

## **Application Bulletin AB-2** **Isolator High Voltage Safety Standards**

IsoLoop Isolators have exceptional high-voltage performance and meet applicable safety standards. The standards summarized in this Bulletin are UL 1577, IEC 61010-1, VDE V 0884-10, and IEC 60601-1.

### **UL 1577**

UL 1577 focuses on voltage breakdown, defined as a high leakage current. There is a destructive test on lot samples and a nondestructive production test on each part.

The destructive test requires the device to withstand the isolation voltage (2500 V<sub>RMS</sub> for standard Isolators; 6000 V<sub>RMS</sub> for high-isolation grades) for one minute. The production test is 120% of the rated isolation voltage without breakdown for one second.

### **IEC61010-1**

IEC61010-1 also focuses on breakdown testing. Test voltages, as well as external creepage and clearance requirements, are defined for various working voltages as summarized below:

Working Voltage (RMS or DC)	External Clearance/ Creepage (mm)	Test Voltage (RMS) 1 min.
150	1.6	1400
300	3.3	2300
600	6.5	3700

**Table 1. IEC 61010-1 requirements (reinforced insulation; pollution degree II; installation category II; on printed wiring board).**

Working voltage generally corresponds to the mains line voltage (e.g., 150 working voltage for 120 V line voltage, 300 working voltage for 220/240 line voltage, or 600 working voltage for 408/480 line voltage). Under IEC61010-1, linear interpolation of clearance and creepage is allowed, but interpolation of test voltage is not.

### **Limitations of IEC 61010 and UL 1577**

Breakdown-based standards such as IEC 61010 and UL 1577 are based on one-minute breakdown voltage, so isolators cannot continuously operate at the isolation voltage, nor is it a measure of transient voltage tolerance. Furthermore, these standards allow “partial discharges” that do not bridge the isolation barrier but degrade the insulation. Small bubbles or impurities can cause partial discharge. Partial-discharge based standards such as IEC 60747-5-5 and VDE 0884 overcome these limitations and are gaining favor. Like pressure testing a surgical glove, partial discharge tests detect tiny imperfections that could grow much larger.

### **IEC 61010-1 Edition 3**

A new Edition of IEC 61010-1 took effect in 2013 for CE marking. “Edition 3” includes an internal creepage requirement of at least 0.4 mm, which cannot be met with modern isolators including IsoLoop Isolators. The new Edition does, however, allow certification of systems using isolators with less internal creepage that meet another safety standard, such as VDE 0884 or IEC 60747.

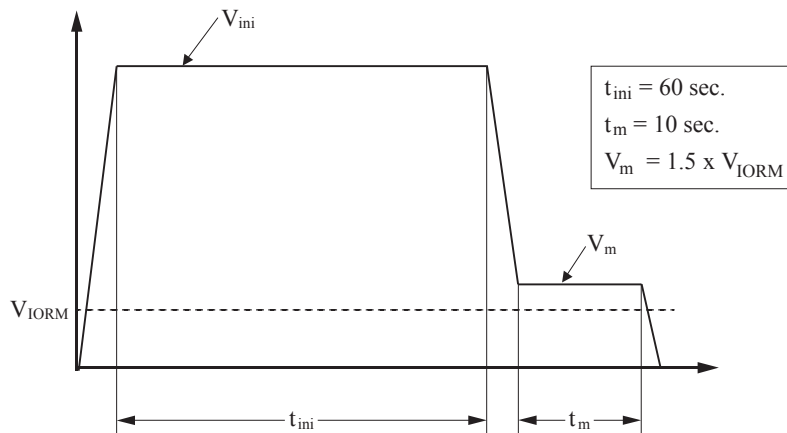
IsoLoop Isolators meet all other requirements of IEC 61010-1 Edition 3, as well as all requirements of IEC 61010-1 Edition 2, and are in conformance with IEC 60747-5-5.

### **VDE V 0884-10**

VDE V 0884-10 is based on partial discharge rather than breakdown testing. The standard includes a lot-sample destructive test called “Method A” and a nondestructive production test on each part (“Method B”). Key parameters are working voltage, transient overvoltage, and surge voltage. IsoLoop Isolators have best-in-class ratings of up to 1000 working volts, and V-Series versions meet the severe VDE 0884-10 surge immunity requirement for reinforced insulation.

