

**Thai Industrial Standard  
for  
Lighting and similar equipment:radio disturbance limits**

**1 Scope**

- 1.1 This standard defines the limits of radio disturbance signal(radiated and conducted) from :
- lighting equipment with a primary of generating and/or distributing light intended for illumination purposes, and intended either for connection to the low voltage electricity supply or for battery operation ;
  - the lighting part of multi-function equipment where one of the primary functions of this is illumination;
  - independent auxiliaries for use with lighting equipment;
  - UV and IR radiation equipment;
  - neon advertising signs;
  - street/flood lighting intended for outdoor use;
  - transport lighting (installed in buses and trains).
- 1.2 This standard does not apply to the followings:
- lighting equipment for aircraft and airports;
  - apparatus for which the electromagnetic compatibility requirements in the radio-frequency range are explicitly formulated in other TIS or IEC or CISPR publications.
- Note Examples are:
- built-in lighting devices in other equipment, for example scale illumination or neon devices;
  - photocopiers;
  - slide projectors;
  - lighting equipment for road vehicles.
- 1.3 The frequency range covered is 9 kHz to 400 GHz.
- 1.4 Multi-function equipment which is subjected simultaneously to different clauses of this standard and/or other standards shall meet the provisions of each clause or standard with the relevant functions in operation. The limits in this standard have been determined on a probabilistic basis to keep the suppression of disturbances within economically reasonable limits while still achieving an adequate level of radio protection and electromagnetic compatibility. In exceptional cases additional provisions may be required.

**2 Definitions**

For the purpose of this standard, the following definitions apply:

- 2.1 Lighting and similar equipment means any equipment, such as incandescent lamp luminaires, fluorescent lamp luminaires, dimmers transformers convertors for lamps, ballasts for discharge lamps (including fluorescent lamps), semi-luminaires for compact fluorescent lamps and for incandescent lamps, self-ballasts lamp, including the equipments or components in clause 1.1.
- 2.2 Continuous disturbance means either broadband disturbance, i.e. disturbance caused by the switching operations or by unstable gas-discharges in the lamp electrode region, or narrowband disturbance, i.e. disturbance caused by electronic control devices operating at dedicated frequencies.

*Note* Instead of the concept of “broadband” and “narrowband”, a distinction is made in this standard between two related kinds of disturbance, defined by the type of the applied detector. For this purpose, limits have been defined with respect to the measurement with the quasi-peak detector and with the average detector. By using this approach broadband and narrowband disturbances also can be assessed.

### 3. Limits

#### 3.1 Frequency ranges

In clauses 3.2, 3.3 and 3.3 limits are given as a function of frequency range. No measurements need to be performed at frequencies where no limits are specified.

*Note* The World Administrative Radiocommunications Conference (WARC) in 1979 has reduced the lower frequency limit in region 1 to 148.5 kHz; for applications falling within the scope of this standard, tests at 150 kHz are considered adequate, since 148.5 kHz falls within the receiver bandwidth.

#### 3.2 Insertion loss

The minimum values of the insertion loss for the frequency range 150 kHz to 1 605 kHz are given in table 1

**Table 1 Minimum values of insertion loss**  
(Clause 3.2)

Frequency range kHz	Minimum values dB
150 to 160	28
160 to 1 400	28 to 20*
1 400 to 1 605	20
* Decreasing linearity with the logarithm of frequency.	

#### 3.3 Disturbance voltages

##### 3.3.1 Mains terminals

The limits of the mains terminal disturbance voltages for the frequency range 9 kHz to 30 kHz are given in table 2a.

**Table 2a – Disturbance voltage limits at mains terminals**  
(Clause 3.3.1)

Frequency range	Limits dB( $\mu$ V)*	
	Quasi-peak	Average
9 kHz to 50 kHz**	110	-
50 kHz to 150 kHz**	90 to 80***	-
150 kHz to 0.5 MHz	66 to 56***	56 to 46***
0.5 MHz to 5 MHz	56	46
5 MHz to 30 MHz	60	50
* At the transition frequency, the lower limit applies.		
** The limit values in the frequency range 9 kHz to 150 kHz are considered to be “provisional limits” which may be modified after some years experience.		
*** The limit decreases linearly with the logarithm of the frequency in the ranges 50 kHz to 150 kHz and 150 kHz to 0.05 MHz.		

### 3.3.2 Load and control terminals

The limits of the load and control terminal disturbance voltages for the frequency range 150 kHz to 30 MHz are given in table 2b.

**Table 2b – Disturbance voltage limits at load and control terminals**  
(Clause 3.3.2)

Frequency range MHz	Limits dB( $\mu$ V)*	
	Quasi-peak	Average
0.15 to 0.50	80	70
0.50 to 30	74	64
* At the transition frequency the lower limit applies.		

### 3.4 Radiated electromagnetic disturbances

The quasi-peak limits of the magnetic component of the radiated disturbance field strength in the frequency range 9 kHz to 30 MHz measured as a current in 2 m, 3 m or 4 m loop antennas around the lighting equipment, are given in table 3.

The limits for the 2m loop diameter apply to equipment not exceeding a length of 1.6m, those for the 3m loop diameter for equipment having a length in between 1.6m and 2.6m and those for the 4 m loop diameter for equipment having a length in between 2.6m and 3.6m.

**Table 3 – Radiated electromagnetic disturbance limits**  
(Clause 3.4)

Frequency range MHz	Limits for loop diameter dB( $\mu$ A)*		
	2 m	3 m	4 m
9 kHz to 70 kHz	88	81	75
70 kHz to 150 kHz	88 to 58**	81 to 51**	75 to 45**
150 kHz to 2.2 MHz	58 to 26**	51 to 22**	45 to 16**
2.2 MHz to 3.0 MHz	58	51	45
3.0 MHz to 30 MHz	22	15 to 16***	9 to 12***

\* At the transition frequency, the lower limit applies.  
\*\* Decreasing linearly with the logarithm of the frequency.  
\*\*\* Increasing linearly with the logarithm of the frequency.

### 3.5 Limits at designated frequencies

Certain frequencies are designated by the International Telecommunication Union (ITU) for use as fundamental frequencies for ISM equipment (Resolution No. 63 (1979) of ITU regulations) These frequencies and related field strength limits are listed in table 4.

**Table 4 – Limits of disturbance field strengths at frequencies designated for use by ISM equipment**  
(Clause 3.5)

Central Frequency MHz	Frequency band MHz	Limit of disturbance Field strength dB ( $\mu$ V/m) Measured at 10 m distance	No. of appropriate footnote to The table of frequency allocation of the ITU radio regulations
6.780	6.765 to 6.795	100 (magnetic component)	524*
13.560	13.553 to 13.567	100 (magnetic component)	534
27.120	26.957 to 27.283	100 (magnetic component)	546
40.680	40.660 to 40.700	100 (electric component)	548
433.922	433.050 to 434.790	100 (electric component)	611*, 622 (region 1 only)
915	902 to 928	100 (electric component)	707 (region 2 only)
2 450	2 400 to 2 500	100 (electric component)	752
5 800	5 725 to 5 875	100 (electric component)	806
24 125	24 000 to 24 250	100 (electric component)	881
61 250	61 000 to 61 500	100 (electric component)	911*
122 500	122 000 to 123 000	100 (electric component)	916*
245 000	244 000 to 246 000	100 (electric component)	922*

\* Use of these frequency bands shall be subjected to special authorization by administrations concerned in agreement with other administrations whose radio communication services might be affected.

## 4 Application of limits

### 4.1 General

Application of the limits for various kinds of lighting equipment as mentioned in the scope of this standard are given in 4.3 to 4.9

No emission requirements apply to lamps other than self-ballasted lamps nor to auxiliaries incorporated in luminaires, in self-ballasted lamps or in semi-luminaires. (See note 2 of 4.4.1)

The disturbance caused by manual or automatic operation of a switch (external or includes in equipment) to connect or disconnect the mains shall be disregarded. This includes manual on/off switches or, switches activated by sensors or ripple control receivers. However, switches which will be repeatedly operated (e.g. such as those of advertising signs) are not included in this exception.

### 4.2 Designated frequencies

Any kind of lighting equipment may operate at the designated frequencies as described in 4.5. Such equipment shall comply with:

- the field strength limits as given in table 4;
- the disturbance voltage limits as given in 4.3, except for the designated frequency bands listed in table 4, where the limits are under consideration;
- the radiated disturbance limits outside the frequency bands as given in table 3.

#### 4.3 Indoor luminaires

##### 4.3.1 General

The following conditions apply to all kinds of indoor luminaires irrespective of the environment in which they are used.

##### 4.3.2 Incandescent lamp luminaires

Incandescent lamp luminaires, where the lamps are a.c. or d.c. operated or which do not incorporate a light regulating device or electronic switch, are not expected to produce electromagnetic disturbance. Therefore they are deemed to fulfil all relevant requirements of this standard without further testing.

Note – Where in this standard the term “incandescent lamp” is used, all type of incandescent lamps including halogen lamps are meant.

##### 4.3.3 Fluorescent lamp luminaires.

The minimum values of insertion loss of table 1 shall apply where a fluorescent lamp luminaire is a starter switch operated type and designated for one of the following lamp types:

- linear fluorescent lamps with a nominal diameter of 15 mm, 25 mm or 38 mm;
- circular fluorescent lamps with a nominal diameter of 28 mm or 32 mm;
- U-type fluorescent lamps with a nominal diameter of 15 mm, 25 mm, or 38 mm;
- Single-capped fluorescent lamps, without starter and with a nominal diameter of 15 mm;
- Single-capped fluorescent lamps, linear shaped, twin and quad tube, with integrated starter and having a nominal diameter of 12 mm.

##### 4.3.4 Other luminaires

Indoor luminaires other than described in 4.3.2 or 4.3.3 shall comply with the main terminal voltage limits given in table 2a. Where the luminaire supplies the lamp (s) with a current having an operation frequency in excess of 100 Hz, it shall comply with the field strength limits given in table 3.

Where the light output of the luminaire is regulated by an external device, the disturbance voltage at control terminals shall not exceed the limits given in table 2b.

#### 4.4 Independent auxiliaries exclusively for use with lighting equipment

##### 4.4.1 General

Independent auxiliaries are electric or electronic devices designed to be applied external to a luminaire and to be used to control the current or voltage of a discharge or incandescent lamp. Examples are dimmers, transformers and convertors for lamps, ballasts for discharge lamps (including fluorescent lamps) and semi-luminaires for compact fluorescent lamps and for incandescent lamps.

*Note 1 - The requirements described in 4.4 are for the sole purpose of checking the electromagnetic emission characteristics of the auxiliary itself. Due to the variety of wiring circuits, it is impossible to describe requirements for the installation. In this respect, it is recommended that the manufacturer give guidelines for the proper use of the auxiliary.*

*2 - The requirements in 4.4 may be used for testing auxiliaries intended to be built in to a luminaire. However, there is no obligation for such testing. Although when the auxiliary complies with the requirements of this subclause, the luminaire shall always be tested.*

#### 4.4.2 Independent light regulating devices

##### 4.4.2.1 Type of devices

There are two types of light regulating devices: those like dimmers which directly regulate the lamps, and those which have a remote control function to regulate the light output via a ballast or convertor.

##### 4.4.2.2 Independent directly operating light regulating devices

Where such devices incorporate semiconductors, they shall comply with the terminal voltage limits given table 2a and 2b, otherwise no limits apply

##### 4.4.2.3 Independent remote control devices

Where such devices generate a d.c. or low-frequency (<500Hz) control signal, no limits apply. For radiofrequency or infrared operating devices, this standard does not apply. Other independent remote control devices shall comply with the terminal voltage limits given in tables 2a and 2b.

#### 4.4.3 Independent transformers and convertors for incandescent lamps

##### 4.4.3.1 General

Transformers for incandescent lamps change only the voltage and do not convert the mains frequency, whereas convertors also convert the frequency. Both kinds of device can incorporate means for regulating the light output of the lamps.

##### 4.4.3.2 Independent transformers

For voltage transformers for incandescent lamps which do not regulate the voltage by means of active electronic components, the condition of 4.3.2 applies. Other independent transformers for incandescent lamps shall comply with the terminal voltage limits given in tables 2a and 2b.

##### 4.4.3.2 Independent convertors

Independent electronic convertors for incandescent lamps shall :

- a) comply with the terminal voltage limits given in tables 2a and 2b; or
- b) where the convertor has a non-detachable load supply cable, or where the manufacturer gives strict installation instructions which define the position, type and maximum length of cable to be connect to the lamp, then the convertor shall comply with terminal voltage limits given in table 2a and with the field strength limits given in table 3.

#### 4.4.4 Independent ballasts for fluorescent and other discharge lamps

4.4.4.1 Independent ballasts designed for a type of fluorescent lamps as mentioned in 4.3.3 and operated with starter shall comply with the minimum values of insertion loss given in table 1.

4.4.4.2 Other independent ballasts shall comply with the mains terminal voltage limits given in table 2a.

Where the ballast supplies the lamp with a current having a frequency in excess of 100 Hz, it shall comply with the field strength limits given in table 3.

Where the light is regulated by an external device, the voltage limit at the control terminals of the ballast shall not exceed the limits given in table 2b.

4.4.5 Semi-luminaires

Semi-luminaires for compact fluorescent lamps and for incandescent lamps, sometimes called adaptors, are devices equipped on the one side with an Edison screw or bayonet cap to allow mounting in a standard incandescent lampholder and on the other side with a lampholder to allow the insertion of a replaceable lamp.

