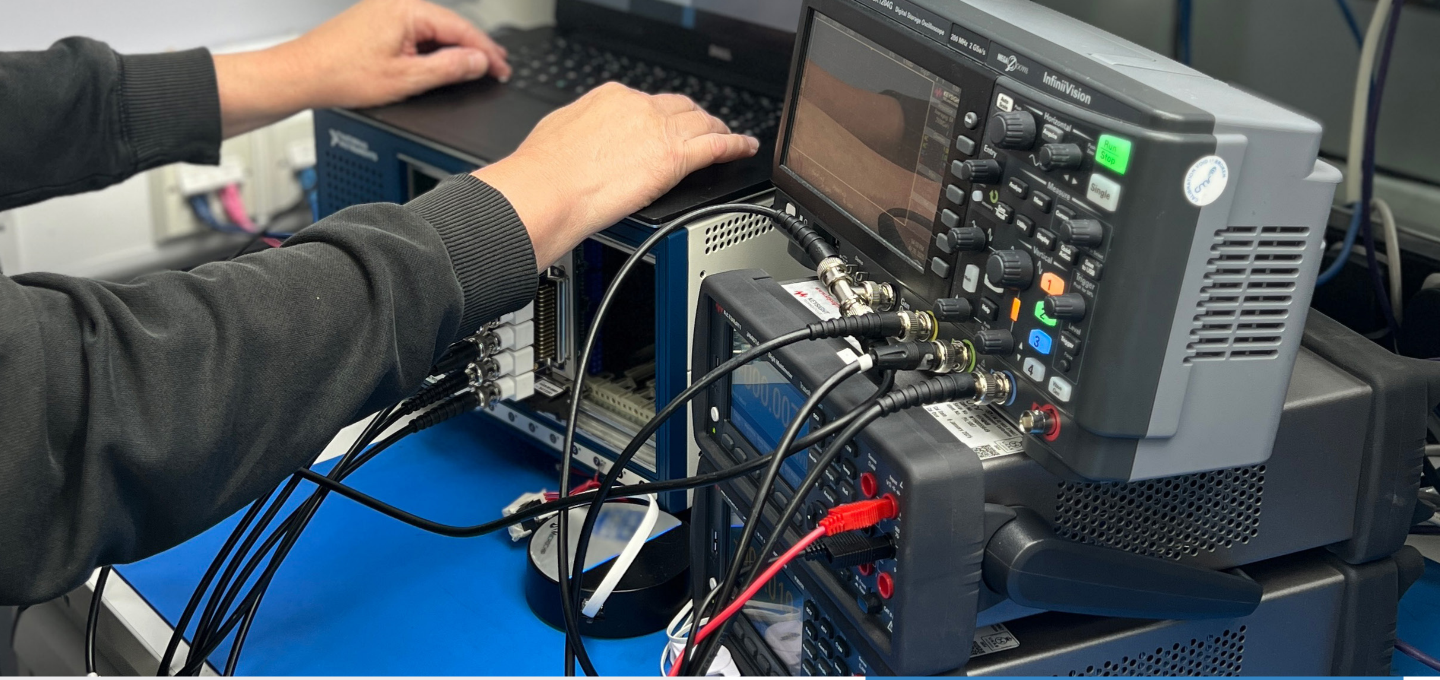
High Potential Testing

Achieve Accurate, Reliable Dielectric Testing with Reed Relay Technology

In this application guide:

- High Potential Testing
- Insulation: Its Role & Testing
- Why High Voltage Reed Relays
- Reed Relay Terminology
- Recommended Products
- Why Pickering Electronics for Reed Relays?

pickering



Verifying the effectiveness of the insulation integrity of materials used in electrical products and systems helps ensure safety, reliability, and longevity.

