

Radiation Hazards in the Great Technology War



IEEE

Taiwan Chapter



Product Safety Engineering Society

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Outline

- **FOREWORD**
- **MICRODISPLAY PROJECTION TECHNOLOGIES**
- **ADVANCES IN LIGHT SOURCE**
- **THE NATURE OF ULTRAVIOLET RADIATION**
- **KNOWN BIOLOGICAL EFFECTS**



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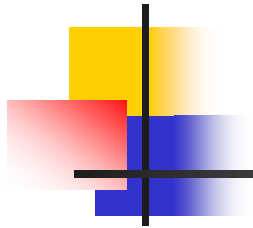
Outline

- **GUIDELINES FOR EXPOSURE LIMITS**
- **ESTIMATION OF UVR IRRADIANCE**
- **NEW UPDATE FROM TC108 MT2**
- **BEFITTING ASSESSMENT GUIDELINES**
- **SUMMARY**



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MODULE#1

FOREWORD



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Foreword

- **58% of women opt a HDTV (high-definition television) set over a 1-carat diamond ring**
 - **It's convincing just now though this study had released by Consumer Electronics Association (CEA) in the end of 2002**



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DTV or HDTV?

■ DTV

- Umbrella term for TV signals transmitted in digital – e.g. the adoption of setup boxes

■ HDTV

- Currently the most robust and detailed TV image
- Lifelike picture and sound that surpasses DVD
- Original impetus for HDTV came from wide-screen movies – increases the sense of “being there”



Fever of HDTV

- **Conventional CRT-based rear projection televisions (RPTVs)**
- **Modern microdisplay-based RPTVs**
 - **Swiftly gaining the market share due to...**
 - **Ever topnotch picture quality**
 - **Lager field of vision**
 - **Smaller form factor**
 - **More affordable price points**



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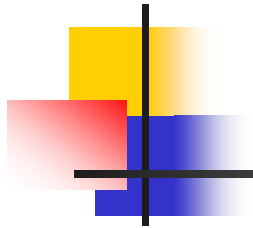
Risk???

- **Simultaneously, people who embracing the stunning viewing screens may have good chance of exposing themselves to radiation hazards without perception.**
 - **Root cause - the light source**



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MODULE#2

MICRODISPLAY PROJECTION TECHNOLOGIES



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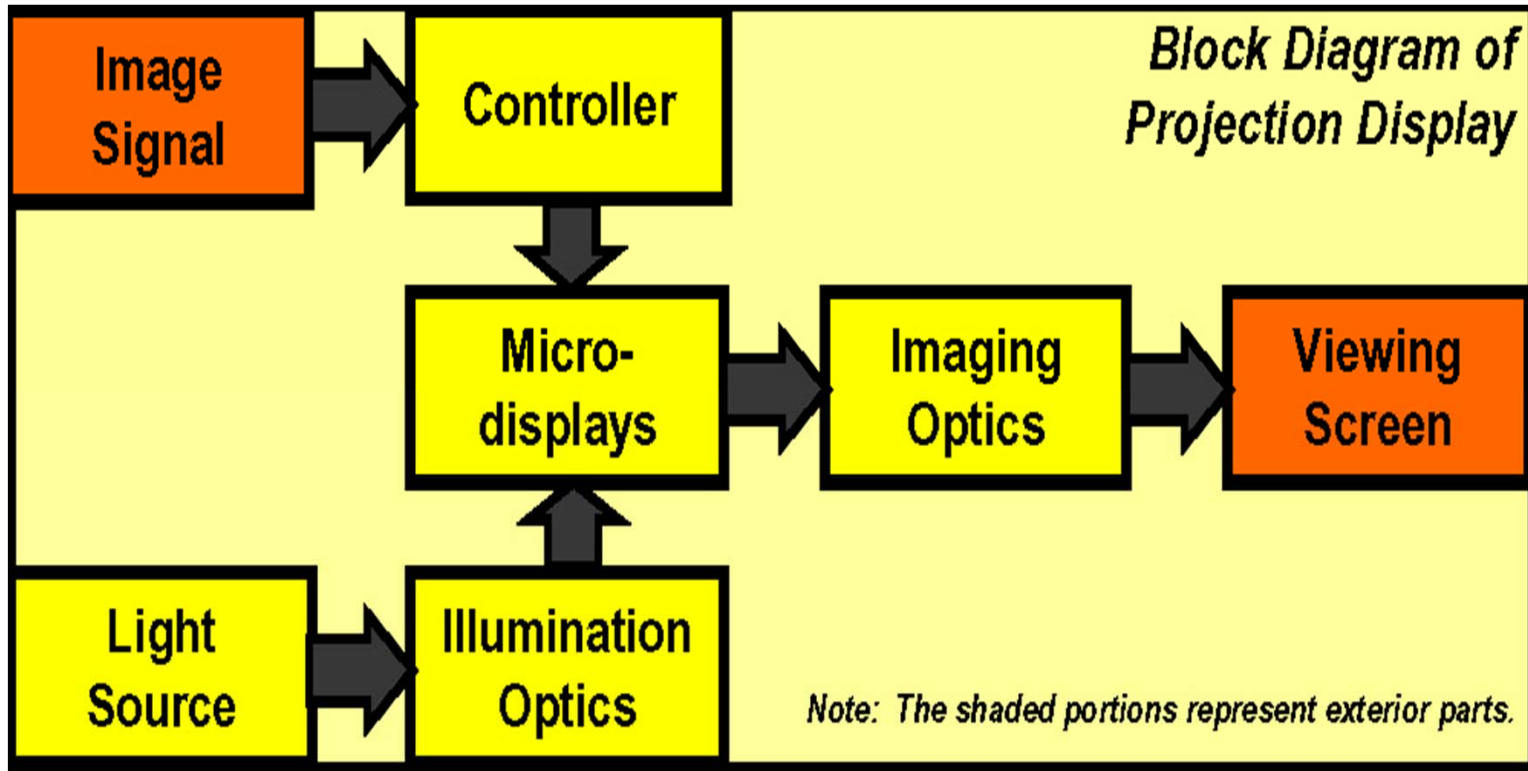
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Great Technology War

