many particular applications are recommended. In certain cases, however, tests are required to determine the most suitable type of suppressor.

The material contained in Section 3, dealing largely with the construction details of suppressors and components for the elimination of fire and accident hazards, is also published in Specification C22.2 No. 8 of the Canadian Electrical Code Part II.

This specification will be revised from time to time as the art develops. Comments or data bearing on this subject will be welcomed and correspondence on the matter should be sent in duplicate to

The General Manager, Canadian Standards Association,
National Research Building,
Sussex Street, Ottawa, Ontario.

This specification was formally approved, by letter ballot, by Panel 2, CE Code Part IV—May, 1946; by the Committee on CE Code Part IV—October, 1946, and by the CSA Main Committee, with authority to publish it as a CSA Standard, in January, 1947.

OTTAWA, August, 1947.

CSA SPECIFICATION C22.4—No. 108–1947

CANADIAN ELECTRICAL CODE

PART IV

SUPPRESSORS FOR RADIO INTERFERENCE

SECTION 1

PRINCIPLES OF THE APPLICATION OF SUPPRESSORS

Scope

101. SCOPE

Section 1 of this specification outlines general principles to be followed in the application of suppressors to electrical circuits and apparatus.

References

102. REFERENCES

102.1. For the theory of, and general requirements for, the suppression of radio interference see CSA Specification C22.4—No. 100 "General Requirements, Definitions and Procedure Relative to the Control of Radio Interference".

102.2. For details of measuring equipment and technique see CSA Specification C22.4—No. 101 "Specifications For Interference Measuring Instruments and Methods of Measurement".

Line-to-Line Component

103. LINE-TO-LINE COMPONENT

Capacitors shall be connected across the supply line according to Fig. 108-1 Circuit 1, in close proximity to the source of interference. These capacitors should, preferably, be non-inductive, have short leads, and be connected close to the source, to ensure that the by-pass circuit through the capacitors has low impedance at radio frequency. Where this simple method does not sufficiently suppress the interference it may be due to the fact that the capacitor circuit is not of sufficiently low impedance compared to that of the supply line, with the result that a considerable part of line-to-line component of the interfering voltage travels along the supply line. This condition may be rectified by inserting inductors as in Fig. 108-1 circuit 2 or 3, in the supply line, to increase its impedance. The best relative position for the inductors depends upon radio frequency characteristics of the interfering device and supply line, and can be determined by experiments.

Line-to-Ground Component

104. LINE-TO-GROUND COMPONENT

104.1. The line-to-ground component usually causes the greater interference to reception, and may be suppressed by connecting capacitors from each line to the frame of the apparatus as shown in Fig. 108-1 Circuits 4 and 7. It is essential that the impedance at radio frequency of the capacitor circuit from the source of interference through the

capacitor to the frame of the apparatus be kept as low as possible. The capacitors should therefore be non-inductively wound, and connected as close to the source as possible with short leads.

104.2. Where the frame of the apparatus is grounded, the capacitors may be connected from each line to the frame, according to Fig. 108-1 Circuit 4.

104.3. Where the frame of the apparatus is ungrounded, it is necessary that a shock limiting capacitor of relatively low capacity be connected in the lead to the apparatus frame (Fig. 108-1 Circuit 7) in order that the current through the capacitor from the line to the apparatus frame may not exceed 0.3 milliampere at the maximum rated voltage and frequency. (See also Section 3).

104.4. Where the method described above does not satisfactorily suppress the interference, it may be necessary to insert choke coils in the supply leads according to Fig. 108-1 Circuits 5, 6, 8 or 9. The best arrangements can be determined by experiment.

105. Connection to Internal Point of Apparatus Circuit

Connection to Internal Point of Apparatus Circuit

In some cases tests indicate that the interference can best be suppressed by connecting capacitors to some point in the circuit in close proximity to the source, rather than to the apparatus terminals. For example, on large commutator motors and generators, individual capacitors should be connected from each brush holder to frame, with leads as short as possible.

106. Connection to Supply Lead

Connection to Supply Lead

106.1. In cases where it is more convenient to connect the suppressor to the supply circuit, and where there is no excessive impedance in the part of the circuit between the suppressor and the source, the suppressor may be connected in the supply lead as close as possible to the apparatus.

106.2. Where the frame of the apparatus is grounded, the arrangements shown in Fig. 108-1 Circuits 1, 2, 3, 3A, 4, 5, 6 or 6A may be used.

106.3. Where the frame of the apparatus is ungrounded, a shock limiting condenser is required, as previously described, and the arrangements shown in Fig. 108-1 Circuits 1, 2, 3, 3A, 7, 8, 9 or 9A may be used.

107. Spark Eliminators and Suppressors

Spark Eliminators and Suppressors

107.1. Sparking at contacts may be eliminated or reduced by the application of spark eliminators or suppressors according to Fig. 108-1 Circuits 10 or 11.

107.2. According to Fig. 108-1 Circuit 10, a resistor in series with a capacitor is connected across the switch or circuit breaker with short leads of low impedance. The value of resistance is just sufficient to limit the current in the capacitor circuit to prevent sparking at the switch.

107.3. Where the interference is caused by a voltage surge built up across a coil of high inductance such as a relay coil used for elevators, control circuits, signalling, etc., this surge may be reduced or eliminated by a suitable capacitor connected across the coil with short leads.

107.4. It is usually found that the application of spark eliminators or suppressors in addition to suppressing radio interference, improves the operation of the associated switches and increases the life of the contacts.

107.5. In order to eliminate interference from high voltage sparks it is necessary to suppress the radio frequency components of the surge at a point in the circuit as near the spark as possible. This can best be accomplished by inserting a suitable resistor in the spark circuit and constructing the entire high tension part of the circuit with as short leads as possible.

107.6. The interference may be further reduced by placing the entire high tension circuit within a grounded shield, which should include an electro-static shield between primary and secondary winding of the transformer. The high tension circuit should be ungrounded unless the centre of the high tension winding of the transformer is grounded. (See Fig. 108-1 Circuit 12).

108. Values of Components of Suppressors

Capacitors

108.1. (a) As a general rule the capacity of capacitors used for the suppression of radio interference is not critical. The degree of suppression attained with capacitors is inversely proportional to the impedance of the capacitor circuit including the capacitor leads. Values from 0.01 to 4.0 microfarads are used values of capacity which depend on circuit conditions and the degree of attenuation desired.

In special cases, however, capacitors of larger capacity may be required the values of which may be best determined by tests.

(b) The special cases referred to above occur when capacity and inductance either in the suppressor or associated electrical apparatus form oscillating circuits and thereby increase the intensity of the interference. In such cases the value of the capacitors may be altered or suitable resistances connected in series with the capacitors.

(c) In the arrangement shown in Fig. 108-1 Circuit 11, the value of the capacitor is not critical and it is usually found that a capacity from 0.1 to 1 microfarad is sufficient. The best value depends upon the electrical characteristics of the associated circuits.

(d) The shock limiting capacitors "C", Fig. 108-1 Circuits 7, 8, 9 and 9A should be of sufficiently low capacity to limit the current to the frame of ungrounded apparatus to within a tolerable limit of 0.3 milliampere as defined in Section 3.

(e) A value of 0.01 microfarad is recommended for the shock limiting capacitors when used according to Fig. 108-1 Circuits 7, 8, 9 and 0.005 microfarad for Fig. 108-1 Circuit 9A, when connected to a 110-volt, 25- or 60-cycle circuit.

NOTE: *The voltage across this shock-limiting capacitor is 55 volts.*

(f) The effectiveness of suppressors in eliminating interference would be materially reduced if the capacity of this shock limiting capacitor were made much less than the value above given.

Inductors

108.2. (a) The inductance of inductors shown in Fig. 108-1, Circuits 2, 3, 5, 6, 8 and 9 is not critical. It may be in the range of 20 to 1000 microhenries.

(b) Where it is necessary to cover wide frequency bands, it is important that the distributed capacity of the inductance be kept low. In cases where the suppressor is desired to suppress the interference at one frequency, or over a narrow frequency band, the inductor may be tuned to have high impedance at such frequency by arranging for the inductance and distributed capacity to be of suitable values or by tuning the inductor with a suitable capacitor. (c) The distributed capacity of inductors may be kept to a minimum by the type of winding, which may either be single layer, or if desired, to economize space, some form of low capacity multi-layer winding such as bank, honey comb or duo-lateral, or sectional winding (particularly for the higher values of inductance), etc.

Resistors

108.3. (a) The exact value of resistance is not critical; but as a general rule it should be of the minimum value found by experiment to give satisfactory results. In the arrangement shown in Fig. 108-1 Circuit 10, resistance of 1 to 50 ohms, is usually found sufficient.

(b) According to the arrangement shown in Fig. 108-1 Circuit 12, a resistor of 5,000 to 25,000 ohms, is usually required. The value of this resistor can best be determined by experiment.

