Hazard-Based Safety Standard

Comparison between ECMA 287, IEC 60950-1, IEC 60065

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***Abstract* – ECMA TC 12 had draft ECMA 287 in 2002 December and provide to IEC TC 108 with items that does not reach consensus. ECMA 287 considers safety evaluation under ITE and AV scope and may differ from current requirements describe in the safety standards IEC 60950-1:2001 and IEC 60065:2001. In this article, we focus on things in ECAMA 287 that are new and will require users of IEC 60950-1 and IEC 60065 to change the way they investigate products.**

I. INTRODUCTION

ECMA 287 is a safety standard of electronic equipment published by ECMA (European Computer Manufacturers Association) International. Since multimedia products have blurred the borderline between different classes of products, traditional safety standards based on specific product category are no longer fulfilled the product technology tendency. This changing situation has generated a new set of conditions that are to be taken into account when designing new equipment. Therefore, the new Standard ECMA 287 was developed which its philosophy has been to define hazard-based requirements, base on sound engineering principles and taking into account relevant IEC product standards and pilot safety documents.

Figure 1 – Three blocks model, energy higher than human body sustainable level transfer to human body will cause hazard.

Hazard	Energy Type	Clause
Electric Shock Hazard	Electrical	3
Fire Hazard	Thermal	4
Burn Hazard	Thermal	5
Mechanical Hazard	Kinetic and Potential	6
Radiation Hazard	Radiant	7
Chemical Hazard	Chemical	8

Table 1 - Clauses construction and energy types in ECMA 287

Hazard caused by different Energy types construct ECMA 287 and three blocks model is used to infer related protection. We will introduce each clause concept and compare with 1st edition of IEC 60950-1 and 7th edition of IEC 60065.

II. SCOPE

Standard ECMA 287 is a new safety standard rather than a merger of IEC 60950-1 and IEC 60065. It covers Office Equipment, Consumer Electronic Equipment; Communication Equipment; or a combination of above e.g. multimedia products that rated not exceeding 600 V rms. or V dc.

III. ELECTRIC SHOCK HAZARDS

Electrical energy that identified as hazardous source will be classified under ES3 and necessary safeguard shall be employed within the equipment. The classification of electrical energy shall base on several factors, for instance, charge voltage and capacitance will use to classify electrical energy stored in capacitor. Electrical energy stored in 91 nF capacitor will be considered safe for human body if the capacitor charged by 100 V peak voltage but, greater than 200 V peak charge voltage will causes harmful effect in physiology if the storage energy transfer to human body. As shown in Figures 2a, 2b and 2c, there are three different electrical types are considered in ECMA 287 and limit criteria are driven from IEC 60479 and IEC 61201.

The skilled person has relevant education and experience to enable him or her to avoid danger. But, instructed person and ordinary person shall be protected by adequate safeguard employed within equipment. ES1 energy source is considered safe if accessed by ordinary person but, for ES2 energy, instructed person is permitted to access under skilled person's advice or supervise. If equipment shall operate under ES3 energy level, double or reinforced safeguard shall be provided to protect ordinary person and principle safeguard still needed when skilled person conducts necessary maintenance work.

Principle and supplementary safeguards prevent risk which may be created by equipment under normal and fault condition. Figure 3 shows protection requirement for ordinary person under different energy classes. In IEC 60950-1, you can say that, ES1 is SELV circuit, ES2 is ELV circuit and, of course, ES3 is circuit working at hazardous voltage. Additionally, safeguards used to avoid electric shock are basic, supplementary, double and reinforced insulation. The basic requirement of each insulation type is same in current ITE and A/V standards but ECMA 287 takes harmonize method to determine equipment construction i.e. clearance that mentioned in IEC 60950-1 annex G, same as IEC 60065 annex J, that base on basic safety standard IEC 60664-1.

As mentioned in IEC 60950-1, insulation breakdown is considered to have occurred when the current that flows as a result of the application of the test voltage rapidly increases in an uncontrolled manner.