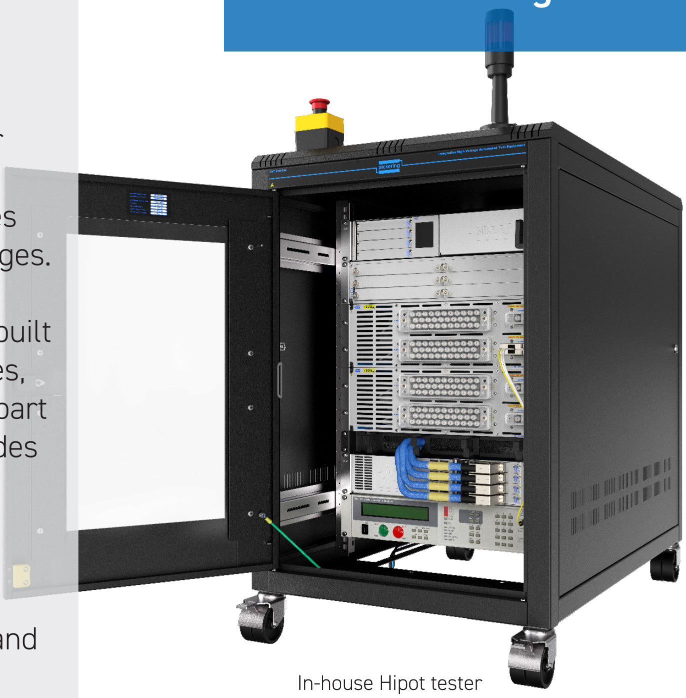
Verification is performed in two ways: dielectric withstand testing (also known as Hipot testing) and dielectric breakdown testing. Both tests require the ability to measure low current and breakdown testing, in particular, requires applying very high voltages.

In this application guide we will explain why high voltage reed relays are ideal for use in test equipment/stations used for determining dielectric breakdown voltages and in verifying dielectric withstand voltages.

This in-house Hipot tester, designed and built by our sister company Pickering Interfaces, showcases our group-wide expertise. As part of the Pickering Group, we combine decades of relay manufacturing knowledge from Pickering Electronics with advanced test system design from Pickering Interfaces.

This dual perspective means we understand high voltage switching from both sides, creating reliable reed relays and integrating them into complex, real-world test environments.

"In this application guide we will explain why high voltage reed relays are ideal for use in test equipment/stations used for determining dielectric breakdown voltages and in verifying dielectric withstand voltages."



In-house Hipot tester

Insulation: Its Role & Testing

A variety of insulation materials are used in electrical components and products to protect people, equipment, and systems by preventing unwanted current paths. For example, plastic-based materials like PVC and polyethylene (PE), as well as synthetic rubber compounds and specialized materials such as polytetrafluoroethylene (PTFE) and silicone, are used to insulate wires and cables.

The choice of material depends on factors such as flexibility requirements, as well as resistance to temperature extremes and chemical exposure.

For components like motors and transformers, the insulation is internal, and materials used include paper, polyester films, glass, fiberglass, resins and varnishes. And for PCBs, the insulation material between the track layers is typically FR-4 (a fiberglass-epoxy laminate); ceramics and polyimides can also be used depending on the application.

Importantly, no insulation material is completely resistant to current, there will always be some leakage. Small currents are generally safe for the user, but if the insulation material is inadequate or there is a manufacturing defect the leakage current becomes dangerous, and the insulator has reached dielectric breakdown.

During the development of a product, a prototype is typically subjected to a dielectric breakdown test. It is a destructive test that subjects components and cables used in the product to increasingly higher voltages to establish the level at which breakdown occurs, i.e. the leakage current reaches an unsafe level. A dielectric withstand test (Hipot testing) on the other hand applies a test voltage above its intended operating voltage and the leakage current is measured to verify that it is within industry standard safety ranges.

Testing is performed when the product is manufactured, and the readings are often kept as not only as a record of the test but also to act as a benchmark for subsequent tests once the product enters service.

Regular dielectric withstand testing is strongly recommended, and a legal requirement in many instances, because the effectiveness of the insulation reduces over time.

For example, within motors and transformers extensive thermal cycling can degrade the insulation material, and the coatings on wires and cables can perish through flexing. Humidity, dust and chemicals can also reduce insulation material effectiveness.

Insulation breakdown can lead to the product or system becoming unsafe in terms of not only the risk of electric shock but also the risk of fire. The product or system might also fail, which could lead to many other types of risk. Also, current leaking through inadequate or failing insulation is a waste of energy.

