

電源供應器 -

安全規範與要求

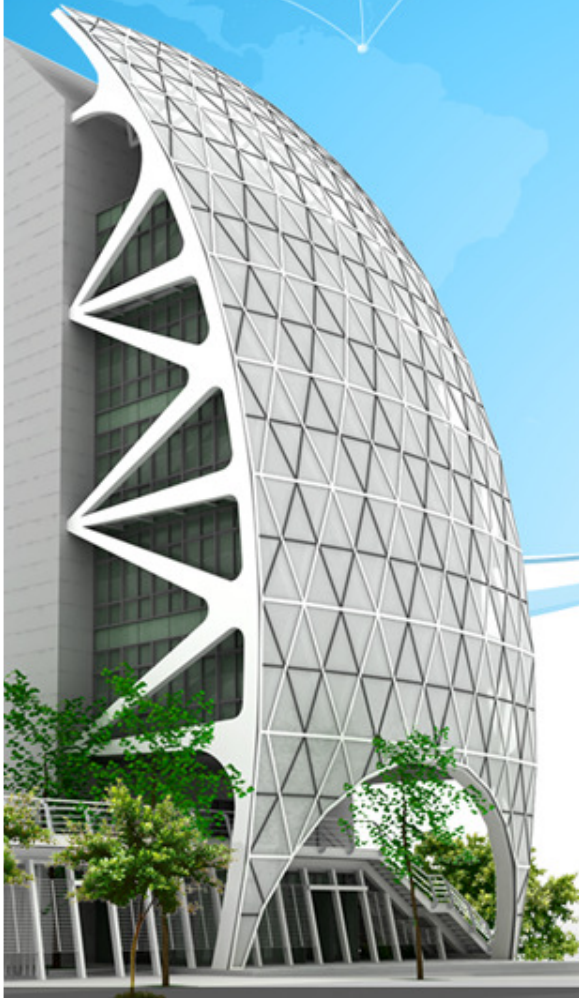
臺
灣
科
大

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2018-4-23

TAIWAN TECH

National Taiwan University of Science and Technology



簡歷



2015~ 專案經理(台灣德國萊茵)

2005~2015 資深工程師 (UL Taiwan)



專長:

- 電子電氣設備安全規範驗證
- 電子電氣設備能源效率法規驗證
- ISO/IEC 17025 實驗室品質與技術管理系統驗證

資格:

- 技術發證官 (Technical Certifier) - 電子設備安全規範
- 審核者(Reviewer) - 電子電氣設備能源效率法規
- TAF認可之稽核員 (ISO/IEC 17025)

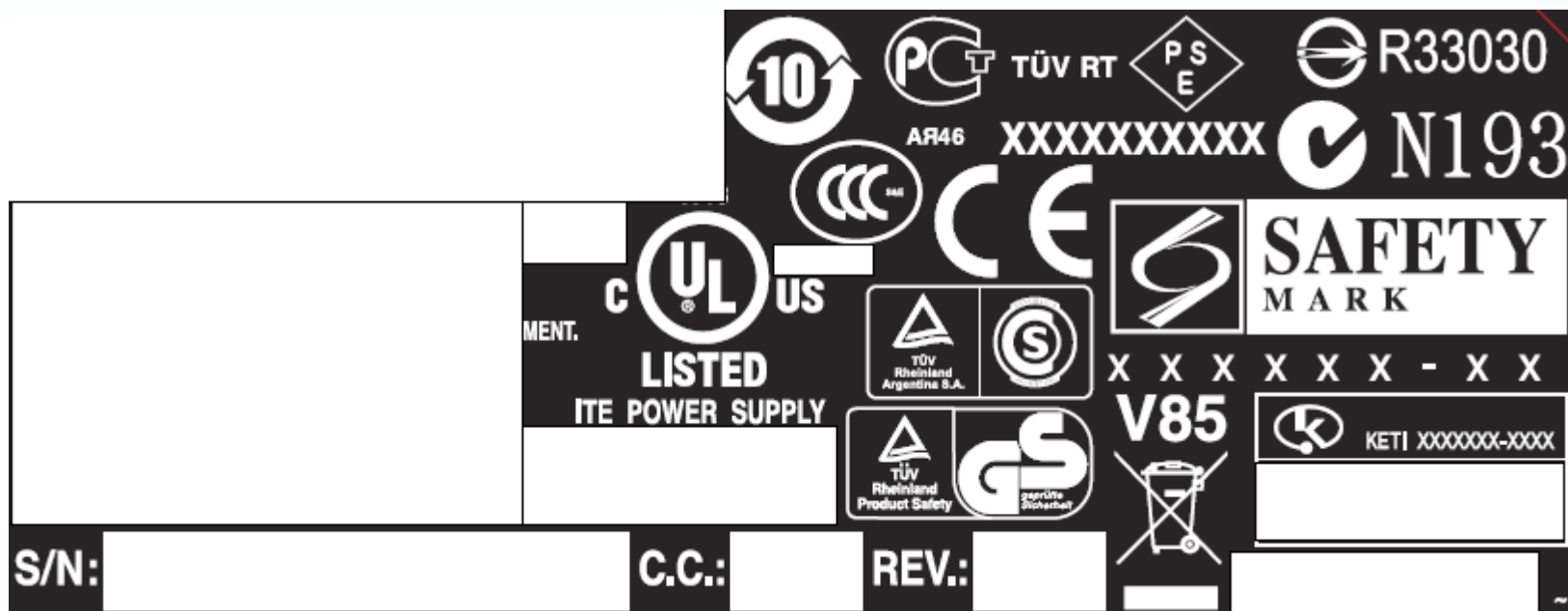


課程大綱

- ❏ 基本觀念
- ❏ Class I, II & III之分類
- ❏ 變壓器基本結構與安規要求
- ❏ 安規工程師如何協助RD人員
- ❏ 總結

基本觀念

為何需要安全規範 “Safety”



基本觀念

📖 因為產品不安全，造成消費者暴露於危險之中。



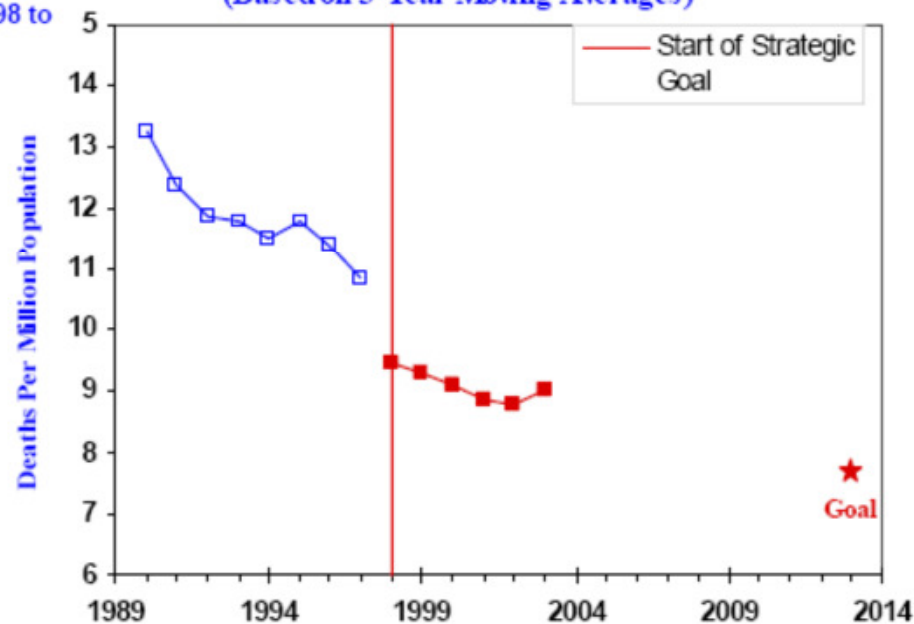
U.S. Consumer Product Safety Commission



FIRE HAZARD

STRATEGIC GOAL: Reduce the rate of death from fire-related causes by 20 percent from 1998 to 2013.

Fire-Related Death Rate Associated with Consumer Products by Year (Based on 3-Year Moving Averages)



基本觀念

- 因為產品之不安全所造成的危害，造成的社會成本以及製造商的財務損失或者更多.....更多。

Chemical Hazards



Children's Hazards



CPSC's Most Wanted:

- Magtastik / Magnetix
- Top 5 Home Hazards
- MagnaMan Figures
- Simplicity Cribs
- Toy Tool Benches
- Kolcraft Play Yards



Household and Recreation Hazards



Electrocution and Shock Hazards



Deaths, injuries and property damage from consumer product incidents cost the nation more than \$800 billion annually

基本觀念

📖 產品安全如何維持？

消費者之回報與不定期檢驗

廠商設計產品納入危害考量

驗證單位協助廠商產品檢驗

政府制定標準並且規定產品責任歸屬

基本觀念

代表的是.....



The screenshot shows the header of the U.S. Department of Labor Occupational Safety & Health Administration website. On the left is the OSHA logo, a circular seal with an eagle and the text 'DEPARTMENT OF LABOR' and 'UNITED STATES OF AMERICA'. To its right, the text reads 'U.S. Department of Labor' and 'Occupational Safety & Health Administration'. Below this is the website address 'www.osha.gov'. To the right of the address is a search bar with the word 'Search' and a 'GO' button. Further right are links for 'Advanced Search' and 'A-Z Index'. Above the search bar and links are several small, rounded rectangular images depicting various workplace safety scenarios, such as a worker in a hard hat, a person in a lab coat, and a person in a hard hat and safety vest.

Organizations Currently Recognized by OSHA as NRTLs

基本觀念

本課程使用之安規標準與參考文件



Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

INTERNATIONAL
STANDARD

IEC
60950-1

Second edition
2005-12

Information technology equipment –
Safety –

Part 1:
General requirements

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Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

基本觀念

📖 消費者網站資訊



<http://www.cpc.gov.tw>



<http://www.cpsc.gov>



Your Online Resource for Recalls <http://www.recalls.gov>



<http://www.fda.gov/>



<http://www.epa.gov/>

Start Your Passion

■ 產品安全之使命

Class I, II & III 之分類 (1)

🔥 分類代表的涵義為何?

◆ 電擊 (Electric Shock) 之危害。舉例來說

未提供良好絕緣

未提供良好接地



Class I, II & III 之分類 (2)

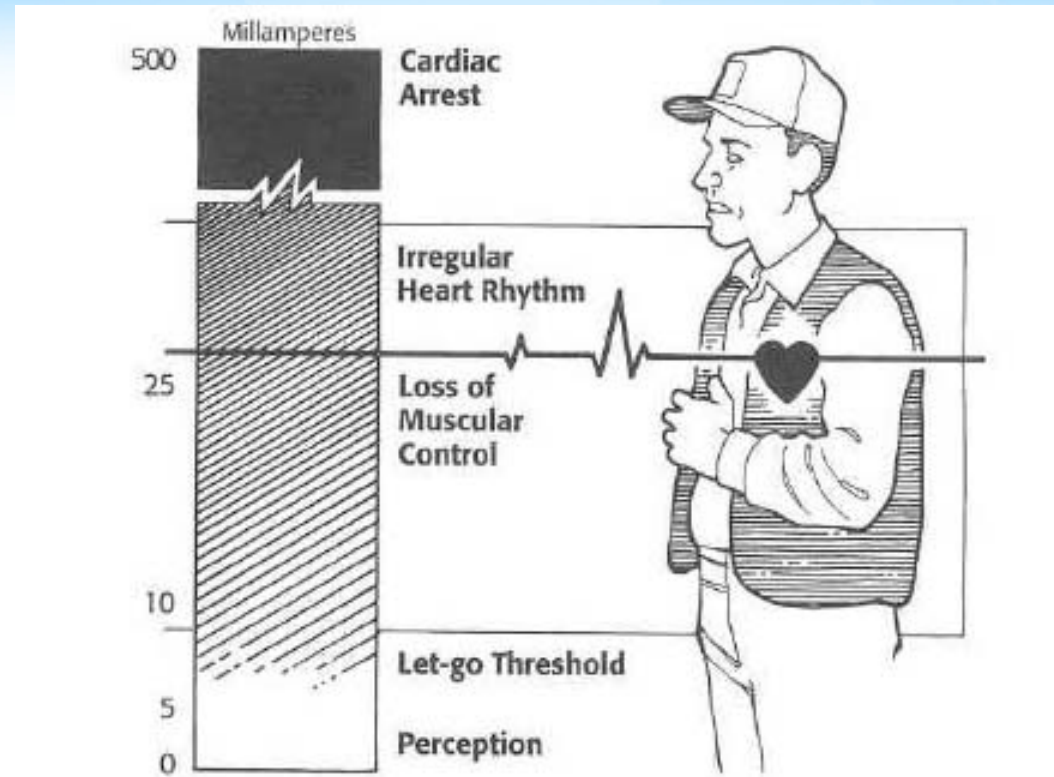


Fig. 1. Increasing levels of current above the "let-go" threshold causes loss of muscular control, irregular heart rhythm, and finally, cardiac arrest.

