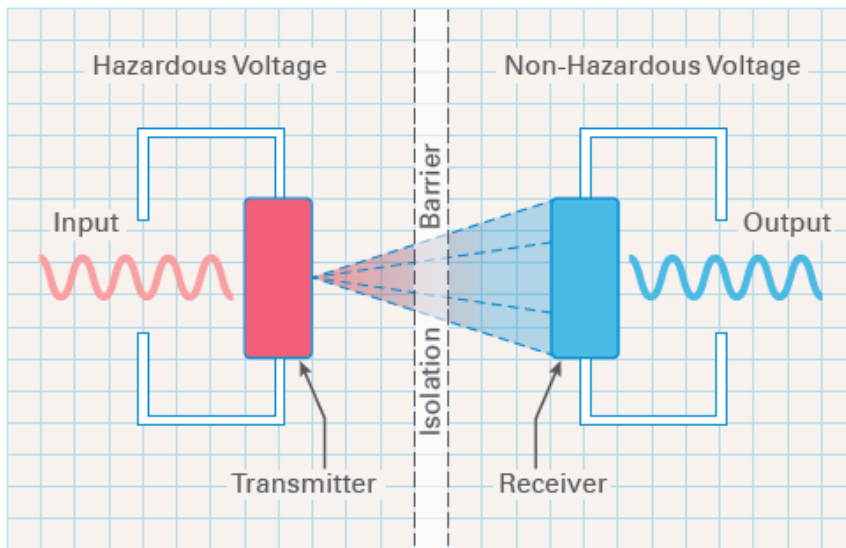




Understanding isolator standards and certification to meet safety requirements

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Electrical products use numerous components, some of which are important for protection of the product user. Isolator components are commonly used to protect/separate product users from dangerous voltages, but knowing how to select the correct isolator for safety protection can be confusing. Is it the isolation voltage, the working voltage, the standard, the certification, or . . . what's most important? This article will clear up the confusion surrounding the selection of isolators for safety applications in situations where hazardous voltage circuits need to be isolated from product users.

Non-hazardous voltage circuits, $\pm 3.3\text{Vdc}$, 5Vdc , and 12Vdc , are typically user-touchable and must be isolated from hazardous voltages, $> 30\text{Vrms}/42.4\text{V}_{\text{peak}}/60\text{Vdc}$, to protect the user from dangerous voltages! Safety isolation is the separation of a section of non-touchable hazardous voltage circuits ($> 30\text{Vrms}/42.4\text{V}_{\text{peak}}/60\text{Vdc}$) from user-touchable circuits ($\leq 30\text{Vrms}/42.4\text{V}_{\text{peak}}/60\text{Vdc}$). There are several levels of safety insulation: Basic, Double, and Reinforced. Reinforced insulation is required between hazardous voltage and user-touchable circuits.

Isolator components are integrated circuit semiconductor devices (ICs) which provide safety isolation (insulation). They function by transmission of signal coupling from primary-to-secondary circuits through various mediums including optical (light), magnetic (inductive) and capacitance (charge). Isolator components are referred to as *safety-critical components* and require special consideration to ensure that they meet the relevant safety standards and are safe for use in products.



The purpose of this article is to highlight the standards, insulation, tests, and ratings for isolators used in hazardous voltage applications where an isolator is used as a safety isolating component. This article will cover important isolator selection parameters, including:

- 1) Component Standards (IEC 60747-5-5, VDE 0884-10¹, UL 1577)
- 2) Reinforced Insulation (tests and spacings)
- 3) Working Voltage, V_{IORM} (supply voltage); e.g., $150 - 600\text{Vac}$ ($210 - 840\text{V}_{\text{peak}}$)
- 4) Isolation Voltage, V_{IOTM} (test voltage); e.g., $2,500 - 5,000\text{Vac}$
- 5) VDE and UL Certifications (International and North America)

¹ IEC 60747-17 (VDE 0884-11) to replace digital isolator standard VDE 0884-10 in the future.

