# Hazard-Based Safety Standard


## Taiwan Chapter 2005 Aug


**Presented by Zenon Wang,**
**A Member of IEEE PSES Taiwan Chapter**

# Hazard-Based Safety Standard

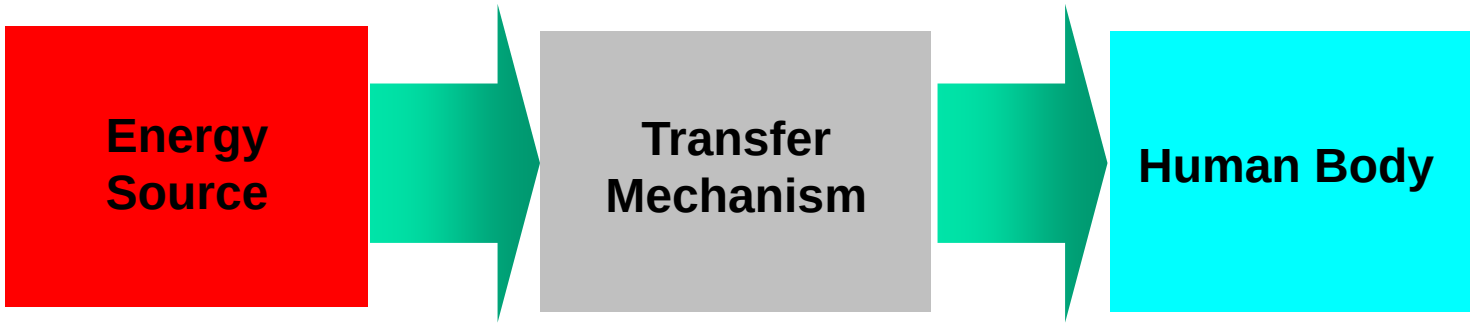
## - ECMA 287 Quickly Review -

- ECMA 287: Multimedia products has blurred the borderline between different classes of products, like IT equipment, audio-video equipment, communication equipment.
- This changing situation has generated a new set of conditions that are to be taken into account when designing new equipment.
- Based on HBSE (Hazard Based Safety Engineering), using engineering principles and relevant IEC standards and pilot safety documents.
- Covers products currently under the scopes of IEC 60065 and 60950-X.
- New safety standard (NOT a merger of IEC 60065 and 60950-1).
- The final draft has been contributed to IEC TC108 to be used by the "Hazard Based Development Team".

# Hazard-Based Safety Standard

- Hazard -

| Type | Energy | Clause |
|---|---|---|
| Electric Shock Hazard | Electrical | 3 |
| Fire Hazard | Thermal | 4 |
| Burn Hazard | Thermal | 5 |
| Mechanical Hazard | Kinetic, Potential | 6 |
| Radiation Hazard | Electromagnetic | 7 |
| Chemical Hazard | Chemical | 8 |

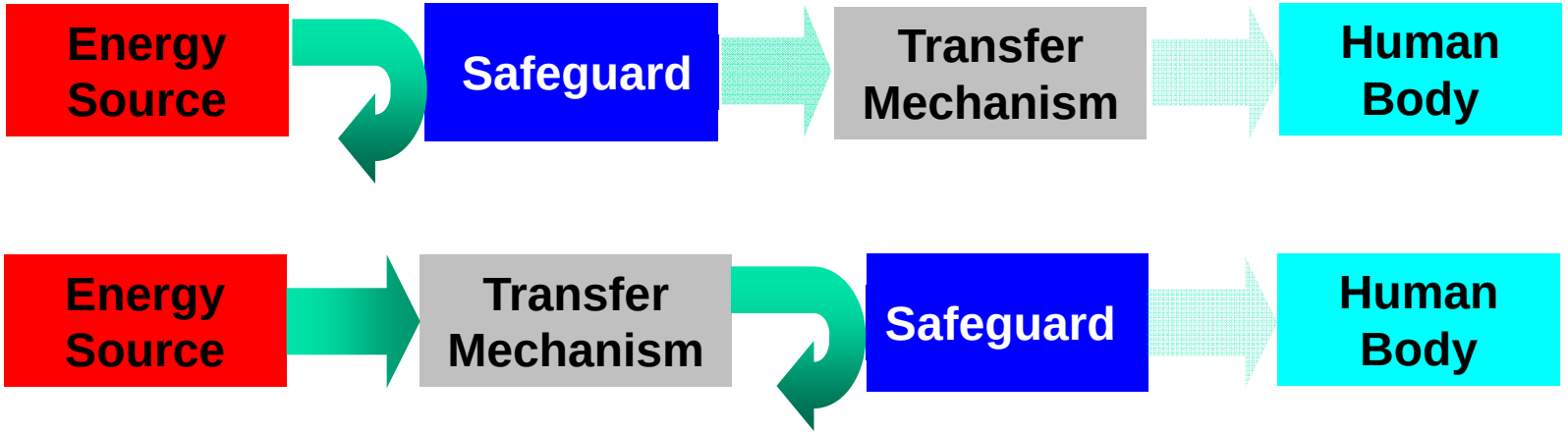


# Hazard-Based Safety Standard

## - Prevention Scheme -


There are two scheme could be designed to prevent the injury,

**<u>interrupt the energy source</u>** or **<u>interfere the transfer mechanism</u>** !!



# Hazard-Based Safety Standard

## - Prevention Scheme -

**The working mechanism of safeguard can be**

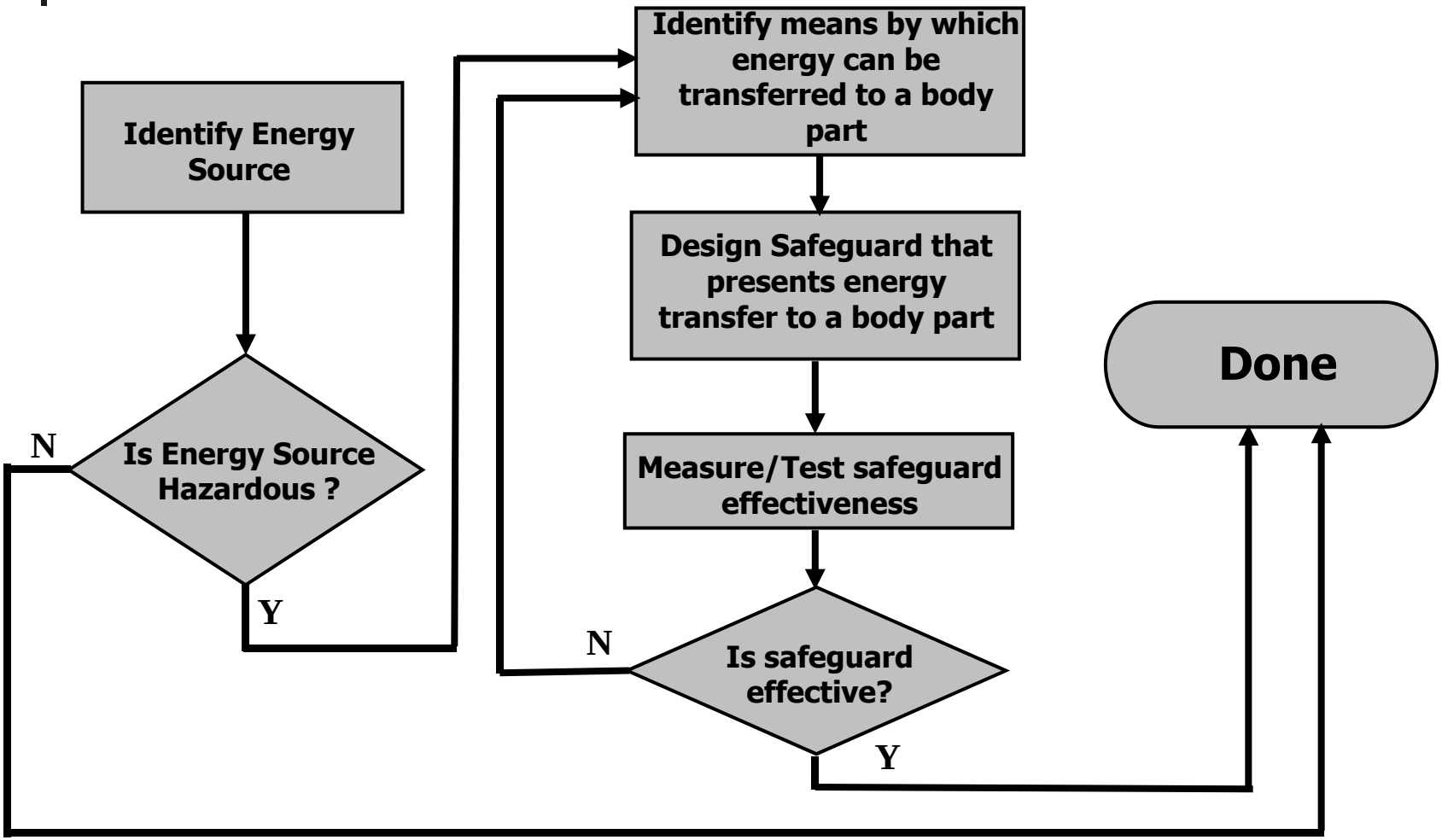
attenuating, impeding, diverting, enveloping, interrupting, disconnecting, barricading, etc.