Class I, II & III 之分類 (3)

🔥 依據UL60950-1 2nd，條文”定義” 1.2.4 預防電擊
(Classes of equipment - protection against Electric Shock)

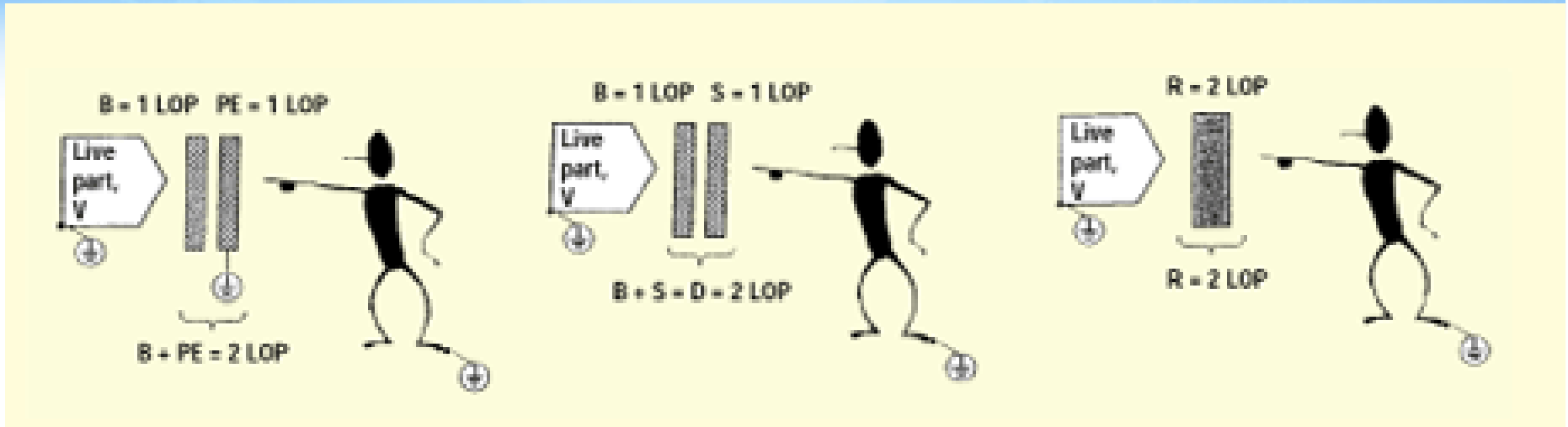
1.2.4.1 CLASS I EQUIPMENT: equipment where protection against electric shock is achieved by

- using BASIC INSULATION and
- providing a means of connection to the PROTECTIVE EARTHING CONDUCTOR in the building wiring those conductive parts that are otherwise capable of assuming HAZARDOUS VOLTAGES if the BASIC INSULATION fails

1.2.4.2 CLASS II EQUIPMENT: equipment in which protection against electric shock does not rely on BASIC INSULATION only, but in which additional safety precautions, such as DOUBLE INSULATION OR REINFORCED INSULATION are provided, there being no reliance on protective earthing

1.2.4.3 CLASS III EQUIPMENT: equipment in which protection against electric shock relies upon supply from SELV CIRCUITS and in which HAZARDOUS VOLTAGES are not generated

Class I, II & III 之分類 (4)



(a)

(b)

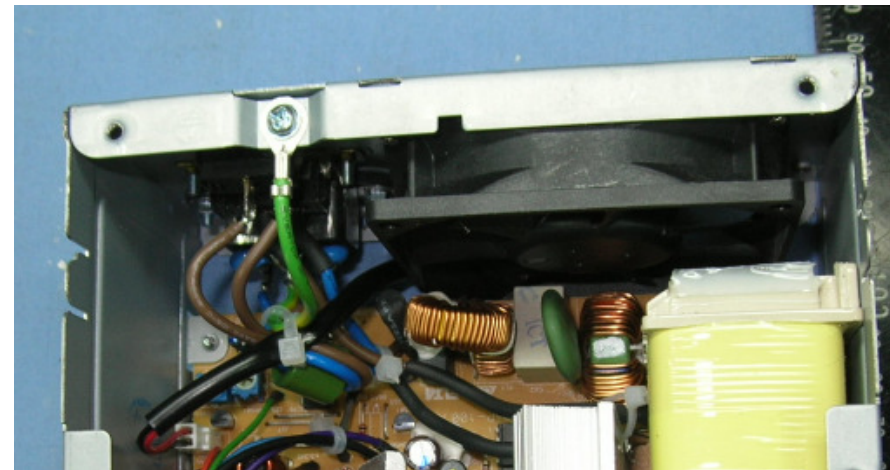
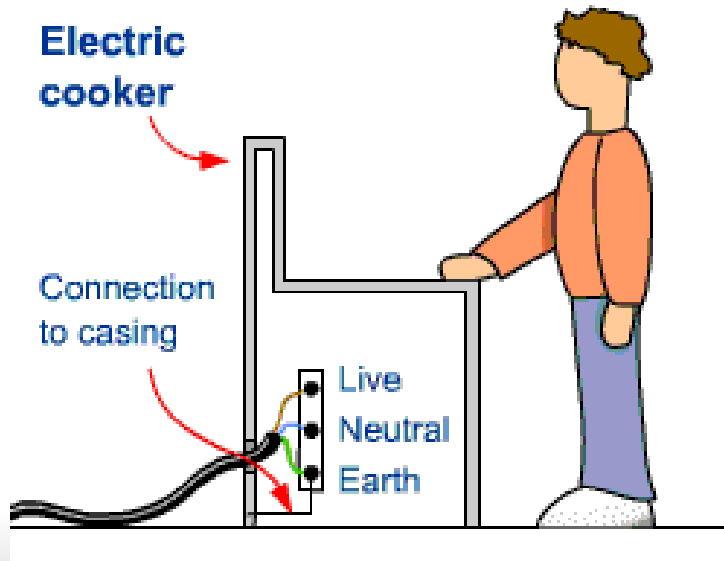
(c)

- (a) 基本絕緣 + 接地 (Basic insulation plus protective earthing)
- (b) 基本絕緣 + 補充絕緣 (Basic plus supplementary insulation)
- (c) 加強絕緣 (Reinforced insulation)

Class I (1)

🔥 預防電擊採用 “Class I”

- ◆ 除了有基本絕緣（Basic Insulation）之外，並且提供、
- ◆ 產品有保護性接地連結到建築物之大地導體，當危險電壓擊穿基本絕緣，能夠將危險電壓/電流導至大地。

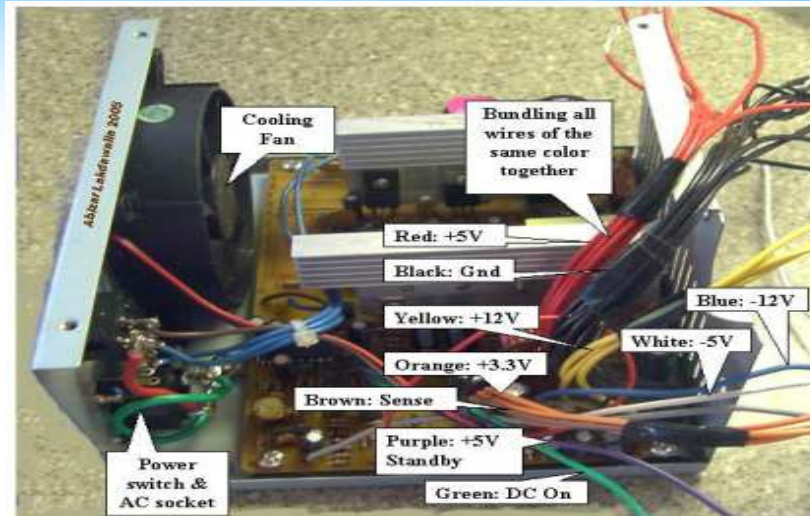


Class I (2)

舉例來說



Connectors:

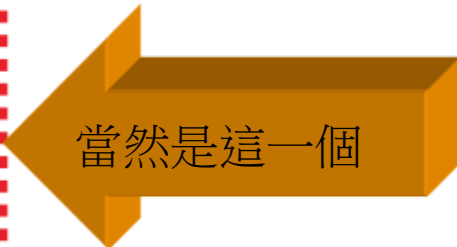
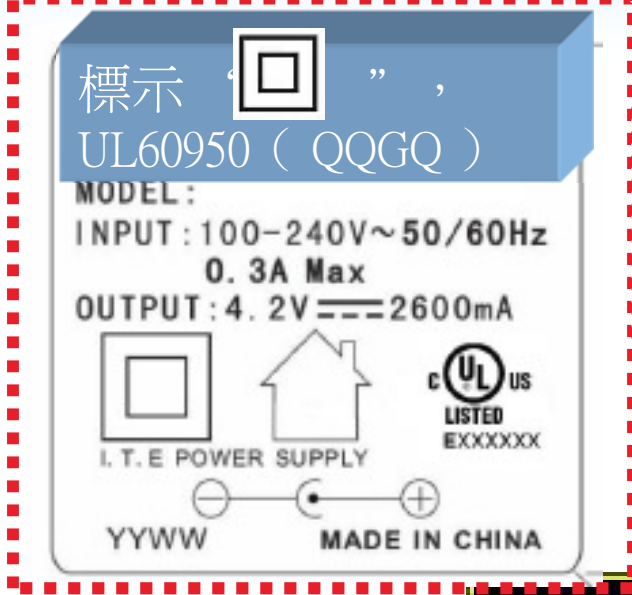


Class II (1)

👉 什麼是“Class II”，有那麼多Class II符號，該是哪一個？



標示“Class 2”，
UL1310 (EPBU)



標示 Laser “Class II”
CFR21 Part 1040



Class II (2)

🔥 預防電擊採用 “Class II”

- ◆ 除了有基本絕緣（Basic Insulation）之外，並且提供補充絕緣（Supplementary Insulation）所組成之雙重絕緣（Double Insulation），或者
- ◆ 提供加強絕緣（Reinforced Insulation），

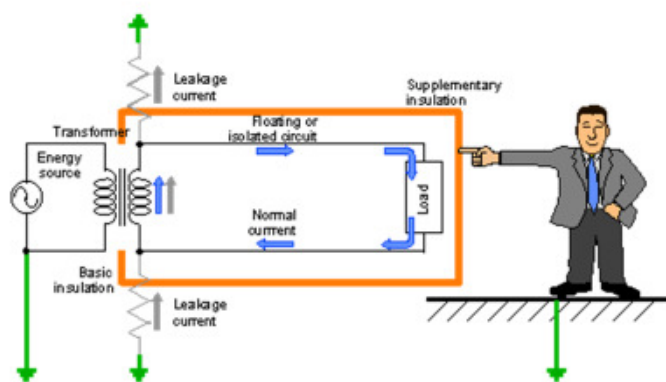
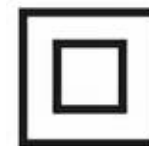
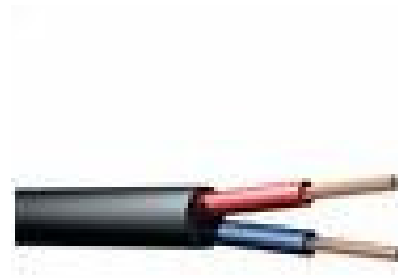


Figure 7



代表設備內部提供
兩層保護等級

Class II (3)

👉 舉例來說



Class III

- ❖ 產品本身並無危險電壓，電力來源是SELV，也不會產生危險電壓。



- ◆ SELV (Self Extra Low Voltage) : 安全極低電壓，電壓被限制在42.4Vpk, 60Vdc，詳情請看章節 2.2 & 2.1

如何評估 Class I、II (1)

◆ 結構符合 (Construction Compliance)

◆ 測試要求 (Testing Requirement)

2.2 安全極低電壓測試 (SELV)
2.6 保護接地 (Protective Earthing) 只有Class I。
2.9 溫溼度測試 (Humidity)
2.10.2 決定工作電壓 (Working Voltage)
2.10.5 固體絕緣 (Solid Insulation)
4.2 機械性測試 (Mechanical)
5.1 接觸電流 (Touch Current)
5.2 電氣性耐壓測試 (Electric Strength)
5.3 異常測試 (Abnormal Condition)
Annex C 變壓器過載測試 (Transformer Overload)
Annex D 接觸電流之量測線路

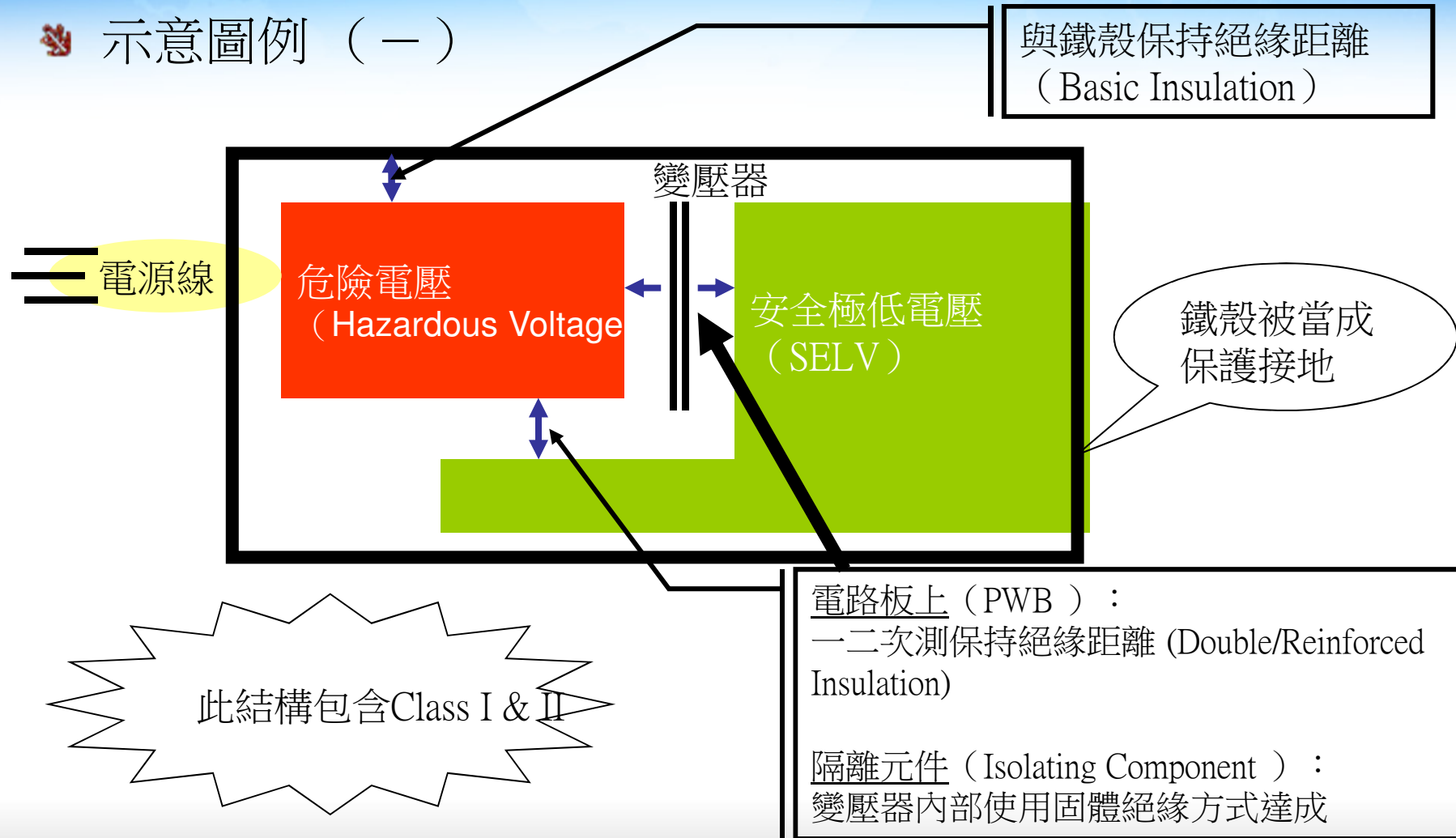
2.10.3 & 2.10.4
隔空距離與沿面距離 (Clearance & Creepage)



達成 Class I 或 II

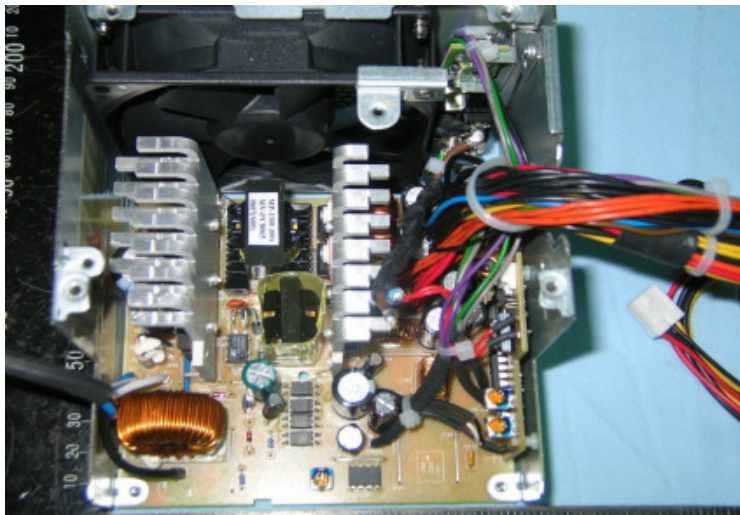
如何評估 Class I、II (2)