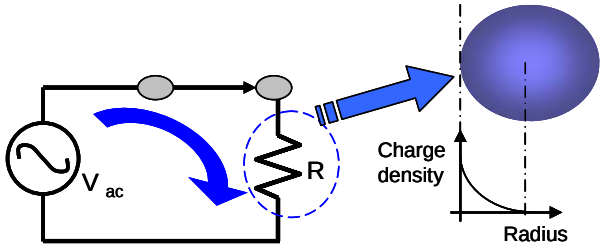


Figure 2a – Due to skin effect, frequency will influence energy source class of ac electric source above 1 kHz. Driven from IEC 60479-1, up to 100 kHz, 0.5 mA multiple frequency in kHz unit is current limit of ES1 but, in TC 108 draft of year 2004, ES2 limit is 5 mA plus 0.95 multiple frequency in kHz but lesser than 100 mA.

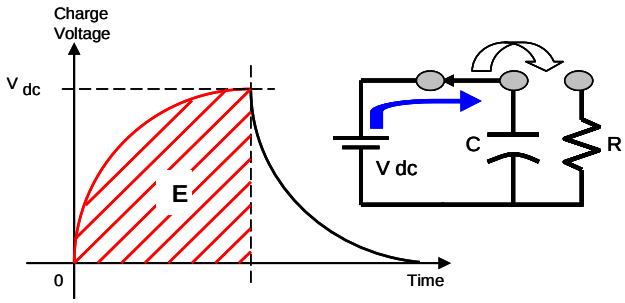


Figure 2b - Capacitance and charge voltage are used to determine the energy source class. If storage energy transfers to human body, the transfer period will be influenced by both values of human impedance and resistance of capacitor. The energy transfer to human body in discharging can be calculated by following formula.

$$E_{discharging} = \frac{1}{2} C V_{dc}^2 \int_{t_0}^{t_1} e^{-\frac{2t}{RC}} dt$$

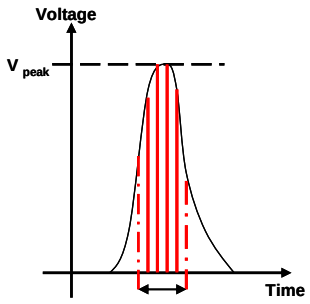


Figure 2c – If the energy is single pulse type, duration and peak voltage are two factors uses in energy source classification. In area of multiple finger contact, 1000 mm^2 approximately, 35 V peak with 100 ms period pulse can be accessed by ordinary person. But, if peak voltage greater than 129 volt, only skilled person permit to conduct the maintenance work under effective principle safeguard provided to prevent risk may be created by equipment. For multiple pulses, these pulses will treat as continuous voltage if minimum time interval between any two pulses lesser than 3 second. In addition, energy from analog telephone network ringing signal as defined in annex M.1 of IEC 60950-1 is taken as ES2.

Energy Source Classification of Different Electrical Energy Types

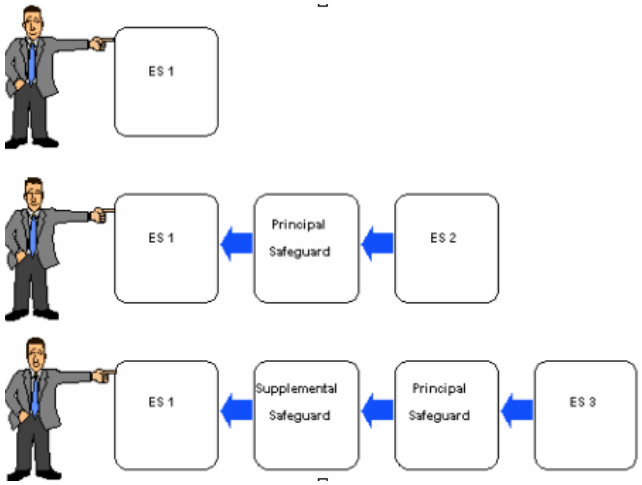


Figure 3 – Ordinary person shall be protected by adequate safeguard from energy source class 3 that considered harmful to human body.

The dimensioning of clearance shall withstand required impulse withstand voltage that determined by equipment voltage rating basis and overvoltage category according to equipment expectative use. Peak working voltage across the clearance, mains transient voltage and peak value of nominal ac mains supply are used to determine appropriate voltage required to withstand and, further more, to determine the minimum clearance. The transient voltage from "external circuit" e.g. outdoor antenna system is not taken into account in IEC 60950-1 but, in ECMA 287, 10/700 µs waveform with 1.5 kV peak voltage should be used for determination testing. But, the testing is applicable to telecommunication network connection only draft hazard-based standard and TC 108 expects 4 kV peak transient voltage will receive if equipment connect to coaxial cable, 5 kV peak for such power fed repeaters and 10 kV from outside antenna system connection. Additionally, it is maybe needed to define external circuit outside the building. Tables 2a, 2b and 2c shows transient voltage used in difference circuit connection. They should be used as initial charge voltage in impulse generator of transient voltage measurement.

