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APEC 2016 Component Level Safety Certification in Systems-IEC60747-17/UL1577

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3/20/2016

Agenda

- What is safety isolation
- Isolation Concepts
- Regulatory Landscape
- New Technologies
- Adapting Standards

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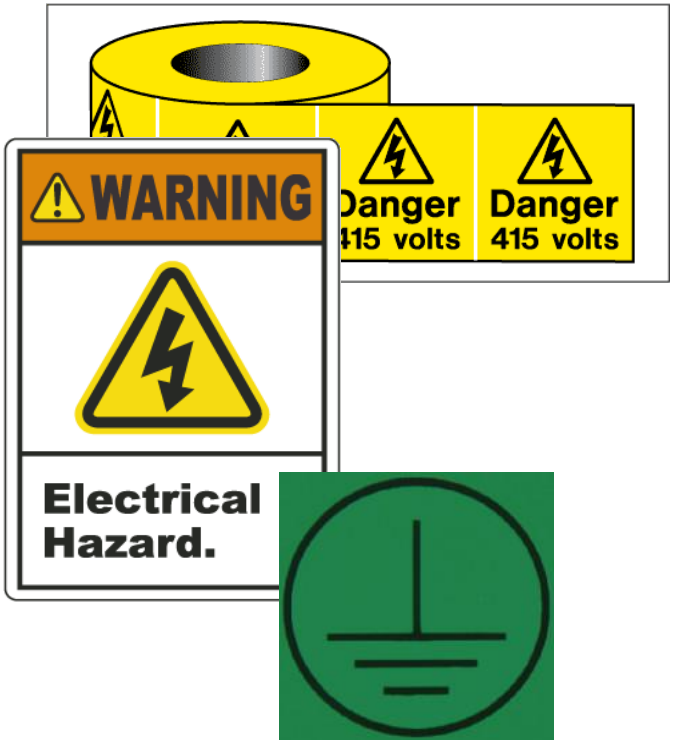
What Is Safety Isolation

Goals of a Safety Standard



- Application of a safety standard is intended to reduce the risk of injury or damage due to the following
  - Electric shock
  - Energy related hazards
  - Fire
  - Heat related hazards
  - Mechanical Hazards
  - Radiation
  - Chemical hazards

IEC

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Requirements for Safety

- Accessible parts must be protected with Double or Reinforced insulation
  - Mains voltage
  - Transients on the Mains
  - Hazardous secondary voltages
  - Internally Generated Transients
- Basic Insulation can be
  - Galvanic Isolation
  - Earthed Chassis
  - Earth referenced secondary circuits containing
    - Overvoltage protection
    - Current limiting
- Double Insulation
  - Basic insulation plus an independent redundant basic insulation
- Reinforced Insulation
  - A single system that provides the protection of double insulation

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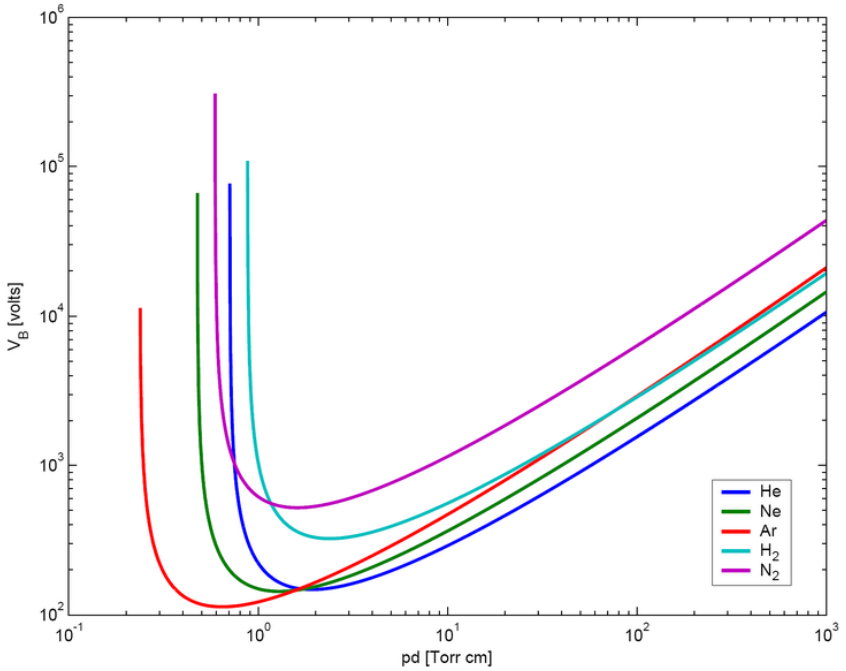
Isolation Concepts