ISOLATOR TECHNOLOGIES

There are three isolator technologies in use today:

- Optical – Uses light (LED) transfer across a transparent nonconductive insulation barrier. Advantage is high electrical isolation values. Uses a silicone polymer insulation.
- Magnetic – Inductive coupling transfer using transformer coil design and provides high isolation at high frequencies. Uses polyimide or silicone dioxide insulation.
- Capacitive – Uses a changing electric field to transmit energy by means of capacitance. Capable of high speeds and relatively small package. Uses silicon dioxide insulation.

Optical isolators, also referred to as optocouplers or optos, employ an opaque silicone polymer material as the internal insulation. Optos have larger footprints and provide high levels of isolation when a film barrier is used. The newer generation of digital isolators, magnetic and capacitive, offer advantages in performance, size, and power efficiency. Digital isolators utilize polyimide/silicone-dioxide for their insulation. Optical isolators rely mostly on thickness for internal spacing whereas digital isolators have insulation of less than one-thousandth of an inch and rely on safety testing. (Figure 1)

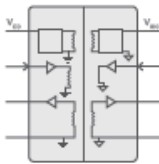
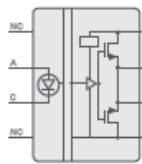
Optical Isolators	Digital Isolators	
		
Dielectric and/or Silicone Insulation	Polyimide Insulation	Silicon Dioxide Insulation
100 - 400 μm Thickness, Typical	20 - 32 μm Thickness, Typical	7 - 15 μm Thickness, Typical
Optical	Magnetic	Capacitive
Standards: IEC 60747-5-5 and UL 1577	Standards: VDE 0884-10 and UL 1577	

FIGURE 1 – Isolators

PRODUCT vs COMPONENT STANDARDS

It is very important to understand the difference between product and component standards, and that product and component safety standards have different scopes, tests, and requirements.

Products are ready for use equipment. Examples of safety standards for products (equipment) are IEC 60950-1 for Information Technology Equipment, IEC 61010-1 for Measurement Equipment, and IEC 60601-1 for Medical Equipment. Products undergo a one-minute isolation test voltage, also called dielectric withstand, high potential or hipot test. Isolators cannot operate continuously at the isolation (test) voltage. Product standards also allow partial discharges that can degrade the insulation barrier due to small bubbles or impurities in the insulation. Product standards do not contain the tests that fully stress (test) the insulation of isolator components.



NOTE: Product standards focus on a dielectric withstand test voltage for isolation. This is a one minute transient test, typically at 2,500 – 5,000Vac. Products cannot operate continuously at the test voltage. Do not assume that an isolator rated for 2,500Vac isolation can operate at this voltage.

Components are electrical/electronic parts that are assembled into (built-in) products. The associated isolator component safety standards are IEC 60747-5-5 for Optical Isolators, VDE 0884-10 for Digital Isolators, and UL 1577 for Optical/Digital Isolators. Component standards have different, oftentimes stricter, safety requirements and tests than product standards. Isolator component standards require partial discharge testing, which is performed to check whether the isolator's internal insulation can break down. Partial discharge is an IEC/VDE isolator component test, which can detect small imperfections that could grow over time. Partial discharge testing is a better measure of the internal insulation of the isolator than the isolation test voltage.



NOTE: Working voltage, V_{IORM} , is specified by IEC 60747-5-5 (optos) and VDE 0884-10 (digital) standards. Working voltage is the voltage that can be continuously applied to the isolator during its operation. Working voltage ratings average between 150 and 600Vac. The isolator's working voltage must be as high as the product's operation, supply voltage.

Components and products must fall within a safety standard's *scope* before the standard can be applied. As shown in [Table 1](#), isolators are components which are not within a product standard's scope. Therefore, product standards are not applicable for isolators.