示意圖例 (一)



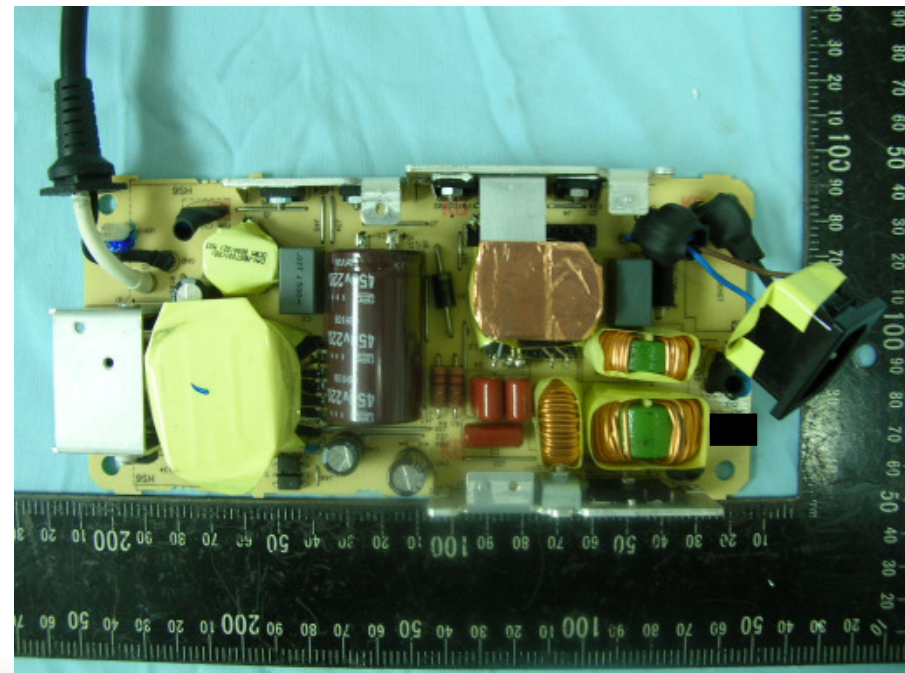
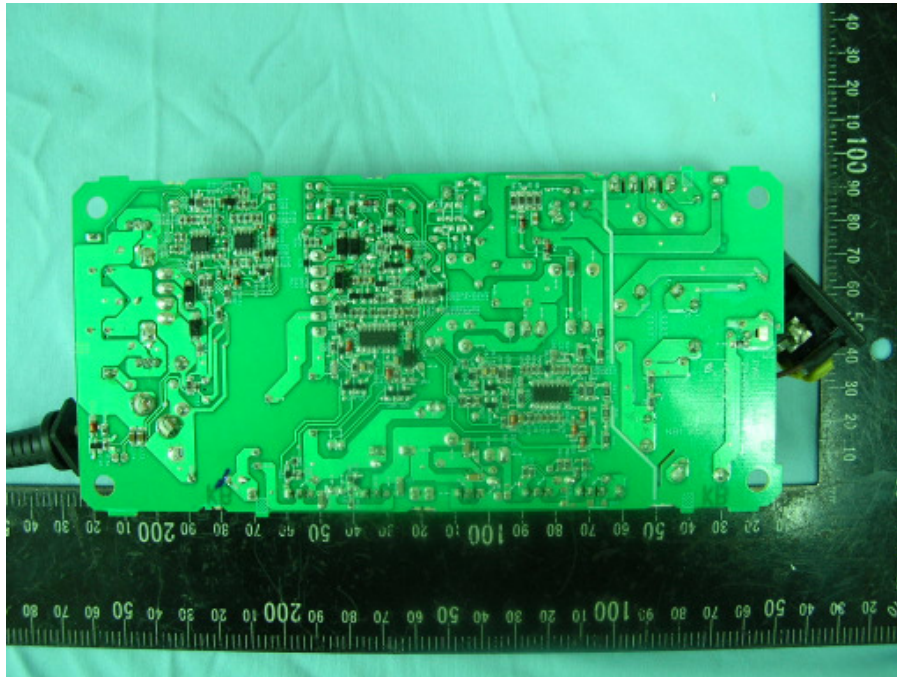
如何評估 Class I、II (3)

實務說明 (Class I)



如何評估 Class I、II (4)

🔥 實務說明 (Class II)





Take a Break

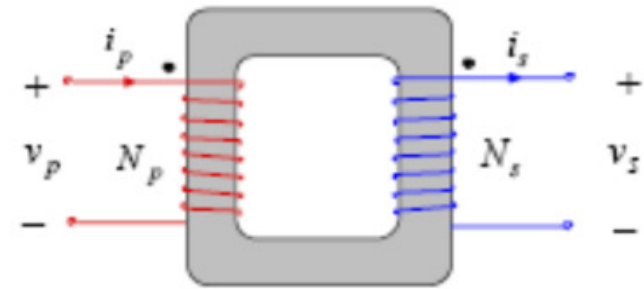
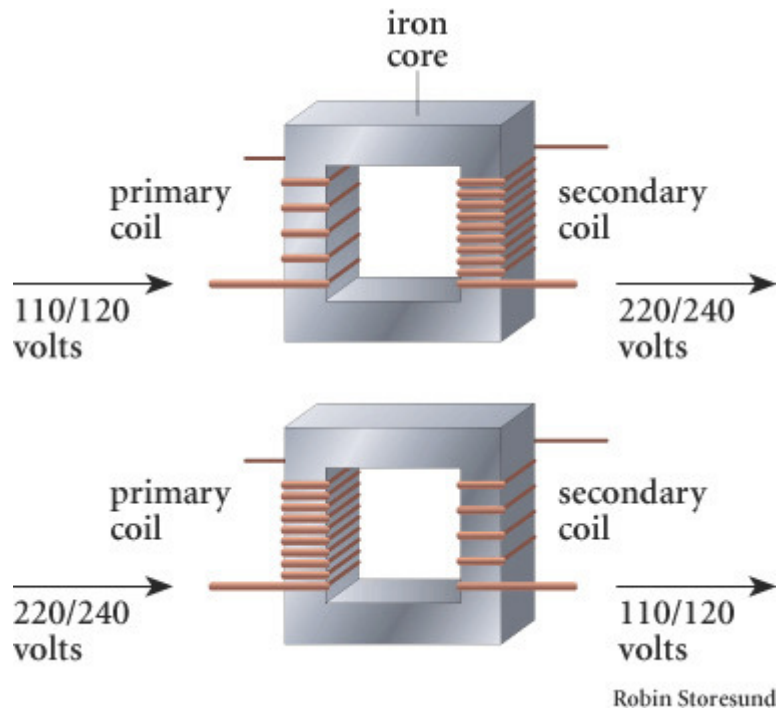
Part II

變壓器基本結構與安規要求



變壓器基本結構 - Transformer (1)

🌿 什麼是變壓器 (Transformer)



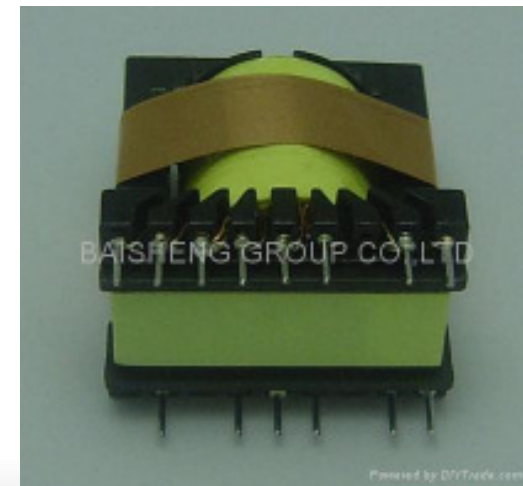
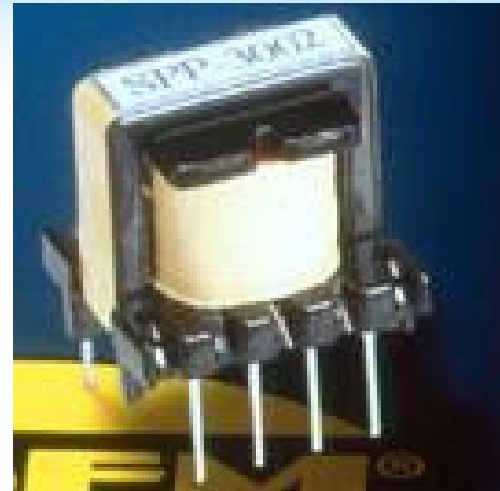
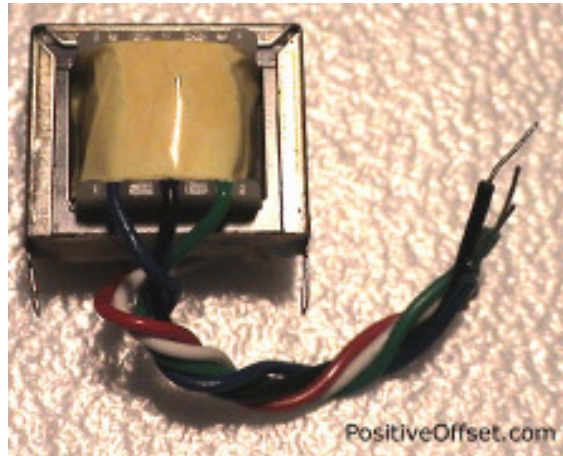
(a) sketch of an ideal transformer

$$\frac{v_p}{v_s} = \frac{N_p}{N_s}$$

$$N_p i_p = N_s i_s$$

變壓器基本結構 - Transformer (2)

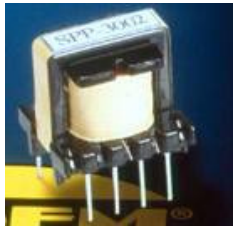
🌸 變壓器之類型 (Type)



變壓器基本結構 - Transformer (3)

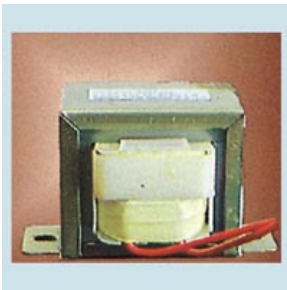
變壓器之類型 (Type)

◆ 交換式電源供應器所使用之變壓器



- a) 高頻，工作效率較佳，漣波雜訊高
- b) 鐵心使用高密度鐵粉心

◆ 類比式/線性電源供應器之線性變壓器 (Linear Transformer)

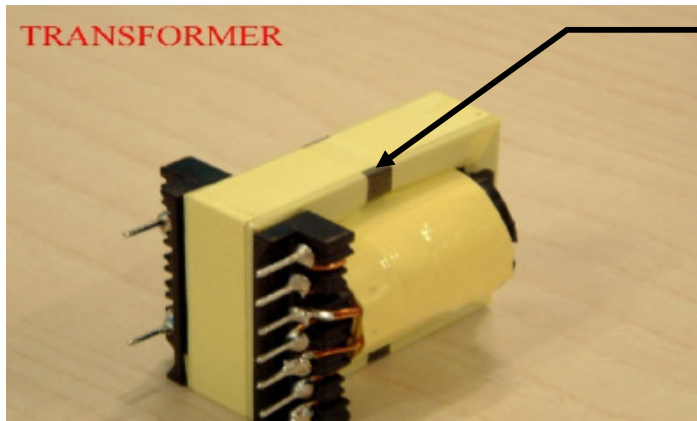


- a) 低頻，工作效率較差，漣波雜訊低
- b) 鐵心使用矽鋼片

◆ 其它工業用之重電變壓器

變壓器基本結構 - Transformer (4)

高頻模式變壓器之組成元件 (Core)



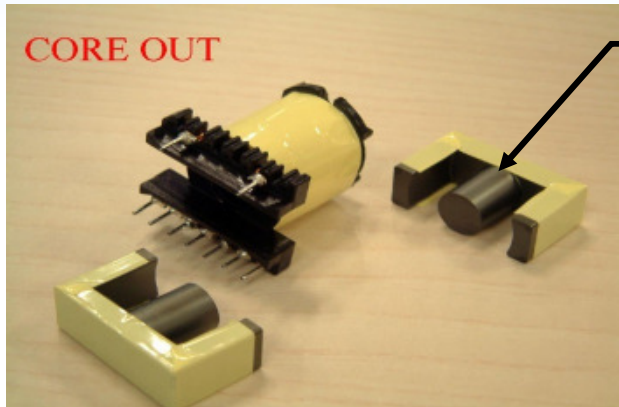
鐵芯 (Core)

型狀	
PQ、RM、EP、EP、POT	
T、UT、ET、UU	

型狀	
EE、EI	
EER、ETD	
LP、EED EED	

變壓器基本結構 - Transformer (5)

🔥 高頻模式變壓器之組成元件 (Core)

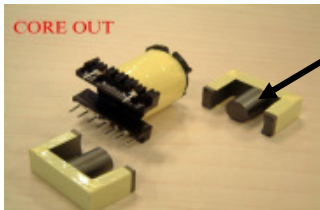


鐵芯 (Core)

型式 成本考量	POT	RM	EE	EER	PQ	EP
磁芯成本	高	高	低	中	高	中
線架成本	低	低	低	中	高	高
繞線成本	低	低	低	低	低	低
繞線難易度	容易	容易	很容易	很容易	容易	容易
組合	簡單	簡單	簡單	中	簡單	簡單
散熱效果	很差	好	很好	好	好	很差
遮罩效果	很好	好	很差	很差	尚可	很好

變壓器基本結構 - Transformer (6)

高頻模式變壓器之組成元件 (Core)

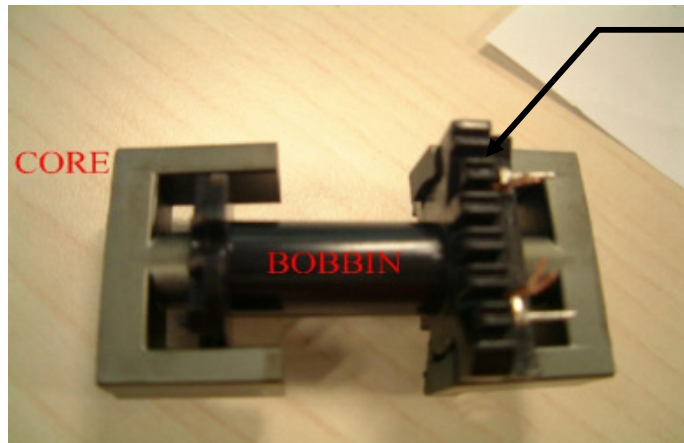


鐵芯 (Core)