Indicated in IEC 60664-1, insulation coordination shall consider environment parameters e.g. relative humidity, condensation, air pressure, pollution, etc. For clearance, air pressure and wide variation temperature are most important factors. Air pressure is variance and seems to impact the

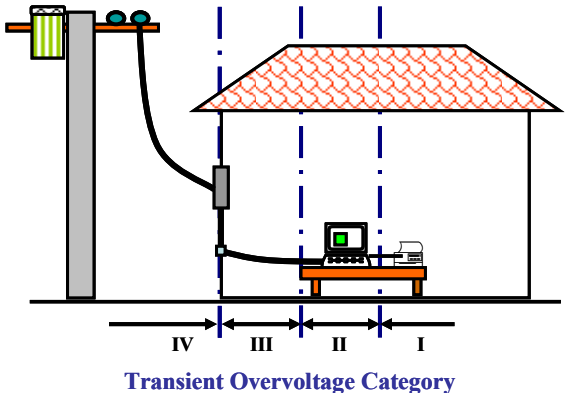


Figure 4 - Overvoltage category

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

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

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

Category IV: Equipment if for use at the origin of the installation.

Transient voltage can be determined by impulse generator of annex N of IEC 60905-1. Voltage measuring meter across the clearance and apply 1.2/50μs, for connection of ac and dc distribution system, and 10/700μs, for connection of external circuit, wave forms to the circuit. See table 2a, 2b, and 2c for initial charge voltage of impulse generator.

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	1500	2500	4000
300, 230/400	420	1500	2500	4000	6000

Table 2a – Transient voltage for ac main supply connection

Earthed	Same building	V peak
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.		

Table 2b – Transient voltage for dc power distribution system

Circuit	V peak
Telecommunication network	1500
Coaxial cable connection	4000
Supply power to accessories	5000
Outdoor antenna system	10000

Table 2c – Transient voltage comes from external circuit

insulation characteristic if equipment works on altitude greater than 2000 m above sea level. IEC 60065 ask to refer IEC 60664-1, table A.2, to correct clearance limit and it is also accepted by hazard based standard. TC 108 has merge altitude corrective factor data not only for clearance dimensioning but also point out the corrective factor for test voltage in electric strength test.

Same in the creepage distance determination, ECMA 287 uses research of clause 3.2 of IEC 60664-1 and values in table 4. It is same as former IEC 60950-1 limit typically and influenced by pollution, relative humidity and condensation, the most important environment factors point out in IEC 60664-1.

In addition to ECMA 287, if bridging component(s) across to or used as insulation, no matter capacitor(s) or resistor(s) (used as reinforced insulation), damp heat test shall be conducted 21 days under 40 temperature and 93% relative humidity conditions. After the damp test, bridging resistor(s) is then subject to ten impulses, 60s interval and initial charge voltage equal to required withstand voltage, of alternating polarity. After the test , resistor shall not have changed more than 10%.

ECMA 287 also consider the evaluation of non-separable thin sheet material, it shall comply with dielectric strength test and apply to 2 times testing voltage of single layer testing if it constructs two layers equivalently or 1.5 times testing voltage if equivalent three layers has been constructed. For think sheet material can be separated for individual testing, mandrel test in CTL decision sheet number 392, established base on IEC 61558-1, is permitted to use as alternative test procedure.

ECMA 287 has same requirement of protective conductor but TC 108 revise related clause to include current rating of circuit under test greater than 16 A. Proposed table and paragraph can be found in UL 60950-1, D1 deviation in sub-clause 2.6.3.4. It is now required by TC 108 that 200% current rating of circuit under test, 120 second, shall be used to check the earthing continuity for all current rating. TC 108 also considers the situation if equipment employed protective conductor as reinforced safeguard. It may be achieved by permanently connection with cross session greater than 10 mm^2 conductor or permanent connection by power supply cord.

About the deficiency of touch current topic in ECMA 287, TC 108 supplements related clauses in draft standard and describe each purpose of three measuring networks in IEC 60990 to help in appropriate selection. IEC 60950-1 and IEC 60990 are both basis standards for reference.