**Several kind of safeguard may used to prevent injury.**

- Equipment Safeguard e.g. insulation
- Environmental Safeguard e.g. protective earthing conductor
- Personal Safeguard e.g. glove for handling hot surface
- Behavioral Safeguard e.g. caution
- Service Condition Safeguard e.g. restriction area for serving

# Hazard-Based Safety Standard

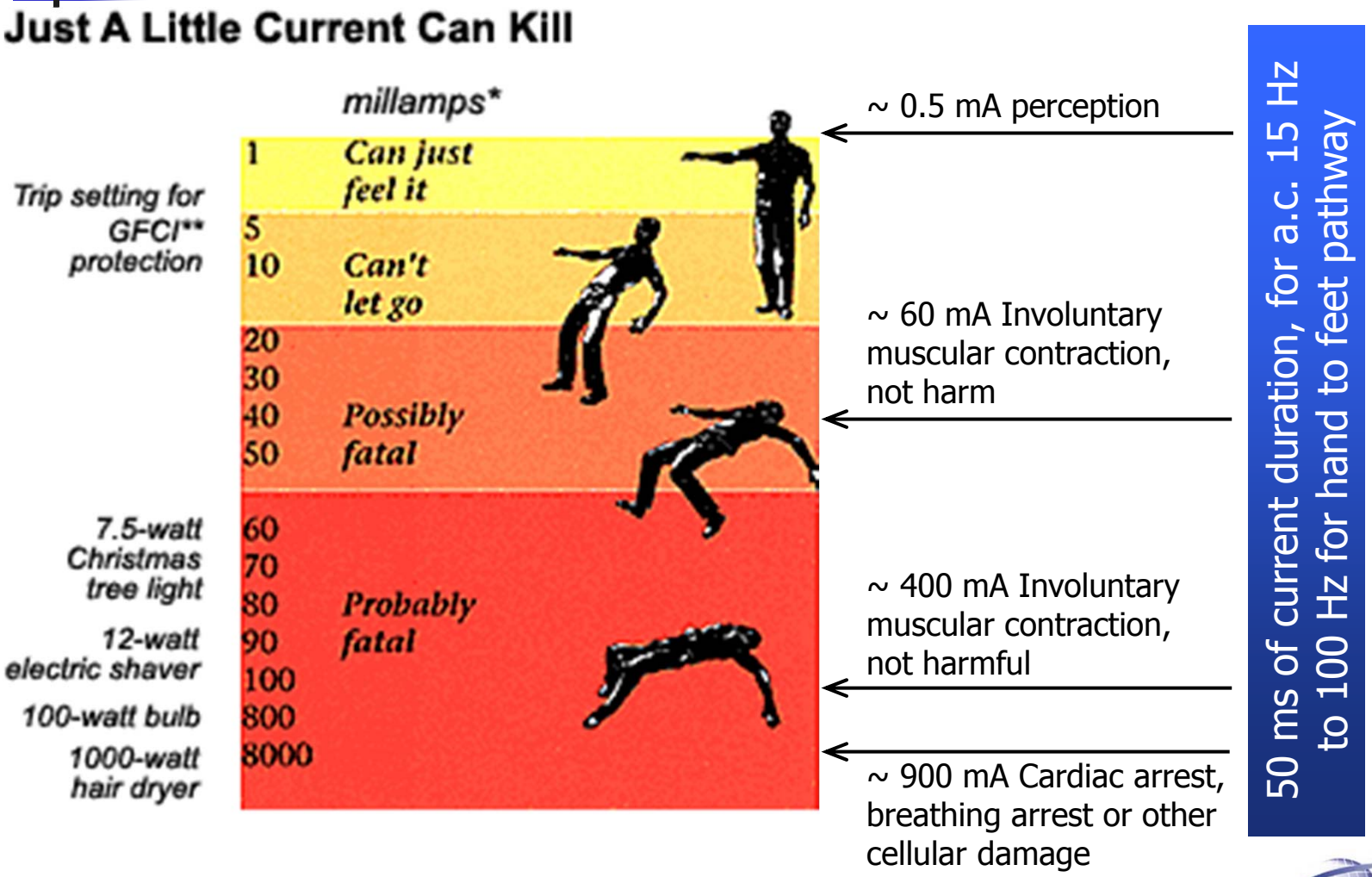
## - Evaluation Procedure -



# Electric Shock Hazard

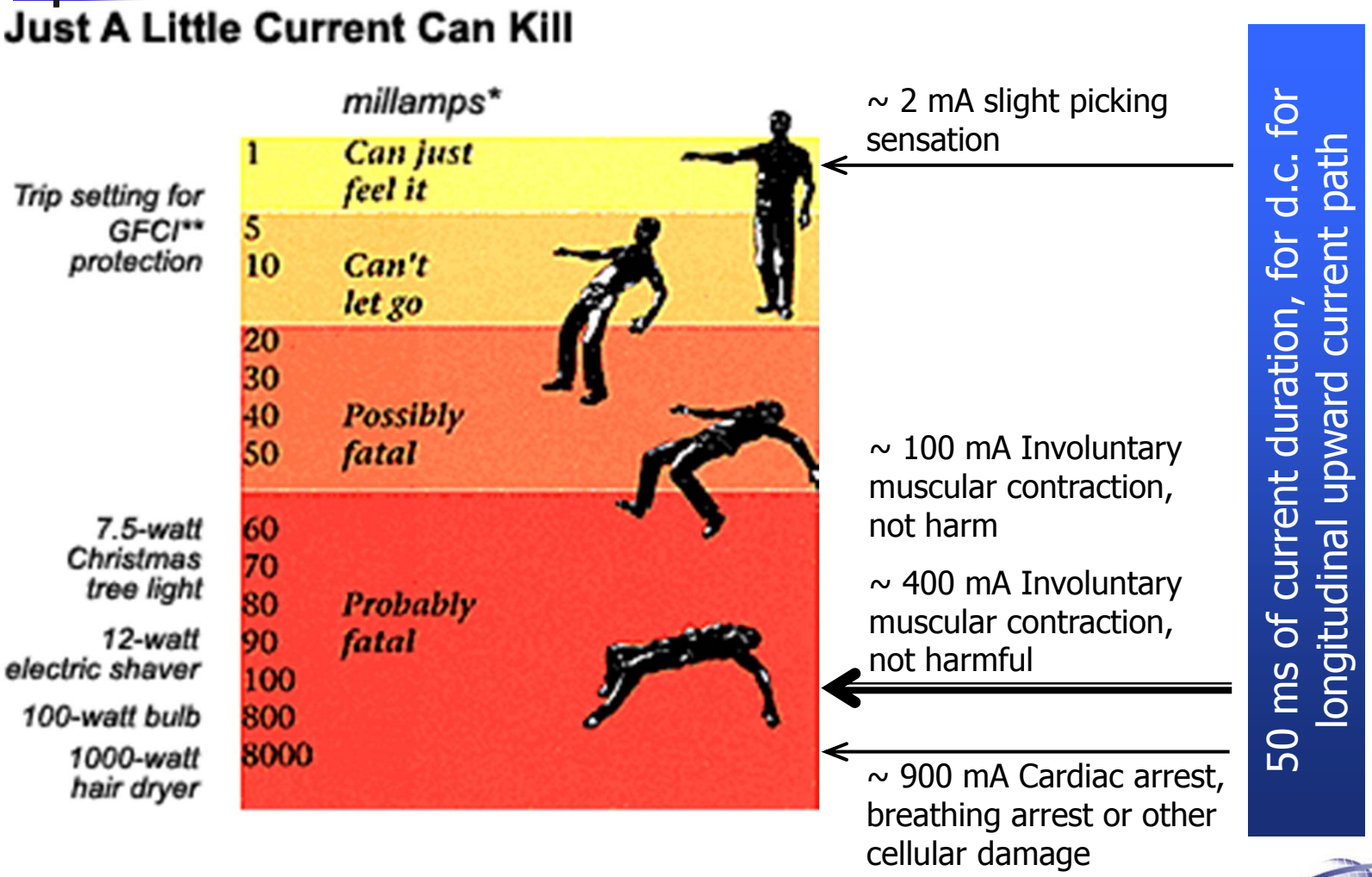
# Hazard-Based Safety Standard

## - Electric Shock Hazard -



# Hazard-Based Safety Standard

## - Electric Shock Hazard -



# Hazard-Based Safety Standard

## - Electric Shock Hazard -

Electric shock is due to current passing through the human body. Depending on the magnitude, the duration, the wave shape and the frequency of the current

Contact Area

**Small:** up to 100 $mm^2$; approx. finger tip contact

**Medium:** > 100 $mm^2$ but ≤ 1000 $mm^2$; approx. multiple finger contact

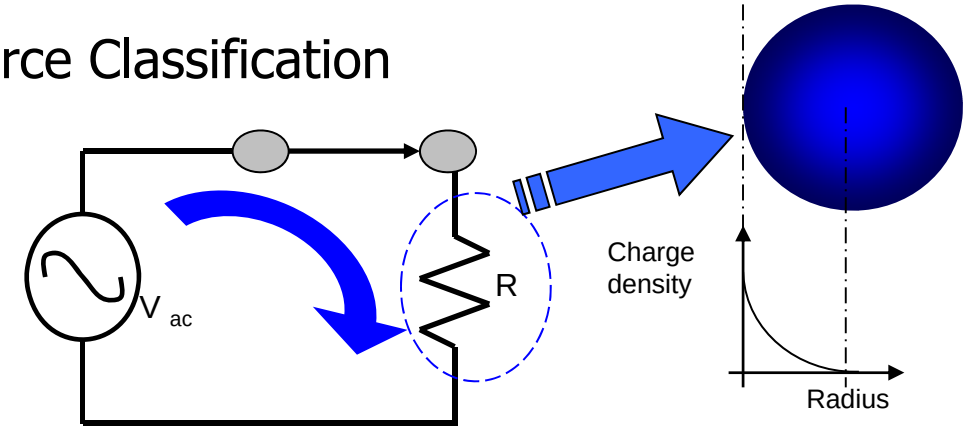
**Large:** > 1000 $mm^2$; approx. adult's hand

*Only large area contact information is included in this presentation.*

# Hazard-Based Safety Standard

## - Electric Shock Hazard -

### Electrical Energy Source Classification

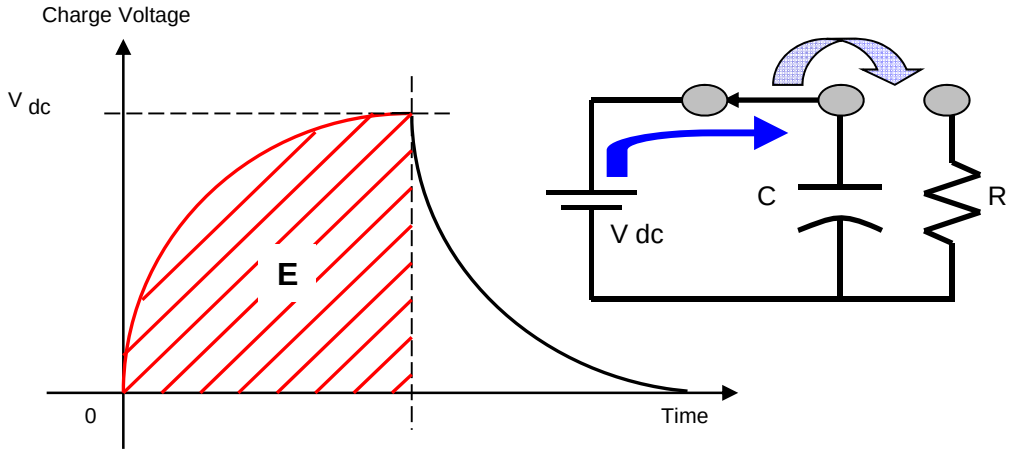



| Energy Source Level | Dry Condition | | ES3 limit |
|---|---|---|---|
| | ES1 limit | ES2 limit | |
| DC | ≤ 2 mA | > 2mA and ≤ 25 mA | > ES2 limit |
| DC | 20 V | 40 V | |
| AC (Up to 1 kHz) | ≤ 0.5 mA r.m.s. | > 0.5 mA and ≤ 5 mA r.m.s. | |
| AC (Up to 1 kHz) | 6 V | 12 V | |
| AC (Up to 100 kHz) | ≤ 0.5 mA r.m.s. x f in kHz | ≤ 5 mA r.m.s. + 0.95 x f in kHz | |
| AC (Up to 100 kHz) | ≤ 6 V r.m.s. + 0.24 x f in kHz | ≤ 12 V r.m.s. + 0.48 x f in kHz | |