Semi-luminaires shall comply with the terminal voltage limits given in table 2a. Where the light source is operated at a frequency exceeding 100 Hz, the unit shall comply with the field strength limits given in table 3.

4.5 Self-ballasted lamps

For self-ballasted lamps, the ballasting and starting arrangements are encapsulated with the lamp into one single unit. These lamps are fitted with Edison screw or bayonet caps and can be inserted directly into an appropriate holder.

Self-ballasted lamps shall comply with the terminal voltage limits given in table 2a.

Where the light source is operated at a frequency exceeding 100 Hz, the unit shall comply with the field strength limits given in table 3.

4.6 Outdoor lighting appliances

4.6.1 General

For the purpose of this standard, the term "outdoor lighting" is used for the general lighting of public areas such as streets, walkways, cycle paths, motorways, tunnels, car parks, service stations and outdoor sports and recreational areas, for security and floodlighting of buildings and the like. Moreover, requirements described in 4.6 apply to the (outdoor) lighting appliances on private grounds, industrial estates and the like.

However, such lighting equipment may be subject to specific emission requirements which are not covered by this standard, for example airport lighting.

This subclause 4.6 does not apply to neon and other advertising signs.

4.6.2 Mounting system

Generally, an outdoor lighting appliance is built up of a support and one or more luminaires. The support could be:

- a pipe (bracket) or the like;
- a mast (column) arm;
- a post top;
- a span or suspension wires;
- a wall or ceiling.

Unless otherwise stated, the emission requirements described in 4.6 apply to the luminaire (including the lamp) and no requirements apply to the luminaire support.

4.6.3 Integrated switching devices

Disturbances caused by the operation of integrated switching devices such as ripple control receivers shall be disregarded.

4.6.4 Incandescent lamp luminaires

The condition of 4.3.2 applies.

4.6.5 Fluorescent lamp luminaires

Luminaires using a type of fluorescent lamp as mentioned in 4.3.3 and operating with starter shall comply with the minimum values of insertion loss given in table 1.

4.6.6 Other luminaires

Outdoor luminaires other than described in 4.6.4 or 4.6.5 shall comply with the mains terminal voltage limits given in table 2a.

Where the lamp in the luminaire is supplied with a current having a frequency in excess of 100 Hz, the electronic ballast shall be incorporated in the luminaire. The luminaire shall comply with the field strength limits given in table 3.

Additional limits for the electrical component of the disturbing field strength are under consideration.

Where the light output of the luminaire is regulated by an external device, the disturbance voltage at the control terminals shall not exceed the limits given in table 2b.

4.7 UV and IR radiation appliances

4.7.1 General

Ultraviolet and infrared radiation appliances are appliances used for medical and cosmetic care, for industrial purposes and for instant zone heating.

This subclause applies to appliances which are mainly used in the residential environment. For other appliances CISPR 11 applies.

4.7.2 IR radiation appliances

For appliances which only contain mains frequency operated incandescent radiation sources (infrared emitters) and which do not include any active electronic components, the condition of 4.3.2 applies.

4.7.3 UV fluorescent lamp appliances

UV appliances using UV lamps identical to those types of fluorescent lamp mentioned in 4.3.3 and operating with a replaceable starter shall comply with the minimum values of insertion loss given in table 1.

4.7.4 Other UV and/or IR appliances

UV and IR appliances other than described in 4.7.2 or 4.7.3 shall comply with the mains terminal voltage limits given in table 2a.

Appliances supplying the radiation source with a current having a modulating frequency in excess of 100 Hz shall comply with the field strength limits given in table 3.

Where the radiation of the appliance is regulated by an external device, the disturbance voltage at the control terminal shall not exceed the terminal voltage limits given in table 2b.



4.8 Transport lighting

4.8.1 General

Light sources are used in transport vehicles for:

- external lighting and signalling purposes:
- lighting of on-board instruments:
- lighting of interior cabins and rooms.

Requirements in 4.8 are set for lighting equipment used on board ships and rail vehicles. Lighting equipment used in/on aircraft is subject to special conditions and falls outside the scope of this standard.

4.8.2 External lighting and signalling

Where devices for lighting or signalling are equipped with incandescent lamps. They are deemed to fulfil all relevant requirements of this standard without further testing. If gas-discharge lamps are used, the lamp and its ballast shall be mounted in one unit, which shall comply with the terminal voltage limits given in table 2a and field strength limits given in table 3.

4.8.3 Lighting of on-board instruments

Lighting of on-board instruments is considered to be subject to the requirements for the instruments.

4.8.4 Lighting of interior cabins and rooms

Equipment for the interior lighting of ships and passenger rail vehicles is considered as indoor lighting equipment and relevant requirements of 4.3 apply.

4.9 Neon and other advertising signs

Limits and method of measurement are under consideration

## 5 Operating conditions for lighting equipment

5.1 General

When measurements of disturbances or insertion loss of lighting equipment are being made, the equipment shall be operated under the conditions specified in 5.2 to 5.6.

The special conditions given in clause 6, 7 and 8 for the different methods of measurement are to be considered additionally as appropriate.

5.2 Lighting equipment

The lighting equipment is to be tested as delivered by the manufacturer under normal operating conditions, for example, as given in IEC 60598 for luminaires.

5.3 Supply voltage and frequency

The supply voltage shall be within  $\pm 2$  % of the rated voltage. The nominal frequency of the mains supply shall be as rated for the equipment.

5.4 Ambient conditions

Measurements shall be carried out in normal laboratory conditions. The ambient temperature shall be within the range 15 ° C to 25 ° C.

5.5 Lamps

5.5.1 Type of lamp used

Terminal disturbance voltage and radiated field measurements shall be carried out with lamps for which the lighting equipment is designed. Lamps of the highest wattage rating allowed for the lighting equipment shall be used.

#### 5.5.2 Ageing time of lamps

Measurements shall be carried out with lamps which have been in operation for at least:

- 2 h for incandescent lamps;
- 100 h for fluorescent and other discharge lamps.

#### 5.5.3 Stabilization time of lamps

Prior to a measurement, the lamp shall be operated until stabilization has been reached. Unless otherwise stated in this standard or specified by the manufacturer, the following stabilization times shall be observed:

- 5 min for incandescent lamps;
- 15 min for fluorescent lamps;
- 30 min for other discharge lamps.

#### 5.6 Replaceable starters

When TIS 183 glow starters are used, the capacitor is replaced by a capacitor of  $5\,000 \pm 50$  pF. The starter shall be retained in its socket unless otherwise specified. Care shall be taken that it maintains its characteristics over the whole frequency range covered by the measurements.

If the manufacturer fits a capacitor external to the starter, the luminaire is measured as manufactured including the starter capacitor.

### **6 Method of insertion loss measurement**

#### 6.1 Circuits for the measurement of insertion loss

##### 6.1.1 For luminaires as described in 4.3.3 and in 4.6.5, the insertion loss is measured as shown in:

- figure 1 for luminaires for linear and U-type fluorescent lamps;
- figure 2 for luminaires for circular fluorescent lamps;
- figure 3 for luminaires for single-capped fluorescent lamps having integral starter.

Dummy lamps are specified in 6.2.4.

In the case of luminaires for fluorescent lamps having a nominal diameter of 25 mm, but which are interchangeable with lamps having a nominal diameter of 38 mm, the insertion loss measurement shall be made with a dummy lamp with a nominal diameter of 38 mm, unless the manufacturer's instructions prescribe the exclusive use of a 25 mm diameter lamp.

##### 6.1.2 For independent ballasts as described in 4.4, the insertion loss shall be measured in the circuit relevant to the ballast to be test. The ballast shall be mounted together with its dummy lamp and starter on a piece of an insulating material, $12\text{mm} \pm 2\text{mm}$ thick. This arrangement shall be considered as a luminaire and the relevant conditions of this clause (6) apply.

##### 6.1.3 UV radiation appliances as described in 4.7.3 are considered as luminaires and the relevant conditions of this clause (6) apply.

#### 6.2 Measuring arrangement and procedure

The measuring arrangement consists of the following parts.

6.2.1 Radiofrequency generator

This is a sine-wave generator, having an output impedance of  $50\ \Omega$  and being suitable for the frequency range covered by this measurement.

6.2.2 Balance-to-unbalance transformer

A low-capacitance balance-to-unbalance transformer is used to obtain a symmetrical voltage from the radiofrequency generator. Electrical and constructional requirements are given in annex A.

6.2.3 Measuring receiver and network

A  $50\ \Omega/50\ \mu\text{H} + 5\ \Omega$  (or  $50\ \Omega/50\ \mu\text{H}$ ) artificial mains network in conjunction with a measuring receiver as specified in TIS 1441 shall be used.

6.2.4 Dummy lamps

The dummy lamps, which are used in the circuits of figures 1, 2, and 3, simulate the r.f. properties of the fluorescent lamps and are shown in figures 4a, 4b, 4c, 4d, 4e and 4f.

When mounting the dummy lamp in the luminaire, it shall remain parallel to the metalwork of the luminaire. Any support necessary to achieve this shall not noticeably alter the capacitance between the dummy lamp and luminaire.

The length of the dummy lamp shall be equal to the fluorescent lamp for which the luminaire is designed. The length of the metal tube shall be as indicated on the relevant dummy lamp data sheet of this standard.

6.2.5 Measuring arrangements

The length of the unscreened connection leads between the transformer and the input terminals of the dummy lamp shall be as short as possible, not exceeding 0.1m in length.

The length of the coaxial connection leads between the luminaire and the measuring network shall not exceed 0.5m. In order to avoid parasitic currents, there shall be only one earth connection at the measuring network. All earth terminals are to be connected to this point.

6.3 Luminaire

With the exception of the possible modification as set out in 5.6 and the replacement of the lamp, the luminaire is measured as manufactured.

Where the luminaire incorporates more than one lamp, each lamp is replaced in turn by the dummy lamp. The insertion loss of multi-lamp luminaires in which the lamps are powered in parallel shall be measured for each lamp and the minimum value of insertion loss measured shall be used for comparison with the relevant limit.

When measuring series-operated lamp luminaires, both lamps shall be replaced by dummy lamp. The input terminals of one dummy lamp shall be connected to the balance-to-unbalance transformer and the input terminals of the remaining dummy lamp are terminal with  $150\ \Omega$  (high frequency type).

If the luminaire has a frame of insulating material, the back of the luminaire shall be placed on a metal sheet, which in turn shall be connected to the reference earth of the measuring network.

6.4 Measurement procedure

6.4.1 The insertion loss is obtained by comparing the voltage  $U_1$ , obtained by connecting the output terminals of the transformer to the terminals of the

measuring network, with the voltage  $U_2$  obtained when the transformers connected to the measuring network through the luminaire to be measured.

#### 6.4.2 Voltage $U_1$

The output voltage  $U_1$  (between 2mV and 1 V) of the transformer is measured by means of the measuring receiver. For the purpose, a direct connection is made between the transformer and the input terminals of the measuring network. The voltage  $U_1$  is measured between either of the two input terminals of the measuring network and earth and shall have substantially the same value, i.e. independent of the arrangement of the measuring network. See annex A for checking of the balance-to-unbalance transformer properties and the saturation effects.

#### 6.4.3 Voltage $U_2$

The voltage  $U_2$  measured with the luminaire connected between the transformer and measuring network may have different valued and therefore may depend on the two positions of the switch of the measuring network. The higher voltage reading is recorded as  $U_2$ .

#### 6.4.4 The insertion loss is given by $20 \lg U_1/U_2$ dB.

*NOTE - The value of the insertion loss as obtained by this method of measurement gives good correlation between the dummy lamp and real lamps when used in the same luminaire.*

#### 6.4.5 Where it is known that the insertion loss measured according to figures 1 or 2, or for series-operated fluorescent lamps according to 6.3, is a minimum for a given orientation of the dummy lamp(s), measurements may be made for this orientation only (e.g. for a luminaire with a single ballast and with the dummy lamp(s) inserted so that the relevant input terminal is directly connected to the neutral supply terminal of the luminaire). In cases where there is any doubt on this point, measurements shall be made for all possible orientations of dummy lamp(s).

## 7 Method of measurement of disturbance voltages

### 7.1 Measuring arrangement and procedure

#### 7.1.1 Mains terminal voltage measurement

The disturbance voltage shall be measured at the mains terminals of the lighting equipment by means of the arrangement described in figures 5 and 6 for the relevant type of equipment.

The output terminals of the artificial mains network (V-network) and the terminals a-b shall be positioned  $0.8 \pm 0.16$  m apart and shall be connected by the two power conductors of a flexible three core cable of 0.8m length.

#### 7.1.2 Load and control terminal voltage measurement

A voltage probe shall be used when measuring on the load or control terminals (see figure 5). It contains a resistor having a resistance value of at least  $1\ 500\ \Omega$  in series with a capacitor with a reactive value negligible to the resistance (in the range 150 kHz to 30 MHz) (see clause 12 of TIS 1441)

The measuring results shall be corrected according to the voltage division between the probe and the measuring set. For this correction, only the resistive parts of the impedance shall be taken into account.

#### 7.1.3 Light regulation

If the lighting equipment incorporates a light regulating control or is controlled by an external device, then the following method shall be applied when measuring the disturbance voltage.