V. FIRE HAZARD

To control the fire spread and prevent to cause damage of

surrounding of apparatus are primarily concern in fire hazard protection. To review IEC 60950-1 and IEC 60065, except for material selection and appropriate fire enclosure provided, to separate the Potential Ignition Source(PIS) and supplied by Limited Power Source(LPS) are critical requirements for these two purposes. If we look into the criteria of these two requirements, we can say that, in the view of power consumption, 15 VA is considered no probability to cause ignition and fire spread will be limited if power consumption lower than 100 VA. Following the concepts and observation, electrical power sources are classified in ECMA 287 i.e. PS1, PS2 and PS3.

Class	PIS	LPS	Description
PS1	N	N/A	Not exceeds 100 W until 1sec and 15 W thereafter.
PS2	Y	Y	Not exceeds LPS limit
PS3	Y	N	Exceeds LPS limit.

Table 3 – Definition of power source classification

It is easily to hear from safety staff says that there is no fire hazard concern if the unit comply with LPS. It is not exactly, it only tell us that, if equipment supplied by LPS has been ignited, apparatus surrounding will "safe." Although fire enclosure can be waived, but material selection still needs to concern e.g. V-2 components mounted on V-1 material. It is clarified in ECMA 287 by separate PIS to PIS1, same as PIS in IEC 60065, and PIS2, supplied poser from power above 15 W. The concept is also accepted by TC 108 but more detail description about measuring period has been discussed in draft HBSDT standard for PIS1 and, also, for power source classification. In draft hazard-based standard, ignition sources of PIS1 and PIS are recognized from arcing of broken connection and from higher component power dissipation.

Protection method, we always need to consider equipment operates under normal and abnormal condition. In normal condition, to avoid exceeding material's rated temperature and separate from arcing are primarily used. And, control fire spread by select component(s) that able to reduce flame spread, or fire enclosure used, and prevent ignition methods e.g. applicable opening construction can be used alternatively or jointly in abnormal condition. To choose appropriate safeguards, table 4 provides general concepts described in hazard-based standard.

PS1	
No safeguard required.	
PS2	
Principle	To minimize the size of the an ignition source
Supplement	To control the spread of fire
PS3	
Principle	To control the spread of fire
Supplement	To use adequate fire enclosure, extinguish system, etc.

Table 4 – Safeguards selection for classified power sources

Requirements of PS2 protection under abnormal condition are familiarity because IEC 60950-1 clauses 4.7.2, 4.7.3 and IEC 60065 clause 20 are consolidated into clause 4.3.3 in ECMA 287, e.g. V-1 PWB used, wiring with flame retardant insulation material, V-2 of component(s) material used, integrated circuit packages with a volume not exceeding 1750 mm^3, etc. ECMA 287 move devices, e.g. thermal cut-out, thermal links and PTC-S thermistor, requirement that consider provide reliable protection to minimize ignition to annex G too. They are same as related sub-clauses of clause 14 in IEC 60065.

For PS3, fire enclosure is considered necessary to use as supplement safeguard to control fire spread or, alternatively, active extinguishing system has be provided. Figure 5a and 5b are also considered as top opening and bottom opening. Construction of fire enclosure opening shall not likely to ignite material on the outside of the enclosure and, if necessary, designed to prevent fire hazard due to entering of foreign objects. Collected illustrations in clause 4.6 of IEC 60950-1 and figure13 of IEC 60065 are used to illustrate several permitted opening construction.

Protection requirements asked in IEC 60950-1 clause 4.3.8 for flammable liquids and vapours are used in ECMA 287 and draft IEC 62368, the TC 108 new hazard-based safety standard.

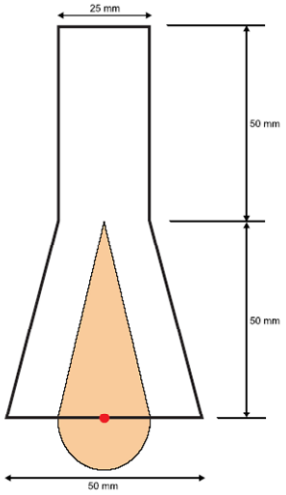


Figure 5a – with respect to potential ignition source, top openings are any openings within the volume.