- **Categorized by tiny panels whether block or transmit light**
 - **Transmissive**
 - **Amorphous LCD (AM-LCD) - Clarity**
 - **Polysilicon LCD (HTPS-LCD) - Sony**
 - **Reflective**
 - **Digital light processing (DLP™) - TI**
 - **Liquid crystal on silicon (LcoS) - JVC**

Formation of Projected Image



Form Factor (Fat or Flat???)

- **CRT-based**
 - Fairly Bulky
- **Microdisplay-based**
 - Mitsubishi's Mini DLP PocketProjector™
 - Seems to realized the dream of projection anywhere



Mitsubishi Launches Mini LED DLP PocketProjector™ on Feb. 8th, 2005



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Digital Light Processing (DLP™)

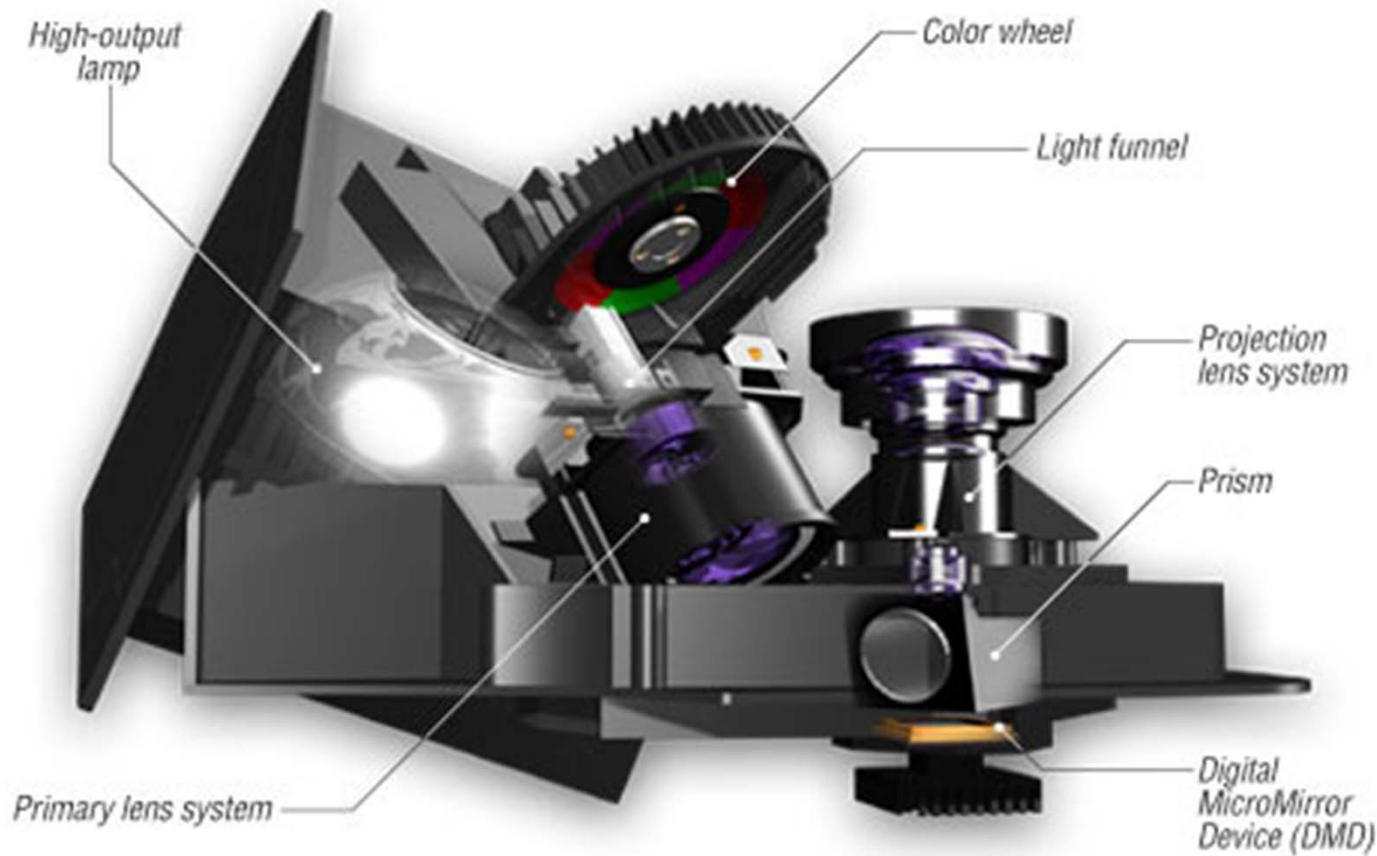
- **Invented in 1987 by Dr. Hornbeck of Texas Instruments Inc.**
- **Digital Micromirror Devices or DMDs**
 - **Grayscale (1,024 shades)**
- **Color Wheel**
 - **“Field sequential” color (1/30 second)**
 - **16.7 million colors for single-chip system**
 - **35 trillion colors for 3-chips system**