## 7.1.3.1 At the mains terminals

An initial survey or scan of the complete frequency range 9 kHz to 30 MHz shall be made with full light output. In addition, the control setting shall be varied for maximum disturbance while maintaining the maximum load at the following frequencies:

9 kHz	50 kHz	100 kHz	160 kHz	240kHz
550 kHz	1 MHz	1.4 MHz	2 MHz	3.5 MHz
6 MHz	10 MHz	22 MHz	30 MHz	

and at all frequencies at which there is a maximum disturbance found in the initial survey.

## 7.1.3.2 At the load and/or control terminals

An initial survey or scan of the complete frequency range 150 kHz to 30 MHz shall be made with full light output. In addition, the control setting shall be varied for maximum disturbance while maintaining the maximum load at the following frequencies:

160 kHz	240 kHz	550 kHz	
1 MHz	1.4 MHz	2 MHz	3.5 MHz
6 MHz	10 MHz	22 MHz	30 MHz.

and at all frequencies at which there is maximum disturbance found in the initial survey.

## 7.1.4 Measurements with an average detector

If the limits for the measurement with the average detector are met when using a receiver with a quasi-peak detector, the test unit shall be deemed to meet both limits and the measurement with the average detector need not be carried out.

## 7.2 Indoor and outdoor luminaires

The measuring arrangement is given in figure 6a.

When the luminaire incorporated more than one lamp, all lamps shall be operated simultaneously. Where it is possible for the user to insert lamps in different ways, measurements shall be made for all cases and the maximum value used for comparison with the relevant limit. In the case of luminaires for fluorescent lamps which are equipped with a replaceable starter, the same terminals are left connected to the starter in both possible measurement positions.

If the luminaire is of metal and is provided with an earthing terminal, it shall be connected to the reference earth of the V-network. If the luminaire is provided with an earthing terminal, but the manufacturer states that it need not be earthed, it shall be measured twice: once with and once without the earth connection. In both cases, the luminaire shall comply with the requirements.

If the luminaire is of metal or plastic (or a combination of the two) and is not intended to be earthed, it shall be mounted systemtrically 0.4 m above a metal plate of dimensions at least 2 m x 2 m. The plate shall be connected to the reference earth of the V-network.

If the measurement is made in a screened enclosure, the distance of 0.4 m may be referred to one of the walls of the enclosure. The luminaire shall be positioned so that its base is parallel to the reference wall and shall be at least 0.8 m from the outer surfaces of the enclosure.

For outdoor luminaires where the ballast is mounted outside the luminaire (in the column), the mains terminal disturbance voltage is measured at the mains input terminals of the ballast.

**7.3 Independent light regulating devices**

**7.3.1 Directly operating devices**

The regulating device shall be arranged as shown in figure 5. The connecting lead length for load and control terminals shall be 0.5 to 1 m long.

Unless otherwise specified by the manufacturer, the regulating device shall be measured with the maximum allowed load consisting of incandescent lamps as specified by the manufacturer.

The regulating device shall first be measured according to the provision of 7.1.3.1. Secondly, the disturbance voltage at the load and control terminals, if any, shall be measured according to the provision of 7.1.3.2.

**7.3.2 Devices having a remote control function**

Such devices shall be connected to a measuring circuit consisting of a resistor, capacitor and/or inductance as specified by the manufacturer. The measuring arrangement as shown in figure 5 then applies. The terminal voltage at the supply and control terminals shall be measured according to the relevant provisions of 7.1.3.

**7.4 Independent transformers and convertors for incandescent lamps**

**7.4.1 Independent transformers shall be measured using the relevant provisions of 7.3.1.**

**7.4.2 Independent electronic convertors having a non-detachable cable, or where the manufacturer gives strict installation instruction, shall be mounted together with the lamp(s) of maximum load on a piece of insulating material, 12 mm ± 2 mm thick. The supply wires between the convertor and the lamp(s) shall be non-detachable, or of the maximum length and type specified in the installation instructions. The assembly shall be placed on a metal plate of dimensions slightly larger than the piece of insulating material. The plate shall be connected to the reference earth of the V-network.**

**7.5 Independent ballasts for fluorescent and other discharge lamps**

The disturbance voltage shall be measured in the circuit relevant to the device to be tested as shown in figure 6b. The device shall be mounted together with its lamp(s) on a piece of insulating material, 12 mm ± 2 mm thick, which shall be placed on a metal plate of dimensions slightly larger than the piece of insulating material. The plate shall be connected to the reference earth of the V-network. If the device is provided with an earth terminal it shall also be connected to that reference earth.

Where a starter or ignitor is necessary to start the lamp, this shall be one suitable for the ballast and lamp. The instructions given in 5.6 apply.

There are no special mains wiring instructions. The wiring between the device under test and the lamp(s) shall be as short as possible to minimize its influence on the measuring results.

**7.6 Self-ballasted lamps and semi-luminaires**

Self-ballasted lamps shall be measured as manufactured. Semi-luminaires shall be measured with a suitable lamp having the maximum power allowed for it.

The circuit for the measurement of the disturbance voltage for self-ballasted lamps or semi-luminaires is shown in figure 6c. Details of the conical metal

housing to be used are given in figure 7. The cable connecting the terminals at the conical housing to the V-network shall not exceed 0.8 m. The conical metal housing shall be connected to the earth terminal of the V-network.

The disturbance voltage shall be measured at the terminals of the self-ballasted lamp or semi-luminaire.

#### 7.7 UV and IR radiation appliances

These appliances are considered as being luminaires and the instructions of 7.1 and 7.2 apply with the following additions.

- In the case of appliances which contain both UV and IR radiation sources, the IR radiation source shall be disregarded if it is mains frequency operated.
- The appliances shall be measured with the lamps as installed. Before making a measurement, the lamps shall be stabilized during a period of 5 min for lamps of the high pressure type and 15 min for lamps of the low pressure type.

### **8 Method of measurement of radiated electromagnetic disturbances**

#### 8.1 Measuring arrangement and procedure

##### 8.1.1 Measuring equipment

The magnetic component shall be measured by means of a loop antenna as described in annex B.

The lighting equipment shall be placed as close as possible to the center of the antenna as shown in figure B.1.

##### 8.1.2 Measurements in three directions

The induced current in the loop antenna is measured by means of a current probe (1 V/A) and the CISPR measuring receiver (or equivalent). By means of coaxial switch the three field directions can be measured in sequence. Each value shall fulfil the requirements given.

##### 8.1.3 Wiring instructions

There are no special instructions for the supply wiring.

##### 8.1.4 Light regulation

If the lighting equipment has a built-in light regulating control or is controlled by an external device, the equipment shall be measured in the half-load and maximum load condition.

#### 8.2 Indoor and outdoor luminaires

For luminaires incorporating more than one lamp, all the lamps are operated simultaneously. It is not necessary to make measurements with lamps in different mounting positions.

#### 8.3 Independent convertors for incandescent lamps

Independent convertors shall be mounted as described in 7.4.2 and the combination shall be measured as a luminaire.

#### 8.4 Independent ballasts for fluorescent and other discharge lamps

Independent ballasts shall be mounted as described in 7.5 and the combination shall be measured as a luminaire.

#### 8.5 Self-ballasted lamps and semi-luminaires

Self-ballasted lamps and semi-luminaires shall be measured when inserted in a relevant lampholder, mounted on a piece of insulating material.

8.6 UV and IR radiation appliances

For UV and IR radiation appliances, the relevant conditions given in 7.7 apply.

8.7 Application of TIS 1441

The description of the loop antenna, relative sensitivities and conversion factors in TIS 1441 has preference over annexes B and C.

**9 Interpretation of CISPR radio disturbance limits**

9.1 Significance of limit

The significance of the limits for type-approved appliances shall be that on a statistical basis at least 80% of the mass-produced appliances comply with the limits with at least 80% confidence.

9.2 Tests

Test shall be made:

- a) either on a sample of appliances of the type, using the statistical method of evaluation in accordance with 9.3.1 and 9.3.2; or
- b) on one appliance only for simplicity's sake (see 9.3.2).

Subsequent tests are necessary from time to time on appliances taken at random from production, especially in the case indicated in item b).

9.3 Statistical method of evaluation

9.3.1 If insertion loss measurements are performed, compliance is achieved when the following relationship is met:

$$\bar{x} - kS_n \geq L$$

Where

$\bar{x}$  is the arithmetic mean of the measured value of  $n$  items in the sample

$$S_n^2 = \sum_n (x_n - \bar{x})^2 / (n - 1)$$

$x_n$  is the value of individual item;

$L$  is the appropriate limit;

$k$  is the factor derived from tables of the non-central t-distribution which ensures with 80 % confidence that 80 % of more of the production exceeds the minimum value of insertion loss; the value of  $k$  depends on the sample size  $n$  and is stated in table 5.

The quantities  $X_n$ ,  $\bar{X}$ ,  $S_n$  and  $L$  are expressed logarithmically (dB).

**Table 5 – Sample size and corresponding  $k$  factor in a non-central t-distribution**  
(Clause 9.3.1)

$n$	3	4	5	6	7	8	9	10	11	12
$k$	2.04	1.69	1.52	1.42	1.35	1.30	1.27	1.24	1.21	1.20

9.3.2 If limits of disturbance terminal voltages or limits of currents induced by radiation are considered, compliance is achieved when the following relationship is met:

$$\bar{x} - kS_n \leq L$$



Where

$\bar{x}$ ,  $s_n$  and  $x_n$  have the same meaning as given under clause 9.3.1;

$k$  is the factor derived from tables of the non-central t-distribution which ensures with 80 % confidence that 80% or more of the production is below the limit; the value of  $k$  depends on the sample size  $n$  and is stated under clause 9.3.1.

The quantities  $x_n$ ,  $\bar{x}$ ,  $s_n$  and  $L$  are expressed logarithmically (dB( $\mu$ V) or dB( $\mu$ A)).

When measurements are made on lighting equipment where the lamp can be replaced, a minimum of five units are tested, each unit with its own lamp. If for reasons of simplicity one unit is tested, it shall be tested with five lamps and the limit shall be met for each lamp.

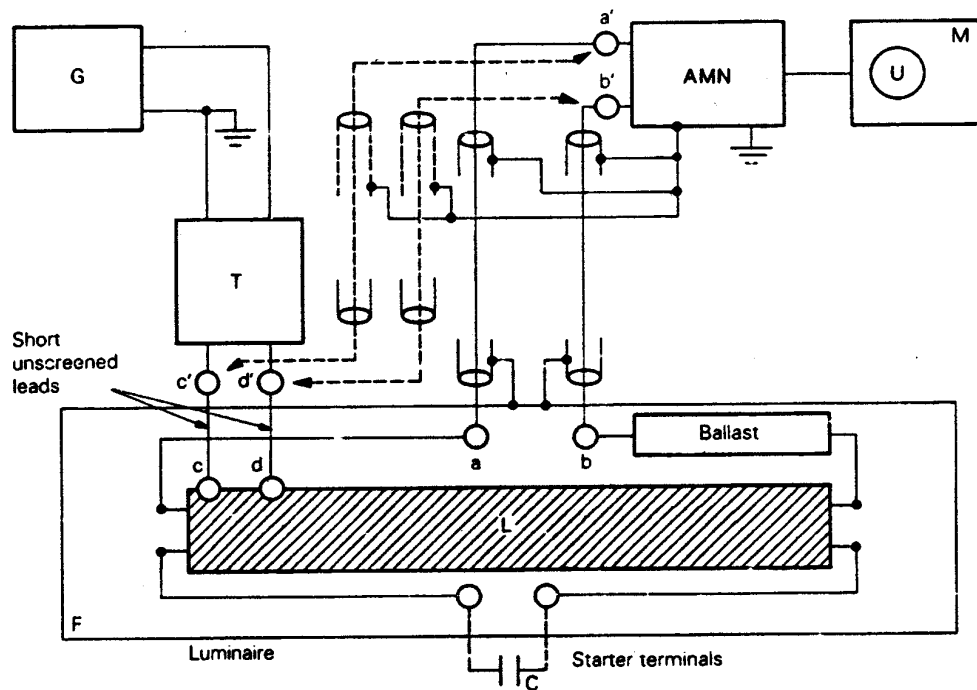
When measurements are made on lighting equipment where the lamp cannot be replaced, a minimum of the five units are to be tested. (Because of the dispersion of the disturbance potential of the lamps, several items shall be considered.)

#### 9.4 The banning of sales

The banning of sales or withdrawal of a type approval, as a result of a dispute, shall be considered only after tests have been carried out using the statistical method of evaluation.

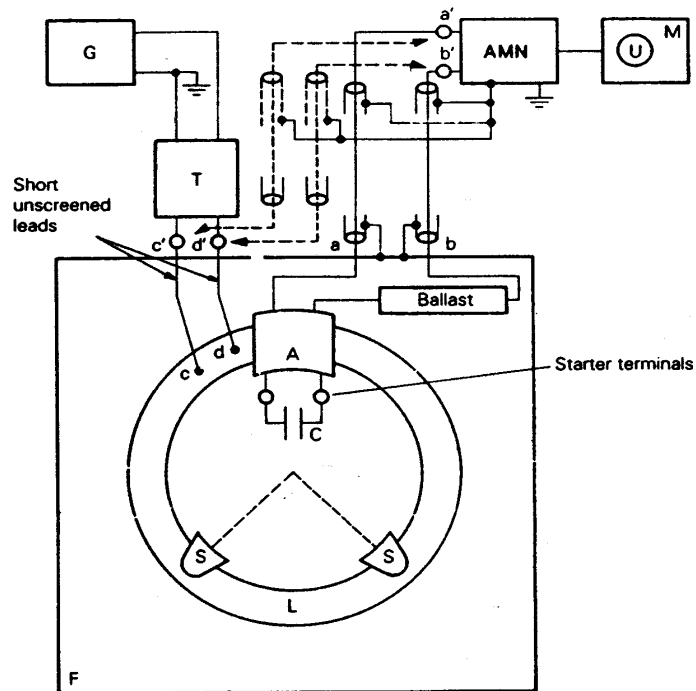
Statistical assessment of compliance with limits shall be made as follows.