Arcing in Air – External Clearance

- Paschen Curve
  - The gas has a minimum breakdown voltage at low pressure where the Mean free path is long
- Required Clearance for Basic and Reinforced insulation set by
  - Altitude
  - Peak Voltage



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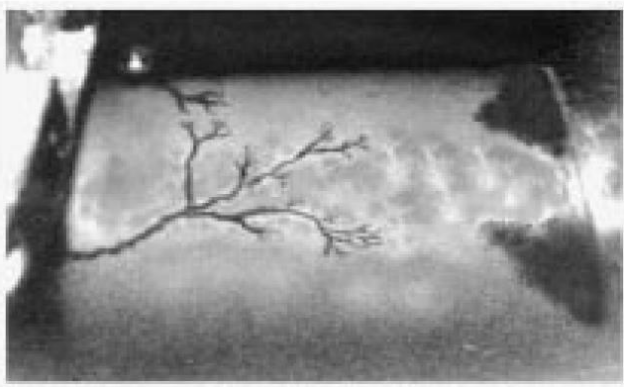
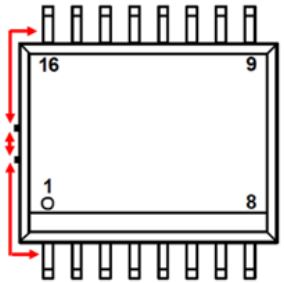
Tracking – External Creepage

- Tracking
  - carbon filaments along a surface leading to leakage and erosion
  - Only Polymer Based Insulation tracks
  - Different polymers track differently
  - Tracking is driven by the average voltage over time
- Creepage
  - Distance along a surface withstanding a potential
  - Required distance to achieve insulation lifetime
  - Reinforced insulation requires 2x the basic requirement





Comparative Tracking Index

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

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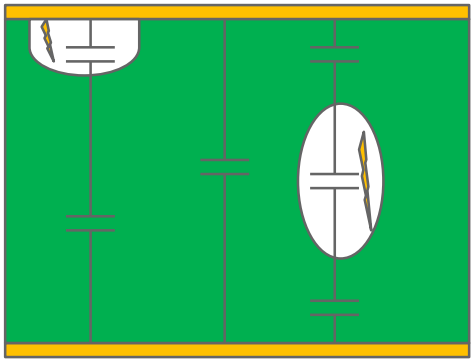
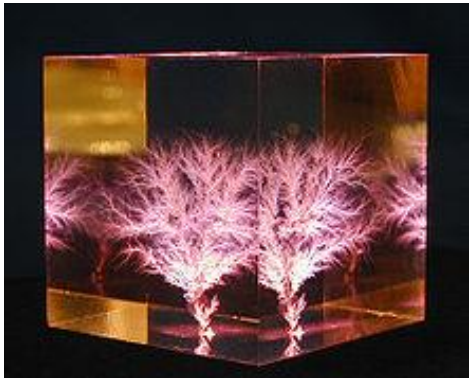
Partial Discharge – Internal Clearance

- Treeing
  - Formation carbon filaments through the bulk of an insulator
  - Driven by Partial Discharge in insulation defects
  - If partial discharge is not detected degradation is assumed not to occur
- Internal Clearance (Distance through insulation)
  - Set based type of insulation
    - Bulk
    - Film





