RECOMMENDATION ITU-R SM.1056

LIMITATION OF RADIATION FROM INDUSTRIAL, SCIENTIFIC AND MEDICAL (ISM) EQUIPMENT

(Question ITU-R 70/1)

(1994)

The ITU Radiocommunication Assembly,

considering

a) that No. 16 of the Radio Regulations (RR) defines ISM applications (of radio-frequency energy) as operation of equipment or appliances designed to generate and use locally radio-frequency energy for industrial, scientific, medical, domestic or similar purposes, excluding applications in the field of telecommunications;

b) that ISM equipment has the potential to cause harmful interference to radiocommunication services and applications throughout the spectrum;

c) that for the optimum use of the frequency spectrum, it is necessary to lay down limits of radiation from ISM equipment outside the bands designated for their use;

d) that the World Administrative Radio Conference (Geneva, 1979) (WARC-79) with its Resolution No. 63 invited the ITU-R to specify, in collaboration with the International Electrotechnical Commission/International Special Committee on Radio Interference (IEC/CISPR), limits to be imposed on radiation from ISM equipment inside and outside the bands designated in the RR for their use;

– that limits shall be specified in the entire radio spectrum allocated to radio services;
– that different radio services need different grades of protection and that the specific protection requirements of safety services and safety communications need to be taken into account;
– that the use of radio-frequency energy for industrial, scientific, medical and domestic purposes is beneficial for the economy and the consumers, and is essential for a number of these applications;

e) that due to the different operating environments and characteristics of ISM equipment several categories of limits are necessary;

f) that radio services operating in the bands designated for use by ISM equipment prior to WARC-79 are required to accept harmful interference and that radiation limits are necessary in all other bands to protect radio services;

g) that radiation from ISM equipment may be costly and technically difficult to suppress and thus development of suppression requirements must take into consideration physical, technological, economic, operational and safety aspects of ISM usage to avoid unnecessarily severe measures;

h) that equipment meeting the radiation limits, which are compromise values, may in some circumstances cause harmful interference; and, there needs to be provisions for measures to be taken to eliminate or reduce interference in individual cases;

j) that the legal and administrative provisions differ in different countries and thus administrations have different methods of applying and enforcing limits;

k) that the CISPR has developed limits and taken into account the principles outlined in § f) and g) and the requirements to harmonize the procedures for the control of interference in order to eliminate technical barriers to trade;

l) that the interference potential depends on the location of ISM equipment within the user's premises and that the measuring distance and the point of reference for *in situ* measurements have to be taken into account;

m) that severe difficulties could arise if different limits were to be recommended by different international bodies for the same class of equipment, *noting*

1. that, for ISM applications, the frequencies typically used by ISM equipment and some current and future ISM applications are shown in Annex 1;

2. that, although the ITU has designated specific frequency bands for ISM applications, other operating frequencies are also being used where practical constraints do not permit the usage of the designated bands;

3. that CISPR Publication 23 "Determination of limits for industrial, scientific and medical equipment" provides details of the derivation of limits;

4. that information technology equipment (ITE) and RF lighting devices which use RF energy have not been considered by the CISPR as ISM equipment and CISPR Publications 15 and 22, respectively, contain a guide for the application of limits and methods of measurements,

recommends

1. that administrations consider the use of the latest edition of CISPR Publication 11, including amendments, as a guide for the application of limits and methods of measurements for ISM equipment regulation in order to protect radiocommunications;

2. that there should be continued cooperation with the CISPR to ensure that radiocommunication needs are fully taken into consideration.

ANNEX 1

Industrial, scientific and medical (ISM) applications

1. Introduction

This Annex includes the ITU definition of ISM applications, a list of frequencies typically used by ISM equipment and describes some current and future ISM applications.

2. ISM applications

According to RR No. 16, ISM application is the operation of equipment or appliances designed to generate and use locally radio-frequency energy for industrial, scientific, medical, domestic or similar purposes, excluding applications in the field of telecommunications.

A partial list of ISM applications and equipment include:

Induction heating equipment (below 1 MHz)

- domestic induction cookers
- metal melting
- billet heating
- tube welding
- soldering and brazing
- component heating
- spot welding
- selective surface heat treating of metal parts
- semiconductor crystal growing and refining
- seam bonding of autobody surfaces
- package sealing
- heating strip steel for galvanizing, annealing and paint drying

RF dielectric heating equipment
(1-100 MHz)

– veneer and lumber drying
– textile drying
– fibreglass drying
– paper and paper coating drying
– plastic pre-heating
– plastic welding and moulding
– food post baking and drying
– meat and fish thawing
– foundry core drying
– glue drying
– film drying
– adhesive curing
– material preheating

