前言

INTRODUCTION

IEC/EN 60825-1

Safety of laser products Part 1:

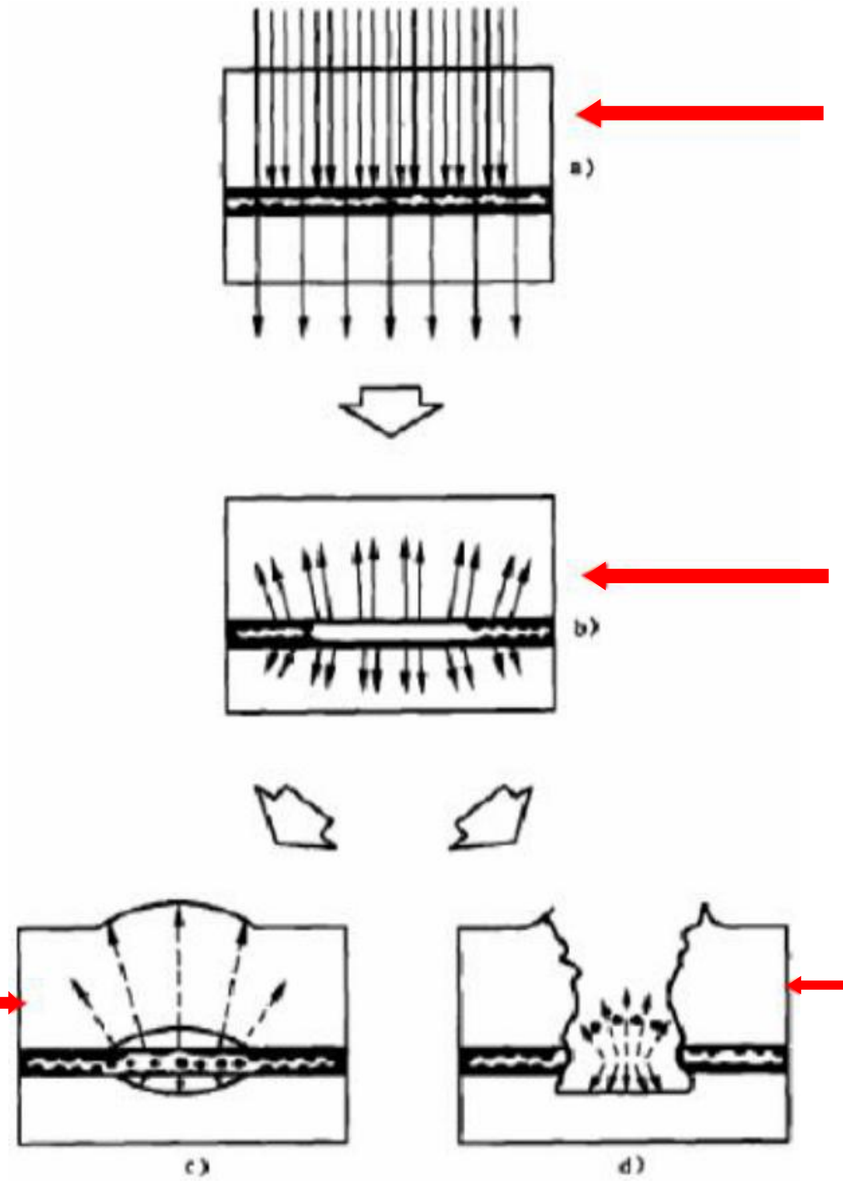
Equipment classification,requirements and user’s guide.

激光产品安全第1部分：设备分类、要求和用户指南。

LED 辐射的危害

- LED的功效不断增大，亮度不断提高，LED发出的光已经足够对人体造成危害。所以必须要关注LED产品在使用过程中的光辐射安全性问题和其它.
- 光源一样，LED的光辐射理论上也能对人体造成危害。
- 伤害主要发生在人的眼睛和皮肤，如皮肤和眼睛的光化学危害、眼睛的近紫外危害、视网膜蓝光光化学危害、视网膜无晶状体光化学危害、视网膜热危害和皮肤热危害等，而两者之中更容易受到伤害的是眼睛。
- 此外，LED也能引起眩光危害。眩光就是在视野中由于亮度的分布或范围不适宜，或在空间或时间上存在着极端的亮度对比，以至引起不舒适和降低物体可见度的视觉条件。

激光辐射对生物组织损伤示意图



组织吸收阿激光能量

长脉冲或连续激光导致的热界面的扩大使损伤区域逐渐扩大

短脉冲高峰值功率激光导致细胞崩解,组织爆裂的损伤

各标准对激光器(以及LED)的要求

1. EN 62115:2005 Annex E(normative) Toys Incorporating lasers and light-emitting diodes

- Lasers and light-emitting diodes in toys shall meet the requirements for Class 1 lasers in accordance with IEC60825-1.
- NOTE 101: Class 1 lasers do not include Class 1M lasers.

2. IEC/EN60065 Audio/Video Apparatus

正常工作不超过1类激光发射极限，异常工作400nm--700nm波长范围外不得大于3R类发射极限，在400nm--700nm波长范围内不得超过1类限值的5倍发射极限。

3. IEC/EN60950-1 Information Technology Equipment

当没有激光警告标志或标语时,激光或者LED部件的发射极限不能超过1类发射极限。

4. CTL 297/05 决议对于使用LED 作为光源的照明设备有明确的要求，LED 应符合IEC/EN 60825－1 标准中1 类或1M类产品的要求。

……

面对诸多要求，我们如何应对？？？

● 解决方案

■ 为了节约昂贵的检测费用，EBO 决议给出了三种处理方法：

1. 如果光强很低，例如用作显示或信号的常用LED，绝大部分符合IEC/EN60825-1的1 类的要求，因此没有必要进行检测。在判断时，盖子、光学和类似部件应用手拿掉。在报告中应指出光强经过判断符合IEC/EN60825-1 标准中1 类激光的要求，没有检测。

2. 在其它情况下，照明设备制造商应被要求提供一个基于相关试验的声明（例如从LED 制造商处），以表明LED模块的辐射没有超过IEC/EN60825-1 标准中1 类或带或不带光学器件时1M 类的要求。在报告中应注明判断是根据制造商的声明。