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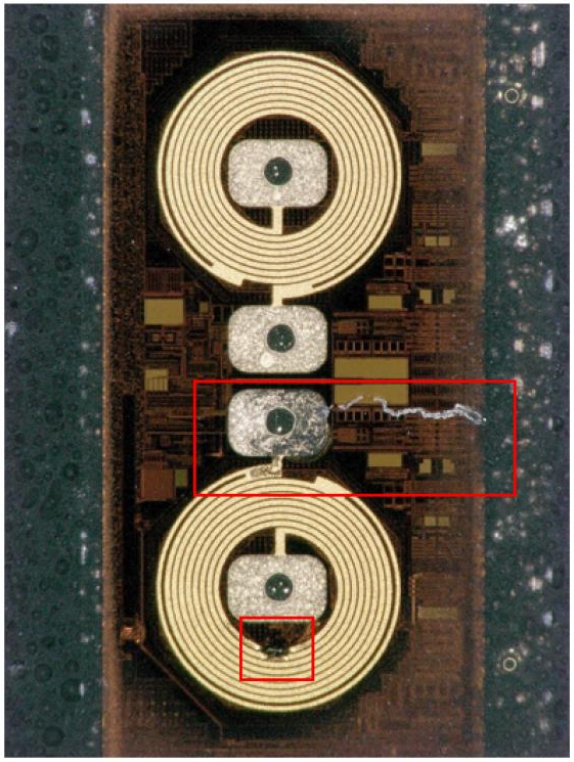
Dielectric Breakdown – Internal Clearance

- Dielectric Strength
  - the maximum electric field an insulator can withstand without breaking down
  - In solids it leads to chemical or mechanical changes to the material
  - Usually permanently degrades the insulation properties
  - Driven by transient high Voltage
- Internal Clearance (Distance through insulation)
  - Set based type and thickness of insulation
  - May have different values along material boundaries



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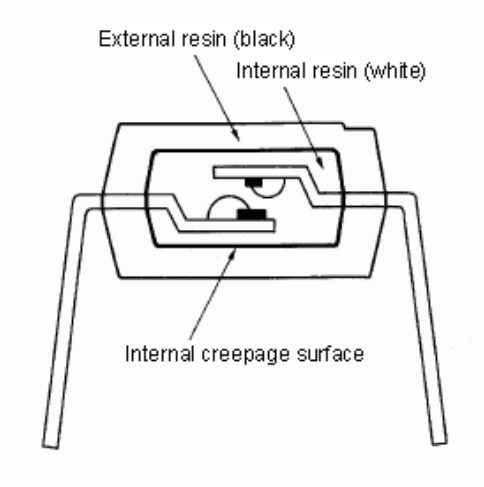
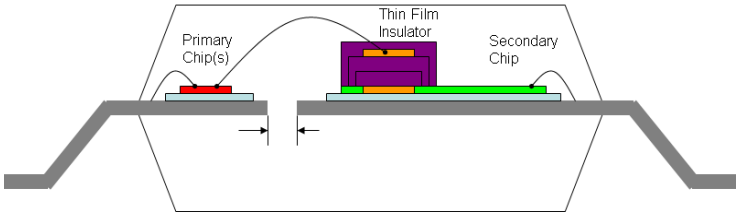
New Technologies

Film vs Mold compound

- The new components rely on high breakdown films such as Polyimide and SiO2
- Mold Compounds supply a parallel Isolation system
- Requirements based on system standards do not scale well to IC structures
- The new materials do not follow the same degradation mechanisms
- The current component standards under and over test different elements





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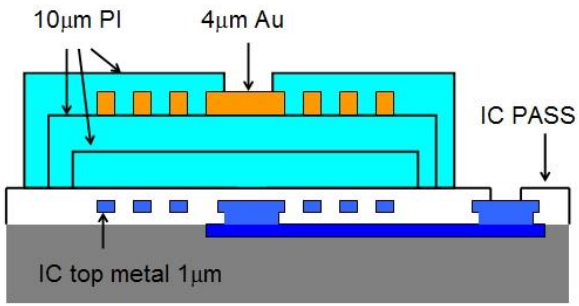
Materials

