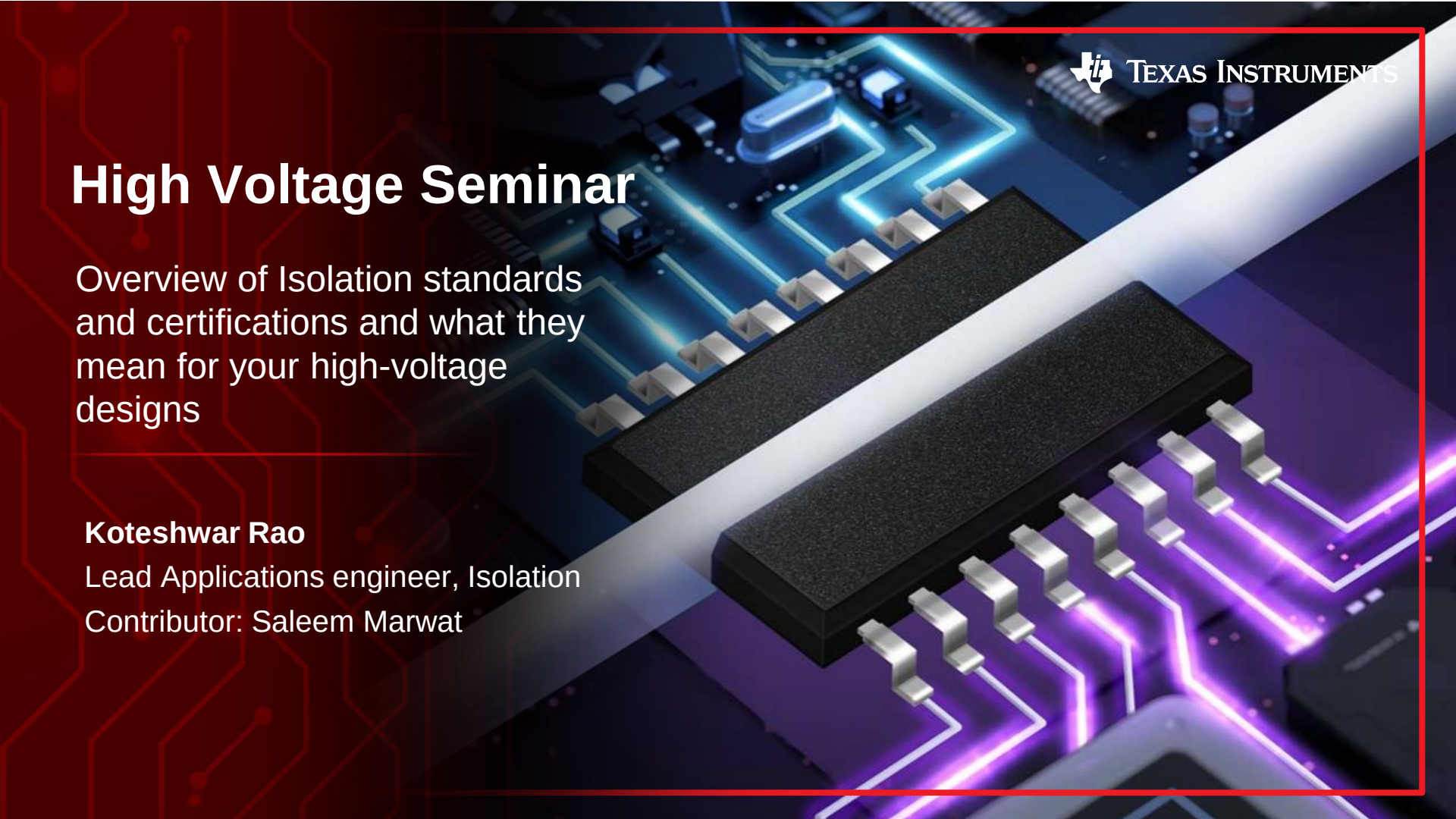

High Voltage Seminar

Overview of Isolation standards and certifications and what they mean for your high-voltage designs