**VDE V 0884-10 Lot-Sample Testing**

Type testing combines transient overvoltage and partial discharge tests as illustrated in Fig. 1:

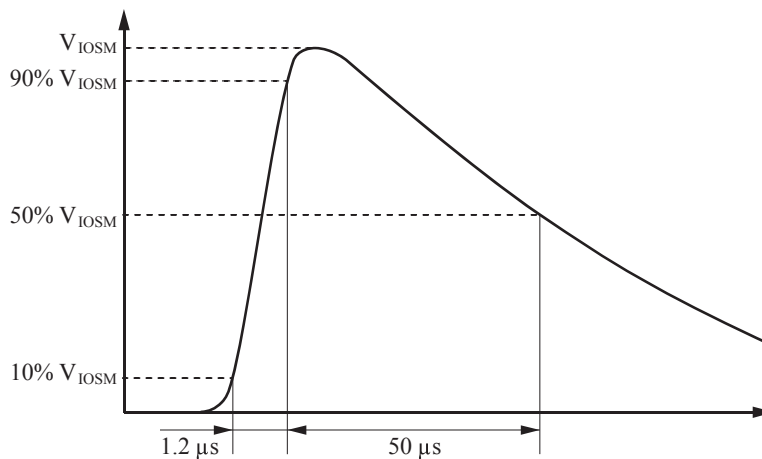


**Figure 1. VDE 0884 “Method A” (destructive) testing.**

$V_{IORM}$  is defined as the rated peak working voltage,  $V_{ini}$  is the rated transient overvoltage, and  $V_m$  is the partial discharge test voltage. In the initial test phase, the transient overvoltage test phase, the test voltage is ramped to  $V_{INITIAL}$  for 60 seconds ( $t_{ini}$ ). Partial discharge, but not breakdown, is allowable in this phase. The voltage is then decreased to the partial discharge test voltage,  $V_m$ , which is  $1.5 \times V_{IORM}$ . The partial discharge test time is 10 seconds ( $t_m$ ), and the partial discharge threshold is 5 picocoulombs.

**VDE V 0884-10 Surge Immunity**

VDE V 0884-10 specifies minimum surge immunity ( $V_{IOSM}$ ) of 10 kV for a reinforced insulation rating. Parts must withstand 50 repetitive surges (25 at each polarity) with the waveform shown below:



**Figure 2. VDE V 0884-10 Surge Voltage test waveform.**

**VDE V 0884-10 Surge Rating**

VDE V 0884-10 defines a “surge rating” with a 60% safety factor above the surge immunity. NVE V-Series isolators have 12.8 kV surge immunity and therefore a surge rating of 8 kV. These specifications are well above reinforced insulation requirements.

**VDE V 0884-10 Service Class**

Service Class under partial discharge standards is determined by the required working voltage and transient overvoltage (see Table 2). Standard IsoLoop Isolators have a rated working voltage of  $600 V_{RMS}$  and a transient overvoltage rating of  $4000 V_{PK}$ . V-Series Isolators have a rated working voltage of  $1000 V_{RMS}$  and a transient overvoltage rating of  $6000 V_{PK}$ . So for example, a working voltage of  $300 V_{RMS}$  is required for 220 V/240 V mains line voltage, and for that working voltage standard Isolators meet Service Class III and V-Series Isolators meet Service Class IV:

Working Voltage $V_{IORM}$ ( $V_{RMS}$ )	Working Voltage $V_{IORM}$ ( $V_{PK}/V_{DC}$ )	Transient Overvoltage ( $V_{INITIAL}; V_{PK}$ )			
		Service Class			
		I	II	III	IV
150	212	800	1500	2500	4000
300	414	1500	2500	4000	6000
600	828	2500	4000	6000	8000
1000	1415	4000	6000	8000	12000

**Table 2. VDE 0884-10 / IEC 60747-5-5 / IEC 60664 transient overvoltage requirements**  
(light green indicates conformance with standard IsoLoop Isolators; dark green shows V-Series conformance).

**VDE V 0884-10 Production Testing**

For nondestructive production testing, the test time is reduced to one second and the test voltage,  $V_{PR}$ , is raised to  $1.875 \times V_{IORM}$ . The partial discharge threshold is 5 picocoulombs.