- Component Standards Scope - Optical and Digital Isolators
IEC 60747-5-5: Optoisolators: This component standard gives the terminology, essential ratings, characteristics, safety tests as well as the measuring methods for photocouplers (optocouplers). Photocoupler is an Optoelectronic device designed for the transfer of the electrical signals by utilizing optical radiation to provide the coupling with electrical isolation between the input and the output. Reinforced insulation.¹ VDE 0884-10: Non-Opto (Digital) Isolators: This component standard gives the terminology, essential ratings, characteristics, safety test and the measuring methods of magnetic and capacitive couplers. Magnetic and capacitive couplers consist of a transmitter stage and a receiver stage on either side of a galvanic insulation barrier. The device transmits a signal across the insulation boundary where a receiver stage is able to detect the transmitted signal and uses the information to generate the electrical output signal. This standard specifies magnetic and capacitive isolation barrier mechanisms and the insulation functions for Basic and Reinforced insulation.¹ UL 1577: Optocouplers and Digital Isolators: This component standard covers optical isolators, also called optical couplers or photocouplers: a) intended to provide unidirectional signal transfer between dielectrically isolated circuits and, b) intended for use in equipment with a supply voltage not exceeding 600Vac (rms or dc). These requirements evaluate the electrical isolation properties of single and double [reinforced]¹ (protection) insulation between the isolated circuits of the optical isolator.
- Product Standards Scope - Information Technology, Measurement, and Medical Equipment
IEC 60950-1: Information Technology Equipment: This equipment standard is applicable to mains-powered or battery-powered information technology equipment, including electrical business equipment and associated equipment, with a rated voltage not exceeding 600V. IEC 61010-1: Measurement, Control, and Laboratory Equipment: This equipment standard specifies general safety requirements for the following types of electrical equipment and their accessories, wherever they are intended to be used: a) electrical test and measurement equipment, b) electrical industrial process-control equipment, c) electrical laboratory equipment. IEC 60601-1: Medical Electrical Equipment: This equipment standard applies to the Basic Safety and Essential Performance of Medical Electrical (ME) Equipment and Medical Electrical Systems, hereafter referred to as ME Equipment and ME Systems.

¹ Reinforced insulation required for safety protection

TABLE 1 – Scope of Component and Product Standards

Another issue with standards is that component standards are not equivalent between Europe/International (IEC/VDE) and North America (UL), which means that isolators need to meet both the IEC/VDE and UL component standards.



CAUTION: Always look for the correct *isolator component standard* for safety evaluation and testing. Isolators also need to meet both IEC/VDE and UL component standards for International: IEC, VDE, CE, and for North America: UL. Isolator component safety standards are: IEC 60747-5-5, VDE 0884-10, and UL 1577.

SPACINGS – CLEARANCE, CREEPAGE, BASIC, REINFORCED

In addition to testing, safety standards require separation of specific circuits for user protection. These are the *spacing distances* between hazardous voltage and nonhazardous, touchable voltage circuits. Basic, Double, and Reinforced are safety insulation levels. Basic is a single layer and Double is two layers. Reinforced is a single insulation system which is equivalent to Double. Products and components must remain safe even when there is a single fault or failure in the insulation. It is assumed that a single fault can occur in one layer of insulation. Reinforced is required to protect users in case of a single fault of the first (Basic) layer. In other words, if a fault occurs in the Basic insulation, the second insulation will still protect the user. Basic is not adequate for protection of product users. Reinforced solves the single fault issue.



NOTE: Safety standards require *Reinforced* insulation to protect product users from hazardous voltages ($>30V_{rms}/42.4V_{peak}/60V_{dc}$).

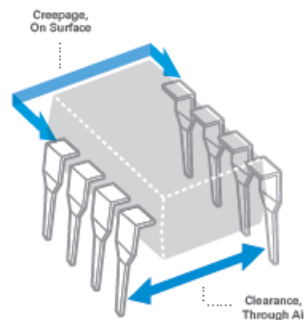


FIGURE 2 – Clearance and Creepage

External spacings are measured from inputs-to-outputs in Clearance and Creepage (Figure 2). Clearance is the shortest distance between two circuits through air. Creepage is the shortest distance on a surface. An isolator's external input-to-output (AC-to-DC) circuit spacings need to meet the distances of a product standard, which is based on the supply voltage to the product. IEC 60950-1 is the primary standard describing spacing requirements. An example is 4.0/3.0 mm Clearance distance and 6.0 mm Creepage distance for an isolator used in a 250Vac product (Table 2).