3. 如果不能提供声明或者我们不能肯定如何判断，则应根据IEC/EN60825-1 标准进行检测。

■ 对于生产LED 照明设备的厂家来讲，根据这个EBO 决议可以有三种方法进行LED 照明设备的检测。

第一是声明，第二是根据LED生产厂的报告或检测结果进行声明，第三是送到权威的第三方实验室进行辐射安全性的检测。

如果所用的LED 不属于属于1 类或1M 类，则应按照激光器处理，需要符合相关的激光产品的安全要求了。

面对诸多要求，我们如何应对？？？

- 由于激光光束的波长、能量容量和脉冲特性有一个很宽的范围，因此增加了它广泛使用中出现的危险，所以不可能将激光产品划分为一个简单的类别来应用普通安全要求。

  IEC/EN 60825-1 标准中激光产品分类为：1类、1M类、2类、2M类、3R类、3B类、4类。由于涉及照明用的LED的产品只与1类和1M类有关，下面将对1类和1M类的定义及相关问题进行介绍。

IEC/EN 60825-1 标准中的定义如下：

1类激光产品

在相应波长和发射持续时间内，人员接近激光辐射不允许超过1 类可达发射限值的激光产品。

1M类激光产品

在相应波长范围内的激光产品。在相应波长和发射持续时间内人员接近激光辐射不允许1类可达发射限值，辐射水平根据9.2g测量，但采用比1类激光产品更小的光阑或距离表观光源更远的距离进行测量。

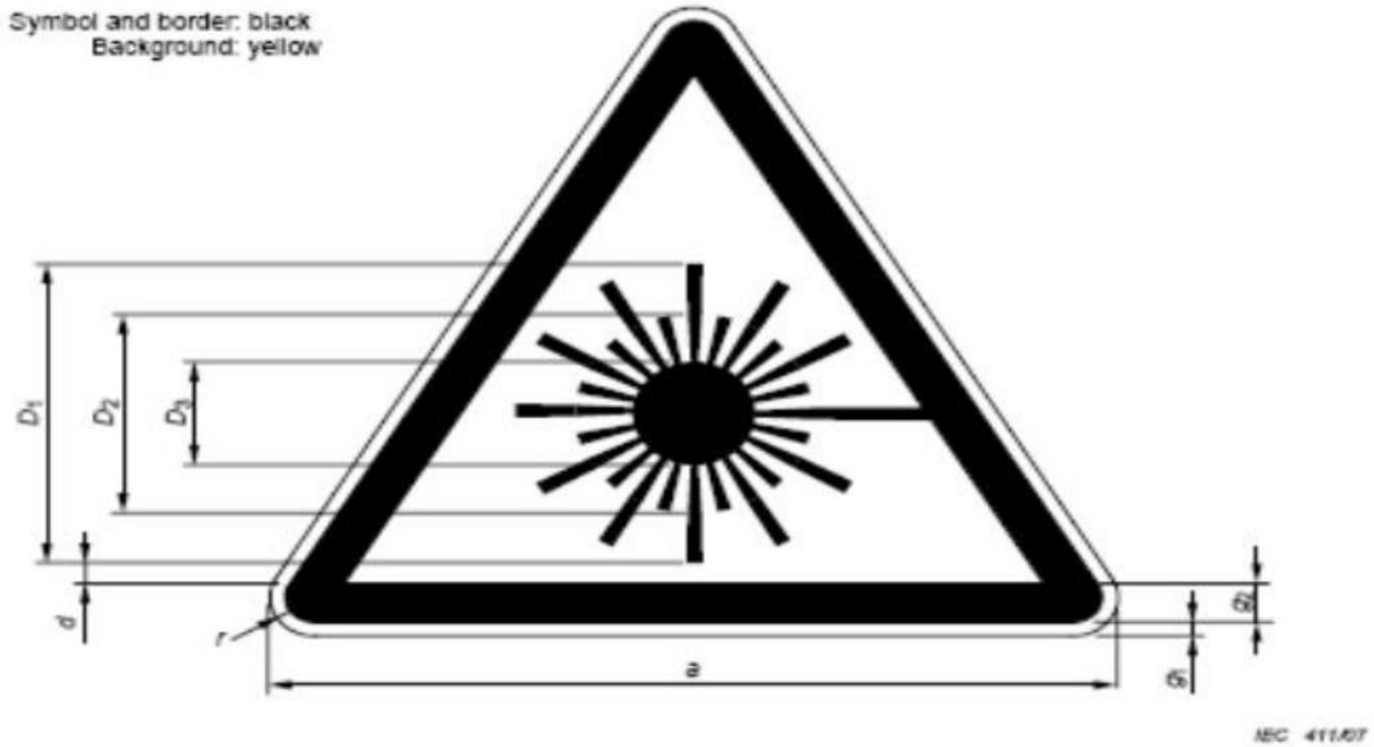
面对诸多要求，我们如何应对？？？

- 不同的激光等级需要的不同标注与警告语

Explanatory label

Warning label

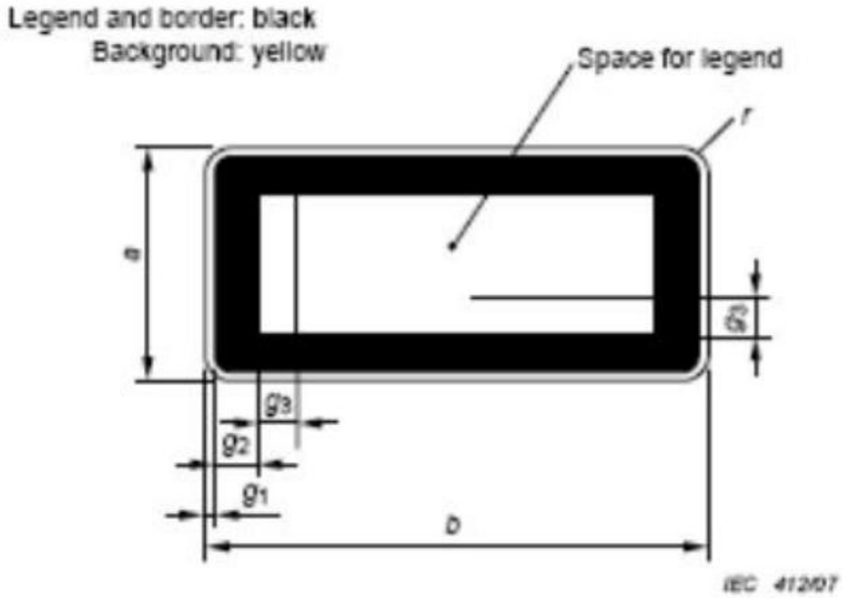
面对诸多要求，我们如何应对？？？



Dimensions in millimetres

a	g_1	g_2	r	D_1	D_2	D_3	d
25	0,5	1,5	1,25	10,5	7	3,5	0,5
50	1	3	2,5	21	14	7	1
100	2	6	5	42	28	14	2
150	3	9	7,5	63	42	21	3
200	4	12	10	84	56	28	4
400	8	24	20	168	112	56	8
600	12	36	30	252	168	84	12

The dimensions D_1, D_2, D_3, g_1 and d are recommended values.