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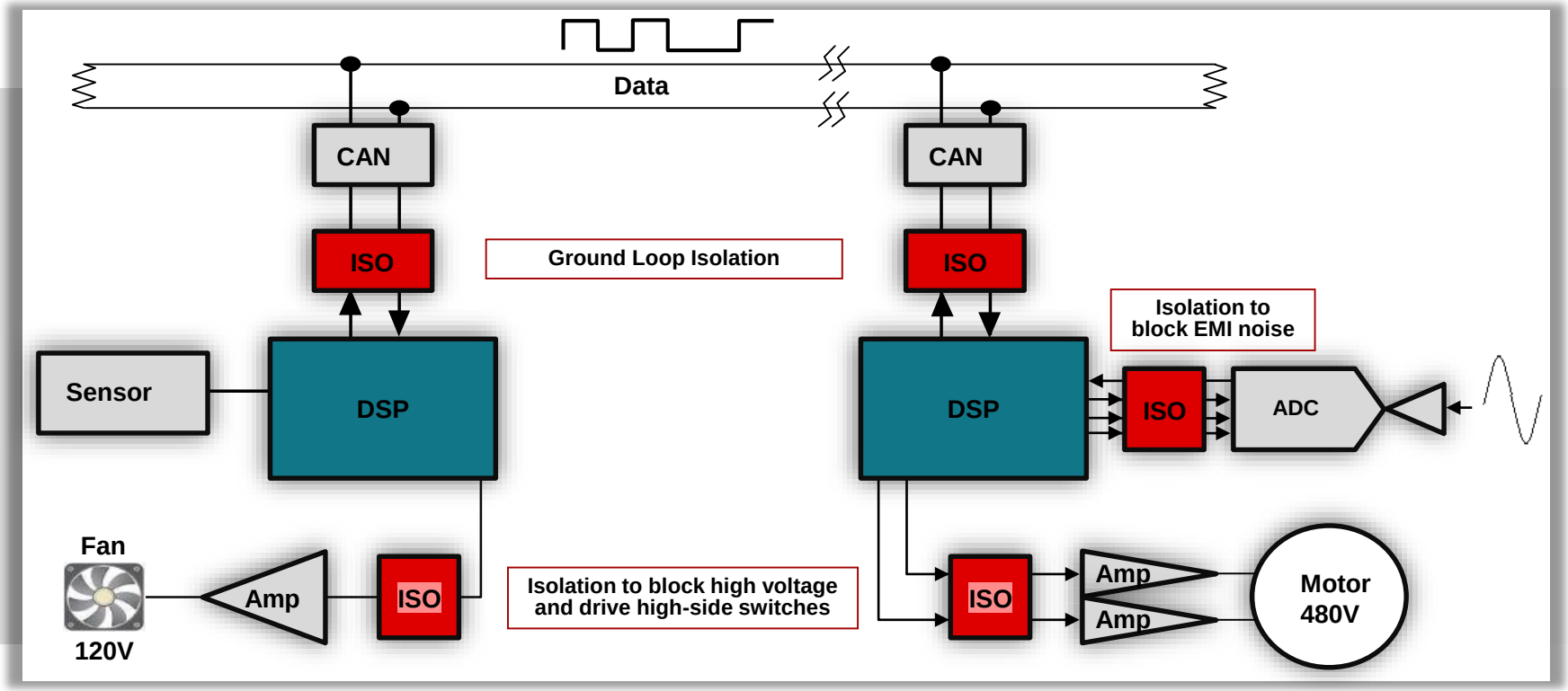
Agenda

- Define isolation
- What is a digital isolator?
- Isolation terminology
- Isolation certification agencies
- Isolation standards
  - Component standards
  - Equipment standards
- Why digital isolators are certified to equipment standards?
- How certified isolators benefit equipment manufacturer’s high voltage designs?