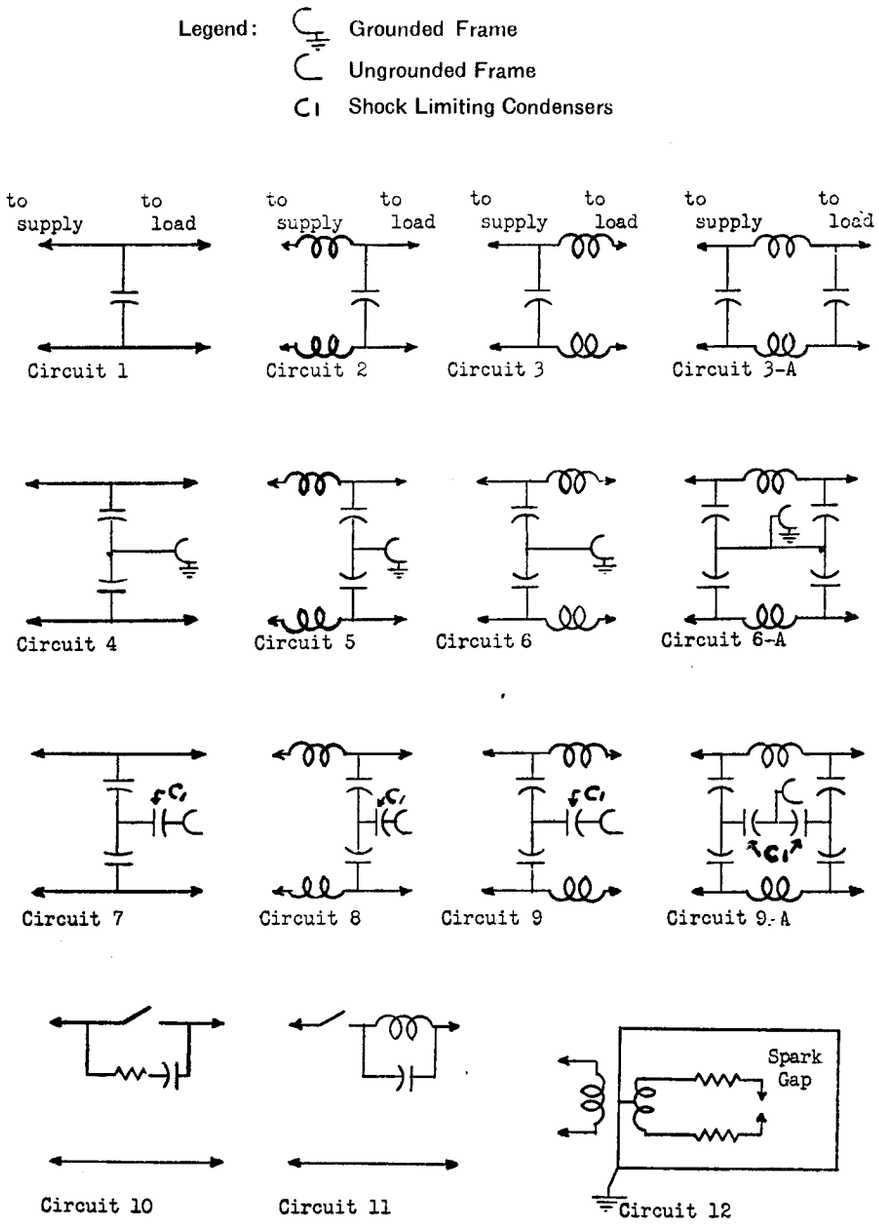
109. WIRING

Wiring

109.1. Leads or connections between the source of interference on the appliance and the suppressor unit should be kept as short as possible, preferably not longer than a few inches. As regards capacitor filters, this is necessary as the efficacy of such filters depends on the provision of paths from each conductor to the frame or ground and between two conductors, whose impedance over the radio frequency bands shall be low compared with both the source and the supply line impedances.

109.2. As regards high-frequency inductors, short leads or connections are also necessary, as the leads between the source of the interference and the inductors may add to the possibility of the propagation of directly-radiated interference from the plant or appliance.

109.3. The leads or connections to suppressors should be mechanically strong and installed and maintained at a high standard, at least equivalent to the general requirements of Parts I and II of the Canadian Electrical Code.



SCHEMATIC DIAGRAMS SHOWING THE APPLICATION OF SUPPRESSORS

FIG. 108-1

SECTION 2
TYPES, CONSTRUCTION AND INSTALLATION OF SUPPRESSORS FOR USE WITH APPLIANCES BUILT, SOLD OR INSTALLED PRIOR TO THE ADOPTION OF THE SPECIFICATION OF THE CANADIAN ELECTRICAL CODE PART IV (RADIO)

201. Scope

General

201.1. Section 2 of this specification applies to types, construction and methods of connecting suppressors (surge trap, filters or interference eliminators) to electrical equipment that was manufactured, sold or installed prior to the adoption of the specifications of the Canadian Electrical Code Part IV (Radio).

Types

201.2. (a) For the purpose of this section of the specification suppressors are classified in four types as outlined in Paragraph 202 and each type is dealt with separately.

(b) For marking and designation of types, see Paragraph 207.

Construction

201.3. Except as stated herein, suppressors shall comply with the requirements of Section 3 of this specification.

202. Definitions

202.1. The following definitions refer to terms printed in bold-faced type in Section 2 of this specification.

202.2. Type A: (External Type) A construction in which acceptable suppressors are either fastened to the external parts of electrical equipment and connected across the interfering device, or are installed in a building and connected to the open wiring systems referred to in Section 5 of the Canadian Electrical Code Part I (5th edition).

202.3. Type B: (Through Cord Type) A construction in which acceptable suppressors are installed in the supply cord of portable equipment. The electrical connections should be in close proximity to the interfering device.

202.4. Type C: (Plug-in Type) A construction in which acceptable suppressors are fastened either directly to or adjacent to supply circuits receptacles (convenience outlets) and connected to the same; or are plugged directly into the supply circuit receptacle, or are plugged into the load end of the supply cord of a portable device. In the last-mentioned case the attachment plug cap on the supply cord of the portable device is in turn inserted into the supply circuit receptacle.

202.5. **Type D:** A construction in which suppressors described in Section 3 are housed within the enclosures of electrical equipment.

203. Type A (External Type)

Installation

203.1. (a) **Type A** suppressors shall be installed by competent persons only.

(b) Suppressors shall be fastened rigidly, and in such a way that they are not liable to be subjected to mechanical injury, during normal operation.

(c) Leads connecting suppressors to apparatus or open wiring systems, shall be as short as possible, and be so located that they are not liable to be subjected to mechanical injury.

(d) Leads shall be so installed that they are not liable to be used as a support for apparatus.

(e) Leads shall enter enclosures of apparatus through smooth, rounded openings, and be fastened securely in position.

(f) Suitable strain relief shall be supplied for the leads passing into electrical equipment.

(g) Enclosures shall be connected to the frame of the apparatus when grounded. Where apparatus is not grounded, a shock-limiting capacitor shall be used complying with the requirements of Paragraph 305.3 of Section 3.

(h) When used on the open-wiring systems referred to in Section 5 of the Canadian Electrical Code Part I (5th edition), the enclosure may or may not be connected to a convenient ground, but in no case shall it be connected to neutral.

(i) Overcurrent protection shall be provided when required by the Inspection Authority, and for stationary apparatus, the general arrangement shall be of dead front type.

Construction

203.2. (a) With the exception of paragraphs 303.5 (d), (e), (f), (g); 303.13 and 303.14 the construction of **Type A** suppressors shall comply with the requirements of Section 3.

(b) Enclosures shall be of incombustible material (e.g. metal, phenolic composition), but need not comply with the requirements of Paragraph 303.2; 303.3 (a) and 303.5 (a), (b), (c) of Section 3.

(c) Internal and external leads shall be at least Type RF 32 and have current-carrying capacities suitable for the application.

204. Type B (Through Cord Type)

Installation

204.1. (a) Suppressors intended for attachment to cords of portable appliances shall be fastened securely to the cord.

(b) Suitable strain relief shall be supplied for the supply cord passing into suppressors.

(c) Conductors shall be installed carefully so that there is no electrical or mechanical damage either to the conductors or their insulation, either at the point of extrance to suppressors, or external to their enclosures.

(d) In connecting leads to terminals, or other leads, only sufficient insulation required for the actual connection shall be removed. Connections shall be made neatly and in a workmanlike manner.

(e) Where the size of supply cords is either too large or too small to fit properly into the space provided in the enclosures of the suppressors, the latter shall be assembled so as to provide insulation and mechanical strength at least equivalent to that provided on the original conductor.

(f) When portable appliances are grounded, the grounding conductor of the suppressor shall be at least Type RF 32.

(g) If the appliance be provided with a grounding conductor in the supply cord, the grounding lead of the suppressor shall be connected thereto. Care shall be taken to insulate the connection adequately from live parts.

(h) Where portable appliances are ungrounded, and it is necessary to connect the live parts of the suppressor to the frame, a shock-limiting capacitor shall be used complying with the requirements of Paragraph 305.3 of Section 3.

Construction

204.2. (a) With the exception of paragraphs 303.5(d), (e), (f), (g); 303.13 and 303.14 the construction of **Type B** suppressors shall comply with the requirements of Section 3.

(b) Enclosures shall be of incombustible material (e.g. metal, phenolic composition), but need not comply with the requirements of Paragraphs 303.2; 303.3 (a); 303.5(a), (b) and (c) of Section 3.

(c) Internal and external leads shall be at least Type RF 32 and have current-carrying capacities suitable for the application.

205. Type C (Plug-in-Type)

Installation

205.1. (a) Suppressors intended for fastening on or adjacent to supply-circuit receptacles (convenience outlets) shall be installed in such a way that they are not subject to mechanical injury.

(b) Suppressors having dead-front receptacles and having suitable means for fastening, may be attached to the frames of electrical equipment and utilized as a means for suppressing radio interference from portable electrical equipment plugged therein.

(c) Suppressors, having grounding terminals, when attached to supply receptacles, shall be grounded either to the supply receptacle, if it be grounded, or to a convenient ground connection.

(d) Grounding leads shall be at least Type RF 32.

(e) Grounding leads attached to supply receptacles shall be as short as possible for the particular application—say 4 or 5 inches, and shall be attached under cover-plate screws. Grounding leads attached to other convenient grounds (e.g. water piping) should be not more than 5 ft. in length, and shall be so located as not to be unduly exposed to mechanical injury.

(f) Ground connections including conductors shall be protected from mechanical injury.

(g) Suppressors complying with the requirements of Paragraph 205.1 (b) shall be connected to the frames of electrical equipment according to the requirements of Paragraphs 205.1 (d), (e) and (f).