Medical equipment

– short-wave and microwave diathermy and hyperthermia equipment
– electrical surgical units (ESU)
– magnetic resonance imaging (MRI)
– ultrasonic diagnostic imaging

Microwave equipment (above 900 MHz)

– domestic and commercial microwave ovens
– food tempering, thawing and cooking
– UV paint and coating curing
– rubber vulcanization
– pharmaceutical processing

Miscellaneous equipment

– RF excited arc welders
– spark erosion equipment

Laboratory and scientific equipment

– signal generators
– measuring receivers
– frequency counters
– flow meters
– spectrum analysers
– weighing machines
– chemical analysis machines
– electronic microscopes
– switched mode power supplies (not incorporated in an equipment)

2.1 Current applications

The frequencies currently employed for industrial, scientific, medical and other non-communications applications cover a very wide spectrum including frequencies other than those designated by the RR. A number of ISM equipments use frequencies of undefined tolerance and stability and some of them use frequencies allocated to the safety services and radionavigation services. Table 1 provides a summary of some of the ISM applications in various frequency bands.

2.2 Future applications

Investigations into new non-communication applications of electromagnetic energy for improving industrial processes are dramatically increasing throughout the world. These investigations are not limited to the ISM bands. Selection of the application frequency for production apparatus is based on many factors, which include, but are not limited to:

– availability of a suitable power source,
– RF interference potential and containment costs,
– safety considerations,
– availability of a suitable ISM frequency, and
– frequency optimization for the particular operation.

A number of new applications promise significant social and economic benefits, which may not be available by any other process and also promise significant savings in energy and the environment.

TABLE 1

ISM equipment in current use

Frequency (MHz)	Major applications	RF power (typical)	Estimated No. in use
Below 0.15	Industrial induction heating (welding and melting of metals)	10 kW-10 MW	> 100 000
	Ultrasonic cleaning (15-30 kHz)	20-1 000 W	> 100 000
	Medical applications (ultrasonic diagnostic imaging)	100-1 000 W	> 10 000
0.15-1	Induction heating (heat treating, package sealing, welding and melting of metals)	1 kW-1 MW	> 100 000
	Ultrasonic medical diagnostics	100-1 000 W	> 100 000
1-10	Surgical diathermy (1-10 MHz dampened wave oscillator)	100-1 000 W	> 100 000
	Wood gluing and wood curing (3.2 and 6.5 MHz)	10 kW-1.5 MW	
	Valve induction generators	1-200 kW	
	production of semi-conductor material	2-10 kW	> 1 000
	RF arc stabilized welding (1-10 MHz dampened wave oscillator)		> 10 000
10-100	Dielectric heating (the majority operate on frequencies in the ISM bands at 13.56, 27.12 and 40.68 MHz, but many also operate on frequencies outside the ISM bands)		
	– ceramics	15-300 kW	< 1 000
	– foundry core drying	15-300 kW	< 1 000
	– textile drying	15-200 kW	> 1 000
	– business products (books, paper, gluing and drying)	5-25 kW	> 1 000
	– food (post baking, meat and fish thawing)	10-100 kW	< 1 000
	– solvent drying		
	– wood drying and gluing (veneer and lumber drying)	5-400 kW	> 10 000
	– general dielectric drying	5-1 000 kW	> 100 000
	– plastic heating (die sealing and plastic embossing)	1-50 kW (most < 5 kW)	> 10 000
	Medical applications		
	– medical diathermy (27 MHz)	100-1 000 W	> 1 000
	– magnetic resonance imaging (10-100 MHz in large shielded rooms)		
100-1 000	Food processing (915 MHz)	< 200 kW	< 1 000
	Medical applications (433 MHz)		
	RF plasma generators		
	Rubber vulcanization (915 MHz)		< 1 000
Above 1 000	RF plasma generators		
	Domestic microwave ovens (2 450 MHz)	600-1 500 W	> 200 million
	Commercial microwave ovens (2 450 MHz)	1.5-200 kW	
	Rubber vulcanization (2 450 MHz)	6-100 kW	< 1 000
	RF excited ultraviolet curing		

Areas of recent investigations include:

2.2.1 Induction heating

While not a new application, new high-flux induction generators are encouraging a number of applications, such as:

– refining of very pure semi-conductor material,

– melting of metals, particularly vacuum melting for the aerospace and automotive industries.

2.2.2 Plasma chemistry

The ISM bands at 27 MHz, 915 MHz and 2 450 MHz, as well as other frequencies are being investigated in the following plasma chemistry experiments:

– diamond growing,
– ceramic processing and sintering,
– raw material processing.