# Hazard-Based Safety Standard

## - Electric Shock Hazard -

### Electrical Energy Source Classification

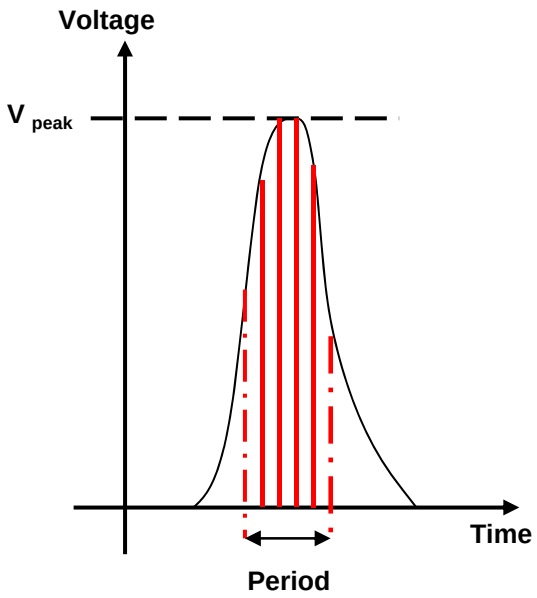



| Capacitance (nF) | ES1 ($V_{peak}$) | ES2 ($V_{peak}$) | ES3 ($V_{peak}$) |
|---|---|---|---|
| 10 000 | 60 | 120 | > ES2 limit |
| 300 | 60 | 120 | |
| 170 | 75 | 150 | |
| 91 | 100 | 200 | |
| 61 | 125 | 250 | |

# Hazard-Based Safety Standard

## - Electric Shock Hazard -

### Electrical Energy Source Classification

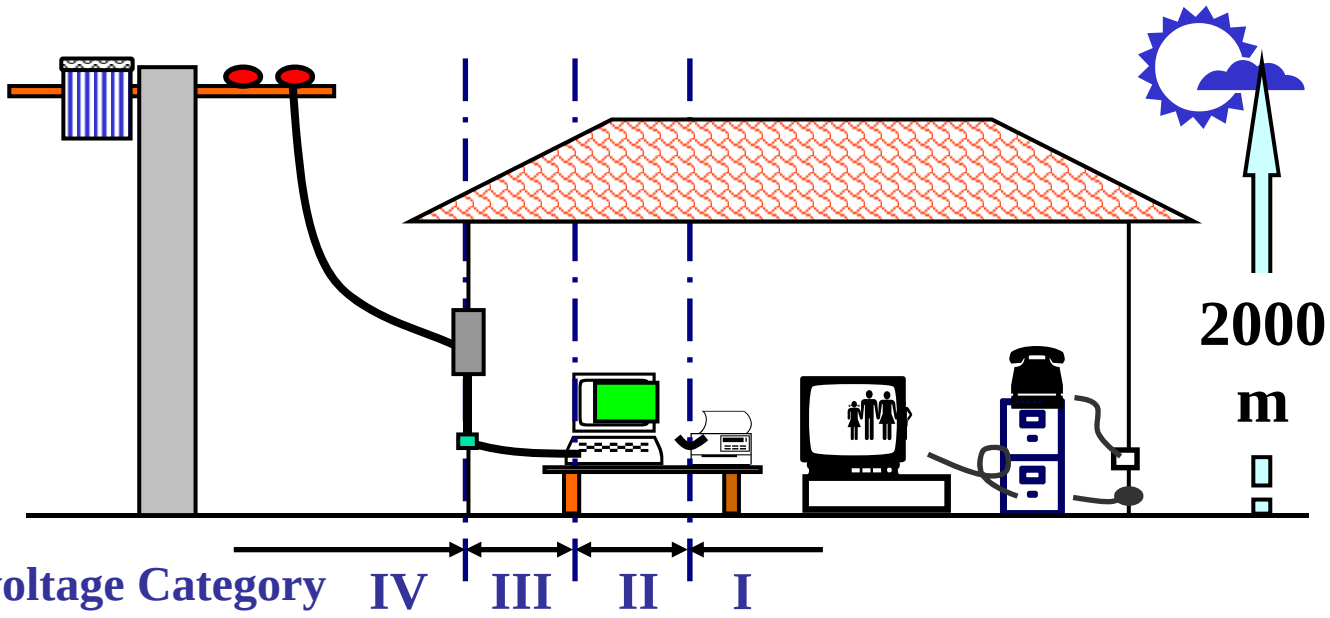



| Pulse duration (mS) | ES1 ($V_{pk}$) | ES2 ($V_{pk}$) | ES3 ($V_{pk}$) |
|---|---|---|---|
| 10 | 20 | 131 | > ES2 limit |
| 50 | | 90 | |
| 80 | | 77 | |
| 200 | | 65 | |
| 500 | | 50 | |
| 700 | | 48 | |

# Hazard-Based Safety Standard

## - Electric Shock Hazard -

Transient voltage, value of specified in standard or measured, shall be used to determine the Clearance




**I.** Equipment for connection to circuit in which measures are taken to limit transient overvoltage to an appropriate low level.

**II.** Energy-consuming equipment to be supplied from the fixed installation.

**III.** Equipment in fixed installations and for cases where the reliability and the availability of the equipment is subject to special requirement.

**IV.** Equipment if for use at the origin of the installation.

# Hazard-Based Safety Standard

## - Electric Shock Hazard -

Specified transient voltage:

| Mains voltage up to and including | | Mains transient voltage, V peak | | | |
|---|---|---|---|---|---|
| | | Overvoltage Category | | | |
| V rms | V peak | I | II | III | IV |
| 150, 120/208, 120/240 | 210 | 800 | 1 500 | 2 500 | 4 000 |
| 300, 230/400 | 420 | 1 500 | 2 500 | 4 000 | 6 000 |

| Circuit (DC Power Distribution System) | V peak |
|---|---|
| Telecommunication network | 1 500 |
| Coaxial cable connection | 4 000 |
| Supply power to accessories | 5 000 |
| Outdoor antenna system | 10 000 |

# Hazard-Based Safety Standard

## - Electric Shock Hazard -

Specified transient voltage:

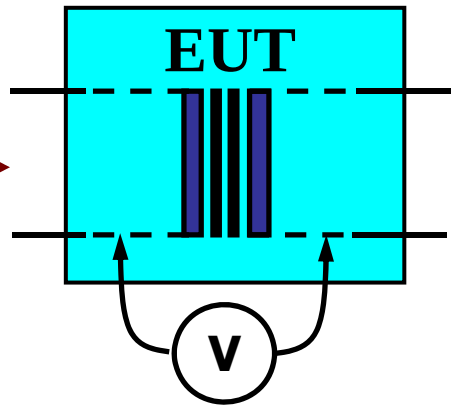
| External Circuit | | V peak |
|---|---|---|
| **Earthed** | **Same building** | |
| Y | Y | Disregard |
| N | Y | The mains transient voltage in the mains from which the dc power is derived. |
| Y | N | The mains transient voltage in the mains from which the dc power is derived |
| N | N | The mains transient voltage in the mains from which the dc power is derived |
| **Note:** If equipment is supplied from a dedicated battery which has no provision for charging from an external mains supply, the transient voltage shall be disregarded. | | |

# Hazard-Based Safety Standard

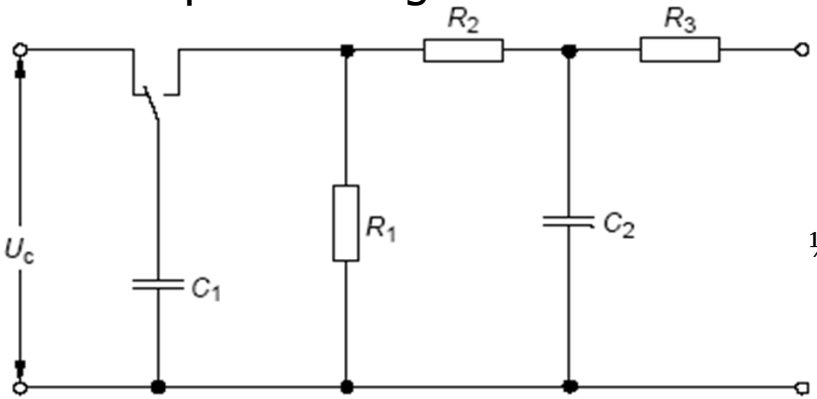
## - Electric Shock Hazard -

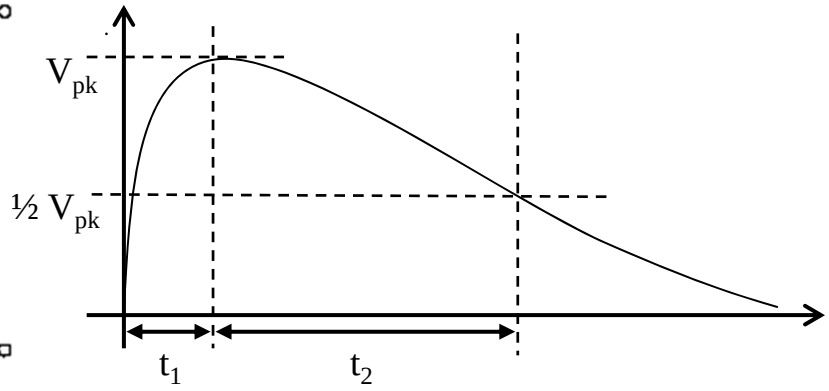
Measurement of transient voltage:

**Initial charge voltage should be specified transient voltage**




ITU-T impulse test generator circuit

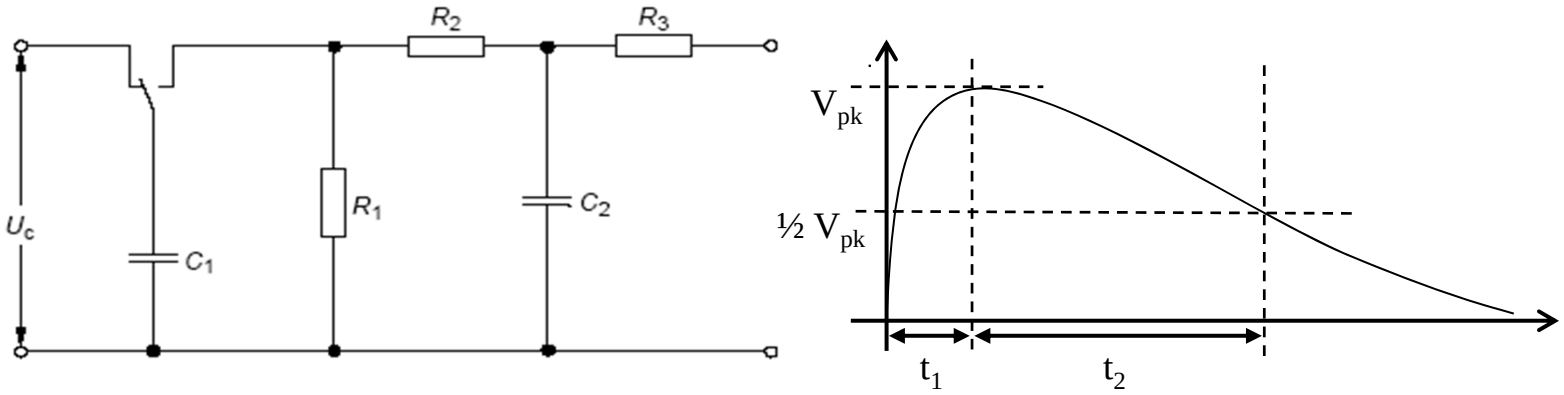


# Hazard-Based Safety Standard

## - Electric Shock Hazard -

Measurement of transient voltage:




**ITU-T impulse test generator circuit**

| Circuit | $t_1$ | $t_2$ | Testing |
|---|---|---|---|
| A.C. Mains | 1.2 | 50 | 3 to 6 impulses with alternative polarity and 1 sec interval between each impulse |
| D.C. Power Distribution System | 1.2 | 50 | 3 to 6 impulses with alternative polarity and 1 sec interval between each impulse |
| External circuit | 10 | 700 | 3 to 6 impulses with alternative polarity and 1 sec interval between each impulse |

# Hazard-Based Safety Standard

## - Electric Shock Hazard -

Clearance requirement under inhomogeneous field

| Required Withstand Volt | Basic & Supplementary Insulation (mm) | | | Reinforced Insulation (mm) | | |
|---|---|---|---|---|---|---|
| $V_{peak}$ or dc | PD1 | PD2 | PD3 | PD1 | PD2 | PD3 |
| 800 | 0.1 | 0.2 | 0.8 | 0.5 | 0.6 | 1.5 |
| 1 000 | 0.15 | | | 0.6 | | |
| 1 200 | 0.25 | | | 0.9 | | |
| 1 500 | 0.5 | | | 1.5 | | |
| 2 000 | 1.0 | | | 2.2 | | |
| 2 500 | 1.5 | | | 3.0 | | |
| 3 000 | 2.0 | | | 2.8 | | |
| 4 000 | 3.0 | | | 5.5 | | |

Linear interpolation is permitted between two nearest points in 0.1 mm increment.

The table is driven from IEC 60664-1 table 2 and calculate according to sub-clause 3.1.5 for reinforced insulation.

# Hazard-Based Safety Standard

## - Electric Shock Hazard -

Clearance requirement for altitude above 2 000 m sea level

| Altitude (m) | Normal barometric pressure kPa | Multiplication on factor for clearances | Multiplication factor for test voltages for electric strength | | | |
|---|---|---|---|---|---|---|
| | | | clearance range in mm | | | |
| | | | ≥ 0.001 to < 0.0625 | ≥ 0.0625 to < 1 | ≥ 1 to < 10 | ≥ 10 to < 100 |
| 2 000 | 80.0 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 3 000 | 70.0 | 1.14 | 1.05 | 1.05 | 1.07 | 1.10 |
| 4 000 | 62.0 | 1.29 | 1.10 | 1.10 | 1.15 | 1.20 |
| 6 000 | 47.0 | 1.70 | 1.25 | 1.15 | 1.35 | 1.48 |
| 8 000 | 35.5 | 2.25 | 1.44 | 1.42 | 1.63 | 1.86 |
| 10 000 | 26.5 | 3.02 | 1.71 | 1.67 | 2.01 | 2.4 |
| This table is developed using figure A.1 of IEC 60664-1, curve number 2 for case A using Impulse test. | | | | | | |

# Hazard-Based Safety Standard

## - Electric Shock Hazard -

Creepage distance (in mm)

| R.M.S. Working Voltage | PD1 | PD2 | | | PD3 | | |
|---|---|---|---|---|---|---|---|
| | Material Group | | | | | | |
| | all | I | II | $III_a$, $III_b$ | I | II | $III_a$, $III_b$ |
| 200 | 0.42 | 1.0 | 1.4 | 2.0 | 2.5 | 2.8 | 3.2 |
| 250 | 0.56 | 1.25 | 1.8 | 2.5 | 3.2 | 3.6 | 4.0 |
| 320 | 0.75 | 1.6 | 2.2 | 3.2 | 4.0 | 4.5 | 5.0 |
| 400 | 1.0 | 2.0 | 2.8 | 4.0 | 5.0 | 5.6 | 6.3 |
| 500 | 1.3 | 2.5 | 3.6 | 5.0 | 6.3 | 7.1 | 8.0 |
| 630 | 1.8 | 3.2 | 4.5 | 6.3 | 8.0 | 9.0 | 10 |
| 800 | 2.4 | 4.0 | 5.6 | 8.0 | 10 | 11 | 12.5 |
| Linear interpolation is permitted between two nearest points in 0.1 mm increment. | | | | | | | |

# Fire Hazard

# Hazard-Based Safety Standard

## - Fire Hazard -

Electrically-caused fire is due to conversion of electrical energy to thermal energy, where the thermal energy heats a fuel material to ignition temperature, followed by ignition and combustion.

Protection Method

**Normal Operation:**

- Not exceeding rated temperature
- Separate from arcing parts

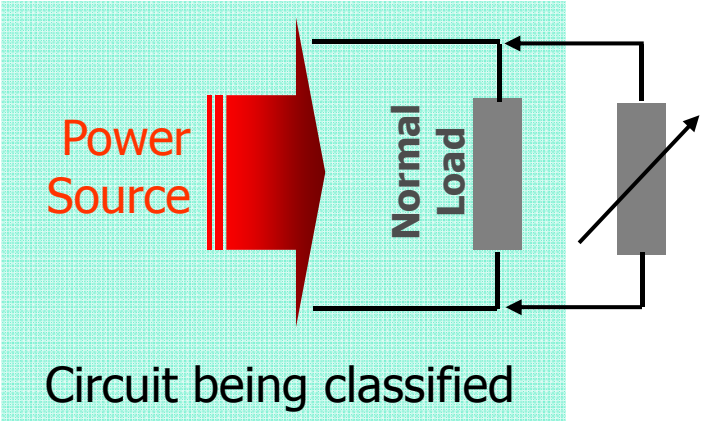
**Abnormal Operation:**

- Control fire spread e.g. select proper flammability component or, if necessary, use fire enclosure
- Prevent ignition e.g. equipment designed that under abnormal condition no part will be ignite

# Hazard-Based Safety Standard

## - Fire Hazard -

### Power Source Classification




1. Adjustable resistive load used to determine the maximum available power to the circuit
2. A fault is introduced into the power source circuit that will result in the maximum power dissipation into the normal load of the circuit being classified

**PS1:** exceed 15 W measured 5 sec after application of the adjustable resistor or fault in the power source circuit

**PS2:** not exceed 100 W measured after 5 sec after application of the adjustable resistor or fault in the power source circuit

**PS3:** exceed PS2 limit or any "no-willing-to-measure" power source circuit

# Hazard-Based Safety Standard

## - Fire Hazard -

### Potential Ignition Source

- **Potential Ignition Source 1**

  a location where an arc may occur due to the opening of a conductor or a contact

  - open circuit voltage exceeds 50 V peak or d.c., and
  - the product of the peak of this voltage and the measured r.m.s. current under normal condition exceeds 15 W

- **Potential Ignition Source 2**

  Any part in a source or a load that has an available power exceeding 15 W under normal or abnormal conditions and in which a component may ignite due to excessive power dissipation.

# Hazard-Based Safety Standard

## - Fire Hazard -

Concept of appropriate safeguard design

**PS1:**

**No safeguard required**

**PS2:**

- **Principle Safeguard:** To minimize the size of the an ignition source
- **Supplementary Safeguard:** To control the spread of fire

Compliance is considered as:

- ✓ Printed wiring boards shall be of flammability class V-1 or better
- ✓ Wiring shall be insulated with flame retardant material
- ✓ All other components shall either
  - be mounted on material of flammability class V-1 or better; or
  - be of Materials of flammability class V-2 or better.

# Hazard-Based Safety Standard

## - Fire Hazard -

Concept of appropriate safeguard design

**PS3:**

- **Principle Safeguard:** To control the spread of fire
- **Supplementary Safeguard:** To use adequate fire enclosure, extinguish system, etc.