Supply Voltage V ACrms	Supply Voltage V _{peak} or dc	Overvoltage Category II / V _{peak}	Clearance for Reinforced / mm	Creepage for Reinforced / mm	Test Voltage V _{peak} or dc
≤ 150	≤ 210	1500	2.0 (1.0)	3.0	2500
> 150 ≤ 300	> 210 ≤ 420	2500	4.0 (3.0)	6.0	4000
> 300 ≤ 600	> 150 ≤ 300	4000	6.4 (6.0)	12.0	6000

1) Values are based on IEC 60950-1 product safety standard

2) Values in brackets apply only if manufacturing is subjected to a quality control program that provides at least the same level of assurance given in annex R.2 of IEC 60950-1

3) Reinforced insulation

4) Pollution Degree 2

5) Overvoltage Category II

6) Material Group IIIa, IIIb

TABLE 2 – Clearances, Creepage and Test Voltage

Internal spacing is the distance through an insulation, which is typically 100 - 400 μm thickness for an optical isolator. A digital isolator's internal spacing, on the other hand, is verified by testing, not thickness, since the insulation thickness is very thin, typically 7 - 32 μm . (Figure 1)

The VDE/UL Certificates, or specifications of the manufacturer, usually give the isolator's external spacing values. Spacing distances can also be easily measured on an isolator sample for verification. For more information on spacings, refer to the relevant product safety standards.

SPECIFICATIONS and CERTIFICATIONS

It's important to know what to look for before selecting an isolator for a product design. Isolator specifications can be confusing and may not tell the whole story. Specifications sometimes state an isolation test voltage (e.g., 2,500 – 5,000 Vac) and product standards (IEC 60950-1, etc) when the specifications should highlight the isolator working voltage (e.g., 150 – 600 Vac) and component standards (IEC 60747-5-5, etc). Another issue is that a specification may state Reinforced according to product standard when the isolator is actually only Basic according to a component standard. Remember that product standards and Basic insulation are inadequate for safety protection.

Always verify that an isolator has VDE and UL Certifications. You can determine if an isolator has the necessary Certifications on the VDE and UL Certification Directories. However, some of the safety ratings may not be found on the Directories. The best way to make sure the isolator meets the safety rules is to obtain a copy of the VDE and UL Certificates from the isolator manufacturer. You may also need the VDE/UL Reports if the Certificates do not show the information.



CAUTION; Focus on the isolator's safety ratings and certifications. Beware if the specifications highlight product standards or isolation voltage. Specifications should clearly show the *component standard(s)*, *working voltage*, and *Reinforced insulation*. Obtain VDE and UL Certifications as proof of safety compliance.

CONCLUSION

It is important to verify the standards, tests and ratings used to evaluate and certify the isolator before selection and incorporation into product designs. Meeting all the isolator component safety rules helps ensure that the end product can meet International and North America safety requirements (IEC, VDE, UL, CE, etc). Product standards, such as IEC 60950-1 or similar, do not adequately address isolator component safety. Be sure to verify that the applicable component standards, IEC 60747-5-5, VDE 0884-10, and UL 1577, have been applied to protect product users and avoid costly product redesign!

The most important things to know when looking for safety isolators are, in order of importance:

- 1) Component Standards (IEC 60747-5-5, VDE 0884-10, UL 1577)
- 2) Reinforced Insulation (tests and spacings)
- 3) Working Voltage, V_{IORM} (supply voltage); e.g., 150 – 600Vac (210 – 840Vpeak)
- 4) Isolation Voltage, V_{IOTM} (test voltage); e.g., 2,500 – 5,000Vac
- 5) VDE and UL Certifications (International and North America)

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