2.2.3 Medical treatment

Some recent investigations include:

– acceleration of chemical analysis using 2 450 MHz,
– local radiation treatment for cancer on frequencies below 400 MHz (hyperthermia),
– tissue fixation,
– magnetic resonance imaging using 10 to 100 MHz in specially shielded rooms,
– treatment of hyperthermia.

2.2.4 Material and food processing

– environment space heating using 5 800 MHz,
– recovery of oil from shale using frequencies below 10 MHz,
– disposal of hazardous waste using microwave frequencies like 2 450 MHz,
– bulk thawing and cooking at 915 MHz, 2 450 MHz and 5 800 MHz,
– clothes drying at 2 450 MHz,
– soil remediation,
– medical waste sterilization,
– pasteurization and sterilization of foods,
– treatment of refuse (13.56 MHz and 2 450 MHz).

2.2.5 Power transfer

Most experiments on transfer of energy have occurred at microwave frequencies, e.g., 2 450 MHz, 5 800 MHz and higher.

– Solar power satellite experiments are continuing at 2 450 MHz and 35 GHz;
– transfer of power to an aircraft at 2 450 MHz;
– electrified roadway – a number of energy transfer stations embedded in the roadway to recharge electrically powered vehicles passing overhead (915 MHz and 2 450 MHz);
– electromagnetic (EM) propulsion systems below 1 MHz.

3. Radiation levels inside the bands designated for ISM applications

3.1. Rationale

There are at least five reasons for setting in-band limits for ISM equipment, which are:

– to control bio-effects;
– to minimize out-of-band emissions for the protection of radio services;
– to minimize in-band emissions for the protection of radio services operating in the ISM bands;
– to minimize radio emissions for the protection of adjacent band radio services;
– to minimize radio emissions to protect electronic or radio services operated in the immediate vicinity of ISM equipment.

The limits and methods of measurement and methods employed for bio-effects compliance are outside the scope of the ITU and the CISPR and therefore bio-effect could not be used for setting in-band limits. However, it has been observed that, in many cases, compliance with the biological effects limits has not substantially reduced radiation levels at CISPR measuring distances.

It should be noted reducing in-band radiation does not necessarily reduce out-of-band radiation, and that the out-of-band radiation can increase through suppression of in-band signals.

In-band limits to protect in-band radio services have not been considered because the services to be protected have not been specified. Furthermore, the setting of restrictive limits will decrease the usefulness of the ISM bands for industrial purposes. The result of this would be to encourage the use of ISM equipment in frequency ranges more suitable to their processes, but detrimental to radio services.

The use of in-band limits to protect radio services adjacent to the ISM bands or to protect electronic or radio equipment in the vicinity of ISM operations is more properly dealt with as an equipment immunity issue. Therefore, this is best resolved by ensuring necessary distance separation or by incorporating adequate immunity characteristics in potential victim equipment. However, the calculation and realization of immunity is practical only if the field strengths to be encountered in practice are known. For this reason, the following table of measured levels of radiation based on measurements in a number of different countries is supplied.

3.2 ITU designated ISM bands and measured levels

Some measurements of the radiation levels generated by ISM equipment in the bands designated for their use have been carried out in different countries and at different locations. Table 2 gives a survey of the results.

TABLE 2

Range of measured levels of field strength from ISM equipment in the ITU-designated ISM bands

Frequency band	Centre frequency	No. of appropriate Footnote to the Table of Frequency Allocations of the ITU RR	Range of measured field strengths (dB(μV/m))(1)
6.765-6.795 MHz	6.78 MHz	524	80-100
13.553-13.567 MHz	13.567 MHz	534	80-120
26.957-27.283 MHz	27.12 MHz	546	70-120
40.66-40.70 MHz	40.68 MHz	548	60-120
433.05-434.79 MHz	433.92 MHz	661, 622 (Region 1)	60-120
902-928 MHz(2)	915 MHz	707 (Region 2)	60-120
2 400-2 500 MHz	2 450 MHz	752	30-120
5.725-5.825 GHz	5.8 GHz	806	No information
24.00-24.25 GHz	24.125 GHz	881	No information
61.00-61.50 GHz	61.25 GHz	911	No information
122-123 GHz	122.5 GHz	916	No information
244-246 GHz	245 GHz	922	No information

(1) The field strength is that existing at a distance of 30 m from the boundary of the building in which the ISM equipment is situated. Therefore the actual distance between the ISM equipment and the measuring point is not known.

(2) 896 MHz in the United Kingdom.

4. Sources for more information

– Journal and Symposium Reports of the
International Microwave Power Institute
13542 Union Village Circle
Clifton, VA 22024
United States of America

– Electric Power Research Institute
P.O. Box 10412
Palo Alto, CA 94303
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