**VDE V 0884-10 Sample Testing**

There are also random sample tests for visual defects, dielectric strength, validation of operation, creepage and clearance, insulation resistance, insulation resistance at elevated temperature, and soldering heat resistance.

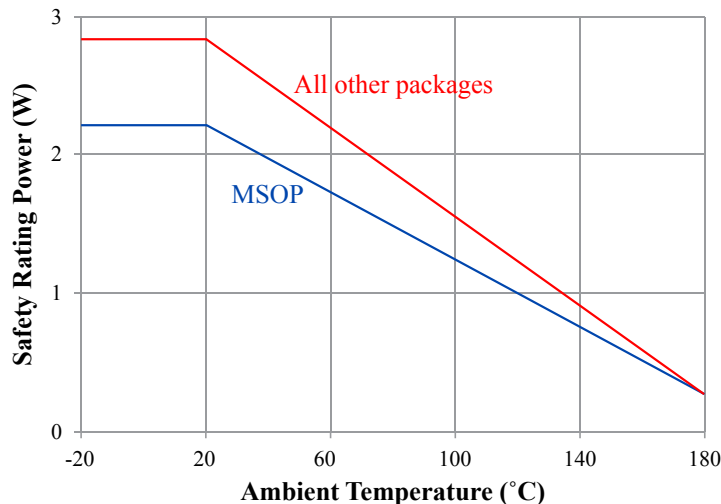
**VDE V 0884-10 Safety-Limiting Values**

“Safety-Limiting Values” are non-operating limits for the isolation barrier to continue to isolate the two potentials. Safety-limiting values for IsoLoop Isolators are summarized in the following table:

Parameter		Symbol	Value	Units
Safety rating ambient temperature		$T_S$	180	°C
Safety rating power (180°C)		$P_S$	270	mW
Supply current safety rating (total of supplies)		$I_S$	54	mA
Safety power derating	3 mm MSOP-8		80	°C/W
	0.15" SOIC-8		60	
	0.15" QSOP-16		60	
	0.15" SOIC-16		60	
	0.3" SOIC-16		60	

**Table 3. IsoLoop safety-limiting values.**

Because of the unique construction of their isolation barrier, IsoLoop isolators have an unusually high safety rating temperature and safety rating power. This is shown in the following curves:



**Figure 3. Safety rating power vs. temperature.**

**IEC 60601-1**

IEC 60601 specifies isolator creepage and isolation voltage for medical safety, and its creepage measurement standards are also used for demanding non-medical applications. As shown in Table 4, standard IsoLoop Isolators meet IEC 60601 Type B, “one Means of Operator Protection,” and “one Means of Patient Protection” requirements. IsoLoop V-Series Isolators meet the most stringent requirements, including those for equipment in contact with the heart:

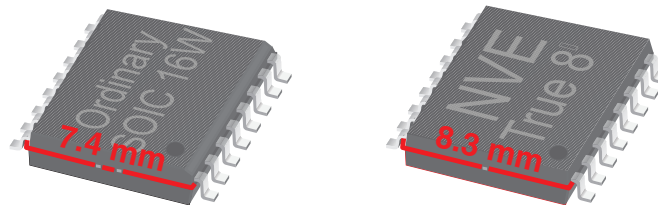
Classification	Isolation Voltage	Creepage
Type B (within patient vicinity) / 1 MOOP	1500 V <sub>RMS</sub>	2.5 mm
Type BF (within patient vicinity) / 2 MOOP	3000 V <sub>RMS</sub>	5 mm
1 MOPP	1500 V <sub>RMS</sub>	4 mm
Type CF (contact with the heart) / 2 MOPP	4000 V <sub>RMS</sub>	8 mm

**Table 4. IEC 60601 requirements.**

**IEC 60601-1 Creepage**

IEC 60601-1 has the most stringent creepage requirements of the applicable standards. For 220/240 V line voltage (250 V<sub>RMS</sub> working voltage) and the most stringent classification, creepage must be at least 8 mm. Unlike IEC 61010-1, IEC 60601 does not allow interpolation of values for clearance and creepage.

