

Product Safety Testing Reduces the Risk of Shock, Fire, Explosions



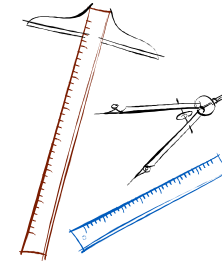
Central Texas Product Safety Engineering Society
April 20, 2010

David Lohbeck, Principal Safety Engineer
National Instruments

Agenda – Product Safety Testing Reduces Risks

Testing - Design - Intro

- **Laws & Standards**
- **Certifications & Marks**
- **Terms, Design & Isolation**
- **Hazards: Shock, Fire, Mechanical, Explosion**
- **Dielectric Tests & Fault (Shorts) Tests**
- **Flammability (Fire) Tests**
- **Hazardous Locations (Explosion) Tests**



Global Requirements

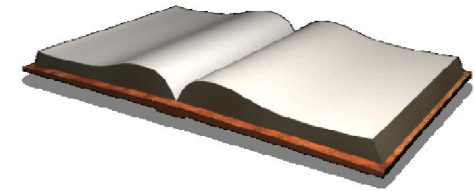


- ✓ **Laws** in U.S., EU, and Globally tell us “**why**” comply
 - Protect consumers, product, surroundings
 - Fines, withdrawal and jail when not in compliance
- ✓ **Standards** show us “**how**” to comply
 - Design, components, documentation, etc
 - Safety tests and Pass/Fail criteria
- ✓ **Certification** is positive “**evidence**” of compliance
 - IEC and national “standards” are basis for certification
 - Certification (Marks) prove safety and ‘*due diligence*’



Meet Standards & Laws are met. Certification proves Safety!

Product Safety Standards



Standard	Equivalent	Scope	Product Types (Environ)
IEC 60950-1	UL, CSA, EN	Information Tech Equip	Computers & similar
IEC 61010-1	UL, CSA, EN	Test, Meas, Ctl, & Lab Eq	Measurement products
IEC 60601-1	UL, CSA, EN	Medical Equipment	Medical devices
IEC 60065	UL, CSA, EN	Electronic Appliances	Audio/visual products
IEC 60335-1	UL, CSA, EN	Electrical Appliances	Household tools & similar
IEC 60079-0	UL, CSA, EN	Electrical Apparatus	(Explosive atmospheres [Hazloc])
Others	-	-	-

Many component standards are not yet harmonized.
All safety aspects must be addressed even if lacking in product standard,

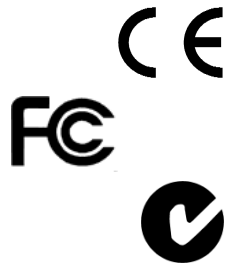
Certifications, Marks, Self-Declarations



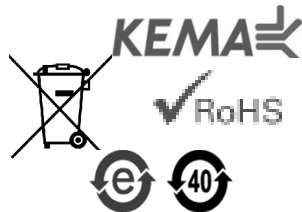
- North American Product Safety
- European Union Product Safety



- North American Hazardous Locations
- European Union Hazardous Locations
- International Marine Approval



- European Union EMC and Safety *
- North American EMI *
- Australian EMI *



- WEEE and RoHS *
 - Quality and Environmental Systems **
- * Self-Declaration
** Organizations

What's the "CE" Marking?

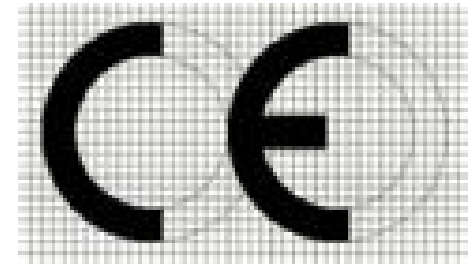


The "goal" of the CE marking:

- Mandatory marking (symbol) for European EMC & safety
- Manufacturers/suppliers self-declaration symbol
- Products may be *placed on the EU market*
- Authorities audit & remove failing products

The CE marking is "not":

- Not a Certification, Approval or Mark (ing)
- Not a safety quality mark
- Not for marketing purposes
- Market may expect Certifications & Marks



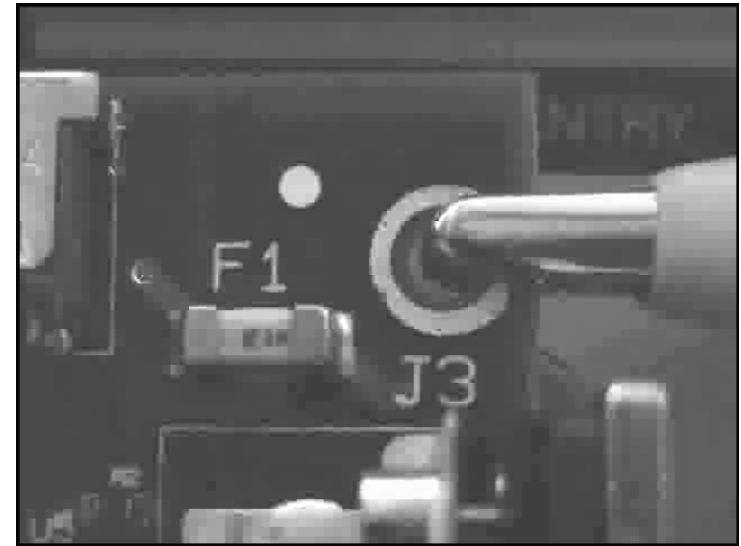
*"Conformite
Europeenne"*

Why Product Safety Testing?