This test shall be performed on a sample of not less than five, and not more than twelve items of the type, but if, in exceptional circumstances, five items are not available, then a sample of four or three shall be used.



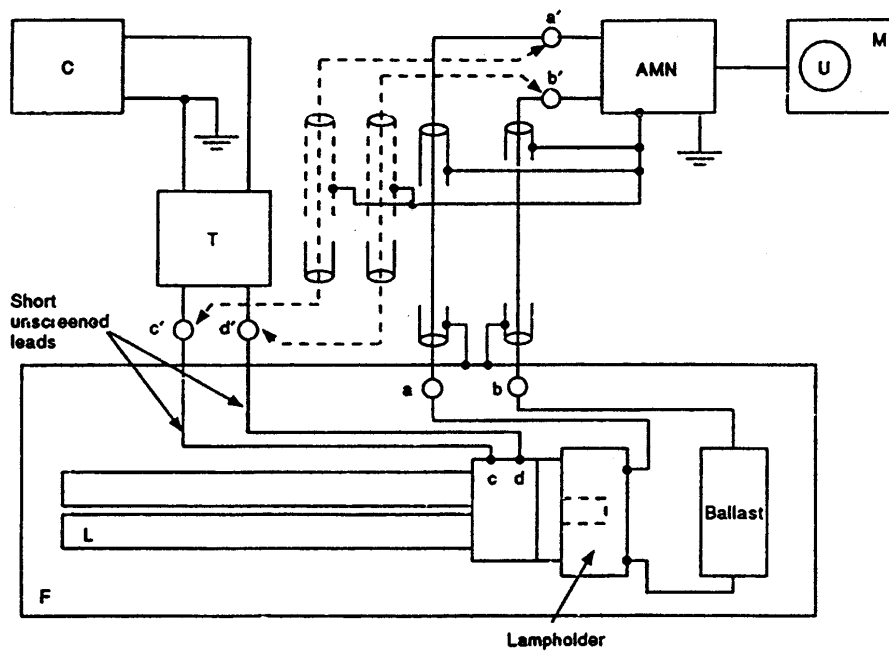
- G** = r.f. generator  
**T** = balance-to-unbalance transformer  
**AMN** = 50 Ω/50 μH + 5 Ω (or 50 Ω/50 μH) artificial mains network as specified in TIS 1441  
**M** = r.f. millivoltmeter or measuring receiver  
**L** = dummy lamp  
**F** = luminaire  
**C** = capacitor  
**a - b** = mains terminals  
**a' - b'** = input terminals of the measuring network AMN  
**c - d** = r.f. terminals of dummy lamp L  
**c' - d'** = output terminals of T  
**a - a' and b - b'** = connections by coaxial cables ( $Z_0 = 75 \Omega$ ), with the respective ends of the screens connected to the reference earth of AMN and F not exceeding 50 cm in length  
**c - c' and d - d'** = connections of the transformer to the dummy lamp shall be made with unshielded leads not exceeding 100 mm in length
- NOTE** - When measuring U-type lamp luminaires the same circuit arrangement is used, but the linear dummy lamp should be replaced by the U-type dummy lamp.

**Figure 1 - Insertion loss measurement on linear and U-type fluorescent lamp luminaires**  
 (Clause 6.1.1, 6.2.4 and 6.4.5)



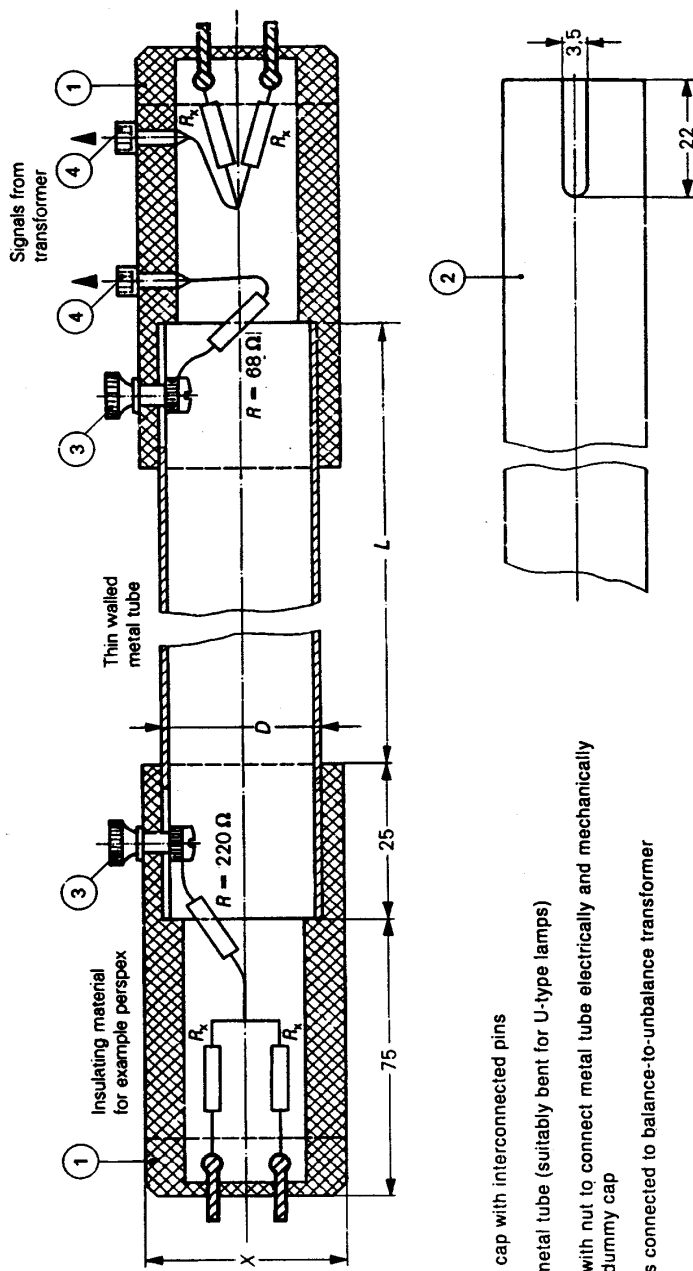
- G** = r.f. generator  
**T** = balance-to-unbalance transformer  
**AMN** =  $50 \Omega/50 \mu\text{H} + 5 \Omega$  (or  $50 \Omega/50 \mu\text{H}$ ) artificial mains network as specified in TIS 1441  
**M** = r.f. millivoltmeter or measuring receiver  
**L** = dummy lamp  
**F** = luminaire  
**C** = capacitor  
**A** = lampholder  
**S** = supports of insulating material  
**a - b** = mains terminals  
**a' - b'** = input terminals of the measuring network AMN  
**c - d** = r.f. terminals of dummy lamp L  
**c' - d'** = output terminals of T  
**a - a' and b - b'** = connections by coaxial cables ( $Z_0 = 75 \Omega$ ), with the respective ends of the screens connected to the reference earth of AMN and F, not exceeding 50 cm in length  
**c - c' and d - d'** = connections of the transformer to the dummy lamp shall be made with unscreened leads not exceeding 100 mm in length

**Figure 2 – Insertion loss measurement on circular fluorescent lamp luminaires**  
 (Clause 6.1.1 and 6.2.4)



- G = r.f. generator
- T = balance-to-unbalance transformer
- AMN =  $50 \Omega/50 \mu\text{H} + 5 \Omega$  (or  $50 \Omega/50 \mu\text{H}$ ) artificial mains network as specified in TIS 1441
- M = r.f. millivoltmeter or measuring receiver
- L = dummy lamp
- F = luminaire
- C = capacitor
- a - b = mains terminals
- a' - b' = input terminals of the measuring network AMN
- c - d = r.f. terminals of dummy lamp L
- c' - d' = output terminals of T
- a - a' and b - b' = connections by coaxial cables ( $Z_0 = 75 \Omega$ ), with the respective ends of the screens connected to the reference earth of AMN and F, not exceeding 50 cm in length
- c - c' and d - d' = connections of the transformer to the dummy lamp shall be made with unshielded leads not exceeding 100 mm in length

**Figure 3 – Insertion loss measurement on luminaires for single-capped fluorescent lamps with integrated starter**  
(Clause 6.1.1 and 6.2.4)

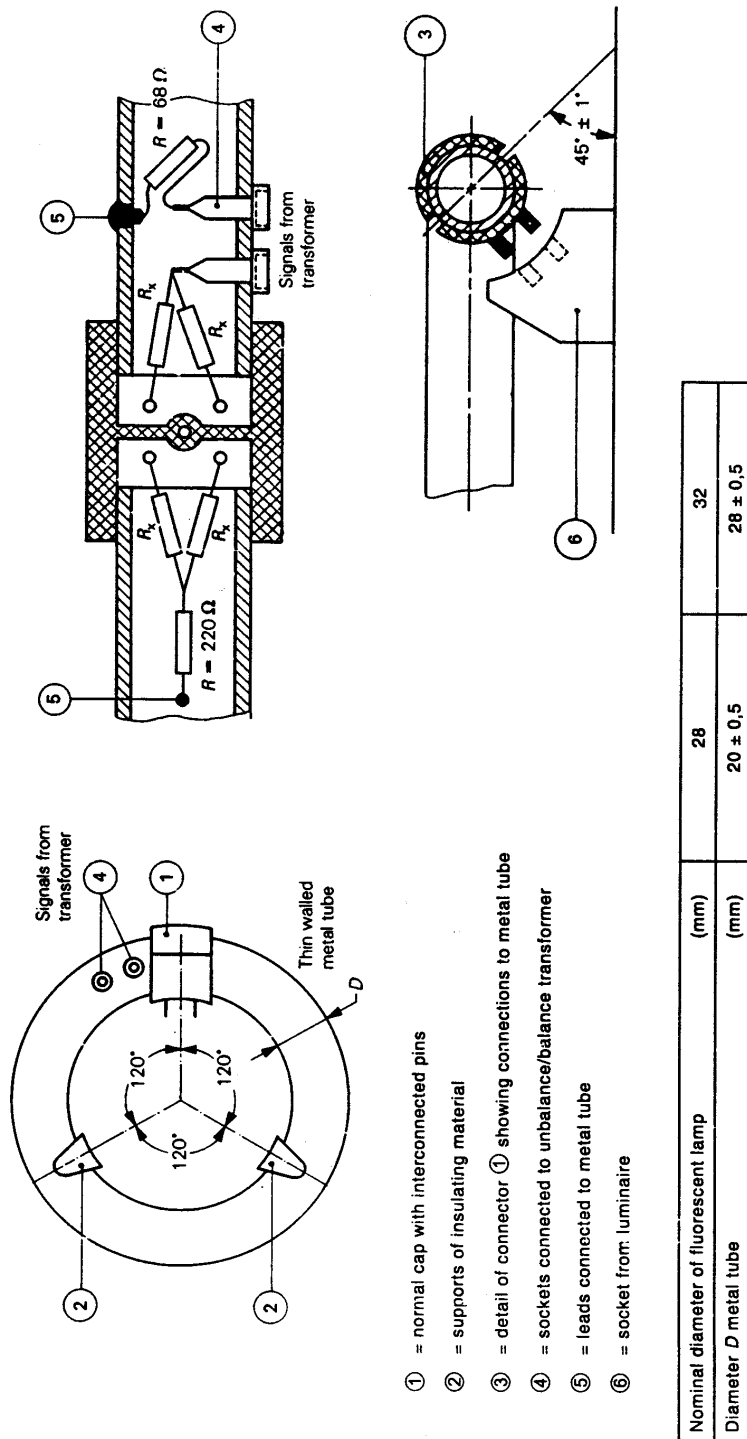


- ① = normal cap with interconnected pins
- ② = detail metal tube (suitably bent for U-type lamps)
- ③ = screw with nut to connect metal tube electrically and mechanically with the dummy cap
- ④ = sockets connected to balance-to-unbalance transformer

Length of real fluorescent lamp minus 0,15 m	L	
Nominal diameter of fluorescent lamp (mm)	25	38
Diameter D of metal tube (mm)	20 ± 0,5	
Diameter X of normal cap (mm)	24	35