Compliance opening dimension of fire enclosure may be…

Top opening:

Not exceed 3 mm in any dimension, or

Not exceed 1 mm width regardless of length

Bottom opening:

Not exceed 6 mm in any dimension, or

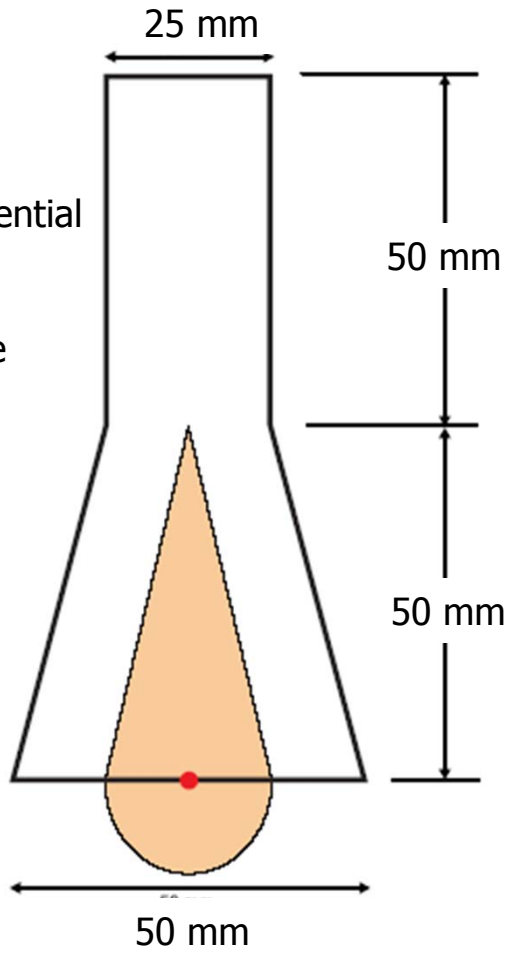
Not exceed 2 mm width regardless of length

# Hazard-Based Safety Standard

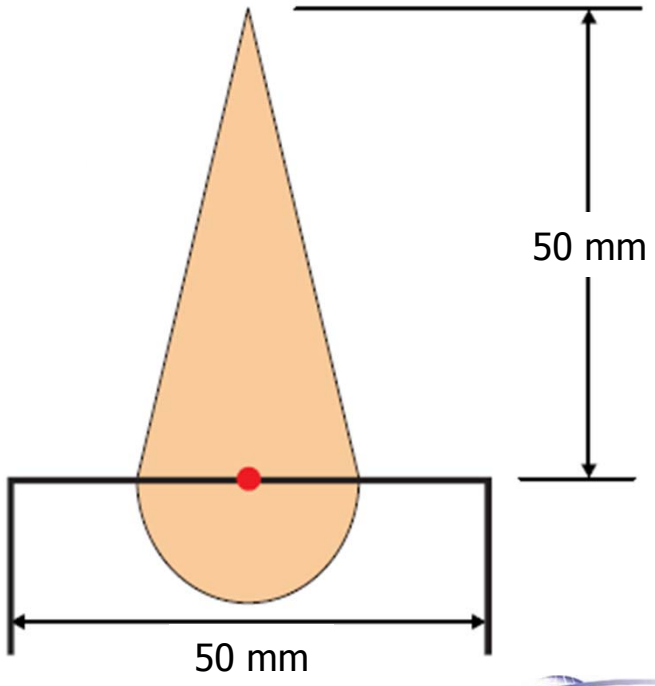
## - Fire Hazard -

### Opening construction of fire enclosure

with respect to potential ignition source, top openings are any openings within the volume.




with respect to potential ignition source, bottom openings are any openings within the volume.

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# Burn Hazard

# Hazard-Based Safety Standard

## - Burn Hazard -

Burns hazards or undesirable reactions may result from high temperatures on accessible surfaces.

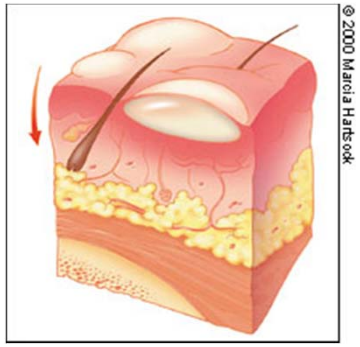

The standard is currently focus on injury that cause by hazardous thermal energy transfer by conduction mechanism.

# Hazard-Based Safety Standard

## - Burn Hazard, EN 563 -

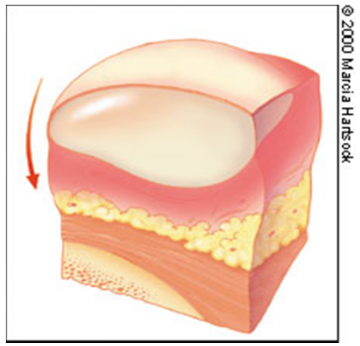
EN 563 is referred in assessment of burn hazard due to hot surface touch

Burn Classification



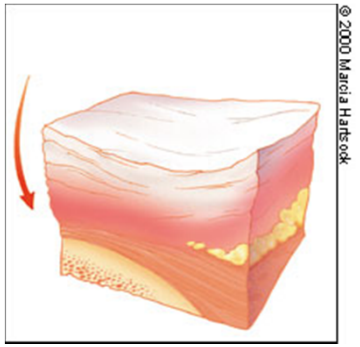

**EN 563**
Superficial partial thickness: Follicles and glands survive.

**ASTM C 1057**
First degree: incomplete necrosis of epidermal layer (redness).




**EN 563**
Deep partial thickness: substantial dermis and glands mostly destroyed.

**ASTM C 1057**
Second degree: complete necrosis of epidermis (blistering).




**EN 563**
Whole thickness: No surviving glands.

**ASTM C 1057**
Third degree: 75% destruction of dermis scarred upon healing.

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# Hazard-Based Safety Standard

## - Burn Hazard, EN 563 -

The most important factors to assess risk of burn hazard are:

- the temperature of the surface;
- the material of which the surface consists;
- the period of contact between the skin and the surface.

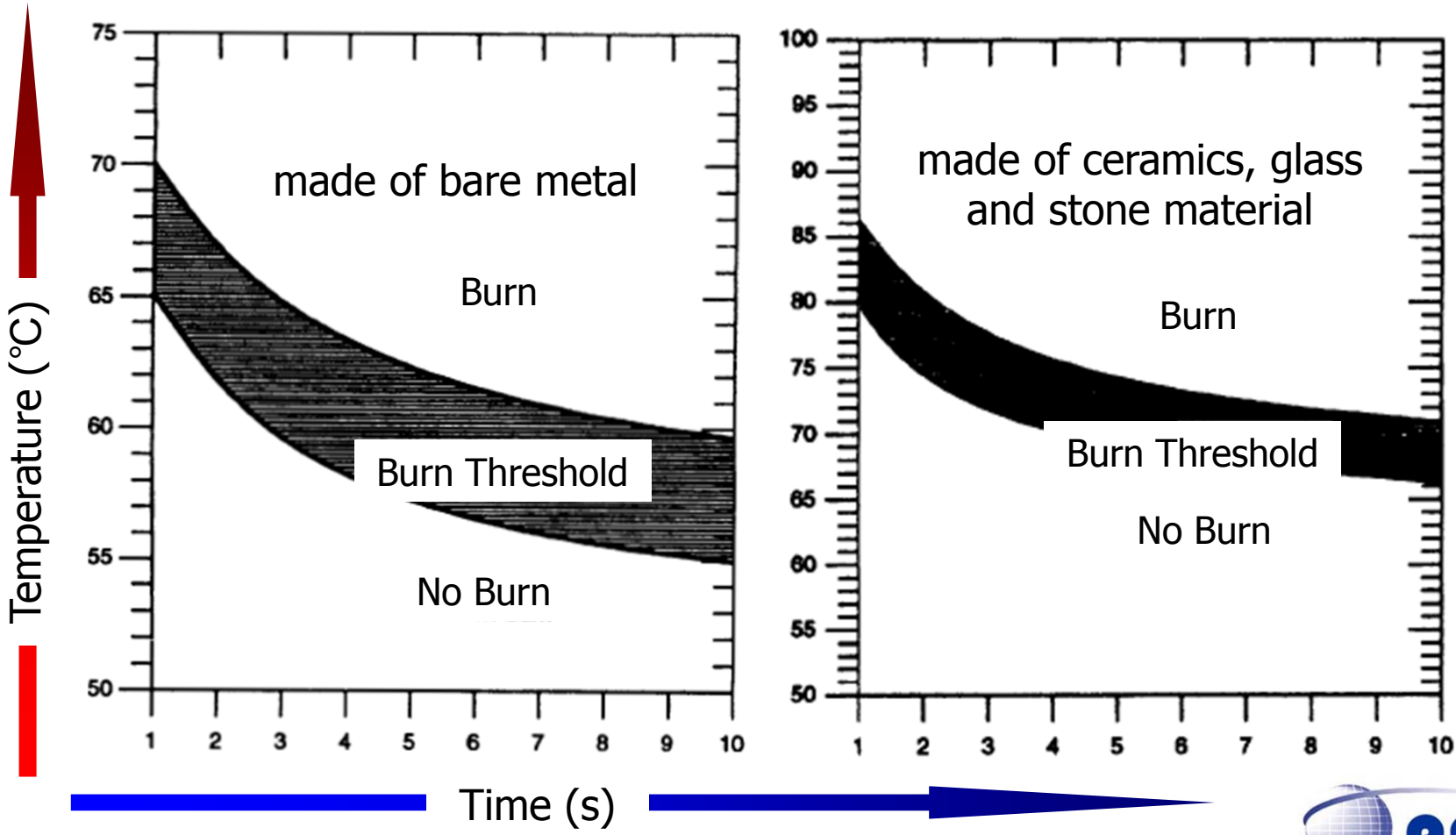
The burn threshold depends on several factors:

- thickness of skin at the touching point,
- touching force,
- moisture of the skin's surface (e.g. sweat),
- contamination of skin (e.g. grease),
- heat conductivity properties of different metals,
- etc