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Digital Light Processing (DLP™)

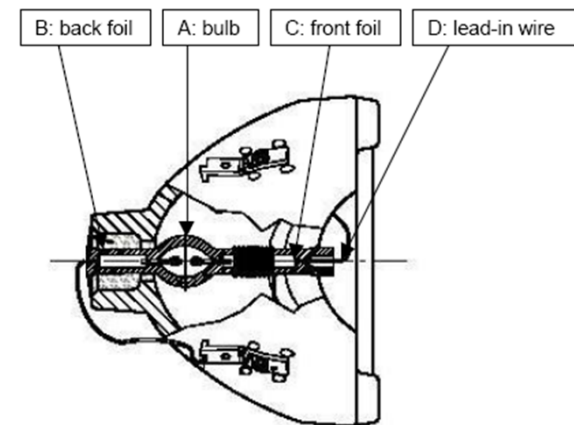


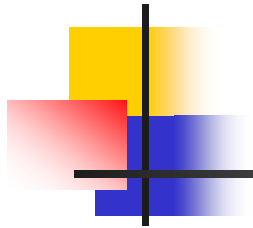
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Application of Safeguard

- **Light (Luminance) output**
 - Designer and safety engineer is aligned
- **Back Reflector**
 - Divergent
 - Thermal burden
 - Light leaks (may incorporated with invisible UVR)





MODULE#3

ADVANCES IN LIGHT SOURCE



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Light Source in Microdisplay Projection

- **Metal Halide Lamp – in early ages**
 - **High efficiency and quality but...**
 - **Long start-up and restarting time (improvable by pulse-start technique)**
 - **Short lifespan due to deposition (e.g. W)**
- **High-pressure Mercury lamp**
 - **Major innovation – UHP by Philips**
 - **100 W UHP lamp surpasses about 250 W metal halide lamp**



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Special Cares for Such Amazing Artifact