The limiting creepage path is usually around the end of the package from pin 1 to 16 or pin 8 to 9. Ordinary JEDEC wide-body packages are nominally 7.4 mm wide, with approximately 8.1 mm between pins around the end before subtracting metal tabs (often called “tie bars”) on the package edge. Tie bars are used in the molding process, and whether internally connected or not, the exposed metal reduces the creepage and must be subtracted under IEC 60601. The tie bar subtraction for ordinary JEDEC packages is typically 0.5 mm, reducing typical creepage to only 7.4 mm even before allowing for mechanical tolerances:



**Figure 4. Typical True 8™ creepage vs. an ordinary wide-body package.**

The NVE True 8™ isolator package was custom tooled for isolation. Even with worst-case package dimensions and pin placement, the NVE package ensures 8 mm minimum creepage as defined under IEC 60601 rules.

**IsoLoop Approvals**

Specifics of IsoLoop Isolator approvals for UL 1577, IEC 61010-1, and IEC 60747-5-5 (VDE 0884) are summarized as follows:

**UL 1577** (Component Recognition Program File Number E207481)

Standard parts tested at 3000 V<sub>RMS</sub> (4240 V<sub>PK</sub>) for 1 sec.; each lot sample tested at 2500 V<sub>RMS</sub> (3530 V<sub>PK</sub>) for 60 sec.  
V-Series parts tested at 7200 V<sub>RMS</sub> (10.2 kV<sub>PK</sub>) for 1 sec.; each lot sample tested at 6000 V<sub>RMS</sub> (8485 V<sub>PK</sub>) for 60 sec.

**IEC 61010-1** (Reinforced Insulation; Pollution Degree II; Material Group III; TUV Certificates N1502812; N1502812-101)

IsoLoop Parts	Working Voltage
MSOP (standard)	150 V <sub>RMS</sub>
MSOP “V” Series (high isolation voltage)	300 V <sub>RMS</sub>
PDIP	300 V <sub>RMS</sub>
SOIC	150 V <sub>RMS</sub>
0.3" SOIC (standard grates)	300 V <sub>RMS</sub>
0.3" SOIC “V” Series (high isolation voltage)	1000 V <sub>RMS</sub>

**VDE V 0884-10** (File Number 5016933-4880-0001)

1 kV and 2.5 kV-rated parts

- Working Voltage ( $V_{IORM}$ ) 600  $V_{RMS}$  (848  $V_{PK}$ ); basic insulation; pollution degree 2
- Isolation voltage ( $V_{ISO}$ ) 2500  $V_{RMS}$
- Transient overvoltage ( $V_{IOTM}$ ) 4000  $V_{PK}$
- Surge rating 4000 V
- Each part tested at 1590  $V_{PK}$  for 1 second, 5 pC partial discharge limit
- Samples tested at 4000  $V_{PK}$  for 60 sec.; then 1358  $V_{PK}$  for 10 sec. with 5 pC partial discharge limit

V-Series 6 kV-rated parts

- Working Voltage ( $V_{IORM}$ ) 1000  $V_{RMS}$  (1415  $V_{PK}$ ); reinforced insulation; pollution degree 2
- Isolation voltage ( $V_{ISO}$ ) 6000  $V_{RMS}$
- Surge immunity ( $V_{IOSM}$ ) 12.8 kV
- Surge rating 8 kV
- Transient overvoltage ( $V_{IOTM}$ ) 6000  $V_{PK}$
- Each part tested at 2387  $V_{PK}$  for 1 second, 5 pC partial discharge limit
- Samples tested at 6000  $V_{PK}$  for 60 sec.; then 2122  $V_{PK}$  for 10 sec. with 5 pC partial discharge limit

**Other High-Voltage Parameters**

NVE's unique polymer-ceramic composite barrier provides superior high-voltage performance. In addition to standards compliance, other best-in-class figures of merit are as follows:

Parameter	Min.	Typ.	Units	Test Conditions
Barrier Impedance (Insulation Resistance)	$10^{14}$		$\Omega$	500 $V_{DC}$
Surge Immunity	12.8 kV			per VDE V 0884-10
Comparative Tracking Index (CTI)	$\geq 600$		V	per IEC 60112
Barrier Life		44000	Years	100°C, 1000 $V_{RMS}$ , 60% CL activation energy

**Table 5. IsoLoop high-voltage specifications.**