8.2.3 Handheld equipment which are normally operated without an earth connection

For this equipment additional measurements shall be made using the artificial hand described in 7.3.5.

The artificial hand shall be applied only on handles and grips and those parts of the appliance specified as such by the manufacturer. Failing the manufacturer's specification the artificial hand shall be applied in the following way.

The general principle in applying the artificial hand is that the metal foil shall be wrapped around all handles (one artificial hand per handle), both fixed and detachable, supplied with the equipment.

Metalwork which is covered with paint or lacquer is considered as exposed metalwork and shall be directly connected to the terminal M of the RC element.

When the casing of the equipment is entirely of metal, no metal foil is needed, but the terminal M of the RC element shall be connected directly to the body of the equipment.

When the casing of the equipment is of insulating material, a metal foil shall be wrapped around the handles.

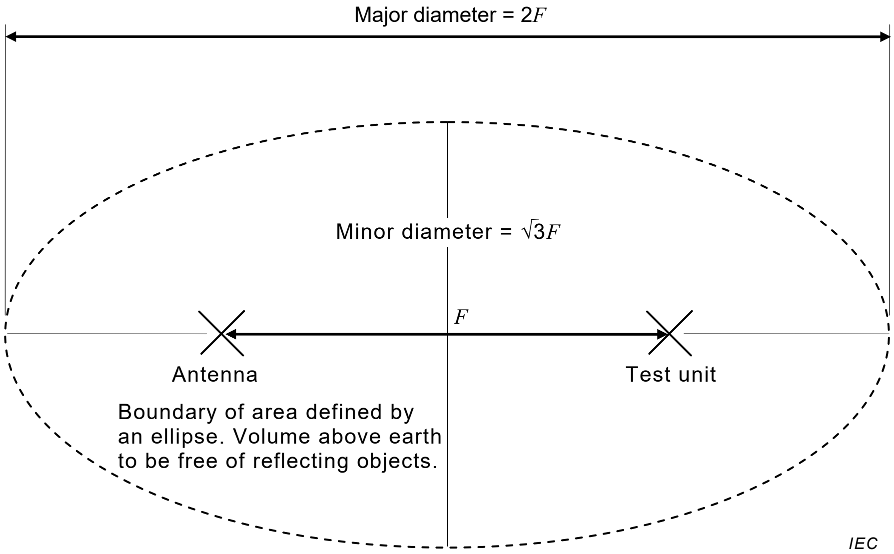
When the casing of the equipment is partly metal and partly insulating materials, and has insulating handles, a metal foil shall be wrapped around the handles.

8.3 OATS and SAC for measurements in the range 9 kHz to 1 GHz

8.3.1 General

The radiation test site shall be flat, free of overhead wires and nearby reflecting structures, sufficiently large to permit adequate separation between the antenna, test unit and reflecting structures.

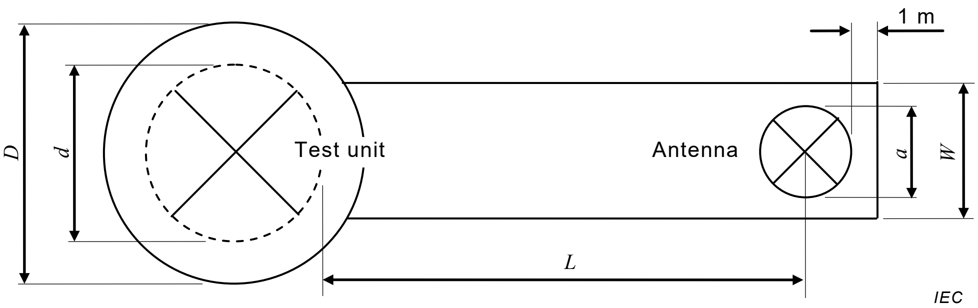
A radiation test site which meets the criteria is within the perimeter of an ellipse having a major axis equal to twice the distance between the foci and a minor axis equal to the square root of three times of this distance. The equipment under test and the measuring equipment are placed at each of the foci respectively. The path length of any ray reflected from an object on the perimeter of this radiation test site will be twice the length of the direct path length between the foci. This radiation test site is depicted in Figure 10.



NOTE For the values of F (measuring distance) see Clause 6.

