# Product Safety Requirements For Audio, Video And Similar Electronic Apparatus

A review of the requirements of IEC 60065 and their application in testing.

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Every night in homes across the country, families sit down to watch TV. Others might gather to watch DVD movies, enjoying that movie theatre experience at home. Did you ever ask "How safe is the equipment I purchased?"

Most people never question the hazards that could result from bringing any of this equipment into their home. Fortunately, before these items can be sold, they must be evaluated to product specific standards written to assess these hazards and to protect the user. In this article, we'll introduce you to IEC 60065, the standard that defines product safety requirements for audio, video and similar electronic apparatus. Protection against electric shock is provided in a framework that resembles those of other safety standards, such as IEC 60950. Protection against fire, however, will introduce a twist on the already established approach of most other standards.

## Standard And Purpose

IEC 60065, "Audio, Video and Similar Electronic Apparatus – Safety Requirements," is the international community's standard and the one we will focus on in this article. As for the rest of the world's markets, there are minor country-specific deviations but the core requirements are unchanged. The United States has the most noticeable name and title difference, where its version of IEC 60065 is referred to as UL 6500, "Audio/Video and musical instruments apparatus for household, commercial and similar general use."

The standards requirements are aimed at providing protection to users and the environment in which the product is used. It is intended to prevent injury or damage from all of the following hazards:

- **Electric Shock:** The levels of voltage a person could be exposed to and the amount of current that could pass through their body on contact with the equipment are measured.
- **Excessive temperature:** Parts of the equipment are monitored to determine temperature and risk of injury.
- **Radiation:** The effects of ionizing and laser radiation are evaluated.
- **Implosion:** The risks of implosion of picture tubes are assessed.
- **Mechanical hazards:** Aspects of the product's mechanical strength and stability are checked.
- **Fire:** The potential origins and prevention of fire in the equipment are examined.

## Scope

The 60065 series pertains to electronic equipment that is meant to be powered by the mains and intended for reception, generation, recording or reproduction of audio, video, and associated signals. It is aimed at entertainment equipment such as stereo equipment, televisions, and powered surround systems. Only the safety aspects of this equipment is addressed. Other issues, such as style or performance, are not covered.

## Electric Shock

Unlike electromagnetic compatibility standards, product safety standards mandate construction as well as performance. A product can pass all the required electrical and mechanical tests but still fail to meet the standard. If it is not built correctly changes must be made to the design.

The construction review is performed first. This review serves two purposes. First it defines the product and therefore the selection of performance tests. Second, it verifies the required details of construction. The tests become the verification of a well designed product's performance. A first step in providing protection against electric shock is identifying and implementing levels of electrical insulation within a product.

## Insulation

Each product must provide two layers of electrical insulation to those circuits or parts that are accessible by the operator. In this way, the operator is still protected if failure of one layer occurs. "Basic," "supplementary," "double" and "reinforced" are the defined categories of insulation. As the definitions for these can change from standard to standard, it might be helpful to define them in the context of 60065. They are as follows:

- **Basic insulation:** Insulation applied to parts from which electric shock could be drawn.
- **Supplementary insulation:** Additional insulation provided in case of a break down of the basic insulation.
- **Double insulation:** Encompasses the combination of basic and supplementary insulation.
- **Reinforced insulation:** A single layer of insulation which provides the same degree of protection against electric shock as double insulation.