Several industry standards relate to dielectric withstand testing, including:

- IEC/EN/UL 61800-5-1
- GB 12668.501, IEC 60950
- GB/T 16927

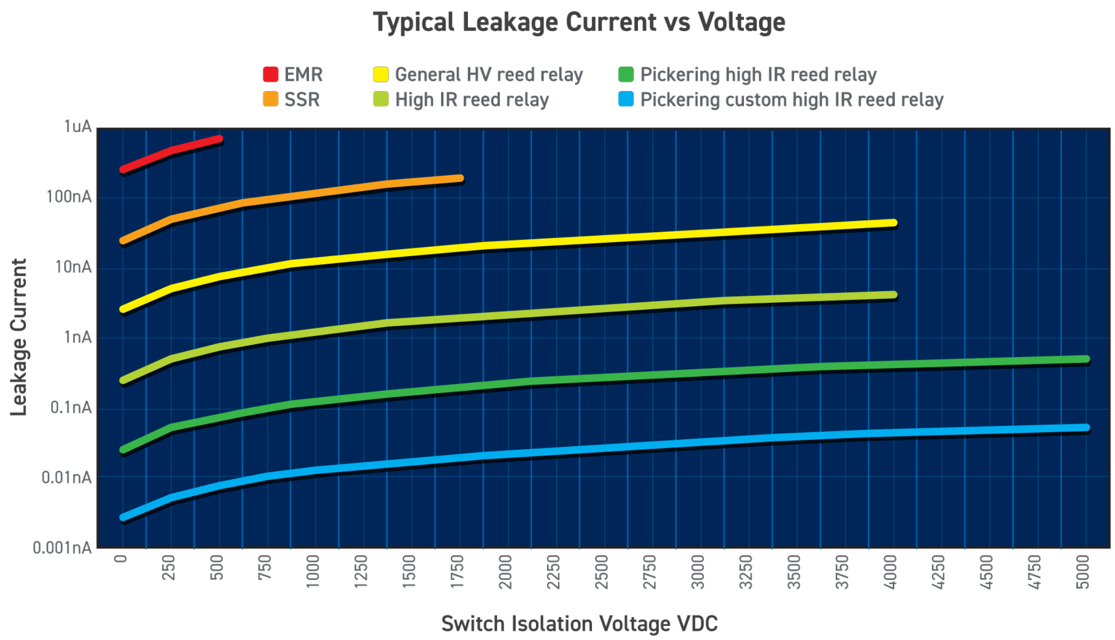
Why High Voltage Reed Relays

Because the contacts in high voltage reed relays are sealed in a vacuum, even compact models like the Pickering Series 104 can achieve a **5 kV** standoff voltage and switch up to **1.5 kV**. Larger relays, such as the Series 62, Series 63, and our new customizable Series 600, offer up to **20 kV** and **12.5 kV** switching. For applications where space or high-density layouts are a priority, Pickering also offers high voltage options in its THT Series 119 and SMD Series 219, delivering up to **3 kV** standoff and **1 kV** switching, all within compact footprints.

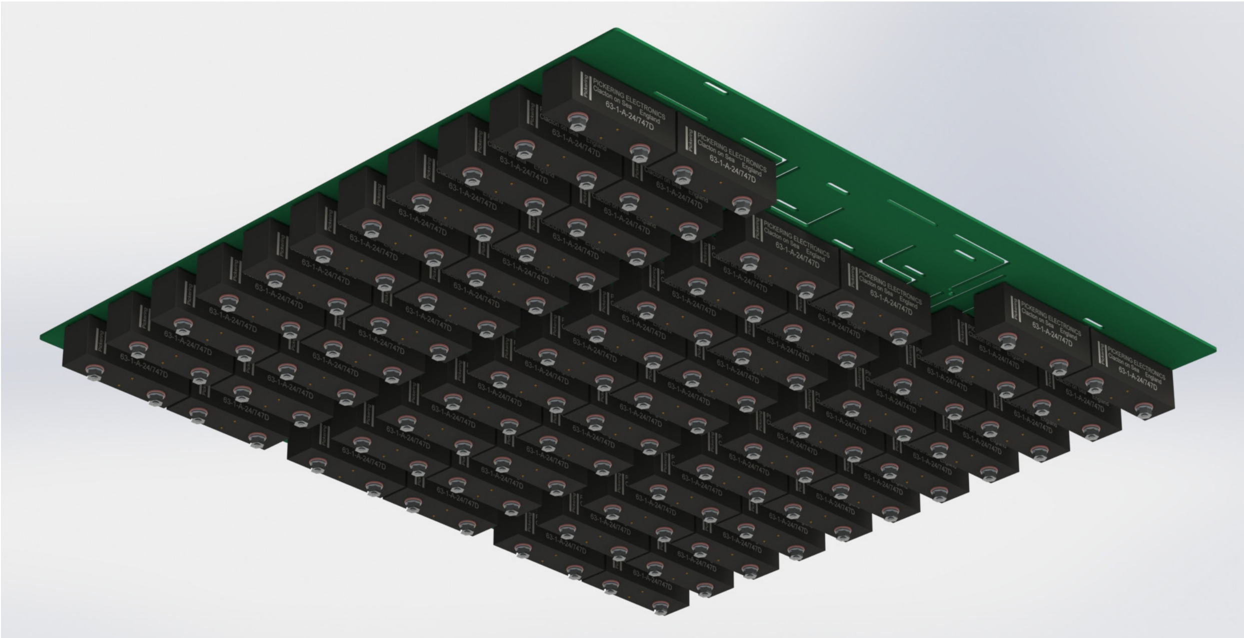
Importantly, these voltage ratings apply to both DC and AC peak, allowing flexibility across various test environments. In contrast, electromechanical relays typically max out at around **500 V** switching, as their open-air contacts limit both standoff and switching voltage capability, making reed relays the superior choice for high voltage isolation.