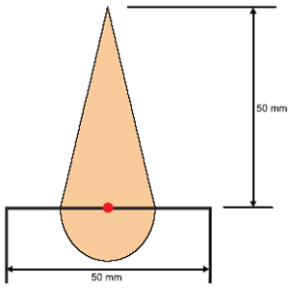


Figure 5b – with respect to potential ignition source, bottom openings are any openings within the volume.

Candle Flame Ignition

TC 108 Special Fire Research Group (SFRG) complete its assignment in 2003 and shows that open flame ignition is primarily of external ignition, 45%, and all death are categorized under candle flame ignition, the 70% ignition causes of external ignition. Material grade lower than V-1 likely to ignite by candle flame and should comply with 12 mm needle flame, similar to 20 mm diameter candle and approximately 50 W output power, heat output test. TC 108 has considers this issue and draft technical specification currently, but, it does not implement to current draft hazard-base standard. Although electrically-caused fire identification and protection are current focus in ECMA 287 and TC 108 draft standard, but external ignition should be concern and analysis by 3 blocks model.

VI. BURN HAZARD

In 2003 January, Reuters story from London entitled "Scientist burns penis with hot laptop" shakes product safety field and drew the fierce debate about current criteria in safety standard. Several safety agencies following to ask manufacturer should comply with IEC 60950-1 criteria of "Handles, knobs, grips, etc., continuously held in normal use" for laptop bottom. Peter E. Perkins had collect ASTM and CENELEC research standards and suggests possible selected safeguard after data collection from designed experiment. His research paper had presents in PSES 1st symposium entitled "Ouch! Hot Laptop."

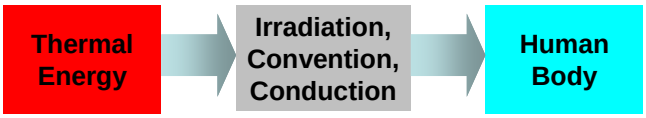


Figure 6 – In physics, thermal energy is transferred by irradiation, convection and conduction.

Unlike electric shock hazard and fire hazard, ECMA 287 does not figure out how to classify thermal energy sources that may cause burn hazard. In 3 blocks model, the other way to protect ordinary person is to interfere transfer mechanism. To avoid user access hot object or surface is more easily to analysis transfer rate of thermal energy in different materials. But, what temperature degree is considered too hot to access by human and how could we to "control" the user's behavior? Yes, for unwilling behavior, caution or warning mark e.g. 60417-1-IEC-5041 always necessary to provided.

How about the temperature degree? Different materials has different physical properties, it causes different thermal transfer efficiency. This is why IEC 60950-1 provides three different limits of user accessible part constructed by metal, glass and plastic materials in table 4B, part 2. In ECMA 287, EN 563, ergonomic data to establish limit values for hot surfaces, is selected to follow as compliance criteria. According to EN 563, no matter what material used, hot surface has temperature 48ºC and touch by human will cause burn hazard if touch period exceeds 10 minute. Besides, if human touch hot surface attain to "touching of a hot surface and extended to reaction time," approximate 4 sec, the burn threshold will be 63ºC for metal, 76ºC for glass and 82ºC for plastic. You can see that all limits are lower than IEC 60950-1, 70ºC for metal, 80ºC for glass and 95ºC for plastic, under "External surfaces of equipment which may be touched." Table 5 collects related information, e.g. touch period, temperature limits, etc, for quickly reference.

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

Table 5 – Burn hazard limit comparison between ECMA 287 and IEC 60950-1

TC 108 accepts ergonomic data in EN 562 and proposed limits in ECMA 287. In addition, TC 108 also considers the possibility to figure out how thermal energy sources can be identified and classified. It is not a good idea to power sources classification used in fire hazard because burn hazard protection should distinct from fire hazard protection due to different nature of hazard (Fire hazard is consider the dire retardant, it means "fire" in normal condition in combustion process. But, flame is not expected and preferable appearance of burn hazard. SFRG figures out that probability of ignition by hot object is significantly low in fire accident).