- **Annoying high-levels of UVR**
 - **Sensitive fabrics, papers, artifacts and even mankind**
- **Ozone may be generate by the photolysis of oxygen**
 - **Proper ventilation**
 - **Excessive inhalation may cause**
 - **headaches, nausea or dizziness**



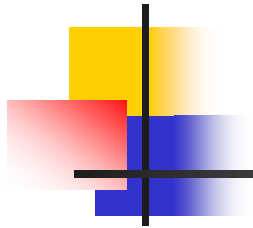
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Special Cares for Such Amazing Artifact

- **Lamp shatter (e.g. splash or collision)**
 - **Limit the accessibility**
- **Hazardous waste (e.g. Hg)**
 - **Cannot be thrown in the trash**
 - **Disposal of spent lamp must be according to applicable federal, state and local regulations**



MODULE#4

THE NATURE OF ULTRAVIOLET RADIATION



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Electromagnetic Radiation

- **Ionizing Radiation**
 - **Sufficient energy to knock out the electron from the orbit**
 - **Ionize atomic oxygen and hydrogen**
- **Non-ionizing Radiation –**
Frequency less than $2.42e+15$ Hz
 - **Relatively low energy**
 - **Atomic Excitation only**



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The Nature of the UVR

- **Unperceivable to human eyes**
 - **Inconspicuous hazard in HBSE**
 - **Generic public could not consciously recognize the danger by the sense of sight**
- **Low penetrability**
 - **Biological effects were limited to skin & eyes, tissues at depth are unlikely to be at risk**



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Classification

- Upon phenomenological basis

TABLE 1 – Ultraviolet Radiation Wavelength Regions

Region	CIE Divisions (nm)	ICNIRP/IEC/ACGIH Divisions (nm)
Ultraviolet C (UVC)	<i>100</i> – 280	180 – 280
Ultraviolet B (UVB)	280 – 315	280 – 315
Ultraviolet A (UVA)	315 – 400	315 – 400

Differences were printed in italics



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Sources of UVR

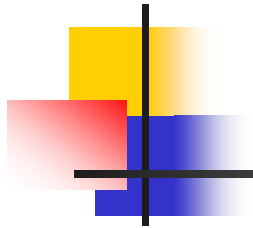
- **Sunlight**

- **All UVC** and **approximately 90% UVB** will be absorbed by ozone (O₃), water vapor (H₂O), oxygen (O) and carbon dioxide (CO₂);
- **UVA** is less affected by the atmosphere.
- **Man-made – may squeeze the limits**
 - Incandescent lamps
 - Gas discharges
 - Electric discharges
 - Fluorescent lamps



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MODULE#5

KNOWN BIOLOGICAL EFFECTS



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Wavelength Dependent

- **Vacuum or extreme UV (10-180 nm)**
 - We do not live under such condition
- **UVC (180-280 nm)**
 - Easily absorbed by stratosphere - Ozone
 - Artificial germicidal UVC lamps - bacteria
 - severe sunburn to the face or inflammation of the cornea (photo keratitis) and conjunctiva (photo conjunctivitis)



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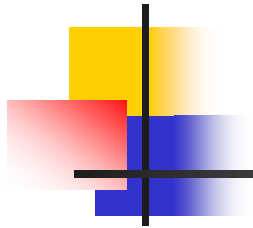
Wavelength Dependent

- **UVB (280-315 nm)**
 - Typically the most destructive
 - Erythema (sunburn) and cataracts
 - Break bonds in the DNA – Skin cancer (y)
- **UVA (315-400 nm)**
 - Cause fluorescent materials to emit visible light - black light
 - Pigment-darkening phenomenon - melanin
 - Vitamin D3 synthesis



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MODULE#6

THRESHOLD LIMITS



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Builders of Criteria

- **American Conference of Governmental Industrial Hygienists (ACGIH)**
 - **Threshold Limit Values (TLVs)**
- **The International Commission on Non-Ionizing Radiation Protection (ICNIRP)**
 - **Exposure limits (ELs)**
- **IEC TR 60825-9, First Edition, 1999-10**
 - **Maximum Permissible Exposures (MPEs)**



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ACGIH & ICNIRP

2001 ACGIH TLVs

Wavelength (nm)	TLV	Protection
180 – 400 (UVR)	30 J m ⁻² eff (8 h)	Skin (and eye below 315 nm)
315 – 400 (UVA)	104 J m ⁻² (<i>t</i> < 1000 s)	Eye
315 – 400 (UVA)	10 W m ⁻² (<i>t</i> ≥ 1000 s)	Eye