(h) Where portable appliances are ungrounded, and it is necessary to connect the live parts of the suppressor to the frame, a shock-limiting capacitor shall be used complying with the requirements of Paragraph 305.3 of Section 3.

Construction

205.2. With the exception of Paragraphs 303.5 (a), (b), (c); 303.13 and 303.14 the construction of **Type C** suppressors shall comply with the requirements of Section 3.

206. Type D

Installation

206.1. Suppressors shall be installed in accordance with the requirements of Parts I and II of the Canadian Electrical Code.

Construction

206.2. Suppressors shall be constructed according to the requirements of Section 3.

207. Marking of the Four Foregoing Types of Suppressors

Marking of the Four Foregoing Types of Suppressors

207.1. Marking of the four foregoing types of suppressors shall comply with the requirements of Section 3 and also the following paragraphs.

207.2. Standard suppressors shall be identified with regard to:

(a) Type of Mounting

(b) Electric Circuit of Suppressor.

(c) Capacitor Section Winding.

207.3. The label of the suppressor shall describe, in approved form, the class of suppressor. For standard types of suppressors the first digit shall consist of one capital letter A, B, C or D, describing the type of mounting and construction. The second digit shall consist of a number, from one to twelve inclusive, describing the electric circuit of the suppressor, according to the diagrams in Fig. 108-1 of Section 1. The third part of the label, specifying the class of suppressor, shall indicate the type of capacitor section winding, according to the following abbreviations:

"Ind."—Inductive type of construction.

"Non".—Non-inductive type of construction.

"Sem."—Semi-non-inductive type of construction.

207.4. Where the above-mentioned abbreviations do not apply, the abbreviation "Spec.", standing for special, may be inserted either as the first or second digit, or last section of the class, or, if no features of the suppressor correspond with the standard features given in the specification, the class of suppressor may be called "Special".

207.5. There are three standard types of capacitor section winding, namely:

(a) The non-inductive construction in which the connections to both plates of the capacitor are brought out in such a manner that the capacity current flows to all parts of the plate of the capacitor directly by the shortest possible path or other equivalent means:

(b) Inductive construction in which the current does not flow directly by the shortest possible path to all parts of the capacitor plate but is required to make one or more turns through the capacitor winding to reach the remote part of the capacitor plate;

(c) Semi-non inductive construction in which one side of the capacitor is constructed according to the non-inductive type, while the other side of the capacitor is constructed according to the inductive type.

APPENDIX A

Recommended Class of Suppressor

The following table of preferred types of suppressors embodies the results and represents the average of many research tests but, in some cases, special tests should be made to obtain the best suppression of radio interference. Alternative recommendations are shown in brackets.

Where SPECIAL types of suppressors, recommended by the manufacturers for their particular apparatus, are available they should be used in preference to the standard types indicated below.

The application of suppressors is intended only to suppress interference created by the normal operation of apparatus in good condition. Interference due to a fault should be eliminated by repair of the fault.

CLASS OF SUPPRESSOR

Interfering Apparatus	Recommended Suppressor	
	Equipment Grounded	Equipment Ungrounded
Battery Chargers	10 (A-4-Non)	10 (A-7-Non)
Bells, Buzzers		A-I-Non (10)
Cash Registers	Special	Special
Drink Mixers	A-4-Non (B-4-Non)	A-7-Non (B-7-Non)
Dental Engines	A-4-Non (D-4-Non)	Ground Equipment
Dental Lathes	A-4-Non	A-7-Non
Electric Tools	A-4-Non (B-4-Non)	A-7-Non (B-7-Non)
Electric Razors		B-3A-Non (C-3A-Non)
Fans	A-4-Non	A-7-Non
Floor Polishers		A-7-Non (B-7-Non)
Food Mixers	A-4-Non (B-4-Non)	A-7-Non (B-7-Non)
Fluorescent Lamps	D-6A-Non (A-6A-Non)	
Grinders	A-4-Non (B-4-Non)	A-7-Non (B-7-Non)
Generators (Small)	A-4-Non	A.7.Non
Hair Clippers		B-3A-Non (B-7-Non)
Hair Driers	A-4-Non	A-7-Non (B-7-Non)
Heating Pads		Repair Thermostat
Massage Apparatus (Portable)	B-4-Non	B-7-Non
Massage Apparatus (Stationary)	A-4-Non	A-7-Non
Neon Signs	A-4-Non	
Motors (Small)	A-4-Non (B-4-Non)	A-7-Non
Movie Projectors (Small)	A-4-Non	B-7-Non
Office Machines	A-4-Non (A-6A-Non)	A-7-Non (A-9A-Non)
Oil Burner Ignition	12 (A-4-Non)	
Refrigerators	A-4-Non	See Note
Relays		A-3A-Non (10)
Rotary Converters	A-4-Non	A-7-Non
Telegraph Keys	A-3A-Non	A-3A-Non (10)
Thermostats	10 (A-3-A-Non)	10 (A-3-A-Non)
Sign Flashers	10 (A-6A-Non)	10 (A-9A-Non)
Sewing Machines	A-4-Non	A-7-Non
Toys		A-7-Non (C-1-Non)
Vacuum Cleaners		A-7-Non (B-7-Non)

Note Re Refrigerators:

Where interference is due to electro static discharge, this condition may be rectified by connecting the motor frame to a suitable point on the compressor with a suitable conductor.

APPENDIX B

APPLICATION OF SUPPRESSORS

Item No.	Item	Type of Suppressor	Fig. 108–1 Circuit No.
1	Appliances for lighting, heating and cooking, having no thermostats and no moving electrical contacts, and motors and generators having no commutators or slip rings, are inherently non-interfering. If found to be creating interference, faults should be located and repaired.	—	
2	Certain equipment can best be made interference-free by special suppressors recommended by the manufacturers of the particular equipment, and should be used in preference to standard types.	Special	Special
3	**Commutator** type motors, generators and other equipment, with frames **grounded,** where suppressor can be mounted on frame, such as neon signs, dental lathes and engines, D.C. generators, fans, hair driers, drink mixers, office machines, oil burner installations, pumps, converters, stokers, etc.	A	A (5, 6, 6A)
4	**Commutator** type motors, generators and other equipment similar to 3 with frames **ungrounded,** such as drink mixers, dental lathes, fans, floor polishers, generators, hair driers, office machines, sewing machines, vacuum cleaners.	A	7
5	**Portable** grounded equipment where it is **not** convenient to mount a suppressor on the apparatus frame may be made interference-free by the use of a through-cord type of suppressor, such as drink mixers, electric tools, fans, food mixers, grinders, hair clippers, hair driers, massage apparatus, vibrators, etc.	B	4 (5, 6, 6A)
6	**Portable** ungrounded equipment where it is **not** convenient to mount a suppressor on the apparatus frame may be made interference-free by the use of a through-cord type of suppressor. Such as drink mixers, electric tools, fans, food mixers, grinders, hair clippers, hair driers, massage apparatus, vibrators, floor polishers, razors, vacuum cleaners, movie projectors, etc.	B	7 (8, 9, 9A)
7	Where it is not practicable to use Types A and B suppressors, all the above listed equipment may be made interference-free to some extent by using various "plug-in" type suppressors at the apparatus line cord terminals. The use of these "plug-in" type suppressors is not recommended as their suppression efficiency is low and there is the possibility of the operator neglecting to use the suppressor.	C	Any Circuit

APPLICATION OF SUPPRESSORS—Continued

Item No.	Item	Type of Suppressor	Fig. 108–1 Circuit No.
8	Certain equipment is so designed that the suppressors may be mounted and connected inside a metal housing, such as cash registers, office machines, dental engines, hair driers, incubator thermostats, sign flashers, sewing machines, electric typewriters, traffic signals, vacuum cleaners, etc.	D	Any Circuit
9	Thermostats as used for heating appliances, ovens, laundry irons, incubators, etc., and buzzers.	A or D	10
10	Relay circuits in which an interfering surge is set up across a coil of high impedance, such as is used for remote control of elevators, etc.	A or D	11
11	Sparks, such as are used for ignition of oil furnaces, for ozonators in air purifiers and flour bleachers, etc.		12

SECTION 3

CONSTRUCTION AND TEST OF SUPPRESSORS FOR USE WITH APPARATUS BUILT, SOLD OR INSTALLED AFTER THE ADOPTION OF THE SPECIFICATIONS OF THE CANADIAN ELECTRICAL CODE PART IV (RADIO)

301. Scope

Scope

301.1. Section 3 of this specification applies to suppressors, and their components, (i.e. capacitors, inductors and resistors) intended to be employed on ac or dc circuits operating at not more than 750 volts to ground, in accordance with the Rules of Parts I, and IV of the Canadian Electrical Code.

301.2. Devices covered by this section are intended for the suppression of radio interference and may be supplied

(a) Individually (as a capacitor, inductor or resistor unit)

or

(b) Incorporated in complete assemblies.

301.3. The requirements of certain clauses of this section are limited to a particular component such as a capacitor or inductor, etc. Where not thus restricted the requirements of this section are intended to apply to all devices included under Paragraph 301.1.

302. Reference

Reference

See CSA Specification C22.2 No. 0 "Definitions and General Requirements" applicable to all specifications of the Canadian Electrical Code Part II. Other references herein to that specification are abbreviated to "Specification C22.2 No. 0".

303. Construction

General

303.1. Component parts of suppressors i.e. capacitors, inductors and resistors shall be of types specifically approved for the use intended or shall be approved as an integral part of, and with, the device.

External Enclosures of Suppressors

303.2. (a) Except for flexible cord for connection to the supply, all wiring and electrical components shall be totally enclosed.

(b) Such enclosures may be dispensed with when suppressors are installed within the enclosure of electrical apparatus, provided that the latter enclosures are equivalent to the requirements of Paragraphs 303.2 (a), (c), (d), (e) and (f).

