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SHIELDING FOR THE SUPPRESSION OF RADIO INTERFERENCE

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TELECOMMUNICATION REGULATORY SERVICE

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SHIELDING FOR THE SUPPRESSION OF RADIO INTERFERENCE

SECTION 1 - GENERAL

1.1 Necessity for Shielding.

Interference to radio communications may be caused by the operation of electrical equipment whenever radio noise on communication frequencies is radiated or conducted from the apparatus. When such radio noise exceeds specified tolerable limits, or harmful interference to communication occurs, the radio noise must be suppressed.

Shielding is the only known method of suppressing radio noise which is radiated directly from the apparatus. As the noise invariably leaves the apparatus by both conduction and radiation, it is also necessary to insert interference suppressors in the power line supplying the apparatus, and in all conductors which pass through the shield.

1.2 General Requirements of a Good Shield.

1.2.1 Include all noise radiators.

The shielded enclosure must include all components and accessories of the noise producing apparatus and any object which may radiate. For example, a shielded cubicle for the suppression of radio noise from diathermy apparatus must enclose, in addition to the apparatus, the patient and operator.

1.2.2 Conductivity of Shielding Material.

The effectiveness of a shield largely depends on the use of material which has a low surface impedance and is continuous.

1.2.3 Continuity.

It is very important that no breaks occur in the shield, such as openings around the perimeter of a door, etc. The material may be either sheet metal, metal foil, or woven screen, provided that the contacts between the wires of the screen are of very low impedance. Galvanized wire mesh provides an excellent material for screening, provided that the mesh is galvanized after weaving. Very small openings in the shield, such as the mesh of wire screening, are not detrimental. A crack 3 - 4 centimetres long, even though less than 0.2 millimetres wide, is usually detrimental. It is, therefore, important that all sections of the shield, such as panels and door openings, etc., be thoroughly bonded. A defect in the shielding produced by paint preventing thorough bonding between sheet metal plates, may form an opening for the radio noise similar to a slot antenna, and allow excessive radiation at high frequency.

1.3 Types of Shielding Material.

A number of materials are available for shielding purposes including:-

Sheet metal, such as aluminum or copper, galvanized iron, etc.

Metal foil, such as aluminum or copper, which may be less than 0.01 millimetres thick.
Metal foil mounted on paper or plywood is frequently used.

Wire gauze or screening and perforated metal, provided that the perimeters of the openings do not exceed two centimetres. The finer the mesh the more effective is the shielding, particularly at high frequencies.

NOTE: Most so-called conducting paints are of limited value for screening, on account of the high impedance. The binder insulates the conducting particles of metal or carbon from each other.

1.4 Single and Double Shield.

A single shield, well constructed and maintained, should provide an attenuation of 40 dB (99% effective) or greater. When a more effective shield is required double or triple shielding should be considered (see para. 2.1).

The usual method of providing a double shield for a room or cubicle is to provide a framework of well-dried lumber preferably sealed to prevent the absorption of moisture. Cover the inside and outside with the shielding material from four to eight centimetres apart. For best results it is important that there should be no contact or electrical connection between the inside and outside shields, except at one point usually where the power supply enters, where the inner and outer shields are bonded together.

Another method of constructing a double shield is the use of a type of construction known as cell type in which panels shielded on both sides and bonded around the perimeter are assembled to form a complete enclosure. Further details of construction are given in subsequent sections.

1.5 Automatic Switch.

In cases where serious interference may arise with the door open, a switch or relay should be installed on the door frame which will make it impossible to operate the machine with the door open. As an alternative, a warning signal may be used to indicate when the door is open.

SECTION 2 - ATTENUATION REQUIRED AND METHODS OF TESTS

2.1 Type of Shield.

Before construction is commenced consideration should be given to the effectiveness or attenuation required. The required attenuation may be calculated by dividing the intensity of the noise from the unsuppressed source, by the permissible intensity of the reduced noise. If the levels are expressed in decibels they should of course be subtracted.

In deciding the attenuation required a liberal allowance should be made for possible deterioration of the shielding with age and the possibility of new radio receiving stations being installed in the vicinity.

As a general rule, single shielding may be relied on for an attenuation of 40 dB (a reduction of 100 times of the field strength in microvolts per metre). However, careful design, construction, and maintenance of the enclosure, together with good line suppression, may result in attenuation up to 66 dB (a 2,000 times reduction of the field in microvolts).