Dimensions in millimetres

a × b	g_1	g_2	g_3	r	Minimum height of lettering
26 × 52	1	4	4	2	Lettering shall be of a size which renders it legible
52 × 105	1,6	5	5	3,2	
84 × 148	2	6	7,5	4	
100 × 250	2,5	8	12,5	5	
140 × 200	2,5	10	10	5	
140 × 250	2,5	10	12,5	5	
140 × 400	3	10	20	6	
200 × 250	3	12	12,5	6	
200 × 400	3	12	20	6	
250 × 400	4	15	25	8	
The dimension g_1 is recommended.					

面对诸多要求，我们如何应对？？？

警示语

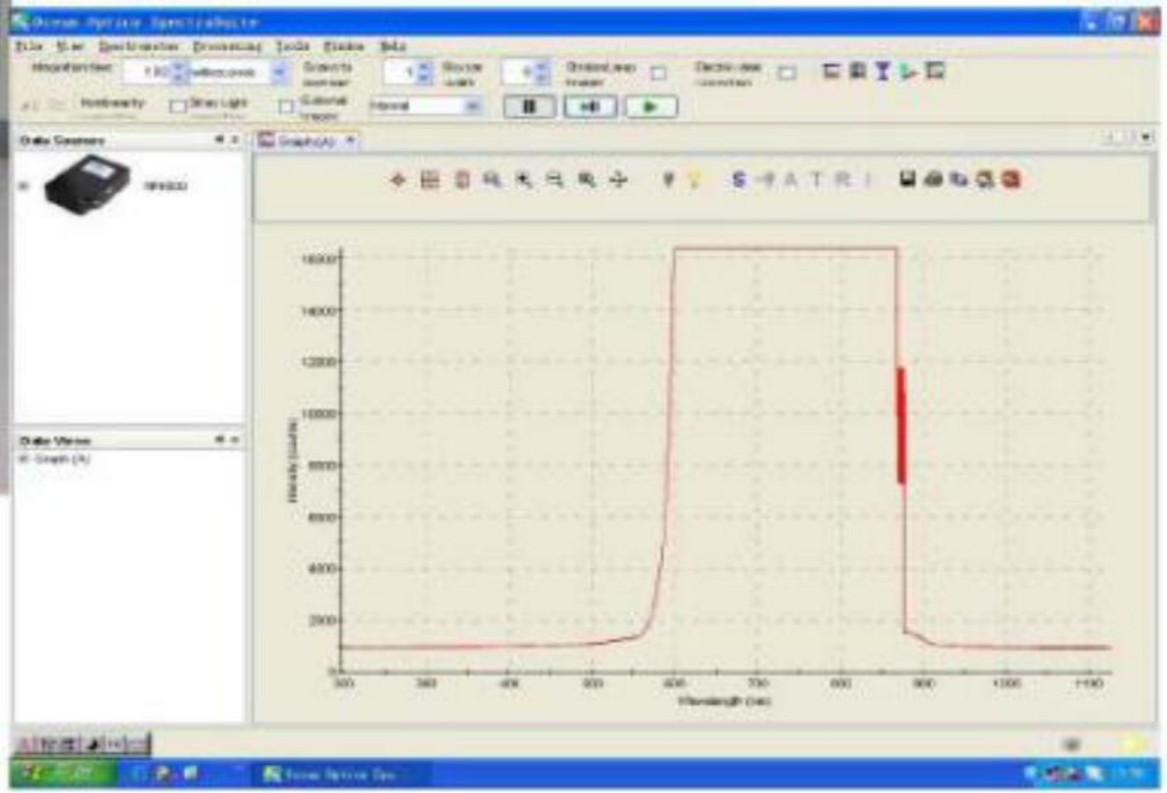
1类	CLASS 1 LED PRODUCT.
1M类	LASER RADIATION DO NOT VIEW DIRECTLY WITH OPTICAL INSTRUMENTS CLASS 1M LED PRODUCT .
2类	LASER RADIATION DO NOT STARE INTO BEAM CLASS 2 LED PRODUCT.
2M	LASER RADIATION DO NOT STARE INTO THE BEAM OR VIEW DIRECTLY WITH OPTICAL INSTRUMENTS CLASS 2M LED PRODUCT.
3R	LASER RADIATION AVOID DIRECT EYE EXPOSURE (400nm to 1400nm) (AVOID EXPOSURE TO BEAM) (other) CLASS 3R LED PRODUCT.
3B	LASER RADIATION AVOID EXPOSURE TO BEAM CLASS 3B LED PRODUCT.
4类	LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION CLASS 4 LED PRODUCT