(c) Provision for ventilation shall be the subject of special investigation, re size of holes, their location, etc.

(d) Except as stated below, enclosures shall be of incombustible, absorption-resisting material. Enclosures, if made of sheet steel, shall be formed from stock not less than No. 24 USSG* in thickness; and, if made of other sheet metal, shall have mechanical strength and rigidity equivalent to that of steel of No. 24 USSG*. Enclosures made of material other than metal shall be made the subject of special investigation.

**For small cylindrical enclosures thinner sheet may be used subject to special investigation regarding their mechanical strength.*

(e) A good grade of treated fibre may be used as part of external enclosures provided that its use is restricted to small areas, etc. (e.g. the end walls of cylindrical enclosures in which live parts are insulated with compound or the equivalent). Such fibre shall be not less than 1/32 in. thick with a minus tolerance of 5 mils.

(f) External enclosures intended for stationary connection to the source of supply shall be provided with rigid means for mounting.

Containers for Capacitors and Inductors

303.3. (a) Capacitor and inductor units shall have containers of metal or other suitable material which shall completely enclose all live parts except:—

1. The supply and grounding leads, if such be used,

or

2. The supply terminals

(b) Electrolytic and paper-insulated capacitors and inductors may be supplied with cardboard containers.

(c) Except as stated in paragraph 303.2 (b), an external enclosure of one of the types required by Paragraph 303.2 shall be used in addition to the container if the device forms a complete suppressor in itself.

(d) Containers shall be so constructed as to prevent leakage of the sealing compound under normal operating conditions. See also Paragraph 303.11 (a).

Protection Against Rusting

303.4. Iron or steel parts shall be protected against rusting as required by Specification C22.2, No. 0.

Connections of Suppressors

303.5. (a) Enclosures intended for stationary connection to the source of supply shall be provided with means for conduit connection.

(b) The thickness of the wall of an enclosure to which conduit or armoured cable is attached shall be not less than No. 16 USSG if made of sheet steel or its equivalent if thinner sheet or other metal be used. Cast metal shall be not less than ⅛ in. in thickness.

(c) Conduit hubs and similar threaded openings shall comply with the requirements of Specification C22.2 No. 0. Holes having 5 full threads or, if tapered, 3 full threads need not have end stops, but the innermost thread shall be smoothly rounded.

(d) If suppressors be provided with flexible cord such cords shall be of suitable length, of approved type and be complete with a suitable attachment plug cap for connection to the supply circuit.

(e) Flexible cords shall have current-carrying capacities at least equal to the input in amperes corresponding to that marked on the device, and shall be of the "hard usage" type e.g. Type SJ, except where the application is known to the manufacturer, in which case it shall be of one of the types of construction (corresponding with the appliance with which it is intended to be used) required by Specification C22.2, No. 0.

NOTE: *A cord may be attached permanently, or a separate cord may be used with suitable means for connection.*

(f) Terminals of the pin- or blade-type may be used on portable suppressors but for connection to the supply only, and shall comply, unless equipped with special plugs and terminals necessitating special investigation, with the requirements of CSA Specification C22.2 No. 42—"Receptacles, Plugs, and similar Wiring Devices" of the Canadian Electrical Code, Part II.

(g) If receptacles, or motor attachment plug bodies, or the equivalent be used for connection to the load i.e. the appliance being protected, they shall be of the dead-front types. Such devices, (unless of special construction necessitating special investigation) shall comply with the requirements of CSA specification C22.2 No. 42—"Receptacles, plugs and Similar Wiring Devices" of the Canadian Electrical Code Part II.

(h) Insulated leads, and cords passing through metal, shall be protected with insulating bushings, such as fibre, soft rubber, phenolic composition, etc., unless sufficient protection is provided on the conductors themselves e.g. Type SJ cord, in which case either the metal may be well rounded, or metal bushing, e.g. grommets shall be used.

(i) Insulated conductors except those from opposite ends of inductors, may be bunched and passed through a single opening.

(j) Cords and leads external to enclosures shall be provided with suitable strain relief.

(k) Wireways shall be smooth and entirely free from sharp edges, burrs, fins, etc.

Conductors

303.6. (a) The current-carrying capacity of conductors shall be suitable for the circuit intended but in no case shall the conductor size be smaller than No. 18B and S Gauge.

(b) Conductors shall be of the stranded type.

(c) The insulation on conductors shall have a covering of braid either dry or treated. Minimum nominal thicknesses of insulation shall be as follows:

1. 0–300 volts.....1/32 in.
2. Over 300 to 750 volts.....3/64 in.

NOTE: *Examples of loads suitable for 0-300 volts are Type FF/32 (Super-Code coil lead wire) and Type CF (heat-resisting wire with varnished-cambric or thermoplastic insulation under an impregnated cotton braid). Examples of leads suitable for over 300 to 750 volts are Type R (Code grade insulation), Type RH (heat-resisting rubber insulation), and Type V (varnished-cloth insulation).*

Joints

303.7. Soldered joints shall be made mechanically secure in addition to soldering. This need not be complied with if some equivalent means be used, e.g. if the joint be held in place by compound.

Terminal Parts

303.8. (a) Wire-binding terminal parts, the identification of terminal parts, and those leads intended for connection to supply circuit wires, shall comply with the requirements of Specification C22.2 No. 0.

(b) Where two or more of any one of the same devices are grouped together in a common unit or enclosure the terminal connections intended for the grounded supply circuit conductor shall be identified. The terminal connections for suppressors, capacitors, inductors, and resistors, when supplied or used singly need not be identified.

(c) Fixed wiring terminals shall be prevented from turning. Screws shall not be less than No. 6.

(d) Wire-binding screws shall thread into metal. (See recommended CSA Dimensional Standard B35–1933).

(e) If parts be totally enclosed, solder lugs may be used.

(f) Terminal parts shall be of non-ferrous metal and shall be so mounted and of such rigidity that they cannot readily be so bent as to come into contact with metal enclosures or parts of opposite polarity.

(g) Terminal parts shall be so located or protected that they will not likely be forced out of their intended position.

Insulating Material

303.9. Bare live parts shall be mounted on heat-resisting absorption-resisting, insulating material such as porcelain, phenolic or cold-moulded composition, or some equivalent. Ordinary (untreated) fibre, rubber, and so-called hot-moulded shellac or tar compositions shall not be used.

NOTE: *The foregoing requirements do not apply to material used for separators, spacers, and similar parts.*

Spacing

303.10. (a) Spacing between bare live parts of opposite polarity and between bare live parts and metal parts (including enclosures) which may be grounded when the device is installed, shall be not less than those given in the following Table:

TABLE 1

SPACING FOR LIVE PARTS

Range of Capacitor or Suppressor Rating* Volts	Minimum Spacing in Inches Gap	Over Surface
Less than 150	1/8**	1/4
Over 150 to 300	1/4	3/8
Over 300 to 750	3/8	1/2

**Voltage ratings of inductors and resistors will be those of the suppressors or circuits with which they are intended to be used.*

***The minimum spacing between wiring terminals of opposite polarity when mounted in the same plane shall be 1/4 in.*

(b) If the foregoing spacings cannot be obtained, insulating liners, barriers, etc., made of the material specified shall be used under the following conditions:

1. The material specified in Paragraph 303.9, if bare live parts are or can come in contact with insulation.

2. Ordinary (untreated) fibre not less than 1/32 in. in thickness (with a minus tolerance of 5 mils), if bare live parts are not liable to come into contact with insulation. As an alternative some equivalent insulation may be used.

Sealing Compound

303.11. (a) Capacitor elements shall be completely sealed in containers so as to exclude moisture.

(b) Sealing compounds shall not flow out of, openings for leads or terminals, or out of containers when the foregoing devices are subjected to a continuous operating temperature equal to that marked on them.

(c) Sealing compounds shall not melt, flake, or crack spontaneously between temperatures of 0C (32F) and 70C (158F).

Elements

303.12. (a) Capacitor elements shall consist of metal foils or plates which shall be chemically neutral and, if of tin, at least 80 per cent purity. If other metals be used, the foils or plates shall have sufficient purity to ensure no deleterious effects from electro-chemical action.

(b) Elements and insulating material shall be arranged to provide rated capacity and be capable of withstanding the dielectric tests required in Paragraph 305.4.

(c) Inductor elements shall consist of coils having a low value of self-capacitance with or without a grounded core and suitable insulating material which shall be capable of withstanding the dielectric test required in Paragraph 305.5.

(d) Resistor elements shall have a low value of self-inductance and suitable insulating material (e.g. refractories), which will be capable of withstanding the dielectric-strength test required in Paragraph 305.5, and normal operating temperatures. Resistor elements, together with their insulating material shall be provided with suitable and rigid means for mounting in their intended manner.

Overcurrent Protection

303.13. Overcurrent protection shall be the subject of special investigation, and for stationary apparatus the general arrangement shall be of the dead-front type.

Grounding

303.14. Portable suppressors shall be grounded as required by

(a) Specification C22.2 No. 0.

(b) Rule 904 of the Canadian Electrical Code Part I.

304. MARKING

Marking

304.1. Except in those cases where suppressors form an integral part of electrical equipment, suppressors shall be marked with the name or trademark or other recognized symbols of identification of the manufacturer, the catalogue number or the equivalent. In general marking shall comply with Specification C22.2, No. 0.

304.2. Suppressors shall be marked with the electrical rating applicable in volts and amperes, number of phases, microfarads, millihenries and ohms, and the type designation required in Section 2.

305. TESTS

Rating

305.1. (a) The capacity in microfarads at rated voltage, maximum rated frequency (if for ac), and normal operating temperature shall not vary from the marked rating by more than the following percentages:

Shock-limiting type.....15 per cent

All other types.....25 per cent

(b) The inductance shall not vary more than 25 per cent from the marked rating at both 25 and 60 cycles.