When attenuation greater than 40 dB is required the merits, complexity, and costs of single and multiple shielding, should be compared before a decision is made. With care, double shielding may give attenuation of the order of 100 dB (a 100,000 times reduction of the field in microvolts).

2.2 Measurements of Radiated Noise Intensity.

Unless an estimate can be made of the intensity of the unsuppressed noise, tests should be conducted.

2.2.1 Standard Noise Measuring Instrument.

Canadian Standards Association Standard C 108.1.1 - 1977 "Electromagnetic Interference Measuring Instrument - C.I.S.P.R. Type", specifies the circuit characteristics of the standard noise measuring instrument.

2.2.2 Location of Noise Meter.

The various standards of CSA series C 108 specify the location of the noise meter relative to the noise source for measurements in connection with recommended limits from various types of interfering apparatus.

2.3 Attenuation of the Power Line Filter or Suppressor.

A filter should be installed in the power supply leads to the interfering apparatus at the point where they enter the shielded enclosure, and this suppressor should provide sufficient attenuation of the conducted radio noise to ensure that the remaining noise on the

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conductor outside the cage is sufficiently low.

The effectiveness of the filter is usually expressed in terms of insertion loss (attenuation) in dB for a specific frequency or frequency band. The insertion loss should be measured in the laboratory but as the effectiveness of the filter may differ in actual practice it is recommended that 10 to 20 dB additional insertion loss be required.

Some of the factors which should be taken into consideration in the design of the filter are:

(a) Frequency range over which the filter is required to be effective.

(b) Power requirements of the power supply.

(c) Ability of the filter to operate under the environmental conditions such as temperature, humidity and corrosion.

To help cope with conditions such as are outlined in section (c), a proper cabinet for housing the filter should be considered.

Power line filters and cabinets are available from engineering firms as stock items or can be custom built.

2.4. Test of Shields for Leaks of RF Energy.

2.4.1 Scanning The Spectrum.

After the shielding has been completed and the suppressors installed in all conductors entering the shield, tests may be made to determine the location of any faulty construction of inadequate suppression.

A portable sensitive radio receiver may be used at various points, approximately 3 metres from the shield. In each location the section of the radio frequency spectrum of interest should be scanned, and the location of the instrument and the frequency of the noise should be noted. If it is found that the noise field within 30 centimetres of the conductors is considerably greater than elsewhere, the effectiveness of the interference suppressor should be improved.

2.4.2 Location of Faults.

When the suppressors are considered satisfactory, according to this test, more detailed investigation may be made by probing.

A small portable radio receiver with loop antenna, or a noise meter with a loop probe, may be used to investigate the noise field in close proximity to the outside of the shield. The sensitivity of the receiver or noise meter should be reduced so that the minimum noise near the shield is just perceptible. The noise field near all openings such as doors, windows, and near the joints of the shielding material, should be investigated. The suppression should be improved at all places where the noise is found to be excessive.

A useful indicating device for locating leaks can be easily constructed using a tuned circuit consisting of a coil and tuning capacitor together with a 0-100 microampere meter diode detector (1N34).

SECTION 3 - SHIELDING ROOM OR CUBICLE

3.1 Location.

3.1.1 For noise suppression a preferred location for radio frequency equipment for industrial or medical purposes, is on the ground floor or in the basement of a building. If located elsewhere, greater care in the design and construction of the shielding is required, to attain the same degree of suppression.

3.1.2 The shielding should not be very close to wiring of power or communication circuits which may pick up the radio frequency energy from the eddy currents in the shielding. Any wiring in the walls adjacent to the shielding should be in grounded conduit.

3.1.3 No metal pipes, such as used for heating or ventilating should be within a few centimetres, or touch or enter the shielding, if the same can be avoided. If it is necessary that pipes should enter the shield they should enter very close to the point where the power circuit enters, and should be bonded to the shielding at the one location only. Connection to the shield at more than one point may provide a loop which may transmit noise energy.

3.2 Doors, Windows, Light, Ventilation, Appearance, etc.

In order to decide on the type of construction, consideration should be given to various requirements, such as doors, windows, light, ventilation, appearance, etc. The appearance of a shielded room or cubicle for use in diathermy treatment is of greater importance than the appearance of a screened enclosure in a factory. Light and ventilation may be provided by the use of wire screen for the walls and the ceiling or parts thereof, and sheet metal or metal foil may be used where light and ventilation are not required.