Insulation can be achieved by these methods:

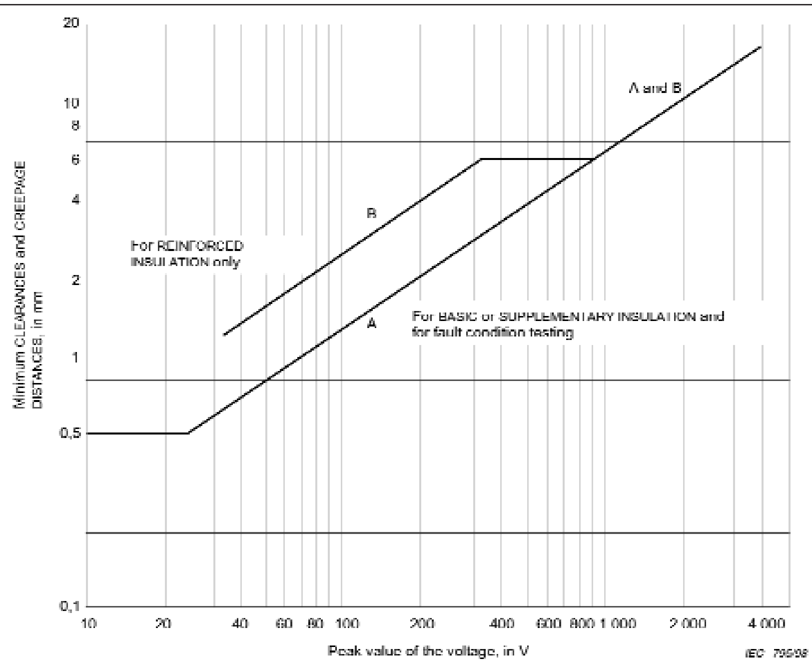
- **Clearance:** The shortest distance between two conductive parts or between a conductive part and the outer surface of an enclosure, when the distance is measured through air.
- **Creepage:** The shortest path between the two conductive parts or between the conductive part and the outer surface of the enclosure, when the path is measured along the surface of the insulation.
- **Solid insulation:** Requires a measurement of thickness rather than space through air or across a surface.

## Clearances, Creepage Distances

The required clearance and creepage distances throughout a product are governed by tables within each particular standard. In order to determine the proper spacings, one must understand the factors that are used in their determination.

The most obvious factor is the working voltage of the circuit. The purpose of providing a specified insulation dimension is to prevent arcing. The second factor is "pollution degree," which primarily affects creepage. The contaminants in the environment where the product is installed can eventually cause conductivity, which would require increased spacing to hold off the same amount of voltage. Pollution degree is measured in steps of 1, 2 and 3. Pollution degree 1 corresponds to circuitry that is sealed to prevent dust and moisture from entering. Pollution degree 2 applies to normal home environments. Pollution degree 3 applies to equipment exposed to conductive pollution or to dry non-conductive pollution which could become conductive in the presence of condensation. The 60065 standard's creepage and clearance distances are all based on pollution degree 2.

Lastly, the class of insulation desired, contributes to the determination of spacing throughout the unit. Creepage and clearance values can be found in Figures 1 and 2 (Figures 9 and 10 from the standard). Figure 2 (Figure 10 from the standard) is used only for




NOTE 1 – The given values are applicable to BASIC, SUPPLEMENTARY and REINFORCED INSULATION.

NOTE 2 – For BASIC, SUPPLEMENTARY and REINFORCED INSULATION, all parts of the circuit CONDUCTIVELY CONNECTED TO THE MAINS are assumed to be at not less than the nominal MAINS voltage with respect to earth.

For parts CONDUCTIVELY CONNECTED TO THE MAINS with voltages in the range of 220 250 V (r.m.s.), the values are equal to those related to 354 V peak.

NOTE 3.– A voltage across the BASIC INSULATION is determined by short-circuiting the SUPPLEMENTARY INSULATION and vice versa.

NOTE 4 For voltages exceeding 4 000 V (peak) a.c. or d.c., the voltage test according to 10.3 is used to determine whether a CLEARANCE and CREEPAGE DISTANCE shall be short-circuited during the tests under fault condition.

NOTE 5 – The graphs are defined by the following:

Curve A: 35 V corresponds to 0,6 mm
354 V corresponds to 3,0 mm

Curve B: 35 V corresponds to 1,2 mm
354 V corresponds to 6,0 mm

NOTE 6 If enamel forms the insulation of a wire and withstands the voltage test prescribed for grade 2 or better of IEC 60317, it is considered to contribute 1 mm to the CLEARANCES and CREEPAGE DISTANCES, with a minimum as specified in 13.1.1.