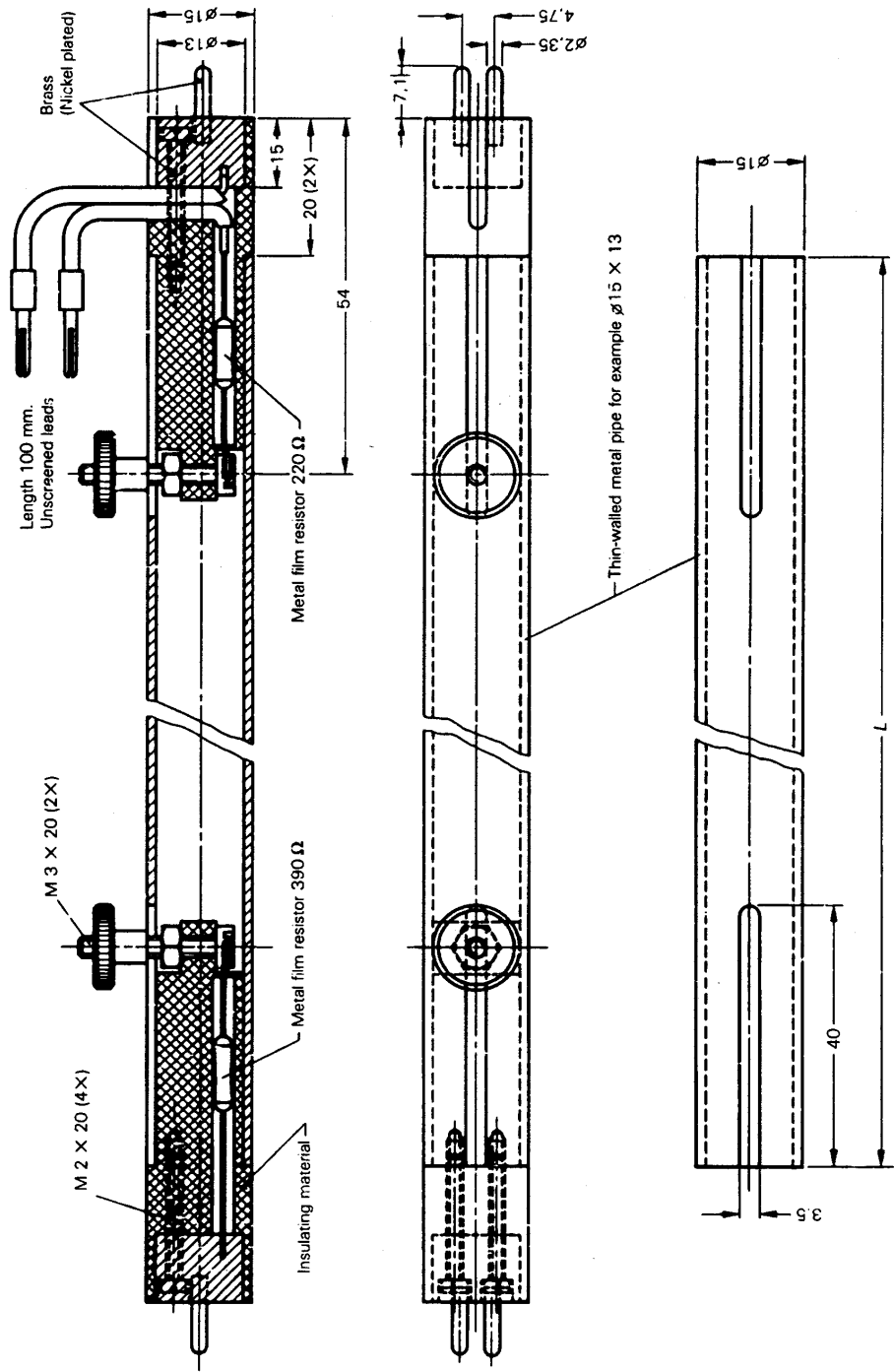
NOTE – Tolerances in dimensions ±1 in the last decimal, tolerances in resistances ±5 % unless otherwise specified.  
The value of resistance  $R_x$  is 4,8 Ω.

Figure 4a – Configuration of linear and U-type dummy lamps  
(Clause 6.2.4)



NOTE - Tolerances in dimensions  $\pm 1$  in the last decimal, tolerances in resistances  $\pm 5\%$  unless otherwise specified. The value of resistance  $R_k$  is  $4,8 \Omega$ .

Figure 4b - Configuration of circular dummy lamps  
 (Clause 6.2.4)



**Figure 4c – Dummy lamp for 15 mm fluorescent lamps**  
(Clause 6.2.4)

NOTE – Tolerances in dimensions ±1 in the last decimal, tolerances in resistances ±5 % unless otherwise specified.  
L = length of the real fluorescent lamp minus 40 mm.







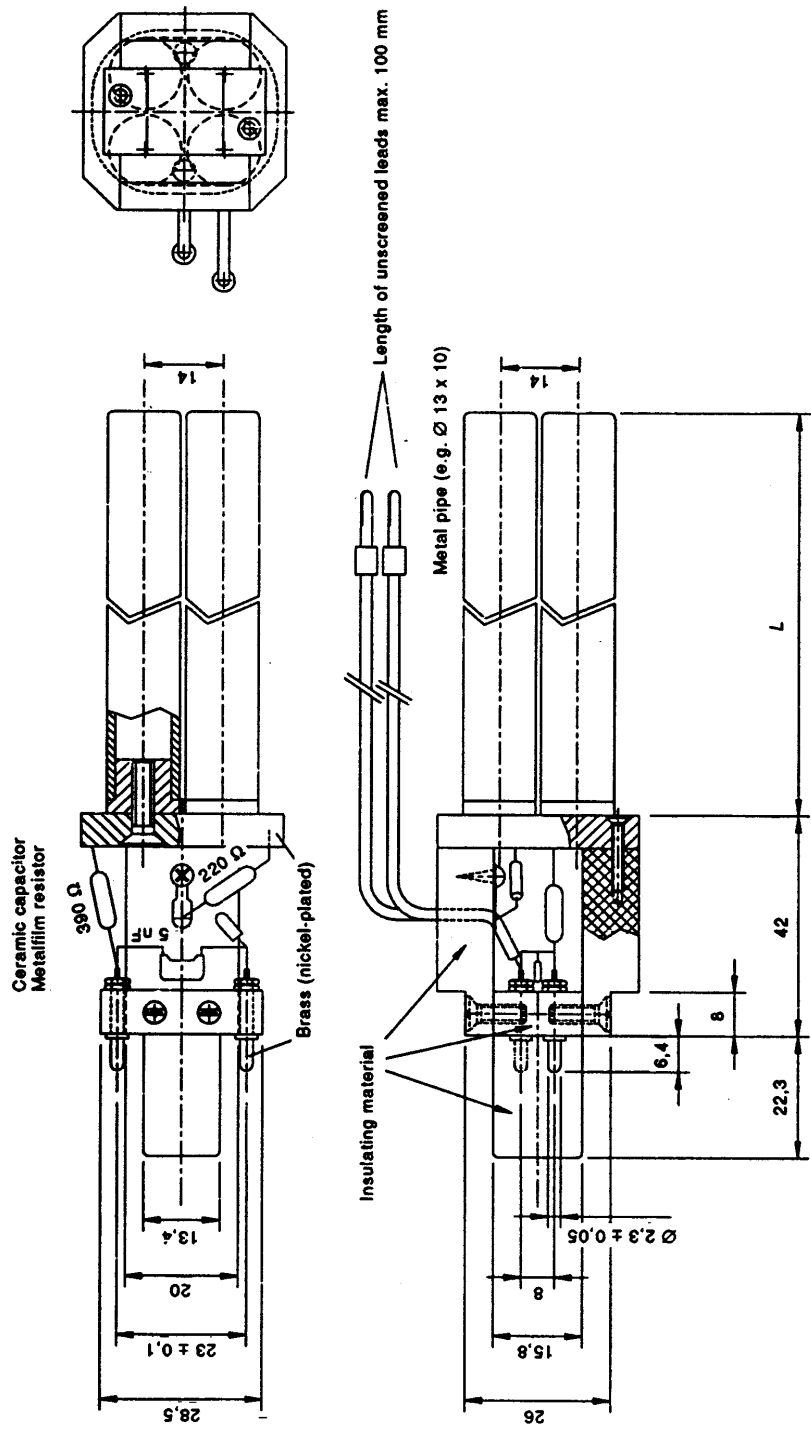
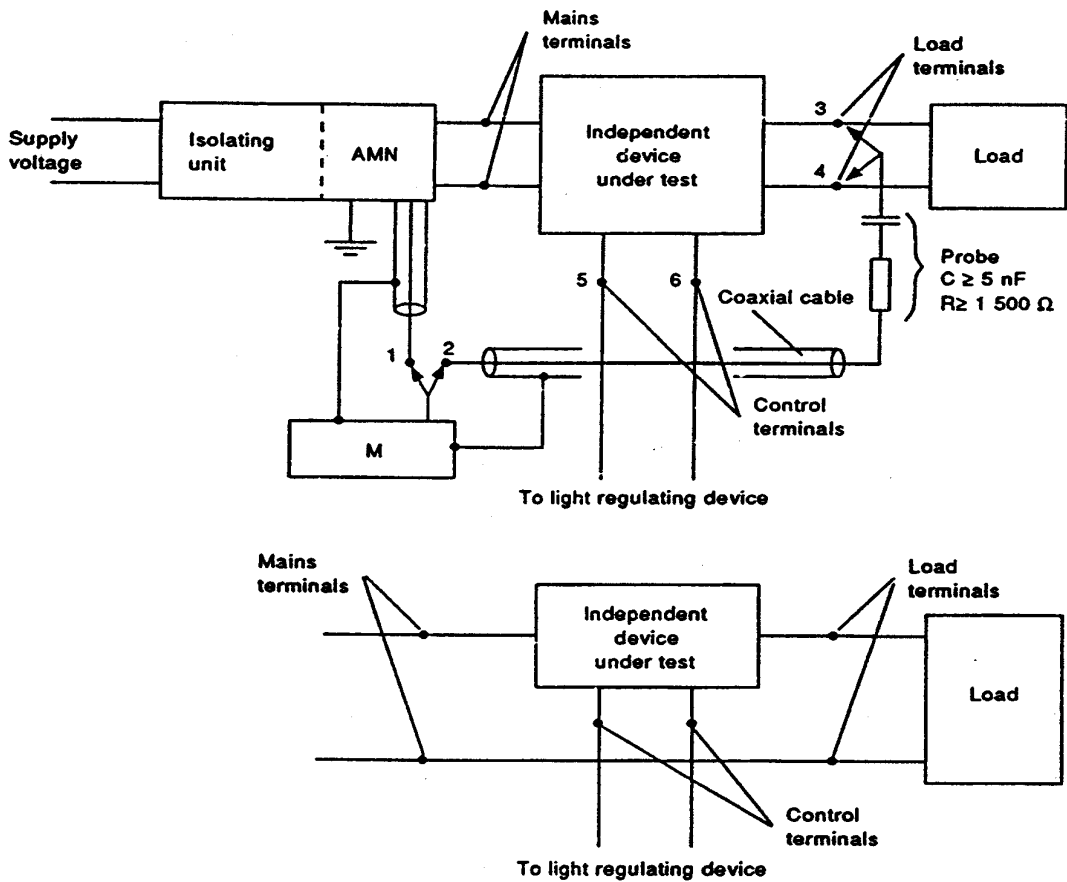


Figure 4f – Dummy lamp for single-capped fluorescent lamps linear shaped, quad tube, diameter 12 mm



AMN =  $50 \Omega/50 \mu\text{H} + 5 \Omega$  (or  $50 \Omega/50 \mu\text{H}$ ) artificial mains network as specified in TIS 1441

M = CISPR measuring receiver

Switch positions and probe connections

1 For mains measurements

2 For load or control measurements

3-4 Successive connections during load measurements

5-6 Successive connections during control measurements (if any)

NOTE 1 – The earth of the measuring receiver shall be connected to the artificial mains V-network.

NOTE 2 – The length of the coaxial cable from the probe shall not exceed 2 m.

NOTE 3 – When the switch is in position 2, the output of the artificial mains V-network at terminal 1 shall be terminated by an impedance equivalent to that of the CISPR measuring receiver.

NOTE 4 – Where a two-terminal device is inserted in one lead only of the supply, measurements shall be made by connecting the second supply lead as indicated in the lower figure.