The superior standoff and switching voltages high voltage reed relays can achieve compared to other switching technologies make them the ideal choice for both dielectric breakdown and strength testing. They can also provide a solution for discharging any capacitance in test circuits by switching a discharge load across the output when it is turned off, ensuring there are no high voltages present that may create a potential safety hazard.

Thanks to the use of potting compounds with very high electrical resistance, reed relays have very low leakage currents (something solid-state relays [SSRs] cannot boast), meaning they will not compromise current measurements taken during dielectric withstand tests, which are more about verifying that the DUT's leakage current is safely low under normal operating conditions. Pickering high voltage relays are tested for insulation resistances over **$10^{12}\Omega$**, but custom options can achieve over **$10^{14}\Omega$**.



This graph compares leakage current performance across a range of switch types as isolation voltage increases.



Above, a high-density switching board developed by Pickering Interfaces for a customer wanting to perform dielectric breakdown testing on cable harnesses. The PCB, which measures 400 x 450mm contains 64 custom reed relays that are based on Pickering's 63 series, and upgraded from 15 to 19kV standoff voltage.

While traditional EMRs and SSRs begin to show significant leakage even at their lower voltage ratings, high-quality reed relays, especially

Pickering's high insulation resistance (IR) and custom high IR options, offer dramatically lower leakage currents, even at much higher voltages.

Pickering's relays maintain insulation resistance levels up to $10^{13}\Omega$ as standard and up to $10^{14}\Omega$ in custom designs, keeping leakage currents in the sub-nanoamp range at voltages up to 5kV. This makes them ideal for precision high-voltage isolation and test applications where low leakage is critical.

Another drawback for semiconductor switching technologies is that for certain failure modes, the high voltage signal path and the low voltage control path may short, resulting in the high voltage signal making its way into the control circuitry causing damage.

Where switching speed is an important consideration, reed relays can operate as fast as 0.2ms, significantly faster than electromechanical relays. Whereas electromechanical relays may only have a mechanical life of a few hundred thousand operations, when used within their rating, reed relays can achieve millions or even billions of operations with no degradation in performance.

Moreover, if many test channels are required, the physical size of the switching device is very important. Even if EMRs could be used at voltages above 500V, their size means switching/matrix boards would need to be very large. Reed relays on the other hand can be used to create very high-density switching and MUX boards.

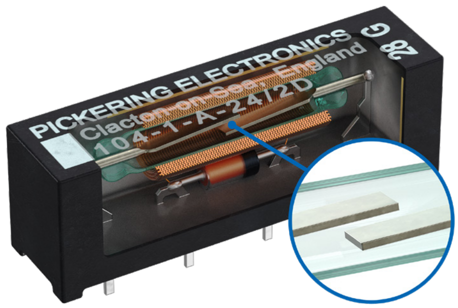
In summary, reed relays are the ideal switching technology for insulation dielectric breakdown and withstand testing applications.

With a wide range of specifications and package sizes, they can provide a solution where it is necessary to isolate or switch high voltages to the DUT, and their inherently very low leakage current will not compromise any current measurements being taken, winning over EMRs and solid-state technology. They are also highly reliable and relatively compact, certainly compared to EMRs.