NOTE 7 – The specified CLEARANCES and CREEPAGE DISTANCES are the minimum actual separations taking into account tolerances in assemblies and piece-parts.

NOTE 8 – See clause 13

**Figure 1: Clearances and creepage distances (Figure 9 from the standard)**

determining distances on printed wiring boards.

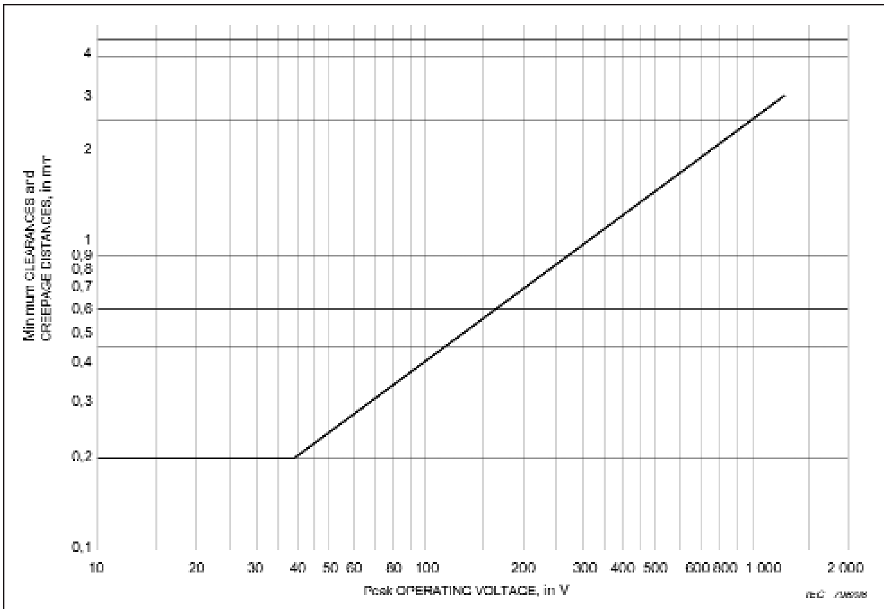
Solid insulation can easily be illustrated by a multi-layer board. For example, planes within a printed wiring board must have a minimum thickness depending on the insulation type but which is much smaller than the required distance when air is the insulation. To qualify this method of insulation, the electric strength test must be performed (to be discussed later in the article). In addition, for double insulation, either the basic or supplementary insulation must have a thickness of at least 0.4 mm. Reinforced insulation is also required to have the same thickness.

## Heating

Beside creepage and clearance distances, the temperature (or heating) test and the electric strength test are performance (as opposed to construction) requirements which establish the integrity and degree of insulation. We will start with heating. Component parts and user-accessible points must not reach excessive temperatures, in order to reduce the risk of fire within an enclosure and physical injury. The standard specifies acceptable temperatures in terms of the rise above ambient, which is usually assumed to be no higher than 35 °C for moderate climates. The equipment is typically monitored with thermo couples, and the data is logged until the unit's temperature has stabilized. At this point, the data is recorded and compared to the permissible temperature rise, per the standard, of the parts on or within the equipment in both normal operating conditions or during a fault condition.

During temperature testing, normal operation requires the equipment under test (EUT), if AC rated, to be operated at 90% and 106% of its rated supply voltage(s). If the product is auto-ranging, the voltage factor adjustments are applied only to the lower and upper limit. The frequency is adjusted to that given on the product label. These supply tolerances are to insure the integrity of the product at expected levels of mains fluctuation.

For audio amplifiers, the signals processed during operation must be




The curve is defined by the formula:

$$\log d = 0{,}78 \log (V/300)$$

with a minimum of 0,2 mm

d = distance

V = peak voltage (V)

NOTE – See 13.2.