Introduction to isolation

What is Isolation?	Isolation is a means of transferring data and/or power between two circuits while preventing hazardous DC or uncontrolled AC transient currents from flowing between the circuits
When to isolate?	• To protect sensitive low voltage circuits and humans from high voltage circuits and systems • To reduce / eliminate large ground potential differences (GPD) in communication systems that are separated by large distance • To communicate reliably with high side components in high-voltage motor/inverter drive systems, switches, and metrology applications • To protect sensitive low voltage circuits and humans from high voltage EMI transients and at the same time improve EMC capabilities of systems

Digital isolators | System view



Terminology | Insulation types

Parameter	Definition
Functional Insulation	Insulation needed for the correct operation of the equipment.
Basic Insulation	Insulation that provides basic protection against electric shock.
Supplementary Insulation	Independent insulation applied in addition to Basic insulation in order to ensure protection against electric shock in the event of a failure of the Basic insulation.
Double Insulation	Insulation comprising both Basic and Supplementary insulation.
Reinforced Insulation	A single insulation system which provides a degree of protection against electric shock equivalent to Double insulation under the conditions specified by the standard.

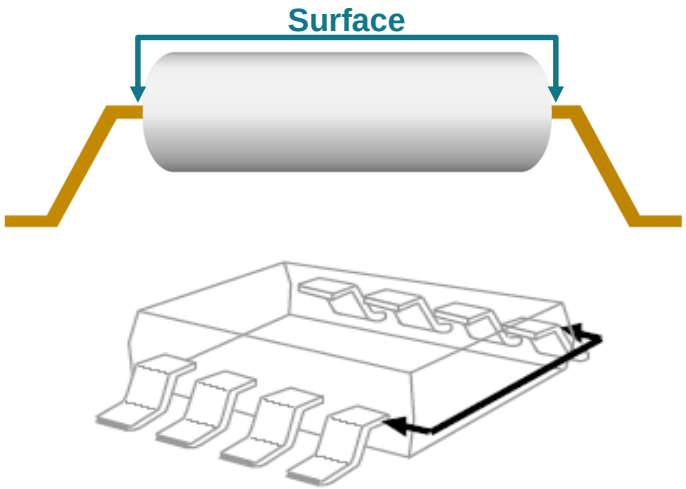
Terminology | Isolation parameters

Parameter	Definition	Relevance
V_{IOTM}	The temporary overvoltage an isolator can tolerate for 60s (defined in pk)	Tolerance to temporary overvoltage on supplies due to load changes, arcing etc.
V_{ISO}	The isolation withstand voltage an isolator can tolerate for 60s (defined in rms or dc)	
V_{IORM}	Maximum repetitive peak voltage that the isolator has to handle on a continuous basis throughout its operating life (defined in pk)	The voltage that the isolator has to handle as part of normal operation (for e.g., an isolated gate driver sees a pk voltage equal to the DC bus voltage).
V_{IOWM}	Maximum continuous working voltage that the isolator has to handle on a continuous basis throughout its operating life (defined in rms or dc)	
V_{SURGE} / $V_{IMPULSE}$	Maximum peak voltage of the 1.2µs/50µs standard surge waveform that the isolator can handle in oil. $V_{IMPULSE}$ is surge test performed in air.	Represents direct and indirect lightening strikes. Min 10kV required for reinforced isolation.
Creepage	Minimum distance from pins on side 1 to side 2 along the surface of the package	Limits working voltage or continuous voltage due to degradation along package surface (called tracking)
Clearance	Minimum distance from pins on side 1 to side 2 through the air	Limits peak voltages and surge voltages in system environment due to air breakdown
CMTI	The maximum rate of change of ground potential difference (between GND1 & GND2) that the isolator can withstand without bit errors	Indicates robustness of isolator to ground noise. Very important in gate-drive applications

For details refer to: High-voltage reinforced isolation: definitions and test methodologies