Figure 10 – Test site

For the 10 m test site, the natural ground plane shall be augmented with a ground plane of metal which shall extend at least 1 m beyond the boundary of the equipment under test at one end and at least 1 m beyond the measurement antenna and its supporting structure at the other end (see Figure 11). The ground plane shall have no voids or gaps other than any perforations which do not exceed 0,1 λ at 1 GHz (about 30 mm).



D = (d + 2) m, where d is the maximum test unit dimension

W = (a + 1) m, where a is the maximum dimension of the antenna

L = measuring distance in metres

Figure 11 – Minimum size of metal ground plane

8.3.2 Validation of the radiation test site (9 kHz to 1 GHz)

Test sites shall be validated according to CISPR 16-1-4 in the frequency ranges where the standard defines requirements.

8.3.3 Disposition of equipment under test (9 kHz to 1 GHz)

For the EUT's earthing and grounding conditions as well as connection to the laboratory's electricity supply network see 7.5.3.1 or 7.5.3.2.

If it is possible to do so, the equipment under test shall be placed on a turntable. The separation between the equipment under test and the measuring antenna shall be the horizontal distance between the reference point of the measuring antenna and the nearest part of the boundary of the equipment under test in one rotation.

8.3.4 Radiation measurements (9 kHz to 1 GHz)

The separation distance between the antenna and the equipment under test shall be as specified in Clause 6. If the field strength measurement at a certain frequency cannot be made at the specified distances because of high ambient noise levels (see 7.2), measurements at this frequency may be made at a closer distance but not less than 3 m. When this is done, the test report shall record the distance actually used and the circumstances of the measurement.

For equipment under test located on a turntable, the turntable shall be rotated fully with a measurement antenna oriented for both horizontal and vertical polarization. The highest recorded level of the electromagnetic radiation disturbance at each frequency shall be recorded.

For equipment under test not located on a turntable the measurement antenna shall be positioned at various points in azimuth for both horizontal and vertical polarization. Care shall be taken that measurements be taken in the directions of maximum radiation and the highest level at each frequency be recorded.

NOTE At each azimuthal position of the measurement antenna the radiation test site requirements specified in 8.3.1 are met.

8.4 Alternative radiation test sites for the frequency range 30 MHz to 1 GHz

Measurements may be performed on radiation test sites which do not have the physical characteristics described in 8.3. Evidence shall be obtained to show that such alternative sites will yield valid results. An alternative radiation test site in the frequency range 30 MHz to 1 GHz is acceptable if the horizontal and vertical site attenuation measurements made as per 5.3 of CISPR 16-1-4:2010/AMD1:2012 are within ± 4 dB of the theoretical site attenuation as given in Tables 1 or 2 of CISPR 16-1-4:2010/AMD1:2012.

Alternative radiation test sites shall allow for, and be validated for, the measurement distance in the frequency range 30 MHz to 1 GHz specified elsewhere in Clause 6 and/or Clause 8 of this standard.

8.5 FAR for measurements in the range 30 MHz to 1 GHz

A fully-anechoic room (FAR) used for measurement of radiated disturbances in the frequency range 30 MHz to 1 GHz shall comply with the requirements in CISPR 16-1-4.

The use of the FAR is restricted to table-top equipment. The size of the EUT suitable to be measured in a FAR is limited by the validated test volume of the given FAR. The test volume of the FAR is validated according to CISPR 16-1-4, and documented in the site validation report.

NOTE For measurements at 3 m separation distance, this validated test volume will likely limit the applicability of the FAR to small size equipment, see definition 3.17.

For measurements in the FAR, the test setup shall be, as far as applicable, the same as described in Clause 8.3 for measurements on an OATS or in a SAC. Further information on performance of emission measurements in a FAR in the range 30 MHz to 1 GHz is found in 7.4 of CISPR 16-2-3:2010/AMD 2:2014.

9 Radiation measurements: 1 GHz to 18 GHz

9.1 Test arrangement

The equipment under test shall be placed on a turntable at a suitable height. Power at the normal voltage shall be supplied. For the EUT's earthing and grounding conditions as well as connection to the laboratory's electricity supply network see 7.5.3.

9.2 Receiving antenna

The measurements shall be made with a directive antenna of small aperture capable of making separate measurements of the vertical and horizontal components of the radiated field. The height above the ground of the centre line of the antenna shall be the same as the height of the approximate radiation centre of the equipment under test. The distance between the receiving antenna and the EUT shall be 3 m.

9.3 Validation and calibration of test site

Test sites shall be validated according to CISPR 16-1-4.