**Figure 5 – Measuring arrangements for an independent light regulating device, transformer and convertor**  
(Clause 7.1.1, 7.1.2, 7.3.1 and 7.3.2)

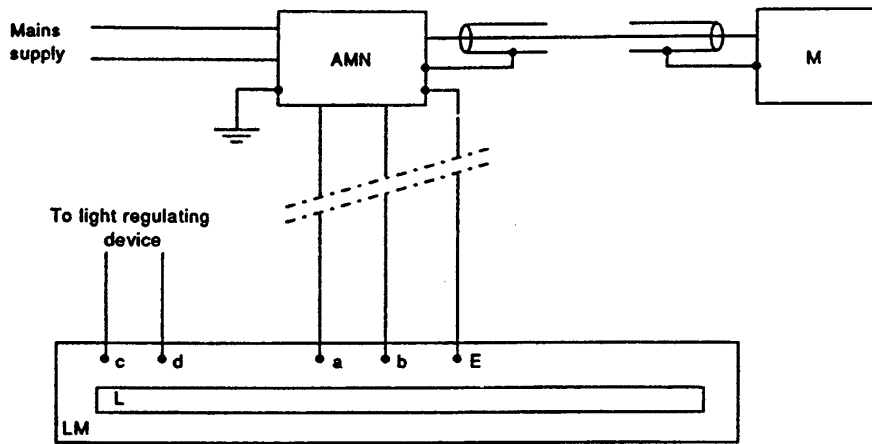


Figure 6a - Luminaires

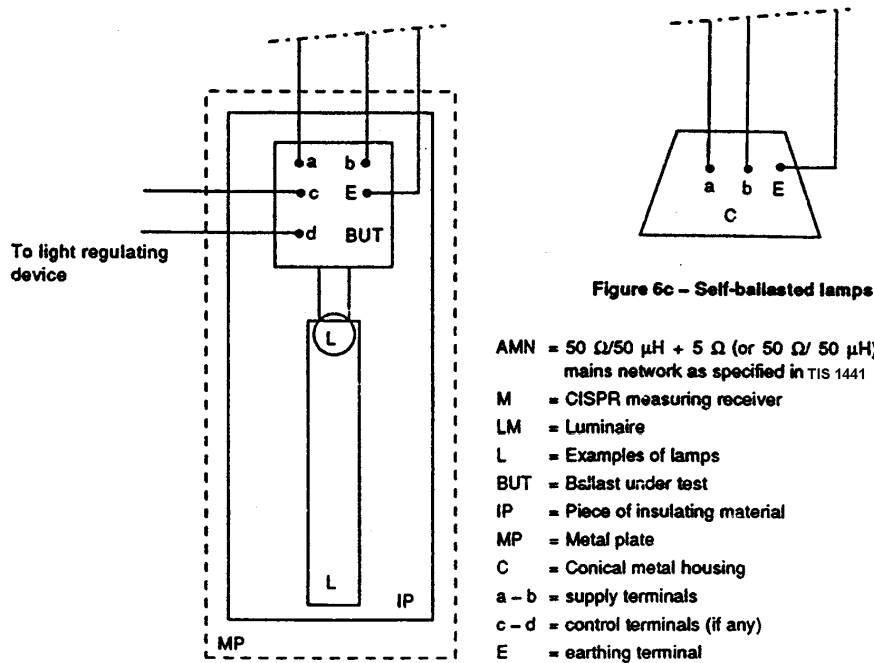
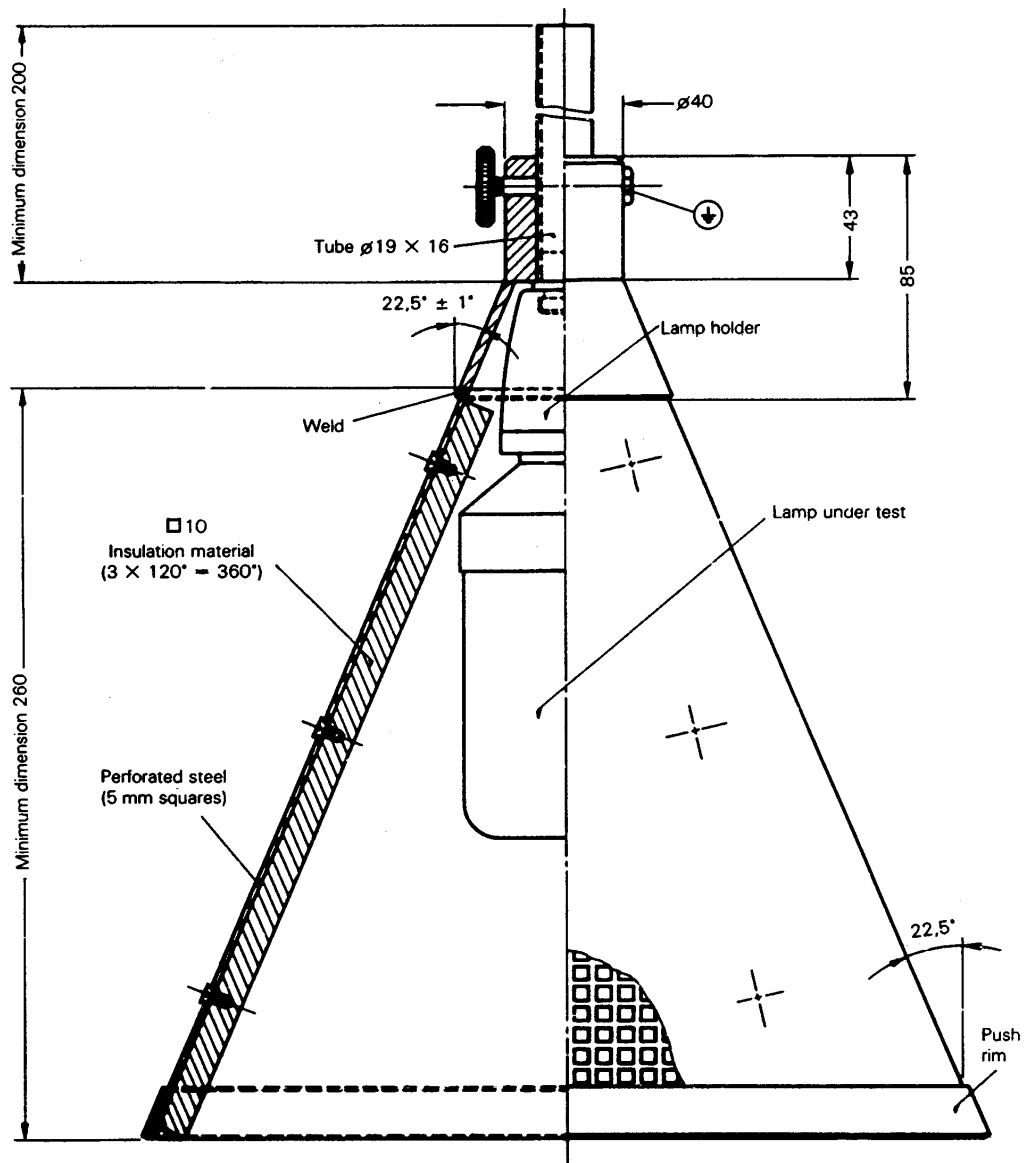


Figure 6c - Self-ballasted lamps

- AMN =  $50 \Omega / 50 \mu\text{H} + 5 \Omega$  (or  $50 \Omega / 50 \mu\text{H}$ ) artificial mains network as specified in TIS 1441
- M = CISPR measuring receiver
- LM = Luminaire
- L = Examples of lamps
- BUT = Ballast under test
- IP = Piece of insulating material
- MP = Metal plate
- C = Conical metal housing
- a - b = supply terminals
- c - d = control terminals (if any)
- E = earthing terminal

Figure 6b - Independent ballasts for fluorescent and other discharge lamps

Figure 6 - Measuring arrangements  
(Clause 7.1.1, 7.2 and 7.5)



*Dimensions in millimetres*

NOTE 1 – Tolerances in dimensions  $\pm 1$  in the last decimal, unless otherwise specified.

NOTE 2 – For good reference, adjust the lamp to the highest position.

**Figure 7 – Conical metal housing for self-ballasted fluorescent lamps**  
(Clause 7.6)

## Annex A

**Electrical and constructional requirements for the low-capacitance balance-to-unbalance transformer****(clause 6.2.2 and 6.4.2)**

## A.1 General

Care is necessary in the construction of the transformer in order to meet the performance requirements. An example of a suitable construction is shown in figures A.2a, A.2b, A.2c and A.2d, together with the materials to be used.

## A.2 Basic requirements

- A.2.1 The output impedance of the transformer, when the input is terminated by  $50 \Omega$ , shall be  $150 \Omega \pm 15 \Omega$  with a phase angle not exceeding  $10^\circ$ . The isolation of the transformer is checked as follows (see figure A.1).

Using a voltmeter with a high impedance (for example  $1 \text{ M}\Omega$ ), but shunted with a  $150 \Omega$  resistor, the voltage  $V_2$  (see figure A.1b) and  $V'_2$  (see figure A.1c) measured between each secondary terminal and the earth connection of the transformer, shall be at least 42 dB below the voltage  $V_1$  (see figure A.1a) measured across the secondary terminals, with constant output level from the r.f. generator.

- A.2.2 Requirements of A.1 shall be met throughout the frequency range 150 kHz to 1 605 kHz.

- A.2.3 The transformer shall be mounted in a metal box. The side where the output terminals are mounted is constructed of an insulating material, and the earth connection of the input terminal shall be connected to the metal box (see figure A.2d).

## A.3 Additional requirements

To allow for simplified measuring procedures, the following additional requirements shall be applied.

- a) In the frequency range 150 kHz to 1 605 kHz, the transformer shall have a transfer-characteristic which is flat within 0.5 dB.
- b) The transformer is constructed in such a way that  $U_1$ , as defined in 4.4.2, can be adjusted to a value of 1 V, without causing saturation effects in the ferrite core.

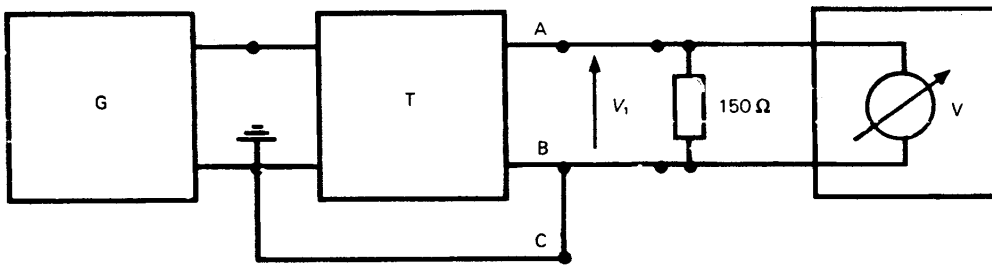


Figure A.1a

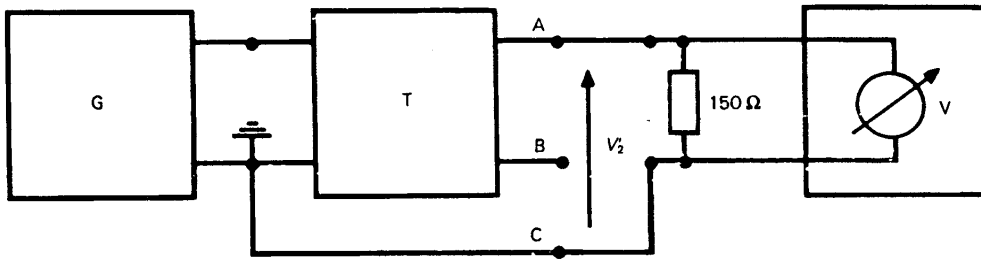


Figure A.1b

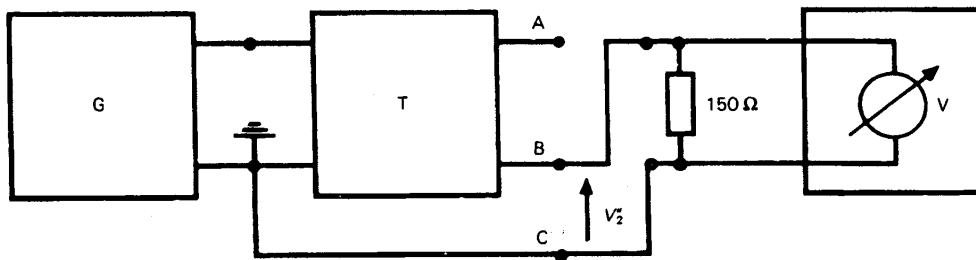


Figure A.1c

Figure A.1 – Isolation test configuration  
(Clause A.2.1)