Safety Hazards

- **Electric shock**
- **Energy**
- **Heat & Fire**
- **Explosion**



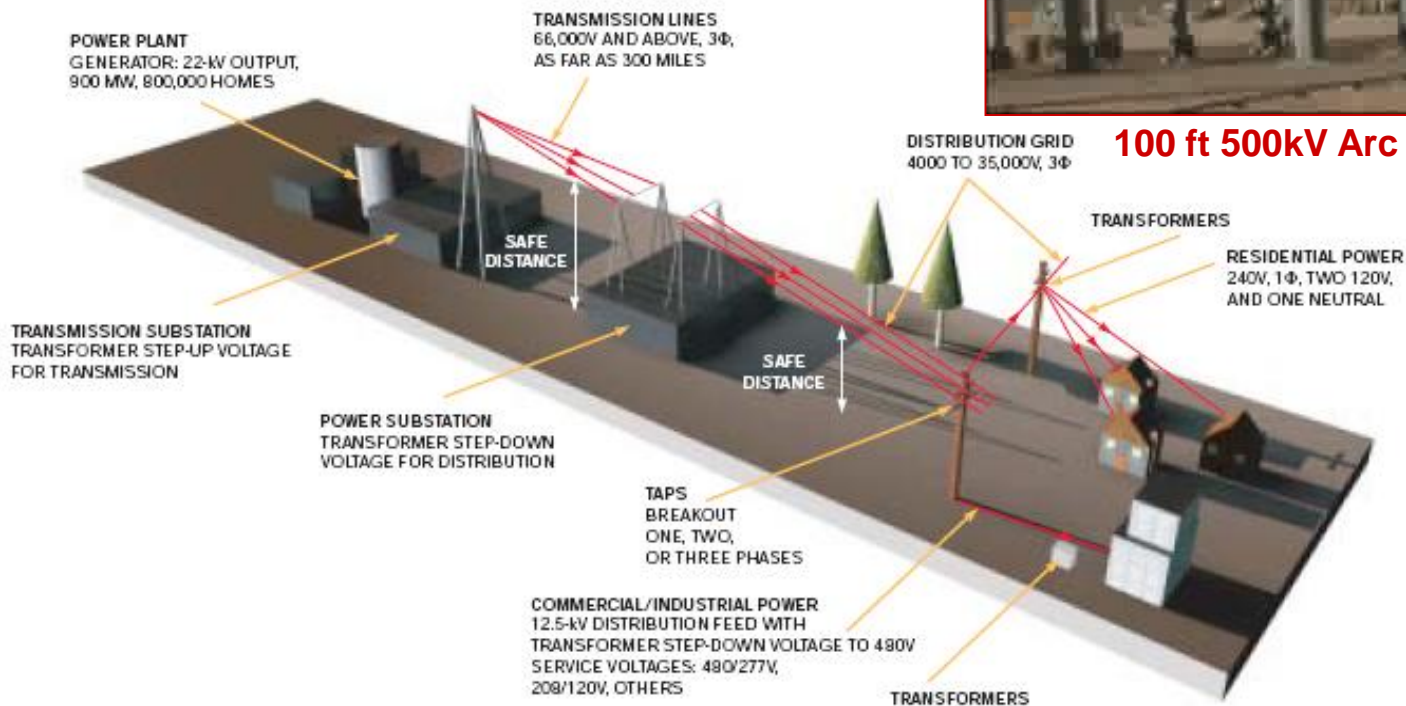
- **Mechanical**
- **Radiation**
- **Chemicals**
- **Sound**

High Voltage > 1,000Vac

- High Voltage for Power Distribution
- Arc's jump 1 inch for every 10,000V
- 10 foot min safe distance at 50kV *



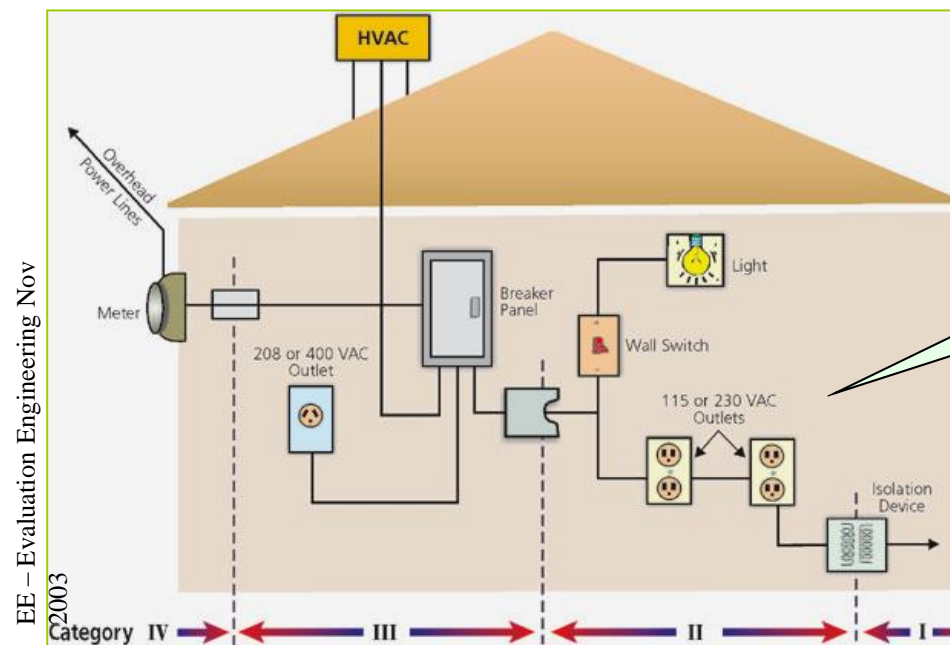
100 ft 500kV Arc on Substation Switch



* OSHA requires 10cm (4in) clearance for each 10kV > 50kV

“Low” Voltage Does NOT Mean “Safe” Voltage

- **Low Voltage** is $< 1,000\text{Vac}$ or $1,500\text{Vdc}$
- **MAINs Voltage** (wall outlets) is 120V (U.S.); 230V (Europe)
- **Hazardous Voltage** is $> 30\text{Vrms}$ & 42.4Vpk or 60Vdc
- **Safe Voltage** (SELV) is $\leq 30\text{Vrms}$ & 42.4Vpk or 60Vdc



