

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

NVE Isolators have exceptional high-voltage performance and meet applicable safety standards. The standards summarized in this Bulletin are VDE 0884-17, UL 1577, 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_{RMS} for standard Isolators; 6000 V_{RMS} for high-isolation grades) for one minute. The production test is 120% of the rated isolation voltage for one second with no breakdown permitted.

Limitations of UL 1577

Breakdown-based standards such as 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 VDE 0884-17 overcome these limitations and preferred by many companies. Like pressure testing a surgical glove, partial discharge tests detect tiny imperfections that could grow much larger.

VDE 0884-17

VDE began certifying to VDE 0884 Edition 17 in 2022. The rigorous standard is formally designated DIN EN IEC 60747-17 (VDE 0884-17):2021-10; EN IEC 60747-17:2020+AC:2021. NVE isolators were some of the first parts to be certified under the new standard.

VDE certifications are primarily based on partial discharge rather than breakdown testing. The 0884-17 standard includes a lot-sample destructive test called “Method A” and a nondestructive production test on each part called “Method B.” Key parameters are Working Voltage, transient overvoltage, and surge voltage. NVE Isolators have best-in-class ratings of up to 1200 Working Volts, and V-Series versions meet the rigorous requirement for reinforced isolation.

Reinforced Isolators That Are Actually Reinforced

Critical systems such as medical instruments often require “reinforced isolation.” This has traditionally required two isolation layers. The new VDE standard has diluted the term by certifying isolators with a single barrier as “reinforced” based on electrical tests.

NVE’s unique isolator construction uses two barrier layers: a special polymer reinforced with a ceramic layer:

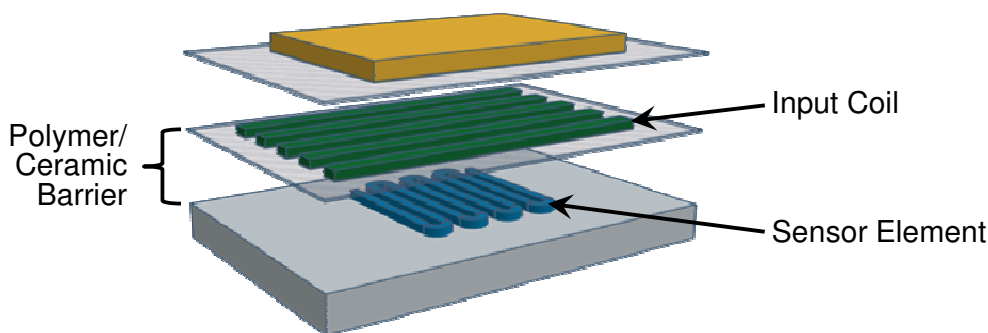


Figure 1. NVE Isolator construction.

Time Dependent Dielectric Breakdown (TDDB) Testing

Unlike earlier standards such as VDE V 0884-10, VDE 0884-17 requires Time Dependent Dielectric Breakdown (TDDB) tests to determine the Working Voltage rating. TDDB is performed by running a sampling of parts to high-voltage failure.

Basic isolation requires an extrapolated failure rate of less than 1000 ppm over 26 years; “reinforced” isolation requires one ppm over 37.5 years at the Working Voltage.

TDDB tests are run at 25 °C and at maximum temperature, and at enough voltages to allow a Weibull curve fit. The VDE Working Voltage rating uses the worst-case temperature and includes a 20% “safety factor.”

The following chart shows the TDDB test results:

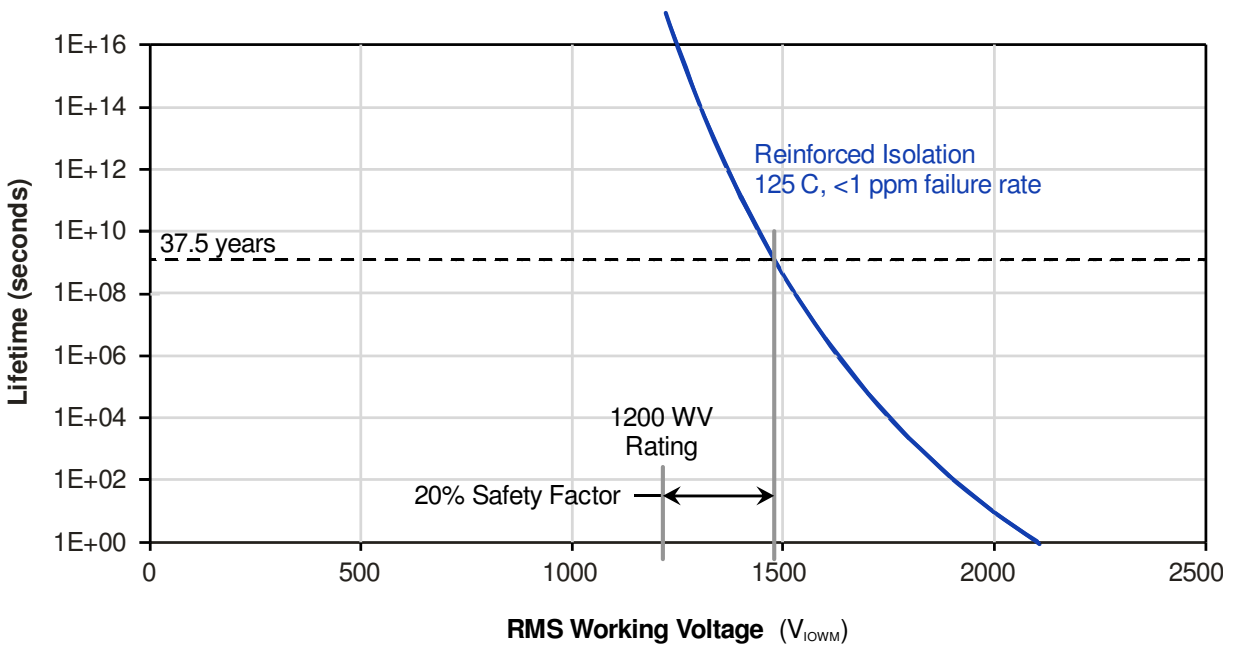


Figure 2. TDDB test data.

VDE Lot-Sample Testing

“Method A” type testing combines transient overvoltage and partial discharge tests as illustrated in Fig. 1:

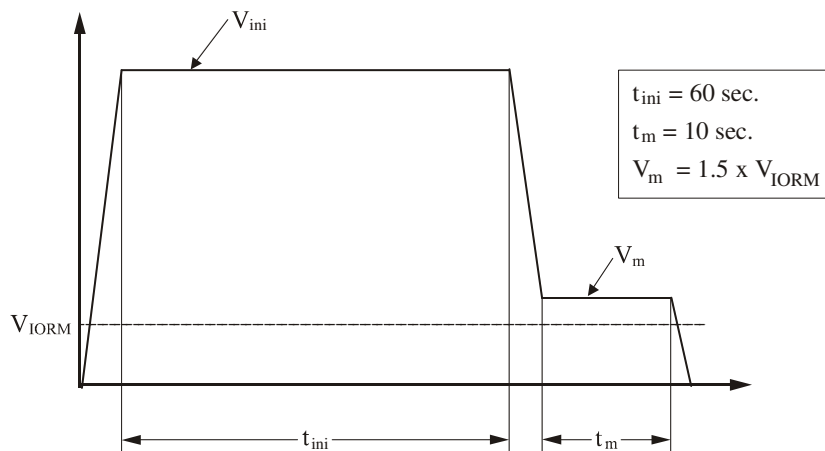


Figure 3. VDE 0884 “Method A” (destructive) testing.

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 Surge Immunity

VDE 0884-17 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:

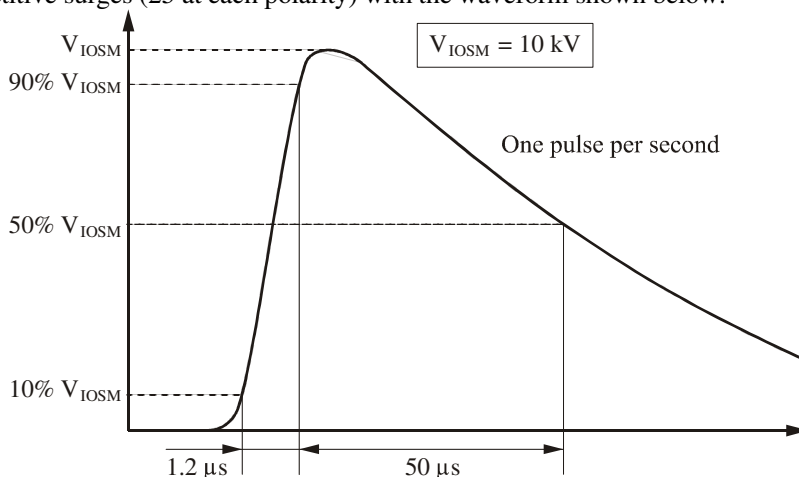


Figure 4. VDE 0884 Surge Voltage test waveform.

VDE Surge Rating

VDE 0884-17 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 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 “Mechanical” 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.

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, NVE’s standard Isolators meet IEC 60601 Type B, “one Means of Operator Protection,” and “one Means of Patient Protection” requirements. V-Series Isolators meet the most stringent requirements, including those for equipment in contact with the heart:

Classification	Min. Isolation Voltage	Min. Creepage
Type B (within patient vicinity) / 1 MOOP	1500 V_{RMS}	2.5 mm
Type BF (within patient vicinity) / 2 MOOP	3000 V_{RMS}	5 mm
1 MOPP	1500 V_{RMS}	4 mm
Type CF (contact with the heart) / 2 MOPP	4000 V_{RMS}	8 mm

Table 1. IEC 60601 requirements.

IEC 60601-1 Creepage

IEC 60601-1 has the most stringent creepage requirements of any isolator standards. For 220/240 V line voltage (250 V_{RMS} working voltage) and the most stringent classification, creepage must be at least 8 millimeters. Unlike other standards, IEC 60601 does not allow interpolation of values for clearance and creepage and requires exposed metal to be subtracted from 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:

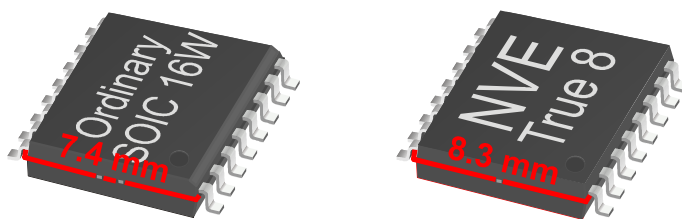


Figure 5. Typical True 8™ creepage vs. an ordinary wide-body package.

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.

NVE Approvals

Details of NVE’s UL 1577 and VDE 0884 approvals are summarized as follows:

UL 1577 (Component Recognition Program File Number E207481)

Standard isolation grade

2500 V rating; each part tested at 3000 V_{RMS} (4243 V_{PK}) for 1 sec.; each lot sample tested at 2500 V_{RMS} (3536 V_{PK}) for 1 min.

V-Series isolation grade

6 kV rating; each part tested at 7.2 kV_{RMS} (10.2 kV_{PK}) for 1 sec.; each lot sample tested at 6 kV_{RMS} (8485 V_{PK}) for 1 min.

IEC 60747-17 (VDE 0884-17):2021-10:

Standard versions (Basic Isolation; VDE File Number 5016933-4880-0001)

- 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.
- Working Voltage (V_{IORM}; pollution degree 2): See Table 3.

V-Series versions (Reinforced Isolation; VDE File Number 5016933-4880-0002)

- Working Voltage (V_{IORM}): 1200 V_{RMS} (1700 V_{PK}) with 20% Safety Factor; pollution degree 2
- Isolation voltage (V_{ISO}): 6000 V_{RMS}
- Surge immunity (V_{IOSM}): 12.8 kV_{PK}
- Surge rating: 8000 V
- 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

Safety-Limiting Values

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

Safety-Limiting Values	Symbol	Value	Units
Safety rating ambient temperature	T_S	180	$^{\circ}\text{C}$
Safety rating power (180 $^{\circ}\text{C}$)	P_S	270	mW
Supply current safety rating (total of supplies)	I_S	54	mA

Table 2. Safety-Limiting Values.