To avoid the possibility, in electro-medical work, of electric shocks a dado of wallboard may be installed about one metre high around the inside of the booth. This also protects the screen from mechanical injury and may improve the appearance of the booth.

3.3 Choice of Cubicle or Shielding Walls of Building.

The walls of an existing building or new permanent walls may be shielded, or a cubicle installed which may be either fixed or portable. Tenants frequently prefer a portable cubicle which may be removed in sections.

Prefabricated cubicles of various standard sizes, consisting of sections which may be conveniently assembled, may be purchased.

3.4 Use of Metal Foil.

3.4.1 Material

Copper or aluminum foil, when properly applied, forms an excellent shield for the suppression of radio noise. Large sheets of unmounted foil are difficult to handle and, therefore, copper and aluminum foil for this purpose is usually supplied mounted on a paper base or some form of wall board. "Copper Armored Fibreen" is a trade name for one of these products.

3.4.2 Preparation of Room.

The room to be shielded should be prepared by removing as many of the projections and fixtures as possible, so as to provide plain smooth surfaces for the shielding material. The electric fixtures, doors, base boards, window and door moldings, picture moldings, and other irregularities should be temporarily removed. The surface of the walls, ceiling, floor and door should be made as regular as possible, and wall board may be fitted over irregularities, such as panels.

3.4.3 Shielding Ceiling and Walls.

Paper backed foil may be mounted on the walls and ceiling with the use of a good waterproof glue. The foil may be applied to the walls in vertical strips, metal surface showing, in a manner similar to that of mounting wallpaper. Care should be taken to make perfect contact between the paper backed foil and the wall and to avoid the trapping of air bubbles. A paperhanger's heavy brush may be used, or a wide roller.

If tinned copper bonding strips are available, copper foil may be mounted with butt joints, as described in paragraph 3.4.5. These butt joints should be made on the flat surface, avoiding the corners wherever possible. If tinned bonding strips are not available, one edge of the paper backed copper foil must be folded before mounting, as described later.

In cutting the foil a few extra centimetres should be allowed for any irregularities in the shape of the room, and the foil trimmed to size when mounting. Ten extra centimetres should be allowed, to permit the wall strips to extend along the floor.

3.4.4 Shielding Floor.

The floor may be covered with paper backed foil, or other shielding material. If foil is used it is recommended that the metal surface be turned down, so as to avoid being damaged during the construction period, or by wear due to slight movement of the linoleum or other floor finish. In order to bond the floor to the walls, it is necessary to fold the edge two centimetres or more, bringing the

metal surface available for bonding to the walls and to the adjacent strips. Great care must be exercised to ensure that there are no loose boards or any irregularities which might cut through the foil. After the bonding, linoleum may be laid on the floor and may or may not be cemented, as desired.

The floor shielding may be bonded to the bottom of the doorway in the following manner:-

The linoleum should be cut in a straight line immediately below the door. Sheet copper may be bonded to the floor shielding and brought up to the surface of the lincleum where it is bonded to a brass sill. This brass sill should be two centimetres or more in width, 1.5 millimetres in thickness, and of a length equal to the width of the doorway.

A simpler method of treating the bottom of the doorway may be tried in cases where no electric wiring below the floor is within one metre of the door. This method consists of extending the floor shielding 30 centimetres beyond the door and omitting the metal door sill, described above. The gap between the floor shield and the door shield should be as small as possible. If tests indicate insufficient suppression, it will probably be necessary to bond the bottom of the doorway, as described in the previous paragraph.

3.4.5 Bonding Copper Foil.

All butt joints of copper foil should be bonded with a tinned copper strip five centimetres wide. The foil should be thoroughly cleaned and flux applied at all butt joints for a width of about five to six centimetres, to ensure that the area covered by the strip is completely cleaned and covered with flux. The bonding strip should then be applied and soldered by merely applying a hot iron and immediately pressing the copper strip to the foil with a handful of cotton waste. A soldering iron (250 watt), having a special five centimetres broad tip, may be used.