Overvoltage
Categories I - IV

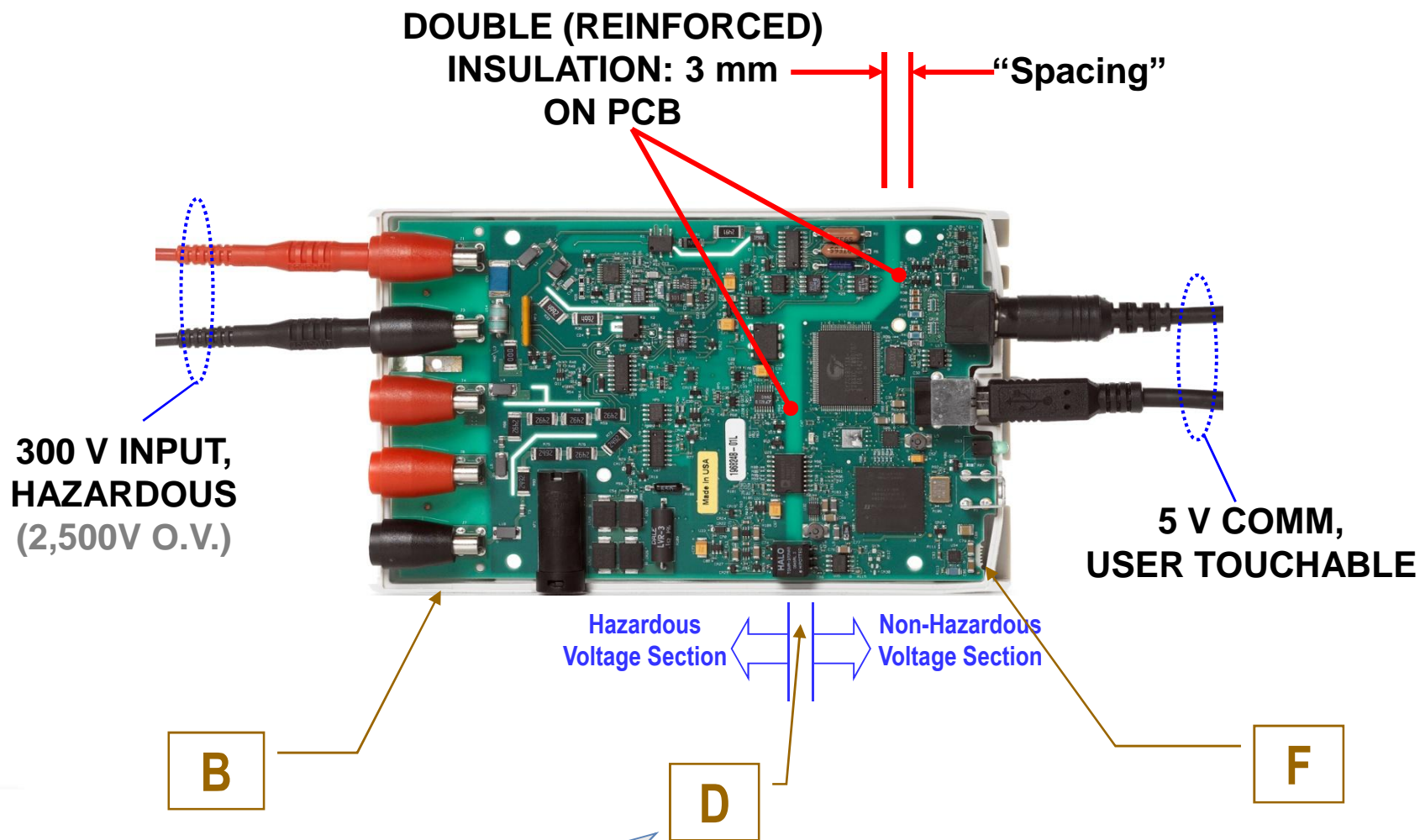
Isolation means there's no direct electrical connection between two or more circuits or between circuits and accessible metal parts.



It's purpose is to isolate “transient overvoltages” and “hazardous voltage” circuits, which if connected together could allow the flow of harmful current, voltage, energy or charge.



Insulation – Functional, Basic, Double



Why Double or Reinforced?
Protect Users, Single Faults, Hipot!

Insulation Spacings and Withstand Values

Basic Insulation ² Pollution Degree 2 Measurement Category II					Double or Reinforced Insulation ² Pollution Degree 2 Measurement Category II				
Working Voltage (rms or DC) up to	Clearance	Creepage on PCB (CTI >175)	Creepage In Equipment (CTI >100)	rms Test Voltage	Working Voltage (rms or DC) up to	Clearance	Creepage on PCB (CTI >175)	Creepage In Equipment (CTI >100)	rms Test Voltage
50	0.2	0.2	1.2	350	50	0.2	0.4	2.4	510
100	0.2	0.2	1.4	490	100	0.4	0.4	2.8	740
150	0.5	0.5	1.6	820	150	1.6	1.6	3.2	1,400
300	1.5	1.5	3.0	1,350	300	3.3	3.3	6.0	2,300
600	3.4	3.0	6.0	2,200	600	6.5	6.5	12.0	3,700
1,000	5.5	5.5	10.0	3,250	1,000	11.5	11.5	20.0	5,550

Table 1. Creepage and Clearance Per IEC 61010-1:1990¹

1. Table 1 is for illustration only. Refer to IEC 61010-1 for tables and actual values.

2. Distances in millimeters; PCB is not coated.

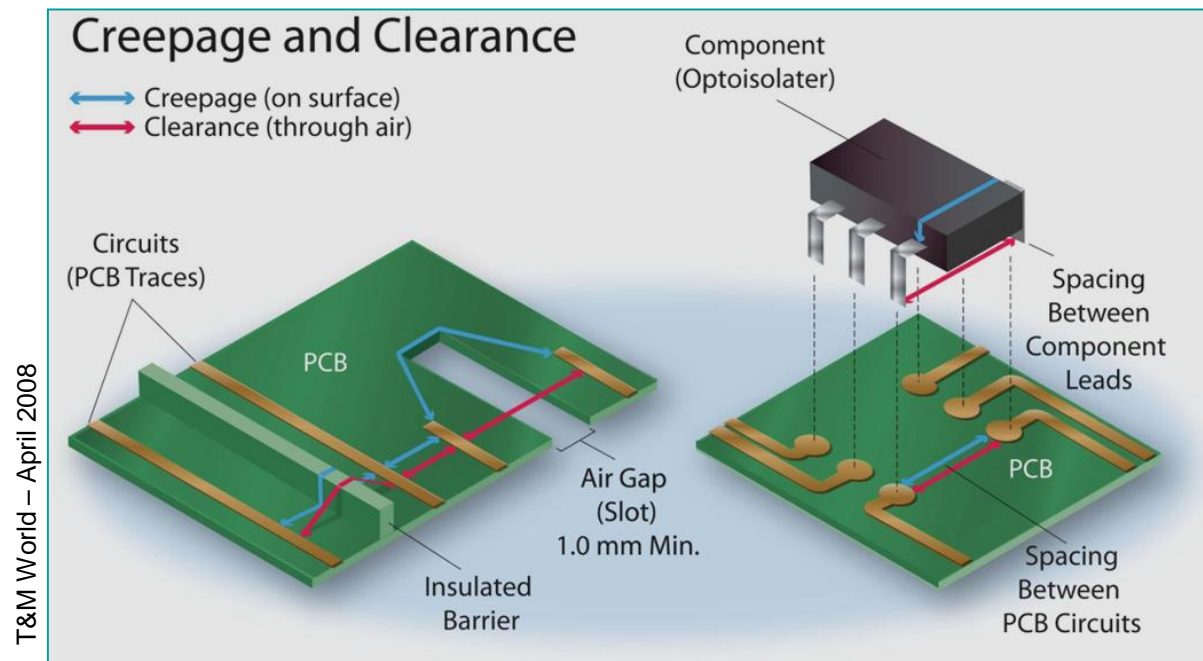
✓ NEED TO KNOW:

- Working Voltage (rating, input, etc)
- Measurement Category
- Pollution Degree 2 (offices/labs)
- Basic or Double/Reinforced Insulation
- Other; CTI, etc

✓ TO FIND - SPACINGS & HIPOT VALUES:

- PCB Spacings
- Other Spacings (components, etc)
- Withstand Test Voltage (AC or DC)

Spacings – Creepage and Clearance



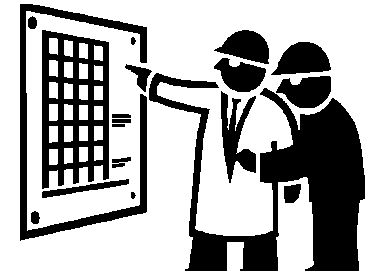
Safety Test Examples



Test ¹	Purpose
<u>Dielectric Withstand (Hipot)²</u>	Dielectric withstand (electric strength), a.k.a. high potential (hipot), stresses insulation to verify high voltage (overvoltage) withstand
<u>Abnormals (Single Faults)</u>	Simulates likely fault conditions that are liable to result in hazards such as, hazardous voltage, current, temperature, fire.
<u>Mechanical Strength (Impact)</u>	Product enclosures are subjected to various force, drop, and impact tests.
<u>Temperature</u>	Temperature shall not cause a hazard in normal or single fault condition, nor shall it cause spread of fire.
<u>Ground Continuity (Ground-bond)²</u>	Ground continuity checks bond strength of metal parts and enclosures to ensure proper grounding.
<u>Cooling Abnormal</u>	Simulates clogged air filters, blocked vent openings and fan malfunction.
<u>Permissible Limits</u>	Accessible parts shall not be hazardous live in normal or single fault condition.
<u>Others</u>	Additional tests may be required depending on product design,

1) ≈ 50 tests in IEC 61010-1. 2) Hipot & Grd-cont in production.

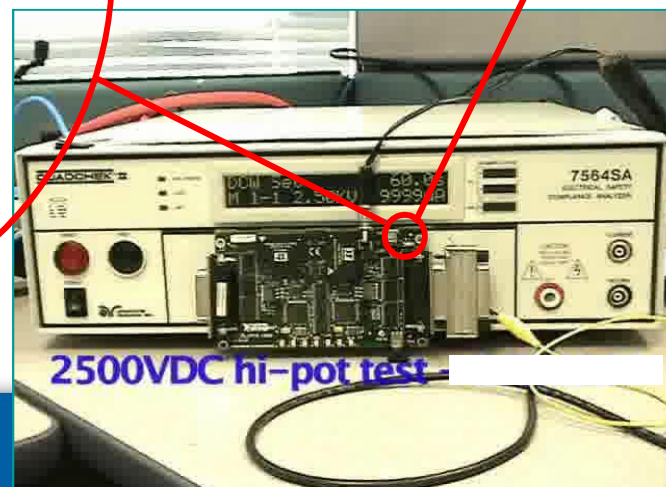
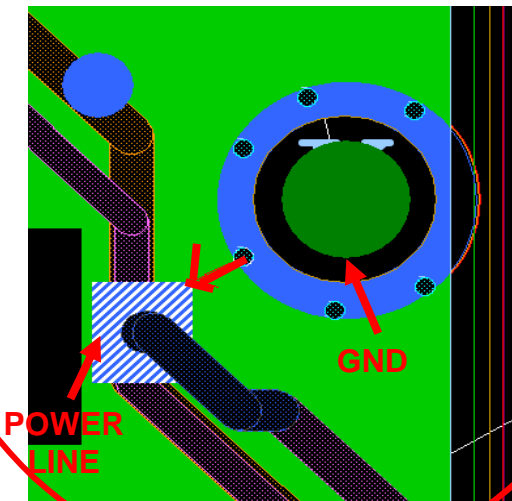
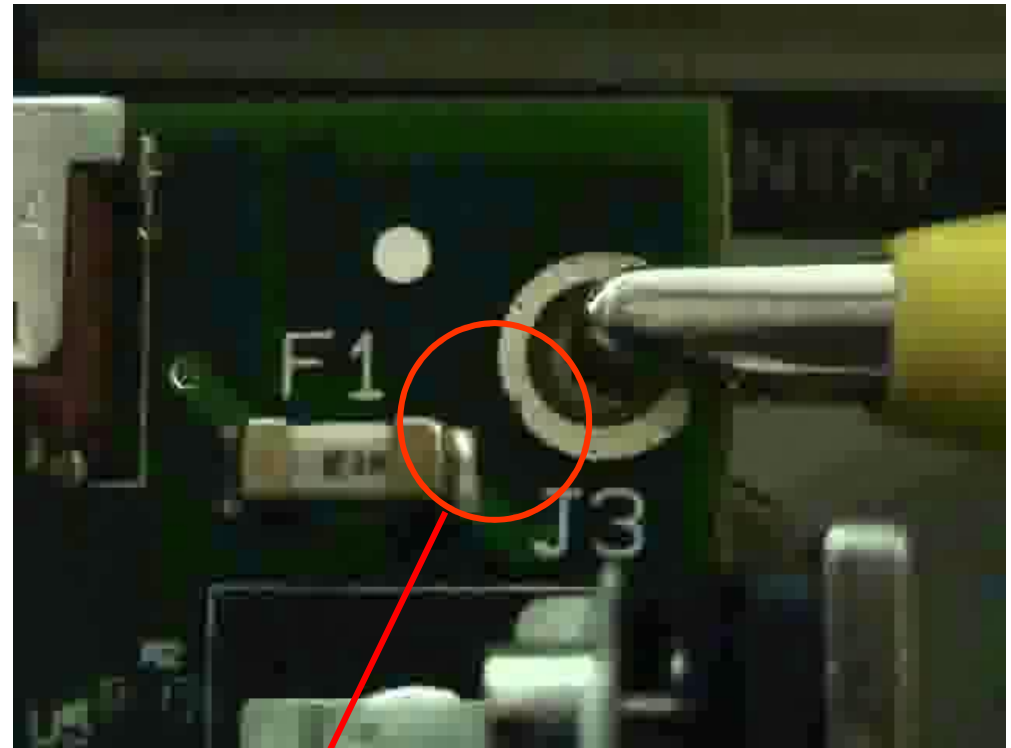
Hipot a.k.a., *high potential or dielectric withstand, is a high-voltage test that checks a products insulation to ensure there's no electrical breakdown.*



- ***“Type Tests”*** – *One minute test for new product “designs,” after 48 hr humidity preconditioning, to verify design meets safety spacings, insulation, etc. (Double/Basic values)*
- ***“Routine Tests”*** – *Two second test in “production,” without humidity preconditioning, to check for manufacturing safety defects such as, loose wire, screw, etc. (Basic value)*