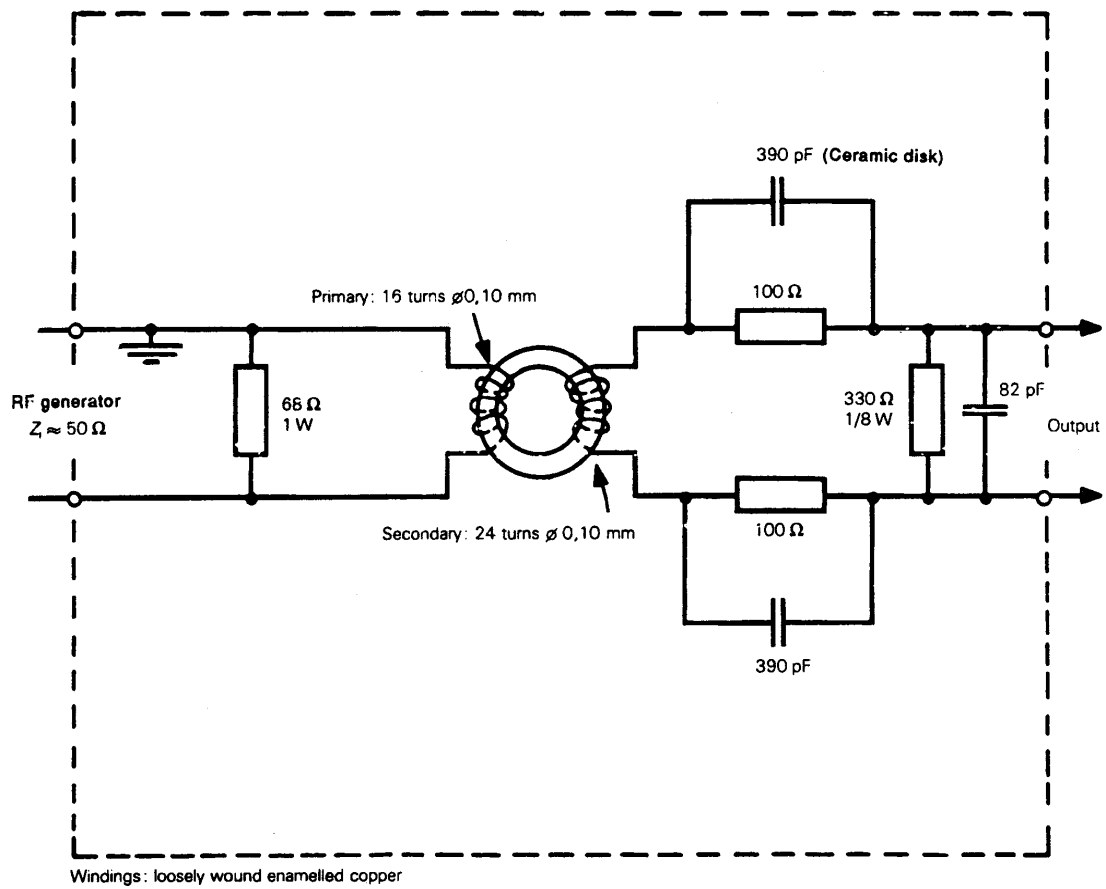
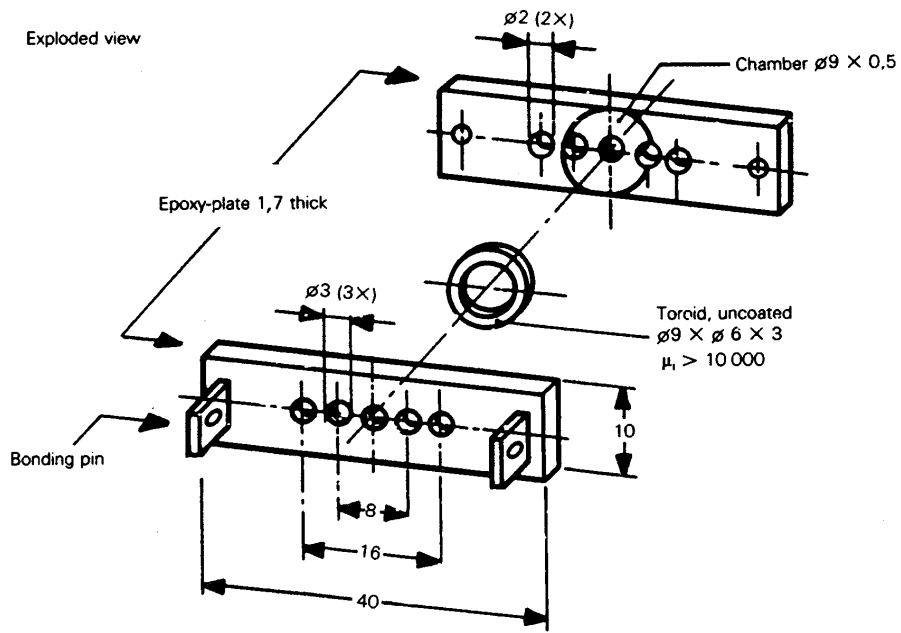


Figure A.2a – Balance-to-unbalance transformer circuit  
(Clause A 1)

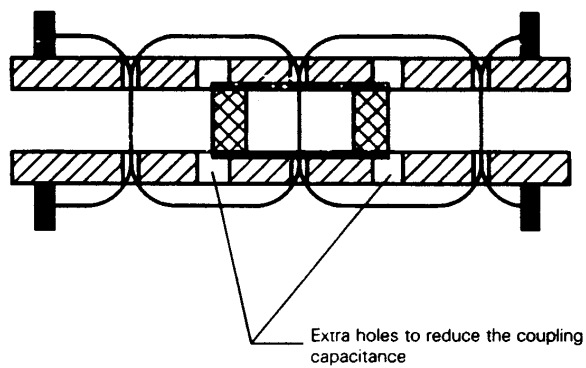




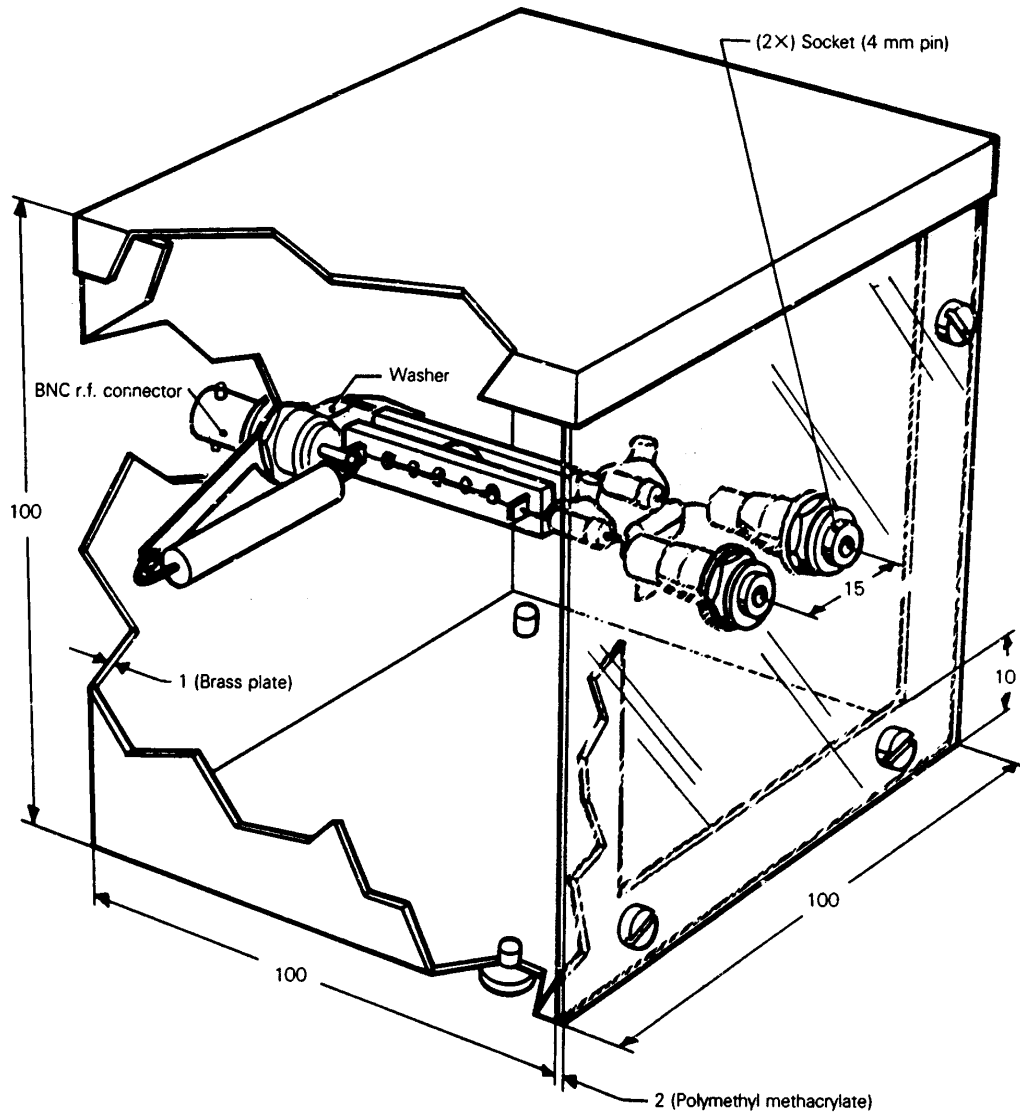
*Dimensions in millimetres*

**Figure A.2b – Details of transformer core construction**  
(Clause A2b)

Cross-section



**Figure A.2c – Details of transformer core construction**  
(Clause A 2c)



*Dimensions in millimetres*

**Figure A.2d – Construction of transformer**  
(Clause A1)

**Annex B****Magnetic field induced current method****(Clause 8.1.1 and 8.7)****B.1 General**

The magnetic component of the disturbance field strength shall be measured by means of the magnetic field induced current method.

**B.2 Loop antenna**

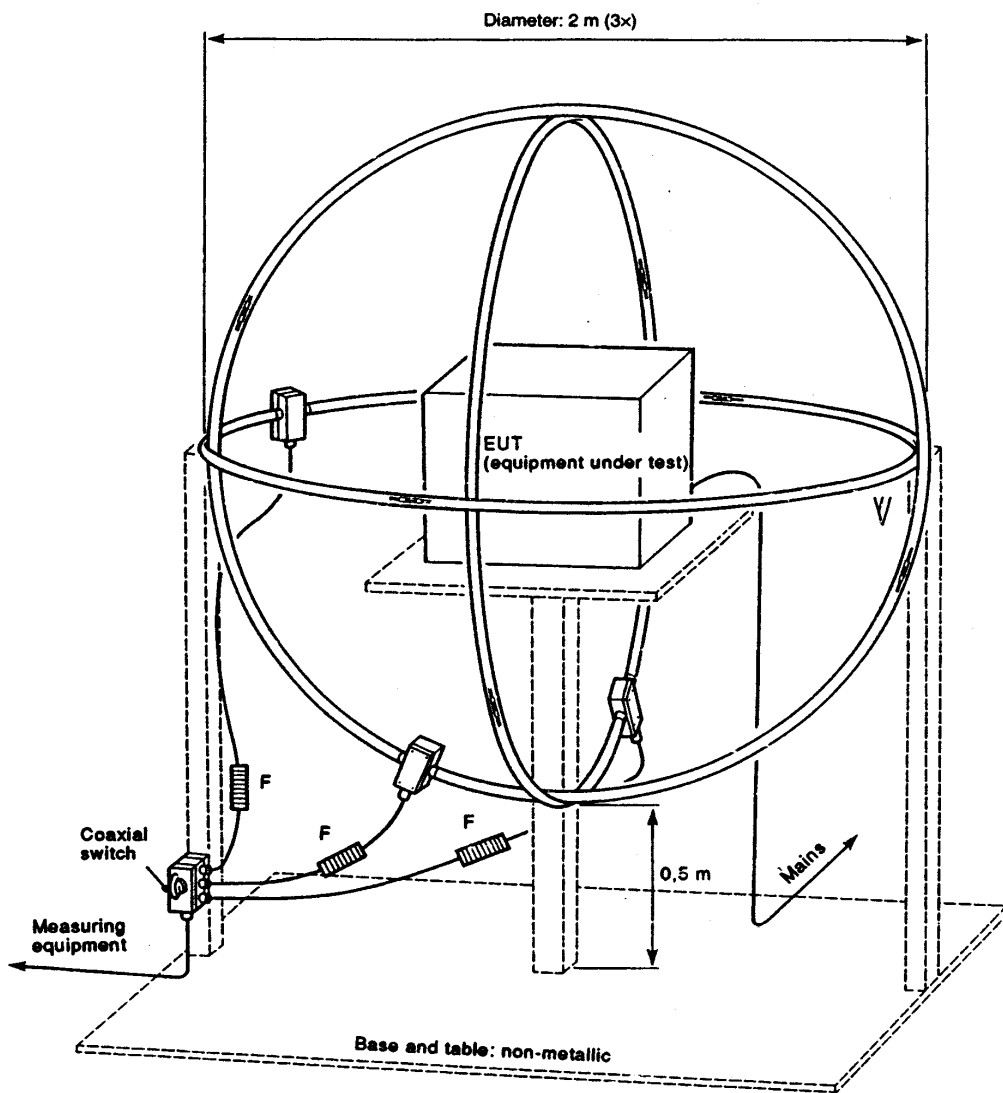
The loop antenna for the measurement of the magnetic field is shown in figure B.1. The loop antenna is provided with a current probe and two sites (see figures B.2 and B.3). The coaxial cables between the current probes and the coaxial switch and between the coaxial switch and the measuring receiver are of good quality (for instance RG223/U) and terminated with collet lock BNC connectors. The coaxial cables are provided with ferrite toroids ( $R_s > 100\Omega$  at 10 MHz, for example, 12 rings ferroxcube 3E2 outer diameter approximately 30 mm).

**B.3 Positioning of the loop antenna**

The distance between the outer diameter of the loop antenna system and nearby objects, such as floor and walls, shall be at least 0.5 m.