Reed Relay Terminology

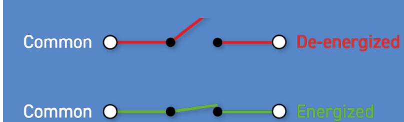
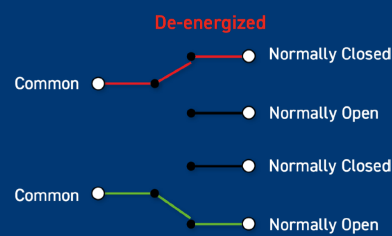
Term	Definition	Why it Matters in Hipot Testing
Maximum Switching Voltage	Highest DC or AC (peak) voltage that can be switched safely.	Ensures the relay can handle the test voltage without arcing or damage during breakdown testing.
Minimum Standoff Voltage	Max voltage that can be applied across open contacts without breakdown.	Critical for safe isolation at high voltages; prevents false failures and safety risks.
Maximum Switching Current	Highest current the relay can switch within power limits.	Important when charging/discharging capacitive DUTs during Hipot tests.
Maximum Carry Current	Highest continuous current through closed contacts.	Ensures the relay won't overheat or fail when test current is sustained.
Coil Voltage	Nominal DC voltage required to energise the relay coil.	Needs to be compatible with control circuitry in the Hipot tester.
Coil Resistance	Resistance of the coil, usually measured at 25°C.	Impacts power consumption and thermal performance of the test system.
Insulation Resistance	Resistance between device pins (ideally >10^{12} Ω, higher for custom parts).	Key to measuring extremely low leakage currents accurately.
Switch-to-Coil Isolation	Voltage that can be applied between switch contacts and coil before breakdown.	Prevents high voltage from feeding back into control electronics — protects test equipment.
Shock Rating	Peak acceleration relay can withstand without malfunction.	Ensures stable operation of relays in rugged or mobile test setups.
Vibration Rating	Frequency/acceleration relay can tolerate without malfunction.	Important for Hipot testing environments subject to vibration (e.g., aerospace, automotive).
External Shield Clearance	Distance between external shield and base of relay.	Poor clearance can cause arcing at high voltages; Pickering uses internal shielding to avoid this.

For high-voltage reed relays, the contact is sealed in a vacuum, greatly increasing the minimum standoff and maximum switching voltages. Insulation resistance is high thanks to pin spacing and the relay's base material. As for external shield clearance, this is not an issue when the EM shielding is on the inside of the device.



By considering these key factors, you can make a well-informed decision when selecting the appropriate reed relay for your Hipot application. Other information you will need to consider when designing your Hipot equipment includes contact configuration and service life.

Contact Configuration (Forms)

Form A	Form B	Form C
		
With the coil de-energized the switch is normally open (NO). If just one switch is present, the form is 1A, meaning single pole single throw normally open (SPST-NO). If two switches are present, the form is 2A, meaning double pole single throw normally open (DPST-NO). With three switches it is 3A (3PST-NO) etc.	With the coil de-energized the switch is normally closed (NC). If just one switch is present, the form is 1B, meaning single pole single throw normally closed (SPST-NC). If two switches are present, the form is 2B, meaning double pole single throw normally closed (DPST-NC). With three switches it is 3B (3PST-NC) etc.	These are changeover devices that break their NC contact (and close the NO one) when the coil is energized. If just one switch is present, the form is 1C, meaning single pole double throw (SPDT). If two switches are present, the form is DPDT, 2C (pictured). With three switches it is 3PDT (or 3C) etc.

What's the Service Life?

This is the one figure on any datasheet, from any manufacturer, that is open to interpretation.

We state 1×10^9 operations for most applications, but the fact of the matter is the figure could be higher or lower depending on the exact application.

Considerations are: How close to voltage and current limits are you operating? What is the switching duty cycle? Are you likely to see inrush currents?

Also, at what point do you consider the device to be failing? When contact resistance increases by 10%? 20%? More?