Substance	Dielectric Strength (V/μm)
Air (relative to nitrogen)	3
Alumina	13.4
SiO_2	470-670
Silicone oil, Mineral oil	10-15
FR4 (Epoxy PCB)	20
Polyethylene	18.9 - 21.7
Epoxy Mold	15.7
Polyimide Film	389-600
Waxed Paper	40 - 60
PTFE (Teflon, Insulating Film)	60 - 173
Mica	118

- System standards based on epoxy mold compounds can be a factor of 20 overly conservative for breakdown

Layers of Films

- Double insulation is created with independent basic and supplemental insulation applied to the same interface
  - This is not always practical when high precision or high speed signals need to pass across the isolation barrier
  - Analog degradation and digital timing errors accumulate with each barrier crossing
- Reinforced insulation allows a single insulation system to be classified as robust as double insulation
  - Components may need to meet additional structural requirements
    - Minimum Thickness of solid insulation
    - Multiple layers of film insulation
    - Increased creepage and clearance
  - Additional type testing during qualification
    - Thermal Cycling
    - Surge
  - Additional Assembly line tests
    - Partial Discharge



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Regulatory Landscape

Types Of standards

- System Standards
  - Master standard for a class of devices to ensures safe operation
- Component Standards
  - Evaluates a specific type of component to allow use under a coordinated standard, providing support across multiple IEC system standards
  - Example IEC60747-5 – Optocoupler standard
- Coordination Standards
  - Sets basic requirements and terminology used in other standards to promote consistency
  - Example: IEC60664-1 Insulation Coordination
- Test Methods
  - Give standard ways to characterize
  - Example: IEC61000-4-xx EMI/EMC

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Common Standards

- Most Common Systems level Standards
  - Determine components specs based on system requirements
    - IEC 60065-1 (Audio Video Systems)
    - IEC 60950-1 (Information Systems)
    - IEC 60601-1 (Medical Equipment)
    - IEC 61010-1 (Instrumentation)
    - IEC61800-5 (Motor Drives and Inverters)

IEC62368

IEC60601 3rd ed

- Piece Part level standards
  - Certify that components meet the manufacturers safety specifications
  - Verify insulation grade and maximum working and transient levels
    - UL 1577 (Used for All Isolators – Not under the IEC umbrella)
    - IEC60747-5 (Optocoupler Isolators)
    - VDE 0884-10 (Non-optocoupler Isolators)
- Coordination Standards
  - IEC60664 Insulation Coordination

System Standards and Component Standards

If safety is involved, components and subassemblies shall conform to one of the following

a) applicable safety requirements of a relevant IEC standard. Conformity with other requirements of the component standard is not required. If necessary for the application, components shall be subjected to the tests of this standard, except that it is not necessary to carry out identical or equivalent tests already performed to check conformity with the component standard;

b) if there is no relevant IEC standard, the requirements of this standard;

c) applicable safety requirements of a non-IEC standard which are at least as high as those of the relevant IEC standard, provided that the component has been approved to the non-IEC standard by a recognized testing authority.

Note: This is not quoted verbatim from IEC61010, and has been compacted for the purposes of illustration

- Most IEC component standards have language similar to the text above.
- This allows use of component standards to determine Reinforced insulation and limits of operation.
- This also allows use of non IEC standards within the IEC system

What Standards For Thin Film Isolators

- How are components be used in the regulatory framework
  - Under Component standards
    - UL recognized them as sufficiently like optocouplers to use UL1577
    - No thin film isolator component support under IEC standards
    - VDE provides an IEC equivalent standard VDE-0884-10
  - Under System Standards
    - They could be qualified under system level standards as solid insulation.
    - System certification of components is rarely portable and does not allow the full capabilities of a part to be documented
    - It is expensive for digital isolator manufacturers to get multiple certifications
- What is needed is a dedicated non-Opto Component Isolation standard
  - Recognized across system standards
  - Allowing direct comparison of insulation characteristics
  - Removes the need to analyze the internal insulation structure