另外：除**1**类和**1M**类外,其它的**LED**产品上都有警告标志，如图：

EBO 亿博检测

测试所需要用到的仪器

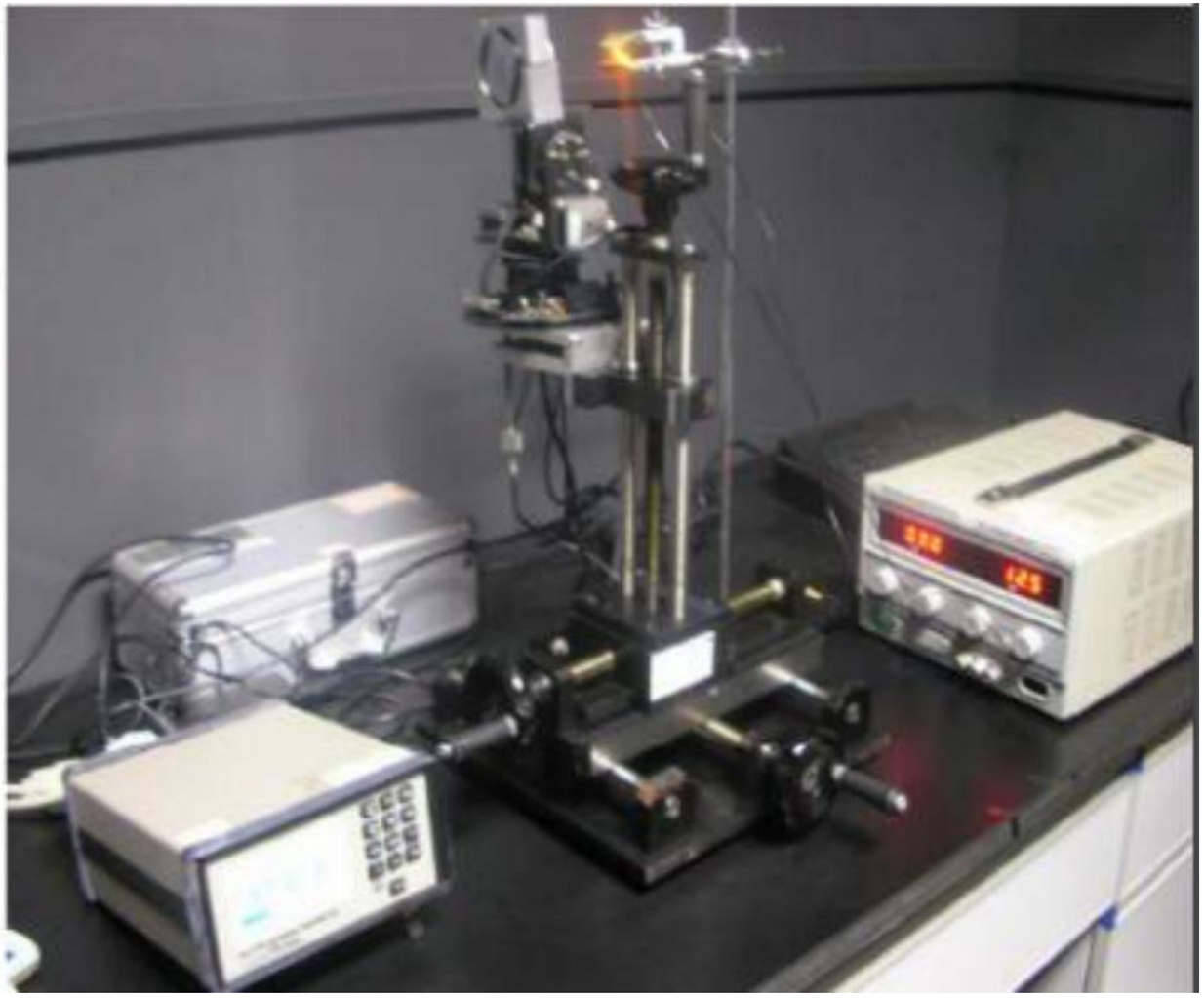
Wavelength meter



Wavelength sample

EBO 亿博检测

测试所需要用到的仪器



IEC/EN 60825-1是什么标准？

目的

- 为了保护人员免受波长范围为180 nm-1 mm激光辐射的伤害，提出激光辐射的安全工作水平并引人按照激光器和激光产品危害程度的分类体系。
- 为用户和制造厂商建立工作程序制订要求并为其提供信息，以便采取适当的预防措施。
- 通过标签、标记和说明确保能够替告与激光产品的可达辐射有关的各种危害。
- 为减小损伤的可能性，使不必要的可达辐射减至最小，并且通过保护措施改进激光辐射危害的控制，通过规定用户控制措施提供激光产品的安全使用。
- 保护人员免受来自操作和使用激光产品造成的其他危害。

EN 60825-1标准的版本号

- **EN 60825-1:1994+A11:1996+A2:2001+ A1 2002**

  -(dop) 2003-07-01　　-(dow) 2004-01-01

- **EN 60825-1:1994+A11:1996+A2:2001+ A1 2002**

  -(dop) 2008-06-01　　-(dow) 2010-09-01

- **EN 60825-1:1994+A11:1996+A2:2001+ A1 2002**

  - (dop) 2008-09-01　　-(dow) ？？？

如何给LED评定等级？

测试流程

参数 → 计算 → 测量 → 计算Q_{AEL}限值 → 分级

测量前参数的确定

- 波长**Wavelength (λ)**

  Thermal Hazard (for allλ)

- 光源直径**Source Diameter (d)**

  Calculate α Measuring distance L

- **EN 60825-1:1994+A11:1996+A2:2001+ A1 2002**

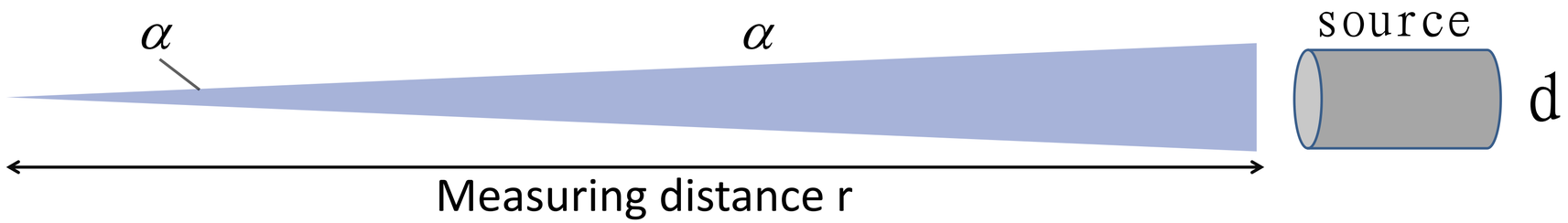
  -0.25s for Class 2, Class 2M and Class 3R & 400nm <λ< 700nm