Current ICNIRP ELs

Wavelength (nm)	EL	Protection
180 – 400 (UVR)	30 J m ⁻² eff (8 h)	Skin (and eye below 315 nm)
315 – 400 (UVA)	104 J m ⁻² (8 h)	Eye
300 – 700	106 J m ⁻² sr ⁻¹ eff (<i>t</i> ≤ 104s)	Blue-light (retina)
300 – 700	100 W m ⁻² sr ⁻¹ eff (<i>t</i> > 104s)	Blue-light (retina)
300 – 700	100 J m ⁻² eff (<i>t</i> ≤ 104 s)	Blue-light (angular subtense $\alpha < 11$ mrad)
300 – 700	10 ⁻² W m ⁻² eff (<i>t</i> > 104 s)	Blue-light (angular subtense $\alpha < 11$ mrad)
380 – 1400	50000/ <i>at</i> 1/4 W m ⁻² sr ⁻¹ eff	Retinal burn (visual stimulus & <i>t</i> < 10s)



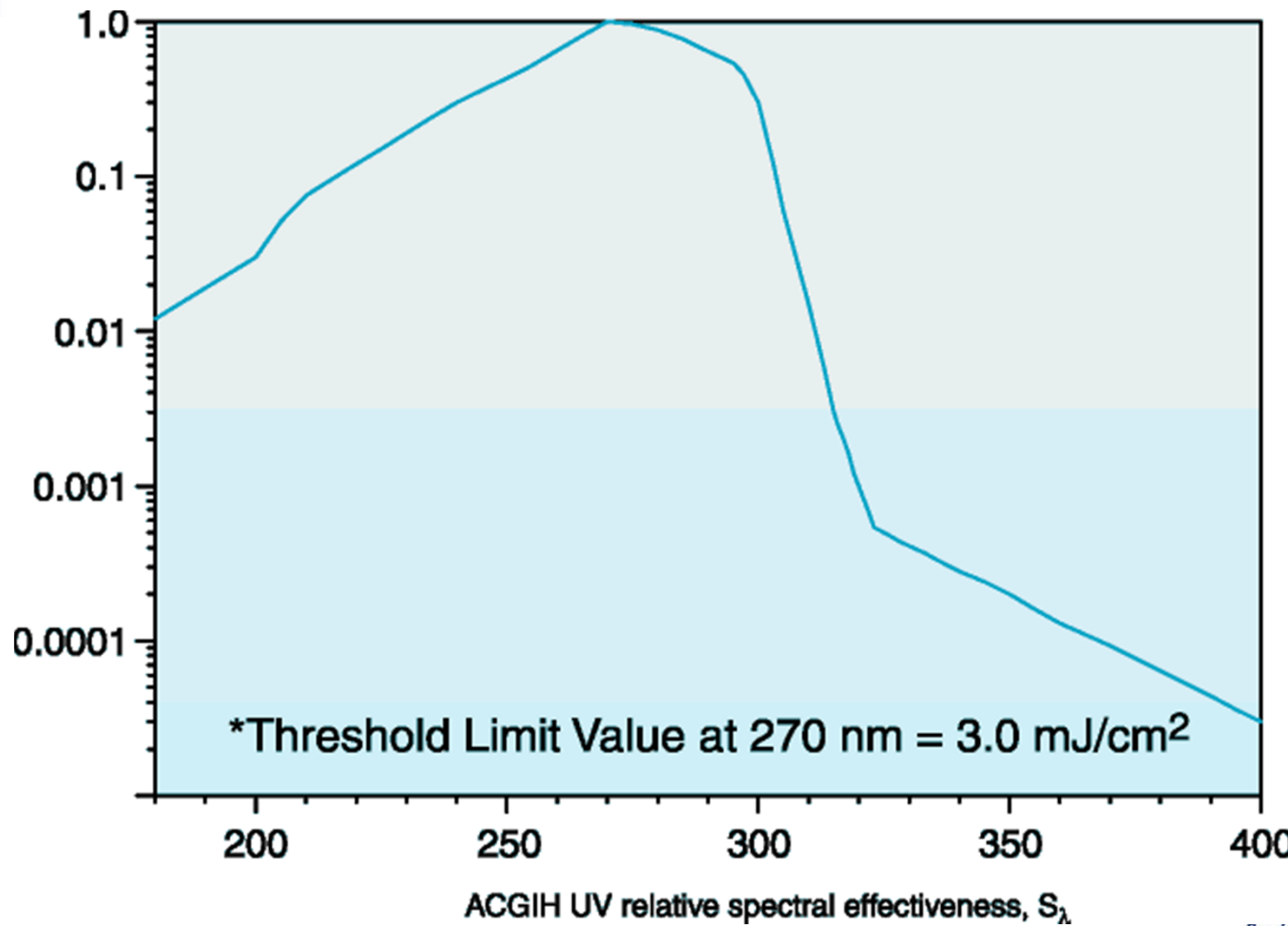
IEC TR 60825-9

IEC TR 60825-9, First Edition, 1999-10

Wavelength (nm)	MPE	Protection