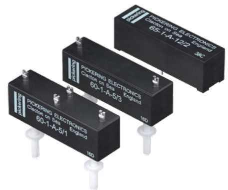
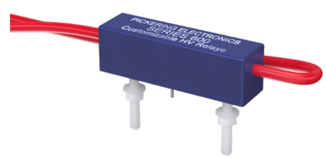
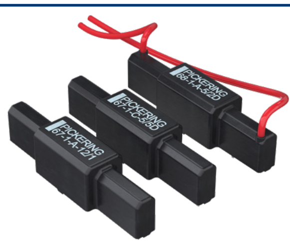
Rest Assured, We're Here to Help

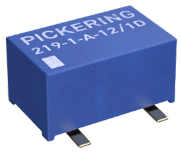
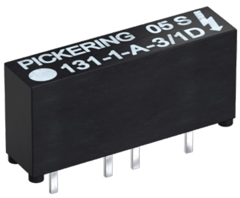
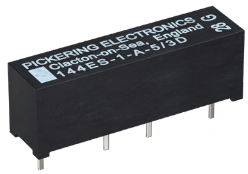
Tell us about your application and we'll not only recommend the most suitable device, but we'll also give you an indication of the device's realistic service life

Speak with our engineers today to find the ideal relay solution for your dielectric testing requirements.

Recommended Products

Pickering Electronics has an extensive range of high-performance, high voltage isolation reed relays that are ideally suited to high voltage measurement applications. Furthermore, with device footprints starting at just 46mm^2, many relays can be accommodated on a single PCB. We particularly recommend the following series.

Series 60 & 65	Series 62 & 63
	
This range has switching voltages up to 12.5 kV and minimum standoff voltages up to 15 kV. Maximum switch current is 3 A (at up to 50 W) and maximum carry current is up to 3.5 A.	This range has switching voltages up to 12.5 kV and minimum standoff voltages up to 20 kV. Maximum switch current is 3 A (at up to 50 W) and maximum carry current is 3.5 A.
Series 100HV	**Series 600**
	
This range has 5, 12 or 24 V coils. HV + high coil resistance reed relays in Form A and Form B. 3000 V stand-off, 1000 V switching. Up to 6800 Ohms coil resistance.	This range is fully customizable. Up to 20kV standoff, 12.5kV switching, and 200W power handling. Available with 5V, 12V, or 24V coils and optional EMF suppression. Offers NO, NC, and changeover contacts. Features vacuum-sealed reed switches, >10^{13}Ω insulation, magnetic/electrostatic shielding, and modular design.
Series 67 & 68	**Series 104**
	
This range has switching voltages up to 7.5 kV and minimum standoff voltages up to 10 kV. Maximum switch current is 3 A (at up to 50 W) and maximum carry current is up to 5 A. High power 200 W switch available. 5, 12 or 24 V coils. Optional electrostatic shield available.	This range has switching voltages up to 1.5 kV and minimum standoff voltages up to 5 kV. Maximum switch current is 1 A (at up to 25 W) and maximum carry current is 1.5 A. High Temperature option available that can withstandup to 125°C (& up to 150°C as a standard build option) Optional electrostatic shield.

Series 219	Series 119
 This surface mount range has switching voltages up to 1kV and minimum standoff voltages up to 3 kV. Maximum switch current is 0.7A (at up to 10W) and maximum carry current is 1.5A.	 This range has switching voltages up to 1kV and minimum standoff voltages up to 3kV. Maximum switch current is 0.7A (at up to 10W) and maximum carry current is 1.25A.
Series 131	**Series 144**
 This range has switching voltages up to 1kV and minimum standoff voltages up to 1.5kV. Maximum switch current is 0.7A (at up to 10W) and maximum carry current is 1.25A.	 This range has switching voltages up to 1kV and minimum standoff voltages up to 3kV. Maximum switch current is 2.0A (at up to 60W) or 1.0A (at up to 80W) and the maximum carry current is 3.0A.

Why Pickering Electronics for Reed Relays?

We've been making reed relays since 1968. It's our core business and has laid the foundation for the switching-based solutions of our sister company Pickering Interfaces.