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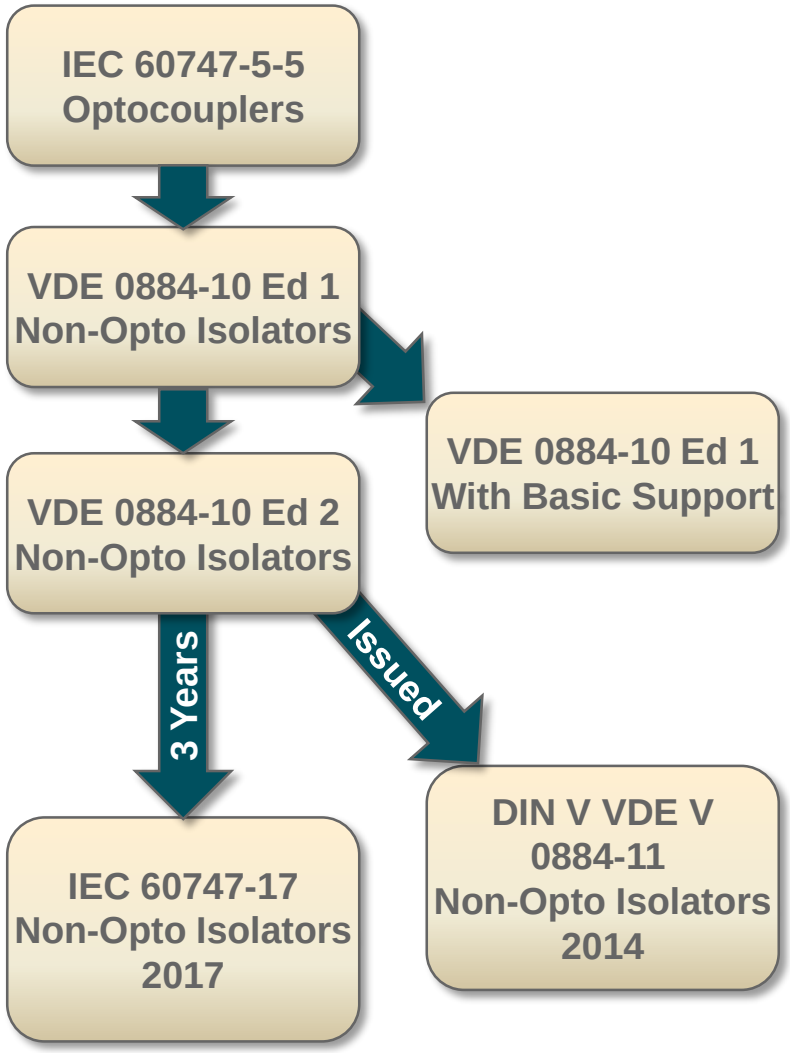
Adapting Standards

DEVELOPMENT OF IEC60747-17

The Component Standard for Non-Opto Isolators

- VDE developed a non-Opto version of the IEC60747-5 Optocoupler Safety standard
- VDE 0884-10 Ed 1
  - Approved 2006
  - Added Characterization - 500hr life test
  - Reinforced Insulation (Basic Added 2014)
  - Unacceptable to IEC
  - Will be withdrawn in September 2017
- VDE 0884-10 Ed2
  - Approved July 2014
  - Changes based on IEC feedback
  - Insulation Based Life Test
- DIN V VDE V 0884-11
  - Issued in September 2014
  - Applies to Germany only
  - Can be used as IEC equivalent standard
- IEC 60747-17 draft submitted
  - July 2014
  - 3 Year Approval Cycle