When tinned copper strips are not available, paper backed foil may be soldered, provided that precautions are taken to avoid the heat from the soldering iron causing the tar used to mount the copper foil on the paper, from running out. One edge of the paper backed foil should be folded over two centimetres (copper face outside rolled flat) before mounting. This folded edge is then mounted, overlapping the plain edge of the strip previously mounted. The edge of the folded joint and the two centimetres of the lower strip should be cleaned and flux applied. "Plumber's Black" may be applied to the adjacent surface, to prevent the solder from flowing where it is not required. The joint should then be soldered and wiped. Those experienced in making lead pipe joints can make a neat bond.

3.4.6 Bonding Aluminum.

Paper backed aluminum foil may be mounted by folding the edges of the adjacent strips in the form of a pleat with the metal sides together. This type of bond usually requires tacking at frequent intervals, or covering with a molding strip of wood or metal, to provide pressure.

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All bonds between ceiling, walls, and floor shielding, and around the windows and doors may be made in a similar manner.

3.4.7 Wiring and Piping near Shield.

There is a considerable field of radiation within a few centimetres of all shielding and it is therefore, necessary to keep all unshielded wire more than thirty centimetres from the outside of the shield. Where such wiring exists, it should be either relocated or placed in conduit.

Long lengths of metal conduit, water or other pipes should not be run in close proximity to the shield, and in no case should conduit or other piping come within five centimetres of the shield.

All pipes or metal which pass through the shielding, such as used for heating, ventilating, water, or electric conduit, should be thoroughly bonded to the shielding; also, the shielding should be fitted tightly around such pipes. Before bonding, care should be taken to ensure that such piping is properly grounded.

All conduit boxes should be covered with a metal plate and bonded to the shield with a short lead. Hot and cold air registers and ventilators should be covered with bronze wire mesh behind the grating.

3.4.8 Door.

The molding which protrudes from the surface of the door may be removed and the panels filled in to a flush surface by wallboard. The surface may then be made smooth by filling crevices with linoleum cement. Paper backed metal foil is then mounted over the door and continued over all edges.

A screen door may be used provided it is completely shielded and bonded on all sides. A screen door frame may be made of wood and covered with insect wire cloth either copper, bronze or iron wire galvanized after weaving. The wire cloth should extend over the entire surface and over the four edges. The screen on the edges should then be covered with spring bronze weather strip. The weather strip should be nailed to the door and soldered to the screen.

3.4.9 Window.

The window should be covered with a wire mesh, either inside or out, as desired. The screen should be thoroughly bonded on all sides with the wall shield. This may be accomplished by using spring bronze weather strip.

3.4.10 Replace Moldings, etc.

The base boards, window and door frames, and door, may then be replaced.

3.4.11 Finish.

The foil should first be cleaned with a weak solution of acetic acid or vinegar and should then be given a coat of sizing, as ordinary paint and paste for wall paper will not adhere to metal finish. This sizing may consist of shellac or lacquer. Paint, enamel or wallpaper may be applied in the ordinary manner. Some prefer the natural appearance of the copper. If this is required, however, the copper should be thoroughly cleaned and be given a coat of clear lacquer, as otherwise the metal will tarnish.

The woodwork may require to be repaired and refinished.

3.5 Power Supply.

The power is provided through an interference suppressor, mounted in an iron box at the point where the service enters. All circuits in the room for lighting or power must be provided through this suppressor.

SECTION 4 - SHIELDING APPARATUS

4.1 General.

A shield for apparatus generally requires to be even more carefully constructed than the shield for a room, due to the fact that conductors carrying large noise currents are frequently in close proximity to the shield. The general instructions given in Sections 1 (General) and 2 (Attenuation Required and Methods of Tests) should be carefully followed, and many of the suggestions given in Section 3 regarding shielding a room or cubicle, are also applicable to the shielding for apparatus.

4.2 Generator and Load Circuit within a Single Shield.

Wherever possible, a single enclosure should contain the entire installation including the RF generator and load circuit. When one generator supplies RF energy for a number of applicators, great care must be taken to ensure that the various sections of the shield are at the same RF potential.

4.2.1 RF Transmission Line.

In order to prevent radiation from the transmission line connecting the generator with the applicator or load circuit, this line should be double shielded.

4.3 Material.

Sheet metal which has sufficient strength and is noncorroding and has low surface conductivity, is best for all parts of the shield except where ventilation is required. Sheet copper or galvanized iron are suitable.