# Hazard-Based Safety Standard

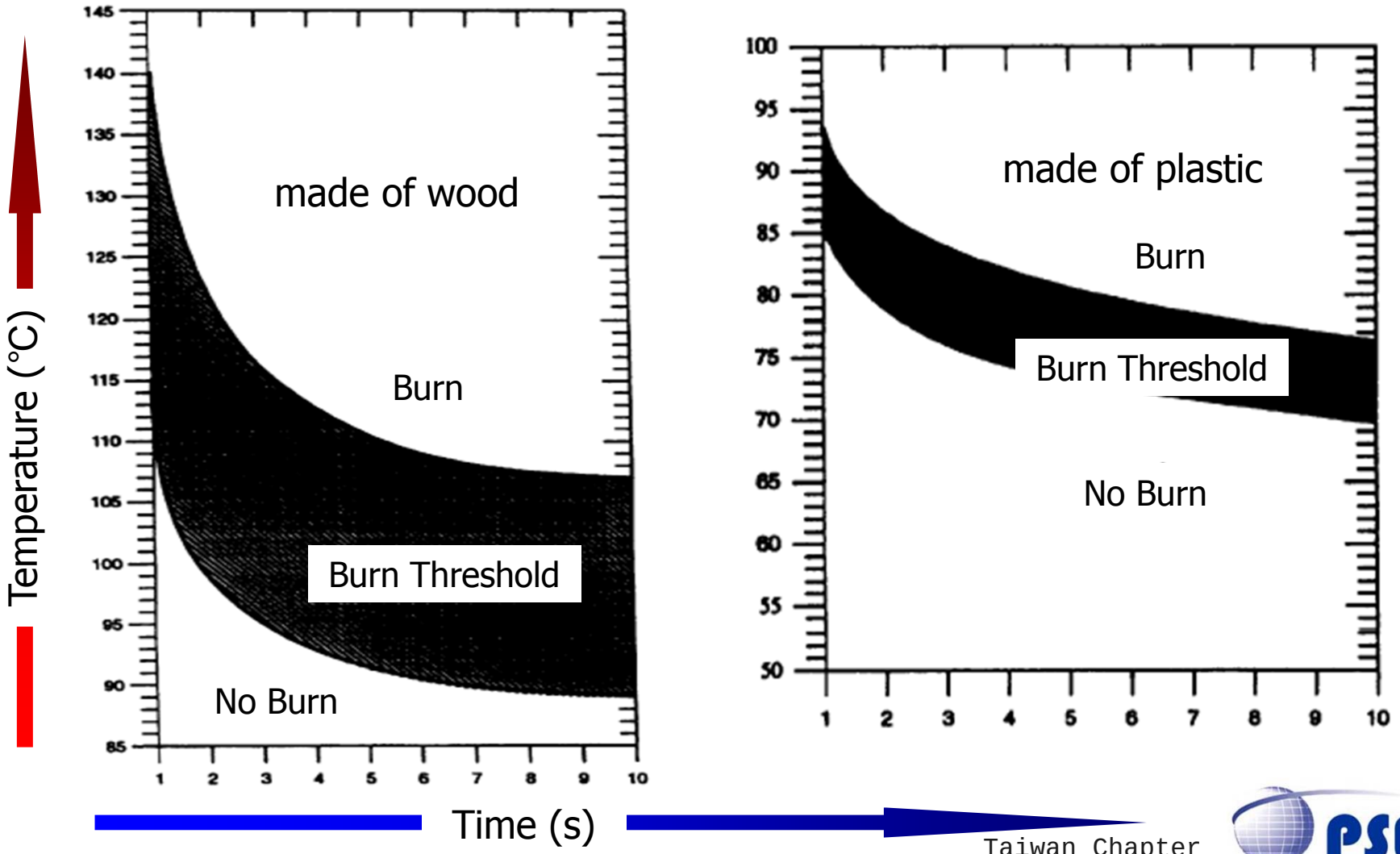
## - Burn Hazard, EN 563 -

Illustration of burn threshold spread from EN 563



# Hazard-Based Safety Standard

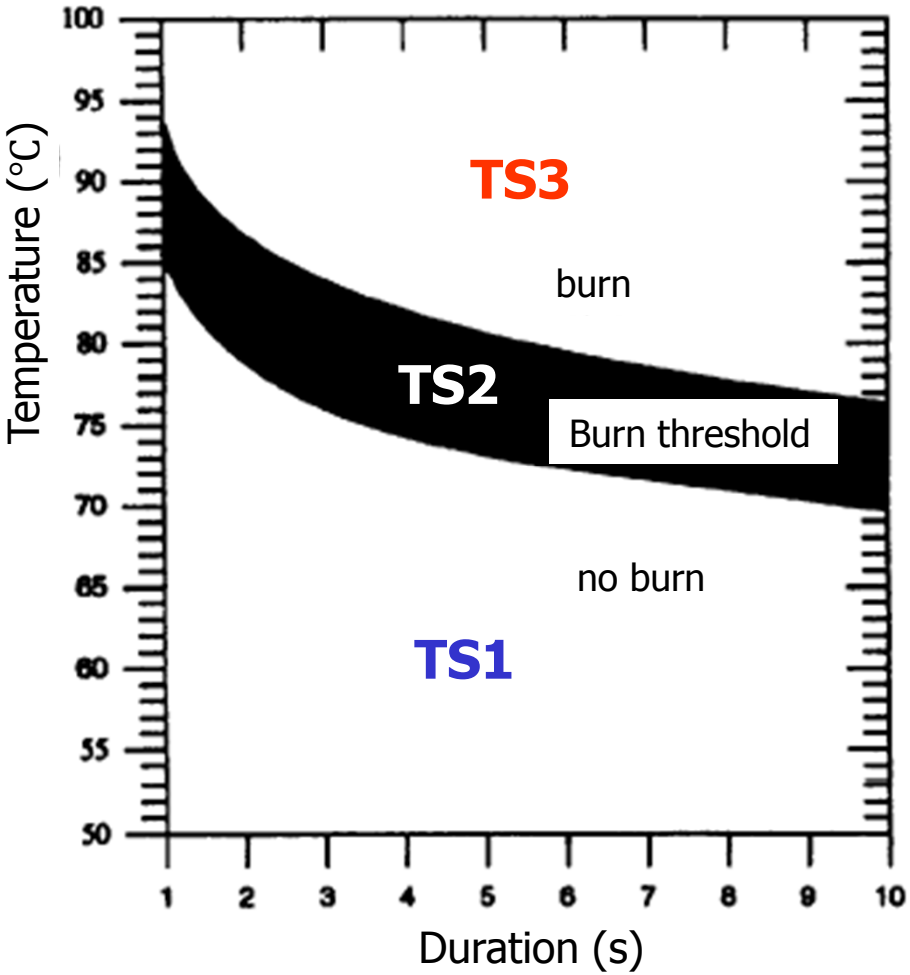
## - Burn Hazard, EN 563 -



# Hazard-Based Safety Standard

## - Burn Hazard, EN 563 -

one possible classification of thermal energy source…




Thermal energy can be calculated by formula:

$Q = M\ Cp\ (T - T_0)$

where

Q: thermal energy (joule)

M: material mass (g)

Cp: specific heat (joule/g-℃)

T:temperature (℃, hot surface)

$T_0$: temperature (℃, skin)

# Hazard-Based Safety Standard

## - Burn Hazard, EN 563 -

estimation of contact periods from EM 563…

| Contact period up to | Examples for touching a hot surface Unintentional | Examples for touching a hot surface Intentional |
|---|---|---|
| 0.5 s | fastest withdrawal following pain sensation without movement restriction | - |
| 1 s | quickly withdrawal following pain sensation | - |
| 4 s | extended reaction time | activation of a switch, pressing a button |
| 10 s | falling against a hot surface without recovery | slight adjustment of a handwheel, valves, etc |
| 1 min | | turning of a handwheel, valves, etc |
| 10 min | | use of control elements |

# Hazard-Based Safety Standard

## - Burn Hazard -

Temperature criteria:

| Part | Contact Period | Material | Limit (ECMA 287) | Limit (IEC 60950-1) |
|---|---|---|---|---|
| Handle, Knob, Grips, etc | continuously | All | 43ºC | 55ºC |
| | short period (10 sec.) | Metallic | 55ºC | 60ºC |
| | | Non-metallic | 65ºC | 70ºC |
| External surface of equipment | may be touched (1 sec.) | Metallic | 65ºC | 70ºC |
| | | Non-metallic | 85ºC | 80ºC |

# Mechanical Hazard

# Hazard-Based Safety Standard

## - Mechanical Hazard -

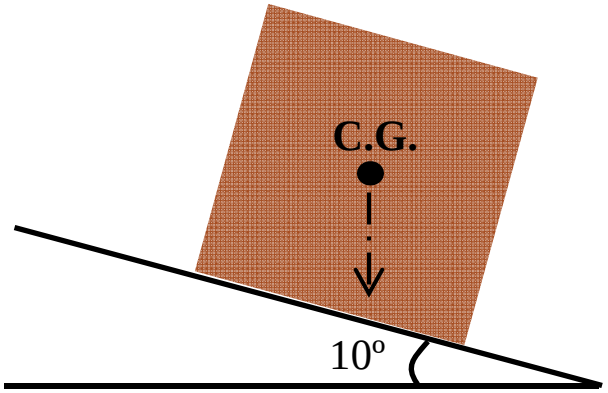
Kinetic energy and potential energy should be considered in mechanical hazard.

The difficult to dealing with mechanical hazard is lack of relevant ergonomic data to classify that, when object in moving status, how many joules will cause human hazard?

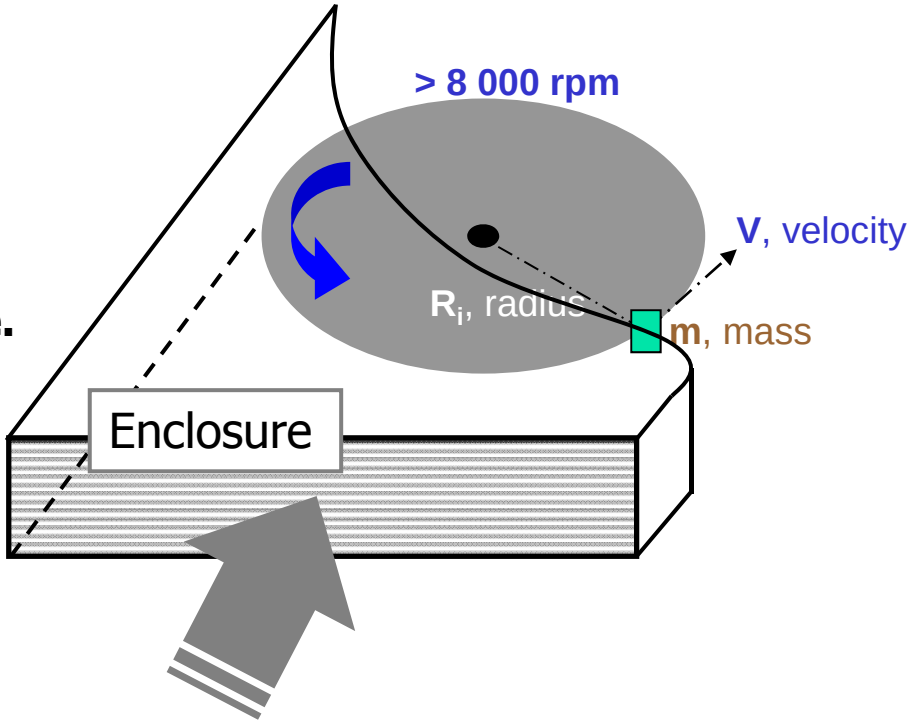
Only the requirements are presented in this material.