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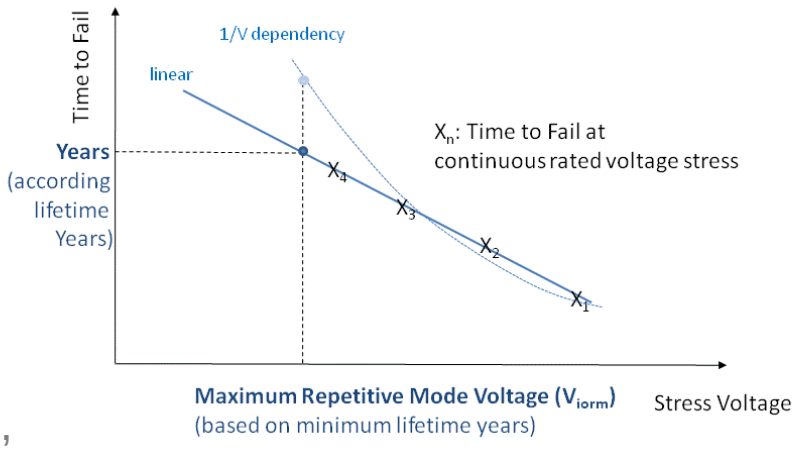
What is new in VDE-0884-11/IEC60747-17?

- **Optocoupler insulation lifetime was "guaranteed" by low partial discharge. No lifetime measurement is done**
- **Explicit Characterization of Thin Film based Digital Isolator lifetime based on test. Partial Discharge is not applicable.**
- **Support for Basic and Reinforced insulation**
  - Lifetime target is20 years
  - Basic insulation evaluated at 26 years, 1000ppm
  - Reinforced insulation evaluated at 46 years, 1ppm
  - 1.2x additional margin for working voltage
- **End of life test verification at 80% of lifetime**

Method of Determining Maximum continuously rated reinforced voltage



Applied method according to 5.2.7

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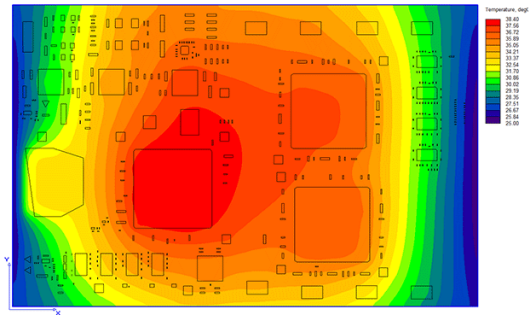
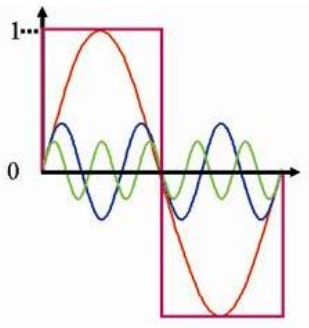
Other Accelerators

- Other factors that affect degradation rate
  - Temperature – can accelerate or decelerate degradation depending ion the material
  - Moisture – usually Increasing moisture acts as a wear out accelerator
  - Frequency and dV/dt usually an accelerator
- The standards can not cover all conditions
- Applications that deviate from 60Hz AC or DC performance should seek additional information from the manufacturer





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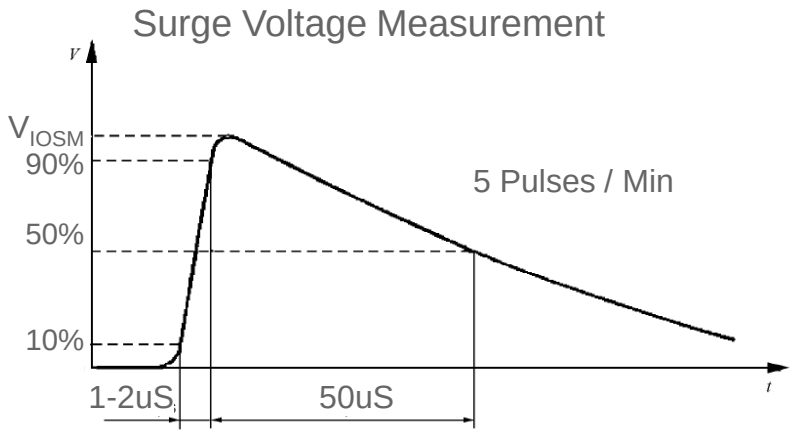
Surge Testing in Non Opto standards