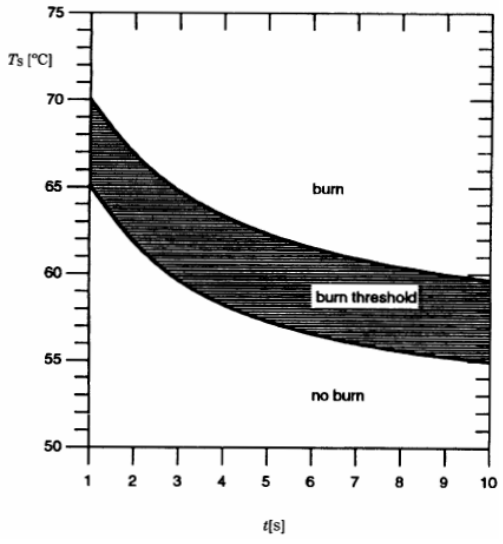


Figure 7 – EN 563, figure 2, burn threshold spread when the skin is in contact with metal-made smooth surface.

Thermal Energy Source Classification:

In EN 563, burns are classified into 3 levels depending on severity, i.e. superficial partial thickness burn, deep partial thickness burn and whole thickness burn. And, burn threshold is defined boundary surface temperature between no burn and superficial thickness burn, the epidermis is completely destroyed but the hair follicles and sebaceous glands as well as the sweat glands are spared. As shown in Figure 7, the burn threshold is not drawn as line but is drawn as spread because burn threshold depend on several factors, e.g. 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.

In addition to temperature, EN 563 figure out the surface temperature which lead to burns during contact of the skin with a hot surface also depend on the contact duration of the skin. The guide of temperature limit selection in EN 563 are: 1 second period is considered as touching of a hot surface and quick withdraw following pain sensation, activation of pressing the button is estimated 4 second period needed and period of 10 second and above is considered as falling against a hot surface without recovery.

Depend on material and selected period, one of classification method of thermal energy sources may be useful, i.e. to classify no burn area as TS1, burn threshold spread area is TS2 and TS3 is covered by burn area. It is accord with public intuition and 3 blocks model can be introduced too.

VII. MECHANICAL HAZARD

Kinetic energy and potential energy are two basic energy forms in classical mechanism and basic rule to identify energy sources in mechanical hazard. Typically, exploding, imploding, and moving parts are kinetic energy forms in current safety standard and to consider energy stored by potential energy form is requirement of equipment stability. Following the procedure of hazard-based safety evaluation, the first step is to classify energy source. But, 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? To avoid equipment instability and provide guarding means to avoid user access hazardous moving part are providing the other thinking in product safety.

ECMA 287 ask guarding means provided to avoid user access sharp edge and corner shall comply with 30N steady force applied by IEC 61032 probe 11. TC 108 additional requires equipment for used in household (e.g. audio- and video equipment and laptop computer) shall subject to steady force 10N applied by IEC 61032 probes 18 and 19, to evaluate possibility of access by children. If safety interlock is used as guarding means, compliance requirement same as clause 2.9 of IEC 60950-1 in ECMA 287 annex L shall be used to evaluate the construction and reliability.

Imploding and exploding are considered in practical application of high pressure lamp e.g CRT. Clauses 4.2.8 and 4.2.9 in IEC 60950-1 are used in ECMA 287 for non-intrinsically protected picture tube and IEC 62965 should be used to evaluate intrinsically protected CRTs. Parts or solid media which may be separated or thrown from a rotating part is additional considered in hazard-based standard draft by TC 108. 800 rpm is considered maybe cause hazard if solid media directly mounted on such rotating capable drivers. Mechanical enclosure provided shall construct to bear the static force, mv^2/Ri, as shown in figure 8.

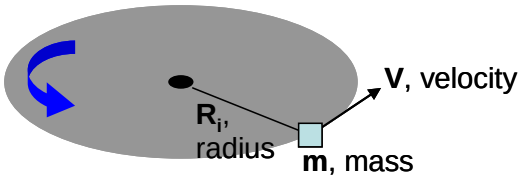
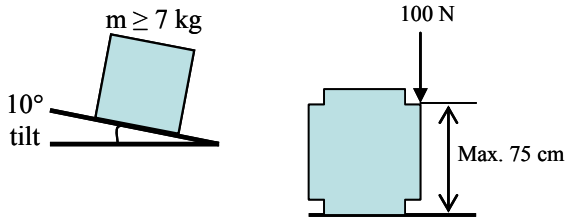