9.4 Measuring procedure

9.4.1 General

The measurements shall take place in free-space conditions, i.e. the reflections on the ground shall not influence the measurements, see CISPR 16-1-4.

The general measuring procedure above 1 GHz specified in CISPR 16-2-3 should be consulted for guidance. Measurements shall be made with the antenna in both horizontal and subsequently vertical polarization. In both cases, the turntable with the equipment under test shall be rotated. It shall be ascertained that, when the equipment under test is switched off, the level of background noise is at least 10 dB below the reference limit, since otherwise the reading may be significantly affected.

A flow chart showing the measurement procedure is shown in Figure 12.

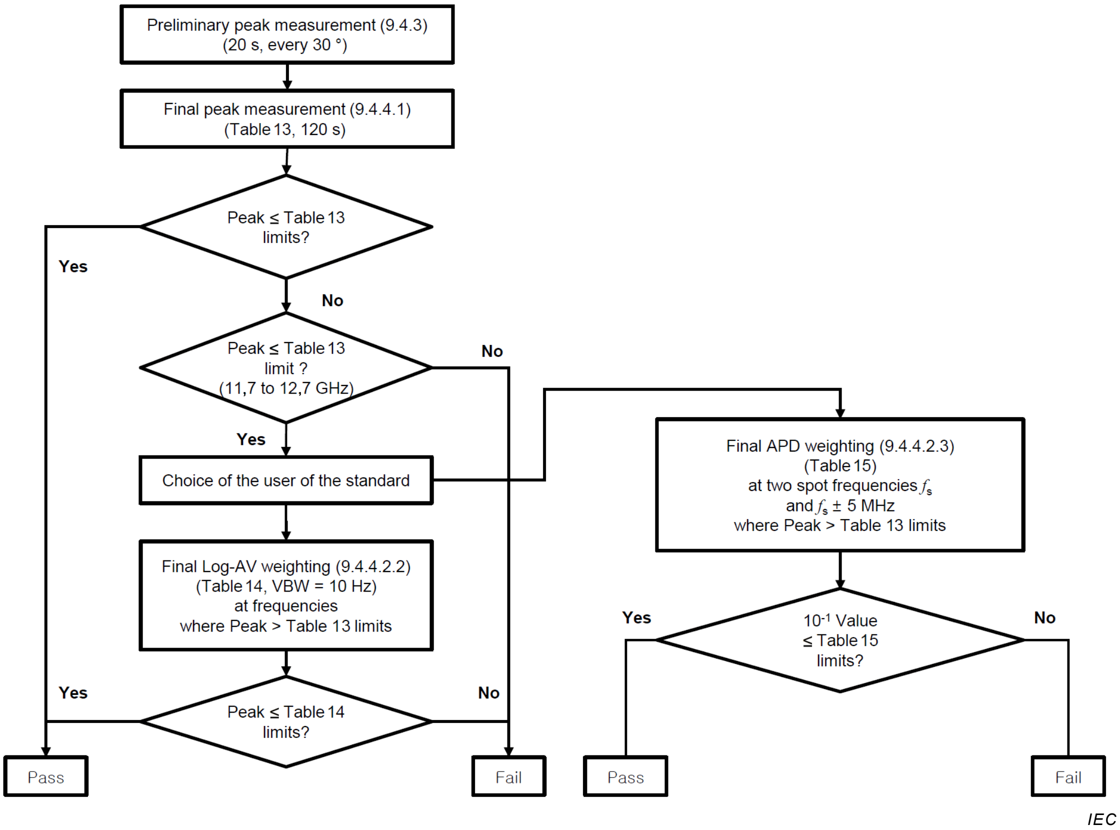


Figure 12 – Decision tree for the measurement of emissions from 1 GHz to 18 GHz of group 2 equipment operating at frequencies above 400 MHz

9.4.2 Operating conditions of the EUT

For microwave ovens, a warm-up period of at least 5 min shall be performed before the measurement.

For all measurements the starting phase of the EUT (a few seconds) is to be ignored.

During the measurements, the microwave oven under test is operated at maximum microwave power setting.

Some microwave ovens automatically turn to an intermittent operation mode if operated for a long time at their highest microwave power setting. In such cases the measurement shall be stopped for a while to allow cooling down until the microwave oven is able to operate at its max power setting without intermittence.

During the measurement, the water load should be exchanged to cold water before it starts to boil. For load conditions of microwave ovens during the measurements see also 7.6.5.