材質 特性項目	鐵氧體	鎳鋼片	非晶 微晶	矽鋼片	MPP	鐵粉芯
磁通密度 gauss	4600~ 5100	7000~ 15000	16000	16000	7000	9000
初始磁導率 μ	250~ 15000	15000	10000	4000	14~250	22~90
最高工作溫度	125°C	200°C	150°C	300°C	200°C	200°C
鐵芯損耗	最低	中	低	最高	低	高
溫度穩定性	一般	好	好	一般	好	一般
加工性	良	良	差	良	良	良
價格	低	一般	高	低	高	最低

變壓器基本結構 - Transformer (7)

高頻模式變壓器之組成元件 – 線架 (Bobbin)



線架 (Bobbin)

1號		聚乙烯對苯二甲酸酯 (Polyethylene Terephthalate , PET) , 俗稱寶特瓶。
2號		高密度聚乙烯 (High Density Polyethylene , HDPE)
3號		聚氯乙烯 (Polyvinylchloride , PVC)
4號		低密度聚乙烯 (Low Density Polyethylene , LDPE)
5號		聚丙烯 (Polypropylene , PP)
6號		聚苯乙烯 (Polystyrene , PS) , 若是發泡聚苯乙烯即為俗稱之「保麗龍」
7號		其他類 (OTHERS)

塑膠材質

尼龍 (NYLON)

聚對苯二甲酸乙二醇酯 PET (POLYETHYLENE TEREPHTHALATE)

液晶聚合物 LCP (LIQUID CRYSTAL POLYESTER)

聚苯硫醚 PPS (塑鋼 POLYPHENYLENS SULFIDE)

電木型 (PHENOLIC)

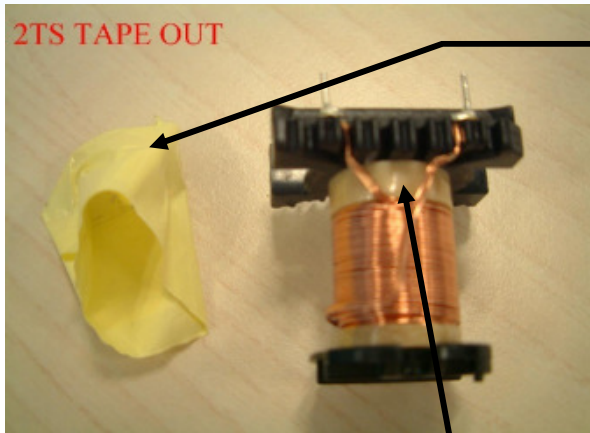
變壓器基本結構 - Transformer (8)

🔥 高頻模式變壓器之組成元件 – 線架 (Bobbin)

材質		NYLON	PHENOLIC	PBT	PET	LCP	PPS
特性							
機械特性	擾曲強度 Kg/cm ²	12500 Mpa	120	1400- 1800	1900	1420	2600
	洛氏硬度	---	120	93	120	91	123
熱學特性	熱變形溫度°C	---	235	205	246	313	260
	融點°C	260	---	225	270	---	---
	耐燃性 UL94	V-0	V-0	V-0	V-0	V-0	V-0
電氣特性	電阻率 ohm-cm	---	1013	>1016	1.0E+16	1013	4*1016
	絕緣強度 Kv/mm	---	10	22	18	---	16
用途		低頻變壓器	高頻變壓器	高頻變壓器、 濾波器	高頻變壓器、 濾波器	SMD 型變壓器	低頻變壓器、 電感器

變壓器基本結構 - Transformer (9)

🔥 高頻模式變壓器之組成元件 - 絕緣膠帶 (Insulation Tape)

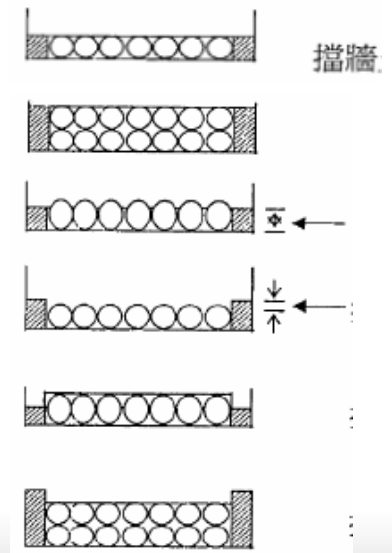


絕緣膠帶 (Insulation Tape)

- 每個繞線層之間之隔開材料，部分設計上也會用反包方式，達成絕緣距離之要求。

沿邊膠帶 (Margin Tape)

- 固定繞線之緊密度在同層之間，不因為外力或者運輸過程中，造成繞線之間，間隔距離改變，造成磁通量改變。當然，絕緣距離也是重要考慮。



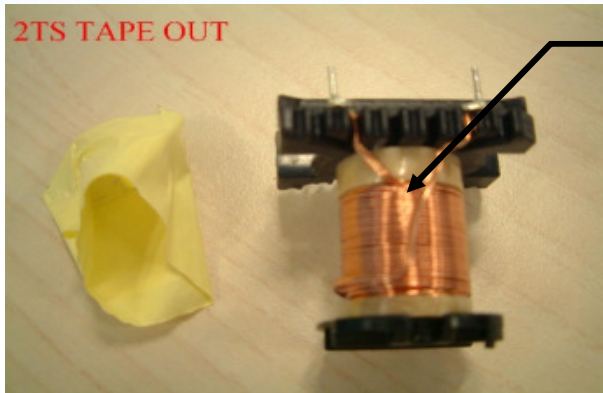
變壓器基本結構 - Transformer (10)

🔥 高頻模式變壓器之組成元件 – 絕緣膠帶 (Insulation Tape)

特性	材質	聚酯薄膜膠帶 Mylar tape	擋牆膠帶 Margin tape	PVC膠帶
特點		有極佳的抗化學品、抗化劑和防潮能力，並可抵受切割及磨損	---	抗拉力、具較好韌性
顏色		各種顏色	淡黃色、白色	各種顏色
絕緣電阻		>1000 k Ω	>1000 k Ω	>1000 k Ω
擊穿電壓		5.5kV	5.5,10,15 kV	5.2kV
相對電痕指數		600I	600II	--
溫度等級		130 $^{\circ}$ C	130 $^{\circ}$ C	85 $^{\circ}$ C
阻燃性		UL94V-0	UL94V-0	--
用途		用於變壓器，馬達、電機、電子阻件之絕緣包紮	各類變壓器端控隔離絕緣用	電工包紮、消磁線圈用

變壓器基本結構 - Transformer (11)

🔥 高頻模式變壓器之組成元件 – 繞線或線圈 (Coil or Wire)



銅質漆包線 (繞線) (Coil / Wire)

- 本身並無絕緣功效，單純為磁場轉換所作用



三層絕緣線 (Triple Insulated Wire)

- 除了繞線本身磁場轉換之作用外，線材所披覆外皮具有絕緣功效。當然，成本較高，製程也較不易。

變壓器基本結構 - Transformer (12)

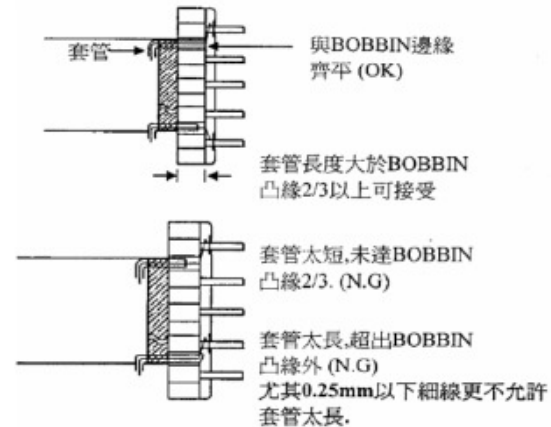
🔥 高頻模式變壓器之組成元件 – 繞線或線圈 (Coil or Wire)

品種	型號	溫度等級	特點	用途
聚氨基甲酸酯漆包線	QA、UEW	130°C 155°C 180°C	直焊性，焊錫前無需先脫漆膜。耐拉伸、耐彎折。	電子變壓器、電感線圈、繼電器、微電機及其他電子儀錶繞組
尼龍複合聚氨基甲酸酯漆包線	QA、UEW	130°C 155°C 180°C	除具備聚氨基甲酸酯漆包線特性外，還具有表面磨擦係數小、耐磨性佳等特點，適合於高速繞線場合。	電子變壓器、電感線圈、繼電器、微電機及其他電子儀錶繞組
聚酯漆包線	QZ、PEW	130°C 155°C 180°C	具有較好的機械特性及耐化學特性。並且具有很好的耐溫特性（溫度等級155°C以上產品）	馬達繞組、鎮流器、大型變壓器等、扼流圈等。
尼龍複合聚酯漆包線	QZ、PEW	130°C 155°C 180°C	除具備聚酯漆包線特性外，還具有表面磨擦係數小、耐磨性佳等特點，適合於高速繞線場合。	馬達繞組、鎮流器、大型變壓器等、扼流圈等。

變壓器基本結構 - Transformer (13)

🔥 高頻模式變壓器之組成元件 - 其他 (Others)

◆ 套管 (Tube)



◆ 亮光漆 (凡力水) (Varnish) : 含浸製程



變壓器安規要求 – Safety (1)

📖 變壓器要求安規的理由在哪裡？

每個變壓器都要控制？

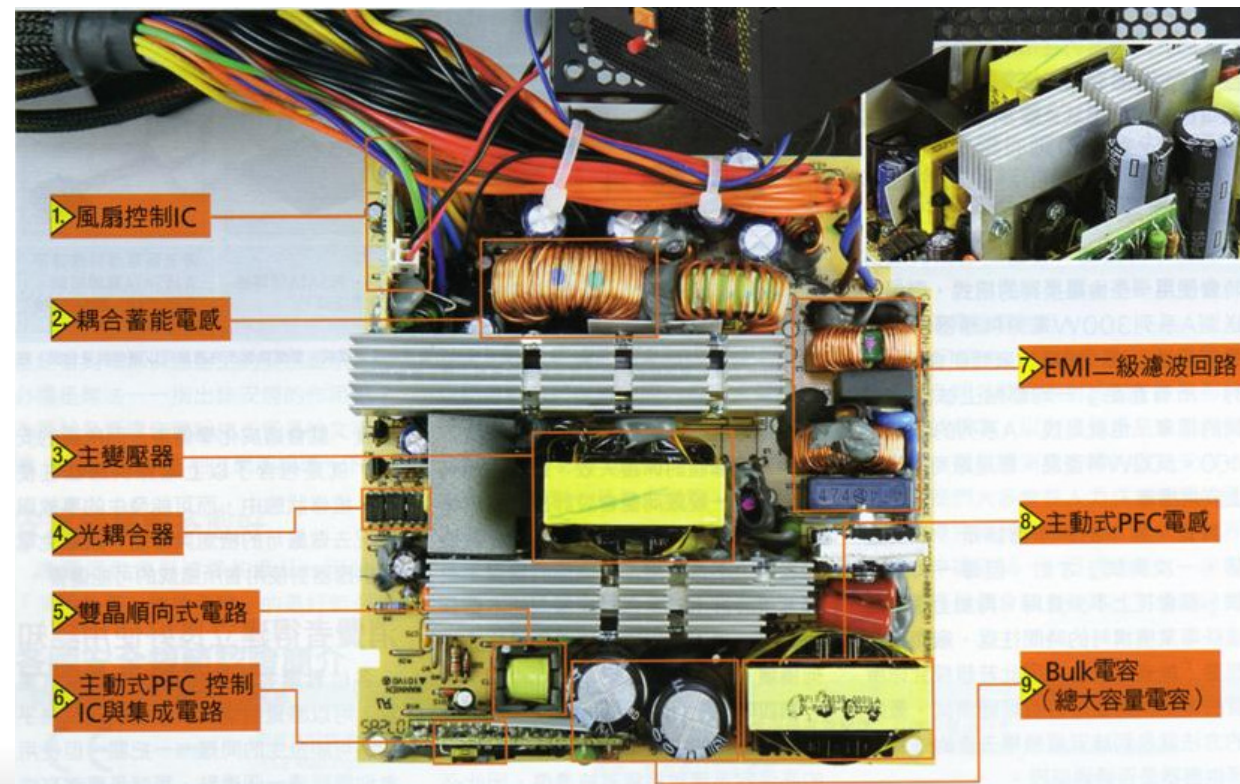
每個內部細節都要控制？



變壓器安規要求 – Safety (2)

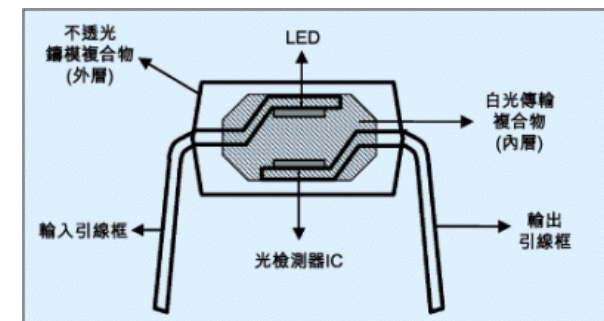
☞ 答案是：

- ◎ 被當作是隔離元件 (Isolating Component)
- ◎ 發熱來源 (Heat Source)
- ◎ 以及有可能之潛在危險 (Potential Hazard)



變壓器安規要求 – Safety (3)

- ❑ 隔離元件的主要目的：
- ❑ 隔離元件只有變壓器嗎？



變壓器安規要求 – Safety (4)