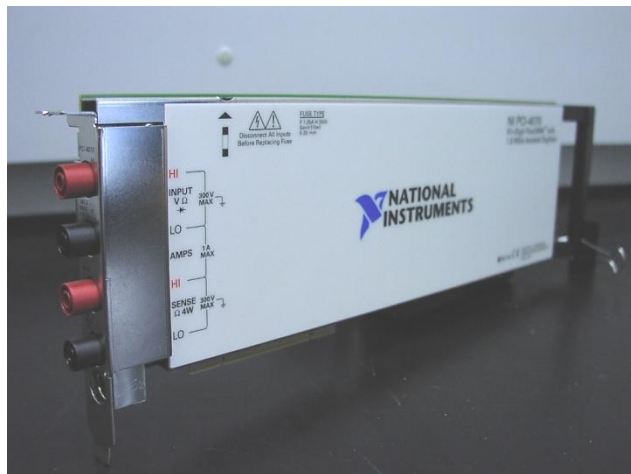
Hipot Arc-Over Example “Shock”



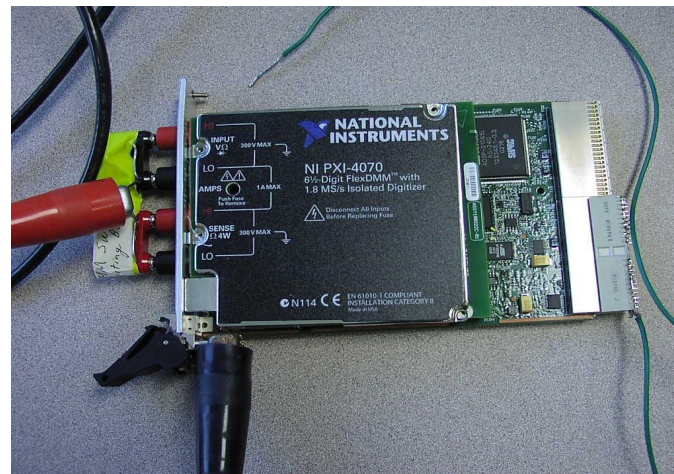
Problem/Solution:

- 1.17mm creepage
Power Line to Gnd pad.
Failed at 2400VDC
- 2.20mm required;
PCB redesign to pass.

Isolation = 1) Input + 2) Spacings + 3) Withstand



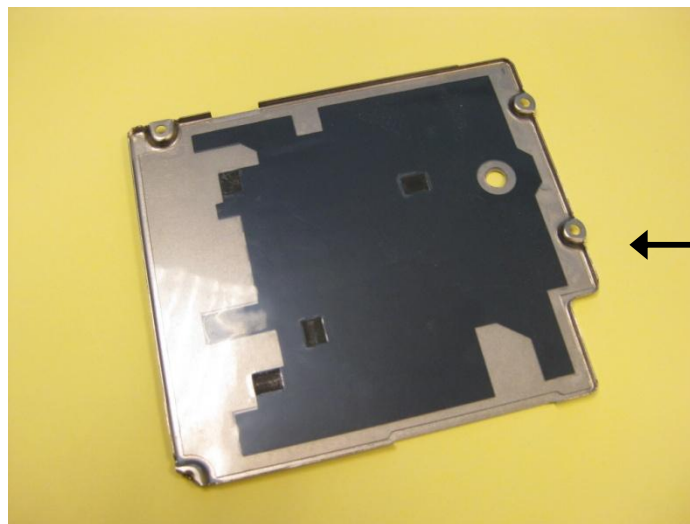
Input: 300V CATII



Withstand Test

Withstand Test (hi-pot):

1. Double: Inputs to PCI Bus:
2300Vrms or 3250VDC
2. Basic: Inputs to Shell/Gnd:
1350Vrms or 1900VDC

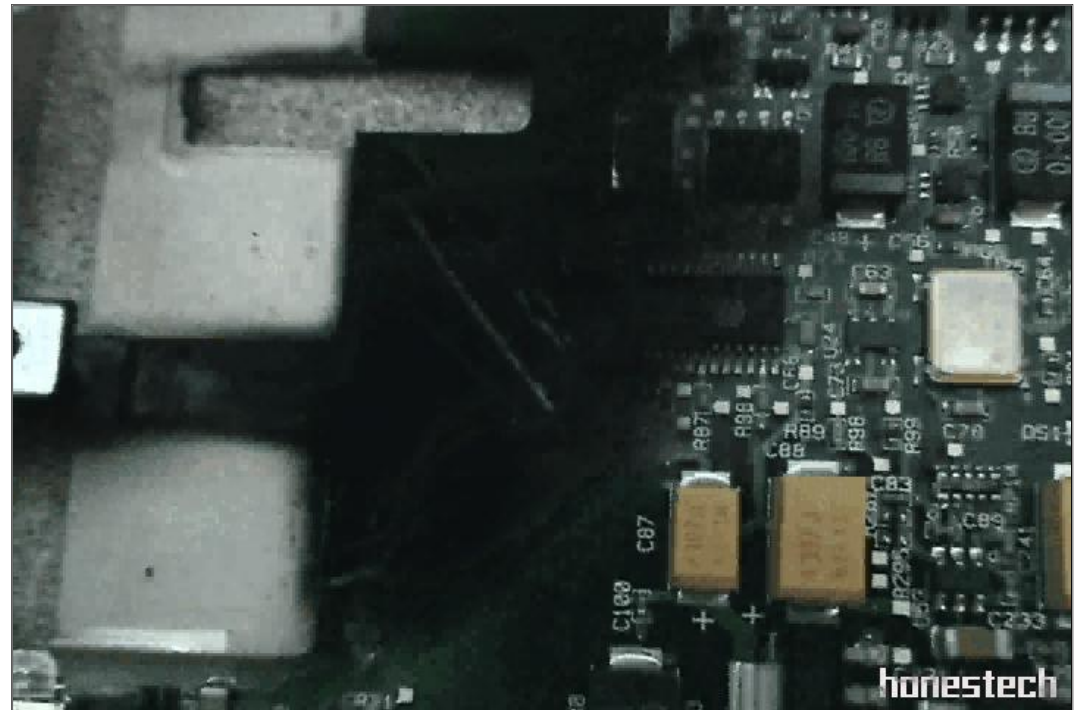


← **Shield with Insulation/
Conductive Layer**

Hipot Test After Fault

1. Voltage Into Current Port
2. Component Explodes
3. Fails Hipot Test (Basic) via Tracking!

Pass Hipot
After Fault
Too!