**Figure 2: Minimum clearances and creepage distances on printed boards (Figure 10 from the standard)**

simulated to generate power characteristic of heavy operation. Pink noise is used to deliver 1/8th the non-clipped output power. Pink noise is a signal whose energy per unit bandwidth is inversely proportional to the frequency. If the non-clipped output power cannot be reached, 1/8th of the maximum deliverable power is used. In either case, there is a North American deviation specifying that the power be no less than 0.5 watts per channel.

**Table 3 – Test voltages for dielectric strength test and values for insulation resistance**

| Insulation | Insulation resistance | AC test voltage (peak) or d.c. test voltage |
|---|---|---|
| 1 Between parts of different polarity DIRECTLY CONNECTED TO THE MAINS. | 2 MΩ | For rated MAINS voltages ≤150 V (r.m.s.) 1 410 V<br>For rated MAINS voltages >150 V (r.m.s.) 2 120 V |
| 2 Between parts separated by BASIC INSULATION or by SUPPLEMENTARY INSULATION. | 2 MΩ | Curve A of figure 7 |
| 3 Between parts separated by REINFORCED INSULATION. | 4 MΩ | Curve B of figure 7 |

NOTE – Curves A and B of figure 7 are defined by the following points:

| OPERATING VOLTAGE $U$ (peak) | Test voltage (peak) | |
|---|---|---|
| | Curve A | Curve B |
| 35 V | 707 V | 1 410 V |
| 354 V | | 4 240 V |
| 1 410 V | 3 980 V | |
| 10 kV | 15 kV | 15 kV |
| >10 kV | 1,5$U$ V | 1,5$U$ V |

**Table 1: Test voltages for dielectric strength test and values for insulation resistance (Table 3 from the standard)**

Heat tests are also performed under single fault conditions. Fault conditions are any single point failure due to a short circuit or open circuit of any one component or condition. Some examples of this with regard to heating would be the covering of ventilation openings or the locking of a fan within the unit, or the shorting of a voltage regulation component.

## Electric Strength

Insulation within a piece of equipment is tested by the application of voltage at a level determined by the type of insulation and the working voltage of the component. This test voltage verifies that there is no insulation breakdown between the two points that the insulation is protecting. For the test, insulation breakdown occurs when current flows uncontrollably when voltage is applied. Momentary arcing is not considered insulation breakdown.

The product is not powered during the test and the voltage is applied for one minute.

Table 1 (Table 3 from the standard) determines the value of the test voltage by either directly stating it or referring to Figure 3 (Figure 7 from the standard), which has a series of curves based on the operating voltage in order to determine the test voltage dependant on the requirement of basic or supplementary insulation (curve A) or reinforced insulation (curve B).

It is possible for insulation to work in dry conditions as well as humid surroundings. However, in these tropical type environments, the worry is that the paper will get wet and loose their dielectric properties. To disprove the hygroscopic nature of the insulating material within a product, humidity treatment is performed.

The product is subjected to air of relative humidity between 90-92% and a temperature of 28-30 degrees Celsius for 48 hours. The test is carried out in a humidity chamber which can simulate these conditions. For tropical