變壓器被視為隔離元件，有哪些安規重點：

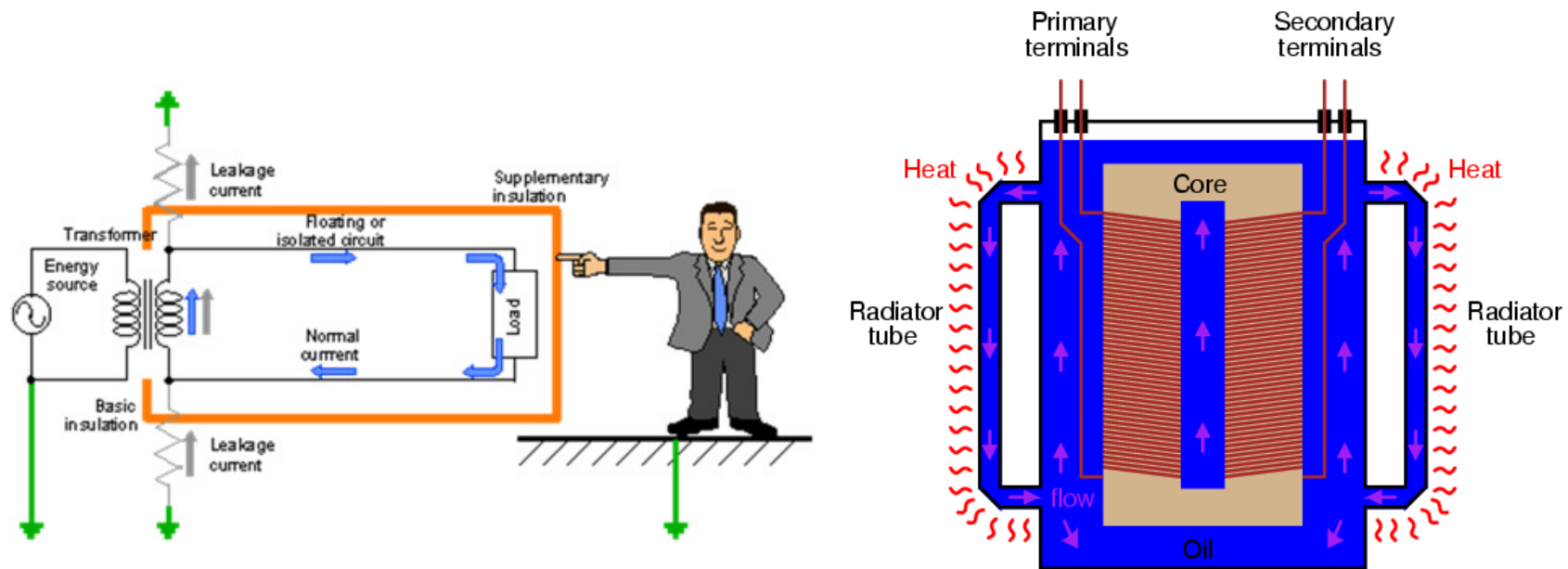


Figure 7

變壓器安規要求 – Safety (5)

變壓器之絕緣考量：結構

- ◆ 第一步：2.10.2 量測工作電壓 (Determine Working Voltage)
- ◆ 第二步：決定所需之距離， 2.10.3 & 2.10.4 空間距離
與沿面距離 (Clearance & Creepage)
- ◆ 第三步：量測變壓器之內外部距離 (Outside & Inside)

變壓器安規要求 – Safety (6)

變壓器之絕緣考量：結構

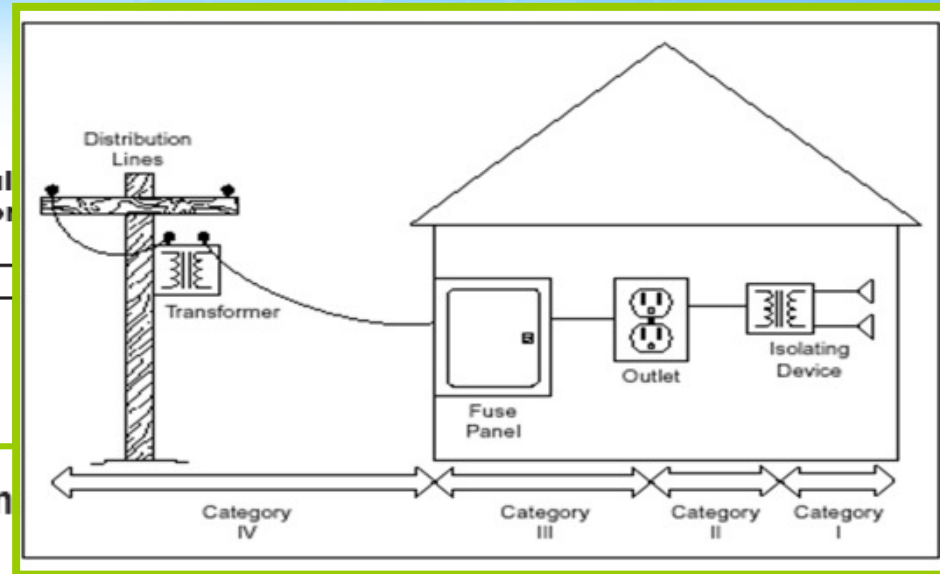
Table 2H – Minimum clearances for insulation and secondary

WORKING VOLTAGE up to and including	MAINS TRANSIENT VOLTAGE 1 500 V (Nominal AC MAINS SUPPLY voltage ≤ 150 V)
-------------------------------------	---

UL60950-1 2nd

Table 2J – AC m

AC MAINS SUPPLY voltage ^a up to and including	MAINS TRANSIENT VOLTAGE ^b	
	V peak	
	Overvoltage Category	
V r.m.s.	I	II
50	330	500
100	500	800
150 ^c	800	1 500
300 ^d	1 500	2 500
600 ^e	2 500	4 000



變壓器安規要求 – Safety (7)

變壓器之絕緣考量：結構

Table 2J – Additional clearances for insulation in primary circuits with peak working voltages exceeding the peak value of the nominal a.c. mains supply voltage

Nominal AC MAINS SUPPLY voltage ≤ 150 V		Nominal AC MAINS SUPPLY voltage > 150 V ≤ 300 V		Additional CLEARANCE mm	
Pollution Degrees 1 and 2	Pollution Degree 3	Pollution Degrees 1, 2 and 3		FUNCTIONAL, BASIC or SUPPLEMENTARY INSULATION	REINFORCED INSULATION
Maximum PEAK WORKING VOLTAGE V	Maximum PEAK WORKING VOLTAGE V	Maximum PEAK WORKING VOLTAGE V			
210 (210)	210 (210)	420 (420)	0	0	
298 (288)	294 (293)	493 (497)	0,1	0,2	
386 (366)	379 (376)	567 (575)	0,2	0,4	
474 (444)	463 (459)	640 (652)	0,3	0,6	
562 (522)	547 (541)	713 (729)	0,4	0,8	
650 (600)	632 (624)	787 (807)	0,5	1,0	
738 (678)	715 (707)	860 (884)	0,6	1,2	
826 (756)	800 (790)	933 (961)	0,7	1,4	
914 (839)		1 006 (1 039)	0,8	1,6	
1 002 (912)		1 080 (1 116)	0,9	1,8	
1 090 (990)		1 153 (1 193)	1,0	2,0	
		1 226 (1 271)	1,1	2,2	
		1 300 (1 348)	1,2	2,4	
		– (1 425)	1,3	2,6	

變壓器安規要求 – Safety (8)

變壓器之絕緣考量：結構

Table 2L – Minimum creepage distances

Comparative Tracking Index (CTI) <http://www.ul.com/plastics/cti.html>

Comparative Tracking Index is expressed as that voltage which causes tracking after 50 drops of 0.1 percent ammonium chloride solution have fallen on the material. The results of testing the nominal 3 mm thickness are considered representative of the material's performance in any thickness.

CTI Range Tracking Index (in Volts)	PLC Assigned
600 and Greater	0
400 through 599	1
250 through 399	2
175 through 249	3
100 through 174	4
Less than 100	5

CREEPAGE DISTANCES in millimetres				
SUPPLEMENTARY INSULATION				
Pollution Degree 2		Pollution Degree 3		
Material Group	IIIa or IIIb	Material Group		
		I	II	IIIa or IIIb
1,2	1,5	1,7	1,9	
1,4	1,8	2,0	2,2	
1,5	1,9	2,1	2,4	
1,6	2,0	2,2	2,5	
2,0	2,5	2,8	3,2	
2,5	3,2	3,6	4,0	
3,2	4,0	4,5	5,0	

Material groups depend on the comparative tracking index (CTI) and are classified as follows:

Material Group I	CTI ≥ 600
Material Group II	400 ≤ CTI < 600
Material Group IIIa	175 ≤ CTI < 400
Material Group IIIb	100 ≤ CTI < 175

The material group is verified by evaluation of the test data for the material according to IEC 60112 using 50 drops of solution A.

1) No minimum CREEPAGE DISTANCE is specified for CLEARANCE, as previously determined in 2.10

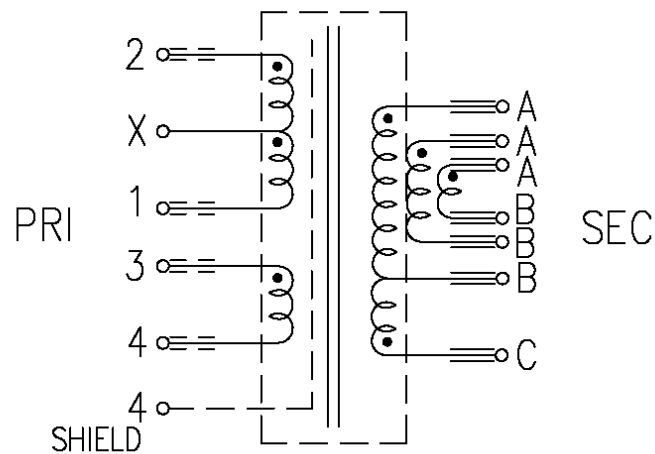
2) Linear interpolation is permitted between the higher 0,1 mm increment.

變壓器安規要求 – Safety (9)

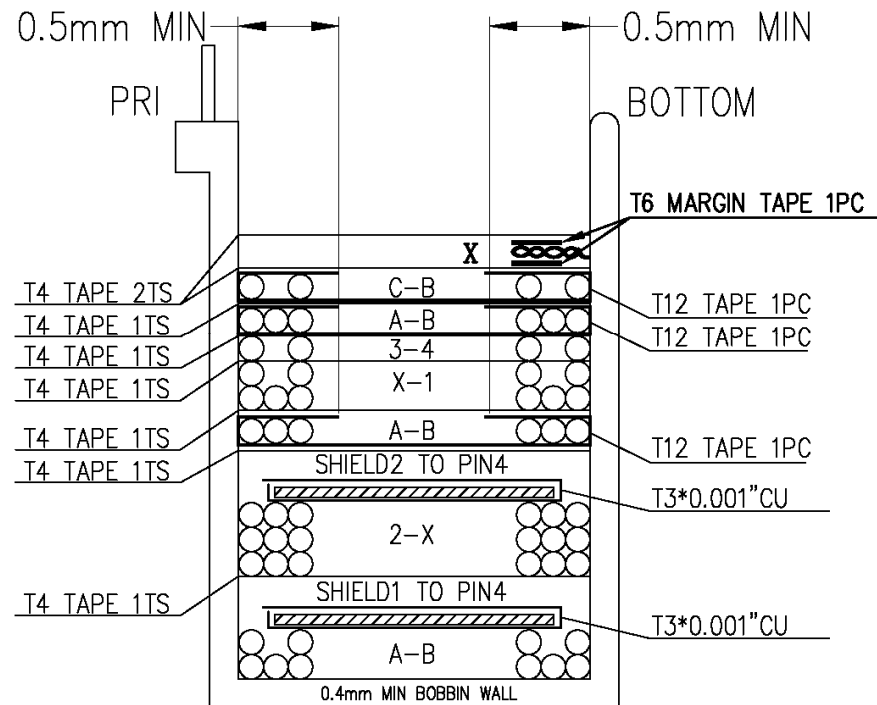
變壓器之絕緣考量：結構

變壓器規格文件 (Transformer SPEC)

2. SCHEMATIC :



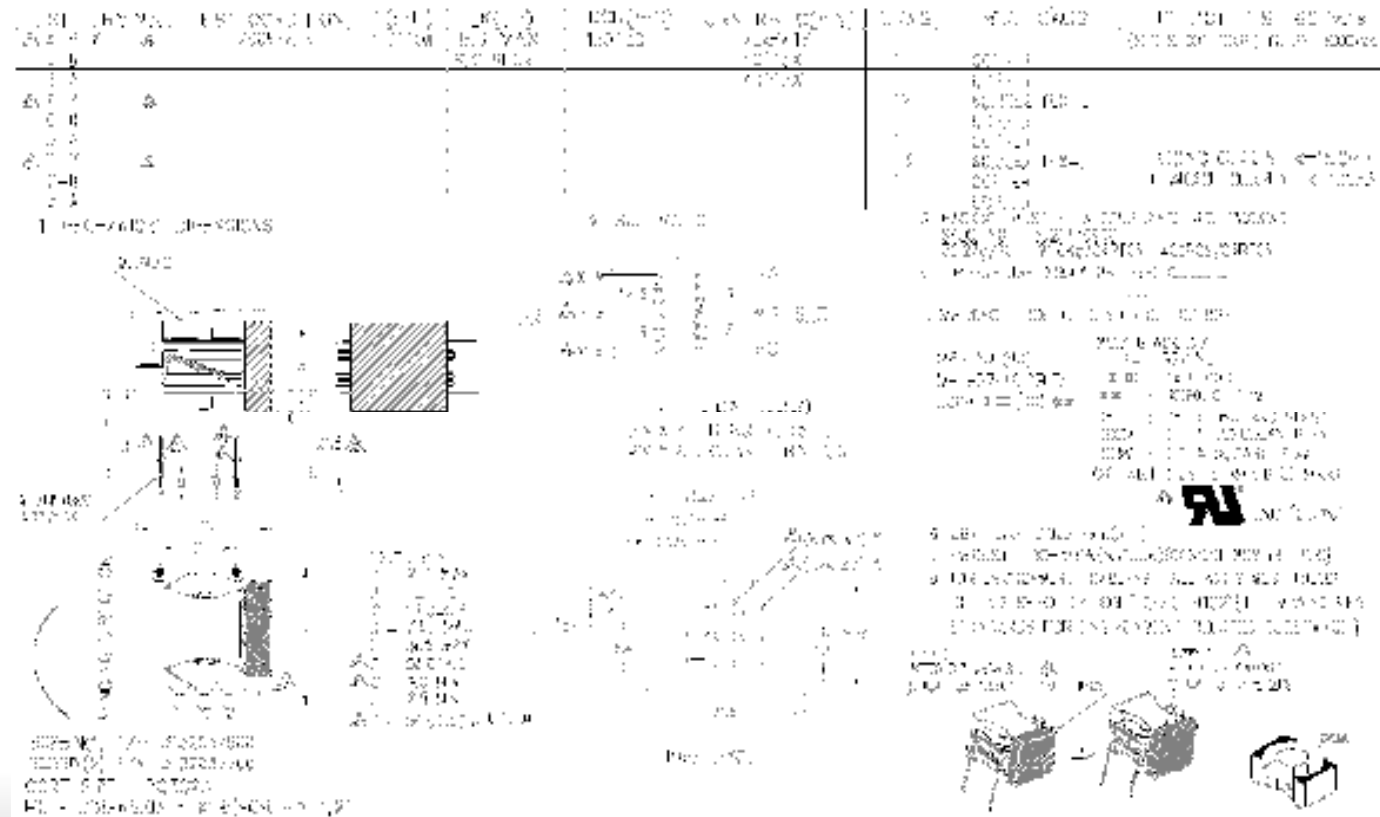
WINDING CONSTRUCTION :



變壓器安規要求 – Safety (10)