(c) The resistance at normal operating temperature shall not vary more than 15 per cent from the marked rating.

Temperature

305.2. (a) Under normal operating conditions i.e. when installed in devices, the temperatures on the external parts of the containers of capacitors shall not exceed the rated temperature.

(b) When carrying continuously the rated current, the temperature rise of the external parts of the containers of inductors, or of skeleton-type windings of inductors, shall not exceed 60C. (108F) in an ambient of 40C (104F) for Class A insulation.

Shock Hazard

305.3. Suppressors shall be so designed that when they are connected in a circuit in the desired arrangement the capacitance (ac) and resistance (dc) shall be such that the current flow shall not exceed 0.3 milliampere at the maximum rated frequency and rated voltage of the apparatus between the grounding medium intended for attachment to exposed, ungrounded, non-current-carrying metal parts of the appliance and each side of the supply circuit.

Dielectric Strength Capacitors

305.4. (a) Except for those of the electrolytic type, capacitors shall be capable of withstanding for a period of 1 minute the application of the following voltages.

TABLE II
VALUES OF TEST VOLTAGES

Range of Capacitor Rating—Volts	Voltage Tests	
	Between Terminals of Capacitor Volts	Between Terminals and Metal Casing Volts
150 or less	1200 (dc)	Twice the Rated Voltage plus 1000 volts ac
Over 150 to 300	1500 (dc)	
Over 300 to 500	2000 (dc) or 1500 (ac)	
Over 500 to 750	3000 (dc) or 2000 (ac)	

(b) The ac test between terminals shall be applied only as a design test and, where necessary, as a final inspection test of the complete appliance with which the capacitor is incorporated.

(c) A-c Tests between terminals shall be made with a voltage of approximately sine wave form and at rated frequency. If d-c tests be made with rectified a-c. the rms ripple voltage superimposed upon the d-c voltage shall not exceed 6 percent of that voltage.

Dielectric Strength

305.5. (a) Suppressors, inductors, and resistors shall be capable of withstanding without breakdown for a period of 1 minute, the application of an a-c potential of twice the rated voltage plus 1000 volts at rated frequency between live parts and exposed non-current-carrying metal parts.

(b) In the case of inductors and resistors which have no marked voltage the "rated voltage" shall be either the voltage rating of the circuit or suppressor with which they are used or else the highest voltage with which they are intended to be used.

SECTION 4
CONSTRUCTION AND TEST OF RADIO INTERFERENCE SUPPRESSION COMPONENTS FOR INTERNAL COMBUSTION ENGINES

401. Scope

Scope

Section 4 of this Specification applies to the design and construction of components for suppressing radio interference from the vehicle and equipment to radio receivers within or without the vehicle.

NOTE: *Air-Craft are excluded.*

402. References

References

402.1. For information regarding the cause and methods of suppressing radio interference, reference should be made to:

CSA Specification C22.4 No. 100 "General Requirements, Definitions and Procedure, relative to the Control of Radio Interference."

402.2. For tolerable limits of radio interference from internal combustion engines see:

CSA Specification C22.4 No. 104 "Specifications for measurement and Tolerable Limits of Radio Interference from vehicles using Internal Combustion Engines".

403. General Information

Causes of Radio Interferences

403.1. (a) Radio interference from automobiles may originate either in the high tension or the low tension circuits.

(b) Interference in the high tension circuit originates at the spark plugs, at the distributor points, and any fault in the high tension circuit.

(c) Interference originating in the low tension circuit may be caused by the gauges, the generator, or other electrical equipment, or by faults in the low tension wiring.

Means of Suppression

403.2. (a) The interference from the ignition system may be suppressed by connecting resistors of approximately 10,000 ohms in each of the high tension leads at the spark plugs and also in the coil-to-distributor lead near the distributor.

(b) Interference from the low tension wiring may be suppressed by connecting capacitors from various points on the low tension wiring to the chassis with very short leads and/or inductors in the low tension circuit.

(c) Bonding the parts of the vehicle is usually required only for the suppression of interference to receivers within the vehicle.

404. Bonding

Bonding

404.1. Bonding, if necessary, shall consist, except as stated below, of a flat tinned woven copper braid at least 1/16 in. by ¼ in., or other suitable material. Solid copper strip may be used, if there be no possibility of independent movement of bonded parts.

404.2. This braid shall be fastened to the vehicle parts by means of heavy terminals soldered to the braid and secured with bolts and tinned washers wherever possible, or the bonding strip may be securely soldered to the vehicle parts. In the case of bolted connections all contract surfaces shall be thoroughly cleaned and covered with a light coating of vaseline.

404.3. When soldering terminals, care shall be taken to ensure that the soldering does not creep along the braid, thereby reducing its flexibility, which might result in fracture from vibration.

404.4. Bonding leads shall be as short as possible to ensure low impedance at radio frequency.

404.5. Bonding strips shall be mounted in such a manner that they may be replaced when the vehicle is serviced.

405. Resistors

Details of Construction

405.1. (a) Metal parts may be made of non-ferrous or ferrous materials. If made of the latter they shall be suitably treated to prevent rusting.

(b) Contacts shall have spring properties so as to ensure good electrical connection throughout their normal life under conditions of actual service.

(c) Insulating material shall have dielectric-strength properties and general construction features suitable for conditions of actual service e.g. non-hygroscopic, non-tracking (no conducting path under normal operation) at service voltage, not liable to collect dust, and suitable for high temperature work.

Notes:

1. *A brittle insulating material will not be accepted.*
2. *A smooth polished surface is desirable to comply with the foregoing requirements.*

(d) The power rating shall be 1 watt at the nominal resistance value of the resistor. See also "Life" tests (Paragraph 405.3(d)) for resistors.

(e) The self-capacitance between terminals of resistors shall have as low a value as possible.

Note: *For this purpose the ratio of the length to the diameter should be large and the terminals small.*

(f) A conducting buffer, if a spring-loaded contact be used, shall be inserted between the spring and resistor element. The ends of the spring shall be turned in, or alternatively, there shall be no burrs projecting from the spring parallel to its axis.

(g) The contact surfaces of the resistor elements shall be metallized and/or the method of making contact with the element shall be electrically sound and robust.

(h) All surfaces of resistor elements, other than those used for contact purposes, shall be free from metal or other conducting particles not forming part of the element.

(i) The assembly of resistors shall be such that the resistor is fastened securely and rigidly.

Marking

405.2. The resistance in ohms shall be marked durably on each resistor.

Tests

405.3. (a) The insulated covering shall be subjected to a test potential of 20 peak-kv, for 1 minute, at any convenient frequency between 25 and 100 cycles per second, applied between the resistance element and a metal conductor temporarily wrapped round the outer surface of the insulated covering.

(b) The resistance of a resistor shall be determined at a test voltage not exceeding that corresponding to the power rating of 1 watt. The resistance so measured shall not differ from the nominal value by more than ±25 per cent. The test will be carried out at atmospheric temperature and pressure.

(c) The maximum temperature rise of a resistor when continuously loaded at 1 watt shall not exceed 60C (108F) in an ambient temperature of 20C (68F).

(d) 1. A spark-gap shall be set up with a 1-mm gap and with one electrode grounded. One terminal of the resistor shall be connected directly to the free electrode of the spark-gap, and the free end of the resistor then connected to an ignition coil similar to the type used on the vehicle under test, the stored primary energy of which is not less than 0.025 joule and not greater than 0.05 joule at break, when the speed of the contact breaker is adjusted to apply 120 impulses per second.

Note: *The energy in joules per impulse is given by the expression* $\frac{1}{2} 12L$.

Where I is the current at break in amp, and L is the primary self-inductance in henries.

2. The test shall be conducted continuously for 300 hr. at a temperature of 80C (176F). At the end of the tests, a further test shall be carried out on the same samples using an ignition coil as above, but under different atmospheric conditions. The relative humidity shall be not less than 75 per cent at 50C (122F), and the test shall be conducted for a period of 50 hr.

3. On conclusion the resistance shall be measured exactly as for the "Type" test (Paragraph 405.3(b)) and

the value shall not have altered more than ±15 per cent, neither shall spark-over occur at any time during the test, nor shall the temperature rise exceed 60C (108F).

(e) Resistors shall be capable of withstanding, without damage, a fall from a height of 6 ft on to a hard surface.

Acceptance

405.4. Resistors shall be tested for resistance, using a test voltage not exceeding that corresponding to the power rating. The resistance so measured shall not differ from the nominal value by more than ±25 per cent. The test will be made under ordinary atmospheric conditions.

406. Capacitors

Details of Construction

406.1. (a) The capacitor tissue shall be suitable for high-temperature work, be homogeneous, free from impurities, alkalinity and acidity, and have a low ash content.

(b) The foil shall be chemically neutral, and, if of tin at least 80 per cent purity. If other metals be used, the foil shall have sufficient purity to ensure no deleterious effects from electrochemical action.

(c) The impregnating and filling compounds shall be chemically neutral, and free from mineral salts, and uncombined chlorine. The compounds shall not be brittle, shall not crack spontaneously at −30C, (−22F) and shall have a sufficiently high melting point so that they will not flow at a temperature below 85C (185F).

(d) Only resin flux shall be used for soldering internal connections. A non-corrosive flux shall be used for external joints and connections.

(e) Enclosures and mounting brackets within engine compartments or exposed locations shall be of incombustible and absorption-resisting material. Ferrous materials shall be prevented from rusting.

(f) External leads shall be stranded flexible tinned copper conductors and as short as possible. The conductors shall have rubber insulation complete with an outer cotton braid which has been suitably treated to exclude moisture. The cotton braid shall have a smooth, polished surface.

(g) The internal connection shall be of tinned copper.

(h) Capacitors shall be so constructed that the high-frequency inductance and resistance are a minimum, through short continuous contact to the electrodes.