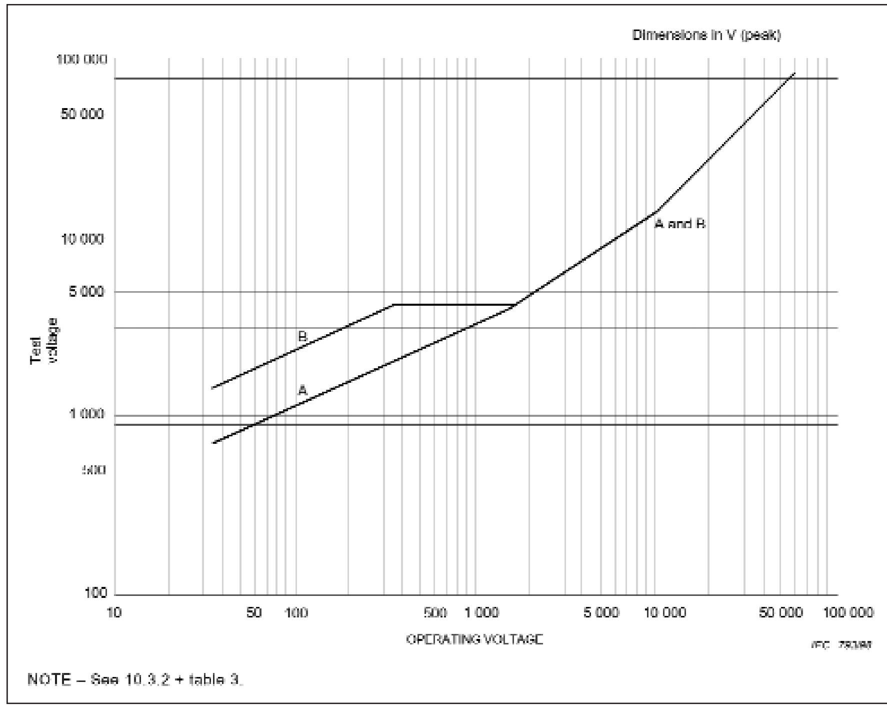
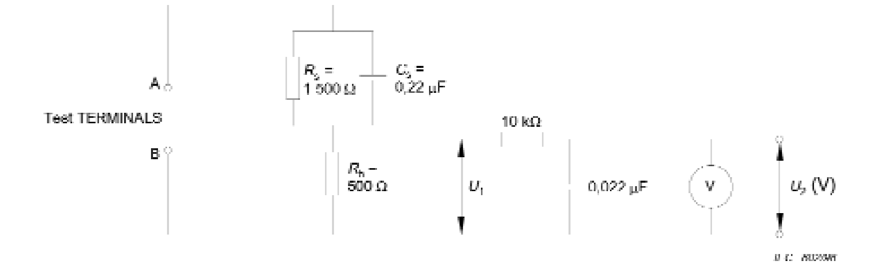


Figure 3: Test voltages (Figure 7 from the standard)

environments, relative humidity remains the same but the temperature is increased to 38-42 degrees Celsius. This test has a duration of 5 days. At the end of the treatment, the unit must comply with the electric strength test described above. Insulation must resist the absorption of water enough to not allow the conduction of voltage during the test.




Resistance values in ohms (Ω)

V: Voltmeter or oscilloscope
(r.m.s. or peak reading)

Input resistance: ≥1 MΩ

Input capacitance: ≤200 pF

Frequency range: 15 Hz to 1 MHz and d.c. respectively

NOTE – Appropriate measures should be taken to obtain the correct value in case of non-sinusoidal waveforms.

The measuring instrument is calibrated by comparing the frequency factor of $U_2$ with the solid line in figure F.2 of IEC 60990 at various frequencies. A calibration curve is constructed showing the deviation of $U_2$ from the ideal curve as a function of frequency.

TOUCH CURRENT = $U_2$/500 (peak value).

NOTE – See 9.1.1.

**Figure 4: Measuring network for touch currents according to IEC 60990 (Figure D.1 from the standard)**

The verification of insulation in order to ensure protection against electric shock is so important that the electric strength test is also a production requirement for customers. In this application not all areas of isolation must be verified as it was done during the product's certification process. The electric strength test is performed on the completed assembly before packaging. The voltage is applied between the mains terminals connected together and accessible terminals and accessible conductive parts. During the test all mains and functional switches are placed in the on position. The production line electric strength test is still based on the insulation class and working voltage, but the levels are much reduced and the duration of the applied levels in only one to four seconds.