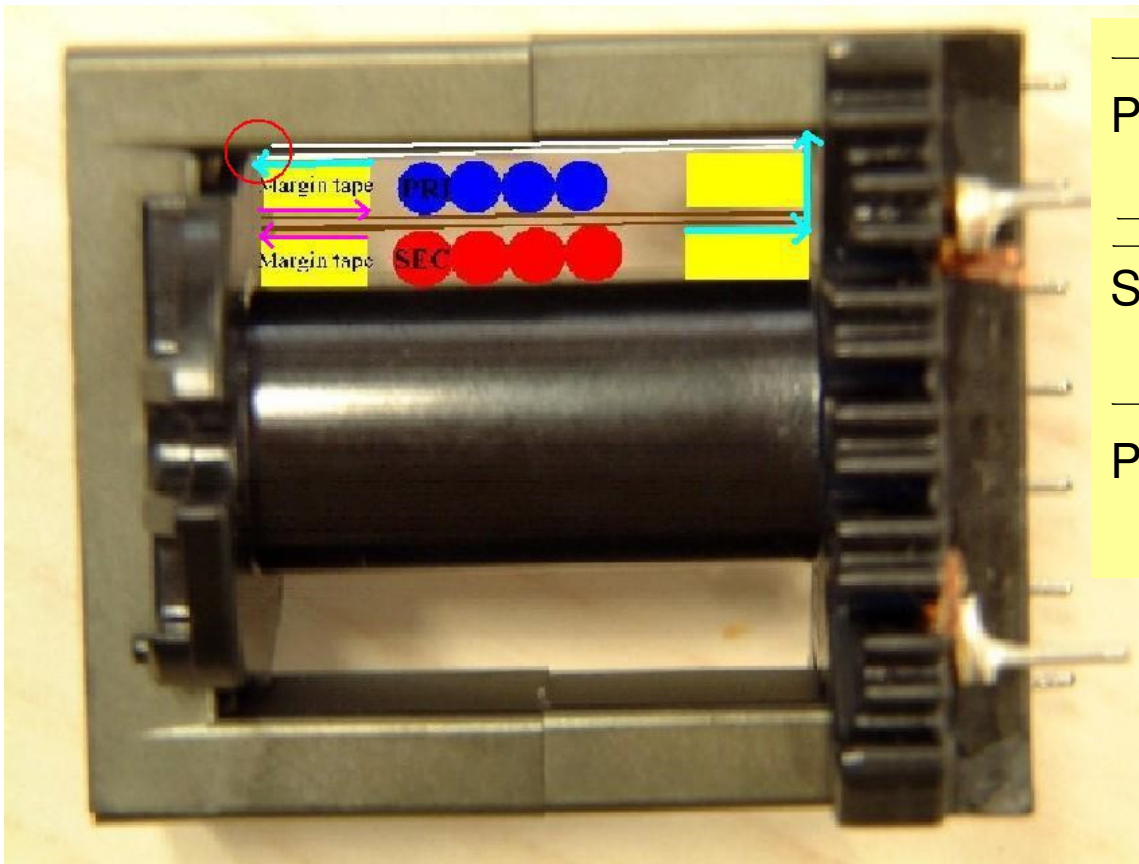
變壓器之絕緣考量：結構

變壓器規格文件 (Transformer SPEC)



變壓器安規要求 – Safety (11)

變壓器之絕緣考量：結構



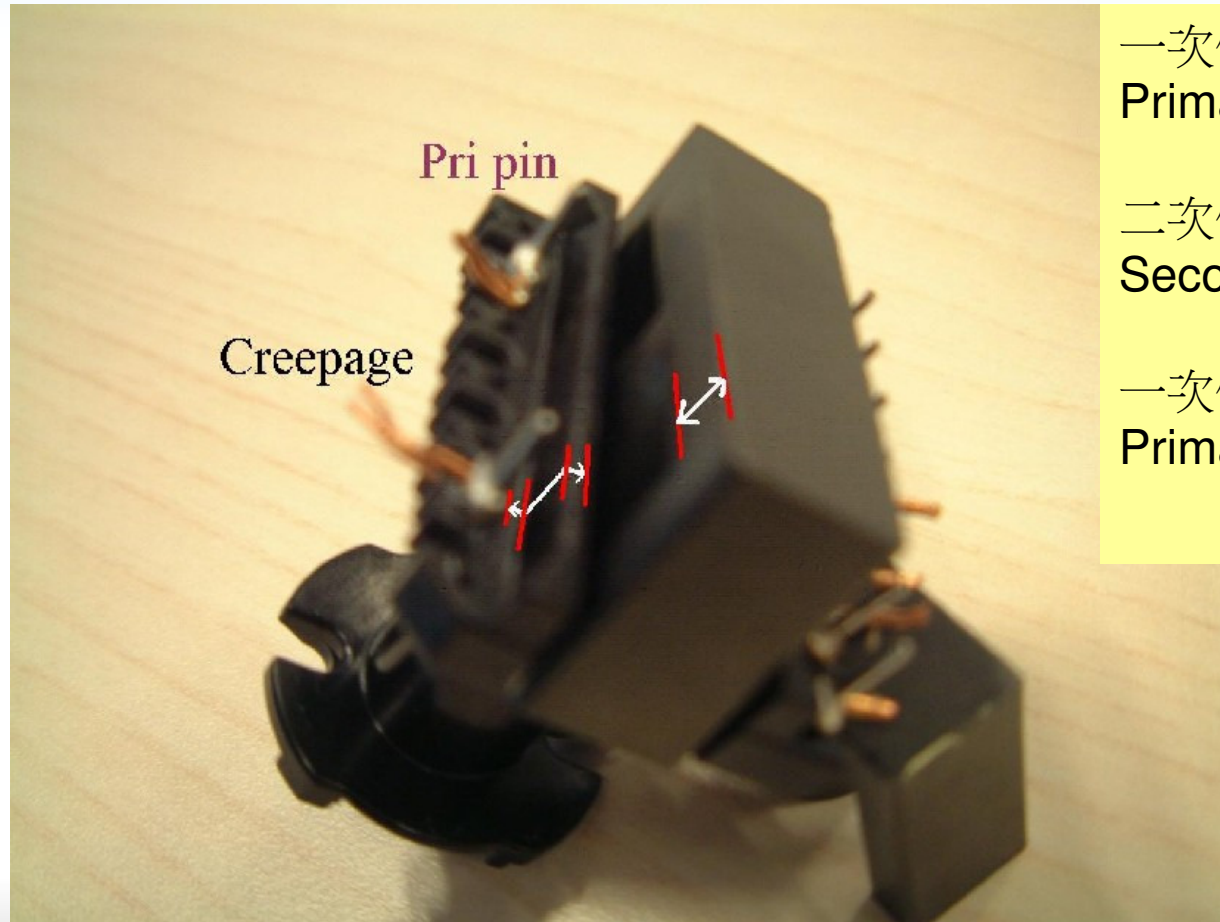
一次側繞線到鐵心
Primary Coil to Core

二次側繞線到鐵心
Secondary Coil to Core

一次側繞線到二次側繞線
Primary Coil to Secondary Coil

變壓器安規要求 – Safety (12)

變壓器之絕緣考量：結構



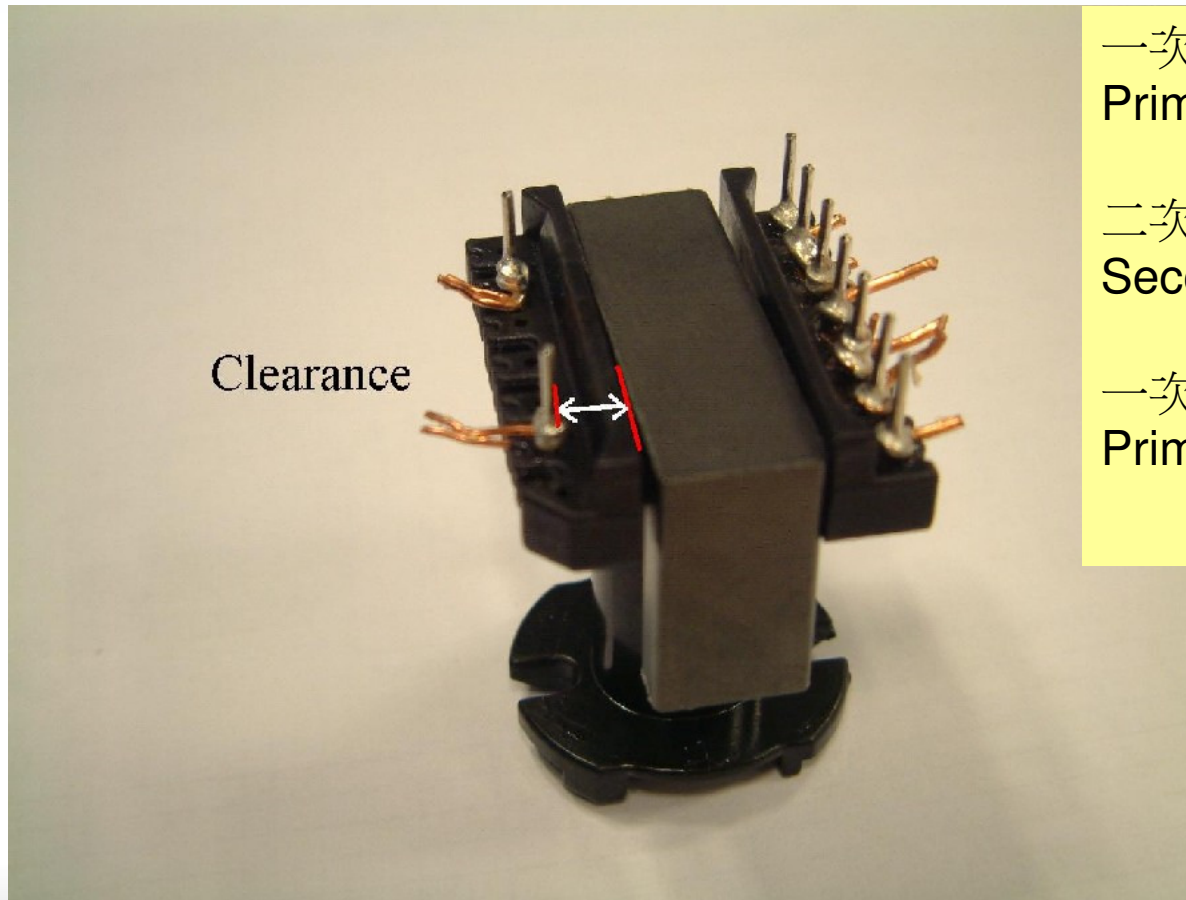
一次側出腳到鐵心
Primary Pin to Core

二次側出腳到鐵心
Secondary Pin to Core

一次側出腳到二次側出腳
Primary Pin to Secondary Pin

變壓器安規要求 – Safety (13)

變壓器之絕緣考量：結構



一次側出腳到鐵心
Primary Pin to Core

二次側出腳到鐵心
Secondary Pin to Core

一次側出腳到二次側出腳
Primary Pin to Secondary Pin

變壓器安規要求 – Safety (15)

5.2.2 電氣絕緣測試之耐壓值

Table 5B – Test voltages for electric strength tests
Part 1

Grade of insulation	Points of application (as appropriate)						
	PRIMARY CIRCUIT to BODY PRIMARY CIRCUIT to SECONDARY CIRCUIT between parts in PRIMARY CIRCUITS					SECONDARY CIRCUIT to BODY between independent SECONDARY CIRCUITS	
	WORKING VOLTAGE					WORKING VOLTAGE	
	$U \leq 184$ V peak or d.c. ²⁾	184 V < $U \leq 354$ V peak or d.c. ³⁾	354 V < $U \leq 1,41$ kV peak or d.c.	$1,41$ kV < $U \leq 10$ kV peak or d.c. ⁴⁾	10 kV < $U \leq 50$ kV peak or d.c.	$U \leq 42,4$ V peak or 60 V d.c. ⁵⁾	$42,4$ V peak or 60 V d.c. < $U \leq 10$ kV peak or d.c. ⁵⁾
	Test voltage, volts r.m.s. ¹⁾					Test voltage, voltage r.m.s. ¹⁾	
FUNCTIONAL	1 000	1 500	see V_a in table 5B, part 2	see V_a in table 5B, part 2	$1,06 U$	500	see V_a in table 5B, part 2
BASIC, SUPPLEMENTARY	1 000	1 500	see V_a in table 5B, part 2	see V_a in table 5B, part 2	$1,06 U$	No test	see V_a in table 5B, part 2
REINFORCED	2 000	3 000	3 000	see V_b in table 5B, part 2	$1,06 U$	No test	see V_b in table 5B, part 2

變壓器安規要求 – Safety (16)

5.2.2 電氣絕緣測試之耐壓值

Table 5B – Test voltages for electric strength tests
Part 2

U peak or d.c.	V _a r.m.s.	V _b r.m.s.	U peak or d.c.	V _a r.m.s.	V _b r.m.s.	U peak or d.c.	V _a r.m.s.	V _b r.m.s.
34	500	800	250	1 261	2 018	1 750	3 257	3 257
35	507	811	260	1 285	2 055	1 800	3 320	3 320
36	513	821	270	1 307	2 092	1 900	3 444	3 444
38	526	842	280	1 330	2 127	2 000	3 566	3 566
40	539	863	290	1 351	2 162	2 100	3 685	3 685
42	551	882	300	1 373	2 196	2 200	3 803	3 803
44	564	902	310	1 394	2 230	2 300	3 920	3 920
46	575	920	320	1 414	2 263	2 400	4 034	4 034
48	587	939	330	1 435	2 296	2 500	4 147	4 147
50	598	957	340	1 455	2 328	2 600	4 259	4 259
52	609	974	350	1 474	2 359	2 700	4 369	4 369
54	620	991	360	1 494	2 390	2 800	4 478	4 478
56	630	1 008	380	1 532	2 451	2 900	4 586	4 586
58	641	1 025	400	1 569	2 510	3 000	4 693	4 693
60	651	1 041	420	1 605	2 567	3 100	4 798	4 798
62	661	1 057	440	1 640	2 623	3 200	4 902	4 902
64	670	1 073	460	1 674	2 678	3 300	5 006	5 006
66	680	1 088	480	1 707	2 731	3 400	5 108	5 108
68	690	1 103	500	1 740	2 784	3 500	5 209	5 209
70	699	1 118	520	1 772	2 835	3 600	5 309	5 309
72	708	1 133	540	1 803	2 885	3 800	5 507	5 507

變壓器安規要求 – Safety (17)

☐ 變壓器之絕緣考量：結構

◆ 實作演練

產品：電源供應器

輸入電壓 I/P: 100~240Vac,

量測變壓器之工作電壓最大為：500Vpk, 300Vrms

Material Group IIIa or IIIb

所需之基本絕緣距離：

所需之雙重/加強絕緣距離：

所需之基本絕緣耐壓：

所需之雙重/加強絕緣耐壓：



@ Take a Break

變壓器安規要求 – Safety (18)

變壓器之熱 (Heat) 考量：溫度 (Thermal)

Table 4B – Temperature limits
Part 1

Part	Maximum temperature (T_{max}) °C
Insulation, including winding insulation:	
– of Class A material	100 ^{1), 2), 3)}
– of Class E material	115 ^{1), 2), 3)}
– of Class B material	120 ^{1), 2), 3)}
– of Class F material	140 ^{1), 2), 3)}
– of Class H material	165 ^{1), 2), 3)}
Synthetic rubber or PVC insulation of internal and external wiring, including power supply cords:	
– without temperature marking	75
– with temperature marking	The temperature marking
Other thermoplastic insulation	⁴⁾
Terminals, including earthing terminals for external earthing conductors of STATIONARY EQUIPMENT, unless provided with a NON-DETACHABLE POWER SUPPLY CORD	85
Parts in contact with a flammable liquid	See 4.3.12
Components	See 1.5.1

¹⁾ If the temperature of a winding is determined by thermocouples, these values are reduced by 10 °C, except in the case of

- a motor, or
- a winding with embedded thermocouples.