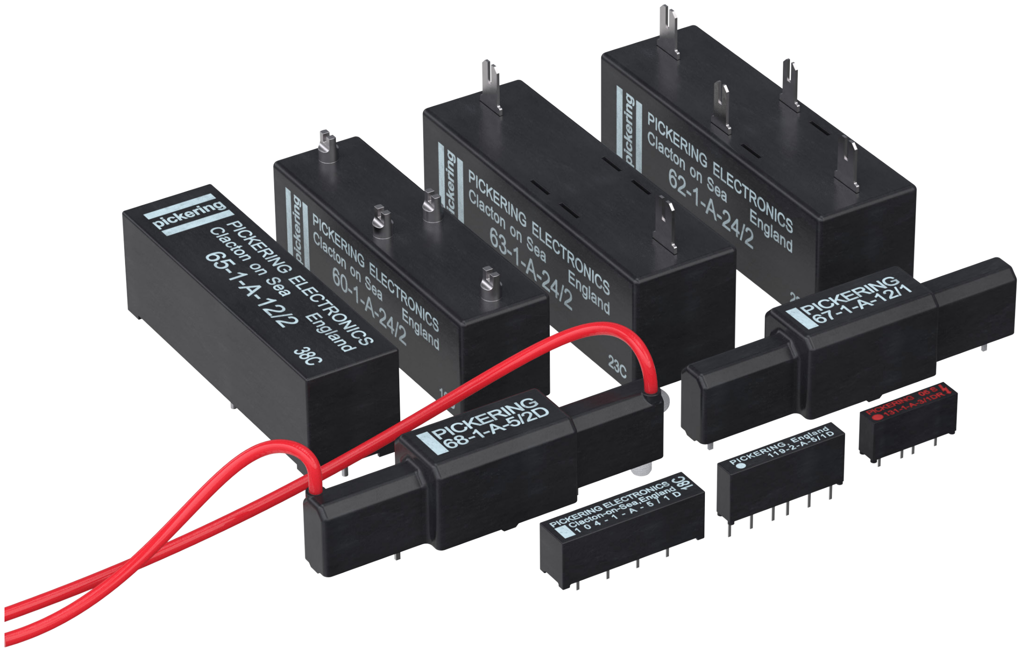
The relays recommended in this guide are all instrumentation grade and the reed contacts will be plated with either Rhodium (electro-plated) or Ruthenium (vacuum spluttered) or for higher voltages, Tungsten, to ensure to ensure a long life – typically up to 5x10^9 operations.

They are of a former-less coil construction, which increases the coil winding volume, maximizes the magnetic efficiency, all allows for the use of less sensitive reed switches, resulting in optimal switching action and extended lifetime at operational extremes.

Internal mu-metal magnetic screening enables ultra-high PCB side-by-side packing densities with minimal magnetic interaction, saving significant cost and space. Our magnetic screen reduces EM interaction to approximately 5%. Low quality relays typically exhibit an EM interaction of 30%.

Our SoftCenter™ technology uses high performance encapsulation materials to achieve the best high voltage performance and provide the maximum cushioned protection of the glass reed switch, minimizing internal lifetime stresses and extending the working life and contact stability.

Inspection at every stage of manufacturing maintaining high levels of quality. Also, 100% testing for all operating parameters including dynamic contact wave-shape analysis with full data scrutiny to maintain consistency. Stress testing of the manufacturing processes, from -20°C to 85°C to -20°C, repeated 3 times.



About Pickering Electronics

Pickering Electronics was established over 50 years ago to design and manufacture high quality reed relays, intended principally for use in instrumentation and test equipment. Today, Pickering's Single-in-Line (SIL/SIP) range is by far the most developed in the relay industry, with devices 25% the size of our competitors' electrically equivalent devices. These small SIL/SIP reed relays are sold in high volumes to large ATE and semiconductor companies throughout the world.

The privately-owned Pickering Group comprises three electronics manufacturers: reed relay company Pickering Electronics; Pickering Interfaces, designers and manufacturers of modular signal switching and simulation products, and Pickering Connect, which designs and manufactures cables and connectors. The group employs over 500 people primarily in the UK and Czech Republic with additional employees in sales offices in the US, China, Germany, Sweden, and France.

Technical Help

Please go to: pickeringrelay.com/help.
If your questions are not answered here, please e-mail: techsales@pickeringrelay.com.
Alternatively, please call our Technical Sales Office on + 44 (0)1255 428141.

Pickering Electronics Ltd.
Stephenson Road
Clacton-on-Sea
CO15 4NL
United Kingdom

Tel: +44 1255 428141
email: techsales@pickeringrelay.com
Web: pickeringrelay.com

Registered in England no. 857509 VAT no GB103 5366 04
Registered Office: Stephenson Rd, Clacton-on-Sea, Essex. CO15 4NL