(i) Contacts shall be made mechanically and electrically secure. If spring-type contacts be used, their spring properties shall be maintained throughout the life of the capacitor.

(j) Insulation on conductors shall be protected from abrasion.

(k) The design and constructional process shall be such that the capacitors are completely sealed so as to exclude moisture.

(l) Means shall be provided to prevent movement of the lead, which may cause it to bend sharply at any one

point, causing possible fracture of the conductors, due to repeated movement or vibration.

Marking

406.2. The values of the test voltages and capacity of capacitors shall be designated and clearly labelled by direct marking, irrespective of any manufacturer's code or catalogue marks. Such marking shall not be removable by rubbing. Colour markings may be used in addition, if required.

Tests

406.3. (a) The complete capacitor shall withstand a test voltage of 400 volts d-c, applied between the terminals, for 1 minute, at the end of which time the product of the insulation resistance in megohms and the capacitance in microfarads shall be not less than 500, except that in no case need the insulation resistance exceed 5000 megohms. The test shall be made in an ambient temperature of 20C ± 5C (68F ± 9F).

(b) The capacitance shall not differ from the nominal value by more than ±20 per cent of the marked rating, at normal temperature and atmospheric pressure.

(c) The temperature of the capacitor shall be raised to 80C (176F), and maintained for 6 hr. The sealing material shall not run out during the test. After cooling to room temperature, the capacitance shall be measured and shall not have altered more than ±15 per cent from its original value measured in Paragraph 406.3(a). The capacitor shall also satisfactorily withstand the test voltage, as previously applied, and the insulation resistance shall not be less than 75 per cent of the value originally measured. See also Paragraph 406.1(c) for low temperature test.

(d) The capacitor shall be subjected to a humid atmosphere (relative humidity from 75 to 100 per cent) at 50C (122F) for a period of 24 hr. After cooling to room temperature, the product of the insulation resistance in megohms (measured at the same temperature) and the capacitance in microfarads shall be not less than 50 per cent of the corresponding product as measured in accordance with Paragraph 406.3(a). The capacitance measured after the test, shall remain within ±5 per cent of the original value measured in Paragraph 406.3(a).

(e) Capacitors shall be capable of withstanding without damage, a fall from a height of 6 ft on to a hard surface.

Acceptance

406.4. (a) Capacitors shall be tested for insulation and capacitance. The test voltage shall be 400 volts d-c, momentarily applied. No capacitor shall break down under this test.

(b) The capacitance shall be measured by an approved capacitance tester, or on a-c mains and the capacitance determined from the nominal frequency and the measured voltage across the capacitor and the current through it. The capacitance so measured shall not differ from the nominal value by more than ±25 per cent.

SECTION 5

CONSTRUCTION CLASSES AND TEST OF RADIO-INTERFERENCE SUPPRESSION COMPONENTS FOR TROLLEY-BUSES AND STREET-CARS (TRAM-CARS)

501. Scope

Scope

Section 5 of this Specification applies to the design and construction of components for suppressing radio interference emanating from trolley-buses and street-cars.

502. Reference

Reference

For detailed information regarding tolerable limits of radio interference from trolley-buses and street-cars reference should be made to:

CSA Specification C22.4 No. 102 "Specifications for Tolerable Limits of Radio Interference from Trolley Buses, Tramways, and Electric Railways and special methods of measurement".

503. General Information

Causes of Interference

503.1. The interference arising from the operation of trolley-buses and street-cars is mainly radiated from the overhead contact wires along with the disturbance are propagated. The sources of interference are the collectors, the main contactors supplying and controlling the motors together with associated relay control circuits and signal circuits, the driving motor and the auxiliary motors.

Means of Suppression

503.2. The three main methods of suppression are:

(a) Filters connected to individual items or groups of items of equipment.

(b) Choke coils in the main supply-leads.

(c) Capacitors from the lines to ground.

504. Choke Coils

Definitions

504.1. (a) A **main choke coil** is a radio-frequency inductor connected in series with the main traction circuit of the vehicle.

(b) A **tuned subsidiary choke coil** is a radio-frequency inductor which is electrostatically or electromagnetically coupled to the main coil and is tuned or adjusted to produce with the latter an impedance maximum on each of the wave bands to be protected.

(c) An **auxiliary-circuit choke coil** is a radio-frequency inductor connected in series with any one or more of the auxiliary circuits on the vehicle.

(d) An **auxiliary circuit** is defined as a circuit on the vehicle which is electrically or electromagnetically connected to the main traction circuit, but which does not carry the main traction current.

Installation

504.2. (a) Where **main choke coils** are fitted to trolley-buses, they are intended to be connected in series with the positive and negative conductors respectively, and to be joined in the circuit at suitable points between the trolley-arm conductors and the main circuit-breakers on the vehicle.

(b) In the case of street-cars, only one **main choke coil** is required, and it should be connected in series with the positive conductor.

(c) The **tuned subsidiary choke coil** shall carry no direct current —i.e. no part of the main traction current.

(d) An **auxiliary-circuit choke coil** may be connected in the positive or negative or in both conductors of an **auxiliary circuit.**

NOTE: *Two circuit arrangements for the installation of choke coils are shown in Figs. 108–3 and 108–4.*

NOTE: *Paragraphs 504.3 (a), (b), (c), (e), (f), (g), (h), (i), (j) and (k) do not apply to air-insulated choke coils.*

Details of Construction

504.3. (a) The **main choke coil** shall be so constructed that it will operate satisfactorily under all weather conditions.

(b) If the coil or coils be contained in a metal enclosure, they shall be supported and insulated from the container in such a manner that it, or they, will not be displaced under normal running conditions.

(c) Provision shall be made on the body of the container for fixing it to the body of the vehicle.

(d) If the **main choke coil** be mounted in an open frame or in a cruciform structure and be exposed to the weather, the coil shall be weather-proof, and the coil, and the frame or structure if of metal, shall be suitably insulated from the body or chassis of the vehicle.

(e) If a coil be assembled in a metal container, the cables from the coil shall pass through suitable watertight and insulated bushings in the container.

(f) The cable entries shall be disposed at opposite sides or ends of the container.

(g) **Main choke coils** shall be insulated with Class B* material. They shall be insulated from their supports and the latter, if of metal, shall be insulated from the chassis. The material used for the coil former shall be such as will not deteriorate or soften at the maximum temperature likely to be attained in service.

(h) **Auxiliary-circuit choke coils** shall be insulated with Class A* material and shall in other respects comply with the requirements of the foregoing paragraph.

** See Appendix A*

(i) If an **auxiliary-circuit choke coil** be intended for mounting in an exposed position and be without complete enclosure, it shall be vacuum-impregnated or otherwise treated to prevent the absorption or penetration of moisture into the winding or windings.

(j) The treatment or location of **auxiliary-circuit choke coils** shall be such that under all conditions of service the windings shall be protected from the ingress of moisture.

(k) Class A insulation may be used for the components of a tuned subsidiary circuit, provided that the components are totally enclosed in a weather-proof container and the cable entries suitably bushed and sealed to prevent the ingress of moisture.

(l) Connection to the coils shall be made by:

1. Flexible cables from the coil joined by soldered or solderless terminals having low contact resistance, or
2. Flexible cables terminating with soldered or solderless terminals connected directly to fixed insulated screw terminals situated on the coil casing or support, these fixed insulated terminals being connected to the end turns of the coil by means of multistrand conductors soldered to the end turns and covered with tough rubber insulation, or
3. The terminals may be made an integral part of the coil being connected to the terminals in the process of manufacture.

If terminals be used they shall be of the screw or stud type, and the connections shall be reliably locked.

NOTE: *It is preferable to screen or shield all connecting cables to choke coils and suitably bond the screens in the chassis.*

(m) **Main Choke Coils:** The winding of the coil shall be rigidly supported in such a way that no change in its impedance is likely to be caused by vibration under normal rubbing conditions.

(n) Weight: The total weight of the coils and their containers shall be as low as possible to facilitate compliance with the tilting angle requirements when the coils are fitted on the roof of the vehicle.

(o) Choke coils shall be constructed and connected in such a manner that no intermittent contact or open circuit is likely to be caused by vibration.

(p) **Auxiliary-circuit** choke coils shall be fixed as close to the source of interference as possible, and preferably not more than 18 in away.

(q) The current rating for the **main choke coil** shall correspond to the current rating of the main motor and auxiliaries. The current rating for **auxiliary-circuit choke coils** shall correspond to the current rating of the apparatus in the relevant circuit which is to be protected.

Marking

504.4. The inductance in millihenries and the current in amperes shall be marked in a permanent manner on each choke coil.

Tests

504.5. (a) When carrying the rated current, and when the coil has reached its final temperature, the voltage drop across the **main choke coil** shall not exceed 0.75 per cent of the working voltage.

(b) **Main choke coil:** The temperature-rise of the **main choke coil** when finally assembled in its container or frame and when carrying its rated current continuously, the temperature having become practically stationary, shall not exceed 120C as determined by resistance measurement.

The measurement shall be made when the container or coil is being subjected to an air current which is passing the surface of the container or coil at a velocity not exceeding 15 mph as measured with an anemometer.

(c) **Auxiliary-circuit choke coils:** The temperature-rise of **auxiliary-circuit choke coils,** when finally assembled in their containers or frames and when carrying their rated currents continuously, the temperature having become practically stationary, shall not exceed 70C as determined by resistance measurement made in still air.

(d) The insulation resistance between windings and mounting details or metal container referred to in paragraph 504.5 (e), or between windings of different polarity mounted on the same former, shall not be less than 20 megohms when tested in the factory.

The insulation resistance test shall be made with a d-c voltage of not less than 500 volts, and shall be applied for a sufficient time for the reading to become practically steady.