## Leakage Current

The last step to protect the user against electric shock is the measurement of touch current. As stated before, this is the amount of current that is available to pass through the body when touching one or more accessible parts. Measurements are taken with the unit powered at 106 % of the rated voltage, with the unit's on/off switch in both positions and with the polarity of the mains input in normal and reverse polarities. The reading is taken between protective earth ground on the supply side to the accessible conductive part on the equipment.

In normal condition, the ground remains closed and both the on/off switch and polarity switches are varied to produce the maximum reading. In single fault condition, the protective earth ground is an open circuit and the process is repeated. The available current is measured with a test circuit that can be seen in Figure 4 (Figure D.1 from the standard). When this test circuit is used, terminals A and B are connected between the two points being measured and the voltage U2 is recorded. This voltage divided by 500 is the amount of touch current.

(The Simpson 228 leakage current meter is a commercially available instrument that incorporates this network and an indicating meter. Using this meter allows the touch current to be read right from the display.)

## Fire

Protection against fire starts with a combination of proper selection of components and protecting them so that, in case of a failure, fire will not arise. The second is housing these components and materials in a fire enclosure. A fire enclosure is that part of the equipment (typically the outer surface material) that reduces the spread of fire or flames from inside a product.

With regard to 60065, the equipment must be designed such that the starting of a fire and its spread is prevented as far as possible and should not endanger its surroundings. Accomplishing this goal is a blend of the use of a fire enclosure as discussed, using proper design to avoid potential ignition sources and selecting low flammability materials for internal parts in the areas of potential ignition sources. Faults where the open circuit voltage exceeds 50 Vpk a.c. or d.c. and the open circuit voltage and measured current exceed 15 VA are considered potential ignition sources.

This is a slightly different philosophy than other standards' approach to fire. Most other standards rely heavily on requirements for openings on all sides and the material of the fire enclosure to contain fire from escaping to the surroundings, or to prevent foreign bodies from entering and causing harm. The potential ignition source approach uses fault testing to rule out fire sources and distancing components and/or materials away from these sources that could start a fire. This allows for practices that might seem at first to be less safe, such as a wooden enclosure on products such as speakers and subwoofers. Let's take a closer look.

Components fall into two categories with the standard. They either have specific flammability requirements or they follow the distance from potential ignition sources rule. Without going into details for each type of component, the following is a list of components that the distance rule does not apply to:

- Mains resistors and capacitors
- Inductors and windings
- Thermal releases, fuses and fuse holders
- Switches
- Safety interlocks
- Motors
- Batteries
- Optocouplers

The distance rule is based on the open circuit voltage of the potential ignition rule and the direction from the source to the part. We will look at the most common voltages as an example. Components whose open circuit voltages are from 50 to 400 pk a.c. or d.c. must have a distance greater than or equal to 13mm downward or sideways and 50 mm upwards to points of ignition. If the distance is less than this, the orientation must be shielded by a barrier shown in Figure 5 (Figure 13 in the standard). Barriers that are used must be spaced at least 5 mm from the source. Printed wiring boards are not considered by the standard to be a proper barrier.