180 – 400 (UVR)	30 J m ⁻² eff (8 h)	Skin (and eye below 315 nm)
315 – 400 (UVA)	104 J m ⁻² (8 h)	Eye
300 – 700	106 J m ⁻² sr ⁻¹ eff (t ≤ 104s)	Blue-light (retina)
300 – 700	100 W m ⁻² sr ⁻¹ eff (t > 104s)	Blue-light (retina)
300 – 700	100 J m ⁻² eff (t ≤ 104 s)	Blue-light (angular subtense α < 11 mrad)
300 – 700	10 ⁻² W m ⁻² eff (t > 104 s)	Blue-light (angular subtense α < 11 mrad)
380 – 1400	<i>50000/at^{1/4} W m⁻² sr⁻¹ eff</i>	Retinal burn (visual stimulus & t < 10s)
380 – 1400	<i>28000/at^{1/4} W m⁻² sr⁻¹ eff</i>	Retinal burn (visual stimulus & t > 10s)

Differences were printed in italics

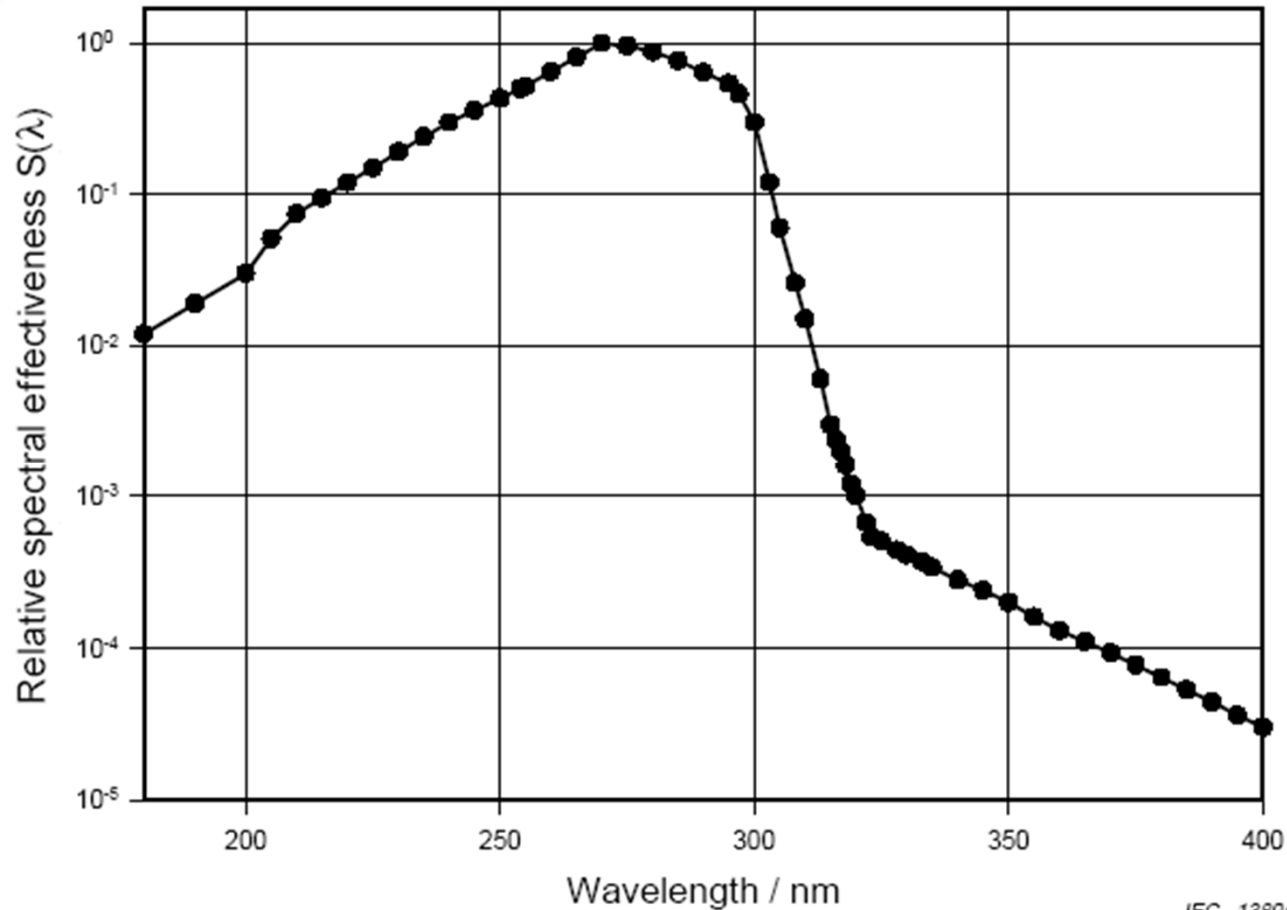
ACGIH Relative Spectral Effectiveness Weighting Function