9.4.3 Preliminary measurement

The preliminary measurement comprises of a series of measurements with the peak detector. Peak measurements in the frequency range above 1 GHz (see Table 13) shall be the result of a maximum hold measurement with the spectrum analyzer. The purpose of the preliminary measurement is to identify the position (azimuth) of the EUT in relation to the measuring antenna which results in maximum emissions for each frequency identified.

To find the direction of the maximum emission, peak measurements in the range above 1 GHz shall be made with the azimuth of the EUT varying every 30° (starting position perpendicular to the front surface plane of the EUT, e.g. in a position perpendicular to the front door, in case of microwave ovens). At each of these 12 positions, a measurement in maximum-hold mode shall be made for a period of at least 20 s. Then, at the azimuth position of the EUT where the maximum emission occurred, the final measurement shall be performed.

9.4.4 Final measurement

9.4.4.1 Peak measurement

Peak measurements shall be performed over the whole frequency range 1 GHz to 2,4 GHz and 2,5 GHz to 18 GHz with the EUT positioned as identified during the preliminary measurement. At this azimuth position, a maximum hold measurement for a period of at least 2 min shall be made for both polarizations, i.e. with the antenna oriented successively in horizontal and in vertical polarization.

The obtained measurement result(s) shall be compared to the peak limit (see Table 13).

If the EUT passes the peak measurement, then the final test result is PASS, see Figure 12.

If the EUT does not pass the peak measurement in the satellite radio broadcasting frequency range 11,7 GHz to 12,7 GHz, then the final test result is FAIL, see Figure 12.

9.4.4.2 Weighted measurement

9.4.4.2.1 General

In cases where readings obtained during the peak measurement in the ranges 1 GHz to 11,7 GHz and 12,7 GHz to 18 GHz exceed the limits specified in Table 13 an additional series of measurements with a weighting function shall be performed.

For demonstration of the fluctuating nature of a disturbance, two alternative methods for weighted measurements are available, see also decision tree in Figure 12.

In any situation where it is necessary to re-test the equipment, the measuring method originally chosen shall be used in order to ensure consistency of the results.

9.4.4.2.2 Log-AV weighting according to Table 14

Weighted measurements with the Log-AV method (see Table 14) shall be performed at the azimuth position of the EUT where the maximum peak emission occurred during the preliminary measurement. A minimum of 5 consecutive sweeps in max-hold mode shall be performed.

These weighted measurements shall be performed with the spectrum analyzer in logarithmic display mode (using the logarithmic amplifier, not a mathematical unit conversion of the displayed values).

NOTE A video bandwidth of 10 Hz together with logarithmic amplification provides a level closer to the average level of the measured signal in logarithmic values. This result is lower than the average level that would be obtained in linear mode.

In preparation of the final measurement, the whole frequency range shall be divided into 7 sub-ranges from 1 GHz to 18 GHz according to Table 18.

For every sub-range where the EUT did not meet the limits of Table 13 identify the frequency of the highest emission level from the peak measurements. These frequencies are the centre frequencies to be used for the series of weighted measurements.

Table 18 – Frequency sub-ranges to be used for weighted measurements

Harmonics of 2,45 GHz, Order no.	**Frequency sub-ranges** GHz
Not defined	1,005 to 2,395
2	2,505 to 6,125 [a]
3	6,125 to 8,575
4	8,575 to 11,025
5	11,025 to 13,475
6	13,475 to 15,925
7	15,925 to 17,995
[a] Measurements in the ISM band 5,720 GHz to 5,880 GHz are excluded, see Table 1.	

Measurements with the Log-AV weighting function shall be performed in the sub-ranges where the EUT did not meet the limits of Table 13 around the centre frequencies identified in the previous step, within a frequency span of 10 MHz.

Compare the measurement results to the limits of Table 14.

If the EUT passes the measurement with the Log-AV weighting function (Table 14), then the final test result is PASS, see Figure 12.

9.4.4.2.3 APD weighting according to Table 15

As an alternative to 9.4.4.2.2, an APD measurement for a period of 30 s shall be performed at the azimuth of the EUT and the polarization of the antenna where the maximum emission was found during the preliminary peak measurements. Measurements shall be made at the following 6 frequencies (see Figure 12);

f_{s1},	f_{s2},
f_{s1} + 5 MHz,	f_{s2} + 5 MHz,
f_{s1} – 5 MHz,	f_{s2} – 5 MHz,

where f_{s1} is the frequency with the highest peak emission in the 1 005 MHz to 2 395 MHz range and f_{s2} is the frequency with the highest peak emission in the 2 505 MHz to 17 995 MHz range (but outside the band 5 720 MHz to 5 880 MHz).