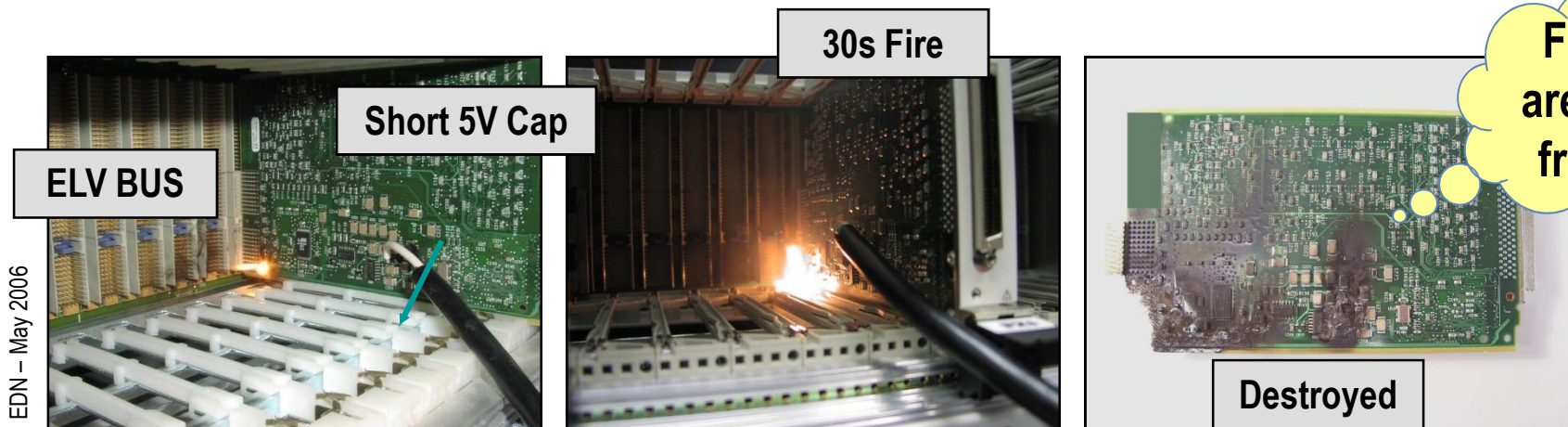


Single Fault Tests – “Fire”

5V-to-Grd Component Short



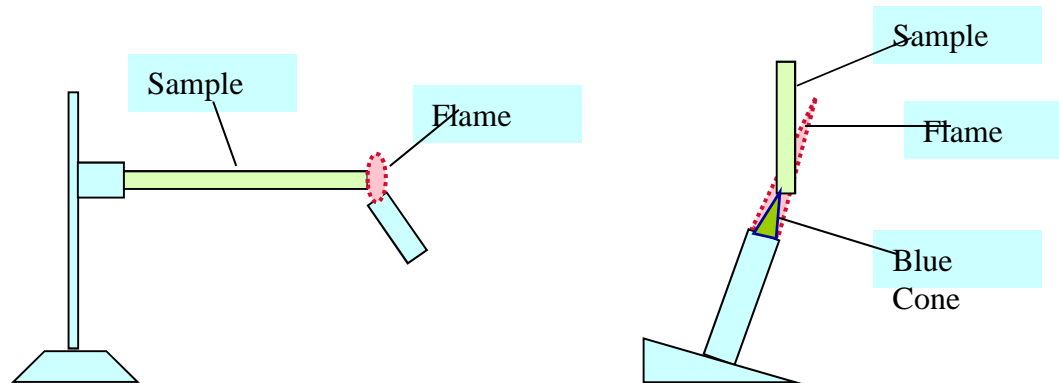
- Short and/or open components; one at a time
- No excessive voltage, current, heat, fire
- Pass hi-pot test after fault



This fire was contained, but what if it get's outside the enclosure?

Flame Tests - Materials & Bottom Openings

- Flame Tests for Plastic Materials (Horizontal (HB) and Vertical (V-0)):



Dangerous Flame Test for Bottom Openings:



UL's Infamous:

***HOT FLAMING
OIL TEST***

See > <http://www.conformity.com/0211dangerous.pdf>

Enclosure Protection



Electrical

- Prevents contact with hazardous voltage
- Ensures isolation from overvoltages



Fire

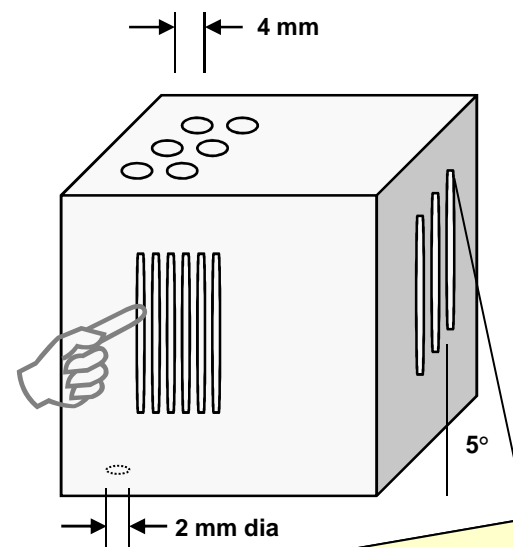
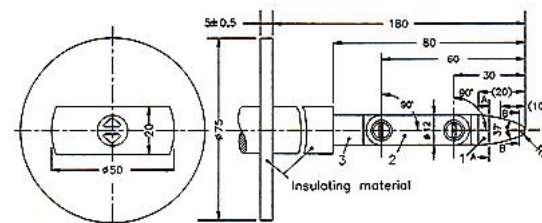
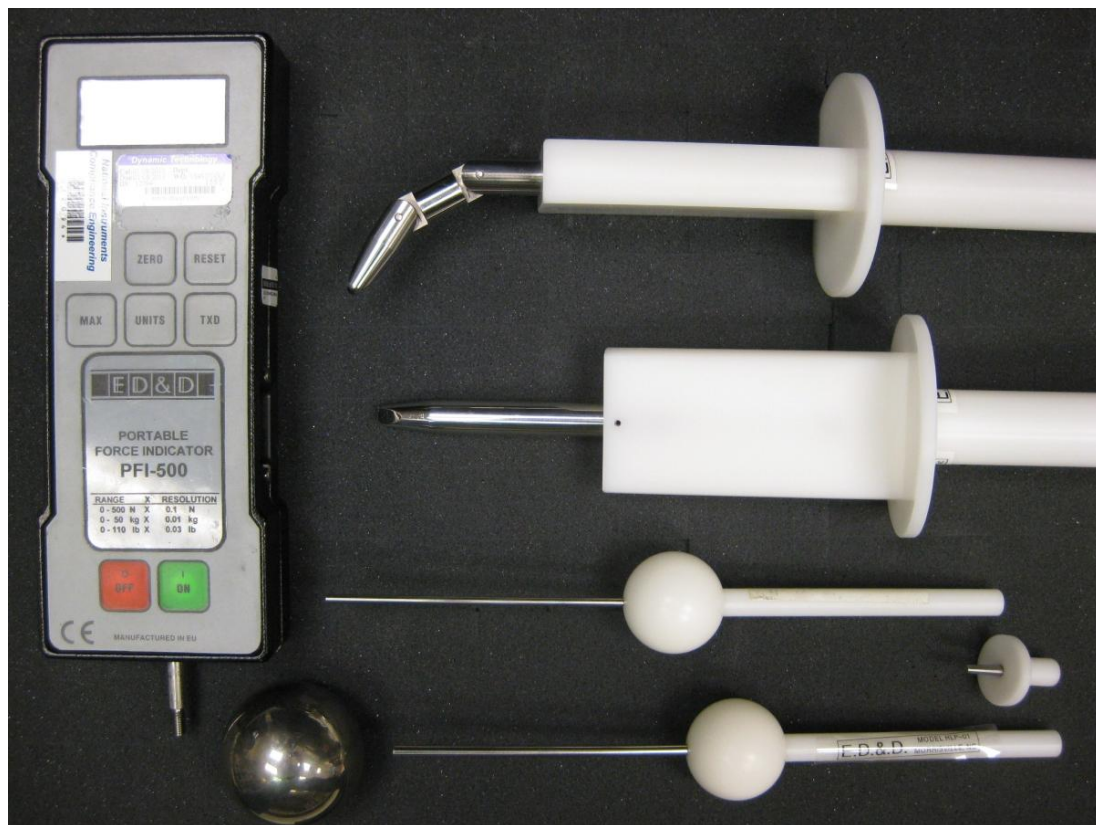
- Minimizes ignition risk within
- Prevents flame propagation outside