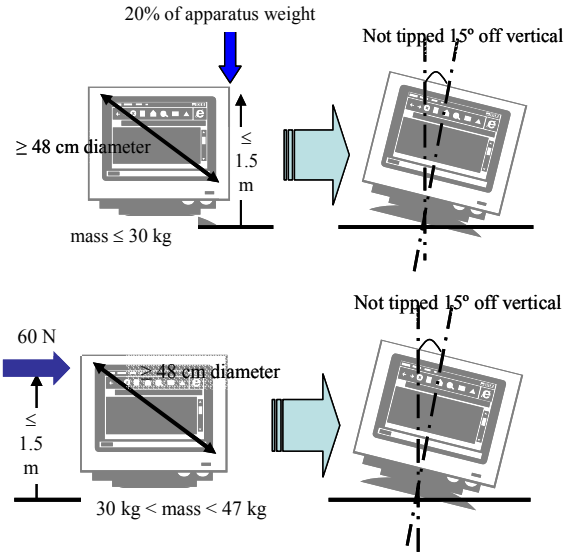
Figure 8 – Static force is calculated according to physical principle, where v is the velocity of the outside diameter of the solid media.

In clause of equipment stability, different to IEC 60950-1 and IEC 60065, the stability test shall be conducted only for equipment greater than 5 kg and shall comply with title test under 15 degree condition in ECMA 287. ECMA 287 provides three different overbalance tests (i.e. 15° tilt test, 40 N downward steady force push and 250 N steady force push for all direction except for upward) for equipment has mass greater than 5 kg, between 5 kg and 30 kg, and above 30 kg. The difference between ECMA 287 and TC 108 draft standard is, TC 108 consider that, stability tests are applicable to equipment has mass 7 kg or above and implement clauses 19.1, 19.2 and 19.3 in IEC 60065 as evaluation method. Figure 9 illustrate stability evaluation methods required in draft hazard-based safety standard clause 6.4

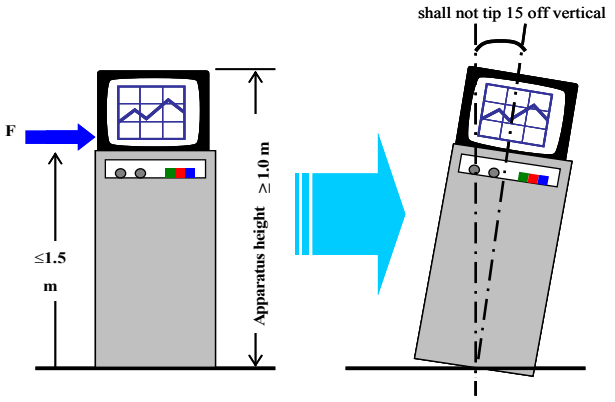
Figure 9 – Stability test(s).



Note: Steady force shall apply to any point(s) on the apparatus with direct viewing CRT that may produce maximum overturning momentum in following situations.



Note: In following apparatus, the applied force shall be 60N if mass under (≥ 25 kg, < 47 kg), 13% of weight if mass under (≥ 47 kg, < 70 kg) or 90 N if mass greater than 70 kg.



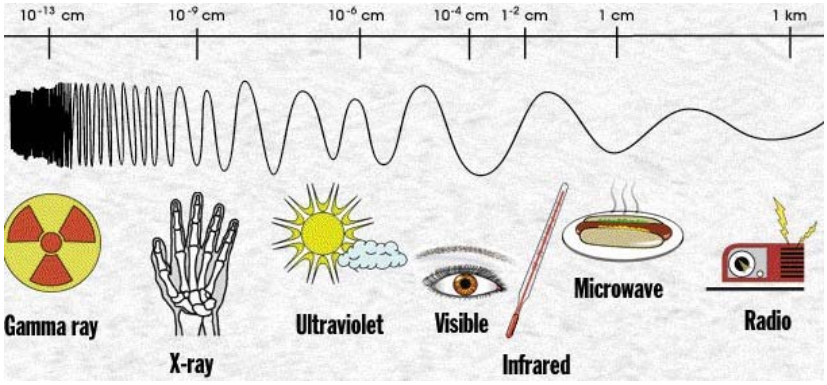


Figure 10 - EM-Wave Spectrum

To pick from website of Jet Propulsion Laboratory of NASA, it illustrate Electromagnetic spectrum and helpful in understand the relationship with wavelength. For Ultraviolet, it is typical to separate into UVA (315 - 400 nm), UVB (280 – 315 nm) and UVC (180 – 280 nm). In general, UVA is primarily factor to cause the hazard because UVC and UVB are absorbed by ozone, water vapor, etc.