# Hazard-Based Safety Standard

## - Mechanical Hazard -



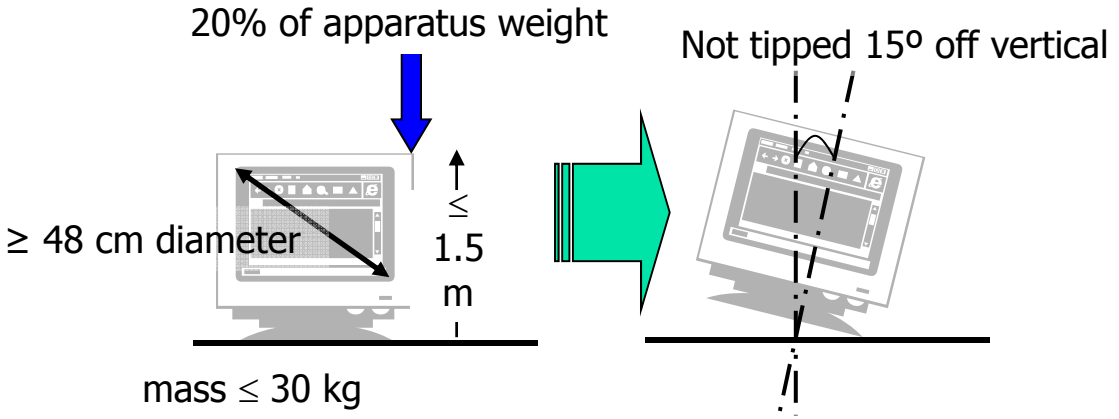

**It shall comply with 10 tilt test only if unit has mass 7 kg or above.**

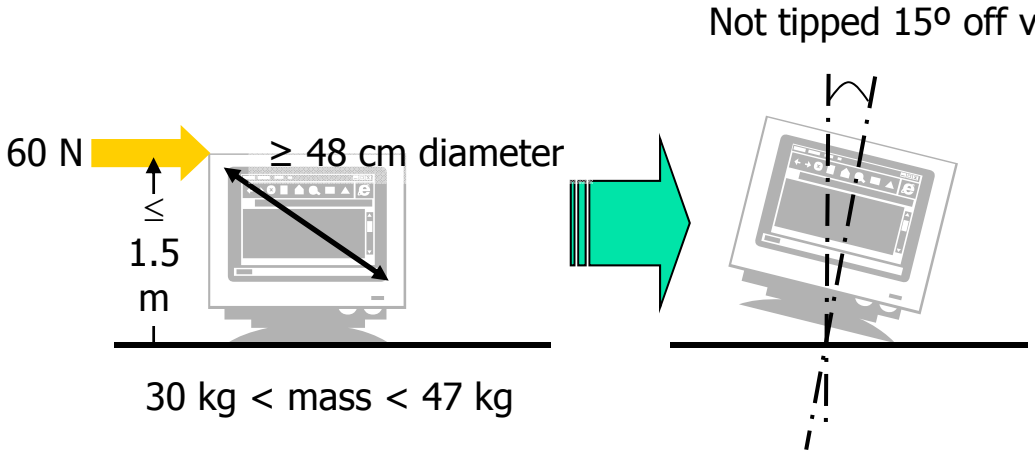



$$F = mV^2 / R_i$$

# Hazard-Based Safety Standard

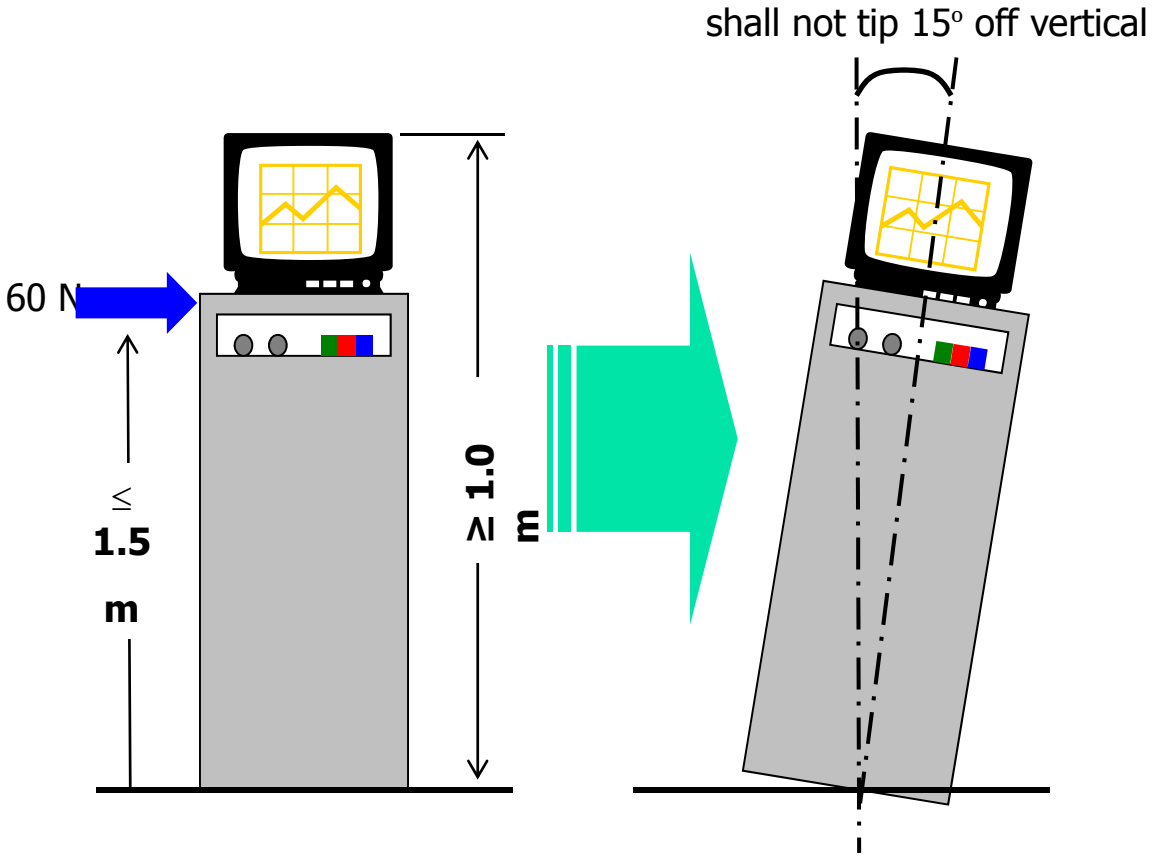
## - Mechanical Hazard -



# Hazard-Based Safety Standard

## - Mechanical Hazard -

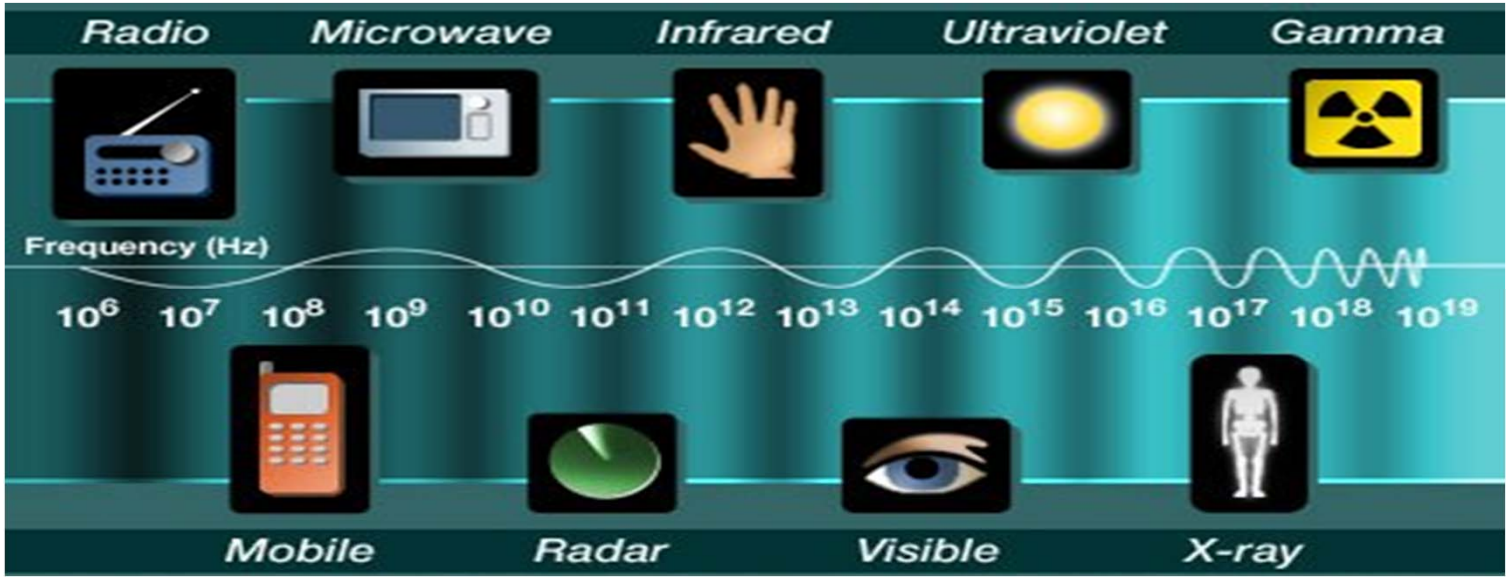


# Radiation Hazard

# Hazard-Based Safety Standard

## - Radiation Hazard -

EM spectrum…




| Radiation | Wavelength (nm) | Standard |
|---|---|---|
| Non-ionizing, laser or LEDs | 180 – 1,000,000 | IEC 60825-1, -2, -12 |
| Incoherent UV | 180 – 400 | IEC 60825-9 |
| Incoherent visible, lamp | 400 – 700 | CIE Publication S009/E:2002 |
| Non-ionizing | 0 – 300 (GHz) | IEC 60825 series |