Compare the measurement results to the limits of Table 15.

If the EUT passes the measurement with the APD weighting function (Table 15), then the final test result is PASS, see Figure 12.

10 Measurement *in situ*

For equipment which is not tested on a radiation test site, measurements shall be made after the equipment has been installed on the user's premises. Measurements shall be made from the exterior wall outside the building in which the equipment is situated at the distance specified in 6.4.

Measurements *in situ* at the place of operation of the equipment to be assessed shall be performed and documented in accordance with 7.7 of CISPR 16-2-3:2010. Further advice for *in situ* measurements is also found in CISPR TR 16-2-5 [2] [3].

The number of measurements made in azimuth shall be as great as reasonably practical, but there shall be at least four measurements in orthogonal directions, and measurements in the direction of any existing radio systems which may be adversely affected.

For the larger commercial microwave ovens it is necessary to ensure that the measurement results are not affected by near field effects. CISPR 16-2-3 should be consulted for guidance.

11 Safety precautions for emission measurements on ISM RF equipment

ISM RF equipment is inherently capable of emitting levels of electromagnetic radiation that are hazardous to human beings. Before testing for electromagnetic radiation disturbance, the ISM RF equipment should be checked with a suitable radiation monitor.

12 Measurement uncertainty

Determining compliance with the limits in this standard shall be based on the results of the compliance measurements taking into account the considerations on measurement instrumentation uncertainty.

Where guidance for the calculation of the instrumentation uncertainty of a measurement is specified in CISPR 16-4-2 this shall be followed, and for these measurements the determination of compliance with the limits in this standard shall take into consideration the measurement instrumentation uncertainty in accordance with CISPR 16-4-2. Calculations to determine the measurement result and any adjustment of the test result required when the test laboratory uncertainty is larger than the value for U_{CISPR} given in CISPR 16-4-2 shall also be included in the test report.

For *in situ* measurements, the contribution of uncertainty due to the site itself is excluded from the uncertainty calculation.

NOTE When performing measurements at distances less than 10 m, higher measurement uncertainties may have to be taken into account.

3 Figures in square brackets refer to the Bibliography.

Annex A
(informative)

Examples of equipment classification

Many types of equipment in the scope of this standard contain two or more types of interference sources, for example an induction heater might incorporate semiconductor rectifiers in addition to its heating coil. For testing purposes the equipment is to be defined in terms of the purpose for which it was designed. For example, the induction heater incorporating semiconductor rectifiers is to be tested as an induction heater (with all disturbances meeting the prescribed limits whatever the source of disturbance) and is not to be tested as if it were a semiconductor power supply.

The standard gives general definitions of group 1 and group 2 equipment and for official purposes the group to which a particular piece of apparatus belongs shall be identified from these definitions. It will, however, be helpful to users of the standard to have a comprehensive list of types of apparatus which have been identified as belonging to a particular group. This will also help in developing the specification where variations in test procedures may be found by experience to be necessary in dealing with specific types of apparatus.

The following lists of group 1 and group 2 equipment are not exhaustive.

Group 1

Group 1 equipment: group 1 contains all equipment in the scope of this standard which is not classified as group 2 equipment.

General:
Laboratory equipment
Medical electrical equipment
Scientific equipment
Semiconductor converters
Industrial electroheating equipment with operating frequencies less than
or equal to 9 kHz
Machine tools
Industrial process measurement and control equipment
Semiconductor manufacturing equipment

Detailed: Signal generators, measuring receivers, frequency counters, flow meters, spectrum analysers, weighing machines, chemical analysis machines, electronic microscopes, switched mode power supplies and semiconductor converters (when not incorporated in an equipment), semiconductor rectifiers/inverters, grid connected power converters (GCPC), resistance heating equipment with built-in semiconductor AC power controllers, arc furnaces and metal melting ovens, plasma and glow discharge heaters, X-ray diagnostic equipment, computerised tomography equipment, patient monitoring equipment, ultrasound diagnostic and therapy equipment, ultrasound washing machines, regulating controls and equipment with regulating controls incorporating semiconductor devices with a rated input current in excess of 25 A per phase

Group 2

Group 2 equipment: group 2 contains all ISM RF equipment in which radio-frequency energy in the frequency range 9 kHz to 400 GHz is intentionally generated and used or only used locally, in the form of electromagnetic radiation, inductive and/or capacitive coupling, for the treatment of material, for inspection/analysis purposes, or for transfer of electromagnetic energy.