- Surge testing is a key requirement for obtaining Reinforced insulation for Optocouplers
  - IEC60747-5-5 requires 10kV
  - VDE-0884-x/IEC60747-17 requires the greater of 1.6x the rating or 10kV
- The standards have added basic insulation support
  - IEC60747-5-2 requires surge at rating
  - VDE-0884-11/IEC60747-17 1.3x the rating
- Until recently reinforced insulation was not achievable with SiO2 insulation



Many system standards that deal with high installation class are indexing to surge rating. Requirements on digital isolators are higher than Optocouplers

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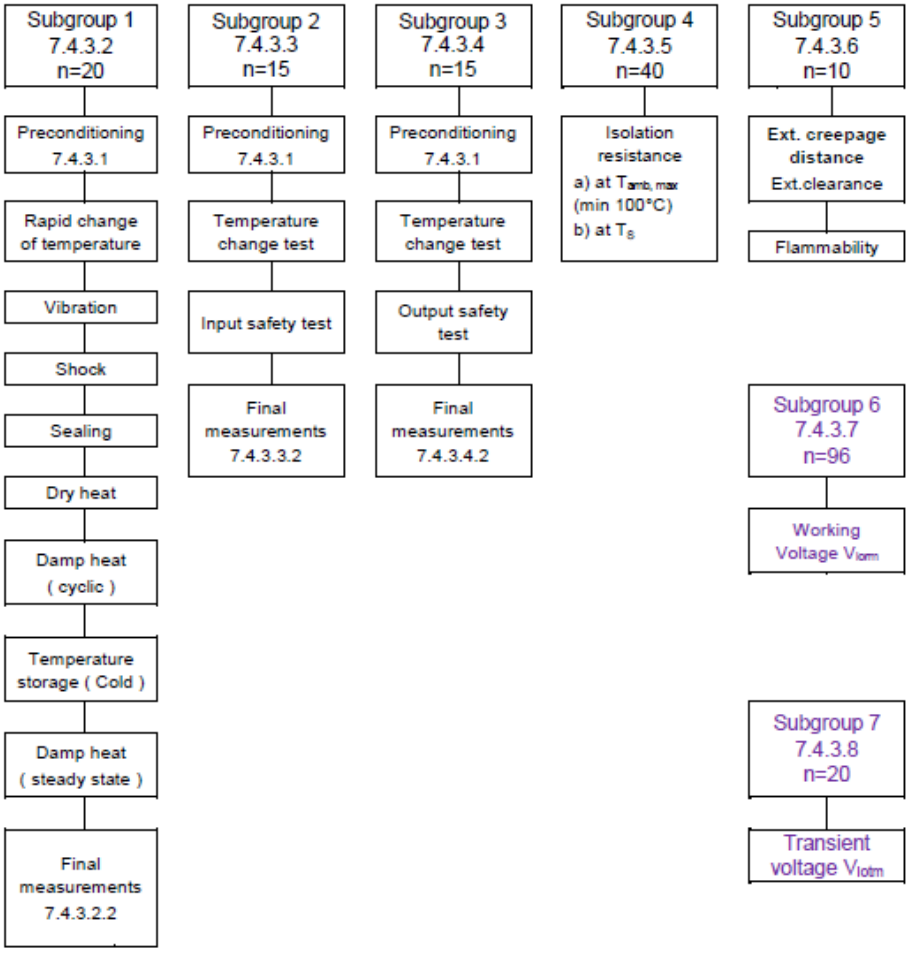
Full Component Test Matrix



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