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IEC TR 60825-9 Relative Spectral Effectiveness



IEC 1380/99



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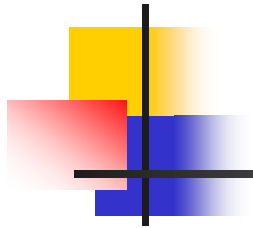
Safety Standards

- **IEC 60950-1:2001 “Information Technology Equipment – Safety – Part 1: General Requirements”**
 - **Clauses 4.3.13 and 4.3.14**
 - **IEC 60825-9 for an 8 h exposure**
- **IEC 60065-1:2001 “Audio, Video and Similar Electronic Apparatus – Safety Requirements”**
 - **Not found**



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MODULE#7

ESTIMATION OF UVR IRRADIANCE

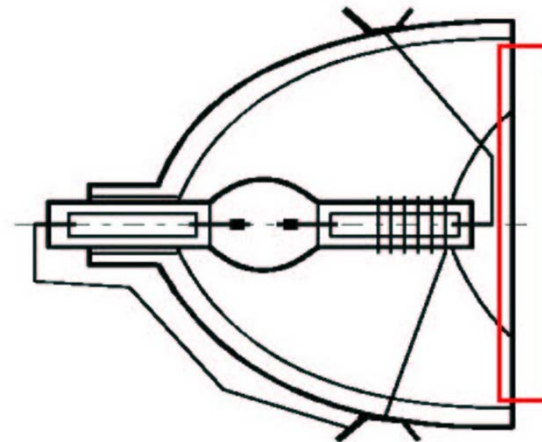


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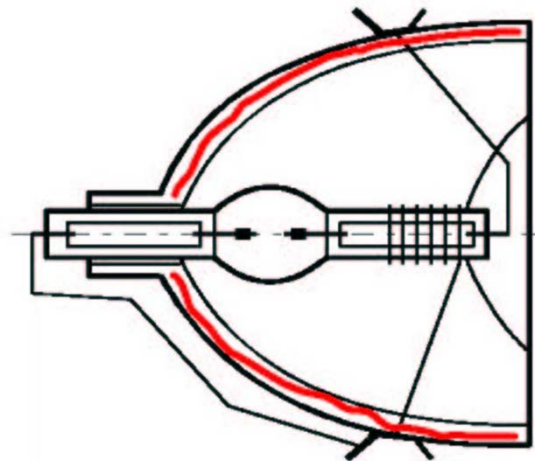
Throughput of Projection Display

- The function of transmission of the optical components
- Typical optical components:
 - UV-IR filter
 - Color wheel
 - Imaging engine
 - Turning mirror
 - Projection screen
 - Distance (air) – inverse square law



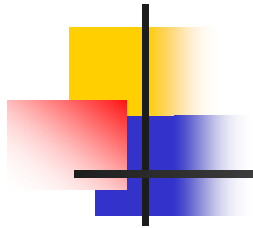
Rear Lamp Reflector

- Varied with specific construction
 - Reflector coating
 - Distance (air)
 - Safeguard if any (e.g. lamp housing)