(e) 1. The unit, as assembled ready for mounting on the vehicle, shall withstand a test-voltage in the factory of 2,500 volts (rms), between the coil winding or windings, and fixing bolts or other conducting coil-mounting details. If necessary, the mounting details shall be placed in position for the purpose of the factory test. Alternatively, if a metal container be used, the test voltage shall be applied between coil winding or windings and container.

2. If two separate windings of different polarity be mounted on one former, 2,500 volts (rms) shall be applied between the windings.

3. The test voltage shall be alternating current of approximately sine wave form, and having a frequency of 60 cycles per second, and it shall be applied for 1 minute.

(f) The capacitors used for tuning the main and subsidiary choke coils shall withstand a test-voltage of 3,000 volts d-c applied for 1 minute across the terminals. The coil and capacitor unit shall be included in the tests specified for the **main choke coil** in Paragraphs 504.5 (b), (d) and (e).

505. Capacitors

Application

505.1. (a) Capacitors or capacitor units intended for the suppression of radio interference from trolley-bus and street-car systems operating at a nominal line voltage not exceeding 650 volts d-c shall be of 3 classes viz: Class TL for use on or in connection with the overhead line, and Classes TB and TC for use on the vehicle.

(b) Class TB capacitors shall, in general, be mounted in protected locations on the vehicle; but Class TL capacitors shall be substituted for Class TB for all locations which may be exposed to the weather, or liable to become wet during cleaning operations.

(c) Class TB capacitors are intended for connection to main or auxiliary circuits in such a way that they are joined across poles of the supply circuit, or shunted across coils or switch contacts. In all cases where capacitors have one terminal joined to the vehicle chassis (or motor frame, etc.) of a trolley-bus, Class TC capacitors shall be used in place of Class TB.

As the chassis of a street-car is connected to ground, Class TB or TL capacitors shall be used in this case.

NOTE: *Class TC capacitors are designed to have sufficient factor of safety against breakdown to obviate all risk of the vehicle chassis thereby becoming live.*

(d) 1. Capacitors shall be classified by the following nomenclature, indicative of the application of the capacitor and of its capacitance.

TABLE I
CLASSIFICATION OF CAPACITORS

Nominal Capacitance Microfarads	Classification		
	For Use on the Vehicle		For Use on or in Connection with the Overhead Line
	Across Poles, Coils, etc.	For Connection to Chassis	
0.05	TB/0.05	TC/0.05	—
0.1	TB/0.1	TC/0.1	TL/0.1
0.2	TB/0.2	TC/0.2	TL/0.2
0.5	TB/0.5	—	TL/0.5
1.0	TB/1	—	TL/1
2.0	TB/2	—	TL/2

NOTE: *Pre-set capacitors used in conjunction with inductors or subsidiary circuits are dealt with in Paragraph 108.1 of Section 1.*

2. If more than one capacitor be enclosed within a single container, this shall be designated by a multiple indication, thus: TL/0.5–0.5 for a dual capacitor unit.

3. If fuses are added see Paragraph 505.3 (b) for additional marking.

4. Tolerance: The actual capacitance value shall not differ from the nominal value by more than ±25 per cent.

(e) In the case of trolley-buses, in order to minimize the risk of shock, the total capacitance connected between the line and chassis shall not exceed 0.1 microfarad.

NOTE: *It is recommended that:*

Where TL capacitors are used in connection with overhead trolley wires they should be placed as near thereto as practicable. Each capacitor unit should be connected to the trolley wire and to the nearest traction pole by an insulated copper conductor of size not less than No. 10 B & S stranded. For metallic poles the connection to the pole may be one of the following:—

1. A welded connection similar to the copper bonds welded to the track rails at the rail joints.

2. A drop-forged copper bond of tramway type driven into a ½-in. diam. hole drilled in the pole and held by expansion by means of a steel drift pin of suitable size driven into it. The wire should be properly soldered into a hole in the bond terminal, which should be not less than ⅝-in. deep.

3. Some equivalent form of construction.

For non-metallic poles the connection from the capacitor to ground should be by means of a conductor having a cross-sectional area of not less than 0.01 sq. in. The conductor should be suitably protected, and provision should be made for a ground connection.

The resistance to ground of the ground electrode, which may be constituted by the pole itself if metallic and/or by special earth electrodes should be as low as possible and preferably not exceed 10 ohms.

Details of Construction

505.2. (a) Classes TB and TC capacitors or capacitor units shall have a casing or container of metal or moulded material or other non-ignitable, non-hygroscopic and moisture-resisting material, and shall be completely

enclosed therein except for openings for the passage of terminals or wire connections, which openings shall be thoroughly sealed with an insulating and waterproof compound e.g. compound of a bituminous nature.

(b) Such sealing compound shall not flow out of these openings when the capacitor is subjected to a continuous operating temperature of 50C (122F), and shall not melt, flake, or crack spontaneously between temperatures of 0C (32F) and 70C (158F). Capacitors shall be mounted in such a position as to ensure that the temperature of the capacitor does not exceed 70C (158F).

(c) Class TL capacitors or capacitor units shall in addition to their normal casing or container, be furnished with an outer weather-proof casing of cast or welded metal construction, completely enclosing the capacitors, fuses and any other accessories that may be used in conjunction with them, except for openings for the passage of wire connections, inspection of fusible cutouts, etc.

For all such openings adequate provision shall be made by means of appropriate seals or gaskets to prevent the ingress of water and chafing of the insulation.

(d) Terminal connections for Class TB capacitors or capacitor units shall be of flexible tinned copper wire insulated with tough rubber; alternatively the capacitor shall be fitted with terminals of the soldering or solderless type.

(e) Terminals shall be mounted on strips or blocks of non-hygroscopic insulating material.

(f) Openings for the passage of flexible wire terminal connections shall be so constructed as to prevent abrasion of the wire, and, if in a metal casing, shall be bushed with insulating material.

(g) Wire connections used either as terminals or internal connections between the capacitor elements and the external terminals shall have a conductor cross-section of not less than No. 22 B and SG.

(h) Class TL capacitors shall be supplied with at least one flexible lead of tinned copper wire, suitably insulated with tough rubber having a minimum wall thickness of $\frac{1}{8}$ in., and provided with a suitable terminal connection. The insulation on the leads shall comply with the test requirements of Appendix B.

(i) Air-gaps and creepage distances over surfaces of insulating material between the live parts of terminals and any metal casing or metal parts electrically connected to such casing, or between terminals or terminal conductors connected to opposite poles of the capacitor shall be not less than $\frac{1}{2}$ in.

(j) Capacitor elements used in the manufacture of Classes TB, TC and TL capacitors shall be constructed of metal foil and interleaving insulating material arranged non-inductively and thoroughly impregnated and sealed into the container.

Where the elements are surrounded by sealing compound, this shall not melt, flake or crack spontaneously between temperatures of 0C (32F) and 70C (158F). In all other instances capacitor elements shall be completely sealed in containers so as to exclude moisture.

(k) Class TC capacitor units may be constructed in either of the following two ways:—

1. They shall be constructed of two capacitor elements of substantially equal electrical capacity (within a tolerance of 10 per cent of each other) connected in series. (See fig. 108-2). One of these capacitor elements shall be designed to withstand the d-c test voltage of 7.500 volts specified in Paragraph 505.4 (a) (ii); the other may be designed to withstand a test of 3,000 volts d-c only. The higher-voltage element shall be connected to the "live" (or red-marked) terminal. The lower-voltage element shall be permanently shunted by a resistance of 0.25 megohm so designed as to be able to withstand without damage or deterioration the permanent application to its terminals of 600 volts d-c and the momentary application of 3,000 volts d-c.

2. They shall be constructed of 3 capacitor elements, 2 being in series for connection across the line, and the third being connected from the central point of the first two to the chassis. The 2 series capacitors (called the line capacitors) shall be designed to withstand the d-c test voltage of 7,500 volts specified in Paragraph 505.4 (a) 1 (ii); the third capacitor may be designed to withstand a test of 3,000 volts d-c only. There shall be a lead from the centre point of the tee, suitable for connection to a terminal convenient for testing purposes.

(l) As the purpose of the foregoing high-voltage tests between the elements of these capacitors is to ensure the maximum of reliability in service, it is essential that, in addition to ample dielectric thickness, ample clearances against flashover be incorporated in the design. The greatest possible care should be taken in the sealing of the container in which the capacitor elements are enclosed.

(m) A metallic plate screen or other division shall be included to separate the low-voltage capacitor element together with its shunting resistance (if any) from all other capacitor elements and connections included in the same container, and shall be so disposed as to enclose the whole of that element against the risk of electrical breakdown from any other element or part in the same container. This screen shall be insulated from the outer metal container (if any), and shall be metallically connected to the junction of the low-voltage element and the adjacent capacitor element or elements.

(n) For Class TL capacitors a fuse-link, if provided, shall be joined between each terminal of the capacitors marked for connection to a "live" pole of the circuit and the internal capacitor element or elements joined thereto. Every such fuse shall be arranged as an integral part of the casing or shall be enclosed therein, and shall comply with the following requirements:—

1. It shall be enclosed in incombustible material.
2. It shall have a clear distance between its ends ends of not less than 2 in.
3. It shall have a resistance not exceeding 1 ohm.
4. It shall have a rated current of 2 amp.
5. It shall be designed to have blowing characteristics similar to those of Type B fuses defined in British Standard 646–1935 or its equivalent.
6. It shall comply with the performance tests for Type B fuses defined in Clause 8 of the British Standard 646–1935 or its equivalent, except that the test shall be made with a d-c test voltage of 600 volts in a circuit adjusted for a prospective current of 1,500 amp.
7. It shall be insulated from any adjacent metal parts, or container within which it may be mounted in such a manner as will withstand a test-voltage of 3,000 volts d-c applied between the fuse-link and the said parts or container.