  -30 000s for λ≤400nm or long-term viewing needed with λ> 400nm

  -100sfor all other cases withλ> 400nm

如何给LED评定等级？

如何计算对向角α



$$\alpha = \tan^{-1}\left(\frac{d}{100}\right)$$

测试距离确定（光源到测量孔径）

- **Thermal Hazard**

  -Distance：$r = 100\sqrt{\frac{\alpha+0,46}{\alpha+max}}$

- **Photochemical Hazard**

  - Distance：$r = 14+86\,\frac{\alpha\text{-}1,5mrad}{\gamma\rho\text{-}1.5mrad}$

Details refer to table 10 of IEC60825-1:1993+A1:1997+A2:2001

如何给LED评定等级？

[a] For the photochemical limits and $t \leq 100$ s, r is given by

r = 14 mm for $\alpha \leq 1{,}5$ mrad

r = 100 mm (α/11 mrad) for 1,5 mrad < $\alpha \leq$ 11 mrad

r = 100 mm for $\alpha >$ 11 mrad

(for the test for Class 1M and 2M, refer to 9.2g) and h))

For the photochemical limits and $t > 100$ s, r is given by (for the definition of γ_p refer to 9.3c).

r = 14 mm for $\alpha \leq 1{,}5$ mrad

$$r = \left(14 + 86\,\frac{\alpha - 1{,}5\ \text{mrad}}{\gamma_p - 1{,}5\ \text{mrad}}\right)\text{mm} \qquad \text{for } 1{,}5\ \text{mrad} < \alpha \leq \gamma_p$$

r = 100 mm for $\alpha > \gamma_p$

(for the test for Class 1M and 2M, refer to 9.2g) and h))

For the thermal limits, r is given by

$$r = (100\ \text{mm})\sqrt{\frac{\alpha + 0{,}46\ \text{mrad}}{\alpha_{max}}}$$ if $\alpha < \alpha_{min}$, r = 14 mm. If $\alpha \geq \alpha_{max}$, r = 100 mm

(for the test for Class 1M and 2M, refer to 9.2g) and h)).

[b] In the wavelength range of 400 nm to 4 000 nm, these values are also applicable for the measurement of power or energy for Class 1M and Class 2M (see 9.2g) and h)).

测量

- Record the reading of the Laser power meter
- Compare the QAEL with the measured power output

如何确定限值QAEL?

Exposure time t in s / Wavelength λ in nm	10^{-13} to 10^{-11}	10^{-11} to 10^{-9}	10^{-9} to 10^{-7}	10^{-7} to $1{,}8 \times 10^{-5}$	$1{,}8 \times 10^{-5}$ to 5×10^{-5}	5×10^{-5} to 1×10^{-3}	1×10^{-3} to 0,35	0,35 to 10	10 to 10^{2}	10^{2} to 10^{3}	10^{3} to 10^{4}	10^{4} to 3×10^{4}
180 to 302,5	3×10^{10} W·m^{-2}		30 J·m^{-2}									
302,5 to 315	$2{,}4 \times 10^{4}$ W		($t \le T_1$) $7{,}9 \times 10^{-7} C_1$ J					$7{,}9 \times 10^{-7} C_2$ J ($t > T_1$)	$7{,}9 \times 10^{-7} C_2$ J			
315 to 400			$7{,}9 \times 10^{-7} C_1$ J						$7{,}9 \times 10^{-3}$ J		$7{,}9 \times 10^{-6}$ W	
400 to 700[d]	$5{,}8 \times 10^{-9} C_5$ J	$1{,}8\, t^{0,75} C_5$ J	$2 \times 10^{-7} C_6$ J		$7 \times 10^{-4}\, t^{0,75} C_5$ J			400 to 600 nm[d]	Retinal photochemical hazard: $3{,}9 \times 10^{-3} C_3$ J using $\gamma_p = 11$ mrad	Retinal photochemical hazard: $3{,}9 \times 10^{-6} C_3$ W using $\gamma_p = 1{,}1\, t^{0,5}$ mrad	Retinal photochemical hazard: $3{,}9 \times 10^{-6} C_3$ W using $\gamma_p = 110$ mrad	
									AND[d]			
								400 to 700 nm[d]	Retinal thermal hazard: $\alpha \le 1{,}5$ mrad: $3{,}9 \times 10^{-4}$ W; $\alpha > 1{,}5$ mrad: $7 \times 10^{-4} C_6 T_2^{-0,25}$ W; ($t \le T_2$) $7 \times 10^{-4}\, t^{0,75} C_6$ J; ($t > T_2$)			
700 to 1 050	$5{,}8 \times 10^{-9} C_4 C_5$ J	$1{,}8\, t^{0,75} C_4 C_5$ J	$2 \times 10^{-7} C_4 C_5$ J		$7 \times 10^{-4}\, t^{0,75} C_4 C_5$ J				$\alpha \le 1{,}5$ mrad: $3{,}9 \times 10^{-4} C_4 C_7$ W; $\alpha \ge 1{,}5$ mrad: $7 \times 10^{-4} C_4 C_5 C_7 T_2^{-0,25}$ W; ($t \le T_2$) $7 \times 10^{-4}\, t^{0,75} C_4 C_5 C_7$ J; ($t > T_2$)			
1 050 to 1 400	$5{,}8 \times 10^{-8} C_5 C_7$ J	$10{,}4\, t^{0,75} C_5 C_7$ J	$2 \times 10^{-6} C_5 C_7$ J			$3{,}6 \times 10^{-3}\, t^{0,75} C_5 C_7$ J						
1 400 to 1 500	8×10^{5} W		8×10^{-4} J			$4{,}4 \times 10^{-3}\, t^{0,25}$ J		$10^{-2}\, t$ J				
1 500 to 1 800	8×10^{5} W		8×10^{-4} J					$1{,}8 \times 10^{-2}\, t^{0,75}$ J	$1{,}0 \times 10^{-3}$ W			
1 800 to 2 600	8×10^{5} W		8×10^{-4} J			$4{,}4 \times 10^{-3}\, t^{0,25}$ J		$10^{-2}\, t$ J				
2 600 to 4 000	8×10^{4} W		8×10^{-5} J		$4{,}4 \times 10^{-3}\, t^{0,25}$ J							
4 000 to 10^{6}	10^{11} W·m^{-2}		100 J·m^{-2}		$5\,600\, t^{0,25}$ J·m^{-2}				1 000 W·m^{-2}			

[a] For correction factors and units, see "Notes to tables 1 to 4".

[b] The AELs for emission durations less than 10^{-13} s are set to be equal to the equivalent power or irradiance values of the AEL at 10^{-13} s.

[c] The angle γ_p is the limiting angle of acceptance for the measuring instrument.