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

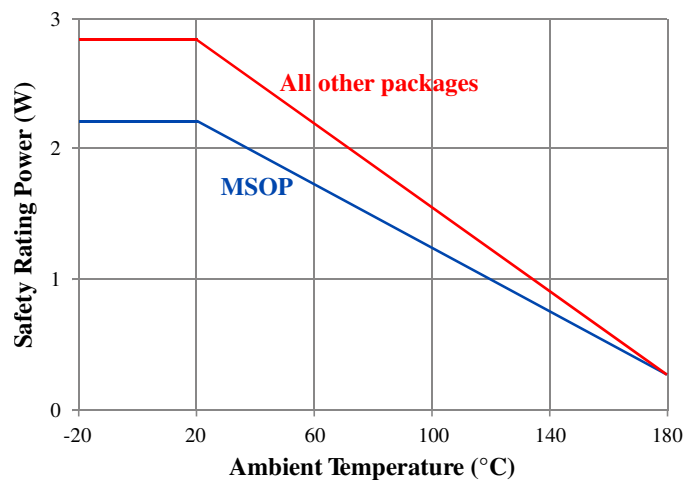


Figure 6. Safety rating power vs. temperature.

Working Voltage Rating

Under VDE 0884-17, the Working Voltage rating is determined from Time Dependent Dielectric Breakdown (TDDDB) testing, and is an important figure of merit for the long-term reliability of the isolation barrier.

Working Voltage depends on the isolator design, as well as package and leadframe characteristics. NVE has designed its packages specifically for isolators to optimize high-voltage performance and safety:

Package	Part # Suffix	Working Voltage Rating (V_{IORM})	Min. Creepage
QSOP16	-1	600 V_{RMS}	4.03 mm
Wide-body SOIC16/True 8 TM (standard versions)	None	600 V_{RMS}	8.03 mm
Narrow-body SOIC16N	-3	700 V_{RMS}	4.03 mm
SOIC8	-3	700 V_{RMS}	4.03 mm
MSOP8	-1	800 V_{RMS}	3.01 mm
PDIP8	-2	900 V_{RMS}	7.08 mm
Wide-body SOIC16/True 8 TM (V-Series)	V	1200 V_{RMS}	8.03 mm

Table 3. Working Voltage Ratings.

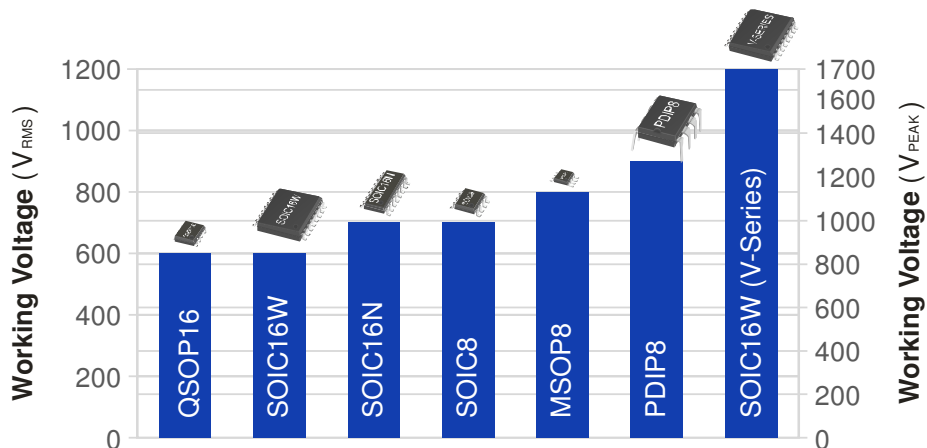


Figure 7. Working Voltage Ratings.

Other High-Voltage Parameters

Other important best-in-class high-voltage figures of merit include:

Parameter	Min.	Typ.	Units	Test Conditions
Barrier Impedance (Insulation Resistance)	10^{14}		Ω	500 V _{DC}
Surge Immunity	12.8 kV			per VDE 0884-17
Comparative Tracking Index (CTI)	≥ 600		V	per IEC 60112
Barrier Life		44000	Years	100°C, 1000 V _{RMS} , 60% CL activation energy

Table 4. NVE Isolator high-voltage specifications.