Mechanical

- Stops access to moving parts
- Stability, rigidity, limits burn

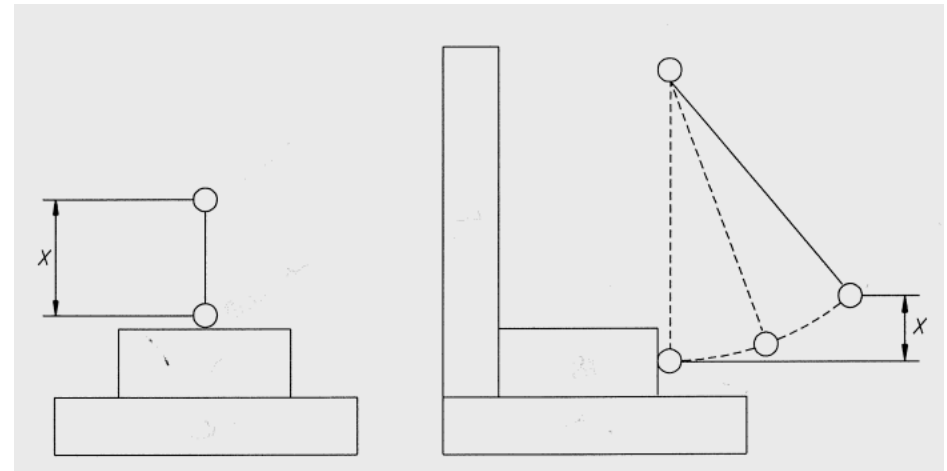
Enclosure Test Devices



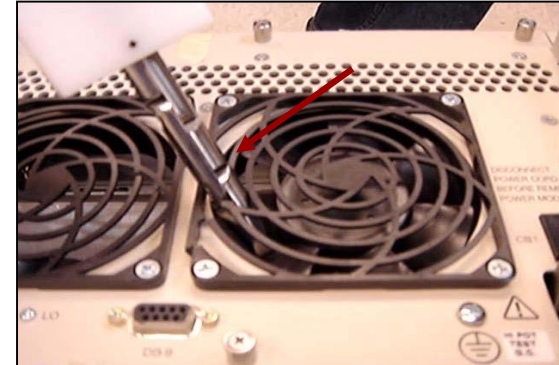
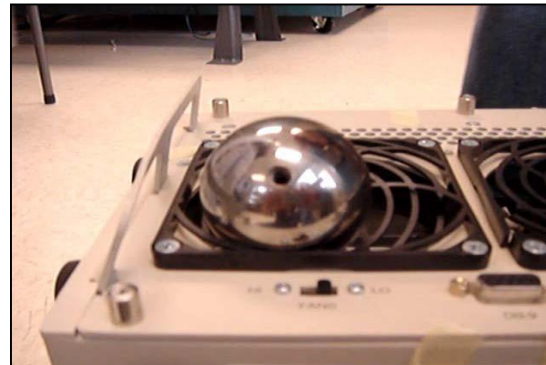
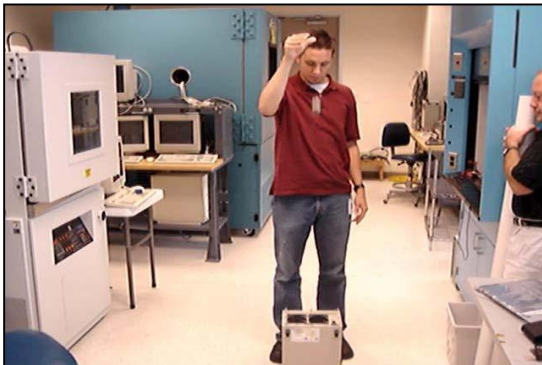
✓ Must remain safe during normal operation (finger) & after single fault (impact)!