[d] In the wavelength range between 400 nm and 600 nm, dual limits apply and a product's emission must not exceed either limit applicable to the class assigned. If exposure times between 1 s and 10 s are used, for wavelengths between 400 nm and 404 nm and for apparent source sizes between 1,5 mrad and 82 mrad, the dual photochemical hazard limit of $3{,}9 \times 10^{-3} C_3$ J is extended to 1 s.

如何确定限值QAEL?

Table 2 – Accessible emission limits for Class 2 and Class 2M laser products

Wavelength λ nm	Emission duration *t* s	Class 2 AEL
400 to 700	$t < 0{,}25$ $t \geq 0{,}25$	Same as Class 1 AEL $C_6 \times 10^{-3}$ W *
* For correction factor and units see "Notes to tables 1 to 4".		

Table 3 – Accessible emission limits for Class 3R laser products [a, b]

Wavelength λ in nm \ Exposure time *t* in s	10^{-13} to 10^{-11}	10^{-11} to 10^{-9}	10^{-9} to 10^{-7}	10^{-7} to $1{,}8 \times 10^{-5}$	$1{,}8 \times 10^{-5}$ to 6×10^{-5}	5×10^{-5} to 1×10^{-3}	1×10^{-3} to 0,35	0,35 to 10	10 to 10^3	10^3 to 3×10^4
180 to 302,5	Not appropriate		Not appropriate							
302,5 to 315	$1{,}2 \times 10^5$ W		$t \leq T_1$: $4 \times 10^{-6} C_1$ J; $t > T_1$: $4{,}0 \times 10^{-6} C_2$ J						$4{,}0 \times 10^{-6} C_2$ J	
315 to 400			$4{,}0 \times 10^{-6} C_1$ J						$4{,}0 \times 10^{-2}$ J	$4{,}0 \times 10^{-6}$ W
400 to 700	$2{,}9 \times 10^{-8} C_6$ J	$5{,}0\, t^{0,75} C_6$ J	$1 \times 10^{-6} C_6$ J	$t < 0{,}25$ s: $3{,}5 \times 10^{-3}\, t^{0,75} C_6$ J; $t \geq 0{,}25$ s: $5{,}0 \times 10^{-3} C_6$ W				$5{,}0 \times 10^{-3} C_6$ W	$5{,}0 \times 10^{-3} C_6$ W	
700 to 1 050	$2{,}9 \times 10^{-8} C_4 C_6$ J	$5{,}0\, t^{0,75} C_4 C_6$ J	$1 \times 10^{-6} C_4 C_6$ J	$3{,}5 \times 10^{-3}\, t^{0,75} C_4 C_6$ J					$\alpha \leq 1{,}5$ mrad: $2{,}0 \times 10^{-3} C_4 C_7$ W $\alpha > 1{,}5$ mrad: $3{,}5 \times 10^{-3} C_4 C_6 C_7 T_2^{-0,25}$ W $t \leq T_2$: $3{,}5 \times 10^{-3}\, t^{0,75} C_4 C_6 C_7$ J; $t > T_2$	
1 050 to 1 400	$2{,}9 \times 10^{-7} C_6 C_7$ J	$52\, t^{0,75} C_6 C_7$ J	$1 \times 10^{-5} C_6 C_7$ J		$1{,}8 \times 10^{-2}\, t^{0,75} C_6 C_7$ J					
1 400 to 1 500	4×10^6 W		4×10^{-3} J			$2{,}2 \times 10^{-2}\, t^{0,25}$ J	$5 \times 10^{-2}\, t$ J		$5{,}0 \times 10^{-2}$ W	
1 500 to 1 800	4×10^7 W		4×10^{-2} J				$9 \times 10^{-2}\, t^{0,75}$ J			
1 800 to 2 600	4×10^6 W		4×10^{-3} J			$2{,}2 \times 10^{-2}\, t^{0,25}$ J	$5 \times 10^{-2}\, t$ J			
2 600 to 4 000	4×10^5 W		4×10^{-4} J	$2{,}2 \times 10^{-2}\, t^{0,25}$ J						
4 000 to 10^6	5×10^{11} W·m^{-2}		500 J·m^{-2}	$2{,}8 \times 10^4\, t^{0,25}$ J·m^{-2}					5 000 W·m^{-2}	

[a] For correction factors and units, see "notes to tables 1 to 4".

[b] The AELs for emission durations less than 10^{-13} s are set to be equal to the equivalent power or irradiance values of the AEL at 10^{-13} s.

如何确定限值QAEL?

Table 4 – Accessible emission limits for Class 3B laser products

Emission duration t s / Wavelength λ nm	$<10^{-9}$	10^{-9} to 0,25	0,25 to 3×10^{4}
180 to 302,5	$3{,}8 \times 10^{5}$ W	$3{,}8 \times 10^{-4}$ J	$1{,}5 \times 10^{-3}$ W
302,5 to 315	$1{,}25 \times 10^{4}\ C_2$ W	$1{,}25 \times 10^{-5}\ C_2$ J	$5 \times 10^{-5}\ C_2$ W
315 to 400	$1{,}25 \times 10^{8}$ W	0,125 J	0,5 W
400 to 700	3×10^{7} W	0,03 J for $t <$ 0,06 s 0,5 W for $t \geq$ 0,06 s	0,5 W
700 to 1 050	$3 \times 10^{7}\ C_4$ W	0,03 C_4 J for $t < 0{,}06\ C_4$ s 0,5 W for $t \geq 0{,}06\ C_4$ s	0,5 W
1 050 to 1 400	$1{,}5 \times 10^{8}$ W	0,15 J	0,5 W
1 400 to 10^{6}	$1{,}25 \times 10^{9}$ W	0,125 J	0,5 W
For correction factors and units, see "Notes to tables 1 to 4".			

如何确定限值QAEL?