General: Microwave-powered UV irradiating apparatus
Microwave lighting apparatus

Industrial induction heating equipment operating at frequencies above 9 kHz

Inductive power transfer / charging equipment [a]

Dielectric heating equipment

Industrial microwave heating equipment

Microwave ovens

Medical electrical equipment

Electric welding equipment

Electro-discharge machining (EDM) equipment

Demonstration models for education and training

[a] Inductive or capacitive power transfer apparatus normally subject to CISPR 11, but forming part of equipment subject to other CISPR standards is excluded from the scope of CISPR 11.

Detailed: Metal melting, billet heating, component heating, soldering and brazing, arc welding, arc stud welding, resistance welding, spot welding, tube welding, industrial laser oscillator exited by high-frequency discharge, wood gluing, plastic welding, plastic preheating, food processing, biscuit baking, food thawing, paper drying, textile treatment, adhesive curing, material preheating, short-wave diathermy equipment, microwave therapy equipment, magnetic resonance imaging (MRI), medical HF sterilizers, high-frequency (HF) surgical equipment, crystal zone refining, demonstration models of high-voltage Tesla transformers, belt generators, etc.

Annex B
(informative)

Precautions to be taken in the use of a spectrum analyzer (see 7.3.1)

Most spectrum analyzers have no radio-frequency selectivity: that is, the input signal is fed directly to a broadband mixer, where it is heterodyned to a suitable intermediate frequency. Microwave spectrum analyzers are obtainable with tracking radio-frequency pre-selectors which automatically follow the frequency being scanned by the receiver. These analyzers overcome to a considerable degree the disadvantages of attempting to measure the amplitudes of harmonic and spurious emissions with an instrument which can generate such components in its input circuits.

In order to protect the input circuits of the spectrum analyzer from damage when measuring weak disturbance signals in the presence of a strong signal, a filter should be provided in the input to give at least 30 dB of attenuation at the frequency of the strong signal. A number of such filters may be required to deal with different operating frequencies.

Many microwave spectrum analyzers employ harmonics of the local oscillator to cover various portions of the tuning range. Without radio-frequency pre-selection, such analyzers may display spurious and harmonic signals. It thus becomes difficult to determine whether a displayed signal is actually at the indicated frequency, or is generated within the instrument.

Many ovens, medical diathermy equipment and other microwave ISM RF equipment receive their input power from rectified a.c. but unfiltered energy sources. Consequently, their emissions are simultaneously modulated in amplitude and frequency. Additional AM and FM are caused by the movement of stirring devices used in ovens.

These emissions have spectral line components as close together as 1 Hz (due to modulation by the oven stirring device), and 50 Hz or 60 Hz (due to the modulation at mains frequency). Considering that the carrier frequency is generally rather unstable, distinguishing these spectral line components is not feasible. Rather, it is the practice to display the envelope of the true spectrum by employing an analyzer bandwidth which is larger than the frequency interval between spectral components (but as a rule small in relation to the width of the spectral envelope).

When the analyzer bandwidth is wide enough to contain a number of adjacent spectral lines, the indicated peak value increases with bandwidth up to the point where the analyzer bandwidth is comparable to the width of the spectrum of the signal. It is essential, therefore, to obtain agreement to use a specified bandwidth in order to compare the amplitudes displayed by different analyzers when measuring emissions typical of present heating and therapeutic devices.

It has been indicated that many oven emissions are modulated at a rate as low as 1 Hz. It has been observed that the displayed spectral envelopes of such emissions are irregular, appearing to vary from scan to scan, unless the number of scans per second is low compared with this lowest frequency component of the modulation.

A suitable rate for investigation of the emission may require 10 s or more to accomplish one scan. Such low scanning rates are not suitable for visual observation unless suitable storage is employed, such as that provided by a storage-type cathode ray tube, a photograph, or a chart recording device. Some attempts have been made to increase the useful scanning frequency by removing or stopping the stirring devices in the oven. However, this may be considered unsatisfactory because the amplitude, frequency and shape of the spectrum are found to vary with the position of the stirrers.