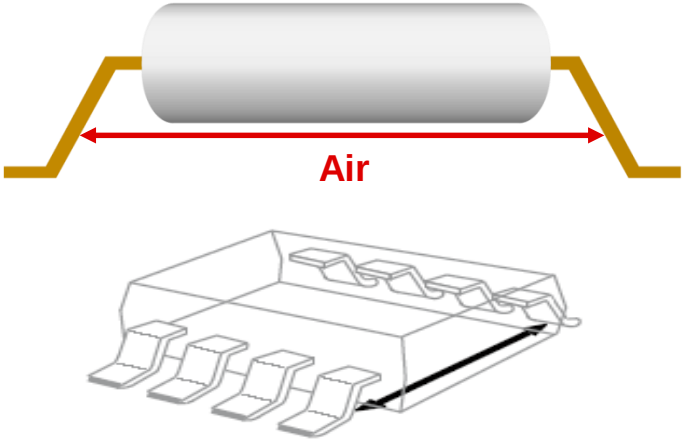
Creepage & clearance

Creepage distance



Shortest distance between two conductive leads, across isolation barrier, measured along surface of insulation

Clearance distance



Shortest distance between two conductive leads, across isolation barrier, measured through air.

Clearance ≤ Creepage

Certification agencies

- Texas Instruments' (TI's) Isolation products are typically certified by some combination of the following 5 agencies:
  - *Verband der Elektrotechnik* (VDE)

    (Electrical Engineering Association)
  - Underwriters Laboratories (UL)
  - Canadian Standards Associations (CSA)
  - *Technischer Uberwachungsverein* (TUV)

    (Association for Technical Inspection)
  - China Quality Certification (CQC)

VDE

- VDE or Electrical Engineering Association, is one of the largest testing agencies in Europe. It is headquartered in Frankfurt, Germany.
- VDE has worked closely with IEC to develop international component-level standard, IEC 60747-17, for digital (capacitive and magnetic) isolators.
- IEC or International Electrotechnical Commission is a non-governmental international standards organization that prepares and publishes International Standards for all electrical, electronic and related technologies
- VDE and IEC websites: www.vde.com and www.iec.ch

VDE Certifications

- TI's ISO products typically get VDE certifications for the following standards:
  - Component Standard for Capacitive and Magnetic Couplers
    - DIN EN IEC 60747-17 (VDE 0884-17)
  - Equipment Standards
    - DIN EN 61010-1: Measurement, control, and lab use equip safety – Part 1 (TI's Basic Insulation Certificate)
    - DIN EN 62368-1: Audio/Video, Information technology equipment safety - Part 1 (TI's Reinforced Insulation Certificate)

- VDE conducts annual factory inspections at the final test sites.
- VDE logo is mandatory, and it is printed on the product shipping label.
- VDE also requires TI to collect quarterly sample data.
- TI's VDE Certificate Links: http://www.ti.com/lit/pdf/szzq073 (Basic)
  http://www.ti.com/lit/pdf/szzq123 (Reinforced)

UL

- UL is Underwriters Laboratories. It is a US-based safety certification agency.
- cUL certification covers Canada as well (similar to CSA)
- Further information about UL can be found at http://ul.com/
- TI's ISO devices are certified to:
  - UL1577 (Component Standard for Safety - Optical Isolators)
  - There is no separate standard for magnetic and capacitive isolators as of today, but certification for digital isolators is allowed under UL 1577.

- UL conducts quarterly factory inspections at the final test sites.
- UL logo is mandatory, and it is printed on the product shipping label.
- UL certificates for ISO devices are available online at www.ti.com in the respective product folders.

CSA

- CSA is Canadian Standards Association.
- CSA provides testing and certification services according to various international and Canadian standards. TI's ISO products typically get the following certifications from CSA:
  - IEC 62368-1 and CSA 62368-1 (Audio/Video & IT Equipment)
  - IEC 61010-1 and CSA 61010-1 (Test & Measurement and Lab Equipment)
  - IEC 60601-1 and CSA 60601-1 (Medical Equipment)
- CSA conducts quarterly factory inspections at the final test site.
- CSA logo is mandatory and it is printed on the shipping label.
- CSA Certificates for ISO devices are available online at www.ti.com in the respective product folders.