Parameter	Spectral region nm	Figures
$C_1 = 5{,}6 \times 10^3\ t^{0{,}25}$	302,5 to 400	1
$T_1 = 10^{0{,}8(\lambda\ -295)} \times 10^{-15}$ s	302,5 to 315	2
$C_2 = 10^{0{,}2(\lambda\ -295)}$	302,5 to 315	3
$T_2 = 10 \times 10^{[(\alpha\ -\alpha min)/98{,}5]}$ s[a]	400 to 1 400	4
$C_3 = 1{,}0$	400 to 450	5
$C_3 = 10^{0{,}02(\lambda\ -450)}$	450 to 600	5
$C_4 = 10^{0{,}002(\lambda\ -700)}$	700 to 1 050	6
$C_4 = 5$	1 050 to 1 400	6
$C_5 = N^{-1/4}$ [b]	400 to 10^6	7
$C_6 = 1$ for $\alpha \leq \alpha_{min}$	400 to 1 400	c
$C_6 = \alpha/\alpha_{min}$ for $\alpha_{min} < \alpha \leq \alpha_{max}$	400 to 1 400	c
$C_6 = \alpha_{max}/\alpha_{min} = 66{,}7$ for $\alpha > \alpha_{max}$[d]	400 to 1 400	c
$C_7 = 1$	700 to 1 150	8
$C_7 = 10^{0{,}018(\lambda\ -1150)}$	1 150 to 1 200	8
$C_7 = 8$	1 200 to 1 400	8

a $T_2 = 10$ s for $\alpha < 1{,}5$ mrad and $T_2 = 100$ s for $\alpha > 100$ mrad

b C_5 is only applicable to pulse durations shorter than 0,25 s

c C_6 is only applicable to pulsed lasers and to CW lasers where thermal injury dominates (see table 1)

d The limiting angle of acceptance γ shall be equal to α_{max}

$\alpha_{min} = 1{,}5$ mrad

$\alpha_{max} = 100$ mrad

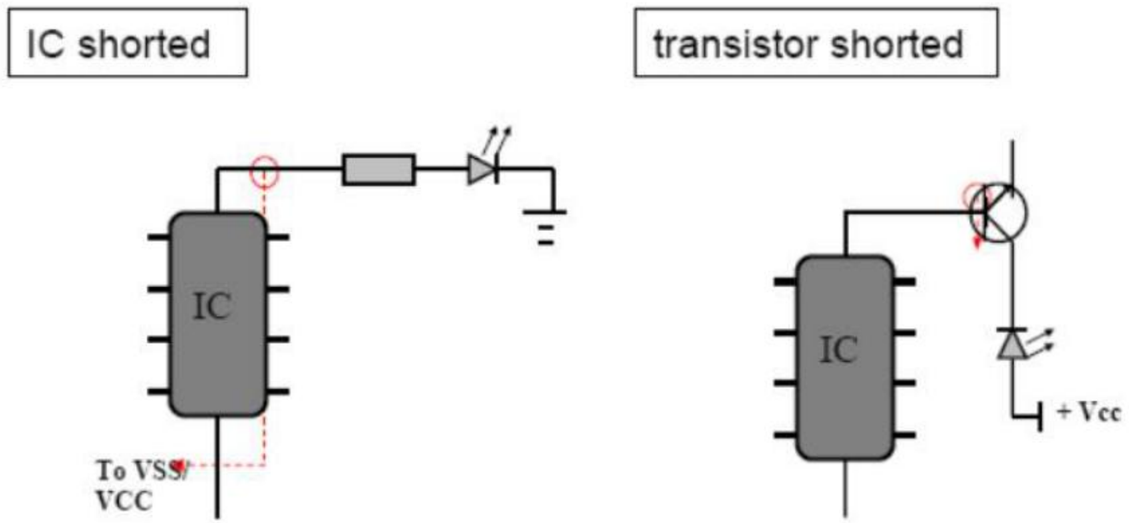
N is the number of pulses contained within the applicable duration (see 8.4f) and 13.3)

如何给LED评定等级？

测试条件

- Normal condition (LED with cover)
- LED without cover
- Fault condition (IC, transistor s/c, resistanceo/c)
- Fault condition without cover