Ball Impact Test

- Enclosures, guards, etc.
- To Pass after impact:
 - No access to fan, sharp edges, etc
 - No access to hazardous voltage
 - Pass hipot test after impact tests



50mm Dia, 500G, 5J, 1m drop/3pts



Potentially Explosive Atmospheres - HazLoc



Source of ignition:

- **Arcs and sparks** – Operation of motors, contactors, switching, plug/unplug comp's
- **High temperatures** – Lamps and lighting fixtures temps can ignite hazardous materials
- **Electrical failure** – Burnt out lamp socket or short

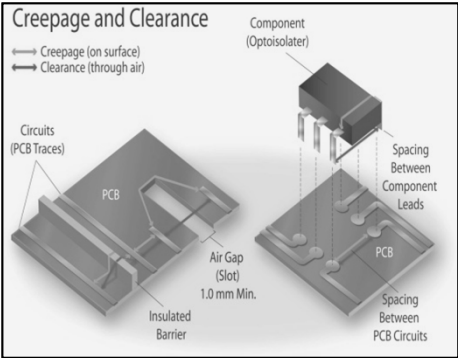
Class defines type of hazard (location):

- **Class I** – Flammable gases, vapors, and liquids (gas refineries, dry cleaners, spray painting)
- **Class II** – Combustible dusts (grain elevators, flour/feed mills, Mg/Al plants, spice/coal manuf)
- **Class III** – Ignitable fibers and flyings (textile and cotton mills, wood processing)

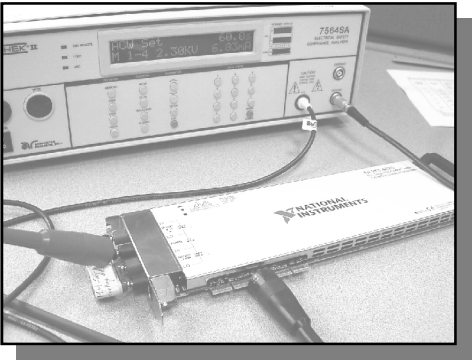
Division (Zone) defines severity of hazard:

- **Div 1** – Exists all or some of the time under normal operating conditions (> 10hr/yr)
- **Div 2** – Not likely to exist under normal operating conditions (1-10 hr/yr)

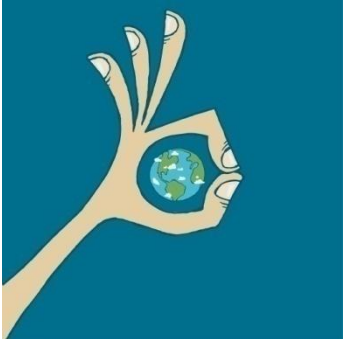
“Checks” for Product Safety



 Design

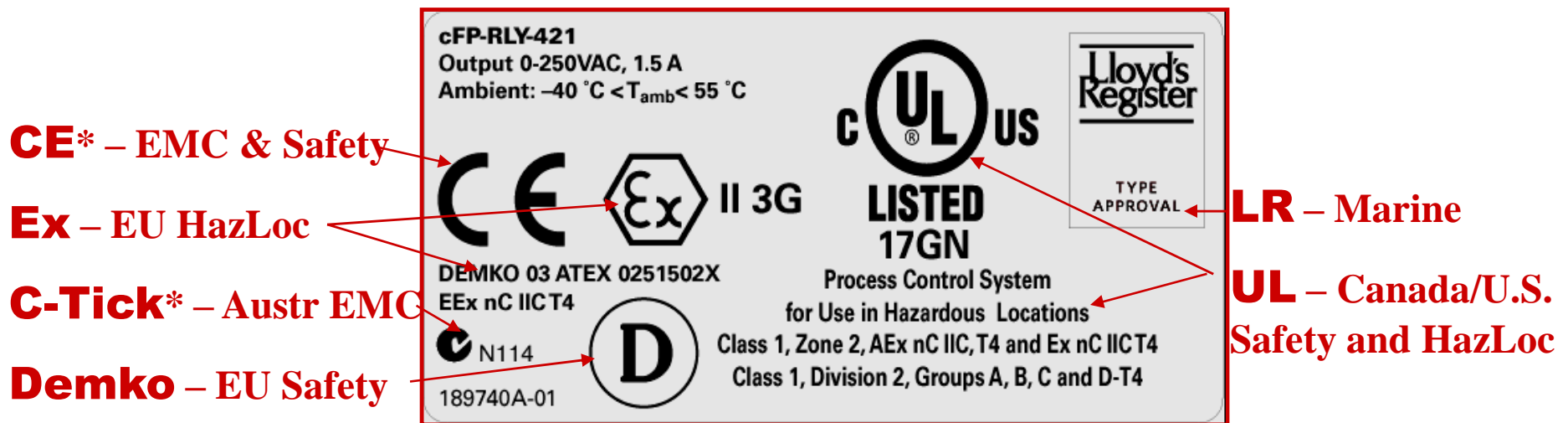


 Testing



 Certification

- Marks Prove Compliance - Design, Testing, Certification



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Certifications by Type (Listed by Model)

- Safety Certifications
- HazLoc Certifications
- EMC Declarations
- Marine Approvals
- MIC Certifications (Korean EMC)
- EU RoHS Declarations

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Marks	Certifications	Title
CE	CE	European Union EMC and Safety
FCC	FCC	North American EMC
C-Tick	C-Tick	Australian EMC
MIC	MIC	Korean EMC
UL	UL	North American Product Safety
Demko or VDE	Demko or VDE	European Union Product Safety
UL	UL	North American Hazardous Locations
Ex	Ex	European Union Hazardous Locations

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- Certification: Safety Design and Certification for Test and Measurement Products - Part 1

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The following tutorials give you the information you need to learn about the important role standards and certification play for international compliance. Simply click on the article or video below to learn about safety and EMC.

Product Safety and EMC Articles

- Hazardous-voltage primer [EDN]
- Safety isolation protects users and electronic instruments [EDN]
- Certification: Safety Design & Certification for Test & Measurement Products - Part 1 [EE]
- Design: Safety Design & Certification for Test & Measurement Products - Part 2 [EE]
- Safety certification for the T&M world [T&MW]
- The CE marking: separating fact from fiction [EDN]
- EMC: Cost & Quality Improvement of Automating Radiated Emission Preliminary Scans [IEEE]
- Website: Product Certification on ni.com/certification [NI]

Product Safety and EMC Videos

Safety in High-Voltage Environments (video: 5:19)
NIWeek 2006 Keynote
This Keynote presentation shows why isolation is important for product safety and in protecting users from hazards posed by high voltages. The concept of isolation at the product PCB level is discussed. Demo's of high voltage testing, a.k.a. withstand or hipot, will be shown with alarming results. Don't miss this one!

Isolation Technologies (video: 5:20)
NIWeek 2006 Keynote
Isolation helps improve product measurement performance and accuracy. Isolation is especially important in adverse environments where common mode voltages and electrical surges are more common. At this Keynote presentation, voltage measurement demo's show how measurements are adversely affected with inadequate isolation and how test accuracy is maintained with proper isolation, even when common mode voltages are present.

Safety and Isolation (audio: 13:04)
NI Podcast, May 26, 2006
Listen to a discussion about isolation and safety considerations when selecting instrumentation. Learn how to avoid frying your new instrumentation hardware by applying too much voltage, and how to understand isolation specifications.

Safety Articles

Video's, Podcast's,
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Questions?

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“And who said safety’s not fun”?