TUV

- TUV or Technical Inspection Association is Germany-based engineering services firm providing international safety testing and certification services.
- TUV SUD America is a subsidiary of TUV SUD AG and provides the same services locally in the US.
- TI typically gets the following certifications through TUV SUD America:
  - EN / UL / CSA 62368-1
  - EN /UL / CSA 61010-1
- TUV performs bi-annual factory inspections at final test sites.
- TUV logo is optional and it isn’t printed on the product shipping label due to space limitation.
- TUV certificates for ISO devices are available online at www.ti.com in the respective product folders.

CQC

- CQC stands for China Quality Certification.
- TI's ISO products typically get the following certification through CQC:
  - GB 4943.1-2022 (Audio/Video & IT Equipment)
- All the testing is done for Altitude ≤ 5000 m and Tropical climate.
- CQC conducts annual factory inspection and requires annual verification test.
- CQC logo is mandatory and it is printed on the product shipping label.
- In addition to paying for regular factory inspections fees, TI pays annual certificate maintenance fee.
- CQC certificates for ISO devices are available online at www.ti.com in the respective product folders.

IEC 60747-17 | Component standard

- As mentioned earlier, we certify ISO component compliance to IEC 60747-17 through VDE. IEC 60747-17 is the first international component standard for digital isolators that was released in Y2020. Previously, IEC standard was only available for optocouplers.
- VDE issues certificates according to DIN EN IEC 60747-17 (VDE 0884-17) to comply with German variant of IEC 60747-17 and EN IEC 60747-17 to comply with European variant of IEC 60747-17.
- Digital isolators have to comply with all required clauses of the standard in order to be certified to this standard.

IEC 60747-17 | Tests

- Routine test
  - A non-destructive production test that 100% of devices are subjected to in the production line
  - It includes testing for isolation, apparent charge magnitude and parametric
- Sample test
  - A destructive quarterly test conduct on a small sample set
  - It includes visual inspection, resistance to soldering heat, apparent charge magnitude, parametric, isolation resistance, and external creepage and clearance.
- Type test
  - A destructive qualification test conducted by certification agency to grant certification to the standard
  - It includes much larger set of tests covering various aspects of device

UL 1577 | Component Standard

- UL 1577 is Underwriters Laboratories' component standard for optocouplers. Digital isolators are allowed to be certified according to this standard.
- Devices can be rated to Single and Double Protection level.
- Double Protection rating is defined for isolators in some unique audio, video and similar applications bridging reinforced insulation.

Single Protection Rating

- Single Protection isolators require the following three tests:
  - Dielectric Voltage-Withstand Test
  - Overload Test
  - Limited Thermal Aging Test.

Double Protection Rating

- In addition to tests listed above, Double Protection isolators require the following two tests:
  - Life Test
  - Discharge Test

IEC 62368-1 | Audio/Video, Information & Communication Technology Equipment Safety Standard

- IEC 62368-1 is an equipment safety standard for Audio/Video, Information and Communication Tech industry.
- For certification, isolation devices are subjected to dielectric tests before and after thermal cycling. Dielectric tests are performed at 1.6 times the rated isolation voltage for devices with Distance Through Insulation (DTI) < 0.4mm.
- Creepage and Clearance are considered in the ratings evaluation.
- Production test for 1 second is required at the rated isolation voltage.
- Certification agencies can issue UL, CSA, and EN (European) versions of IEC 62368-1 based on regional needs.

IEC 61010-1 | Measurement, Control, and Laboratory use Equipment Safety Standard

- IEC 61010-1 is a safety standard for electrical equipment for measurement, control, and laboratory use.
- For certification, isolation devices are subjected to dielectric tests.
- Reinforced rating for isolators with DTI < 0.4mm is accepted per Clause 14.1a based on IEC 62368-1 reinforced rating.
- Creepage and Clearance are considered in the ratings evaluation.
- Certification agencies can issue UL, CSA, and EN versions of IEC 61010-1 based on regional needs.