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## - Radiation Hazard -

Pathological effects associated with excessive exposure to light, from IEC 60815-1

| Spectral region | Eye | Skin | |
|---|---|---|---|
| UVC (180 – 280 nm) | Photokeratitis | Erythema (sunburn)<br>Accelerated skin aging process<br>Increased pigmentation | |
| UVB (280 – 315 nm) | | | |
| UVA (315 – 400 nm) | Photochemical cataract | Pigment darkening<br>Photosensitive | Skin burn |
| Visible (400 – 780 nm) | Photochemical and thermal retinal injury | | |
| IR A (780 – 1 400 nm) | Cataract, retinal burn | | |
| IR B (1.4 – 3.0 μm) | Aqueous flare, cataract, corneal burn | | |
| IR C (3.0 μm – 1 mm) | Corneal burn only | | |

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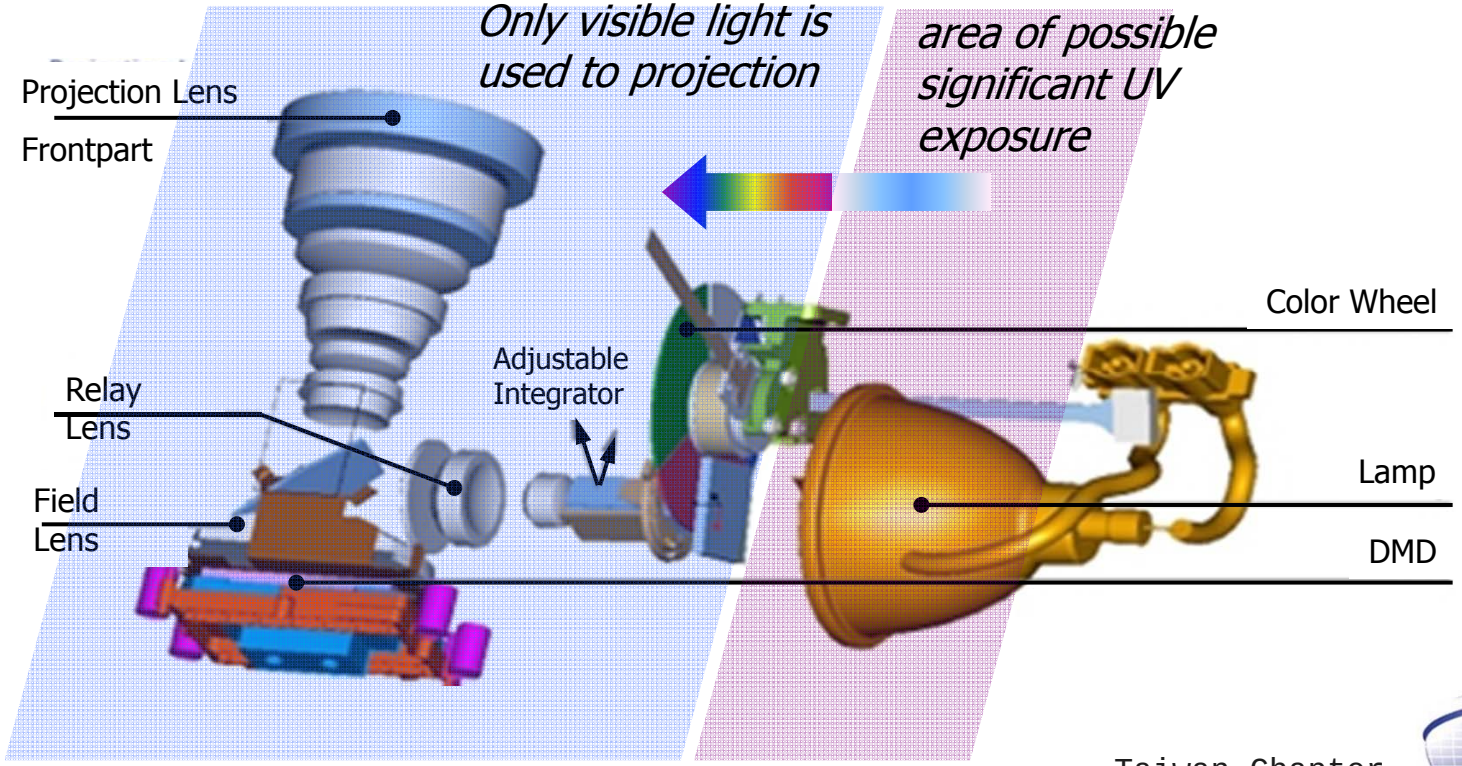
## - Radiation Hazard -

Illustration of typical design of LCD projector…

Lamps typically used in LCD projectors generally emit total UV radiation levels of 16-20W, which typically is less than 20% of the total radiation.



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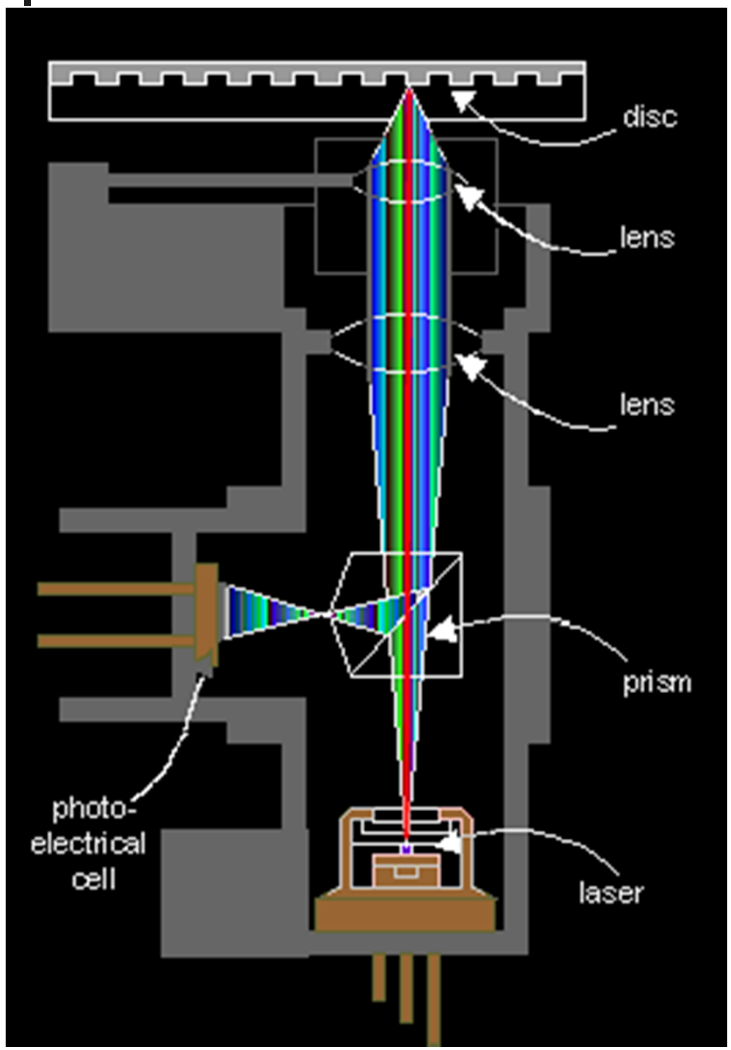
## - Radiation Hazard -




| IEC 60825-1+A1+A2 | |
|---|---|
| **Class 1** | No considered to be hazardous |
| **Class 1M** | May be hazardous if the user employs optics within the beam |
| **Class 2** | Eye protection is normally afforded by aversion responses, including the blink reflex |
| **Class 2M** | Viewing the laser output may be more hazardous if the user employs optics within the beam. |
| **Class 3R** | Direct intrabeam viewing is potentially hazardous but the risk is lower than for Class 3B |
| **Class 3B** | Normally hazardous when direct intrabeam exposure occurs. Viewing diffuse reflection is normally safe. |
| **Class 4** | Capable of producing hazardous diffuse reflections, may cause skin injury and could also constitute a fire hazard |

# Chemical Hazard

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## - Chemical Hazard -

A chemical hazard can be in the form of solids, powders, liquids or gases. Dust and other particulate materials can also be chemical hazards depending on their composition.

Chemical hazards can arise from three major sources:

1) Consumable Items – examples such as printer cartridges, toners, paper, cleaning fluids, batteries

2) Non-consumables, including materials of equipment construction

3) Products produced during the normal operation of the equipment, for example dust from paper handling systems, ozone from laser printing

# Hazard-Based Safety Standard

## - Chemical Hazard -

Chemicals used in the manufacture and subsequent use of the equipment shall be selected, where possible, which are classified as non-hazardous and are not restricted in use by the region that the product is manufactured for use in.

Compliance is checked by either:-

- a certificate of conformity or,
- a supplier declaration or,
- by reference to material safety data sheets for the materials used.

# Hazard-Based Safety Standard

## - Chemical Hazard -

Where hazardous chemicals have to be used as no viable alternatives exist…

- Minimize Exposure to Chemical Hazards
  - ✓by limiting the use levels of the hazardous material where hazardous chemicals are used or produced
  - ✓by using guarding and/or containment of the chemical hazard
- Use personal protective equipment
  This is the lowest level of protection from exposure to chemical hazards and should only be used where no better solution exists.
- Use of warning labels and instructions
  Warning marks and instructions shall be applied to the equipment unless the chemical hazard potential has been eliminated.

# Hazard-Based Safety Standard

- Summary -

Base on three blocks model in Hazard-Based engineering, interrupt the energy source or interfere the transfer mechanism are both scheme can be used to prevent injury. Select the proper scheme and measure the effectiveness by sound engineering principles are used to determine the compliance.

TC 108 still circulate and review several proposal in development of Hazard-Based safety standard. Unknown body susceptibility is not the only one difficult, safety requirements in former standard should be classified the energy sources and identified the transfer mechanism. Input from industry-wide is useful and valuable in current develop stage.

# Hazard-Based Safety Standard

Thank you !!

Taiwan Chapter
since 4/29/05

PSES
Product Safety Engineering Society