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MODULE#8

NEW UPDATE FROM TC108 MT2



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Interpretation of IEC TC 108

- **IEC TC 108 MT2 Interpretation Panel issued the interpretation toward IEC60950-1, Ed. 1, 4.3.13 and 4.3.14 (question 49) on April 29, 2005**
- **The opinion –**
 - **only applicable to a device which has predominate radiation emission in UV region (180-400 nm)**



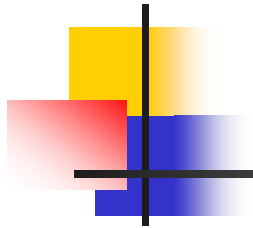
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Interpretation of IEC TC 108

- **With the issuance of this interpretation, projection displays will no longer require to measure UV as it did not emit UV radiation “significantly” or “predominantly” in wavelengths between 180-400 nm.**



MODULE#9

BEFITTING SAFETY ASSESSMENT



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EN 14255-1:2005

- **Measurement and assessment of personal exposures to incoherent optical radiation – Part 1: Ultraviolet radiation emitted by artificial sources in the workplace**
 - **Not apply to which in leisure time**
 - **Not specify the limit values**
 - **National regulations or**
 - **International recommendations**
 - **Not apply to radiation emission products**
 - **IEC/EN 60335-2-27 → Sunbeds**
 - **IEC/EN 60335-2-59 → Insect killers**



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Flowchart of Procedure

a) Preliminary Review – Paper exercise

- Clear statement can be made
 - Steps **b)** through **e)** need not to be applied
- Provision of protective measures if hazardous

b) Work Task Analysis

c) Measurement of UV-exposure



Flowchart of Procedure

Adobe Acrobat
Document

- d) Assessment of UV-exposure**
- e) Decision about Protective Measures**
 - Provision of protective measures if hazardous**
- f) Decision about Repetition**
- g) Preparation of Report → End up**



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The Difficulties

- **To carry out a full set of radiometric hazard assessment would:**
 - **Never be inexpensive**
 - **Considerable equipment,**
 - **Expertise and**
 - **Time**
- **If adequate and precise UVR emission data are available, it may be waived or limited as minimum**



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Matters Needing Attention

- Free of stray light and reflections
- Maximum operating condition
- Hot spot on the accessible surface
- Proviso of inverse square law
 - At least 10 times the largest dimension of the source - Error can be exactly 1%
- Safety interlock system shall evaluate to IEC 60950-1, 2.8 (e.g. inadvertent re-activation, durability)



Important Notions

- **Flowchart of procedure**
- **If the insignificance can be clearly determined, no further action is required**
- **Bring the uncertainty in**
 - **30% in accordance with ENV 13005**



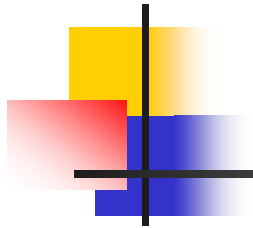
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Important Notions

- **Comparison among methods, e.g.**
 - **Broad-band radiometer + Detector which simulates the weighting function**
 - **Quick, inexpensive and flexible but uncertainty may be large**
 - **Spectroradiometer in the wavelength-range between 180-400 nm**
 - **Relatively accurate but increased cost**



SUMMARY



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Summary

- **Why almost exposure are for workers?**
 - **Employees will still have UVR exposure regardless whether they want to make use of UVR sources or not**
 - **Inescapable**
 - **Users are considered unlikely to give rise to exposure in excess of the limits if they can recognize the danger**
 - **Very helpful in hazard assessment**



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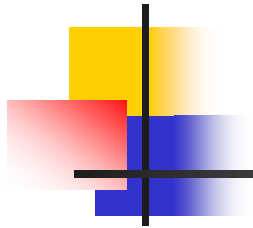
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Summary

- **Why the limits adopt 8 hours exposure for users using information technology equipment? (I don't know)**
 - **American adults spent 4 hours watching TV without enforcement**
 - **Behavioral safeguard, personal avoidance?**
- **Role-playing of the lamp supplier**
 - **Slim the assessment to paper exercise**
 - **Manufacturer's spectroradiometric classification data may greatly simplify it**





**Thanks
for your attendance!**



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