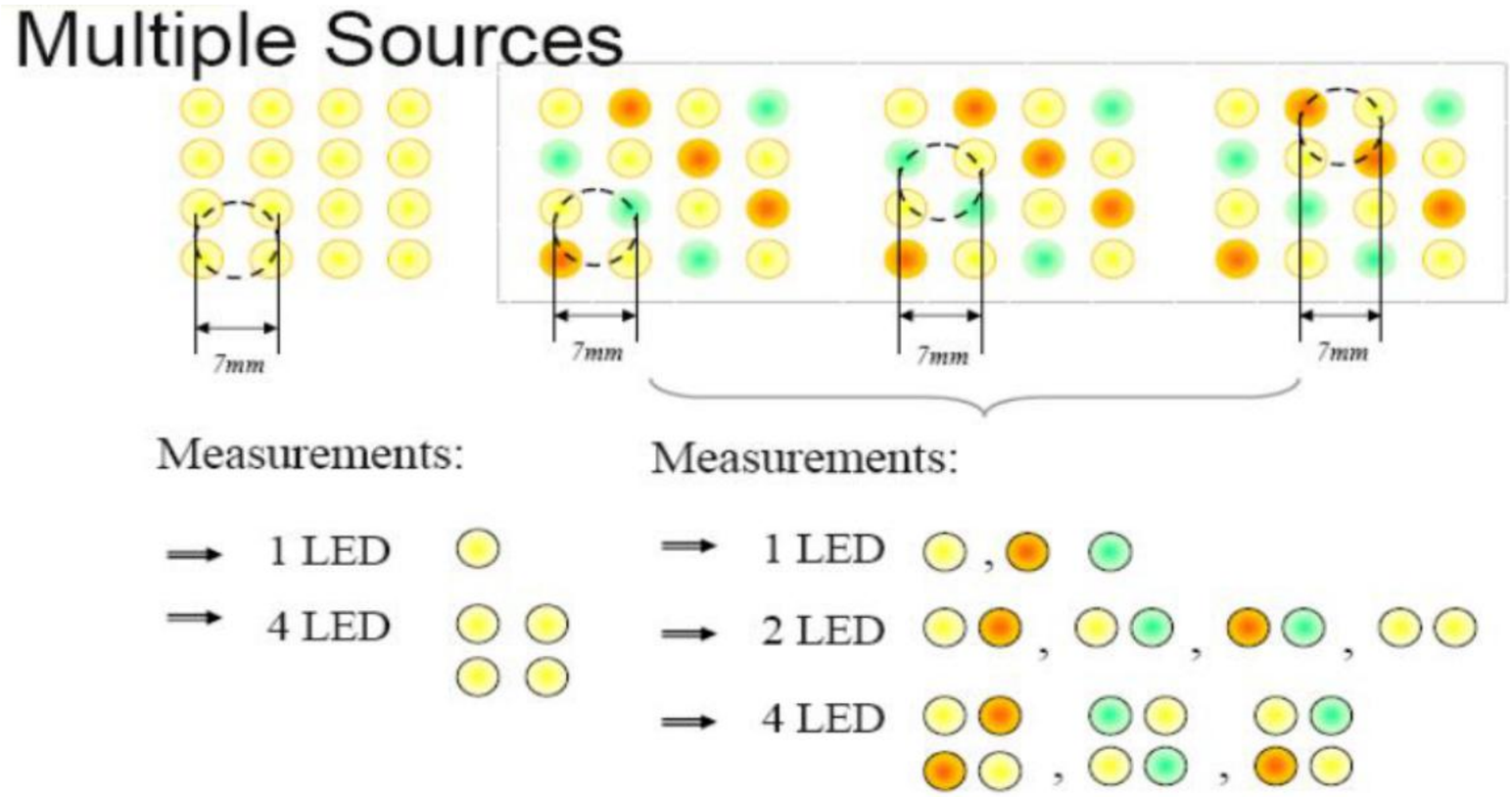
Fault test point



如何给LED评定等级？

Multiple Sources

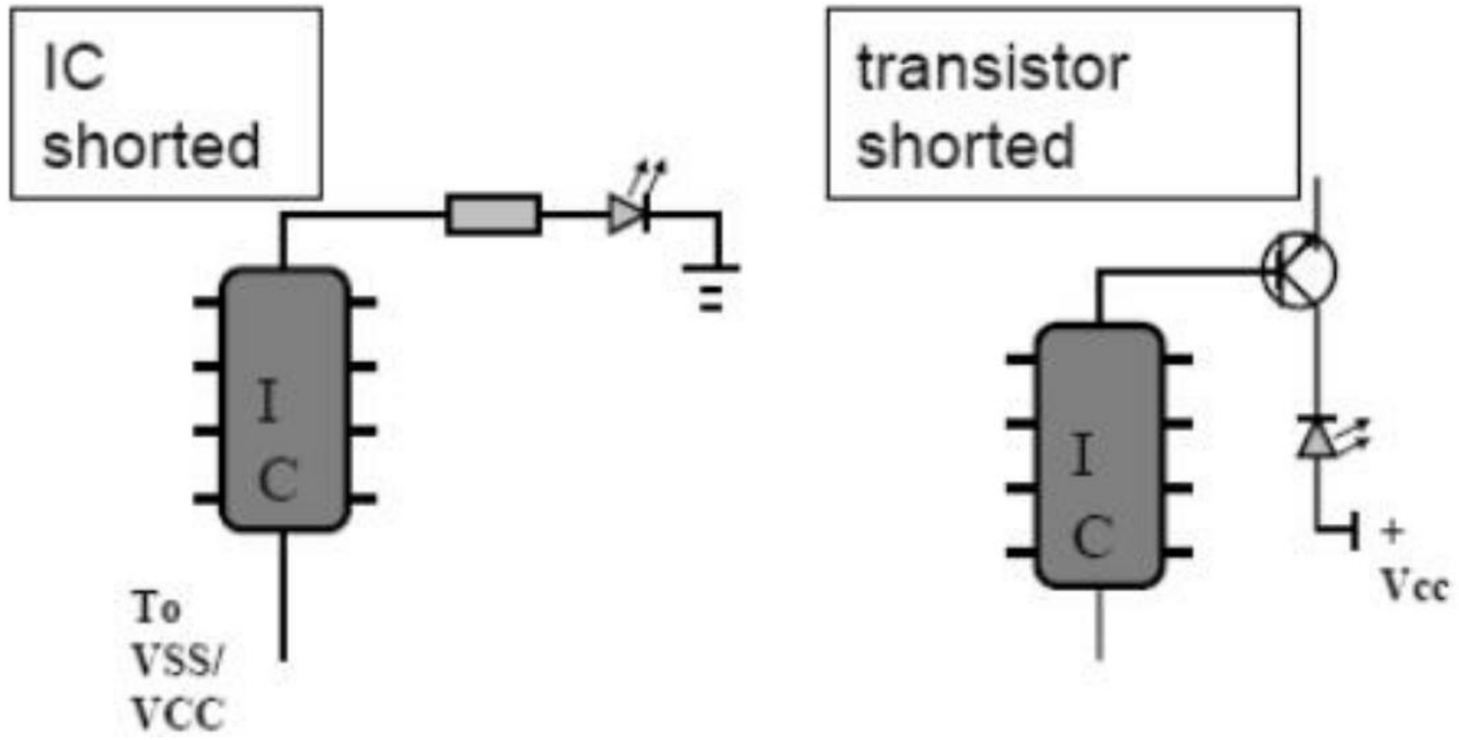
- Perform the measurement within the area of 7mm circular boundary
- Find the power of all possible source combination
- Aim at finding the maximum power that the product can emit



如何给LED评定等级？

测试结果超过了限值怎么办？

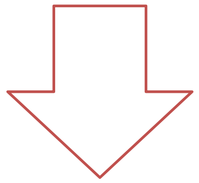
- 正常
- 异常



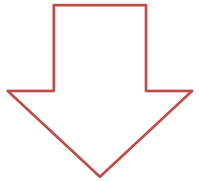
案例分析

White LED: λ =500 nm; rating: 3.0V, 20 mA;LED Diameter: 5 mm;

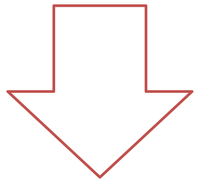
■ $\alpha = \tan^{-1}\left[\frac{D}{L}\right] = 5 \div 100 \times 1000 = 50$ mrad



■ Distance : $r = 100\sqrt{\frac{\alpha + 0{,}46}{\alpha \max}} = 71$mm



■ Measured Thermal Hazard Power: $Q=188.1X10^{-6}W$



案例分析

■ 将测量值与标准限值进行比对

1类LED: $Q_{ALE(1)} = 7X10^{-4} C_6 T_2^{-0.25}$ W

$$C6 = \frac{a}{a\ \min} \approx 33.3$$

$T2 = 10X10^{[(a-a\ min)/98.5]}$ S≈31.07 s

■ 得：$Q_{ALE(1)} = 98.7X10^{-4}$ W

$Q < Q_{ALE(1)}$

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