²⁾ The classification of insulating materials (Classes A, E, B, F and H) is in accordance with IEC 60085.

變壓器安規要求 – Safety (19)

- ☐ 變壓器之絕緣考量：除了結構，還有
 - ⊗ 溫溼度測試 (2.9 Humidity)
 - ⊗ 電氣絕緣測試 (5.2 Electric Strength)
 - ⊗ 固體絕緣測試 (2.10.5 Solid Insulation)

變壓器安規要求 – Safety (20)

變壓器之熱 (Heat) 考量：溫度 (Thermal)

絕緣系統之分類 (Insulation System Classification)



Table 1 – Thermal class assignment

ATE or RTE °C		Thermal class °C	Letter designation ^a
≥90	<105	90	Y
≥105	<120	105	A
≥120	<130	120	E
≥130	<155	130	B
≥155	<180	155	F
≥180	<200	180	H
≥200	<220	200	N
≥220	<250	220	R
≥250 ^b	<275	250	-

^a If desired, the letter designation may be added in parentheses, e.g. Class 180 (H). Where space is a factor, such as on a nameplate, the product TC may elect to use only the letter designation.

^b Designations of thermal classes over 250 shall increase by increments of 25 and be designated accordingly.

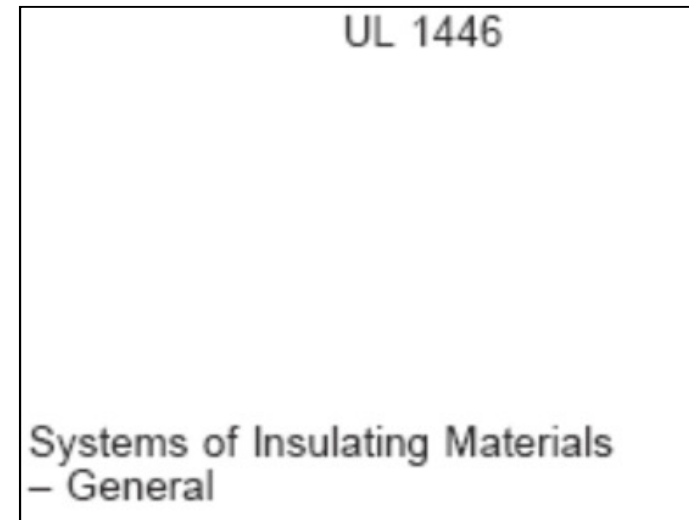


Table 4.1
Maximum hot-spot temperatures of insulation systems

System class	Maximum hot-spot temperature,	
	°C	(°F)
120(E)	120	(248)
130(B)	130	(266)
155(F)	155	(311)
180(H)	180	(356)
200(N)	200	(392)
220(R)	220	(428)
240(S)	240	(464)
Over 240(C)	Over 240	(Over 464)

變壓器安規要求 – Safety (21)

- ❏ 變壓器之材料有絕緣系統之認證，Class B (含)以上，有哪些好處。
 - ◆ 表示變壓器溫度等級可以宣告更高。
 - ◆ 在高溫時，宣告有具有絕緣系統之材料，在限制值內之電氣絕緣、耐壓特性以及可靠度受到保障。
 - ◆ 由於選用絕緣系統上，材料集合可以搭配，靈活度增高
 - ◆ 使用UL1446所認證之絕緣系統，可以減少終端產品在UL後續工廠檢驗時的廠驗項目。

變壓器安規要求 – Safety (22)

當使用到絕緣系統之認證，安規報告會如何描述？

20. Transformer (T1)	XX.	XX	Open type construction.	--	--
20-1. Insulation System	XX (廠家)	XX (型號)	Class B	OBJY2	UL
20-2. Core	--	--	Ferrite core, see Enclosure for dimension details.	--	--
20-3. Bobbin	SUMITOMO BAKELITE CO LTD	PM-8375, PM-9820, PM-9630	Phenolic, rated V-0 min., 150 degree C, min. 0.7mm thickness	QMFZ2	UL
20-4. Triple insulation wire (Primary)	FURUKAWA ELECTRIC CO LTD	TEX-E	Min. 130 degree C.	OBJT2	UL
20-4a. Triple insulation wire (Primary) (alternate)	TOTOKU ELECTRIC CO LTD	TIW-3	Min. 155 degree C.	OBJT2	UL
20-4b. Triple insulation wire (alternate)	TOTOKU ELECTRIC CO LTD	TIW-2	Min. 130 degree C.	OBJT2	UL
20-5. Metal plate (secondary)	--	--	Copper, see Enclosure for dimension details.	--	--
20-6. TUBING	GREAT HOLDING INDUSTRIAL PRODUCTS INC	TFL, TFT, TFS	Rated 200 degree C.	YDPU2	UL
20-7. VARNISH	JOHN C DOLPH CO	BC-346A	Rated 200 degree C.	OBOR2	UL

變壓器安規要求 – Safety (23)

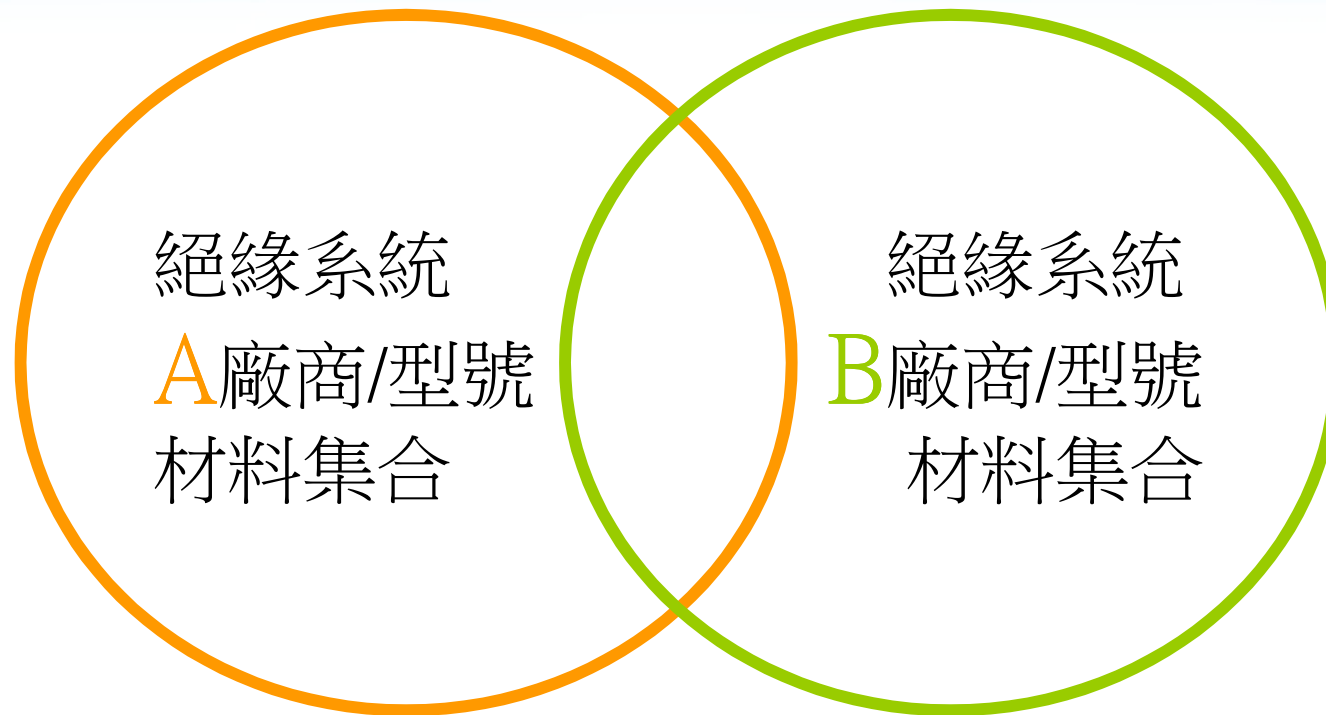
當使用到絕緣系統之認證，安規報告會如何描述？

變壓器規格文件 (Transformer SPEC)

9. MATERIAL LIST :					
NO.	PART	MANUFACTURER	MANUFACTURER PART NO.	DESCRIPTION	UL FILE NO.
1	BOBBIN	SUNITOMO BAKELITE CO. LTD.	150°C 94V-0 PN-B630,PN-9820	PHENOLIC	E41428
		SUNITOMO BAKELITE CO. LTD.	150°C 94V-0 PN-B375	PHENOLIC	E41429
2	TUBING	GREAT HOLDING INDUSTRIAL CO.,LTD	200°C TFL VM-1 200°C TFS VP-1 200°C TFL VM-1	POLYETRAFLUOROETHYLENE(PTFE)	E58255
3	MAGNET WIRE	FURUKAWA ELECTRIC CO. LTD	130°C NO. TEX-E (VDE NO. C86735)	TRIPLE INSULATED WIRE	F205460
		TOTOKU ELECTRIC CO. LTD.	155°C NO. TH-3 (VDE NO:4085154) 130°C NO. TH-2 (VDE NO:4085152)	POLYESTER(INNER,MODULE) POLYAMIDE(OUTER)	E166483
4	VARNISH	JOHN D. DOLPH CO.	90°C NO. RC-348A		E317427
5	INSULATOR	E I DUPONT DE NEMOURS & CO. INC	155°C 94V-0 FR530	POLYETHYLENE TEREPHTHALATE	E41938
		DUPONT-TORAY CO. LTD. RAPTOR BUSINESS DIV	240°C 94V-0 500MM,300MM		E73117
8	TAPE	3M COMPANY	130°C MATERIAL GROUP I NO.1381-1	POLYESTER FILM INSULATING TAPE	E17305
		3M COMPANY	130°C MATERIAL GROUP II NO.1380F-1	POLYESTER FILM INSULATING TAPE	E17305
		3M COMPANY	130°C MATERIAL GROUP II NO.1381F-1	MULTILAYER POLYETHYLENE TEREPHTHALATE FILM TAPE	E17305
		3M COMPANY	130°C MATERIAL GROUP III NO.1380F-2	POLYESTER FILM INSULATING TAPE	E17305
		SYMCO INC	150°C MATERIAL GROUP (FOR UL) GROUP I (FOR UL)	POLYETHYLENE-TEREPHTHALATE FILM INSULATING TAPE	E30282
		JINLIANG YANHU PRESSURE SENSITIVE GLUE COLLE	130°C MATERIAL GROUP I NO.C1	POLYETHYLENE TEREPHTHALATE FILM TAPE (YELLOW COLOR)	E34511

變壓器安規要求 – Safety (24)

當使用到多個絕緣系統，該如何評估？



變壓器安規要求 – Safety (25)

各絕緣材料之相關標準與產品類別

- ◆ 絕緣系統 (Insulation System) : UL1446
- ◆ 絕緣膠帶 (Insulation Tape) : UL510
- ◆ 套管 (Tubing) : UL224
- ◆ 線架 (Bobbin) : UL94, UL746C
- ◆ 凡力水 (Varnish) : UL1446
- ◆ 三層絕緣線 (Triple Insulated Wire: UL2353
- ◆ 繞線 (Coil) : UL1446 (ANSI MW1000)

Part III

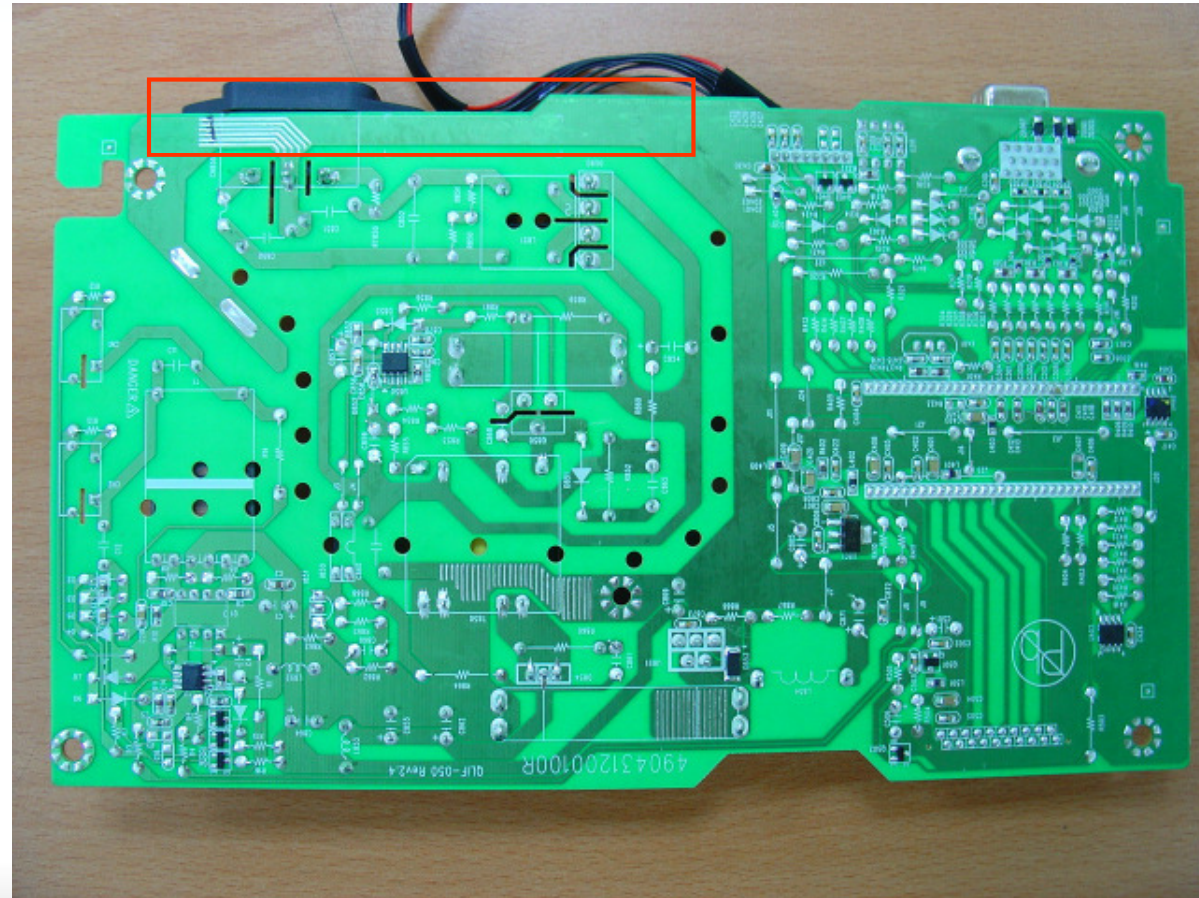
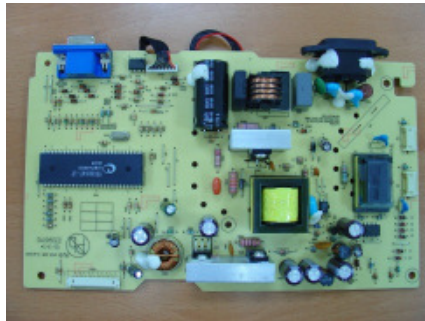
案例分析

變壓器之選擇與要求

安規工程師如何協助R&D人員

案例分析 (1)

遇到PWB之走線有保護接地考量時，該如何是好呢？



案例分析 (2)

遇到PWB之走線有保護接地考量時，該如何是好呢?