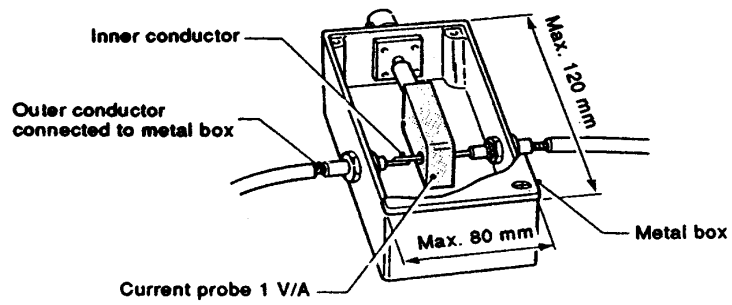
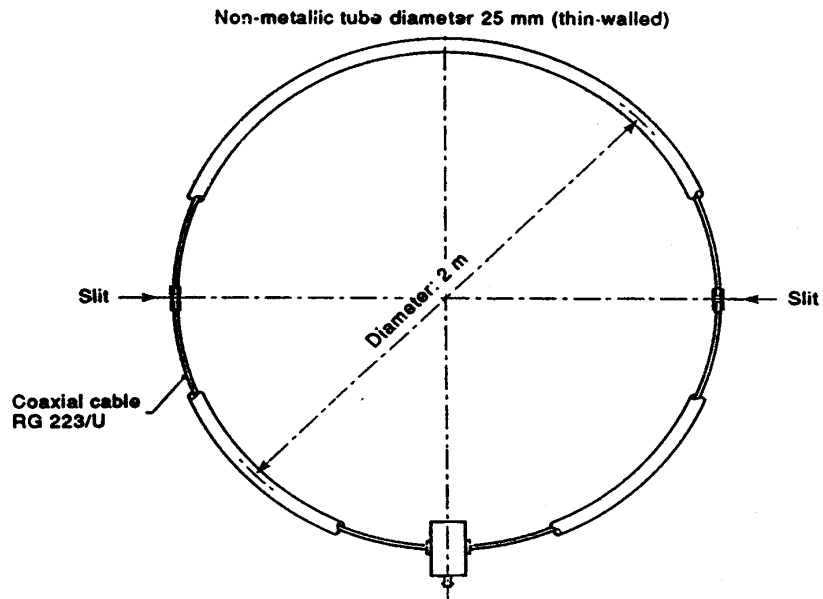
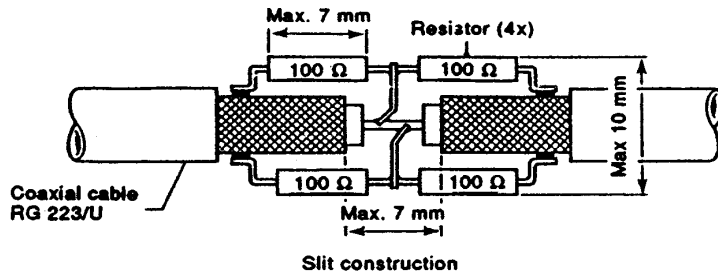
**B.4 Verification**

Verification of the measuring set-up shall be carried out regularly with a calibration-(balun) dipole, powered by an r.f. generator (see figure B.4). The reproducibility of the measurements shall be within  $\pm 2$  dB.

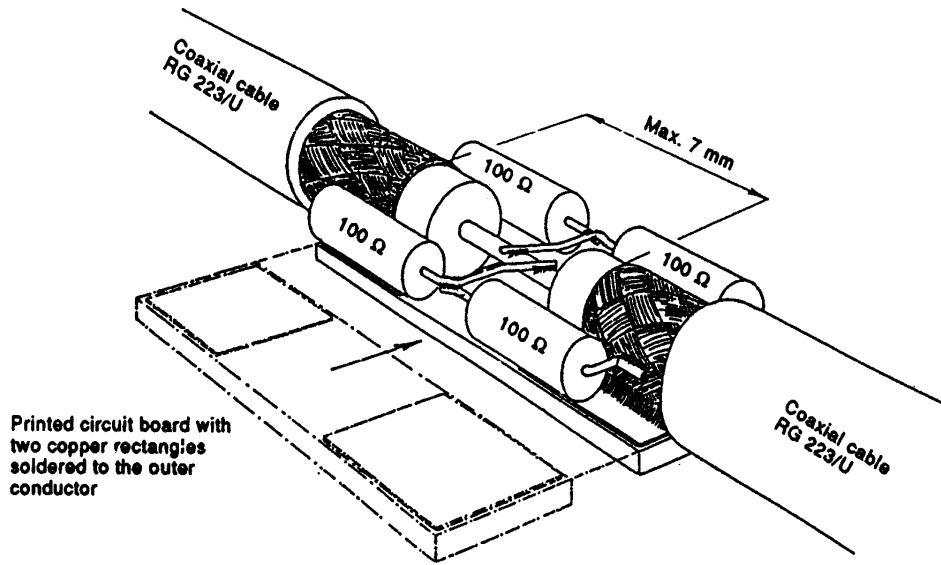


F = ferrite absorber

**Figure B.1 – Test set-up for measuring magnetic fields in X, Y and Z direction  
(frequency range 9 kHz and 30 MHz)  
(Clause 8.1.1 and B2)**



**Figure B.2 – Large-loop construction**  
(Clause B2)



**Figure B.3 – Example of a slit construction for the large-loop antenna**  
(Clause B2)

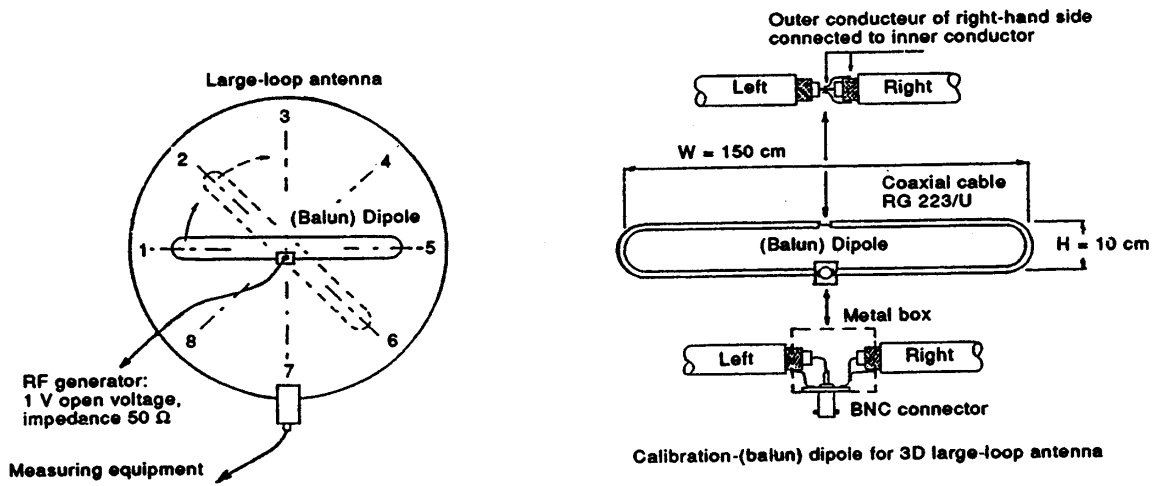
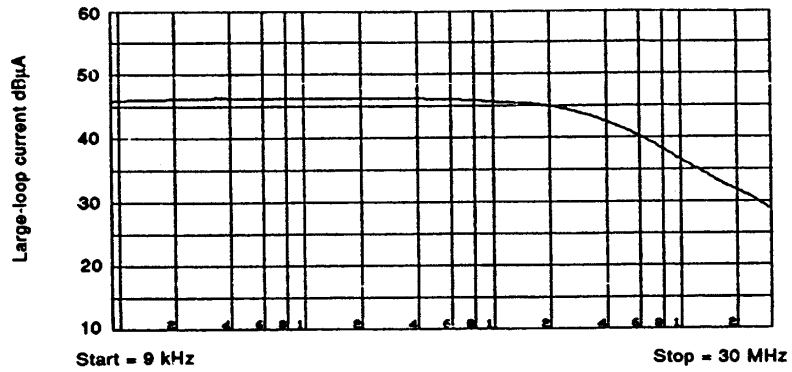
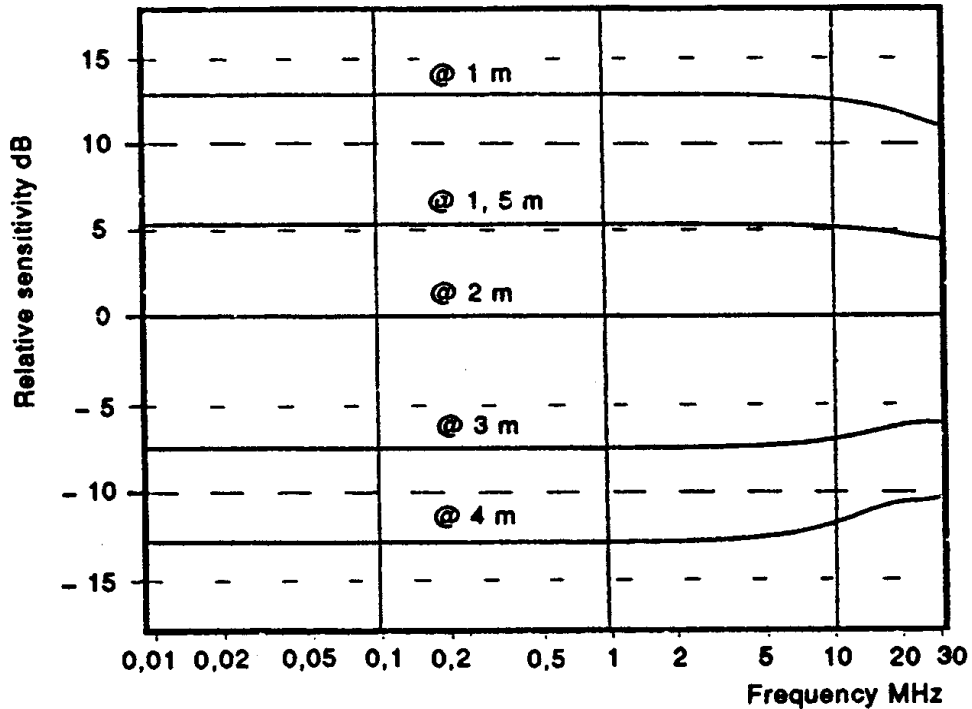


Figure B.4 – Test set-up for verification of the large-loop antenna  
(Clause B2)

**Annex C**  
**Relative sensitivities and conversion factors for**  
**large-loop antennas(LLAs)**  
**(Clause 8.7)**



The following examples may explain the use of figure C.1

- a) Measuring frequency : 100 kHz  
 LLA loop diameter : 2 m  
 Current induced by EUT : X dB $\mu$ A  
 Then, for the same EUT :  
 In the case of a 1.0 m LLA : current measured = X+13dB $\mu$ A  
 In the case of a 3.0 m LLA : current measured = X+7 dB $\mu$ A
- b) LLA loop diameter : D m  
 Relative sensitivity : S dB (for diameter D).  
 Current induced by EUT : Y dB $\mu$ A (in LLA with diameter D).

Then the field strength H (dB $\mu$ V/m) at a distance of d m from the EUT follows from :

$$H(\text{dB}\mu\text{V/m}) = Y(\text{dB}\mu\text{A}) - S(\text{dB}) + C_d(\text{dB}\Omega/\text{m})$$

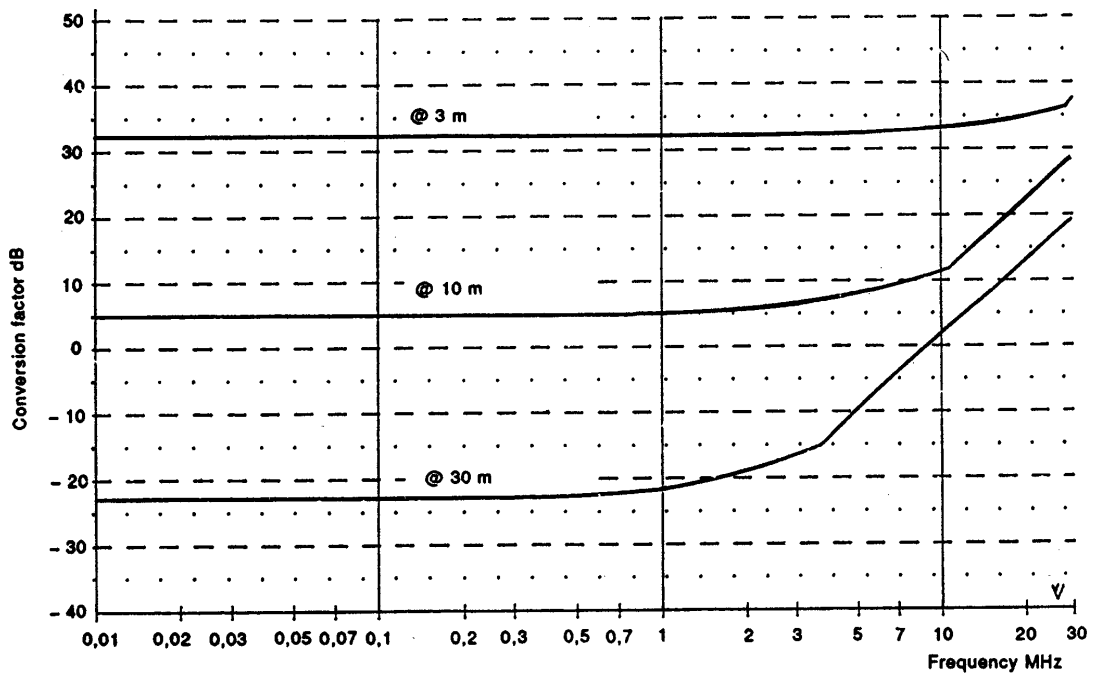
Where  $C_d$  is the conversion factor taken from figure C.2 for the chosen distance d.

For example :

$$F = 100 \text{ kHz}, D = 3\text{m}, d = 30 \text{ m}, \text{ Then}$$

$$H = (Y+7-22) = (Y-15) \text{ dB}\mu\text{V/m}.$$





[current (dB $\mu$ A) + conversion factor (dB) = magnetic field (dB $\mu$ V/m)]  
 (distance is measured from the centres of DUT and the antenna)

**Figure C.2 – Correlation between the current in the 2 m loop antenna  
 and the magnetic field at the indicated distances  
 (Annex C)**

\_\_\_\_\_