Where ventilation is required panels may be made of woven wire, but is essential that the resistance of each wire contact of the mesh, and from the screen to the frame remains extremely low. Woven wire galvanized after weaving, or perforated galvanized iron, is suitable, provided that the circumference of the largest opening does not exceed two centimetres.

4.4 Construction

The bonding between panels should preferably be continuous, by either welding or soldering. If the panels are to be spot welded, rivetted, or bolted, the panels should have a liberal overlap and the connecting points close together. It is essential that the bonding between panels has very low resistance at all points and maintains this low resistance throughout its life.

4.5 Openings for Inspection and Movement of Products.

The doors of all openings should have a liberal overlap and means provided to ensure low contact resistance at all points about their perimeters. In order to ensure low contact resistance at all times the contact must be kept free from dirt or corrosion. A wiping contact at the door tends, as the door is closed, to remove dust and loose dirt which might otherwise increase contact resistance. Some type of spring material or cushion is required between the door and the door frame, and this may be spring bronze weather stripping or copper braid covering a rubber tube.

4.6 Grounding.

The grounding of the shield is not essential for the suppression of radio noise. In fact, the radiation of noise is sometimes increased by grounding the shield. The shield is usually required to be grounded according to safety regulations. If it is found that the grounding increases the radiation of noise, the RF currents may be kept out of the ground wire by the insertion of a radio frequency choke. All connections from shield to ground, including the power supply conduit, must be treated in this way. The choke coil should have a current carrying capacity equal to that of the ground wire and should be enclosed in a metal shield throughly bonded to the shield of the interfering apparatus.

SECTION 5 - MEANS OF IMPROVING EFFECTIVENESS OF A SHIELDED ROOM OR CAGE

5.1 Conducted Noise.

When the radio noise on any conductor is found to be excessive, an effort should be made to improve the installation of the suppressor, paying particular attention to the bonding of the suppressor.

The suppressor case should be thoroughly bonded to the shielding material of the room or cage. The case of the suppressor should be in rigid contact with the shielding at the point where the electric circuit enters the shield. The use of leads for bonding the suppressor case to the shield of the room or

compartment is not satisfactory, as the impedance of leads will retard the flow of the noise currents from the suppressor to the shield.

Ensure that all instructions for the installation of the suppressor have been accurately carried out.

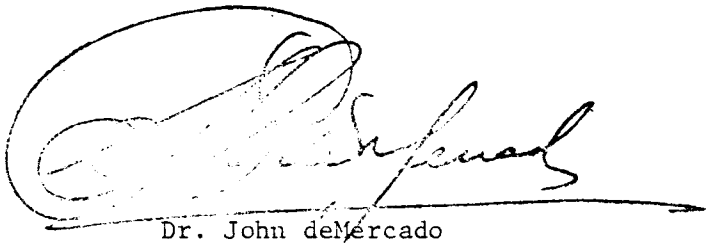
If, after the best suppressor for the purpose has been correctly installed and the noise on the conductor is excessive, the bonding of the conduit from the suppressor to ground should be checked. The ground lead from the conduit to earth should be as short as possible, preferably only a few centimetres. If necessary, a special driven ground should be used for the purpose and the conduit carried to this driven ground.

Where radio noise is excessive on other conductors which do not enter the shield, it may be caused by such conductors being closely coupled to the shielding material. Wherever possible no electrical conductors should be run within twenty centimetres of the shielding materiel. Where it is impossible to provide sufficient space for such conductors, the section of such conductors in close priximity to the shield should be enclosed in grounded metal conduit.

5.2 Radiated Noise.

After all leaks found by the method of test described in para. 2.4 have been corrected, and the radiated interference is found to be excessive, improved suppression may be attained by adding an additional shield in parts of the interior of the enclosure.

Where conductors carrying large noise currents are in close proximity to the shielding material, excessive eddy currents are induced in this shield. These excessive eddy currents may cause excessive radiation beyond the shielded enclosure. In order to prevent this condition the coupling between the conductors carrying excessive noise currents within the shield and the shielding material should be reduced, either by increased separation or additional shield. If such conductors are lying on the floor improved suppression may be attained by installing a sub-floor, to increase the separation of such conductors from the shield, or a barrier to keep the wires from the shielding on the wall. If this separation should not be sufficient, an extra partial shield may be installed here and bonded to the common bond at the electric power inlet.



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