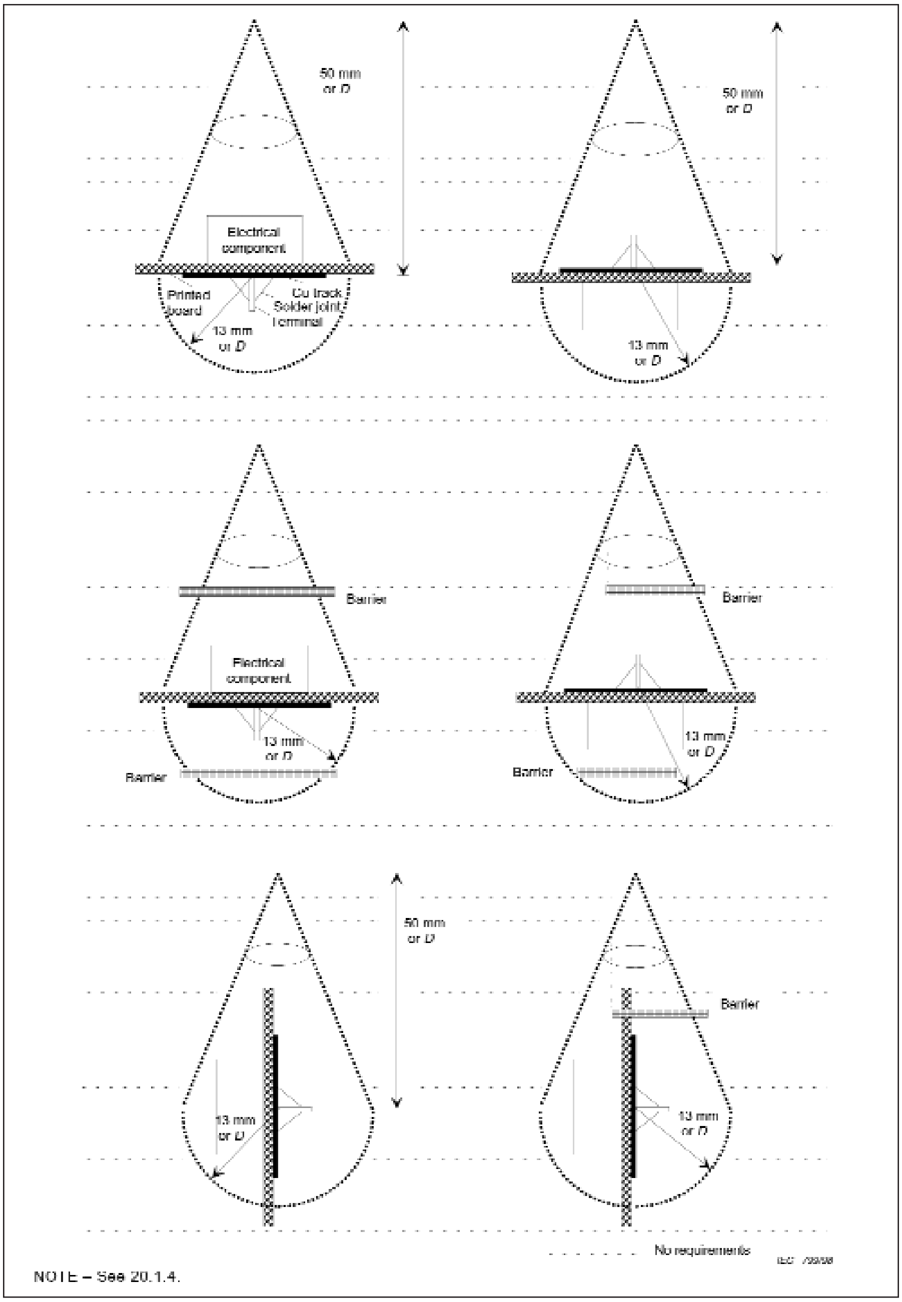



**Figure 5: Distances from potential ignition sources (Figure 13 from the standard)**

Open circuit voltages above 4kV peak a.c. or d.c. in normal conditions must be contained in a fire enclosure that meets at least flammability FV 1 of IEC 60707. Wood and wood based material satisfy this requirement if the thickness of the material is at least 6 mm. Wood based products are mainly machined natural wood such as fiber board or chip board. IEC 60707 follows the more familiar UL 94 with similar rating schemes of FV 0, FV 1, FV 2 and FH. Proving these classifications requires conditioning of samples of the material in its smallest thickness. Samples are burned with a Bunsen burner. Classifications are determined by successive flame applications for timed durations and timing the resulting burn time.

## Conclusion

As you can see a lot of effort goes into writing a standard to address hazards and protect the users. Products complying with these standards have been well designed and tested in order to meet all the requirements. Having a product evaluated to a relevant safety standard does not mean that it is completely safe. However, you can rest easy that foreseeable issues relevant to that specific type of equipment have been addressed. ■

## About The Author

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