IEC 60601-1 | Medical Equipment Safety Standard

- IEC 60601-1 is a safety standard for Medical electrical equipment.
- For certification, isolation devices are subjected to defibrillation proof test (5000 V_{DC}). It is followed by 4000 V_{RMS} dielectric test.
- Two Means of Patient Protection (2 MOPP) designation is equivalent to Reinforced Insulation.
- Thermal Cycling is required for IEC 60601-1. Dielectric tests are performed at 1.6 times the rated isolation voltage for devices with DTI < 0.4mm.
- The standard also requires the devices to pass 4-hour operating test with maximum temperature and currents followed by a dielectric test.
- Creepage and Clearance are considered in the ratings evaluation. For example:

Table 12 – Minimum CREEPAGE DISTANCES and AIR CLEARANCES providing MEANS OF PATIENT PROTECTION

WORKING VOLTAGE V d.c. up to and including	WORKING VOLTAGE V r.m.s. up to and including	Spacing providing one MEANS OF PATIENT PROTECTION		Spacing providing two MEANS OF PATIENT PROTECTION	
		CREEPAGE DISTANCE mm	AIR CLEARANCE mm	CREEPAGE DISTANCE mm	AIR CLEARANCE mm
17	12	1,7	0,8	3,4	1,6
43	30	2	1	4	2
85	60	2,3	1,2	4,6	2,4
177	125	3	1,6	6	3,2
354	250	4	2,5	8	5

How are digital isolators certified to equipment standards?

- Question: Can a tiny semiconductor component be certified to all clauses of a complex equipment standard? The answer is ‘No’.
- Digital isolators are certified to only a few clauses of the equipment standard related to high voltage insulation.

Digital isolator

Certified to HV
Insulation Clauses

End equipment

IEC Equipment Standard Clauses used to certify digital isolators

Evaluation	Clause of Standard		
	IEC 62368-1: 2018	IEC 60601-1 Ed3:2005 +A1:2012	IEC 61010-1: Ed3:2010 +A1:2016
Creepage	5.4.3	8.9	6.7.2.1 or Tables K.1 to K.4
Clearance	5.4.2	8.9	6.7.2.1 or Tables K.1 to K.4
Distance through insulation	5.4.4.2 or evaluated by 5.4.4.4, 5.4.7	8.8.2 and/or evaluated by 8.9.3.2 and/or Layers and/or 8.9.3.3	6.7.2.2.2 or Table K.9 or Layers. N/A for reinforced; Accepted per clause 14.1a) based on IEC 62368-1.
Thermal cycling	5.4.1.5.3, 5.4.7	8.9.3.4	6.7.2.2.2Form A.17
Humidity	5.4.8, Five days (tropical)	5.7, Two days	6.8.2, Two days
Dielectric after thermal cycling	5.4.9.1, times 1.6 (for 60% margin)	8.8.3, times 1.6 (for 60% margin)	6.7.2.2.1 or Tables K.1 to K.7 times 1.6 (for 60% margin)
Temperature test	5.4.1.4	11	10
Dielectric after temperature test	5.4.9.1	8.8.3	6.7.2 or Tables K.1 to K.7
Defibrillation test	N/A	8.5.5.1	N/A
IEC 60112 evaluation and material classification	5.4.3.3	8.9.1.7	6.7.1.3

How certified isolators facilitate equipment manufacturer's high-voltage designs?

- When equipment manufacturers select certified components for their high voltage designs, they save:
  - Time
  - Money
  - Engineering effort
- Only component manufacturers have the complex construction details of the insulation barrier required by certification agencies.
- Certifying a single component typically costs tens of thousands of dollars.
- Engineering effort required to certify another manufacturer's component is daunting.
- Finally, certified components reduce the risk of insulation failure once designed-in to end equipment.

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