Beside, TC 108 also employ requirements of wall, ceiling or rack mount and handle strength test that same as clauses 4.2.10 and 4.3.2 of IEC 60950-1 and clause 19.6 of IEC 60065.

VIII. RADIATION HAZARD

There are limit information about radiation in ECMA 287 and only laser and ionizing radiation are mentioned to comply with IEC 60825 laser requirements and 1 μs/hr limit for ionizing radiation measurement follow IEC 60950-1, annex H. But, except for ionizing radiation and coherent visible radiation, it is required to investigate incoherent visible radiation i.e. LEDs and ultraviolet in current version of IEC 60950-1.

Same as IEC 60950-1 requirements, TC 108 drafted hazard-based standard requires UV exposure shall evaluate to comply with IEC 60825-9 relevant limit for an 8 h exposure and employed with necessary warning text and ISO 3864+IEC 60417 symbol 5751 marking. Besides, TC 108 also clear figure out each radiation exposure in wavelength classification.

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

Table 6 – Required standards used to evaluate compliance of radiation exposure limit.

IX. CHEMICAL HAZARD

Chemical hazard is hazards that may arise from the inhalation of vapors or fumes, from ingestion of these substances, or from physical contact of these materials. Ozone concentration should limited under 0.1 ppm (0.2 mg/m^3), calculates as 8 hr time-weighted average and same requirements of dust, particles, liquid and gases used in equipment as clauses 4.3.9 and 4.3.10 of IEC 60950-1. For ozone exposure measurement clause 7.4 in ECMA 328 is proposed to measure chemical emissions in ECMA 287 but TC 108 chemical hazard team propose measuring equipment in accordance with ASTM D5156-95.

In TC 108 draft standard, chemical hazard is identical to arisen from three major sources, i.e. consumable items e.g. printer cartridge, non-consumable items e.g. equipment construction material and product produced during normal equipment operation e.g. ozone from photocopy machine. Currently, to provide a certificate of conformity, supplier declaration and reference to material safety data sheets for used materials are acceptable methods to check compliance. Although personal protective equipment is acceptable to use, but it is considered as lowest level of protection and only permitted to use if no better solution existed. Beside, warning label and instructions are essential applied to all equipments.

X. SUMMARY

First step to approach safety evaluation under hazard-based engineering concept is, to identify energy source(s) that used for equipment operation is hazardous or not? If the energy source may cause harmful physiological reaction from human, try to understand that, how is it transfers to human, what is the mechanism and how is it possible transfer path? Interrupt or interference (e.g. attenuator, deflector, etc.) transfer mechanism is next step to design appropriate safeguard. If the energy form and/or human susceptibility are unknown, use the bad experience. But, unlike former safety standard, hazard-based safety standard cannot only construct by bad experience we met. Any bad experience or accident shall be analysis as possible as by sound engineering principle(s).

In the other side, more and more research should be put into understand the susceptibility of human body because only limited amount of ergonomic data can be collected from existed research paper and bibliography. The study method may include simulation base on pathology data, biomedical and biophysical research, statistic data of field accident, etc. Beside, TC 108 still works on identification of each hazard and establish consistent standard content base on 3 blocks model.

Finally, it is appreciate that, Rich Nute provides us valuable comment and documents used to extend our study to include updated concept in hazard-based safety standard.

XI. REFERENCE

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[3] Standard IEC 60065, Standard for Audio, Video and similar electric apparatus – Safety requirements, 7th edition, 2001.

[4] Standard IEC 60664-1, Insulation coordination for equipment within low-voltage systems, Part 1: Principles, requirements and tests, 1st edition, 1992, with amendment 1, 2002.

[5] TC108/AGS/SFRG Study on the ignition of ICT and Audio/Video equipment by external ignition source, 2003.

[6] Standard EN563, Safety of machinery - Temperatures of touchable surfaces - Ergonomics data to establish temperature limit values for hot surfaces, 1994.

[7] Standard UL 60950-1, Standard for Information Technology Equipment – Safety, Part 1: General requirements, 1st edition, 2003.

[8] Standard UL 60065, Standard for Audio, Video and similar electric apparatus – Safety requirements, 7th edition, 2003.