PROTECTIVE BONDING CONDUCTORS and their terminals of non-standard constructions, such as printed wiring protective traces, shall also be evaluated in accordance with the Limited Short-Circuit Test in CSA C22.2 No. 0.4, Bonding and Grounding of Electrical Equipment [Protective Grounding]. PROTECTIVE BONDING CONDUCTORS that can be determined to meet the equivalent of the minimum conductor sizes in table 2D and are provided with terminals not more than one size smaller than the sizes in table 3E (see 3.3.5) are considered to comply without test.

D1
D1
D1
D1
D1
D1

REFERENCE

(Adapted from **CSA C22.2, No. 0.4-M1982**)
Capacity of Test Circuit

Nominal Voltage	Equipment Full-Load Amperes, Single-Phase				Test Circuit Capacity, A
	120	208	240	277 V	
0 - 9.8	0 - 5.4	0 - 4.9	-	200	
9.9 - 16.0	5.5 - 8.8	5.0 - 8.0	6.5	1000	
15.1 - 34.0	8.9 - 18.8	8.1 - 17.9	-	2000	
34.1 - 80.0	18.7 - 44.0	17.1 - 40.0	-	3500	
Over 80	Over 44	Over 40	Over 6.5	5000	

案例分析 (4)

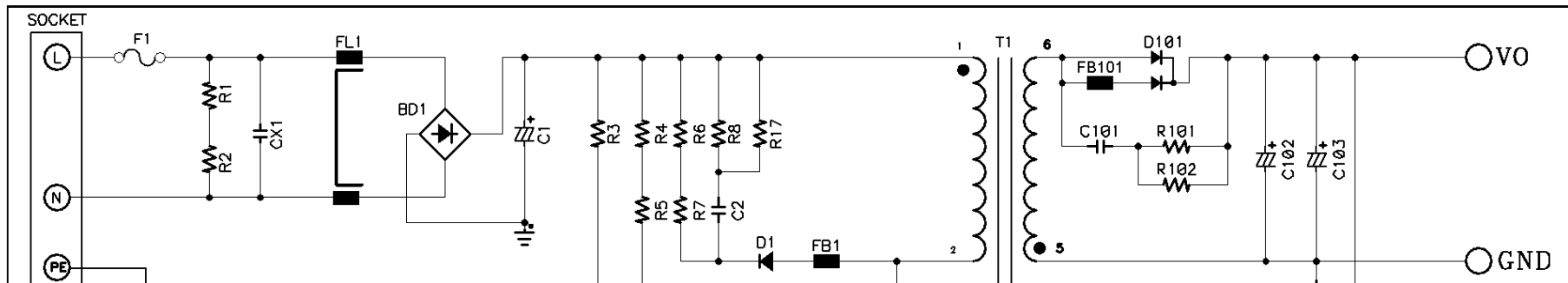
變壓器過載測試 (Annex C : Transformer Overload) 溫度限制值是否要減10度呢?

Table C.1
Permitted temperature limits for transformer windings

Protection method	Maximum temperature °C				
	Class A	Class E	Class B	Class F	Class H
Protection by inherent or external impedance	150	185	175	190	210
Protection by protective device which operates during the first hour	200	215	225	240	260
Protection by any protective device:					
- maximum after first hour	175	190	200	215	235
- arithmetic average during the 2nd hour and during the 72nd hour	150	185	175	190	210

案例分析 (5)

什麼樣的情況，輸出過載測試 (Power Supply Output Overload) 可以等同變壓器過載測試 (Transformer Overload) ?



案例分析 (6)

📖 平板變壓器 (Planer Transformer) 如何評估?

◆ 距離 (Distance)

最上/下層版 : 條文 2.10.3 & 2.10.4

內層板 : 條文 2.10.5.3 or 2.10.7 & 2.10.8

◆ 熱 (Thermal)



案例分析 (7)

📖 異常測試是否要考慮最大環境溫度 (Tma) ?

◆ 答案是.... **需要**

- 2.10.7 – Enclosed and sealed parts
- 4.2.7 – Stress relief test
- 4.3.12 – Flammable liquids
- 4.5.1 – Temperature Limits
- 4.5.2 – Resistance to abnormal heat
- 5.3.7 – Unattended equipment
- 5.3.8 – Compliance criteria for abnormal operating and fault conditions
- Annex A – Tests for resistance to heat and fire (A.1, A.2)
- Annex B.3 – Motor tests under abnormal conditions – maximum temperatures
- Annex C.1 – Transformers – overload test
- Annex E – Temperature rise of a winding
- Annex NAA (3.2.3) – Field Wiring supply connections
- Annex NAE (3.3.4) – Range of conductor sizes to be accepted by field wiring terminals

案例分析 (8)

📖 產品評估的高度超過2000公尺以上怎麼辦?

1.1.2 Additional requirements

– equipment intended to be used in vehicles, on board ships or aircraft, in tropical countries, or at altitudes greater than 2 000 m;

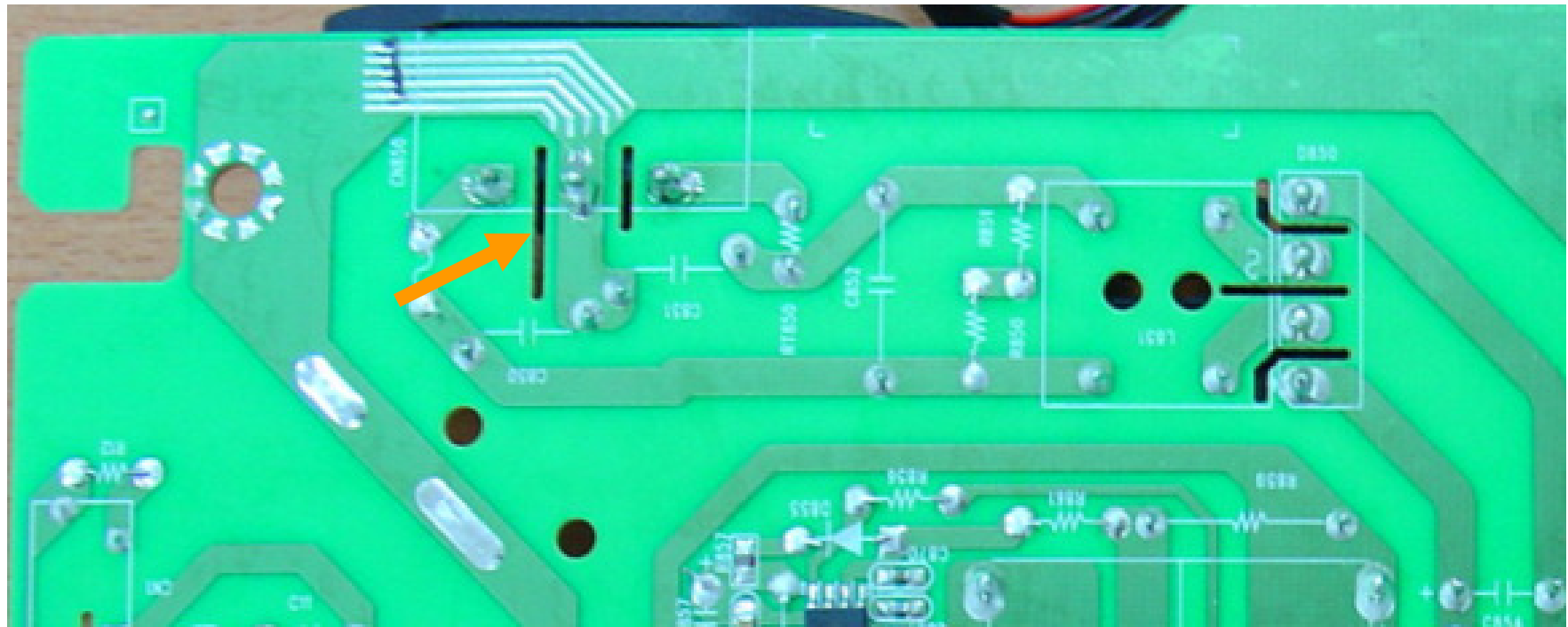
◆ 空間距離 (請看PAG對於沿面距離之要求) **需要增加**，根據

G.6 Determination of minimum clearances

For equipment to be operated at more than 2 000 m above sea level, the multiplication factors of table A.2 of IEC 60664-1:1992 shall be used in addition to table G.2. Interpolation of the table A.2 values is permitted.

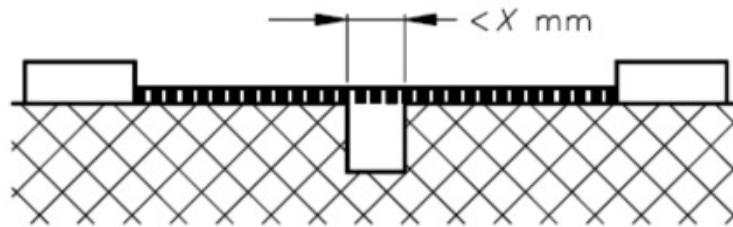
案例分析 (9)

如何看有效的剖溝，來增加沿面距離



案例分析 (10)

如何看有效的剖溝，來增加沿面距離



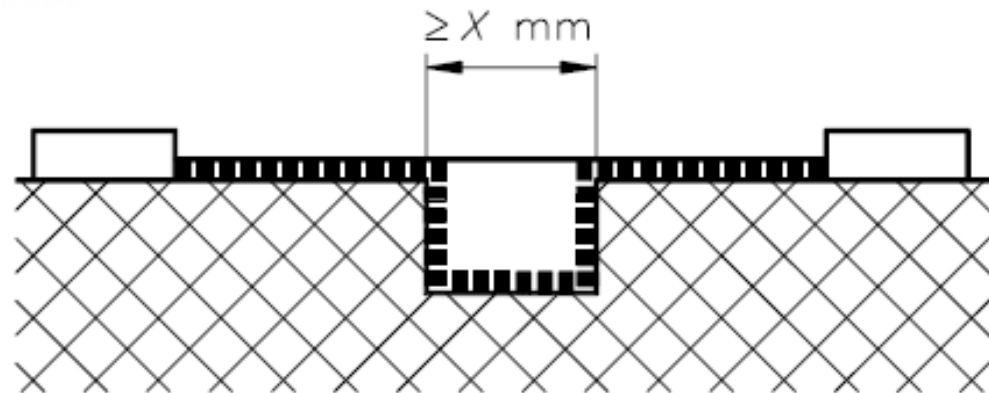
Condition: Path under consideration includes a parallel or converging-sided groove of any depth with width less than X mm.

Rule: CLEARANCE and CREEPAGE DISTANCE are measured directly across the groove.



Table F.1 – Value of X

Pollution degree (see 2.10.1)	X mm
1	0,25
2	1,0
3	1,5



案例分析 (11)

如何看空間/沿面距離

Figure F.3 – V-shaped groove

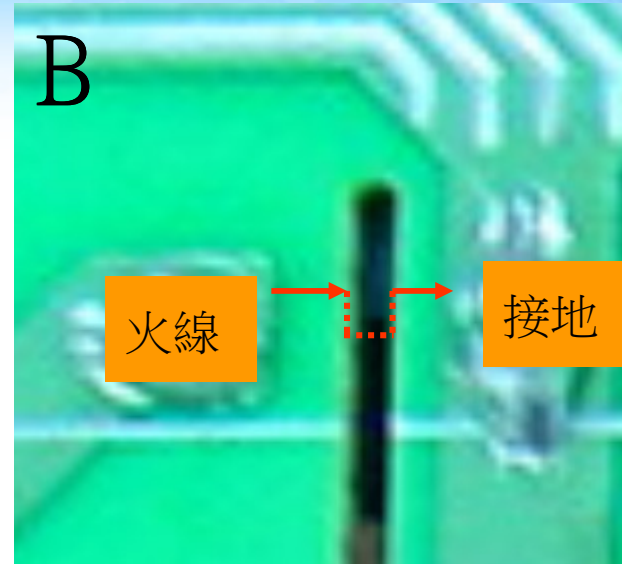
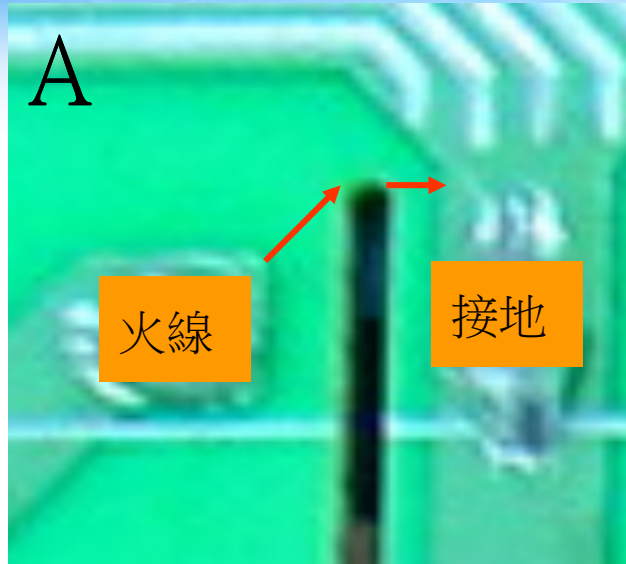


Condition: Path under consideration includes a rib.

Rule: CLEARANCE is the shortest direct air path over the top of the rib. CREEPAGE DISTANCE path follows the contour of the rib.

————— Clearance
- - - - - Creepage distance

實作演練



◆ 請問A與B那個是正確的量測方法?

安規工程師如何協助R&D人員

④ 建立Critical Component Database

時常使用之重要零件需分類建檔並隨時update資料
保持兩個以上的供應商

④ 最初結構設計參與

先行了解產品設計之功能及適當的安規要求
PWB Layout、外殼的尺寸及元件的間距之設計規劃
安規考量上元件使用的規定與準則
成品的結構檢驗

☉ Thanks for your
attention



☉ 期待再相會

Contact Information

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