(o) For Class TB capacitors connected across opposite poles the foregoing requirements shall apply, except that the resistance shall not exceed 0.3 ohm and the rated current shall be 5 amp.

(p) No fuse shall be fitted in Class TC capacitors.

Marking

505.3. (a) Each capacitor or capacitor unit shall be marked with the appropriate classification as given in Paragraph 505.1.

(b) If fuses be provided, the type designations shall be TLF and TBF. See also Paragraph 505.2 (p).

(c) Terminals shall be appropriately marked for purposes of identification and a diagram of connections shall be supplied.

(d) The terminal connections to all capacitors intended for joining to the live pole of the associated circuit shall be red; such terminals shall be those joined to fuses forming part of the complete capacitor unit.

(e) Terminal connections intended for joining to ground or chassis of the vehicle shall be black. Fuses shall not be included in this terminal connection.

Tests

505.4. (a) The nature and thickness of the insulating material used in the construction of the capacitor elements and the method of their assembly in the container shall be such that the complete capacitor shall be capable of withstanding the following tests:—

1. Dielectric Strength:

(i) **Class TB and TL Capacitors:** A test voltage of 3,000 volts d-c shall be applied between terminals of the capacitors and also between all terminals and the metal casing (if any) for a period of 1 minute.

(ii) **Class TC Capacitors:** A test voltage of 7,500 volts d-c shall be applied between the outer terminals of the capacitor for a period of 1 minute. Where these capacitors are fitted into metal containers, the black terminal or terminal wire shall be connected to the container for this test; and a second similar test shall also be applied between both terminals of the capacitor and the metallic case.

If this test be made with rectified ac-, the rms ripple voltage super-imposed upon the d-c voltage shall not exceed 6 per cent of such d-c voltage.

2. Insulation Resistance:

Tests for insulation resistance shall be made with a d-c voltage of not less than 500 volts applied for a period of 1 minute. The insulation resistance at a temperature of 20C (68F) shall be not less than the following values:

TABLE II
INSULATION RESISTANCE

Classification of Capacitor	Insulation Resistance	
	Between Terminals of Caoacitor (Megohms)	Between Terminals and Metal Casing (Megohms)
TB/ or TC/ or TL/0.05 TB/ or TC/ or TL/0.1	3000	
TB/ or TC/ or TL/0.2 TB/ or TC/ or TL/0.5	2000	500
TB/ or TC/ or TL/1	1000	
TB/ or TC/ or TL/2	500	

Where the ambient temperature at the conclusion of the test differs by a few degrees from that at the commencement, an appropriate allowance on the measured insulation resistance values shall be made.

(b) Capacitors shall be heated in an enclosure to 65C (149F), and then immersed for 24 hours in a solution of 38 gm. of sodium chloride (NaCl) in 1 kgm. of distilled water, maintained at a temperature of 25C (77F).

(c) At the conclusion of the foregoing test and while at room temperature, the product of the insulation resistance and capacitance shall be not less than 100 megohm-microfarads.

(d) There shall be no corrosion, and no visible signs of softening of the sealing compound or escaping of the impregnating materials.

APPENDIX A

CLASSIFICATION OF INSULATING MATERIALS

NOTE: *The following Classification is adapted from A.I.E.E. Standard No. 1 June 1940.*

1. **Classification of Materials:** Insulating materials are classified in the following way:—

(a) **Class O:** Cotton, silk, paper and similar organic materials when neither impregnated nor immersed in oil.

(b) **Class A:** Cotton, silk, paper and similar organic materials when impregnated or immersed in oil also the substance known as enamel applied to enamelled wire.

NOTE:—*Impregnated Cotton, Paper or Silk (also Compound-treated insulation). An insulatiin is considered to be "impregnated" when a suitable substance replaces the air between its fibres, even if this substance does not completely fill the spaces between the insulated conductors. The impregnating substance, in order to be considered suitable must have good insulating properties; must entirely cover the fibres and render them adherent to each other and to the conductor; must not produce interstices within itself as a consequence of evaporation of the solvent or through any other cause; must not flow at the temperature limit specified; must not unduly deteriorate under prolonged action of heat.*

(c) **Class B:** Mica and asbestos and similar inorganic materials in built-up form or combined with binding cement,. If Class A material is used in small quantities for structural purposes only, in conjunction with Class B insulation, the combined materials may be considered as Class B, provided the electrical and mechanical properties of the insulated winding are not impaired by the application of the temperature permitted for Class B material. (The word "impair" is here used in the sense of causing any change which could disqualify the insulating material for continuous service.)

(d) **Class C:** Mica, without binding cement, porcelain, glass quartz and other similar materials.

2. **Insulation Made up of Different Materials:** When the insulation is made up of different materials (except in those cases defined under Class B) the temperature rise attained by each material shall not exceed the limit permitted for that material.

3. **Examples:**

(a) When the different insulating materials are used on various parts of one winding (for instance, in the slot and for the end windings) the limit of temperature rise applicable to any part of the winding is that set for the insulation used on the part.

(b) When the insulation on any part consists of superimposed layers of insulating materials falling in different classes (for instance, superimposed layers of Class A and Class B material) the two following cases arise:

(i) If it is possible to measure the temperatures attained by the various layers, each of the materials is entitled to the temperature rise which is assigned to it.

(ii) If it is not possible to measure the temperatures attained by the various layers, the temperature rise applicable to the part of the winding under consideration is to be taken as that for the insulating material with the lowest limit.

APPENDIX B

TESTS FOR INSULATING CONDUCTORS

FOR CONNECTIONS TO CLASS TL CAPACITORS

Tough rubber sheathed cable for use in connection with Class TL capacitors shall be suitable for meeting the following tests:

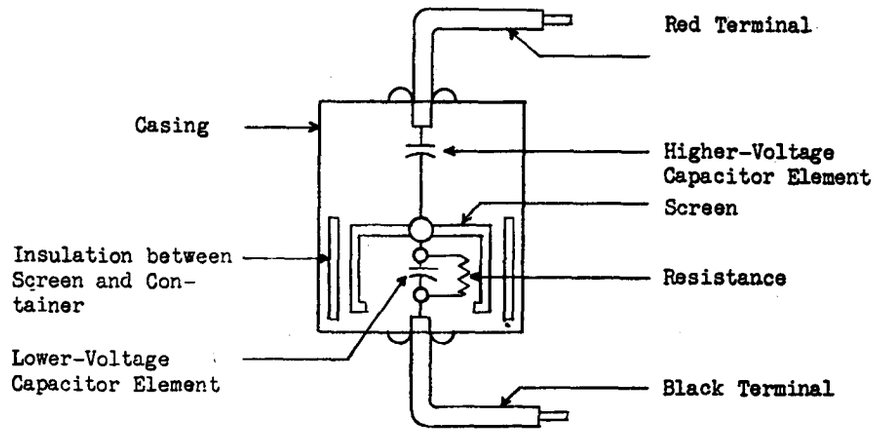
(a) **Voltage Test on Insulated Conductors:** Every length of insulated conductor shall be subject to an a-c voltage test of 6,000 volts (rms) at any convenient frequency between 25 and 100 cycles per second and approximately of sine-wave form, between conductor and earth for 5 minutes after 12 hours' immersion in water, and while still immersed.

(b) **Extended Voltage Tests on Samples of Finished Cable:** The cable shall be capable of withstanding the following test:—

Nine turns of a sample of the finished cable wound on to a metal mandrel having a diameter of 5 times that of the overall diameter with a pitch equivalent to the diameter of the mandrel shall be subjected to an a-c voltage test of 8,000 volts (rms) at any convenient frequency between 25 and 100 cycles per second and of approximately sine-wave form, for a period of 1 hour, voltage being applied between conductor and earthed mandrel. During tests the wound mandrel shall be left suspended freely in air.

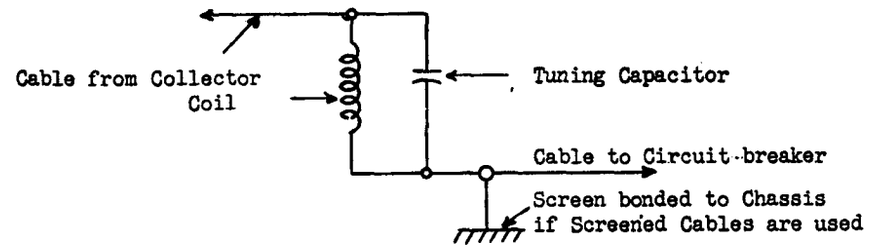
(c) **Moisture-absorption Test:** The following moisture-absorption test shall be carried out on all cable except metal-covered cable:

One 6-in. sample, taken from each consignment, with ends sealed in paraffin wax, shall absorb not more than 10 per cent by weight after immersion in water for 24 hours.



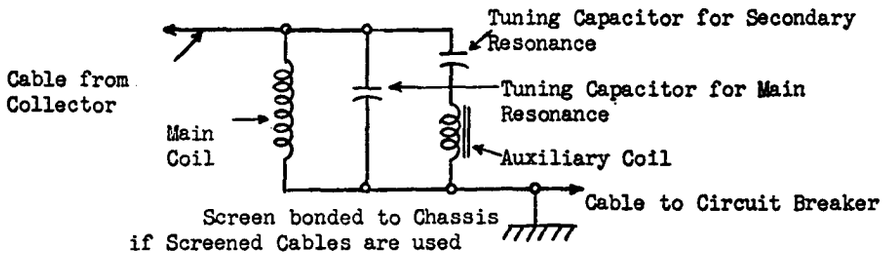
CONSTRUCTION OF CLASS T-C CAPACITORS

FIG. 108-2



CIRCUIT ARRANGEMENT OF SINGLE-WAVE CHOKE COIL

FIG. 108-3



CIRCUIT ARRANGEMENT OF ONE FORM OF DOUBLE-WAVE CHOKE COIL

FIG. 108-4